University of Southern Queensland

Faculty of Health, Engineering and Sciences

Investigation on the properties of concrete with Expanded Polystyrene

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ABSTRACT

Expanded polystyrene (EPS) Concrete is a form of light weight concrete made from cement and EPS beads. EPS concrete is a popular material used in construction industry due to its environmental characteristics. The recent years has shown an exponential growth in the application of the EPS because of its variety of characteristics that benefits it over the normal concrete. EPS concrete has good insulating and energy absorbing properties. The research on this topic can be tracked back to 1973, when cook first investigated the use of EPS replacing the aggregate in concrete.

The purpose of this project is to investigate the mechanical properties of concrete, when the fine aggregate is replaced by EPS. During the initial research on this topic, a gap was identified in using Fly Ash (FA) as a substitute to cement. Fly Ash has properties similar to that of cement and is proved by many researchers to increase the mechanical properties of concrete. The literature review suggested that the addition of EPS decreases the various properties of concrete. So, in order to substitute the lack of strength in concrete sue to aggregate replacement with EPS, Fly ash is used in this project to find the total effect on the mechanical properties of concrete. After the completion of literature review it is decided to use a percentage replacement of replacement of 10%, 20%, 30% fine aggregate with EPS beads. The replacement of cement with Fly Ash was capped at 20% as it gives the best results, which is suggested by the literature review. The experimental tests for this project were conducted in accordance to the relevant Australian Standards. The fresh concrete tests considered for this project are slump test, compaction factor test and Vebe test. The hardened concrete tests conducted for this project are compressive strength, indirect tensile strength and flexural strength test. The samples for hardened concrete test are tested after the 28-days of curing.

The experimental part of this project started with making the concrete mix with percentage replacement of EPS and Fly Ash. A control mix was made with no replacement and it was used as a standard to compare the results from other mixed batches. The other batches with different percentage replacement of fine aggregate and cement with EPS and Fly Ash respectively. The tests for fresh concrete resulted in a decrease in the workability of concrete with the replacement of fine aggregate with EPS. The addition of Fly Ash in the mix it

slightly increased the workability, but it still couldn't compare to the results from the control batch. But the difference between the control mix and mix with EPS and Fly Ash wasn't significantly less. A similar observation is made from the results of hardened concrete testing. The compressive strength of the samples with only EPS replacement is significantly less than the control sample. The addition of Fly Ash resulted in increase of compressive strength and the last sample had a comparable strength to that of control sample. The results for indirect tensile strength are very similar to that of compressive strength results. The flexural strength test resulted in a little unexpected outcome. The flexural strength for the samples with only EPS replacement is higher than the samples with EPS and Fly Ash replacement.

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I would like to thank Dr Weena Lokuge for her immense support and encouragement throughout this project. This project was completed without any major roadblocks because of her advice and support on the problems that were faced during the project. I would also like to thank the technical staff for their support during the experimental work for the project. Finally, I would like to thank my friends and family for their patience and support throughout this year.

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NOMENCLATURE

EPS = Expanded Polystyrene

FA = Fly Ash

LWAC = Lightweight Aggregate Concrete

Chapter 1

Introduction

Expanded polystyrene (EPS) Concrete is a form of light weight concrete made from cement and EPS beads. EPS concrete is a popular material used in construction industry due to its environmental characteristics. The recent years has shown an exponential growth in the application of the EPS because of its variety of characteristics that benefits it over the normal concrete.

1.1 Research Scope

The study is based on finding the physical properties for the mechanical of concrete using EPS as aggregates. EPS is an excellent packaging material which is made up of 98% of air. So, its very lightweight, strong and has good insulating properties. Cook experimented with EPS particles in concrete in the 1970s (Cook, 1972). The systematic research began in the 1990s, when a French scholar used different proportions of EPS particle in concrete to determine the relationship between strength and porosity.

The density and strength parameters defined the correct mix stage for the EPS concrete, which was manufactured by partially replacing standard particles in concrete. The link between strength and a wide variety of densities of EPS concrete might be produced by altering the mix scale of the EPS particle. Several research have also been conducted on the effect of expanded polystyrene particle size on concrete compressive strength. To strengthen the homogeneity of the EPS particle in LWC and ensure that the particle does not float during concrete vibration, Chen and Liu employed styrene butadiene rubber (SBR) latex as a polymeric additive in EPS concrete. (B. Chen and J. Liu, 2005). Several research on the effect of expanded polystyrene particle size on concrete compressive strength have also been conducted. To improve the homogeneity of the EPS particle in LWC and ensure that the particle does not float during concrete vibration, Chen and Liu employed styrene-butadiene rubber (SBR) latex as a polymeric additive in EPS concrete.

The majority of research on unmodified expanded polystyrene (EPS) concrete has revealed that increasing the number of EPS particles affects the concrete's toughness and mechanical qualities. Furthermore, in these studies, smaller EPS bead sizes in concrete have been proven to improve strength. For example, an experiment looked at the engineering qualities of concrete by partially replacing natural coarse aggregate with an equivalent amount of chemically coated EPS at 30%, 50%, and 70%. Compressive power, unit weight, and modulus of elasticity all reduced as EPS content in concrete increased, but drying shrinkage and creep increased (L. Jiang, 2012).

When compared to conventional cement, studies have shown that incorporating fly ash (FA) in concrete can save a significant amount of energy and money in the cement manufacturing process, as well as improve the engineering qualities of concrete. For example, EPS beads were used in concrete and mortar using processed (rather than unprocessed) fly ash as the cementitious ingredient in a recent study. The concretes had densities ranging from 550 to 2200 kg/m3. The percentage of EPS replacements ranged from zero to ninety-five percent. The EPS concrete mixes prepared with treated fly ash have lower water absorption values and better chemical resistance than regular concrete, according to the findings.

1.2 Research Objectives

There has been a considerable amount of research conducted on the properties of Expanded polystyrene concrete. The research conducted pointed out some variables that affect the durability of the EPS concrete. However there only a marginal amount of research available that combines the tests on EPS concrete to find out the effects of the variables. The variables that are identified through the research are as follows:

- Variation of the EPS particle sizes.
- Replacement of Coarse aggregate volume.
- Replacement of Fly Ash (FA) with cement.

The research was focused on these variables, which are the most important to provide durability to the concrete. Although there is a considerable amount of research on using Fly Ash as a replacement for cement in tradition concrete but using Fly Ash with EPS concrete is very few.

Chapter 2

Literature Review

2.1 Introduction

The literature review for this project focuses on three main aspects of the EPS concrete. Through the initial research on this project, it was determined that the main variables that affect the mechanical properties were the size of EPS beads and the replacement of coarse aggregates with EPS beads. Essentially these factors determine the various properties of concrete and variations to these factors varies the properties of concrete. But in the initial research, a research gap was identified, being the replacement of peatland cement with Fly Ash (FA) to further reduce the impact of EPS concrete on the environment. So, this literature review is carried out using these three aspects as a base.

2.2 EPS particle Size

The size of expanded polystyrene particles greatly effects the compressive strength of the concrete. Another factor that affects the workability and the compressive strength of the concrete is the formation and the number of EPS particles used as aggregate in concrete. The research on this topic started in 1973, with the investigation by D.J. Cook on using EPS as aggregates in concrete (Miled, K. and Le Roy, R., 2007).

The EPS particle size used in most of the is 1mm, 2.5mm and 6.3mm. The concrete was then mixed with the different EPS particle size as the main aggregate to minimise the effects of any other aggregate, to find out the compressive strength of the concrete based on the different EPS particle sizes.

Fig. 2.1 – EPS concrete cylinders containing respectively 1 mm, 2.5 mm, and 6.3 mm EPS beads. (Shi, W., Miao, L. and Luo, J., 2016)

Three different batches were created using similar quantities of cement, sand, and water. The only variable in this test was the EPS particle size. The other variable was the density of the EPS concrete which was also achieve by varying the amount of polystyrene. It was also noted that the for a very low density concrete the effects of EPS particle sizes becomes negligible (Parant and Le Roy, 1999). A series of tests were conducted and the results from all the tests concluded that the concrete with EPS particle size of 1mm had the highest compressive strength. The compressive strength of the concrete without EPS particles and with normal aggregates was used as a matrix to compare the compressive strength with concrete with different EPS particle size.

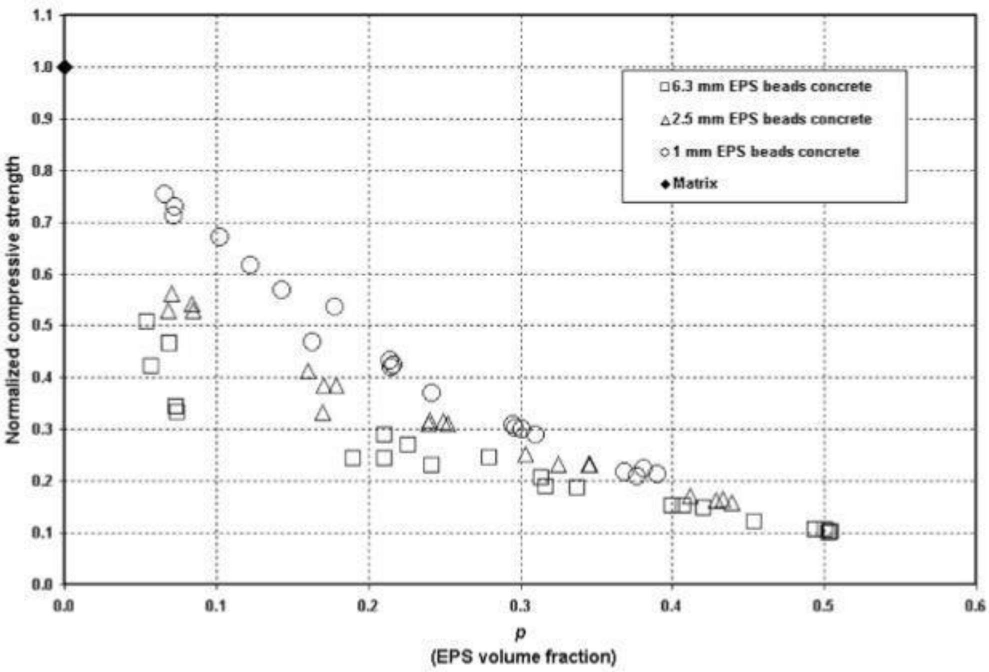


Fig. 2.2 – Compressive strength test results. (Babu, G. and Babu, S., 2004)

The compressive strength of the of concrete with 6.3mm EPS was less than the 1mm EPS particle size by a considerable margin. Although the difference between the compressive strength of 2.5mm and 6.3mm was very close.

At the Vietnam Institute for Building Science and Technology, Vietnam used EPS particle size of 0.63mm 1.25mm and 5mm. In this the test were conducted using the different EPS particle size and using coarse aggregates of size greater than 10mm. The tests were conducted to find the workability and the compressive strength of the concrete mixed with EPS. The test revealed that the smaller EPS particle has the highest workability from all the other concrete with greater particle size (Minh, D. and Phuong, L., 2018). The workability decreased with the increase in the size of EPS particle size and during the slump test it was determined that the slump can be increased by using smaller EPS particle size. The compressive strength results were no exception.

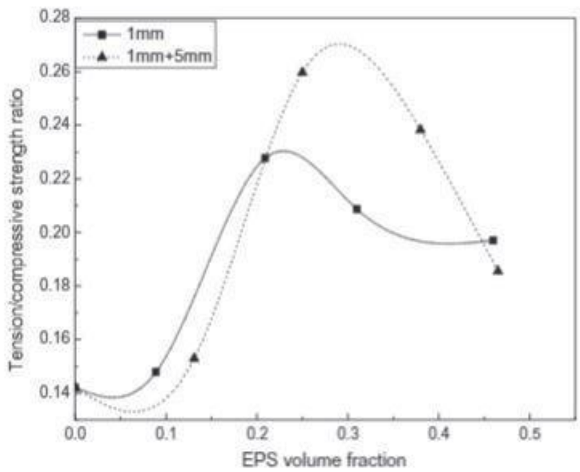


Fig. 2.3 – Ratio of compressive and tensile strength test. (Minh D. and Phuong L. 2018)

The compressive strength increased with the decrease in the EPS particle size. But the other factor that affected the results was the size of the coarse aggregates and it was suggested that use of coarse aggregates more than 10mm decreases the workability and the compressive strength of the concrete.

EPS particle sizes of 1mm, 1.5mm, 2.8mm and 6mm was is used by Sang-Yeop Chungand Mohamed Abd Elrahmanand Dietmar Stephan in their research. But with different sized particles, different formations were also used determine the effects of formation on the compressive strength of the concrete. The results in this case were also similar to the other discussed papers. The concrete with EPS particle size of 1mm had the highest compressive strength. But the regularly arranged particles also had the improvement in the compressive strength.

Extended polystyrene (EPS) dots are a fake superlight total (regular thickness 30 kg/m3) with a smooth surface and adjustable shape. Previous research on extended polystyrene (EPS) concrete fuses millimetre-size EPS circles into mortar or concrete glue to minimise thickness and thermal conductivity. In terms of functionality and volume stability, EPS concrete surpasses conventional lightweight cement (LWAC). It's been utilised to make light-weight concrete bricks, as well as major load-bearing components. Primary components made of EPS cement may be manufactured on the building site. This offers benefits over other materials, such as autoclaved cell solids, which require a highly controlled environment in a production facility for manufacturing interaction. The disadvantages of EPS concrete, on the other hand, are well-known, including low thermal resistance (i.e., EPS combusts and releases toxic gas at temperatures over its start point) and the tendency for EPS totals to isolate during mixing due to their thinness. Low mechanical strength and a tendency for failure have been observed with EPS concrete. Aglan et al. used concrete glue to include microscopic size empty expandable thermoplastic microspheres (ETM) with typical molecular sizes of 35–55mm. Concrete glues containing 0.1–0.4 wt% ETM enhanced stiffness and fracture strength, according to the researchers. This study uses two types of EPS dots, one with a normal molecule size of 2.5 mm (dubbed "medium") and the other with a molecule size of 1 mm (dubbed "little"). An air stream strainer was used to evaluate the molecular size of EPS globules. Medium and small EPS dots were tested at densities of 0.013 g/cm3 and 0.031 g/cm3, respectively. According to the maker's material datasheet, the thermoplastic microspheres are delivered by AkzoNobel and have a usual molecular size of 35–55l m. Gas psychometry was used to test the thickness of ETM particles at 0.025 g/cm3.

The tests were performed on different types of mixtures in this article, but we are only interested in the EPS particle size effecting the properties of concrete. The proportion of material used are given below.

