University of Southern Queensland

Faculty of Health, Engineering and Sciences

Evaluation of Issues Affecting Stabilised Granular Pavements

Dissertation submitted by

Shaun Perkins

In fulfilment of the requirements of

ENG4111 and ENG4112 Research Project

towards the degree of

Bachelor of Engineering (Honours) (Civil)

Submitted October 2022

Abstract

Transport for NSW and other road authorities manage roads within their allocated maintenance budgets. Significant funding is provided each year to rehabilitate pavements that have reached the end of their service life. Transport for NSW is obligated as the state road authority in NSW to complete pavement rehabilitations using the most efficient and sustainable techniques available. Insitu stabilisation of existing pavements is a sustainable method of recycling an existing pavement with minimal addition of new materials to achieve a design life comparable with other rehabilitation techniques. There are however, a number of factors that significantly impact the achievable life of stabilised pavements. To ensure that stabilisation remains a viable rehabilitation method, it is essential that the influence of these detrimental factors on the life and cost of the pavement are understood.

This report has completed a review of the available literature providing a background to stabilisation, different binders available, their effects and factors that cause this type of pavement to exhibit signs of distress and fail. The thickness and the density of the stabilised layer have been identified through the review of the literature as factors that can significantly impact the properties of a stabilised pavement, however the effect on the life and cost of the pavement has not been examined.

This report has examined two case study projects and three theoretical pavements typical of the existing pavements found in northern NSW on rural State Highways. The impacts of thickness and relative compaction nonconformances have been examined and discussed through theoretical sensitivity analysis. The analysis has presented that construction of a stabilised pavement with thickness of 10 mm less than required to achieve the expected design life, can result in a reduction of the pavement life of 45 %. The relative compaction has also been demonstrated to reduce the life of stabilised pavements of up to 28 %, even when within the tolerances allowed for in current specifications. Additionally, a density gradient resulting in lower density in the lower half of a layer has been shown to reduce the life of up to 37 % which is currently permitted under TfNSW specifications.

Whole of life cost analysis has been completed for stabilised pavements with nonconforming thickness and relative compaction to determine the financial impact to TfNSW of accepting a nonconforming pavement and whether payment deductions could be applied to recover the cost of increased maintenance required to extend the life of these pavements out to the 20-year design period. It was determined that a payment deduction of 30 % could be applied for thickness nonconformances up to 10 mm below the design thickness and confirmed that the deductions applied by TfNSW for relative compaction are suitable. The impacts beyond the financial cost are also raised, such as the reputational damage a road authority may suffer as a result of major maintenance required on a recently completed stabilisation project.

University of Southern Queensland

Faculty of Health, Engineering and Sciences

ENG4111 & ENG4112 Research Project

Limitations of Use

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

[redacted]

Shaun Perkins

Student Number: [redacted]

Acknowledgements

The author would like to thank the following people for their advice and support throughout the completion of this dissertation.

Dr Andreas Nataatmadja for his advice and guidance in the completion of this research project.

Leigh Wardle and Pavement Science for access to CIRCLY 7.0 software for use during the project.

TfNSW for access to their projects and records.

My wife Sarah for her support throughout my studies.

Table of Contents

Abstract ... i

Limitations of Use ... ii

Certification ... iii

Acknowledgements ... iv

List of Figures ... xvi

List of Tables ... xvii

1 Introduction ... 1

1.1 Road Pavement ... 1

1.1.1 Flexible Pavements ... 2

1.1.2 Rigid Pavements ... 2

1.1.2.1 Subgrade ... 3

1.1.2.2 Subbase ... 3

1.1.2.3 Base ... 4

1.1.2.4 Wearing Surface ... 4

1.2 Pavement Rehabilitation ... 4

1.2.1 Pavement Overlay ... 4

1.2.2 Pavement Reconstruction ... 5

1.2.3 Pavement Stabilisation ... 5

1.3 Binders ... 6

1.3.1 Lime ... 6

1.3.1.1 Quicklime ... 6

1.3.1.2 Hydrated Lime ... 6

1.3.2 Cement ... 7

1.3.3 Cementitious Binders ... 7

1.3.4 Chemical Binders ... 7

1.3.5 Bituminous Binders ... 7

1.4 Pavement Stabilisation with Slow Setting Binders ... 7

1.4.1 Granular Stabilisation 8
1.4.2 Lime Stabilisation 8
1.4.3 Cementitious Stabilisation 9
1.5 The Problem 10
1.6 Project Aims 11
1.7 Project Objectives 11
1.8 Project Outline 12
Literature Review 12
Methodology 12
Case Study Project Review 12
Results 12
Discussion 12
Conclusion 12
2 Literature Review 13
2.1 Issues Affecting Stabilised Granular Pavement Performance 13
2.1.1 Design Issues 13
2.1.1.1 Pavement Investigation Deficiencies 14
2.1.1.2 Mix Design 14
2.1.1.2.1 Existing Pavement Material 15
2.1.1.2.2 Binder Type and Content 15
2.1.1.3 Subgrade California Bearing Ratio 16
2.1.1.4 Structural Design 17
2.1.1.5 Design Traffic 18
2.1.1.6 Flexural Modulus 20
2.1.1.7 Fatigue 22
2.1.2 Construction Issues 23
2.1.2.1 Thickness 23
2.1.2.2 Mixing 24
2.1.2.3 Compaction and Moisture 24

2.1.2.4 Curing ... 26
2.2 Stabilised Pavement Maintenance ... 26
2.2.1 Heavy Patching ... 26
2.2.2 Crack Sealing ... 27
2.2.3 Resealing ... 27
2.3 Pavement Lifecycle ... 27
2.3.1 Environmental and Social Expectations ... 28
2.3.2 Sustainability and Ethics ... 29
2.4 Life Cycle Cost Analysis ... 29
2.5 TfNSW Pavement Stabilisation Specifications ... 30
2.5.1 Compaction ... 30
2.5.2 Thickness ... 31
2.6 Summary ... 31
3 Methodology ... 33
3.1 Introduction ... 33
3.2 Pavement Analysis Methodology ... 33
3.3 Review of Granular Pavement Stabilisation Projects ... 34
3.4 Pavement Modelling in CIRCLY ... 34
3.4.1.1 Thickness with Uniform Characteristics ... 38
3.4.1.2 Thickness with Variable Characteristics ... 38
3.4.1.3 Compaction ... 40
3.5 Economic Assessment of Nonconforming Stabilised Pavements ... 41
4 Case Study Project Review ... 42
4.1 Braemar Pavement Rehabilitation Project Case Study ... 42
4.1.1 Project Background ... 42
4.1.2 Pavement Design ... 43
4.2 Boree Pavement Rehabilitation Project Case Study ... 44
4.2.1 Project Background ... 44
4.2.2 Pavement Design ... 44

4.3 Visual Inspection of Case Study Projects ... 45
4.4 Project Quality Assurance Records ... 46
4.4.1.1 Thickness of Bound Layer ... 46
4.4.1.2 Compaction Records ... 47
5 Results ... 49
5.1 Braemar Project Review ... 49
5.1.1 Thickness Records ... 49
5.1.2 Compaction Records ... 50
5.1.3 Unconfined Strength Records ... 51
5.1.4 Visual Inspection ... 52
5.2 Boree Project Review ... 54
5.2.1 Thickness Records ... 54
5.2.2 Compaction Records ... 54
5.2.3 Unconfined Strength Records ... 54
5.2.4 Visual Inspection ... 55
5.3 Pavement Modelling ... 58
5.3.1 Thickness with Constant Modulus ... 58
5.3.2 Thickness with Adjusted Modulus ... 61
5.3.3 Variable Compaction ... 67
5.4 Whole of Life Cost Analysis ... 71
5.4.1 Pavement Thickness ... 71
5.4.2 Pavement Compaction ... 72
6 Discussion ... 74
6.1 Thickness ... 74
6.2 Compaction ... 75
6.3 Recommendations for Compliance ... 77
6.3.1 Payment Deduction for Thickness ... 77
6.3.2 Payment Deduction for Compaction ... 77
6.3.3 Summary of Compliance Recommendations ... 77

7 Conclusion 79
7.1 Further work 80
References 81
Appendix A – Project Specification 84
Appendix B – Risk Assessment 86
Appendix C – CIRCLY Results 90
Braemar Project 91
Original Pavement Design 91
Analysis of Original Pavement Design in CIRCLY 7.0 92
Braemar Project with Uniform Characteristics – 350 mm Thick 93
Braemar Project with Uniform Characteristics – 340 mm Thick 94
Braemar Project with Uniform Characteristics – 330 mm Thick 95
Braemar Project with Uniform Characteristics – 320 mm Thick 96
Braemar Project with Uniform Characteristics – 310 mm Thick 97
Braemar Project with Uniform Characteristics – 300 mm Thick 98
Braemar Project with Uniform Characteristics – 290 mm Thick 99
Braemar Project with Uniform Characteristics – 280 mm Thick 100
Braemar Project with Uniform Characteristics – 270 mm Thick 101
Braemar Project with Variable Characteristics – 350 mm Thick 102
Braemar Project with Variable Characteristics – 340 mm Thick 103
Braemar Project with Variable Characteristics – 330 mm Thick 104
Braemar Project with Variable Characteristics – 320 mm Thick 105
Braemar Project with Variable Characteristics – 310 mm Thick 106
Braemar Project with Variable Characteristics – 300 mm Thick 107
Braemar Project with Variable Characteristics – 290 mm Thick 108
Braemar Project with Variable Characteristics – 280 mm Thick 109
Braemar Project with Variable Characteristics – 270 mm Thick 110
Braemar Project with 105% Compaction 111
Braemar Project with 104% Compaction 112

Braemar Project with 103% Compaction ... 113
Braemar Project with 102% Compaction ... 114
Braemar Project with 101% Compaction ... 115
Braemar Project with 100% Compaction ... 116
Braemar Project with 99% Compaction ... 117
Braemar Project with 98% Compaction ... 118
Braemar Project with 97% Compaction ... 119
Braemar Project with 96% Compaction ... 120
Braemar Project with 95% Compaction ... 121
Braemar Project with 94% Compaction ... 122
Braemar Project with 93% Compaction ... 123
Braemar Project with 92% Compaction ... 124
Braemar Project with 91% Compaction ... 125
Braemar Project with 90% Compaction ... 126
Boree Project ... 127
Original Pavement Design Analysis ... 127
Analysis of Original Pavement Design in CIRCLY 7.0 ... 128
Boree Project with Uniform Characteristics – 350 mm Thick ... 129
Boree Project with Uniform Characteristics – 340 mm Thick ... 130
Boree Project with Uniform Characteristics – 330 mm Thick ... 131
Boree Project with Uniform Characteristics – 320 mm Thick ... 132
Boree Project with Uniform Characteristics – 310 mm Thick ... 133
Boree Project with Uniform Characteristics – 300 mm Thick ... 134
Boree Project with Uniform Characteristics – 290 mm Thick ... 135
Boree Project with Uniform Characteristics – 280 mm Thick ... 136
Boree Project with Uniform Characteristics – 270 mm Thick ... 137
Boree Project with Variable Characteristics – 350 mm Thick ... 138
Boree Project with Variable Characteristics – 340 mm Thick ... 139
Boree Project with Variable Characteristics – 330 mm Thick ... 140

Boree Project with Variable Characteristics – 320 mm Thick 141
Boree Project with Variable Characteristics – 310 mm Thick 142
Boree Project with Variable Characteristics – 300 mm Thick 143
Boree Project with Variable Characteristics – 290 mm Thick 144
Boree Project with Variable Characteristics – 280 mm Thick 145
Boree Project with Variable Characteristics – 270 mm Thick 146
Boree Project with 105% Compaction 147
Boree Project with 104% Compaction 148
Boree Project with 103% Compaction 149
Boree Project with 102% Compaction 150
Boree Project with 101% Compaction 151
Boree Project with 99% Compaction 152
Boree Project with 98% Compaction 153
Boree Project with 97% Compaction 154
Boree Project with 96% Compaction 155
Boree Project with 95% Compaction 156
Boree Project with 94% Compaction 157
Boree Project with 93% Compaction 158
Boree Project with 92% Compaction 159
Boree Project with 91% Compaction 160
Boree Project with 90% Compaction 161
Theoretical Pavements 162
CBR3 Pavement 20 Year Design 162
CBR3 Pavement with Uniform Characteristics – 350 mm Thick 163
CBR3 Pavement with Uniform Characteristics – 340 mm Thick 164
CBR3 Pavement with Uniform Characteristics – 330 mm Thick 165
CBR3 Pavement with Uniform Characteristics – 320 mm Thick 166
CBR3 Pavement with Uniform Characteristics – 310 mm Thick 167
CBR3 Pavement with Uniform Characteristics – 300 mm Thick 168

CBR3 Pavement with Uniform Characteristics – 290 mm Thick 169
CBR3 Pavement with Uniform Characteristics – 280 mm Thick 170
CBR3 Pavement with Uniform Characteristics – 270 mm Thick 171
CBR3 Pavement with Variable Characteristics – 350 mm Thick 172
CBR3 Pavement with Variable Characteristics – 340 mm Thick 173
CBR3 Pavement with Variable Characteristics – 330 mm Thick 174
CBR3 Pavement with Variable Characteristics – 320 mm Thick 175
CBR3 Pavement with Variable Characteristics – 310 mm Thick 176
CBR3 Pavement with Variable Characteristics – 300 mm Thick 177
CBR3 Pavement with Variable Characteristics – 290 mm Thick 178
CBR3 Pavement with Variable Characteristics – 280 mm Thick 179
CBR3 Pavement with Variable Characteristics – 270 mm Thick 180
CBR 3 Pavement with 105 % Compaction 181
CBR 3 Pavement with 104 % Compaction 182
CBR 3 Pavement with 103 % Compaction 183
CBR 3 Pavement with 102 % Compaction 184
CBR 3 Pavement with 101 % Compaction 185
CBR 3 Pavement with 100 % Compaction 186
CBR 3 Pavement with 99 % Compaction 187
CBR 3 Pavement with 98 % Compaction 188
CBR 3 Pavement with 97 % Compaction 189
CBR 3 Pavement with 96 % Compaction 190
CBR 3 Pavement with 95 % Compaction 191
CBR 3 Pavement with 94 % Compaction 192
CBR 3 Pavement with 93 % Compaction 193
CBR 3 Pavement with 92 % Compaction 194
CBR 3 Pavement with 91 % Compaction 195
CBR 3 Pavement with 90 % Compaction 196
CBR5 Pavement 20 Year Design 197

CBR5 Pavement with Uniform Characteristics – 350 mm Thick 198
CBR5 Pavement with Uniform Characteristics – 340 mm Thick 199
CBR5 Pavement with Uniform Characteristics – 330 mm Thick 200
CBR5 Pavement with Uniform Characteristics – 320 mm Thick 201
CBR5 Pavement with Uniform Characteristics – 310 mm Thick 202
CBR5 Pavement with Uniform Characteristics – 300 mm Thick 203
CBR5 Pavement with Uniform Characteristics – 290 mm Thick 204
CBR5 Pavement with Uniform Characteristics – 280 mm Thick 205
CBR5 Pavement with Uniform Characteristics – 270 mm Thick 206
CBR5 Pavement with Variable Characteristics – 350 mm Thick 207
CBR5 Pavement with Variable Characteristics – 340 mm Thick 208
CBR5 Pavement with Variable Characteristics – 330 mm Thick 209
CBR5 Pavement with Variable Characteristics – 320 mm Thick 210
CBR5 Pavement with Variable Characteristics – 310 mm Thick 211
CBR5 Pavement with Variable Characteristics – 300 mm Thick 212
CBR5 Pavement with Variable Characteristics – 290 mm Thick 213
CBR5 Pavement with Variable Characteristics – 280 mm Thick 214
CBR5 Pavement with Variable Characteristics – 270 mm Thick 215
CBR 5 Pavement with 105 % Compaction 216
CBR 5 Pavement with 104 % Compaction 217
CBR 5 Pavement with 103 % Compaction 218
CBR 5 Pavement with 102 % Compaction 219
CBR 5 Pavement with 101 % Compaction 220
CBR 5 Pavement with 100 % Compaction 221
CBR 5 Pavement with 99 % Compaction 222
CBR 5 Pavement with 98 % Compaction 223
CBR 5 Pavement with 97 % Compaction 224
CBR 5 Pavement with 96 % Compaction 225
CBR 5 Pavement with 95 % Compaction 226

CBR 5 Pavement with 94 % Compaction 227
CBR 5 Pavement with 93 % Compaction 228
CBR 5 Pavement with 92 % Compaction 229
CBR 5 Pavement with 91 % Compaction 230
CBR 5 Pavement with 90 % Compaction 231
CBR7 Pavement 20 Year Design with Constant Modulus 232
CBR7 Pavement with Uniform Characteristics – 350 mm Thick 233
CBR7 Pavement with Uniform Characteristics – 340 mm Thick 234
CBR7 Pavement with Uniform Characteristics – 330 mm Thick 235
CBR7 Pavement with Uniform Characteristics – 320 mm Thick 236
CBR7 Pavement with Uniform Characteristics – 310 mm Thick 237
CBR7 Pavement with Uniform Characteristics – 300 mm Thick 238
CBR7 Pavement with Uniform Characteristics – 290 mm Thick 239
CBR7 Pavement with Uniform Characteristics – 280 mm Thick 240
CBR7 Pavement with Uniform Characteristics – 270 mm Thick 241
CBR7 Pavement with Variable Characteristics – 350 mm Thick 242
CBR7 Pavement with Variable Characteristics – 340 mm Thick 243
CBR7 Pavement with Variable Characteristics – 330 mm Thick 244
CBR7 Pavement with Variable Characteristics – 320 mm Thick 245
CBR7 Pavement with Variable Characteristics – 310 mm Thick 246
CBR7 Pavement with Variable Characteristics – 300 mm Thick 247
CBR7 Pavement with Variable Characteristics – 290 mm Thick 248
CBR7 Pavement with Variable Characteristics – 280 mm Thick 249
CBR7 Pavement with Variable Characteristics – 270 mm Thick 250
CBR 7 Pavement with 105 % Compaction 251
CBR 7 Pavement with 104 % Compaction 252
CBR 7 Pavement with 103 % Compaction 253
CBR 7 Pavement with 102 % Compaction 254
CBR 7 Pavement with 101 % Compaction 255

CBR 7 Pavement with 100 % Compaction 256

CBR 7 Pavement with 99 % Compaction 257

CBR 7 Pavement with 98 % Compaction 258

CBR 7 Pavement with 97 % Compaction 259

CBR 7 Pavement with 96 % Compaction 260

CBR 7 Pavement with 95 % Compaction 261

CBR 7 Pavement with 94 % Compaction 262

CBR 7 Pavement with 93 % Compaction 263

CBR 7 Pavement with 92 % Compaction 264

CBR 7 Pavement with 91 % Compaction 265

CBR 7 Pavement with 90 % Compaction 266

Appendix D – Whole of Life Cost Analysis 267

Conforming Pavement 268

Uniform Modulus - Nonconforming Thickness -10mm 269

Variable Modulus – Nonconforming Thickness -10mm 270

Nonconforming Compaction = 98% 271

Nonconforming Compaction = 95% 272

List of Figures

Figure 2. 1 Typical formation and flexible pavement structure 2
Figure 2. 2 - Typical flexible and rigid pavement structure 3
Figure 2. 3 - Factors affecting pavement performance 13
Figure 2. 4 - Procedure for determining design traffic 19
Figure 2. 5 - Dry density ratio vs Unconfined compressive strength 25
Figure 2. 6 - Life Cycle Phases (Transport for NSW 2018) 28

Figure 3. 1 – Modulus vs fatigue constant determined from modulus and fatigue constant provided by TfNSW 36
Figure 3. 2 – Comparison of flexural strength and modulus calculated for the postulated method for fatigue constant and maximum fatigue constant 37
Figure 3. 3 – Variation in binder content as stabilised layer thickness is changed during insitu stabilisation 39
Figure 3. 4 – CIRCLY 7.0 Analysis of the Boree Project with 290 mm stabilised layer thickness 40

Figure 4. 1- Map showing Summerland Way between Grafton and Casino, NSW 42
Figure 4. 2– Test pit in existing pavement at the Braemar project 43
Figure 4. 3 – Stabilisation of the Boree project 45
Figure 4. 4 - Stabilisation of the Braemar project 46
Figure 4. 5 – Density testing at the Braemar project 48

Figure 5. 1 - Summary of thickness conformance at the Braemar project 49
Figure 5. 2 - Thickness survey histogram presenting distribution of thickness for Braemar project 50
Figure 5. 3 - Shoving on the centerline of the Braemar project 52
Figure 5. 4 - S45R final seal of Braemar project as preventative maintenance 53
Figure 5. 5 – Transverse shrinkage cracking at the Boree project 56
Figure 5. 6 – Cracking at western pavement interface of the Boree project 57
Figure 5. 7 – Design life for varying thickness over a range of subgrade strengths 61
Figure 5. 8 – Comparison of design life provided by varying thickness of stabilised base layer 62
Figure 5. 9 – Comparison of design life provided by varying thickness of stabilised base layer 64
Figure 5. 10 – Theoretical pavements modelled with characteristics that vary with thickness 67
Figure 5. 11 – Impact of dry density ratio on design life on case study and theoretical pavements 70

List of Tables

Table 2. 1 - Preliminary binder selection guide ... 16
Table 2. 2 - Typical presumptive subgrade CBR values ... 17
Table 2. 3 - Factors affecting modulus of stabilised materials ... 21

Table 3. 1 - Deductions for relative compaction ... 31

Table 5. 1 - Relative compaction results from the Braemar project ... 51
Table 5. 2 Braemar UCS results ... 51
Table 5. 3 – Braemar project visual inspection summary ... 52
Table 5. 4 – Relative compaction results from the Boree project ... 54
Table 5. 5 – Unconfined compressive strength test results from the Boree project ... 55
Table 5. 6 - Boree project visual inspection summary ... 55
Table 5. 7 - Braemar Project with varying thickness of stabilised layer ... 58
Table 5. 8 - Boree Project with varying thickness of stabilised layer ... 59
Table 5. 9 - Theoretical pavement with subgrade CBR of 3 % with varying thickness of stabilised layer ... 59
Table 5. 10 - Theoretical pavement with subgrade CBR of 5 % with varying thickness of stabilised layer ... 60
Table 5. 11 - Theoretical pavement with subgrade CBR of 7 % with varying thickness of stabilised layer ... 60
Table 5. 12 – Braemar project with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus ... 61
Table 5. 13 – Comparison of design life achieved on the Braemar project with constant modulus and adjusted modulus ... 63
Table 5. 14 - Boree Project with varying thickness of the stabilised base layer, adjusted select layer thickness and cemented modulus ... 63
Table 5. 15 - Comparison of design life achieved on the Boree project with constant modulus and adjusted modulus ... 64
Table 5. 16 – CBR3 pavement with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus ... 66
Table 5. 17 – CBR5 pavement with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus ... 66
Table 5. 18 – CBR7 pavement with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus ... 66

Table 5. 19 – Braemar project with modulus adjusted based on dry density ratio 68
Table 5. 20 – Braemar project with modulus adjusted with density for lower half of cemented layer 68
Table 5. 21 – Boree project with modulus adjusted based on dry density ratio................................... 69
Table 5. 22 - Boree project with modulus adjusted with density for lower half of cemented layer 69
Table 5. 23 – Effect of compaction on case study projects and theoretical pavements 70

Table 6. 1 – Impact on design life of constructing a stabilised pavement with thickness reduced by 10mm and uniform modulus 74
Table 6. 2 - Impact on design life of constructing a stabilised pavement with thickness reduced by 10mm and modulus varied with thickness 74
Table 6. 3 – Impact of relative compaction on design life of stabilised pavements 76

1 Introduction

The road network in New South Wales (NSW) extends for approximately 185,000 km (Transport for NSW 2022). Transport for New South Wales (TfNSW) is responsible for the management and funding of 18,036 km of classified State Roads in NSW (Transport for New South Wales 2020a). State Roads are the primary arterial roads between major regional centers, towns and interstate. TfNSW is responsible for managing these State Roads which includes determining priorities, providing funding and completing maintenance and construction work (Roads and Traffic Authority 2008). State Roads in NSW have flexible and rigid pavement types depending on their location, traffic volume and required service life. State Highway pavements in NSW under the management of TfNSW in the North Region are generally designed to have a design life of 20 years before rehabilitation or replacement is required.

Pavements deteriorate over their life and the design life can be considerably reduced due to a range of factors such as increased traffic volume and loading, drainage issues, construction issues and subgrade strength. As pavements deteriorate, they are required to be maintained to extend their useful life. The greater the severity of factors affecting a pavement, the greater the level of maintenance and therefore cost is required.

1.1 Road Pavement

Natural ground surfaces do not possess the required strength and durability characteristics for traffic loading and therefore need to be built up to provide a structural formation for traffic to travel on. Where the road formation refers to the entire road structure, the pavement serves two specific purposes as set out in Austroads (2018c);

1. To perform as an engineering structure capable of supporting traffic loading over a designed period of time, and
2. To provide a good quality riding surface to provide the road user with comfortable travel, appropriate drainage for the terrain and adequate skid resistance.

A pavement must possess characteristics that provide resistance to traffic loading. These characteristics are provided by the materials used and the construction methods used to place the materials. Austroads (2018c) separates pavement into two types;

1. Flexible pavement and rigid pavement. Flexible pavements include unbound granular pavements and bound pavements which may be either stabilised granular materials or asphalt over compacted subgrade.
2. Rigid pavements that consist of a concrete base and subbase of granular material, bound material or lean mix concrete over compacted subgrade.

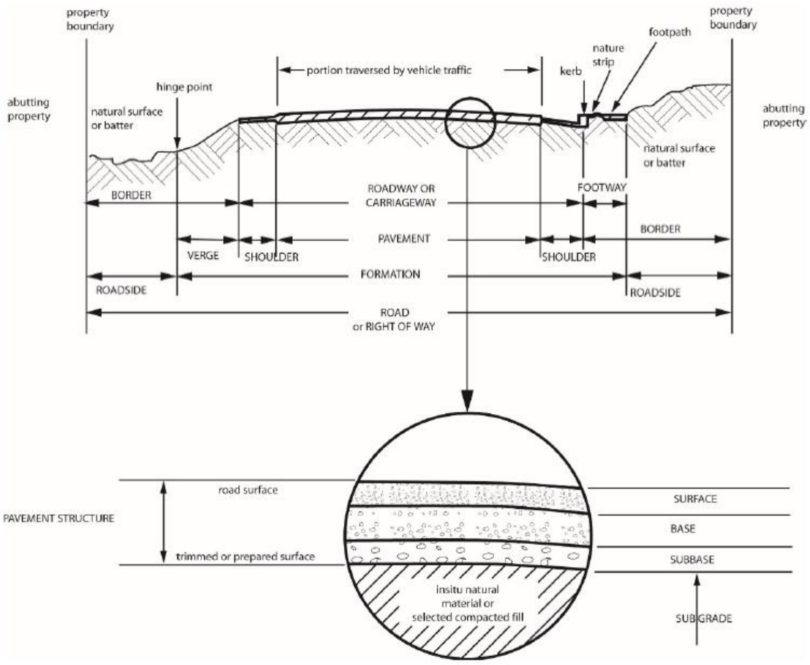

Figure 2. 1 Typical formation and flexible pavement structure
(Source: Austroads 2018c)

1.1.1 Flexible Pavements

In contrast to rigid pavements, Yoder & Witczak (1991) describe the load carrying capacity of flexible pavements as being due to the load distributing properties of the multi-layered pavement. Flexible pavements are constructed with materials of increasing quality in each layer above subgrade, and it is this structure of layers of increasing strength that distribute the traffic loadings to the subgrade. The thickness of the flexible pavement is therefore determined by the strength of the underlying subgrade (Yoder & Witczak 1991). Flexible pavements comprising of unbound granular materials with thin bituminous surfacing are designed empirically, while flexible pavements with bound or deep lift asphalt layers are designed using a mechanistic method (Austroads 2018c).

1.1.2 Rigid Pavements

Rigid pavements have a high modulus of elasticity and as a result, distribute loads from traffic over a wide area of subgrade. The strength of the concrete used in rigid pavements is the critical factor considered in design as most of the structural support is provided by the concrete base course, causing variations in subgrade strength to be less of a concern than for flexible pavements (Yoder & Witczak 1991).

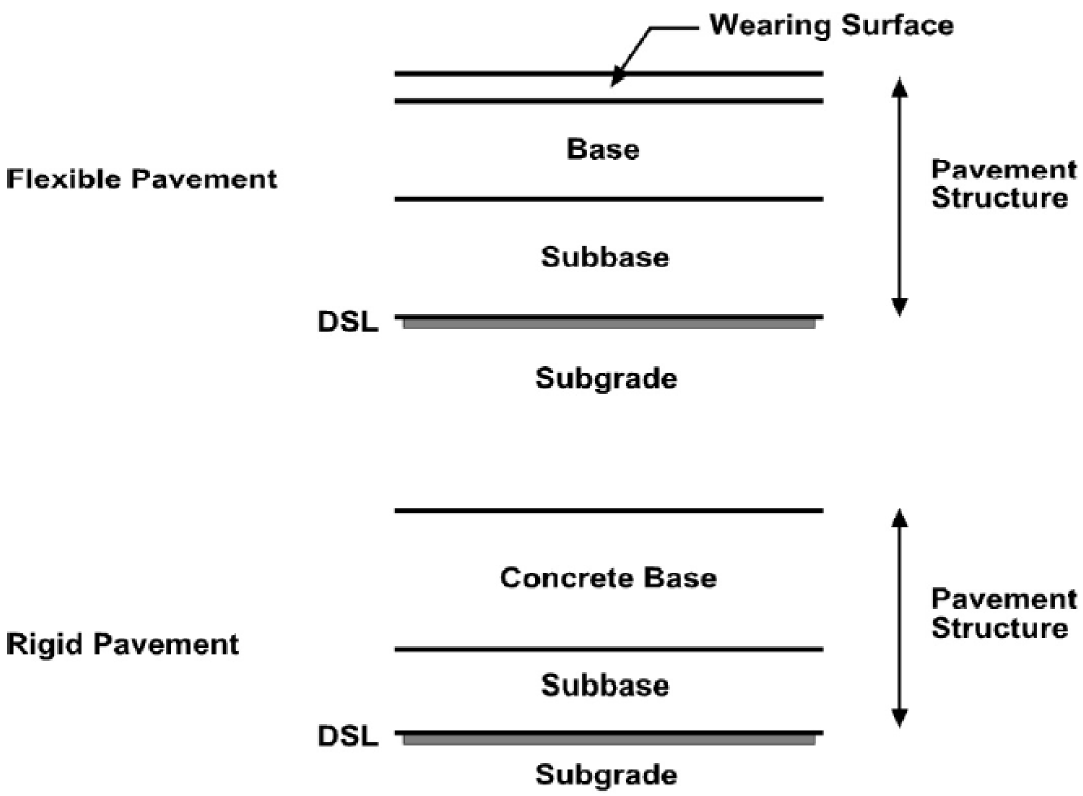

Figure 2. 2 - Typical flexible and rigid pavement structure
(Source: Austroads 2018c)

1.1.2.1 Subgrade

The subgrade is the existing soil that a pavement is constructed over. Subgrade materials are generally variable in quality depending on the location, topography, soil type and drainage in the surrounding area. Its characteristics are determined through testing to inform the design of the overlying pavement layers (Austroads 2018c). The pavement layers provide a covering thickness over the subgrade which is generally low strength existing soil. The pavement layers distribute traffic loadings so that the lower strength subgrade can support the load (Austroads 2017).

1.1.2.2 Subbase

The subbase in a flexible pavement is made up of lower quality materials, often with a larger particle size distribution. The purpose of the subbase layer is to provides support to the base layer and reduce the stresses and strains on the subgrade. The subbase experiences lower stress levels than the base layer, which allows for lower quality and less expensive materials to be used for its construction (Austroads 2018c).

1.1.2.3 Base

Flexible pavements contain a base course which is made up of the highest quality materials in the pavement. The base course provides the majority of load carrying support for the pavement. Unbound granular base courses perform under traffic loading as if the particles are not bound together (Austroads 2018c). Base layers can be stabilised with a binder to improve the material characteristics. The changes to characteristics depend on the type of binder used and the content used (Austroads 2018a). The changes to pavements based on binder type will be discussed further in section 1.3.

1.1.2.4 Wearing Surface

Wearing surfaces placed over flexible pavement base courses in Australia are generally sprayed seals or asphalt. Bituminous sprayed seals consist of a single size stone placed over a film of sprayed hot bitumen as a cost-effective method of increasing functional performance by providing driving surface with adequate skid resistance and a moisture barrier to keep water out of the pavement. Spray seals don't provide any structural performance gains to a flexible pavement (Austroads 2018c).

If structural performance gains are required from the wearing course, asphalt is used. While thin layers of asphalt less than 50 mm are not generally considered as adding structural performance, they do provide functional performance similar to sprayed seals with the added benefit of improving rideability (Austroads 2018c). To gain structural performance thicker layers of asphalt are required, which are modelled mechanistically (Austroads 2017).

1.2 Pavement Rehabilitation

Pavements serve two main functions as part of a road: structural performance and functional performance. To satisfy the structural performance requirements the pavement must be constructed of materials of appropriate quality to resist the traffic loads that particular road services. The functional performance requirements are met by the pavement providing ride quality suitable the level of service required for the particular road (Austroads 2018c).

Pavements have a limited life before work is required to improve the pavement condition. When a pavement reaches the end of its life, it will exhibit signs of distress and failure that reduce the ride quality and road user safety. To rectify the pavement distress the road authority must either invest in considerable ongoing maintenance or rehabilitation of the pavement. A number of methods for rehabilitating a pavement at the end of its life are available to road authorities which are discussed in the following sections.

1.2.1 Pavement Overlay

A pavement can be overlayed with additional pavement material to improve the structural capacity of the pavement. The overlay can be constructed from a range of materials, from crushed granular materials, asphalt, or bound materials. The increased thickness of the pavement provides additional height over the subgrade which reduces rutting of the pavement caused by subgrade deformation (Austroads 2019a).

1.2.2 Pavement Reconstruction

Reconstruction of a pavement requires the complete excavation and replacement of the pavement layers. The existing pavement is excavated and disposed of, allowing for the construction of new pavement layers to meet current design requirements. The cost of complete pavement reconstruction is high and is the most environmentally unsustainable method of rehabilitation.

1.2.3 Pavement Stabilisation

Stabilisation is a common practice when rehabilitating existing road pavements. The following benefits can be achieved by stabilising existing granular pavements:

- particle size distribution and plasticity issues can be corrected through granular and/ or lime stabilisation
- The strength of pavement materials
- The bearing capacity of pavement materials
- The permeability and/or moisture sensitivity, which can result in a loss of strength, of the material can be reduced through lime or cementitious stabilisation
- Provide cost-effective pavement configurations through the provision of stabilised pavement rather than reconstruction
- Existing pavements can be recycled, resulting in reduced costs and improved sustainability (Austroads 2019b)

Rehabilitation of a granular pavement through stabilisation is widely accepted as a cost-effective rehabilitation option. Stabilisation of existing pavements is most often completed through in situ stabilisation techniques. In situ stabilisation is completed by adding a binding agent to the pavement and mechanically incorporating into the pavement with a road recycler/pulverisor (Austroads 2019b). The mixed pavement is compacted and cured to form a bound layer with considerable tensile strength (Austroads 2018c). There are a number of methods available to rehabilitate a granular pavement using stabilisation techniques depending on the thickness of the existing pavement, the quality of pavement materials, the strength of the subgrade, the traffic loading, available equipment for construction, the climate and the whole of life costs (Austroads 2019b).

Stabilisation is achieved through mechanical mixing of pavement materials with a binder and/or gravel. The mixing may be achieved through the use of a stationary pugmill or in situ stabilisation on site with mobile plant. Commonly used binders include lime, cement, blends of cement and/or lime with ground granulated blast furnace slag and/or fly ash (Austroads 2018a). The type of binder used depends on the existing material properties and the outcome required from the stabilisation process. Stabilisation of existing pavements is generally accepted as a cost effective treatment to rehabilitate a pavement, increase its performance and reduce maintenance costs on highly trafficked main roads such as state highways (Austroads 2019b).

1.3 Binders

Binders are additives used in combination with mechanical mixing of pavement materials to improve the qualities of the materials. Binders used in pavement stabilisation are manufactured to standards provided as Australian Standards or to the specification of road authorities (Austroads 2018a). Binders commonly used in Australia to stabilise pavements materials are discussed further in this section.

1.3.1 Lime

The variants of lime used as a binder in pavement stabilisation are quicklime and hydrated lime. Both quicklime and hydrated lime variants are produced form limestone. Limestone is a sedimentary rock made up of calcium carbonate. Quicklime is calcium oxide and hydrated lime is calcium hydroxide (AustStab 2010). Other forms of lime are available such as dolomite lime and agricultural lime but these are not suitable for pavement stabilisation (Austroads 2019b) and will not be discussed further.

1.3.1.1 Quicklime

Quicklime is produced by heating limestone to temperatures over 900 degrees Celsius which removes the carbon dioxide and produces calcium oxide. Quicklime is available as a dry product and reacts rapidly with water which produces hydrated lime and heat (Austroads 2019b). When used on site quicklime must be hydrated before incorporation into the pavement. Hydration of quicklime for use is referred to as slaking (Austroads 2018a). Quicklime has approximately 30% more effective lime than hydrated lime which makes the cost per tonne cheaper but must be considered when mix design is calculated to avoid higher strength gain than required (Austroads 2018a).

1.3.1.2 Hydrated Lime

In order to manufacture hydrated lime, quicklime must be hydrated with water. Pure calcium oxide requires 320 litres of water per tonne of calcium oxide to be slaked (Austroads 2018a). The mass of water in hydrated lime makes it more expensive per tonne than quicklime. The advantages to using hydrated lime are the need for less water on site and increased productivity due to being able to immediately mix with the pavement (AustStab 2010).

1.3.2 Cement

The cements typically used as a binder in pavement stabilisation are general purpose cements. The two types of general purpose cements used in stabilisation are Portland cement and blended cement. Portland cement is a mixture of Portland cement clinker and calcium sulphate. Blended cement is Portland cement combined with fly ash, ground granulated blast furnace slag and/or silica flume. Blended cement has a longer working time than Portland cement and is therefore used more frequently in pavement stabilisation that Portland cement (Austroads 2019b).

1.3.3 Cementitious Binders

Cementitious binders are combinations of pozzolanic materials that react with the calcium hydroxide produced from the hydration of lime or cement to form cementitious materials. The pozzolanic materials used are generally ground granulated bast furnace slag and fly ash. Cementitious binders are generally more economical than using cement as a binder and provide a longer working time which reduces risk of the binder curing prior to adequate compaction (Austroads 2018a).

1.3.4 Chemical Binders

Chemical binders used in pavement stabilisation can be in the form of synthetic polymers, organic compounds, ionic compounds and salts. Chemical binders are typically very dependent on the existing pavement materials therefore the type of chemical binder selected must be carefully considered (Austroads 2018a). Chemical binders are often used as compaction aids and for their water repelling properties (Das 2003).

1.3.5 Bituminous Binders

Bituminous stabilisation can be completed using either foamed bitumen or bitumen emulsion either with a secondary binder such as lime or cement to increase the stiffness of the bound pavement or without (Austroads 2018a). Using bitumen to stabilise a pavement increases cohesion between non-plastic materials and reduces moisture sensitivity in materials that would otherwise experience a loss of stability when the moisture content increases (Austroads 2019b).

1.4 Pavement Stabilisation with Slow Setting Binders

Rehabilitation of existing flexible pavements through in situ stabilisation using slow setting binders is a process used by TfNSW to re-cycle a pavement at the end of its life. Pavement stabilisation is defined as “a process by which the intrinsic properties of pavement materials or earthworks materials are altered by the addition of a stabilisation binder or granular material to meet performance expectations in its operating, geological and climatic environment” (Austroads 2019b). Pavement stabilisation provides a range of benefits including increasing pavement strength, increasing modulus of materials and reducing moisture sensitivity (Austroads 2019b).

TfNSW defines slow setting binders as “A binder that is expected to give a Working Time greater than 6 hours” (Roads and Maritime Services 2012). The increased working time provided by slow setting binders is beneficial for compaction and trimming of stabilised pavements. Where a binder such as GP cement is used the working time is limited to 2-3 hours (Serruto & Pardo 2001) making construction difficult and inefficient by limiting the area that can be mixed in a single operation, slow setting binders providing at least 6 hours of working time increase efficiency of construction by allowing for greater area to be mixed in a single operation. The increased efficiency of using slow setting binders improves the likelihood that the stabilisation will meet compaction requirements and reduces the cost of the stabilising operation. Using slow setting binders also provides longer term benefits over other binders. The risk of shrinkage cracking is reduced when slow setting binders are used provided appropriate trafficking, curing and sealing is completed (Serruto & Pardo 2001). Slow setting binders produce smaller, closer spaced cracks than other binders that are faster setting. The type of cracking produced by slow setting binders reduces the potential for the cracks to reflect through the bituminous surfacing (Austroads 2017).

1.4.1 Granular Stabilisation

Granular stabilisation is the improvement of a pavement by the addition of granular materials to alter the particle size distribution and plasticity. Granular stabilisation can be completed in-situ to rehabilitate an existing pavement. It is a method often used for the improvement of existing pavements that are poorly graded or have excess fines particles due to the original source of the pavement gravel. Granular stabilisation improves the strength of an existing pavement by increasing the internal friction created by the particle size distribution and altering cohesion through the clay fraction (Austroads 2019b). Granular stabilisation is often combined with other forms of stabilisation using slow setting binders as a combination treatment. The addition of additional granular material in this manner also allows for minor surface shape correction to an existing pavement with unsatisfactory crossfall or superelevation.

1.4.2 Lime Stabilisation

Quicklime or hydrated lime may be used for a binder with comparable effects providing the difference in free lime is accounted for in the mix design and the construction process differences are factored in to the cost (Austroads 2019b). Lime is used as a binder as it improves the properties of pavement materials by increasing strength, reducing swell, improving durability and workability. The benefits that lime provides for pavement stabilisation allow for improved construction processes and increased performance of pavements (Mallela et al. 2004). Lime stabilisation is used to improve pavement materials that have higher than desired plasticity index values, provide an increase in strength, reduce the reactivity to moisture and increase workability by changing clay particles from plastic to friable in nature (Austroads 2018c).

Pavement material with large quantity of fine particles and high plasticity can be improved by stabilising with lime. The immediate effect of the lime stabilisation is flocculation of the clay particles which improves the workability, reduces the plasticity and increases the strength of the pavement due to internal friction (Mallela et al. 2004).

If the pavement material being treated contains pozzolans such as silica and alumina, a pozzolanic reaction will occur between the pozzolans and calcium hydroxide that has cementitious properties. The pozzolanic reaction results in additional increase in strength and durability (Mallela et al. 2004). A pozzolanic additive can be added to lime to force this reaction when mixed with pavement materials which will be covered in section 2.4.3 Cementitious Stabilisation.

When used in small quantities less than 2% by mass, improvements in workability, strength and moisture susceptibility are gained without considerable tensile strength gain. This is often referred to as modification. When used in larger quantities lime will increase the modulus and tensile strength of the pavement materials. This is referred to as a bound pavement (Austroads 2006).

1.4.3 Cementitious Stabilisation

Cementitious stabilisation is the stabilisation of a pavement with a cement or other cementitious product. The other cementitious products used are combinations of lime and a pozzolanic material such as fly ash or ground granulated blast furnace slag (Austroads 2019b). The pozzolanic materials are not self-cementing and require lime or cement to activate (Little et al. 2000).

Cementitious stabilisation can be used on a wide range of pavement materials. The reaction caused by cementitious stabilisation is between the binder and water and will occur regardless of the pavement material (Austroads 2019b). The reactions caused by pozzolanic materials are generally slow and continue for long time in the presence of moisture and suitable temperatures (Austroads 2018a). The main benefits provided by cementitious stabilisation are reduction of moisture sensitivity and the creation of bonds between pavement particles. The reduction is susceptibility to moisture increases the stability of the stabilized pavement even when the moisture conditions fluctuate. The development of bonds between particles increases the tensile strength and elastic modulus of the pavement (Austroads 2019b).

Cement stabilisation is more susceptible to issues caused by poor construction due to the short working time and is not considered a slow setting binder. Failure to properly compact the pavement prior to curing will result in a lower strength than expected. Using a higher percentage of binder than specified can cause large block cracking induced by rapid curing and shrinkage (Austroads 2018a). The best results are provided by using a supplementary cementitious material chosen based on laboratory testing of varying binder types with samples of the pavement to be stabilised (Austroads 2018a). The use of supplementary cementitious materials such as lime and fly ash or ground granulated blast furnace slag provides the benefits of cementitious stabilisation as well as those from slow setting binders.

1.5 The Problem

TfNSW North region extends from the Hunter region to the Queensland border and west to Gunnedah. Stabilised pavements constructed in the North region are exhibiting signs of distress requiring additional maintenance over the standard routine maintenance requirements in the early stages of life. The signs of distress that these rehabilitated sections of pavement are exhibiting suggest that these pavements will not meet the expected design service life without additional maintenance and may need to be rehabilitated earlier than desired. The additional maintenance and shortened life have a financial implication for TfNSW' funding profile. The additional operational expense of increased maintenance is funded by reducing planned maintenance in other areas. The capital expenditure of rehabilitating the pavement earlier than designed is funded by pushing the rehabilitation of a different section of pavement out to a future year, which in turn increases the operational maintenance of the delayed pavement.

TfNSW has developed specifications for the rehabilitation of existing pavements by stabilisation with slow setting binders. TfNSW requires that stabilisation of granular pavements meet the requirements of its specifications that have been developed to ensure pavements perform as designed. Construction of pavement with non-conforming parameters risk reducing life and increasing maintenance costs. Significant increases to maintenance costs over the life of a pavement can detrimentally affect the whole of life cost of the asset. This will in turn impact the viability of stabilisation as a pavement rehabilitation option when considered against other rehabilitation options as part of a whole of life comparison.

When a pavement is not rehabilitated to the standard required, the design life may not be achieved. Assessing the financial impacts of nonconforming pavement rehabilitation will provide a basis for reviewing current construction specifications. TfNSW specifications R75 and R73 set out the requirements for pavement stabilisation using slow setting binders including layer thickness, compaction requirements and unconfined compressive strength (UCS). TfNSW R75 and R73 include payment deductions for nonconforming relative compaction but not for nonconforming thickness (Transport for New South Wales 2020b). This dissertation will review the impact to design life of constructing nonconforming stabilised pavement, the financial costs resulting from the additional maintenance required to maintain an acceptable level of service to determine if the deductions currently applied in the specification are sufficient to recover costs incurred by TfNSW. The financial implications of accepting non-conforming pavements will be examined through a whole of life cost analysis using unit rates for maintenance activities in TfNSW' North region.

1.6 Project Aims

The aims of this project are:

i. This project aims to review effects of nonconforming compaction and layer thickness on the life of stabilised pavements; and
ii. To investigate the cost implications due to reduced life and increased maintenance requirements of stabilised pavements constructed with non-conforming compaction and layer thickness; and
iii. To propose methods of improving conformance with specification requirements to ensure design life is achieved.

1.7 Project Objectives

In order to achieve the aims of this project, the report will:

- Conduct literature review into stabilised pavements and the issues that impact their performance.
- Complete a desktop review of the pavement design, layer thickness and compaction records from construction of two stabilised pavements in TfNSW' northern region to determine areas with non-compliant parameters that may impact the life of the pavement.
- Use mechanistic pavement design software CIRCLY to model non-conforming sections of the case study projects to determine theoretical changes to design life.
- Model three theoretical stabilised pavements with varying subgrade CBR in CIRCLY with pavement profiles indicative of those found in the northern region of NSW to review the impacts of varying layer thickness and compaction on design life.
- Complete visual investigations at the two case study sites to determine current pavement condition.
- Calculate the expected life of the case study stabilised pavement projects and compare to the design life of these projects to understand the financial implications of construction non-conformances to TfNSW.
- Complete whole of life cost analysis of the case study projects to compare costs of completing the projects in line with the pavement design and specification against projects with non-conforming thickness and compaction.
- Propose methods to improve TfNSW specifications to ensure design life is achieved.

1.8 Project Outline

Literature Review

Chapter 2 is a thorough review of the literature available regarding stabilisation of granular pavements with a focus on the use of slow setting binders. It examines the factors that impact the performance of stabilised pavements throughout the service life ranging from initial investigation through to maintenance.

Methodology

Following on from the literature review, Chapter 3 provides a summary of the methods that were used throughout the project. It outlines and explains the techniques and resources that were used to achieve the project objectives.

Case Study Project Review

Two case study projects were examined. The style background information for each of the case study projects is discussed in this chapter.

Results

The results obtained through completion of the tasks set out in the methodology are explained in Chapter 4. Summaries of the data used and produced during the project are provided and analysed to achieve project objectives.

Discussion

An analysis and discussion on the results presented in Chapter 4 are presented. The outcomes of the analysis completed are presented to tie in with the literature and expand the current knowledge in the areas identified in the literature review.

Conclusion

The work completed throughout the project is summarised the work completed during the project, the aims that were met and the objectives that were used to achieve them. Potential areas further work to expand on this project are suggested.

2 Literature Review

An introduction to binders used in granular pavement stabilisation and methods of stabilisation was provided in the previous chapter. This literature review will research the factors that affect the effectiveness of stabilisation as a pavement treatment, the maintenance required for stabilised pavements and the pavement lifecycle. The information contained in this literature review will identify knowledge gaps in the literature and guide the research in the remainder of this dissertation.

2.1 Issues Affecting Stabilised Granular Pavement Performance

Pavements are designed and constructed to withstand traffic loadings and to provide safe and comfortable travel for road users over a specified design life. Pavements often perform in a manner that does not match the intent of the design, require additional maintenance, and need to be rehabilitated earlier than expected due to a range of factors. These factors fall into two categories:

1. Design issues relating to insufficient investigation and the use of incorrect material characteristics.
2. Construction issues such as compaction, thickness and drainage.

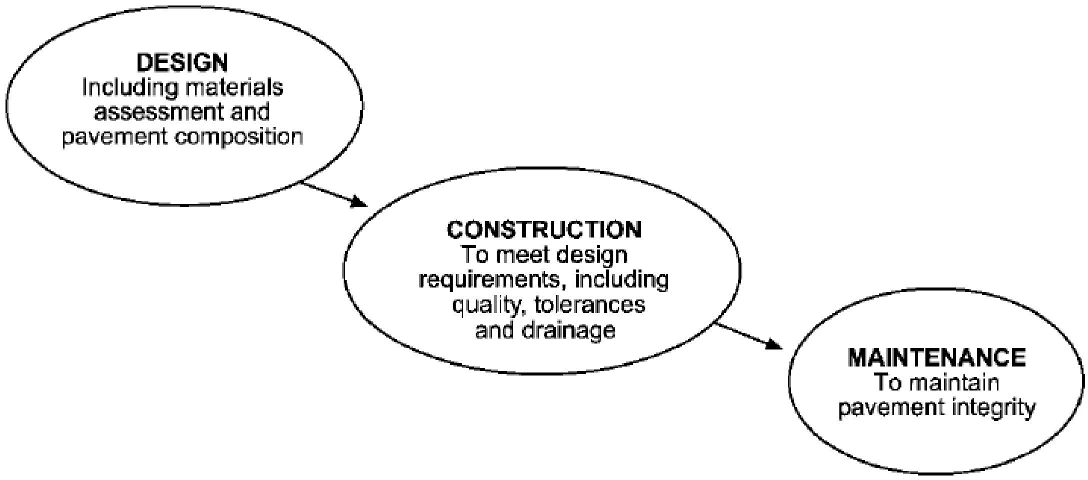

Figure 2. 3 - Factors affecting pavement performance
(Source: Austroads 2017)

2.1.1 Design Issues

The design of a pavement is critical to ensuring the required service life is achieved and funds are not wasted on a pavement that will be short lived or require maintenance above acceptable levels. Rehabilitation of an existing pavement through stabilisation with slow setting binders is considered to be a cost-effective treatment, but certain factors need to be considered when designing and constructing stabilised pavements to ensure their viability over the entire service life. Investigation must be completed to provide information regarding the existing pavement materials including their depth and quality, the subgrade conditions and local climate conditions including determining periods of typical high rainfall (Austroads 2019c).

2.1.1.1 Pavement Investigation Deficiencies

To begin the pavement design process the existing pavement and surrounding site must be investigated. The existing pavement needs to be examined for signs of distress and their causes, identify areas of past maintenance and the cause, existing layer thickness and material types (Austroads 2017).

Signs of distress and evidence of previously completed maintenance such as patching work may indicate lack of thickness in the pavement, insufficient compaction during construction, or low quality materials that will all need to be addressed in the design of the new pavement. Failure to identify and account for these issues may lead to a reduced pavement life and therefore increased costs due to maintenance or early reconstruction/rehabilitation (Austroads 2017).

The climate of the region must also be considered. Wet climates may cause increases to construction costs due to lost time and the need to rework wet pavement (Austroads 2017). In dry climates the availability of water for construction may be minimal causing increased costs due to haulage of water.

The design traffic of the road must be accommodated to ensure that the pavement is structurally capable of withstanding the loads from the repeated passage of vehicles. Vehicles are classified by Austroads into 12 classes based on axle groups. The pavement must be designed to handle the cumulative loading from all axle groups, their type and load traversing the pavement (Austroads 2017).

2.1.1.2 Mix Design

A mix design for a stabilised pavement is completed to calculate the ideal quantity of binder that is required to form a pavement with the desired characteristics. Samples of the pavement materials combined with varying quantity of binder are prepared and tested using the unconfined compressive strength (UCS) test method which allows for the optimum binder content to be selected based on the strength of test samples (Austroads 2019b).

A successful stabilised pavement mix design must account for a range of factors that will affect the pavement performance. The material characteristics are the most controllable factors during the mix design process including the binder type and content, the existing pavement material to be stabilised and the moisture content of the mix (White 2007).

2.1.1.2.1 Existing Pavement Material

The existing pavement materials that will be stabilised will impact the performance of a stabilised pavement over its service life. It is critical to review the characteristics of the host pavement materials as not all binders are suited to all host materials (White & Gnanendran 2002).

The existing pavement depth should be examined to determine the layer depth to ensure that the mixing process does not extend deeper than the existing pavement and incorporate poor quality materials from the subgrade into the bound layer (White 2007). Subgrade materials are unlikely to contain adequate strength and mechanical properties to benefit the bound layer and will likely reduce the life of the pavement.

Testing should be carried out on the host materials that are being considered for stabilisation to determine the particle size distribution and plasticity. The base material should be well graded with a plasticity index not greater than 20% (White 2007). If the host materials are not adequately graded, granular stabilisation should be considered to improve the particle size distribution as part of the mix design (Gray 2017).

The testing completed to determine the particle size distribution and plasticity can be used as guide to determine which binders are most likely to be effective, reducing the cost of testing mix designs unnecessarily with binders that are not likely to provide the desired results.

2.1.1.2.2 Binder Type and Content

The binder type selected for a stabilised pavement is selected based on host material properties and testing with samples of the host material. Table 2.1 provides a guide to preliminary binder selection based on the host materials.

Particle size	More than 25% passing 75 µm sieve			Less than 25% passing 75 µm sieve		
Plasticity index (PI)	PI ≤ 10	10 < PI < 20	PI ≥ 20	PI ≤ 6 & PI x %passing 75 µm ≤ 60	PI ≤ 10	PI > 10
Binder type						
Cement and cementitious blends[1,3]	Usually suitable	Doubtful	Usually not suitable	Usually suitable	Usually suitable	Usually suitable
Lime	Doubtful	Usually suitable	Usually suitable	Usually not suitable	Doubtful	Usually suitable
Bitumen	Doubtful	Doubtful	Usually not suitable	Usually suitable	Usually suitable	Usually not suitable
Bitumen/ lime blends	Usually suitable	Doubtful	Usually not suitable	Usually suitable	Usually suitable	Doubtful
Granular	Usually suitable	Usually not suitable	Usually not suitable	Usually suitable	Usually suitable	Doubtful
Dry powder polymers	Usually suitable	Usually suitable	Usually unsuitable	Usually suitable	Usually suitable	Usually not suitable
Other proprietary chemical products[2]	Usually not suitable	Usually suitable	Usually suitable	Usually not suitable	Doubtful	Usually suitable

Table 2. 1 - Preliminary binder selection guide
(Source: Austroads 2019)

Slow setting binders such as lime and cementitious blends are primarily used in pavement rehabilitation through stabilisation. The use of slow setting binders is required to allow for adequate compaction of deep lift stabilised layers before the excessive curing had occurred (White & Gnanendran 2002).

The percentage of binder used to stabilise pavement materials is selected through laboratory testing of samples of the host material with a binder of varying percentage by mass of granular pavement material. The required binder content will vary depending on the characteristics required from the pavement and the material being stabilised (Gray 2017).

Using a higher binder content than required will result in strength gain over the requirement leading to shrinkage cracking and reduced service life. Pavements that exhibit block cracking will require crack sealing to prevent moisture infiltration to the pavement and underlying subgrade (Austroads 2009). Applying less than the design binder content result in a pavement with a strength lower than required to provide the service life expected. Additional patching is likely to be required in this instance (Austroads 2009).

2.1.1.3 Subgrade California Bearing Ratio

Determining the California bearing ratio (CBR) of a subgrade is essential to the structural design of a pavement. The subgrade provides support to road pavement and is regarded as one of the most critical factors in determining the pavement materials, thickness and design life (Austroads 2017). The higher the bearing capacity of a subgrade, the lower the thickness of overlying pavement required to achieve a desired design life (Austroads 2018b).

Determining a design CBR can be completed through field testing and laboratory testing. Care needs to be taken when design CBR is adopted from field testing. Results from field testing provide the CBR at the time of testing and do not account for increased moisture in the subgrade. This method should be limited to conditions that are expected to remain the same for the service life of the pavement being designed. Laboratory testing can be used in the situation described above and in situations where the subgrade conditions such as moisture and density are likely to change as these changes can be replicated in the laboratory (Austroads 2017).

In situations where testing methods are unavailable or not warranted due to the cost, presumptive CBR values can be adopted, however care needs to be taken to ensure that previous experience from subgrade testing and/or pavement performance is taken in to account (Austroads 2017). Adoption of presumptive subgrade CBR values may cause the structural design of the pavement to be insufficient and therefore require increased maintenance or lead to the construction of a pavement that is over designed and cause the intimal construction cost to be higher than necessary. Table 2.2 shows typical presumptive values for subgrade CBR.

