THE IMPACT OF TRENCHING ON URBAN ROAD OPERATION AND MAINTENANCE

LEONG WENG WAH

B ENG

2005

University of Southern Queensland

Faculty of Engineering and Surveying

The Impact of Trenching on Urban Road Operation and Maintenance

A dissertation submitted by

Leong Weng Wah

in fulfillment of the requirements of

Courses ENG4111 and 4112 Research Project

towards the degree of

Bachelor of Engineering (Civil)

Submitted: January, 2005

ABSTRACT

Trenching works on road pavement is essential with most utility cables being underground. However, such works often leads to road deterioration due to a number of reasons. Trenching works on road pavement usually occurs in the road shoulder to minimize disturbance to traffic.

This project aims to investigate the impact of such trenching works on urban road operation and maintenance work. Information regarding the impact of trenching, current standards and Codes of Practice, factors leading to the deterioration of roads after trenching and current methods used by local councils are researched. A number of sites around the Klang valley are then investigated and compared with the current standards available. The advantages and disadvantages of both methods are identified and the best possible methods are then determined.

From the investigation, it can be concluded that both the standards employed by the local city council and the usual practice of the contractor have their own advantages. The standards and guidelines provided by the local city councils are found to be more effective whereas the usual practice of the sub-contractor is found to be more economical. Therefore, there should be a closer liaison between the road authority and utility department's personnel with the contractor.

.

University of Southern Queensland

Faculty of Engineering and Surveying

ENG4111 & ENG4112 *Research Project*

Limitations of Use

CERTIFICATION OF DISSERTATION

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

LEONG WENG WAH
0050012473

Signature

Date

ACKNOWLEDGEMENTS

First and foremost I would like to thank my supervisor, Assoc Professor Ron Ayers, for putting up with me and giving me valuable advices and recommendations throughout the course of this project. I would not have had completed this project without his timely adviced.

I would also like to thank my local supervisor, Mr. Ng Kah Chuan who took time off his hectic schedule to guide and help me in this project.

ZAFAS Pte. Ltd., Inter Region Pte. Ltd., Mentari Murni Pte. Ltd., Persada – Electrical and Engineering Works Pte. Ltd. and Abadi Ria Pte. Ltd., for providing the case study for my project and explaining the detail procedures and materials involved.

Geraldine P. Rozario who helped me made this project a success by introducing several key people in the government sector.

I am also very grateful to Madeline Chia who actually took time off her holiday to help me proof read my project.

Last but not least my family and friends for all their continuous support and encouragement. I am forever indebted to you all.

W.W. Leong

University of Southern Queensland

January 2005

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Aims

The aims of the project were to investigate the impact of creating trenches in urban roads for the purpose of cable or drainage system installation. The impacts to be considered were :-

i) the impact on the operation of the road and surrounding road networks during the trenching operation;

ii) the impact on the operation of the road following restoration of the trench, and particularly if failure occurred during the restoration; and

iii) the impact on maintenance operations and budgets caused by defective trench restorations.

1.2 Objectives

The objectives of this project were to :-

i) determine the best practice regarding technique for trenching and pavement restoration as well as control of trenching operations in roads;

ii) determine techniques and methods used by local city council for trenching and pavement restoration; and

iii) suggest a better method of trenching and pavement restoration;

1.3 Background of Malaysia

Malaysia is located at South East Asia and is situated to the North West of Australia. Malaysia comprised of 13 states and a Wilayah Persekutuan (where Kuala Lumpur lies). Out of the 13 states, only Sabah and Sarawak lies over at the Borneo Island whereas the other 11 states as well as Wilayah Persekutuan lie over at Peninsular Malaysia

Figure 0.1.1: Map of Malaysia

(http://travel.yahoo.com/p-travelguide-577736-map_of_malaysia-i;_ylt=AiKvfCrEXD7wvIqvP2LoAJNTFWoL)

The state which lies over the west coast of Peninsular Malaysia, mentioned from South to North, are Johore Darul Takzim, Malacca, Negeri Sembilan Darul Khusus, Selangor Darul Ehsan, Perak Darul Ridzuan, Penang, Kedah Darul Aman and Perlis Indera Kayangan. Over at the East Cost of Peninsular Malaysia, mentioned from South to North, there are Pahang Darul Makmur, Terengganu Darul Iman and Kelantan Darul Naim.

1.4 Background of Roads in Malaysia

In the year 1993, Malaysia has 60,734 kilometres of roads with 973 kilometres of it consisting of expressway and toll highway, 14,554 kilometres of it coming from other federal roads and 45,207 kilometres of it coming from state roads. (http://www.jkr.gov.my/jln/hari-jkr/Road8.htm)

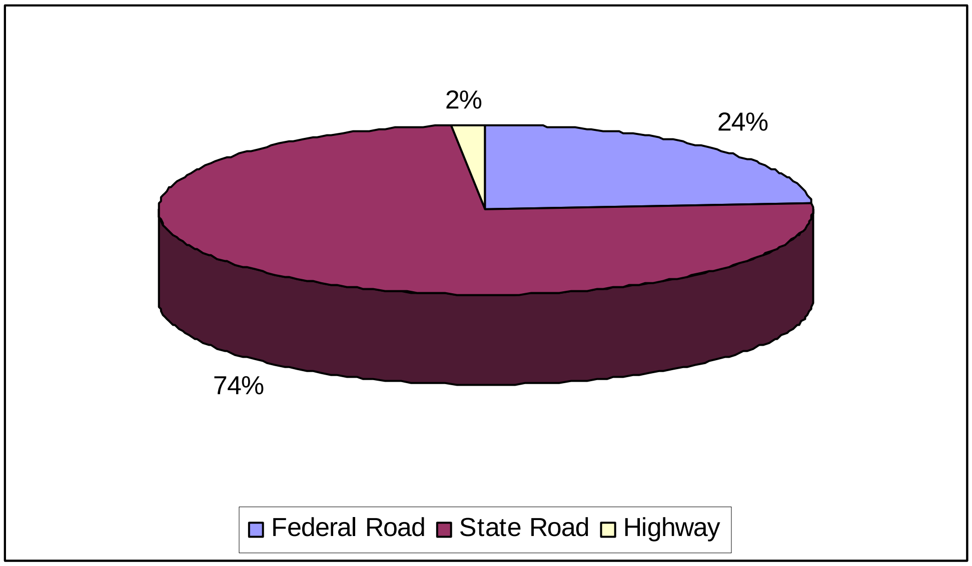


Figure 1.0.2 - Roads in Malaysia

However out of the 60,731 kilometres of roads, 45,273 of the roads are paved. 973 kilometres of the paved roads consist of expressway and toll highway, 13,590 kilometres of it coming from federal roads and 30,710 kilometres of it coming from state roads. (http://www.jkr.gov.my/jln/hari-jkr/Road8.htm)

The North-South Expressway, which connects Bukit Kayu Hitam from the North to the Johor Causeway in the South, is 850 kilometres long. Over at the east coast, there is also an East-West Expressway. (http://www.abcmalaysia.com/tour_malaysia/trnprt_road.htm) For safety reasons, the speed limit at these expressways is set to 110 km/hr.

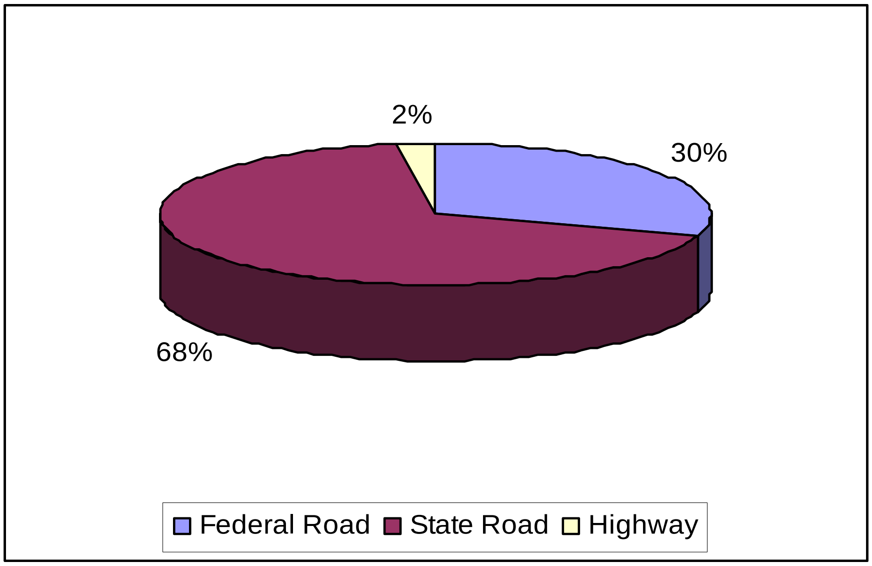


Figure 1.0.3: Paved Roads in Malaysia

Malaysian roads are divided into two main categories :-

i) Federal Roads ii) State Roads

Of the 60,734 kilometres of roads, 24% of it is Federal Roads, and the remaining 74%, State Roads.

1.4.1 Federal Roads

Federal roads consists of :

i) National Expressways and Highways under the administration of the Malaysian Highway Authority (MHA)

ii) Highways and roads under the Public Works Department, Malaysia (JKR)

iii) Regional Development Scheme Roads

iv) Federal Land Consolidation Authority (FELCRA) schemes

v) Other Regional Development Authority Scheme and minor roads leading to and within Federal Government Institutions.

Below is a bar chart showing the federal roads of every state in Malaysia. The federal road is furthered detailed into pavement federal road, gravel federal road and earth federal roads.

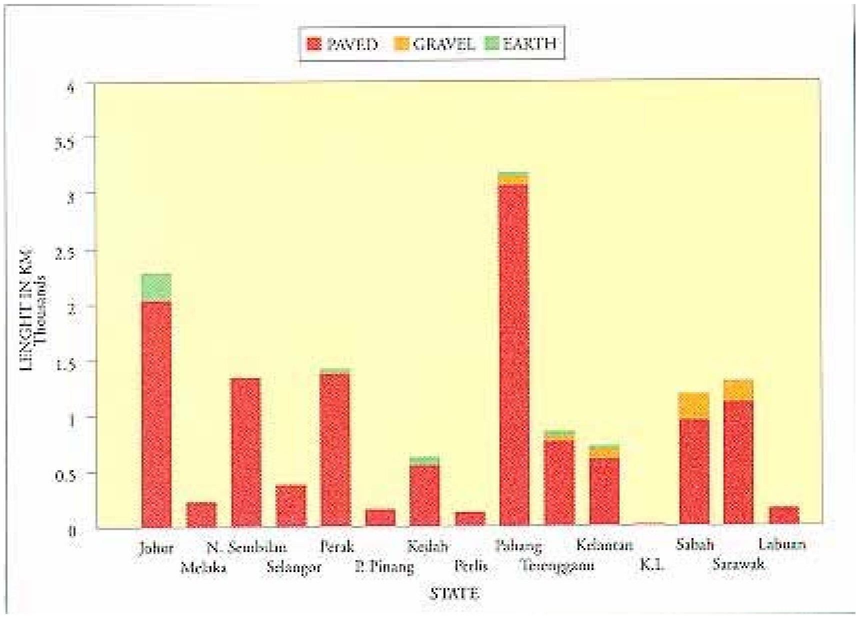


Figure 1.0.4: Federal Roads of Every State in Malaysia

(http://www.jkr.gov.my/jln/hari-jkr/rdstat.htm)

1.4.2 State Roads

State roads comprise of roads providing intra - state travel between districts, Urban Collector Roads and other Minor Roads within the villages and the rural inhabited areas. (http://www.jkr.gov.my/jln/hari-jkr/Road8.htm)

Below is another bar chart showing the state roads of every state in Malaysia. The state roads is furthered detailed into pavement state road, gravel state road and earth state roads

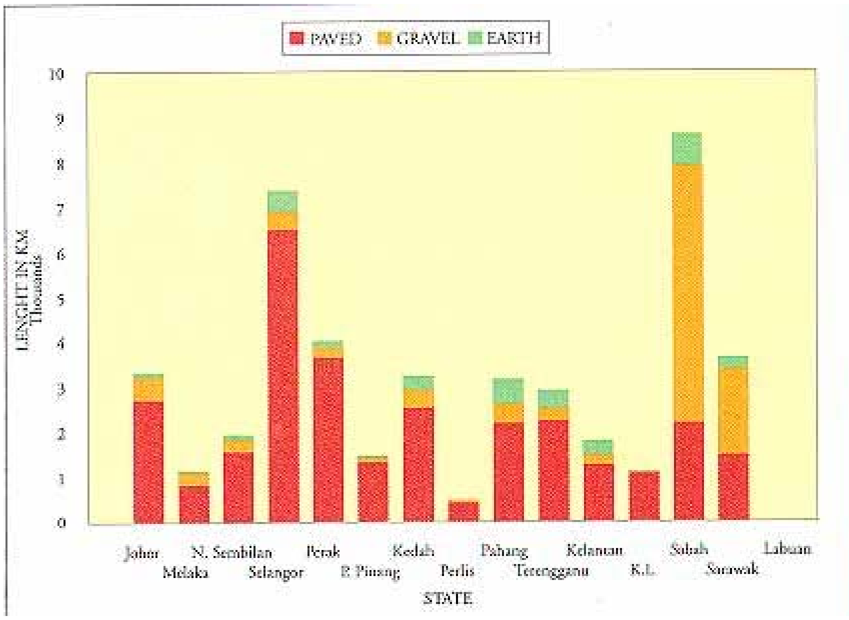


Figure 1.0.5: State Roads of Every State in Malaysia
(http://www.jkr.gov.my/jln/hari-jkr/rdstat.htm)

1.5 Roads Administration and Maintenance

Federal roads, apart from those which have been privatised, are funded by the Federal Government. These funds are allocated by the Public Works Department (JKR) for administrative and maintenance purposes. The maintenance of State Roads is the responsibility of the local State Government. However, the Federal Government would fund the State Government through annual State Road Grants.

1.6 Trenching

Trenches are usually excavated on existing road pavements for cable or drainage installation. According to dictionary.com, trench is defined as

"A deep furrow or ditch"

while trenching simply means

"To dig a trenches or a trench"

The definition of trench is better defined by Longman Dictionary of Contemporary English as

"A long narrow hole dug into the surface of the ground".

Trenching is usually done on the side or shoulder of the road to minimise the disturbance to traffic flow. However, trenching along the side of the roads is to be avoided if possible. Trenching is ideal if it can be done on footpaths along the road as this not only minimises traffic disturbance but also saves cost and time as well.

1.7 Trenching Works in Malaysia

Highways, Federal, State, City and Town Roads have their own designated road authorities. This will be explained in detailed in Chapter 5 – Standards and Code of Practice. However, as the site chosen for the case study was situated around the Klang Valley, this simply meant that the road authorities involved was the Public Works Department of Malaysia (JKR) who had the authority on State Road and had been given the authority on Federal Road by the Ministers of Works.

Although all trenching works around the Klang Valley should be submitted to the Kuala Lumpur JKR, prior notification should be provided to the local City Council of Kuala Lumpur (Dewan Bandaraya Kuala Lumpur [DBKL]). This enables the local city council to monitor and answer all enquiries from the public. According to Mr. Khor Keat Hin, a senior officer at DBKL, there was a total of 102.66 km of cables laid in the year 2003. In the year 2003, Tenaga National Berhad (TNB), who is also the sole supplier of electricity in Malaysia, laid a total of 50.785 km of cables, while Telekom, the national telecommunication company, laid 4.246 km of cables and Perbadanan Urus Air Selangor

(PUAS), the supplier of water in the Klang Valley, laid only 2 km of cables. Other telecommunication company, such as Maxis, Time Celcom and DIGI laid a total of 45.629 km of cables in that year as well.

Table 1.1 - Trenching in Kuala Lumpur for 2003

Utility Company	Length (km)
Tenaga Nasional Berhad (TNB)	50.785
Telekom	4.246
PUAS	2
Others	45.629

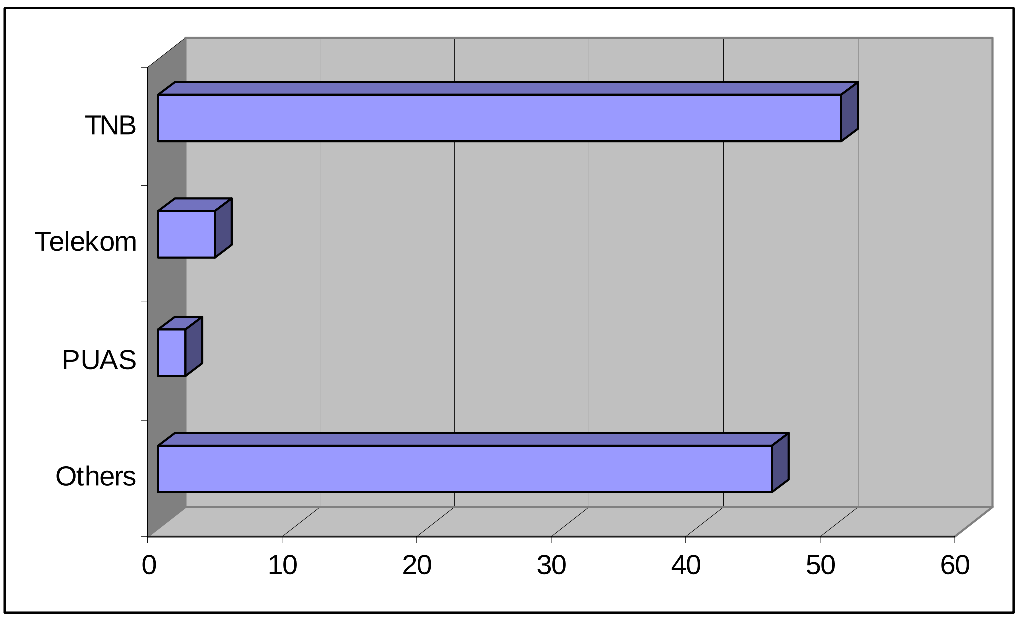


Figure 1.0.6 – Trenching Length (km) in Kuala Lumpur for 2003

2. LITERATURE REVIEW

Normally roads throughout the world deteriorate very slowly and almost imperceptibly in the first 10-15 years, and then deteriorate much more rapidly unless timely maintenance is undertaken. It is estimated that $90 billion could be saved, by spending $12 billion on earlier preventive work. (Road deterioration and Maintenance Effects, 1987)

Roads have a design period of 10 – 15 years. Therefore, the deterioration rate of roads within that time frame is expected to be slow. After 15 years, roads are expected to deteriorate much more rapidly as the design life of the roads are expected to retire. Therefore, if maintenance work was undertaken before the roads deteriorates further, the cost would be much lower compared to the roads which has deteriorated and shows visible signs of road deficiencies.

2.1 Causes of Pavement Deterioration

There are lots of causes to the deterioration in pavement. Based on “Highway Engineering” (1987) and “Traffic and Highway Engineering” (1997) a number of causes to pavement deterioration have been identified. However 10 of the main causes contributing to pavement deterioration, are :

Figure 2.1: Pavement Deterioration from Trenching Work

i) Weathering/surface water/fuel spillage

These cause embrittlement and failure of the binder, with gradual loss of fine and coarse aggregate. Frost heave may also occur when water penetrates the sub grade.

ii) Traffic loading

Traffic causes repeated flexing of the pavement leading to fatigue, crazing and structural failure, especially where the sub grade is weak and distribution of loads are uneven due to inadequate depth of construction of the carriageway.

iii) Thermal movement

Changes in temperature between night and day and seasonally causes expansion and contraction of the carriageway, especially where a macadam surface overlies a concrete foundation. This may progressively cause fatigue and failure at reflective cracks in the surface.

iv) Moisture movement

Swelling and shrinkage of sub-grades containing clays and silt may occur due to changes in moisture content. Consequently, reflective cracking and heaving may occur, the extent of which depends on the type and thickness of construction.

v) Differential movement flexure

This problem occurs at boundaries of different construction which gives rise to adverse stresses.

vi) Slippage cracking

These are characteristically crescent shaped cracks whose ends are pointing away from the direction of traffic flow. They form due to friction from braking or turning wheels, usually in areas of soft, binder-rich surface mix or where a poor bond between the surface and base course exists.

vii) Reflective joint cracking

This occurs with composite pavement construction. Thermal or moisture induced movement of a rigid slab foundation causes cracking to develop in the more flexible surfacing over joints and shrinkage cracks. Spalling, which is fragmentation of the pavement either side of the crack, may then occur due to fatigue caused by traffic loading.

viii) Pushing

This term describes the permanent longitudinal displacement of a localised area of the flexible pavement surface caused by traffic. Normally occurring in soft or binder-rich surfacing materials, it may also arise where bituminous macadam butts up to a concrete carriageway and is subjected to differential thermal movement.

ix) Potholes

These are small bowl shaped depressions, usually less than 0.9 meters in diameter, having sharp edges and vertical sides near the rim. Water collecting inside the hole causes further deterioration. Potholes usually occur as a result of traffic dislodging small pieces of surfacing in areas where the binder has become embrittled or subjected to stripping in the constant presence of water. If not combated effectively early on, the hole may expand to affect the foundations.

Figure 2.2 : Pothole

x) Rutting

Rutting is the formation of depressions or tracks in the pavement surface caused by wheel loads and high temperature, depending on the type and design of the carriageway surfacing.

The loading rate increases with the magnitude of the imposed load, thus at high temperatures heavy traffic loading is likely to cause rutting. The conditions where the pavement reaches a temperature above 45 degrees Celsius, or goes above the softening point of the binder used within the wearing course, causes rutting to accelerate.

Of the 10 causes of pavement deterioration, traffic loading and potholes are the two main causes of pavement deterioration in trenching works. When a particular road has been patched up after trenching work has been done, it is expected to settle within 6 months. During that time, due to constant traffic loading, the roads which had been patched up are usually settled to a level below the existing road level. Due to rain collecting inside the hole, stripping occurs and further deteriorates the road

2.2 Types of Maintenance

The frequency and type of maintenance depends upon the severity of the problem. Therefore there are different categories of road maintenance relating to the type of problem, each employing different strategies to resolve them.

“Highway Engineering” (1987) and “Traffic and Highway Engineering” (1997) has categorized road maintenance into three main groups:
i) cyclic maintenance ii) structural maintenance iii) winter maintenance.

The following are brief descriptions of these categories and what they are supposed to achieve:

2.2.1 Category 1: Cyclic Maintenance

This is general or routine maintenance carried out frequently to aid movement of traffic. This may involve gully emptying, grass cutting, weed killing, repair to signs and renewal of markings.

The extent and frequency of these activities depend on the budget allocated by the local authority based on its own needs.

i) Grass cutting

Rural areas

It is important to keep grass cut where it may inhibit the visibility of drivers i.e. at the corners of a junction or on the sides of cuttings in a bend in the road. This also stops encroachment of vegetation on the carriageway and encourages more roots to grow thus improving the binding of the soil on verges and slopes.

Urban areas

Usually 12 cuts a year is sufficient, which takes place mainly when growth of vegetation is at its most prolific i.e during the summer season.

ii) Gully maintenance

It is essential to keep the drainage system of carriageways operational. The frequency of emptying the gullies is dependant on local conditions such as the presence of dirty industry.

2.2.2 Category 2: Structural Maintenance

Structural maintenance is programmed when required for correcting specific faults according to an identified need.

i) Patching

This includes repairs to potholes or trench subsidence in carriageways and footways.

ii) Renewal of Traffic Signs

Signs which have been damaged by vandalism or traffic accidents, or are merely too old should be replaced.

iii) Renewal of Carriageway Markings

Carriageway markings that have been worn away by traffic must be reinstated for the safety of road users. This activity may be included as part of a Cyclic maintenance regime.

Figure 2.3: Reinstated Pavement without Road Marking

iv) Surface Dressing

Porous surfaces must be sealed against entry of water, to prevent the onset of further deterioration or to restore the skidding resistance.

v) Resurfacing of the carriageway

Resurfacing is performed to correct general deterioration of the surface, deformation, structural failure, surface irregularity, unsatisfactory camber or crossfall.

2.2.3 Category 3: Winter Maintenance

Snow and ice can pose a very serious hazard to vehicles; so it is of great importance to prevent or remove the effects they can cause the movement of traffic. Due to the unpredictability of adverse weather, it is necessary to have 24 hour availability of equipment and crews to clear snow or pre-salt the roads upon receiving weather warnings.

Three main methods of maintenance are performed:-

i) Salting

Salting should be carried out as a preventative method, but may be done in the early stages of snowfall. Salting is unviable when the snow becomes hard packed to a depth of 80 mm or more.

ii) Gritting

Gritting is carried out where snow has become hard packed and reduces the slipperiness of the roads. Single sized 6 to 10 mm material such as crushed stone, sand, grit or cinders may be used.

iii) Ploughing

Ploughing is employed to remove snow that is hard packed to a depth of 50mm. Vee-ploughs are suitable for depths of 0.5 to 2.0 meters.

The type of road maintenance which is connected to trenching lies in Category 2: Structural Maintenance. Trenching for cable installation and drainage along the road involves the excavation of existing road pavement. Patching, renewal of traffic signs, renewal of carriageway marking and surface dressing are just some of the maintenance work involved when trenching is conducted on existing road pavements.

2.3 Evaluation Pavement Performance :-

The evaluation on pavement performance is based on two main criteria, which are :

i) evaluation of pavement surface conditions based on parameters such as cracking, rutting, surface roughness and skid resistance
ii) evaluation of structural adequacy of pavement

This evaluation is done by testing portions of pavement in isolation or testing an entire road pavement in non-destructive way. The performance of a typical pavement needs to be evaluated so that timely measures can be undertaken to ensure and prolong the life expectancy of a pavement.

2.4 Quality Control

Road performance can be maintained to a satisfactory condition if there is a good quality control. Quality control of a specific road can be controlled by :-

i) cleaning of existing surface
ii) application of tack coat
iii) laying and rolling temperature
iv) compacting and rolling

(Roadwork Standard:- Tech Report, 1990)

Prior to the application of tack coat, the existing surface needs to be cleaned. This would mean a smooth even surface. Tack coat is then applied evenly to the surface. The laying and rolling of asphalt should be of appropriate temperature. Asphalt is then compacted to ensure that they are settled and smoothly connected to other roads.

Figure 2.4: Laying of Asphalt After Tack Coat is Applied

3. PROJECT METHODOLOGY

After determining the project objectives and aims, the project methodology was determined. Three main areas which were of significant importance to the project were:- :

1. Literature Review
2. Case studies
3. Comparison of Data and Conclusions

The methods employed, the information gathered and the problems faced for each of these three areas are described in the following sections.

3.1 Literature Review

The literature review was an important task for the project as it gave a general and background information regarding roads, their maintenance and other relevant information. However, before anything was gathered, the type of information and data needed were first determined. The important information needed were :

i. current methods of traffic control and road network management during trenching operations
ii. factors leading to the deterioration of roads after trenching operations
iii. current methods used by local councils and other road authorities to minimise subsequent trench failures

iv. current standards and Codes of Practice controlling trenching operations and restoration

3.1.1 Methods Employed

After determining the critical information needed, libraries and local city council around Selangor and Kuala Lumpur were visited. The places visited to gather the information were :

i) PRIME College - Library
ii) Public Works Department, Malaysia (JKR)
iii) Standard and Industrial Research Institute of Malaysia (SIRIM) – Library
iv) University Putra Malaysia (UPM) – Library
v) Kuala Lumpur International University College (KLIUC) – Library

The medium used to obtain the information needed were through :

1. books
2. magazines
3. journals
4. technical papers
5. the World Wide Web (internet)

Despite having listed the important information needed, other relevant information closely related to trenching was also gathered. For example : information regarding trenching, the road systems in Malaysia and general types of road maintenance. As told by my supervisor in University of Southern Queensland, Prof. Ron Ayers, “It is better to have more information than less.” This was because with more information, it was just a process of trimming it down but in the case of less information, one would have the trouble to gather more.

3.1.2 Problems and Difficulties

Information regarding trenching was hard to find. Therefore to find even more specific information, such as trenching on road pavement, it was more difficult. Even the internet failed to provide sufficient relevant information. Search engines such as Yahoo and Google were able to successfully locate matches when the word ‘trenching’ or ‘trenching + road pavement’ or even ‘trenching on road pavement’was typed. There were a long list of matches found with each of these search engines, however only a few had information relevant to the project. Books, magazines, journals, and technical papers were not much help either. Although some of the information proved useful for the introduction chapter, specific information regarding trenching was hard to obtain.

Standards of the local city council needed to be obtained so that the standard procedures and material expected from the local city council in a typical trenching work site would be known. The officers in charge of trenching in the local city council and the Public Works Department of Malaysia were very co-operative and more than happy to spend some time from their hectic schedule to provide information. Unfortunately much detailed information was not given as it was labeled as confidential and therefore inaccessible.

3.2 Case Studies

The case study is a major element of this project. A number of 3 –5 sites around the Klang Valley and Kuala Lumpur were chosen as the case study.

The selection of the sites were based on these criteria :

i) the trenching sites must be one which actually cuts through an existing road pavement;

ii) different contractors should be chosen for each separate case study;

iii) the sites chosen must be one with the approval of the local city council or the Public Works Department of Malaysia (JKR);

iv) prior notifications should be given to the contractors and the approval of site visits should be approved; and

v) sites visited should be of a safe nature with minimal life threatening hazard

3.2.1 Methods Employed

i) Locating the trenching site

The Public Work Department (JKR) and the local city council of various districts were visited, namely :

a. Subang Jaya
b. Petaling Jaya
c. Kajang
d. Kuala Lumpur

There was usually a department, which handled trenching works in each of the local city council and JKR offices visited. After meeting with the relevant officers in charge, enquiries were made regarding the possibilities of any ongoing or future trenching works for drainage or cable installation. The name of the contractor, the company's name and their contact numbers were usually given. The contractors were then called and the possibility of a site visit was determined. If the answer was favourable, the date and time was then arranged (usually over the night).

All trenching works were done at night except areas near a housing estate. Trenching works were done at night because traffic flow was at its' very minimal during the night. Night works for trenching were prohibited in areas near housing estate because noise caused from trenching works would disturb the residents staying nearby. The normal operating hours for a trenching work done at night was from 10.00 p.m. to 6 a.m.

ii) Safety Precaution

Before visiting the trenching site, a list of safety precautions was followed to ensure the safety of the visitor and others at the site as well. As safety is a very important issue, the precautions listed below were not taken lightly as site conditions and situations were hard to predict.

i) Steel capped boots or at least a pair of covered shoe should be worn on site
ii) Hard hats should also be worn at all times
iii) Reflective jackets or bright colored shirt should be worn as most trenching works in Malaysia was conducted at night
iv) Shirts must be neatly tucked in to avoid from being hooked
v) Listen to the instructions of the site supervisors at all times and do not wander off without their permission
vi) Photographs should only be taken with the permission of the site supervisor as the flash from the camera might distract the staff operating the machineries.

iii) Information and Data Collections

The information and data collected at the site were through 2 different mediums:

a) Interview sessions with the site supervisor
b) observations

a) Interview sessions with the site supervisor

The information, which was needed was gathered by interviewing the site supervisor. General questions regarding the trenching site were asked. Any area of uncertainty or doubts regarding the trenching site, materials and procedures were also asked during that time in order to obtain a better understanding.

Listed below were a list of general questions asked to the site supervisors :

i) What is the name of the project?
ii) Who is/are the construction authority?
iii) Who is the main contractor?
iv) Are there any sub-contractors involved? If there are, who are they?
v) When did the construction started?
vi) When is it scheduled to finish?
vii) What is the cost of the project?
viii) What is the average number of workforce in a day?
ix) What major plant item do they use on site?

A standard form similar to the questions above was created to ease the task of data collection at the site. This helped standardise the questions posed to all site supervisors and avoided the possibility of forgetting important questions. The form mentioned above can be found in the Appendix Chapter.

b) Observations

Observing a trenching site was very straight forward. Information which needed to be recorded were :

i) the materials brought to the site
ii) the step-by-step methods and procedures used by the contractors

iii) problems which arosed at the site and the solutions that were implemented

All information was recorded as detailed as possible. Any enquiries regarding the materials or procedures used were directed to the project supervisor or the project engineer (if there were one) on site.

3.2.2 Problems and Difficulties

The only problem faced in this area was locating suitable sites to be considered as a case studies. The problem did not lie with the local city council or the Public Works Department of Malaysia, as they were more than willing to provide any assistance. The few sites which were used as case studies in fact were trenching sites recommended by them.

According to Mr. Khor Keat Hin , the engineer in charge of trenching in Public Works Department of Kajang, not all trenching works were done with the knowledge of the controlling authority. Trenching works submitted to the controlling authority for approval were those, which were large scale and usually involved more than a days work. Trenching works done for cable maintenance or a trenching length of only a few meters were usually not asked for approval. Even if the controlling authority did find out about the matter, there was not much that could be done as they do not have the authority to punish them. All that could be done was for them to lodge a report with the police and wait for the local police to take the necessary action.

Therefore, a suitable trenching site was hard to locate as there were few sites where the information was sent to the controlling authority for authorization.

3.3 Comparison of Data and Conclusions

After gathering all the information from the case study of various trenching sites, the information was then compiled. The material as well as the methods and procedures of each site was then compared. By comparing each and every trenching site investigated, the best methods for each individual part was then determined.

Having determined the best possible methods and materials from various methods employed by the contractor, it was then compared with the Codes and Standards of Practice of the local city council. Both methods were not compared as a whole but separated into smaller sections and then compared. Based on the results of the comparison, the conclusions were then determined.

4. STANDARDS AND CODE OF PRACTICE

The standards and code of practice employed by the local city council is written in a book entitled '*Guidelines For Works Related To Public Utility Installation Within The Road Reserve In Malaysia*'

These guidelines have been compiled by the Road Engineering Association of Malaysia with the aid from a committee in the Maintenance Unit, Roads Branch of the Public Works Department. The aim of the guidelines is to provide uniform and standard procedures to control the excavation in roadways so that disruption in road traffic is minimised and the safety of road users are not compromised.

The problems taken into consideration are :-

i) Disruption to road traffic
ii) Safety for road users
iii) Damage to roads
iv) Damage to utility in or under the roadway

There are basically 3 different guidelines, which are :

a) Relocation of existing public utility and road works for maintenance repair of utility installations
b) Guidelines for installation of new utility service
c) Conditions and specifications of application

4.1 Guidelines For Relocation of Existing Public Utility Installations and Road Works For Maintenance Repair of Utility Installations

The guidelines are related to the work categorised as follows:-

Table 4.1: Work Categories for Utility Installations

CATEGORY I	Relocation of existing utility installation because of road widening or other construction
CATEGORY II	Excavation of road for upgrading of existing utility service
CATEGORY III	Excavation of road for carrying out maintenance work on existing utility installation
CATEGORY IV	Emergency Repair

Emergency Repair – Category IV

In case of emergency repairs such as burst water pipes or cable breakage that need to be carried out urgently, the relevant utility company may carry out the repair prior to obtaining approval from the relevant road authority. The utility company however must carry out the work in accordance with the General Conditions and Work Specifications. It must also submit an application in the prescribed form together with payment of necessary fees and guarantee to the road authority within 24 hours of the commencement of the repair work.

For each of the categories listed above (except for Category IV), 2 parties are involved,

a) Work initiator
b) Controlling authority

4.1.1 Work Initiator

Excavation and relocation works can be initiated by:-

Table 4.2: Different Types Work Initiator

Road Authority	For relocation of utility installations
Road Contractor	For relocation of utility installations
Developer	For relocation or upgrading of utility installations
Utility Company	For upgrading or maintenance of utility installations

The work initiator is responsible for :-

i. obtaining the services of a Professional Engineer to prepare engineering design, worked drawings and specifications for the proposed work
ii. endorsing the plans prepared by the Professional Engineer and submitting to the relevant controlling authority
iii. paying the prescribed fees and guarantees for the proposed work
iv. carrying out works, upon approval by the controlling authority, according to the approved plans, specifications and prescribed conditions

4.2.2 Controlling Authority

For all categories of work, there are two controlling authorities which is :-

i) Road Authority
ii) Utility Owner

The Road Authorities consist of :-

i) Minister of Works - for Federal Roads
(who delegates the authority of Public Works Department of Malaysia [JKR])
ii) Director General of Malaysian Highway Authority - for designated highway

iii) Public Works Department of Malaysia [JKR] - for State Roads

iv) Mayor - for city roads

v) Municipal Council - for town roads

The Utility Owners comprise of :-

i) Tenaga Nasional Berhad (TNB)

ii) Telekom Malaysia Berhad

iii) Jabatan Kerja Air

iv) Petronas Gas Berhad

v) Time Telecom Berhad

vi) MAXIS

vii) Etc

Each of these utility owners are empowered to manage the utility installations under the respective utility act.

The controlling authority is responsible to :-

i. scrutinize the application by the work initiator and approve/disapprove without undue delay

ii. impose prescribed fees, guarantees and conditions of approval

iii. supervise and monitor the work carried out by the work initiator and enforce conditions of approval

The inter-relationship among type of work, work initiator and controlling authority is :-

Table 4.3: Relationship between Type of Work, Work Initiator and Controlling Authority

CATEGORY	TYPE OF WORK	WORK INITIATOR	CONTROLLING AUTHORITY	
			FOR ROADS	FOR UTILITY
I (a)	Relocation of existing utility installation	Road authority	-	Utility owner
I (b)		Road contractor	Road authority	Utility owner
I (c)		Developer	Road authority	Utility owner
I (d)		Utility owner	Road authority	-
II	Upgrading or expansion of utility service	Utility owner	Road authority	-
III (a)	Routine maintenance of existing utility installation	Utility owner	Road authority	-
III (b)	Emergency repair	Utility owner	Road authority	-

Coordination

With respect to all Categories except for Category IV, the Controlling Authority will submit a brief report on the proposed work to the "State Coordination Committee for Public Utility Services (JKKN)" or the Local Authority Coordination Committee for Public Utility Services", whichever is relevant.

Financial responsibility for work

Except for Category I (c) of which work relocation of existing utility installation is initiated by a Developer, the cost of work under all Categories will be borne by the respective utility company.

Procedures

The following procedures shall apply to works under all Categories except Category III(b) :-

i) Engineering Design

1. Work Initiator shall appoint a Professional Engineer registered with the Board of Engineers, Malaysia, under the relevant engineering discipline to carry out the design of the proposed work.

2. Upon application by the design engineer on behalf of the Work Initiator, the relevant utility company will cooperate in furnishing to the design engineer’s detailed information of the existing installations and record of their locations

3. The design drawings of the proposed works shall be in an A1 sized hard copy, containing sufficient details of the utility installations, their existing location (for relocation works) and the proposed work location. Locations of the installations must be accurately surveyed and referenced to local benchmarks and features. The design engineer shall refer to the Controlling Authority concerned for the format of the engineering presentation.