Table 2.1 – Materials used in this research. (Haibo. L 2017)

Group ID#	Material	Particle size (μm)*			Wall thickness – t (μm)**	t/D_{50}	Density (g/cm³)	Crush strength (MPa)***
		D_{10}	D_{50}	D_{90}				
EPS-M	EPS beads (2.5 mm)	–	250	–	–	–	0.013	–
EPS-S	EPS beads (1 mm)	–	100	–	–	–	0.031	–
TPMS	Thermoplastic microsphere	–	35–55	–	–	–	0.025	–
HGM K25	Hollow glass microsphere (HGM)	25	55	90	0.85	0.015	0.25	0.75
HGM S32		20	40	70	0.88	0.022	0.32	2
HGM S38HS		19	44	70	1.20	0.027	0.28	5.5
HGM H50		15	35	50	1.70	0.049	0.50	10
HGM S60		12	29	48	1.49	0.051	0.60	10
FAC E106	Fly ash cenosphere (FAC)	42.6	81.3	125.2	4.8	0.059	0.91	1.6–3.2
FAC E160		44.9	90.6	155.4	6.0	0.066	0.76	1.6–3.2
FAC E200/600		81.3	349.1	457.2	16.5	0.047	0.82	1.6–3.2

Unlike thermal properties, the kind and size of LWF employed determine the compressive strength of the. The compressive strength of numerous lightweight useable fillers and volume fractions is summarised in Table 2.1, with compressive strength plotted versus dry thickness of the materials. As shown in Fig. 2.4, the compressive strength of EPS dot sand expandable thermoplastic microspheres (ETM) falls rapidly as mf rises (a). The weakening is mostly due to the presentation of the delicate overall stage, which causes pressure fractures to form inside the materials while mechanical stacking is taking place. While Roy et alearlier.'s study on EPS concrete showed that smaller molecules offer better strength, there is no obvious difference in compressive strength between two different size EPS mortar groups (2.5 mm and 1 mm) (see Fig. 2.4. a). In any case, it was observed that when mf is low, LWC combos with ETM have compressive properties that are about 15% greater than their EPS companion. The explanation is considered to be a reduction in air content caused by the incorporation of ETM particles. On the other hand, the compressive strength of LWC mortars such as HGM and FAC is greatly reliant on the molecule size and shell quality (such as thickness) employed. When mf is low (15%), the compressive strength of LWC mortars improves with larger HGM focuses, as illustrated in Fig. 2.4. (b).

This is thought to be due to circular state, which improves the rheological characteristic (i.e., flowability) of newly mixed sand and reduces the air content (Table 2.1). When the volume part of HGM goes higher (>15 percent), the compressive strength begins to deteriorate – i.e., the empty design of HGMs allows pressure cracks to spread through the molecular shell, causing injury and material disappointment. With the same LWF volume concentration (or thickness), mortars with smaller molecules and a thicker shell offer higher mechanical strength, as shown in Fig. 2.4. (b). When the volume portion of EPS is high, this pattern becomes more prominent. At EPS 7%, the compressive strength is 32% (15 Mpa). while at EPS 28%, compressive strength is about 125% (27 Mpa) more grounded than the 100% EPS replacement. It's worth noting that the compressive strength of LWCC mortars containing almost 30% (absolute volume division) H50 and S60 HGM particles is nearly identical to the reference mortar, despite their densities being around 25% lower (see Table 2.1 and Fig. 2.4 (b)).

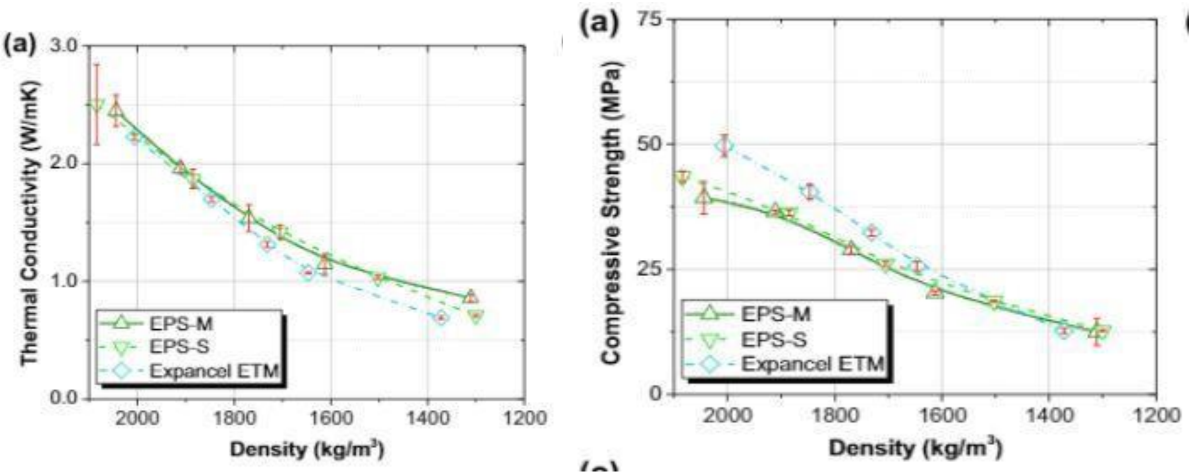


Fig. 2.4 – Thermal Conductivity and Compressive strength Vs Density of EPS (Haibo. L 2017)

2.3 Aggregate volume replacement

The amount of aggregate in concrete determines the strength and durability of the concrete. More number of coarse aggregates means that the concrete will have better compressive strength and durability. Usually, the ratio of coarse and fine aggregates is 45% - 75%. But if we replace it with EPS, then we need to determine the correct ration to determine the optimum strength and durability of concrete. There had been extensive research in the past to determine the optimum ratio.

2.3.1 Fine aggregate replacement

The percentage of 0, 10, 15, 20, 30 and 40% fine aggregates replaced by EPS was considered by Md. Golam Kibria. The use of this range of percentage will allow us to determine the best possible percentage of replacement. The replacement cannot be 100% because EPS has a less compressive strength then the fine aggregates such as river sand (Golam Kibria, 2017). The EPS beads are made up of 98% air and 2% polystyrene (Tamut T., 2014). The concrete was mixed with different percentages of coarse aggregates replacement with EPS beads. Then several tests were conducted to find the compressive strength of the concrete. The results revealed that as the replacement percentage increases the compressive strength decreases. The compressive strength for 0% replacement of coarse aggregates was 3500 psi (24 Mpa) and for 40% was 750 psi (5 Mpa). This shows that the addition of EPS particles decreases the compressive strength of the concrete.

Another research by Wenbo Shi in which the same range of replacement from 0% – 40% is used. The results of 28 days strength tests were really like the above report and the concrete with 0% replacement of fine aggregate had the highest compressive strength. But with the addition of EPS particles increases the shock and vibration property of the concrete.

Fig. 2.5 – Failure mode of the EPS concrete with different EPS particles percentage (Rajah R.. 1999).

The figure 2.5 represents failure mode of the concrete block under load. The block with 40% of EPS particles has a clean failure face. The difference between the compressive strength of 20% and 30% replacement ratio had less difference.

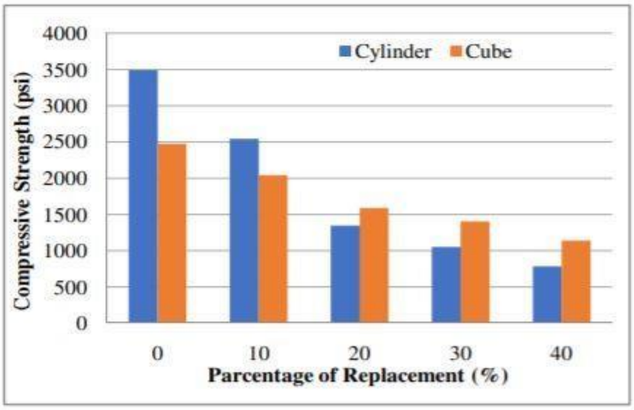


Fig. 2.6 – Compressive strength for different percentage replace of Aggregates. (Rajah R. 1999)

The research conducted on the bearing strength of the concrete with the replacement of coarse aggregates with EPS particles. The coarse aggregate used for this experiment was basalt. The percentage of replacement was 0%, 10%, 20% and 30% (R. Sri Ravindrarajah, 1999). The results were very peculiar because the bearing strength ratio of the 30% replacement concrete was the highest. This shows that the failure process was changed from brittle to ductile due to the energy absorption properties of the polystyrene. This supports the failure mode in the Fig 2.5 and suggests that the addition of EPS beads can be beneficial.

The above research shows that with the increase in EPS aggregate volume decreases the compressive strength of the concrete. But in another research which used fine aggregates with < 5mm aggregate size, the comparison between other properties is also described. The size of EPS beads used in this project was less than 5 mm and the size of fine and coarse aggregate volume was also calculated with sieve analysis.

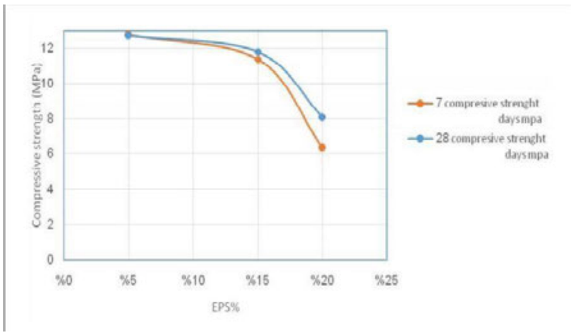
Table 2.2 – Fine aggregate proportions. (Herki M. 2017)

Sieve Size (mm)	Passing %	Standard passing % of zone (2)
4.75	93	90-100
2.7	83.4	75-100
1.18	69	55-90
0.6	47.31	35-59
0.3	15.405	8-30
0.15	0.707	0-10

Table 2.3 – Coarse aggregate proportions. (Herki M. 2017)

Sieve size (mm)	Passing %	Limit of Iraq SpecificationNo.45-1984
12.5	100	100
9.5	88	100-85
4.75	10	25-0
2.36	2.5	5-0

The compressive strength test of the samples prepared shows the same trend. With the increase in volume of EPS it decreases the compressive strength. But if it is compared with normal concrete the decrease seems apparent due to the high compressive strength. These tests show that, in comparison to the control mix, increasing the polystyrene volume increases the voids. The polystyrene beads tend to connect loosely with the cement due to the smooth surface of the polystyrene. After compression tests, the polystyrene particles could be easily plucked and removed from the rupture surfaces of the cubes. Failure occurs through the cement paste-polystyrene contact at substantially lower stress levels due to this poor bonding feature.



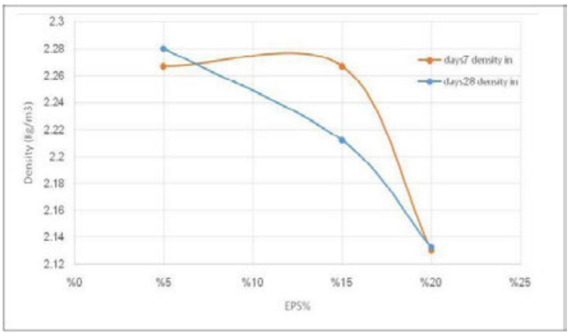


Fig. 2.7 – Compressive strength and density of EPS concrete. (Thomas T. 2017)

2.3.2 Coarse aggregate replacement

The coarse aggregates in the concrete mix usually makes up the strength and durability of concrete. So, replacing the coarse aggregates with EPS which are weaker than gravel or any other coarse aggregate will result in the decrease in strength. The replacement of coarse aggregate by Jayanth M.P. (2018) in an experimental study shows the effects of complete replacing the coarse aggregates with EPS beads. In this experiment the main focus is on the compressive strength and the water absorption rate of the concrete mix to determine the workability of concrete.

Table 2.4 – Materials used for concrete mix (Jayanth M.P. 2018).

Mixes	Density Kg/m3	Cement in Kg/m3	Coarse aggregate Kg/m³	EPS beads Kg/m³	Fine aggregates Kg/m³	Water Kg/m³
M0	2410	400	1089	0	695	160
M1	2261	400	1056	0.78	645	160
M2	1950	400	995	1.48	598	160
M3	1801	400	593	2.67	645	160
M4	1500	400	292	3.89	645	160
M5	990	400	0	6.02	424	160

The compressive strength test and the water absorption test was done on the concrete mix containing this different mix of materials. But the main changes were the replacement of coarse aggregate with EPS.

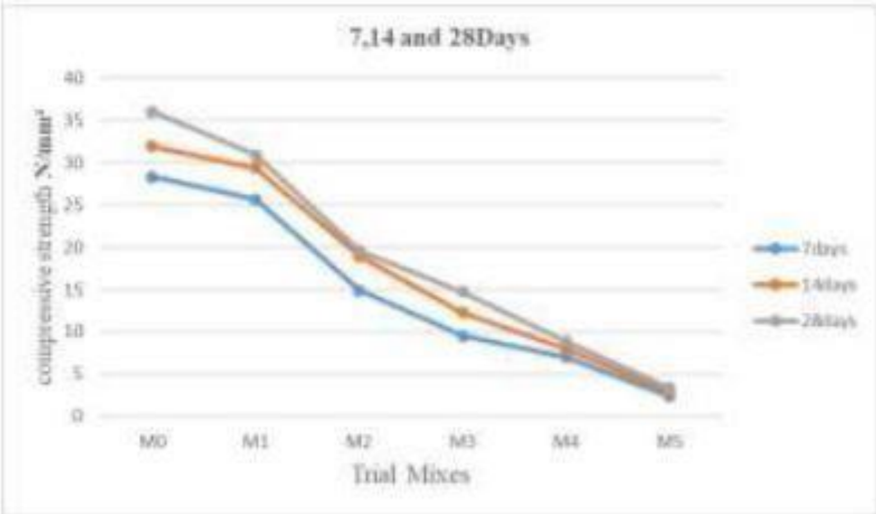


Fig 2.8 – Compressive strength results of different concrete mix (Jayanth M.P. 2018).

As it was predicted that the compressive strength decreased with increase in the volume replacement of EPS with coarse aggregate. But the decrease is much more rapid and apparent when compared with fine aggregate replacement.