Description of subgrade		Typical CBR values (%)	
Material	Unified Soil Classification	Excellent to good drainage	Fair to poor drainage
Highly plastic clay Silt	CH ML	5 4	2–3 2
Silty-clay Sandy-clay	CL CL	5–6	3–4
Sand	SW, SP	10–18	10–18

Table 2. 2 - Typical presumptive subgrade CBR values
(Source: Austroads 2017)

2.1.1.4 Structural Design

Structural design of flexible pavements is completed using empirical design, mechanistic design or a combination of both methods depending on the type of pavement. Empirical design relies on the use of design charts to determine minimum cover required over subgrade. Structural design of cemented pavements is predominately completed using mechanistic design software such as CIRCLY in combination with empirical design charts and pavement material properties (Gray 2017). Bound materials are considered to be isotropic and linear elastic. Mechanistic design software such as CIRCLY assess pavement design by calculating the horizontal tensile strain at the bottom of the bound layer and the vertical compressive strain at the top of the subgrade layer (Austroads 2019b).

The mechanistic pavement software CIRCLY calculates a cumulative damage factor (CDF) for each layer in the pavement structure. The CDF can be converted to years of life by dividing by the number of years used as the design period. Alternatively, organisations such as TfNSW have created add on applications for use with CIRCLY that complete the calculation necessary to provide the achievable life of each pavement layer.

The structural design process can be the direct cause of early pavement distress or unnecessarily increased construction cost if not completed correctly. The use of inaccurate data in the design process such as material properties or design traffic can result in a pavement design that is not suitable for the location.

2.1.1.5 Design Traffic

A pavement must have sufficient structural capacity to withstand the heaviest vehicles as well as the cumulative traffic load imposed over the designed life. Austroads (2017) classifies vehicles commonly using Australian roads into 12 classes based on vehicle length, axles, the number of axle groups and the load applied to the road by these axle groups. The passage of light vehicles over a pavement has been documented to have little impact of the deterioration of a pavement, negating the need to include light vehicles in the design of a pavement (Austroads 2017).

Stabilised pavement design relies on the mechanistic-empirical design process which uses the modulus of the bound layers to determine the axle repetitions required to cause failure in the pavement structure. The typical design period for a pavement rehabilitation ranges from 10 to 20 years and is used in the calculation of the cumulative axle repetitions (Austroads 2019a). To calculate the expected axle repetitions over the life of a pavement Austroads (2017) provides the process shown in Figure 2.4.

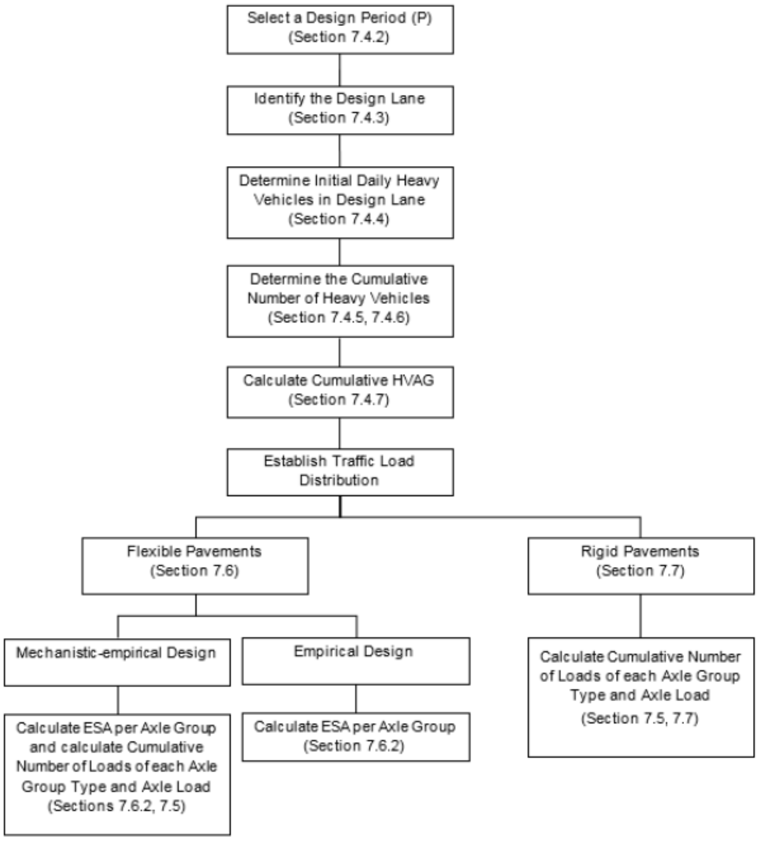

Figure 2. 4 - Procedure for determining design traffic
(Source: Austroads 2017)

To calculate the life of a proposed pavement design through the mechanistic-empirical design method a calculation of the estimated total number of axle repetitions over the life of the pavement based on the current traffic data is required which is referred to in Austorads (2017) as the design traffic. Mechanistic-empirical design calculates the axle repetitions that a pavement structure can withstand during its life otherwise referred to as the allowable traffic. The calculated axle repetitions over the life of the pavement are compared with the axle repetitions required to cause failure in the pavement to provide a design life in years.

For flexible pavements the equivalent standard axles (ESA) per axle group are calculated followed by the cumulate number of loads applied by each axle group type and axle load. ESA is the term generally used to refer to the design traffic loading in the mechanistic-empirical design method (Austroads 2017). Austroads (2017) defines the standard axle as “a single axle with dual tyres (SADT) applying a load of 80 kN to the pavement”.

The mechanistic-empirical design method for the design of stabilised pavements also requires the cumulative heavy vehicle axle groups (HVAG) over the design period which is defined as the design traffic (N_{DT}). Design traffic calculation is completed as determined by Austroads (2017) is shown in equation 2.1.

$$N_{DT} = 365 * CGF * AADT * DF * \%\frac{HV}{100} * LDF * N_{HVAG}$$

Equation 2. 1

Where;

CGF = cumulative growth factor

$AADT$ = annual average daily traffic

DF = direction factor

$\%HV$ = average percentage of heavy vehicles

LDF = lane distribution factor

N_{HVAG} = average number of axle groups per heavy vehicle

The impact that traffic loading has on the performance of stabilised pavements is well documented and discussed in the literature such as Austroads (2017) that outlines the procedure for determining the design traffic over a design period shown in equation 2.1. Preparing a pavement design based on traffic assumptions or incorrect traffic data may lead to an under designed pavement that will not meet the required traffic loading before failure. The pavement may be designed thinner than required to meet the fatigue requirements for the actual traffic loading over the design period. The inadequate design will cause increased maintenance costs to be incurred by the road authority due to the early fatigue of the pavement.

2.1.1.6 Flexural Modulus

The primary design input for a stabilised pavement mechanistic-empirical design is the flexural modulus of the stabilised layers. The modulus of a stabilised pavement increases with binder content which is usually greater than 3% by mass, but is limited by the increased likelihood of shrinkage cracking which decreases the modulus. (Austroads 2017). Shrinkage cracking can be limited through control over the spread rate, mixing depth and quality of mixing to ensure the target mix design is achieved (Louw & Jones 2015). Factors that affect the modulus of stabilised pavements are shown in Table 2.3.

Factor	Effect of increasing factor
Proportion of coarse angular particles	Increase
Density	Increase
Compaction moisture content	Increase up to an optimum value and then decrease
Stress level	No change
Cementitious binder content	Increase
In-service moisture content	Slight decrease
Age	Increase
Extent of cracking	Decrease
Efficiency of mixing	Increase
Temperature	No change
Rate of loading	No change

Table 2. 3 - Factors affecting modulus of stabilised materials
(Source: Austroads 2017)

When completing pavement design the appropriate modulus for the stabilised materials must be adopted. The value of the cemented modulus is taken as an estimate of the in-situ flexural modulus after curing for 90 days. This method is adopted based on the assumption that stabilised materials will be cured to a point where there will be minimal change in properties after this period (Austroads 2017).

TfNSW requires that in-situ stabilised pavements designed in accordance with Austroads Guide to Pavement Technology: Part 5 (2019a) that are over 300mm thick are modelled as two separate layers for design purposes. The two layers are modelled with separate modulus with the lower layer having a reduced modulus compared to the upper layer to account for reduced compaction in the lower two thirds of the deep lift stabilised pavement (Transport for NSW 2021b). Pavements that are designed in accordance with Austroads Guide to Pavement Technology: Part 2 (2017) and RMS supplement (2018) are modelled as a single layer with uniform modulus for the full depth of the layer.

Flexural modulus can be calculated by means of laboratory testing of test slabs prepared using the material to be stabilised mixed with the design binder content. Test beams are cut from the slabs and moist cured for 90 days before they are tested for modulus. This method while the most accurate may not be used due to the lead time required, availability of testing equipment and personnel in some regions. Another method used method of calculating the flexural modulus of bound materials is by using developed relationships between unconfined compressive strength (UCS) and modulus where the UCS is multiplied by a factor "k_{UCS}" between 1150 and 1400 (Austroads 2017).

This method is often used as it is relatively cost effective, more readily accessible and takes less time to complete the UCS testing compared to laboratory testing of prepared slab samples making it the preferred method of testing and determining modulus (White 2007). When modelled in mechanistic-empirical software the bound layers are assigned a modulus. The assigned value for the modulus is then used to determine the strain at the bottom of the bound layers and the vertical strain at the top of subgrade caused by axle movement. The strains are used to calculate the number of load repetitions that the bound pavement can withstand before failure (White 2007).

2.1.1.7 Fatigue

Stabilised pavements crack as a result of continuous repetitions of tensile strain in the pavement that exceeds the capacity of the bound layer. This cracking is known as fatigue cracking and its prevention is the main criteria for structural design of bound pavements. Fatigue service life can be estimated from the measured flexural strength and modulus (Austroads 2019b).

Fatigue is the failure criteria modelled in CIRCLY for bound pavements as it is generally the failure criterion that defines the fatigue life of this pavement type (White 2007). Austroads (2012) defined the in-service fatigue relationship as:

$$N = RF\left(\frac{(\frac{113000}{E^{0.804}} + 191)}{\mu\varepsilon}\right)^{12}$$

Equation 2. 2

Where;

$N =$ the number of allowable repetitions of the load induced strain

$RF =$ the reliability factor for cemented material fatigue

$E =$ cemented material modulus (MPa)

$\mu\varepsilon =$ load induced tensile strain at the bottom of the bound layer

Further research in this area led Austroads (2017) to replace the above method shown in equation 2.2 for determining fatigue in the earlier version of Austroads (2012) based on the recommendations proposed by (Geoffrey Jameson 2014) to determine the in-service fatigue relationship for cemented materials with the equation 2.3.

$$N = RF\left(\frac{K}{\mu\varepsilon}\right)^{12}$$

Equation 2. 3

The methodology for calculating the fatigue relationship was updated to provide for more conservative fatigue characteristics of stabilised layers. Using equation 2.3, the value for K, the in-service fatigue constant is determined by multiplying the fatigue constant k, determined through laboratory fatigue data by the laboratory to field shift factor which has a presumptive value of 1.55 (Austroads 2017). To ensure that the value for the in-service fatigue constant does not allow for calculation of stabilised layers that are thinner than a layer of lean mix concrete, a maximum value of in-service fatigue constant is determined using equation 2.4, where E is the design modulus, or in the case of cemented materials the flexural modulus.

$$Kmax = \frac{18880}{\sqrt{E}}$$

Equation 2. 4

Jameson (2013) has summarised that the exponent used in the fatigue relationship varies depending on the region or country and has been accepted to be as high as 32 by some countries. Austroads (2017) accepts the exponent as 12 to ensure that the fatigue relationship for allowable repetitions of strain are conservative. Adoption of the exponent as 12 reduces the likelihood of cemented pavements failing earlier in their design life than intended (Jameson 2013).

2.1.2 Construction Issues

The construction of a stabilised pavement is critical to ensuring that the design characteristics are achieved. Meeting the requirements of the pavement structural design will provide the highest likelihood that the pavement will achieve the expected design life with minimal maintenance requirements. Non-conformances in stabilised pavement construction may lead to increased maintenance requirements and reduced service life, causing the pavement to be rehabilitated early.

2.1.2.1 Thickness

The thickness of stabilised pavements is determined based on the subgrade CBR and the depth of cover required over the subgrade as well as the design traffic. The total thickness of cover required subgrade increases as subgrade CBR decreases (Austroads 2017). Design traffic is factored into the calculation of thickness with CBR. As the design traffic increases, the depth of pavement must also increase to account for the increased traffic loading (Austroads 2017). TfNSW requires an additional 10 mm to be applied to the bound layer thickness as the critical layer as a construction tolerance (Transport for NSW 2021b).

The review of literature appears to show a lack of research into the effects bound layer thickness changes have on pavement life. This is likely due to the fact that thickness of stabilised layers is considered to be isotropic in modulus throughout the layer (Austroads 2017). However, it has been determined that as a bound layer increases in depth, the greater the variation in density and binder distribution (White 2007). Constructing a stabilised pavement at a thickness other than the designed thickness will vary the binder content by mass of pavement. A thinner insitu stabilised pavement than designed will have more binder mixed through the pavement material resulting greater strength gain than desired, which combined with the reduced traffic loading capacity of the thinner pavement will cause a shorter than desired life before major maintenance or rehabilitation is required. Care also needs to be taken not to construct a stabilised pavement thicker than designed. A thicker pavement will contain less binder than designed in the mix, therefore creating a pavement with a lower modulus which will decrease the life of the pavement. This variation in binder content as the thickness of cemented layers bound through insitu stabilisation increase or decrease appears to have not been examined in the literature.

The impact of variability in modulus values has been reported by Jameson (2014) as major challenge in calculating the life of a stabilised pavement. As varying the thickness of a stabilised pavement while maintaining constant binder application rate will vary the modulus of the pavement, the impact on the life of pavements constructed with varying thickness could be analysed to close this gap in the current knowledge.

2.1.2.2 Mixing

Adequate mixing of stabilised pavements is important to guarantee that the mixed pavement on site will perform as designed in the laboratory. Uniform distribution of the binder through the pavement materials is critical to achieve the designed strength and modulus (Gray 2017). Austroads (2017) describes how inefficient mixing may leave areas of pavement material with insufficient binder which will create a weaker area than the surrounding pavement. These areas of lower strength will create stress concentrations which reduces the fatigue life of the pavement (Austroads 2017). Use of appropriate deep lift stabilisation equipment with sufficient power is necessary to achieve uniformity in the pavement (White 2007).

2.1.2.3 Compaction and Moisture

The compactive effort applied to stabilised pavements is an important factor to consider as compaction increases the density of pavement materials which in turn increases the modulus of stabilised materials (White 2007). The moisture of the pavement mix affects the density achievable. Varying from optimum moisture will usually result in decreased density for a given compactive effort (Austroads 2017) which Holtz is due to the surrounding of individual particles with moisture, preventing the mechanical interlock that densification depends on (Holtz & Kovacs 1981). During the pavement design, standard compaction is used to confirm the optimum density of the design materials to ensure that the design modulus can be achieved (G Vorobieff & R Yeo 2002). During the construction process, equivalent compaction must be achieved to ensure that the same modulus achieved in the laboratory during the design stage in achieved on site.

Compaction needs to be completed within the working time of the binder used (Austroads 2019c) and as soon as possible after the mixing of the binder and water to ensure that the hydration process does not cure the pavement before the required compaction has been achieved (Austroads 2017). The longer the delay between mixing and compaction, the more the binder will strengthen the pavement mix and reduce workability (White 2007). White (2007) reported that increased delay in compaction after addition of binder resulted in decreased density which in turn resulted in reduced modulus.

Another factor to be considered when constructing deep lift bound pavement over 200 mm in depth, the lower portion of the layer may achieve a lower density than the higher portion of the layer. This effect is referred to as a density gradient or profile in the literature. Transport for NSW (2021) requires that bound layers over 300mm in depth be sub layered when modelled in CIRCLY to account for the lower third of the pavement having a reduced modulus resulting from the reduced density. Despite the density gradient, constructing deep lift bound pavements is preferred over multiple thin layers due to the risk of debonding between the layers significantly reducing pavement performance (Austroads 2012). Appropriate compactive equipment relative to the depth of layer is required to achieve the required density and minimize the density gradient in deep lift pavements. For deep-lift stabilised pavements 18 tonne vibratory padfoot and smooth drum rollers are required as a minimum (Austroads 2019c). Heavier rollers up to 30 tonnes are available which can provide the maximum dry density at full depth of deep lift stabilised layers providing site conditions allow for the heavier equipment and increased loads.

It is generally accepted that as the density of pavement materials increase, so too does the modulus up to an optimum point as reported by Austroads (2017). As modulus is primary material parameter for mechanistic pavement design software CIRCLY that is widely used in Australia, the relationship between density and modulus is of relevance. White (2007) reported that Foley, et al (2001) conducted research that found the UCS increased by approximately 15 % per 1 % increase in dry density ratio (DDR), equal to 0.4 MPa. White (2007) additionally discussed research by Transport South Australia (1998) that found that an increase in DDR of 1 % resulted in an increase in UCS of 0.2 MPa. Andrews (1998) investigated the relationship between dry density ratio and unconfined compressive strength as shown in Figure 2.5 which presents an increase in unconfined compressive strength of 0.1811 MPa per 1 % increase in dry density ratio.

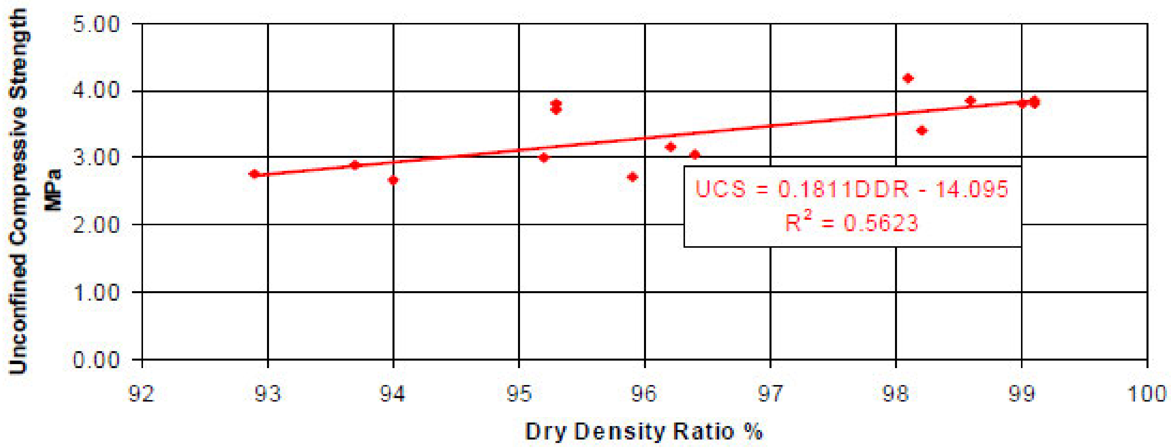

Figure 2. 5 - Dry density ratio vs Unconfined compressive strength
(Source: Andrews (1998))

While the literature generally accepts that the flexural modulus of cemented materials increase with the density of the material, the research to date has focused on the relationship between density and unconfined compressive strength. Relationships between the flexural modulus and the relative density of a stabilised pavements appear to not have been examined in any detail. Jameson (2014) reported that variation in density of a stabilised pavement impact the accuracy of calculating the life of a stabilised pavement but a relationship was not defined. The gap in the current knowledge could be improved through the analysis of the relationship between compaction and design life over a range of pavement conditions. This would allow for a broad approach to quickly determine the impact of accepting nonconforming compaction during construction in terms of lost years of pavement life.

2.1.2.4 Curing

Stabilised pavements gain strength through curing. Curing is the process where the binder hydrates with water within the pavement materials, leading to the formation of cementitious materials in the case of cementitious stabilisation (White 2007). The hydration of the binder begins immediately after the binder comes in contact with water in the mixing process. If cement is used in the binder the initial strength gain will be rapid within the first day. If the binder is a slow setting blend without cement the reactions are pozzolanic, which are slow but continue for a long period of time if moisture is present (Austroads 2019b).

2.2 Stabilised Pavement Maintenance

As a pavement ages, fatigue will present in varying ways due to the underlying cause. Regular maintenance of pavement is required to limit defects and ensure conditions are suitable for traffic. It is essential to identify the cause of pavement distress to prevent completing maintenance activities that will not address the cause of the distress (Austroads 2009).

2.2.1 Heavy Patching

Heavy patching is the process of completing deep repairs to selected areas of pavement using stabilisation methods. Heavy patching is often used when a stabilised pavement exhibits localised failures such as rutting, shoving and crocodile cracking. Heavy patching is a suitable repair method for these types of failures due to the nature and cause of the failures. Crocodile cracking is often caused by lack of compaction and fatigue which can be repaired through the targeted patching. Shoving and rutting are often caused by inadequate compaction and insufficient pavement thickness that can be addressed through localised heavy patching to sufficient depth (Austroads 2019a). Patching a granular pavement in this manner is generally used to provide a repair to a targeted section of pavement with the aim of delivering an increase in life for the failed area in line with the surrounding pavement.

2.2.2 Crack Sealing

Stabilised pavements are susceptible to shrinkage and fatigue cracking. Pavements with higher binder content produce larger sized blocks than pavement that a lightly bound due to the higher strength of the pavement materials (Austroads 2019b). Other factors such as late trafficking of pavement, insufficient compaction, errors in binder application rate can add to crack formation. Pavement cracking needs to be addressed to prevent moisture infiltration into the pavement which will lead to additional failures.

Crack sealing is used to treat cracked stabilised pavements. The material used for crack sealing may be polymer or rubber modified bitumen products that are used at high temperatures to fill cracks while maintaining flexibility. The flexibility of the crack sealant is essential to allow for movement of the cracked pavement. Due to the continual movement of the cracked pavement the crack sealing will fail after a few years and need to be re-applied (Austroads 2019a).

Crack sealing may also be used to treat asphalt wearing courses where the underlying pavement condition has caused cracking to occur. Crack sealing of asphalt wearing courses provides the same benefit as sealing of bound pavements by preventing the infiltration of moisture into the pavement.

2.2.3 Resealing

Sprayed seals are applied to flexible pavements including stabilised pavements to provide a range of benefits over an unsealed pavement. Benefits provided by sealing a pavement include providing skid resistance, protecting the pavement from moisture ingress, minimize dust generation by traffic and minimize wear on the pavement and therefore increase the life of the pavement (Austroads 2018d).

Sprayed seals deteriorate over time and their effectiveness decreases. A pavement should be resealed when one or more of the benefits provided by a sprayed seal have deteriorated to a point where the underlying pavement is put at risk or level of service provided by the seal is no longer sufficient. Applying a reseal restores the waterproofing of the pavement and provides new aggregate wearing surface for traffic (Austroads 2018d).

2.3 Pavement Lifecycle

Life cycle costing is defined as “assessing the cost of a product over its life cycle” (Transport for NSW 2018). The lifecycle of a pavement asset includes the following stages as outlined in Figure 2.6 (Transport for NSW 2018):

- The determination of the need for the asset.
- Planning for the use of the asset including specification of design.
- Acquisition of the pavement through construction/ rehabilitation.
- Operation and maintenance of the pavement asset.

- Disposal of the asset at the end of its useful life.

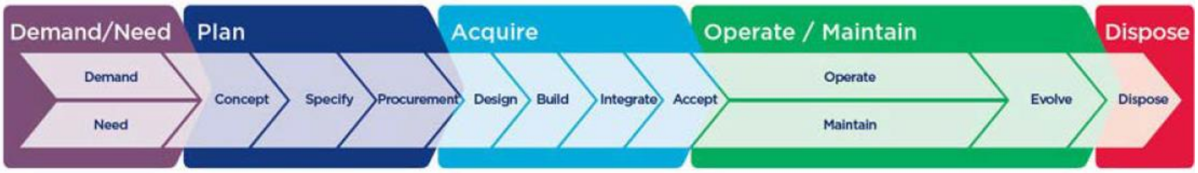

Figure 2. 6 - Life Cycle Phases (Transport for NSW 2018)

When roads authorities review pavement construction and/or rehabilitation methods the cost of construction is always considered to ensure planned works are within budget constraints. Different pavement types have varying maintenance requirements therefore it is critical that the life cycle cost is also considered as part of the options analysis to ensure the minimum costs over the life of the pavement. A pavement design that requires additional and/or more expensive maintenance throughout its life may offset an initial cost saving at construction reducing its viability as a treatment (AustStab 1996).

The cost of pavement maintenance and rehabilitation are continually increasing. It is important that roads authorities such as TfNSW utilize processes that consider the economic impact of selected pavement rehabilitation techniques. Life Cycle Cost Analysis (LCCA) is such a process that facilitates the investigation of economic viability of different pavement rehabilitation options (Babashamsi et al. 2016).

2.3.1 Environmental and Social Expectations

The Australian public expects that government agencies such as TfNSW manage road networks and associated activities in a sustainable and economically viable manner. It is expected that government undertake road maintenance and construction practices that result in minimal delays to traffic and community by adopting rehabilitation methods based on efficiency and cost effectiveness (White & Gnanendran 2002).

Environmental sustainability is a key consideration for roads authorities when planning for pavement works. Recycling existing products and using by-products of other industries prevents waste from entering landfills, saving communities valuable space and resources. Considerations for environmental sustainability will continue to guide government planning to implement practices that reduce waste and re-use by-products of other industries such as ground granulated blast furnace slag and fly ash used in cementitious stabilisation (White & Gnanendran 2002).

The NSW Government has implemented policy to guide its agencies including TfNSW in environment and sustainability management. The intent of this policy is to drive continual improvement in the management of TfNSW' infrastructure to ensure the greatest possible efficiency is achieved. Whole of life benefits and impacts must be considered alongside, environmental protection and sustainability (Transport for NSW 2020).

2.3.2 Sustainability and Ethics

A duty of care is assumed by all people undertaking work. The responsibility for ensuring that research completed will aid in the progression of sustainable practices and that the research itself will be completed in a sustainable and ethical manner is held by those completing the research. This research project will examine the practice of stabilising pavement materials using slow setting binders and the issues that affect the performance of this practice.

The practice of stabilisation of an existing pavement re-uses the existing pavement materials in the new pavement rather than removing and disposing of thousands of tonnes of materials. Slow setting binder also contain by-products from other industries that are used to add and/or increase the pozzolanic reactions within the pavement materials to increase the strength. Combining the recycling of existing materials with the use of by-products from other industries into a single project provides great environmental benefits in terms of reduced waste, haulage costs and fuel consumption.

2.4 Life Cycle Cost Analysis

When examining the cost of pavement rehabilitation, the design options need to be considered from a whole of life perspective. The costs throughout the pavement service life from design, construction, maintenance through to future rehabilitation must be evaluated in order to determine the most cost-effective option available. Life Cycle Cost Analysis (LCCA) is a method that can be used to compare different pavement rehabilitation options based on the Net Present Value (NPV) (Babashamsi et al. 2016). LCCA is especially useful when comparing alternative options that provide equivalent level of service and design life but differ in terms of initial cost and level of maintenance required to maintain the required level of service (Fuller 2010).

When considering pavement rehabilitation, the life of the pavement is considered to include the length of time from construction through to rehabilitation. The initial construction may be a rehabilitation of a previous pavement or construction of completely new pavement. The costs incurred when investigating different pavement types can be considered to be construction and maintenance. The rehabilitation at the end of service life is considered in the subsequent LCCA.

In order to accurately compare alternative pavement costs the present value must be calculated. The present value of life cycle costs over a given analysis period defined by desired service life includes the initial construction cost, costs associated with maintenance and at what point during the analysis period they are incurred and the salvage value at the end of service life (Austroads 2018c).

LCCA relies on the NPV of future costs such as maintenance. Future costs within the analysis period need to be discounted back to their present value to allow for direct comparison of pavement options in terms of current value. All future cash flow, whether positive or negative is to be discounted using the appropriate discount rate and then summed (Žižlavský 2014). Inflation is excluded from NPV calculations used in the life cycle costing of pavements, allowing all future costs associated with the assessed option to be considered as present day costs (Austroads 2018c).

2.5 TfNSW Pavement Stabilisation Specifications

Pavement rehabilitation completed by TfNSW on the North Region is most commonly completed using insitu stabilisation methods. The rehabilitation of pavements in this manner is managed through the TfNSW specification “R75 Insitu Pavement Stabilisation Using Slow Setting Binders” (2020b). While not as common as insitu stabilisation, imported plant mixed stabilised materials are used and are constructed under TfNSW specification “R73 Plant Mixed Heavily Bound Pavement Course” (Transport for NSW 2021a).

2.5.1 Compaction

Transport for NSW (2020a) sets out the requirements for compaction on pavement rehabilitation projects using insitu stabilisation. Compaction is required to be completed immediately after the addition of the binder into the pavement material and must be completed in a continuous operation. These standards are required to ensure that the pavement is as homogenous as possible allowing for uniform compaction and reduced possibility of failing to meet compaction requirements caused by compaction delay. Each lot is sampled for insitu density and the material tested is removed for testing in the laboratory to determine the relative compaction. For non-cohesive materials such as granular pavement materials in a base course, relative compaction or dry density ratio (DDR) is determined by TfNSW in accordance with TfNSW Test Method T166 (2012) as shown below:

$$Relative\ Compaction = \frac{FDD}{MDD} * 100\%$$

Equation 2. 5

Where:

FDD = Field dry density

MDD = Maximum dry density

TfNSW (2020a) requires that relative compaction for bound layers less than 250 mm thick must be greater 102 %. Bound layers greater than 250 mm thick must have a characteristic valuer for relative compaction at 300 mm greater than or equal to 100 %. The lower third of the layer may have an individual relative compaction of greater than or equal to 95 %. In the circumstance where the bound layer will be greater than 250 mm, the design should allow for this reduced compaction the lower third of the layer. TfNSW requires that his is modelled in CIRCLY by reducing the modulus in the lower third of the layer to 3200 MPa (Transport for NSW 2021b). This reduction in modulus required by TfNSW implies a decrease in modulus of 7 % per 1 % of relative compaction below maximum dry density which is similar to the reported research by White (2007), and Transport South Australia (1998).

TfNSW (2020a) allows for acceptance of stabilised pavements with non-conforming compaction with a payment deduction for the stabilised pavement pay item. The deductions are dependent on the degree of non-conformity as shown in Table 3.1. The specification also allows for acceptance of a lot with a thickness greater than 250 mm where the relative compaction is lower than 95 % in the lower third of the layer with a deduction of 20 % to the pavement pay item for the nonconforming section.

Pavement Course Thickness ≤ 250 mm		**Pavement Course Thickness > 250 mm**	
Relative Compaction (1)	**Deduction (2)**	**Relative Compaction (1)**	**Deduction (2)**
≥ 101 to < 102%	10%	≥ 98 to < 100%	10%
≥ 100 to < 101%	30%	≥ 95 to < 98%	30%
< 100%	Reject (3)	< 95%	Reject (3)

Table 3. 1 - Deductions for relative compaction
(Source: Transport for NSW 2020)

2.5.2 Thickness

TfNSW (2020b) requires that the thickness of insitu stabilised pavement layers be a minimum of 10mm greater than the design thickness and up to a maximum of 30mm greater than the design thickness. There are currently no deductions available to accept nonconforming pavement thickness. Nonconformances of this type are intended to be managed through the standard nonconformance process in the specification that specifies that nonconforming lots not accepted with a pay item deduction must be replaced or rectified at the expense of the contractor (Transport for New South Wales 2020b). Complete replacement of a bound pavement is prohibitively expensive often leading to the rectification process. Rectification of stabilised pavement must consider the binder already incorporated into the pavement materials along with the effects of re-mixing the pavement and adding additional binder. Even with the completion of the rectification process according to the specification, construction of a homogenous pavement using this method is unlikely to be achieved. Differential curing and distress is likely to present as early failures requiring additional maintenance. Minor nonconformances due to thickness are often accepted as is to reduce the risk associated with re-working a recently bound pavement. Without a deduction process for thickness, the cost of the nonconformance must be borne by TfNSW.

2.6 Summary

The literature review has examined the available written sources regarding stabilised pavement and the factors that affect its performance over time. A review was completed of techniques used for stabilisation of granular pavements, different binders available and circumstances that stabilisation is accepted as a viable rehabilitation method. Research and technical material is available and well documented for pavement issues and maintenance techniques required for remediation of pavement defects. Three key issues that were identified as lacking in research outcomes and suitable for additional investigation are:

- There is minimal research regarding the impact of non-conforming thickness of stabilised pavements on performance over time. The thickness of a pavement bound through insitu stabilisation will cause a variation in the application rate of the binder, which will in turn drive an increase in strength of the pavement materials. The strength of pavement materials has been linked to modulus through an established relationship that will be explored in the following chapters through modelling in CIRCLY to establish a relationship between thickness and design life.
- Research into the impact of non-conforming compaction of stabilised pavements on the performance over time is broad in nature. The research appears to focus on the impacts to unconfined compressive strength and not on the modulus of the stabilised materials. The variation in modulus caused by variation in density will be examined in the following chapters. This analysis will allow for modelling in CIRCLY to determine a relationship between compaction and design life.
- The financial impacts of increased maintenance requirements due to a pavement failing to meet the design life expected does not appear to have been examined in the literature. While increased maintenance is known to come at increased cost, a relationship between nonconformances for thickness or compaction and the lost life and increased maintenance has not been established. The cost incurred by roads authorities for maintenance is considerable and will be examined through whole of life cost analysis.

3 Methodology

3.1 Introduction

Study of available literature and research in Chapter 2 of this project has been completed to determine the extent of knowledge regarding the design, construction and performance of stabilised pavements. The research has identified that stabilised pavements with insufficient modulus will result in a reduced pavement life. Research has been reviewed that examined the relationship between compaction and unconfined compressive strength which can then be related to modulus.

While thickness is a factor examined in the research, the impact of constructing a non-conforming stabilised pavement layer is not examined in terms of the impact on pavement life. The literature review has also identified that there is a knowledge gap when considering the consequences of insufficient compaction and its effect on modulus and in turn, the life of the pavement. Expanding on these issues, the financial impact that construction of a bound pavement with nonconforming thickness or compaction has for the asset owner in terms of increased maintenance and/or early rehabilitation has not been found to be examined.

To increase the body of knowledge relating to stabilised pavements this project has examined the theoretical impacts of thickness and relative compaction on the life of stabilised pavements and from there, the incurred cost of nonconformance. The costs of increased pavement maintenance impact the viability of the selected pavement type and must be funded by the road authority or asset owner and are therefore of interest.

3.2 Pavement Analysis Methodology

The financial impact of constructing a bound pavement with thickness or compaction nonconformances over the life of a bound pavement was the focus of the remaining sections in this project. To enable the examination of financial impact, pavements with varying thickness and pavements with varying compaction were modelled in CIRCLY to determine relationships between design life, varying bound layer thickness and varying compaction.

The impact on the life of the pavement was used to calculate the financial implications of nonconforming pavement according to the calculated relationships. Whole of life calculations were completed for bound pavements of varying thickness and compaction to calculate a cost per square meter over the design life of the pavement. The unit rate determined was used to assess the suitability of specifications currently in use to recover the cost of non-conforming pavement from the construction contractor.

3.3 Review of Granular Pavement Stabilisation Projects

TfNSW manages the classified roads in the NSW classed as State Roads. State Roads are the primary arterial links between major urban areas and are the principal traffic and freight carrying routes for NSW. TfNSW is responsible for the management of State Roads including funding, maintenance, construction and reconstruction of road assets (Roads and Traffic Authority 2008). Under this responsibility, TfNSW rehabilitates pavements of State Roads when they reach the end of their useful life which is determined by a reduction in service level to a point where TfNSW considers the life to be complete. Rehabilitating a pavement through stabilisation to create a heavily bound pavement is a common treatment implemented by TfNSW.

Two heavily bound stabilised pavement projects were examined by review of the pavement design reports that contain examinations of the pavement conditions, traffic volumes and site conditions used to prepare the pavement rehabilitation design. A review of the completed pavement stabilisation projects' quality assurance records was completed to identify any nonconformances in the thickness or compaction. The current condition of these pavements was examined through visual field investigations to record pavement defects and signs of previous maintenance completed. A comparison of the construction nonconformances and current pavement condition was completed to determine if the observed defects in the pavement were likely to have been caused by the construction.

3.4 Pavement Modelling in CIRCLY

In order to examine the impact of pavement nonconformances caused by construction, the case study projects and three theoretical pavements were modelled in CIRCLY. The case study pavements were analysed using the original pavement designs to create a base line for design life, followed by variations to the thickness and compaction of the bound layer. The original pavement design was completed using RMS' software FPD2 which was not compatible with CIRCLY 7.0 at the time the modelling was completed for this research causing the results vary slightly from the original design.

The analysis in CIRCLY was completed using the design traffic calculated at the time of design for the case study projects with the RMS presumptive traffic load distribution (TLD) included in Roads and Maritime Services (2018). The theoretical pavements used the RMS presumptive TLD and the average design traffic of the two case study projects.

The theoretical pavements were designed based on a common pavement structure within the North region in NSW being 200 mm of base quality material and 200 mm of subbase quality material over subgrade of varying CBR subgrade. This often requires the overlay of additional base quality material prior to stabilisation to maintain at least 100 mm of granular subbase depending on the stabilised layer thickness required. The three theoretical pavements contained the same pavement structure but ranged in subgrade strength using 3 %, 5 % and 7 % CBR to predict the impact of non-conforming construction over a range of conditions. The existing subbase layer was modelled with a modulus of 250 MPa to comply with Roads and Maritime Services supplement to Austroads (2018) maximum presumptive modulus.

Each material used to create a layer in CIRCLY requires definition of the modulus, Poisson's ratio and fatigue constant. Calculation of the modulus was completed using equation 8 from Austroads (2017) shown below as equation 3.1.

$$E_{flex} = k_{UCS} * UCS$$

Equation 3. 1

The value for k_{UCS} adopted for this project depends on the circumstance of its use. For the case study projects, k_{UCS} was back calculated from the design UCS and modulus which is explained as each project is discussed. For the three theoretical pavements the average value from the range recommended by Austroads (2017) of 1275 was adopted to be conservative.

The Poisson's ratio adopted for this project was the typical value of Poisson's ratio for cemented materials recommended by Austroads (2017) and required by Roads and Maritime Services (2018) of 0.2.

The fatigue constant used in the CIRCLY analysis was calculated using a linear relationship between the upper and lower values for fatigue constant and flexural modulus provided by TfNSW (2021b) for cemented materials. The values provided for fatigue constant corresponding to cemented modulus at 5000 MPa and 3200 MPa are 263 and 312 respectively (Transport for NSW 2021b).

The relationship between flexural modulus and fatigue constant adopted is shown in equation 3.2.

$$K = -0.0272E + 399.11$$

Equation 3. 2

While the actual values of the fatigue constant would not form a linear relationship, it was considered acceptable for the purposes of this project as the intent was to relate the results back to the TfNSW specification for stabilised pavements using a postulated model for fatigue constant and flexural modulus. To confirm that the values adopted for fatigue constant were suitable for the purposes of this theoretical analysis, a comparison was made with the maximum value recommended by Austroads (2017) to ensure that stabilised granular pavements are thicker than lean mix concrete pavements which showed that the postulated values remained under the maximum values for fatigue constant and were within 1 % to 8 % of the limit as presented in Figure 3.1. This relationship becomes less accurate as the modulus increases or decreases away from the design modulus of 5000 MPa and outside the bounds of

3000 to 6000 MPa would be unsuitable. The equation for k_{max} that was used in Figure 3.1 is presented in equation 2.4.

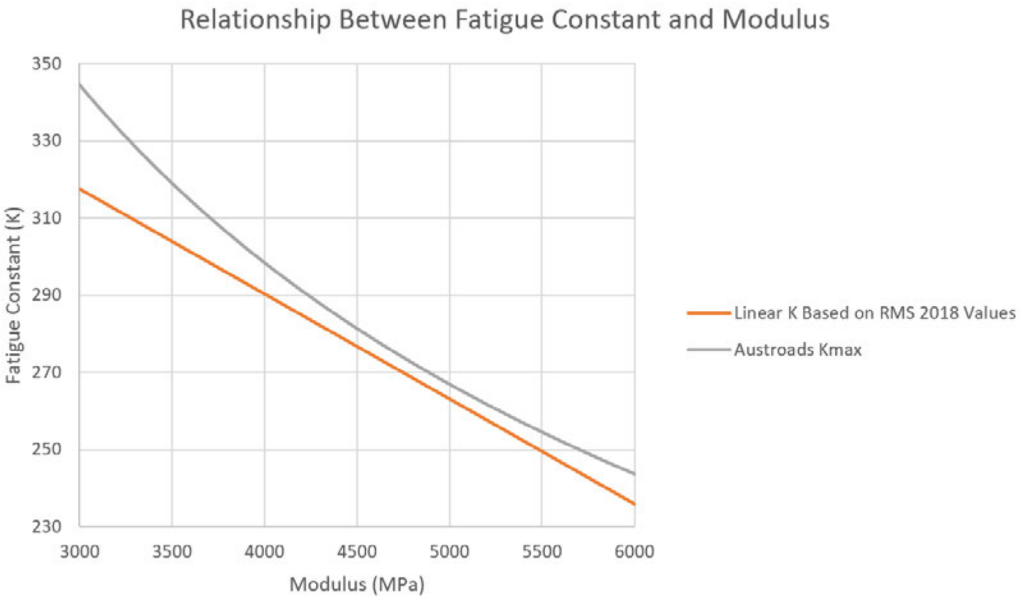

Figure 3. 1 – Modulus vs fatigue constant determined from modulus and fatigue constant provided by TfNSW (Source: TfNSW (2021b))

To further verify the postulated method of calculating the theoretical fatigue constant, the flexural strength was calculated using the modulus and fatigue constant from the postulated method and the K_{max} method from Austroads (2017). Figure 3.2 presents the results of flexural strength calculations that were determined using equation 3.3 derived from Austroads (2017). The postulated method is shown to provide a flexural strength that follows a similar curve to those determined using K_{max} while remaining under the limit, ensuring that the values adopted will not provide thicknesses less than would be required for a corresponding layer of lean mix concrete.

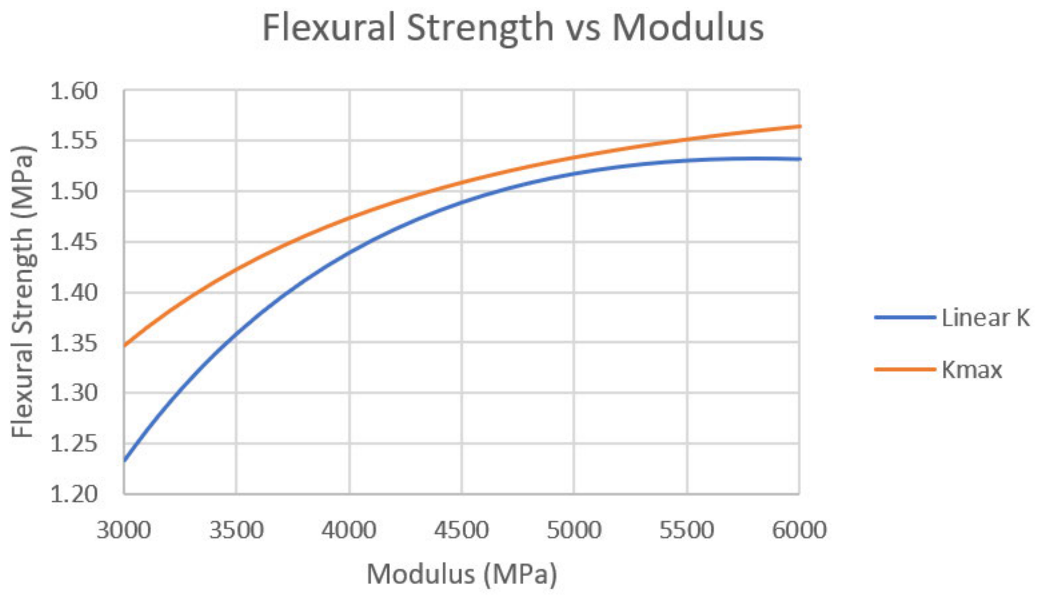

Figure 3. 2 – Comparison of flexural strength and modulus calculated for the postulated method for fatigue constant and maximum fatigue constant

$$FS = \frac{(K + 285)E - 919300}{240E}$$

Equation 3. 3

Where:

FS = Flexural strength (MPa)

E = Modulus (MPa)

K = Fatigue constant

CIRCLY calculates the cumulative damage factor for each pavement layer using equation 3.4. The pavement is limited by the layer with the highest CDF and therefore lowest capability to withstand traffic loading applied through the strain distribution mechanism of each material.

$$CDF = \frac{n}{N}$$

Equation 3. 4

Where n is the number of repetitions of the load and N is the allowable repetitions of the load that are calculated to cause the pavement to fail. A CDF of 1 indicates that the pavement layer has reached the design period, while a CDF of greater than 1 indicates early failure of the layer and a CDF of less than 1 indicates excess life over the required design period. Cemented layers distribute the stress from traffic loading as tensile strain at the bottom of the cemented layer. CIRCLY determines the tensile strain at the bottom of the stabilised layer and displays in a report which was saved for inclusion in the appendices for each material modelled.

The pavement life in years was back calculated from the cumulative damage factor (CDF) CIRCLY produces using the method in equation 3.5.

$$Design\ Life = \frac{CDF}{Design\ Period}$$

Equation 3. 5

3.4.1.1 Thickness with Uniform Characteristics

The case study projects, and the theoretical pavements were modelled in CIRCLY over a range of pavement thicknesses. The thickness was varied in 10 mm increments to calculate the cumulative damage factor which was then converted to years of design life. The optimum thickness for each pavement over a 20 year design period was calculated using CIRCLY's automated process for thickness. The modulus used for this process was the modulus used for the original pavement designs completed by TfNSW. TfNSW used a modulus of 5000 MPa as required in RMS Supplement to Austroads Guide to Pavement Technology Part 2: Structural Design. RMS (2018) also provides the Poisson's ratio of 0.2 and fatigue constant of 263 which was adopted for this process. Modelling the pavements in CIRCLY with uniform characteristics regardless of constructed thickness replicated the performance of a stabilised pavement constructed with plant mixed stabilised materials as would be required under TfNSW R73 Specification: Construction of Plant Mixed Heavily Bound Pavement (Transport for NSW 2021a).

This process provided a design life for each thickness analysed at each of the two case study projects as well as the three theoretical pavements. The variation in design life was used to calculate the impact of failing to construct to the design thickness in terms of years by decreasing the design period to the achievable life.

3.4.1.2 Thickness with Variable Characteristics

Secondary analysis was completed for the two case study projects and the three theoretical pavements to reproduce results that as closely resembled site conditions as possible when working under TfNSW R75 Specification for insitu stabilisation (Transport for New South Wales 2020b). The stabilised layer thickness was varied as it was in the previous process detailed in section 3.4.1.1. The thickness of the underlying layer was also varied in line with the stabilised layer to replicate the effect of raising or lowering the mixer in the pavement. As thickness of the stabilised layer was reduced in CIRCLY, the underlying granular subbase layer thickness was increased. The opposite was modelled for increasing thickness by decreasing the thickness of the granular subbase layer. The subbase thickness was modelled at 100 mm thickness for the optimum design thickness and the thickness varied with the corresponding stabilised base thickness for all other thicknesses analysed in CIRCLY. The thickness of each layer as well as other characteristics can be found in Appendix C.

In order to replicate the construction implications of variable thickness when using insitu stabilisation, the percentage of binder in the mix was varied to suit the depth of the stabilised layer. The binder spread rate was kept constant which caused a variation depending on the thickness. A thicker layer had less binder and a thinner layer had more binder by mass of pavement materials. Figure 3.3 demonstrates this for the two case study projects and equation 3.6 provides the method used to determine the binder percentage for each thickness that was analysed in CIRCLY.

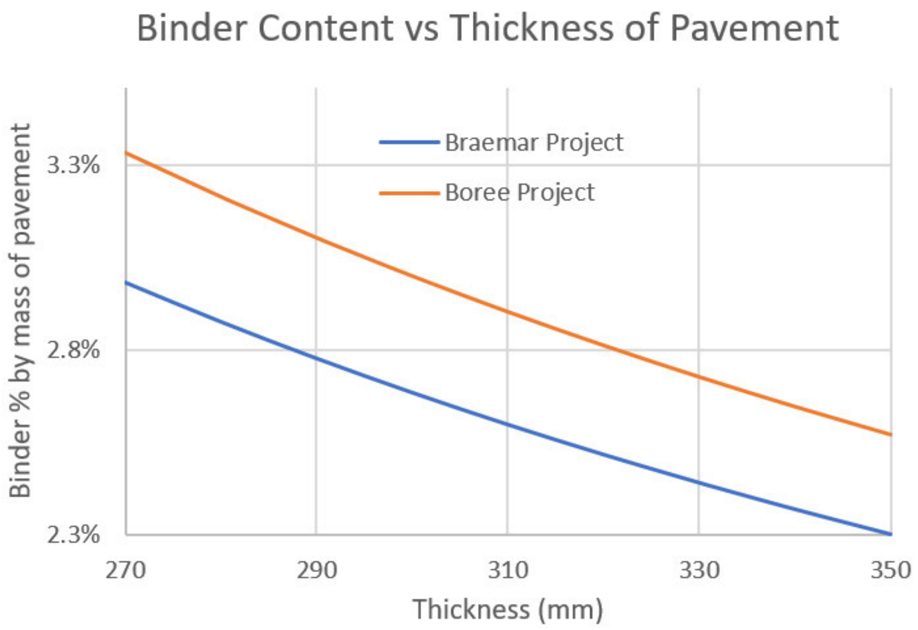

Figure 3. 3 – Variation in binder content as stabilised layer thickness is changed during insitu stabilisation

$$Binder\ \% = \frac{SR}{thickness * density}$$

Equation 3. 6

Where:

SR = spread rate (kg/m^2)

Using the relationship between binder percentage and thickness presented in equation 3.6, the UCS was calculated for each thickness using the results from the original pavement investigation UCS testing discussed in sections 4.1.2 and 4.2.2 and then the modulus for each thickness was calculated from the UCS using equation 3.1. The UCS for the theoretical pavements was calculated by combining all the test results from the two case study projects to create a linear relationship between binder percentage and UCS. The fatigue constant for each thickness was calculated using equation 3.2 and then a new cemented material was created in CIRCLY for each thickness analysed. Figure 3.9 illustrates this process for a stabilised layer thickness of 290 mm and design modulus of 5066 MPa.

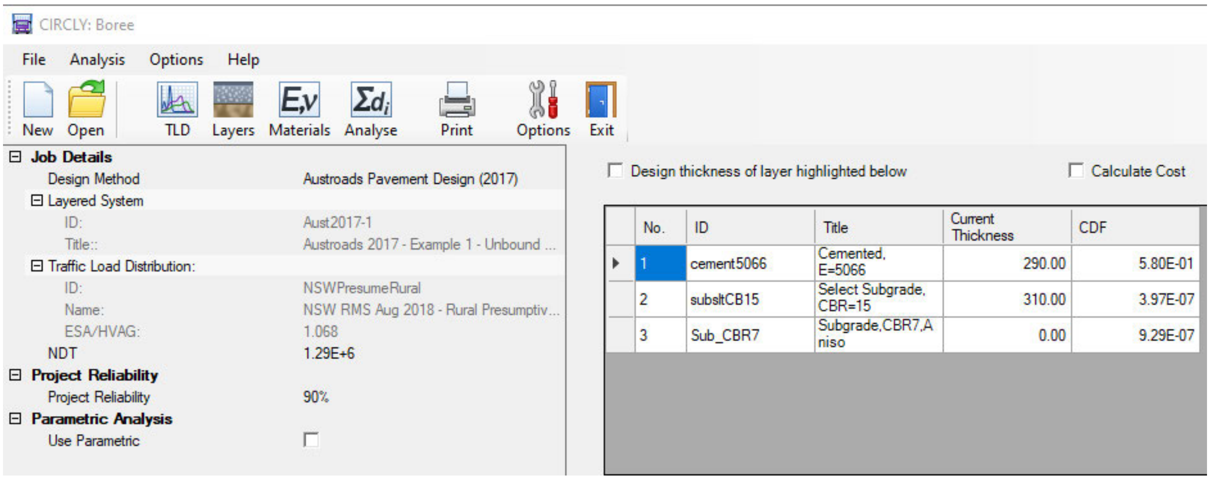

Figure 3. 4 – CIRCLY 7.0 Analysis of the Boree Project with 290 mm stabilised layer thickness

3.4.1.3 Compaction

Analysis of the case study projects and the theoretical pavements for variable compaction was completed by adopting the relationship determined by Andrews (1998). According to Andrews (1998) the UCS will increase with the dry density ratio as shown in equation 3.7.

$$UCS = 0.1811DDR - 14.095$$

Equation 3. 7

UCS values were calculated for each DDR using equation 3.7 and then converted to modulus using equation 3.1. The value used for the constant k_{UCS} for the case study projects was the value adopted during the original pavement designs which is described in sections 4.1.2 and 4.2.2. To examine the theoretical pavements the middle of the range recommended by Austroads (2017) of 1150 to 1400 was used for the k_{UCS} value which is 1275. The fatigue constant was calculated using the same process used for the pavement modelling for thickness using equation 3.2.

Compaction was modelled in CIRCLY over a practical range of 90 % to 105 %. TfNSW R75 specification allows for reduced compaction in the lower half of a stabilised layer thicker than 250 mm. To replicate this outcome, the Braemar and Boree project were also modelled with 95% compaction in the lower half of the layer to calculate the reduced design life. To measure the density gradient during construction of the Braemar project, density testing was completed at 150 mm depth and at 300 mm depth in the same location for each test required.

3.5 Economic Assessment of Nonconforming Stabilised Pavements

A stabilised pavement not constructed according to specifications is considered to have a reduced design life. When a stabilised pavement has reached the end of its design life it is considered to be cracked and considered an unbound pavement for any further modelling as the tensile strength resulting from the isotropic properties of the homogeneous bound layer has greatly reduced (Austroads 2017). After the bound layer has reached its allowable fatigue loading, the post cracked phase can be considered by continuing to fatigue the other layers in the pavement structure providing that the cracking does not reflect to the pavement surface. If the bound layer is the base course and is only covered by a thin wearing course such as sprayed seal or thin asphalt the post cracked phase can't be considered in the mechanistic design. For the purposes of this research, the bound layer is modelled as the base course making analysis of the post cracked phase unsuitable for the mechanistic design (Austroads 2017).

The economic assessment of the stabilised pavements in this research focuses on the increased maintenance required to extend the life of the pavement to the end of the original design period or completing early rehabilitation to reset the pavement life with what would be considered a new pavement. The whole of life cost method will be used to allow maintenance costs to be included in the analysis over the life of the pavement, rather than just the initial construction cost. The whole of life cost method will allow for all expenditure throughout the life of the pavement to be considered at the present value (Transport for New South Wales 2016).

As the stabilised pavement will be considered for future rehabilitation, the requirements set out in TfNSW supplement to Austroads Guide to Pavement Technology Part 5 will be followed. The residual salvage value of the pavement will be considered as 25 % of the initial construction cost. The real discount rate will be 7 % along with sensitivity tests completed for 4 % and 10 %. The analysis period will be 20 years to align with the design period for rehabilitated pavements on state highways in the northern region of NSW.

4 Case Study Project Review

4.1 Braemar Pavement Rehabilitation Project Case Study

One of the State Roads managed by TfNSW North Region is the Summerland Way. The Summerland Way is 198km in length and connects the towns of Grafton, Casino and Kyogle to the Queensland Border where it joins the Mount Lindesay Highway. The Summerland Way pavement is predominantly flexible granular pavement, made up of both unbound and bound sections. TfNSW often considers stabilisation of the pavement on the Summerland Way when reviewing potential rehabilitation options due to the existing pavement thicknesses and subgrade CBR presenting as suitable. A project that has been recently completed on this road is the Braemar Pavement Rehabilitation between Grafton and Casino.

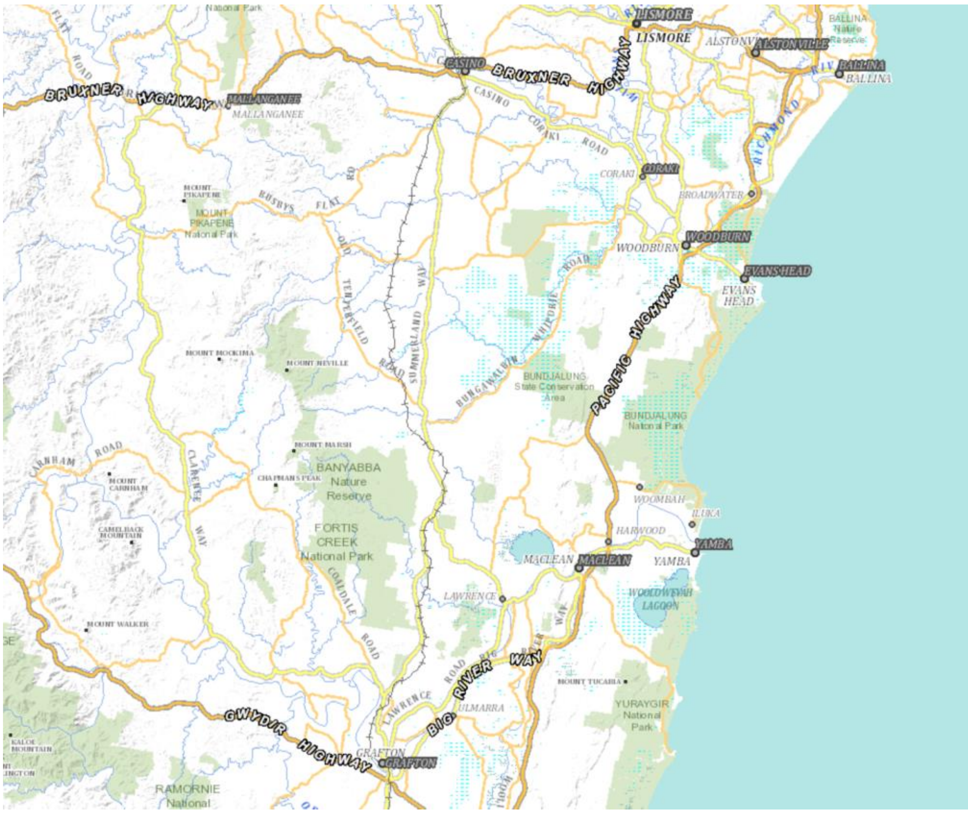

Figure 4. 1- Map showing Summerland Way between Grafton and Casino, NSW
(Source: NSW Spatial Services)

4.1.1 Project Background

The Braemar project was completed in 2020. The existing pavement consisted of 30 mm of sprayed seals, 250 mm of stabilised granular base, 150 mm unbound granular subbase, 200 mm of select material over a subgrade with CBR of 4%. The pavement was 19 years old at the time of pavement investigation and was exhibiting block cracking and slight rutting in the wheel paths indicating fatigue of stabilised base layer. The failures in the pavement were determined to be the result of inadequate pavement stabilisation depth and variable material qualities within the pavement.

Figure 4. 2– Test pit in existing pavement at the Braemar project
(Source: Roads and Maritime Services 2019)

4.1.2 Pavement Design

The average annual daily traffic was calculated from sample traffic classifiers placed on Summerland Way from 1995 to 2007. 1266 vehicles per day were projected to use the road in 2019, of which heavy vehicles made up 18.9% and the road was experiencing 1.3% growth (Roads and Maritime Services 2019a). The AADT and growth factor were used to calculate the design traffic for the project of 2.68 x 10^6 cumulative heavy vehicle axle groups in design lane over design period of 20 years.

