CHAPTER 1

INTRODUCTION

1.1 Background of Study

According to the numerous statistics online, the world's population is exploding. This increasing rate of the population will occur to more waste is being produced and will cause to more pollution. In general idea, pollution is the simplest way to kill our mother nature which is Earth. Pollution is the indication of contaminating the environment that causes hostile changes. [1] One of it is disposing hazardous waste like pesticides and toxic chemicals that are washed from land to water.

Even industrialization is becoming an important component to a nation's development, it has its negative consequences and that includes the contamination of the environment by the hazardous wastes that are produced from these industrial companies. [2] Due to the toxicity and hazards, it is very difficult to dispose the waste and not degrading the environment.

Every type of waste has its own way of disposing, and before disposing it will undergo to some processes like chemical treatments to neutralize the hazards present. With solidification/stabilization (S/S) technology, it also helps to stabilize in minimizing the contaminants of the waste. It is one way of treatment technology that depends on the reaction between a binder and waste to reduce the mobility of the contaminant. [2]

1.2 Objectives of Study

- To compare the characteristics of the solidified material by differing the ratio and the addition of binder.
- To investigate the effect of additive binder on the properties of immobilized sludge cement paste.
- To reduce the toxicity of sludge by immobilizing using Portland cement as main binder.

1.3 Problem Statement

From the environmental sector of Malaysia, the country is one of the largest export nations worldwide. But as mentioned earlier, these enhance the pollution rate and contaminate the environment. Aside from the industrial development of the country, it is also important to give emphasis to the environmental protection and prevention of pollution. [3] Among of the environmental problems, difficulties of disposing hazardous and toxic waste arise due to the consideration and possible threats not just to the environment but also to the people, itself.

The waste management in Malaysia especially in hazardous materials increases as the time goes by due to the population increase and the development of the country (see Figure 1). There will be a need of more licensed disposal area for the hazardous waste are not advisable to disposed anywhere due to the high risk of soil and underground water contaminants that will affect the environment and also to the human health.

There is no problem with the chemical treatments and the other process that were usually used for waste treatment. Just that with S/S technology, it is cheaper and more convenient since the waste is stabilized and also used for useful purposes like constructions of road and buildings.

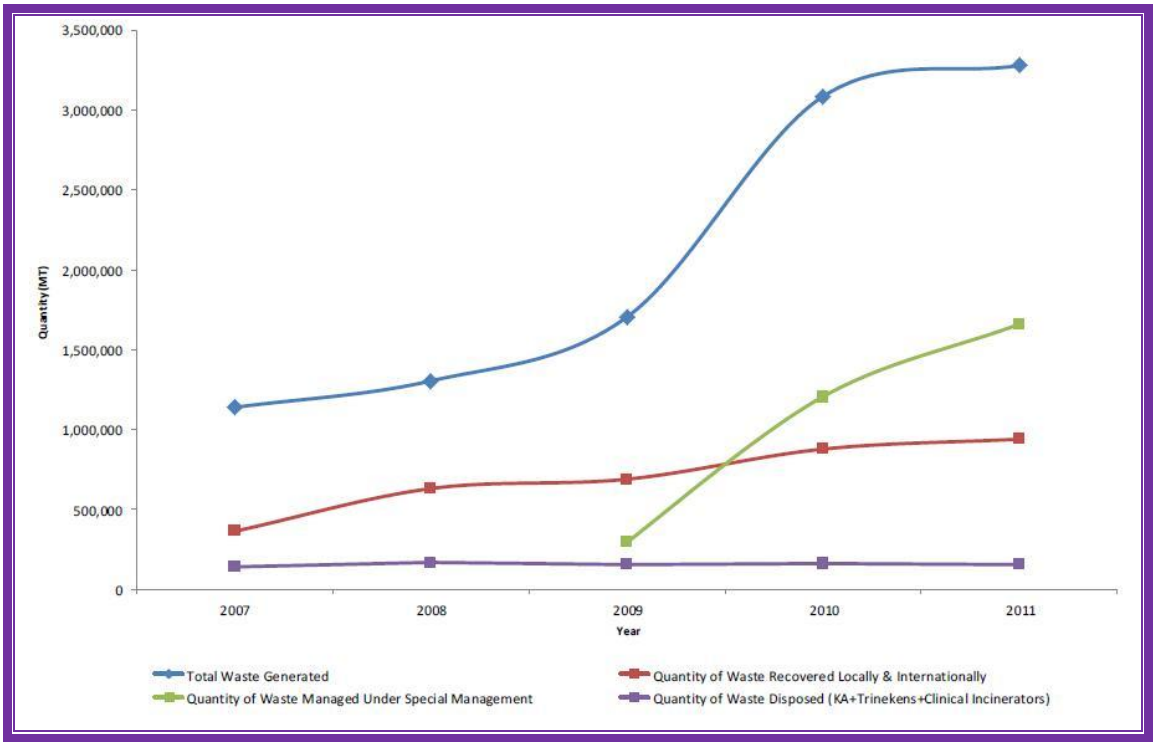


Figure 1.1: Trend Schedule Waste Management from 2007-2011 [4].