Table 2.5 – Water absorption rate (Jayanth M.P. 2018)

Trial mix	Dry weight in grams (W_1)	Wet weight in grams (W_2)	Percentage of water absorption
M0	8.030	8.224	1.411
M1	7.780	7.890	1.414
M2	7.010	7.160	2.139
M3	6.430	6.580	2.332
M4	5.20	5.550	3.730
M5	3.460	3.620	4.624

The cube specimens were compressed in a Universal Testing Machine with a capacity of 2000 kN, as per IS: 516-1959. The load was applied at a rate of 140 kg/sq.cm/min without shock. At 7 and 28 days after curing, a set of three cubes for each of the mixes were tested for compressive strength. For each specimen, the ultimate load at which it failed was recorded. If the individual deviation was less than 15% of the average, a linear average was determined over three specimens. After testing, the rupture surface and distribution of polystyrene beads were visually evaluated. Figure 2.8 depicts the compression test results. The compressive strength of all concrete mixes increased as the age of the concrete grew. The compressive strength of concrete is found to decrease as the quantity of polystyrene beads increases. When compared to lightweight concrete, standard weight concrete has higher compressive strength at all ages. Compressive strength of EPS-based concretes of 5%, 10%, 15%, 20%, 25%, and 30% was found to be 91 percent, 77 percent, 71 percent, 63 percent, 56 percent, and 45 percent at 28 days, respectively, when compared to control concrete.

The compressive strengths of all EPS-based concrete mixes, in general, fall as the amount of polystyrene beads in the mix increases. This can be attributed to,

a. In comparison to the control mix, increasing the polystyrene volume increases the voids.

b. The polystyrene beads tend to connect loosely with the cement paste due to the smooth surface of the polystyrene. After compression tests, the polystyrene particles could be easily plucked and removed off the cubes' rupture surfaces. Failure occurs through the cement paste-polystyrene contact at substantially lower stress levels due to this poor bonding feature.

c. Because of the low specific gravity of polystyrene, the total density of the concrete is reduced. Compressive strength is affected by density, hence increasing the mix's density will enhance its compression strength.

At 7 days, the compressive strength of 0 percent EPS (control concrete) was 31.77 MPa, and at 28 days, it had grown significantly to 37.18 MPa. The compressive strength of 5 percent, 10 percent, 15 percent, 20 percent, 25 percent, and 30 percent EPS-based concretes, on the other hand, rose from 7 to 28 days, with an absolute difference of roughly 6 to 9 MPa.

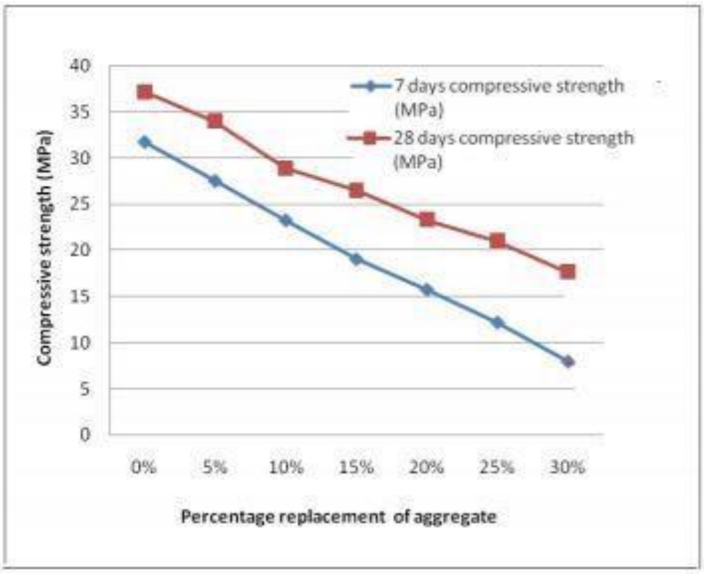


Fig. 2.9 – Compressive strength variation percentage of EPS variation. (Thomas T.)

Split tensile tests were carried out on standard cylindrical specimens of all EPS-based concrete mixes in accordance with IS 5816: 1999. This is an indirect method of delivering tension in the form of splitting. According to I.S. standards, the test was performed on cylinders with a diameter of 150 mm and a height of 300 mm. The specimen is placed horizontally between the platens of the testing machine. Thin strips of 12 mm wide and 3 mm thick were placed between the cylinder and the platens of the testing machine. The load was gradually raised at 140 kN/minute until the vertical diameter split and the failure occurred. As illustrated in Fig. 2.9, the stone aggregates and EPS beads were evenly dispersed throughout the matrix.

Fig. 2.10 – Broken surfaces of failed cylinders. (Thomas. T)

Figure 2.11 shows the results of split tensile tests. The bar chart clearly shows that the more polystyrene particles in the concrete mixture, the lower the tensile strength. A mix with 15% EPS has an 80 percent relative strength, whereas a mix with 30% EPS has a 70 percent relative strength.

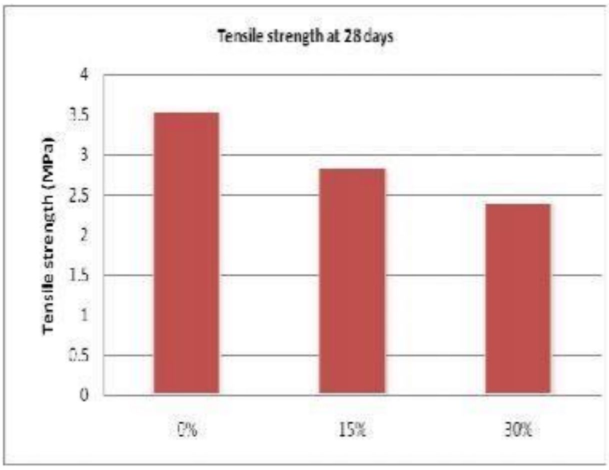


Fig. 2.11 – Split Tensile strength at 28 days. (Thomas. T)

The following conclusions were drawn from the study.

1. The compressive and tensile strength of concrete is reduced as the amount of EPS beads in the mix is increased.
2. Without the use of a specific bonding agent, all of the EPS concretes are very workable and may be compacted and finished quickly.
3. With more EPS beads in the mix, the workability improves.
4. The use of EPS as a substitute material in the construction of non-structural parts has shown to be successful, and it also acts as a means of EPS disposal.
5. The findings indicate that expanded polystyrene concrete has potential for non-structural applications such as wall panels and partition walls.

2.4 Fly Ash Replacement

Fly ash is used in concrete to increase the workability of the concrete and the strength and durability of the concrete. The amount of Portland cement is reduced when fly ash is added to the concrete, which improves the environment benefits of concrete. Fly ash is also cost effective as it cheaper than cement.

The performance of concrete incorporating flay ash and EPS aggregates is investigated in a study by K. Ganesh Babu and D. Saradhi Babu. In this study, fly ash was used to replace 50% of the total cementitious material by weight. The experiments were carried out by producing concrete samples in the shape of blocks. One sample had 50% fly ash and EPS particles, whereas the other just had fly ash and one standard concrete mix. The tests were then carried out on the various samples. The results revealed that samples containing solely fly ash had a relatively poor water absorption rate. The sample containing fly ash and EPS particles, on the other hand, showed a considerably higher absorption rate. The sample containing fly ash and EPS particles had a higher compressive strength than the one without fly ash.

The amount of fly ash replaced can also be reduced from 50% to a lower proportion. The outcomes will be drastically different if the fly ash concentration in concrete is reduced to 25%. M.L. Berndt explored this in his 2009 research on the subject. The compressive strength was reduced when the flay ash concentration was reduced, while the water absorption rate rose as the fly ash content was reduced. In the study report by Liu Haibo, however, the fly ash concentration is utilised in 5 percent increments from 0 to 40%. The samples are created with various amounts of fly ash, and tests are done to assess the concrete's compressive strength. The results showed that when the amount of fly ash in the concrete increases, the compressive strength falls. However, the change in compressive strength from 0% to 20% was just 8 Mpa. The inclusion of fly ash and EPS particles enhanced other parameters like as durability, weather resistance, and thermal insulation. M. A. Herki utilised a proportion of 0 percent, 20%, and 40% in concrete to substitute Portland cement in another study published in 2007. However, the findings were remarkably comparable to those of another study. The cement's compressive strength was reduced as the fly ash concentration increased.

Table 2.6 – Concrete Mixture. (Herki M. 2017)

W/B	Mix No.	SPS (%)	FA (%)	Mix Constituents					Slump (mm)
				Binders (kg/m^3)		Aggregates (kg/m^3)		Water (kg/m^3)	
				Cement	FA	NA	SPS		
0.8	1	0	0	320	0	1920	0	256	8
	2	60	0	320	0	768	345	256	44
	3	100	0	320	0	0	575	256	25
	4	0	20	256	64	1920	0	256	5
	5	60	20	256	64	768	345	256	35
	6	100	20	256	64	0	575	256	20
	7	0	40	192	128	1920	0	256	3
	8	60	40	192	128	768	345	256	25
	9	100	40	192	128	0	575	256	15

W/B—water/binder ratio; SPS—stabilised polystyrene; FA—fly ash; NA—natural aggregate.

A few studies have demonstrated the significance of using fly debris (FA) in concrete, which can save a lot of energy and money in concrete assembly while also improving the design qualities of cement when used instead of regular concrete. For example, a new paper discusses the use of EPS dots in both cement and mortar, with the cementitious material being manufactured (rather than natural) fly detritus. The densities of the cements ranged between 550 and 2200 kg/m3. The percentage of EPS substitutions increased from 0% to 95%.

The thickness of EPS cements appears to decrease as the FA component increases. For example, the thickness of the control combination (0 percent EPS + 0 percent FA) was 2171 kg/m3, but with 40 percent FA content in concrete, it was reduced to 2161 kg/m3. According to a new study, the low thickness of LWAC incorporating FA is most likely due to the greater air content and lack of FA design. The strength of control and EPS cements weakened as FA concentration increased, according to the results presented in a distributed report. At 28 days old, the control concrete (60 percent EPS + 0 percent FA) had a strength of 11 Mpa, whereas the solid-containing concrete (60 percent EPS + 20 percent FA) had a strength of 8 Mpa; the strength lowering rate was roughly 27 percent. This is supported by a study that found that in concrete containing a natural FA, strength acquisition must be lower because no preparation is used. LWAC with 60 percent EPS totals and up to 40 percent FA can fulfil RILEM's (The International Union of Laboratories and Experts in Construction Materials, Systems, and Structures) Sort II main and protective strength criteria, according to the compressive strength values found in this study.

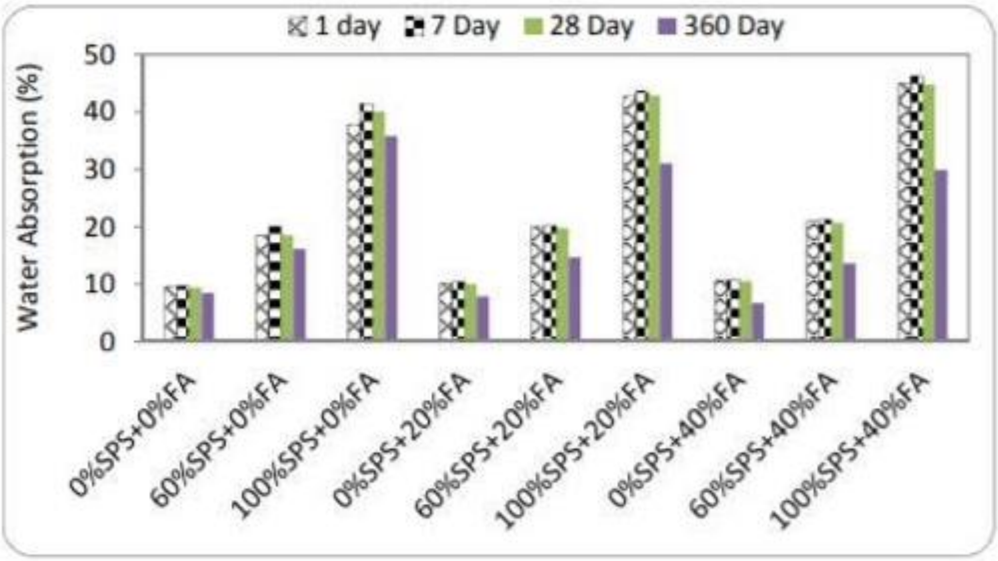


Fig. 2.12 – Water Absorption of concrete with different % of FA and EPS (Minh D. Phuong L. 2018).

The EPS and FA-rich solid may be used in low-strength cement applications such walkways, cycling paths, and noise reduction, or it can be utilised to create lightweight blocks and squares with low warm conductivity. The solid containing FA had much greater WA than the control mix. The underlying WA (30-min) declined with ageing. However, as demonstrated in Figure 2.12 and Table 2.6, the total WA grew at seven days old enough, then somewhat reduced at 28 days old enough, and ultimately considerably decreased at 360 days old enough. Cements with varying amounts of EPS total and FA showed retention rates of 2.8 percent to 32.5 percent and 2.6 percent to 19.3 percent at 30 minutes at 28 and 360 days, respectively. Concrete with 100 percent EPS + 40 percent FA had the greatest reduction in WA in long distance mending of 360 days old enough. Water absorption (WA) of cements rose with a rise in FA replacement levels in the early stages of restoration, but declined with long-term restoration. That means that as the FA concentration in EPS cements increased, the rate of absorption increased at a young age and then decreased after a long rest period. The higher pace of assimilation in cements containing FA might be because of the impact of moderate reactivity of FA particles at early ages as has been accounted for before.

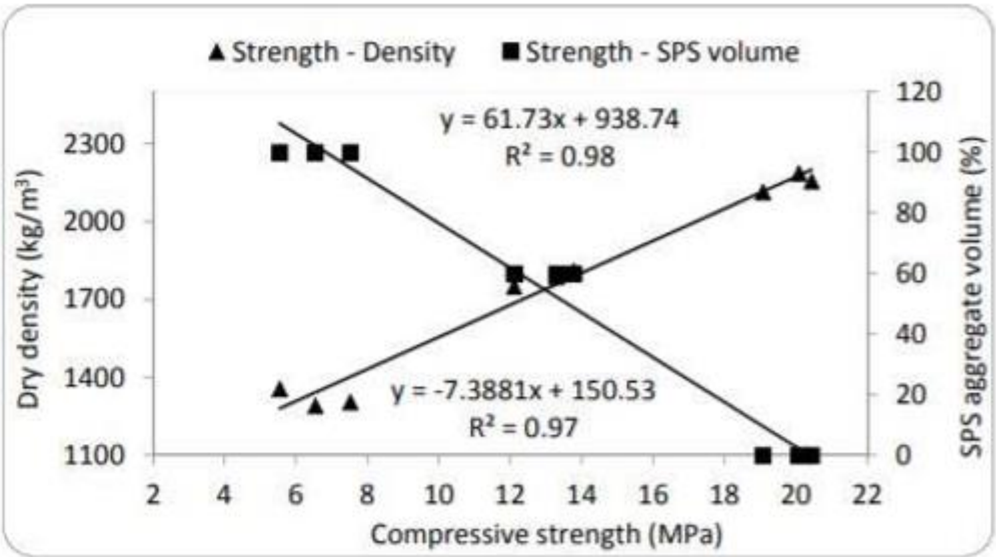


Fig. 2.13 – Relationship between dry density, EPS aggregate volume and compressive strength.