UCS trials were conducted using samples of the existing pavement materials to determine the appropriate binder type and quantity to be used for the stabilisation. Trials were completed at 1.5 % and 3.0 % of binder to develop a relationship between binder content and unconfined compressive strength. Two binder types were trialed, hydrated lime and a mix of hydrated lime and ground granulated blast furnace slag. Using the results from the UCS trials, a binder content of 2.5 % by mass of 70:30 ground granulated blast furnace slag to hydrated lime was adopted to achieve the desired UCS. An average UCS of 3.3MPa was achieved which was intended to provide a flexural modulus of 5000MPa. Using

Austroads (2017) equation 8 shown in section 2.7.1.6 of a k value of 1515 was used which is higher than the range recommended by Austroads (2017). This relationship equates to a k value range of 1429 to 1667 which is outside the recommended range provided by Austroads (2017) but accepted by TfNSW for this project.

A cemented layer depth of 330 mm including a 10 mm construction tolerance was adopted incorporating 50 mm of material to be bound (MB20). The addition of the MB20 to the pavement prior to mixing was added to aid in prevention of mixing in gravel from the underlying subbase layer to reduce early strength gain and the resulting shrinkage cracks as well as to improve the quality of the base layer through mechanical stabilisation. The pavement design was modeled in CIRCLY using TfNSW add on FPD2 and calculated to have a design life of 20.5 years which can be viewed in Appendix C.

4.2 Boree Pavement Rehabilitation Project Case Study

Another example of the State Roads managed by TfNSW North Region is the Oxley Highway. The Oxley Highway connects the towns of Port Macquarie, Wauchope, Walcha and Bendemeer where it joins the New England Highway. The Oxley Highway pavement is predominantly flexible granular pavement, made up of both unbound and bound sections. TfNSW often considers stabilisation of the pavement on the Oxley Highway when reviewing potential rehabilitation options due to the existing pavement thicknesses and subgrade CBR presenting as suitable. A project that has been recently completed on this road is the Boree Pavement Rehabilitation in the Walcha Local Government Area.

4.2.1 Project Background

The Braemar project was completed in 2019. The existing pavement consisted of 30 mm of sprayed seals, 150 mm of stabilised granular base, 150 mm stabilised granular subbase, and 300 mm of marginal select quality material over a subgrade with CBR of 7 %. The pavement was 26 years old at the time of pavement investigation and was exhibiting transverse cracks indicating shrinkage of the bound layers as well as block cracking, minor rutting, shoving and flushing in the wheel paths indicating fatigue of stabilised base layers (Regional Geotechnical Solutions 2019).

4.2.2 Pavement Design

The average annual daily traffic was calculated from sample traffic classifiers placed on the Oxley Highway. The AADT was 1266 vehicles per day were projected to use the road in 2019, of which heavy vehicles made up 9 % and the road was experiencing 1.3% growth which provided a design traffic in N_{DT} of 1.29E+06 (Regional Geotechnical Solutions 2019). The AADT and growth factor were used to calculate the design traffic for the project of 1.29×10^6 cumulative heavy vehicle axle groups in design lane over design period of 20 years.

Figure 4. 3 – Stabilisation of the Boree project
(Source: Shaun Perkins 2020)

The pavement adopted for design was a 300 mm stabilisation of the existing base and subbase layers to form a single stabilised layer. The existing select layer was retained in the reconstructed pavement (Roads and Maritime Services 2019b). Trials were completed at 1.5 % and 3.0 % of binder to develop a relationship between binder content and unconfined compressive strength. Two binder types were trialed, hydrated lime and a mix of hydrated lime and ground granulated blast furnace slag. The binder selected for use was a 70:30 blend of ground granulated blast furnace slag and hydrated lime. A binder percentage of 3 % by mass of pavement was adopted to provide a UCS of 3.9 MPa to achieve the modulus of 5000 MPa used in the structural pavement design. According to Austroads (2017) equation 8, a UCS of 3.9 MPa and modulus of 5000 MPa provide a k_{UCS} of 1299 which is within the range recommended by Austroads (2017). The pavement design was modeled in CIRCLY using TfNSW add on FPD2 and calculated to have a design life of over 50 years which can be viewed in Appendix C.

4.3 Visual Inspection of Case Study Projects

Visual inspection of the Braemar and Boree pavement rehabilitation projects were completed based on Austroads (2019a) section 3.3 Field Survey. Inspection was completed by recording pavement defects on a copy of the construction plans as a mapping sheet. Photographs of pavement defects were taken with GPS positioning to ensure correlation between construction records and field inspection records. A measuring wheel was also used to record the chainage of the defects relative to the construction drawings to ensure thew accuracy of the GPS records.

The visual condition inspection recorded pavement defects in line with the recommendations in Austroads (2019a) including the distress type, distress severity, distress extent and the location of distress. The assessment was completed to identify the areas of distress that may be linked to construction non-conformances and included assessment for:

- Wearing surface deterioration
- Pavement deformation
- Pavement cracking reflecting through the wearing surface
- Potholes in the pavement, either present or repaired
- Previous patching of the pavement

4.4 Project Quality Assurance Records

The Braemar and Boree pavement rehabilitation projects were completed under TfNSW specification R75 Insitu Pavement Stabilisation Using Slow Setting Binders. R75 is used for major rehabilitation of existing granular pavements to a maximum depth of 400mm. Quality assurance records for the project were maintained as required by TfNSW R75. Lot records were examined for each day's production which included the compaction and moisture records, survey records for thickness and surface levels, binder spread and mixing records and the UCS results.

Figure 4. 4 - Stabilisation of the Braemar project
(Source: Shaun Perkins 2020)

4.4.1.1 Thickness of Bound Layer

The thickness of the bound layer at the Braemar project was 320 mm with a construction tolerance of 10 mm as the bound layer was the critical layer in the pavement structure, providing a total thickness of 330 mm. Actual thickness of the bound layer was determined through survey. During the mixing process, the bottom of the bound pavement was surveyed. After compaction and trimming of the bound layer the final surface was surveyed at the same locations as the previous survey to determine thickness at given intervals. Survey conformance reports were provided for each day's production which were used to identify areas of non-complying thickness.

The Boree project was designed with a 300 mm stabilised layer which did not include a construction tolerance. Actual thickness of the bound layer was determined manually by digging holes in the mixed layer and measuring from string lines set to offset pegs at design finish surface level plus 100 mm at 25-meter intervals. After final trimming the final surface was surveyed to allow for thickness calculations. The thickness records were intended to be used to cross reference with pavement defects identified during the visual inspection.

4.4.1.2 Compaction Records

Compaction of the bound layer was completed as required by TfNSW (2020b) R75 Specification. Compaction was completed immediately after mixing the binder into the granular pavement material and was completed as a continuous operation for each lot. For both the Braemar project and the Boree project, the bound layer was constructed with a thickness over 250 mm, therefore the relative compaction required for conformance under TfNSW R75 was 100 % for the upper 150 mm of the layer and at least 95 % for the lower 150 mm of the layer with a characteristic value for the entire layer of not less than 100 %. The Braemar project was tested for compaction as required however the Boree project was only tested at full layer depth. Density tests were completed to allow for the relative compaction calculations to be completed and reported. The reports provided for the relative compaction in each lot were used to model the pavement in CIRCLY.

Figure 4. 5 – Density testing at the Braemar project
(Source: Shaun Perkins 2020)

5 Results

5.1 Braemar Project Review

A thorough review of the Braemar project was completed as part of this research. The pavement was inspected visually to identify defects, and through examination of the construction records available to identify any non-conforming areas that may not provide the expected design life.

5.1.1 Thickness Records

TfNSW R75 specification requires that the thickness of the stabilised layer must be within 10 mm to 30 mm above the design thickness. The design thickness for this project was 330 mm including a 10 mm construction tolerance. Therefore, the range of acceptable thickness for the Braemar project is 330 mm to 360 mm. Figure 5.1 presents an overview of the survey results for thickness, revealing that 93 % of the project was constructed within tolerance, 6 % of the project was below the target thickness and 1 % was over the thickness tolerance.

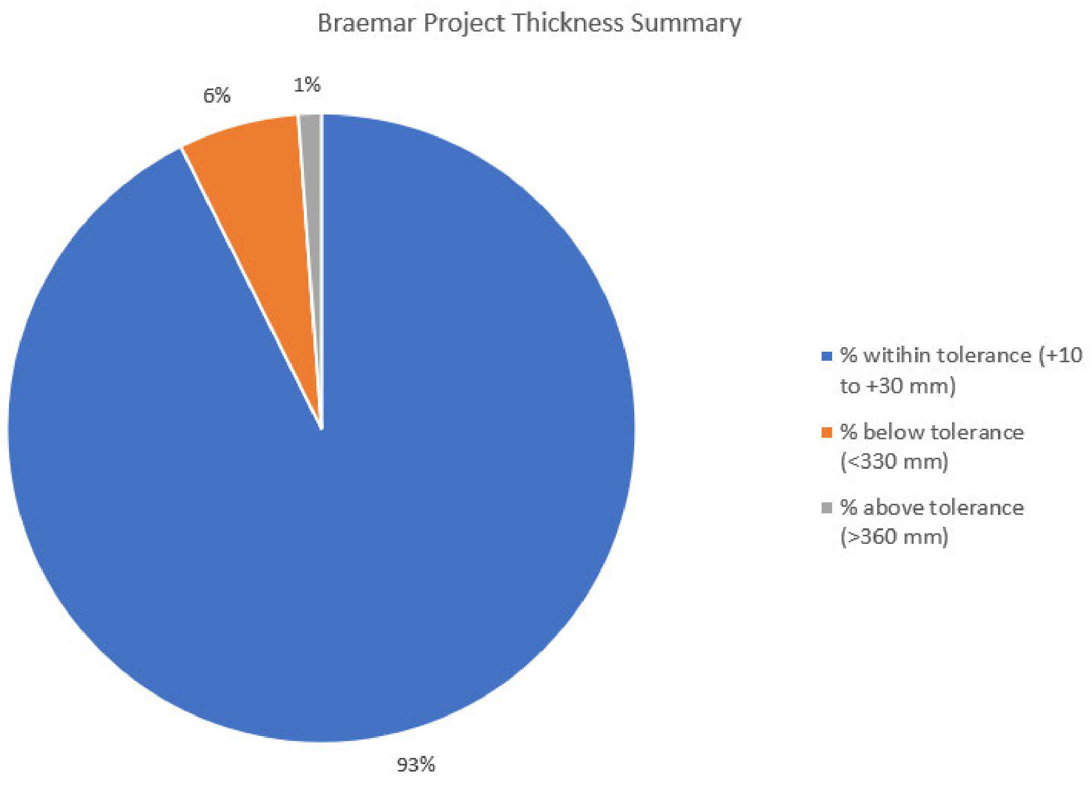

Figure 5. 1 - Summary of thickness conformance at the Braemar project

Figure 5.2 presents a histogram of the thickness survey results in 10 mm bins to show the distribution of the stabilised layer thickness over the length of the project. Of the area that provided inadequate thickness, 4 % was within 1 mm to 10 mm low, 1 % was between 11 mm to 20 mm low and 1 % was more than 20 mm below the required thickness.

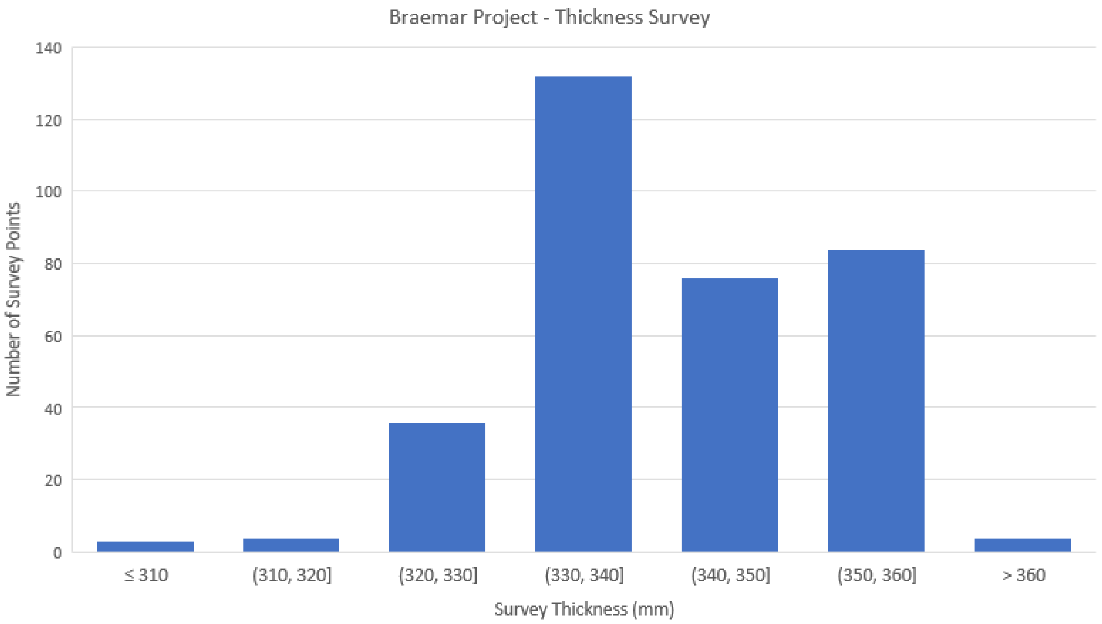

Figure 5. 2 - Thickness survey histogram presenting distribution of thickness for Braemar project

The Braemar project had a surface area of 12,606 m^2 that was rehabilitated through insitu stabilisation. Using the data presented in figure 5.1, 781 m^2 was recorded as being constructed with inadequate thickness that is likely to result in reduced life for these sections as can be seen in the CIRCLY analysis of varying thicknesses for the Braemar project in Section 5.3.

5.1.2 Compaction Records

The characteristic value of the relative compaction required for the Braemar project was 100% at the full depth of stabilisation as the layer was greater than 250 mm thick. The stabilisation was completed in 12 lots, with each lot tested using standard compaction with five tests completed per lot. The characteristic value of the tests is calculated as described in TfNSW Q4 Specification (2021c).

$$Q = x - ks$$

Equation 5. 1

Where;

x = mean of test results

s = standard deviation of test results

k = a constant which depends on the number of samples used

The results from the compaction testing are provided in Table 5.1 showing that all lots were constructed with conforming compaction at the Braemar project. Analysis in CIRCLY to review the impact of nonconforming compaction is discussed in section 5.3.

Table 5. 1 - Relative compaction results from the Braemar project

Braemar Compaction Results				
Lot	Chainage Start	Chainage End	Lane	Characteristic Value
1	79140	78840	NB	105
2	78540	78861	NB	101.6
3	78710	79140	SB	104.3
4	78710	78540	SB	103.5
6	78540	78175	NB	103.2
7	78175	77813	NB	105.9
8	78534	78175	SB	102.1
9	78175	77812	SB	102.8
11	77820	77515	NB	104.2
12	77510	77210	NB	101.9
13	77825	77510	SB	101.7
14	77510	77210	SB	101.5

5.1.3 Unconfined Strength Records

One UCS test was completed for each lot of the Braemar project. Each test was completed in pairs with the average for each pair reported in Table 5.2. The average of all UCS tests completed at the Braemar project was 3.2 MPa, 0.2 MPa lower than the average UCS of 3.3 MPa used in the original pavement design to achieve a modulus of 5000 MPa for the stabilised layer. Unconfined compressive strength is not defined through TfNSW R75 specification as a requirement. It is used solely for the pavement design process to calculate the required binder and content to achieve the desired cemented modulus.

Table 5. 2 Braemar UCS results

Braemar Unconfined Compressive Strength Results				
Lot	Chainage Start	Chainage End	Lane	Average UCS (Mpa)
1	79140	78840	NB	2.4
2	78540	78861	NB	2.7
3	78710	79140	SB	2.8
4	78710	78540	SB	2.1
6	78540	78175	NB	2.9
7	78175	77813	NB	2.9
8	78534	78175	SB	3.0
9	78175	77812	SB	3.0
11	77820	77515	NB	3.8
12	77510	77210	NB	4.7
13	77825	77510	SB	3.3
14	77510	77210	SB	3.0

5.1.4 Visual Inspection

The visual inspection of the Braemar project was completed by walking through the length of the project examining the pavement for any issues or defects. The pavement was considered to be in good condition with only few minor defects requiring maintenance. Table 5.3 summarises the pavement issues identified during the visual inspection, their location, and the corresponding lot from the construction records.

Table 5. 3 – Braemar project visual inspection summary

Braemar Project - Visual Inspection Record			
Chainage	Lane	Lot Number	Description of Defect
77930	SB	9	Shove in outer wheel path
78325	Centreline	7 & 8	Shove on centreline
78580	SB	4	Two potholes, previously repaired
78610 - 78650	SB	3	Rut in outer wheel path
78725-78740	SB	2	longitudinal crack
78890	SB	3	Evidence of pothole repair in inner wheel path
79000-79025	NB	1	Minor flushing of seal

The rutting identified from chainage 78610 to chainage 78650 is a typical failure expected from insufficient thickness however the construction records from this section show that the required thickness was achieved at this location indicating that the failure was likely caused by different factors. The shoves at chainages 77930 and 78325 were likely caused by factors other than compaction or thickness as the construction records for both sections are conforming.

Figure 5. 3 - Shoving on the centerline of the Braemar project
(Source: Shaun Perkins 2022)

A final seal using rubber modified bitumen SR45 with 10 mm aggregate was completed in December 2021 as a preventative treatment for possible shrinkage cracking of the stabilised pavement experienced on other projects in the region.

Figure 5. 4 - S45R final seal of Braemar project as preventative maintenance
(Source: Shaun Perkins 2022

5.2 Boree Project Review

5.2.1 Thickness Records

Record for thickness from the Boree project were not available for review at the time that this research was completed. The project quality assurance handover from the construction contractor does not appear to have been completed for thickness records. The compaction records show that the density gauge probe was driven to 300 mm and in the absence of other records, the thickness was considered to be as designed for the purpose of this research.

5.2.2 Compaction Records

The characteristic value of the relative compaction required for the Boree project was 100% at the full depth of stabilisation as the layer was greater than 250 mm thick. No testing at 150 mm was completed as required by TfNSW R75 specification. The stabilisation was completed in 9 lots, with each lot tested using standard compaction with five tests completed per lot. The characteristic value of the tests is calculated as described in TfNSW Q4 Specification (2021c) and shown in Table 5.4.

The results from the compaction testing are provided in Table 5.4 showing that all lots were constructed with conforming compaction at the Boree project when considered as full depth testing. Given the conforming compaction results, there is no evidence to suggest compaction would be a cause for pavement distress at the Boree project.

Table 5. 4 – Relative compaction results from the Boree project

Boree Compaction Results				
Lot	**Chainage Start**	**Chainage End**	**Lane**	**Characteristic Value**
WC-2-1	0	250	WB	102.4
WC-2-2	0	250	EB	103
WC-2-3	250	490	WB	104.5
WC-2-4	250	490	EB	102.1
WC-2-5	490	570	WB & EB	104.7
WC-2-6	570	810	WB	102.1
WC-2-7	570	810	EB	103.7
WC-2-8	810	1040	EB	102.7
WC-2-9	810	1040	WB	102.3

5.2.3 Unconfined Strength Records

Five UCS tests were completed for each lot of the Boree project. Each test was completed in pairs with the average for each pair reported in Table 5.5. The average of all UCS tests completed at the Boree project was 4.0 MPa, 0.1 MPa higher than the average of 3.9 MPa used in the original pavement design to achieve a modulus of 5000 MPa for the stabilised layer.

Table 5. 5 – Unconfined compressive strength test results from the Boree project

Boree Unconfined Compressive Strength Results								
Lot	Chainage Start	Chainage End	Lane	Average UCS (Mpa)				
WC-2-1	0	250	WB	4.5	3.0	3.5	3.5	3.0
WC-2-2	0	250	EB	4.5	3.0	3.5	3.5	4.5
WC-2-3	250	490	WB	3.0	4.5	4.0	4.5	4.0
WC-2-4	250	490	EB	3.5	4.5	4.5	4.5	4.0
WC-2-5	490	570	WB & EB	4.5	4.5	4.5	3.0	4.0
WC-2-6	570	810	WB	5.0	4.5	4.0	2.5	3.5
WC-2-7	570	810	EB	5.0	4.5	3.0	3.5	4.5
WC-2-8	810	1040	EB	4.5	4.0	4.5	4.0	5.0
WC-2-9	810	1040	WB	4.5	4.5	4.5	4.0	4.5

5.2.4 Visual Inspection

The visual inspection of the Boree project was completed by walking through the length of the project examining the pavement for any issues or defects. The pavement was considered to be in relatively good condition with only few minor defects requiring maintenance. Transverse shrinkage cracking extending the full width of the pavement was identified at regular intervals of approximately 10 m over the entire length of the pavement rehabilitation. The shrinkage cracking may have been due to improper curing prior to the primer seal application. The pavement was trafficked immediately after the compaction and trimming which would be expected to cause microcracking in the pavement, limiting the shrinkage cracking but that does not appear to have occurred. No potholes or shoves were identified. A summary of the visual inspection, the issues identified, their location and the corresponding lot from the construction records are presented in Table 5.6. Given the lack of thickness records and the conforming compaction and strength records, it is not evident that construction nonconformances caused the issues the pavement at the Boree project is experiencing.

Table 5. 6 - Boree project visual inspection summary

Boree Project - Visual Inspection Record			
Chainage	Lane	Lot Number	Description of Defect
0	EB & WB	1 & 2	Transverse crack at pavement interface
0 - 15	Centreline	1 & 2	Longitudinal crack on centreline
Throughout	EB & WB	All	Transverse cracking at approximate 10 m intervals
1037	EB & WB	8 & 9	Transverse crack at pavement interface. Crockodile cracking. Longitudinal crack on centreline

Figure 5. 5 – Transverse shrinkage cracking at the Boree project
(Source: Shaun Perkins 2022)

At both ends of the pavement where the stabilised pavement tapers down to join the existing pavement, a longitudinal crack was identified along the centerline at the joint between two construction lots as well as transverse cracking at the interface with the existing pavement. At the western end of the pavement crocodile cracking was identified between the two tapered lots and the existing pavement. These failures were likely caused by insufficient thickness caused by a combination of the mixer maintaining thickness to the end of the lot and the surface being trimmed down to tie in with the existing pavement.

Figure 5. 6 – Cracking at western pavement interface of the Boree project
(Source: Shaun Perkins 2022)

5.3 Pavement Modelling

5.3.1 Thickness with Constant Modulus

Pavement modelling was completed in CIRCLY using the pavement structure and traffic details used in the original pavement design. Roads and Maritime Services modelled the stabilised layer in the two case study projects as a single layer with a modulus of 5000 MPa and a fatigue constant of 263 which was replicated for this analysis. The optimum thickness was determined in CIRCLY to set a reference thickness. The thickness was also varied in increments of 10 mm to replicate useable pavement design process and the design life in years calculated for each thickness.

CIRCLY indicated that the optimum thickness for the Braemar project was 322 mm which was 2 mm thicker than the original design. A reduction of thickness of 10 mm to 312 mm for the Braemar project resulted in a loss of pavement life of 42 % while an increase of thickness of 10 mm to 332 mm resulted in an increased life of 70 %. Table 5.7 provides a summary of the CIRCLY analysis completed for varying thickness of the stabilised layer at the Braemar project with a constant modulus for each thickness considered.

Table 5. 7 - Braemar Project with varying thickness of stabilised layer

Braemar Project - Thickness Comparison - Constant Modulus						
Thickness	**CDF**	**Repetitions at Failure**	**Life Consumed**	**Design Life (years)**	**Variance in life (years)**	**Variance in Life (%)**
270	1.96E+01	1.37E+05	1960%	1.0	19.4	95%
280	1.07E+01	2.50E+05	1070%	1.9	18.5	91%
290	5.91E+00	4.53E+05	591%	3.4	17.0	83%
300	3.32E+00	8.07E+05	332%	6.0	14.4	70%
310	1.89E+00	1.42E+06	189%	10.6	9.8	48%
312	1.69E+00	1.59E+06	169%	11.8	8.6	42%
320	1.09E+00	2.46E+06	109%	18.3	2.0	10%
322	9.81E-01	2.73E+06	98%	20.4	0.0	0%
330	6.40E-01	4.19E+06	64%	31.3	-10.9	-53%
332	5.76E-01	4.65E+06	58%	34.7	-14.3	-70%
340	3.80E-01	7.05E+06	38%	52.6	-32.2	-158%
350	2.28E-01	1.18E+07	23%	87.7	-67.3	-330%

Analysis in CIRCLY summarised in Table 5.8 indicated that the optimum thickness for the Boree project was 282 mm which was 18 mm thinner than the original design, however the bound layer in the original design needed to be at least 300 mm thick to avoid leaving a thin residual bound layer from the previously bound subbase. The original design achieved a design life of over 50 years which is consistent with this analysis which achieved a design life of 59 years at 300 mm thick. A reduction of thickness from the optimum thickness of 282 mm of 10mm to 272 mm for the Boree project resulted in a loss of pavement life of 45 % while an increase of thickness to 292 mm resulted in an increased life of 80 %. Using the minimum thickness of 300 mm adopted for the original design to incorporate all existing stabilised materials, a loss of thickness of 10 mm would result in a loss of life of 25.8 years or 44 %.

Table 5. 8 - Boree Project with varying thickness of stabilised layer

Boree Project - Thickness Comparison - Constant Modulus						
Thickness	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	2.00E+00	6.44E+05	200%	10.0	10.7	52%
272	1.77E+00	7.28E+05	177%	11.3	9.4	45%
280	1.09E+00	1.18E+06	109%	18.3	2.3	11%
282	9.67E-01	1.33E+06	97%	20.7	2.0	10%
290	6.03E-01	2.14E+06	60%	33.2	-12.5	-60%
292	5.37E-01	2.40E+06	54%	37.2	-16.6	-80%
300	3.39E-01	3.80E+06	34%	59.0	-38.3	-185%
310	1.93E-01	6.68E+06	19%	103.6	-82.9	-401%
320	1.12E-01	1.15E+07	11%	178.6	-157.9	-763%
330	6.54E-02	1.97E+07	7%	305.8	-285.1	-1379%
340	3.88E-02	3.32E+07	4%	515.5	-494.8	-2392%
350	2.33E-02	5.53E+07	2%	858.4	-837.7	-4050%

CIRCLY indicated that the optimum thickness for the theoretical pavement with constant cemented modulus of 5000 MPa and subgrade CBR of 3 % was 342 mm which provided a design life of 21 years. A reduction of thickness to 332 mm resulted in a loss of pavement life of 8.8 years or 42 % while an increase of thickness to 352 mm resulted in an increased life of 35.9 years or 71 %. A summary of the CIRCLY results modelling the design life for varying thicknesses with constant modulus for the theoretical pavement with subgrade CBR of 3 % is provided in Table 5.9

Table 5. 9 - Theoretical pavement with subgrade CBR of 3 % with varying thickness of stabilised layer

Theoretical Pavement - Subgrade CBR3 - Thickness Comparison - Constant Modulus						
Base Thickness (mm)	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	6.42E+01	8.70E+01	6420%	0.3	20.7	99%
280	3.40E+01	4.61E+01	3400%	0.6	20.4	97%
290	1.84E+01	1.08E+05	1840%	1.1	19.9	95%
300	1.01E+01	1.96E+05	1010%	2.0	19.0	91%
310	5.61E+00	3.54E+05	561%	3.6	17.4	83%
320	3.18E+00	6.24E+05	318%	6.3	14.7	70%
330	1.82E+00	1.09E+06	182%	11.0	10.0	48%
332	1.64E+00	1.21E+06	164%	12.2	8.8	42%
340	1.06E+00	1.87E+06	106%	18.9	2.1	10%
342	9.54E-01	2.08E+06	95%	21.0	0.0	0%
350	6.26E-01	3.17E+06	63%	31.9	-11.0	-52%
352	5.56E-01	3.57E+06	56%	35.9	-15.0	-71%

CIRCLY indicated that the optimum thickness for the theoretical pavement with constant cemented modulus of 5000 MPa and subgrade CBR of 5 % was 315 mm which provided a design life of 20 years. A reduction of thickness to 305 mm resulted in a loss of pavement life of 8.7 years or 25 % while an increase of thickness to 325 mm resulted in an increased life of 14.9 years or 74 %. A summary of the CIRCLY results modelling the design life for varying thicknesses with constant modulus for the theoretical pavement with subgrade CBR of 5 % is provided in Table 5.10

Table 5. 10 - Theoretical pavement with subgrade CBR of 5 % with varying thickness of stabilised layer

Theoretical Pavement - Subgrade CBR5 - Thickness Comparison - Constant Modulus						
Thickness	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	1.48E+01	1.34E+05	1480%	1.4	18.7	93%
280	7.91E+00	2.51E+05	791%	2.5	17.5	87%
290	4.29E+00	4.63E+05	429%	4.7	15.4	77%
300	2.37E+00	8.37E+05	237%	8.4	11.6	58%
305	1.77E+00	1.12E+06	177%	11.3	8.7	44%
310	1.33E+00	1.49E+06	133%	15.0	5.0	25%
315	9.99E-01	1.99E+06	100%	20.0	0.0	0%
320	7.55E-01	2.63E+06	76%	26.5	-6.5	-32%
325	5.73E-01	3.46E+06	57%	34.9	-14.9	-74%
330	4.36E-01	4.55E+06	44%	45.9	-25.9	-129%
340	2.55E-01	7.78E+06	26%	78.4	-58.4	-292%
350	1.51E-01	1.31E+07	15%	132.5	-112.4	-562%

CIRCLY indicated that the optimum thickness for the theoretical pavement with constant cemented modulus of 5000 MPa and subgrade CBR of 7 % was 298 mm which provided a design life of 20.9 years. A reduction of thickness to 288 mm resulted in a loss of pavement life of 9.4 years or 38 % while an increase of thickness to 308 mm resulted in an increased life of 16.4 years or 79 %. A summary of the CIRCLY results modelling the design life for varying thicknesses with constant modulus for the theoretical pavement with subgrade CBR of 3 % is provided in Table 5.11.

Table 5. 11 - Theoretical pavement with subgrade CBR of 7 % with varying thickness of stabilised layer

Theoretical Pavement - Subgrade CBR7 - Thickness Comparison - Constant Modulus						
Thickness	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	5.29E+00	3.75E+05	529%	3.8	17.1	82%
280	2.83E+00	7.01E+05	283%	7.1	13.8	66%
288	1.74E+00	1.14E+06	174%	11.5	9.4	45%
290	1.54E+00	1.29E+06	154%	13.0	7.9	38%
298	9.59E-01	2.07E+06	96%	20.9	0.0	0%
300	8.53E-01	2.33E+06	85%	23.4	-2.6	-12%
308	5.37E-01	-1.00E+00	54%	37.2	-16.4	-79%
310	4.80E-01	4.13E+06	48%	41.7	-20.8	-100%
320	2.74E-01	7.24E+06	27%	73.0	-52.1	-250%
330	1.58E-01	1.26E+07	16%	126.6	-105.7	-507%
340	9.28E-02	2.14E+07	9%	215.5	-194.7	-933%
350	5.51E-02	3.60E+07	6%	363.0	-342.1	-1640%

Figure 5.7 provides a summary of the design life achieved in CIRCLY for the two case study projects and three theoretical pavements when a constant cemented modulus is applied. The figure shows that the theoretical pavement with subgrade CBR of 3 % requires a bound layer over 340 mm thick to achieve the 20 year design life. This result aligns with the recommendation in TfNSW (2021b) that granular pavements less than 400 mm thick should not be stabilised unless the subgrade has a CBR greater than 5 %. Insufficient granular material remains after the stabilisation process to form a layer of any benefit to the pavement.

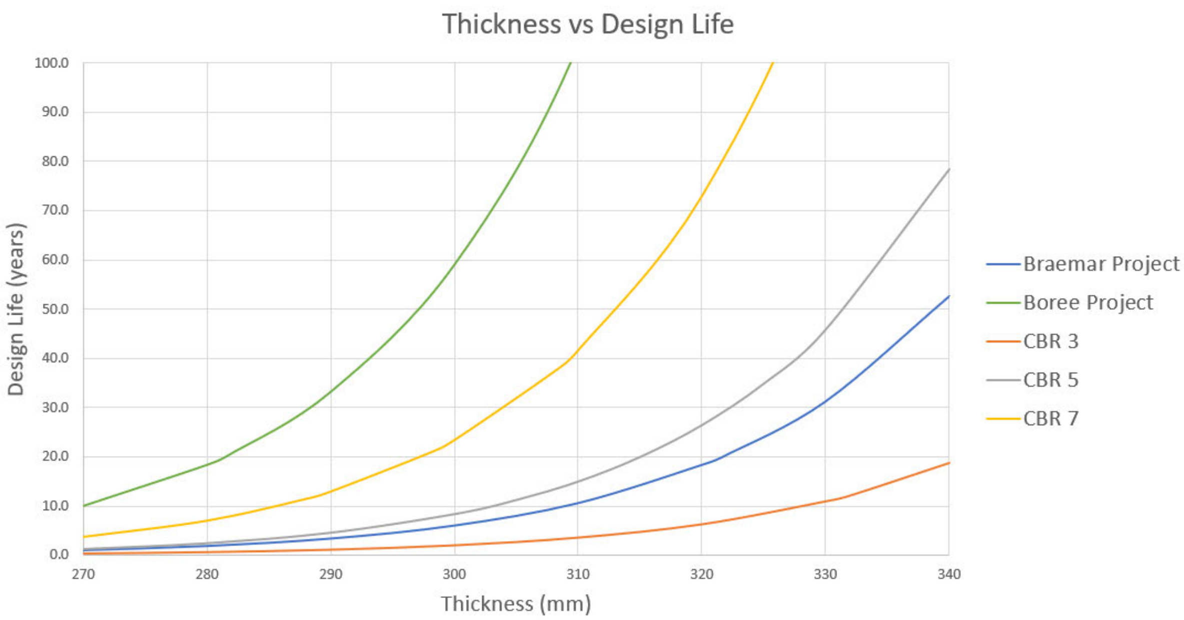

Figure 5. 7 – Design life for varying thickness over a range of subgrade strengths

5.3.2 Thickness with Adjusted Modulus

Using the target spread rate for the binder on the Braemar project, an actual application rate in tonnes per square meter was calculated for each thickness modelled in CIRCLY. The actual application rate was used to calculate the unconfined compressive strength based on the UCS trials completed for the project's original pavement design. The UCS was then converted to cemented modulus using equation 8 from Austroads (2017) and the k_{UCS} value of 1515 adopted by TfNSW for the UCS trials. As well as varying the thickness of the stabilised layer, the underlying subbase layer was adjusted to replicate the effect of the mixer running deeper or shallower during a pavement rehabilitation. The results from the thickness modelling in CIRCLY are presented in Table 5.12.

Table 5. 12 – Braemar project with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus

Braemar Project - Thickness Comparison - Variable Modulus											
Thickness (mm)	Subbase Thickness (mm)	Actual Spread Rate %	Actual UCS (Mpa)	Actual modulus (Mpa)	Fatigue Constant k	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	180	3.0%	3.9	5909	238	1.00E+01	2.68E+05	1000%	2.0	19.3	91%
280	170	2.9%	3.8	5758	243	5.80E+00	4.62E+05	580%	3.4	17.9	84%
290	160	2.8%	3.6	5455	251	3.75E+00	7.15E+05	375%	5.3	16.0	75%
300	150	2.7%	3.5	5303	255	2.39E+00	1.12E+06	239%	8.4	12.9	61%
310	140	2.6%	3.4	5152	259	1.56E+00	1.72E+06	156%	12.8	8.5	40%
320	130	2.5%	3.3	5000	263	1.03E+00	2.60E+06	103%	19.4	1.9	9%
322	128	2.5%	3.3	5000	263	9.39E-01	2.85E+06	94%	21.3	0.0	0%
330	120	2.4%	3.2	4848	267	7.00E-01	3.83E+06	70%	28.6	-7.3	-34%
340	110	2.4%	3.1	4697	271	4.83E-01	5.55E+06	48%	41.4	-20.1	-94%
350	100	2.3%	3.0	4545	275	3.41E-01	7.86E+06	34%	58.7	-37.4	-175%

Figure 5.8 plots the results from the CIRCLY analysis of varying thickness while keeping the modulus constant and varying thickness while also adjusting the modulus based on the actual binder applied in the mix. The CIRCLY modelling shows that the pavements constructed with thinner cemented layers

than the design requires, they perform slightly better due to the higher modulus created by the addition of additional binder. Stabilised pavements constructed thicker than the design requires result in less life than analysis with constant modulus provides, but still meet the required design life. Table 5.13 presents the increase or decrease in design life achieved by adjusting the modulus with thickness in both years and percentage of the life achieved against the results when calculated with constant modulus.

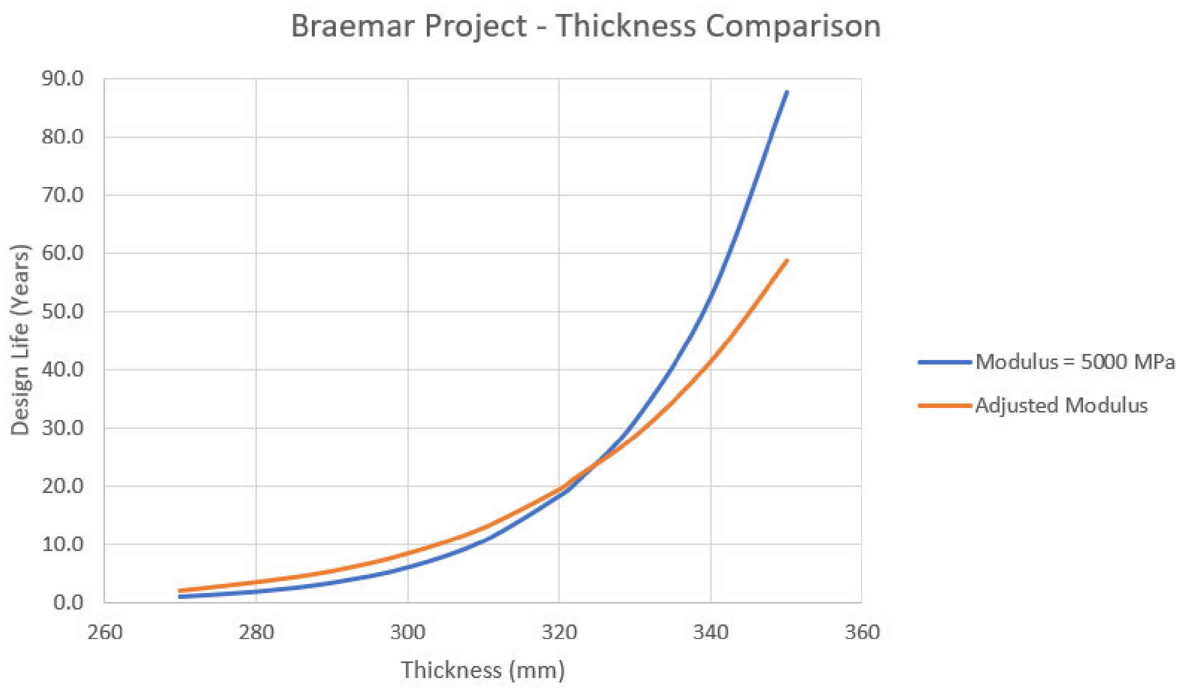

Figure 5. 8 – Comparison of design life provided by varying thickness of stabilised base layer

Table 5. 13 – Comparison of design life achieved on the Braemar project with constant modulus and adjusted modulus

Braemar Project - Thickness Comparison				
Thickness (mm)	Design Life Achieved		Increase in Life (Years)	Increase in Life (%)
	Constant Modulus	Adjusted Modulus		
270	1.0	2.0	1.0	96%
280	1.9	3.4	1.6	84%
290	3.4	5.3	1.9	58%
300	6.0	8.4	2.3	39%
310	10.6	12.8	2.2	21%
320	18.3	19.4	1.1	6%
322	20.4	21.3	0.9	4%
330	31.3	28.6	-2.7	-9%
340	52.6	41.4	-11.2	-21%
350	87.7	58.7	-29.1	-33%

Using the target spread rate for the binder on the Boree project, an actual application rate in tonnes per square meter was calculated for each thickness modelled in CIRCLY. The actual application rate was used to calculate the unconfined compressive strength based on the UCS trials completed for the project's original pavement design. The UCS was then converted to cemented modulus using equation 8 from Austroads (2017) and the k_{UCS} value of 1298.7 adopted by TfNSW for the UCS trials. As well as varying the thickness of the stabilised layer, the underlying selected layer was adjusted to replicate the effect of the mixer running deeper or shallower during a pavement rehabilitation. The results from the thickness modelling in CIRCLY are presented in Table 5.14.

Table 5. 14 - Boree Project with varying thickness of the stabilised base layer, adjusted select layer thickness and cemented modulus

Boree Project - Thickness Comparison - Variable Modulus											
Thickness (mm)	Subbase Thickness (mm)	Actual Spread Rate %	Actual UCS (Mpa)	Actual modulus (Mpa)	Fatigue Constant k	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
250	350	3.6%	4.7	6105	233	5.05E+00	2.55E+05	505%	4.0	55.0	93%
260	340	3.5%	4.5	5846	240	2.47E+00	5.22E+05	247%	8.1	50.9	86%
270	330	3.3%	4.3	5586	247	1.56E+00	8.27E+05	156%	12.8	46.2	78%
280	320	3.2%	4.2	5456	251	8.72E-01	1.48E+06	87%	22.9	36.1	61%
282	318	3.2%	4.0	5196	258	8.47E-01	1.52E+06	85%	23.6	35.4	60%
290	310	3.1%	3.9	5066	261	5.80E-01	2.22E+06	58%	34.5	24.5	42%
300	300	3.0%	3.9	5000	263	3.39E-01	3.81E+06	34%	59.0	0.0	0%
310	290	2.9%	3.8	4936	265	2.01E-01	6.42E+06	20%	99.5	-40.5	-69%
320	280	2.8%	3.7	4806	268	1.30E-01	9.92E+06	13%	153.8	-94.8	-161%
330	270	2.7%	3.6	4676	272	8.20E-02	1.57E+07	8%	243.9	-184.9	-313%
340	260	2.6%	3.5	4547	275	5.52E-02	2.34E+07	6%	362.3	-303.3	-514%
350	250	2.6%	3.4	4417	279	3.64E-02	3.54E+07	4%	549.5	-490.5	-831%

Figure 5.9 plots the results from the CIRCLY analysis of varying thickness while keeping the modulus constant and varying thickness while also adjusting the modulus based on the actual binder applied in the mix. The CIRCLY modelling for the Boree project validates the modelling for the Braemar project and shows that the pavements constructed with thinner cemented layers than the design requires, they perform slightly better due to the higher modulus created by the addition of additional binder. Stabilised

pavements constructed thicker than the design requires result in less life than analysis with constant modulus provides, but still meet the required design life. Table 5.15 presents the increase or decrease in design life achieved by adjusting the modulus with thickness in both years and percentage of the life achieved when compared with the results from the same analysis completed with constant modulus.

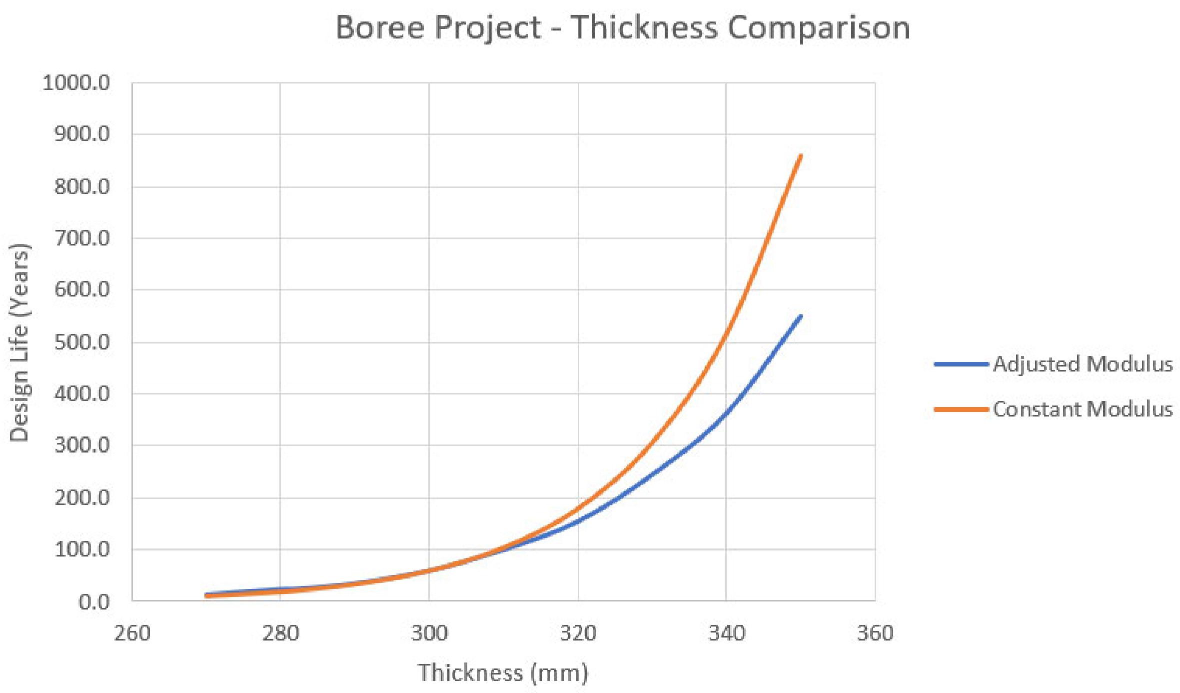

Figure 5. 9 – Comparison of design life provided by varying thickness of stabilised base layer

Table 5. 15 - Comparison of design life achieved on the Boree project with constant modulus and adjusted modulus

Boree Project - Thickness Comparison				
	Design Life Achieved			
Thickness (mm)	**Constant Modulus**	**Adjusted Modulus**	**Increase in Life (Years)**	**Increase in Life (%)**
270	10.0	12.8	2.8	28%
280	18.3	22.9	4.6	25%
282	20.7	23.6	2.9	14%
290	33.2	34.5	1.3	4%
300	59.0	59.0	0.0	0%
310	103.6	99.5	-4.1	-4%
320	178.6	153.8	-24.7	-14%
330	305.8	243.9	-61.9	-20%
340	515.5	362.3	-153.1	-30%
350	858.4	549.5	-308.9	-36%

Using a target spread rate of 3 % for the binder on the three theoretical pavements, an actual application rate in tonnes per square meter was calculated for each thickness modelled in CIRCLY. The actual application rate was used to calculate the unconfined compressive strength based on the UCS trials completed for the project's original pavement design. The UCS was then converted to cemented modulus using equation 3.1 and the k_{UCS} value of 1284 back calculated from the modulus and UCS at the optimum design thickness. As well as varying the thickness of the stabilised layer, the underlying selected layer was adjusted to replicate the effect of the mixer running deeper or shallower during a pavement rehabilitation. The results from the thickness modelling in CIRCLY are presented in Tables 5.16, 5.17 and 5.18 for each of the three theoretical pavements. Figure 5.10 plots the results from Tables 5.16, 5.17 and 5.18 showing the impact of thickness on the design life when the variation in binder as a percentage of the dry mass of pavement created by varying the stabilisation depth is accounted for.

Table 5. 16 – CBR3 pavement with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus

CBR3 Theoretical Pavement - Thickness Comparison - Variable Modulus												
Thickness (mm)	Subbase Thickness (mm)	Target Spread Rate %	Actual Spread Rate %	Actual UCS (Mpa)	Actual modulus (Mpa)	Fatigue Constant k	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	172	0.03	3.8%	4.7	6096	233	3.66E+01	5.41E+04	3660%	0.5	20.4	97%
280	162	0.03	3.7%	4.6	5910	238	2.07E+01	9.57E+04	2070%	1.0	20.0	95%
290	152	0.03	3.5%	4.5	5737	243	1.18E+01	1.68E+05	1180%	1.7	19.3	92%
300	142	0.03	3.4%	4.3	5575	247	7.12E+00	2.78E+05	712%	2.8	18.2	87%
310	132	0.03	3.3%	4.2	5424	252	4.13E+00	4.79E+05	413%	4.8	16.1	77%
320	122	0.03	3.2%	4.1	5283	255	2.20E+00	9.00E+05	220%	9.1	11.9	57%
330	112	0.03	3.1%	4.0	5149	259	1.63E+00	1.21E+06	163%	12.3	8.7	41%
332	110	0.03	3.1%	4.0	5124	260	1.47E+00	1.35E+06	147%	13.6	7.4	35%
340	102	0.03	3.0%	3.9	5024	262	1.06E+00	1.87E+06	106%	18.9	2.1	10%
342	100	0.03	3.0%	3.9	5000	263	9.54E-01	2.08E+06	95%	21.0	0.0	0%
350	92	0.03	2.9%	3.8	4906	266	6.60E-01	3.00E+06	66%	30.3	-9.3	-45%
352	90	0.03	2.9%	3.8	4883	266	6.23E-01	3.18E+06	62%	32.1	-11.1	-53%

Table 5. 17 – CBR5 pavement with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus

CBR5 Theoretical Pavement - Thickness Comparison - Variable Modulus												
Thickness (mm)	Subbase Thickness (mm)	Actual Spread Rate %	Actual UCS (Mpa)	k_UCS	Actual modulus (Mpa)	Fatigue Constant k	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	145	3.5%	4.4	1284	5685	244	9.82E+00	2.02E+05	982%	2.0	18.0	90%
280	135	3.4%	4.3	1284	5514	249	5.63E+00	3.52E+05	563%	3.6	16.5	82%
290	125	3.3%	4.2	1284	5354	253	3.41E+00	5.81E+05	341%	5.9	14.2	71%
300	115	3.2%	4.1	1284	5206	258	1.98E+00	1.00E+06	198%	10.1	9.9	50%
305	110	3.1%	4.0	1284	5135	259	1.63E+00	1.21E+06	163%	12.3	7.8	39%
310	105	3.0%	3.9	1284	5066	261	1.27E+00	1.56E+06	127%	15.7	4.3	21%
315	100	3.0%	3.9	1284	5000	263	9.99E-01	1.98E+06	100%	20.0	0.0	0%
320	95	3.0%	3.8	1284	4936	265	7.85E-01	2.52E+06	79%	25.5	-5.5	-27%
325	90	2.9%	3.8	1284	4874	267	6.24E-01	3.17E+06	62%	32.1	-12.0	-60%
330	85	2.9%	3.7	1284	4813	268	5.09E-01	3.89E+06	51%	39.3	-19.3	-96%
340	75	2.8%	3.7	1284	4698	271	3.31E-01	5.98E+06	33%	60.4	-40.4	-202%
350	65	2.7%	3.6	1284	4589	274	2.16E-01	9.17E+06	22%	92.6	-72.6	-363%

Table 5. 18 – CBR7 pavement with varying thickness of the stabilised base layer, adjusted subbase layer thickness and cemented modulus

CBR5 Theoretical Pavement - Thickness Comparison - Variable Modulus												
Thickness (mm)	Subbase Thickness (mm)	Actual Spread Rate %	Actual UCS (Mpa)	k_UCS	Actual modulus (Mpa)	Fatigue Constant k	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
270	128	3.3%	4.2	1284	5426	252	3.81E+00	5.20E+05	381%	5.2	15.6	75%
280	118	3.2%	4.1	1284	5264	256	2.31E+00	8.57E+05	231%	8.7	12.2	58%
288	110	3.1%	4.0	1284	5143	259	1.57E+00	1.26E+06	157%	12.7	8.1	39%
290	108	3.1%	4.0	1284	5113	260	1.41E+00	1.40E+06	141%	14.2	6.7	32%
298	100	3.0%	3.9	1284	5000	263	9.59E-01	2.06E+06	96%	20.9	0.0	0%
300	98	3.0%	3.9	1284	4973	264	8.61E-01	2.30E+06	86%	23.2	-2.4	-11%
308	90	2.9%	3.8	1284	4867	267	5.89E-01	3.36E+06	59%	34.0	-13.1	-63%
310	88	2.9%	3.8	1284	4841	267	5.55E-01	3.57E+06	56%	36.0	-15.2	-73%
320	78	2.8%	3.7	1284	4717	271	3.43E-01	5.77E+06	34%	58.3	-37.5	-180%
330	68	2.7%	3.6	1284	4601	274	2.23E-01	8.88E+06	22%	89.7	-68.8	-330%
340	58	2.6%	3.5	1284	4492	277	1.45E-01	1.37E+07	15%	137.9	-117.1	-561%
350	48	2.6%	3.4	1284	4389	280	9.45E-02	2.10E+07	9%	211.6	-190.8	-915%

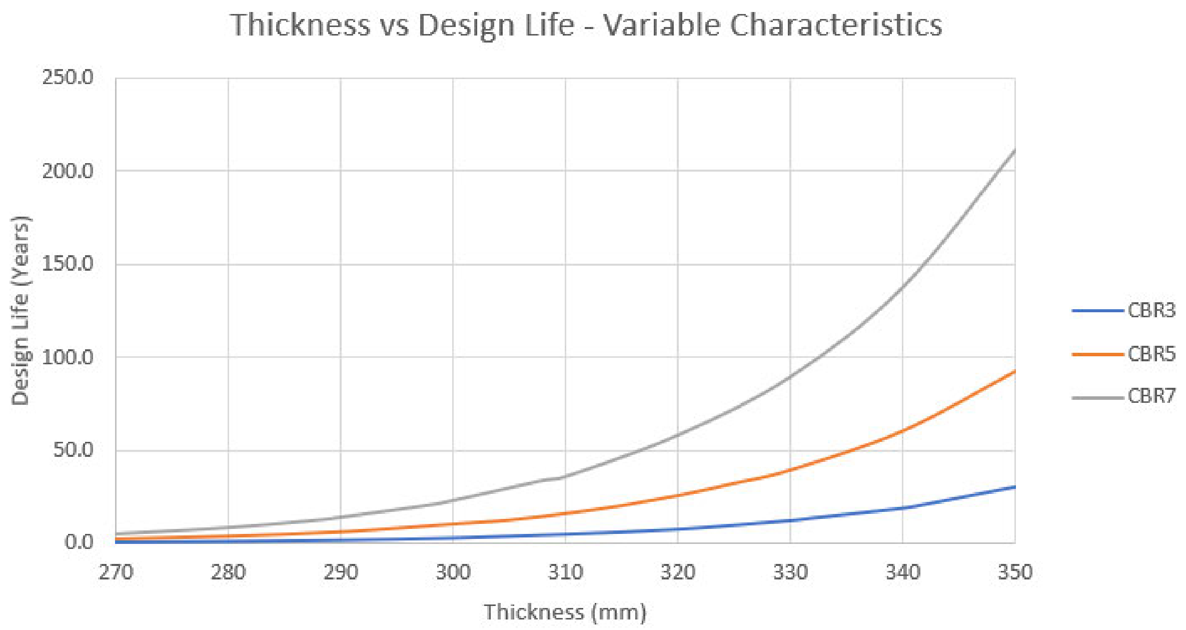

Figure 5. 10 – Theoretical pavements modelled with characteristics that vary with thickness

5.3.3 Variable Compaction

The Braemar project was modelled in CIRCLY over a range of compaction using Andrews (1998) relationship. The unconfined compressive strength was calculated using equation 3.7 using the dry density ratio which then allowed for the calculation of the corresponding modulus for analysis in CIRCLY using equation 3.1. The thickness of the pavement used was the optimum design thickness of 322 mm calculated in section 5.3.1 of this paper which achieved a design life of 20.4 years with a modulus of 5000 MPa. Table 5.19 presents the design life calculated in CIRCLY by adjusting the stabilised layer modulus with the dry density ratio at the Braemar project while keeping the pavement structure the same as the original pavement design and assuming the same compaction was achieved throughout the full layer depth.

Table 5. 19 – Braemar project with modulus adjusted based on dry density ratio

Braemar Project - Compaction Comparison - Variable Modulus										
DDR %	UCS (Mpa)	k_UCS	Modulus (Mpa)	Fatigue Constant (k)	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
90	1.5	1515	2256	338	3.94E+01	6.80E+04	3940%	0.5	19.9	98%
91	1.7	1515	2530	330	2.08E+01	1.29E+05	2080%	1.0	19.4	95%
92	1.9	1515	2805	323	1.15E+01	2.33E+05	1150%	1.7	18.6	91%
93	2.0	1515	3079	315	7.19E+00	3.73E+05	719%	2.8	17.6	86%
94	2.2	1515	3354	308	4.59E+00	5.84E+05	459%	4.4	16.0	79%
95	2.4	1515	3628	300	3.24E+00	8.27E+05	324%	6.2	14.2	70%
96	2.6	1515	3902	293	2.31E+00	1.16E+06	231%	8.7	11.7	58%
97	2.8	1515	4177	286	1.72E+00	1.56E+06	172%	11.6	8.8	43%
98	2.9	1515	4451	278	1.39E+00	1.93E+06	139%	14.4	6.0	29%
99	3.1	1515	4726	271	1.12E+00	2.39E+06	112%	17.9	2.5	12%
100	3.3	1515	5000	263	9.81E-01	2.73E+06	98%	20.4	0.0	0%
101	3.5	1515	5274	256	8.49E-01	3.16E+06	85%	23.6	-3.2	-16%
102	3.7	1515	5549	248	7.93E-01	3.38E+06	79%	25.2	-4.8	-24%
103	3.8	1515	5823	241	7.29E-01	3.68E+06	73%	27.4	-7.0	-35%
104	4.0	1515	6098	233	7.25E-01	3.70E+06	73%	27.6	-7.2	-35%
105	4.2	1515	6372	226	7.06E-01	3.80E+06	71%	28.3	-7.9	-39%

Further analysis in CIRCLY was completed to examine the impact of compaction with a density gradient throughout the layer. The top half of the stabilised layer was modelled with 100 % compaction and the lower half of the layer was modelled at 95 % to replicate a scenario allowed for in TfNSW R75 specification. Table 5.20 presents the results showing that the lower half of the layer is the critical layer in the design and limits the life of the pavement to 12.4 years. CIRCLY calculates an inaccurate design life for the upper half of the cemented layer in this case. Analysis of the same structure during the post cracked phase of the lower half of the cemented layer using a vertical modulus of 500 MPa for the cracked portion provides a design life of 0.02 years, confirming that the lower portion of the layer with the lower compaction does become the critical layer and reduce the expected life of the pavement.