1.4 Relevancy of the Project

In different countries, there are regulations and acts that are followed in disposing various type of waste including the toxic, but in Malaysia it is called, Waste Management. Waste management controls the rise of catastrophic pollution and its dangerous effects to the environment and human. It also helps to make the Mother Nature healthy and contaminant-free.

By using the Portland cement and RHA, it is an easy way in managing hazardous waste produced by the industries. Immobilizing the contaminants using cement and RHA that neutralize the toxicity and at the same time using it for useful purposes.

1.5 Feasibility of the Project

Mostly the research and reviews are done during the last semester- FYP I. In this semester's, FYP II is the development and experimental work of the project. Through the guidance of supervisor and also from the laboratory technicians, will be able to push through the experiments and analysis.

The major concern for the said project is the major binder which is the Portland cement bought from Tasek Sdn. Bhd., the additive which is Rice Husk Ash prepared at block J with the assistance of Mr, Azran, and the industrial waste which is from Lotte Chemical Titan Sdn Bhd. and lastly the supply of water and other tools from concrete laboratory in block 13.

CHAPTER 2

LITERATURE REVIEW

2.1 Stabilization/Solidification

2.1.1 Definition

Stabilization/Solidification (S/S) is a process that involves the mixing of waste with a binder to reduce the contaminant leachability by both physical and chemical means and to convert the hazardous waste into an environmentally acceptable waste form for land disposal or construction use [5].

Many studies have proven that stabilization is one of the methods for removing hazardous wastes. The stabilization/solidification system captures the waste within a solid matrix having a high structural level which converts the waste into leach resistant and impermeable so that the release of hazards and toxics will be deliberate even though flowing water may contact them. The waste will be mechanically, physically and chemically stable for handling, transport and disposal [6].

The possible hazards that can be treated using S/S technology are: metal bearing wastes, activated sludge, fly ash, lime/ limestone wet scrubber, lead containing waste, metal fines, inorganic sludge from electroplating, paint sludge from automobile industries and etc.. The physical and chemical characteristics of the sludge or the hazardous waste creates a great influence on the immobility of the contaminants, thus, consideration of its properties are significant in treating the S/S [2].

From the previous research projects, there are different kinds of binder used for the stabilization. Among of the binders that are used are cement, Rice Husk Ash (RHA), Fly Ash, Pulverized fuel ash (PFA) and Condensed silica fume. The most eminent binder used in stabilization is cement. Cement has the characteristic of porosity and continuous hydrating material. Thus, cement-base solidification technology is widely used because of the waste leaching behavior. A. El-Dakroury, 2008 says that, it is related to the pore structure and to the composition of pore solution. The rate of dissolution in leaching varies as function of phase chemistry and exposes or enlarges pores. In order to avoid wide-spread diffusion of toxicity to the human and environment, the waste contaminants are incorporated in cement and with different additive binder [6].

It is proven to some of the experiments that the additive binder helps to increase the strength of the solidified waste. Also by increasing the ratio of the water, cement and the sludge, the porosity of the solidified material will be increased. Additive binder which has higher silica content that will form soluble silicate and retard the tricalcium silicate hydration by nucleation mechanisms, helps the major binder which is cement to strengthen the immobilized sludge and increasing its porosity [7].

2.1.2 S/S Technology Mechanisms

Stabilization/Solidification involves mixing of Portland cement into contaminated material to physically solidify and chemically stabilized the contaminants within the treated materials. In untreated soil with contaminants, the ground water move through the contaminated soil dissolving and physically carrying away the contaminants. S/S technology can be used to treat soil, sediments and sludge.

While during solidification, cement mixed into the soil reacts with water or hydrates, this reaction will form physical bonds that encapsulate and immobilize contaminants. Solidification often lowers the permeability of the treated material. This inhibits water movement and prevents leaching.

Stabilization describes chemical changes to the hazardous constituents. Cement added to the contaminated soil begins to hydrate producing calcium hydroxide. This increases the pH of the material. Calcium hydroxide and the pure water react of some of the contaminants converting them into less soluble compound, reaction involving cement and water also produce carbonate and silicate compounds. Some of the contaminant in the waste becomes incorporated into the compound, forming insoluble carbonate and silicate compounds. This development further reduces the leachability of the contaminants.

Stabilization attempts to reduce the solubility or chemical reactivity of a waste by changing its chemical state or by physical entrapment (microencapsulation). While, solidification systems tries to convert the waste into an easily handled solid with reduced hazards from volatilization, leaching or spillage. The two developments are discussed together because both have common purpose of improving the containment of potential pollutants in treated wastes, waste fixation or waste encapsulation [5].