This study evaluated the combined consequences of two types of waste materials using a new reuse method of densification. The issue of EPS isolation in concrete stated in the literature has been improved by covering them with a standard earth fastener. The strength, UPV, and thickness of concrete were lowered while water consumption rose by increasing the quantity of EPS and FA in the concrete. The level of EPS and FA substitution determines the degree of strength and UPV decrease. For example, at 28 days old, the solid containing 60% EPS and 20% FA exhibited a 50% and 19% reduction in strength and UPV, respectively, when compared to the control concrete. The epic cement created in the current examination can be utilized in the accompanying applications:

- LWAC comprising 60 percent EPS totals and up to 40 percent FA can adjust to the Sort II primary, as well as meet RILEM's (The International Union of Laboratories and Experts in Construction Materials, Systems and Structures) strength requirement.

- The solid, which is high in EPS and FA, can be used in low-strength cement applications such as pathways, cycling paths, and commotion reducers, or it can be used to make lightweight blocks and squares with low warm conductivity.

It is possible to apply this unique lightweight total produced utilising waste EPS and natural FA in lightweight solid production if EPS total is made properly and with correct solid mix plan. In any case, more sturdiness and mechanical trials, such as water infiltration, parting elasticity, and the impact of the connection between the covering and the EPS particles, should have been done as future work before this novel eco-friendly material could be demonstrated sufficient for use in various development applications.

Chapter 3

Testing Methodology

3.1 Introduction

The study of structural safety needs in extreme situations like as earthquakes, accidental collisions, or explosions involves the behaviour of concrete loading. Pendulum testing, drop weight tests, and other methods are used to provide early experimental data on those materials under dynamic loads. But in this project, we will be testing the samples under the Australian standards for testing concrete i.e., AS1012.

3.2 Compression Strength Test

A compressive strength test is used to determine how well concrete can withstand loads that compress it. Crushing concrete specimens in a compression testing equipment determines the concrete's compressive strength. The pure tension produced up in the concrete owing to tensile stresses is referred to as the tensile strength of the concrete. Because it accounts for around 10% of the compressive strength, it has a big impact on the structural strength of the other elements.

On cured concrete, the compressive strength test is a straightforward technique. Furthermore, many of concrete's appealing features are due to its compressive strength. Cylindrical specimens should be prepared for compressive strength testing according to Australian Standards AS1012.9, as shown in figure 3.2 below (AS1012.9 2014). The compressive strength testing will be carried out in line with AS1012.9, an Australian Standard (AS1012.9 2014). All compressive strength tests will be performed on cylindrical specimens measuring 100 mm in diameter and 200 mm in length.

Fig. 3.2 – Compression Machine at Toowoomba Campus. (USQ, Z1)

At the University of Southern Queensland's Toowoomba campus, the SANS compression unit (shown in figure 3.3) will be utilised to analyse the second batch of samples. The samples are evaluated in the same way as the above samples, but at a 1mm per minute loading rate. Finally, each specimen's compressive strength is determined by multiplying the greatest force applied by the cross-sectional area of the specimens. At the age of 28 days, the compressive strength of both specimens was measured. Three cylinders will be used to test each mix design, with the average compressive strength being reported.

Fig. 3.3 – SNAS Compression Machine at Toowoomba Campus. (P11, USQ)

The specimens are manufactured in moulds designed specifically for testing. Non-absorbent material should be used to make the moulds. The mould's measurements must be consistent with the measurements provided in AS1012.8.1 section 6.1.2. To prevent concrete from spilling out of the moulds, they are placed atop a base plate. The compaction of the concrete is conducted with the help of a rod. The dimensions of both the rod and base plates are stated in AS1012.8.1.

3.3 Flexural Strength Test

Tensile strength tests were used to assess the flexural strength of EPS. A four-point flexural load is applied to an unreinforced concrete beam before it fails in this test. The elastic theory equation in equation 1 was used to compute the ultimate flexural strength of each test specimen. Three beam specimens were tested, with the average maximum flexural strength for each mix design being recorded. The trial specimen's flexural strength will be tested using a four-point bending device at the University of Southern Queensland's Toowoomba campus. According to the test technique established in the Australian Standard AS1012.11, a 100 x 100 x 350 mm prism will be loaded at a rate of 1 MPa per minute till failure (AS1012.11 2000). This research used a 510mm beam spread.

A laser displacement sensor tracked the load assembly travel distance as the two-point loads were applied to compute the flexural specimens' mid-span deflection. For exact mid span deflection of flexural specimens, the laser displacement sensor is positioned under the specimen at the mid span and immediately checks the specimen deflection. On the Toowoomba campus, the 4-point bending test is performed. The weight is gradually raised, and at the time of collapse, the average depth and width of the specimen are measured. The specimens' ultimate flexural strength will be calculated using the same formula as the trial series specimens (see equation 1). Where fctf is the tensile strength in MPa, F is the maximum applied force in KN, L is the span length in mm, Li is the loading length (inner span), b is the average width of the specimen at the failure section in mm, and d is the average depth of the specimen at the failure section in mm. The equation 1 is as follow:

$$f_{ctf} = \frac{3F(L - L_i)}{2bd^2}$$

3.4 Indirect Tensile Strength test

Indirect tensile strength will be conducted according to Australian standard AS1012.10. This test is conducted to determine the tensile strength of the concrete. The test is done on the cylindrical specimen and the specimens are of dimensions 150 mm x 300 mm. The specimens are placed horizontally between the loading surfaces of the compression testing machine. The indirect tensile strength of the specimen is calculated by,

$$T = (2000P) / (\pi LD)$$

Where:

T = Indirect tensile strength, Mpa

P = Maximum applied force, KN

L = Length, mm

D = Diameter, mm

3.5 Vebe Test

The main goal of the Vee-Bee test is to figure out how workable freshly mixed concrete is. The Vee-Bee test determines the mobility and compatibility of freshly mixed concrete. The Vee-bee test is used to determine the relative effort needed to move the mass of concrete from one form to another. That is, according to the test, by undergoing a vibration phase, the conical shape is transformed into a cylindrical shape. The effort is measured using a timer that counts down in seconds. The remoulding effort is the amount of work measured in seconds. The time it takes to fully remould something is an indicator of its workability, and it's measured in Vee-Bee seconds. The experiment is named after V Bahrmer, a Swedish developer. Dry concrete can also be used with this process. The remoulding activity will be so fast for concrete with a slump value greater than 50mm that it will be impossible to keep up that the measurement of time is not possible.

This test will be conducted in accordance with Australian Standard AS 1012.3.3 – 1998_R2014. The apparatus needed for the test according to the standard are as follows:

- Consistometer - A vibrating table is supported and balanced on elastic supports in this apparatus. A sheet metal slump cone, a weighing balance, a cylindrical jar, a standard iron tamping rod, and trowels are also included in the kit. The cylindrical jar should have an internal diameter and height of 240 and 200 mm respectively.

Fig. 3.4 – Consistometer at Toowoomba Campus. (USQ, Z1)

- Rod – The rod used for this test should be approximately 600 mm long and 16 mm of diameter.
- Stopwatch – The stopwatch should be readable to at least 0.5s.

- Scoop - The scoop should be made up of non-absorbent material.

The sheet metal slump cone is initially mounted inside the cylinder container in the consistometer.

Four layers of concrete are used to fill the cone. Each concrete layer is a quarter of the cone's height. After pouring, each layer is tamped twenty-five times with a regular tamping rod. The rounded end of the rod is used for tamping. The strokes are evenly dispersed throughout the canvas. The second and subsequent layers of concrete must be penetrated by the strokes used by the second and subsequent layers of concrete. With the support of a trowel, the concrete is struck off to make it level after the final layer has been placed and compacted. This ensures that the cone is completely full. The glass disc attached to the swivel arm is transferred and placed on top of the slump cone inside the cylindrical container after the concrete cone has been prepared. The glass disc must be positioned so that it meets the top of the concrete level, and the reading must be taken using the graduated rod. The cylindrical cone is now extracted immediately by slowly raising the cone vertically. The reading is taken after the transparent disc on top of the concrete is moved to its new location. Phase 4: The slump is determined by the difference between the values calculated in steps 3 and 4. The electrical vibrator is now turned on, and the stopwatch must be started at the same time. In the cylindrical tub, the concrete is allowed to spread out. The vibration will continue until the concrete is remoulded. When the concrete surface becomes horizontal and the concrete surface adheres uniformly to the transparent disc, this is the point. In seconds, the time needed for complete remoulding is reported. This time in seconds is used to determine the fresh concrete's workability. Vee-Bee’s seconds are used to measure time.

3.6 Testing of the consistency of concrete – Slump test.

This test will be conducted in accordance with the standard AS 1012.3.1:2014. This standard explains the methodology for testing the consistency of the fresh concrete using Slump test method. The fundamental technique of this test entails layering fresh concrete into the slump curve, rodding each layer, and then removing the slump cone's support for the concrete. The ‘slump of the concrete' refers to the vertical subsidence of the concrete that occurs when the slump cone is elevated. If the qualities and amounts of the elements used to manufacture the concrete do not vary from batch to batch, it is also assumed that the slump of fresh concrete does not vary between individual batches of concrete.

The Apparatus required to perform this test should also have the measurements stated in the standard. Let us look on the mould which will hold the concrete. The mould should be made of non-reactive rigid material at least 1.5mm thick and in the shape of a cone. The bottom and the top of the cone should be open and at right-angles to the axis of the cone. The mould should also have means to lift the cone. The dimensions of the cone are as follows.

1. Bottom diameter – 200±5 mm
2. Top diameter – 100±5 mm
3. Vertical height – 300±5 mm

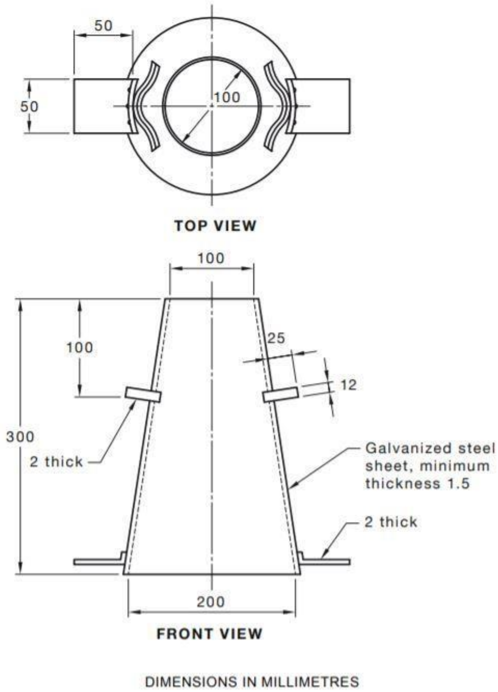


Fig. 3.5 – Dimension of mould for slump test. (AS 1012.3.1:2014)

A metal rod with a diameter of 161 mm, a length of 60010 mm, and at least one end tapered over a distance of roughly 25 mm to a spherical shape with a radius of approximately 5 mm shall be used for compacting concrete in the mould. The rod's length should not exceed 1000 mm.

The coop must be composed of non-absorbent material that is not easily affected by cement paste, have a capacity of at least 1 litre, and be able to hold concrete increments. The base plate must be made of a smooth, stiff, non-absorbent material, such as a 3 mm thick metal plate.

This section explains the steps involved in performing this test. Begin the test immediately after the test sample has been mixed for concrete collected in the field. Begin the test in accordance with AS 1012.2 for laboratory-prepared concrete. Make sure the mould's internal surface is clean and free of set concrete. After cleaning the mould, apply oil to the interior surface. Place the mould on a nonporous horizontal base plate that is flat. Pour the prepared concrete mix into the mould in four fairly equal thicknesses. Tamp each layer in a regular manner with 25 strokes of the rounded end of the tamping rod around the cross section of the mould. Tamping can penetrate the underlying layer, allowing subsequent layers to adhere to it. Remove any excess concrete and level the floor using a trowel. Any mortar or water that has gotten between the mould and the base plate should be removed. As soon as possible, lift the mould from the concrete in a vertical direction. The slump is described as the difference between the mould's height and the height point of the specimen being measure

Chapter 4

Concrete Testing

4.1 Resource requirements

The main aspect of this project is physical testing of the sample concrete blocks made with EPS (expanded polystyrene). There are some physical resources required to construct the concrete samples. The resources collection will be an important task and can take a substantial amount of time depending on the availability of the products. The raw material required for this project are,

1. Portland Cement.
2. Sand.
3. Fly Ash.
4. Expanded polystyrene beads.
5. Coarse aggregates.

The cost for each of the products is only an estimation because the amount required for each of the products needs to be determined beforehand. The amount is also subjected to change during the progression of the project the approximate price of the raw materials is given below.

1. Portland Cement - $0.35 per Kg.
2. Sand – $0.55 per Kg.

3. Fly Ash - $0.93 per Kg.

4. Expanded polystyrene beads – $0.3 per L.

5. Coarse aggregates - $0.5 per Kg

The access to laboratories will also be required to construction of samples and testing of the samples. USQ Toowoomba campus has a concrete laboratory in building Z1, which will be required for testing purposes for this project. The booking of the laboratory must be completed early in the project as it can be difficult to gain access later on due to other students booking the lab for their project. There will also be a scheduled training and safety induction in order to handle the testing machines in the laboratory.

There can be delays in the testing of the concrete samples due to many unforeseen reasons. So, the schedule to access the laboratory must be negotiated with USQ taking the delays into account.

4.2 Material Estimation

Table 4.1 – Number of samples required for testing.

		0% Fly Ash	20% Fly Ash			
Test 1 Compressive	Samples with EPS	Samples of each %		Dimension for each Sample (mm)	Volume of each sample required (m^3)	Total Volume(m^3)
	0%	2	0	100 x 200	0.00157	0.00314
	10%	2	2	100 x 200	0.00157	0.00628
	20%	2	2	100 x 200	0.00157	0.00628
	30%	2	2	100 x 200	0.00157	0.00628
Test 2 Indirect	Samples with EPS	Samples of each %				
	0%	2	0	100 x 200	0.00157	0.00314
	10%	2	2	100 x 200	0.00157	0.00628
	20%	2	2	100 x 200	0.00157	0.00628
	30%	2	2	100 x 200	0.00157	0.00628
Test 3 Flexural	Samples with EPS	Samples of each %				
	0%	2	0	100 x 100 x 500	0.005	0.01
	10%	0	0	100 x 100 x 500	0.005	0
	20%	2	2	100 x 100 x 500	0.005	0.02
	30%	2	2	100 x 100 x 500	0.005	0.02
		Total Samples	38		Total volume of concrete (m^3)	0.01628

The material estimation for this project is discussed in this section. The following table depicts the different tests involved in this project and the total number of samples required to complete the testing.