4. The proposed work will generally comply with the General Conditions and Work Specifications as contained in the “Model Application Document”. The design engineer may, subjected to the approval of the Controlling Authority, modify the standard specifications or conditions as relevant to the specific work. Such modifications are to be stated in a page attached to the Model Application Document, the format of which must be followed.

5. The Application Document will be endorsed by the Work Initiator as well as the Professional Engineer who makes the design.

ii) Submission & Approval

1. The Work Initiator will make an application to the relevant Controlling Authority using *Borang 1 or Form 1* (please refer to the appendix), attaching two sets of Application Document for each of the Controlling Authorities. The application forms will be duly endorsed by the Word Initiator as Applicant, as well as by the design engineer.

2. Upon receipt of the application, the Controlling Authority shall, within reasonable time, process and reply to the applicant whether the application has been approved or requires amendment or re-submission. *Borang 2 or Form 2,* is a model form of approval. In *Borang 2,* the Controlling Authority for road will state the amount of deposit required for securing proper execution of the works.

3. A Road Work Permit will be issued by the Controlling Authority for road after receiving the payment of the deposit. *Borang 3 or Form 3,* is a model form of the Road Work Permit. No work shall commence without a Road Work Permit.

iii) Work Execution

1. For the relevant part of the design, work must be carried out by suitably qualified contractors registered with the Construction Industry Development Board, Malaysia and approved by the Controlling Authority

2. The submitting engineer for the works will supervise the execution of the works by the contractor to ensure compliance with the design, specifications and approval conditions

3. When the engineer is satisfied that all work has been satisfactorily completed, he will submit *Borang 4 or Form 4* to the Controlling Authority.

4. If the controlling authority is satisfied with the works after inspection, it will issue a Certificate of Acceptance of Works as in *Borang 5 or Form 5*, but withholding the deposit for a period of six months from the date of the Certificate.

5. Within the six-month period, the applicant will be responsible for repairing any defects occurring after the Certificate of Acceptance of Works. Upon expiry of the six-month period and on condition that all defects have been rectified, the Controlling Authority shall issue *Borang 6 or Form 6,* whereby the deposit shall be refunded.

4.2 Guidelines For Installation of New Utility Service Within Road Reserves

4.2.1 Nature of work

This part of the Guideline relates to the application by the utility owner for installing new utility services within the road reserves.

4.2.2 Work Initiator & Controlling Authority

The Work Initiator will be the utility company, which wants to install new utility services within the road reserve while the Controlling Authority shall be the respective Road Authority

4.2.3 Procedures

Basically, the procedures and conditions set out in Part 1 of these Guidelines shall apply. The Work Initiator will submit its proposal as the Applicant, following the said procedures.

In addition, the Applicant will include an agreement form in the format of *Borang 7 or Form 7* (please refer to appendix) in the Application Document.

4.3 Conditions and Specifications of Particular Application

4.3.1 General Conditions

1. No work shall commence without an official Road Work Permit.

2. All work shall be carried out in accordance with the Specifications contained herein.

3. Unless otherwise approved, all utility installations laid across the road under the pavement, shall be done by means of trenchless horizontal tunneling technique.

4. A joint site inspection by the Applicant and representative of the Controlling Authority will be carried out prior to commencement of work to ensure satisfactory arrangements at site for traffic management and public safety.

5. The Applicant shall at all times keep the site clean and tidy. Approval must be obtained from the Controlling Authority for storing material and equipment on site. Upon completion of work, the site will be cleared of all material and equipment and be reinstated to the satisfaction of the Controlling Authority.

6. The applicant will be responsible for coordinating with other utility companies who own existing installations in the vicinity of the work to protect their installations and to avoid disruption to services. The Applicant will comply with the conditions set by such utility companies.

7. Unless approved otherwise, the Applicant will observe the working hours stated in the Road Work Permit.

8. There shall be two informational signboards, each measuring at least 2 meters by 2 meters in size, made of approved material and placed at each side of the work site 48 hours prior to the commencement of work. Information on the signboard should contain brief description of work, commencement and completion dates and the name, address and telephone number of the Applicant. Location of the signboards should be approved by the Controlling Authority.

9. Where hydrants are involved, the Applicant should inform the Fire and Rescue Department in writing seven days prior to the commencement of work, and shall comply with conditions set by the Department.

10. The Applicant should observe and comply with the regulations of the local authority pertaining to cutting and removal of trees.
11. The Applicant should be responsible for obtaining permission from private land owners if the work shall encroach upon private land or access. All existing access must be kept open to traffic at all times. Temporary diversion approved by the Controlling Authority shall be provided where necessary.

12. Under no circumstances shall any public road be closed to traffic without the approval of the Controlling Authority.

13. The Applicant will be liable for damage, loss and claims from third parties for the damage to public utility installation, private or public property or personal injury or death from whatsoever that would arise out of or in consequence to the works and shall indemnify the Controlling Authority against the same.

14. The Applicant should, before commencement of work, submit to the Controlling Authority a certified true copy of the insurance policy taken in the joint names of the Applicant and the Controlling Authority.

15. The Applicant should give notice in writing to the Controlling Authority at least 48 hours in advance prior to the commencement of work. Notice should also be given upon completion of work.

16. Only the contractor or sub-contractor registered with the Construction Industry Development Board, Malaysia, under the relevant trade group, shall be allowed to carry out all or any part of the work.

17. The Applicant will be responsible for liaisons with the local Police Department for traffic control on work site and for the provision of the necessary manpower.

18. At the time of submitting this application, the Applicant will be deemed to have obtained the approval of the owner of the utility installation to carry out the proposed work, and shall indemnify the Controlling Authority against claim of damage or compensation from the owner for whatsoever cause arising out of the work.

4.3.2 Work Specifications

1. The applicant shall submit to the Controlling Authority for approval details of the system and design of the trenchless excavation across the road. All crossings shall, unless constrained by site condition, be at right angles to the centerline of the road.

2. Where approval has been granted for open excavation, road pavement at the edges of the trench must be cut in straight lines by means of a diamond cutter to a depth of at least 300 mm.

3. No excavated material shall be used for backfilling. All excavated materials must be removed from the site immediately.

4. Excavated trenches shall be provided with adequate temporary retaining walls or shuttering to protect against collapse and subsidence or cracking in adjoining pavement or property.

5. All existing drainage shall be maintained at all times. Temporary diversions, where unavoidable, may be allowed provided prior approval of the Controlling Authority has been obtained.

6. Unless otherwise approved, all underground pipes and cables shall be laid with at least 1000 mm cover measured from the surface of the road, walkway or ground.

7. Prior to the excavation of the trench for laying service installation, the Applicant shall excavate pilot pits at locations approved by the Controlling Authority in conjunction with the utility owner to ascertain the exact location of existing service installations. The number of pilot pits should be sufficient to provide confidence in avoiding damage to existing installations.

8. The length of trench that can be excavated and left open at any one time shall be limited to 100 meters. For telecommunication cables, 250 meters may be allowed.

9. Construction materials shall not be stacked on site. Only materials required for the day's work shall be brought onto site.

10. The signage for traffic control and management on site shall follow the standard "Traffic Management and Safety at Road Construction Site" attached in the appendix. Layout of temporary road diversions, traffic control and location of sign boards should be in accordance with the traffic management drawings submitted by the Applicant and approved by the Controlling Authority.

11. Backfilling material for the trench after completion of installation of utility service shall be granular material of approved grading. Original excavated material from the trench shall not be used. The backfill material shall be compacted in layers not exceeding 250 mm with appropriate compactor. The degree of compaction of each layer below the pavement course shall not be less than 95% of the dry density obtained using the British Standard heavy Compaction Test. The Controlling Authority shall have the right to demand re-compaction or removal of backfilled material if tests reveal that the compaction is below specification. The Applicant shall bear the costs of re-compaction or removal of backfilled material if tests reveal that the compaction is below specification. The Applicant shall bear the costs of re-compaction or removal of backfill material.

12. The controlling Authority reserves the right to carry out tests on the quality of the material and workmanship any time during the work. The Applicant shall facilitate the testing and bear all costs thereof.

13. Unless the reinstatement of road pavement is done immediately after backfilling, the trench shall be temporarily covered with steel plates of suitable thickness securely

spiked to facilitate temporary opening to traffic. Such steel plates shall be maintained until permanent pavement reinstatement is done.

14. The road pavement shall be reinstated to the same structure as that of the existing pavement at the least. The Applicant shall submit his proposal (drawings and specifications) to the Controlling Authority for approval. When in doubt, the Controlling Authority shall decide on the pavement structure and material specifications for reinstatement and his decision on this matter shall be final.

15. Pavement reinstatement shall be completed within 3 days after backfilling for trenches along the road, within 24 hours for cross trenches and immediately for pilot pits.

16. The reinstated pavement shall be finished flush with the surface of the adjoining existing pavement.

17. The Applicant shall be liable to carry out repairs to defects in the works at his own costs for a period of six (6) months from the date of acceptance by the Controlling Authority.

Try to put in some pictures here. It was very boring because this was like some contract and the words were very technical. Maybe putting some pictures will help explain some of the steps.

5. CASE STUDIES

In order to give a clearer picture of a site, the information gathered is separated into three different categories, which are :-

i) General Information
ii) Materials Used
iii) Methods Employed

5.1 Case Study No. 1 – 33 kV Underground Cable (Bangi)

After interviewing an engineer with the Public Works Department (JKR) of Kajang, Mr. Lu Kim Hee, on 7th May, the author was informed of an ongoing trenching work in Section 10, Bandar Baru Bangi. The project involved the installation of 33 kV underground cables for Tenaga National Berhad (TNB). This project was awarded to Pembinaan Tajri Sdn. Bhd. A site visit was then arranged with the project manager, Mr. Hairuddin.

5.1.1 General Information

The case study for this site was conducted on 8th May 2004 at 10.00 p.m. The working hour for this trenching work was from 9.00 p.m. till 6.00 a.m. All trenching work was expected to stop by 5.00 a.m. and the contractors were expected to clear up the site and removed all rubbish and unused material.

According to the contract, the project was entitled ‘Installation and Commissioning of 33kV XLPE Underground Cable for TNB Distribution Network in Selangor – Mainhead “A”’. The length of the cables was estimated to be 5000 m or 5 km long and would be from University Kebangsaan Malaysia (UKM) to Section 10 – Bandar Puteri, Bandar Baru Bangi. Pembinaan Tajri Pte. Ltd. was awarded the right to conduct the project but had also subcontracted the project to Zafas Pte. Ltd. According to Mr Peter, the project co-ordinator of ZAFAS Pte. Ltd., the project was tendered in 2002 and work was only allowed to commence early May 2004.

There were a total of 20 general workers, a project manager, project co-ordinator and project supervisor, making it a total of 23 employees working for the contractor. On the day of the site visit, one supervisor as well as one executive officer working for TNB were also present to check and monitor on the work quality of the contractor.

5.1.2 Materials Used

The materials used at this site were :-

- i) fine sand
- ii) XLPE power cable
- iii) pilot cable
- iv) double wall corrugated pipe
- v) protective slab
- vi) tack coat
- vii) asphalt

As for the plant and equipment, there were only five such as:-

i) loader with backhoe attachment

ii) diamond cuter

iii) hand compactor

iv) jumping rammer

v) highway trucks

The length of cables needed to be installed were 5000 m, whereas a drum of cable has approximately a length of 500 m. This would mean that a minimum total of 10 drums of cables would be required for each cable. As there were a total of six power cables and two pilot cables, the amount of drums required were 60 drums of power cables and 20 drums of pilot cables.

One corrugated pipe came in a length of 6 m. By dividing 5000 with 6, we get a total of 833.33. This would mean that a minimum total of 834 corrugated pipes would be required per cable. A total of 5004 – 150 mm diameter HDPE double wall corrugated pipe and 1668 number – 100 mm diameter HDPE double wall corrugated pipe was needed.

Pilot cables consist of optical fibres and copper wires. It is used to detect electronic signals. Whenever one of the three cables malfunctions, an electronic signal is sent by the pilot cable. Thus, appropriate actions can be taken to repair or replace the faulty cable. Maintenance personnel are able to repair the cables underground by getting into the joint bay which is at a distance of 500 m from one another.

There are 3 different types of XLPE cables which are differentiated by colour – blue, yellow and red. They are placed at 120º apart. The cables are placed in such a way that the yellow cables seat on top of the blue and red. The three cables are similar to any electronic plug where yellow represents earth, red represents life and blue represents neutral.

5.1.3 Methods Employed

a) General Cable Route

Before the actual trenching work was carried out, the route of the cable was determined. The excavation of trenching was carried out in accordance with the route indicated in the route drawing. Corrugated pipes to be laid were ensured to be available before the excavation started so that laying of pipe could be started as soon as the trench was completed. The work done had to be organised to ensure minimum time between the opening of the ground surfaces and final restoration.

b) Supervision of Works

The project manager was responsible for the supervision of work and had a responsibility to ensure maximum personal safety to personnel directly engaged under the contract as well as the general public. Similar to any other construction site, a site supervisor was appointed and supervision work was delegated to them. A project co-ordinator had also been appointed to ensure sufficient amount of material, plants, machinery and general workers were available at the site.

c) Breaking of Surface

A diamond cutter was used to cut the sides of the trench sharply in straight lines on asphaltic road surface. A nozzle located on the diamond cutter sprayed water onto the road. Water was sprayed to reduce dust particles as the cutter cut the asphalt road and to ensure the blade of the cutter was always cool. As the blade of the cutter started heating up, the shape of the cutter tended to change and this would reduce its efficiency. The width of the trench, cut at the shoulder of the asphalt road was 1300 mm or 1.3 m.

Excavated machine was then used to excavate asphalt road surface as well as soil underneath the pavement to the desired depth. The excavated machine used at this site was a loader with a backhoe attachment. A loader with a backhoe attachment was used instead of a backhoe because the front end bucket enables better support and thus reducing the need to manoeuvre the plant around. The depth of the trench excavated was 1.2 m deep.

d) Construction of Trenches

Corrugated pipes were ensured to be available before excavation on any section of the site begun. This ensured that the pipes were ready to be laid when the trench was completed. The change of level was necessary when there was a variation of depth in the trenches. The rise and fall of the depth was gradual.

Trenches were kept as straight as possible and the bottom of the trenches were level and smooth without stones or hard lumps. According to the drawings submitted by Pembinaan Tajri Pte. Ltd. for approval, the bottom of the trench should be filled with sand to a thickness of 100 mm to form a bed before cables are laid. However, cables were actually laid on the bottom of the trench without a layer of sand. After the pipes were laid, fine sand of approximately 300 mm depth, measured from the top of the corrugated pipe, were filled into the trench. A protective cover made out of reinforced concrete was placed atop of the sand. The protective cover functioned as a precaution as well as a notice indicating an electric cable located 300 mm beneath the cover.

Figure 5.1: Protective cover

Power and pilot cables were laid in the same trench. As specified by TNB, who was the client, the cables were all laid in corrugated pipes. For power cables, corrugated pipes of 150 mm in diameter were used where as for pilot cables, corrugated pipes of 100 mm in diameter were used.

e) Excavated Material

Excavated material was deposited neatly beside the open trench. It was placed neatly so that it caused minimum disturbance to traffic and accessibility to the property. After backfilling of trench, the surplus material was removed by using a loader with backhoe attachment to haul the material onto highway trucks. The trucks then off loaded the surplus material at a suitable place.

Figure 5.2: Excavated Material Deposited Beside Open Trench

f) Obstruction

Whenever the cables or corrugated pipes crossed with any other utility cables, the usage of mechanical excavating machines, in this case a loader with backhoe attachment was stopped within one metre on either side of these cables. Instead, hoes were used to excavate the trench to the required depth. This was one reason why the trenching site required a rather large amount of general workers.

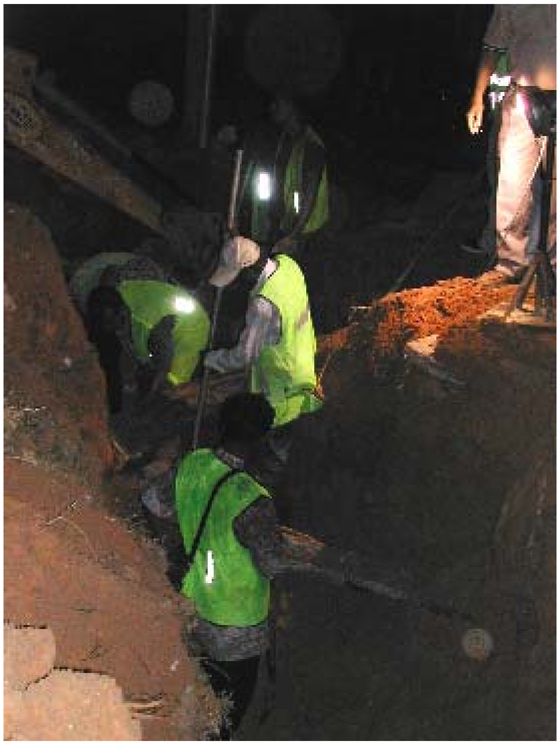


Figure 5.3: Hoes Used Whenever Cable Obstruct

g) Backfilling and Reinstatement

The backfilling of trenches and joint bays were done as soon as possible after cable laying and/or cable jointing was completed. After the corrugated pipes and protective slabs were laid, the trenches were supposed to be filled with fine sand. However, some of the trenches were filled with sand and existing excavated soil while other trenches were filled entirely with existing excavated soil. After the trenches were filled, a layer of crusher run with a thickness of 3 to 4 inches was applied before a jumping rammer was used to compact the soil as much as possible.

Tack coat was then applied evenly on top of the compacted soil. A thin layer of hot plant mix (premix) approximately 2 inches thick was then spread evenly on top of the soil with a rake.

Before the premix was compacted with the aid of a hand compactor, water was sprayed onto the premix. Although the level of the newly reinstated pavement was slightly higher than the actual pavement, the level was expected to sink gradually with time. If the level of the pavement was found to be lower than the actual pavement after 6 months, the control authority expects the contractor to mill from the inner trench all the way to the shoulder of the road or to resurface the entire road from shoulder to shoulder.

Figure 5.4: Jumping Rammer Compacting the Soil

h) Clearing of Site

All surplus material, debris, rubbish and unused materials during erection and all temporary erections including equipment were removed after work on site was completed. However, corrugated pipes and raw materials such as coarse sand and premix were still left on site.

i) Temporary Sign Boards

A suitable Danger Notice Board which served as a warning to the public that dangerous condition prevail were erected, was put up where trench excavation and installation of cables were being carried out.

A temporary signed board was placed at 100 metres away from the working site to warn road users of the work carried out in front. The signboards were maintained until the installation of cables had been completed and disturbed surfaces were reinstated

j) Temporary Warning Lights

Temporary warning lights that flashed continuously were used during the whole duration of the trenching work. Temporary signboards and cone barriers were put up along the entire length of the trench to divert traffic to a safer lane. This helped ensure the safety of all road users as well as working personnel.

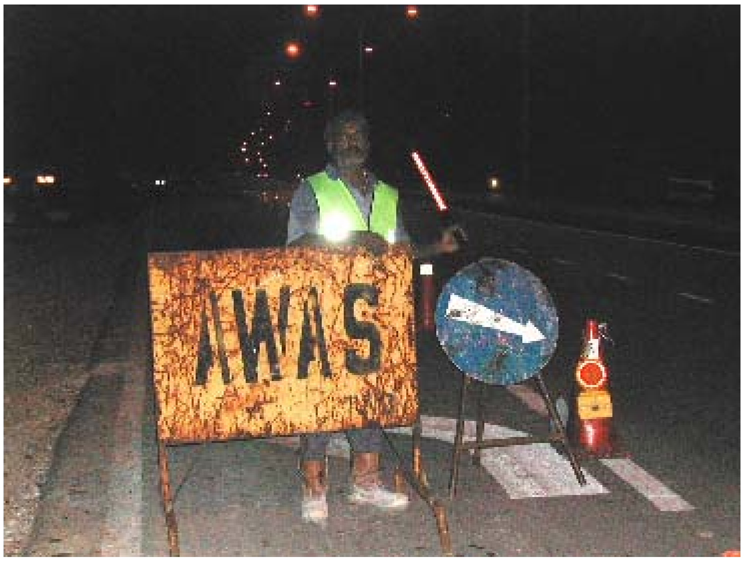


Figure 5.5: Temporary Warning Lights and Sign Boards

k) Extra Features

According to Mr. Peter, the length of trench that could be finished in a day was approximately 30 m. By dividing the entire length of 5000 m with the length of trench done in a day which was 30 m, the total time required to finish the trenching work would be 167 days, which is approximately five and a half months. To be able to finish a trenching work of 1.2 m in depth and a length of 5 km in 167 days was considered fast.

The contractors were able to finish this trenching work in such a short duration of time because at a single time, a minimum number of three trenches were excavated. Each one of the trenches excavated started from the joint bay which was at a constant distance of 500 m. By doing so, the contractor was able to save time and maximise the amount of work done in a day.

5.2 Case Study No. 2 – Underground Gas Piping (Kajang)

On 13th December 2004, an appointment was made with Mr Rahman, a professional engineer with the Kajang Municipal Council (MPKJ). The author was informed of an ongoing trenching work in Chua River, Kajang. The project involved the installation of gas pipes for Gas Malaysia and was awarded to Inter Region Pte. Ltd. A site visit was arranged with the project manager for the trenching work Mr Zali.

5.2.1 General Information

The site was visited on 13th December 2004 at 10.00 p.m. The working hours for this trenching work were from 9.00 p.m. till 6.00 a.m. As with the previous site, trenching work was expected to stop by 5.00 a.m. and the contractor was responsible for clearing and cleaning up the site.

The working hour for a particular trenching work depends on site conditions. The local city council could approve trenching works in three different timeframes.

- 8.00 a.m. – 5.00 p.m.

  The day time work permit is only issued to trenching works done in / near housing areas. This is because the noise caused by trenching work would disturb residents resting or sleeping during the night. Furthermore, most of the residents are expected to be at work or at school during the day.

- 9.00 p.m. – 6.00 a.m.

  The night time work permit is issued to trenching works done at areas which are highly populated. Such places would include industrial areas, working areas and the heart of the city. This is because the amount of traffic during the night is minimal compared to the day. Therefore trenching works would cause minimal disturbance to traffic.

- a 24 hour work permit

  A 24 hour work permit is only issued when it involves Horizontal Directional Drilling (HDD) work. Horizontal Directional Drilling or better known as HDD is a type of cable installation. HDD is a faster and quieter method compared to that of an open cut method. It also requires less workforce and minimal excavation on road pavement. A 24 hour work permit is allowed because HDD work requires only minimal space and the noise produced is very minimal.

The installation of this gas pipe was to supply gas to Muda Paper Mill. The length of the piping was estimated to be 7.2 km long and would stretch from PKNS Complex – Section 7, Bandar Baru Bangi – Cheng River – Angkat Hill – Muda Paper Mill. Inter Region Pte. Ltd. had been awarded the right to conduct the project. According to Inter Region Pte. Ltd.'s site supervisor Mr Azam, the project begun in August 2004 and was expected to be completed by March 2005. Mr. Azam even added that the total cost of the entire project was RM 3.5 million which is equivalent to A$ 1.25 million.

There were a total of 17 employers which consisted of 15 general workers, a site supervisor and a quantity surveyor working for the contractor. On the night of the site visit, a supervisor from Gas Malaysia was also present to check and monitor on the work quality of the contractor.

The installation of gas piping requires a lot of expertise. Therefore, Inter Region Pte. Ltd. hired a few subcontractors to aid them with this project. The subcontractors were :

- Nusatek Pte. Ltd. - for X-ray work
- PresCan Pte. Ltd. - for X-ray work
- Datmap Pte. Ltd. - for utility mapping
- Heaven Corrosion Pte. Ltd. - for cathodic protection
- Gan Construction Pte. Ltd. - for welding work

5.2.2 Materials Used

The materials used over at this site were :-

i) fine sand or quarry dust

ii) mild steel pipes with a diameter of 8 inches schedule (SCH) 40

iii) protective slab

iv) plastic protective cover

v) tack coat

vi) asphalt

As for the plant and equipment:-

i) loader with backhoe attachment

ii) diamond cuter

iii) hand compactor

iv) generator set

v) welding machine

vi) highway trucks

vii) horizontal directional drilling (HDD) machine

HDD was able to install 300 m of cable or piping in three hours. However HDD work was only used when the pipes were needed to cross a road. This is because the cost of using HDD machine is very high and would cost much more compared to open cut. It is a requirement of the Kuala Lumpur City Council (DBKL) that all underground cable or piping installation which requires the pipe or cable to cross any road to use the HDD method.

Utilities mapping was also used at this trenching site. Utilities mapping (radio-detector) was used to detect any other utility cables or pipes underneath the road pavement before the road was cut. Utility mapping was done along the entire 7.2 km span.

The utility mapping method uses sound wave to detect any cables or pipes being underground. Utility mapping is very important when it comes to the installation of gas piping because it uses mild steel pipe which is rigid rather than corrugated pipe which is very flexible.

X-ray test was an essential part in this project. X-ray was used to detect defects in the joint, pinhole or crack around the pipe. The leaking of gas from the pipe could result in injuries or worse, death. Therefore, this particular part was taken very seriously by the contractor. X-ray was used especially after two pipes were joined by welding. The welding around the diameter of the pipe was a full weld. Therefore, to check whether the welding managed to join both pipes perfectly and to avoid pinhole, x-ray was used.

Cathodic protection (CP) test was also another important test used. CP was used to prevent the mild steel pipes from corrosion. Magnesium was placed on top of the pipe and two wires from the magnesium would be attached to the pipe. After the trench had been filled with sand, water was sprayed on top of the soil. The chemical reaction between the water and the magnesium would prevent corrosion.

The length of one mild steel pipe was three metres long. The length of pipe needed to be installed was 7200 m. By dividing 7200 with 3, the total needed was 2400. This would mean that a minimum total of 2400 mild steel pipes would be required for this project.

5.2.3 Methods Employed

a) General Cable Route

Before the actual trenching work was carried out, the route of the cable was determined. The excavation of trenching was carried out in accordance with the route indicated in the route drawing. Mild steel pipes to be weld were ensured to be available before the excavation started so that welding of pipe could be started as soon as the trench was completed. The work done had to be organized to ensure minimum time between the opening of the ground surfaces and final restoration.

b) Supervision of Works

The project manager was responsible for the supervision of works and had a responsibility to ensure maximum personal safety to personnel directly engaged under the contract as well as general public. Similar to the previous site, a site supervisor was appointed and supervision work was delegated to them. A quantity surveyor had also been appointed to ensure sufficient amount of materials, plants, machinery and general workers were available at the site.

c) Utility Mapping

However, before the actual excavation work started, utilities mapping was done along the entire route to determine all existing underground utility cable or piping. The depth of all existing underground cables were recorded and the depth of the trench was then determined. The depth of the trench which had been approved by the local city council was within the range of 0.9 to 2 m. As there was a minimum clearance of 300mm from other utility cables, the depth of the trench was within 1.5 to 1.75 m.

c) Breaking of Surface

A diamond cutter was used to cut the sides of the trench sharply in straight lines on asphaltic road surface. Water was sprayed immediately in front of the blade to reduce dust particles as the cutter cuts the asphalt road and to ensure the blade of the cutter was always cool. Water was stored on a small tank in the diamond cutter and flowed from the tank through a thin plastic pipe. The width of the trench, cut at the shoulder of the asphalt road was 600 mm or 0.6 m.

A loader with a backhoe attachment was then used to excavate asphalt road surface as well as soil underneath the pavement to the desired depth. The loader with a backhoe attachment was used instead of a backhoe because backhoe plants are very rare in

Malaysia. More than 90% of excavated work in Malaysia is done by using loaders with a backhoe attachment. Furthermore, this plant provides better stability and requires less manoeuvrability.

Figure 5.6: Diamond Cutter Cutting The Asphalt Road

d) Construction of Trenches

Mild steel pipes were ensured to be available before excavation on any section of the site begun. This ensured that the pipes were ready to be welded when the trench was completed.

Trenches were kept as straight as possible and the bottom of the trenches were level and smooth without stones or hard lumps. A layer of sand approximately 200 mm thick was placed on the bottom of the trench. Pipes were placed on top of the bed of sand. After the pipes were laid, fine sand of approximately 300 mm depth, measured from the top of the corrugated pipe, was filled into the trench. A protective cover made out of reinforced concrete was placed atop of the sand. A yellow plastic protective cover was placed on top of the concrete slab. However, before the protective cover was even placed, the layer of sand was compacted with a hand compactor. The yellow plastic protective cover function as a precaution as well as a notice indicating gas piping located 300 mm beneath the cover.

e) Welding

The piping used was Schedule (SCH) 40 – Mild Steel Pipe with a diameter of 8 inches and a thickness of 8mm. Straight piping was welded together before being placed on the open trench. The long straight piping was lowered down to the open trench by using a loader. However, piping which required fittings such as elbow or tees were usually welded inside a joint pit.

Before the piping was welded, the two pipes were clamped together using a large clamp. The piping was fully welded which meant that the entire diameter of the piping was welded together. X-ray was then done on the joint each time a pipe was welded. This ensured that the pipe was fully welded and no cracks or pinhole which would allow gas leakage to occur. After the x-ray had been done, the piping underwent cathodic protection which prevents the pipes from corrosion

Figure 5.7: Pipes Clamped Before Welding

f) Excavated Material

Excavated material was transferred to highway trucks as soon as it was excavated by a loader. It was deposited neatly beside the open trench if no highway trucks were available. It was placed neatly so that it only caused minimum disturbance to traffic and accessibility to the property. After backfilling of the trench, the surplus material was removed by using a loader with backhoe attachment to haul the material onto highway trucks which then off loaded the surplus material at a suitable place.

g) Joint Pit

Joint pit was used whenever welding works were to be carried out inside the open trench. Usually, welding works were done inside the trench because the piping needed to be fitted with fittings of either an elbow or a tee. The size of a joint pit was almost 2 m x 2 m. The depth of the joint pit was the same as the depth of the trench, which was 1.5 to 1.75 m. The base or floor of the joint pit was also smooth and free from large rocks.

Figure 5.8: Joint Pit with Cable Obstruction

h) Obstruction

Whenever the trenching path crossed with any other utility cables, the usage of mechanical excavating machine, in this case the loader with backhoe attachment was stopped within one metre on either side of these cables. Instead hoes were used to excavate the trench to the required depth. With the aid of utilities mapping, the chance of a broken existing utility cable was greatly reduced. Utility mapping also enabled the loader operators to work more efficiently as most of the cable obstruction locations were known. Cable obstruction was a major reason trenching site requires a rather large amount of general workers.

i) Exposed Open Trench or Joint Pits

Trenches and joint pits which were left open overnight were covered using a thick mild steel plate. Mild steel plates were used because it is able to withstand and take heavy loading. This served as a safety precaution.

Figure 5.9: Covered Open Trench

j) Backfilling and Reinstatement

The backfilling of trenches and joint bays were done as soon as possible after the pipe was welded. After the pipes and protective slabs were laid on the compacted fine sand, the trenches were filled with another layer of fine sand. When the trenches were filled, a layer of crusher run with a thickness of 3 to 4 inches was applied. Then a hand compactor was used to compact the soil again, making it a total of two layers of compacted soil. Tack coat which was added with water was then applied evenly on top of the compacted soil. A thin layer of hot plant mix (premix) approximately 2 inches thick was then spread evenly on top of the soil with a hoe. Before the premix was compacted with the aid of a hand compactor, water was sprayed onto the premix. Water was sprayed because as the temperature of the premix reduced, the bond between the premix increased. The level of the premix was flushed with existing pavement. According to Mr. Azam, the level of premix was expected to sink a little, probably 1 to 2 inches. Milling would be conducted once the entire 7.2 km of piping were laid.

k) Horizontal Directional Drilling (HDD)

HDD was done whenever the piping was required to cross a road. Two pits were excavated, one at the front and the second at the back. However, the back pit had a maximum length of 300 m from the front pit. HDD requires a lot of water as it softens the grounds and thus makes drilling work much easier. HDD was first drilled horizontally underground across to the second pits. After drilling through, the piping was tied to a rod connected to the HDD machine. The HDD machine then pulled the rod back and thus the pipe was pulled as well. Rollers are placed at 12 m intervals to smoothen the long pipe entering and exiting the drilled hole. Both ends of the mild steel pipes were securely sealed to avoid water from entering the pipes.

Figure 5.10: Horizontal Direction Drilling (HDD)

j) Clearing of Site

All surplus material, debris, rubbish and unused materials during erection and all temporary erections including equipment were removed after work on site was completed by using highway trucks.

i) Temporary Sign Boards

A suitable Danger Notice Board which served as a warning to the public that dangerous condition prevail were erected, was put up where trench excavation and installation of cables were being carried out.

A temporary signed board was placed at 100 metres away from the working site to warn road users of the work carried out in front. The signboards were maintained until the installation of cables had been completed and disturbed surfaces were reinstated

j) Temporary Warning Lights

Temporary warning lights that flashed continuously were used during the whole duration of the trenching work. Temporary signboards and cone barriers were put up along the entire length of the trench to divert traffic to a safer lane. This helped ensure the safety of all road users as well as working personnel.

Figure 5.11: Temporary Sign Boards and Warning Lights

5.3 Case Study No. 3 – 11 kV Underground Cable (Cheras)

On 14th December 2004, an appointment was made with Mr Roslan, an officer with the Kuala Lumpur City Council (DBKL). The author was informed of an ongoing trenching work around the area of Rizab Road, Cheras. The project involved the installation and commissioning of 11 kV underground cables for Tenaga National Berhad (TNB) and was awarded to Mentari Murni Pte. Ltd. A site visit was arranged with the project manager for the trenching work, Mr. Rizal.

5.3.1 General Information

The site was visited on 17th January 2004 at 11.07 p.m. For the open cut, the working hours were from 9.00 p.m. till 6.00 a.m. while all trenching work were expected to stop by 5.00 a.m. and the 1 hour allocated was used to clean up the site and remove all rubbish and unused material. However for the HDD work, a 24 hour work permit was issued.

According to the contract, the project involved the installation and commissioning of 11 kV Underground Cable for TNB Distribution Network in Selangor. The installation of this 11 kV cable was to supply electricity to the newly built Brunsfield Condominiums. The length of the cables was estimated to be 1600 m or 1.6 km long and would be from Brunsfield Condominiums to PPU (Sub-Station) Miharja. Mentari Murni Pte. Ltd. who had been awarded the right to conduct this project had subcontracted the project to Gan Brothers Pte. Ltd. According to Mentari Murni Pte. Ltd.'s site supervisor, Mr Hamzah, the project begun in 10th December 2004 and was expected to be completed by 23 December 2004. He even added that the total cost for the entire project was RM 170,000 which is equivalent to A$ 61, 000.

There were actually four main work areas where the cables were to be installed and they were :

I) Cheras Road (from the junction of Cheras Road to the junction of Lombong Road

II) Across Cheras Road using HDD method (from the pedestrian bridge to the junction of Timun Road)

III) Timun Road (from the junction of Cheras Road to the front of P/E Kundur Road)

IV) Lombong Road (from the junction of Cheras Road to the front of PPU Miharja through Palong Road)

There were a total of 10 employers which consisted of 7 general workers, a project manager, a site supervisor and a foreman working for the contractor. On the night of the site visit, a cable supervisor working for TNB was also present to check and monitor on the work quality of the contractor.

5.3.2 Materials Used

The materials used over at this site were :-

i) fine sand

ii) XLPE power cable

iii) double wall corrugated pipe

iv) protective plastic cover

v) tack coat

vi) asphalt

As for the plant and equipment, there was :

i) a loader with backhoe attachment

ii) diamond cuter

iii) hand compactor

iv) compact roller

v) jumping rammer

vi) highway trucks

vii) horizontal directional drilling (HDD) machine

The length of cables needed to be installed was 1600 m whereas a drum of cable has approximately a length of 500 m. However, as there would be three cables at 1600 m, the minimum number of cable drums required was 10. A corrugated pipe came in lengths of 6 m. By dividing 1600 with 6, a total of 266.67 is obtained. This would mean that a minimum total of 267 corrugated pipes would be required for this project.

There are 3 different types of XLPE cables which are differentiated by colour – blue, yellow and red. They are placed at 120º apart. The cables are placed in such a way that the yellow cables seat on top of the blue and red. The three cables are similar to any electronic plug where yellow represents earth, red represents life and blue represents neutral. However, unlike the 33 kV cables, the three XLPE power cables were placed into one corrugated pipe instead of three.

5.3.3 Methods Employed

a) General Cable Route

Before the actual trenching work was carried out, the route of the cable was determined. The excavation of trenching was carried out in accordance with the route indicated in the route drawing. Corrugated pipes to be laid were ensured to be available before the excavation started so that laying of pipe could be started as soon as the trench was completed. The work done had to be organised to ensure minimum time between the opening of the ground surfaces and final restoration.

b) Supervision of Works

The project manager, Mr. Rizal, was responsible for the supervision of works and had a responsibility to ensure maximum personal safety to personnel directly engaged under the contract as well as the general public. Similar to any other construction site, a site supervisor, in this case Mr. Hamzah, was appointed and supervision work was delegated to him. A foreman had also been appointed to lead the other general workers and to ensure the work was done efficiently.

c) Breaking of Surface

A diamond cutter was used to cut the sides of the trench sharply in straight lines on asphaltic road surface. Water was sprayed onto the road to reduce dust particles and ensure the blade of the cutter was always cool. The width of the trench, cut at the shoulder of the asphalt road was 500 mm or 0.5 m.

A loader with a backhoe attachment was then used to excavate asphalt road surface as well as soil underneath the pavement to the desired depth. The depth of the trench was usually between the range of 1.5 to 2 feet. Whenever the depth of the trench was less than 1 foot, G.I. pipe of six inches in diameter was used and whenever the size of the trench was more than 1 foot, double wall corrugated pipes of six inches in diameter were used.

d) Construction of Trenches

Corrugated pipes were ensured to be available before excavation on any section of the site begun. This ensured that the pipes were ready to be laid when the trench was completed. The change of level was necessary when there was a variation of depth in the trenches. The rise and fall of the depth was gradual.

Trenches were kept as straight as possible and the bottom of the trenches were level and smooth without stones or hard lumps. The bottom of the trench was filled with sand to a thickness of 100 mm to form a bed before cables were laid. After the pipes were laid, fine sand of approximately 300 mm depth, measured from the top of the corrugated pipe, was filled into the trench. A protective plastic cover, orange in colour was placed atop of the sand. The protective cover functioned as a precaution as well as a notice indicating an electric cable located 300 mm beneath the cover.