Table 5. 20 – Braemar project with modulus adjusted with density for lower half of cemented layer

Braemar Project - Compaction Comparison - Variable Modulus								
DDR %	UCS (Mpa)	k_UCS	Modulus (Mpa)	Fatigue Constant (k)	CDF	Repetitions at Failure	Life Consumed	Design Life (years)
100	3.3	1515	5000	263	1.94E-07	1.38E+13	0%	103092784
95	2.4	1515	3628	300	1.61E+00	1.66E+06	161%	12.4

The Boree project pavement was analysed in CIRCLY using the same methodology as the Braemar project. The modulus of the stabilised layer was adjusted with the corresponding dry density ratio and analysed to determine the design life. The results of this analysis are summarised in Table 5.21.

Table 5. 21 – Boree project with modulus adjusted based on dry density ratio

Boree Project - Compaction Comparison - Variable Modulus										
DDR %	UCS (Mpa)	k_UCS	Modulus (Mpa)	Fatigue Constant (k)	CDF	Repetitions at Failure	Life Consumed	Design Life (years)	Variance in life (years)	Variance in Life (%)
90	2.1	1282	2678	326	4.48E+00	2.88E+05	448%	4.5	54.5	92%
91	2.3	1282	2910	320	2.88E+00	4.48E+05	288%	6.9	52.1	88%
92	2.5	1282	3143	314	1.94E+00	6.65E+05	194%	10.3	48.7	83%
93	2.6	1282	3375	307	1.42E+00	9.08E+05	142%	14.1	44.9	76%
94	2.8	1282	3607	301	1.04E+00	1.24E+06	104%	19.2	39.8	67%
95	3.0	1282	3839	295	7.94E-01	1.62E+06	79%	25.2	33.8	57%
96	3.2	1282	4071	288	6.49E-01	1.99E+06	65%	30.8	28.2	48%
97	3.4	1282	4303	282	5.25E-01	2.46E+06	53%	38.1	20.9	35%
98	3.5	1282	4536	276	4.35E-01	2.97E+06	44%	46.0	13.0	22%
99	3.7	1282	4768	269	3.55E-01	3.63E+06	36%	56.3	2.7	5%
100	3.9	1282	5000	263	3.39E-01	3.81E+06	34%	59.0	0.0	0%
101	4.1	1282	5232	257	3.03E-01	4.26E+06	30%	66.0	-7.0	-12%
102	4.3	1282	5464	250	2.91E-01	4.43E+06	29%	68.7	-9.7	-16%
103	4.4	1282	5697	244	2.71E-01	4.76E+06	27%	73.8	-14.8	-25%
104	4.6	1282	5929	238	2.59E-01	4.98E+06	26%	77.2	-18.2	-31%
105	4.8	1282	6161	232	2.52E-01	5.12E+06	25%	79.4	-20.4	-35%

Analysing the density gradient allowed for TfNSW R75 specification for the Boree project was completed in CIRCLY. The results are shown in Table 5.22. As with the same analysis completed for the Braemar project CIRCLY calculated an unrealistic life for the upper portion of the stabilised layer. For the Boree project, the density gradient did not result in shorter life than the design period of 20 years as the pavement structure over delivered originally and provided a life of greater than 50 years. It did however, make the lower half of the layer the critical layer in the pavement structure.

Table 5. 22 - Boree project with modulus adjusted with density for lower half of cemented layer

Boree Project - Compaction Comparison - Variable Modulus								
DDR %	UCS (Mpa)	k_UCS	Modulus (Mpa)	Fatigue Constant (k)	CDF	Repetitions at Failure	Life Consumed	Design Life (years)
100	3.9	1282	5000	263	3.14E-08	4.11E+13	0%	636942675
95	3.0	1282	3839	295	4.49E-01	2.87E+06	45%	44.5

It has been determined through analysis in CIRCLY based on Andrews (1998) relationship between compaction and UCS of stabilised materials that the design life of a stabilised layer decreased with compaction. Figure 5.11 displays the relationship between dry density ratio and design life modelled in CIRCLY for the two case study projects and the three theoretical pavements. The Boree project follows a similar relationship to the other four pavements analysed for compaction but has a significantly higher design life due to the original design providing a life greater than 50 years. It highlights that the design life depends on more than just the compaction and corresponding modulus. The Boree project was modelled with lower design traffic than the other pavements and 200 mm additional cover between the stabilised layer and the subgrade which results in a longer design life.

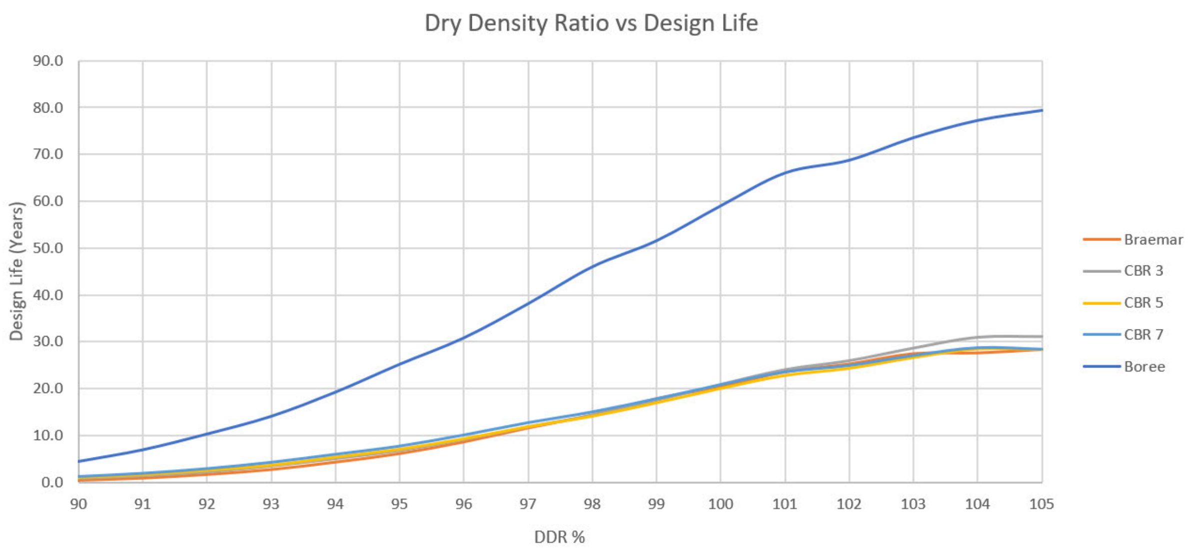

Figure 5. 11 – Impact of dry density ratio on design life on case study and theoretical pavements

Table 5.23 presents a summary of the compaction analysis completed in CIRCLY for the case study projects and the theoretical pavements. The data suggests that as pavements are designed with a certain cemented modulus based on the 100 % relative compaction of the particular material being stabilised, a loss of compaction will result in a loss of modulus.

Table 5. 23 – Effect of compaction on case study projects and theoretical pavements

Compaction Comparison											
	Design Life					**Variance in Design Life (%)**					
DDR %	**Braemar**	**Boree**	**CBR3**	**CBR5**	**CBR7**	**Braemar**	**Boree**	**CBR3**	**CBR5**	**CBR7**	**Average**
90	0.5	4.5	0.9	1.0	1.2	98%	92%	96%	95%	94%	95%
91	1.0	6.9	1.4	1.6	1.9	95%	88%	93%	92%	91%	92%
92	1.7	10.3	2.3	2.5	2.9	91%	83%	89%	87%	86%	87%
93	2.8	14.1	3.5	3.6	4.3	86%	76%	83%	82%	80%	81%
94	4.4	19.2	5.1	5.3	6.0	79%	67%	76%	73%	71%	73%
95	6.2	25.2	6.8	7.0	7.7	70%	57%	67%	65%	63%	64%
96	8.7	30.8	9.2	9.3	10.1	58%	48%	56%	54%	52%	53%
97	11.6	38.1	11.9	11.8	12.7	43%	35%	43%	41%	39%	40%
98	14.4	46.0	14.4	14.1	15.0	29%	22%	31%	30%	28%	28%
99	17.9	56.3	17.5	16.9	17.9	12%	5%	16%	15%	14%	13%
100	20.4	59.0	21.0	20.0	20.9	0%	0%	0%	0%	0%	0%
101	23.6	66.0	24.1	22.8	23.6	-16%	-12%	-15%	-14%	-13%	-14%
102	25.2	68.7	26.0	24.3	25.0	-24%	-16%	-24%	-22%	-20%	-21%
103	27.4	73.8	28.7	26.6	27.1	-35%	-25%	-37%	-33%	-30%	-32%
104	27.6	77.2	31.1	28.5	28.8	-35%	-31%	-48%	-42%	-38%	-39%
105	28.3	79.4	31.2	28.3	28.4	-39%	-35%	-49%	-42%	-36%	-40%

5.4 Whole of Life Cost Analysis

Whole of life cost analysis was completed to model a number of scenarios in order to determine if the current requirements of TfNSW R75 Specification are accurate or if amendments should be considered to more accurately recover cost of nonconforming construction. Initially a stabilised pavement constructed to conform with the design requirements was analysed with a discount rate of 7%. Sensitivity tests were completed at 4% and 10%.

To complete the cost analysis rates per square meter were adopted based on the experience of the Northern Project Development team at TfNSW. Costs included in the analysis relate solely to the pavement as all other maintenance activities for traffic facilities, drainage and vegetation were considered to be equal regardless of pavement type. The whole of life cost analysis tables are included in Appendix D.

5.4.1 Pavement Thickness

To analyse the pavement thickness over the life of the pavement, the defects likely to be experienced were considered in the increased maintenance regime. As the pavement reduces in thickness, the modulus is expected to rise due to the increased binder content by mass of pavement materials. The distress expected to occur is increased shrinkage cracking initially followed by large scale block and crocodile cracking as the stabilised layer fatigues due to applied strain the bottom of the layer. The cracking will allow moisture into the pavement and cause shoving and rutting to occur. The maintenance required was expected to be crack sealing and patching.

The conforming pavement analysis initial construction cost of \$150/m^2 was applied in year 0, final seal applied in year 1 at \$7/m^2, routine maintenance at \$0.50/m^2 in all years and salvage in the form of pavement rehabilitation at -\$37.50/m^2 or 25% of the construction value. Patching of 5% of the pavement area at year 9 in preparation for resealing, a reseal in year 10 and another 5% of the surface area to be patched in year 15. The cost analysis provided a net present value of the conforming stabilised pavement as \$159.56/m^2 at 7% discount rate. The 4 % sensitivity analysis returned a cost of \$156.49/m^2 and the 10% sensitivity analysis returned a cost of \$160.56/m^2.

Using the relationships developed between thickness and design life in section 4.3 of this paper, a scenario where the stabilised pavement was constructed to at 10 mm below the design thickness was analysed. The average pavement loss for a reduction in thickness of 10 mm was found to be 45 % or 9 years out of the 20-year design period for a stabilised pavement with uniform characteristics regardless of layer thickness such as a plant mixed pavement constructed under TfNSW R73 specification. To analyse a pavement constructed in this manner, the analysis included additional maintenance of the stabilised pavement leading up to the end of life and after the 11-year point, when the pavement was considered to be cracked. Crack sealing was added every third year of 10 % of the pavement, patching of 10 % of the pavement in year 5, patching of 35% of the pavement in year 9 in preparation for resealing, resealing with a rubber modified bitumen and geotextile in year 10 to limit cracking through the wearing course and patching of a further 35 % of the pavement in year 15. The salvage value of the pavement in this option was reduced to 15 % of the original construction value as the pavement was considered to be unsuitable for an asphalt overlay as it had been in the post cracked phase for 11 years prior to the salvage year. The cost analysis provided a net present value of the nonconforming stabilised pavement as $\$202.97/m^2$ at 7% discount rate. The 4 % sensitivity analysis returned a cost of $\$215.91/m^{2,}$ and the 10 % sensitivity analysis returned a cost of $\$193.11/m^2$.

The average pavement loss for a reduction in thickness of 10 mm was found to be 36 % or 7 years out of the 20-year design period for a stabilised pavement with varying characteristics depending on the layer thickness such as a insitu stabilised pavement constructed under TfNSW R75 specification. To analyse a pavement constructed in this manner, the analysis included additional maintenance of the stabilised pavement leading up to the end of life and after the 13-year point, when the pavement was considered to be cracked. Crack sealing was added every third year of 10 % of the pavement, patching of 7.5 % of the pavement in year 5, patching of 35% of the pavement in year 9 in preparation for resealing, resealing with a rubber modified bitumen and geotextile in year 10 to limit cracking through the wearing course and patching of a further 35 % of the pavement in year 15. The salvage value of the pavement in this option was reduced to 15 % of the original construction value as the pavement was considered to be unsuitable for an asphalt overlay as it had been in the post cracked phase for 7 years prior to the salvage year. The cost analysis provided a net present value of the nonconforming stabilised pavement as $\$201.46/m^2$ at 7% discount rate. The 4 % sensitivity analysis returned a cost of $\$214.16/m^2$ and the 10 % sensitivity analysis returned a cost of $\$191.56/m^2$.

5.4.2 Pavement Compaction

The base line used for the compaction analysis was the same cost analysis developed for the conforming thickness analysis as the conforming thickness was modelled at 100 % relative compaction. Using the same analysis as completed for the conforming thickness model, the net present value of the conforming compaction analysis was calculated to be $\$159.56/m^2$.

Two scenarios were modelled through cost analysis. The first scenario was of a stabilised pavement constructed with a relative compaction of 98 %. The second scenario was a pavement constructed at 95 % relative compaction. The failures in the pavement expected to occur from lack of compaction were rutting of the stabilised layer, crocodile cracking as the pavement fatigues which would allow moisture into the pavement. This would induce deformation of the subgrade and allow shoving to occur. The maintenance required to remediate the above failures was increased pothole repairs and patching of the pavement to rectify cracked areas and shoves.

The analysis completed in CIRCLY provides an average loss of pavement life for 98 % relative compaction of 29 % or 6 years, resulting in a pavement life of 14 years. As with the thickness analysis, the salvage value for the nonconforming pavement was reduced to 15 % of the construction value. Patching of 5 % of the pavement was included in year 5, 10% of the pavement in year 9 and 15 % of the pavement in year 14. The reseal in year 10 was changed to a rubber modified bitumen to limit cracking of the wearing course. Increased pothole patching was allowed for by increasing the routine maintenance cost by 5 % each year. The cost analysis provided a net present value of the nonconforming stabilised pavement as \$175.76/m^2 at 7% discount rate. The 4 % sensitivity analysis returned a cost of \$179.92/m^2 and the 10 % sensitivity analysis returned a cost of \$172.15/m^2.

The analysis completed in CIRCLY, provides an average loss of pavement life for 95 % relative compaction of 64 % or 13 years, resulting in a pavement life of 7 years. As with the thickness analysis, the salvage value for the nonconforming pavement was reduced to 15 % of the construction value. Patching of 10 % of the pavement was included in years 3 and 6, 30% of the pavement in year 9 in preparation for resealing, 10 % of the pavement in year 12, 15% in year 15 and 20 % in year 18. The reseal in year 10 was changed to a rubber modified bitumen to limit cracking of the wearing course. Increased pothole patching was allowed for by increasing the routine maintenance cost by 5 % each year. The net present value of the nonconforming pavement was calculated as \$203.06/m^2 with a discount rate of 7 %. The 4 % sensitivity analysis returned a cost of \$216.06/$m^{2,}$ and the 10 % sensitivity analysis returned a cost of \$193.36/m^2.

6 Discussion

6.1 Thickness

The analysis completed in Chapter 5 shows that the thickness of stabilised pavement has a significant impact on the life of the pavement. The results from the analysis of the two case study projects and the three theoretical pavements using uniform modulus for the entire depth of the stabilised layer show an average loss of pavement life of 45 % from the loss of 10 mm of stabilised layer thickness which is presented in Table 6.1. The analysis completed for varying the modulus with thickness to replicate insitu stabilisation provided a loss of 37 % of the design life when the pavement thickness was reduced by 10 mm from the optimum thickness which is shown in Table 6.2. The difference between the two methods of determining pavement life demonstrate the effect of modulus and the fatigue constant on the calculated life of stabilise pavements. The impact is reduced using the insitu stabilisation process but is still considerable and will result in a unacceptable outcome. This demonstrates the importance of ensuring the 10 mm construction tolerance applied to the stabilised base layer is included in the design drawings and is constructed accordingly. If the construction tolerance is included, a nonconformance of 10 mm will only result in the design life being achieved rather than a loss of pavement life of the design thickness is targeted.

Table 6. 1 – Impact on design life of constructing a stabilised pavement with thickness reduced by 10mm and uniform modulus

Thickness Comparison - Uniform Modulus						
Variance in Design Life (%)						
Thickness (mm)	Braemar	Boree	CBR3	CBR5	CBR7	Average
-10	48%	45%	42%	44%	45%	45%

Table 6. 2 - Impact on design life of constructing a stabilised pavement with thickness reduced by 10mm and modulus varied with thickness

Thickness Comparison - Variable Modulus						
Variance in Design Life (%)						
Thickness (mm)	Braemar	Boree	CBR3	CBR5	CBR7	Average
-10	35%	38%	35%	39%	39%	37%

The modelling in CIRCLY of the variation in modulus of the stabilised layer as the thickness of the layer changes supports the importance of ensuring the design thickness is achieved. TfNSW R75 specification requires a thickness of +10 mm to +30 mm for thickness which was supported by this modelling. While the binder percentage by mass reduces in a thicker layer stabilised with the same binder quantity as the design thickness, the life of the layer was shown to not be adversely affected. The modulus of the stabilised layer reduces when the layer is constructed thicker than designed but due to the increased thickness, the life of the pavement is still increased.

The review of the case study project records provided evidence that the thickness of the Braemar project did not meet specification in a number of areas. Thye thickness required on this project was 330 mm including the 10 mm construction tolerance. 4 % of the pavement was up to 10 mm below the thickness required, which will likely result in a reduced life of 18.3 years. 1 % of the pavement was up to 20 mm below the required thickness, which may lead to a reduced life of 9.8 years and a further 1 % was greater than 20 mm thinner than required which will likely result in a life of 3.8 years. Increased maintenance is expected to be required for these areas. The thinner pavement in these areas will have a higher binder content and therefore modulus which is likely to cause increased strength gain and therefore shrinkage cracking, allowing moisture into the pavement. The maintenance required will be crack sealing and heavy patching of the stabilised layer.

The review of the Boree case study project revealed that the thickness records had not been handed over to the TfNSW Asset branch by the construction team. As there were no records for thickness, the possible pavement distress arising from any nonconformances could not be reviewed. The site inspection did however identify that the pavement is exhibiting shrinkage cracking for the full length of the project. This may be the result of the pavement being constructed thinner than required and causing increased strength gain but the UCS results from the construction records do not seem to support this. In any case, crack sealing is required to limit moisture infiltrating the pavement. A rubber modified reseal may need to be considered when the spray seal reaches the end of its useful life.

The whole of life cost analysis completed to examine the financial impact of constructing a pavement with nonconforming thickness was completed to determine if a payment deduction could be applied when thickness is not achieved rather than rejecting the affected lot. The cost analysis identified that for a loss of 10 mm, a roads authority would need to apply a payment deduction of 30 % to the pavement pay item to recover the cost of the increased maintenance over the 20-year design life. TfNSW R75 Specification allows for maximum payment deduction of 30 % for other areas before the affected lot is rejected. If the same principle was adopted for thickness, then a deduction could be applied for pavements constructed with up to 10 mm less than the design thickness at 30 % of the cost of the pavement in the affected lot. Deductions for thickness greater than 10 mm below the design thickness are not recommended to be accepted as the required maintenance cost would be too high to justify the deduction.

6.2 Compaction

The impacts that failing to meet the compaction requirements have on the life of stabilised pavements was examined in Chapter 4 through relationships identified in previous research that were able to relate compaction to UCS and then to modulus using the relationship provided in Austroads (2017). Compaction was found to have a significant impact on the life of stabilised pavements by modifying the achieved modulus in the stabilised layer. The CIRCLY analysis calculated that a reduction of compaction to 98 % will reduce the life of the pavement by 28 % while a compaction of 95 % reduces the life by 64 % which is presented in Table 6.3.

Table 6. 3 – Impact of relative compaction on design life of stabilised pavements

Compaction Comparison						
Variance in Design Life (%)						
DDR %	Braemar	Boree	CBR3	CBR5	CBR7	Average
90	98%	92%	96%	95%	94%	95%
95	70%	57%	67%	65%	63%	64%
98	29%	22%	31%	30%	28%	28%

The review of the case study projects construction records for compaction demonstrated that both achieved the 100 % relative compaction required for stabilised layers greater than 250 mm thick. The characteristic values for compaction at the Braemar project ranged from 101 % to 105 % which may cause an increase in life of 16 % to 39 % according to the modelling in CIRCLY. The characteristic values for compaction at the Boree project ranged from 102 % to 104 % which may cause an increase in life of 12 % to 31 % according to the modelling in CIRCLY.

Whole of life cost analysis was completed for varying compaction results to identify the financial impact of constructing stabilised pavements with nonconforming compaction. TfNSW R75 Specification includes deductions for nonconforming compaction which this analysis aimed to test. The cost analysis identified that relative compaction of 98 % would require a payment deduction of 11 % to the pavement pay item for the affected lot. TfNSW R75 specification requires a pay item deduction of 10 % for compaction between 98 % and less than 100 %. The cost analysis completed appears to verify the deduction in the specification.

The cost analysis identified that relative compaction of 95 % would require a payment deduction of 29 % to the pavement pay item for the affected lot which supports the TfNSW R75 specification requirement to impose a pay item deduction of 30 % for compaction between 95 % and less than 98 %. The cost analysis completed appears to verify the deduction in the specification, however it is important to consider the reputational damage associated with a nonconformance this severe as the loss of pavement life will result in excessive maintenance requirements and disturbance for the road users.

Stabilised pavements with compaction nonconformances are expected to exhibit distress in the form of rutting, crocodile cracking and shoving. Patching would be required to remediate failures caused by compaction nonconformances.

6.3 Recommendations for Compliance

The project quality control plans should be adequately detailed to allow the construction team to ensure that the pavement constructed meets the requirements for thickness and compaction. The methods for survey for thickness and trimming of compacted surface should be appropriately detailed. The same should apply to compaction including the size of the compaction equipment required and timing of compactive effort. The quality plans should be sufficiently detailed to give the project the highest likelihood of achieving the required thickness and compaction. The quality plans should be reviewed by an appropriately qualified person at the roads authority to ensure completeness. Ensuring the road authority review and acceptance of the contractors' plans is essential to ensuring compliance and benefits both parties.

6.3.1 Payment Deduction for Thickness

Back calculation from the whole of life cost analysis was completed to calculate pay item deductions that would be required to offset the cost of nonconforming thickness or compaction. The unit rate required to recover the cost of additional maintenance likely to be required was \$106.59/m^2. When converted to a pay item deduction, the road authority would need to apply a 29% deduction of the pavement pay item to accept the pavement rather than rejecting the affected area. The calculation for the payment deduction is shown in Appendix D, Uniform Modulus - Nonconforming Thickness -10mm.

The same process applied to a pavement with modulus that varies with the thickness of the stabilised layer resulted in a required unit rate for construction of the stabilised layer of \$108.10/m^2, creating the need for a pay item deduction of 28 %. The calculation for the payment deduction is shown in Appendix D, Variable Modulus - Nonconforming Thickness -10mm.

6.3.2 Payment Deduction for Compaction

To recover the costs of increased maintenance resulting from only achieving a relative compaction of 98 % the construction rate would need to be reduced to \$133.80/m^2, a deduction of 11 % to the pavement pay item. If considering relative compaction of 95%, the construction rate would need to be reduced to \$106.50/m^2, a deduction of 29 % to the pavement pay item. The calculation for the payment deduction is shown in Appendix D, Nonconforming Compaction = 98% and Nonconforming Compaction = 95%.

6.3.3 Summary of Compliance Recommendations

The payment deductions discussed in sections 6.3.1 and 6.3.2 could be implemented by the road authority such as TfNSW if construction does not meet the requirements for conformance and the pavement is considered to be at risk of early distress and failure. The implementation of appropriate quality assurance plans and payment deductions representing the threat of lost income are considered to be appropriate requirements in ensuring the road authority's specifications are met.

Another element to consider is the reputational damage to the roads authority when considering a pay item deduction for nonconforming work. The public expects that road works completed by roads authorities be completed competently and efficiently. Returning to a rehabilitated section of road to complete major maintenance will negatively impact the reputation of the roads authority and should be considered when determining whether to amend specifications either organisation wide or locally.

7 Conclusion

This project aimed to review the effects of nonconforming compaction and layer thickness on the life of pavements stabilised with slow setting binders using insitu stabilisation. Analysis was completed using relationships from Austroads guides and previous published research to model varying thicknesses and compaction ratios in mechanistic pavement design software CIRCLY. Analysis was completed on two case study projects and on three theoretical pavements that are typical of existing pavements in the northern region of NSW. Optimum thickness was determined and compared against varying thicknesses in increments of 10 mm to replicate constructable layers to determine the impact on the achievable life for each pavement type. Compaction was modelled between 90 % and 105 % as a practical range of compactions that may be achieved during construction. The compaction ratios were converted to modulus and modelled in CIRCLY to present the impact on design life.

The analysis has provided evidence that the thickness of a stabilised layer and its compaction have a significant impact on the achievable design life of the pavement. The results from this research show that the life of a pavement will reduce drastically as thickness reduces from the optimum thickness. The impact of compaction has also been shown to drastically impact the pavement life. Both factors require appropriate planning and implementation to ensure that construction is completed to the specifications requirements to allow for the design life to be achieved.

This project also aimed to investigate the cost implications due to reduced life and increased maintenance requirements of stabilised pavements constructed with non-conforming compaction and layer thickness. This was achieved through whole of life cost analysis of a pavement constructed in conforming condition and pavements constructed to reduced thickness and compaction. The whole of life cost analysis provided unit rates for both conforming and nonconforming pavements due to thickness and compaction to demonstrate the present value of stabilised pavement construction nonconformances.

The final aim of this project was to use the impact on the design life and calculated cost implication of nonconformance to propose methods of improving compliance with the specification. This was achieved by back calculating the results of the whole of life cost analysis to determine the unit rate that would be required during construction in order to balance out the cost of nonconforming pavement with the cost of conforming pavement over the design period. Reducing the thickness by 10 mm from the optimum thickness was demonstrated to reduce the life of a stabilised pavement to a point where a payment deduction of 30 % would need to be applied to recover the cost of increased maintenance. Cost analysis of compaction confirmed the payment deductions of 10 % and 30 % in TfNSW R75 specification are appropriate for compaction up to 2 % and 5 % below the required 100 % respectively.

In conclusion, this project has demonstrated the loss of pavement life resulting from constructing a stabilised pavement through insitu stabilisation that has nonconforming thickness or relative compaction of the stabilised layer. The financial impact of these nonconformances has been reviewed through whole of life cost analysis and methods to encourage compliance with the specification have been discussed such as appropriate quality management plans and payment deductions for both thickness and compaction.

7.1 Further work

Additional work could be completed expand on the results provided through this dissertation. This dissertation has completed desktop analysis using pavement software CIRCLY to examine the theoretical impacts of pavement nonconformances on design life and the corresponding financial impact. As this analysis was based on theoretical parameters for the stabilised materials, a number of assumptions were made and conversions between parameters were required to model the materials in CIRCLY. The fatigue constant was adopted based on a linear relationship between two accepted values for fatigue constant set out in TfNSW (2021b). This relationship was used to ensure that the stabilised materials reacted in a similar way to the materials used in the original TfNSW designs for the case study projects and to ensure that the thickness remained greater than a lean mix concrete layer would be if designed as the same layer in a pavement (Austroads 2017). Ideally the fatigue constant would be calculated using the fatigue constant would be calculated by flexure beam testing of prepared beams of stabilised materials but this was unfortunately not achievable within the scope of this project.

To expand on this research non-destructive testing could be completed at the case study projects in the form of falling weight deflectometer (FWD) testing to determine the insitu modulus of the stabilised pavements. The data collected from the FWD testing could be used to compare with the theoretical modulus adopted in this dissertation and the relationship TfNSW adopted to select the original design UCS which was calculated to achieve the required modulus. The insitu modulus could then be used for modelling in CIRCLY to predict the expected life of the pavement and to determine how the design life varied from the theoretical analysis in this project.

In this dissertation thickness and compaction were examined independently. In future research they could be analysed together the calculate a relationship to define their combined impact on stabilised pavement life. Samples could be prepared in a laboratory at a range of relative compaction to determine the actual modulus achieved which could then be modelled in CIRCLY to determine the expected life. The samples could also be prepared with varying binder types and at varying percentages to determine a relationship between binder content and modulus directly. This dissertation relied on a relationship between dry density ratio and unconfined compressive strength to calculate modulus for the compaction analysis. Future research could test beams in the laboratory to determine a relationship between relative compaction and modulus directly for certain materials.

References

Andrews, RC 1998, *MTRD Report No. 94/MT/89 - 1 Mechanistic Characterisation of Cementitiously Stabilised Pavement Materials*, 19 Bridge Road Wakely Heights SA 5098.

Austroads 2006, *Guide to Pavement Technology Part 4D: Stabilised Materials*, Austroads Ltd., Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2009, *Guide to Pavement Technology Part 7 Pavement Maintenance*, Austroads Ltd.

Austroads 2012, *Guide to Pavement Technology Part 2: Pavement Structural Design*, Austroads Ltd, Level 9, Robell House 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2017, *Guide to Pavement Technology Part 2: Pavement Structural Design*, Austroads Ltd., Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2018a, *Guide to Pavement Technology Part 4L Stabilising Binders*, Austroads Ltd, Sydney NSW 2000 Australia.

Austroads 2018b, *Guide to Pavement Technology Part 4I: Earthworks Materials*, Austroads Ltd., Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2018c, *Guide to Pavement Technology Part 1: Introduction to Pavement Technology*, Austroads Ltd, Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2018d, *Guide to Pavement Technology Part 4K: Selection and Design of Sprayed Seals*, Austroads Ltd., Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2019a, *Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design*, Austroads Ltd., Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2019b, *Guide to Pavement Technology Part 4D Stabilised Materials*, Austroads Ltd, Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

Austroads 2019c, *Guide to Pavement Technology Part 8: Pavement Construction*, Austroads Ltd, Level 9, 287 Elizabeth Street Sydney NSW 2000 Australia.

AustStab 1996, *Life Cycle Costing of Stabilised Pavements*, AustStab.

AustStab 2010, *AustStab Technical Note No. 4: What is Lime?*, AustStab, Cherrybrook NSW 2126.

Babashamsi, P, Md Yusoff, NI, Ceylan, H, Md Nor, NG & Salarzadeh Jenatabadi, H 2016, 'Evaluation of pavement life cycle cost analysis: Review and analysis', *International Journal of Pavement Research and Technology*, vol. 9, no. 4, pp. 241-54.

Das, BM 2003, 'Chemical and mechanical stabilization', *Transportation Research Board*.

Fuller, S 2010, 'Life-cycle cost analysis (LCCA)', *National Institute of Building Sciences, An Authoritative Source of Innovative Solutions for the Built Environment*, vol. 1090.

G Foley & Australian Stabilisation Expert Group 2001, 'Contract report - Mechanistic Design Issues for Stabilised Pavement Materials', *Austroads*, vol. RC91022-3.

G Vorobieff & R Yeo 2002, *APRG Technical Note 12*, Effect of design, construction and environmental factors for long-term performance of stabilised materials.

Geoffrey Jameson 2014, 'Improved Fatigue Characterisation of Cemented Materials', *26th ARRB Conference - Research Driving Efficiency*: *Proceedings of the 26th ARRB Conference - Research Driving Efficiency* ARRB Group Ltd, Syndey NSW.

Gray, W 2017, *Best practice guide for pavement stabilisation*, NZ Transport Agency research report 622, NZ Transport Agency, Wellington 6141, New Zealand.

Holtz, RD & Kovacs, WD 1981, *An Introdcution to Geotechnical Engineering*, Prentice-Hall Inc., Englewood Cliffs, New Jersey 07632.

Jameson, G 2013, *Technical Basis of Austroads Guide to Pavement Technology Part 2: Pavement Structural Design*, ARRB Group Ltd, Vermont South, Victoria, Australia.

Little, DN, Males, EH, Prusinski, JR & Stewart, B 2000, 'Cementitious stabilization', *Transportation in the new millennium*.

Louw, S & Jones, D 2015, 'Pavement Recycling: Literature Review on Shrinkage Crack Mitigation in Cement-Stabilized Pavement'.

Mallela, J, Quintus, HV & Smith, K 2004, 'Consideration of lime-stabilized layers in mechanistic-empirical pavement design', *The National Lime Association*, vol. 200, pp. 1-40.

Regional Geotechnical Solutions 2019, *Proposed Pavement Rehabilitation – Segment 3080 Boree*, Port Macquarie NSW 2444.

Roads and Maritime Services 2012, *Test method T147 Working time for road construction materials (Blended in the laboratory with slow setting binders)* Roads and Maritime Services, Sydney, https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/documents/test-methods/t147.pdf>.

Roads and Maritime Services 2018, *Roads and Maritime Supplement to Austroads Guide to Pavement Technology Part 2: Pavement Structural Design*, Roads and Maritime Services.

Roads and Maritime Services 2019a, *Pavement Rehabilitation MR83 Segment 3545* N2018027, Roads and Maritime Services.

Roads and Maritime Services 2019b, *HW11 Segment 3080 Boree*, Grafton NSW 2460.

Roads and Traffic Authority 2008, *NSW Road Management Arrangements*, Roads and Traffic Authority, Sydney NSW.

Serruto, M & Pardo, L 2001, 'Evaluation of stabilised marginal pavement materials using established and newly developed cementitious binders', *20th ARRB Conference Melbourne*.

Transport for New South Wales 2012, *Test method T166 Relative compaction of road construction materials*, TfNSW, https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/documents/test-methods/t166.pdf>.

Transport for New South Wales 2016, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, Transport for NSW, Sydney NSW.

Transport for New South Wales 2020a, *What We Do*, viewed 27/03/2022, <https://roads-waterways.transport.nsw.gov.au/about/what-we-do/index.html>.

Transport for New South Wales 2020b, *INSITU PAVEMENT STABILISATION USING SLOW SETTING BINDERS*, Transport for New South Wales, Sydney NSW.

Transport for NSW 2018, *Life Cycle Costing*, Transport for NSW.

Transport for NSW 2020, *Transport Environment and Sustainability Policy*, Transport for NSW, Chippendale NSW 2008.

Transport for NSW 2021a, *Plant Mixed Heavily Bound Pavement Course*, QA Specification R73, https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/documents/specifications/r073.pdf>.

Transport for NSW 2021b, *Supplement to Austroads Guide*, Supplement to Austroads Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design, Transport for NSW, https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/document-types/supplements-austroads-guides/pavement-technology.html>.

Transport for NSW 2021c, *QA Specification Q4*, Quality Management System (Type 4), Transport for NSW, https://roads-waterways.transport.nsw.gov.au/business-industry/partners-suppliers/documents/specifications/q04.pdf>.

Transport for NSW 2022, *NSW Road Network*, https://www.transport.nsw.gov.au/operations/logistics-network/nsw-road-network>.

Transport South Australia 1998, *Mechanistic Characterisation of Cementitiously Stabilised Pavement Materials*.

White, G & Gnanendran, C 2002, 'The characterisation of cementitious insitu stabilised pavement materials: The past, the present and the future', *Road & transport research*, vol. 11, no. 4, pp. 56-.

White, GW 2007, 'Laboratory characterisation of cementitiously stabilised pavement materials', UNSW, Sydney.

Yoder, EJ & Witczak, MW 1991, *Principles of pavement design*, John Wiley & Sons.

Žižlavský, O 2014, 'Net present value approach: method for economic assessment of innovation projects', *Procedia-Social and Behavioral Sciences*, vol. 156, pp. 506-12.

Appendix A – Project Specification

ENG4111/4112 Research Project

Project Specification

For: Shaun Perkins

Title: Evaluation of Issues Affecting Stabilised Granular Pavements

Major: Civil

Supervisors: Dr Andreas Nataatmadja

Enrollment: ENG4111 – EXT S1, 2022

ENG4112 – EXT S2, 2022

Project Aims:

i. This project aims to review effects of nonconforming compaction and layer thickness on the life of stabilised pavements; and
ii. To investigate the cost implications due to reduced life and increased maintenance requirements of stabilised pavements constructed with non-conforming compaction and layer thickness; and
iii. To propose methods of improving conformance with specification requirements to ensure design life is achieved.

Programme: Version 1, 15th March 2022

1. Conduct literature review into stabilised pavements and specifications for construction.
2. Complete a desktop review of the pavement design, layer thickness and compaction records from construction of two stabilised pavements in TfNSW North to determine areas with non-compliant parameters that may impact the life of the pavement.
3. Use CIRCLY to model non-conforming sections of the case study projects to determine theoretical changes to design life.
4. Model three theoretical stabilised pavements in CIRCLY with pavement profiles indicative of those found in the North region with varying subgrade CBR.
5. Complete visual investigations in line with Austroads Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design at the identified project sites to determine current pavement condition with emphasis on the areas of non-conforming construction parameters.
6. Calculate the expected life of the case study stabilised pavement projects and compare to the design life of these projects to understand the financial implications of construction non-conformances to TfNSW. Complete whole of life cost analysis of the case study projects to compare costs of completing the projects in line with the pavement design and specification against projects with non-conforming thickness and compaction.
7. Propose methods to improve TfNSW specifications to ensure design life is achieved.

Appendix B – Risk Assessment

All persons conducting a business or undertaking in Australia are required to manage the safety of the personnel involved in the business or undertaking. The Australian Government has produced the Work Health and Safety Act 2011 with the main objective of providing "balanced and nationally consistent framework to secure the health and safety of workers and workplaces".

All work practices involve hazards that have the potential to put the personnel and equipment involved at risk. In order to manage the risk, those responsible are required to complete risk assessments and to implement controls to manage and reduce the risks identified.

As part of this dissertation a risk assessment has been completed to identify and manage risk. The risk assessment has been completed in line with USQ's Risk Management System using the Risk Management Plan.

UNIVERSITY OF SOUTHERN QUEENSLAND

University of Southern Queensland **Offline Version**

USQ Safety Risk Management System

Note: This is the offline version of the Safety Risk Management System (SRMS) Risk Management Plan (RMP) and is only to be used for planning and drafting sessions, and when working in remote areas or on field activities. It must be transferred to the online SRMS at the first opportunity.

Safety Risk Management Plan – Offline Version

Assessment Title:	Engineering Research Project: Evaluation of Issues Affecting Stabilised Granular Pavements	Assessment Date:	24/05/2022
Workplace (Division/Faculty/Section):	USQ/Civil Engineering	Review Date:(5 Years Max)	31/12/2023

Context

Description:

What is the task/event/purchase/project/procedure?	Research project
Why is it being conducted?	Requirement of Bachelor of Engineering
Where is it being conducted?	NSW Mid North Coast and North Coast
Course code (if applicable)	ENG4111/ENG4112
Chemical name (if applicable)	

What other nominal conditions?

Personnel involved	Shaun Perkins
Equipment	Office equipment, car, field notes
Environment	Office, roadside
Other	
Briefly explain the procedure/process	Research project involving office research and report preparation combined with inspection of road condition at two sites

Assessment Team - who is conducting the assessment?

Assessor(s)	Shaun Perkins
Others consulted:	Dr Andreas Nataatmadja

This document is uncontrolled once printed and may not be the latest version. Access the online SRMS for the latest version. Safety Risk Management Plan V1.1

Eg 1. Enter Consequence

Eg 2. Enter Probability

Eg 3. Find Action

	Consequence				
Probability	**Insignificant** No Injury 0-$5K	**Minor** First Aid $5K-$50K	**Moderate** Med Treatment $50K-$100K	**Major** Serious Injuries $100K-$250K	**Catastrophic** Death More than $250K
Almost Certain 1 in 2	M	H	E	E	E
Likely 1 in 100	M	H	H	E	E
Possible 1 in 1000	L	M	H	H	H
Unlikely 1 in 10 000	L	L	M	M	M
Rare 1 in 1 000 000	L	L	L	L	L

Recommended Action Guide

E=Extreme Risk – Task ***MUST NOT*** proceed
H=High Risk – Special Procedures Required (See USQSafe)
M=Moderate Risk – Risk Management Plan/Work Method Statement Required
L=Low Risk – Use Routine Procedures

Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
Hazards: From step 1 or more if identified	*The Risk:* What can happen if exposed to the hazard without existing controls in place?	*Consequence:* What is the harm that can be caused by the hazard without existing controls in place?	*Existing Controls:* What are the existing controls that are already in place?	*Risk Assessment:* Consequence x Probability = Risk Level			*Additional controls:* Enter additional controls if required to reduce the risk level	*Risk assessment with additional controls:*			
				Probability	Risk Level	ALARP? Yes/no		Consequence	Probability	Risk Level	ALARP? Yes/no
Example											
Working in temperatures over 35º C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy.	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
Working in office for long periods	Repetetive strain injury/ sore back/eye strain	Select a consequence	Ergonomic desk, chair, keyboard and mouse. Adjustable screen	Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Driving to site	vehicle accident	Select a consequence	Fatigue management through breaks at 1 hour intervals, drive with passenger to share driving, use vehicle with high safety rating	Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Site inspection	Worker on foot hit by vehicle leading to serious injury/death	Select a consequence	Use spotter to watch traffic in line with Traffic control at work sites manual, walk on shoulder clear of traffic, park vehicle in locaation at least 3m clear of shoulder	Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Working in the sun	heat stress, heat stroke, exhaustion leading to accident or death	Select a consequence	Hydration, regular breaks in shade or air conditioning, broad brimmed hat, long sleeve shirt, long pants, work with buddy system	Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No
Working outdoors	Snake/Insect bite leading to hospitalisation or death	Select a consequence	Work in pairs, long sleeve shirt, long poants, leather boots, carry first aid kit, work in areas with adequate mobile coverage	Select a probability	Select a Risk Level	Yes or No		Select a consequence	Select a probability	Select a Risk Level	Yes or No

Step 6 - Approval				
Drafter's name:	Shaun Perkins		Draft date:	24/05/2022
Drafter's comments:	Site inspections will be completed in line with TfNSW North Region SWMS for site inspections. Vehicle used for travel is registered and comprehensively insured. PPE required is owned already. Previous experience on road works sites/ site inspections is 15 years.			
Approver's name:	Andreas Nataatmadja	Approver's title/position:	Senior Lecturer/ Project Supervisor	
Approver's comments:				
I am satisfied that the risks are as low as reasonably practicable and that the resources required will be provided.				
Approver's signature:	[redacted]		Approval date:	25/05/2022

This document is uncontrolled once printed and may not be the latest version. Access the online SRMS for the latest version. Safety Risk Management Plan V1.1

Appendix C – CIRCLY Results

Braemar Project

Original Pavement Design

FLEXIBLE PAVEMENT DESIGN - SUMMARY REPORT

Project Details

Project title: MR83 Braemar state forest Seg 3540-3550
Location:
Designer: AM
Date of design: 20 September 2019
Comments: Heavily Bound-20 years design life
Design reliability: 90%

Traffic Details

	Asphalt (SAR5)	Subgrade (SAR7)	Cemented (SAR12)
Design traffic:	2.67E+06	3.91E+06	3.05E+07

Design period: 20 years
Annual growth rate: 1.3%

Layer Details

Layer No	Thickness (mm)	Description	Material	Ev (MPa)	Sub-layer?	Lower I/F	% Vol Bitumen
1	320	Heavily Bound	Cemented	5,000	N/A	Rough	N/A
2	120	Granular Sub-base	Granular	250	yes	Rough	N/A
3	200	Fill	Sel. S/G	80	yes	Rough	N/A
4	S/Inf	Cohesive Subgrade	Subgrade	40	N/A	N/A	N/A

Load Details

Half/Full axle model: Full
Tyre contact stress: 750 kPa

Design Details

Design filename: C:\ABDULLAH\PROJECTS_Pavement\N2018027 MR83 Braemar state forest seg-3540-3550\2.2 Design\2.2 HB2.fpd
FPD software version: 5U (22 April 2015)
CIRCLY software version: 5.0i (7 July 2006)

Results

Layer No	Thickness (mm)	Description	Ev (MPa)	Ev/Eh	Poisson's Ratio	Lower I/F
1	320	Heavily Bound	5,000	1.0	0.20	Rough
2.1	24	S/L Granular	150	2.0	0.35	Rough
2.2	24	S/L Granular	132	2.0	0.35	Rough
2.3	24	S/L Granular	117	2.0	0.35	Rough
2.4	24	S/L Granular	103	2.0	0.35	Rough
2.5	24	S/L Granular	91	2.0	0.35	Rough
3.1	40	S/L Sel. S/G	80	2.0	0.35	Rough
3.2	40	S/L Sel. S/G	70	2.0	0.35	Rough
3.3	40	S/L Sel. S/G	61	2.0	0.35	Rough
3.4	40	S/L Sel. S/G	53	2.0	0.35	Rough
3.5	40	S/L Sel. S/G	46	2.0	0.35	Rough
4	S/Inf	Cohesive Subgrade	40	2.0	0.45	N/A

Layer No	Description	Failure Criterion	Max. Microstrain		Failure Reps.	Life Consumed	Pavement Life (years)
			Hor.	Vert.			
1	Heavily Bound	Fatigue	-78.17	N/A	3.14E+07	97%	20.5
2	Granular Sub-base	N/A	N/A	N/A	N/A	N/A	N/A
3	Fill	Rutting	N/A	155.8	2.70E+12	0%	>50
4	Cohesive Subgrade	Rutting	N/A	200.7	4.59E+11	0%	>50

Analysis of Original Pavement Design in CIRCLY 7.0

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force    92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                   Gear        X          Y     Scaling     Theta
   No.        ID                     No.                          Factor
    1         ESA750-Full             1       -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full             1        165.0       0.0   1.00E+00      0.00
    3         ESA750-Full             1       1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full             1       1965.0       0.0   1.00E+00      0.00
    1         SAST53                  1          0.0       0.0   1.00E+00      0.00
    2         SAST53                  1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8            Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4             Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      subsltCB8            EZZ         0.009150    7.000
    4     top      Sub_CBR4             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      320.00    Cement5000
                                           SADT(80):  7.830E-05
                                           SAST(53):  5.675E-05

    3      200.00    subsltCB8
                                           SADT(80):  1.526E-04

    4        0.00    Sub_CBR4
                                           SADT(80):  1.994E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      320.00    Cement5000            Total:     1.093E+00
                                           SAST:      5.244E-02
                                           SADT:      3.837E-01
                                           TAST:      2.018E-03
                                           TADT:      6.244E-01
                                           TRDT:      3.058E-02
                                           QADT:      2.896E-04

    2      120.00    Gran_250                              n/a

    3      200.00    subsltCB8             Total:     1.026E-06

    4        0.00    Sub_CBR4              Total:     6.675E-06
```

Braemar Project with Uniform Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load              Load             Load          Radius   Pressure/   Exponent
   No.   ID                Category         Type                   Ref. stress
    1    ESA750-Full       ESA750-Full      Vertical Force   92.1    0.75        0.00
    2    SAST53            SAST53           Vertical Force  102.4    0.80        0.00

   Load Locations:
   Location   Load              Gear        X          Y     Scaling     Theta
   No.        ID                No.                          Factor
    1         ESA750-Full        1       -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full        1        165.0       0.0   1.00E+00     0.00
    3         ESA750-Full        1       1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full        1       1965.0       0.0   1.00E+00     0.00
    1         SAST53             1          0.0       0.0   1.00E+00     0.00
    2         SAST53             1       2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      350.00    Cement5000
                                           SADT(80):  6.875E-05
                                           SAST(53):  4.901E-05

    3      200.00    subsltCB8
                                           SADT(80):  1.335E-04

    4        0.00    Sub_CBR4
                                           SADT(80):  1.765E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      350.00    Cement5000            Total:     2.278E-01
                                           SAST:      9.039E-03
                                           SADT:      8.065E-02
                                           TAST:      3.479E-04
                                           TADT:      1.312E-01
                                           TRDT:      6.427E-03
                                           QADT:      6.086E-05

    2      120.00    Gran_250                              n/a

    3      200.00    subsltCB8             Total:     4.027E-07

    4        0.00    Sub_CBR4              Total:     2.843E-06
```

Braemar Project with Uniform Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                 Load                 Load           Radius   Pressure/   Exponent
   No.   ID                   Category             Type                    Ref. stress
    1    ESA750-Full          ESA750-Full          Vertical Force   92.1    0.75        0.00
    2    SAST53               SAST53               Vertical Force  102.4    0.80        0.00

   Load Locations:
   Location   Load                Gear         X          Y     Scaling    Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1        -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full          1         165.0       0.0   1.00E+00     0.00
    3         ESA750-Full          1        1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full          1        1965.0       0.0   1.00E+00     0.00
    1         SAST53               1           0.0       0.0   1.00E+00     0.00
    2         SAST53               1        2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8            Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4             Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      subsltCB8            EZZ         0.009150    7.000
    4     top      Sub_CBR4             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle      Unitless
   No.               ID                             Strain
    1      340.00    Cement5000
                                          SADT(80): 7.173E-05
                                          SAST(53): 5.141E-05

    3      200.00    subsltCB8
                                          SADT(80): 1.394E-04

    4        0.00    Sub_CBR4
                                          SADT(80): 1.836E-04

Results:

   Layer  Thickness  Material             Axle      CDF
   No.               ID                   Group
    1      340.00    Cement5000           Total:    3.796E-01
                                          SAST:     1.601E-02
                                          SADT:     1.341E-01
                                          TAST:     6.161E-04
                                          TADT:     2.181E-01
                                          TRDT:     1.068E-02
                                          QADT:     1.012E-04

    2      120.00    Gran_250                             n/a

    3      200.00    subsltCB8            Total:    5.453E-07

    4        0.00    Sub_CBR4             Total:    3.750E-06
```

Braemar Project with Uniform Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                    Load                    Load              Radius    Pressure/     Exponent
   No.    ID                      Category                Type                        Ref. stress
    1     ESA750-Full             ESA750-Full             Vertical Force      92.1      0.75          0.00
    2     SAST53                  SAST53                  Vertical Force     102.4      0.80          0.00

   Load Locations:
   Location    Load                    Gear          X            Y     Scaling        Theta
   No.         ID                      No.                              Factor
    1          ESA750-Full              1         -165.0          0.0   1.00E+00        0.00
    2          ESA750-Full              1          165.0          0.0   1.00E+00        0.00
    3          ESA750-Full              1         1635.0          0.0   1.00E+00        0.00
    4          ESA750-Full              1         1965.0          0.0   1.00E+00        0.00
    1          SAST53                   1            0.0          0.0   1.00E+00        0.00
    2          SAST53                   1         2130.0          0.0   1.00E+00        0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus     P.Ratio
   No.    i/face   ID                                (or Ev)     (or vvh)  F           Eh          vh
    1     rough    Cement5000             Iso.       5.00E+03    0.20
    2     rough    Gran_250               Aniso.     2.50E+02    0.35      1.85E+02    1.25E+02    0.35
    3     rough    subsltCB8              Aniso.     8.00E+01    0.45      5.52E+01    4.00E+01    0.45
    4     rough    Sub_CBR4               Aniso.     4.00E+01    0.45      2.76E+01    2.00E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.    Perform.   Shift
   No.             ID                                Constant    Exponent   Factor
    1     bottom   Cement5000             ETH         0.000263    12.000
    3     top      subsltCB8              EZZ         0.009150     7.000
    4     top      Sub_CBR4               EZZ         0.009150     7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                 Axle       Unitless
   No.               ID                                  Strain
    1      330.00    Cement5000
                                              SADT(80):  7.490E-05
                                              SAST(53):  5.398E-05

    3      200.00    subsltCB8
                                              SADT(80):  1.457E-04

    4        0.00    Sub_CBR4
                                              SADT(80):  1.912E-04

Results:

   Layer  Thickness  Material                 Axle       CDF
   No.               ID                       Group
    1      330.00    Cement5000               Total:     6.403E-01
                                              SAST:      2.876E-02
                                              SADT:      2.254E-01
                                              TAST:      1.107E-03
                                              TADT:      3.668E-01
                                              TRDT:      1.797E-02
                                              QADT:      1.701E-04

    2      120.00    Gran_250                                n/a

    3      200.00    subsltCB8                Total:     7.446E-07

    4        0.00    Sub_CBR4                 Total:     4.984E-06
```

Braemar Project with Uniform Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X           Y     Scaling      Theta
   No.         ID                    No.                             Factor
    1          ESA750-Full            1        -165.0        0.0    1.00E+00       0.00
    2          ESA750-Full            1         165.0        0.0    1.00E+00       0.00
    3          ESA750-Full            1        1635.0        0.0    1.00E+00       0.00
    4          ESA750-Full            1        1965.0        0.0    1.00E+00       0.00
    1          SAST53                 1           0.0        0.0    1.00E+00       0.00
    2          SAST53                 1        2130.0        0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subs1tCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      subs1tCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      320.00    Cement5000
                                            SADT(80):  7.830E-05
                                            SAST(53):  5.675E-05
    3      200.00    subs1tCB8
                                            SADT(80):  1.526E-04
    4        0.00    Sub_CBR4
                                            SADT(80):  1.994E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      320.00    Cement5000             Total:     1.093E+00
                                            SAST:      5.244E-02
                                            SADT:      3.837E-01
                                            TAST:      2.018E-03
                                            TADT:      6.244E-01
                                            TRDT:      3.058E-02
                                            QADT:      2.896E-04

    2      120.00    Gran_250                              n/a

    3      200.00    subs1tCB8              Total:     1.026E-06

    4        0.00    Sub_CBR4               Total:     6.675E-06
```

Braemar Project with Uniform Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                 Load                 Load            Radius    Pressure/    Exponent
   No.   ID                   Category             Type                      Ref. stress
    1    ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2    SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                   Gear        X          Y      Scaling     Theta
   No.         ID                     No.                           Factor
    1          ESA750-Full             1       -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full             1        165.0       0.0   1.00E+00      0.00
    3          ESA750-Full             1       1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full             1       1965.0       0.0   1.00E+00      0.00
    1          SAST53                  1          0.0       0.0   1.00E+00      0.00
    2          SAST53                  1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.      5.00E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8              Aniso.    8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4               Aniso.    4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   Cement5000             ETH        0.000263   12.000
    3     top      subsltCB8              EZZ        0.009150    7.000
    4     top      Sub_CBR4               EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor       Type
    1      2.00       Cement Stabilised
    3      1.00       Subgrade (Selected Material) (Austroads 2017)
    4      1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      310.00    Cement5000
                                            SADT(80):  8.193E-05
                                            SAST(53):  5.974E-05

    3      200.00    subsltCB8
                                            SADT(80):  1.599E-04

    4        0.00    Sub_CBR4
                                            SADT(80):  2.081E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      310.00    Cement5000             Total:     1.892E+00
                                            SAST:      9.712E-02
                                            SADT:      6.615E-01
                                            TAST:      3.738E-03
                                            TADT:      1.076E+00
                                            TRDT:      5.271E-02
                                            QADT:      4.992E-04

    2      120.00    Gran_250                              n/a

    3      200.00    subsltCB8              Total:     1.426E-06

    4        0.00    Sub_CBR4               Total:     9.013E-06
```

Braemar Project with Uniform Characteristics – 300 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subsltCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	subsltCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	300.00	Cement5000	SADT(80):	8.583E-05
			SAST(53):	6.297E-05
3	200.00	subsltCB8	SADT(80):	1.679E-04
4	0.00	Sub_CBR4	SADT(80):	2.175E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	300.00	Cement5000	Total:	3.319E+00
			SAST:	1.828E-01
			SADT:	1.156E+00
			TAST:	7.036E-03
			TADT:	1.880E+00
			TRDT:	9.209E-02
			QADT:	8.720E-04
2	120.00	Gran_250		n/a
3	200.00	subsltCB8	Total:	2.003E-06
4	0.00	Sub_CBR4	Total:	1.228E-05

Braemar Project with Uniform Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load               Gear          X           Y     Scaling      Theta
   No.        ID                 No.                             Factor
    1         ESA750-Full         1         -165.0         0.0   1.00E+00      0.00
    2         ESA750-Full         1          165.0         0.0   1.00E+00      0.00
    3         ESA750-Full         1         1635.0         0.0   1.00E+00      0.00
    4         ESA750-Full         1         1965.0         0.0   1.00E+00      0.00
    1         SAST53              1            0.0         0.0   1.00E+00      0.00
    2         SAST53              1         2130.0         0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.       5.00E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8              Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4               Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.  Shift
   No.             ID                                Constant   Exponent  Factor
    1     bottom   Cement5000             ETH         0.000263   12.000
    3     top      subsltCB8              EZZ         0.009150    7.000
    4     top      Sub_CBR4               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1      290.00    Cement5000
                                             SADT(80):  9.002E-05
                                             SAST(53):  6.647E-05

    3      200.00    subsltCB8
                                             SADT(80):  1.765E-04

    4        0.00    Sub_CBR4
                                             SADT(80):  2.276E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1      290.00    Cement5000              Total:     5.907E+00
                                             SAST:      3.500E-01
                                             SADT:      2.047E+00
                                             TAST:      1.347E-02
                                             TADT:      3.331E+00
                                             TRDT:      1.631E-01
                                             QADT:      1.545E-03

    2      120.00    Gran_250                                 n/a

    3      200.00    subsltCB8               Total:     2.843E-06

    4        0.00    Sub_CBR4                Total:     1.688E-05
```

Braemar Project with Uniform Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force    92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                   Gear        X           Y      Scaling     Theta
   No.        ID                     No.                            Factor
    1         ESA750-Full             1       -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full             1        165.0        0.0    1.00E+00      0.00
    3         ESA750-Full             1       1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full             1       1965.0        0.0    1.00E+00      0.00
    1         SAST53                  1          0.0        0.0    1.00E+00      0.00
    2         SAST53                  1       2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.       5.00E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8              Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4               Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.  Shift
   No.             ID                                Constant   Exponent  Factor
    1     bottom   Cement5000             ETH         0.000263   12.000
    3     top      subsltCB8              EZZ         0.009150    7.000
    4     top      Sub_CBR4               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1       280.00   Cement5000
                                             SADT(80): 9.453E-05
                                             SAST(53): 7.028E-05
    3       200.00   subsltCB8
                                             SADT(80): 1.858E-04
    4         0.00   Sub_CBR4
                                             SADT(80): 2.386E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1       280.00   Cement5000              Total:     1.067E+01
                                             SAST:      6.822E-01
                                             SADT:      3.681E+00
                                             TAST:      2.626E-02
                                             TADT:      5.989E+00
                                             TRDT:      2.933E-01
                                             QADT:      2.778E-03

    2       120.00   Gran_250                                n/a

    3       200.00   subsltCB8               Total:     4.082E-06

    4         0.00   Sub_CBR4                Total:     2.345E-05
```

Braemar Project with Uniform Characteristics – 270 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subsltCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	subsltCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	270.00	Cement5000		
			SADT(80):	9.939E-05
			SAST(53):	7.441E-05
3	200.00	subsltCB8		
			SADT(80):	1.961E-04
4	0.00	Sub_CBR4		
			SADT(80):	2.504E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	270.00	Cement5000	Total:	1.961E+01
			SAST:	1.354E+00
			SADT:	6.722E+00
			TAST:	5.213E-02
			TADT:	1.094E+01
			TRDT:	5.357E-01
			QADT:	5.072E-03
2	120.00	Gran_250		n/a
3	200.00	subsltCB8	Total:	5.936E-06
4	0.00	Sub_CBR4	Total:	3.294E-05