The total number of samples required for this project is 45 and the total volume of concrete mix required is 0.1525 m^3. The table shows the mix design used to calculate the amount of different materials used in the concrete mix.

Table 4.2 – Details of concrete mix used.

Mix Design Used to Calculate the Quantity of material	
	Ratio
W:C:A	0.5:1:3.5
Aggregate cement ratio	0.51
Water cement ratio	0.57
Sand	34% of Aggregate
10 mm Aggregate	28% of Aggregate
15 mm Aggregate	38% of Aggregate
EPS	0 - 30% of fine Aggregate
Fly Ash	20% of Cement

The following table shows the quantity of each material used and the total cost of the project. The total cost to complete the project is $148.

Table 4.3 – Materials required for the project.

Material Required for the project	Volmue (m^3)	Quantity in Kg	Bag Size available	Bags Required	Price Per Bag(AU $)	Total Cost (AU $)
Cement	0.03600	86.40	20 kg	4	6.9	30
Sand	0.04284	102.82	20 kg	5	7.3	38
Fly Ash	0.00720	17.28	15 Kg	1	17.7	20
EPS	0.03780	90.7	-	-	-	-
10mm Agg.	0.03528	84.7	20 kg	4	7	30
15mm Agg.	0.03352	80.4	20 kg	4	7	28
Water	0.01800	18	-	-	-	-
						146

4.3 Specimen preparation

In this study, concrete mixtures with and without Expanded Polystyrene beads were employed. The experimental study for this dissertation is conducted using these mixes. A single control concrete mixture with no fine aggregate replacement, as well as concrete mixes with fine aggregate replacements of EPS beads ranging from 0% to 30% by fine aggregate volume, are included in the experimental concrete batches. The EPS beads are available in three sizes: 1mm, 2.5mm, and 6.3mm.

The concrete mixture was designed using the methods outlined in the Australian standards

AS1012.8.1 (2014) and AS1012.8.2 (2014). The quantities of cement, water, and coarse aggregate in the control and EPS beads mixes were not altered. The fine aggregate was substituted with varied amounts of EPS beads in the experimental batches of rubberized concrete. To obtain consistent characteristics throughout the concrete mixture, vigorous mixing is necessary for entire material blending. This ensures that the surface of all aggregate particles is coated with water cement paste and that the mix is homogenous.

For the control mixes, Yousff et al. (2014) designed the following mixing procedure:

• For one minute, combine dry sand and gravel.

• Stir in half of the water for one minute.

• Let it rest for two minutes.

• Mix for two minutes after adding cementitious materials, water, and admixtures.

The EPS mixes are made in the same way, except that the EPS aggregate is combined for one minute in an external container with dry cementitious materials. The goal is to improve the EPS-cement surface connection, which is one of the most important factors impacting EPS strength.

The fresh concrete mixture is slump tested (AS1012.8.1 2014; AS1012.8.2 2014) and allowed to cure for 24 hours before being placed into concrete casting cylinders and beam moulds. After 24 hours, the specimens are taken from the cylinder and beam moulds and put in a huge curing tank to cure for 28 days at 242°F before being evaluated for hardened concrete characteristics. Three prototypes have been built for each concrete design composition.

The samples are divided into batches for different percentage of EPS and Fly Ash. The particle size of that is used in this project is 2.5 mm because this was the only size available at the time of project. The different particle size EPS were to be made on special request and would have been made in New south wales. But in the time of this pandemic would have delayed the project as the making and delivery of the EPS would have taken a lot of time and funds. The EPS percentage replacement will be volume replacement of sand. This weight of EPS will be determined by the formula.

$$W = P \times \frac{Density\ of\ EPS}{Density\ of\ Sand}$$

Where:

W is the weight of EPS in Kg

P is the weight of sand that will be replaced according to the percentage.

Density of EPS = 25 Kg/m^3

Density of Sand = 1442 Kg/m^3

Now the weight of each material required for concrete is specified in the table below.

Table 4.5 – Materials required for each batch.

	Batch Details		**Materials Used**					
Batch No.	**EPS %**	**FLY ASH %**	**Cement (Kg)**	**Sand (Kg)**	**Aggregate (Kg)**	**EPS (g)**	**Fly Ash (Kg)**	**Water (Kg)**
1	**0**	**0**	**10**	**12**	**20**	**0**	**0**	**2.14**
2	**10**	**0**	**4.5**	**5.405**	**8.6**	**9.5**	**0**	**0.94**
3	**10**	**20**	**3.6**	**5.405**	**8.6**	**9.5**	**0.9**	**0.94**
4	**20**	**0**	**10**	**11.7**	**20**	**30**	**0**	**2.14**
5	**20**	**20**	**8**	**11.7**	**20**	**30**	**2**	**2.14**

6	30	0	10	11.5	20	50	0	2.14
7	30	20	8	11.5	20	50	2	2.14

So, each batch was used to make 5 cylinders and 2 beams for hardened concrete testing. But for 10% EPS replacement we will only use 5 cylinders as it was suggested by the supervisor because it will increase the number of samples and costing more. After the samples were set in moulds for 24 hours the samples were then taken into curing room for strengthening for 28 days.

4.4 Ethical Responsibility

This project is undertaken by myself, and I shall be responsible for maintaining the Ethical value. The profession of engineering is based on learning and using our knowledge and skills to benefit the community by developing engineering solutions for a sustainable future. This project is based on using EPS as a substitute in concrete to make a light weight and more environmentally friendly alternative. This project requires studying the information that is available on the past and present work completed by others on this topic. During the process of researching there is a very fine line of taking inspirations and ideas from a person's work or copying the work. The end goal of this project will be to gather information and produce new solution and ideas to further add to the abundance of research in this topic.

The Engineers Australia maintains the Code of Ethics to guide the engineers to a path which is ethically correct in values. Engineers Australia understands that, while our ethical beliefs and principles are eternal, norms of acceptable behaviour are not permanently fixed. Over time, community standards, engineering practise requirements and goals, and members' behaviour in general will evolve and change. Engineers Australia's General Regulations on competency, continuing professional development, and the Code of Ethics are the minimum requirements for members. Within limits, what is appropriate behaviour may also be determined by the unique circumstances of each individual. There are some guidelines provided by Engineers Australia on professional conduct (Engineers Australia, 2019). The following are the selected guidelines which are related to this project in my understanding,

1. Demonstrate integrity.
    a. be discerning and do what you think is right.
    b. accept, as well as give, honest and fair criticism.
    c. apply knowledge and skills without bias in respect of race, religion, gender, age, sexual orientation, marital or family status, national origin, or mental or physical abilities.
    d. give proper credit to those to whom proper credit is due.
2. Practise competently
    a. continue to develop relevant knowledge and expertise.
    b. neither falsify nor misrepresent qualifications, grades of membership, experience or prior responsibilities.
    c. practise in accordance with legal and statutory requirements, and with the standards of the day accepted within the Engineers Australia community.
3. Exercise leadership
    a. Uphold the reputation and trustworthiness of the practice of engineering.
    b. provide clear and timely communications on issues such as engineering services, costs, outcomes, and risks.
4. Promote sustainability.
    a. incorporate social, cultural, health, safety, environmental and economic considerations into the engineering task.
    b. in identifying sustainable outcomes consider all options in terms of their economic, environmental, and social consequences.

c. aim to deliver outcomes that do not compromise the ability of future life to enjoy the same or better environment, health, wellbeing, and safety as currently enjoyed.

Chapter – 5

Concrete Testing Results

5.1 Fresh concrete testing results.

The fresh concrete tests performed for this project were:

1. Slump Test
2. Vebe Test
3. Compaction factor test

These tests were performed on fresh concrete were performed on different batches and then the batches were set in cylindrical and beam moulds for 24 hours. The samples were put in the curing room in Z1 lab for 28-days.

Fig. 5.1 – Samples in the Curing room in Z1 Civil Lab USQ

Each batch was tested for the three fresh concrete tests mentioned above. The dimension of the moulds used, and the number of samples prepared can be seen in table 4.1. The batches were mixed in the concrete mixer, but the EPS was mixed with hand. This was done to prevent any EPS particle from being trapped in the mixer because the weight of the EPS is very less compared to other materials. After the completion of the mixing process the concrete was test for Slump, Compaction factor and vebe test.

Fig. 5.2 – Vebe Test Z1 Civil Lab USQ

The above picture shows the concrete in a wheelbarrow which was used to transport the concrete to different testing apparatus. Each test was performed with the material from same batch for all the seven batches the results of the tests are shown below.

Table 5.1 – Results of Slump Testing.

	Batch details		
Batch No.	**EPS %**	**FLY ASH %**	**Slump Test results (mm)**
1	0	0	95
2	10	0	90
3	10	20	80
4	20	0	85
5	20	20	75
6	30	0	80
7	30	20	65

The values of the slump test reveals that the addition of Fly Ash improved the slump in every batch. This would suggest that the addition of Fly Ash increase the workability of the concrete. The batches with only EPS have the increased value of slump when compared with the batches with both EPS and Fly Ash. With the increase in percentage replacement of EPS the workability of the concrete increases. The increase in the workability is considerable as we can see in the fig 5.3. This could be due to the water absorption properties of EPS. Fly Ash also absorbs water which father increase the workability of concrete. There is a steady increase across all the batches and the margin of increases is also very similar form batch to batch. But, the slump values of the batch with 20% and 30% EPS has the same value of slum. This could be caused due to many reasons, but it could be assumed that EPS can only absorb a certain amount of water and more EPS will not affect it.

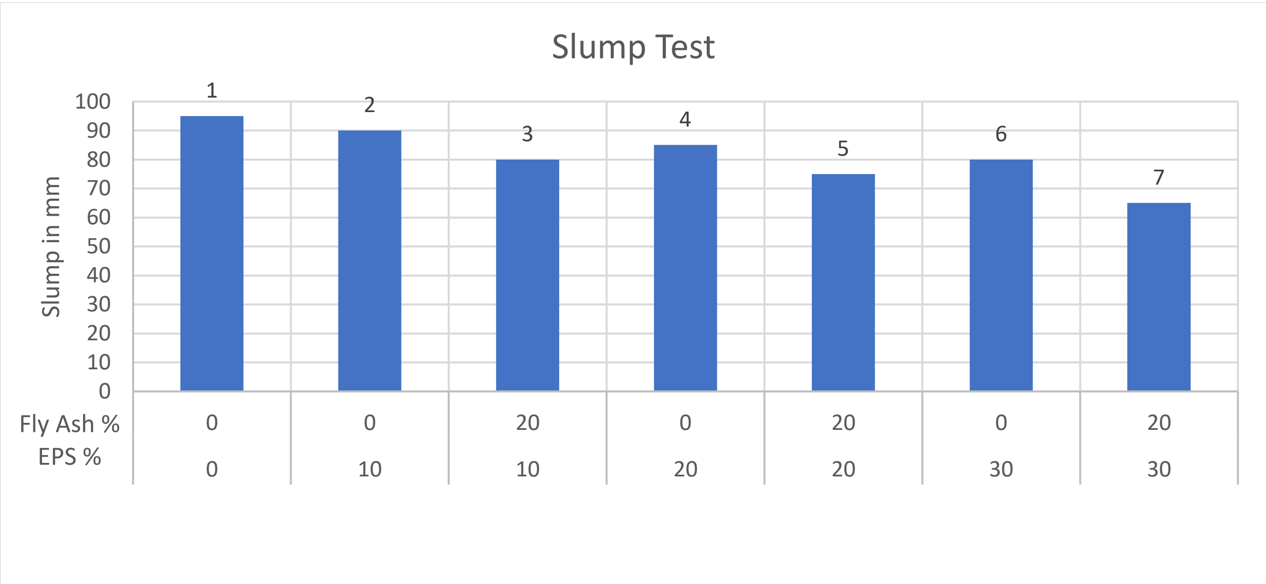


Fig. 5.3 – Slump Test values

Table 5.2 – Results of Compaction Factor Testing.

	Batch detials			Compaction factor test resutls			
Batch No.	EPS %	FLY ASH %	Slump Test results (mm)	Partially comapcted (kg)	Fully Compacted (kg)	Empty cylinder weight (kg)	Compaction factor
1	0	0	95	24.85	25.05	12.4	0.9842
2	10	0	90	23.15	23.25	12.4	0.9908
3	10	20	80	24.85	24.95	12.4	0.9920
4	20	0	85	23.25	23.35	12.4	0.9909
5	20	20	75	24.35	24.45	12.4	0.9917
6	30	0	80	23.65	23.75	12.4	0.9912
7	30	20	65	24.2	24.3	12.4	0.9916

The value of compaction factor test lies between 0.75 to 0.99. The higher the value of compaction factor, higher the workability of concrete. The values compaction factor for each batch is depicted in the table 5.2. The addition of EPS increases the value of compaction factor. But with the addition of Fly Ash, it further increases the workability of concrete. This is a very similar result to the slump test and expected from the literature review. But in this test the highest value is form batch 3, which has EPS and Fly Ash. Batch 3 has a value of 9920 which is not exceptionally higher than the other values. It can be concluded that there were some complications with the test or the batch itself. As wee can see from the fig 5.4, the values don't have a higher difference and the values with higher concentration of EPS and Fly Ash have a similar result.

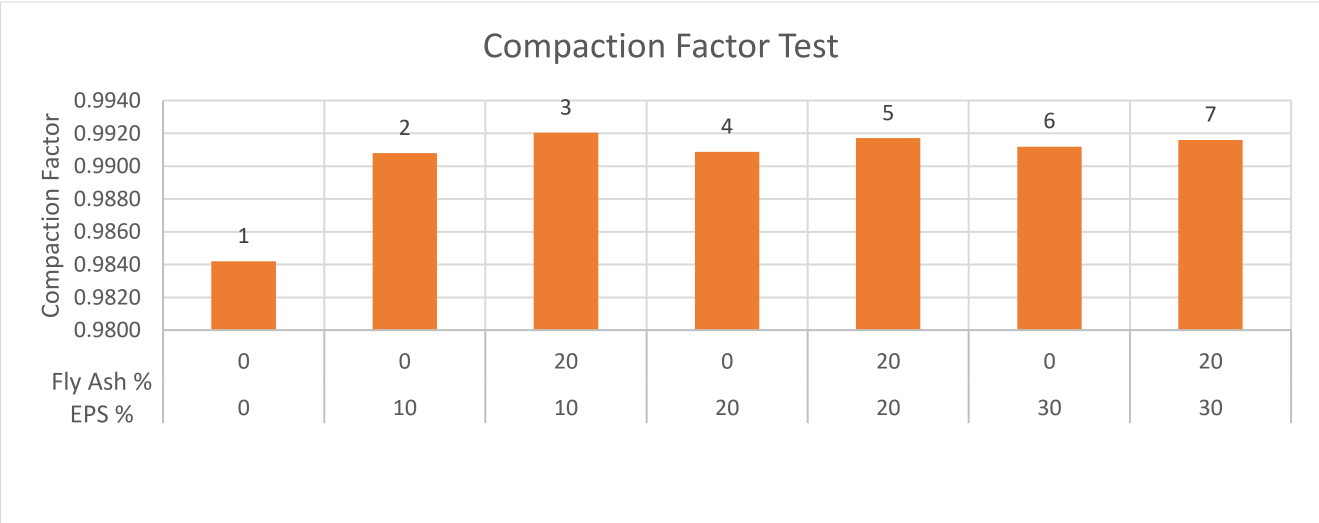


Fig. 5.4 – Compaction Factor Test Values

Table 5.3 – Results of Vebe Testing.