An orange protective plastic cover was used to indicate cables of 11 kV (ST cable) 300m underground while green protective plastic covers indicated 1 kV (Light Voltage [LV] cable) cables underground. 11 kV cables were used for cables linking sub-stations whereas 1 kV cables were used for cables linking sub-stations to feeder pillars.

Figure 5.12: Orange Protective Plastic Cover

e) Excavated Material

Excavated material was thrown by a loader onto a highway truck. While awaiting the highway truck to arrive, excavated material was deposited neatly beside the open trench. It was placed neatly to minimise disturbance to traffic and accessibility to the property. After backfilling of the trench, the surplus material was removed by using a loader with backhoe attachment to haul the material onto highway trucks which then off loaded the surplus material at a suitable place.

f) Pilot Hole / Trial Holes

Pilot holes were used to ascertain cable routes and to confirm or locate other obstructions and existing cable services along the route. The pilot holes were 3 feet in length and 4 feet in depth. A total of three to four pilot holes were excavated along the entire cable route.

g) Obstruction

Whenever the cables or corrugated pipes crossed with any utility cables, the usage of mechanical excavating machines, in this case the loader with backhoe attachment was stopped within 1 metre on either side of these cables. Instead, general workers would use hoes to excavate the trench to the required depth.

h) Backfilling and Reinstatement

The backfilling of trenches and joint bays were done as soon as possible after cable laying and/or cable jointing was completed. After the corrugated pipes and protective slabs were laid, the trenches were filled with fine sand. After the trenches were filled, a layer of crusher run with a thickness of 3 to 4 inches were applied before a jumping rammer was used to compact the soil as much as possible. Tack coat was then applied evenly on top of the compacted soil. A thin layer of hot plant mix (premix) approximately 2 inches thick was then spread evenly on top of the soil with a rake. Before the premix was compacted with the aid of a compact roller, water was sprayed onto the premix to enhance the bond between the premix. The finished first layer of premix was ensured to finish flush with existing road pavement.

The premix was then left to cool and settle for 24 hours. The next day, a second layer of premix was applied to areas of the pavement which settled. Tack coat was applied evenly to the first layer of premix. After spreading the premix evenly, a compact roller was used to further compact the premix till it finished flush with the existing pavement. If there were signs of settlement on the premix after 15 weeks,, the entire length of the trench would have to undergo milling.

Figure 5.13: Second Layer of Asphalt, First Layer of Asphalt and Existing Road

i) Horizontal Directional Drilling (HDD)

HDD was used when the cables were required to cross Cheras Road, as required by DBKL. Two pits were excavated, one at the front and the second pit across the road. However, the second pit had a maximum length of 300 m from the front pit.

HDD requires a lot of water to soften the ground and thus making drilling work much easier. Therefore, a huge plastic container which stored water stored was available. The water was collected from rivers or drains using a pump and a filter which filtered all large unwanted particles. The HDD first drilled horizontally underground across to the second pits. After drilling through, the corrugated pipes were tied to a rod connected to the HDD machine. The HDD machine then pulled the rod back and thus the pipe was pulled as well. Rollers were placed at 12 m intervals to smoothen the long pipes entering and exiting the drilled hole. Both ends of the corrugated pipes were tightly sealed to avoid water from penetrating inside of the pipe.

j) Clearing of Site

All surplus material, debris, rubbish and unused materials during erection and all temporary erections including equipment were removed after work on site was completed.

k) Temporary Sign Boards

A suitable Danger Notice Board which served as a warning to the public that dangerous condition prevail were erected, was put up where trench excavation and installation of cables were being carried out.

A temporary signed board was placed at 100 metres away from the working site to warn road users of the work carried out in front. The signboards were maintained until the installation of cables had been completed and disturbed surfaces were reinstated

j) Temporary Warning Lights

Temporary warning lights that flashed continuously were used during the whole duration of the trenching work. Temporary signboards and cone barriers were put up along the entire length of the trench to divert traffic to a safer lane. This helped ensure the safety of all road users as well as working personnel.

m) Extra Features

The trenching works done were not separated to a few sections. According to Mr. Hamzah, the trenching works done were not separated because the work progress would be slowed and there would be a problem in diverting and controlling traffic. More sections of trenching works would results in a longer trench, thus impacting traffic flow. The additional number of trenching sections would require a larger number of general workers. Problems were more prone to happen as supervision on each and every section of trenching site was greatly reduced.

5.4 Case Study No. 4 – 33 kV Underground Cable (Serdang)

On 20th December 2004, an appointment was made with Mr Zul, an officer at the Kuala Lumpur City Council (DBKL). The author was informed of an ongoing trenching work around the area of Bandar Tasik Selatan, Serdang. The project involved the installation of 33 kV underground cables for Tenaga National Berhad (TNB) and was awarded to Persada – Electrical and Engineering Works Pte. Ltd. A site visit was arranged with the site supervisor Mr. Balan.

5.4.1 General Information

The site was visited on 24th December 2004 at 10.45 a.m. The working hours for this trenching work was from 9.00 a.m. till 6.00 p.m. while all trenching work was stopped at around 5.00 p.m. and the contractors cleared and cleaned up the site and removed all rubbish and unused material.

The project was entitled ‘Installation and Commissioning of 33kV XLPE Underground Cables for TNB Distribution Network from Lilo PPU Desa Petaling to PPU Desa Tun Razak. The lengths of the cables were estimated to be 4000 m or 4 km long. Persada – Electrical and Engineering Works Pte. Ltd. was awarded the right to conduct the project but had subcontracted the project to Low Hoe Hui Pte. Ltd. According to Low Hoe Hui Pte. Ltd.’s site supervisor Mr Balan, the trenching work was initially done by a previous subcontractor in the year 2002. However, due to some internal problems, the trenching work was only resumed on 15 December 2004 by Low Hoe Hui Pte. Ltd. Mr. Balan added that the RM 2 million project which is equivalent to A$ 714,000 was scheduled to be complete by 31st March 2005.

There were a total of 17 employers which consisted of 15 general workers, a site supervisor and a project coordinator working for the contractor. On the night of the site visit, a cable supervisor working for TNB and an officer working for Persada – Electrical and Engineering Works Pte. Ltd. were also present to check and monitor on the work quality of the contractor.

5.4.2 Materials Used

The materials used over at this site were :-

i) quarry dust
ii) XLPE power cable
iii) pilot cable
iv) double wall corrugated pipe
v) protective slab
vi) tack coat
vii) asphalt

As for the plant and equipment, there were :

i) loader with backhoe attachment
ii) diamond cuter
iii) compact roller
iv) hand compactor
v) highway trucks

The length of the trench was 4000 m whereas a drum of cable had approximately a length of 500 m. However, in the trench, there would be six power cables and two pilot cables. This would mean that a minimum total of 48 drums of power cables and 16 drums of pilot cables would be required.

A corrugated pipe comes in lengths of 6 m. By multiplying 4000 m with 6 power cables and dividing that with 6m, a total of 4000 is obtained. This would mean that a minimum total of 4000, 150 mm diameter HDPE double wall corrugated pipes would be required for this project. By using the same method, the number of 100 mm diameter HDPE double wall corrugated pipes required would be 1334.

Pilot cables consist of optical fibres and copper wires and were used to detect electronic signals. Whenever one of the three cables malfunctioned, an electronic signal was sent by the pilot cable. Thus appropriate actions would be taken to repair or replace the faulty cable.

There are 3 different types of XLPE cables which are differentiated by colour – blue, yellow and red. They are placed at 120º apart. The cables are placed in such a way that the yellow cables seat on top of the blue and red. The three cables are similar to any electronic plug where yellow represents earth, red represents life and blue represents neutral.

Figure 5.14: Position of the Cables Laid

5.4.3 Methods Employed

a) General Cable Route

Before any trenching work was to commence, the route of the cable was first determined. The excavation of trenching was carried out in accordance with the route indicated in the route drawing. Corrugated pipes to be laid were ensured to be available before the excavation started so that laying of pipe could be started as soon as the trench was completed. The work done needed to be organised to ensure minimum time between the opening of the ground surfaces and final restoration.

b) Supervision of Works

The project manager from Persada – Electrical and Engineering Works Pte. Ltd., was responsible for the supervision of works and had a responsibility to ensure maximum personal safety to personnel directly engaged under the contract as well as general public. However, a site supervisor, Mr. Balan, was appointed and supervision work was delegated to him. A project co-ordinator had also been appointed to ensure sufficient amount of material, plant, machinery and general workers were available at the site and to ensure the trenching works were running smoothly whenever the site supervisor was away.

c) Breaking of Surface

A diamond cutter was used to cut the sides of the trench sharply in straight lines on asphaltic road surface. The water tank on the diamond cutter was ensured to be full as water reduced dust particles and ensured the blade of the cutter was always cool. The width of the trench, cut at the shoulder of the asphalt road was 1300 mm or 1.3 m.

An excavated machine was then used to excavate the asphalt road surface as well as soil underneath the pavement to the desired depth. The excavated machine used at this site was a loader with a backhoe attachment. A loader with a backhoe attachment was used instead of a backhoe because the front end bucket enables better support and thus reduces the need to manoeuvre the plant around. The depth of the trench excavated was 1.2 m deep.

Figure 5.15: Diamond Cutter Cutting in Straight Line

d) Construction of Trenches

Corrugated pipes were ensured to be available before excavation on any section of the site started. The change of level was necessary when there was a variation of depth in the trenches. The rise and fall of the depth was gradual.

Trenches were kept as straight as possible and the bottom of the trenches were level and smooth without stones or hard lumps. The bottom of the trench was filled with sand to a thickness of 100 mm to form a bed before cables were laid. The bed of sand was very important as it ensured that no stones or hard lumps were beneath the corrugated pipes. The corrugated pipes might break when there is stone lying underneath the pipe as it is being compacted. The bed of sand served as a safety precaution to avoid the breakage of corrugated pipes and cables.

After the pipes were laid, fine sand of approximately 300 mm depth, measured from the top of the corrugated pipe, was filled into the trench. The fine sand used was all from the excavated trench. Whenever there was insufficient fine sand, quarry dust was used.

According to the project co-ordinator, quarry dust was used instead of fine sand because it costs cheaper than fine sand and works effectively.

Figure 5.16: Quarry Dust Used

A protective cover made out of reinforced concrete was placed atop of the sand. The protective cover functioned as a precaution as well as a notice indicating an electric cable was located 300 mm beneath the cover.

Power and pilot cables were laid in the same trench. As specified by the client, the cables were all laid in corrugated pipes. For power cables, corrugated pipes of 150 mm in diameter were used where as for pilot cable, corrugated pipes of 100 mm in diameter were used.

e) Excavated Material

Excavated material was deposited neatly beside the open trench. It was placed neatly so that it caused minimum disturbance to traffic and accessibility to the property. After backfilling of the trench, the surplus material was removed by using a loader with backhoe attachment to haul the material onto highway trucks which then off loaded the surplus material at a suitable place. Most of the excavation material except for the asphaltic road surface was reused.

f) Obstruction

Whenever the cables or corrugated pipes crossed with any other utility cables, the usage of loader was stopped within 1 metre on either side of these cables. Instead general workers used hoes to excavate the trench to the required depth.

g) Joint Bay

Joint bay was placed at every 50 metres. Joint bay is the place where cables are joined and tied together. The joint bays chosen had firm level ground and no obstructions. The length and width of the joint bay was 2 metres long. The end of the corrugated pipes entering or exiting the joint bay were wrapped with a gunnysack to avoid sand and water from entering the corrugated pipes.

Figure 5.17: Corrugated Pipes Wrapped with Gunnysack

h) Backfilling and Reinstatement

The backfilling of trenches and joint bays were done as soon as possible after corrugated pipe laying and/or jointing was completed. After the corrugated pipes and protective slabs were laid, the trenches were supposed to be filled with fine sand. However, some of the trenches were filled with existing sand. After the trenches were filled, a layer of existing crusher run with a thickness of 3 to 4 inches was applied before a compact roller was used to compact the soil as much as possible. Tack coat was then applied evenly on top of the compacted soil. A thin layer of hot plant mix (premix) approximately 2 inches thick was then spread evenly on top of the soil with a rake. Before the premix was compacted with the aid of the compact roller, water was sprayed onto the premix.

As soon as the premix arrived, it was spread onto the compacted soil. The premix needed to be very hot when premix was spread onto the compacted soil. This was to avoid premix from becoming a large chunk. However after the premix was spread evenly, water was sprayed onto the premix to cool it off. When premix cools, it enhances the bond between the premix, thus making it harder and stronger.

Figure 5.18: Water Sprayed to Cool Asphalt

If the pavement settles after 12 weeks, the controlling authority expects the contractor to reinstate the road pavement by undergoing milling method.

i) Installation of Cable

Roding was inserted into the corrugated pipe from the first joint bay all the way to the other end, which would be the second joint bay. Pulling wire rope was then tied to the roding and a WINS machine then pulled the roding along with the pulling wire rope. As the wire rope reached the first joint bay, power cables or pilot cables were then tied to the wire rope. The wire rope and the cables were then pulled by another WINS machine to the second joint bay. The above method was repeated until the cables reached the desired locations.

Figure 5.19: Installation of Cable

j) Clearing of Site

All surplus material, debris, rubbish and unused materials during erection and all temporary erections including equipment were removed after work on site is completed. However, corrugated pipes and protective slabs were still left on site.

k) Temporary Sign Boards

A suitable Danger Notice Board which served as a warning to the public that dangerous condition prevail were erected, was put up where trench excavation and installation of cables were being carried out.

A temporary signed board was placed at 100 metres away from the working site to warn road users of the work carried out in front. The signboards were maintained until the installation of cables had been completed and disturbed surfaces were reinstated

Figure 5.20: Temporary Sign Boards

j) Temporary Warning Lights

Temporary warning lights that flashed continuously were used during the whole duration of the trenching work. Temporary signboards and cone barriers were put up along the entire length of the trench to divert traffic to a safer lane. This helped ensure the safety of all road users as well as working personnel.

m) Extra Features

According to Mr. Balan, the trenching work done was separated into:

1. The installation of cables
2. Road cutting, installation of corrugated pipes and reinstatement of premix

The length of trenching done in a day was approximately 90 m. However, the length of cables installed in a day was 2500 m or to be more specific, 5 cables with a length of 500 m. This simply means that to install eight cables of 500 m, 6 of those being power cables and the other 2 being pilot cables, it required a durations of 2 days work. By dividing 500 m with 90 m per day, we get a total of 6 days work. This simply means that a period of 6 days work of road cutting, installation of corrugated pipes and reinstatement of premix would have to be done before a 2 days work of cable installation can proceed.

5.5 Case Study No. 5 – 33 kV Underground Cable (Ampang)

On 14th December 2004, an appointment was made with Mr Nifiri, an officer at the Kuala Lumpur City Council (DBKL). The author was informed of an ongoing trenching work at Ampang. The project involved the relocation of existing 33 kV underground cables for Tenaga National Berhad (TNB) and was awarded to Abadi Ria Pte. Ltd. A site visit was arranged with Mr. Brian Teo of Abadi Ria Pte. Ltd.

5.5.1 General Information

The site was visited on 17th December 2004 at 10.28 a.m. The working hour for this trenching work was from 9.00 a.m. till 6.00 p.m. The project was entitled ‘Relocation of Existing TNB 33 kV Cable (XLPE 2 nos.) and Oil Filled Cable (2 nos. of circuit) at Stormwater Management and Road Tunnel at Smart Project (Package B1-1-8) Near Ampang FOE MCEG – Gamuda JV’.

The length of the cables was estimated to be 500 m or 0.5 km long and would be from PMU Pandan Mewah to four separate location:

1) SSU Texas Instrument
2) PPU Ampang Point
3) PPU Ampang Specialist
4) PPU Pandan Indah

Abadi Ria Pte. Ltd. who had been awarded the right to conduct the project had subcontracted the project to TK Construction and Engineering Pte. Ltd. According to Mr Brian Teo, the trenching work which cost a total of RM 1.5 million which is equivalent to A$ 536, 000. The project started on 10th October 2004 and was scheduled to be completed by 31st January 2005.

Mr Brian added that the actual trenching work would only require a month to be completed. The reason it took more than three months to be completed was because Abadi Ria Pte. Ltd. had to wait for TNB to shutdown the existing cables. The personnel in TNB had to shut down a cable and transfer the electricity supply to another cable, thus overloading the cable. Overloading cables are not good as it reduces the lifespan of the cable. Therefore as soon as the cable was overloaded, the power cable was joint, tested, and commissioned of reciting cables.

The reciting of existing TNB 33 kV cable included XLPE cable (2 circuits) and oil-filled cable (2 circuits) where it crossed the proposed SMART project. The reciting work took placed from the existing TNB joint bay No. 1 (JB1) to joint bay No. 3 (JB3). The work was generally divided into two main sections :-

5) Horizontal Directional Drilling (HDD) crossing under the SMART driveway
6) Reciting 33 kV circuit using XLPE cables within the SMART right of way.

There were a total of 21 employers which consisted of 16 general workers, a project manager and 4 site supervisors working for the contractor. On the night of the site visit, a cable supervisor working for TNB was also present to check and monitor on the work quality of the contractor.

5.5.2 Materials Used

The materials used over at this site were :-

i) fine sand
ii) XLPE power cable
iii) pilot cable
iv) double wall corrugated pipe
v) protective slab
vi) tack coat

vii) asphalt

As for the plant and equipment, there were :

i) loader with backhoe attachment
ii) diamond cuter
iii) compact roller
iv) hand compactor
v) highway trucks
vi) HDD machine

The length of the trench was 500 m whereas a drum of cable has approximately a length of 500 m. However, there were six power cables and two pilot cables in the trench. This would mean that a minimum total of 6 drums of power cables and 2 drums of pilot cables would be required.

A corrugated pipe comes in lengths of 6 m. By multiplying 500 m with 6 power cables and dividing that with 6m, a total of 500 is obtained. This would mean that a minimum total of 500 – 150 mm diameter HDPE double wall corrugated pipes would be required for this project. By using the same method, the number of 100 mm diameter HDPE double wall corrugated pipe required would be 167.

Pilot cables consist of optical fibres and copper wires which are used to detect electronic signals whenever one of the three power cables is faulty.

There are 3 different types of XLPE cables which are differentiated by colour – blue, yellow and red. The cables are placed in such a way that the yellow cables seat on top of the blue and red. The yellow cable represents earth, red represents life and blue represents neutral.

5.5.3 Methods Employed

a) General Cable Route

The reciting of the 33 kV cable route was determined at site by a joint site survey between the main contractor and subcontractor. The site survey determined the overall route location and estimated the required cable length that start from JB1 to JB3. All obstruction such as existing services were highlighted to avoid and prevent any unnecessary damages and to obtain consent of the appropriate authorities.

Corrugated pipes to be laid were ensured to be available before the excavation started so that laying of pipe could be started as soon as the trench was completed. The work done needed to be organised to ensure minimum time between the opening of the ground surfaces and final restoration.

b) Supervision of Works

The project manager, Mr Brian Teo, was responsible for the supervision of works and had a responsibility to ensure maximum personal safety to personnel directly engaged under the contract as well as general public. However, four site supervisors were appointed and supervision work was delegated to them.

c) Breaking of Surface

The excavation of any section was commenced once the cables to be laid were available at site and was made ready for laying as soon as the excavation of the trench and piping completed. A diamond cutter was used to cut the sides of the trench sharply in straight lines on asphaltic road surface. Water sprayed onto the road pavement reduced dust particles and ensured the blade of the cutter was always cool. The width of the trench, cut at the shoulder of the asphalt road was 1300 mm or 1.3 m.

A loader with a backhoe attachment was then used to excavate asphalt road surface as well as soil underneath the pavement to the desired depth. The loader was used because the front end bucket enabled better support and thus reduces the need to manoeuvre the plant around. The depth of the trench excavated was 1.5 m deep.

d) Construction of Trenches

Trenches were kept as straight as possible and the bottom of the trenches were level and smooth without stones or hard lumps. Sand bedding of 50 mm thickness was filled at the bottom of the trench. The bed of sand served as a safety precaution to avoid breakage to corrugated pipes and cables when the layer of fine sand on top of it is being compacted.

After the pipes were laid, fine sand of approximately 150 mm depth, measured from the top of the corrugated pipe, was filled into the trench. A protective cover made out of reinforced concrete slab was placed on top of the sand. The protective cover functioned as a precaution as well as a notice to indicate an electric cable located 150 mm beneath the slab.

Figure 5.21: Laying of Protective Slabs

Power and pilot cables were laid in the same trench. As specified by the client, the cables were all laid in corrugated pipes. For power cables, corrugated pipes of 150 mm in diameter were used where as for pilot cable, corrugated pipes of 100 mm in diameter were used.

e) Excavated Material

Excavated material was deposited neatly beside the open trench. It was placed neatly so that it caused minimum disturbance to traffic and accessibility to the property. After backfilling of the trench, the surplus material was removed by using a loader with backhoe attachment to haul the material onto highway trucks which then off loaded the surplus material at a suitable place. Most of the excavated material except for the asphaltic road surface was reused.

f) Obstruction

Whenever the cables or corrugated pipes crossed with any other utility cables, the usage of loader was stopped within 1 metre on either side of these cables. Instead general workers used hoes to excavate the trench to the required depth. The trenching work was slowed tremendously whenever cable obstruction occurred.

Figure 5.22: Obstructing Cable Damaged During Excavation

g) Trial Hole

Trial hole was made at JB1 and JB3 to locate the existing TNB 33 kV cable and to confirm and locate the existing oil tank position for the oil-filled cable. The trial hole was excavated and backfilled with the excavated material on the same day prior to general excavation work at a particular location.

Figure 5.23: Joint Bay 1

h) Backfilling and Reinstatement

The backfilling of trenches were done as soon as possible after corrugated pipe laying and/or jointing was completed. After the corrugated pipes and protective slabs were laid, the trenches were backfilled with excavated material before a compact roller was used to compact the soil as much as possible. Tack coat was then applied evenly on top of the compacted soil. A thin layer of hot plant mix (premix) approximately 4 inches thick was then spread evenly on top of the soil with a rake. Before the premix was compacted with the aid of the compact roller, water was sprayed onto the premix.

As soon as the premix arrived, it was spread onto the compacted soil. The premix needs to be very hot when premix is spread onto the compacted soil. This is to avoid the premix from becoming a large chunk. According to Mr. Brian, the secret to laying a good pavement is to ensure that the weather is hot and the premix which arrived hot is laid immediately. He then added that the reason most of the reinstated pavement following trenching work had potholes were because the premix had cool when it was laid.

If the pavement settled after 12 weeks, the controlling authority expects the contractor to reinstate the road pavement by undergoing milling method.

i) Horizontal Directional Drilling (HDD)

The cable route was ascertained to run below the portion of the SMART driveway. The HDD work was to start from the first site survey as to ascertain the acquired profile of HDPE pipe laid under the SMART driveway.

This included the extensive investigation using radio detection of the HDD crossing, pin-pointing the entry and exit pit of drilling point after considering the position of utilities, accessibility and geographical of sites

I) Planning and designing of the bore

The drill profile was designed with a minimum depth of 2 m below the road to prevent any subsurface settlement. Additional details of underground utilities were marked clearly on the plan and reviewed at site. The final adjustment was made at site when necessary.

II) Preparation of drilling fluids

Highly viscous (HI – VIS) drilling fluids were used to ensure hole stability and reduce fluid loss. Drilling fluid at adequate Funnel Viscosity gave a good performance for hole stabilisation and to suspend and transport the spoils out from the tunnel. The drilling fluid was consistently monitored and maintained at designed Funnel Viscosity using Marsh Funnel Equipment.

Additive such as polymer were required to enhance the characteristics of bentonite by building up a filter cake on the hole wall as well as enhanced lubrication and cooling in the hole. pH strips were used to test the pH level water and if the strips showed a value below the required pH, soda ash was added into water to neutralise acid in the water. Properties of the bentonite were measured during each bentonite mixing to ensure the consumption of bentonite at the required properties.

Throughout the forward run phase, the location and direction of the drill was monitored at every 3.0 m interval. Whenever the drill head strayed off course, the locator technician informed the drilling operator via two-way radios. The operator then made the required adjustment until the drill head got back to its original course.

When the drill head reached the exit pit, it was removed and a 10 inch diameter fluid jet reamer was attached and the back reaming operation was reversed from the exit pit towards the entry pit. A swivel was installed at the back of the reamer to allow the drill rods (which will then be connected at the back of reamer during back reaming) to remain at a condition of free rotated while the rig machine rotates the drill string at the front of the reamer.

During back reaming activity, drill rods were extracted from the entry point. In order to remain a string inside the tunnel while hole enlargement, drill rods were jointed up at exit pit until reamer reached the entry pit.

The required size of the tunnel was 30% greater than the product pipe diameter to reduce the friction which is exerted on the product pipes during pull back activity and prevent any subsurface settlement.

III) Drilling operation

- Site preparation

A small pit (1.5 m length x 1.0 m width x 1.0 m depth) was dug at the entry and exit point to cater for the cut material and bentonite fluid. These pits served to verify that the vicinity was hazard free from utilities.

- Setting up and calibration of HDD tracking equipment

The transmitter was inside the drill head housing and jointed to the first length of the 3.0 m and $2^{3}/_{8}$ inch diameter rod, which was already installed onto the rig machine.

- Pilot drill

The first length of the drill rod guided by the drill head was rotated and jacked into the ground without any bending. When the end of the first drill rod reached the jaw of the machine, the first rod was considered drilled into the ground and the second rod was then joined at its end. Bending started during the second rod drilling.

Figure 5.24: Drill Head of the HDD

- Stringing of HDPE pipes - 8 inch HDPE pipe for 33 kV cable
  4 inch HDPE pipe for pilot cable

When the 10 inch back reaming was completed, the product pipes were attached to the 20 tonnes swivel and guided with a 10 inch barrel reamer to be pulled into the enlarge tunnel. The 10 inch barrel reamer used during pipe installation was to ensure that the hole was properly enlarged and conditioned in order to reduce the friction and pulling pressure. Suitable pulley eye was used and joint at the end of the 160 mm diameter HDPE pipe. With proper D-shackles, the pulley was connected to the 20 tonnes swivel. Reamer was installed at the front of the swivel.

- Site cleaning

Upon completion of all installation works, the drilling equipment was properly packed and ready for mobilization.

j) Installation of Cable

The cable pulling through all installed corrugated pipes were commenced after all trenching, piping and HDD works were completed. All checks point were opened. Pulling wire rope was inserted through pipes from JB1 to JB3. Cable gride or supporting roller was placed at appropriate places. New cable drums were prepared on cable jack. Pulling eye was prepared on new cable. Cables were pulled using cable puller via wire rope.

The above procedures were repeated until all cables were pulled from JB1 to JB3. After all cables were laid, testing of cables was conducted as required and witnessed by TNB.

Figure 5.25: Cable Joining

k) Clearing of Site

All surplus material, debris, rubbish and unused materials during erection and all temporary erections including equipment were removed after work on site is completed. However, corrugated pipes and protective slabs were still left on site.

l) Temporary Sign Boards

A suitable Danger Notice Board which served as a warning to the public that dangerous condition prevail were erected, was put up where trench excavation and installation of cables were being carried out.

A temporary signed board was placed at 100 metres away from the working site to warn road users of the work carried out in front. The signboards were maintained until the installation of cables had been completed and disturbed surfaces were reinstated

j) Temporary Warning Lights

Temporary warning lights that flashed continuously were used during the whole duration of the trenching work. Temporary signboards and cone barriers were put up along the entire length of the trench to divert traffic to a safer lane. This helped ensure the safety of all road users as well as working personnel.

n) Shutdown of Existing Cable

Upon completion of reciting cable installation, a request for shut-down was forwarded to TNB. This approval required the utility of existing TNB 33 kV cable for the jointing, testing and commissioning of reciting cables.

6. DISCUSSIONS

After gathering all the information needed from the various case studies around the Klang Valley, the methods and procedure of each case study was then compared. The comparisons of data were done through two different methods :

i) Data comparison between the various sites in Klang Valley
ii) Data comparison between the best possible methods employed and the Standards and Codes of Practice of the local city council.

Listed below are the case studies that were investigated :

i) Case Study 1 – 33 kV Underground Cable for TNB (Bangi)
ii) Case Study 2 – Underground Gas Piping for Gas Malaysia (Kajang)
iii) Case Study 3 – 11 kV Underground Cable for TNB (Cheras)
iv) Case Study 4 – 33 kV Underground Cable for TNB (Serdang)
v) Case Study 5 – 33 kV Underground Cable for TNB (Ampang)

6.1 Comparisons of Data between Various Sites in the Klang Valley

a) Working Hours

Case studies 1, 2, and 3 were all conducted during the night whereas case studies 4 and 5 were conducted during the day.

Trenching works with the exception of the HDD method caused serious noise pollution. Noise caused from loaders as it hauled and excavated the road, diamond cutter as it cut the road, jumping rammer as it rammed and compacted the soil and hand compactor as it compacted onto the premix were just some of the activities that contributed to noise pollution in a trenching site. Therefore, trenching work done in or near housing areas such as case studies 4 and 5 were only allowed to work during the day as the noise caused from trenching works would disturb residents nearby trying to rest or sleep.

Furthermore, trenching work done in the day had an advantage over those that were done during the night because the weather during the day was warmer. This made the laying of the premix more effective. When the premix was hot, the asphalt was loose. This enabled it to be spread easily. When the premix became cold, the bitumen hardened thus, causing the asphalt to bond. As it cooled, the premix became hard and made the spreading work difficult. This was the reason premix should be hot when it arrived and as it is being spread. As it is being compacted, premix should be added with water to cool off.

Trenching works done in industrial areas, working areas and in the heart of the city were all done during the night because traffic flow was high during the day. Trenching works conducted during the day not only caused noise problem to working people but adds to stress, anxiety and disrupt traffic flow.

In the Klang Valley, traffic congestion is a very common thing. If trenching works were allowed during the day, this will definitely worsen the whole scenario as traffic lanes near the trenching works would have to be closed. Traffic flow is known to be at its minimal during the night or the early morning. The advantage of conducting a night trenching work is that traffic management and traffic diversion would be less critical.

Case study 1 was near an industrial area while case study 2 at a working area and case study 3 in the city.

b) General Cables Route

All of the case studies adopted the same procedure. Before the trenching work was carried out, the route of the cables were first determined. Piping was ensured to be available before trenching started so that laying of pipes started as soon as the trench was completed.

c) Supervision of Works

Although all five sites had a project manager, the project manager usually delegated the supervision work to the site supervisor. With the exception of case study 5 which had 4 site supervisors, the other four case studies had only one site supervisor each. With more site supervisors, the supervision job would be more efficient. Certain sites adopted to delegates supervisors job to quantity surveyor or project co-ordinator.

Basically, one site supervisor is sufficient for a trenching site if the general workers are experienced and trustworthy. However, if sectioning of trenches were done, to have an extra hand is always a smart choice.

d) Breaking of Surface

There was no difference among all 5 sites in their method of breaking the asphalt road pavement. The usual method conducted was with the diamond cutter. it was used to cut 2 sides on the asphaltic road surface. Water was sprayed onto the road through a nozzle which was linked to the water tank on the diamond cutter. Loader with a backhoe attachment then excavated the cut asphalt road surface as well as soil underneath the pavement to the desired depth.

However, Mr. Brian Teo from Abadi Ria did raised a very good question when he questioned on the methods employed when the existing asphalt road pavement was more than 700 mm thick. He added that a diamond cutter was only able to cut up to 600 mm of an asphalt road pavement. In this case, the diamond cutter would cut the road pavement to 600 mm deep and loader would just have to excavate all 300 mm thick of asphalt road pavement. The loader operator would have to be careful to minimise the damage to the asphalt road pavement on the side of the trench.

e) Construction of Trenches

The construction of trenches done in all 5 sites was different from each other.

Site 1 - laid the pipes on the trench without a layer of sand
- fine sand 300 mm thick measured from the top of the pipes were filled onto the trench

Site 2 - pipes were laid on a bed of sand 200 mm thick
- fine sand 300 mm thick measured from the top of the pipes were filled into the trench and compacted with a hand compactor

Site 3 - pipes were laid on a bed of sand 100 mm thick
- fine sand 300 mm thick measured from the top of the pipes were filled into the trench

Site 4 - pipes were laid on a bed of excavated sand 100 mm thick
- excavated sand 300 mm thick measured from the top of the pipes were filled into the trench

Site 5 - pipes were laid on a bed of sand 50 mm thick
- fine sand 150 mm thick measured from the top of the pipes were filled into the trench

Pipes must be laid on a bed of sand to avoid the possibility of the pipes or cables breaking as a result of compaction. The bed of sand cushioned the impact of the compaction and ensured no rocks or hard lumps laid below the piping. Clean fine sand was used instead of the excavated sand because the content of the excavated sand was unknown. There might be rocks, small pebbles or crusher run inside the lump of excavated sand as the crusher run might have mix inside the sand as it was excavated out of the trench by loaders. The minimum depth of 100 mm was required as the bed of sand because sand less than 100 mm thickness might not be able to cushion the compaction.

Fine compacted sand of 300 mm thickness measured from the top of the pipes was the minimum depth of the sand that had to be filled and compacted by hand compactor before protective slabs was placed on top of it. This was because the protective slab served as a warning as well as a safety precaution indicating cables or piping underneath the slab. Bucket from loaders were capable of piercing through the protective slab and sand underneath the slab. A thickness of 150 mm was too shallow as the bucket would pierce right through the slab, sand and damage the cables underneath. By compacting the sand, the void ratio in the sand would be greatly reduced thus, the impact of the bucket might reduce as it pierced through the sand. The compacted sand would also reduce settlement on the premix after reinstatement.

Therefore a proper construction of trenches should have a bed of fine sand 100 mm thick. After the piping was joined, fine sand should be filled to a depth of 300 mm measured from the top of the piping. It should then be compacted with the aid of a hand compactor before protective slabs should be placed on top of it.

f) Excavation Material

All excavation material besides site 2 and 3 were deposited neatly beside the open trench. The excavation material was used for backfilling. All surplus excavation material after backfilling was removed by hauling into a highway trucks.

Site 2 and 3 deposited all excavated material into a highway trucks. Excavated material would only be deposited neatly beside the open trench while awaiting the arrival of the highway truck.

All excavated material should be removed as it is prohibited to be reused for backfilling. Excavated material should be removed as the mixture of existing sand and crusher run would cause voids in between thus, causing improper compaction. Therefore, to ensure a proper compaction, clean fine sand and crusher run should be used separately whereas all excavation material should not be reused to avoid impurities.

g) Obstruction

Each of the case studies adopted the same procedure when cable obstruction occurred. The usage of loader was stopped while the usage of general workers with hoe was used to excavate the trench to the desired depth.

Case 2 adopted utility mapping to overcome cable obstruction problem. This was because unlike the other cases where a flexible corrugated pipe was used, case 2 used a mild steel pipe which was hard and rigid. Corrugated pipe is flexible thus enabling the pipe to bend below existing utility cables by 300 mm.

According to Mr. Brian Teo, the corridor of a utility mapping was usually 4 m wide along the entire length of the trench. However when utility mapping was to be done in Putrajaya, the minimum corridor width of the utility mapping was 20 m along the entire length of the trench.

Utility mapping is not necessary to overcome cable obstruction problem. However, whenever rigid hard pipe was involved (e.g. steel pipes) the use of utility mapping became necessary to overcome cable obstruction. The reason utility mapping was not necessary with flexible pipe was because the cost of utility mapping was very high. Damage to cables can be avoided as long as loader operators are more careful and observant.

h) Backfilling and Reinstatement

The methods employed by all 5 sites were basically the same. However the materials used differed.

Site 1 - trench was backfilled with existing soil after protective slabs were laid
- 3 to 4 inches thick of crusher run were laid and compacted with a jumping rammer
- tack coat was applied evenly onto the compacted soil before 2 inches of premix were spread, sprayed with water and compacted with a hand compactor.

Site 2 - trench was filled with fine sand after protective slabs were laid
- 3 to 4 inches thick of crusher run were laid and compacted with a hand compactor
- tack coat was applied evenly onto the compacted soil before 2 inches of premix were spread, sprayed with water and compacted with a hand compactor

Site 3 - trench was trench was filled with fine sand after protective slabs were laid
- 3 to 4 inches thick of crusher run were laid and compacted with a jumping rammer
- tack coat was applied evenly onto the compacted soil before 2 inches of premix were spread, sprayed with water and compacted with a compact roller
- a second layer of premix was laid the following day at areas where premix settled. Again tack coat was applied before premix were spread, sprayed and compacted with a compact roller

Site 4 - trench was backfilled with existing sand after protective slabs were laid
- 3 to 4 inches thick of existing crusher run were laid and compacted with a compact roller

- tack coat was applied evenly onto the compacted soil before 2 inches of premix were spread, sprayed with water and compacted with a compact roller

Site 5 - trench was backfilled with existing soil and compacted with a compact roller
- tack coat was applied evenly onto the compacted soil before 2 inches of premix were spread, sprayed with water and compacted with a compact roller

A proper backfilling and reinstatement should be one where the trench is backfilled with sand and 3 to 4 inches thick of crusher run is compacted with a jumping rammer or a compact roller. Tack coat is then applied evenly on top of the compacted soil before 2 inches of hot premix is spread, sprayed with water and compacted with a compact roller. After 12 weeks, if the asphalt road pavement settled, milling would have to be done along the entire length of the trench.

As mentioned earlier excavated material should not be reused because the impurities of the material contribute to air voids. The presence of stones or crusher runs in fine sand could contribute to air void after compaction. The high percentage of air voids causes compaction to be improper.

Crusher run was placed at a thickness of 3 to 4 inches beneath the premix to serve as a foundation for the asphalt while tack coat is placed to serve as a bonding agent between the compacted soil and the premix. Hot premix of 2 inches thick was sufficient. However, premix was expected to finish flush with existing asphalt road pavement. According to Mr. Brian Teo, if trenching work was done during the night, premix level should be finished one inch higher than the existing road surface. This was because premix should be laid in hot weather. During the night, the bitumen hardens faster thus causing the premix to bond even before it was spread. As the top layer of the premix is expected to be scraped off, the layer of premix should be laid an inch higher to overcome this problem.

Water was added after the premix was spread because bitumen in the premix needed to be cooled so that it bonds the asphalt together. It is compacted to reduce the air void so that the bond between asphalt is high. Compact roller was preferred over hand compactor because the compaction capacity of the compact roller was 1 tonne while a hand compactor was only capably of reaching a capacity of a few hundred kilos.

i) Clearing of Site

All of the 5 sites investigated removed all surplus material, debris, rubbish and unused materials during erection and all temporary erections. Sites must be cleared and cleaned after trenching work was done because materials left at site could be hazardous to public as well as road users. This was also a form of protection against theft.

j) Traffic Control and Safety

Although all 5 sites put up suitable danger notice board 100 m away from the working site, temporary signboards, flashing lights and cone barriers to divert traffic to a safer lane, only site 1 had a better traffic control over all the other 4 sites.