Braemar Project with Variable Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load               Gear        X          Y      Scaling     Theta
   No.        ID                 No.                           Factor
    1         ESA750-Full         1       -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full         1        165.0       0.0    1.00E+00     0.00
    3         ESA750-Full         1       1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full         1       1965.0       0.0    1.00E+00     0.00
    1         SAST53              1          0.0       0.0    1.00E+00     0.00
    2         SAST53              1       2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement4545           Iso.       4.55E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8            Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4             Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement4545           ETH         0.000275   12.000
    3     top      subsltCB8            EZZ         0.009150    7.000
    4     top      Sub_CBR4             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      350.00    Cement4545
                                           SADT(80):  7.434E-05
                                           SAST(53):  5.312E-05
    3      200.00    subsltCB8
                                           SADT(80):  1.413E-04
    4        0.00    Sub_CBR4
                                           SADT(80):  1.867E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      350.00    Cement4545            Total:     3.410E-01
                                           SAST:      1.391E-02
                                           SADT:      1.206E-01
                                           TAST:      5.352E-04
                                           TADT:      1.962E-01
                                           TRDT:      9.611E-03
                                           QADT:      9.101E-05

    2      100.00    Gran_250                              n/a

    3      200.00    subsltCB8             Total:     5.986E-07

    4        0.00    Sub_CBR4              Total:     4.220E-06
```

Braemar Project with Variable Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                    Load                   Load             Radius    Pressure/    Exponent
   No.   ID                      Category               Type                       Ref. stress
    1    ESA750-Full             ESA750-Full            Vertical Force     92.1     0.75          0.00
    2    SAST53                  SAST53                 Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                  Gear         X          Y     Scaling     Theta
   No.        ID                    No.                           Factor
    1         ESA750-Full            1        -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full            1         165.0       0.0   1.00E+00     0.00
    3         ESA750-Full            1        1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full            1        1965.0       0.0   1.00E+00     0.00
    1         SAST53                 1           0.0       0.0   1.00E+00     0.00
    2         SAST53                 1        2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement4697            Iso.       4.70E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement4697            ETH         0.000271   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      340.00    Cement4697
                                           SADT(80):  7.541E-05
                                           SAST(53):  5.413E-05
    3      200.00    subsltCB8
                                           SADT(80):  1.447E-04
    4        0.00    Sub_CBR4
                                           SADT(80):  1.902E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      340.00    Cement4697            Total:     4.833E-01
                                           SAST:      2.077E-02
                                           SADT:      1.705E-01
                                           TAST:      7.994E-04
                                           TADT:      2.775E-01
                                           TRDT:      1.359E-02
                                           QADT:      1.287E-04

    2      110.00    Gran_250                             n/a

    3      200.00    subsltCB8             Total:     7.072E-07

    4        0.00    Sub_CBR4              Total:     4.810E-06
```

Braemar Project with Variable Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

    ID: NSWPresumeRural
    Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
    ESA/HVAG: 1.068

Details of Load Groups:

    Load   Load                   Load                   Load             Radius    Pressure/    Exponent
    No.    ID                     Category               Type                       Ref. stress
     1     ESA750-Full            ESA750-Full            Vertical Force     92.1     0.75          0.00
     2     SAST53                 SAST53                 Vertical Force    102.4     0.80          0.00

    Load Locations:
    Location    Load                   Gear        X          Y      Scaling      Theta
    No.         ID                     No.                           Factor
     1          ESA750-Full             1       -165.0       0.0    1.00E+00      0.00
     2          ESA750-Full             1        165.0       0.0    1.00E+00      0.00
     3          ESA750-Full             1       1635.0       0.0    1.00E+00      0.00
     4          ESA750-Full             1       1965.0       0.0    1.00E+00      0.00
     1          SAST53                  1          0.0       0.0    1.00E+00      0.00
     2          SAST53                  1       2130.0       0.0    1.00E+00      0.00

Details of Layered System:

    ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

    Layer  Lower    Material               Isotropy   Modulus    P.Ratio
    No.    i/face   ID                                (or Ev)    (or vvh)  F           Eh          vh
     1     rough    Cement4848             Iso.       4.85E+03   0.20
     2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02    1.25E+02    0.35
     3     rough    subsltCB8              Aniso.     8.00E+01   0.45      5.52E+01    4.00E+01    0.45
     4     rough    Sub_CBR4               Aniso.     4.00E+01   0.45      2.76E+01    2.00E+01    0.45

    Performance Relationships:
    Layer  Location Material               Component  Perform.   Perform.   Shift
    No.             ID                                Constant   Exponent   Factor
     1     bottom   Cement4848             ETH         0.000267   12.000
     3     top      subsltCB8              EZZ         0.009150    7.000
     4     top      Sub_CBR4               EZZ         0.009150    7.000

    Reliability Factors:
    Project Reliability: Austroads 90%
    Layer  Reliability  Material
     No.   Factor        Type
     1      2.00        Cement Stabilised
     3      1.00        Subgrade (Selected Material) (Austroads 2017)
     4      1.00        Subgrade (Austroads 2017)

    Details of Layers to be sublayered:
    Layer no.  2:  Austroads (2004) sublayering
    Layer no.  3:  Austroads (2004) sublayering

Strains:

    Layer  Thickness  Material                Axle       Unitless
    No.               ID                                 Strain
     1      330.00    Cement4848
                                              SADT(80):  7.661E-05
                                              SAST(53):  5.526E-05

     3      200.00    subsltCB8
                                              SADT(80):  1.484E-04

     4        0.00    Sub_CBR4
                                              SADT(80):  1.941E-04

Results:

    Layer  Thickness  Material                Axle       CDF
    No.               ID                      Group
     1      330.00    Cement4848              Total:     7.004E-01
                                              SAST:      3.180E-02
                                              SADT:      2.465E-01
                                              TAST:      1.224E-03
                                              TADT:      4.011E-01
                                              TRDT:      1.964E-02
                                              QADT:      1.860E-04

     2      120.00    Gran_250                                n/a

     3      200.00    subsltCB8               Total:     8.464E-07

     4        0.00    Sub_CBR4                Total:     5.543E-06
```

Braemar Project with Variable Characteristics – 320 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subsltCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	subsltCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	320.00	Cement5000	SADT(80):	7.793E-05
			SAST(53):	5.650E-05
3	200.00	subsltCB8	SADT(80):	1.525E-04
4	0.00	Sub_CBR4	SADT(80):	1.984E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	320.00	Cement5000	Total:	1.034E+00
			SAST:	4.970E-02
			SADT:	3.628E-01
			TAST:	1.913E-03
			TADT:	5.903E-01
			TRDT:	2.891E-02
			QADT:	2.738E-04
2	130.00	Gran_250		n/a
3	200.00	subsltCB8	Total:	1.024E-06
4	0.00	Sub_CBR4	Total:	6.449E-06

Braemar Project with Variable Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y      Scaling      Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1         -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full           1          165.0       0.0    1.00E+00      0.00
    3         ESA750-Full           1         1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full           1         1965.0       0.0    1.00E+00      0.00
    1         SAST53                1            0.0       0.0    1.00E+00      0.00
    2         SAST53                1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5152            Iso.       5.15E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5152            ETH         0.000259   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor         Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      310.00    Cement5152
                                           SADT(80):  7.939E-05
                                           SAST(53):  5.785E-05
    3      200.00    subsltCB8
                                           SADT(80):  1.570E-04
    4        0.00    Sub_CBR4
                                           SADT(80):  2.030E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      310.00    Cement5152            Total:     1.557E+00
                                           SAST:      7.945E-02
                                           SADT:      5.444E-01
                                           TAST:      3.058E-03
                                           TADT:      8.859E-01
                                           TRDT:      4.339E-02
                                           QADT:      4.109E-04

    2      140.00    Gran_250                              n/a

    3      200.00    subsltCB8             Total:     1.254E-06

    4        0.00    Sub_CBR4              Total:     7.579E-06
```

Braemar Project with Variable Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                 Load                 Load              Radius    Pressure/    Exponent
   No.   ID                   Category             Type                        Ref. stress
    1    ESA750-Full          ESA750-Full          Vertical Force     92.1      0.75         0.00
    2    SAST53               SAST53               Vertical Force    102.4      0.80         0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1         -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1          165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1         1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1         1965.0       0.0   1.00E+00      0.00
    1         SAST53                1            0.0       0.0   1.00E+00      0.00
    2         SAST53                1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material              Isotropy  Modulus    P.Ratio
   No.    i/face  ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough   Cement5303            Iso.      5.30E+03   0.20
    2     rough   Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough   subsltCB8             Aniso.    8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough   Sub_CBR4              Aniso.    4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5303           ETH         0.000255   12.000
    3     top      subsltCB8            EZZ         0.009150    7.000
    4     top      Sub_CBR4             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      300.00    Cement5303
                                          SADT(80): 8.099E-05
                                          SAST(53): 5.935E-05

    3      200.00    subsltCB8
                                          SADT(80): 1.619E-04
    4        0.00    Sub_CBR4
                                          SADT(80): 2.081E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      300.00    Cement5303           Total:     2.394E+00
                                          SAST:      1.301E-01
                                          SADT:      8.344E-01
                                          TAST:      5.007E-03
                                          TADT:      1.358E+00
                                          TRDT:      6.649E-02
                                          QADT:      6.297E-04

    2      150.00    Gran_250                             n/a

    3      200.00    subsltCB8            Total:     1.556E-06

    4        0.00    Sub_CBR4             Total:     9.002E-06
```

Braemar Project with Variable Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                 Load            Radius     Pressure/    Exponent
   No.    ID                    Category             Type                       Ref. stress
    1     ESA750-Full           ESA750-Full          Vertical Force    92.1      0.75          0.00
    2     SAST53                SAST53               Vertical Force   102.4      0.80          0.00

   Load Locations:
   Location   Load                 Gear         X          Y      Scaling      Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full           1         165.0       0.0    1.00E+00      0.00
    3         ESA750-Full           1        1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full           1        1965.0       0.0    1.00E+00      0.00
    1         SAST53                1           0.0       0.0    1.00E+00      0.00
    2         SAST53                1        2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F          Eh         vh
    1     rough    Cement5455            Iso.      5.46E+03  0.20
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.    8.00E+01  0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.    4.00E+01  0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.  Perform.  Shift
   No.             ID                              Constant  Exponent  Factor
    1     bottom   Cement5455            ETH        0.000251  12.000
    3     top      subsltCB8             EZZ        0.009150   7.000
    4     top      Sub_CBR4              EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      290.00    Cement5455
                                          SADT(80):  8.273E-05
                                          SAST(53):  6.097E-05

    3      200.00    subsltCB8
                                          SADT(80):  1.672E-04

    4        0.00    Sub_CBR4
                                          SADT(80):  2.135E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      290.00    Cement5455           Total:     3.748E+00
                                          SAST:      2.174E-01
                                          SADT:      1.301E+00
                                          TAST:      8.367E-03
                                          TADT:      2.117E+00
                                          TRDT:      1.037E-01
                                          QADT:      9.818E-04

    2      160.00    Gran_250                             n/a

    3      200.00    subsltCB8            Total:     1.951E-06

    4        0.00    Sub_CBR4             Total:     1.079E-05
```

Braemar Project with Variable Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load              Radius    Pressure/    Exponent
   No.    ID                    Category              Type                        Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force      92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force     102.4     0.80          0.00

   Load Locations:
   Location    Load                 Gear          X           Y      Scaling       Theta
   No.         ID                   No.                              Factor
    1          ESA750-Full           1        -165.0        0.0    1.00E+00       0.00
    2          ESA750-Full           1         165.0        0.0    1.00E+00       0.00
    3          ESA750-Full           1        1635.0        0.0    1.00E+00       0.00
    4          ESA750-Full           1        1965.0        0.0    1.00E+00       0.00
    1          SAST53                1           0.0        0.0    1.00E+00       0.00
    2          SAST53                1        2130.0        0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5758            Iso.       5.76E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5758            ETH         0.000243   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor       Type
    1      2.00       Cement Stabilised
    3      1.00       Subgrade (Selected Material) (Austroads 2017)
    4      1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1       280.00   Cement5758
                                           SADT(80):  8.303E-05
                                           SAST(53):  6.151E-05

    3       200.00   subsltCB8
                                           SADT(80):  1.705E-04

    4         0.00   Sub_CBR4
                                           SADT(80):  2.168E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1       280.00   Cement5758            Total:     5.800E+00
                                           SAST:      3.562E-01
                                           SADT:      2.006E+00
                                           TAST:      1.371E-02
                                           TADT:      3.263E+00
                                           TRDT:      1.598E-01
                                           QADT:      1.513E-03

    2       170.00   Gran_250                               n/a

    3       200.00   subsltCB8             Total:     2.231E-06

    4         0.00   Sub_CBR4              Total:     1.199E-05
```

Braemar Project with Variable Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius     Pressure/    Exponent
   No.    ID                     Category               Type                       Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location  Load                   Gear        X           Y      Scaling      Theta
   No.       ID                     No.                            Factor
    1        ESA750-Full             1       -165.0        0.0    1.00E+00      0.00
    2        ESA750-Full             1        165.0        0.0    1.00E+00      0.00
    3        ESA750-Full             1       1635.0        0.0    1.00E+00      0.00
    4        ESA750-Full             1       1965.0        0.0    1.00E+00      0.00
    1        SAST53                  1          0.0        0.0    1.00E+00      0.00
    2        SAST53                  1       2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5909            Iso.       5.91E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5909            ETH         0.000238   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1      270.00    Cement5909
                                           SADT(80):  8.509E-05
                                           SAST(53):  6.344E-05

    3      200.00    subsltCB8
                                           SADT(80):  1.768E-04

    4        0.00    Sub_CBR4
                                           SADT(80):  2.232E-04

Results:

   Layer  Thickness  Material              Axle        CDF
   No.               ID                    Group
    1      270.00    Cement5909            Total:      1.004E+01
                                           SAST:       6.620E-01
                                           SADT:       3.455E+00
                                           TAST:       2.548E-02
                                           TADT:       5.622E+00
                                           TRDT:       2.753E-01
                                           QADT:       2.607E-03

    2      180.00    Gran_250                                n/a

    3      200.00    subsltCB8             Total:      2.880E-06

    4        0.00    Sub_CBR4              Total:      1.471E-05
```

Braemar Project with 105% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1         -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1          165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1         1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1         1965.0       0.0   1.00E+00      0.00
    1         SAST53                1            0.0       0.0   1.00E+00      0.00
    2         SAST53                1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement6372            Iso.      6.37E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.    8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.    4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   cement6372            ETH        0.000226   12.000
    3     top      subsltCB8             EZZ        0.009150    7.000
    4     top      Sub_CBR4              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      322.00    cement6372
                                            SADT(80):  6.470E-05
                                            SAST(53):  4.651E-05

    3      200.00    subsltCB8
                                            SADT(80):  1.309E-04

    4        0.00    Sub_CBR4
                                            SADT(80):  1.749E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      322.00    cement6372             Total:     6.807E-01
                                            SAST:      2.968E-02
                                            SADT:      2.400E-01
                                            TAST:      1.142E-03
                                            TADT:      3.906E-01
                                            TRDT:      1.913E-02
                                            QADT:      1.811E-04

    2      128.00    Gran_250                              n/a

    3      200.00    subsltCB8              Total:     3.520E-07

    4        0.00    Sub_CBR4               Total:     2.669E-06
```

Braemar Project with 104% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load              Radius    Pressure/     Exponent
   No.    ID                   Category             Type                        Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1      0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4      0.80          0.00

   Load Locations:
   Location    Load                Gear          X           Y      Scaling       Theta
   No.         ID                  No.                              Factor
    1          ESA750-Full          1         -165.0        0.0    1.00E+00       0.00
    2          ESA750-Full          1          165.0        0.0    1.00E+00       0.00
    3          ESA750-Full          1         1635.0        0.0    1.00E+00       0.00
    4          ESA750-Full          1         1965.0        0.0    1.00E+00       0.00
    1          SAST53               1            0.0        0.0    1.00E+00       0.00
    2          SAST53               1         2130.0        0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower     Material              Isotropy   Modulus    P.Ratio
   No.    i/face    ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough     cement6098            Iso.       6.10E+03   0.20
    2     rough     Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough     subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough     Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement6098             ETH         0.000233   12.000
    3     top      subsltCB8              EZZ         0.009150    7.000
    4     top      Sub_CBR4               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      322.00    cement6098
                                           SADT(80):  6.684E-05
                                           SAST(53):  4.811E-05

    3      200.00    subsltCB8
                                           SADT(80):  1.344E-04

    4        0.00    Sub_CBR4
                                           SADT(80):  1.787E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      322.00    cement6098            Total:     6.981E-01
                                           SAST:      3.088E-02
                                           SADT:      2.460E-01
                                           TAST:      1.189E-03
                                           TADT:      4.002E-01
                                           TRDT:      1.960E-02
                                           QADT:      1.856E-04

    2      128.00    Gran_250                              n/a

    3      200.00    subsltCB8             Total:     4.225E-07

    4        0.00    Sub_CBR4              Total:     3.098E-06
```

Braemar Project with 103% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1         -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1          165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1         1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1         1965.0       0.0   1.00E+00      0.00
    1         SAST53                1            0.0       0.0   1.00E+00      0.00
    2         SAST53                1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5823             Iso.      5.82E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8              Aniso.    8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4               Aniso.    4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement5823             ETH         0.000241   12.000
    3     top      subsltCB8              EZZ         0.009150    7.000
    4     top      Sub_CBR4               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1       322.00   cement5823
                                            SADT(80):  6.916E-05
                                            SAST(53):  4.984E-05

    3       200.00   subsltCB8
                                            SADT(80):  1.381E-04

    4         0.00   Sub_CBR4
                                            SADT(80):  1.828E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1       322.00   cement5823             Total:     7.010E-01
                                            SAST:      3.151E-02
                                            SADT:      2.468E-01
                                            TAST:      1.213E-03
                                            TADT:      4.016E-01
                                            TRDT:      1.967E-02
                                            QADT:      1.863E-04

    2       128.00   Gran_250                               n/a

    3       200.00   subsltCB8              Total:     5.117E-07

    4         0.00   Sub_CBR4               Total:     3.633E-06
```

Braemar Project with 102% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load             Radius    Pressure/     Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X          Y      Scaling     Theta
   No.         ID                    No.                             Factor
    1          ESA750-Full            1        -165.0        0.0    1.00E+00      0.00
    2          ESA750-Full            1         165.0        0.0    1.00E+00      0.00
    3          ESA750-Full            1        1635.0        0.0    1.00E+00      0.00
    4          ESA750-Full            1        1965.0        0.0    1.00E+00      0.00
    1          SAST53                 1           0.0        0.0    1.00E+00      0.00
    2          SAST53                 1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5549            Iso.       5.55E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5549            ETH         0.000248   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor       Type
    1      2.00       Cement Stabilised
    3      1.00       Subgrade (Selected Material) (Austroads 2017)
    4      1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering
   Layer no.   3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      322.00    cement5549
                                           SADT(80):  7.165E-05
                                           SAST(53):  5.171E-05
    3      200.00    subsltCB8
                                           SADT(80):  1.421E-04
    4        0.00    Sub_CBR4
                                           SADT(80):  1.872E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      322.00    cement5549            Total:     7.611E-01
                                           SAST:      3.478E-02
                                           SADT:      2.678E-01
                                           TAST:      1.339E-03
                                           TADT:      4.357E-01
                                           TRDT:      2.134E-02
                                           QADT:      2.021E-04

    2      128.00    Gran_250                               n/a

    3      200.00    subsltCB8             Total:     6.247E-07

    4        0.00    Sub_CBR4              Total:     4.288E-06
```

Braemar Project with 101% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5274	Iso.	5.27E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subs1tCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5274	ETH	0.000256	12.000	
3	top	subs1tCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	322.00	cement5274	SADT(80):	7.437E-05
			SAST(53):	5.376E-05
3	200.00	subs1tCB8	SADT(80):	1.465E-04
4	0.00	Sub_CBR4	SADT(80):	1.919E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	322.00	cement5274	Total:	8.133E-01
			SAST:	3.784E-02
			SADT:	2.859E-01
			TAST:	1.456E-03
			TADT:	4.651E-01
			TRDT:	2.278E-02
			QADT:	2.157E-04
2	128.00	Gran_250		n/a
3	200.00	subs1tCB8	Total:	7.708E-07
4	0.00	Sub_CBR4	Total:	5.104E-06

Braemar Project with 100% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                 Load            Radius    Pressure/    Exponent
   No.    ID                     Category             Type                      Ref. stress
    1     ESA750-Full            ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53                 SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X            Y      Scaling     Theta
   No.         ID                    No.                               Factor
    1          ESA750-Full            1         -165.0         0.0    1.00E+00      0.00
    2          ESA750-Full            1          165.0         0.0    1.00E+00      0.00
    3          ESA750-Full            1         1635.0         0.0    1.00E+00      0.00
    4          ESA750-Full            1         1965.0         0.0    1.00E+00      0.00
    1          SAST53                 1            0.0         0.0    1.00E+00      0.00
    2          SAST53                 1         2130.0         0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh          vh
    1     rough    Cement5000             Iso.       5.00E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    subsltCB8              Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01    0.45
    4     rough    Sub_CBR4               Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   Cement5000             ETH         0.000263   12.000
    3     top      subsltCB8              EZZ         0.009150    7.000
    4     top      Sub_CBR4               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1      322.00    Cement5000
                                             SADT(80):  7.760E-05
                                             SAST(53):  5.618E-05

    3      200.00    subsltCB8
                                             SADT(80):  1.512E-04

    4        0.00    Sub_CBR4
                                             SADT(80):  1.977E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1      322.00    Cement5000              Total:     9.814E-01
                                             SAST:      4.644E-02
                                             SADT:      3.447E-01
                                             TAST:      1.788E-03
                                             TADT:      5.608E-01
                                             TRDT:      2.747E-02
                                             QADT:      2.601E-04

    2      120.00    Gran_250                               n/a

    3      200.00    subsltCB8               Total:     9.613E-07

    4        0.00    Sub_CBR4                Total:     6.292E-06
```

Braemar Project with 99% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/     Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                 Gear          X           Y      Scaling      Theta
   No.         ID                   No.                              Factor
    1          ESA750-Full           1          -165.0         0.0   1.00E+00      0.00
    2          ESA750-Full           1           165.0         0.0   1.00E+00      0.00
    3          ESA750-Full           1          1635.0         0.0   1.00E+00      0.00
    4          ESA750-Full           1          1965.0         0.0   1.00E+00      0.00
    1          SAST53                1             0.0         0.0   1.00E+00      0.00
    2          SAST53                1          2130.0         0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4726            Iso.       4.73E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4726            ETH         0.000271   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Selected Material) (Austroads 2017)
    4       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle      Unitless
   No.               ID                              Strain
    1       322.00   cement4726
                                           SADT(80): 8.085E-05
                                           SAST(53): 5.863E-05

    3       200.00   subsltCB8
                                           SADT(80): 1.563E-04

    4         0.00   Sub_CBR4
                                           SADT(80): 2.032E-04

Results:

   Layer  Thickness  Material              Axle      CDF
   No.               ID                    Group
    1       322.00   cement4726            Total:    1.122E+00
                                           SAST:     5.417E-02
                                           SADT:     3.935E-01
                                           TAST:     2.085E-03
                                           TADT:     6.403E-01
                                           TRDT:     3.136E-02
                                           QADT:     2.970E-04

    2       120.00   Gran_250                             n/a

    3       200.00   subsltCB8             Total:    1.214E-06

    4         0.00   Sub_CBR4              Total:    7.631E-06
```

Braemar Project with 98% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement4451	Iso.	4.45E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subsltCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement4451	ETH	0.000278	12.000	
3	top	subsltCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	322.00	cement4451		
			SADT(80):	8.443E-05
			SAST(53):	6.135E-05
3	200.00	subsltCB8		
			SADT(80):	1.619E-04
4	0.00	Sub_CBR4		
			SADT(80):	2.092E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	322.00	cement4451	Total:	1.392E+00
			SAST:	6.871E-02
			SADT:	4.878E-01
			TAST:	2.645E-03
			TADT:	7.937E-01
			TRDT:	3.887E-02
			QADT:	3.681E-04
2	120.00	Gran_250		n/a
3	200.00	subsltCB8	Total:	1.555E-06
4	0.00	Sub_CBR4	Total:	9.359E-06

Braemar Project with 97% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement4177	Iso.	4.42E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subsltCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement4177	ETH	0.000279	12.000	
3	top	subsltCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	322.00	cement4177	SADT(80):	8.490E-05
			SAST(53):	6.171E-05
3	200.00	subsltCB8	SADT(80):	1.626E-04
4	0.00	Sub_CBR4	SADT(80):	2.100E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	322.00	cement4177	Total:	1.425E+00
			SAST:	7.054E-02
			SADT:	4.993E-01
			TAST:	2.715E-03
			TADT:	8.124E-01
			TRDT:	3.979E-02
			QADT:	3.768E-04
2	120.00	Gran_250		n/a
3	200.00	subsltCB8	Total:	1.605E-06
4	0.00	Sub_CBR4	Total:	9.606E-06

Braemar Project with 96% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius     Pressure/     Exponent
   No.    ID                     Category               Type                       Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1     0.75           0.00
    2     SAST53                 SAST53                 Vertical Force    102.4     0.80           0.00

   Load Locations:
   Location   Load                    Gear        X           Y        Scaling     Theta
   No.        ID                      No.                              Factor
    1         ESA750-Full              1       -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full              1        165.0        0.0    1.00E+00      0.00
    3         ESA750-Full              1       1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full              1       1965.0        0.0    1.00E+00      0.00
    1         SAST53                   1          0.0        0.0    1.00E+00      0.00
    2         SAST53                   1       2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus     P.Ratio
   No.    i/face   ID                                (or Ev)     (or vvh)  F           Eh          vh
    1     rough    cement3902             Iso.       3.90E+03    0.20
    2     rough    Gran_250               Aniso.     2.50E+02    0.35      1.85E+02    1.25E+02    0.35
    3     rough    subsltCB8              Aniso.     8.00E+01    0.45      5.52E+01    4.00E+01    0.45
    4     rough    Sub_CBR4               Aniso.     4.00E+01    0.45      2.76E+01    2.00E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.    Perform.    Shift
   No.             ID                                Constant    Exponent    Factor
    1     bottom   cement3902             ETH         0.000293    12.000
    3     top      subsltCB8              EZZ         0.009150     7.000
    4     top      Sub_CBR4               EZZ         0.009150     7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      322.00    cement3902
                                           SADT(80):  9.279E-05
                                           SAST(53):  6.772E-05
    3      200.00    subsltCB8
                                           SADT(80):  1.749E-04
    4        0.00    Sub_CBR4
                                           SADT(80):  2.230E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      322.00    cement3902            Total:     2.307E+00
                                           SAST:      1.196E-01
                                           SADT:      8.062E-01
                                           TAST:      4.604E-03
                                           TADT:      1.312E+00
                                           TRDT:      6.425E-02
                                           QADT:      6.084E-04

    2      120.00    Gran_250                              n/a

    3      200.00    subsltCB8             Total:     2.671E-06

    4        0.00    Sub_CBR4              Total:     1.461E-05
```

Braemar Project with 95% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load              Radius    Pressure/    Exponent
   No.    ID                    Category              Type                        Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1      0.75         0.00
    2     SAST53                SAST53                Vertical Force    102.4      0.80         0.00

   Load Locations:
   Location    Load                 Gear          X          Y      Scaling     Theta
   No.         ID                   No.                             Factor
    1          ESA750-Full           1        -165.0        0.0   1.00E+00     0.00
    2          ESA750-Full           1         165.0        0.0   1.00E+00     0.00
    3          ESA750-Full           1        1635.0        0.0   1.00E+00     0.00
    4          ESA750-Full           1        1965.0        0.0   1.00E+00     0.00
    1          SAST53                1           0.0        0.0   1.00E+00     0.00
    2          SAST53                1        2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3628            Iso.      3.63E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subs1tCB8             Aniso.    8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.    4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement3628            ETH         0.000300   12.000
    3     top      subs1tCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      322.00    cement3628
                                          SADT(80): 9.772E-05
                                          SAST(53): 7.149E-05

    3      200.00    subs1tCB8
                                          SADT(80): 1.825E-04

    4        0.00    Sub_CBR4
                                          SADT(80): 2.309E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      322.00    cement3628           Total:     3.237E+00
                                          SAST:      1.725E-01
                                          SADT:      1.129E+00
                                          TAST:      6.641E-03
                                          TADT:      1.837E+00
                                          TRDT:      8.999E-02
                                          QADT:      8.521E-04

    2      120.00    Gran_250                             n/a

    3      200.00    subs1tCB8            Total:     3.597E-06

    4        0.00    Sub_CBR4             Total:     1.865E-05
```

Braemar Project with 94% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load            Load              Load          Radius   Pressure/     Exponent
   No.    ID              Category          Type                   Ref. stress
    1     ESA750-Full     ESA750-Full       Vertical Force   92.1   0.75          0.00
    2     SAST53          SAST53            Vertical Force  102.4   0.80          0.00

   Load Locations:
   Location   Load          Gear      X         Y     Scaling     Theta
   No.        ID            No.                       Factor
    1         ESA750-Full    1     -165.0     0.0    1.00E+00     0.00
    2         ESA750-Full    1      165.0     0.0    1.00E+00     0.00
    3         ESA750-Full    1     1635.0     0.0    1.00E+00     0.00
    4         ESA750-Full    1     1965.0     0.0    1.00E+00     0.00
    1         SAST53         1        0.0     0.0    1.00E+00     0.00
    2         SAST53         1     2130.0     0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material       Isotropy  Modulus   P.Ratio
   No.    i/face  ID                       (or Ev)   (or vvh)  F          Eh         vh
    1     rough   cement3354     Iso.      3.35E+03  0.20
    2     rough   Gran_250       Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough   subsltCB8      Aniso.    8.00E+01  0.45      5.52E+01   4.00E+01   0.45
    4     rough   Sub_CBR4       Aniso.    4.00E+01  0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material      Component  Perform.   Perform.   Shift
   No.             ID                       Constant   Exponent   Factor
    1     bottom  cement3354     ETH        0.000308   12.000
    3     top     subsltCB8      EZZ        0.009150    7.000
    4     top     Sub_CBR4       EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material        Axle       Unitless
   No.               ID                         Strain
    1      322.00    cement3354
                                     SADT(80):  1.033E-04
                                     SAST(53):  7.575E-05
    3      200.00    subsltCB8
                                     SADT(80):  1.910E-04
    4        0.00    Sub_CBR4
                                     SADT(80):  2.397E-04

Results:

   Layer  Thickness  Material        Axle       CDF
   No.               ID              Group
    1      322.00    cement3354      Total:     4.591E+00
                                     SAST:      2.523E-01
                                     SADT:      1.599E+00
                                     TAST:      9.711E-03
                                     TADT:      2.601E+00
                                     TRDT:      1.274E-01
                                     QADT:      1.206E-03

    2      120.00    Gran_250                      n/a

    3      200.00    subsltCB8       Total:     4.953E-06

    4        0.00    Sub_CBR4        Total:     2.422E-05
```

Braemar Project with 93% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load              Radius    Pressure/    Exponent
   No.    ID                   Category             Type                        Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1      0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4      0.80         0.00

   Load Locations:
   Location    Load                Gear          X          Y      Scaling     Theta
   No.         ID                  No.                             Factor
    1          ESA750-Full          1         -165.0       0.0    1.00E+00      0.00
    2          ESA750-Full          1          165.0       0.0    1.00E+00      0.00
    3          ESA750-Full          1         1635.0       0.0    1.00E+00      0.00
    4          ESA750-Full          1         1965.0       0.0    1.00E+00      0.00
    1          SAST53               1            0.0       0.0    1.00E+00      0.00
    2          SAST53               1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3079            Iso.       3.08E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement3079            ETH         0.000315   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      322.00    cement3079
                                           SADT(80):  1.096E-04
                                           SAST(53):  8.065E-05

    3      200.00    subsltCB8
                                           SADT(80):  2.008E-04
    4        0.00    Sub_CBR4
                                           SADT(80):  2.496E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      322.00    cement3079            Total:     7.188E+00
                                           SAST:      4.086E-01
                                           SADT:      2.498E+00
                                           TAST:      1.573E-02
                                           TADT:      4.065E+00
                                           TRDT:      1.991E-01
                                           QADT:      1.885E-03

    2      120.00    Gran_250                             n/a

    3      200.00    subsltCB8             Total:     7.006E-06

    4        0.00    Sub_CBR4              Total:     3.215E-05
```

Braemar Project with 92% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1        1965.0       0.0   1.00E+00      0.00
    1         SAST53                1           0.0       0.0   1.00E+00      0.00
    2         SAST53                1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement2805            Iso.      2.81E+03  0.20
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    subsltCB8             Aniso.    8.00E+01  0.45      5.52E+01   4.00E+01   0.45
    4     rough    Sub_CBR4              Aniso.    4.00E+01  0.45      2.76E+01   2.00E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.  Perform.  Shift
   No.             ID                              Constant  Exponent  Factor
    1     bottom   cement2805            ETH        0.000323  12.000
    3     top      subsltCB8             EZZ        0.009150   7.000
    4     top      Sub_CBR4              EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Selected Material) (Austroads 2017)
    4      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      322.00    cement2805
                                            SADT(80):  1.169E-04
                                            SAST(53):  8.629E-05

    3      200.00    subsltCB8
                                            SADT(80):  2.118E-04

    4        0.00    Sub_CBR4
                                            SADT(80):  2.607E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      322.00    cement2805             Total:     1.154E+01
                                            SAST:      6.807E-01
                                            SADT:      4.000E+00
                                            TAST:      2.620E-02
                                            TADT:      6.508E+00
                                            TRDT:      3.187E-01
                                            QADT:      3.018E-03

    2      120.00    Gran_250                              n/a

    3      200.00    subsltCB8              Total:     1.020E-05

    4        0.00    Sub_CBR4               Total:     4.366E-05
```

Braemar Project with 91% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement2530	Iso.	2.53E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	subsltCB8	Aniso.	8.00E+01	0.45	5.52E+01	4.00E+01	0.45
4	rough	Sub_CBR4	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement2530	ETH	0.000330	12.000	
3	top	subsltCB8	EZZ	0.009150	7.000	
4	top	Sub_CBR4	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Selected Material) (Austroads 2017)
4	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering
Layer no. 3: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	322.00	cement2530		
			SADT(80):	1.254E-04
			SAST(53):	9.292E-05
3	200.00	subsltCB8		
			SADT(80):	2.247E-04
4	0.00	Sub_CBR4		
			SADT(80):	2.735E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	322.00	cement2530	Total:	2.079E+01
			SAST:	1.279E+00
			SADT:	7.187E+00
			TAST:	4.924E-02
			TADT:	1.170E+01
			TRDT:	5.728E-01
			QADT:	5.424E-03
2	120.00	Gran_250		n/a
3	200.00	subsltCB8	Total:	1.541E-05
4	0.00	Sub_CBR4	Total:	6.108E-05

Braemar Project with 90% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Braemar - Design

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 2.68E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load              Radius    Pressure/     Exponent
   No.    ID                    Category              Type                        Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1      0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4      0.80          0.00

   Load Locations:
   Location   Load                Gear         X           Y      Scaling     Theta
   No.        ID                  No.                             Factor
    1         ESA750-Full          1         -165.0        0.0    1.00E+00     0.00
    2         ESA750-Full          1          165.0        0.0    1.00E+00     0.00
    3         ESA750-Full          1         1635.0        0.0    1.00E+00     0.00
    4         ESA750-Full          1         1965.0        0.0    1.00E+00     0.00
    1         SAST53               1            0.0        0.0    1.00E+00     0.00
    2         SAST53               1         2130.0        0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F           Eh          vh
    1     rough    Cement2256            Iso.       2.26E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02    1.25E+02    0.35
    3     rough    subsltCB8             Aniso.     8.00E+01   0.45      5.52E+01    4.00E+01    0.45
    4     rough    Sub_CBR4              Aniso.     4.00E+01   0.45      2.76E+01    2.00E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement2256            ETH         0.000338   12.000
    3     top      subsltCB8             EZZ         0.009150    7.000
    4     top      Sub_CBR4              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Selected Material) (Austroads 2017)
    4       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering
   Layer no.  3:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      322.00    Cement2256
                                          SADT(80):  1.354E-04
                                          SAST(53):  1.008E-04
    3      200.00    subsltCB8
                                          SADT(80):  2.397E-04
    4        0.00    Sub_CBR4
                                          SADT(80):  2.883E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      322.00    Cement2256            Total:     3.936E+01
                                           SAST:      2.540E+00
                                           SADT:      1.356E+01
                                           TAST:      9.775E-02
                                           TADT:      2.207E+01
                                           TRDT:      1.081E+00
                                           QADT:      1.024E-02

    2      120.00    Gran_250                             n/a

    3      200.00    subsltCB8             Total:     2.427E-05

    4        0.00    Sub_CBR4              Total:     8.832E-05
```

Boree Project

Original Pavement Design Analysis

ole Pavement Design 2.0 - Summary Report

Design Filename: C:\Users\hughesmj\Desktop\Boree.fpd
FPD software verion: FPD 2.0 Version 1A (21 December 2018)
CIRCLY software version: 5.0i (7 July 2006)

Project Details

Project Title: Boree
Location: Segment 3080
Pavement Tag: Heavily Bound
Comments:
Date of Design: 17/06/2019
Designer: Pavement and Geotechnical Northern
Project Reliability (%): 90
WMAPT (°C): 29
Design Speed (km/h): 100

Load Details

Single Axle Single Tyre (SAST) — Standard Axle Load: 53 kN — Tyre Contact Stress: 800 kPa
Single Axle Dual Tyre (SADT) — Standard Axle Load: 80 kN — Tyre Contact Stress: 750 kPa

Traffic Details

PTL report: N/A
TLD Title: TLD for Rural Roads (refer Austroads 2008 Pavement Design Guide - Table F.2)
Design Period (yrs): 20 — Design Traffic - N_{DT} (HVAG): 1.29E+06 — N_{DT} (ESAs): 1.12E+06
Annual growth rate (%): 2.0 — N_{DT} for asphalt fatigue (HVAG): 1.29E+06 — ESA/HVAG: 0.87017

Axle Group	SAST	SADT	TAST	TADT	TRDT	QADT	
Proportions	0.3440	0.0980	0.0070	0.3200	0.2310	0.0000	Default from TLD

Layer Details

Layer No.	Description	Material	Thickness (mm)	Ev (MPa)	Ev / Eh	Poisson's Ratio	Lower Interface	% Vol. Bitumen	Sublayer?
1	Heavily Bound (R73/R75)	Cemented	300	5,000	1.0	0.20	Rough	N/A	N/A
2	Selected Material (SMZ)	Selected Subgrade	300	150	2.0	0.35	Rough	N/A	Yes
3	Cohesive Subgrade	Subgrade	S/Inf	70	2.0	0.45	N/A	N/A	N/A

Layer Results

Layer No.	Description	Thickness (mm)	Vertical Modulus (MPa)	Stress Param. f (MPa)	k Factor	Failure Criterion	Maximum Microstrains SAST Hor.	Maximum Microstrains SADT Hor.	Maximum Microstrains SADT Vert.	Expected Reps (ESAs)	Allowable Reps (ESAs)	CDF (Damage)	Estimated Life in Years
1	Heavily Bound (R73/R75)	300	5,000	N/A	263	Fatigue	-56.39	-75.33	N/A	1.12E+06	N/A	**0.28**	**>50**
2.1	S/L Selected Material (SMZ)	60	150	111	9150	Rutting	N/A	N/A	141.3	1.12E+06	4.77E+12	0.00	>50
2.2	S/L Selected Material (SMZ)	60	129	95	9150	Rutting	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.3	S/L Selected Material (SMZ)	60	111	82	9150	Rutting	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4	S/L Selected Material (SMZ)	60	95	70	9150	Rutting	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.5	S/L Selected Material (SMZ)	60	82	60	9150	Rutting	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	Cohesive Subgrade	S/Inf	70	48	9150	Rutting	N/A	N/A	162.4	1.12E+06	1.80E+12	0.00	>50

Note: For construction purposes, an additional 10mm must be added to the critical layer, the damage for which is highlighted in bold above.

Non-conformances

Layer No.	Non-conformance description	Reference
1	Cemented layer thickness exceeds specified maximum of 250 mm for design in accordance with R73. Thicker layers may be constructed using R75 in-situ stabilisation.	RMS Supplement Table 1

Analysis of Original Pavement Design in CIRCLY 7.0

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                 Load            Radius    Pressure/    Exponent
   No.    ID                    Category             Type                      Ref. stress
    1     ESA750-Full           ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                  Gear          X          Y      Scaling     Theta
   No.        ID                    No.                             Factor
    1         ESA750-Full            1         -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full            1          165.0       0.0    1.00E+00      0.00
    3         ESA750-Full            1         1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full            1         1965.0       0.0    1.00E+00      0.00
    1         SAST53                 1            0.0       0.0    1.00E+00      0.00
    2         SAST53                 1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.      5.00E+03  0.20
    2     rough    subsltCB15            Aniso.    1.50E+02  0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH        0.000263   12.000
    2     top      subsltCB15            EZZ        0.009150    7.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    Cement5000
                                           SADT(80):  7.533E-05
                                           SAST(53):  5.639E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.413E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  1.624E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    Cement5000            Total:     3.389E-01
                                           SAST:      2.338E-02
                                           SADT:      1.162E-01
                                           TAST:      8.998E-04
                                           TADT:      1.891E-01
                                           TRDT:      9.259E-03
                                           QADT:      8.768E-05

    2      300.00    subsltCB15            Total:     2.888E-07

    3        0.00    Sub_CBR7              Total:     7.651E-07
```

Boree Project with Uniform Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load                 Gear        X          Y      Scaling     Theta
   No.        ID                   No.                           Factor
    1         ESA750-Full           1        -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full           1         165.0       0.0    1.00E+00     0.00
    3         ESA750-Full           1        1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full           1        1965.0       0.0    1.00E+00     0.00
    1         SAST53                1           0.0       0.0    1.00E+00     0.00
    2         SAST53                1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy   Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)   F          Eh         vh
    1     rough    Cement5000          Iso.       5.00E+03   0.20
    2     rough    subsltCB15          Aniso.     1.50E+02   0.35       1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7            Aniso.     7.00E+01   0.45       4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component  Perform.   Perform.   Shift
   No.             ID                             Constant   Exponent   Factor
    1     bottom   Cement5000          ETH         0.000263   12.000
    2     top      subsltCB15          EZZ         0.009150    7.000
    3     top      Sub_CBR7            EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material            Axle       Unitless
   No.               ID                             Strain
    1      350.00    Cement5000
                                         SADT(80):  6.038E-05
                                         SAST(53):  4.377E-05

    2      300.00    subsltCB15
                                         SADT(80):  1.122E-04

    3        0.00    Sub_CBR7
                                         SADT(80):  1.325E-04

Results:

   Layer  Thickness  Material            Axle       CDF
   No.               ID                  Group
    1      350.00    Cement5000          Total:     2.329E-02
                                         SAST:      1.120E-03
                                         SADT:      8.171E-03
                                         TAST:      4.312E-05
                                         TADT:      1.330E-02
                                         TRDT:      6.511E-04
                                         QADT:      6.166E-06

    2      300.00    subsltCB15          Total:     5.757E-08

    3        0.00    Sub_CBR7            Total:     1.836E-07
```

Boree Project with Uniform Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load            Radius   Pressure/    Exponent
   No.    ID                  Category            Type                     Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force    92.1    0.75         0.00
    2     SAST53              SAST53              Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location   Load               Gear        X          Y     Scaling    Theta
   No.        ID                 No.                          Factor
    1         ESA750-Full         1      -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full         1       165.0       0.0   1.00E+00     0.00
    3         ESA750-Full         1      1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full         1      1965.0       0.0   1.00E+00     0.00
    1         SAST53              1         0.0       0.0   1.00E+00     0.00
    2         SAST53              1      2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus   P.Ratio
   No.    i/face   ID                             (or Ev)   (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.      5.00E+03  0.20
    2     rough    subsltCB15           Aniso.    1.50E+02  0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH        0.000263   12.000
    2     top      subsltCB15           EZZ        0.009150    7.000
    3     top      Sub_CBR7             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      340.00    Cement5000
                                           SADT(80):  6.298E-05
                                           SAST(53):  4.593E-05
    2      300.00    subsltCB15
                                           SADT(80):  1.173E-04
    3        0.00    Sub_CBR7
                                           SADT(80):  1.377E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      340.00    Cement5000            Total:     3.880E-02
                                           SAST:      1.996E-03
                                           SADT:      1.356E-02
                                           TAST:      7.683E-05
                                           TADT:      2.207E-02
                                           TRDT:      1.081E-03
                                           QADT:      1.024E-05

    2      300.00    subsltCB15            Total:     7.819E-08

    3        0.00    Sub_CBR7              Total:     2.405E-07
```

Boree Project with Uniform Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load               Gear         X          Y     Scaling      Theta
   No.        ID                 No.                           Factor
    1         ESA750-Full         1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full         1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full         1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full         1        1965.0       0.0   1.00E+00      0.00
    1         SAST53              1           0.0       0.0   1.00E+00      0.00
    2         SAST53              1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.       5.00E+03   0.20
    2     rough    subsltCB15             Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7               Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   Cement5000             ETH         0.000263   12.000
    2     top      subsltCB15             EZZ         0.009150    7.000
    3     top      Sub_CBR7               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.    Factor       Type
    1       2.00       Cement Stabilised
    2       1.00       Subgrade (Selected Material) (Austroads 2017)
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      330.00    Cement5000
                                            SADT(80): 6.576E-05
                                            SAST(53): 4.826E-05

    2      300.00    subsltCB15
                                            SADT(80): 1.226E-04

    3        0.00    Sub_CBR7
                                            SADT(80): 1.432E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      330.00    Cement5000             Total:     6.541E-02
                                            SAST:      3.609E-03
                                            SADT:      2.277E-02
                                            TAST:      1.389E-04
                                            TADT:      3.706E-02
                                            TRDT:      1.815E-03
                                            QADT:      1.719E-05

    2      300.00    subsltCB15             Total:     1.070E-07

    3        0.00    Sub_CBR7               Total:     3.173E-07
```

Boree Project with Uniform Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                Load                Load           Radius    Pressure/   Exponent
   No.   ID                  Category            Type                     Ref. stress
    1    ESA750-Full         ESA750-Full         Vertical Force    92.1     0.75        0.00
    2    SAST53              SAST53              Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location   Load                Gear          X          Y      Scaling    Theta
   No.        ID                  No.                             Factor
    1         ESA750-Full          1         -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1          165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1         1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1         1965.0       0.0    1.00E+00     0.00
    1         SAST53               1            0.0       0.0    1.00E+00     0.00
    2         SAST53               1         2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.      5.00E+03   0.20
    2     rough    subsltCB15            Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH        0.000263   12.000
    2     top      subsltCB15            EZZ        0.009150    7.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1      320.00    Cement5000
                                           SADT(80):  6.874E-05
                                           SAST(53):  5.076E-05
    2      300.00    subsltCB15
                                           SADT(80):  1.284E-04
    3        0.00    Sub_CBR7
                                           SADT(80):  1.492E-04

Results:

   Layer  Thickness  Material              Axle        CDF
   No.               ID                    Group
    1      320.00    Cement5000            Total:      1.117E-01
                                           SAST:       6.622E-03
                                           SADT:       3.871E-02
                                           TAST:       2.549E-04
                                           TADT:       6.298E-02
                                           TRDT:       3.085E-03
                                           QADT:       2.921E-05

    2      300.00    subsltCB15            Total:      1.477E-07

    3        0.00    Sub_CBR7              Total:      4.219E-07
```

Boree Project with Uniform Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y      Scaling     Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1         -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full           1          165.0       0.0    1.00E+00      0.00
    3         ESA750-Full           1         1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full           1         1965.0       0.0    1.00E+00      0.00
    1         SAST53                1            0.0       0.0    1.00E+00      0.00
    2         SAST53                1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    subsltCB15            Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    2     top      subsltCB15            EZZ         0.009150    7.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      310.00    Cement5000
                                           SADT(80):  7.192E-05
                                           SAST(53):  5.346E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.346E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  1.556E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      310.00    Cement5000            Total:     1.932E-01
                                           SAST:      1.234E-02
                                           SADT:      6.662E-02
                                           TAST:      4.750E-04
                                           TADT:      1.084E-01
                                           TRDT:      5.309E-03
                                           QADT:      5.028E-05

    2      300.00    subsltCB15            Total:     2.056E-07

    3        0.00    Sub_CBR7              Total:     5.656E-07
```

Boree Project with Uniform Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/   Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75        0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full           1         165.0       0.0   1.00E+00     0.00
    3         ESA750-Full           1        1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full           1        1965.0       0.0   1.00E+00     0.00
    1         SAST53                1           0.0       0.0   1.00E+00     0.00
    2         SAST53                1        2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.       5.00E+03   0.20
    2     rough    subsltCB15             Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7               Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   Cement5000             ETH        0.000263   12.000
    2     top      subsltCB15             EZZ        0.009150    7.000
    3     top      Sub_CBR7               EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1       300.00   Cement5000
                                            SADT(80):  7.533E-05
                                            SAST(53):  5.639E-05
    2       300.00   subsltCB15
                                            SADT(80):  1.413E-04
    3         0.00   Sub_CBR7
                                            SADT(80):  1.624E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1       300.00   Cement5000             Total:     3.389E-01
                                            SAST:      2.338E-02
                                            SADT:      1.162E-01
                                            TAST:      8.998E-04
                                            TADT:      1.891E-01
                                            TRDT:      9.259E-03
                                            QADT:      8.768E-05

    2       300.00   subsltCB15             Total:     2.888E-07

    3         0.00   Sub_CBR7               Total:     7.651E-07
```

Boree Project with Uniform Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear         X          Y       Scaling    Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1       -165.0       0.0     1.00E+00      0.00
    2         ESA750-Full           1        165.0       0.0     1.00E+00      0.00
    3         ESA750-Full           1       1635.0       0.0     1.00E+00      0.00
    4         ESA750-Full           1       1965.0       0.0     1.00E+00      0.00
    1         SAST53                1          0.0       0.0     1.00E+00      0.00
    2         SAST53                1       2130.0       0.0     1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    subsltCB15            Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    2     top      subsltCB15            EZZ         0.009150    7.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor       Type
    1      2.00       Cement Stabilised
    2      1.00       Subgrade (Selected Material) (Austroads 2017)
    3      1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      290.00    Cement5000
                                           SADT(80):  7.899E-05
                                           SAST(53):  5.955E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.486E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  1.698E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      290.00    Cement5000            Total:     6.031E-01
                                           SAST:      4.503E-02
                                           SADT:      2.055E-01
                                           TAST:      1.733E-03
                                           TADT:      3.343E-01
                                           TRDT:      1.637E-02
                                           QADT:      1.551E-04

    2      300.00    subsltCB15            Total:     4.098E-07

    3        0.00    Sub_CBR7              Total:     1.045E-06
```

Boree Project with Uniform Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load             Radius    Pressure/    Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location    Load                 Gear          X          Y     Scaling      Theta
   No.         ID                   No.                            Factor
    1          ESA750-Full          1         -165.0        0.0    1.00E+00      0.00
    2          ESA750-Full          1          165.0        0.0    1.00E+00      0.00
    3          ESA750-Full          1         1635.0        0.0    1.00E+00      0.00
    4          ESA750-Full          1         1965.0        0.0    1.00E+00      0.00
    1          SAST53               1            0.0        0.0    1.00E+00      0.00
    2          SAST53               1         2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.      5.00E+03   0.20
    2     rough    subsltCB15             Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7               Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   Cement5000             ETH         0.000263   12.000
    2     top      subsltCB15             EZZ         0.009150    7.000
    3     top      Sub_CBR7               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle      Unitless
   No.               ID                               Strain
    1      280.00    Cement5000
                                            SADT(80): 8.294E-05
                                            SAST(53): 6.299E-05

    2      300.00    subsltCB15
                                            SADT(80): 1.564E-04

    3        0.00    Sub_CBR7
                                            SADT(80): 1.778E-04

Results:

   Layer  Thickness  Material               Axle      CDF
   No.               ID                     Group
    1      280.00    Cement5000             Total:    1.090E+00
                                            SAST:     8.828E-02
                                            SADT:     3.687E-01
                                            TAST:     3.398E-03
                                            TADT:     5.999E-01
                                            TRDT:     2.938E-02
                                            QADT:     2.782E-04

    2      300.00    subsltCB15             Total:    5.876E-07

    3        0.00    Sub_CBR7               Total:    1.442E-06
```

Boree Project with Uniform Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                    Load                    Load              Radius    Pressure/     Exponent
   No.    ID                      Category                Type                        Ref. stress
    1     ESA750-Full             ESA750-Full             Vertical Force     92.1      0.75          0.00
    2     SAST53                  SAST53                  Vertical Force    102.4      0.80          0.00

   Load Locations:
   Location   Load                    Gear         X          Y     Scaling     Theta
   No.        ID                      No.                           Factor
    1         ESA750-Full              1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full              1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full              1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full              1        1965.0       0.0   1.00E+00      0.00
    1         SAST53                   1           0.0       0.0   1.00E+00      0.00
    2         SAST53                   1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                Isotropy  Modulus   P.Ratio
   No.    i/face   ID                                (or Ev)   (or vvh)  F          Eh          vh
    1     rough    Cement5000              Iso.      5.00E+03  0.20
    2     rough    subsltCB15              Aniso.    1.50E+02  0.35      1.11E+02   7.50E+01    0.35
    3     rough    Sub_CBR7                Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material                Component  Perform.   Perform.   Shift
   No.             ID                                 Constant   Exponent   Factor
    1     bottom   Cement5000              ETH         0.000263   12.000
    2     top      subsltCB15              EZZ         0.009150    7.000
    3     top      Sub_CBR7                EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle        Unitless
   No.               ID                                  Strain
    1      270.00    Cement5000
                                             SADT(80): 8.719E-05
                                             SAST(53): 6.672E-05
    2      300.00    subsltCB15
                                             SADT(80): 1.652E-04
    3        0.00    Sub_CBR7
                                             SADT(80): 1.865E-04

Results:

   Layer  Thickness  Material                Axle        CDF
   No.               ID                      Group
    1      270.00    Cement5000              Total:      2.002E+00
                                             SAST:       1.762E-01
                                             SADT:       6.717E-01
                                             TAST:       6.783E-03
                                             TADT:       1.093E+00
                                             TRDT:       5.353E-02
                                             QADT:       5.069E-04

    2      300.00    subsltCB15              Total:      8.600E-07

    3        0.00    Sub_CBR7                Total:      2.011E-06
```

Boree Project with Variable Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                    Load                    Load              Radius    Pressure/    Exponent
   No.    ID                      Category                Type                        Ref. stress
    1     ESA750-Full             ESA750-Full             Vertical Force     92.1      0.75          0.00
    2     SAST53                  SAST53                  Vertical Force    102.4      0.80          0.00

   Load Locations:
   Location    Load                    Gear          X           Y       Scaling     Theta
   No.         ID                      No.                               Factor
    1          ESA750-Full              1        -165.0         0.0     1.00E+00     0.00
    2          ESA750-Full              1         165.0         0.0     1.00E+00     0.00
    3          ESA750-Full              1        1635.0         0.0     1.00E+00     0.00
    4          ESA750-Full              1        1965.0         0.0     1.00E+00     0.00
    1          SAST53                   1           0.0         0.0     1.00E+00     0.00
    2          SAST53                   1        2130.0         0.0     1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4177             Iso.       4.42E+03   0.20
    2     rough    subsltCB15             Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7               Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement4177             ETH         0.000279   12.000
    2     top      subsltCB15             EZZ         0.009150    7.000
    3     top      Sub_CBR7               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      350.00    cement4177
                                           SADT(80): 6.647E-05
                                           SAST(53): 4.835E-05

    2      250.00    subsltCB15
                                           SADT(80): 1.191E-04

    3        0.00    Sub_CBR7
                                           SADT(80): 1.477E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      350.00    cement4177            Total:     3.639E-02
                                           SAST:      1.819E-03
                                           SADT:      1.274E-02
                                           TAST:      6.999E-05
                                           TADT:      2.073E-02
                                           TRDT:      1.015E-03
                                           QADT:      9.616E-06

    2      250.00    subsltCB15            Total:     8.710E-08

    3        0.00    Sub_CBR7              Total:     3.932E-07
```

Boree Project with Variable Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius   Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location   Load                Gear        X          Y      Scaling      Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full          1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full          1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full          1        1965.0       0.0   1.00E+00      0.00
    1         SAST53               1           0.0       0.0   1.00E+00      0.00
    2         SAST53               1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material              Isotropy  Modulus    P.Ratio
   No.    i/face  ID                              (or Ev)    (or vvh)  F          Eh          vh
    1     rough   Cement4545            Iso.      4.55E+03   0.20
    2     rough   subsltCB15            Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01    0.35
    3     rough   Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement4545           ETH         0.000275   12.000
    2     top      subsltCB15           EZZ         0.009150    7.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      340.00    Cement4545
                                           SADT(80):  6.783E-05
                                           SAST(53):  4.960E-05

    2      260.00    subsltCB15
                                           SADT(80):  1.226E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  1.499E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      340.00    Cement4545            Total:     5.540E-02
                                           SAST:      2.936E-03
                                           SADT:      1.933E-02
                                           TAST:      1.130E-04
                                           TADT:      3.146E-02
                                           TRDT:      1.541E-03
                                           QADT:      1.459E-05

    2      260.00    subsltCB15            Total:     1.071E-07

    3        0.00    Sub_CBR7              Total:     4.373E-07
```

Boree Project with Variable Characteristics – 330 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement4676	Iso.	4.68E+03	0.20			
2	rough	subsltCB15	Aniso.	1.50E+02	0.35	1.11E+02	7.50E+01	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement4676	ETH	0.000272	12.000	
2	top	subsltCB15	EZZ	0.009150	7.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
2	1.00	Subgrade (Selected Material) (Austroads 2017)
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	330.00	cement4676		
			SADT(80):	6.930E-05
			SAST(53):	5.094E-05
2	270.00	subsltCB15		
			SADT(80):	1.265E-04
3	0.00	Sub_CBR7		
			SADT(80):	1.524E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	330.00	cement4676	Total:	8.197E-02
			SAST:	4.619E-03
			SADT:	2.850E-02
			TAST:	1.778E-04
			TADT:	4.638E-02
			TRDT:	2.272E-03
			QADT:	2.151E-05
2	270.00	subsltCB15	Total:	1.329E-07
3	0.00	Sub_CBR7	Total:	4.899E-07