	Batch detials		Vebe test results	
Batch No.	EPS %	FLY ASH %	Vebe Sec (Sec)	Vebe slump (mm)
1	0	0	2.29	90.000
2	10	0	2.06	85.000
3	10	20	2.26	75.000
4	20	0	1.66	75.000
5	20	20	2.25	65.000
6	30	0	1.92	80.000
7	30	20	2.05	60.000

The Vee-bee test values between 0 – 3 seconds indicate better workability of concrete. All the values from the samples for this project lies between 0 – 3 seconds, which implies that the workability of concrete with EPS and Fly Ash is high. But with the addition of EPS, it decreased the workability, but the addition of Fly Ash increases the workability of the concrete. This implies a variation form the results form the other two tests. But the vebe test has a higher degree of human error as the time is noted by a human and it can have different value depending on who is operating the stopwatch. The results form batches with Fly Ash and EPS follow the observations form other tests and have a similar increase in workability.

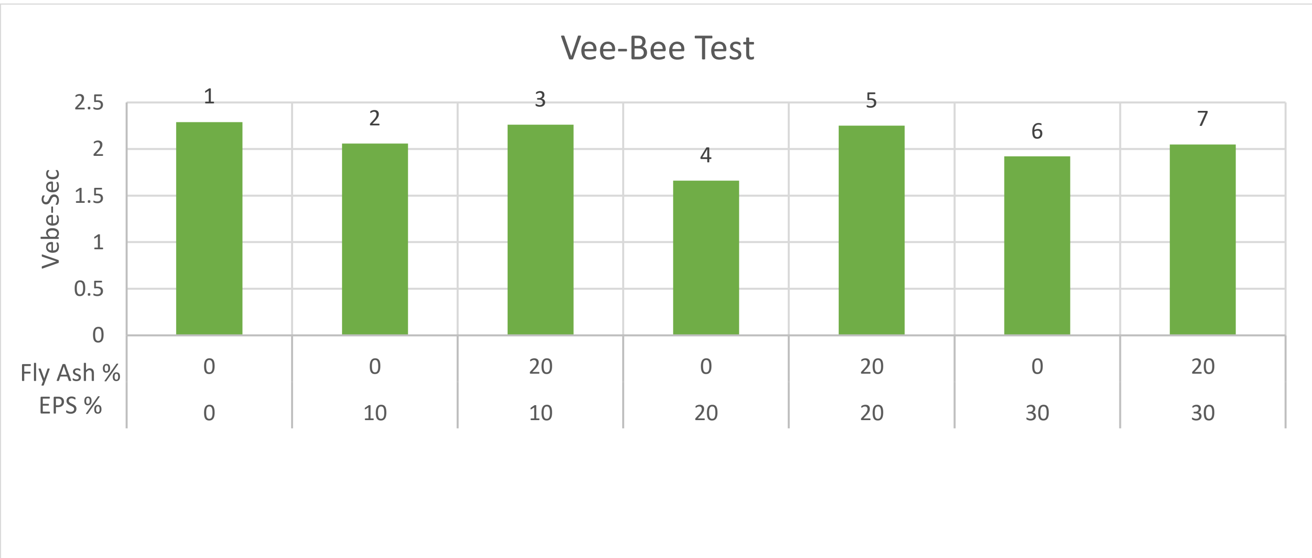


Fig. 5.5 – Vee-Bee Test Values

5.2 Hardened concrete testing results.

The hardened refers to the hardening of concrete for a specific period and once the concrete has hardened, it can be extensively tested to prove its ability to operate as planned or to discover its characteristics when its history is unknown. For new concrete, this usually involves casting test specimens from fresh concrete and testing their various properties as the concrete matures. For this project, the concrete was tested after 28-days of curing. The tests that were considered for this project are:

1. Compressive Strength Test
2. Indirect Tensile Strength Test
3. Flexural Strength Test.

Each test was conducted according to the Australian standards for concrete testing and the results are compared to provide a conclusion in the end.

5.2.1 Compressive Strength Test

The compressive strength for all the batches is tabulated below. The table provides the compressive strength and the maximum load before failure. The batch with no EPS and Fly Ash have the highest compressive strength, which was expected as it was concluded in the literature review for this project.

Table 5.4 – Results of Compressive Strength Testing.

	Batch detials		Compressive strenght test	
Batch No.	EPS %	FLY ASH %	Maximum Load (KN)	Compressive strength (Mpa)
1	0	0	315.3	40.166
2	10	0	107	13.631
3	10	20	274.4	34.955
4	20	0	194.1	17.465
5	20	20	284.1	36.191
6	30	0	216.9	27.631
7	30	20	238.5	38.362

The results made it clear that, the traditional concrete is strongest in terms of compressive strength. The batches with only EPS, has the lowest compressive strength and it increases with the addition of more EPS. But, with the addition of Fly Ash showed a considerable amount of improvement in the compressive strength of the samples.

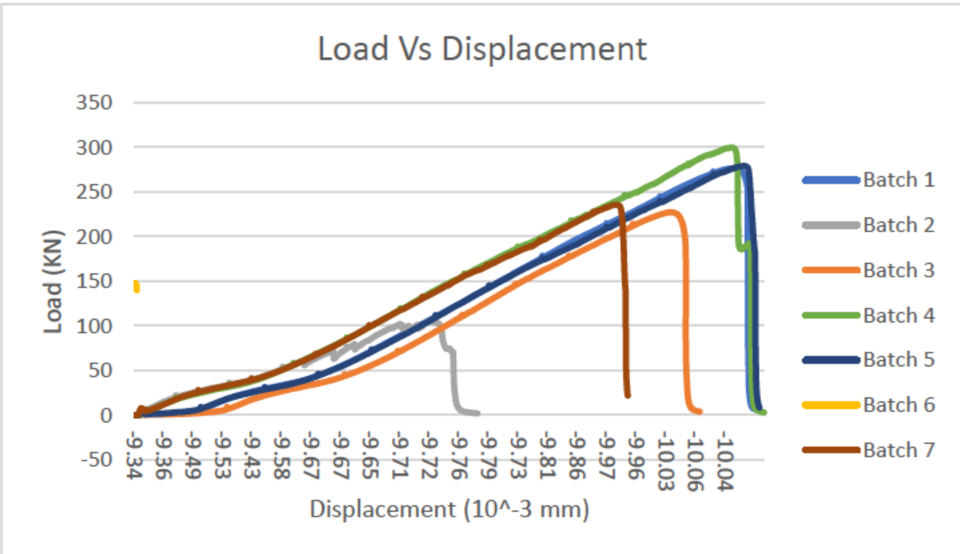


Fig. 5.6 – Load-Displacement for Compressive Strength

This graph depicts the displacement of the sample with increase in the load applied is increased. It can be seen that the batch 1 has the highest degree of displacement with a relative high load. This will give batch 1, the highest compressive strength out of all the batches. But we can also see that batches 5 and 7 shows a very similar curve and the failure load for batch 5 is even higher than batch 1, but with a less degree of displacement. Both these batches have a compressive very close to that of batch 1. This is due to the addition of Fly Ash with EPS that these results were achievable, and this confirms the claim that Fly Ash increases the strength parameters of concrete. It can also be seen that the other batches with just the EPS have lower failure loads and less displacement. This shows that EPS has a negative effect on the mechanical properties of concrete. But with this graph we can also see that the failure load increases with the increase in the replacement of EPS with fine aggregate. EPS itself has density of 25 kg/m^3, but if the amount is substantial it can have a positive effect on concrete's strength.

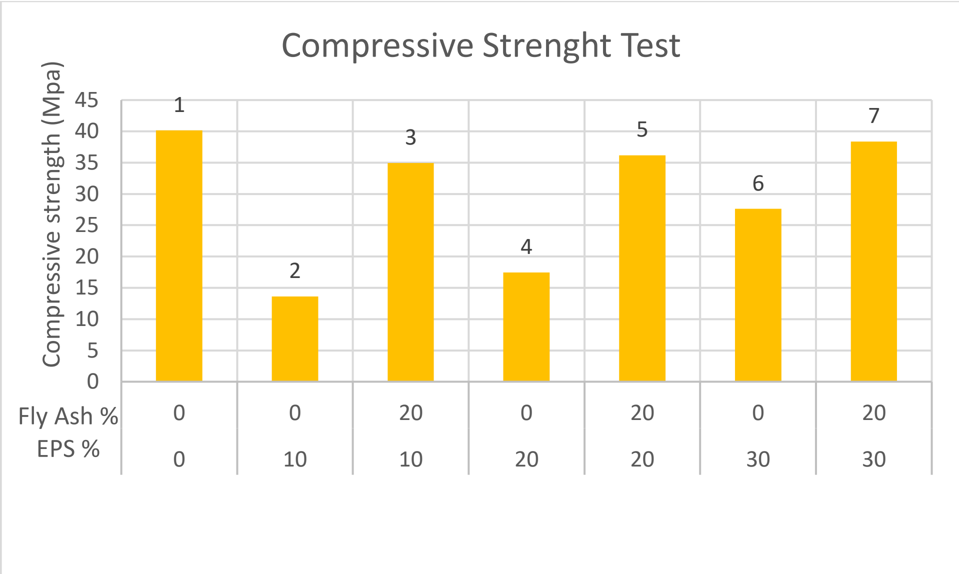


Fig. 5.7 – Compressive strength result Compression

This graph shows the compressive strength for each batch. The compressive strength of batch 1 is highest and batch 2 has the lowest compressive strength. The compressive strength increases with both the addition of Fly Ash and increase in the percentage replacement of EPS. But the addition of Fly Ash has more prominent effect on the compressive strength, and this is supported by the properties of Fly Ash to increase the strength of concrete. Batch 7 has nearly the same compressive strength as the batch 1. This tells us that, it is essential to use more EPS and Fly Ash in order to compensate the lack of strength by the EPS. EPS has a density of 25 kg/m^3 and sand has a density of 1440 kg/m^3, this indicates that there should be some form of additive to facilitate the lack of strength form EPS.

Fig. 5.8 – Sample from Batch – 1 after failure

The above pictures show a sample from batch 1 being tested and the sample after it has been put under compressive loading. There is a big crack formed in the middle of the sample after the failure. This is a diagonal shear failure with is the most common in compressive testing. But the sample is still intact, and no breakage was observed.

Fig. 5.9 – Sample from Batch – 2 after failure

This picture shows the sample from batch 2 and we can see that there is no visible crack but a big chunk from the top layer has been sheared. This indicates that the ductile behaviour of concrete is decreased, and the failure point is decreased as well.

Fig. 5.10 – Sample from Batch – 3 after failure

This sample was from batch 3 and we can see that it has a very uniform crack going through the middle. As it is discussed above the addition of Fly Ash increases the strength and it can bee seen by comparing the samples from batch 2 and 3. This samples do not show any clear shearing or breakage and it can be concluded that Fly Ash increased the ductile nature of concrete.

Fig. 5.11 – Sample from Batch – 4 after failure

This is another sample from batch 4 and we can clearly see the shear failure due to compressive loading. This is another indication that the addition of only EPS decreases the ductile behaviour of concrete. The sample has a clear shear failure in the middle and this is considered to be the worst case as it will not hold its structural integrity under a continues loads once it has failed.

5.2.2 Indirect Tensile Strength Test

At the age of 28 days, the concrete split tensile strength test was conducted in addition to the compressive strength test. The information will be gathered via tensile strength tests of concrete mixtures using EPS and Fly Ash as a fine aggregate and cement replacement. The table below depicts the results of the testing for different samples from different batches. From this table we can see that the sample from batch 7 has the highest tensile strength, which is unusual and does not match with the results from the literature review. Batch 1 should have the highest tensile strength, but with addition of EPS and Fly Ash we were able to get a higher tensile strength. All the batches were made into four samples and these values are the best results form the samples. The tensile strength decreases with the addition of EPS and it is clear from the graph below. But with the increase in the

Table 5.5 – Results of Tensile Strength Testing.

	Batch detials		Tensile Strenght test	
Batch No.	EPS %	FLY ASH %	Force at Failure (KN)	Tensile Strenght (Mpa)
1	0	0	104.3	3.320
2	10	0	67	2.133
3	10	20	88.4	2.814
4	20	0	91.4	2.909
5	20	20	106.6	3.393
6	30	0	94	2.992
7	30	20	107.1	3.409

The tensile strength decreases with the addition of EPS and it is clear from the graph below. But with the increase in the percentage replacement of EPS with fine aggregate, it increases the tensile strength. This is also facilitated with an additional increase in EPS with the addition of Fly Ash. This is can be seen in the graph and one of the reasons behind the increase of tensile strength of batch 7 than batch 1. Batch 5 also has more tensile strength than batch 1, this proves that the performance of concrete mixed with EPS and Fly Ash is better than traditional concrete. These results are the best results from a number of samples and all the samples showed similar results and it safe to assume that there were no alterations to the batches as they were prepared with a standard procedure across all the batches.