Site 1 and 2 were the only two sites which placed mild steel plates over an exposed open trench or joint bay. The other three sites only placed signboards and cone barriers to warn public of the exposed open trench. This was especially dangerous for road users or pedestrians using the roads during the night

Between sites 1 and 2, site 1 was the only site that fully utilised all road signboards and notice boards. Site 1 was also the only site which placed cone barriers along the entire length of the trenching work. Flashing lights were also placed on some of the cone barriers to show and warn road users that trenching work was going on along the entire stretch of the flashing lights. Signs such as “keep right”, “work in progress” and “caution” were just some of the road signs used by contractor of site 1.

Site 1 was the only site which had all the workers wearing reflective jackets. This was especially important for trenching works done during the night where visibility was limited.

6.2 Comparisons of Data between the Best Possible Methods Employed and the Standards and Codes of Practice

a) Working Hours and Cable Route

The working hours for all trenching work were approved by the local city council before any trenching work tarted. Drawings of all cable routes for the trenching work were also submitted to the local city council for approval. Any trenching work done without the authorisation of the local city council, if caught, a penalty will be imposed in terms of cash, jail time or both.

b) Breaking of Surface

Similar to the standard, road pavement at the edges of the trench was cut in straight lines with the aid of a diamond cutter to a depth of at least 300 mm. However, the depth of the cut should be revised to a range of 300 to 600 mm as a diamond cutter is only able to cut to a maximum depth of 600 mm as mentioned earlier.

c) Construction of Trenches

There is no standard for the construction of trenches according to the standard given by the Kuala Lumpur City Council (DBKL). However, according to Mr. Hashim (the cable supervisor for Case 1) and Mr. Vincent (the cable supervisor for Case 3), it was a requirement from all utility companies in Malaysia that cables or piping should be laid on a bed of sand 3 inches (76.2 mm) thick and fine sand must be filled to a depth of 6 inches (152.4 mm) measured from the top of the cable or piping where protective slabs are to be placed. Similarly, the best method employed was to have a bed of fine sand 100 mm thick. After the piping was joined, fine sand should be filled to a depth of 300 mm measured from the top of the piping before protective slabs were to be placed.

Both depth of the methods employed were thicker than that of the standard because any damage to the cables done during trenching work would be bared by the contractor. Due to the thicker sand, the cost for the construction is expected to increase. According to the project co-ordinator, sand can be replaced with quarry dust which works just as fine as sand. The cost of a tonne of sand is RM 4.00 while a tonne of quarry dust just cost a mere RM 0.80. With this, cables are safer from damage caused by compaction and the cost of the trenching work could be reduced as well.

d) Excavated Material

According to the standard, no excavated material shall be used for backfilling and must be removed from the site immediately. This was similar to the best method employed. However, while waiting for the highway trucks, excavated material can be deposited neatly onto the side of the trench so as to cause minimal disturbance to traffic. Excavated material might contained other material like rocks which could increase the air voids. Air void contributes to the settlement of newly reinstated premix.

e) Backfilling and Reinstatement

Backfilling written in the standard differs from that of the best method employed. According to Mr. Brian Teo from Abdi Ria, the standard of the local city council for compaction was actually similar to the Fill Density Test (FDT).

FDT is actually a type of soil compaction test. After 200 mm thickness of soil is compacted, a sample of the compacted soil is taken and burned with a Bunsen burner. By calculating the mass before and after burned, the dry density of the soil can be calculated. The degree of compaction shall not be less than 95% of the dry density obtained. FDT shall be carried out at every 200 mm layer of soil and at every 25 m distance. FDT must also be carried out by a third party and is usually done by personnel from Kuala Lumpur

International University College (KLIUC). If the test is to be carried out on layers of sand, it is called Sand Replacement Test. However the methods are similar to the FDT. Whenever the degree of compaction is more than 95% of the dry density, the contractor has an option to compact the layer of soil again or to excavate all the material out, backfill the trench and to compact it all over again.

Based on the standard, the trench shall be filled with sand, 3 to 4 inches thick of crusher run. Tack coat is applied before premix of 2 inches thick is spread, compacted and finished flush with existing road surface. If the pavement settles before 6 months, the contractor has to conduct a milling method along the entire length of the trench.

The best method employed is to backfilled the trench with sand till 300 mm thick, compact it, before protective slabs is placed on top of it. Fine sand is then filled before crusher run of 3 to 4 inches thick is compacted.

Tack coat is applied evenly onto the compacted soil and premix of approximately 2 inches is spread, sprayed with water and compacted. The level of the asphalt road pavement should be finish flushed with existing road surface. After 15 weeks if the level of pavement settled, the entire stretch of the trench have to undergo milling.

Although the method of backfilling between the standard and the best method employed is different, the method of reinstatement is similar. FDT is an effective method of compaction compared to the best method employed. However FDT consumes a lot of time and is very expensive. Furthermore, there are no guarantees that the asphalt road would not settle after undergoing FDT. Roads which undergo FDT but settles after 15 weeks still requires to milling.

By adopting the best method employed, the layer of soil is compacted twice and the premix compacted once. If the premix settles tremendously the following day, a second layer of premix could be laid to serve as a temporary reinstatement before milling is to be conducted. This method of compaction ensures the trenching work to be a lot faster and enables the contractor to start work on other trenching site thus improving turnover. This method is also a lot cheaper compared to the standard which requires FDT. Furthermore, the cost of the construction would increase if milling is required even after FDT. By using the best method, asphalt is expected to settle as it is a temporary reinstatement. However the settlement of the asphalt would not pose a serious problem for road users. After milling, the asphalt road surface is expected to finish flush with existing road surface and no further settlement is expected. Milling method is the final and permanent reinstatement.

f) Clearing of Site

The standard employed by the local city council is similar to the best method employed as all surplus material, debris, rubbish and unused material are removed during erection and all temporary erections. Sites must be cleared and cleaned after trenching work is completed because materials left at site could be hazardous to public as well as road users.

g) Traffic Control and Safety

Exposed open trench or joint bay is to be covered with mild steel plates of suitable thickness securely spiked until backfilling and reinstatement is done as suggested by the standard. Open trench or joint bay which is not covered could pose a dangerous problem to all road users and pedestrian especially during the night.

Although traffic management of the best method employed is similar to the standard, there is no compromise. All traffic management should comply with the standard "*Traffic Management and Safety at Road Construction Site*." Traffic management is a very critical aspect as it involves not only the safety and well being of working personnel but road users and pedestrians as well. Different road conditions require different traffic management. However, the standards written by the local authority is a very detailed standard which takes into account most traffic condition.

.

7. RECOMMENDATIONS

After comparing the standards of the local city council and the best methods employed by the contractor, both methods have their own advantages and disadvantages. For example, backfilling, the best possible methods employed by the contractor were found to be better despite the fact that the method with the better compaction is the one from the standards employed by the local city council. However, for traffic control and safety, the standards employed by the local city council must be followed without any compromise.

Contractors who adhere strictly by the standards found it hard to compete with contractors who were flexible and did not adhere to the standard. At the end of the day, the contractor with the cheapest tender is the one awarded with the contract. The contractors who strictly followed the standards found it hard to win tenders compared to those who did not. A contractor is a businessman who is out to earn a living. In order to be competitive, all contractors are flexible when it comes to standards.

Standards employed by the local City Councils have its flaws as well. According to Mr Leong, a researcher working for the government, the standards used these days have been actually amended from the standards of the 1980s. Small minor adjustments were made and the new standards are now being implemented. Time, people and lifestyle have change, therefore so must the standards.

There should be a closer liaison between the road authority, utility department and contractors. The differences between ideal standards and compromised construction practices have to be minimised. Road authorities such as the Public Works Department of Malaysia (JKR) and Road Engineering Association of Malaysia should seat down with a couple of well-established cable or pipe laying companies and come out with a standard that is fair to both parties. However, public interest should always be placed as the top priority.

Without a proper standard to follow, contractors would find ways to minimise cost. One of the most common ways of minimising cost is to use excavated material. Standards would have to be fair and reasonable to all parties before all parties would abide to it. Only a minority of contractors or none at all would abide to standards which are unfair or unreasonable.

However, safety standards need to be followed with no compromise. Safety standards are important not only to working personnel but to road users and pedestrians as well. Safety should be given top priority in all trenching sites so that accidents and injuries could be reduced and curbed.

8. Future Works

The local supervisor could try to implement a closer and stricter supervision on all trenching site. This is definitely something possible. However, the price of tender is expected to gradually increase as by then the materials and methods employed would follow strictly with the standard which requires a higher cost. Closer supervision by the local authority should definitely be considered.

Fill Density Test (FDT) should also be research further especially in trenching works. One of the main concerned is the probability that a particular reinstated pavement would settle, even if a little, after having undergone FDT. If the probability is high, then the local city council should look at other alternatives to soil compaction in trenching work. The degree of settlement of a particular pavement which had been reinstated following trenching work, by adopting the methods employed by the contractor, should also be researched. The degree of settlement should then be compared with the probability that a reinstated pavement would settle following FDT. Having done that, cost is brought into the picture and the method which is more cost effective as well as efficient is chosen.

The performance of premix laid is still in doubt; therefore several tests, researched and comparisons on premix should be taken:

i) premix laid during the day compared with premix laid during the night
ii) fresh premix from the plant compared with premix left at site for three to six hours later

iii) cold mix asphalt laid during the hot weather with no addition of water compared with cold mix asphalt added with water from 25 milliliters to 250 milliliters.

By conducting the entire above test, the most practical method of premix laying will then be ascertained.

Researched should also be carried out to determine the maximum depth to which a diamond cutter is able to cut. The proper method to excavate asphalt road surface thicker than those capable to be cut by a diamond cutter should be determined. The best method is the one that caused minimal damage to the surrounding road near the trenching work.

9. Conclusions

As a conclusion, the standards and guidelines provided by the local city council were found to be more effective whereas the usual practice of the contractor was found to be more economical. Standards and guidelines are usually the best method to be employed with little emphasis on cost. The usual practice of the contractor is usually more practical.

Standards employed by local City Councils take into consideration the best possible method available and public interest at heart but fail to look at the contractor's point of view. The method of statement submitted by the contractors need not necessary be the exact method employed by the contractor. Adopting the best possible method available is possible and feasible. However, the cost of construction would definitely have to be increased due to this.

Contracts are awarded to the tenderers with the least cost. Therefore, in the eyes of the contractor, to commensurate with the cost submitted in the tender, they would find ways to minimise construction costs. Contractors opt to cut down on material instead of labour because by minimising labour costs. This increases the duration of the construction. Therefore, the work carried out by the contractors is not strictly in agreement with the terms specified in the contract.

List of References

William D.O. Patterson 1987, *Road Deterioration and Maintenance Effects*, The John Hopkin University Press

1990, *Roadwork Standard:-Technical Report*, Austroads

2002, *Guidelines For Works Related To Public Utility Installations Within The Road Reserve*, Road Engineering Association of Malaysia, Shah Alam

Nicholas J. Garber 1997, *Traffic and Highway Engineering*, PWS Publishing Company, Massachusetts

Paul H. Wright 1987, *Highway Engineering – Fifth Edition*, John Wiley & Sons Inc, Canada

1995, *Longman Dictionary of Contemporary English*, Longman Group Ltd, England

Transport ~ The Road, viewed 14 April 2004, http://www.abcmalaysia.com/tour_malaysia/trnprt_road.htm

Road Network, viewed 14 April 2004, http://www.jkr.gov.my/jln/hari-jkr/Road8.htm

Roads Administration and Maintenance, viewed 14 April 2004,
http://www.jkr.gov.my/jln/hari-jkr/Road12.htm

Dictionary.com, viewed 28 August 2004,
http://dictionary.reference.com/search?q=trenching

APPENDIX A:

PROJECT SPECIFICATIONS

University of Southern Queensland
FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/4112 Research Project
PROJECT SPECIFICATION
Issue B: 4 May 2004

STUDENT	:	**LEONG WENG WAH**
TOPIC	:	**The Impact of Trenching on Urban Road Operation and Maintenance**
SUPERVISOR	:	USQ - Associate Professor Ron Ayers Prime College – Mr Ng Kah Chuan
ENROLMENT	:	ENG 4111 – S1, 2004; ENG 4112 – S2, 2004

PROJECT AIM : The project aims to investigate the impact of creating trenches in urban roads for the purpose of cable or drainage system installation. The impacts to be considered will be (a) the impact on the operation of the road and surrounding road network during the trenching operation, (b) the impact on the operation of the road following restoration of the trench, and particularly if failure occurs in the restoration, and (c) the impact on maintenance operations and budgets caused by defective trench restorations.

PROGRAMME :

1. Research information on the impacts of trenching, and in particular:
   - current methods of traffic control and road network management during trenching operations;
   - factors leading to the deterioration of roads after trenching operations;
   - current methods used by local councils and other road authorities to minimize subsequent trench failures; and
   - current standards and Codes of Practice controlling trenching operations and restoration.
2. From current literature determine what is world's best practice in regard to:
   - Control of trenching operations in roads; and
   - Techniques for trench and pavement restoration
3. Select and investigate a number of cases of urban road deterioration following damage due to poor trench restoration. The number of cases will probably be in the order of 10 to 15.
4. Analyze all data collected and compare the performance of the selected roads against existing standards and best practice.
5. Formulate recommendations as to how current practices may be amended to minimize the adverse impacts of trenching.
6. Compare the cost of current with the proposed maintenance methods to ensure the proposed methods are economical and feasible. (Optional).

7. Report findings through oral presentation at the Project Conference, and in the required written format.

AGREED :

__________________ (Student) _______________(USQ Supervisor)

_______/_______/_______ _______/_______/_______

APPENDIX B:

CASE STUDY QUESTIONNAIRE

CASE STUDY

Time : Date :

Location :

Contractor :

Site Supervisor :

Contact Number :

Project's Title :

Client's name	
Sub Contractor	
Date	Start – Finish –
Estimated Cost	
Number of Workforce	General Workers - Project manager - Project co-ordinator - Etc -
Plants and heavy Equipment	
Materials	
Trenching Dimensions	Length – Depth – Width –
Extra Features	

APPENDIX C:

APPLICATION FORM FOR TRENCHING WORK

BORANG 1

PERMOHONAN UNTUK KERJA-KERJA MENGOREK JALAN

Kepada : ______________________________

____

____
(Pihak berkuasa yang meluluskan)

Tajuk Projek : ______________________________

____

No. Lukisan : ______________________________

____

Saya/kami, pemaju projek tersebut di atas ini, memohon kepada pihak tuan untuk menjalankan kerja-kerja mengorek jalan seperti ditunjuk dalam Dokumen Permohonan yang disertakan bersama-sama ini. Jurutera Profesional yang dinamakan di bawah ini telah dilantik oleh saya/kami untuk menyediakan rekabentuk kejuruteraan.

Saya/kami dengan ini berjanji seperti berikut :-

(a) Pegawai-pegawai pihak tuan berhak untuk memasuki tapak kerja pada bila-bila masa yang munasabah untuk memeriksa kerja yang dijalankan.

(b) Saya/kami secara bersama-sama dan berasingan dengan Jurutera Profesional bertanggungjawab ke atas keselamatan orang ramai, kerosakan harta benda dan lain-lain “third party liabilities” akibat daripada kerja-kerja yang dipohon.

Sekian. Diharap permohonan ini dapat diluluskan.

Terima kasih.

9

Figure C1: Borang / Form 1

BORANG 1(contd)

Tnadatangan Pemaju Projek : ____________________

Nama Penandatangan & No. K/P : ____________________

Jawatan Penandatangan : ____________________

Nama Pemaju Projek : ____________________

Alamat Pemaju Projek : ____________________
____
____

Tel. : ____________________ Fax : ____________________

Tarikh : ____________________

Tanandatangan Jurutera Profesional : ____________________

Nombor daftar Jurutera Profesional : ____________________

Nama Jurutera Profesional : ____________________

Alamat : ____________________
____
____

Tel : ____________________ Fax : ____________________

Tarikh : ____________________

Perhatian :

1. *Kegagalan pemohon mengisikan borang ini dengan lengkap dan tepat akan melambatkan proses pelulusan permohonan.*
2. *Pastikan penandatangan Jurutera Profesional di dalam borang ini dan di atas pelan-pelan adalah jurutera yang sama.*

10

Figure C2: Borang / Form 1

BORANG 1(contd)

INSTRUCTIONS TO APPLICANT

1. Application, complete with drawings, design calculations and other relevant information, shall be submitted in triplicate in accordance with the "Model Application Document".
2. The description of work shall contain sufficient details of the nature, location and extent of the work involved.
3. Application must be accompanied by
   - (a) key plan to a scale of 1:50,000 or 1:100,000 showing the general location and routing of the utility installation, indicating kilometer post, direction and distances from major town or distinctive local reference points.
   - (b) location plan to a scale of 1:5,000 or 1:10,000 showing the utility installation in details. Location of important features such as manholes, junction box, hydrants, etc. are to be shown. The type and location of other utility installations, if any, must also be shown.
   - (c) plan(s) showing the road carriageway cross-section and the position of the proposed and existing utility installations.
   - (d) traffic management plan showing details of proposed road diversion, construction warning signage, temporary access provision, etc.
4. The Professional Engineer who signs the application form must be the same person as the one who has endorsed the design documents.

11

Figure C3: Borang / Form 1

BORANG 2

Logo dan alamat rasmi pihak yang memberi kelulusan

Rujuk kami : ____________

Tarikh : ____________

Kepada : ____________
____
____
(nama dan alamat pemohon)

PERMOHONAN UNTUK KERJA-KERJA MENGOREK JALAN

Tajuk Projek : ____________
____

No. Lukisan : ____________
____

Merujuk kepada permohonan tuan yang bertarikh ………………. untuk kerja tersebut di atas ini, dengan sukacita dimaklumkan bahawa permohonan tuan telah diluluskan. Walau bagaimanapun, sila ambil perhatian bahawa tuan tidak dibenarkan memulakan kerja tanpa **PERMIT UNTUK MENJALANKAN KERJA** yang dikeluarkan oleh pihak kami. Untuk mendapatkan Permit itu, tuan adalah dikehendaki mengemukakan kepada pejabat ini **WANG CAGARAN** sebanyak Ringgit ………
…………………………...
dalam bentuk bank deraf di atas nama ……………………………………………………… Wang Cagaran ini adalah untuk menjamin pihak tuan menjalankan kerja-kerja mengikut pelan-pelan, spesifikasi dan syarat-syarat yang dikenakan. Pihak kami berhak untuk merampas wang cagaran ini sekiranya pihak tuan gagal menjalankan tanggungjawab pihak tuan. Wang Cagaran ini akan dilepaskan setelah **BORANG 6** dikeluarkan oleh pejabat ini.

Kelulusan ini mungkin dibatalkan sekiranya tuan gagal mengemukakan Wang Cagaran dalam tempoh tiga puloh (30) hari daripada tarikh surat ini.

Sekian.

Yang menurut perintah,

____
____
____
(Nama dan jawatan pegawai yang diberi kuasa menandatangani kelulusan)

s.k. Jurutera Profesional yang berkenaan

12

Figure C4: Borang / Form 2

BORANG 3

Logo dan alamat rasmi pihak yang memberi kelulusan

Rujuk kami : ____________________
Tarikh : ____________________

Kepada :______________________
____
____
(nama dan alamat pemohon)

Tuan,

PERMIT UNTUK MENJALANKAN KERJA JALAN
Projek ………………………………………………

Dengan hormatnya saya diarah merujuk kepada surat tuan bertarikh ……………. dan memaklumkan bahawa kebenaran adalah diberi di bawah Sek. 85 Undang-Undang Malaysia Akta 333 (Akta Pengangkutan Jalan 1987) untuk kerja-kerja yang tersebut di atas di …………………………… tertakluk kepada syarat-syarat, spesifikasi dan lukisan-lukisan sabagaimana yang ditunjukkan di dalam Dokumen Permohonan.

Kebenaran ini pada keseluruhannya diberi saperti berikut :

TEMPOH PERMIT ……………… hingga …………… (tarikh)

MASA KERJA (i) Hari berja : ………….. hingga …………
(ii) Hari minggu/kelepasan am ………….. hingga …………
(iii) *(syarat khas)* ………….. hingga …………

Kerja tidak dibenarkan pada waktu puncak trafik, iaitu ……….hingga ……. dan ……... hingga ……..

(PIHAK KAMI BERHAK UNTUK MEMINDAH MASA KERJA DENGAN MEMBERI NOTIS DUA HARI)

Sekiranya keadaan memaksa, permohonan boleh dibuat untuk Permit Khas untuk berkeja di waktu puncak trafik. Bayaran ganguan trafik akan ditetapkan oleh pihak kami atas pengeluaran Permit Khas itu.

Sekian.

Saya yang menurut perintah,

………………………………
(Pegawai yang diberi kuasa)

<u>Pegawai-pegawai Yang Bertanggungjawab</u>
Pemegang Permit :
No. Tel. :
Kontraktor :
No. Tel. :

s.k. 1. Ketua Pegawai Polis Daerah berkenaan
2. Pihak Penguatkuasa yang berkenaan
3. Pihak yang bertanggungjawab penyelenggaraan jalan

13

Figure C5: Borang / Form 3

BORANG 4

PERMOHONAN UNTUK PEMERIKSAAN KERJA-KERJA MENGOREK/MEMBAIKPULIH JALAN

Kepada : ______________________
____
____
(Pihak berkuasa yang meluluskan)

Tuan,

Tajuk Projek : ______________________________
____

Permit Kerja No. ______________________________

Dengan ini saya sabagai Jurutera Profesional yang bertanggungjawab untuk projek tersebut di atas ini memberi notis bahawa kerja-kerja telah disempurnakan dengan memuaskan.

Saya mengesahkan bahawa kerja-kerja tersebut telah dilaksanakan mengikut pelan-pelan, spesifikasi dan syarat-syarat yang diluluskan oleh pihak tuan. Saya mengambil tanggungjawab sepenuhnya terhadap kerja-kerja ini.

Saya mengesahkan bahawa segala kerosakan kepada premis berhampiran, jalan, longkang, siarkaki dan lain-lain telah dibaikpulih dan tapak kerja telah dibersihkan dan dalam keadaan yang sempurna.

Saya mengemukakan satu set "as-built plan" bernombor ______________ dan mengesahkan bahawa semua butir-butir yang terkandung dalamnya adalah benar dan betul.

Dengan ini, saya memohon tuan memeriksa kerja-kerja tersebut dan seterusnya mengeluarkan Borang 5 (Sijil Penerimaan Kerja).

Sekian. Terima kasih.

Tandatangan : ______________________

Tarikh : ______________________

Nama, Nombor Pendaftaran, dan alamat Jurutera Profesional :

____
____
____
____

s.k. Pemohon (Pemaju projek)

14

Figure C6: Borang / Form 4

BORANG 5

Logo dan alamat rasmi pihak yang memberi kelulusan

SIJIL PENERIMAAN KERJA

Rujuk kami : ______________________

Tarikh : ______________________

Kepada : ______________________
____
____
(Jurutera Profesional yang bertanggungjawab)

Tuan,

Tajuk Projek : ______________________
____

Permit Kerja No. ______________________

Merujuk kepada permohonan tuan dalam Borang 4 yang bertarikh ____________ , dengan ini pejabat ini mengambil maklum bahawa kerja-kerja yang berkenaan yang dilakukan dibawah pengelolaan tuan telah siap dengan memuaskan.

Tuan adalah diingatkan bahawa pihak tuan masih bertanggungjawab terhadap sabarang kerosakan dan kecacatan dalam tempoh enam (6) bulan. Sijil Sempurna Keja (Borang 6) akan dikeluarkan sekiranya tiada kecacatan berlaku atas kerja-kerja tersebut dalam tempoh enam bulan dari tarikh Sijil ini.

Sekian.

....
(Tandatangan pegawai yang diberi kuasa)

Nama : ______________________

Jawatan : ______________________

s.k. Pemohon (Pemaju projek)

15

Figure C7:Borang / Form 5

BORANG 6

Logo dan alamat rasmi pihak yang memberi kelulusan

SIJIL SEMPURNA KERJA

Rujuk kami : ____________________

Tarikh : ____________________

Kepada : ________________________
____
____
(Jurutera Profesional yang bertanggungjawab)

Tuan,

Tajuk Projek : ____
____

Permit Kerja No. ____

Dengan ini saya mengesahkan bahawa pejabat ini berpuashati dengan kerja-kerja tersebut di atas ini dan semua kerja pembaikian kerosakan / kecacatan. Wang cagaran yang berkenaan akan dikembalikan selepas ini.

Sekian.

……………………………………………...
(Tandatangan pegawai yang diberi kuasa)

Nama : ____________________
Jawatan : ____________________

s.k. (1) Pemohon (Pemaju projek)
(2) Pegawai Kewangan
Sila kembalikan wang cagaran sebanyak RM …………… kepada pemohon dalam tempoh 60 hari daripada tarikh Sijil ini.

16

Figure C8: Borang / Form 6

BORANG 7

AGREEMENT BETWEEN

THE GOVERNMENT OF MALAYSIA

AND

....
(Name of utility company)

FOR

....
(Name of project)
....

AGREEMENT No. ....

17

Figure C9: Borang / Form 7

BORANG 7(contd.)

AGREEMENT

An agreement made this .... day of .... in the year .... between the Government of Malaysia (hereinafter referred to as "the Government") of the one part and *(Name of utility company)* .... of (address) .... (hereinafter referred to as "the Applicant") on the other part.

WHEREAS

1. The Applicant has submitted an application to the Government in the form of the attached Application Document for the installation of .... *(Description of project)*

2. The Government has approved the application subject to the conditions stated in the Application Document and the procedures set out in the "Guidelines For Works Related To Public Utility Installations Within The Road Reserve" published by Road Engineering Association of Malaysia.

NOW it is hereby agreed that

a. The Government shall allow the Applicant occupation of the space taken up by the said utility installation.

b. The Application shall comply with all conditions stipulated by the Government in granting the approval.

c. The Applicant shall, at his own costs, relocate or dismantle the said installation from the site upon demand made by the Government for whatsoever reason.

In witness hereof, the parties have hereto caused this AGREEMENT to be signed in their respective names as of the date first above written.

For and on behalf of the
GOVERNMENT

By:
Name:
Designation:

In the presence of :

Name:
Designation:

For and on behalf of the
APPLICANT

By:
Name:
Designation:

In the presence of :

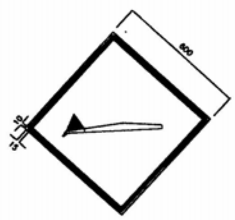
Name:
Designation:

18

Figure C10: Borang / Form 7

APPENDIX D:

TRAFFIC MANAGEMENT AND SAFETY ROAD CONSTRUCTION MANAGEMENT

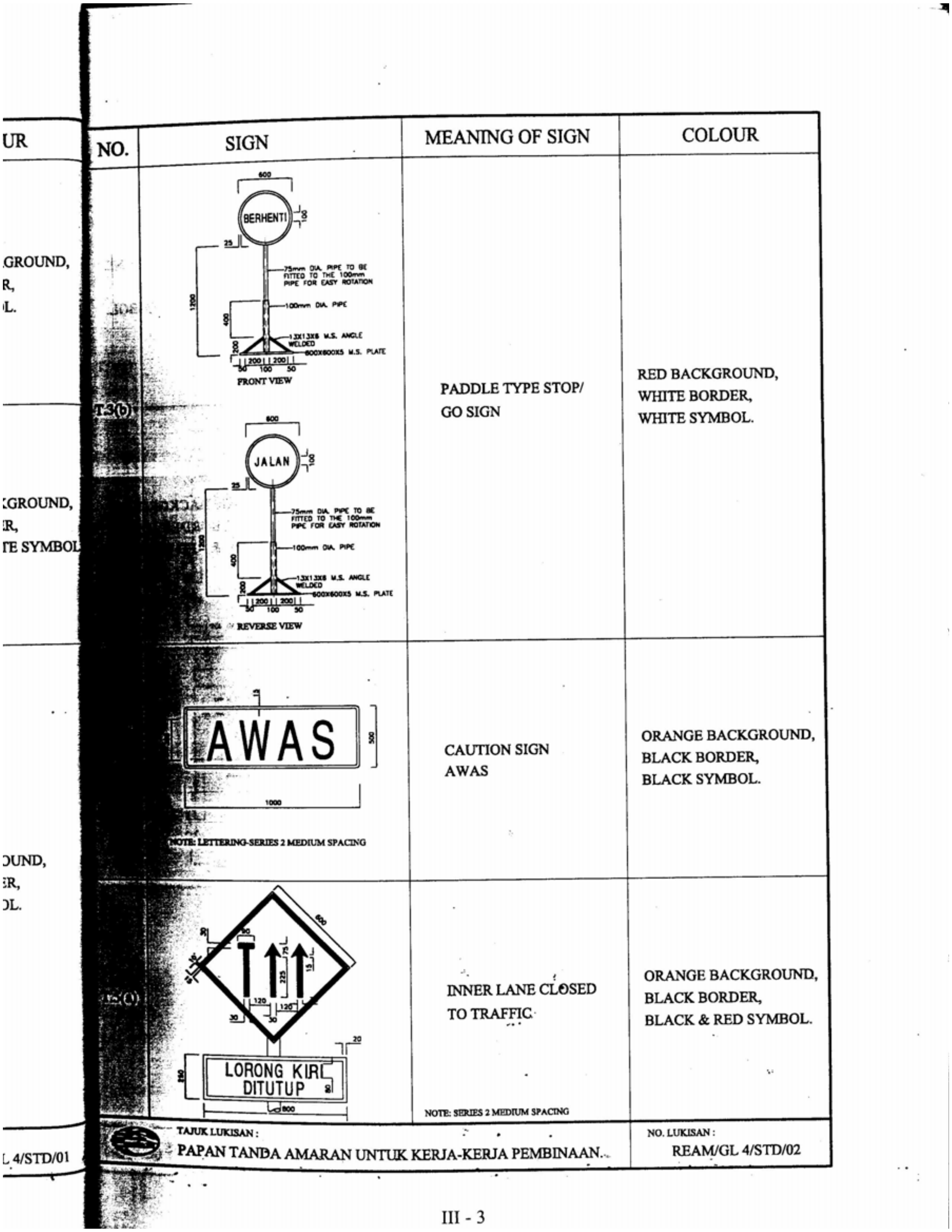
NO.	SIGN	MEANING OF SIGN	COLOUR
T.1		ROAD WORKS	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
T.2		MATERIAL PILED BY ROADSIDE	ORANGE BACKGROUND, BLACK BORDER, BLACK & WHITE SYMBOL.
T.3(a)	 FRONT VIEW  REVERSE VIEW	HAND DISC STOP/ GO SIGN	RED BACKGROUND, WHITE BORDER, WHITE SYMBOL.

TAJUK LUKISAN : PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN : REAM/GL 4/STD/01

III - 2

Figure D1: Sign Boards

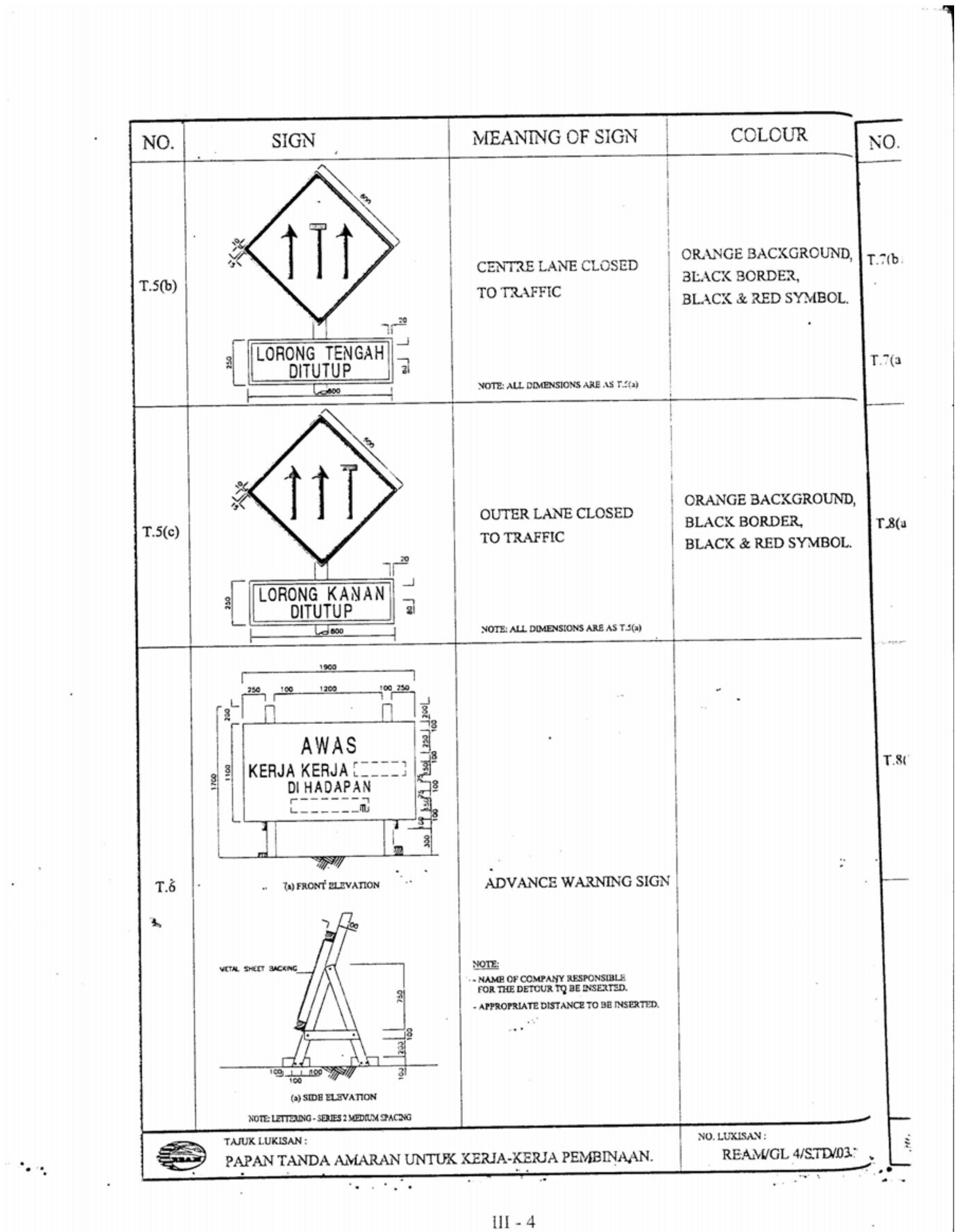


NO.	SIGN	MEANING OF SIGN	COLOUR
T3(b)	BERHENTI — FRONT VIEW; JALAN — REVERSE VIEW	PADDLE TYPE STOP/ GO SIGN	RED BACKGROUND, WHITE BORDER, WHITE SYMBOL.
	AWAS NOTE: LETTERING-SERIES 2 MEDIUM SPACING	CAUTION SIGN AWAS	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
	LORONG KIRI DITUTUP	INNER LANE CLOSED TO TRAFFIC NOTE: SERIES 2 MEDIUM SPACING	ORANGE BACKGROUND, BLACK BORDER, BLACK & RED SYMBOL.

TAJUK LUKISAN:	NO. LUKISAN:
PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.	REAM/GL 4/STD/02

III - 3

Figure D2: Sign Boards



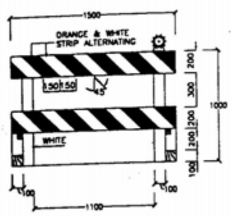
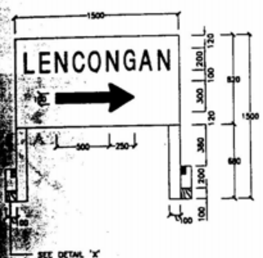
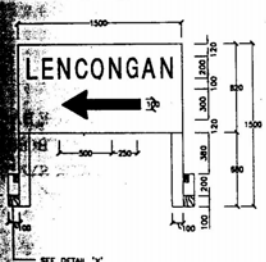
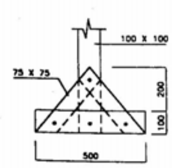
NO.	SIGN	MEANING OF SIGN	COLOUR
T.5(b)	LORONG TENGAH DITUTUP	CENTRE LANE CLOSED TO TRAFFIC NOTE: ALL DIMENSIONS ARE AS T.5(a)	ORANGE BACKGROUND, BLACK BORDER, BLACK & RED SYMBOL.
T.5(c)	LORONG KANAN DITUTUP	OUTER LANE CLOSED TO TRAFFIC NOTE: ALL DIMENSIONS ARE AS T.5(a)	ORANGE BACKGROUND, BLACK BORDER, BLACK & RED SYMBOL.
T.6	AWAS KERJA KERJA DI HADAPAN (a) FRONT ELEVATION METAL SHEET BACKING (a) SIDE ELEVATION NOTE: LETTERING - SERIES 2 MEDIUM SPACING	ADVANCE WARNING SIGN NOTE: - NAME OF COMPANY RESPONSIBLE FOR THE DETOUR TO BE INSERTED. - APPROPRIATE DISTANCE TO BE INSERTED.	

TAJUK LUKISAN : PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN : REAM/GL 4/STD/03.