2.1.3 Advantages of S/S Technology

Table 2.1: Advantages and Disadvantages of S/S Technology [2]

Advantages	Disadvantages
• can be completed in a relatively short time period	• does not destroy or remove the contaminants
• can be used to treat recalcitrant contaminants (e.g. heavy metals, PCBs, dioxins)	• may be difficult to predict long-term behaviour
• may be performed *in situ* or *ex situ*	• may result in an overall increase in volume of material
• process equipment occupies a relatively small footprint	• consumption of natural resources
• the physical properties of the soil are often improved by treatment (e.g. increased strength, lower permeability)	• may require long-term maintenance of protection systems and/or long-term monitoring

2.2 Raw Materials

I. Ordinary Portland cement (OPC)

Portland cement or also known as Ordinary Portland cement (OPC) is the most common type of cement generally used worldwide. Aside from it is widely used, it is also cheap.

Table 2.2: Chemical Composition of Ordinary Portland cement (OPC)

CHEMICAL COMPOSITION OF OPC

Compound	Concentration (%)
Silica (SiO_2)	22.0
Alumina (Al_2O_3)	4.91
Iron Oxide (Fe_2O_3)	3.76
Calcium Oxide (CaO)	64.64
Magnesium Oxide (MgO)	2.25
Sulfur Oxide (SO_3)	2.45

There are different types of Portland cement available. [8] Each type differs primarily in their contents and in their fineness, and in terms of their performance, they differ in the rate of hydration, resistance from sulfate attack. The different types are listed in Table 2.3.

Table 2.3: General properties of the types of portland cement. [8]

	Classification	Characteristics	Applications
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

II. Rice Husk Ash (RHA)

In Malaysia, they produce rice as it is their main staple food. Rice husk is considered a form of waste from the rice-milling process and it is usually left to rot or burn in the field. These practices can bring serious environmental problem such as methane (gas that contributes to greenhouse effect or global warming) production in its slow rotting process, while open burning generates various pollutants such as smoke, dust, acid gases and volatile organic compounds that are obviously have a significant impacts on human and environment. In order to minimize the effects, rice husk is combusted using incinerator to produce rice husk ash (RHA).

Like fly ash and silica fume, RHA also exhibits high degree of amorphousness and it is suitable for use as cement aggregate or pozzolan. Pozzolanic material like RHA comprises silica and alumina that react chemically with calcium hydroxide that form cementitious properties. [9]

Figure 2.1: RHA Incinerator at Block J-2

III. Industrial waste

Pb (lead) Sludge *from Yokohama Reclamation Sdn Bhd*

With the rapid growth in the industrial sector, more wastes are being produced. One of the wastes that occupy the fifth position in the metal industries is the heavy metal lead (Pb).

Soil is one of the few things that can be affected and contaminated with lead and other sources. Once soil is contaminated, lead will accumulate in the upper 8-inches of the soil and is highly immobile. [10] Contamination remains a long term exposure of lead and it was found to be acute toxic to human beings when open to elevated concentration.

One of the companies that produce sludge containing lead (Pb) metal is the Yokohama Reclamation (M) Sdn Bhd located at Pengkalan Industrial Estate in Ipoh, Perak. The reclamation plant has advanced machineries that utilize the latest technology in doing the lead reclamation. Mainly Yokohama is an industry that derives the usable materials from discarded and expired automotive batteries. Automotive batteries that are usually lead-acid batteries are fabricated of a plastic case, lead and electrolyte solution. These components cause hazardous risk to the environment and to human health. Hence proper disposal and process to reduce the risk of exposure is done at the Yokohama Reclamation plant.

Figure 2.2: Battery recycling at Yokohama. (Source: Yokohama website)

Scrap/expired batteries are the main raw material of the plant. These batteries will be sent to crusher and after that it will be sorted into four parts: – 1: polypropylene chips (from the body/casing battery), 2: Paste containing the lead (Pb), 3: Acidic water, and 4: Metal (Pb) Plating. Each component will be sent to different process. The paste and the metal plating which contains Pb substance will be sent to furnace for melting to produce their product for the new batteries. The acid water will be sent to water treatment. This water will be treated with sodium liquid then chemicals will be added in order to separate the heavy metal through sedimentation. Treated water will be then sent for testing and if the water passed, 30% of it will be used for the process. The sediment obtain from the water treatment will be sent to filter-pressing. It will form a sludge cake– this is then the waste product.

Table 2.4: Lead (Pb) Properties

Lead (Pb) properties	
Atomic Number: 82 Atomic Weight: 207.19 Specific Gravity: 11.34 Bluish or silvery grey metal Melting point at 327.5 °C Boiling point (at atmospheric pressure) 1740 °C	

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

Research and designing of the project is followed by the methodology used shown in the flowchart in Figure 3.1 below:

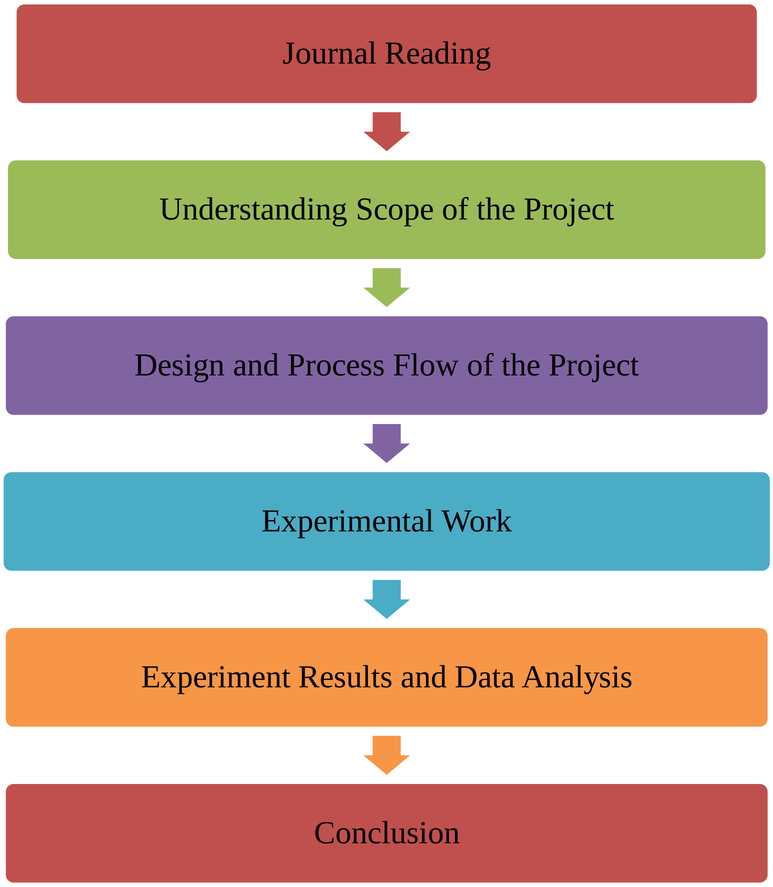


Figure 3.1: Flowchart of the research method

3.2 Experimental Method

The experimental method of stabilization/solidification technology follows the material preparation, material sampling and testing, mixture design, raw material mixing, mixture initial testing, pouring, curing (drying) and the final testing and performance criteria which are illustrated in the flowchart below in Figure 3.2:

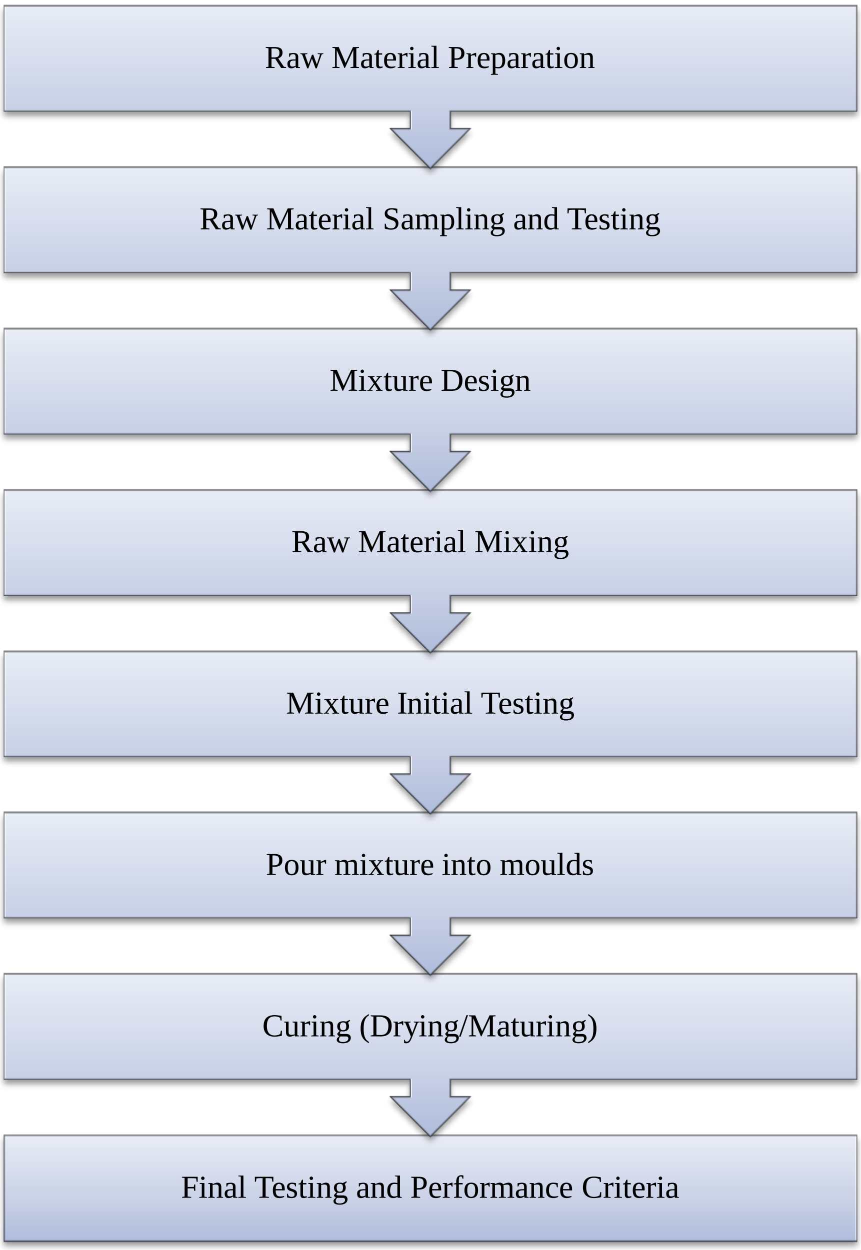


Figure 3.2: Experimental flowchart of S/S technology

3.3 Project Activities

A. Preparation of RHA

Rice husk is prepared at Block J-1 with the assistance of the lab technician, Mr. Azran. Eight (8) bags of rice husk is prepared and poured inside the incinerator for combustion. The temperature of the incinerator is set at 700°C. The combustion of the rice husk took whole day. The next day, the combusted rice husk ash is taken out from the incinerator and then put into a ball-mill grinder to produce a fine powder rice husk ash. Two (2) batches of grinding are taken and each batch took 2-3hours. Then the rice husk ash is then use for the additive binder.

Figure 3.3: Preparation of RHA: RHA after taking out from the incinerator (photo above). RHA ready to put inside the ball-mill grinder (photo below).

B. Preparation of sample/ mixture design

Calculation is conducted to measure the proper ratio of waste, cement, water and RHA. After obtaining the respective values, the variables- waste, cement, water and RHA is then weighed and mixed. (See appendix for the calculation.)

Table 3.1: Mixture Design Summary

Parameters	Batch 1: Waste + Cement + Water	Batch 2: Waste + Cement + Water + RHA
Amount of waste (kg)	1.3725 kg	1.3725 kg
Amount of cement (kg)	5.49 kg	5.49 kg
Amount of water (kg)	2.745 kg	2.745 kg
Amount of RHA (kg)	N/A	0.8235 kg

C. Mixture of the sample

In achieving good properties of the sample, one important phase is the mixing. Mixing will be very difficult without the right equipment. In mixing, it is the process of distributing evenly the cement paste and the mixture of the waste, the mixture is ensured to be fully saturated in water to remove large air voids. Furthermore, mixing breaks up the agglomerate clusters of cement particles and allowing air entraining admixture generating the correct air void system.

Figure 3.4: Mixing Process

D. Initial sample testing

The initial sample testing refers to the measurement of the initial state of the raw sample mixture (paste). Investigating the different physical and chemical properties of the paste mixture but there is a restriction with the rheological properties; due to the unavailability of the equipment/machine it is impossible to measure the rheological properties of the paste.

E. Pouring of the mixture

Mixture sample is poured into the moulds according to batches. Batches may differ according to the mixture design, ratio and content of mixture, of the samples. Pouring consist of placing, consolidation and finishing. Performing the proper way of pouring will vary and determine the performance criteria of the final sample. The mould is then taken out the day after casting (after 24 hours).