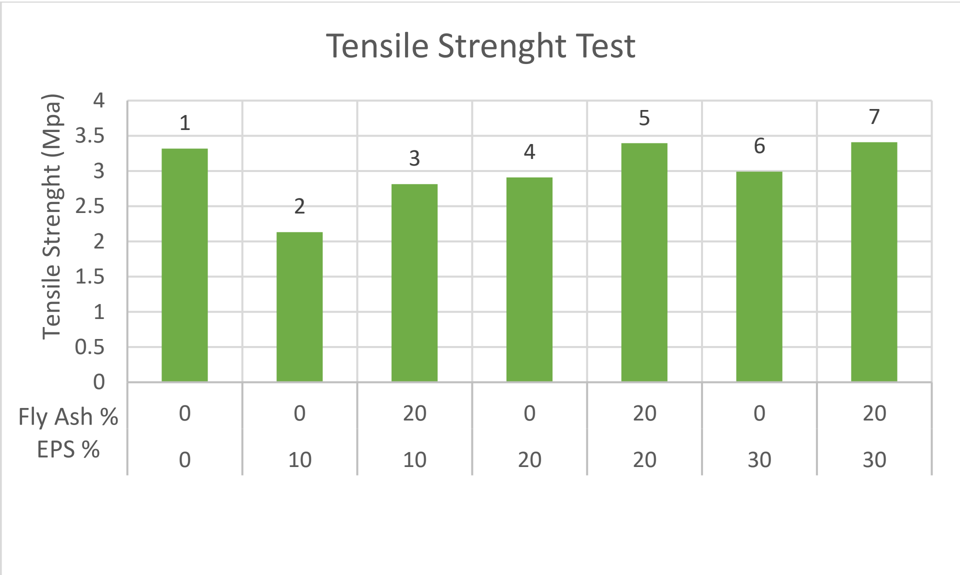


Fig. 5.12 – Indirect Tensile Strength Result Compression

The graph below is the visual depiction of the load applied on the sample and the deflection induced in the sample because of the load applied. The curves from different samples makes the difference between samples clearer. The curve for batch 1 is very uniform and the plastic region has a continuous drop and elastic region also has uniform increase without any dips. The curve for batch 7 has some disturbance in the region where it transfers from elastic to plastic region. It almost has a sudden drop form the peak which indicates that it less ductile than traditional concrete. A similar curve can be seen with batch 5 with having a sudden drop in transitioning from elastic to plastic. In fact, all the other batches has a similar curve, which confirms the findings from the compression testing.

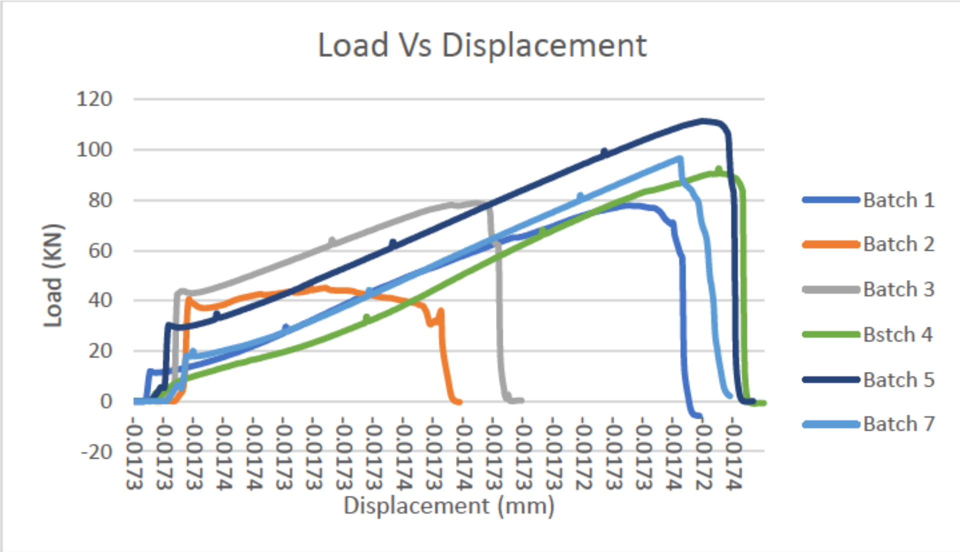


Fig 5.13 – Load-Displacement curve for Indirect Tensile Strength samples

Fig. 5.14 – Sample from Batch – 1 after failure under tensile stress

The above picture shows the sample from batch 1 which has been tested under tensile stress. There is a stress crack running along the middle of the sample, but the crack appears to be on the surface, and it took a chisel and hammer to break the sample. The crack lengthen across the sample and this result is expected from tensile testing.

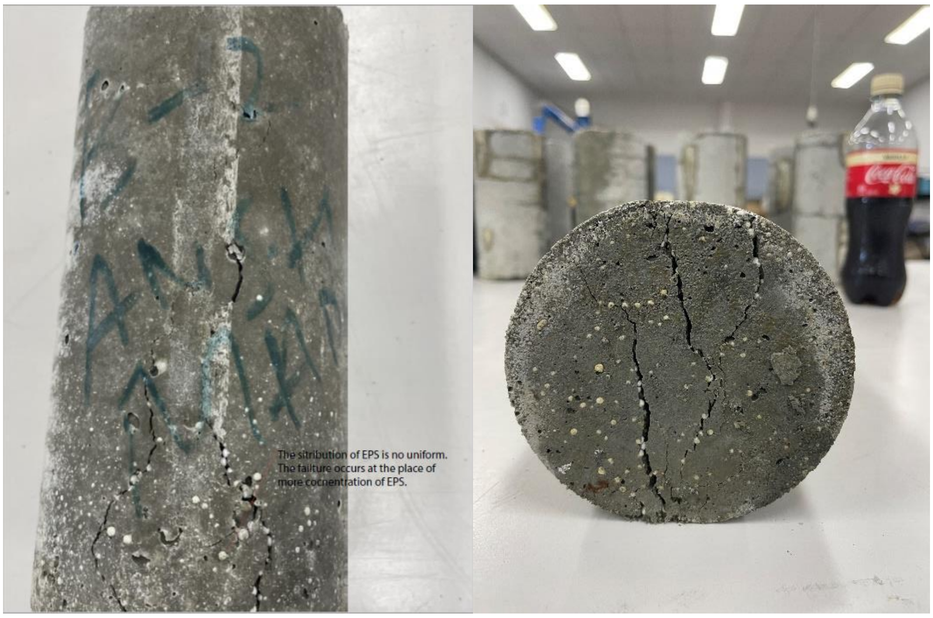


Fig. 5.15 – Sample from Batch – 2 after failure under tensile stress

This sample is from batch 2 which was tested for tensile strength. There are several different cracks running along the length and width of the sample. The shear failure states that this sample is brittle and shows less elastic behaviour that samples form batch 1, which is more elastic. This sample shattered under tensile strength and it has less tensile strength, which indicates that the addition of EPS results in more brittle concrete. This picture also points out one of the reasons for such less tensile strength is because of the un-even distribution of the concrete.

Fig. 5.16 – Distribution of EPS in a sample

The above picture shows the distribution EPS beads in the concrete in the sample for batch 2. The distribution is more concentrated on the top of the sample which made it fail with a lower failure load. This was a concern when the project was started but unfortunately with limited time for testing a solution for this could not be implemented.

Fig. 5.17 – Sample from Batch – 7 after failure under tensile stress

This picture shows the sample from batch 3 which has been tested under tensile stress. There is an obvious visual difference between this sample and the previous sample. The crack formed is very similar to that of the sample from batch 1. The only variable in this batch was the addition of Fly Ash, which makes the tensile strength for this batch a lot closer to that of batch 1. This further proves that the addition of Fly Ash significantly improves the strength of the concrete.

5.2.2 Flexural Strength Test

The flexural strength test is performed to measure the amount of stress a concrete beam can withstand to resist any bending failures. The flexural strength of concrete is measured as the modulus of rupture, which is calculated as it was discussed in the chapter 3. The testing machine needed to be adjusted for the size of the beams and this was done according to Australian standards.

Fig. 5.18 – Testing machine after the calibration for test

The table below shows the test results for all the batches. It can be seen from the table that the batch with the highest percentage of EPS has the highest value of modulus of rupture. This falls in line with the literature review conducted in previous chapters.

Table 5.5 – Results of Flexural Strength Testing.

	Batch detials		Flexural Strenght test				
Batch No.	EPS %	FLY ASH %	Average width at the section of failure (mm)	Average depth at the section of failure (mm)	Span Length (L) (m)	Force at failure	Modulus of rupture (Mpa)
1	0	0	103	105	308	11.172	3.030161812
2	10	0			308		
3	10	20			308		
4	20	0	103	100	308	12.606	3.769561165
5	20	20	104	103	308	11.532	3.219197053
6	30	0	104	102	308	14.346	4.083643865
7	30	20	103	102	308	13.266	3.812880035

The samples from batches 3 and 4 were not tested because of the time constraints and the results from these two batches can be predicted by the other four batches. But if we see the graph below, we can see that the flexural strength of the traditional concrete is less than the concrete with EPS and Fly Ash. This is completely opposite to the test results from compression and tensile testing as the batches with EPS and Fly Ash has less flexural strength than the batches with only EPS.

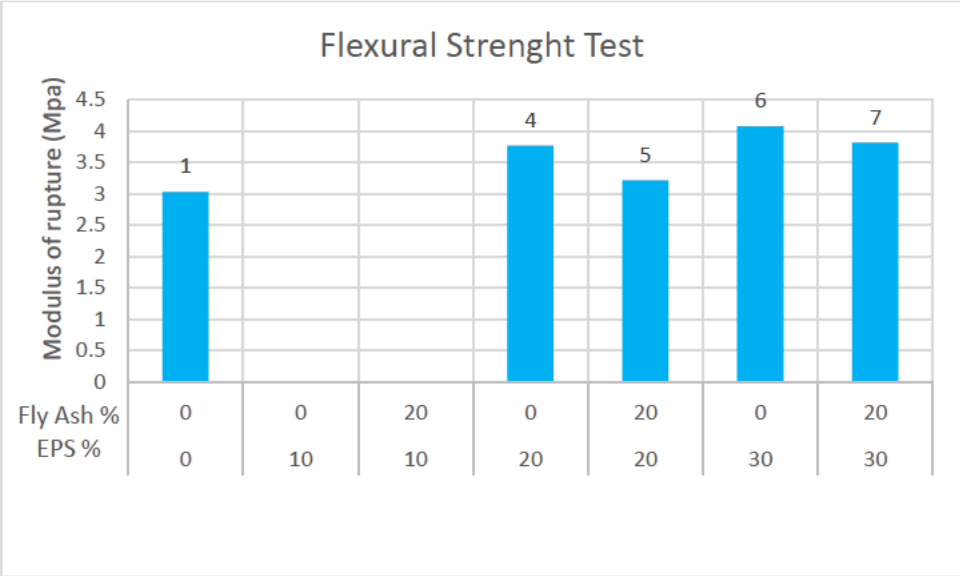


Fig. 5.19 – Indirect Tensile Strength Result Compression

The graph below depicts the load and the displacement of the sample due to the load applied on the sample. It is clear from the graph that batch 7 has the highest applied load but the displacement is less than that of batch 6. Batch 6 has a displacement of 2.45 mm and a load of 10000 KN and it has the highest flexural strength. The curve for batch 1 and batch 6 has similar curve but it has more time for displacement than batch 1. The batches with Fly Ash have less displacement but higher failure load, which means that these samples were more flexible and less structural integrity.

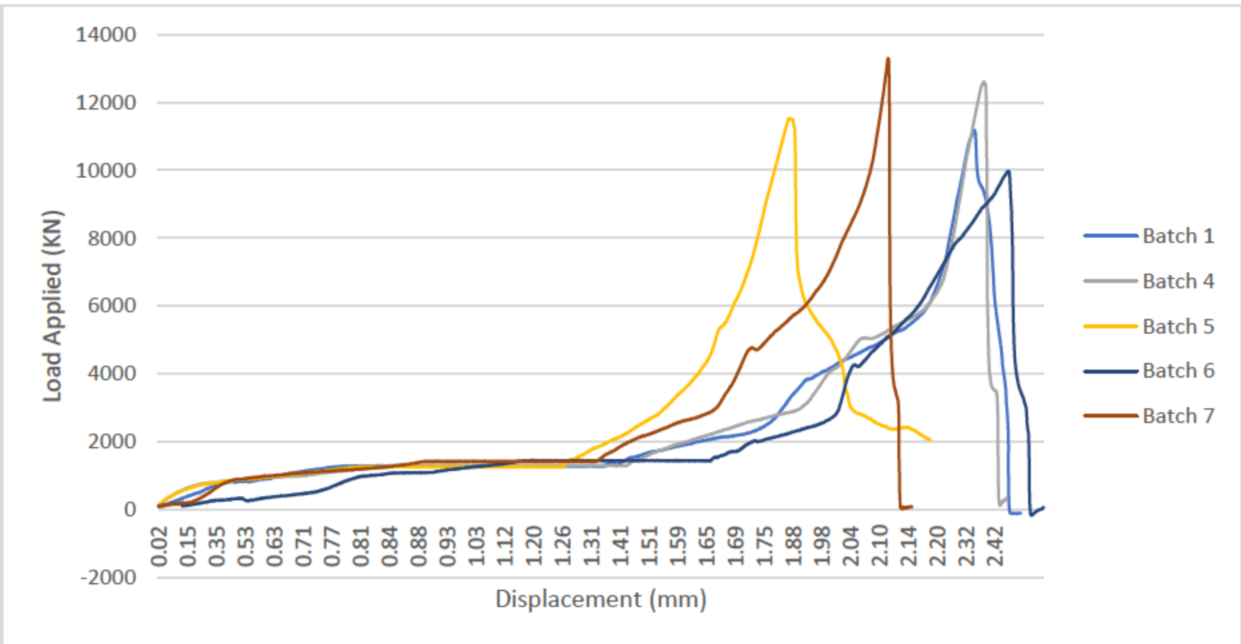


Fig 5.20 – Load-Displacement curve for Flexural Strength samples

Fig 5.21 - Sample from Batch – 1 after failure under bending

This picture shows the beam from batch 1 which was tested in the testing machine. The crack in the beam runs along the middle, splitting the beam. This is a result expected from a traditional concrete beam. The flexural strength of the batch 1 is also the normal value.

Fig 5.22 - Sample from Batch – 6 after failure under bending

The picture above shows the beam from batch 6 after the testing, which has the highest flexural strength. The crack is formed in the middle, but it is more prominent, and it was easy to split. The cross section again reveals the uneven distribution of EPS. But the distribution of not concentrated in one place which could be the reason for the higher flexural strength. This indicates that the distribution of EPS, affects the mechanical properties of concrete.