Boree Project with Variable Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75         0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location  Load                   Gear          X           Y     Scaling    Theta
   No.       ID                     No.                             Factor
    1        ESA750-Full             1         -165.0        0.0   1.00E+00     0.00
    2        ESA750-Full             1          165.0        0.0   1.00E+00     0.00
    3        ESA750-Full             1         1635.0        0.0   1.00E+00     0.00
    4        ESA750-Full             1         1965.0        0.0   1.00E+00     0.00
    1        SAST53                  1            0.0        0.0   1.00E+00     0.00
    2        SAST53                  1         2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4806            Iso.       4.81E+03   0.20
    2     rough    subsltCB15            Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4806            ETH        0.000268   12.000
    2     top      subsltCB15            EZZ        0.009150    7.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      320.00    cement4806
                                            SADT(80):  7.092E-05
                                            SAST(53):  5.243E-05

    2      280.00    subsltCB15
                                            SADT(80):  1.307E-04
    3        0.00    Sub_CBR7
                                            SADT(80):  1.551E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      320.00    cement4806             Total:     1.298E-01
                                            SAST:      7.789E-03
                                            SADT:      4.493E-02
                                            TAST:      2.998E-04
                                            TADT:      7.312E-02
                                            TRDT:      3.581E-03
                                            QADT:      3.391E-05

    2      280.00    subsltCB15             Total:     1.669E-07

    3        0.00    Sub_CBR7               Total:     5.547E-07
```

Boree Project with Variable Characteristics – 310 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement4936	Iso.	4.94E+03	0.20			
2	rough	subsltCB15	Aniso.	1.50E+02	0.35	1.11E+02	7.50E+01	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement4936	ETH	0.000265	12.000	
2	top	subsltCB15	EZZ	0.009150	7.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
2	1.00	Subgrade (Selected Material) (Austroads 2017)
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	310.00	cement4936		
			SADT(80):	7.269E-05
			SAST(53):	5.406E-05
2	290.00	subsltCB15		
			SADT(80):	1.352E-04
3	0.00	Sub_CBR7		
			SADT(80):	1.581E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	310.00	cement4936	Total:	2.007E-01
			SAST:	1.286E-02
			SADT:	6.918E-02
			TAST:	4.951E-04
			TADT:	1.126E-01
			TRDT:	5.513E-03
			QADT:	5.221E-05
2	290.00	subsltCB15	Total:	2.122E-07
3	0.00	Sub_CBR7	Total:	6.341E-07

Boree Project with Variable Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load              Radius    Pressure/    Exponent
   No.    ID                   Category             Type                        Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1      0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4      0.80         0.00

   Load Locations:
   Location   Load                 Gear          X          Y      Scaling     Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1         -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full           1          165.0        0.0   1.00E+00     0.00
    3         ESA750-Full           1         1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full           1         1965.0        0.0   1.00E+00     0.00
    1         SAST53                1            0.0        0.0   1.00E+00     0.00
    2         SAST53                1         2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.      5.00E+03   0.20
    2     rough    subsltCB15            Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    2     top      subsltCB15            EZZ         0.009150    7.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    Cement5000
                                           SADT(80):  7.533E-05
                                           SAST(53):  5.639E-05
    2      300.00    subsltCB15
                                           SADT(80):  1.413E-04
    3        0.00    Sub_CBR7
                                           SADT(80):  1.624E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    Cement5000            Total:     3.389E-01
                                           SAST:      2.338E-02
                                           SADT:      1.162E-01
                                           TAST:      8.998E-04
                                           TADT:      1.891E-01
                                           TRDT:      9.259E-03
                                           QADT:      8.768E-05

    2      300.00    subsltCB15            Total:     2.888E-07

    3        0.00    Sub_CBR7              Total:     7.651E-07
```

Boree Project with Variable Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                  Load                  Load            Radius    Pressure/    Exponent
   No.   ID                    Category              Type                      Ref. stress
    1    ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2    SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1        1965.0       0.0   1.00E+00      0.00
    1         SAST53                1           0.0       0.0   1.00E+00      0.00
    2         SAST53                1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement5066            Iso.       5.07E+03   0.20
    2     rough    subsltCB15            Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01    0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5066            ETH         0.000261   12.000
    2     top      subsltCB15            EZZ         0.009150    7.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      290.00    cement5066
                                          SADT(80): 7.814E-05
                                          SAST(53): 5.889E-05
    2      310.00    subsltCB15
                                          SADT(80): 1.479E-04
    3        0.00    Sub_CBR7
                                          SADT(80): 1.670E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      290.00    cement5066           Total:     5.798E-01
                                          SAST:      4.314E-02
                                          SADT:      1.976E-01
                                          TAST:      1.660E-03
                                          TADT:      3.215E-01
                                          TRDT:      1.575E-02
                                          QADT:      1.491E-04

    2      310.00    subsltCB15           Total:     3.967E-07

    3        0.00    Sub_CBR7             Total:     9.288E-07
```

Boree Project with Variable Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                Load                Load            Radius   Pressure/    Exponent
   No.   ID                  Category            Type                     Ref. stress
    1    ESA750-Full         ESA750-Full         Vertical Force    92.1    0.75          0.00
    2    SAST53              SAST53              Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location   Load               Gear         X          Y     Scaling    Theta
   No.        ID                 No.                           Factor
    1         ESA750-Full         1        -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full         1         165.0        0.0   1.00E+00     0.00
    3         ESA750-Full         1        1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full         1        1965.0        0.0   1.00E+00     0.00
    1         SAST53              1           0.0        0.0   1.00E+00     0.00
    2         SAST53              1        2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5455           Iso.       5.46E+03   0.20
    2     rough    subsltCB15           Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5455           ETH         0.000251   12.000
    2     top      subsltCB15           EZZ         0.009150    7.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle        Unitless
   No.               ID                               Strain
    1      280.00    Cement5455
                                          SADT(80):  7.773E-05
                                          SAST(53):  5.885E-05

    2      320.00    subsltCB15
                                          SADT(80):  1.494E-04

    3        0.00    Sub_CBR7
                                          SADT(80):  1.671E-04

Results:

   Layer  Thickness  Material             Axle        CDF
   No.               ID                   Group
    1      280.00    Cement5455           Total:      8.736E-01
                                          SAST:       6.834E-02
                                          SADT:       2.964E-01
                                          TAST:       2.630E-03
                                          TADT:       4.824E-01
                                          TRDT:       2.362E-02
                                          QADT:       2.237E-04

    2      320.00    subsltCB15           Total:      4.256E-07

    3        0.00    Sub_CBR7             Total:      9.317E-07
```

Boree Project with Variable Characteristics – 270 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Boree

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5586	Iso.	5.59E+03	0.20			
2	rough	subsltCB15	Aniso.	1.50E+02	0.35	1.11E+02	7.50E+01	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5586	ETH	0.000247	12.000	
2	top	subsltCB15	EZZ	0.009150	7.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
2	1.00	Subgrade (Selected Material) (Austroads 2017)
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	270.00	cement5586		
			SADT(80):	8.023E-05
			SAST(53):	6.115E-05
2	330.00	subsltCB15		
			SADT(80):	1.560E-04
3	0.00	Sub_CBR7		
			SADT(80):	1.714E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	270.00	cement5586	Total:	1.560E+00
			SAST:	1.314E-01
			SADT:	5.259E-01
			TAST:	5.059E-03
			TADT:	8.557E-01
			TRDT:	4.191E-02
			QADT:	3.969E-04
2	330.00	subsltCB15	Total:	5.759E-07
3	0.00	Sub_CBR7	Total:	1.113E-06

Boree Project with 105% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement6161	Iso.	6.16E+03	0.20			
2	rough	subsltCB15	Aniso.	1.50E+02	0.35	1.11E+02	7.50E+01	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement6161	ETH	0.000232	12.000	
2	top	subsltCB15	EZZ	0.009150	7.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
2	1.00	Subgrade (Selected Material) (Austroads 2017)
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	300.00	cement6161	SADT(80):	6.486E-05
			SAST(53):	4.817E-05
2	300.00	subsltCB15	SADT(80):	1.244E-04
3	0.00	Sub_CBR7	SADT(80):	1.469E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	300.00	cement6161	Total:	2.519E-01
			SAST:	1.590E-02
			SADT:	8.695E-02
			TAST:	6.118E-04
			TADT:	1.415E-01
			TRDT:	6.929E-03
			QADT:	6.561E-05
2	300.00	subsltCB15	Total:	1.185E-07
3	0.00	Sub_CBR7	Total:	3.788E-07

Boree Project with 104% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/   Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1    0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4    0.80          0.00

   Load Locations:
   Location   Load                 Gear         X          Y      Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full           1         165.0       0.0    1.00E+00      0.00
    3         ESA750-Full           1        1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full           1        1965.0       0.0    1.00E+00      0.00
    1         SAST53                1           0.0       0.0    1.00E+00      0.00
    2         SAST53                1        2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5929           Iso.      5.93E+03   0.20
    2     rough    subsltCB15           Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement5929           ETH         0.000238   12.000
    2     top      subsltCB15           EZZ         0.009150    7.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle      Unitless
   No.               ID                               Strain
    1      300.00    cement5929
                                            SADT(80): 6.669E-05
                                            SAST(53): 4.959E-05
    2      300.00    subsltCB15
                                            SADT(80): 1.274E-04
    3        0.00    Sub_CBR7
                                            SADT(80): 1.496E-04

Results:

   Layer  Thickness  Material               Axle      CDF
   No.               ID                     Group
    1      300.00    cement5929             Total:    2.589E-01
                                            SAST:     1.660E-02
                                            SADT:     8.924E-02
                                            TAST:     6.390E-04
                                            TADT:     1.452E-01
                                            TRDT:     7.112E-03
                                            QADT:     6.735E-05

    2      300.00    subsltCB15             Total:    1.396E-07

    3        0.00    Sub_CBR7               Total:    4.314E-07
```

Boree Project with 103% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load           Radius    Pressure/    Exponent
   No.    ID                  Category            Type                     Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force    92.1    0.75          0.00
    2     SAST53              SAST53              Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location   Load                Gear         X          Y      Scaling    Theta
   No.        ID                  No.                            Factor
    1         ESA750-Full          1        -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1         165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1        1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1        1965.0       0.0    1.00E+00     0.00
    1         SAST53               1           0.0       0.0    1.00E+00     0.00
    2         SAST53               1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material            Isotropy  Modulus   P.Ratio
   No.    i/face  ID                            (or Ev)   (or vvh)  F         Eh        vh
    1     rough   cement5697          Iso.      5.70E+03  0.20
    2     rough   subsltCB15          Aniso.    1.50E+02  0.35      1.11E+02  7.50E+01  0.35
    3     rough   Sub_CBR7            Aniso.    7.00E+01  0.45      4.83E+01  3.50E+01  0.45

   Performance Relationships:
   Layer  Location Material           Component Perform.  Perform.  Shift
   No.             ID                           Constant  Exponent  Factor
    1     bottom   cement5697         ETH        0.000244  12.000
    2     top      subsltCB15         EZZ        0.009150   7.000
    3     top      Sub_CBR7           EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      300.00    cement5697
                                          SADT(80):  6.863E-05
                                          SAST(53):  5.111E-05
    2      300.00    subsltCB15
                                          SADT(80):  1.305E-04
    3        0.00    Sub_CBR7
                                          SADT(80):  1.526E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      300.00    cement5697           Total:     2.713E-01
                                          SAST:      1.770E-02
                                          SADT:      9.343E-02
                                          TAST:      6.811E-04
                                          TADT:      1.520E-01
                                          TRDT:      7.445E-03
                                          QADT:      7.050E-05

    2      300.00    subsltCB15           Total:     1.656E-07

    3        0.00    Sub_CBR7             Total:     4.936E-07
```

Boree Project with 102% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5464	Iso.	5.46E+03	0.20			
2	rough	subsltCB15	Aniso.	1.50E+02	0.35	1.11E+02	7.50E+01	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5464	ETH	0.000250	12.000	
2	top	subsltCB15	EZZ	0.009150	7.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
2	1.00	Subgrade (Selected Material) (Austroads 2017)
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	300.00	cement5464		
			SADT(80):	7.071E-05
			SAST(53):	5.275E-05
2	300.00	subsltCB15		
			SADT(80):	1.339E-04
3	0.00	Sub_CBR7		
			SADT(80):	1.557E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	300.00	cement5464	Total:	2.907E-01
			SAST:	1.930E-02
			SADT:	9.996E-02
			TAST:	7.429E-04
			TADT:	1.627E-01
			TRDT:	7.966E-03
			QADT:	7.544E-05
2	300.00	subsltCB15	Total:	1.979E-07
3	0.00	Sub_CBR7	Total:	5.682E-07

Boree Project with 101% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1    0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4    0.80          0.00

   Load Locations:
   Location   Load                  Gear         X          Y     Scaling     Theta
   No.        ID                    No.                           Factor
    1         ESA750-Full            1       -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full            1        165.0        0.0   1.00E+00     0.00
    3         ESA750-Full            1       1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full            1       1965.0        0.0   1.00E+00     0.00
    1         SAST53                 1          0.0        0.0   1.00E+00     0.00
    2         SAST53                 1       2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                 Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                  (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5232               Iso.       5.23E+03   0.20
    2     rough    subsltCB15               Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7                 Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material                 Component  Perform.   Perform.   Shift
   No.             ID                                  Constant   Exponent   Factor
    1     bottom   cement5232               ETH         0.000257   12.000
    2     top      subsltCB15               EZZ         0.009150    7.000
    3     top      Sub_CBR7                 EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                 Axle       Unitless
   No.               ID                                  Strain
    1      300.00    cement5232
                                              SADT(80):  7.294E-05
                                              SAST(53):  5.450E-05

    2      300.00    subsltCB15
                                              SADT(80):  1.375E-04

    3        0.00    Sub_CBR7
                                              SADT(80):  1.589E-04

Results:

   Layer  Thickness  Material                 Axle       CDF
   No.               ID                       Group
    1      300.00    cement5232               Total:     3.031E-01
                                              SAST:      2.050E-02
                                              SADT:      1.041E-01
                                              TAST:      7.892E-04
                                              TADT:      1.694E-01
                                              TRDT:      8.294E-03
                                              QADT:      7.854E-05

    2      300.00    subsltCB15               Total:     2.381E-07

    3        0.00    Sub_CBR7                 Total:     6.573E-07
```

Boree Project with 99% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location   Load                 Gear         X          Y     Scaling    Theta
   No.        ID                   No.                           Factor
    1         ESA750-Full           1       -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full           1        165.0       0.0   1.00E+00     0.00
    3         ESA750-Full           1       1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full           1       1965.0       0.0   1.00E+00     0.00
    1         SAST53                1          0.0       0.0   1.00E+00     0.00
    2         SAST53                1       2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4768           Iso.       4.77E+03   0.20
    2     rough    subsltCB15           Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement4768           ETH        0.000271   12.000
    2     top      subsltCB15           EZZ        0.009150    7.000
    3     top      Sub_CBR7             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    cement4768
                                           SADT(80):  7.791E-05
                                           SAST(53):  5.842E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.455E-04
    3        0.00    Sub_CBR7
                                           SADT(80):  1.661E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    cement4768            Total:     3.547E-01
                                           SAST:      2.498E-02
                                           SADT:      1.214E-01
                                           TAST:      9.615E-04
                                           TADT:      1.976E-01
                                           TRDT:      9.676E-03
                                           QADT:      9.163E-05

    2      300.00    subsltCB15            Total:     3.535E-07

    3        0.00    Sub_CBR7              Total:     8.966E-07
```

Boree Project with 98% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load            Radius    Pressure/     Exponent
   No.    ID                  Category            Type                      Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force    92.1      0.75          0.00
    2     SAST53              SAST53              Vertical Force   102.4      0.80          0.00

   Load Locations:
   Location   Load               Gear        X          Y      Scaling     Theta
   No.        ID                 No.                           Factor
    1         ESA750-Full         1       -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full         1        165.0       0.0    1.00E+00      0.00
    3         ESA750-Full         1       1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full         1       1965.0       0.0    1.00E+00      0.00
    1         SAST53              1          0.0       0.0    1.00E+00      0.00
    2         SAST53              1       2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy   Modulus     P.Ratio
   No.    i/face   ID                             (or Ev)     (or vvh)  F          Eh         vh
    1     rough    cement4536          Iso.       4.54E+03    0.20
    2     rough    subsltCB15          Aniso.     1.50E+02    0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7            Aniso.     7.00E+01    0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component  Perform.    Perform.   Shift
   No.             ID                             Constant    Exponent   Factor
    1     bottom   cement4536          ETH         0.000276    12.000
    2     top      subsltCB15          EZZ         0.009150     7.000
    3     top      Sub_CBR7            EZZ         0.009150     7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material            Axle       Unitless
   No.               ID                             Strain
    1      300.00    cement4536
                                         SADT(80):  8.069E-05
                                         SAST(53):  6.063E-05

    2      300.00    subsltCB15
                                         SADT(80):  1.499E-04

    3        0.00    Sub_CBR7
                                         SADT(80):  1.701E-04

Results:

   Layer  Thickness  Material            Axle       CDF
   No.               ID                  Group
    1      300.00    cement4536          Total:     4.350E-01
                                         SAST:      3.131E-02
                                         SADT:      1.486E-01
                                         TAST:      1.205E-03
                                         TADT:      2.419E-01
                                         TRDT:      1.184E-02
                                         QADT:      1.122E-04

    2      300.00    subsltCB15          Total:     4.368E-07

    3        0.00    Sub_CBR7            Total:     1.058E-06
```

Boree Project with 97% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/   Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load             Gear         X           Y      Scaling     Theta
   No.        ID               No.                             Factor
    1         ESA750-Full       1        -165.0        0.0    1.00E+00     0.00
    2         ESA750-Full       1         165.0        0.0    1.00E+00     0.00
    3         ESA750-Full       1        1635.0        0.0    1.00E+00     0.00
    4         ESA750-Full       1        1965.0        0.0    1.00E+00     0.00
    1         SAST53            1           0.0        0.0    1.00E+00     0.00
    2         SAST53            1        2130.0        0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4303           Iso.      4.30E+03   0.20
    2     rough    subsltCB15           Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component Perform.   Perform.  Shift
   No.             ID                             Constant   Exponent  Factor
    1     bottom   cement4303           ETH        0.000282   12.000
    2     top      subsltCB15           EZZ        0.009150    7.000
    3     top      Sub_CBR7             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      300.00    cement4303
                                          SADT(80): 8.373E-05
                                          SAST(53): 6.305E-05
    2      300.00    subsltCB15
                                          SADT(80): 1.548E-04
    3        0.00    Sub_CBR7
                                          SADT(80): 1.744E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      300.00    cement4303           Total:     5.245E-01
                                          SAST:      3.865E-02
                                          SADT:      1.789E-01
                                          TAST:      1.488E-03
                                          TADT:      2.911E-01
                                          TRDT:      1.426E-02
                                          QADT:      1.350E-04

    2      300.00    subsltCB15           Total:     5.460E-07

    3        0.00    Sub_CBR7             Total:     1.260E-06
```

Boree Project with 96% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear         X          Y      Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full           1         165.0       0.0    1.00E+00     0.00
    3         ESA750-Full           1        1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full           1        1965.0       0.0    1.00E+00     0.00
    1         SAST53                1           0.0       0.0    1.00E+00     0.00
    2         SAST53                1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4071            Iso.      4.07E+03   0.20
    2     rough    subsltCB15            Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement4071            ETH        0.000288   12.000
    2     top      subsltCB15            EZZ        0.009150    7.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    cement4071
                                           SADT(80):  8.703E-05
                                           SAST(53):  6.568E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.600E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  1.790E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    cement4071            Total:     6.489E-01
                                           SAST:      4.901E-02
                                           SADT:      2.208E-01
                                           TAST:      1.886E-03
                                           TADT:      3.594E-01
                                           TRDT:      1.760E-02
                                           QADT:      1.667E-04

    2      300.00    subsltCB15            Total:     6.900E-07

    3        0.00    Sub_CBR7              Total:     1.513E-06
```

Boree Project with 95% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load             Radius    Pressure/    Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear        X          Y     Scaling     Theta
   No.        ID                   No.                          Factor
    1         ESA750-Full           1       -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1        165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1       1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1       1965.0       0.0   1.00E+00      0.00
    1         SAST53                1          0.0       0.0   1.00E+00      0.00
    2         SAST53                1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3839           Iso.       3.84E+03   0.20
    2     rough    subsltCB15           Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement3839           ETH         0.000295   12.000
    2     top      subsltCB15           EZZ         0.009150    7.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      300.00    cement3839
                                          SADT(80):  9.063E-05
                                          SAST(53):  6.856E-05
    2      300.00    subsltCB15
                                          SADT(80):  1.658E-04
    3        0.00    Sub_CBR7
                                          SADT(80):  1.840E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      300.00    cement3839           Total:     7.937E-01
                                          SAST:      6.155E-02
                                          SADT:      2.695E-01
                                          TAST:      2.369E-03
                                          TADT:      4.385E-01
                                          TRDT:      2.148E-02
                                          QADT:      2.034E-04

    2      300.00    subsltCB15           Total:     8.833E-07

    3        0.00    Sub_CBR7             Total:     1.834E-06
```

Boree Project with 94% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                Load                Load            Radius    Pressure/    Exponent
   No.   ID                  Category            Type                      Ref. stress
    1    ESA750-Full         ESA750-Full         Vertical Force    92.1     0.75          0.00
    2    SAST53              SAST53              Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location  Load                 Gear         X          Y     Scaling     Theta
   No.       ID                   No.                            Factor
    1        ESA750-Full           1       -165.0       0.0   1.00E+00     0.00
    2        ESA750-Full           1        165.0       0.0   1.00E+00     0.00
    3        ESA750-Full           1       1635.0       0.0   1.00E+00     0.00
    4        ESA750-Full           1       1965.0       0.0   1.00E+00     0.00
    1        SAST53                1          0.0       0.0   1.00E+00     0.00
    2        SAST53                1       2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3607            Iso.      3.61E+03   0.20
    2     rough    subsltCB15            Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   cement3607            ETH        0.000301   12.000
    2     top      subsltCB15            EZZ        0.009150    7.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    cement3607
                                           SADT(80):  9.460E-05
                                           SAST(53):  7.175E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.721E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  1.895E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    cement3607            Total:     1.045E+00
                                           SAST:      8.334E-02
                                           SADT:      3.539E-01
                                           TAST:      3.208E-03
                                           TADT:      5.759E-01
                                           TRDT:      2.820E-02
                                           QADT:      2.671E-04

    2      300.00    subsltCB15            Total:     1.147E-06

    3        0.00    Sub_CBR7              Total:     2.249E-06
```

Boree Project with 93% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/   Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75        0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location    Load                Gear         X          Y     Scaling     Theta
   No.         ID                  No.                           Factor
    1          ESA750-Full          1       -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full          1        165.0       0.0   1.00E+00      0.00
    3          ESA750-Full          1       1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full          1       1965.0       0.0   1.00E+00      0.00
    1          SAST53               1          0.0       0.0   1.00E+00      0.00
    2          SAST53               1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3375            Iso.      3.38E+03   0.20
    2     rough    subsltCB15            Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement3375            ETH        0.000307   12.000
    2     top      subsltCB15            EZZ        0.009150    7.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00       Cement Stabilised
    2       1.00       Subgrade (Selected Material) (Austroads 2017)
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle      Unitless
   No.               ID                               Strain
    1       300.00   cement3375
                                            SADT(80): 9.899E-05
                                            SAST(53): 7.528E-05

    2       300.00   subsltCB15
                                            SADT(80): 1.791E-04

    3         0.00   Sub_CBR7
                                            SADT(80): 1.954E-04

Results:

   Layer  Thickness  Material               Axle      CDF
   No.               ID                     Group
    1       300.00   cement3375             Total:    1.424E+00
                                            SAST:     1.171E-01
                                            SADT:     4.811E-01
                                            TAST:     4.507E-03
                                            TADT:     7.829E-01
                                            TRDT:     3.834E-02
                                            QADT:     3.631E-04

    2       300.00   subsltCB15             Total:    1.515E-06

    3         0.00   Sub_CBR7               Total:    2.790E-06
```

Boree Project with 92% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location   Load                 Gear          X           Y       Scaling     Theta
   No.        ID                   No.                               Factor
    1         ESA750-Full           1         -165.0        0.0     1.00E+00     0.00
    2         ESA750-Full           1          165.0        0.0     1.00E+00     0.00
    3         ESA750-Full           1         1635.0        0.0     1.00E+00     0.00
    4         ESA750-Full           1         1965.0        0.0     1.00E+00     0.00
    1         SAST53                1            0.0        0.0     1.00E+00     0.00
    2         SAST53                1         2130.0        0.0     1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement3143           Iso.      3.14E+03   0.20
    2     rough    subsltCB15           Aniso.    1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement3143           ETH         0.000314   12.000
    2     top      subsltCB15           EZZ         0.009150    7.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    Cement3143
                                           SADT(80):  1.039E-04
                                           SAST(53):  7.923E-05

    2      300.00    subsltCB15
                                           SADT(80):  1.868E-04

    3        0.00    Sub_CBR7
                                           SADT(80):  2.019E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    Cement3143            Total:     1.942E+00
                                           SAST:      1.650E-01
                                           SADT:      6.540E-01
                                           TAST:      6.349E-03
                                           TADT:      1.064E+00
                                           TRDT:      5.212E-02
                                           QADT:      4.935E-04

    2      300.00    subsltCB15            Total:     2.036E-06

    3        0.00    Sub_CBR7              Total:     3.510E-06
```

Boree Project with 91% Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement2910	Iso.	2.91E+03	0.20			
2	rough	subsltCB15	Aniso.	1.50E+02	0.35	1.11E+02	7.50E+01	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement2910	ETH	0.000320	12.000	
2	top	subsltCB15	EZZ	0.009150	7.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
2	1.00	Subgrade (Selected Material) (Austroads 2017)
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	300.00	Cement2910	SADT(80):	1.094E-04
			SAST(53):	8.369E-05
2	300.00	subsltCB15	SADT(80):	1.955E-04
3	0.00	Sub_CBR7	SADT(80):	2.091E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	300.00	Cement2910	Total:	2.882E+00
			SAST:	2.536E-01
			SADT:	9.671E-01
			TAST:	9.762E-03
			TADT:	1.574E+00
			TRDT:	7.707E-02
			QADT:	7.298E-04
2	300.00	subsltCB15	Total:	2.800E-06
3	0.00	Sub_CBR7	Total:	4.491E-06

Boree Project with 90% Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: Boreee - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.29E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load           Radius     Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1         -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full           1          165.0       0.0   1.00E+00     0.00
    3         ESA750-Full           1         1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full           1         1965.0       0.0   1.00E+00     0.00
    1         SAST53                1            0.0       0.0   1.00E+00     0.00
    2         SAST53                1         2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement2678            Iso.       2.68E+03   0.20
    2     rough    subsltCB15            Aniso.     1.50E+02   0.35      1.11E+02   7.50E+01   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement2678            ETH         0.000326   12.000
    2     top      subsltCB15            EZZ         0.009150    7.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    2      1.00        Subgrade (Selected Material) (Austroads 2017)
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1       300.00   cement2678
                                           SADT(80):  1.155E-04
                                           SAST(53):  8.873E-05
    2       300.00   subsltCB15
                                           SADT(80):  2.052E-04
    3         0.00   Sub_CBR7
                                           SADT(80):  2.172E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1       300.00   cement2678            Total:     4.476E+00
                                           SAST:      4.094E-01
                                           SADT:      1.496E+00
                                           TAST:      1.576E-02
                                           TADT:      2.434E+00
                                           TRDT:      1.192E-01
                                           QADT:      1.129E-03

    2       300.00   subsltCB15            Total:     3.937E-06

    3         0.00   Sub_CBR7              Total:     5.845E-06
```

Theoretical Pavements

CBR3 Pavement 20 Year Design

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load               Load                 Load            Radius    Pressure/    Exponent
   No.    ID                 Category             Type                      Ref. stress
    1     ESA750-Full        ESA750-Full          Vertical Force     92.1    0.75          0.00
    2     SAST53             SAST53               Vertical Force    102.4    0.80          0.00

   Load Locations:
   Location    Load               Gear          X          Y      Scaling     Theta
   No.         ID                 No.                             Factor
    1          ESA750-Full         1         -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full         1          165.0       0.0   1.00E+00      0.00
    3          ESA750-Full         1         1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full         1         1965.0       0.0   1.00E+00      0.00
    1          SAST53              1            0.0       0.0   1.00E+00      0.00
    2          SAST53              1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh          vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    Cement5000
                                           SADT(80): 7.947E-05
                                           SAST(53): 5.633E-05

    3        0.00    Sub_CBR3
                                           SADT(80): 2.308E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    Cement5000            Total:     9.542E-01
                                           SAST:      3.547E-02
                                           SADT:      3.388E-01
                                           TAST:      1.365E-03
                                           TADT:      5.513E-01
                                           TRDT:      2.700E-02
                                           QADT:      2.557E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     1.373E-05
```

CBR3 Pavement with Uniform Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load            Radius    Pressure/    Exponent
   No.    ID                  Category            Type                      Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force    92.1     0.75         0.00
    2     SAST53              SAST53              Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load             Gear        X          Y      Scaling    Theta
   No.        ID               No.                           Factor
    1         ESA750-Full       1       -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full       1        165.0       0.0    1.00E+00     0.00
    3         ESA750-Full       1       1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full       1       1965.0       0.0    1.00E+00     0.00
    1         SAST53            1          0.0       0.0    1.00E+00     0.00
    2         SAST53            1       2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F         Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02  1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01  1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   Cement5000            ETH        0.000263   12.000
    3     top      Sub_CBR3              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      350.00    Cement5000
                                           SADT(80):  7.673E-05
                                           SAST(53):  5.419E-05

    3        0.00    Sub_CBR3
                                           SADT(80):  2.230E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      350.00    Cement5000            Total:     6.259E-01
                                           SAST:      2.226E-02
                                           SADT:      2.226E-01
                                           TAST:      8.569E-04
                                           TADT:      3.622E-01
                                           TRDT:      1.774E-02
                                           QADT:      1.680E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     1.080E-05
```

CBR3 Pavement with Uniform Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius     Pressure/    Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1      0.75         0.00
    2     SAST53                SAST53                Vertical Force    102.4      0.80         0.00

   Load Locations:
   Location    Load                 Gear          X          Y     Scaling     Theta
   No.         ID                   No.                            Factor
    1          ESA750-Full           1       -165.0        0.0    1.00E+00      0.00
    2          ESA750-Full           1        165.0        0.0    1.00E+00      0.00
    3          ESA750-Full           1       1635.0        0.0    1.00E+00      0.00
    4          ESA750-Full           1       1965.0        0.0    1.00E+00      0.00
    1          SAST53                1          0.0        0.0    1.00E+00      0.00
    2          SAST53                1       2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.       5.00E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3               Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   Cement5000             ETH         0.000263   12.000
    3     top      Sub_CBR3               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      340.00    Cement5000
                                            SADT(80): 8.017E-05
                                            SAST(53): 5.689E-05

    3        0.00    Sub_CBR3
                                            SADT(80): 2.328E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      340.00    Cement5000             Total:     1.062E+00
                                            SAST:      3.991E-02
                                            SADT:      3.768E-01
                                            TAST:      1.536E-03
                                            TADT:      6.131E-01
                                            TRDT:      3.003E-02
                                            QADT:      2.843E-04

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR3               Total:     1.459E-05
```

CBR3 Pavement with Uniform Characteristics – 330 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR3	Aniso.	3.00E+01	0.45	2.07E+01	1.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	Sub_CBR3	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	330.00	Cement5000		
			SADT(80):	8.386E-05
			SAST(53):	5.980E-05
3	0.00	Sub_CBR3		
			SADT(80):	2.433E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	330.00	Cement5000	Total:	1.824E+00
			SAST:	7.262E-02
			SADT:	6.459E-01
			TAST:	2.795E-03
			TADT:	1.051E+00
			TRDT:	5.147E-02
			QADT:	4.874E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR3	Total:	1.988E-05

CBR3 Pavement with Uniform Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                       Gear         X          Y     Scaling     Theta
   No.        ID                         No.                           Factor
    1         ESA750-Full                 1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full                 1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full                 1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full                 1        1965.0       0.0   1.00E+00      0.00
    1         SAST53                      1           0.0       0.0   1.00E+00      0.00
    2         SAST53                      1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F         Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02  1.25E+02   0.35
    3     rough    Sub_CBR3             Aniso.     3.00E+01   0.45      2.07E+01  1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      Sub_CBR3             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      320.00    Cement5000
                                            SADT(80):  8.781E-05
                                            SAST(53):  6.294E-05
    3        0.00    Sub_CBR3
                                            SADT(80):  2.546E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      320.00    Cement5000             Total:     3.177E+00
                                            SAST:      1.343E-01
                                            SADT:      1.122E+00
                                            TAST:      5.168E-03
                                            TADT:      1.826E+00
                                            TRDT:      8.941E-02
                                            QADT:      8.467E-04

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR3               Total:     2.733E-05
```

CBR3 Pavement with Uniform Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                 Load                 Load            Radius   Pressure/    Exponent
   No.   ID                   Category             Type                     Ref. stress
    1    ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75          0.00
    2    SAST53               SAST53               Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location  Load                Gear          X          Y     Scaling     Theta
   No.       ID                  No.                            Factor
    1        ESA750-Full          1        -165.0        0.0   1.00E+00      0.00
    2        ESA750-Full          1         165.0        0.0   1.00E+00      0.00
    3        ESA750-Full          1        1635.0        0.0   1.00E+00      0.00
    4        ESA750-Full          1        1965.0        0.0   1.00E+00      0.00
    1        SAST53               1           0.0        0.0   1.00E+00      0.00
    2        SAST53               1        2130.0        0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.      5.00E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   Cement5000            ETH        0.000263   12.000
    3     top      Sub_CBR3              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      310.00    Cement5000
                                           SADT(80):  9.205E-05
                                           SAST(53):  6.634E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.668E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      310.00    Cement5000            Total:     5.613E+00
                                           SAST:      2.524E-01
                                           SADT:      1.976E+00
                                           TAST:      9.713E-03
                                           TADT:      3.216E+00
                                           TRDT:      1.575E-01
                                           QADT:      1.491E-03

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR3              Total:     3.792E-05
```

CBR3 Pavement with Uniform Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/   Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location  Load              Gear        X         Y       Scaling     Theta
   No.       ID                No.                           Factor
    1        ESA750-Full        1       -165.0      0.0    1.00E+00      0.00
    2        ESA750-Full        1        165.0      0.0    1.00E+00      0.00
    3        ESA750-Full        1       1635.0      0.0    1.00E+00      0.00
    4        ESA750-Full        1       1965.0      0.0    1.00E+00      0.00
    1        SAST53             1          0.0      0.0    1.00E+00      0.00
    2        SAST53             1       2130.0      0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material             Isotropy   Modulus    P.Ratio
   No.    i/face  ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough   Cement5000           Iso.       5.00E+03   0.20
    2     rough   Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough   Sub_CBR3             Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component  Perform.   Perform.  Shift
   No.             ID                             Constant   Exponent  Factor
    1     bottom   Cement5000          ETH        0.000263   12.000
    3     top      Sub_CBR3            EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle        Unitless
   No.               ID                               Strain
    1      300.00    Cement5000
                                          SADT(80):  9.662E-05
                                          SAST(53):  7.002E-05

    3        0.00    Sub_CBR3
                                          SADT(80):  2.800E-04

Results:

   Layer  Thickness  Material             Axle        CDF
   No.               ID                   Group
    1      300.00    Cement5000           Total:     1.007E+01
                                          SAST:      4.827E-01
                                          SADT:      3.534E+00
                                          TAST:      1.858E-02
                                          TADT:      5.750E+00
                                          TRDT:      2.816E-01
                                          QADT:      2.667E-03

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR3             Total:     5.316E-05
```

CBR3 Pavement with Uniform Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                  Load                  Load            Radius   Pressure/   Exponent
   No.   ID                    Category              Type                     Ref. stress
    1    ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75        0.00
    2    SAST53                SAST53                Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location   Load                Gear          X          Y      Scaling     Theta
   No.        ID                  No.                             Factor
    1         ESA750-Full          1         -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1          165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1         1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1         1965.0       0.0    1.00E+00     0.00
    1         SAST53               1            0.0       0.0    1.00E+00     0.00
    2         SAST53               1         2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3             Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      Sub_CBR3             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      290.00    Cement5000
                                          SADT(80):  1.015E-04
                                          SAST(53):  7.403E-05
    3        0.00    Sub_CBR3
                                          SADT(80):  2.943E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      290.00    Cement5000           Total:     1.835E+01
                                          SAST:      9.405E-01
                                          SADT:      6.417E+00
                                          TAST:      3.620E-02
                                          TADT:      1.044E+01
                                          TRDT:      5.114E-01
                                          QADT:      4.843E-03

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR3             Total:     7.532E-05
```

CBR3 Pavement with Uniform Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                    Load                    Load            Radius     Pressure/     Exponent
   No.    ID                      Category                Type                       Ref. stress
    1     ESA750-Full             ESA750-Full             Vertical Force     92.1     0.75          0.00
    2     SAST53                  SAST53                  Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                    Gear          X           Y      Scaling      Theta
   No.         ID                      No.                              Factor
    1          ESA750-Full              1         -165.0       0.0     1.00E+00      0.00
    2          ESA750-Full              1          165.0       0.0     1.00E+00      0.00
    3          ESA750-Full              1         1635.0       0.0     1.00E+00      0.00
    4          ESA750-Full              1         1965.0       0.0     1.00E+00      0.00
    1          SAST53                   1            0.0       0.0     1.00E+00      0.00
    2          SAST53                   1         2130.0       0.0     1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower     Material              Isotropy   Modulus     P.Ratio
   No.    i/face    ID                               (or Ev)     (or vvh)   F          Eh          vh
    1     rough     Cement5000            Iso.       5.00E+03    0.20
    2     rough     Gran_250              Aniso.     2.50E+02    0.35       1.85E+02   1.25E+02    0.35
    3     rough     Sub_CBR3              Aniso.     3.00E+01    0.45       2.07E+01   1.50E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.    Perform.   Shift
   No.             ID                                Constant    Exponent   Factor
    1     bottom   Cement5000             ETH         0.000263    12.000
    3     top      Sub_CBR3               EZZ         0.009150     7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      280.00    Cement5000
                                            SADT(80): 1.069E-04
                                            SAST(53): 7.838E-05
    3        0.00    Sub_CBR3
                                            SADT(80): 3.099E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      280.00    Cement5000             Total:     3.403E+01
                                            SAST:      1.868E+00
                                            SADT:      1.185E+01
                                            TAST:      7.190E-02
                                            TADT:      1.928E+01
                                            TRDT:      9.445E-01
                                            QADT:      8.944E-03

    2      100.00    Gran_250                                 n/a

    3        0.00    Sub_CBR3               Total:     1.080E-04
```

CBR3 Pavement with Uniform Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                Load                Load           Radius   Pressure/   Exponent
   No.   ID                  Category            Type                    Ref. stress
    1    ESA750-Full         ESA750-Full         Vertical Force    92.1   0.75         0.00
    2    SAST53              SAST53              Vertical Force   102.4   0.80         0.00

   Load Locations:
   Location   Load               Gear        X          Y      Scaling     Theta
   No.        ID                 No.                           Factor
    1         ESA750-Full         1       -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full         1        165.0       0.0    1.00E+00      0.00
    3         ESA750-Full         1       1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full         1       1965.0       0.0    1.00E+00      0.00
    1         SAST53              1          0.0       0.0    1.00E+00      0.00
    2         SAST53              1       2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.      5.00E+03  0.20
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.    3.00E+01  0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      270.00    Cement5000
                                           SADT(80): 1.126E-04
                                           SAST(53): 8.314E-05
    3        0.00    Sub_CBR3
                                           SADT(80): 3.268E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      270.00    Cement5000            Total:     6.424E+01
                                           SAST:      3.787E+00
                                           SADT:      2.227E+01
                                           TAST:      1.458E-01
                                           TADT:      3.624E+01
                                           TRDT:      1.775E+00
                                           QADT:      1.681E-02

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     1.569E-04
```

CBR3 Pavement with Variable Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load             Radius    Pressure/   Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location   Load                Gear         X          Y      Scaling     Theta
   No.        ID                  No.                            Factor
    1         ESA750-Full          1        -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full          1         165.0       0.0    1.00E+00      0.00
    3         ESA750-Full          1        1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full          1        1965.0       0.0    1.00E+00      0.00
    1         SAST53               1           0.0       0.0    1.00E+00      0.00
    2         SAST53               1        2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4906            Iso.      4.91E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   cement4906            ETH        0.000266   12.000
    3     top      Sub_CBR3              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1      350.00    cement4906
                                             SADT(80): 7.796E-05
                                             SAST(53): 5.507E-05
    3        0.00    Sub_CBR3
                                             SADT(80): 2.258E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1      350.00    cement4906              Total:     6.603E-01
                                             SAST:      2.360E-02
                                             SADT:      2.348E-01
                                             TAST:      9.083E-04
                                             TADT:      3.821E-01
                                             TRDT:      1.871E-02
                                             QADT:      1.772E-04

    2       92.00    Gran_250                                n/a

    3        0.00    Sub_CBR3                Total:     1.177E-05
```

CBR3 Pavement with Variable Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force   92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force  102.4     0.80          0.00

   Load Locations:
   Location   Load                Gear         X           Y     Scaling     Theta
   No.        ID                  No.                            Factor
    1         ESA750-Full          1       -165.0        0.0   1.00E+00      0.00
    2         ESA750-Full          1        165.0        0.0   1.00E+00      0.00
    3         ESA750-Full          1       1635.0        0.0   1.00E+00      0.00
    4         ESA750-Full          1       1965.0        0.0   1.00E+00      0.00
    1         SAST53               1          0.0        0.0   1.00E+00      0.00
    2         SAST53               1       2130.0        0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                 Isotropy  Modulus   P.Ratio
   No.    i/face   ID                                 (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement5024               Iso.      5.02E+03  0.20
    2     rough    Gran_250                 Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3                 Aniso.    3.00E+01  0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material                 Component  Perform.  Perform.  Shift
   No.             ID                                  Constant  Exponent  Factor
    1     bottom   cement5024               ETH        0.000262   12.000
    3     top      Sub_CBR3                 EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle      Unitless
   No.               ID                                Strain
    1      340.00    cement5024
                                             SADT(80): 7.985E-05
                                             SAST(53): 5.666E-05

    3        0.00    Sub_CBR3
                                             SADT(80): 2.321E-04

Results:

   Layer  Thickness  Material                Axle      CDF
   No.               ID                      Group
    1      340.00    cement5024              Total:    1.059E+00
                                             SAST:     3.977E-02
                                             SADT:     3.760E-01
                                             TAST:     1.531E-03
                                             TADT:     6.117E-01
                                             TRDT:     2.996E-02
                                             QADT:     2.837E-04

    2      102.00    Gran_250                               n/a

    3        0.00    Sub_CBR3                Total:    1.428E-05
```

CBR3 Pavement with Variable Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/     Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                Gear        X          Y      Scaling     Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1       -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1        165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1       1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1       1965.0       0.0    1.00E+00     0.00
    1         SAST53               1          0.0       0.0    1.00E+00     0.00
    2         SAST53               1       2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5149             Iso.       5.15E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3               Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement5149             ETH         0.000259   12.000
    3     top      Sub_CBR3               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1      330.00    cement5149
                                           SADT(80):  8.182E-05
                                           SAST(53):  5.831E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.388E-04

Results:

   Layer  Thickness  Material              Axle        CDF
   No.               ID                    Group
    1      330.00    cement5149            Total:      1.633E+00
                                           SAST:       6.448E-02
                                           SADT:       5.783E-01
                                           TAST:       2.482E-03
                                           TADT:       9.410E-01
                                           TRDT:       4.609E-02
                                           QADT:       4.364E-04

    2      112.00    Gran_250                               n/a

    3        0.00    Sub_CBR3              Total:      1.743E-05
```

CBR3 Pavement with Variable Characteristics – 320 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5283	Iso.	5.28E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR3	Aniso.	3.00E+01	0.45	2.07E+01	1.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5283	ETH	0.000259	12.000	
3	top	Sub_CBR3	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	320.00	cement5283		
			SADT(80):	8.385E-05
			SAST(53):	6.002E-05
3	0.00	Sub_CBR3		
			SADT(80):	2.459E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	320.00	cement5283	Total:	2.195E+00
			SAST:	9.133E-02
			SADT:	7.757E-01
			TAST:	3.515E-03
			TADT:	1.262E+00
			TRDT:	6.182E-02
			QADT:	5.854E-04
2	122.00	Gran_250		n/a
3	0.00	Sub_CBR3	Total:	2.140E-05

CBR3 Pavement with Variable Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load              Radius    Pressure/    Exponent
   No.    ID                  Category            Type                        Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force     92.1      0.75          0.00
    2     SAST53              SAST53              Vertical Force    102.4      0.80          0.00

   Load Locations:
   Location   Load                Gear        X          Y      Scaling      Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1       -165.0       0.0    1.00E+00       0.00
    2         ESA750-Full          1        165.0       0.0    1.00E+00       0.00
    3         ESA750-Full          1       1635.0       0.0    1.00E+00       0.00
    4         ESA750-Full          1       1965.0       0.0    1.00E+00       0.00
    1         SAST53               1          0.0       0.0    1.00E+00       0.00
    2         SAST53               1       2130.0       0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy  Modulus   P.Ratio
   No.    i/face   ID                            (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement5424          Iso.      5.42E+03  0.20
    2     rough    Gran_250            Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3            Aniso.    3.00E+01  0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component Perform.  Perform.  Shift
   No.             ID                            Constant  Exponent  Factor
    1     bottom   cement5424          ETH        0.000252  12.000
    3     top      Sub_CBR3            EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material            Axle      Unitless
   No.               ID                            Strain
    1      310.00    cement5424
                                         SADT(80): 8.597E-05
                                         SAST(53): 6.183E-05
    3        0.00    Sub_CBR3
                                         SADT(80): 2.534E-04

Results:

   Layer  Thickness  Material            Axle      CDF
   No.               ID                  Group
    1      310.00    cement5424          Total:    4.125E+00
                                         SAST:     1.812E-01
                                         SADT:     1.454E+00
                                         TAST:     6.973E-03
                                         TADT:     2.366E+00
                                         TRDT:     1.159E-01
                                         QADT:     1.097E-03

    2      132.00    Gran_250                          n/a

    3        0.00    Sub_CBR3            Total:    2.646E-05
```

CBR3 Pavement with Variable Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load              Gear          X          Y       Scaling     Theta
   No.        ID                No.                              Factor
    1         ESA750-Full        1         -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full        1          165.0        0.0    1.00E+00      0.00
    3         ESA750-Full        1         1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full        1         1965.0        0.0    1.00E+00      0.00
    1         SAST53             1            0.0        0.0    1.00E+00      0.00
    2         SAST53             1         2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement5575           Iso.      5.58E+03   0.20
    2     rough    Gran_250             Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR3             Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01    0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement5575           ETH         0.000247   12.000
    3     top      Sub_CBR3             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    cement5575
                                           SADT(80):  8.816E-05
                                           SAST(53):  6.372E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.615E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    cement5575            Total:     7.117E+00
                                           SAST:      3.304E-01
                                           SADT:      2.502E+00
                                           TAST:      1.272E-02
                                           TADT:      4.071E+00
                                           TRDT:      1.994E-01
                                           QADT:      1.888E-03

    2      142.00    Gran_250                             n/a

    3        0.00    Sub_CBR3              Total:     3.293E-05
```

CBR3 Pavement with Variable Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load            Gear        X         Y      Scaling     Theta
   No.         ID              No.                          Factor
    1          ESA750-Full      1        -165.0       0.0  1.00E+00      0.00
    2          ESA750-Full      1         165.0       0.0  1.00E+00      0.00
    3          ESA750-Full      1        1635.0       0.0  1.00E+00      0.00
    4          ESA750-Full      1        1965.0       0.0  1.00E+00      0.00
    1          SAST53           1           0.0       0.0  1.00E+00      0.00
    2          SAST53           1        2130.0       0.0  1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy   Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5737          Iso.       5.74E+03   0.20
    2     rough    Gran_250            Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3            Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component  Perform.   Perform.   Shift
   No.             ID                             Constant   Exponent   Factor
    1     bottom   cement5737          ETH         0.000243   12.000
    3     top      Sub_CBR3            EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      290.00    cement5737
                                           SADT(80):  9.043E-05
                                           SAST(53):  6.568E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.700E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      290.00    cement5737            Total:     1.178E+01
                                           SAST:      5.788E-01
                                           SADT:      4.128E+00
                                           TAST:      2.228E-02
                                           TADT:      6.716E+00
                                           TRDT:      3.289E-01
                                           QADT:      3.115E-03

    2      152.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     4.125E-05
```

CBR3 Pavement with Variable Characteristics – 280 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5910	Iso.	5.91E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR3	Aniso.	3.00E+01	0.45	2.07E+01	1.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5910	ETH	0.000238	12.000	
3	top	Sub_CBR3	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	280.00	cement5910		
			SADT(80):	9.279E-05
			SAST(53):	6.775E-05
3	0.00	Sub_CBR3		
			SADT(80):	2.792E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	280.00	cement5910	Total:	2.066E+01
			SAST:	1.076E+00
			SADT:	7.217E+00
			TAST:	4.143E-02
			TADT:	1.174E+01
			TRDT:	5.751E-01
			QADT:	5.446E-03
2	162.00	Gran_250		n/a
3	0.00	Sub_CBR3	Total:	5.208E-05

CBR3 Pavement with Variable Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force    92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear         X          Y      Scaling      Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0    1.00E+00       0.00
    2         ESA750-Full           1         165.0       0.0    1.00E+00       0.00
    3         ESA750-Full           1        1635.0       0.0    1.00E+00       0.00
    4         ESA750-Full           1        1965.0       0.0    1.00E+00       0.00
    1         SAST53                1           0.0       0.0    1.00E+00       0.00
    2         SAST53                1        2130.0       0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus   P.Ratio
   No.    i/face   ID                               (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement6096             Iso.      6.10E+03  0.20
    2     rough    Gran_250               Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3               Aniso.    3.00E+01  0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component Perform.  Perform.  Shift
   No.             ID                               Constant  Exponent  Factor
    1     bottom   cement6096             ETH        0.000233  12.000
    3     top      Sub_CBR3               EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      270.00    cement6096
                                           SADT(80):  9.524E-05
                                           SAST(53):  6.990E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.889E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      270.00    cement6096            Total:     3.656E+01
                                           SAST:      2.023E+00
                                           SADT:      1.273E+01
                                           TAST:      7.786E-02
                                           TADT:      2.071E+01
                                           TRDT:      1.014E+00
                                           QADT:      9.605E-03

    2      172.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     6.624E-05
```

CBR 3 Pavement with 105 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load               Gear          X           Y      Scaling     Theta
   No.        ID                 No.                              Factor
    1         ESA750-Full         1       -165.0         0.0    1.00E+00      0.00
    2         ESA750-Full         1        165.0         0.0    1.00E+00      0.00
    3         ESA750-Full         1       1635.0         0.0    1.00E+00      0.00
    4         ESA750-Full         1       1965.0         0.0    1.00E+00      0.00
    1         SAST53              1          0.0         0.0    1.00E+00      0.00
    2         SAST53              1       2130.0         0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement6127             Iso.      6.13E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3               Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement6127             ETH         0.000232   12.000
    3     top      Sub_CBR3               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      342.00    cement6127
                                            SADT(80):  6.783E-05
                                            SAST(53):  4.784E-05

    3        0.00    Sub_CBR3
                                            SADT(80):  2.053E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      342.00    cement6127             Total:     6.412E-01
                                            SAST:      2.251E-02
                                            SADT:      2.282E-01
                                            TAST:      8.664E-04
                                            TADT:      3.713E-01
                                            TRDT:      1.818E-02
                                            QADT:      1.722E-04

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR3               Total:     6.054E-06
```

CBR 3 Pavement with 104 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full           1         165.0       0.0    1.00E+00      0.00
    3         ESA750-Full           1        1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full           1        1965.0       0.0    1.00E+00      0.00
    1         SAST53                1           0.0       0.0    1.00E+00      0.00
    2         SAST53                1        2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                 (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5896              Iso.       5.90E+03   0.20
    2     rough    Gran_250                Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3                Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material                Component  Perform.   Perform.  Shift
   No.             ID                                 Constant   Exponent  Factor
    1     bottom   cement5896              ETH         0.000239   12.000
    3     top      Sub_CBR3                EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00        Cement Stabilised
    3       1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle        Unitless
   No.               ID                                  Strain
    1      342.00    cement5896
                                             SADT(80):  6.990E-05
                                             SAST(53):  4.935E-05

    3        0.00    Sub_CBR3
                                             SADT(80):  2.099E-04

Results:

   Layer  Thickness  Material                Axle        CDF
   No.               ID                      Group
    1      342.00    cement5896              Total:     6.439E-01
                                             SAST:      2.284E-02
                                             SADT:      2.290E-01
                                             TAST:      8.793E-04
                                             TADT:      3.727E-01
                                             TRDT:      1.825E-02
                                             QADT:      1.728E-04

    2      100.00    Gran_250                                 n/a

    3        0.00    Sub_CBR3                Total:     7.068E-06
```

CBR 3 Pavement with 103 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                Gear          X          Y      Scaling     Theta
   No.         ID                  No.                             Factor
    1          ESA750-Full          1         -165.0       0.0     1.00E+00     0.00
    2          ESA750-Full          1          165.0       0.0     1.00E+00     0.00
    3          ESA750-Full          1         1635.0       0.0     1.00E+00     0.00
    4          ESA750-Full          1         1965.0       0.0     1.00E+00     0.00
    1          SAST53               1            0.0       0.0     1.00E+00     0.00
    2          SAST53               1         2130.0       0.0     1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement5665            Iso.      5.67E+03  0.00
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.    3.00E+01  0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5665            ETH        0.000245   12.000
    3     top      Sub_CBR3              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    cement5665
                                           SADT(80):  7.422E-05
                                           SAST(53):  5.251E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.197E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    cement5665            Total:     9.834E-01
                                           SAST:      3.575E-02
                                           SADT:      3.495E-01
                                           TAST:      1.376E-03
                                           TADT:      5.687E-01
                                           TRDT:      2.785E-02
                                           QADT:      2.637E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     9.736E-06
```

CBR 3 Pavement with 102 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                  Load                  Load            Radius    Pressure/    Exponent
   No.   ID                    Category              Type                      Ref. stress
    1    ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2    SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                Gear          X          Y     Scaling     Theta
   No.         ID                  No.                            Factor
    1          ESA750-Full          1         -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full          1          165.0       0.0   1.00E+00      0.00
    3          ESA750-Full          1         1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full          1         1965.0       0.0   1.00E+00      0.00
    1          SAST53               1            0.0       0.0   1.00E+00      0.00
    2          SAST53               1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5434            Iso.       5.43E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement5434            ETH         0.000251   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      342.00    cement5434
                                          SADT(80):  7.449E-05
                                          SAST(53):  5.269E-05

    3        0.00    Sub_CBR3
                                          SADT(80):  2.200E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      342.00    cement5434           Total:     7.684E-01
                                          SAST:      2.788E-02
                                          SADT:      2.731E-01
                                          TAST:      1.073E-03
                                          TADT:      4.444E-01
                                          TRDT:      2.176E-02
                                          QADT:      2.061E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR3             Total:     9.821E-06
```

CBR 3 Pavement with 101 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius   Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location    Load                Gear         X          Y     Scaling     Theta
   No.         ID                  No.                           Factor
    1          ESA750-Full          1       -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full          1        165.0       0.0   1.00E+00      0.00
    3          ESA750-Full          1       1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full          1       1965.0       0.0   1.00E+00      0.00
    1          SAST53               1          0.0       0.0   1.00E+00      0.00
    2          SAST53               1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5203            Iso.      5.20E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   cement5203            ETH        0.000258   12.000
    3     top      Sub_CBR3              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    cement5203
                                           SADT(80):  7.705E-05
                                           SAST(53):  5.456E-05

    3        0.00    Sub_CBR3
                                           SADT(80):  2.256E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    cement5203            Total:     8.289E-01
                                           SAST:      3.046E-02
                                           SADT:      2.945E-01
                                           TAST:      1.172E-03
                                           TADT:      4.791E-01
                                           TRDT:      2.347E-02
                                           QADT:      2.222E-04

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR3              Total:     1.170E-05
```

CBR 3 Pavement with 100 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius     Pressure/    Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X           Y      Scaling       Theta
   No.         ID                    No.                              Factor
    1          ESA750-Full           1          -165.0        0.0     1.00E+00       0.00
    2          ESA750-Full           1           165.0        0.0     1.00E+00       0.00
    3          ESA750-Full           1          1635.0        0.0     1.00E+00       0.00
    4          ESA750-Full           1          1965.0        0.0     1.00E+00       0.00
    1          SAST53                1             0.0        0.0     1.00E+00       0.00
    2          SAST53                1          2130.0        0.0     1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      342.00    Cement5000
                                            SADT(80): 7.947E-05
                                            SAST(53): 5.633E-05

    3        0.00    Sub_CBR3
                                            SADT(80): 2.308E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      342.00    Cement5000             Total:     9.542E-01
                                            SAST:      3.547E-02
                                            SADT:      3.388E-01
                                            TAST:      1.365E-03
                                            TADT:      5.513E-01
                                            TRDT:      2.700E-02
                                            QADT:      2.557E-04

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR3               Total:     1.373E-05
```

CBR 3 Pavement with 99 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load            Radius    Pressure/    Exponent
   No.    ID                  Category            Type                      Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force    92.1     0.75          0.00
    2     SAST53              SAST53              Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1         -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full           1          165.0       0.0   1.00E+00     0.00
    3         ESA750-Full           1         1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full           1         1965.0       0.0   1.00E+00     0.00
    1         SAST53                1            0.0       0.0   1.00E+00     0.00
    2         SAST53                1         2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material              Isotropy  Modulus   P.Ratio
   No.    i/face  ID                              (or Ev)   (or vvh)  F         Eh        vh
    1     rough   cement4724            Iso.      4.74E+03  0.20
    2     rough   Gran_250              Aniso.    2.50E+02  0.35      1.85E+02  1.25E+02  0.35
    3     rough   Sub_CBR3              Aniso.    3.00E+01  0.45      2.07E+01  1.50E+01  0.45