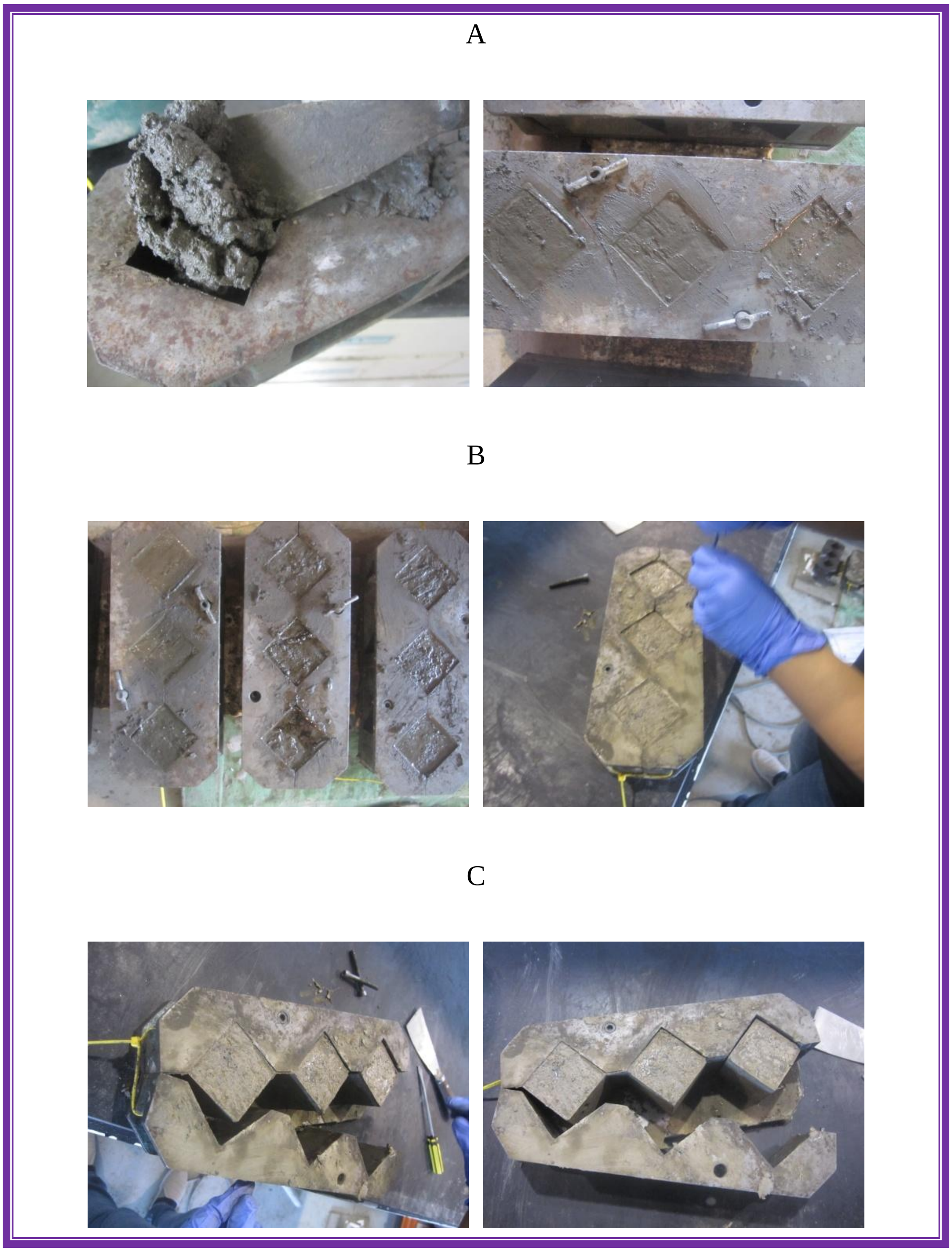


Figure 3.5: (A) Pouring Process, (B) Before and After Casted sample, (C) Taking out of the mould after 24 hours casting.

F. Curing (drying/maturing)

The proper curing determines the best strength and hardness of sample. Cement usually requires moist to gain strength and hardened fully. Cement strength is influenced by its moisture level during the hardening process. As the cement hardens and gains strength, it becomes less vulnerable. The most critical period is the first hours and days after casted. In curing process, the cement paste must be saturated with water and controlling the relative humidity around the sample. The sample can be covered with plastic or damp fabric to prevent evaporation or spraying with water occasionally.

G. Testing and performance criteria of product sample

After the maturing/curing process, the sample will undergo several tests to distinguish the performance criteria. In order to relate the rheological properties obtained from the early step, compressibility, strength test, permeable porosity and other relates tests will be conducted to check the characteristics and to investigate the effect of the mixture designs, ratio and mixture contents.

3.4 Key Milestone

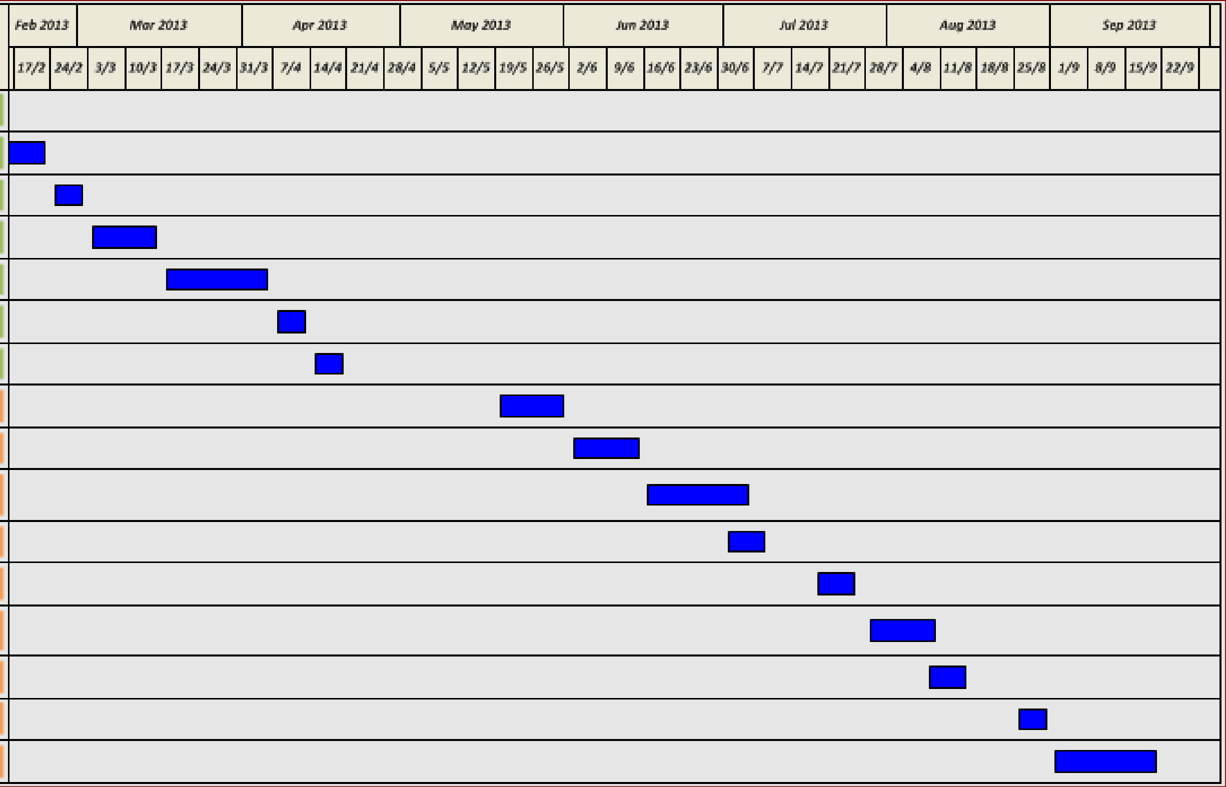
The key milestone shows the framework of project. It signifies the derivation of the critical processes which outlines or may affect the future of the project.