Chapter 6

6.1 Conclusion

This project aimed to find out the effect on the mechanical properties of concrete when fine aggregates are replaced by EPS and cement is replaced by Fly Ash. After conducting the fresh and hardened concrete testing, the results were observed, and it was concluded that:

- The addition of EPS increases the workability of concrete, which is supported by the results of slump, compaction factor and vebe tests. Furthermore, the addition of Fly Ash also increases the workability even further. The increase in workability is gradual and it can be concluded the more percentage replacement of EPS and Fly Ash results in better workability.
- The compressive strength test results conclude that with the addition of EPS, the compressive strength of the concrete decreased by a significant margin. The decrease from the control mix is 67% for batch 2. This make it clear that the addition of EPS is not beneficial for the compressive strength. But with the addition of Fly Ash increases the compressive strength of the baches with EPS. The increase in quite significant with an average of 33% increase from the batches with only EPS replacement. The batch 7 has almost the same compressive strength, which has 30% EPS and 20% Fly Ash.
- The tensile strength depicts a similar result to compressive strength results. The batches with only EPS reduced the tensile strength and the reduction was significant. But similar to compressive strength test results, the addition of Fly Ash facilitates and increased the tensile strength of the concrete when added with EPS. This concludes that the replacement of fine aggregate with EPS reduces the strength of the concrete. But the replacement of cement with Fly Ash increases the strength of concrete.
- The flexural strength test results indicate that the batches with only EPS replacement have more flexural strength, which is in line with the observations from the literature review. But with the addition of Fly Ash reduce the flexural strength and the reduction is significant and constant with every batch.

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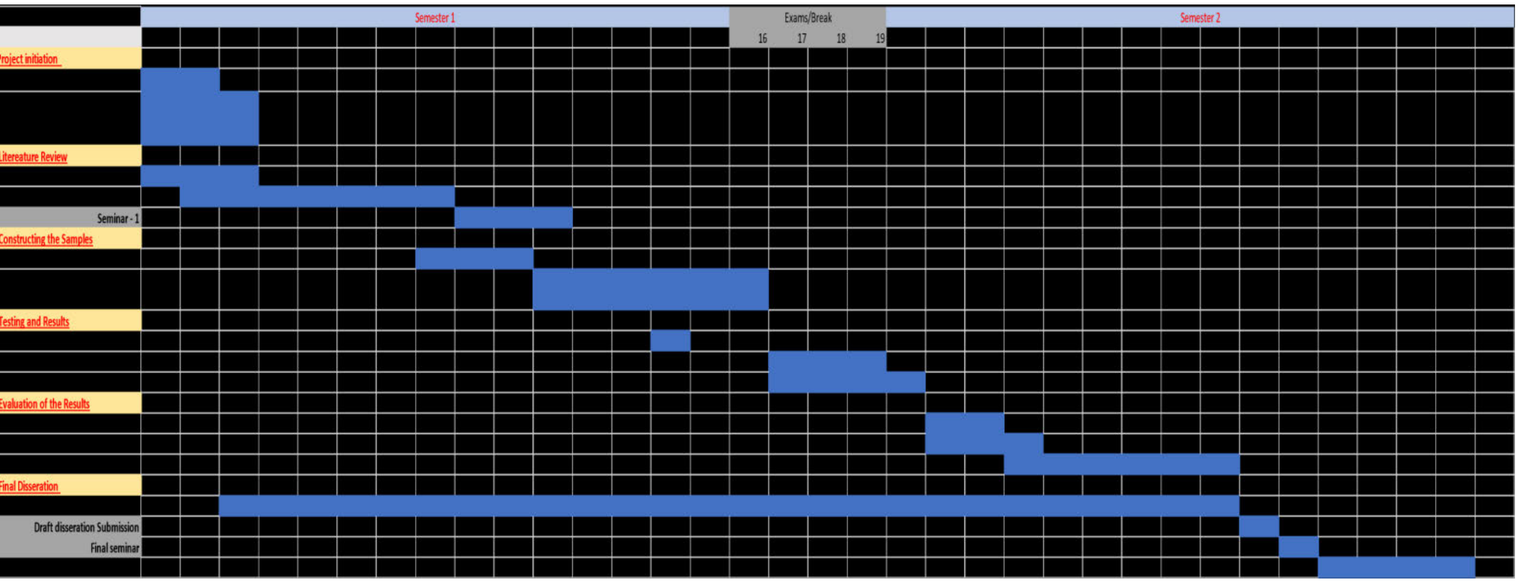
Appendix

Project timeline



Risk Management Plan.

University of Southern Queensland   Print View

UNIVERSITY OF SOUTHERN QUEENSLAND

USQ Safety Risk Management System

Version 2.0

Safety Risk Management Plan

Risk Management Plan ID:	Status:	Current User:	Author:	Supervisor:	[redacted]
RMP_2021_5859	*Approve*	[redacted]	[redacted]	[redacted]	[redacted]

Assessment Title:	Investigation on the properties of concrete with Expanded Polystyrene	Assessment Date:	29/07/2021
Workplace (Division/Faculty/Section):	204060 - School of Civil Engineering and Surveying	Review Date: (5 years maximum)	

Approver: *Weena Lokuge*	*Supervisor: (for notification of Risk Assessment only)* *Weena Lokuge*

Context

DESCRIPTION:

What is the task/event/purchase/project/procedure?	Testing the concrete samples with Expanded Polystyrene and comparing the results with traditional concrete.		
Why is it being conducted?	To find out the mechanical properties such as compressive strength, flexural strength and etc.		
Where is it being conducted?	The tests will be conducted in the Z4 laboratory in USQ Toowoomba campus.		
Course code (if applicable)	ERP2021	Chemical Name (if applicable)	

WHAT ARE THE NOMINAL CONDITIONS?

Personnel involved	Anshdeep Singh, Weena Lokuge, Pumika Ariyadasa
Equipment	Axial Loading Machine, Concrete Mixer, Shovel, Wheelbarrow, Scale, Metal Rod, Cylindrical and beam Moulds, Oven for water absorption test.
Environment	Laboratory Conditions
Other	
Briefly explain the procedure/process	This will involve mixing of fresh concrete and casting of cylindrical and beam moulds for flexural strength testing, tensile testing, compressive strength testing, consistency testing

Assessment Team - who is conducting the assessment?

Assessor(s):	Weena Lokuge, Pumika Ariyadasa
Others consulted: (eg elected health and safety representative, other personnel exposed to risks)	

Risk Matrix

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

Recommended Action Guide

Extreme:	E= Extreme Risk – Task ***MUST NOT*** proceed
High:	**H** = High Risk – Special Procedures Required (Contact USQSafe) Approval by VC only
Medium:	M= Medium Risk - A Risk Management Plan/Safe Work Method Statement is required
Low:	L= Low Risk - Manage by routine procedures.

Risk Register and Analysis

	Step 1	Step 2	Step 2a	Step 2b	Step 3			Step 4				
	Hazards: From step 1 or more if identified	*The Risk:* What can happen if exposed to the hazard without existing controls in place?	*Consequence:* What is the harm that can be caused by the hazard without existing controls in place?	*Existing Controls:* What are the existing controls that are already in place?	*Risk Assessment:* Consequence x Probability = Risk Level			*Additional Controls:* Enter additional controls if required to reduce the risk level	*Risk assessment with additional controls:* Has the consequence or probability changed?			
					Probability	*Risk Level*	*ALARP*		*Consequence*	*Probability*	*Risk Level*	*ALARP*
	Example											
	Working in temperatures over 35° C	*Heat stress/heat stroke/exhaustion leading to serious personal injury/death*	*catastrophic*	*Regular breaks, chilled water available, loose clothing, fatigue management policy.*	*possible*	*high*	*No*	*temporary shade shelters, essential tasks only, close supervision, buddy system*	*catastrophic*	*unlikely*	*mod*	*Yes*
1	Casting of th...	Dust or any smaller particles going into eyes or inhaling while working, it can cause breathing difficulty and irritation of eyes	Moderate	Wearing a mask during the testing and wear personal protective. Induction training for workplace health and safety for the laboratory.	Rare	Low						
2	Lifting heavy ...	Muscle injury and strains can occur.	Minor	By using correct techniques to pick up heavy objects. Induction training for workplace health and safety for the laboratory.	Unlikely	Low						
3	Operating th...	This can cause serious injury if the machines are handled without proper induction	Major	Operate the machines with care and follow the instructions given. Induction training for workplace health and	Rare	Low						

4	Mixing of co...	Concrete can cause micro cuts and scrapes to skin if allowed to dry on skin	Minor	Wear safety equipment such as gloves and wear long sleeve shirts. Induction training for workplace health and safety for the laboratory.	Unlikely	Low						
5	Tripping over...	This can cause serious injuries and possible fractures.	Minor	Keep the workplace clean at all times. Induction training for workplace health and safety for the laboratory.	Unlikely	Low						
6	Exposure to ...	Ilness	Minor	If any symptoms of COVID-19 or even cold no one will attend the laboratory	Unlikely	Low						
7	Ingestion of ...	EPS beads can get stuck causing blockage to the airways.	Moderate	The EPS beads are very light weight and can be easily blown away by very subtle winds. The EPS beads should be kept in a safe place.	Rare	Low						
8	Concrete Sa...	This can cause serious cuts to the operator.	Moderate	Limit use of equipment to trained staff member. Training on correct use and handling of tool in accordance to USQ safety handling manual.	Rare	Low						
9	Exposure to ...	It can cause skin irritation irritation and serious eye	Minor	Wear safety equipment such as glasses and mask to avoid the risk of exposure.	Unlikely	Low						

Step 5 - Action Plan (for controls not already in place)

	Additional Controls:	*Exclude from Action Plan: (repeated control)*	*Resources:*	*Persons Responsible:*	*Proposed Implementation Date:*

Supporting Attachments

No file attached

Step 6 – Request Approval

Drafters Name: *Anshdeep Singh* *Draft Date:* *29/07/2021*

Drafters Comments:

Assessment Approval: All risks are marked as ALARP

Maximum Residual Risk Level: Low - Manager/Supervisor Approval Required

Document Status: *Approve*

Step 6 – Approval

Approvers Name: *Weena Lokuge* *Approvers Position Title:* *Project supervisor*

Approvers Comments:

I am satisfied that the risks are as low as reasonably practicable and that the resources required will be provided.

Approval Decision: Approve *Approve / Reject Date:* 29/07/2021 *Document Status:* *Approve*

Resource Request Form

Faculty of Health, Engineering and Sciences
ENG4111 Research Project Part 1 & ENG4112 Research Project Part 2
UNDERGRADUATE PROJECT RESOURCE REQUEST

This form must be typed and completed in full.

Student Name:	**Anshdeep Singh**
Student Number:	[redacted]
Program/Major:	**Bachelor of Civil Engineering (Honours)**
Project Title: (Full title needed)	**Investigation on the properties of concrete with Expanded Polystyrene**
Supervisor/s:	**Weena Lokuge**
Funds requested: (to nearest $50)	**$100**

Please provide a brief description of what is to be purchased:

To complete this project, it is required to purchase cement, concrete grade sand, fly ash, 10 - 15mm aggregates.

Cement and Fly Ash is to be purchased from COBBLEPATCH LOGANLEA
675-679 KINGSTON ROAD, Contact number – 07 3299 7666.
Cement required 44 kg. It is sold in 20 kg bags and each bag is $6.95. This project it is required to purchase 3 bags for $21.
Fly ash required 18 kg. It is also slod in 20 kg bags and each bag is $14.90. It is required to purchase 1 bag for $14.90.

Aggregates and sand are to be purchased from Bunnings Toowoomba North, Contact number – 07 4592 4800.
Sand required is 58 kg. It is sold in 20 kg bags and each bag is $7.98. The specific product is Brunnings 20kg Landscape Paver Sand. It is required to purchase 3 bags for $23.94.
Total Aggregates required is 82 kg. It is sold in 20 kg bags and each bag is $7.98. The specific product is Ki-Carma 20kg 10-20mm Drainage Gravel. It is required to purchase 5 bags for $39.90.

The total budget of the project is $99.74.

I confirm that these funds are essential to successfully complete this project: Anshdeep Singh

Supervisor: __[redacted]____________ **Date: _30/07/2021_____**
Signature

Examiner: ________________________________ **Date:** ______________

USQ collects personal information to assist the University in providing tertiary education and related ancillary services and to be able to contact you regarding enrolment, assessment and associated USQ services. Personal information will not be disclosed to third parties without your consent unless required by law.

Project Resource Number	

The Project Resource Number is allocated and budget total confirmed as above. The student must quote this number on every request for project parts and on every workshop job form. The Examiner will then endorse these forms for further action. Note that there is no mechanism for students to initiate purchases in advance and then seek reimbursement.

Project Specifications

ENG4111/4112 Research Project

Project Specification

For: Anshdeep Singh

Title: Investigation on the properties of concrete made with expanded polystyrene

Major: Civil Engineering (Honours)

Supervisors: Professor Weena Lokuge

Enrollment: ENG4111 – ONC S1, 2021

ENG4112 – ONC S2, 2021

Project Aim: To investigate and determine the durability properties by conducting research and tests such as tensile strength test, compressive strength test, Sump test, setting time, permeability test and workability.

Programme: Version 1, 17th March 2021

1. Conducting an initial research to find out the properties of expanded polystyrene (EPS) and a background research to identify the existing work about this topic.
2. Acquire the materials required to form specific samples that will be developed from the initial research.
3. Constructing the different samples to start the physical testing and gathering the results from testing.
4. Analyzing the results from the testing and comprehending it to deduct a conclusion about the durability properties.
5. Deducing a conclusion from the analysis of the results and providing a clear evidence of the pros and cons of the concrete with EPS over traditional concrete.

If time and resource permit:

6. Researching about the possible addition of other materials to strengthen the EPS concrete.
7. Testing the new samples to acquire results and comparing it with the results form earlier results to comprehend the improvements.

Resource Planning

The main aspect of this project is physical testing of the sample concrete blocks made with EPS (expanded polystyrene). There are some physical resources required to construct the concrete samples. The resources collection will be an important task and can take a substantial amount of time depending on the availability of the products.

The raw material required for this project are,

1. Portland Cement.
2. Sand.
3. Fly Ash.
4. Expanded polystyrene beads.
5. Coarse aggregates.

The cost for each of the products is only an estimation because the amount required for each of the products needs to be determined beforehand. The amount is also subjected to change during the progression of the project The approximate price of the raw materials is given below.

1. Portland Cement - \$0.35 per kg.
2. Sand – \$0.55 per Kg.
3. Fly Ash - \$0.93 per Kg.
4. Expanded polystyrene beads – \$0.3 per L.
5. Coarse aggregates - \$0.5 per Kg

The access to laboratories will also be required to construction of samples and testing of the samples. USQ Toowoomba campus has a concrete laboratory in building Z1, which will be required for testing purposes for this project. The booking of the laboratory must be completed early on in the project as it can be difficult to gain access later on due to other students booking the lab for their project. There will also be a scheduled training and safety induction in order to handle the testing machines in the laboratory.

There can be delays in the testing of the concrete samples due to many unforeseen reasons. So, the schedule to access the laboratory must be negotiated with USQ taking the delays into account.