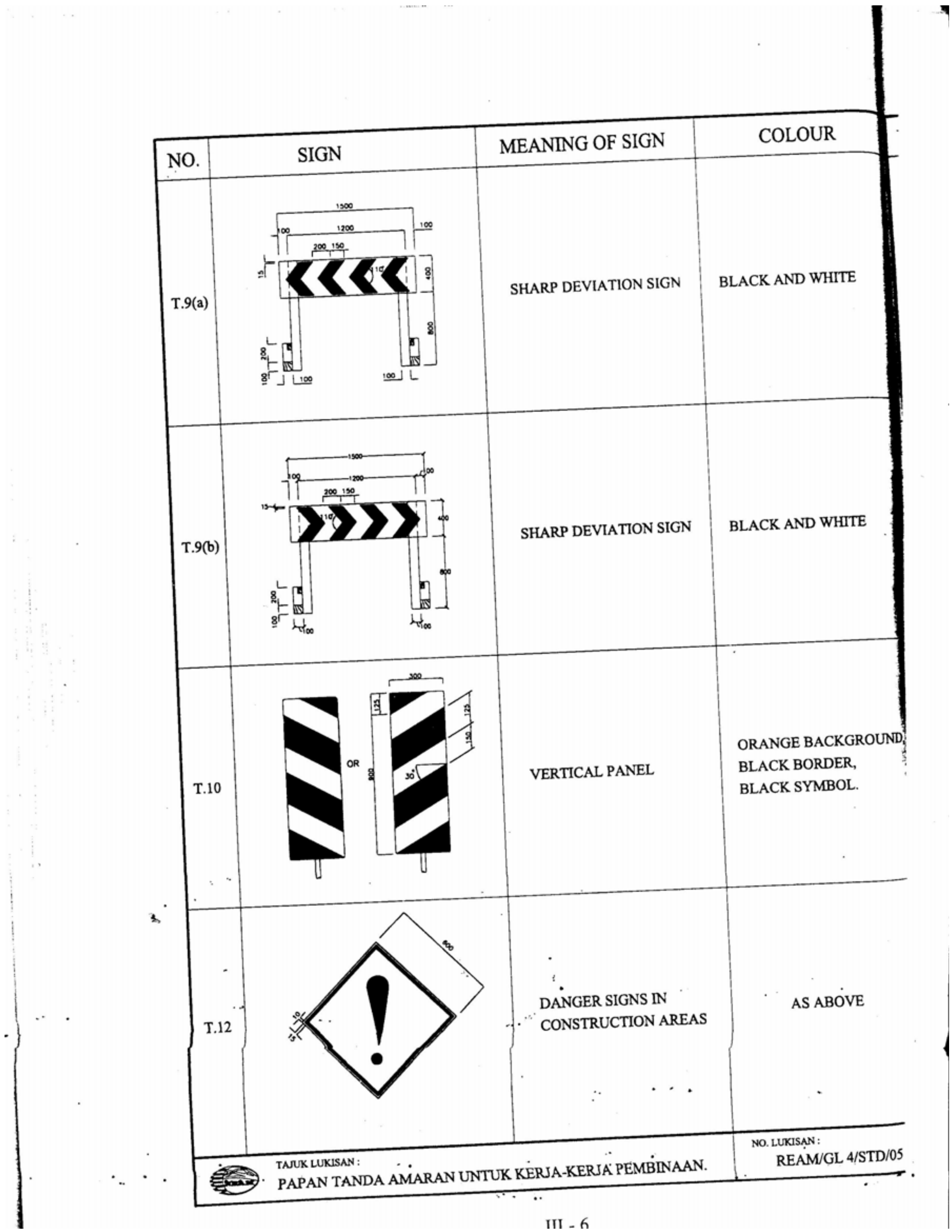
III - 4

Figure D3: Sign Boards

UR	NO.	SIGN	MEANING OF SIGN	COLOUR
KGROUND, ER, SYMBOL.	T.7(b) T.7(a)		BARRICADES TYPE II FOR BARRICADES TYPE I WITH ONLY WITH UPPER HORIZONAL BOARD	ORANGE & WHITE STRIP BLACK BORDER, BLACK SYMBOL.
KGROUND, ER, SYMBOL.			DEVIATION SIGN	ORANGE BACKGROUND, BLACK LETTERING, BLACK SYMBOL.
			DEVIATION SIGN	ORANGE BACKGROUND, BLACK LETTERING, BLACK SYMBOL.
		 DETAIL 'X' NOTE: LETTERING - SERIES 2 MEDIUM SPACING		
4/STD/03		TAJUK LUKISAN: PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.		NO. LUKISAN: REAM/GL 4/STD/04

III - 5

Figure D4: Sign Boards



NO.	SIGN	MEANING OF SIGN	COLOUR
T.9(a)		SHARP DEVIATION SIGN	BLACK AND WHITE
T.9(b)		SHARP DEVIATION SIGN	BLACK AND WHITE
T.10	OR	VERTICAL PANEL	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
T.12		DANGER SIGNS IN CONSTRUCTION AREAS	AS ABOVE

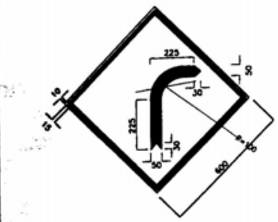
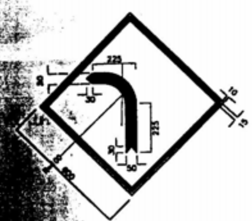
TAJUK LUKISAN : PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN : REAM/GL 4/STD/05

III - 6

Figure D5: Sign Boards

)UR
WHITE
) WHITE
ACKGROUN
RDER,
MBOL.
BOVE
GL 4/STD/05

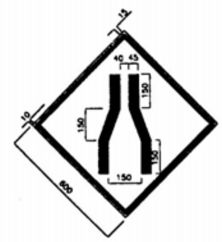
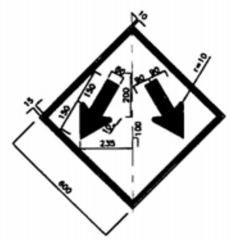
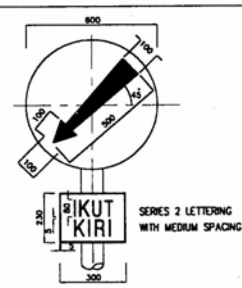
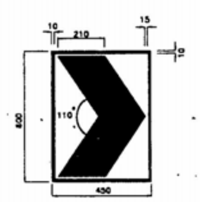
NO.	SIGN	MEANING OF SIGN	COLOUR
T.13(a)		TO THE RIGHT	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
[illegible]		TO THE LEFT	AS ABOVE
[illegible]		ROAD NARROWS ON FAR SIDE	AS ABOVE
[illegible]		ROAD NARROWS ON NEAR SIDE	AS ABOVE

TAJUK LUKISAN: PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN: REAM/GL 4/STD/06

III - 7

Figure D6: Sign Boards

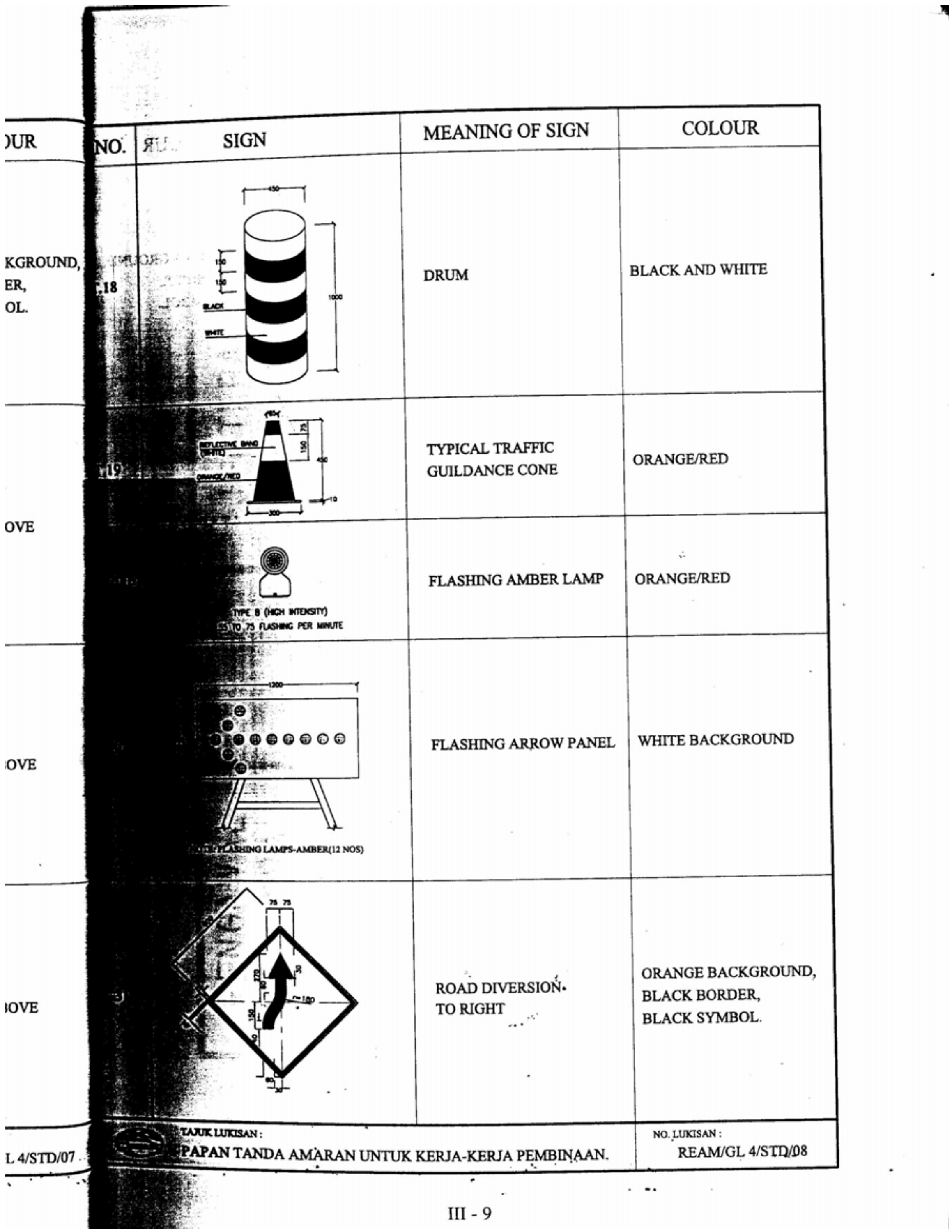
NO.	SIGN	MEANING OF SIGN	COLOUR
T.14(b)		ROAD NARROWS AHEAD	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
T.15		PASS EITHER SIDE	AS ABOVE
T.16		KEEP LEFT	AS ABOVE
T.17(a)		CHEVRON DELINEATOR	AS ABOVE

TAJUK LUKISAN: PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN: REAM/GL 4/STD/07

III - 8

Figure D7: Sign Boards



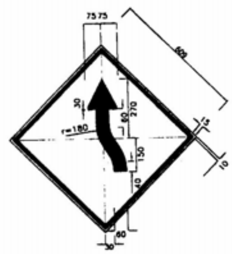
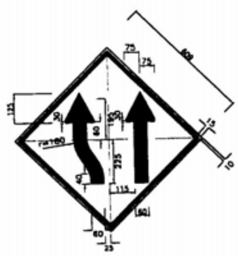
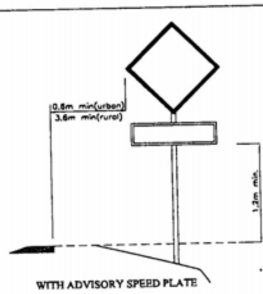
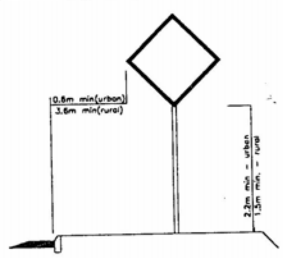
NO.	SIGN	MEANING OF SIGN	COLOUR
18	450; 150; 150; 1000; BLACK; WHITE	DRUM	BLACK AND WHITE
19	REFLECTIVE BAND (WHITE); ORANGE/RED; 75; 150; 450; 300; 10	TYPICAL TRAFFIC GUILDANCE CONE	ORANGE/RED
	TYPE B (HIGH INTENSITY) 55 TO 75 FLASHING PER MINUTE	FLASHING AMBER LAMP	ORANGE/RED
	1200; FLASHING LAMPS-AMBER(12 NOS)	FLASHING ARROW PANEL	WHITE BACKGROUND
	75 75; 225; 30; 150; 60	ROAD DIVERSION TO RIGHT	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.

TAJUK LUKISAN : PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN : REAM/GL 4/STD/08

III - 9

Figure D8: Sign Boards

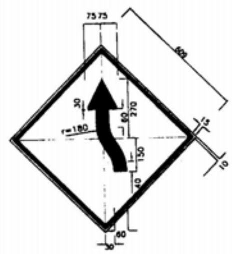
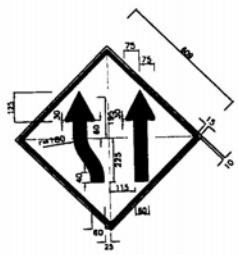
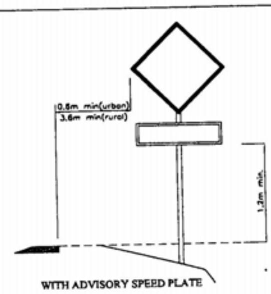
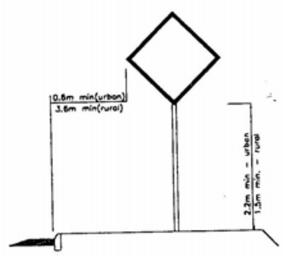
NO.	SIGN	MEANING OF SIGN	COLOUR
T.32		ROAD DIVERSION TO LEFT	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
T.33		ROAD DIVERSION ON ONE SIDE	AS ABOVE
		HEIGHT & LATERAL LOCATION OF TEMPORARY SIGNS	
		HEIGHT & LATERAL LOCATION OF TEMPORARY SIGNS	

TAJUK LUKISAN : PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN : REAM/GL 4/STD/09

III - 10

Figure D9: Sign Boards

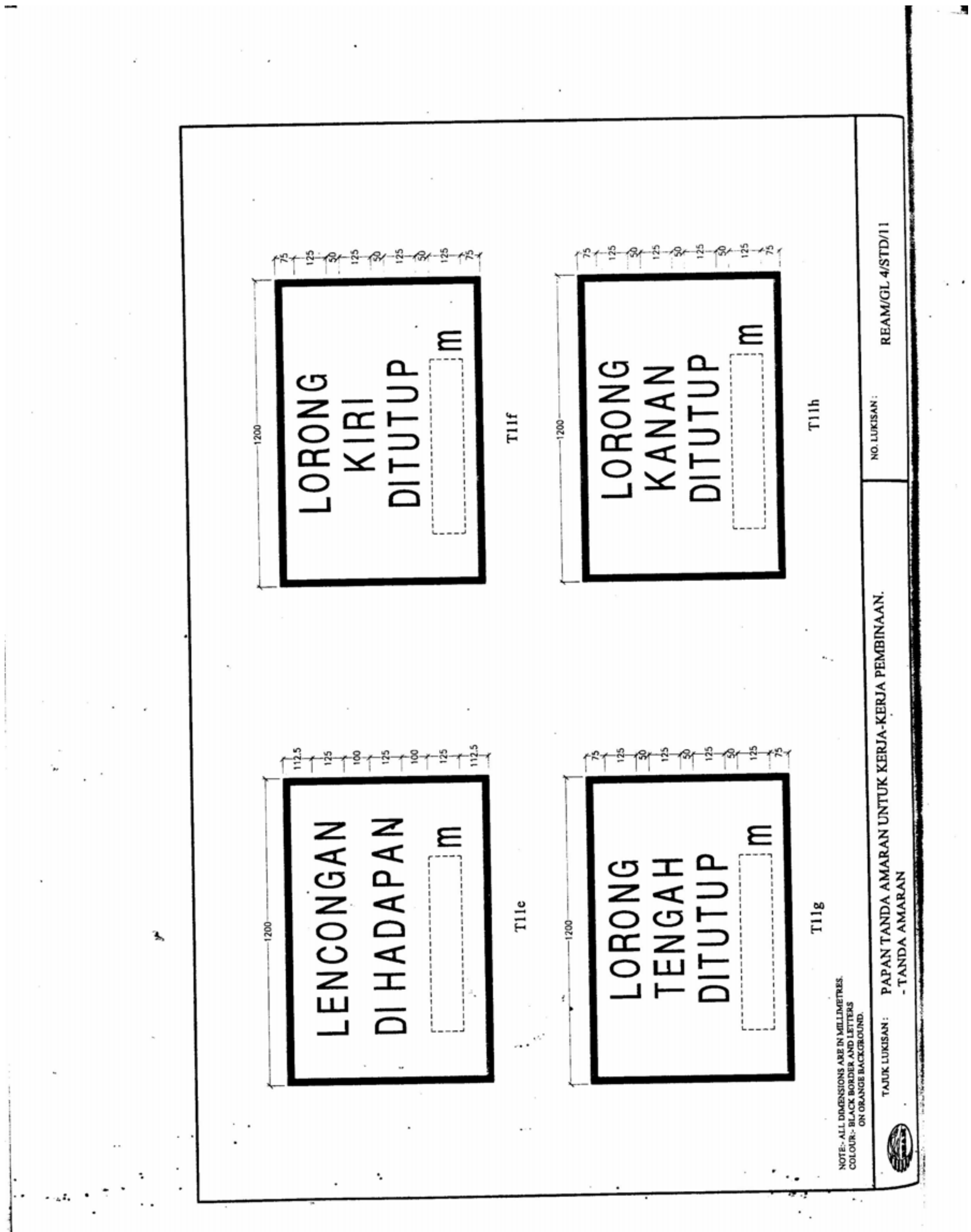
NO.	SIGN	MEANING OF SIGN	COLOUR
T.32		ROAD DIVERSION TO LEFT	ORANGE BACKGROUND, BLACK BORDER, BLACK SYMBOL.
T.33		ROAD DIVERSION ON ONE SIDE	AS ABOVE
		HEIGHT & LATERAL LOCATION OF TEMPORARY SIGNS	
		HEIGHT & LATERAL LOCATION OF TEMPORARY SIGNS	

TAJUK LUKISAN :
PAPAN TANDA AMARAN UNTUK KERJA-KERJA PEMBINAAN.

NO. LUKISAN :
REAM/GL 4/STD/09

III - 10

Figure D10: Sign Boards



III - 12

Figure D11: Sign Boards

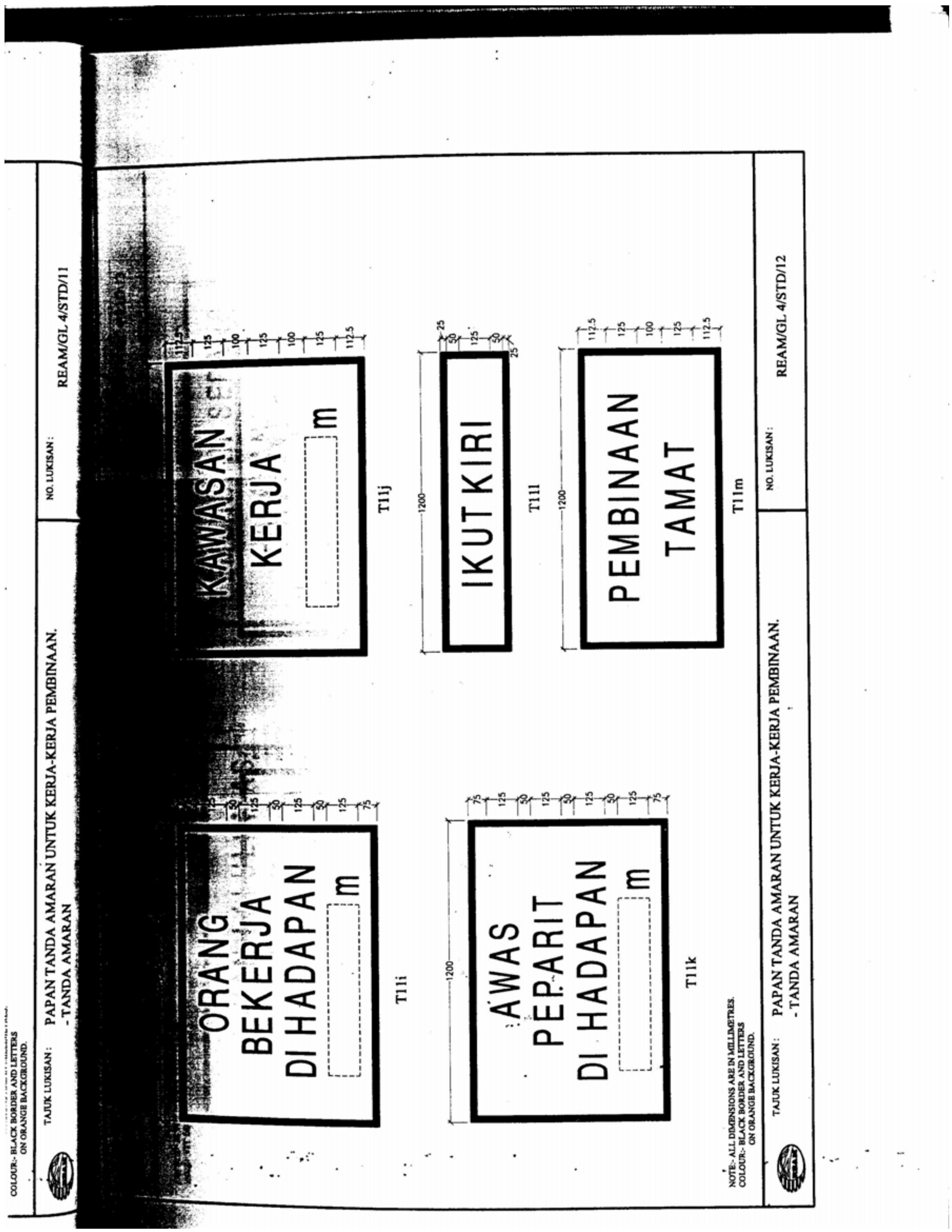


Figure D12: Sign Boards

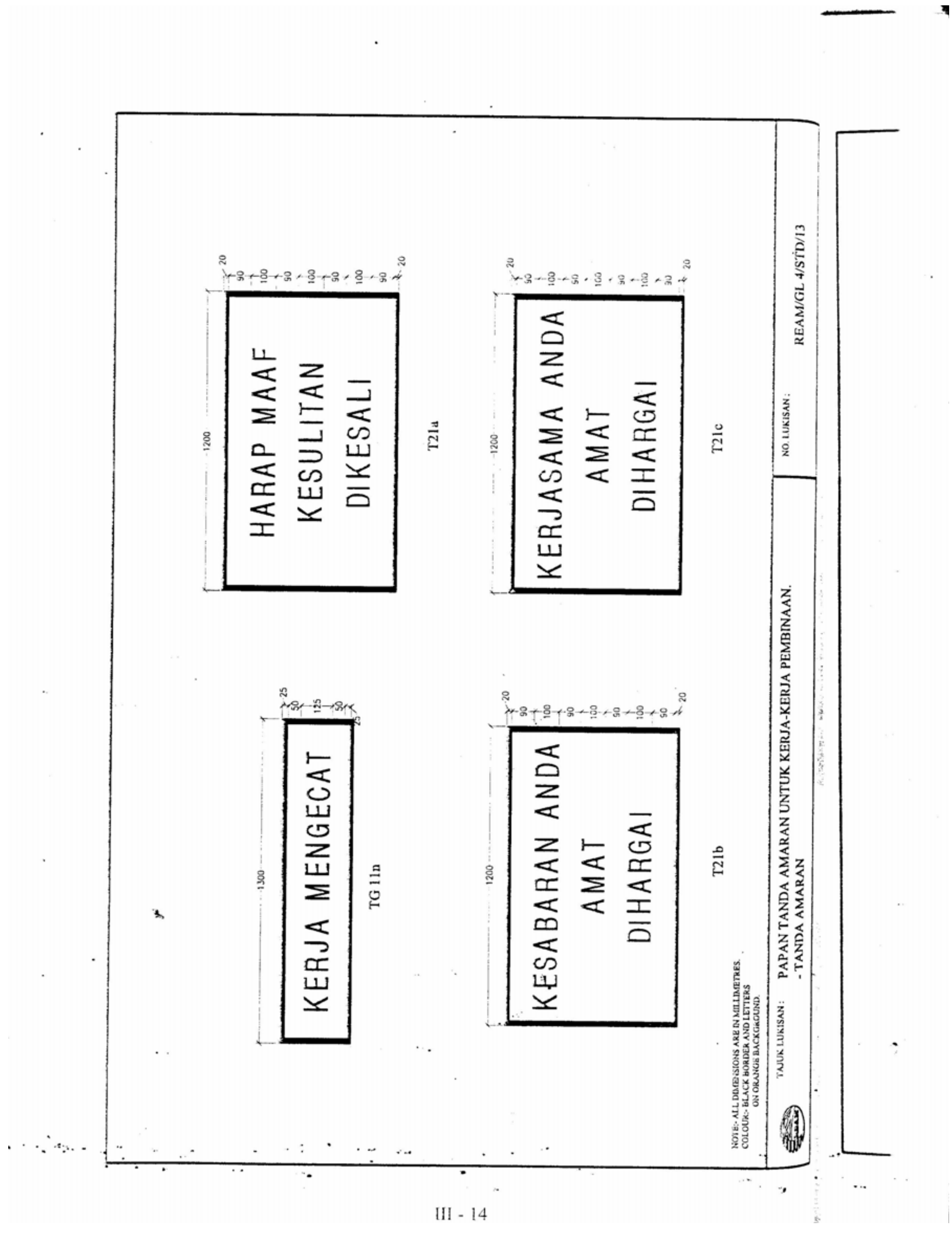


Figure D13: Sign Boards

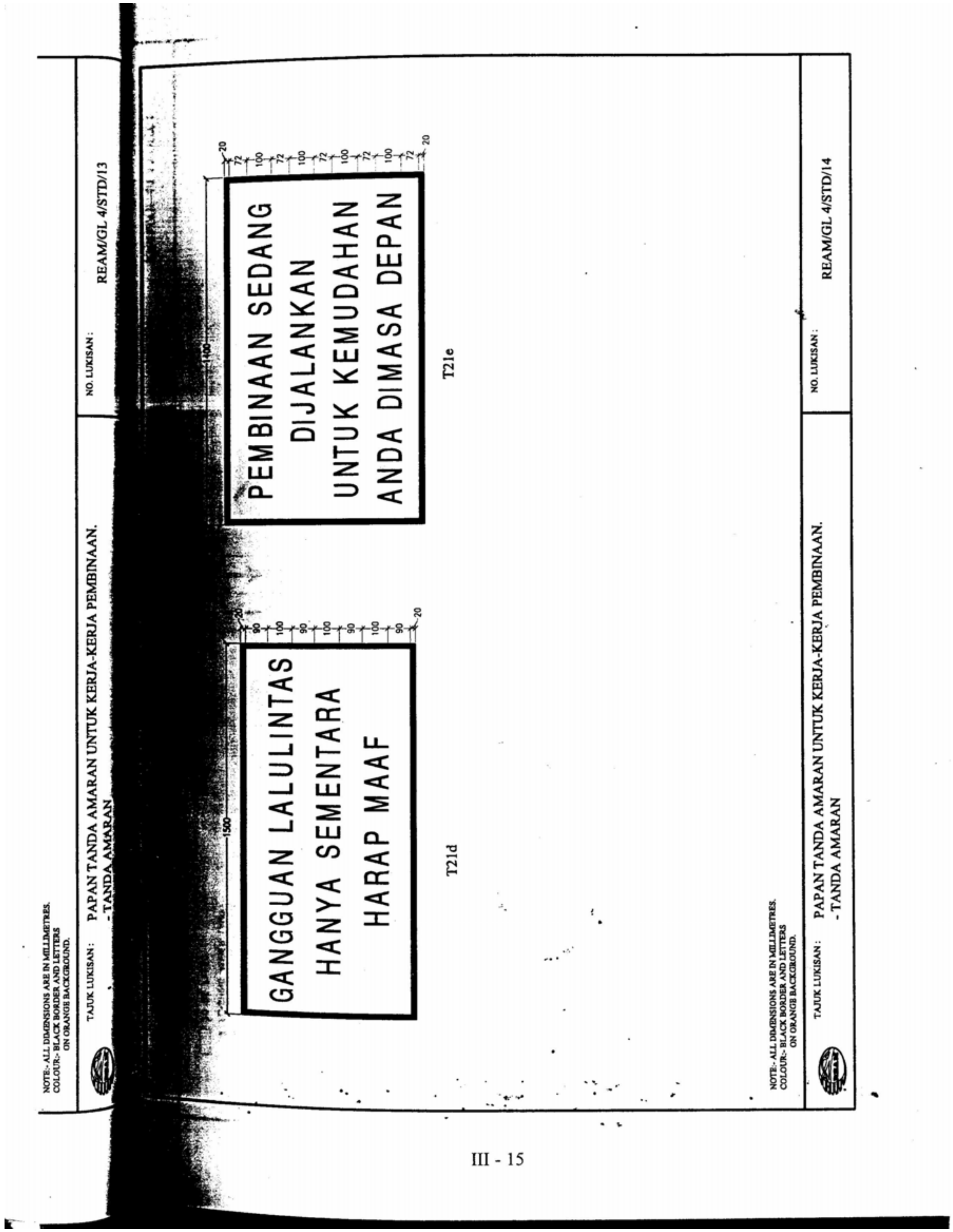


Figure D14: Sign Boards

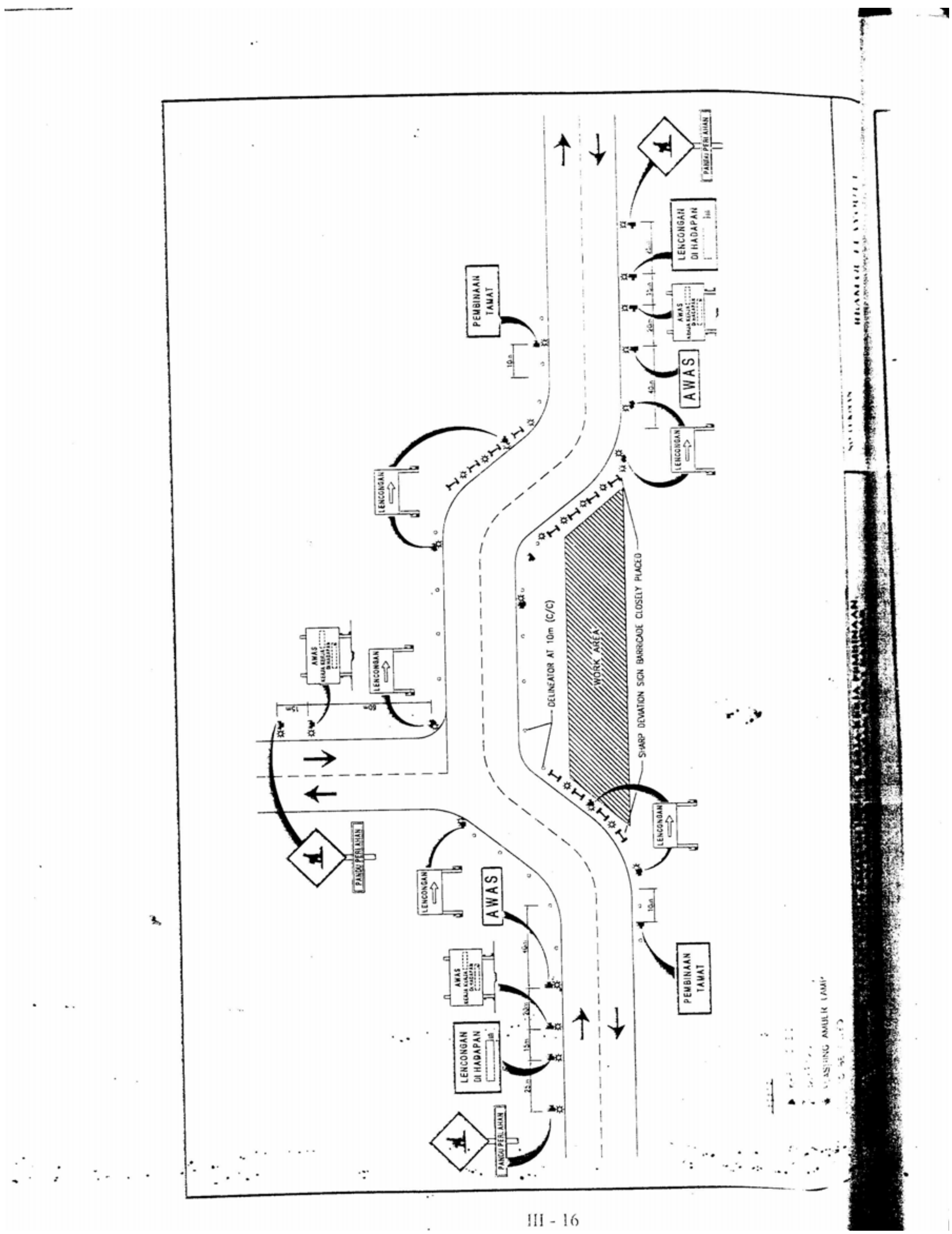


Figure D15: Traffic Management

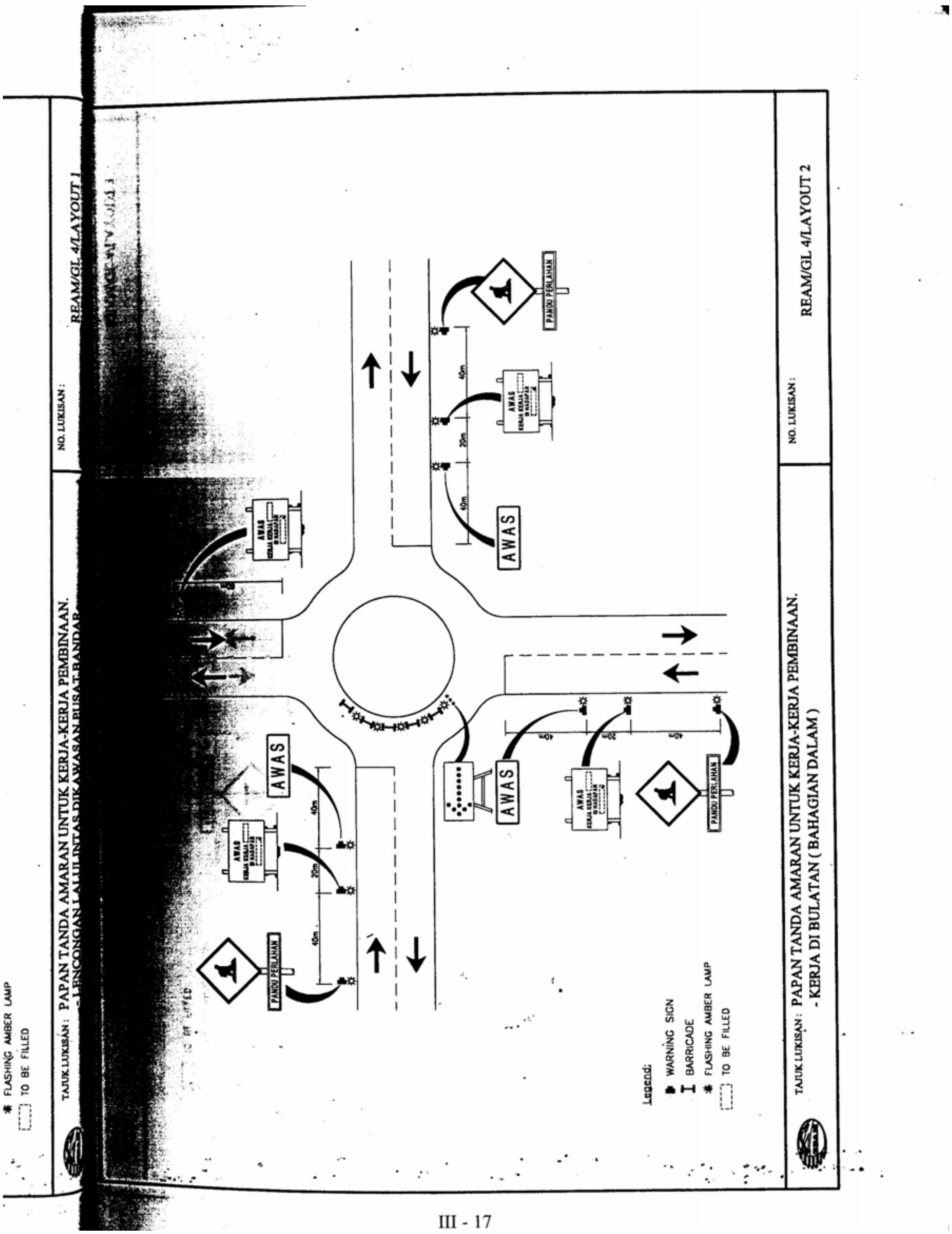
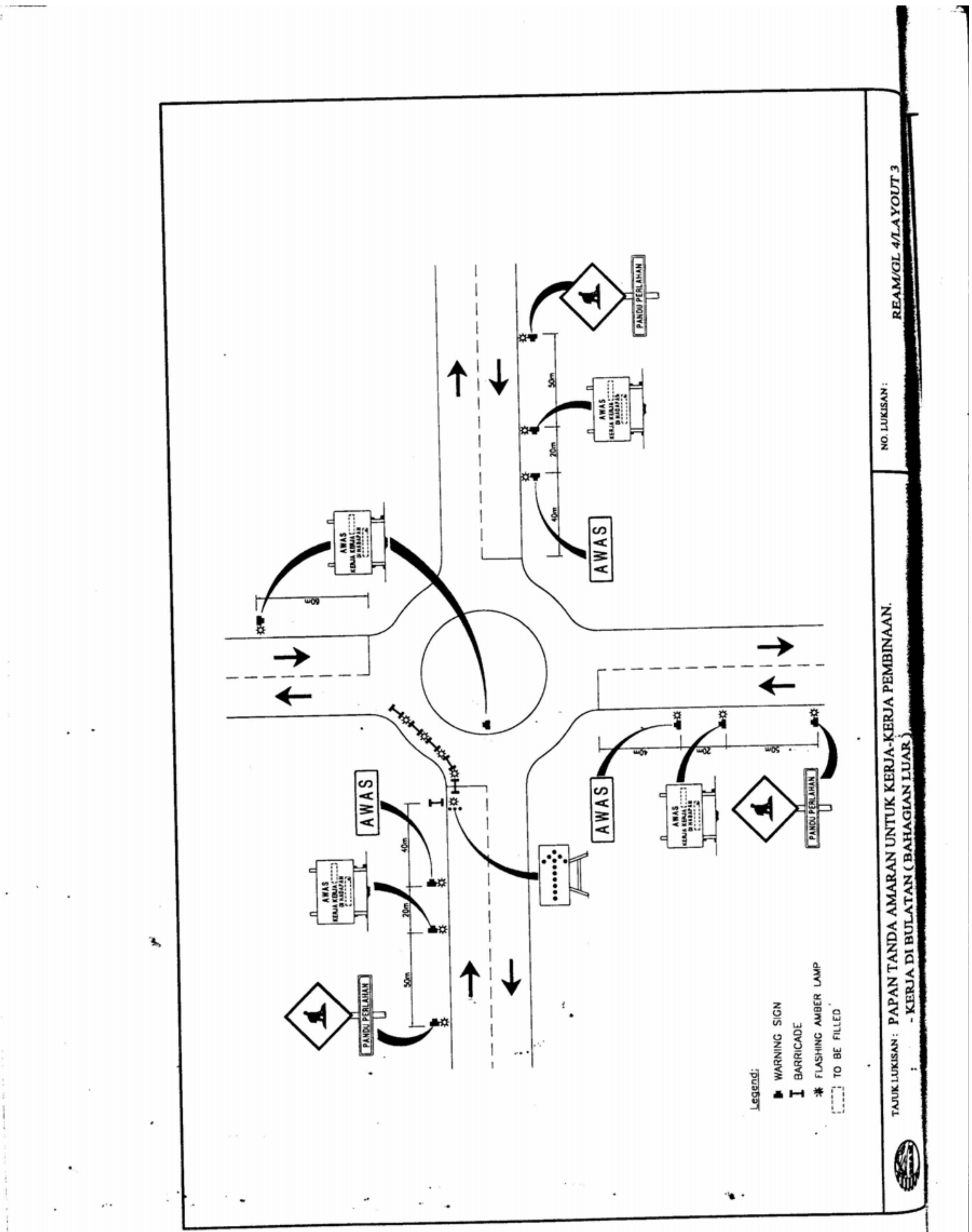