   Performance Relationships:
   Layer  Location Material             Component Perform.  Perform.  Shift
   No.             ID                             Constant  Exponent  Factor
    1     bottom  cement4724            ETH        0.000270  12.000
    3     top     Sub_CBR3              EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    cement4724
                                           SADT(80):  8.280E-05
                                           SAST(53):  5.877E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.379E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    cement4724            Total:     1.140E+00
                                           SAST:      4.304E-02
                                           SADT:      4.045E-01
                                           TAST:      1.657E-03
                                           TADT:      6.582E-01
                                           TRDT:      3.224E-02
                                           QADT:      3.053E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     1.699E-05
```

CBR 3 Pavement with 98 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius     Pressure/    Exponent
   No.    ID                     Category               Type                       Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                   Gear          X          Y     Scaling     Theta
   No.        ID                     No.                            Factor
    1         ESA750-Full             1        -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full             1         165.0        0.0    1.00E+00      0.00
    3         ESA750-Full             1        1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full             1        1965.0        0.0    1.00E+00      0.00
    1         SAST53                  1           0.0        0.0    1.00E+00      0.00
    2         SAST53                  1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                Isotropy  Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4511              Iso.      4.51E+03   0.20
    2     rough    Gran_250                Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3                Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material                Component Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement4511              ETH        0.000276   12.000
    3     top      Sub_CBR3                EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      342.00    cement4511
                                            SADT(80): 8.606E-05
                                            SAST(53): 6.116E-05
    3        0.00    Sub_CBR3
                                            SADT(80): 2.448E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      342.00    cement4511             Total:     1.393E+00
                                            SAST:      5.336E-02
                                            SADT:      4.938E-01
                                            TAST:      2.054E-03
                                            TADT:      8.036E-01
                                            TRDT:      3.936E-02
                                            QADT:      3.727E-04

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR3               Total:     2.077E-05
```

CBR 3 Pavement with 97 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                Gear          X          Y      Scaling      Theta
   No.         ID                  No.                              Factor
    1          ESA750-Full          1         -165.0       0.0    1.00E+00      0.00
    2          ESA750-Full          1          165.0       0.0    1.00E+00      0.00
    3          ESA750-Full          1         1635.0       0.0    1.00E+00      0.00
    4          ESA750-Full          1         1965.0       0.0    1.00E+00      0.00
    1          SAST53               1            0.0       0.0    1.00E+00      0.00
    2          SAST53               1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4280            Iso.       4.28E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement4280            ETH         0.000283   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    cement4280
                                           SADT(80): 8.961E-05
                                           SAST(53): 6.378E-05
    3        0.00    Sub_CBR3
                                           SADT(80): 2.523E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    cement4280            Total:     1.678E+00
                                           SAST:      6.534E-02
                                           SADT:      5.946E-01
                                           TAST:      2.515E-03
                                           TADT:      9.676E-01
                                           TRDT:      4.739E-02
                                           QADT:      4.488E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3              Total:     2.565E-05
```

CBR 3 Pavement with 96 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius     Pressure/    Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                Gear          X          Y      Scaling     Theta
   No.        ID                  No.                             Factor
    1         ESA750-Full          1         -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1          165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1         1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1         1965.0       0.0    1.00E+00     0.00
    1         SAST53               1            0.0       0.0    1.00E+00     0.00
    2         SAST53               1         2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus   P.Ratio
   No.    i/face   ID                             (or Ev)   (or vvh)  F         Eh         vh
    1     rough    cement4049           Iso.      4.05E+03  0.20
    2     rough    Gran_250             Aniso.    2.50E+02  0.35      1.85E+02  1.25E+02   0.35
    3     rough    Sub_CBR3             Aniso.    3.00E+01  0.45      2.07E+01  1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component Perform.  Perform.  Shift
   No.             ID                             Constant  Exponent  Factor
    1     bottom   cement4049           ETH        0.000289  12.000
    3     top      Sub_CBR3             EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle      Unitless
   No.               ID                             Strain
    1      342.00    cement4049
                                          SADT(80): 9.352E-05
                                          SAST(53): 6.666E-05
    3        0.00    Sub_CBR3
                                          SADT(80): 2.605E-04

Results:

   Layer  Thickness  Material             Axle      CDF
   No.               ID                   Group
    1      342.00    cement4049           Total:    2.178E+00
                                          SAST:     8.630E-02
                                          SADT:     7.714E-01
                                          TAST:     3.321E-03
                                          TADT:     1.255E+00
                                          TRDT:     6.148E-02
                                          QADT:     5.821E-04

    2      100.00    Gran_250                            n/a

    3        0.00    Sub_CBR3             Total:    3.206E-05
```

CBR 3 Pavement with 95 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location    Load                Gear         X           Y     Scaling     Theta
   No.         ID                  No.                            Factor
    1          ESA750-Full          1        -165.0        0.0   1.00E+00     0.00
    2          ESA750-Full          1         165.0        0.0   1.00E+00     0.00
    3          ESA750-Full          1        1635.0        0.0   1.00E+00     0.00
    4          ESA750-Full          1        1965.0        0.0   1.00E+00     0.00
    1          SAST53               1           0.0        0.0   1.00E+00     0.00
    2          SAST53               1        2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F           Eh          vh
    1     rough    cement3818            Iso.       3.82E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02    1.25E+02    0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01    1.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement3818            ETH         0.000295   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    cement3818
                                           SADT(80):  9.783E-05
                                           SAST(53):  6.985E-05
    3        0.00    Sub_CBR3
                                           SADT(80):  2.694E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    cement3818            Total:     2.925E+00
                                           SAST:      1.180E-01
                                           SADT:      1.035E+00
                                           TAST:      4.543E-03
                                           TADT:      1.684E+00
                                           TRDT:      8.249E-02
                                           QADT:      7.812E-04

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR3              Total:     4.059E-05
```

CBR 3 Pavement with 94 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1    0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4    0.80          0.00

   Load Locations:
   Location   Load                Gear          X          Y       Scaling     Theta
   No.        ID                  No.                              Factor
    1         ESA750-Full          1         -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full          1          165.0       0.0    1.00E+00      0.00
    3         ESA750-Full          1         1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full          1         1965.0       0.0    1.00E+00      0.00
    1         SAST53               1            0.0       0.0    1.00E+00      0.00
    2         SAST53               1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement3587             Iso.       3.59E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR3               Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.  Shift
   No.             ID                                Constant   Exponent  Factor
    1     bottom   cement3587             ETH         0.000302   12.000
    3     top      Sub_CBR3               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      342.00    cement3587
                                            SADT(80):  1.026E-04
                                            SAST(53):  7.339E-05

    3        0.00    Sub_CBR3
                                            SADT(80):  2.792E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      342.00    cement3587             Total:     3.918E+00
                                            SAST:      1.613E-01
                                            SADT:      1.385E+00
                                            TAST:      6.208E-03
                                            TADT:      2.254E+00
                                            TRDT:      1.104E-01
                                            QADT:      1.045E-03

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3               Total:     5.214E-05
```

CBR 3 Pavement with 93 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load             Gear        X          Y      Scaling     Theta
   No.        ID               No.                           Factor
    1         ESA750-Full       1       -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full       1        165.0       0.0    1.00E+00     0.00
    3         ESA750-Full       1       1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full       1       1965.0       0.0    1.00E+00     0.00
    1         SAST53            1          0.0       0.0    1.00E+00     0.00
    2         SAST53            1       2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3356           Iso.       3.36E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3             Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement3356           ETH         0.000308   12.000
    3     top      Sub_CBR3             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      342.00    cement3356
                                          SADT(80): 1.080E-04
                                          SAST(53): 7.735E-05
    3        0.00    Sub_CBR3
                                          SADT(80): 2.901E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      342.00    cement3356           Total:     5.692E+00
                                          SAST:      2.395E-01
                                          SADT:      2.010E+00
                                          TAST:      9.218E-03
                                          TADT:      3.271E+00
                                          TRDT:      1.602E-01
                                          QADT:      1.517E-03

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR3             Total:     6.809E-05
```

CBR 3 Pavement with 92 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                 Gear          X           Y      Scaling     Theta
   No.         ID                   No.                              Factor
    1          ESA750-Full           1         -165.0        0.0    1.00E+00      0.00
    2          ESA750-Full           1          165.0        0.0    1.00E+00      0.00
    3          ESA750-Full           1         1635.0        0.0    1.00E+00      0.00
    4          ESA750-Full           1         1965.0        0.0    1.00E+00      0.00
    1          SAST53                1            0.0        0.0    1.00E+00      0.00
    2          SAST53                1         2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3125            Iso.       3.13E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3              Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement3125            ETH         0.000314   12.000
    3     top      Sub_CBR3              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1       342.00   cement3125
                                            SADT(80):  1.140E-04
                                            SAST(53):  8.183E-05
    3         0.00   Sub_CBR3
                                            SADT(80):  3.022E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1       342.00   cement3125             Total:     8.658E+00
                                            SAST:      3.731E-01
                                            SADT:      3.055E+00
                                            TAST:      1.436E-02
                                            TADT:      4.970E+00
                                            TRDT:      2.434E-01
                                            QADT:      2.305E-03

    2       100.00   Gran_250                                n/a

    3         0.00   Sub_CBR3               Total:     9.062E-05
```

CBR 3 Pavement with 91 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load               Load               Load          Radius    Pressure/    Exponent
   No.    ID                 Category           Type                    Ref. stress
    1     ESA750-Full        ESA750-Full        Vertical Force    92.1    0.75         0.00
    2     SAST53             SAST53             Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location  Load              Gear         X          Y      Scaling    Theta
   No.       ID                No.                            Factor
    1        ESA750-Full        1        -165.0       0.0    1.00E+00    0.00
    2        ESA750-Full        1         165.0       0.0    1.00E+00    0.00
    3        ESA750-Full        1        1635.0       0.0    1.00E+00    0.00
    4        ESA750-Full        1        1965.0       0.0    1.00E+00    0.00
    1        SAST53             1           0.0       0.0    1.00E+00    0.00
    2        SAST53             1        2130.0       0.0    1.00E+00    0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement2894             Iso.      2.89E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3               Aniso.    3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement2894             ETH         0.000320   12.000
    3     top      Sub_CBR3               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle      Unitless
   No.               ID                             Strain
    1      342.00    cement2894
                                          SADT(80): 1.208E-04
                                          SAST(53): 8.692E-05
    3        0.00    Sub_CBR3
                                          SADT(80): 3.158E-04

Results:

   Layer  Thickness  Material             Axle      CDF
   No.               ID                   Group
    1      342.00    cement2894           Total:    1.387E+01
                                          SAST:     6.133E-01
                                          SADT:     4.886E+00
                                          TAST:     2.361E-02
                                          TADT:     7.951E+00
                                          TRDT:     3.894E-01
                                          QADT:     3.687E-03

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR3             Total:    1.233E-04
```

CBR 3 Pavement with 90 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR3 - Compaction Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1    0.75          0.00
    2     SAST53                 SAST53                 Vertical Force    102.4    0.80          0.00

   Load Locations:
   Location   Load                  Gear          X          Y      Scaling     Theta
   No.        ID                    No.                             Factor
    1         ESA750-Full            1        -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full            1         165.0        0.0    1.00E+00      0.00
    3         ESA750-Full            1        1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full            1        1965.0        0.0    1.00E+00      0.00
    1         SAST53                 1           0.0        0.0    1.00E+00      0.00
    2         SAST53                 1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement2663           Iso.       2.66E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR3             Aniso.     3.00E+01   0.45      2.07E+01   1.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement2663           ETH         0.000327   12.000
    3     top      Sub_CBR3             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.    Factor        Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      342.00    cement2663
                                           SADT(80): 1.286E-04
                                           SAST(53): 9.277E-05

    3        0.00    Sub_CBR3
                                           SADT(80): 3.311E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      342.00    cement2663            Total:     2.271E+01
                                           SAST:      1.034E+00
                                           SADT:      7.989E+00
                                           TAST:      3.979E-02
                                           TADT:      1.300E+01
                                           TRDT:      6.367E-01
                                           QADT:      6.029E-03

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR3              Total:     1.720E-04
```

CBR5 Pavement 20 Year Design

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load              Radius     Pressure/    Exponent
   No.    ID                   Category             Type                         Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force      92.1      0.75          0.00
    2     SAST53               SAST53               Vertical Force     102.4      0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y      Scaling     Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1         -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full           1          165.0       0.0    1.00E+00      0.00
    3         ESA750-Full           1         1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full           1         1965.0       0.0    1.00E+00      0.00
    1         SAST53                1            0.0       0.0    1.00E+00      0.00
    2         SAST53                1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      315.00    Cement5000
                                            SADT(80): 7.967E-05
                                            SAST(53): 5.817E-05
    3        0.00    Sub_CBR5
                                            SADT(80): 2.093E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      315.00    Cement5000             Total:     9.994E-01
                                            SAST:      5.209E-02
                                            SADT:      3.491E-01
                                            TAST:      2.005E-03
                                            TADT:      5.681E-01
                                            TRDT:      2.782E-02
                                            QADT:      2.635E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5               Total:     6.927E-06
```

CBR5 Pavement with Uniform Characteristics – 350 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR5	Aniso.	5.00E+01	0.45	3.45E+01	2.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	Sub_CBR5	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	350.00	Cement5000		
			SADT(80):	6.812E-05
			SAST(53):	4.876E-05
3	0.00	Sub_CBR5		
			SADT(80):	1.794E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	350.00	Cement5000	Total:	1.509E-01
			SAST:	6.277E-03
			SADT:	5.333E-02
			TAST:	2.416E-04
			TADT:	8.677E-02
			TRDT:	4.250E-03
			QADT:	4.024E-05
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR5	Total:	2.357E-06

CBR5 Pavement with Uniform Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius     Pressure/    Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load              Gear        X          Y       Scaling     Theta
   No.        ID                No.                            Factor
    1         ESA750-Full        1       -165.0       0.0     1.00E+00     0.00
    2         ESA750-Full        1        165.0       0.0     1.00E+00     0.00
    3         ESA750-Full        1       1635.0       0.0     1.00E+00     0.00
    4         ESA750-Full        1       1965.0       0.0     1.00E+00     0.00
    1         SAST53             1          0.0       0.0     1.00E+00     0.00
    2         SAST53             1       2130.0       0.0     1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   Cement5000           ETH        0.000263   12.000
    3     top      Sub_CBR5             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00       Cement Stabilised
    3      1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle        Unitless
   No.               ID                               Strain
    1      340.00    Cement5000
                                          SADT(80):  7.114E-05
                                          SAST(53):  5.120E-05
    3        0.00    Sub_CBR5
                                          SADT(80):  1.872E-04

Results:

   Layer  Thickness  Material             Axle        CDF
   No.               ID                   Group
    1      340.00    Cement5000           Total:      2.548E-01
                                          SAST:       1.127E-02
                                          SADT:       8.978E-02
                                          TAST:       4.338E-04
                                          TADT:       1.461E-01
                                          TRDT:       7.155E-03
                                          QADT:       6.775E-05

    2      100.00    Gran_250                            n/a

    3        0.00    Sub_CBR5             Total:      3.173E-06
```

CBR5 Pavement with Uniform Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                  Load            Radius    Pressure/    Exponent
   No.    ID                     Category              Type                      Ref. stress
    1     ESA750-Full            ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                 SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                  Gear          X          Y      Scaling     Theta
   No.        ID                    No.                              Factor
    1         ESA750-Full            1         -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full            1          165.0       0.0   1.00E+00      0.00
    3         ESA750-Full            1         1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full            1         1965.0       0.0   1.00E+00      0.00
    1         SAST53                 1            0.0       0.0   1.00E+00      0.00
    2         SAST53                 1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material                Isotropy   Modulus    P.Ratio
   No.    i/face  ID                                 (or Ev)    (or vvh)  F          Eh         vh
    1     rough   Cement5000              Iso.       5.00E+03   0.20
    2     rough   Gran_250                Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough   Sub_CBR5                Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.  Shift
   No.             ID                                Constant   Exponent  Factor
    1     bottom  Cement5000              ETH         0.000263   12.000
    3     top     Sub_CBR5                EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      330.00    Cement5000
                                            SADT(80):  7.438E-05
                                            SAST(53):  5.383E-05
    3        0.00    Sub_CBR5
                                            SADT(80):  1.955E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      330.00    Cement5000             Total:     4.357E-01
                                            SAST:      2.055E-02
                                            SADT:      1.530E-01
                                            TAST:      7.908E-04
                                            TADT:      2.490E-01
                                            TRDT:      1.220E-02
                                            QADT:      1.155E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5               Total:     4.307E-06
```

CBR5 Pavement with Uniform Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load               Load               Load           Radius   Pressure/    Exponent
   No.   ID                 Category           Type                    Ref. stress
    1    ESA750-Full        ESA750-Full        Vertical Force   92.1    0.75         0.00
    2    SAST53             SAST53             Vertical Force  102.4    0.80         0.00

   Load Locations:
   Location   Load                Gear        X          Y      Scaling     Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1       -165.0        0.0    1.00E+00     0.00
    2         ESA750-Full          1        165.0        0.0    1.00E+00     0.00
    3         ESA750-Full          1       1635.0        0.0    1.00E+00     0.00
    4         ESA750-Full          1       1965.0        0.0    1.00E+00     0.00
    1         SAST53               1          0.0        0.0    1.00E+00     0.00
    2         SAST53               1       2130.0        0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F         Eh        vh
    1     rough    Cement5000            Iso.      5.00E+03  0.20
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02  1.25E+02  0.35
    3     rough    Sub_CBR5              Aniso.    5.00E+01  0.45      3.45E+01  2.50E+01  0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.  Perform.  Shift
   No.             ID                              Constant  Exponent  Factor
    1     bottom   Cement5000            ETH        0.000263  12.000
    3     top      Sub_CBR5              EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle      Unitless
   No.               ID                              Strain
    1      320.00    Cement5000
                                           SADT(80): 7.784E-05
                                           SAST(53): 5.666E-05

    3        0.00    Sub_CBR5
                                           SADT(80): 2.045E-04

Results:

   Layer  Thickness  Material              Axle      CDF
   No.               ID                    Group
    1      320.00    Cement5000            Total:    7.552E-01
                                           SAST:     3.805E-02
                                           SADT:     2.643E-01
                                           TAST:     1.464E-03
                                           TADT:     4.301E-01
                                           TRDT:     2.106E-02
                                           QADT:     1.995E-04

    2      100.00    Gran_250                            n/a

    3        0.00    Sub_CBR5              Total:    5.898E-06
```

CBR5 Pavement with Uniform Characteristics – 310 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR5	Aniso.	5.00E+01	0.45	3.45E+01	2.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	Sub_CBR5	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	310.00	Cement5000		
			SADT(80):	8.156E-05
			SAST(53):	5.973E-05
3	0.00	Sub_CBR5		
			SADT(80):	2.142E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	310.00	Cement5000	Total:	1.327E+00
			SAST:	7.162E-02
			SADT:	4.628E-01
			TAST:	2.757E-03
			TADT:	7.530E-01
			TRDT:	3.688E-02
			QADT:	3.492E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR5	Total:	8.155E-06

CBR5 Pavement with Uniform Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                Load             Radius    Pressure/    Exponent
   No.    ID                    Category            Type                       Ref. stress
    1     ESA750-Full           ESA750-Full         Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53              Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                  Gear          X          Y     Scaling     Theta
   No.        ID                    No.                            Factor
    1         ESA750-Full            1         -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full            1          165.0       0.0   1.00E+00     0.00
    3         ESA750-Full            1         1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full            1         1965.0       0.0   1.00E+00     0.00
    1         SAST53                 1            0.0       0.0   1.00E+00     0.00
    2         SAST53                 1         2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F         Eh        vh
    1     rough    Cement5000            Iso.      5.00E+03  0.20
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02  1.25E+02  0.35
    3     rough    Sub_CBR5              Aniso.    5.00E+01  0.45      3.45E+01  2.50E+01  0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.  Perform.  Shift
   No.             ID                               Constant  Exponent  Factor
    1     bottom   Cement5000            ETH        0.000263   12.000
    3     top      Sub_CBR5              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle         Unitless
   No.               ID                                Strain
    1      300.00    Cement5000
                                          SADT(80): 8.556E-05
                                          SAST(53): 6.305E-05
    3        0.00    Sub_CBR5
                                          SADT(80): 2.247E-04

Results:

   Layer  Thickness  Material             Axle         CDF
   No.               ID                   Group
    1      300.00    Cement5000           Total:       2.368E+00
                                          SAST:        1.372E-01
                                          SADT:        8.221E-01
                                          TAST:        5.280E-03
                                          TADT:        1.338E+00
                                          TRDT:        6.551E-02
                                          QADT:        6.204E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5             Total:       1.139E-05
```

CBR5 Pavement with Uniform Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                    Load                 Load              Radius    Pressure/    Exponent
   No.    ID                      Category             Type                        Ref. stress
    1     ESA750-Full             ESA750-Full          Vertical Force      92.1     0.75          0.00
    2     SAST53                  SAST53               Vertical Force     102.4     0.80          0.00

   Load Locations:
   Location    Load                    Gear          X          Y      Scaling      Theta
   No.         ID                      No.                             Factor
    1          ESA750-Full              1         -165.0       0.0     1.00E+00      0.00
    2          ESA750-Full              1          165.0       0.0     1.00E+00      0.00
    3          ESA750-Full              1         1635.0       0.0     1.00E+00      0.00
    4          ESA750-Full              1         1965.0       0.0     1.00E+00      0.00
    1          SAST53                   1            0.0       0.0     1.00E+00      0.00
    2          SAST53                   1         2130.0       0.0     1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.      5.00E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH        0.000263   12.000
    3     top      Sub_CBR5              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1      290.00    Cement5000
                                           SADT(80):  8.987E-05
                                           SAST(53):  6.666E-05
    3        0.00    Sub_CBR5
                                           SADT(80):  2.361E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      290.00    Cement5000            Total:     4.293E+00
                                           SAST:      2.675E-01
                                           SADT:      1.483E+00
                                           TAST:      1.030E-02
                                           TADT:      2.413E+00
                                           TRDT:      1.182E-01
                                           QADT:      1.119E-03

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR5              Total:     1.609E-05
```

CBR5 Pavement with Uniform Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load           Radius    Pressure/     Exponent
   No.    ID                    Category              Type                     Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                   Gear          X          Y      Scaling     Theta
   No.        ID                     No.                             Factor
    1         ESA750-Full             1         -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full             1          165.0       0.0    1.00E+00      0.00
    3         ESA750-Full             1         1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full             1         1965.0       0.0    1.00E+00      0.00
    1         SAST53                  1            0.0       0.0    1.00E+00      0.00
    2         SAST53                  1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F           Eh          vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02    1.25E+02    0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01    2.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1      280.00    Cement5000
                                           SADT(80):  9.453E-05
                                           SAST(53):  7.059E-05
    3        0.00    Sub_CBR5
                                           SADT(80):  2.484E-04

Results:

   Layer  Thickness  Material              Axle        CDF
   No.               ID                    Group
    1      280.00    Cement5000            Total:      7.912E+00
                                           SAST:       5.316E-01
                                           SADT:       2.718E+00
                                           TAST:       2.046E-02
                                           TADT:       4.423E+00
                                           TRDT:       2.166E-01
                                           QADT:       2.051E-03

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR5              Total:      2.299E-05
```

CBR5 Pavement with Uniform Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/   Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y      Scaling     Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1        -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full           1         165.0        0.0    1.00E+00      0.00
    3         ESA750-Full           1        1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full           1        1965.0        0.0    1.00E+00      0.00
    1         SAST53                1           0.0        0.0    1.00E+00      0.00
    2         SAST53                1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle        Unitless
   No.               ID                               Strain
    1      270.00    Cement5000
                                          SADT(80):  9.957E-05
                                          SAST(53):  7.487E-05
    3        0.00    Sub_CBR5
                                          SADT(80):  2.619E-04

Results:

   Layer  Thickness  Material             Axle        CDF
   No.               ID                   Group
    1      270.00    Cement5000           Total:      1.485E+01
                                          SAST:       1.078E+00
                                          SADT:       5.070E+00
                                          TAST:       4.149E-02
                                          TADT:       8.250E+00
                                          TRDT:       4.040E-01
                                          QADT:       3.826E-03

    2      100.00    Gran_250                                 n/a

    3        0.00    Sub_CBR5             Total:      3.328E-05
```

CBR5 Pavement with Variable Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load             Gear          X           Y      Scaling     Theta
   No.        ID               No.                              Factor
    1         ESA750-Full       1         -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full       1          165.0        0.0   1.00E+00     0.00
    3         ESA750-Full       1         1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full       1         1965.0        0.0   1.00E+00     0.00
    1         SAST53            1            0.0        0.0   1.00E+00     0.00
    2         SAST53            1         2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4589            Iso.       4.59E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4589            ETH         0.000274   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle      Unitless
   No.               ID                             Strain
    1      350.00    cement4589
                                          SADT(80): 7.313E-05
                                          SAST(53): 5.247E-05
    3        0.00    Sub_CBR5
                                          SADT(80): 1.907E-04

Results:

   Layer  Thickness  Material             Axle      CDF
   No.               ID                   Group
    1      350.00    cement4589           Total:    2.164E-01
                                          SAST:     9.248E-03
                                          SADT:     7.639E-02
                                          TAST:     3.559E-04
                                          TADT:     1.243E-01
                                          TRDT:     6.088E-03
                                          QADT:     5.765E-05

    2       65.00    Gran_250                             n/a

    3        0.00    Sub_CBR5             Total:    3.613E-06
```

CBR5 Pavement with Variable Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                   Load                   Load              Radius    Pressure/    Exponent
   No.   ID                     Category               Type                        Ref. stress
    1    ESA750-Full            ESA750-Full            Vertical Force     92.1      0.75          0.00
    2    SAST53                 SAST53                 Vertical Force    102.4      0.80          0.00

   Load Locations:
   Location  Load                   Gear         X          Y      Scaling     Theta
   No.       ID                     No.                            Factor
    1        ESA750-Full             1       -165.0       0.0    1.00E+00      0.00
    2        ESA750-Full             1        165.0       0.0    1.00E+00      0.00
    3        ESA750-Full             1       1635.0       0.0    1.00E+00      0.00
    4        ESA750-Full             1       1965.0       0.0    1.00E+00      0.00
    1        SAST53                  1          0.0       0.0    1.00E+00      0.00
    2        SAST53                  1       2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus     P.Ratio
   No.    i/face   ID                                (or Ev)     (or vvh)  F          Eh         vh
    1     rough    cement4698             Iso.       4.70E+03    0.20
    2     rough    Gran_250               Aniso.     2.50E+02    0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5               Aniso.     5.00E+01    0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.    Perform.  Shift
   No.             ID                                Constant    Exponent  Factor
    1     bottom   cement4698             ETH         0.000271    12.000
    3     top      Sub_CBR5               EZZ         0.009150     7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      340.00    cement4698
                                            SADT(80):  7.492E-05
                                            SAST(53):  5.401E-05
    3        0.00    Sub_CBR5
                                            SADT(80):  1.956E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      340.00    cement4698             Total:     3.311E-01
                                            SAST:      1.494E-02
                                            SADT:      1.165E-01
                                            TAST:      5.751E-04
                                            TADT:      1.896E-01
                                            TRDT:      9.288E-03
                                            QADT:      8.795E-05

    2       75.00    Gran_250                               n/a

    3        0.00    Sub_CBR5               Total:     4.315E-06
```

CBR5 Pavement with Variable Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                    Load                    Load            Radius    Pressure/    Exponent
   No.    ID                      Category                Type                      Ref. stress
    1     ESA750-Full             ESA750-Full             Vertical Force    92.1     0.75         0.00
    2     SAST53                  SAST53                  Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location    Load                  Gear          X          Y     Scaling     Theta
   No.         ID                    No.                            Factor
    1          ESA750-Full            1         -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full            1          165.0       0.0   1.00E+00      0.00
    3          ESA750-Full            1         1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full            1         1965.0       0.0   1.00E+00      0.00
    1          SAST53                 1            0.0       0.0   1.00E+00      0.00
    2          SAST53                 1         2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                Isotropy  Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4813              Iso.      4.81E+03   0.20
    2     rough    Gran_250                Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5                Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material                Component  Perform.   Perform.   Shift
   No.             ID                                 Constant   Exponent   Factor
    1     bottom   cement4813              ETH         0.000268   12.000
    3     top      Sub_CBR5                EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1      330.00    cement4813
                                             SADT(80):  7.677E-05
                                             SAST(53):  5.562E-05
    3        0.00    Sub_CBR5
                                             SADT(80):  2.008E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1      330.00    cement4813              Total:     5.091E-01
                                             SAST:      2.431E-02
                                             SADT:      1.787E-01
                                             TAST:      9.355E-04
                                             TADT:      2.908E-01
                                             TRDT:      1.424E-02
                                             QADT:      1.349E-04

    2       85.00    Gran_250                               n/a

    3        0.00    Sub_CBR5                Total:     5.190E-06
```

CBR5 Pavement with Variable Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/     Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                   Gear          X          Y        Scaling     Theta
   No.         ID                     No.                               Factor
    1          ESA750-Full             1         -165.0        0.0      1.00E+00     0.00
    2          ESA750-Full             1          165.0        0.0      1.00E+00     0.00
    3          ESA750-Full             1         1635.0        0.0      1.00E+00     0.00
    4          ESA750-Full             1         1965.0        0.0      1.00E+00     0.00
    1          SAST53                  1            0.0        0.0      1.00E+00     0.00
    2          SAST53                  1         2130.0        0.0      1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement4936             Iso.       4.94E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5               Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement4936             ETH         0.000265   12.000
    3     top      Sub_CBR5               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00         Cement Stabilised
    3      1.00         Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      320.00    cement4936
                                            SADT(80):  7.868E-05
                                            SAST(53):  5.730E-05
    3        0.00    Sub_CBR5
                                            SADT(80):  2.064E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      320.00    cement4936             Total:     7.849E-01
                                            SAST:      3.972E-02
                                            SADT:      2.746E-01
                                            TAST:      1.529E-03
                                            TADT:      4.469E-01
                                            TRDT:      2.189E-02
                                            QADT:      2.073E-04

    2       95.00    Gran_250                              n/a

    3        0.00    Sub_CBR5               Total:     6.279E-06
```

CBR5 Pavement with Variable Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/     Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                Gear         X          Y      Scaling    Theta
   No.         ID                  No.                            Factor
    1          ESA750-Full          1        -165.0       0.0    1.00E+00     0.00
    2          ESA750-Full          1         165.0       0.0    1.00E+00     0.00
    3          ESA750-Full          1        1635.0       0.0    1.00E+00     0.00
    4          ESA750-Full          1        1965.0       0.0    1.00E+00     0.00
    1          SAST53               1           0.0       0.0    1.00E+00     0.00
    2          SAST53               1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5066            Iso.       5.07E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5066            ETH         0.000261   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      310.00    cement5066
                                            SADT(80):  8.067E-05
                                            SAST(53):  5.905E-05
    3        0.00    Sub_CBR5
                                            SADT(80):  2.123E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      310.00    cement5066             Total:     1.274E+00
                                            SAST:      6.846E-02
                                            SADT:      4.444E-01
                                            TAST:      2.635E-03
                                            TADT:      7.232E-01
                                            TRDT:      3.542E-02
                                            QADT:      3.354E-04

    2      105.00    Gran_250                               n/a

    3        0.00    Sub_CBR5               Total:     7.654E-06
```

CBR5 Pavement with Variable Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/   Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75        0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location    Load              Gear       X          Y      Scaling      Theta
   No.         ID                No.                          Factor
    1          ESA750-Full        1       -165.0       0.0    1.00E+00      0.00
    2          ESA750-Full        1        165.0       0.0    1.00E+00      0.00
    3          ESA750-Full        1       1635.0       0.0    1.00E+00      0.00
    4          ESA750-Full        1       1965.0       0.0    1.00E+00      0.00
    1          SAST53             1          0.0       0.0    1.00E+00      0.00
    2          SAST53             1       2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5206           Iso.       5.21E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   cement5206           ETH         0.000258   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      300.00    cement5206
                                           SADT(80):  8.270E-05
                                           SAST(53):  6.087E-05

    3        0.00    Sub_CBR5
                                           SADT(80):  2.186E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      300.00    cement5206            Total:     1.982E+00
                                           SAST:      1.132E-01
                                           SADT:      6.885E-01
                                           TAST:      4.357E-03
                                           TADT:      1.120E+00
                                           TRDT:      5.487E-02
                                           QADT:      5.196E-04

    2      115.00    Gran_250                               n/a

    3        0.00    Sub_CBR5              Total:     9.385E-06
```

CBR5 Pavement with Variable Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load           Radius    Pressure/    Exponent
   No.    ID                     Category               Type                     Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force    92.1    0.75          0.00
    2     SAST53                 SAST53                 Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location   Load               Gear          X           Y       Scaling      Theta
   No.        ID                 No.                               Factor
    1         ESA750-Full         1         -165.0        0.0    1.00E+00       0.00
    2         ESA750-Full         1          165.0        0.0    1.00E+00       0.00
    3         ESA750-Full         1         1635.0        0.0    1.00E+00       0.00
    4         ESA750-Full         1         1965.0        0.0    1.00E+00       0.00
    1         SAST53              1            0.0        0.0    1.00E+00       0.00
    2         SAST53              1         2130.0        0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5354            Iso.      5.35E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5354            ETH         0.000253   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      290.00    cement5354
                                           SADT(80):  8.483E-05
                                           SAST(53):  6.279E-05
    3        0.00    Sub_CBR5
                                           SADT(80):  2.253E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      290.00    cement5354            Total:     3.412E+00
                                           SAST:      2.075E-01
                                           SADT:      1.181E+00
                                           TAST:      7.988E-03
                                           TADT:      1.921E+00
                                           TRDT:      9.408E-02
                                           QADT:      8.909E-04

    2      125.00    Gran_250                                n/a

    3        0.00    Sub_CBR5              Total:     1.160E-05
```

CBR5 Pavement with Variable Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                 Load                 Load            Radius   Pressure/    Exponent
   No.   ID                   Category             Type                     Ref. stress
    1    ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75          0.00
    2    SAST53               SAST53               Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location  Load                 Gear          X          Y     Scaling    Theta
   No.       ID                   No.                            Factor
    1        ESA750-Full           1        -165.0       0.0    1.00E+00     0.00
    2        ESA750-Full           1         165.0       0.0    1.00E+00     0.00
    3        ESA750-Full           1        1635.0       0.0    1.00E+00     0.00
    4        ESA750-Full           1        1965.0       0.0    1.00E+00     0.00
    1        SAST53                1           0.0       0.0    1.00E+00     0.00
    2        SAST53                1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus   P.Ratio
   No.    i/face   ID                               (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement5514             Iso.      5.51E+03  0.20
    2     rough    Gran_250               Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5               Aniso.    5.00E+01  0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component Perform.  Perform.  Shift
   No.             ID                               Constant  Exponent  Factor
    1     bottom   cement5514             ETH        0.000249  12.000
    3     top      Sub_CBR5               EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      280.00    cement5514
                                           SADT(80): 8.701E-05
                                           SAST(53): 6.477E-05

    3        0.00    Sub_CBR5
                                           SADT(80): 2.324E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      280.00    cement5514            Total:     5.626E+00
                                           SAST:      3.651E-01
                                           SADT:      1.938E+00
                                           TAST:      1.405E-02
                                           TADT:      3.153E+00
                                           TRDT:      1.544E-01
                                           QADT:      1.462E-03

    2      135.00    Gran_250                              n/a

    3        0.00    Sub_CBR5              Total:     1.444E-05
```

CBR5 Pavement with Variable Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius   Pressure/    Exponent
   No.    ID                   Category             Type                    Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location    Load                Gear          X          Y     Scaling     Theta
   No.         ID                  No.                            Factor
    1          ESA750-Full          1         -165.0       0.0   1.00E+00     0.00
    2          ESA750-Full          1          165.0       0.0   1.00E+00     0.00
    3          ESA750-Full          1         1635.0       0.0   1.00E+00     0.00
    4          ESA750-Full          1         1965.0       0.0   1.00E+00     0.00
    1          SAST53               1            0.0       0.0   1.00E+00     0.00
    2          SAST53               1         2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5685             Iso.      5.69E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5               Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5685             ETH        0.000244   12.000
    3     top      Sub_CBR5               EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      270.00    cement5685
                                            SADT(80):  8.927E-05
                                            SAST(53):  6.685E-05

    3        0.00    Sub_CBR5
                                            SADT(80):  2.401E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      270.00    cement5685             Total:     9.817E+00
                                            SAST:      6.805E-01
                                            SADT:      3.365E+00
                                            TAST:      2.619E-02
                                            TADT:      5.475E+00
                                            TRDT:      2.681E-01
                                            QADT:      2.539E-03

    2      145.00    Gran_250                               n/a

    3        0.00    Sub_CBR5               Total:     1.811E-05
```

CBR 5 Pavement with 105 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                Load                Load           Radius   Pressure/    Exponent
   No.   ID                  Category            Type                    Ref. stress
    1    ESA750-Full         ESA750-Full         Vertical Force    92.1    0.75         0.00
    2    SAST53              SAST53              Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location   Load                Gear         X          Y     Scaling     Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1        -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full          1         165.0        0.0   1.00E+00     0.00
    3         ESA750-Full          1        1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full          1        1965.0        0.0   1.00E+00     0.00
    1         SAST53               1           0.0        0.0   1.00E+00     0.00
    2         SAST53               1        2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement6127            Iso.       6.13E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement6127            ETH         0.000232   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      315.00    cement6127
                                           SADT(80):  6.829E-05
                                           SAST(53):  4.954E-05
    3        0.00    Sub_CBR5
                                           SADT(80):  1.864E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      315.00    cement6127            Total:     7.059E-01
                                           SAST:      3.416E-02
                                           SADT:      2.476E-01
                                           TAST:      1.315E-03
                                           TADT:      4.029E-01
                                           TRDT:      1.973E-02
                                           QADT:      1.869E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR5              Total:     3.077E-06
```

CBR 5 Pavement with 104 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location    Load                   Gear           X          Y      Scaling      Theta
   No.         ID                     No.                              Factor
    1          ESA750-Full             1          -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full             1           165.0       0.0   1.00E+00      0.00
    3          ESA750-Full             1          1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full             1          1965.0       0.0   1.00E+00      0.00
    1          SAST53                  1             0.0       0.0   1.00E+00      0.00
    2          SAST53                  1          2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5896             Iso.       5.90E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5               Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement5896             ETH         0.000239   12.000
    3     top      Sub_CBR5               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle        Unitless
   No.               ID                                 Strain
    1      315.00    cement5896
                                            SADT(80):  7.032E-05
                                            SAST(53):  5.107E-05

    3        0.00    Sub_CBR5
                                            SADT(80):  1.905E-04

Results:

   Layer  Thickness  Material               Axle        CDF
   No.               ID                     Group
    1      315.00    cement5896             Total:     7.024E-01
                                            SAST:      3.446E-02
                                            SADT:      2.462E-01
                                            TAST:      1.326E-03
                                            TADT:      4.006E-01
                                            TRDT:      1.962E-02
                                            QADT:      1.858E-04

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR5               Total:     3.588E-06
```

CBR 5 Pavement with 103 % Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5665	Iso.	5.67E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR5	Aniso.	5.00E+01	0.45	3.45E+01	2.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5665	ETH	0.000245	12.000	
3	top	Sub_CBR5	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	315.00	cement5665		
			SADT(80):	7.249E-05
			SAST(53):	5.271E-05
3	0.00	Sub_CBR5		
			SADT(80):	1.949E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	315.00	cement5665	Total:	7.515E-01
			SAST:	3.741E-02
			SADT:	2.632E-01
			TAST:	1.440E-03
			TADT:	4.283E-01
			TRDT:	2.097E-02
			QADT:	1.986E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR5	Total:	4.208E-06

CBR 5 Pavement with 102 % Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5434	Iso.	5.43E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR5	Aniso.	5.00E+01	0.45	3.45E+01	2.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5434	ETH	0.000251	12.000	
3	top	Sub_CBR5	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	315.00	cement5434		
			SADT(80):	7.481E-05
			SAST(53):	5.447E-05
3	0.00	Sub_CBR5		
			SADT(80):	1.996E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	315.00	cement5434	Total:	8.216E-01
			SAST:	4.152E-02
			SADT:	2.875E-01
			TAST:	1.598E-03
			TADT:	4.678E-01
			TRDT:	2.291E-02
			QADT:	2.170E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR5	Total:	4.969E-06

CBR 5 Pavement with 101 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load             Radius    Pressure/   Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1      0.75        0.00
    2     SAST53                SAST53                Vertical Force   102.4      0.80        0.00

   Load Locations:
   Location    Load             Gear        X          Y      Scaling     Theta
   No.         ID               No.                           Factor
    1          ESA750-Full       1       -165.0       0.0    1.00E+00     0.00
    2          ESA750-Full       1        165.0       0.0    1.00E+00     0.00
    3          ESA750-Full       1       1635.0       0.0    1.00E+00     0.00
    4          ESA750-Full       1       1965.0       0.0    1.00E+00     0.00
    1          SAST53            1          0.0       0.0    1.00E+00     0.00
    2          SAST53            1       2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement5203            Iso.       5.20E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5203            ETH         0.000258   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      315.00    cement5203
                                           SADT(80):  7.731E-05
                                           SAST(53):  5.637E-05

    3        0.00    Sub_CBR5
                                           SADT(80):  2.046E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      315.00    cement5203            Total:     8.768E-01
                                           SAST:      4.503E-02
                                           SADT:      3.066E-01
                                           TAST:      1.733E-03
                                           TADT:      4.988E-01
                                           TRDT:      2.443E-02
                                           QADT:      2.313E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5              Total:     5.910E-06
```

CBR 5 Pavement with 100 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75         0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load                    Gear          X          Y     Scaling     Theta
   No.        ID                      No.                            Factor
    1         ESA750-Full              1         -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full              1          165.0       0.0    1.00E+00     0.00
    3         ESA750-Full              1         1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full              1         1965.0       0.0    1.00E+00     0.00
    1         SAST53                   1            0.0       0.0    1.00E+00     0.00
    2         SAST53                   1         2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      315.00    Cement5000
                                           SADT(80):  7.967E-05
                                           SAST(53):  5.817E-05

    3        0.00    Sub_CBR5
                                           SADT(80):  2.093E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      315.00    Cement5000            Total:     9.994E-01
                                           SAST:      5.209E-02
                                           SADT:      3.491E-01
                                           TAST:      2.005E-03
                                           TADT:      5.681E-01
                                           TRDT:      2.782E-02
                                           QADT:      2.635E-04

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR5              Total:     6.927E-06
```

CBR 5 Pavement with 99 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load             Radius    Pressure/    Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                Gear         X          Y       Scaling      Theta
   No.        ID                  No.                             Factor
    1         ESA750-Full          1         -165.0      0.0     1.00E+00      0.00
    2         ESA750-Full          1          165.0      0.0     1.00E+00      0.00
    3         ESA750-Full          1         1635.0      0.0     1.00E+00      0.00
    4         ESA750-Full          1         1965.0      0.0     1.00E+00      0.00
    1         SAST53               1            0.0      0.0     1.00E+00      0.00
    2         SAST53               1         2130.0      0.0     1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus    P.Ratio
   No.    i/face   ID                             (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4724           Iso.      4.74E+03   0.20
    2     rough    Gran_250             Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement4724           ETH         0.000270   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      315.00    cement4724
                                          SADT(80): 8.291E-05
                                          SAST(53): 6.064E-05
    3        0.00    Sub_CBR5
                                          SADT(80): 2.157E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      315.00    cement4724           Total:     1.178E+00
                                          SAST:      6.264E-02
                                          SADT:      4.110E-01
                                          TAST:      2.411E-03
                                          TADT:      6.688E-01
                                          TRDT:      3.276E-02
                                          QADT:      3.102E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR5             Total:     8.557E-06
```

CBR 5 Pavement with 98 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius     Pressure/    Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1      0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4      0.80          0.00

   Load Locations:
   Location   Load                 Gear         X           Y        Scaling    Theta
   No.        ID                   No.                               Factor
    1         ESA750-Full           1        -165.0        0.0     1.00E+00     0.00
    2         ESA750-Full           1         165.0        0.0     1.00E+00     0.00
    3         ESA750-Full           1        1635.0        0.0     1.00E+00     0.00
    4         ESA750-Full           1        1965.0        0.0     1.00E+00     0.00
    1         SAST53                1           0.0        0.0     1.00E+00     0.00
    2         SAST53                1        2130.0        0.0     1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4511           Iso.       4.51E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement4511           ETH         0.000276   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      315.00    cement4511
                                           SADT(80): 8.607E-05
                                           SAST(53): 6.306E-05
    3        0.00    Sub_CBR5
                                           SADT(80): 2.219E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      315.00    cement4511            Total:     1.420E+00
                                           SAST:      7.697E-02
                                           SADT:      4.950E-01
                                           TAST:      2.963E-03
                                           TADT:      8.055E-01
                                           TRDT:      3.945E-02
                                           QADT:      3.736E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5              Total:     1.044E-05
```

CBR 5 Pavement with 97 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load             Radius    Pressure/    Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80         0.00

   Load Locations:
   Location   Load                Gear        X          Y      Scaling     Theta
   No.        ID                  No.                           Factor
    1         ESA750-Full          1       -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1        165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1       1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1       1965.0       0.0    1.00E+00     0.00
    1         SAST53               1          0.0       0.0    1.00E+00     0.00
    2         SAST53               1       2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4280           Iso.       4.28E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement4280           ETH         0.000283   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      315.00    cement4280
                                          SADT(80): 8.953E-05
                                          SAST(53): 6.571E-05
    3        0.00    Sub_CBR5
                                          SADT(80): 2.287E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      315.00    cement4280           Total:     1.688E+00
                                          SAST:      9.334E-02
                                          SADT:      5.875E-01
                                          TAST:      3.593E-03
                                          TADT:      9.560E-01
                                          TRDT:      4.682E-02
                                          QADT:      4.434E-04

    2      100.00    Gran_250                            n/a

    3        0.00    Sub_CBR5             Total:     1.288E-05
```

CBR 5 Pavement with 96 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/   Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear         X          Y      Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1        -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full           1         165.0       0.0   1.00E+00      0.00
    3         ESA750-Full           1        1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full           1        1965.0       0.0   1.00E+00      0.00
    1         SAST53                1           0.0       0.0   1.00E+00      0.00
    2         SAST53                1        2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material              Isotropy  Modulus    P.Ratio
   No.    i/face  ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough   cement4049            Iso.      4.05E+03   0.20
    2     rough   Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough   Sub_CBR5              Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component Perform.   Perform.  Shift
   No.             ID                             Constant   Exponent  Factor
    1     bottom   cement4049           ETH        0.000289   12.000
    3     top      Sub_CBR5             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1      315.00    cement4049
                                           SADT(80):  9.331E-05
                                           SAST(53):  6.861E-05
    3        0.00    Sub_CBR5
                                           SADT(80):  2.360E-04

Results:

   Layer  Thickness  Material              Axle        CDF
   No.               ID                    Group
    1      315.00    cement4049            Total:     2.159E+00
                                           SAST:      1.220E-01
                                           SADT:      7.505E-01
                                           TAST:      4.695E-03
                                           TADT:      1.221E+00
                                           TRDT:      5.981E-02
                                           QADT:      5.663E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5              Total:     1.606E-05
```

CBR 5 Pavement with 95 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                 Load                 Load            Radius    Pressure/   Exponent
   No.   ID                   Category             Type                      Ref. stress
    1    ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75        0.00
    2    SAST53               SAST53               Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location   Load                Gear         X          Y      Scaling     Theta
   No.        ID                  No.                            Factor
    1         ESA750-Full          1        -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1         165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1        1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1        1965.0       0.0    1.00E+00     0.00
    1         SAST53               1           0.0       0.0    1.00E+00     0.00
    2         SAST53               1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy  Modulus    P.Ratio
   No.    i/face   ID                            (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3818          Iso.      3.82E+03   0.20
    2     rough    Gran_250            Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5            Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component Perform.   Perform.   Shift
   No.             ID                            Constant   Exponent   Factor
    1     bottom   cement3818          ETH        0.000295   12.000
    3     top      Sub_CBR5            EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1       315.00   cement3818
                                            SADT(80):  9.747E-05
                                            SAST(53):  7.182E-05
    3         0.00   Sub_CBR5
                                            SADT(80):  2.440E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1       315.00   cement3818             Total:     2.852E+00
                                            SAST:      1.650E-01
                                            SADT:      9.901E-01
                                            TAST:      6.349E-03
                                            TADT:      1.611E+00
                                            TRDT:      7.891E-02
                                            QADT:      7.472E-04

    2       100.00   Gran_250                              n/a

    3         0.00   Sub_CBR5               Total:     2.029E-05
```

CBR 5 Pavement with 94 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location    Load                Gear         X          Y      Scaling     Theta
   No.         ID                  No.                            Factor
    1          ESA750-Full          1         -165.0       0.0    1.00E+00     0.00
    2          ESA750-Full          1          165.0       0.0    1.00E+00     0.00
    3          ESA750-Full          1         1635.0       0.0    1.00E+00     0.00
    4          ESA750-Full          1         1965.0       0.0    1.00E+00     0.00
    1          SAST53               1            0.0       0.0    1.00E+00     0.00
    2          SAST53               1         2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material              Isotropy   Modulus    P.Ratio
   No.    i/face  ID                               (or Ev)    (or vvh)  F          Eh          vh
    1     rough   cement3587            Iso.       3.59E+03   0.20
    2     rough   Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough   Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01    0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.  Shift
   No.             ID                              Constant   Exponent  Factor
    1     bottom   cement3587           ETH         0.000302   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      315.00    cement3587
                                          SADT(80): 1.021E-04
                                          SAST(53): 7.538E-05

    3        0.00    Sub_CBR5
                                          SADT(80): 2.528E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      315.00    cement3587           Total:     3.753E+00
                                          SAST:      2.225E-01
                                          SADT:      1.301E+00
                                          TAST:      8.564E-03
                                          TADT:      2.117E+00
                                          TRDT:      1.037E-01
                                          QADT:      9.816E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR5             Total:     2.601E-05
```

CBR 5 Pavement with 93 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                Load                Load            Radius   Pressure/   Exponent
   No.    ID                  Category            Type                     Ref. stress
    1     ESA750-Full         ESA750-Full         Vertical Force    92.1    0.75         0.00
    2     SAST53              SAST53              Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location   Load               Gear         X          Y     Scaling    Theta
   No.        ID                 No.                           Factor
    1         ESA750-Full         1        -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full         1         165.0       0.0   1.00E+00     0.00
    3         ESA750-Full         1        1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full         1        1965.0       0.0   1.00E+00     0.00
    1         SAST53              1           0.0       0.0   1.00E+00     0.00
    2         SAST53              1        2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3125            Iso.       3.13E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5              Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement3125            ETH         0.000314   12.000
    3     top      Sub_CBR5              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      315.00    cement3125
                                            SADT(80):  1.130E-04
                                            SAST(53):  8.384E-05
    3        0.00    Sub_CBR5
                                            SADT(80):  2.734E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      315.00    cement3125             Total:     7.964E+00
                                            SAST:      4.993E-01
                                            SADT:      2.750E+00
                                            TAST:      1.922E-02
                                            TADT:      4.474E+00
                                            TRDT:      2.191E-01
                                            QADT:      2.075E-03

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5               Total:     4.499E-05
```

CBR 5 Pavement with 92 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load    Load                   Load                   Load            Radius    Pressure/    Exponent
   No.     ID                     Category               Type                      Ref. stress
    1      ESA750-Full            ESA750-Full            Vertical Force    92.1      0.75         0.00
    2      SAST53                 SAST53                 Vertical Force   102.4      0.80         0.00

   Load Locations:
   Location   Load                   Gear          X           Y      Scaling     Theta
   No.        ID                     No.                              Factor
    1         ESA750-Full             1         -165.0        0.0    1.00E+00     0.00
    2         ESA750-Full             1          165.0        0.0    1.00E+00     0.00
    3         ESA750-Full             1         1635.0        0.0    1.00E+00     0.00
    4         ESA750-Full             1         1965.0        0.0    1.00E+00     0.00
    1         SAST53                  1            0.0        0.0    1.00E+00     0.00
    2         SAST53                  1         2130.0        0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                 (or Ev)    (or vvh)   F          Eh         vh
    1     rough    cement2894              Iso.       2.89E+03   0.20
    2     rough    Gran_250                Aniso.     2.50E+02   0.35       1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5                Aniso.     5.00E+01   0.45       3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material                Component  Perform.   Perform.   Shift
   No.             ID                                 Constant   Exponent   Factor
    1     bottom   cement2894              ETH         0.000320   12.000
    3     top      Sub_CBR5                EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1      315.00    cement2894
                                             SADT(80):  1.195E-04
                                             SAST(53):  8.892E-05

    3        0.00    Sub_CBR5
                                             SADT(80):  2.856E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1      315.00    cement2894              Total:     1.245E+01
                                             SAST:      8.059E-01
                                             SADT:      4.290E+00
                                             TAST:      3.102E-02
                                             TADT:      6.981E+00
                                             TRDT:      3.419E-01
                                             QADT:      3.238E-03

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR5                Total:     6.099E-05
```

CBR 5 Pavement with 91 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X           Y     Scaling     Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1         -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full           1          165.0        0.0   1.00E+00     0.00
    3         ESA750-Full           1         1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full           1         1965.0        0.0   1.00E+00     0.00
    1         SAST53                1            0.0        0.0   1.00E+00     0.00
    2         SAST53                1         2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement2894           Iso.       2.89E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5             Aniso.     5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement2894           ETH         0.000320   12.000
    3     top      Sub_CBR5             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      342.00    cement2894
                                          SADT(80):  1.059E-04
                                          SAST(53):  7.747E-05
    3        0.00    Sub_CBR5
                                          SADT(80):  2.535E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      342.00    cement2894           Total:     2.892E+00
                                          SAST:      1.542E-01
                                          SADT:      1.009E+00
                                          TAST:      5.935E-03
                                          TADT:      1.641E+00
                                          TRDT:      8.039E-02
                                          QADT:      7.613E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR5             Total:     2.653E-05
```

CBR 5 Pavement with 90 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load               Load               Load           Radius    Pressure/   Exponent
   No.    ID                 Category           Type                     Ref. stress
    1     ESA750-Full        ESA750-Full        Vertical Force    92.1     0.75        0.00
    2     SAST53             SAST53             Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location    Load               Gear        X          Y     Scaling     Theta
   No.         ID                 No.                          Factor
    1          ESA750-Full         1       -165.0       0.0   1.00E+00      0.00
    2          ESA750-Full         1        165.0       0.0   1.00E+00      0.00
    3          ESA750-Full         1       1635.0       0.0   1.00E+00      0.00
    4          ESA750-Full         1       1965.0       0.0   1.00E+00      0.00
    1          SAST53              1          0.0       0.0   1.00E+00      0.00
    2          SAST53              1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement2663             Iso.      2.66E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR5               Aniso.    5.00E+01   0.45      3.45E+01   2.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement2663             ETH         0.000327   12.000
    3     top      Sub_CBR5               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      315.00    cement2663
                                           SADT(80):  1.269E-04
                                           SAST(53):  9.474E-05

    3        0.00    Sub_CBR5
                                           SADT(80):  2.993E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      315.00    cement2663            Total:     1.985E+01
                                           SAST:      1.330E+00
                                           SADT:      6.822E+00
                                           TAST:      5.119E-02
                                           TADT:      1.110E+01
                                           TRDT:      5.437E-01
                                           QADT:      5.148E-03

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR5              Total:     8.477E-05
```

CBR7 Pavement 20 Year Design with Constant Modulus

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load           Radius    Pressure/    Exponent
   No.    ID                    Category              Type                     Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1    0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location   Load                  Gear         X           Y       Scaling      Theta
   No.        ID                    No.                              Factor
    1         ESA750-Full            1        -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full            1         165.0        0.0    1.00E+00      0.00
    3         ESA750-Full            1        1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full            1        1965.0        0.0    1.00E+00      0.00
    1         SAST53                 1           0.0        0.0    1.00E+00      0.00
    2         SAST53                 1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor       Type
    1      2.00       Cement Stabilised
    3      1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      298.00    Cement5000
                                          SADT(80): 7.928E-05
                                          SAST(53): 5.922E-05
    3        0.00    Sub_CBR7
                                          SADT(80): 1.962E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      298.00    Cement5000           Total:     9.587E-01
                                          SAST:      6.461E-02
                                          SADT:      3.293E-01
                                          TAST:      2.487E-03
                                          TADT:      5.358E-01
                                          TRDT:      2.624E-02
                                          QADT:      2.485E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR7             Total:     4.405E-06
```

CBR7 Pavement with Uniform Characteristics – 350 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	350.00	Cement5000		
			SADT(80):	6.261E-05
			SAST(53):	4.528E-05
3	0.00	Sub_CBR7		
			SADT(80):	1.553E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	350.00	Cement5000	Total:	5.513E-02
			SAST:	2.577E-03
			SADT:	1.937E-02
			TAST:	9.918E-05
			TADT:	3.152E-02
			TRDT:	1.544E-03
			QADT:	1.462E-05
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	8.599E-07

CBR7 Pavement with Uniform Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                  Gear          X           Y      Scaling     Theta
   No.        ID                    No.                              Factor
    1         ESA750-Full            1         -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full            1          165.0        0.0    1.00E+00      0.00
    3         ESA750-Full            1         1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full            1         1965.0        0.0    1.00E+00      0.00
    1         SAST53                 1            0.0        0.0    1.00E+00      0.00
    2         SAST53                 1         2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000             Iso.      5.00E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7               Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   Cement5000             ETH        0.000263   12.000
    3     top      Sub_CBR7               EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      340.00    Cement5000
                                            SADT(80):  6.537E-05
                                            SAST(53):  4.754E-05
    3        0.00    Sub_CBR7
                                            SADT(80):  1.620E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      340.00    Cement5000             Total:     9.285E-02
                                            SAST:      4.634E-03
                                            SADT:      3.251E-02
                                            TAST:      1.783E-04
                                            TADT:      5.291E-02
                                            TRDT:      2.591E-03
                                            QADT:      2.454E-05

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7               Total:     1.155E-06
```

CBR7 Pavement with Uniform Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                  Load              Radius    Pressure/   Exponent
   No.    ID                     Category              Type                        Ref. stress
    1     ESA750-Full            ESA750-Full           Vertical Force     92.1      0.75        0.00
    2     SAST53                 SAST53                Vertical Force    102.4      0.80        0.00

   Load Locations:
   Location  Load                  Gear         X          Y     Scaling    Theta
   No.       ID                    No.                           Factor
    1        ESA750-Full            1        -165.0       0.0   1.00E+00     0.00
    2        ESA750-Full            1         165.0       0.0   1.00E+00     0.00
    3        ESA750-Full            1        1635.0       0.0   1.00E+00     0.00
    4        ESA750-Full            1        1965.0       0.0   1.00E+00     0.00
    1        SAST53                 1           0.0       0.0   1.00E+00     0.00
    2        SAST53                 1        2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus   P.Ratio
   No.    i/face   ID                             (or Ev)   (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.      5.00E+03  0.20
    2     rough    Gran_250             Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component Perform.  Perform.  Shift
   No.             ID                             Constant  Exponent  Factor
    1     bottom   Cement5000           ETH        0.000263  12.000
    3     top      Sub_CBR7             EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      330.00    Cement5000
                                          SADT(80):  6.832E-05
                                          SAST(53):  4.999E-05

    3        0.00    Sub_CBR7
                                          SADT(80):  1.692E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      330.00    Cement5000           Total:     1.583E-01
                                          SAST:      8.457E-03
                                          SADT:      5.524E-02
                                          TAST:      3.255E-04
                                          TADT:      8.988E-02
                                          TRDT:      4.402E-03
                                          QADT:      4.169E-05

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR7             Total:     1.565E-06
```