In FYP I, all related outline and knowledge is compiled for the literature review of the research project. Also, preparing for the raw materials, tools, apparatus and equipment to be used for the experimental work.

For FYP II, fully experimental work will be conducted to investigate and compare the relative results from the objectives mentioned in chapter 1 of this extended proposal.

3.5 Gantt Chart

No	Task Name	Start	Finish	Duration
1	Project title proposal and approval	14/1/2013	18/1/2013	1w
2	Research and journal reading	21/1/2013	22/2/2013	5w
3	Extended Proposal Report	25/2/2013	1/3/2013	1w
4	Proposal Defense	4/3/2013	15/3/2013	2w
5	Purchasing raw materials and chemicals	18/3/2013	5/4/2013	3w
6	Booking laboratory and equipment	8/4/2013	12/4/2013	1w
7	Interim Report	15/4/2013	19/4/2013	1w
8	Experimental work: mixture design	20/5/2013	31/5/2013	2w
9	Experimental work: casting & curing	3/6/2013	14/6/2013	2w
10	Experimental work: Batch sampling	17/6/2013	5/7/2013	3w
11	Progress Report	2/7/2013	8/7/2013	1w
12	Pre-Sedex	19/7/2013	25/7/2013	1w
13	Experimental work: Sample testing	29/7/2013	9/8/2013	2w
14	Technical Paper	9/8/2013	15/8/2013	1w
15	Oral Presentation	26/8/2013	30/8/2013	1w
16	Project Dissertation	2/9/2013	20/9/2013	3w



3.6 Tools Required

The list of the raw materials, tools and equipment required for the project are categorized according to type of materials.

Table 3.2: Raw materials used for the project

Raw materials	
Cement	Ordinary Portland cement (OPC)
Additive Binder	Rice Hush Ash (RHA)
Water supply	Distilled water
Industrial waste	Lead (Pb) Sludge from Yokohama Reclamation Plant

Table 3.3: Tools used for the project

Tools	
Mould	4 set of 50x50x50mm mould
Mixer	25mL stainless steel mixer
Vibrating table	For the mixture to even out inside the mould
Curing cabinet	For air drying/ storage for maturity

CHAPTER 4

RESULTS & DISCUSSION

4.1 Data Gathering & Analysis

Compressibility test is designed to evaluate the compressibility of the material like the cement-to-water ratio. The following data are gathered and collected from the Compressibility test of the cement-to-water ratio. The highest average sample peak load, kN for the compressible value from the data will be the optimum proportion ratio of the cement to water.

Table 4.1: Data summary of compressibility test for cement-to-water ratio

Cement-to-water ratio compression test				
Compressible Test (Day 9)				
Sample	Ratio (W/C)	Weight (g)	Compressible Value	
			Average Sample peak load (kN)	Sample stress
1	0.4	210.1	59.2	23.67
2	0.45	225.7	111.4	44.55
3	0.5	205.2	29.5	11.82
Compressible Test (Day 17)				
Sample	Ratio (W/C)	Weight (g)	Compressible Value	
			Average Sample peak load (kN)	Sample stress
1	0.4	198.3	59.8	23.92
2	0.45	214.1	133.4	53.37
3	0.5	203.5	89.0	35.60
Compressible Test (Day 28)				
Sample	Ratio (W/C)	Weight (g)	Compressible Value	
			Average Sample peak load (kN)	Sample stress
1	0.4	196.7	60.2	24.52
2	0.45	201.8	141.6	56.65
3	0.5	198.1	90.7	36.60

From the compressibility test data, the cement-to-water ratio chart shown in Figure 4.1 below illustrates the optimum ratio of from the three tested ratio: 0.4, 0.45 and 0.5 respectively. The ratios are chosen from the standards according to various literature reviews.