Figure D16: Traffic Management



III - 18

Figure D17: Traffic Management

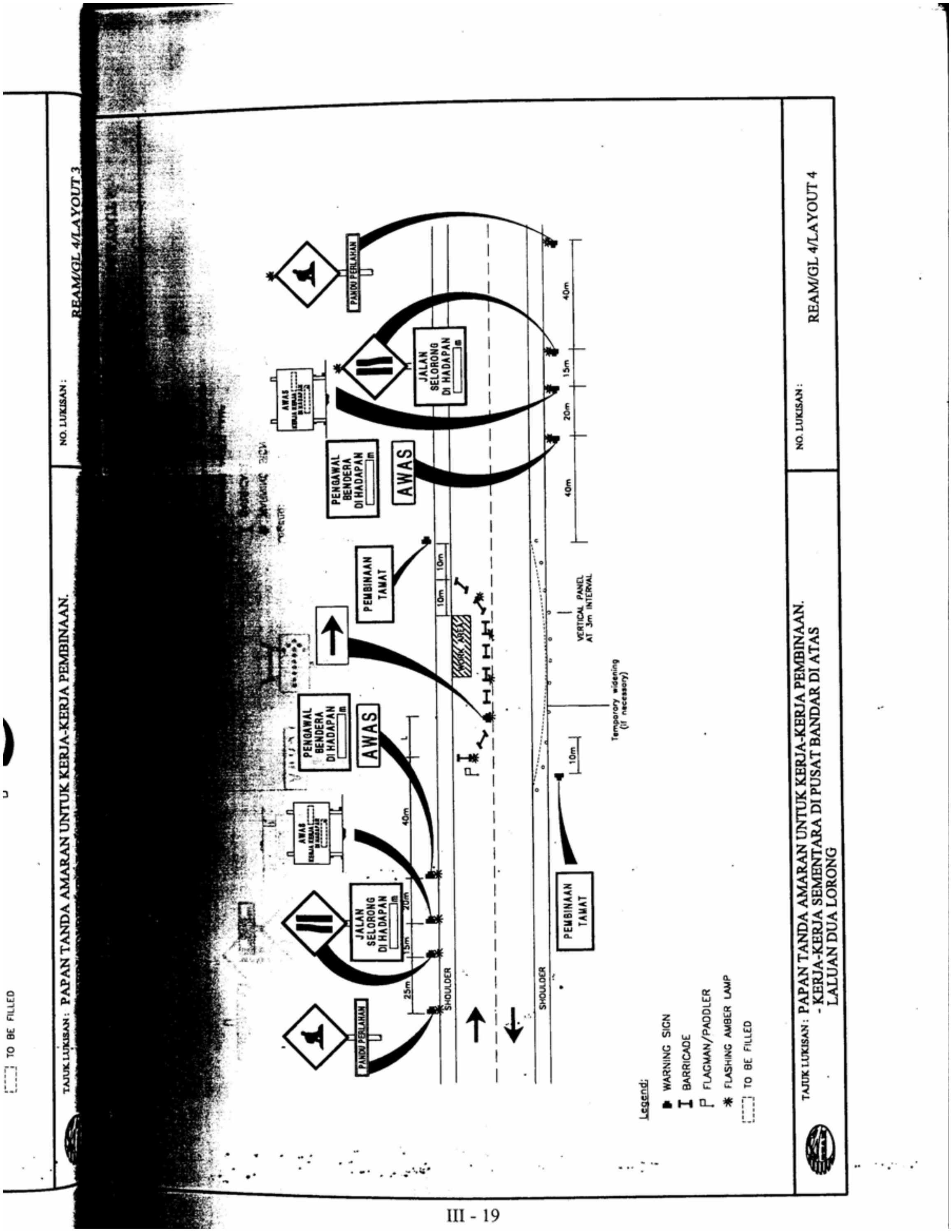


Figure D18: Traffic Management

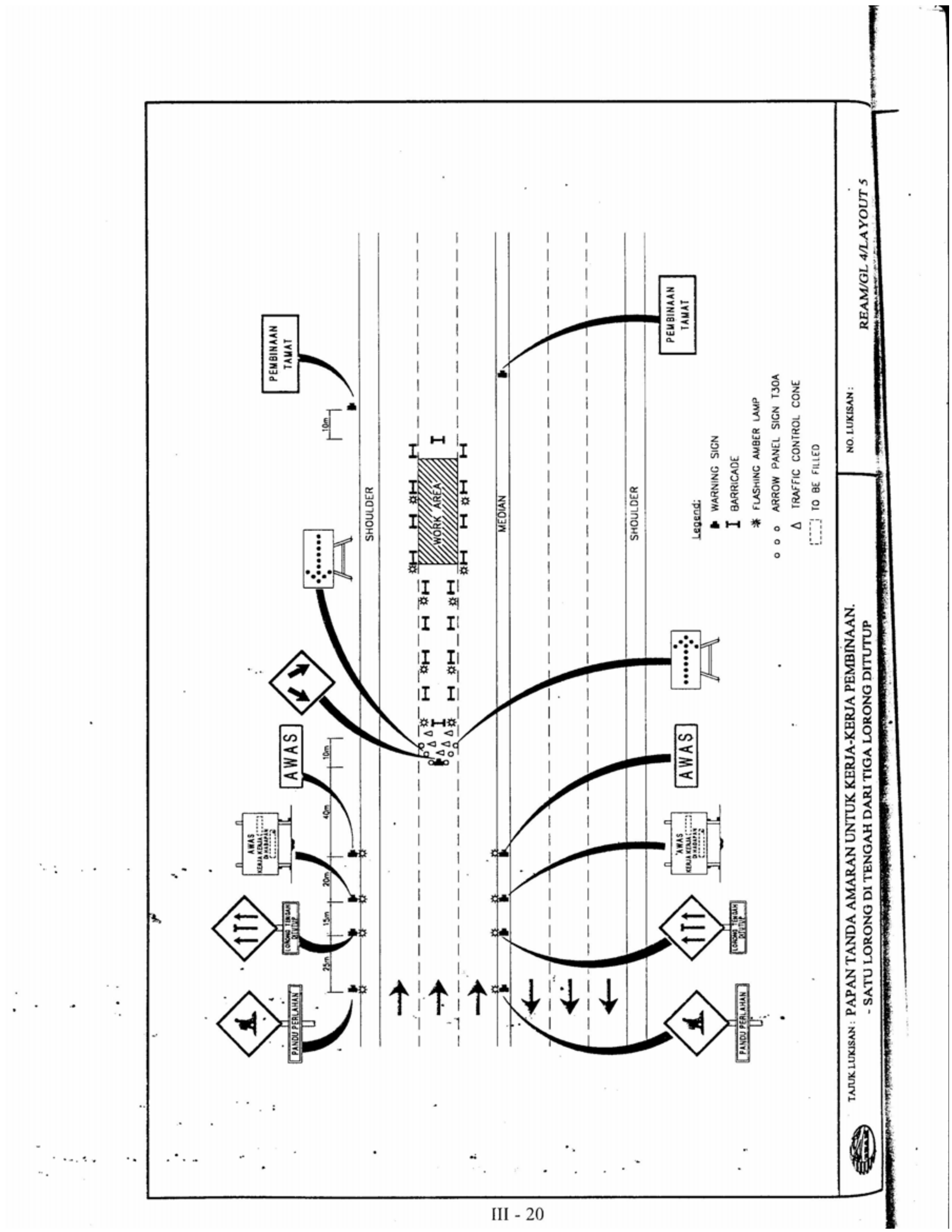
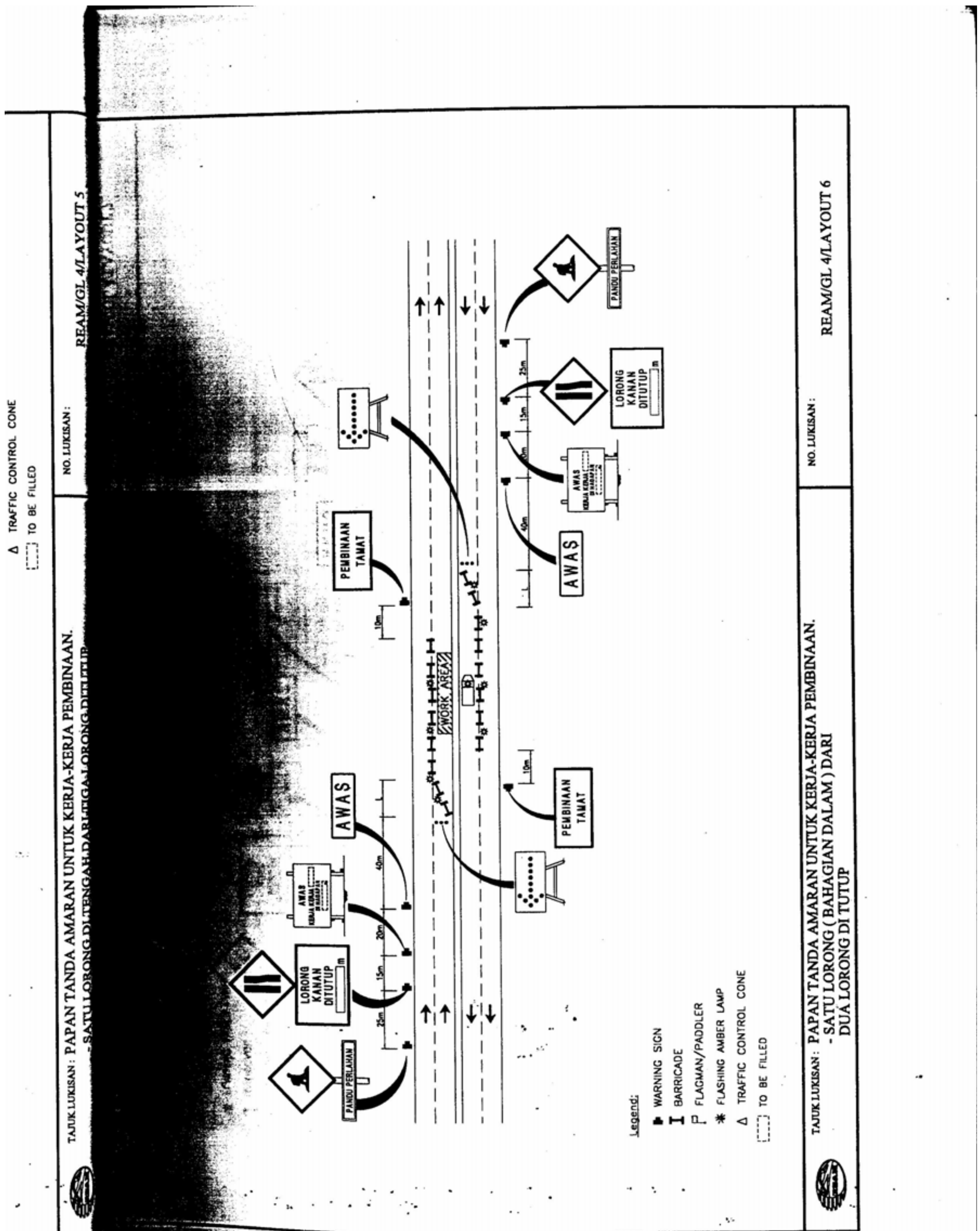
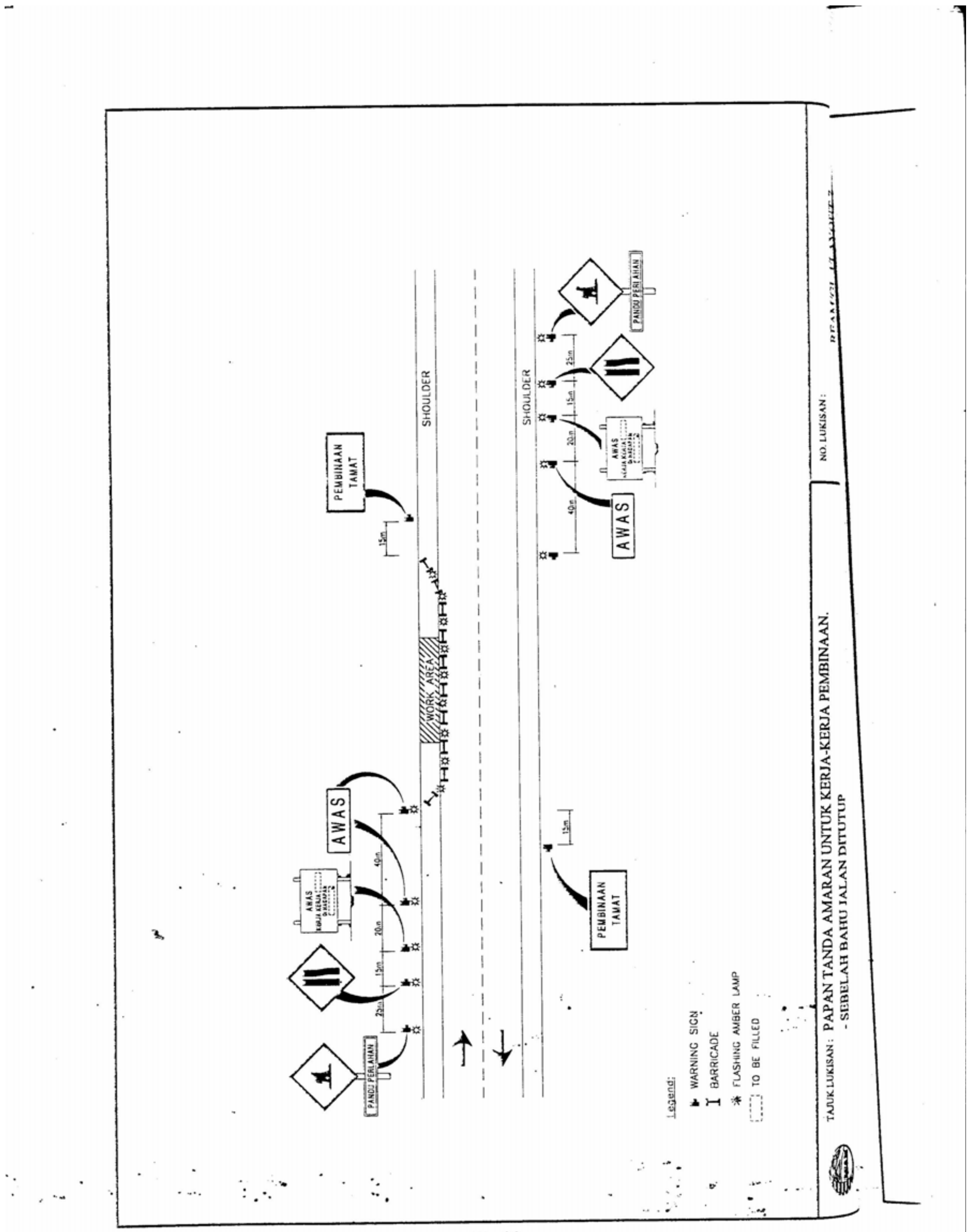