CBR7 Pavement with Uniform Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load               Load               Load            Radius    Pressure/   Exponent
   No.    ID                 Category           Type                      Ref. stress
    1     ESA750-Full        ESA750-Full        Vertical Force    92.1     0.75        0.00
    2     SAST53             SAST53             Vertical Force   102.4     0.80        0.00

   Load Locations:
   Location    Load               Gear         X          Y     Scaling     Theta
   No.         ID                 No.                           Factor
    1          ESA750-Full         1        -165.0       0.0   1.00E+00     0.00
    2          ESA750-Full         1         165.0       0.0   1.00E+00     0.00
    3          ESA750-Full         1        1635.0       0.0   1.00E+00     0.00
    4          ESA750-Full         1        1965.0       0.0   1.00E+00     0.00
    1          SAST53              1           0.0       0.0   1.00E+00     0.00
    2          SAST53              1        2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy  Modulus   P.Ratio
   No.    i/face   ID                            (or Ev)   (or vvh)  F          Eh         vh
    1     rough    Cement5000          Iso.      5.00E+03  0.20
    2     rough    Gran_250            Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7            Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component Perform.  Perform.  Shift
   No.             ID                            Constant  Exponent  Factor
    1     bottom   Cement5000          ETH        0.000263  12.000
    3     top      Sub_CBR7            EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material            Axle       Unitless
   No.               ID                             Strain
    1      320.00    Cement5000
                                         SADT(80):  7.148E-05
                                         SAST(53):  5.263E-05
    3        0.00    Sub_CBR7
                                         SADT(80):  1.770E-04

Results:

   Layer  Thickness  Material            Axle       CDF
   No.               ID                  Group
    1      320.00    Cement5000          Total:     2.737E-01
                                         SAST:      1.568E-02
                                         SADT:      9.506E-02
                                         TAST:      6.035E-04
                                         TADT:      1.547E-01
                                         TRDT:      7.575E-03
                                         QADT:      7.173E-05

    2      100.00    Gran_250                            n/a

    3        0.00    Sub_CBR7            Total:     2.140E-06
```

CBR7 Pavement with Uniform Characteristics – 310 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	310.00	Cement5000		
			SADT(80):	7.487E-05
			SAST(53):	5.548E-05
3	0.00	Sub_CBR7		
			SADT(80):	1.853E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	310.00	Cement5000	Total:	4.796E-01
			SAST:	2.954E-02
			SADT:	1.658E-01
			TAST:	1.137E-03
			TADT:	2.698E-01
			TRDT:	1.321E-02
			QADT:	1.251E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	2.953E-06

CBR7 Pavement with Uniform Characteristics – 300 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Cement5000	Iso.	5.00E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	Cement5000	ETH	0.000263	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	300.00	Cement5000	SADT(80):	7.852E-05
			SAST(53):	5.857E-05
3	0.00	Sub_CBR7	SADT(80):	1.943E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	300.00	Cement5000	Total:	8.529E-01
			SAST:	5.662E-02
			SADT:	2.933E-01
			TAST:	2.179E-03
			TADT:	4.772E-01
			TRDT:	2.337E-02
			QADT:	2.213E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	4.117E-06

CBR7 Pavement with Uniform Characteristics – 290 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load             Radius    Pressure/    Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X           Y      Scaling     Theta
   No.         ID                    No.                              Factor
    1          ESA750-Full            1        -165.0         0.0    1.00E+00      0.00
    2          ESA750-Full            1         165.0         0.0    1.00E+00      0.00
    3          ESA750-Full            1        1635.0         0.0    1.00E+00      0.00
    4          ESA750-Full            1        1965.0         0.0    1.00E+00      0.00
    1          SAST53                 1           0.0         0.0    1.00E+00      0.00
    2          SAST53                 1        2130.0         0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000            Iso.       5.00E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   Cement5000            ETH         0.000263   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle        Unitless
   No.               ID                                Strain
    1       290.00   Cement5000
                                           SADT(80): 8.244E-05
                                           SAST(53): 6.192E-05
    3         0.00   Sub_CBR7
                                           SADT(80): 2.041E-04

Results:

   Layer  Thickness  Material              Axle        CDF
   No.               ID                    Group
    1       290.00   Cement5000            Total:      1.541E+00
                                           SAST:       1.104E-01
                                           SADT:       5.266E-01
                                           TAST:       4.250E-03
                                           TADT:       8.569E-01
                                           TRDT:       4.197E-02
                                           QADT:       3.974E-04

    2       100.00   Gran_250                               n/a

    3         0.00   Sub_CBR7              Total:      5.802E-06
```

CBR7 Pavement with Uniform Characteristics – 280 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                Gear         X          Y      Scaling     Theta
   No.         ID                  No.                            Factor
    1          ESA750-Full          1        -165.0       0.0    1.00E+00      0.00
    2          ESA750-Full          1         165.0       0.0    1.00E+00      0.00
    3          ESA750-Full          1        1635.0       0.0    1.00E+00      0.00
    4          ESA750-Full          1        1965.0       0.0    1.00E+00      0.00
    1          SAST53               1           0.0       0.0    1.00E+00      0.00
    2          SAST53               1        2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      280.00    Cement5000
                                           SADT(80):  8.668E-05
                                           SAST(53):  6.557E-05

    3        0.00    Sub_CBR7
                                           SADT(80):  2.147E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      280.00    Cement5000            Total:     2.829E+00
                                           SAST:      2.194E-01
                                           SADT:      9.605E-01
                                           TAST:      8.445E-03
                                           TADT:      1.563E+00
                                           TRDT:      7.654E-02
                                           QADT:      7.248E-04

    2      100.00    Gran_250                                n/a

    3        0.00    Sub_CBR7              Total:     8.272E-06
```

CBR7 Pavement with Uniform Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80         0.00

   Load Locations:
   Location   Load                Gear         X          Y      Scaling     Theta
   No.        ID                  No.                            Factor
    1         ESA750-Full          1        -165.0       0.0    1.00E+00     0.00
    2         ESA750-Full          1         165.0       0.0    1.00E+00     0.00
    3         ESA750-Full          1        1635.0       0.0    1.00E+00     0.00
    4         ESA750-Full          1        1965.0       0.0    1.00E+00     0.00
    1         SAST53               1           0.0       0.0    1.00E+00     0.00
    2         SAST53               1        2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material            Isotropy  Modulus    P.Ratio
   No.    i/face   ID                            (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000          Iso.      5.00E+03   0.20
    2     rough    Gran_250            Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7            Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component  Perform.   Perform.   Shift
   No.             ID                             Constant   Exponent   Factor
    1     bottom   Cement5000          ETH         0.000263   12.000
    3     top      Sub_CBR7            EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle        Unitless
   No.               ID                               Strain
    1      270.00    Cement5000
                                          SADT(80):  9.126E-05
                                          SAST(53):  6.954E-05
    3        0.00    Sub_CBR7
                                          SADT(80):  2.262E-04

Results:

   Layer  Thickness  Material             Axle        CDF
   No.               ID                   Group
    1      270.00    Cement5000           Total:      5.285E+00
                                          SAST:       4.445E-01
                                          SADT:       1.781E+00
                                          TAST:       1.711E-02
                                          TADT:       2.899E+00
                                          TRDT:       1.420E-01
                                          QADT:       1.344E-03

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR7             Total:      1.195E-05
```

CBR7 Pavement with Variable Characteristics – 350 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load             Radius    Pressure/    Exponent
   No.    ID                   Category             Type                       Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force     92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y     Scaling     Theta
   No.        ID                   No.                            Factor
    1         ESA750-Full           1         -165.0       0.0   1.00E+00     0.00
    2         ESA750-Full           1          165.0       0.0   1.00E+00     0.00
    3         ESA750-Full           1         1635.0       0.0   1.00E+00     0.00
    4         ESA750-Full           1         1965.0       0.0   1.00E+00     0.00
    1         SAST53                1            0.0       0.0   1.00E+00     0.00
    2         SAST53                1         2130.0       0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4389            Iso.      4.39E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4389            ETH         0.000280   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      350.00    cement4389
                                           SADT(80):  6.970E-05
                                           SAST(53):  5.061E-05

    3        0.00    Sub_CBR7
                                           SADT(80):  1.715E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      350.00    cement4389            Total:     9.454E-02
                                           SAST:      4.625E-03
                                           SADT:      3.314E-02
                                           TAST:      1.780E-04
                                           TADT:      5.393E-02
                                           TRDT:      2.641E-03
                                           QADT:      2.501E-05

    2       48.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     1.719E-06
```

CBR7 Pavement with Variable Characteristics – 340 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius   Pressure/    Exponent
   No.    ID                   Category             Type                    Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location   Load               Gear          X          Y     Scaling     Theta
   No.        ID                 No.                            Factor
    1         ESA750-Full         1        -165.0        0.0   1.00E+00      0.00
    2         ESA750-Full         1         165.0        0.0   1.00E+00      0.00
    3         ESA750-Full         1        1635.0        0.0   1.00E+00      0.00
    4         ESA750-Full         1        1965.0        0.0   1.00E+00      0.00
    1         SAST53              1           0.0        0.0   1.00E+00      0.00
    2         SAST53              1        2130.0        0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower   Material             Isotropy   Modulus    P.Ratio
   No.    i/face  ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough   cement4492           Iso.       4.49E+03   0.20
    2     rough   Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough   Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material            Component  Perform.   Perform.   Shift
   No.             ID                             Constant   Exponent   Factor
    1     bottom   cement4492          ETH         0.000277   12.000
    3     top      Sub_CBR7            EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      340.00    cement4492
                                           SADT(80): 7.143E-05
                                           SAST(53): 5.213E-05

    3        0.00    Sub_CBR7
                                           SADT(80): 1.756E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      340.00    cement4492            Total:     1.448E-01
                                           SAST:      7.506E-03
                                           SADT:      5.059E-02
                                           TAST:      2.889E-04
                                           TADT:      8.232E-02
                                           TRDT:      4.032E-03
                                           QADT:      3.818E-05

    2       58.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     2.029E-06
```

CBR7 Pavement with Variable Characteristics – 330 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load    Load                   Load                 Load            Radius    Pressure/    Exponent
   No.     ID                     Category             Type                      Ref. stress
    1      ESA750-Full            ESA750-Full          Vertical Force    92.1     0.75          0.00
    2      SAST53                 SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                    Gear          X           Y      Scaling      Theta
   No.         ID                      No.                              Factor
    1          ESA750-Full              1        -165.0        0.0    1.00E+00      0.00
    2          ESA750-Full              1         165.0        0.0    1.00E+00      0.00
    3          ESA750-Full              1        1635.0        0.0    1.00E+00      0.00
    4          ESA750-Full              1        1965.0        0.0    1.00E+00      0.00
    1          SAST53                   1           0.0        0.0    1.00E+00      0.00
    2          SAST53                   1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4601             Iso.       4.60E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7               Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.  Shift
   No.             ID                                Constant   Exponent  Factor
    1     bottom   cement4601             ETH         0.000274   12.000
    3     top      Sub_CBR7               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      330.00    cement4601
                                           SADT(80):  7.321E-05
                                           SAST(53):  5.371E-05
    3        0.00    Sub_CBR7
                                           SADT(80):  1.800E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      330.00    cement4601            Total:     2.225E-01
                                           SAST:      1.225E-02
                                           SADT:      7.748E-02
                                           TAST:      4.714E-04
                                           TADT:      1.261E-01
                                           TRDT:      6.175E-03
                                           QADT:      5.847E-05

    2       68.00    Gran_250                             n/a

    3        0.00    Sub_CBR7              Total:     2.414E-06
```

CBR7 Pavement with Variable Characteristics – 320 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                  Gear        X          Y      Scaling     Theta
   No.        ID                    No.                           Factor
    1         ESA750-Full            1       -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full            1        165.0       0.0   1.00E+00      0.00
    3         ESA750-Full            1       1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full            1       1965.0       0.0   1.00E+00      0.00
    1         SAST53                 1          0.0       0.0   1.00E+00      0.00
    2         SAST53                 1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material                 Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                  (or Ev)    (or vvh)  F           Eh          vh
    1     rough    cement4717               Iso.       4.72E+03   0.20
    2     rough    Gran_250                 Aniso.     2.50E+02   0.35      1.85E+02    1.25E+02    0.35
    3     rough    Sub_CBR7                 Aniso.     7.00E+01   0.45      4.83E+01    3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material                 Component  Perform.   Perform.   Shift
   No.             ID                                  Constant   Exponent   Factor
    1     bottom   cement4717               ETH         0.000271   12.000
    3     top      Sub_CBR7                 EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                 Axle      Unitless
   No.               ID                                 Strain
    1      320.00    cement4717
                                              SADT(80): 7.505E-05
                                              SAST(53): 5.536E-05
    3        0.00    Sub_CBR7
                                              SADT(80): 1.847E-04

Results:

   Layer  Thickness  Material                 Axle      CDF
   No.               ID                       Group
    1      320.00    cement4717               Total:    3.431E-01
                                              SAST:     2.008E-02
                                              SADT:     1.190E-01
                                              TAST:     7.728E-04
                                              TADT:     1.936E-01
                                              TRDT:     9.483E-03
                                              QADT:     8.980E-05

    2       78.00    Gran_250                               n/a

    3        0.00    Sub_CBR7                 Total:    2.891E-06
```

CBR7 Pavement with Variable Characteristics – 310 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/     Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force    92.1      0.75          0.00
    2     SAST53                 SAST53                 Vertical Force   102.4      0.80          0.00

   Load Locations:
   Location  Load                    Gear          X          Y      Scaling     Theta
   No.       ID                      No.                             Factor
    1        ESA750-Full              1        -165.0        0.0    1.00E+00      0.00
    2        ESA750-Full              1         165.0        0.0    1.00E+00      0.00
    3        ESA750-Full              1        1635.0        0.0    1.00E+00      0.00
    4        ESA750-Full              1        1965.0        0.0    1.00E+00      0.00
    1        SAST53                   1           0.0        0.0    1.00E+00      0.00
    2        SAST53                   1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement4841            Iso.      4.84E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4841            ETH        0.000267   12.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      310.00    cement4841
                                           SADT(80):  7.693E-05
                                           SAST(53):  5.707E-05

    3        0.00    Sub_CBR7
                                           SADT(80):  1.897E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      310.00    cement4841            Total:     5.546E-01
                                           SAST:      3.457E-02
                                           SADT:      1.916E-01
                                           TAST:      1.331E-03
                                           TADT:      3.117E-01
                                           TRDT:      1.527E-02
                                           QADT:      1.446E-04

    2       88.00    Gran_250                             n/a

    3        0.00    Sub_CBR7              Total:     3.485E-06
```

CBR7 Pavement with Variable Characteristics – 300 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius    Pressure/    Exponent
   No.    ID                   Category             Type                      Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load               Gear         X           Y      Scaling     Theta
   No.        ID                 No.                             Factor
    1         ESA750-Full         1        -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full         1         165.0        0.0    1.00E+00      0.00
    3         ESA750-Full         1        1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full         1        1965.0        0.0    1.00E+00      0.00
    1         SAST53              1           0.0        0.0    1.00E+00      0.00
    2         SAST53              1        2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus   P.Ratio
   No.    i/face   ID                             (or Ev)   (or vvh)  F         Eh        vh
    1     rough    cement4973           Iso.      4.97E+03  0.20
    2     rough    Gran_250             Aniso.    2.50E+02  0.35      1.85E+02  1.25E+02  0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01  0.45      4.83E+01  3.50E+01  0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.  Perform.  Shift
   No.             ID                              Constant  Exponent  Factor
    1     bottom   cement4973           ETH        0.000264   12.000
    3     top      Sub_CBR7             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle        Unitless
   No.               ID                               Strain
    1      300.00    cement4973
                                          SADT(80):  7.888E-05
                                          SAST(53):  5.885E-05
    3        0.00    Sub_CBR7
                                          SADT(80):  1.951E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      300.00    cement4973           Total:     8.610E-01
                                          SAST:      5.727E-02
                                          SADT:      2.960E-01
                                          TAST:      2.204E-03
                                          TADT:      4.817E-01
                                          TRDT:      2.359E-02
                                          QADT:      2.234E-04

    2       98.00    Gran_250                              n/a

    3        0.00    Sub_CBR7             Total:     4.232E-06
```

CBR7 Pavement with Variable Characteristics – 290 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5113	Iso.	5.11E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5113	ETH	0.000260	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	290.00	cement5113		
			SADT(80):	8.090E-05
			SAST(53):	6.072E-05
3	0.00	Sub_CBR7		
			SADT(80):	2.008E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	290.00	cement5113	Total:	1.408E+00
			SAST:	1.001E-01
			SADT:	4.815E-01
			TAST:	3.851E-03
			TADT:	7.835E-01
			TRDT:	3.837E-02
			QADT:	3.634E-04
2	108.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	5.180E-06

CBR7 Pavement with Variable Characteristics – 280 mm Thick

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5264	Iso.	5.26E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5264	ETH	0.000256	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	280.00	cement5264		
			SADT(80):	8.297E-05
			SAST(53):	6.265E-05
3	0.00	Sub_CBR7		
			SADT(80):	2.068E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	280.00	cement5264	Total:	2.309E+00
			SAST:	1.756E-01
			SADT:	7.853E-01
			TAST:	6.759E-03
			TADT:	1.278E+00
			TRDT:	6.258E-02
			QADT:	5.926E-04
2	118.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	6.382E-06

CBR7 Pavement with Variable Characteristics – 270 mm Thick

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                   Load                   Load            Radius    Pressure/     Exponent
   No.   ID                     Category               Type                      Ref. stress
    1    ESA750-Full            ESA750-Full            Vertical Force     92.1    0.75          0.00
    2    SAST53                 SAST53                 Vertical Force    102.4    0.80          0.00

   Load Locations:
   Location   Load                  Gear         X          Y      Scaling     Theta
   No.        ID                    No.                            Factor
    1         ESA750-Full            1        -165.0       0.0    1.00E+00      0.00
    2         ESA750-Full            1         165.0       0.0    1.00E+00      0.00
    3         ESA750-Full            1        1635.0       0.0    1.00E+00      0.00
    4         ESA750-Full            1        1965.0       0.0    1.00E+00      0.00
    1         SAST53                 1           0.0       0.0    1.00E+00      0.00
    2         SAST53                 1        2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy   Modulus    P.Ratio
   No.    i/face   ID                                (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement5426             Iso.       5.43E+03   0.20
    2     rough    Gran_250               Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR7               Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement5426             ETH         0.000252   12.000
    3     top      Sub_CBR7               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material                Axle       Unitless
   No.               ID                                 Strain
    1       270.00   cement5426
                                             SADT(80):  8.510E-05
                                             SAST(53):  6.467E-05
    3         0.00   Sub_CBR7
                                             SADT(80):  2.133E-04

Results:

   Layer  Thickness  Material                Axle       CDF
   No.               ID                      Group
    1       270.00   cement5426              Total:     3.807E+00
                                             SAST:      3.103E-01
                                             SADT:      1.287E+00
                                             TAST:      1.194E-02
                                             TADT:      2.094E+00
                                             TRDT:      1.026E-01
                                             QADT:      9.712E-04

    2       128.00   Gran_250                               n/a

    3         0.00   Sub_CBR7                Total:     7.922E-06
```

CBR 7 Pavement with 105 % Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement6127	Iso.	6.13E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement6127	ETH	0.000232	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	298.00	cement6127		
			SADT(80):	6.819E-05
			SAST(53):	5.055E-05
3	0.00	Sub_CBR7		
			SADT(80):	1.748E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	298.00	cement6127	Total:	7.034E-01
			SAST:	4.360E-02
			SADT:	2.431E-01
			TAST:	1.678E-03
			TADT:	3.955E-01
			TRDT:	1.937E-02
			QADT:	1.834E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	1.965E-06

CBR 7 Pavement with 104 % Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement5896	Iso.	5.90E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement5896	ETH	0.000239	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	298.00	cement5896		
			SADT(80):	7.017E-05
			SAST(53):	5.210E-05
3	0.00	Sub_CBR7		
			SADT(80):	1.787E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	298.00	cement5896	Total:	6.951E-01
			SAST:	4.376E-02
			SADT:	2.399E-01
			TAST:	1.684E-03
			TADT:	3.904E-01
			TRDT:	1.912E-02
			QADT:	1.811E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	2.289E-06

CBR 7 Pavement with 103 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/     Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X            Y       Scaling     Theta
   No.         ID                    No.                                Factor
    1          ESA750-Full            1          -165.0          0.0    1.00E+00      0.00
    2          ESA750-Full            1           165.0          0.0    1.00E+00      0.00
    3          ESA750-Full            1          1635.0          0.0    1.00E+00      0.00
    4          ESA750-Full            1          1965.0          0.0    1.00E+00      0.00
    1          SAST53                 1             0.0          0.0    1.00E+00      0.00
    2          SAST53                 1          2130.0          0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement5665            Iso.      5.67E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement5665            ETH         0.000245   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      298.00    cement5665
                                          SADT(80):  7.229E-05
                                          SAST(53):  5.375E-05

    3        0.00    Sub_CBR7
                                          SADT(80):  1.828E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      298.00    cement5665           Total:     7.383E-01
                                          SAST:      4.724E-02
                                          SADT:      2.545E-01
                                          TAST:      1.818E-03
                                          TADT:      4.142E-01
                                          TRDT:      2.028E-02
                                          QADT:      1.921E-04

    2      100.00    Gran_250                            n/a

    3        0.00    Sub_CBR7             Total:     2.683E-06
```

CBR 7 Pavement with 102 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                  Gear          X          Y      Scaling     Theta
   No.         ID                    No.                              Factor
    1          ESA750-Full            1         -165.0       0.0    1.00E+00      0.00
    2          ESA750-Full            1          165.0       0.0    1.00E+00      0.00
    3          ESA750-Full            1         1635.0       0.0    1.00E+00      0.00
    4          ESA750-Full            1         1965.0       0.0    1.00E+00      0.00
    1          SAST53                 1            0.0       0.0    1.00E+00      0.00
    2          SAST53                 1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus   P.Ratio
   No.    i/face   ID                              (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement5434            Iso.      5.43E+03  0.20
    2     rough    Gran_250              Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component Perform.  Perform.  Shift
   No.             ID                              Constant  Exponent  Factor
    1     bottom   cement5434            ETH        0.000251  12.000
    3     top      Sub_CBR7              EZZ        0.009150   7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.    Factor       Type
    1       2.00       Cement Stabilised
    3       1.00       Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      298.00    cement5434
                                           SADT(80):  7.455E-05
                                           SAST(53):  5.552E-05

    3        0.00    Sub_CBR7
                                           SADT(80):  1.871E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      298.00    cement5434            Total:     8.009E-01
                                           SAST:      5.214E-02
                                           SADT:      2.758E-01
                                           TAST:      2.007E-03
                                           TADT:      4.488E-01
                                           TRDT:      2.198E-02
                                           QADT:      2.081E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     3.166E-06
```

CBR 7 Pavement with 101 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius   Pressure/    Exponent
   No.    ID                   Category             Type                    Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75         0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location    Load               Gear          X          Y      Scaling      Theta
   No.         ID                 No.                              Factor
    1          ESA750-Full         1         -165.0       0.0    1.00E+00       0.00
    2          ESA750-Full         1          165.0       0.0    1.00E+00       0.00
    3          ESA750-Full         1         1635.0       0.0    1.00E+00       0.00
    4          ESA750-Full         1         1965.0       0.0    1.00E+00       0.00
    1          SAST53              1            0.0       0.0    1.00E+00       0.00
    2          SAST53              1         2130.0       0.0    1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material               Isotropy  Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement5203             Iso.      5.20E+03   0.20
    2     rough    Gran_250               Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7               Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material               Component  Perform.   Perform.   Shift
   No.             ID                                Constant   Exponent   Factor
    1     bottom   cement5203             ETH         0.000258   12.000
    3     top      Sub_CBR7               EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      298.00    cement5203
                                           SADT(80): 7.699E-05
                                           SAST(53): 5.742E-05

    3        0.00    Sub_CBR7
                                           SADT(80): 1.918E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      298.00    cement5203            Total:     8.476E-01
                                           SAST:      5.619E-02
                                           SADT:      2.915E-01
                                           TAST:      2.163E-03
                                           TADT:      4.743E-01
                                           TRDT:      2.323E-02
                                           QADT:      2.200E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     3.762E-06
```

CBR 7 Pavement with 100 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Thickness Comparison

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load           Radius    Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1     0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y       Scaling     Theta
   No.        ID                   No.                              Factor
    1         ESA750-Full           1         -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full           1          165.0        0.0    1.00E+00      0.00
    3         ESA750-Full           1         1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full           1         1965.0        0.0    1.00E+00      0.00
    1         SAST53                1            0.0        0.0    1.00E+00      0.00
    2         SAST53                1         2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    Cement5000           Iso.       5.00E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   Cement5000           ETH         0.000263   12.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      298.00    Cement5000
                                          SADT(80): 7.928E-05
                                          SAST(53): 5.922E-05
    3        0.00    Sub_CBR7
                                          SADT(80): 1.962E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      298.00    Cement5000           Total:     9.587E-01
                                          SAST:      6.461E-02
                                          SADT:      3.293E-01
                                          TAST:      2.487E-03
                                          TADT:      5.358E-01
                                          TRDT:      2.624E-02
                                          QADT:      2.485E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR7             Total:     4.405E-06
```

CBR 7 Pavement with 99 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR5 - Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                  Load                  Load            Radius    Pressure/    Exponent
   No.   ID                    Category              Type                      Ref. stress
    1    ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2    SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location   Load                 Gear          X           Y      Scaling     Theta
   No.        ID                   No.                              Factor
    1         ESA750-Full           1         -165.0        0.0   1.00E+00      0.00
    2         ESA750-Full           1          165.0        0.0   1.00E+00      0.00
    3         ESA750-Full           1         1635.0        0.0   1.00E+00      0.00
    4         ESA750-Full           1         1965.0        0.0   1.00E+00      0.00
    1         SAST53                1            0.0        0.0   1.00E+00      0.00
    2         SAST53                1         2130.0        0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)   F          Eh         vh
    1     rough    cement4724            Iso.       4.74E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35       1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45       4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4724            ETH         0.000270   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      298.00    cement4724
                                           SADT(80):  8.243E-05
                                           SAST(53):  6.169E-05
    3        0.00    Sub_CBR7
                                           SADT(80):  2.022E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      298.00    cement4724            Total:     1.118E+00
                                           SAST:      7.706E-02
                                           SADT:      3.834E-01
                                           TAST:      2.966E-03
                                           TADT:      6.239E-01
                                           TRDT:      3.056E-02
                                           QADT:      2.894E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     5.435E-06
```

CBR 7 Pavement with 98 % Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement4511	Iso.	4.51E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement4511	ETH	0.000276	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	298.00	cement4511	SADT(80):	8.550E-05
			SAST(53):	6.412E-05
3	0.00	Sub_CBR7	SADT(80):	2.079E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	298.00	cement4511	Total:	1.335E+00
			SAST:	9.394E-02
			SADT:	4.569E-01
			TAST:	3.616E-03
			TADT:	7.434E-01
			TRDT:	3.641E-02
			QADT:	3.448E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	6.623E-06

CBR 7 Pavement with 97 % Compaction

CIRCLY - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

ID: NSWPresumeRural
Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
ESA/HVAG: 1.068

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA750-Full	ESA750-Full	Vertical Force	92.1	0.75	0.00
2	SAST53	SAST53	Vertical Force	102.4	0.80	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA750-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA750-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA750-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA750-Full	1	1965.0	0.0	1.00E+00	0.00
1	SAST53	1	0.0	0.0	1.00E+00	0.00
2	SAST53	1	2130.0	0.0	1.00E+00	0.00

Details of Layered System:

ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	cement4280	Iso.	4.28E+03	0.20			
2	rough	Gran_250	Aniso.	2.50E+02	0.35	1.85E+02	1.25E+02	0.35
3	rough	Sub_CBR7	Aniso.	7.00E+01	0.45	4.83E+01	3.50E+01	0.45

Performance Relationships:

Layer No.	Location	Material ID	Component	Perform. Constant	Perform. Exponent	Shift Factor
1	bottom	cement4280	ETH	0.000283	12.000	
3	top	Sub_CBR7	EZZ	0.009150	7.000	

Reliability Factors:
Project Reliability: Austroads 90%

Layer No.	Reliability Factor	Material Type
1	2.00	Cement Stabilised
3	1.00	Subgrade (Austroads 2017)

Details of Layers to be sublayered:
Layer no. 2: Austroads (2004) sublayering

Strains:

Layer No.	Thickness	Material ID	Axle	Unitless Strain
1	298.00	cement4280		
			SADT(80):	8.884E-05
			SAST(53):	6.676E-05
3	0.00	Sub_CBR7		
			SADT(80):	2.142E-04

Results:

Layer No.	Thickness	Material ID	Axle Group	CDF
1	298.00	cement4280	Total:	1.569E+00
			SAST:	1.129E-01
			SADT:	5.360E-01
			TAST:	4.346E-03
			TADT:	8.722E-01
			TRDT:	4.271E-02
			QADT:	4.045E-04
2	100.00	Gran_250		n/a
3	0.00	Sub_CBR7	Total:	8.154E-06

CBR 7 Pavement with 96 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load            Radius    Pressure/    Exponent
   No.    ID                    Category              Type                      Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force    92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location  Load                   Gear          X          Y      Scaling     Theta
   No.       ID                     No.                              Factor
    1        ESA750-Full             1         -165.0       0.0    1.00E+00     0.00
    2        ESA750-Full             1          165.0       0.0    1.00E+00     0.00
    3        ESA750-Full             1         1635.0       0.0    1.00E+00     0.00
    4        ESA750-Full             1         1965.0       0.0    1.00E+00     0.00
    1        SAST53                  1            0.0       0.0    1.00E+00     0.00
    2        SAST53                  1         2130.0       0.0    1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy  Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F           Eh         vh
    1     rough    cement4049            Iso.      4.05E+03   0.20
    2     rough    Gran_250              Aniso.    2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.    7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement4049            ETH        0.000289   12.000
    3     top      Sub_CBR7              EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      298.00    cement4049
                                            SADT(80): 9.250E-05
                                            SAST(53): 6.965E-05

    3        0.00    Sub_CBR7
                                            SADT(80): 2.210E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      298.00    cement4049             Total:     1.982E+00
                                            SAST:      1.461E-01
                                            SADT:      6.760E-01
                                            TAST:      5.624E-03
                                            TADT:      1.100E+00
                                            TRDT:      5.387E-02
                                            QADT:      5.102E-04

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7               Total:     1.015E-05
```

CBR 7 Pavement with 95 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                Load            Radius     Pressure/    Exponent
   No.    ID                   Category            Type                       Ref. stress
    1     ESA750-Full          ESA750-Full         Vertical Force    92.1      0.75          0.00
    2     SAST53               SAST53              Vertical Force   102.4      0.80          0.00

   Load Locations:
   Location    Load                Gear         X           Y      Scaling     Theta
   No.         ID                  No.                             Factor
    1          ESA750-Full          1        -165.0        0.0     1.00E+00      0.00
    2          ESA750-Full          1         165.0        0.0     1.00E+00      0.00
    3          ESA750-Full          1        1635.0        0.0     1.00E+00      0.00
    4          ESA750-Full          1        1965.0        0.0     1.00E+00      0.00
    1          SAST53               1           0.0        0.0     1.00E+00      0.00
    2          SAST53               1        2130.0        0.0     1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3818            Iso.       3.82E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement3818            ETH         0.000295   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material               Axle       Unitless
   No.               ID                                Strain
    1      298.00    cement3818
                                            SADT(80):  9.651E-05
                                            SAST(53):  7.284E-05
    3        0.00    Sub_CBR7
                                            SADT(80):  2.285E-04

Results:

   Layer  Thickness  Material               Axle       CDF
   No.               ID                     Group
    1      298.00    cement3818             Total:     2.585E+00
                                            SAST:      1.955E-01
                                            SADT:      8.798E-01
                                            TAST:      7.524E-03
                                            TADT:      1.432E+00
                                            TRDT:      7.011E-02
                                            QADT:      6.639E-04

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR7               Total:     1.280E-05
```

CBR 7 Pavement with 94 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                 Load                 Load            Radius   Pressure/    Exponent
   No.    ID                   Category             Type                     Ref. stress
    1     ESA750-Full          ESA750-Full          Vertical Force    92.1    0.75          0.00
    2     SAST53               SAST53               Vertical Force   102.4    0.80          0.00

   Load Locations:
   Location   Load                 Gear          X          Y      Scaling    Theta
   No.        ID                   No.                             Factor
    1         ESA750-Full           1        -165.0        0.0   1.00E+00     0.00
    2         ESA750-Full           1         165.0        0.0   1.00E+00     0.00
    3         ESA750-Full           1        1635.0        0.0   1.00E+00     0.00
    4         ESA750-Full           1        1965.0        0.0   1.00E+00     0.00
    1         SAST53                1           0.0        0.0   1.00E+00     0.00
    2         SAST53                1        2130.0        0.0   1.00E+00     0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy  Modulus   P.Ratio
   No.    i/face   ID                             (or Ev)   (or vvh)  F          Eh         vh
    1     rough    cement3587           Iso.      3.59E+03  0.20
    2     rough    Gran_250             Aniso.    2.50E+02  0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7             Aniso.    7.00E+01  0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.  Perform.  Shift
   No.             ID                              Constant  Exponent  Factor
    1     bottom   cement3587           ETH        0.000302   12.000
    3     top      Sub_CBR7             EZZ        0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material             Axle       Unitless
   No.               ID                              Strain
    1      298.00    cement3587
                                          SADT(80): 1.009E-04
                                          SAST(53): 7.638E-05
    3        0.00    Sub_CBR7
                                          SADT(80): 2.366E-04

Results:

   Layer  Thickness  Material             Axle       CDF
   No.               ID                   Group
    1      298.00    cement3587           Total:     3.353E+00
                                          SAST:      2.605E-01
                                          SADT:      1.138E+00
                                          TAST:      1.003E-02
                                          TADT:      1.852E+00
                                          TRDT:      9.072E-02
                                          QADT:      8.591E-04

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR7             Total:     1.637E-05
```

CBR 7 Pavement with 93 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force     92.1    0.75           0.00
    2     SAST53                 SAST53                 Vertical Force    102.4    0.80           0.00

   Load Locations:
   Location   Load                  Gear         X          Y      Scaling     Theta
   No.        ID                    No.                            Factor
    1         ESA750-Full            1       -165.0        0.0    1.00E+00      0.00
    2         ESA750-Full            1        165.0        0.0    1.00E+00      0.00
    3         ESA750-Full            1       1635.0        0.0    1.00E+00      0.00
    4         ESA750-Full            1       1965.0        0.0    1.00E+00      0.00
    1         SAST53                 1          0.0        0.0    1.00E+00      0.00
    2         SAST53                 1       2130.0        0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement3356            Iso.       3.36E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.   Shift
   No.             ID                               Constant   Exponent   Factor
    1     bottom   cement3356            ETH         0.000308   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor         Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      298.00    cement3356
                                           SADT(80):  1.059E-04
                                           SAST(53):  8.032E-05
    3        0.00    Sub_CBR7
                                           SADT(80):  2.457E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      298.00    cement3356            Total:     4.703E+00
                                           SAST:      3.762E-01
                                           SADT:      1.593E+00
                                           TAST:      1.448E-02
                                           TADT:      2.591E+00
                                           TRDT:      1.269E-01
                                           QADT:      1.202E-03

    2      100.00    Gran_250                               n/a

    3        0.00    Sub_CBR7              Total:     2.126E-05
```

CBR 7 Pavement with 92 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                  Load                  Load             Radius    Pressure/    Exponent
   No.    ID                    Category              Type                       Ref. stress
    1     ESA750-Full           ESA750-Full           Vertical Force     92.1     0.75          0.00
    2     SAST53                SAST53                Vertical Force    102.4     0.80          0.00

   Load Locations:
   Location    Load                Gear          X          Y      Scaling      Theta
   No.         ID                  No.                             Factor
    1          ESA750-Full          1        -165.0        0.0   1.00E+00       0.00
    2          ESA750-Full          1         165.0        0.0   1.00E+00       0.00
    3          ESA750-Full          1        1635.0        0.0   1.00E+00       0.00
    4          ESA750-Full          1        1965.0        0.0   1.00E+00       0.00
    1          SAST53               1           0.0        0.0   1.00E+00       0.00
    2          SAST53               1        2130.0        0.0   1.00E+00       0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material             Isotropy   Modulus    P.Ratio
   No.    i/face   ID                              (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement3125           Iso.       3.13E+03   0.20
    2     rough    Gran_250             Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7             Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material             Component  Perform.   Perform.   Shift
   No.             ID                              Constant   Exponent   Factor
    1     bottom   cement3125           ETH         0.000314   12.000
    3     top      Sub_CBR7             EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material            Axle        Unitless
   No.               ID                              Strain
    1      298.00    cement3125
                                         SADT(80):  1.114E-04
                                         SAST(53):  8.474E-05
    3        0.00    Sub_CBR7
                                         SADT(80):  2.557E-04

Results:

   Layer  Thickness  Material            Axle        CDF
   No.               ID                  Group
    1      298.00    cement3125          Total:     6.878E+00
                                         SAST:      5.677E-01
                                         SADT:      2.322E+00
                                         TAST:      2.185E-02
                                         TADT:      3.779E+00
                                         TRDT:      1.851E-01
                                         QADT:      1.753E-03

    2      100.00    Gran_250                             n/a

    3        0.00    Sub_CBR7            Total:     2.812E-05
```

CBR 7 Pavement with 91 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load   Load                   Load                   Load            Radius    Pressure/    Exponent
   No.    ID                     Category               Type                      Ref. stress
    1     ESA750-Full            ESA750-Full            Vertical Force    92.1     0.75          0.00
    2     SAST53                 SAST53                 Vertical Force   102.4     0.80          0.00

   Load Locations:
   Location    Load                 Gear          X          Y     Scaling      Theta
   No.         ID                   No.                            Factor
    1          ESA750-Full           1         -165.0       0.0    1.00E+00      0.00
    2          ESA750-Full           1          165.0       0.0    1.00E+00      0.00
    3          ESA750-Full           1         1635.0       0.0    1.00E+00      0.00
    4          ESA750-Full           1         1965.0       0.0    1.00E+00      0.00
    1          SAST53                1            0.0       0.0    1.00E+00      0.00
    2          SAST53                1         2130.0       0.0    1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh         vh
    1     rough    cement2894            Iso.       2.89E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02   0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01   0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement2894            ETH         0.000320   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.  2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      298.00    cement2894
                                           SADT(80):  1.176E-04
                                           SAST(53):  8.974E-05

    3        0.00    Sub_CBR7
                                           SADT(80):  2.669E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      298.00    cement2894            Total:     1.054E+01
                                           SAST:      9.002E-01
                                           SADT:      3.548E+00
                                           TAST:      3.465E-02
                                           TADT:      5.773E+00
                                           TRDT:      2.828E-01
                                           QADT:      2.678E-03

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     3.795E-05
```

CBR 7 Pavement with 90 % Compaction

```
CIRCLY  - Version 7.0 (1 February 2022)

Job Title: CBR7 Compaction Analysis

Design Method: Austroads 2017

NDT (cumulative heavy vehicle axle groups over design period): 1.98E+06

Traffic Load Distribution:

   ID: NSWPresumeRural
   Name: NSW RMS Aug 2018 - Rural Presumptive (Table 18)
   ESA/HVAG: 1.068

Details of Load Groups:

   Load  Load                  Load                  Load            Radius   Pressure/    Exponent
   No.   ID                    Category              Type                     Ref. stress
    1    ESA750-Full           ESA750-Full           Vertical Force    92.1    0.75         0.00
    2    SAST53                SAST53                Vertical Force   102.4    0.80         0.00

   Load Locations:
   Location   Load               Gear        X          Y     Scaling     Theta
   No.        ID                 No.                          Factor
    1         ESA750-Full         1       -165.0       0.0   1.00E+00      0.00
    2         ESA750-Full         1        165.0       0.0   1.00E+00      0.00
    3         ESA750-Full         1       1635.0       0.0   1.00E+00      0.00
    4         ESA750-Full         1       1965.0       0.0   1.00E+00      0.00
    1         SAST53              1          0.0       0.0   1.00E+00      0.00
    2         SAST53              1       2130.0       0.0   1.00E+00      0.00

Details of Layered System:

   ID: Aust2017-1 Title: Austroads 2017 - Example 1 - Unbound Granular Pavement

   Layer  Lower    Material              Isotropy   Modulus    P.Ratio
   No.    i/face   ID                               (or Ev)    (or vvh)  F          Eh          vh
    1     rough    cement2663            Iso.       2.66E+03   0.20
    2     rough    Gran_250              Aniso.     2.50E+02   0.35      1.85E+02   1.25E+02    0.35
    3     rough    Sub_CBR7              Aniso.     7.00E+01   0.45      4.83E+01   3.50E+01    0.45

   Performance Relationships:
   Layer  Location Material              Component  Perform.   Perform.  Shift
   No.             ID                               Constant   Exponent  Factor
    1     bottom   cement2663            ETH         0.000327   12.000
    3     top      Sub_CBR7              EZZ         0.009150    7.000

   Reliability Factors:
   Project Reliability: Austroads 90%
   Layer  Reliability  Material
    No.   Factor        Type
    1      2.00        Cement Stabilised
    3      1.00        Subgrade (Austroads 2017)

   Details of Layers to be sublayered:
   Layer no.   2:  Austroads (2004) sublayering

Strains:

   Layer  Thickness  Material              Axle       Unitless
   No.               ID                               Strain
    1      298.00    cement2663
                                           SADT(80):  1.247E-04
                                           SAST(53):  9.545E-05
    3        0.00    Sub_CBR7
                                           SADT(80):  2.795E-04

Results:

   Layer  Thickness  Material              Axle       CDF
   No.               ID                    Group
    1      298.00    cement2663            Total:     1.642E+01
                                           SAST:      1.455E+00
                                           SADT:      5.507E+00
                                           TAST:      5.601E-02
                                           TADT:      8.962E+00
                                           TRDT:      4.389E-01
                                           QADT:      4.156E-03

    2      100.00    Gran_250                              n/a

    3        0.00    Sub_CBR7              Total:     5.246E-05
```

Appendix D – Whole of Life Cost Analysis

Conforming Pavement

Whole of Life Cost Analysis - Conforming Pavement - Discount Rate = 7%																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing																					
Patching										$4.25						$4.25					
Reseal		$7.00									$7.00										
Rehabilitation																					-$37.50
Total	$150.00	$7.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$4.75	$7.50	$0.50	$0.50	$0.50	$0.50	$4.75	$0.50	$0.50	$0.50	$0.50	-$37.00
Present Value	$150.00	$7.01	$0.44	$0.41	$0.38	$0.36	$0.33	$0.31	$0.29	$2.58	$3.81	$0.24	$0.22	$0.21	$0.19	$1.72	$0.17	$0.16	$0.15	$0.14	-$9.56
Net Present Value	$150.00	$157.01	$157.45	$157.85	$158.24	$158.59	$158.93	$159.24	$159.53	$162.11	$165.92	$166.16	$166.38	$166.59	$166.78	$168.51	$168.68	$168.83	$168.98	$169.12	$159.56

Whole of Life Cost Analysis - Conforming Pavement - Discount Rate = 4%																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing																					
Patching										$4.25						$4.25					
Reseal		$7.00									$7.00										
Rehabilitation																					-$37.50
Total	$150.00	$7.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$4.75	$7.50	$0.50	$0.50	$0.50	$0.50	$4.75	$0.50	$0.50	$0.50	$0.50	-$37.00
Present Value	$150.00	$7.21	$0.46	$0.44	$0.43	$0.41	$0.40	$0.38	$0.37	$3.34	$5.07	$0.32	$0.31	$0.30	$0.29	$2.64	$0.27	$0.26	$0.25	$0.24	-$16.89
Net Present Value	$150.00	$157.21	$157.67	$158.12	$158.55	$158.96	$159.35	$159.73	$160.10	$163.43	$168.50	$168.83	$169.14	$169.44	$169.73	$172.36	$172.63	$172.89	$173.14	$173.37	$156.49

Whole of Life Cost Analysis - Conforming Pavement - Discount Rate = 10%																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing																					
Patching										$4.25						$4.25					
Reseal		$7.00									$7.00										
Rehabilitation																					-$37.50
Total	$150.00	$7.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$4.75	$7.50	$0.50	$0.50	$0.50	$0.50	$4.75	$0.50	$0.50	$0.50	$0.50	-$37.00
Present Value	$150.00	$6.82	$0.41	$0.38	$0.34	$0.31	$0.28	$0.26	$0.23	$2.01	$2.89	$0.18	$0.16	$0.14	$0.13	$1.14	$0.11	$0.10	$0.09	$0.08	-$5.50
Net Present Value	$150.00	$156.82	$157.23	$157.61	$157.95	$158.26	$158.54	$158.80	$159.03	$161.05	$163.94	$164.11	$164.27	$164.42	$164.55	$165.69	$165.79	$165.89	$165.98	$166.06	$160.56

Uniform Modulus - Nonconforming Thickness -10mm

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - 10mm Less than Design - Discount Rate = 7%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$8.50				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.50	$3.00	$0.50	$9.00	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$150.00	$7.01	$0.44	$2.45	$0.38	$6.42	$2.00	$0.31	$0.29	$17.81	$6.35	$0.24	$1.33	$0.21	$0.19	$11.87	$0.17	$0.16	$0.89	$0.14	-$5.69
Net Present Value	$150.00	$157.01	$157.45	$159.89	$160.28	$166.69	$168.69	$169.00	$169.29	$187.11	$193.46	$193.70	$195.03	$195.24	$195.43	$207.30	$207.47	$207.63	$208.52	$208.66	$202.97

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - 10mm Less than Design - Discount Rate = 4%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$8.50				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.50	$3.00	$0.50	$9.00	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$150.00	$7.21	$0.46	$2.67	$0.43	$7.40	$2.37	$0.38	$0.37	$23.01	$8.44	$0.32	$1.87	$0.30	$0.29	$18.18	$0.27	$0.26	$1.48	$0.24	-$10.04
Net Present Value	$150.00	$157.21	$157.67	$160.34	$160.77	$168.17	$170.54	$170.92	$171.28	$194.29	$202.74	$203.06	$204.93	$205.23	$205.52	$223.71	$223.98	$224.23	$225.71	$225.95	$215.91

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - 10mm Less than Design - Discount Rate = 10%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$8.50				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.50	$3.00	$0.50	$9.00	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$150.00	$6.82	$0.41	$2.25	$0.34	$5.59	$1.69	$0.26	$0.23	$13.89	$4.82	$0.18	$0.96	$0.14	$0.13	$7.84	$0.11	$0.10	$0.54	$0.08	-$3.27
Net Present Value	$150.00	$156.82	$157.23	$159.49	$159.83	$165.42	$167.11	$167.37	$167.60	$181.49	$186.31	$186.48	$187.44	$187.58	$187.71	$195.55	$195.66	$195.76	$196.30	$196.38	$193.11

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - 10mm Less than Design - Discount Rate = 7% - Required Construction Cost for Cost Recovery																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$106.59																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$8.50				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$106.59	$7.50	$0.50	$3.00	$0.50	$9.00	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$106.59	$7.01	$0.44	$2.45	$0.38	$6.42	$2.00	$0.31	$0.29	$17.81	$6.35	$0.24	$1.33	$0.21	$0.19	$11.87	$0.17	$0.16	$0.89	$0.14	-$5.69
Net Present Value	$106.59	$113.60	$114.03	$116.48	$116.86	$123.28	$125.28	$125.59	$125.88	$143.70	$150.05	$150.29	$151.62	$151.83	$152.02	$163.89	$164.06	$164.22	$165.11	$165.25	$159.56

Variable Modulus – Nonconforming Thickness -10mm

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - Variable Modulus - 10mm Less than Design - Discount Rate = 7%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$6.38				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.50	$3.00	$0.50	$6.88	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$150.00	$7.01	$0.44	$2.45	$0.38	$4.90	$2.00	$0.31	$0.29	$17.81	$6.35	$0.24	$1.33	$0.21	$0.19	$11.87	$0.17	$0.16	$0.89	$0.14	-$5.69
Net Present Value	$150.00	$157.01	$157.45	$159.89	$160.28	$165.18	$167.18	$167.49	$167.78	$185.59	$191.95	$192.19	$193.52	$193.72	$193.92	$205.79	$205.96	$206.12	$207.00	$207.14	$201.46

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - Variable Modulus - 10mm Less than Design - Discount Rate = 4%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$6.38				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.50	$3.00	$0.50	$6.88	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$150.00	$7.21	$0.46	$2.67	$0.43	$5.65	$2.37	$0.38	$0.37	$23.01	$8.44	$0.32	$1.87	$0.30	$0.29	$18.18	$0.27	$0.26	$1.48	$0.24	-$10.04
Net Present Value	$150.00	$157.21	$157.67	$160.34	$160.77	$166.42	$168.79	$169.17	$169.54	$192.54	$200.99	$201.31	$203.19	$203.49	$203.78	$221.96	$222.23	$222.49	$223.97	$224.20	$214.16

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - Variable Modulus - 10mm Less than Design - Discount Rate = 10%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$6.38				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.50	$3.00	$0.50	$6.88	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$150.00	$6.82	$0.41	$2.25	$0.34	$4.27	$1.69	$0.26	$0.23	$13.89	$4.82	$0.18	$0.96	$0.14	$0.13	$7.84	$0.11	$0.10	$0.54	$0.08	-$3.27
Net Present Value	$150.00	$156.82	$157.23	$159.49	$159.83	$164.10	$165.79	$166.05	$166.28	$180.17	$184.99	$185.16	$186.12	$186.26	$186.40	$194.24	$194.34	$194.44	$194.98	$195.06	$191.79

Whole of Life Cost Analysis - Nonconforming Pavement Thickness - Variable Modulus - 10mm Less than Design - Discount Rate = 7% - Required Construction Cost for Cost Recovery																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$108.10																				
Routine Maintenance		$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50	$0.50
Crack Sealing				$2.50			$2.50			$2.50			$2.50			$2.50			$2.50		
Patching						$6.38				$29.75						$29.75					
Reseal		$7.00									$12.00										
Rehabilitation																					-$22.50
Total	$108.10	$7.50	$0.50	$3.00	$0.50	$6.88	$3.00	$0.50	$0.50	$32.75	$12.50	$0.50	$3.00	$0.50	$0.50	$32.75	$0.50	$0.50	$3.00	$0.50	-$22.00
Present Value	$108.10	$7.01	$0.44	$2.45	$0.38	$4.90	$2.00	$0.31	$0.29	$17.81	$6.35	$0.24	$1.33	$0.21	$0.19	$11.87	$0.17	$0.16	$0.89	$0.14	-$5.69
Net Present Value	$108.10	$115.11	$115.55	$118.00	$118.38	$123.28	$125.28	$125.59	$125.88	$143.70	$150.05	$150.29	$151.62	$151.83	$152.02	$163.89	$164.06	$164.22	$165.11	$165.25	$159.56

Nonconforming Compaction = 98%

Whole of Life Cost Analysis - Pavement Compaction = 98% - Discount Rate = 7%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching						$4.25				$8.50					$12.75						
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.53	$0.55	$0.58	$4.86	$0.64	$0.67	$0.70	$9.24	$9.78	$0.81	$0.86	$0.90	$13.69	$0.99	$1.04	$1.09	$1.15	$1.20	-$21.24
Present Value	$150.00	$7.01	$0.46	$0.45	$0.44	$3.46	$0.43	$0.42	$0.41	$5.03	$4.97	$0.39	$0.38	$0.37	$5.31	$0.36	$0.35	$0.35	$0.34	$0.33	-$5.49
Net Present Value	$150.00	$157.01	$157.47	$157.92	$158.36	$161.82	$162.25	$162.67	$163.07	$168.10	$173.07	$173.46	$173.84	$174.21	$179.52	$179.88	$180.23	$180.58	$180.91	$181.25	$175.76

Whole of Life Cost Analysis - Pavement Compaction = 98% - Discount Rate = 4%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching						$4.25				$8.50					$12.75						
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.53	$0.55	$0.58	$4.86	$0.64	$0.67	$0.70	$9.24	$9.78	$0.81	$0.86	$0.90	$13.69	$0.99	$1.04	$1.09	$1.15	$1.20	-$21.24
Present Value	$150.00	$7.21	$0.49	$0.49	$0.49	$3.99	$0.50	$0.51	$0.51	$6.49	$6.60	$0.53	$0.53	$0.54	$7.91	$0.55	$0.55	$0.56	$0.57	$0.57	-$9.69
Net Present Value	$150.00	$157.21	$157.70	$158.19	$158.68	$162.67	$163.18	$163.69	$164.20	$170.69	$177.30	$177.83	$178.36	$178.90	$186.81	$187.36	$187.91	$188.47	$189.04	$189.61	$179.92

Whole of Life Cost Analysis - Pavement Compaction = 98% - Discount Rate = 10%																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$150.00																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching						$4.25				$8.50					$12.75						
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.53	$0.55	$0.58	$4.86	$0.64	$0.67	$0.70	$9.24	$9.78	$0.81	$0.86	$0.90	$13.69	$0.99	$1.04	$1.09	$1.15	$1.20	-$21.24
Present Value	$150.00	$6.82	$0.43	$0.41	$0.40	$3.02	$0.36	$0.34	$0.33	$3.92	$3.77	$0.29	$0.27	$0.26	$3.61	$0.24	$0.23	$0.22	$0.21	$0.20	-$3.16
Net Present Value	$150.00	$156.82	$157.25	$157.67	$158.06	$161.08	$161.44	$161.78	$162.11	$166.03	$169.80	$170.08	$170.36	$170.62	$174.22	$174.46	$174.68	$174.90	$175.11	$175.30	$172.15

Whole of Life Cost Analysis - Pavement Compaction = 98% - Discount Rate = 7% - Required Construction Cost for Cost Recovery																					
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Construction	$133.80																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching						$4.25				$8.50					$12.75						
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$133.80	$7.50	$0.53	$0.55	$0.58	$4.86	$0.64	$0.67	$0.70	$9.24	$9.78	$0.81	$0.86	$0.90	$13.69	$0.99	$1.04	$1.09	$1.15	$1.20	-$21.24
Present Value	$133.80	$7.01	$0.46	$0.45	$0.44	$3.46	$0.43	$0.42	$0.41	$5.03	$4.97	$0.39	$0.38	$0.37	$5.31	$0.36	$0.35	$0.35	$0.34	$0.33	-$5.49
Net Present Value	$133.80	$140.81	$141.27	$141.72	$142.16	$145.62	$146.05	$146.47	$146.87	$151.90	$156.87	$157.26	$157.64	$158.01	$163.32	$163.68	$164.03	$164.38	$164.71	$165.05	$159.56

Nonconforming Compaction = 95%

Whole of Life Cost Analysis - Pavement Compaction = 95% - Discount Rate = 7%																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$150.00																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching				$8.50			$8.50			$25.50			$8.50			$12.75			$17.00		
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.53	$9.05	$0.58	$0.61	$9.14	$0.67	$0.70	$26.24	$9.78	$0.81	$9.36	$0.90	$0.94	$13.74	$1.04	$1.09	$18.15	$1.20	-$21.24
Present Value	$150.00	$7.01	$0.46	$7.39	$0.44	$0.43	$6.09	$0.42	$0.41	$14.27	$4.97	$0.39	$4.15	$0.37	$0.37	$4.98	$0.35	$0.35	$5.37	$0.33	-$5.49
Net Present Value	$150.00	$157.01	$157.47	$164.86	$165.30	$165.73	$171.82	$172.24	$172.65	$186.92	$191.89	$192.28	$196.43	$196.80	$197.17	$202.15	$202.50	$202.85	$208.21	$208.55	$203.06

Whole of Life Cost Analysis - Pavement Compaction = 95% - Discount Rate = 4%																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$150.00																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching				$8.50			$8.50			$25.50			$8.50			$12.75			$17.00		
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.53	$9.05	$0.58	$0.61	$9.14	$0.67	$0.70	$26.24	$9.78	$0.81	$9.36	$0.90	$0.94	$13.74	$1.04	$1.09	$18.15	$1.20	-$21.24
Present Value	$150.00	$7.21	$0.49	$8.05	$0.49	$0.50	$7.22	$0.51	$0.51	$18.43	$6.60	$0.53	$5.84	$0.54	$0.54	$7.63	$0.55	$0.56	$8.96	$0.57	-$9.69
Net Present Value	$150.00	$157.21	$157.70	$165.74	$166.24	$166.74	$173.96	$174.47	$174.98	$193.42	$200.02	$200.55	$206.39	$206.93	$207.48	$215.11	$215.66	$216.22	$225.18	$225.75	$216.06

Whole of Life Cost Analysis - Pavement Compaction = 95% - Discount Rate = 10%																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$150.00																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching				$8.50			$8.50			$25.50			$8.50			$12.75			$17.00		
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$150.00	$7.50	$0.53	$9.05	$0.58	$0.61	$9.14	$0.67	$0.70	$26.24	$9.78	$0.81	$9.36	$0.90	$0.94	$13.74	$1.04	$1.09	$18.15	$1.20	-$21.24
Present Value	$150.00	$6.82	$0.43	$6.80	$0.40	$0.38	$5.16	$0.34	$0.33	$11.13	$3.77	$0.29	$2.98	$0.26	$0.25	$3.29	$0.23	$0.22	$3.26	$0.20	-$3.16
Net Present Value	$150.00	$156.82	$157.25	$164.05	$164.45	$164.83	$169.98	$170.33	$170.66	$181.78	$185.55	$185.84	$188.82	$189.08	$189.33	$192.62	$192.84	$193.06	$196.32	$196.52	$193.36

Whole of Life Cost Analysis - Pavement Compaction = 95% - Discount Rate = 7% - Required Construction Cost for Cost Recovery																					
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Construction	$106.50																				
Routine Maintenance		$0.50	$0.53	$0.55	$0.58	$0.61	$0.64	$0.67	$0.70	$0.74	$0.78	$0.81	$0.86	$0.90	$0.94	$0.99	$1.04	$1.09	$1.15	$1.20	$1.26
Crack Sealing																					
Patching				$8.50			$8.50			$25.50			$8.50			$12.75			$17.00		
Reseal		$7.00									$9.00										
Rehabilitation																					-$22.50
Total	$106.50	$7.50	$0.53	$9.05	$0.58	$0.61	$9.14	$0.67	$0.70	$26.24	$9.78	$0.81	$9.36	$0.90	$0.94	$13.74	$1.04	$1.09	$18.15	$1.20	-$21.24
Present Value	$106.50	$7.01	$0.46	$7.39	$0.44	$0.43	$6.09	$0.42	$0.41	$14.27	$4.97	$0.39	$4.15	$0.37	$0.37	$4.98	$0.35	$0.35	$5.37	$0.33	-$5.49
Net Present Value	$106.50	$113.51	$113.97	$121.36	$121.80	$122.23	$128.32	$128.74	$129.15	$143.42	$148.39	$148.78	$152.93	$153.30	$153.67	$158.65	$159.00	$159.35	$164.72	$165.05	$159.56