Figure D19: Traffic Management



III - 21

Figure D20: Traffic Management



III - 22

Figure D21: Traffic Management

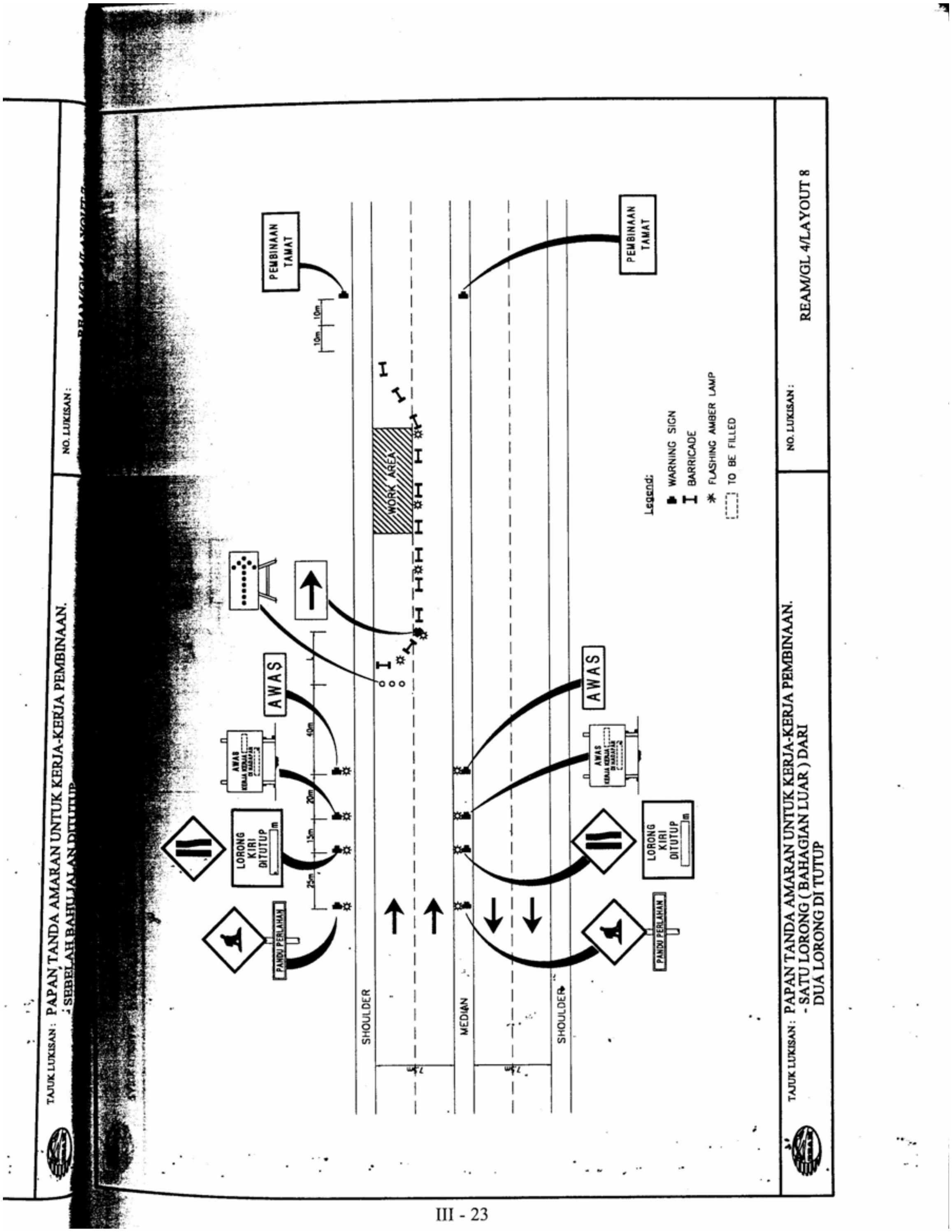


Figure D22: Traffic Management

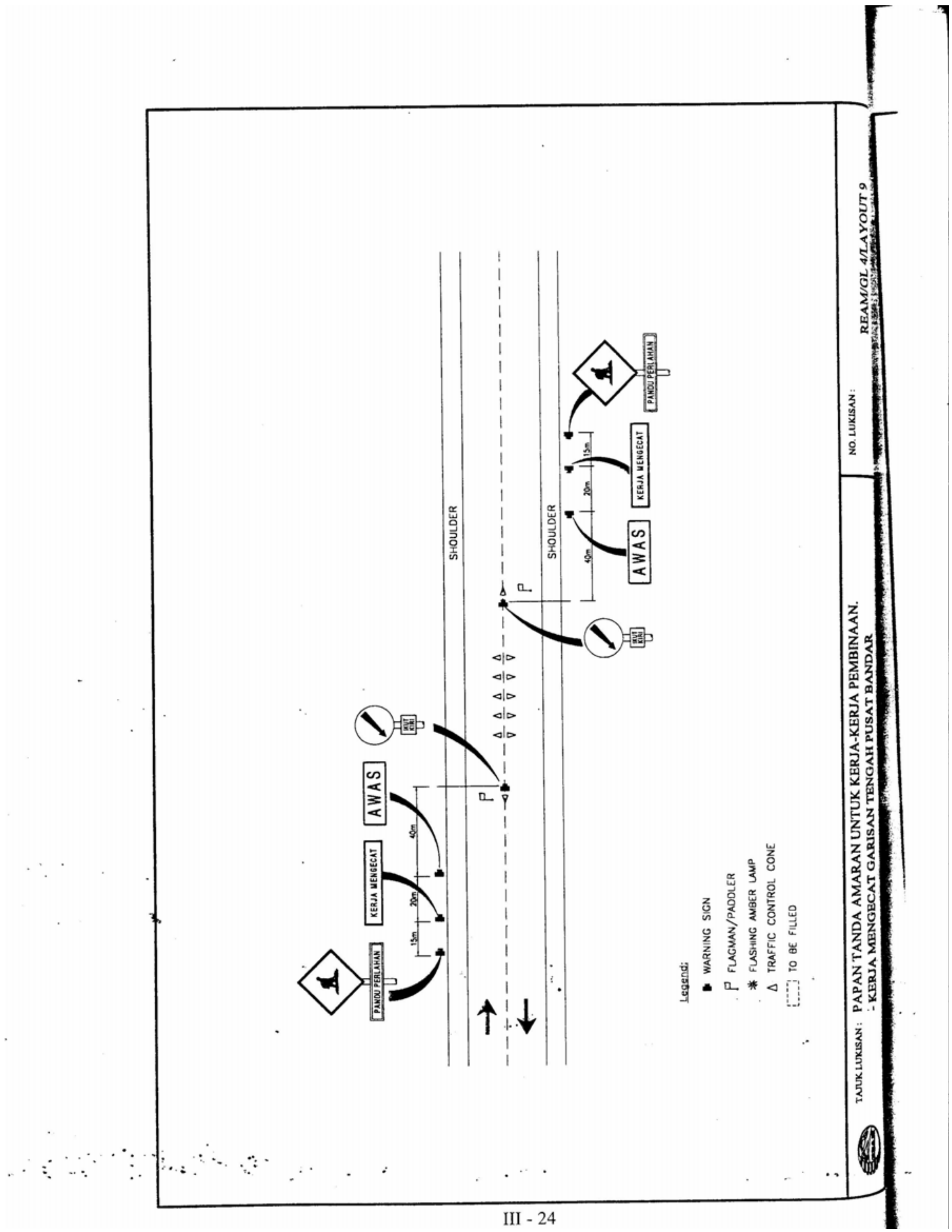


Figure D23: Traffic Management

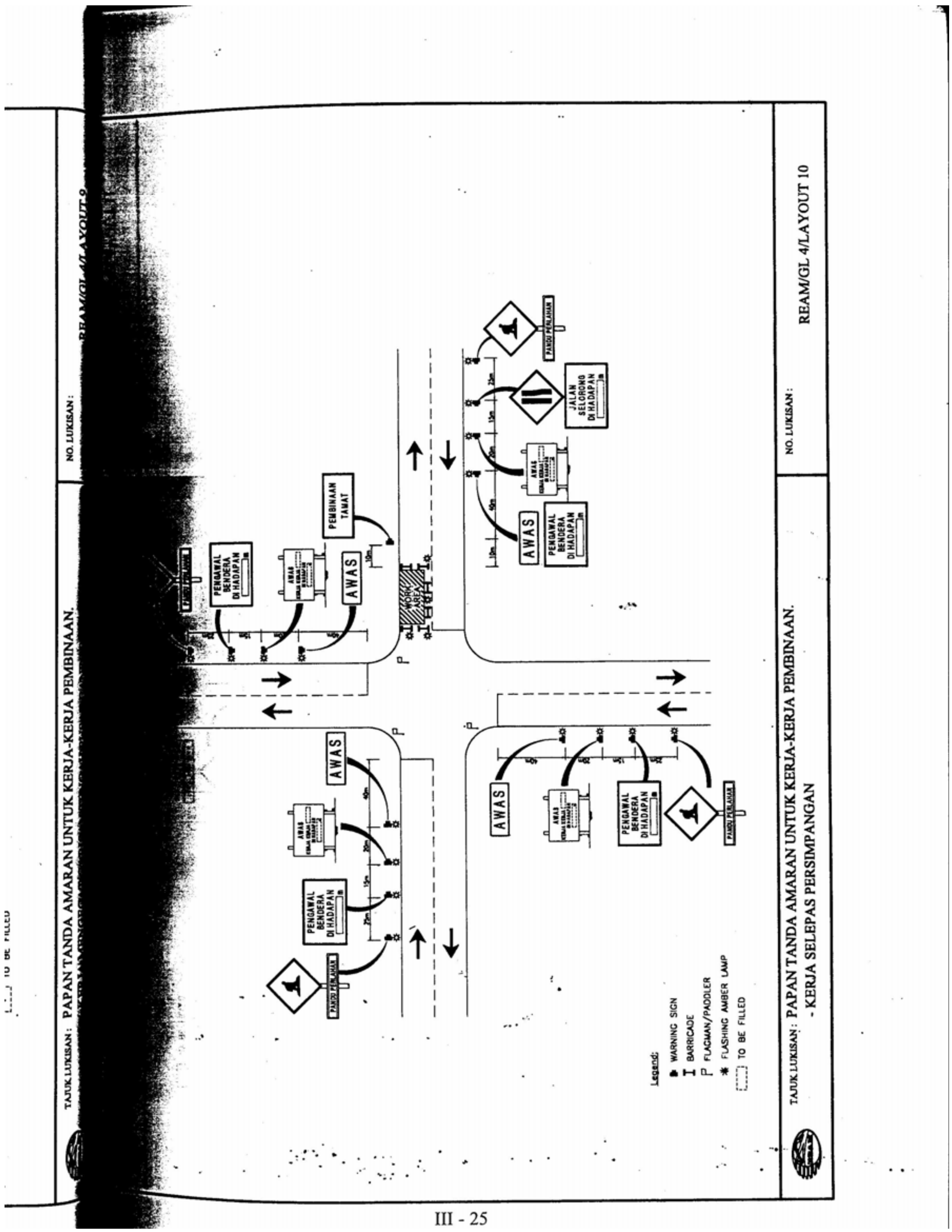


Figure D24: Traffic Management

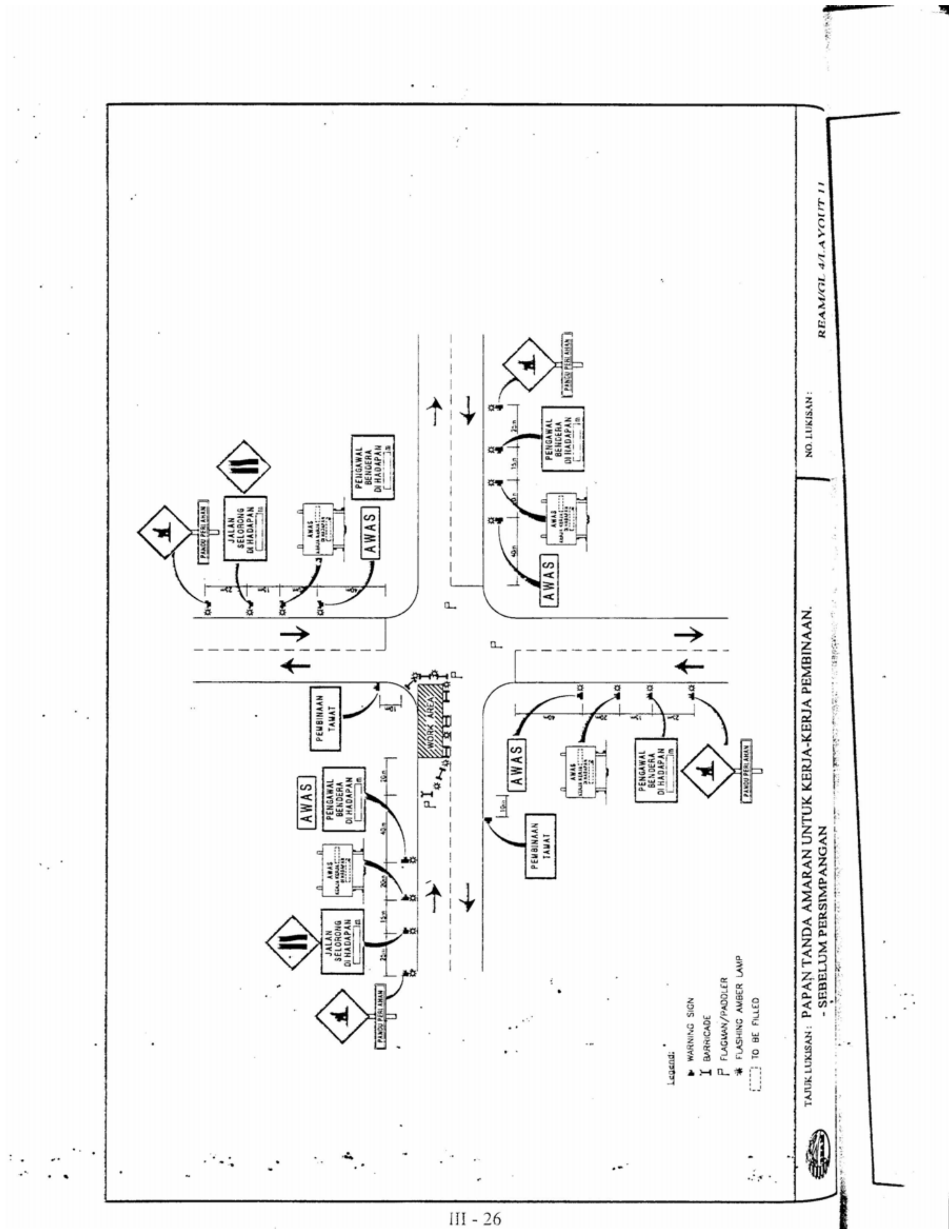


Figure D25: Traffic Management

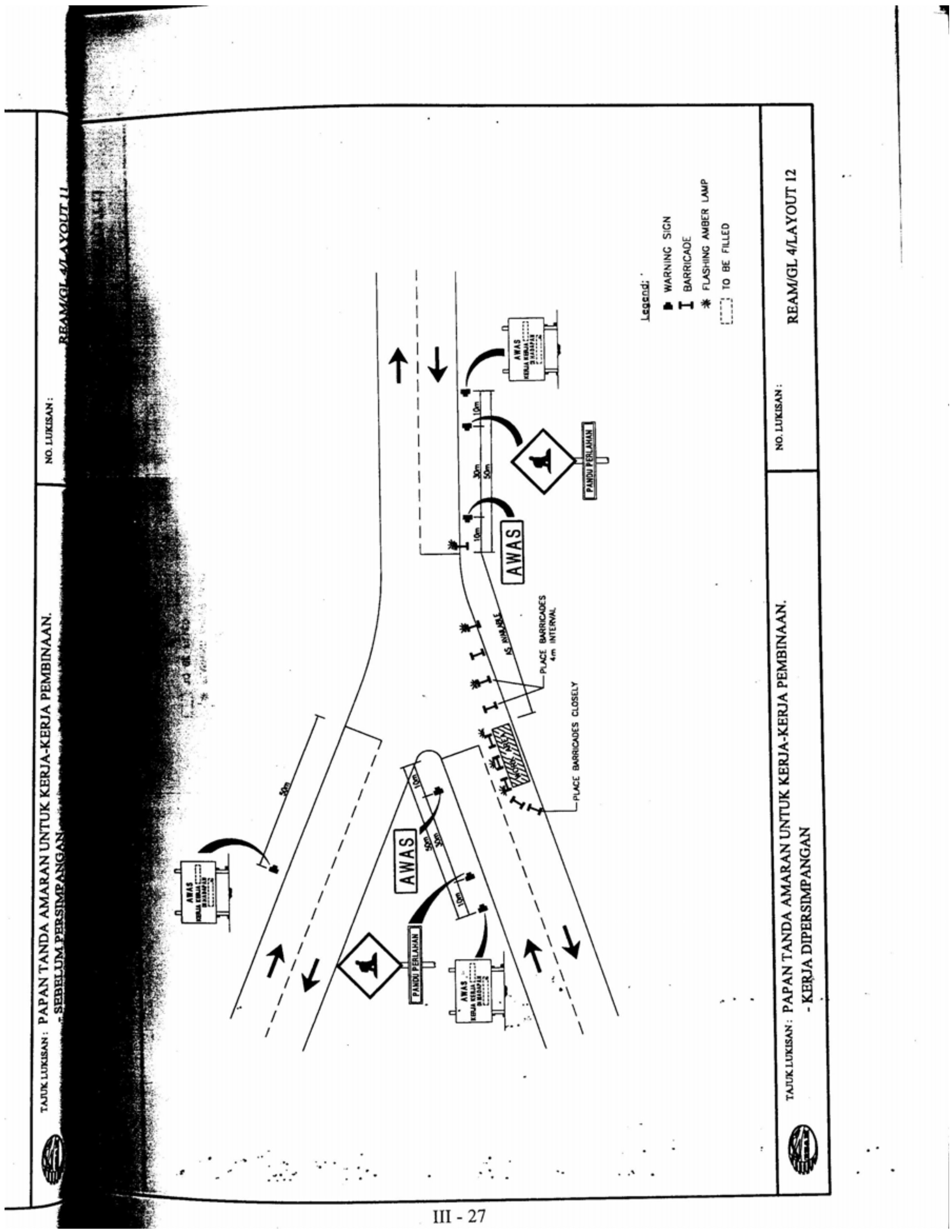


Figure D26: Traffic Management

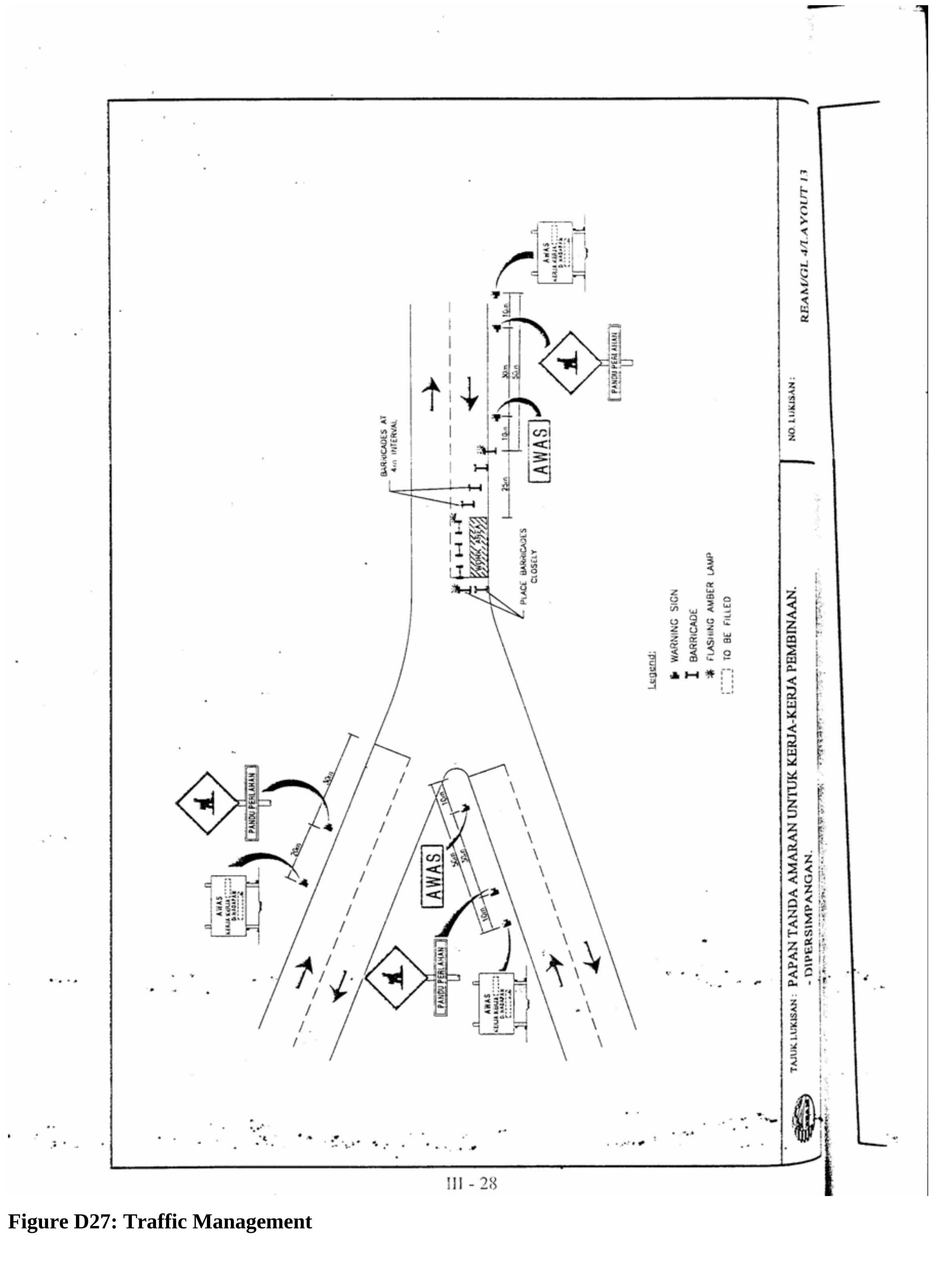


Figure D27: Traffic Management

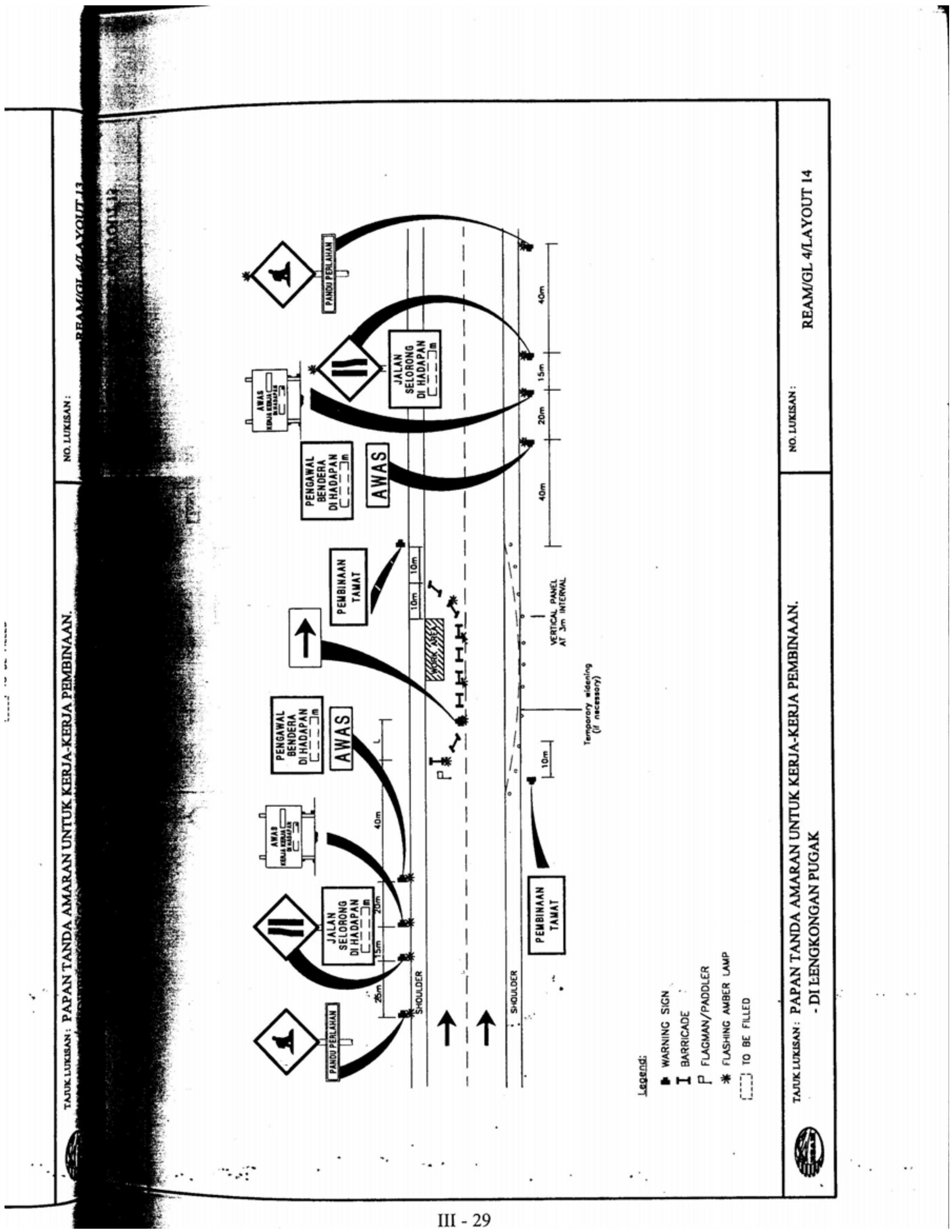


Figure D28: Traffic Management

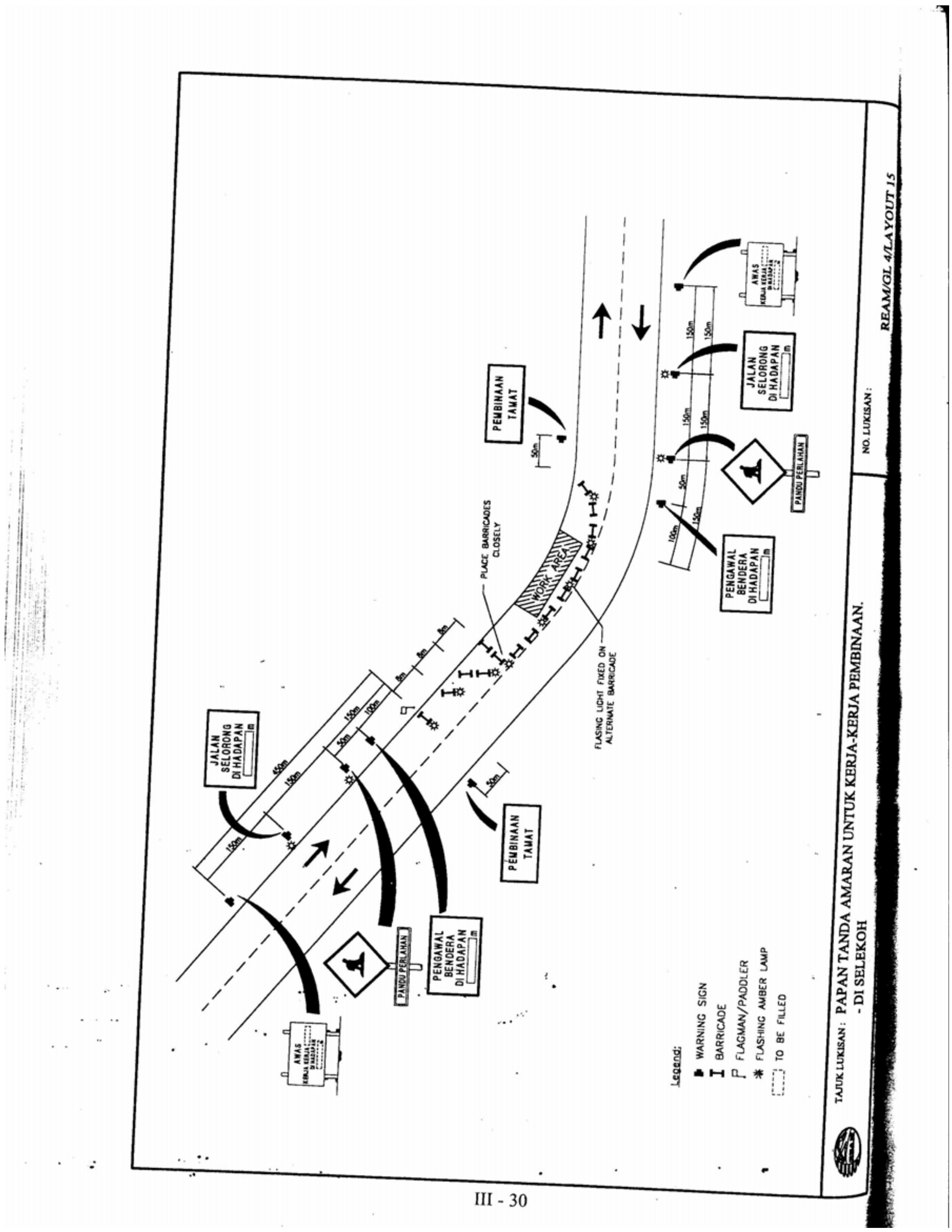


Figure D29: Traffic Management

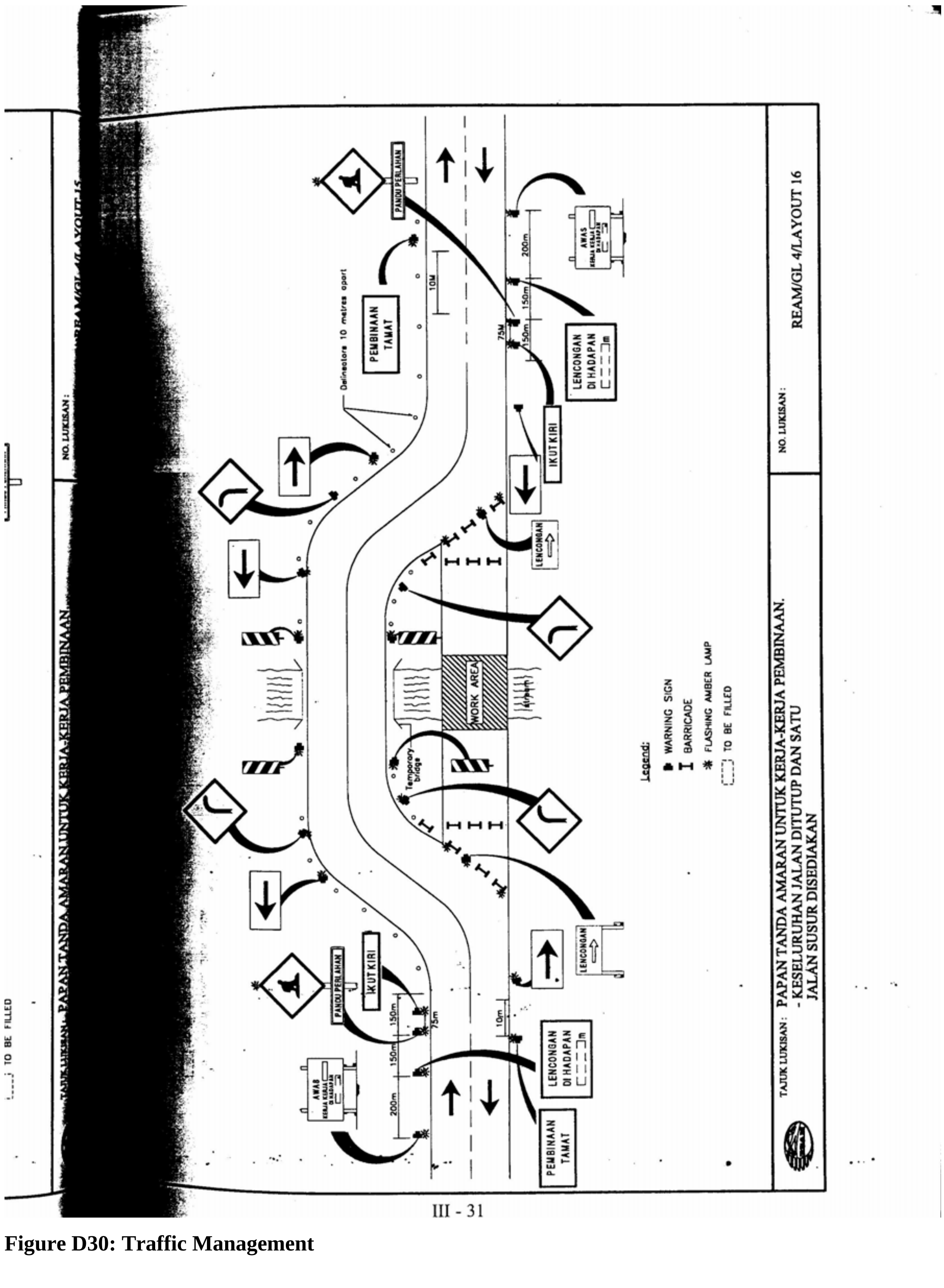


Figure D30: Traffic Management

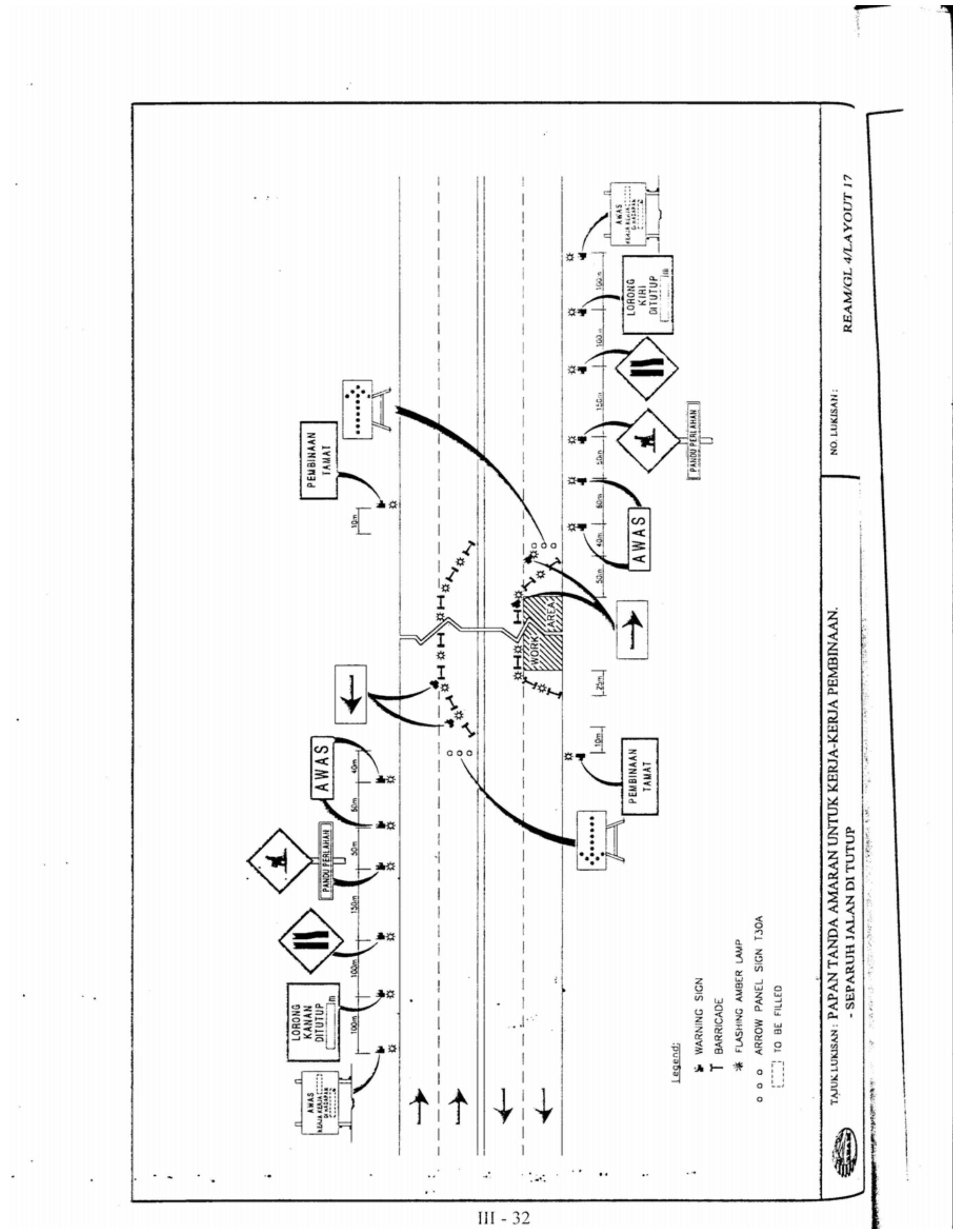


Figure D31: Traffic Management

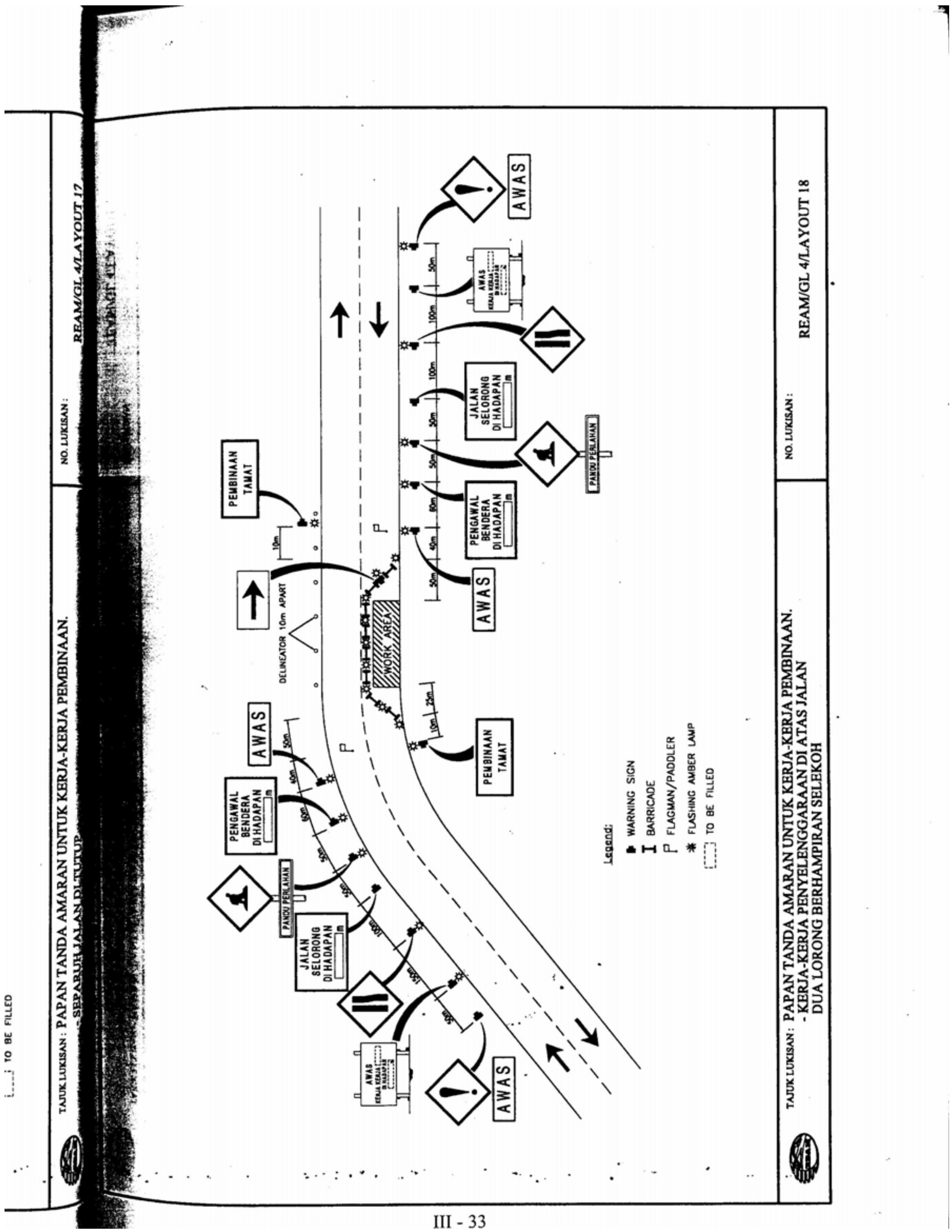


Figure D32: Traffic Management

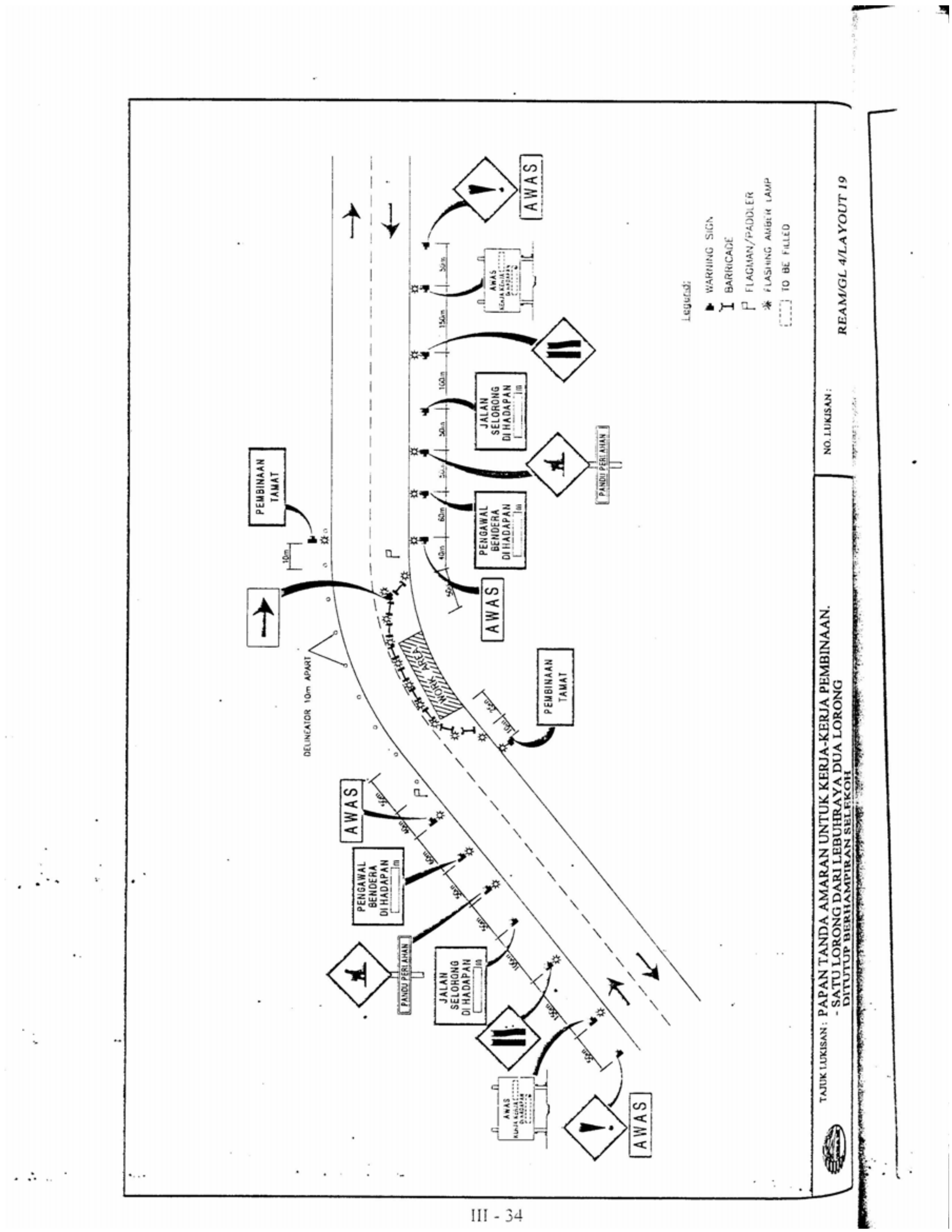


Figure D33: Traffic Management

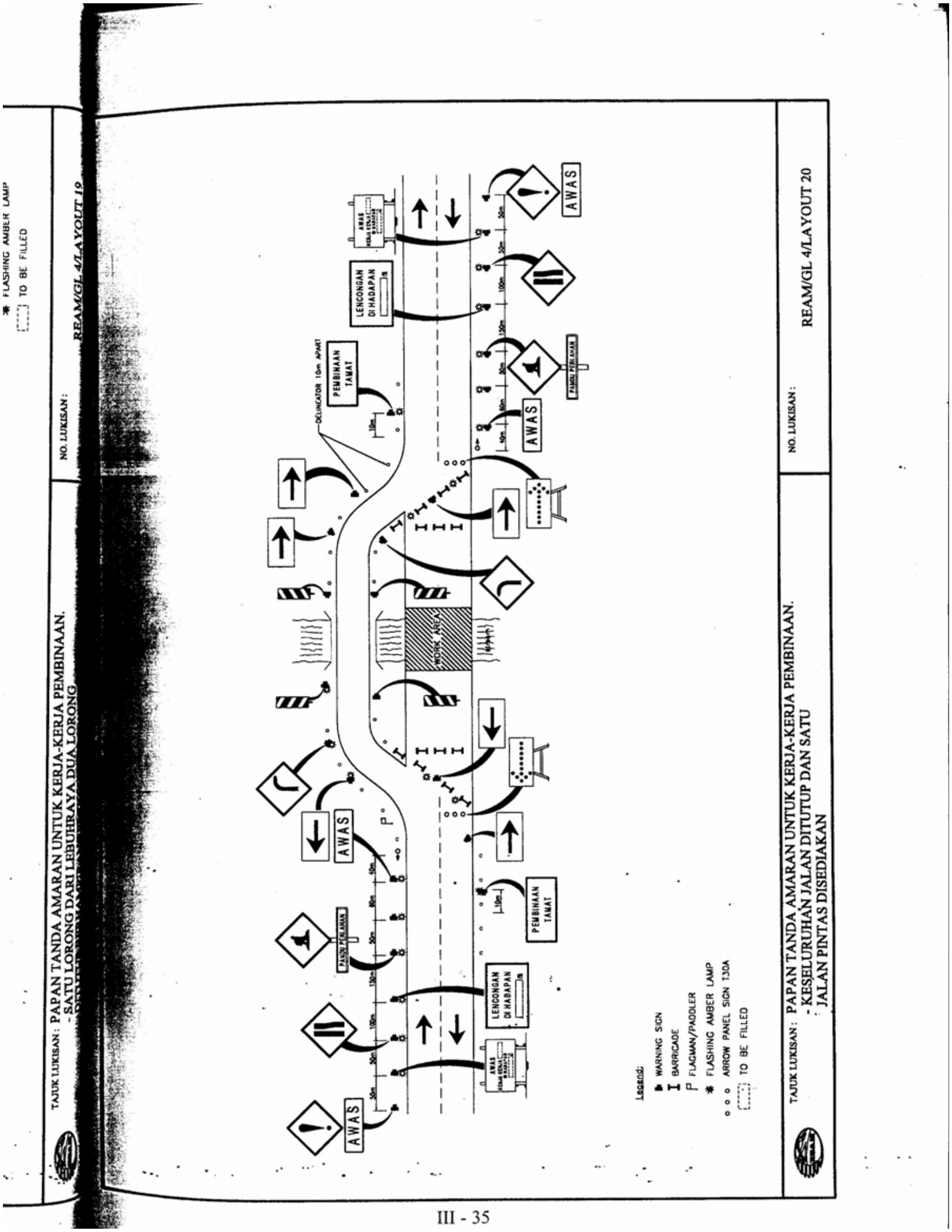


Figure D34: Traffic Management

APPENDIX E:

PHOTOGRAPHS

Case Study 1

Figure E1.1: Temporary Sign Board

Figure E1.2: Cable Obstruction

Figure E1.3: Multiple Layer of Asphalt

Figure E1.4: Excavation Material

Figure E1.5: Excation Material Used for Backfilling

Figure E1.6: Fine Sand

Case Study 2

Figure E2.1: Construction of Trench

Figure E2.2: Pipe Clamp and Protective Cover

Figure E2.3: Pipe Rollers

Figure E2.4: Water Storage for HDD

Figure E2.5: HDD Machine

Figure E2.6: Pipe Coming Out from Exit Pit

Case Study 3

Figure E3.1: Roding

Figure E3.: Compact Roller

Figure E3.3: Poor Traffic Management

Figure E3.4: Tack Coat

Figure E3.5: Premix is Spread

Case Study 4

Figure E4.1: Joint Bay Not Covered

Figure E4.2: Pulling Cable Machine

Figure E4.3: Excavation of Pavement

Figure E4.4: Excavated Material Side of Trench

Figure E4.5: Pulling Cable Method

Figure E4.6: Cleaning of Site

APPENDIX F:

TECHNICAL DRAWINGS

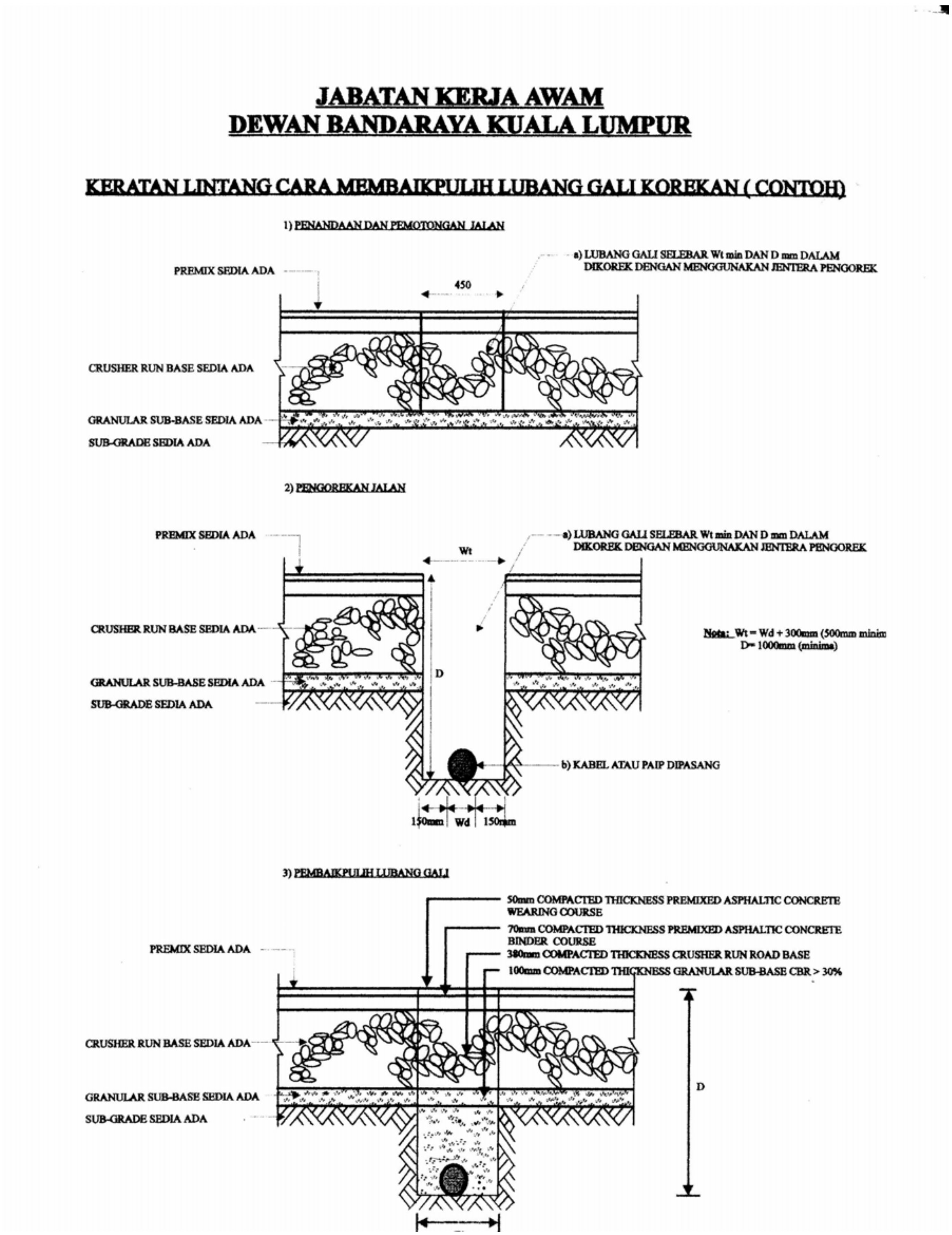


Figure F1: Trench Drawing

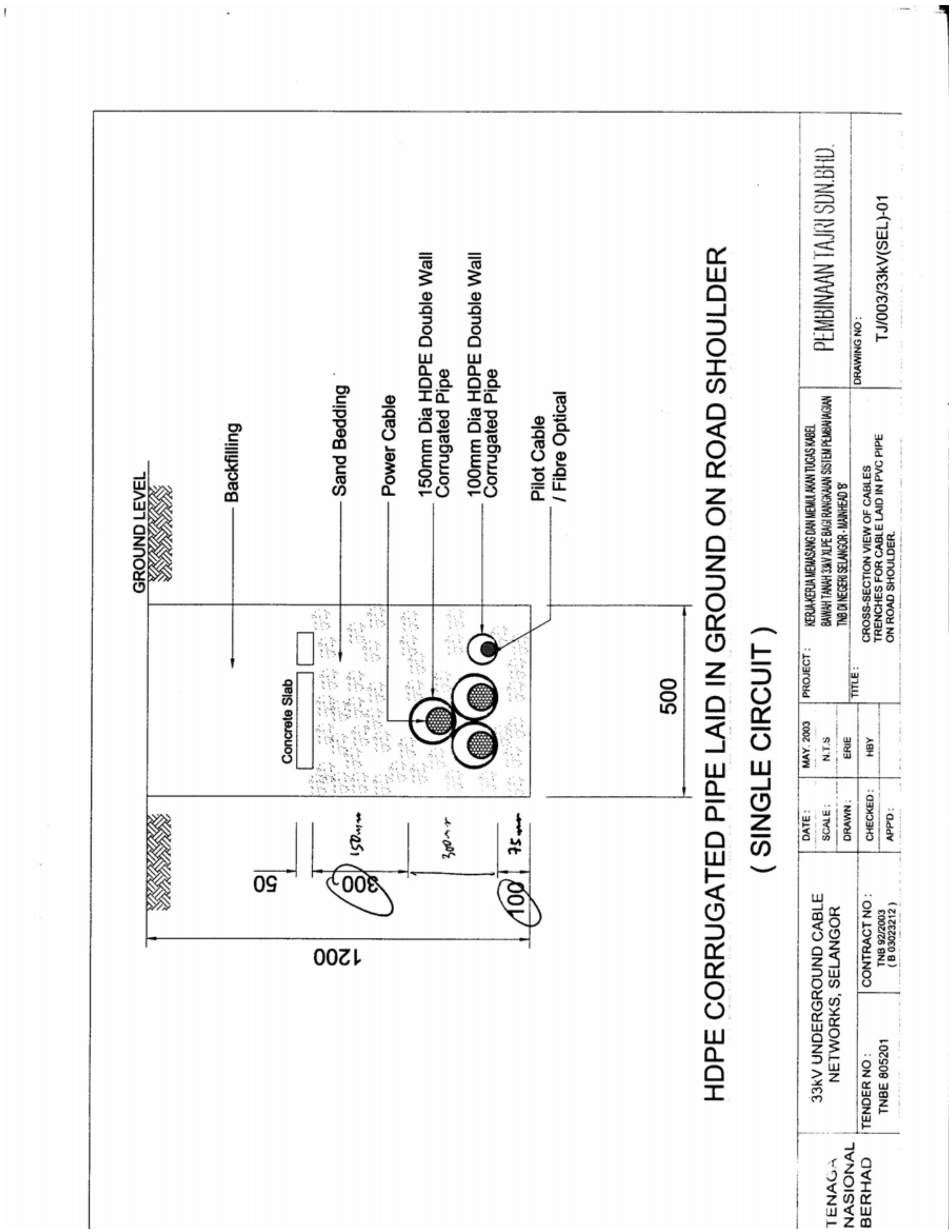


Figure F2: Trench Drawing

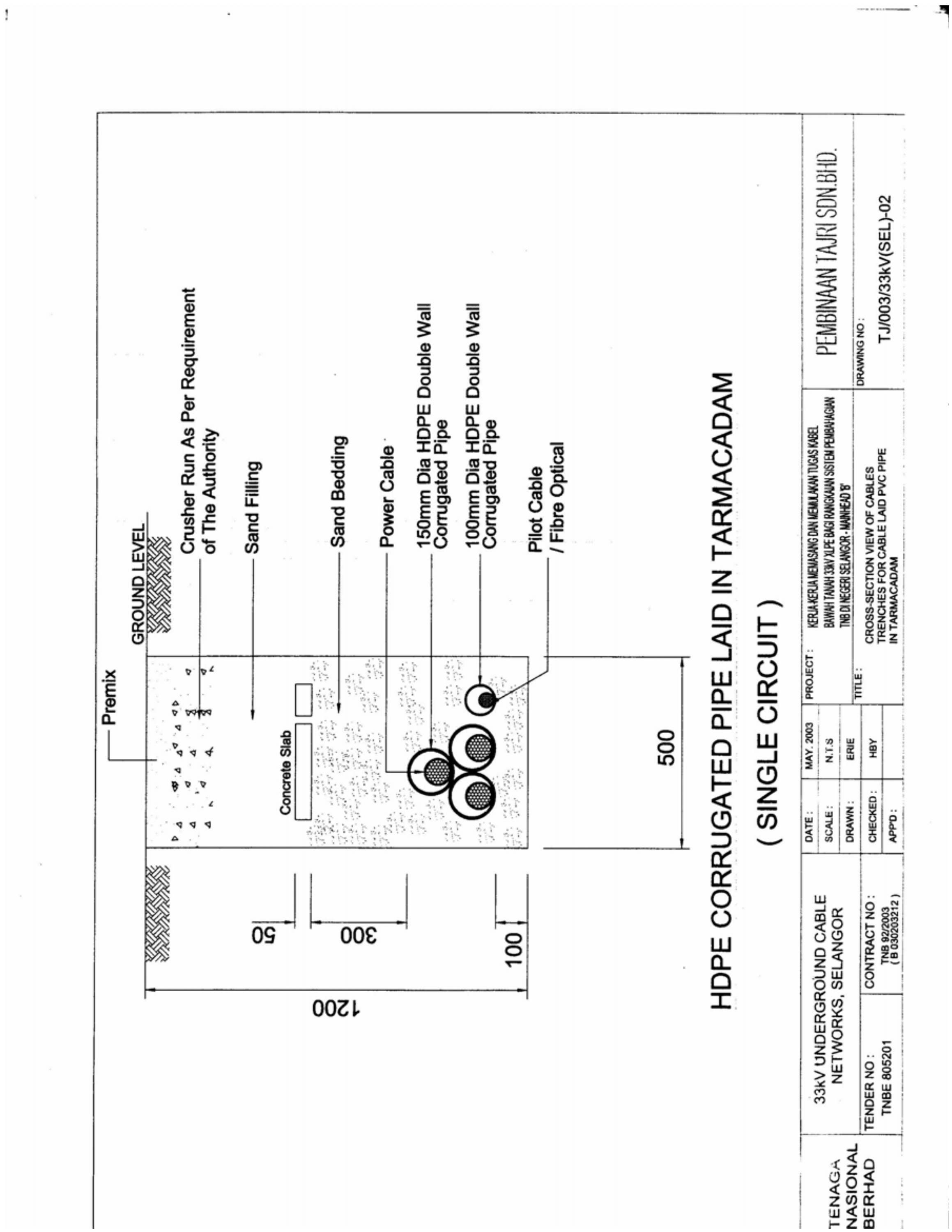


Figure F3: Trench Drawing

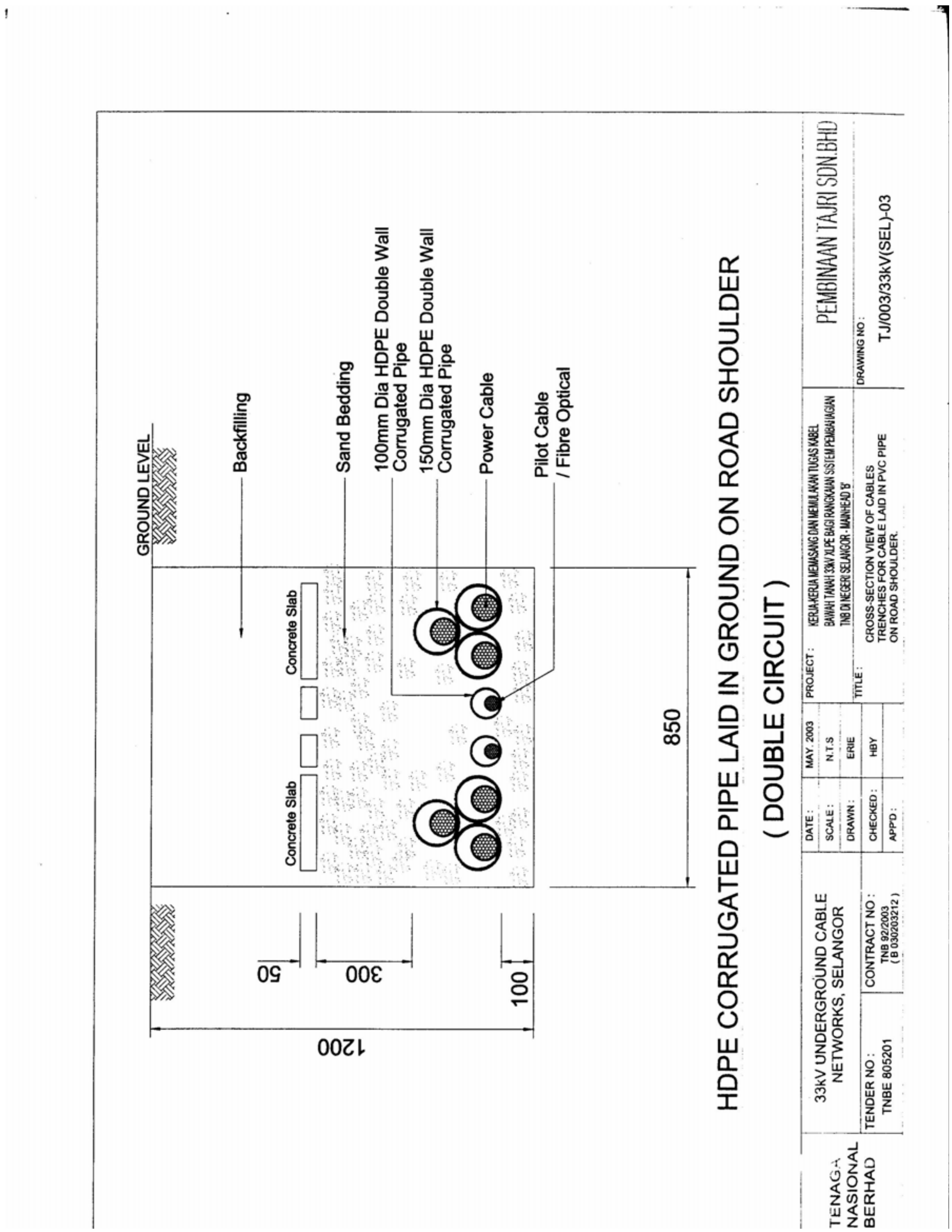


Figure F4: Trench Drawing

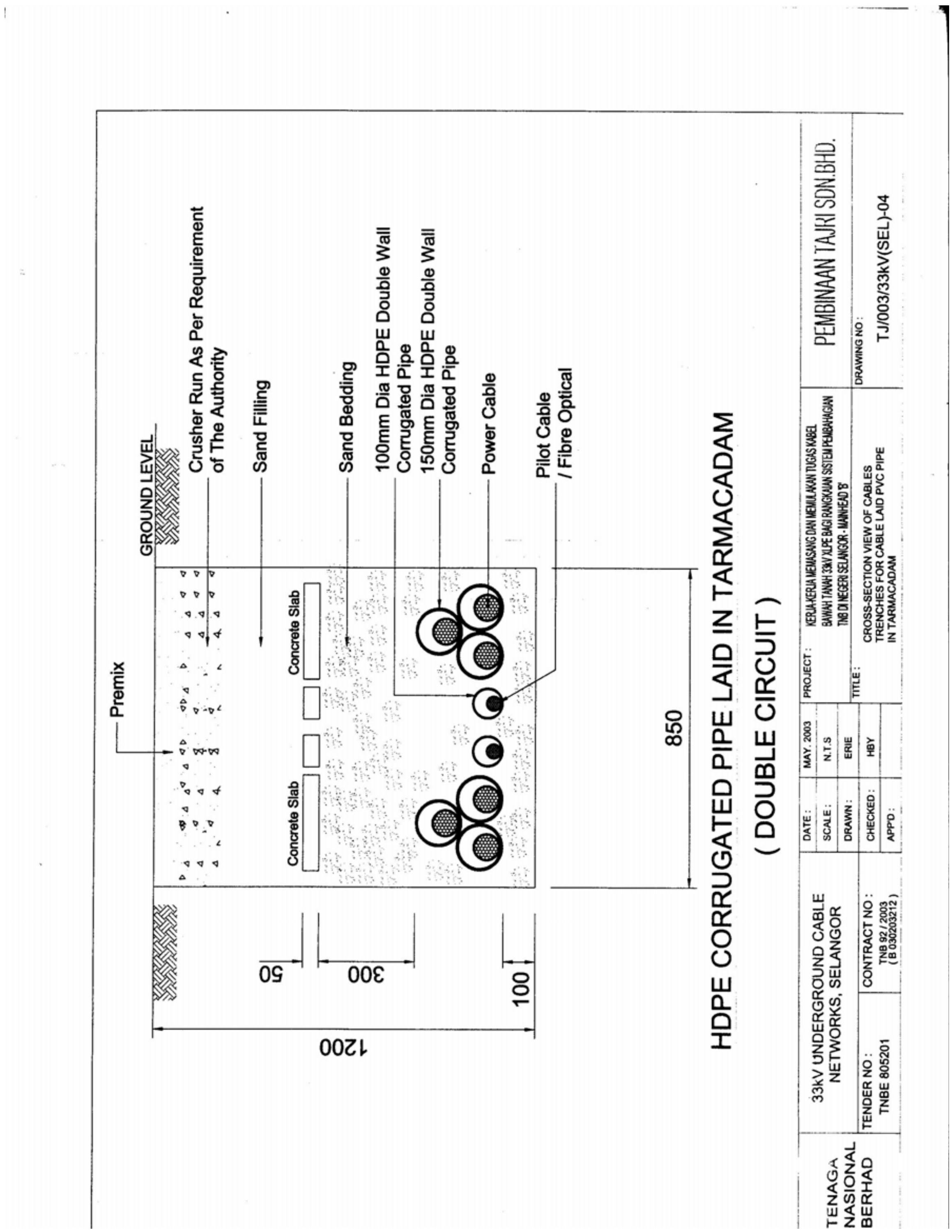


Figure F5: Trench Drawing

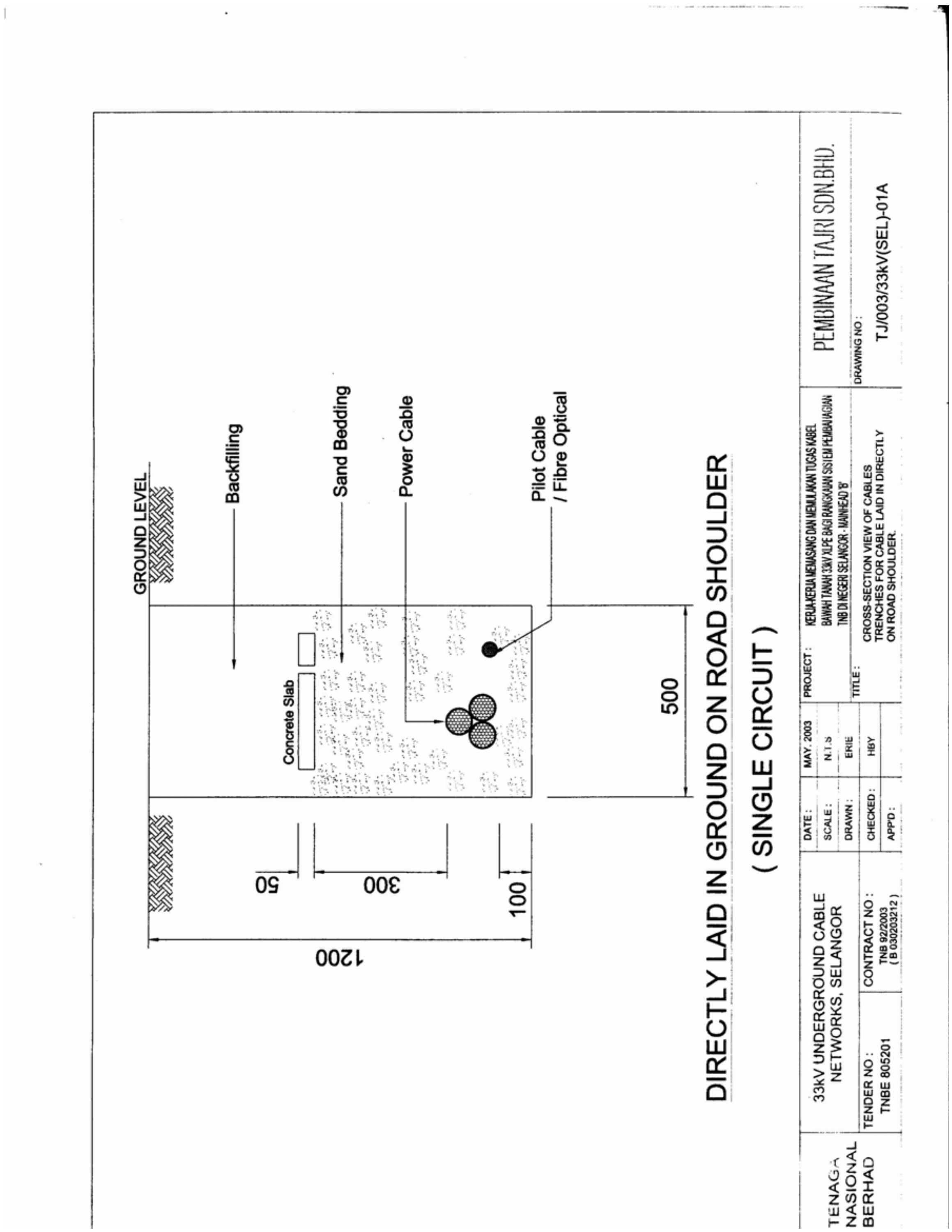


Figure F6: Trench Drawing

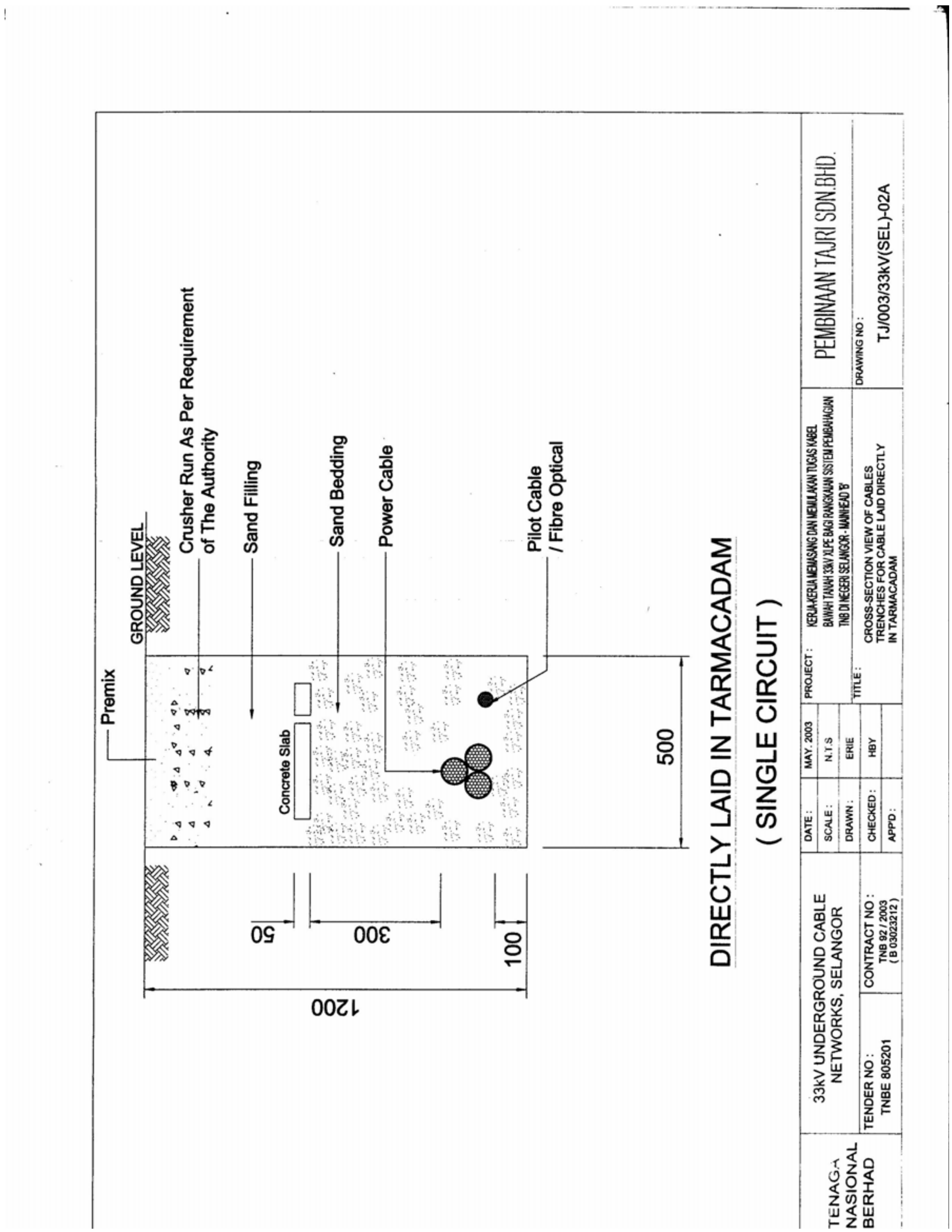


Figure F7: Trench Drawing

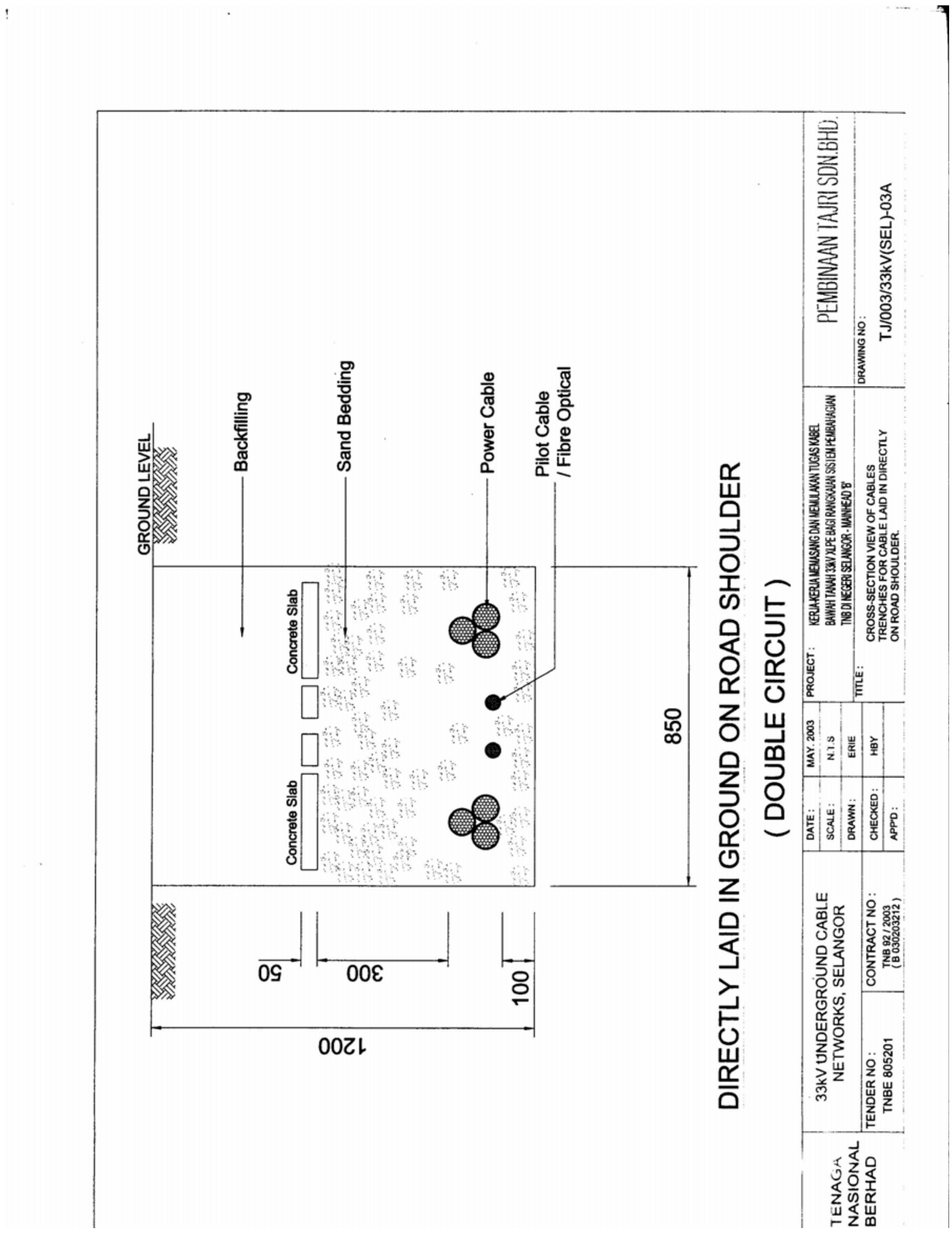


Figure F8: Trench Drawing

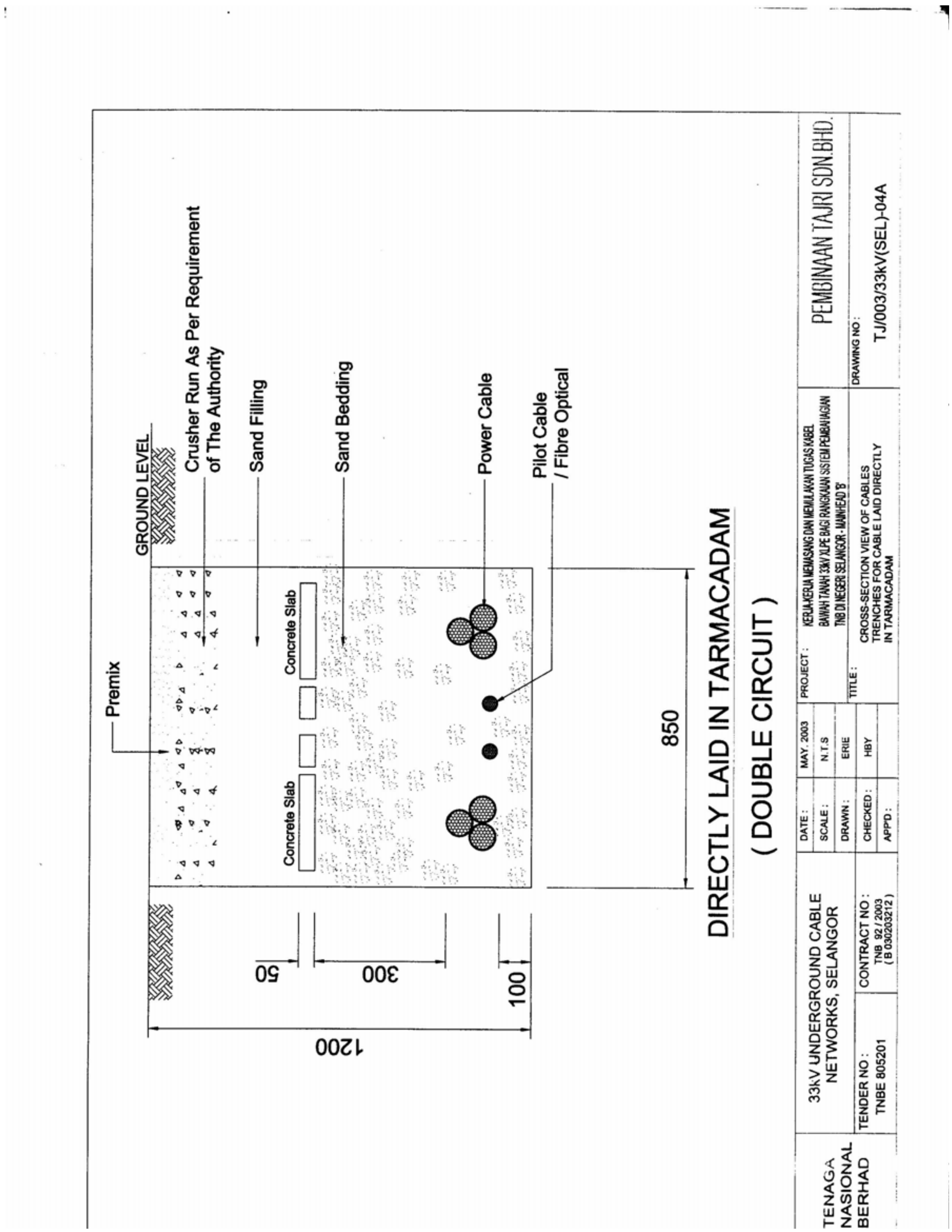


Figure F9: Trench Drawing

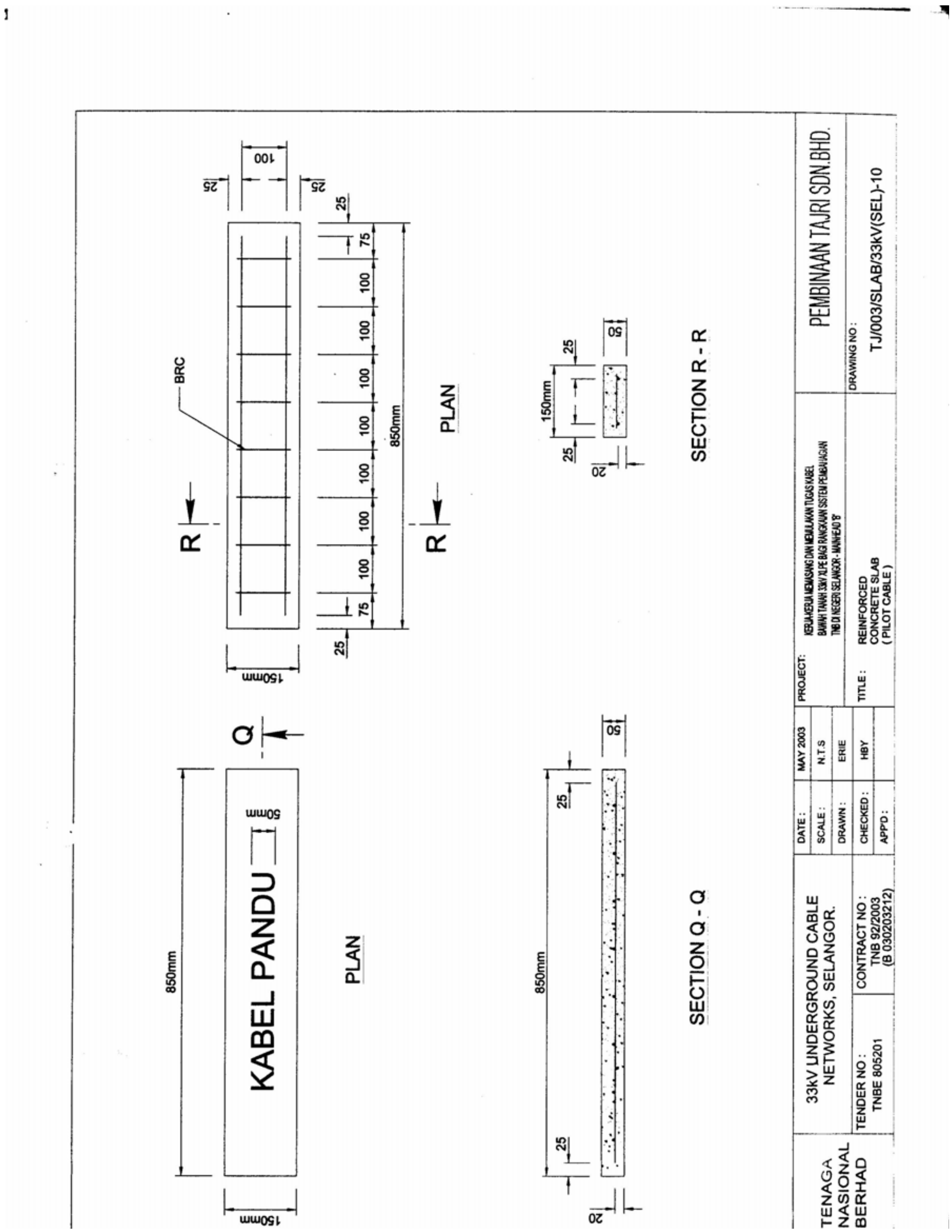


Figure F10: Protective Slab Drawing

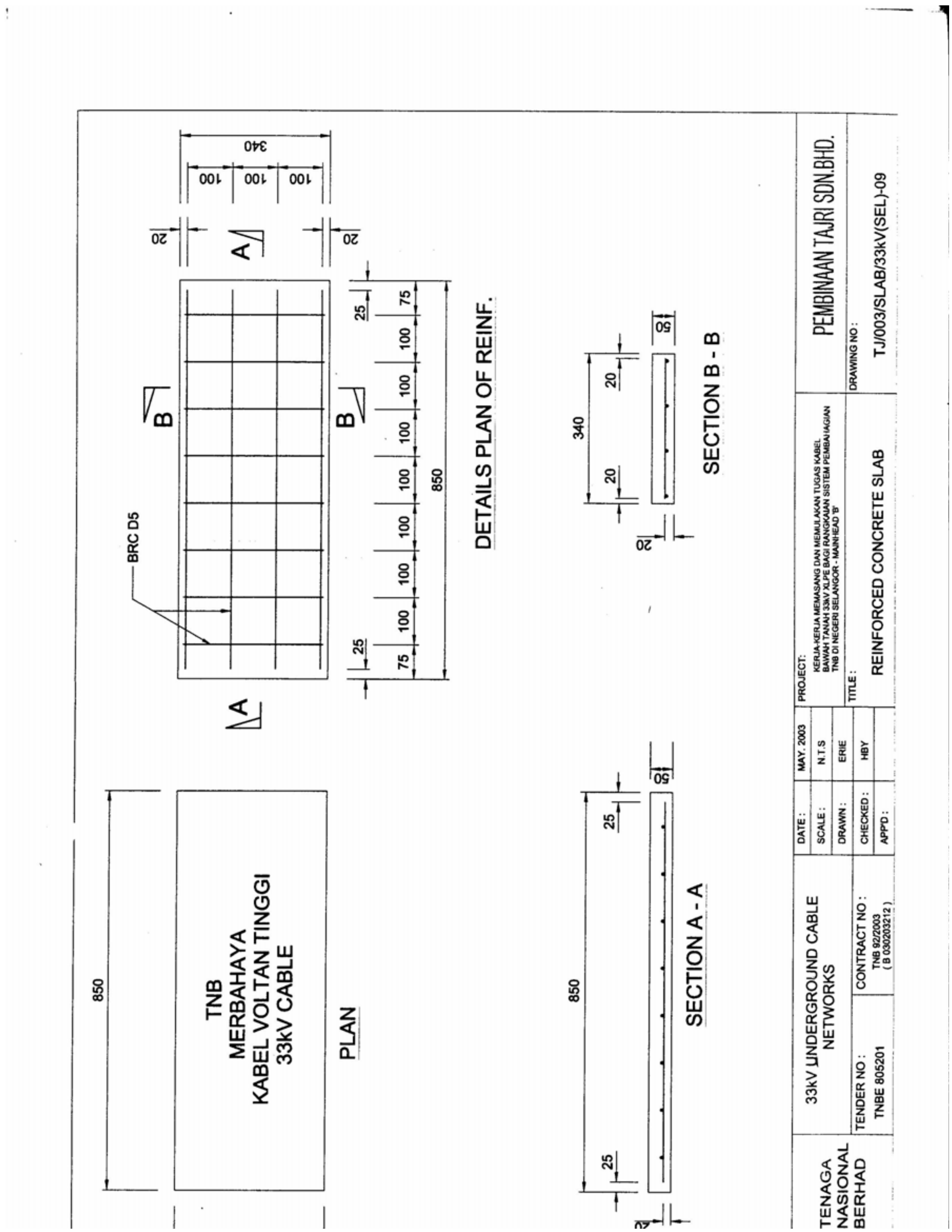


Figure F0.1: Protective Slab Drawing

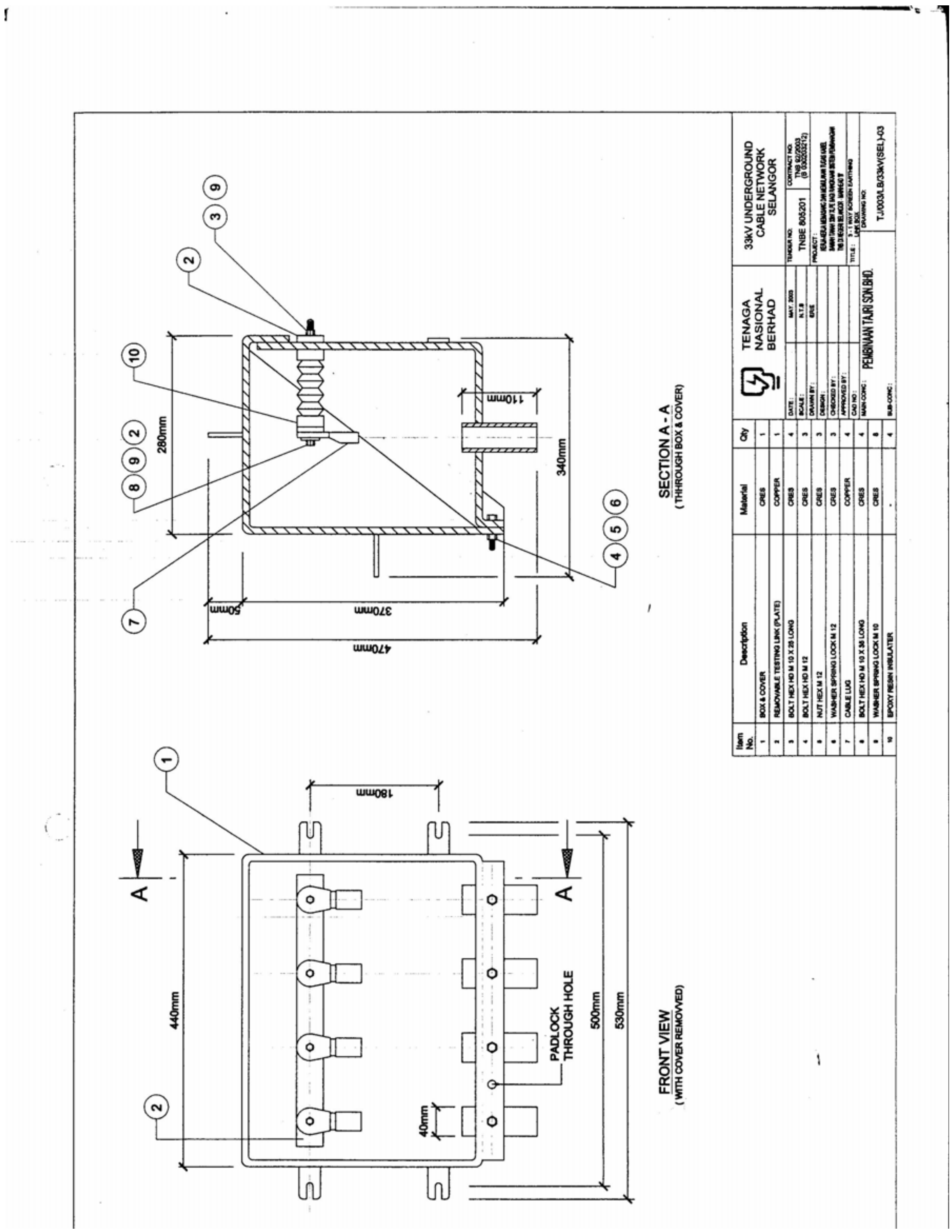


Figure F0.2: Link Box Drawing

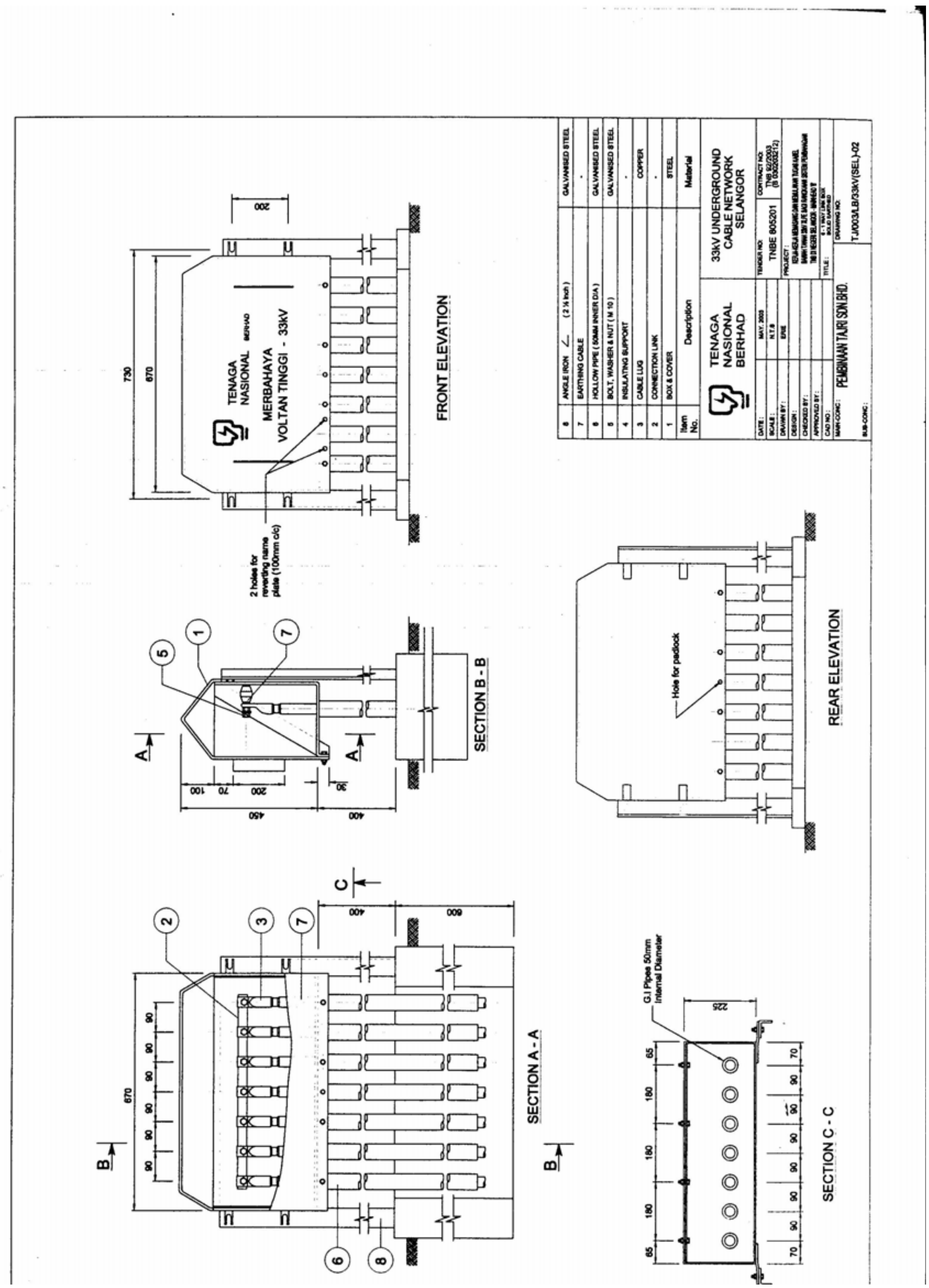


Figure F13: Link Box Drawing

APPENDIX G:

SITE PLAN

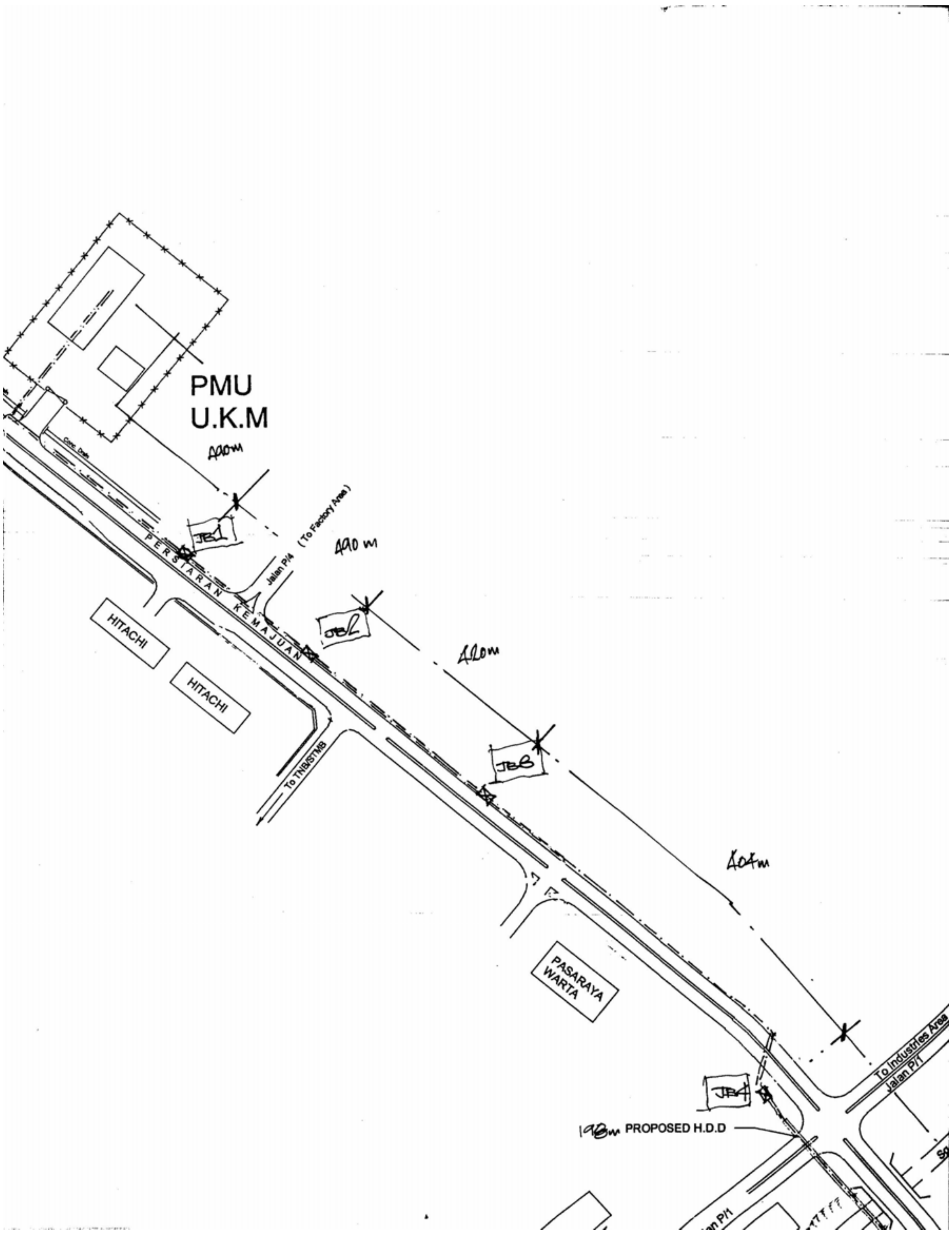


Figure G1: Site Plan of Site 1