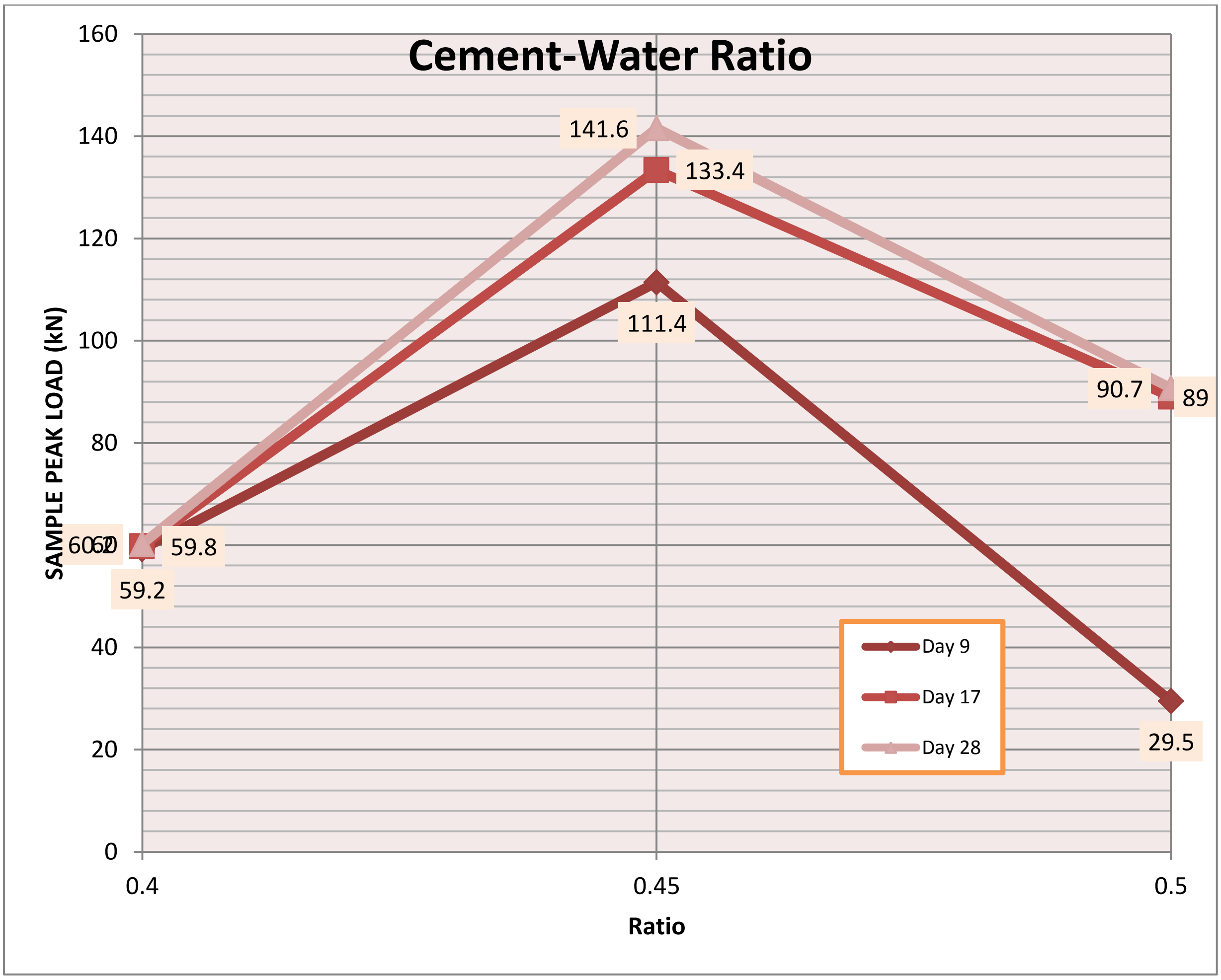


Figure 4.1: Cement-water ratio graph

The first batch sampling is consisting of sludge + cement + water. Batch 1 is tested at various days (day 3, day 15, day 23 and day 28, respectively) for compressibility test. The Table 4.2 represents the data gathered from the test.

Table 4.2: Batch 1 samples consisting sludge + cement + water.

Batch 1: Sludge + Cement + Water			
Compressible Test for Batch 1 (Day 3)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Remarks
1	194.8	~16.2	Sample too soft
2	198.6	~15.7	Sample too soft
3	196.0	~15.4	Sample too soft
Compressible Test for Batch 1 (Day 15)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	187.4	33.6	13.46
Compressible Test for Batch 1 (Day 23)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	183.3	30.1	12.03
2	190.4	26.1	10.44
Compressible Test for Batch 1 (Day 28)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	189.7	27.7	11.07

The Figure 4.2 below shows the batch 1 at day 1 after demoulding that consists of sludge + cement + water.

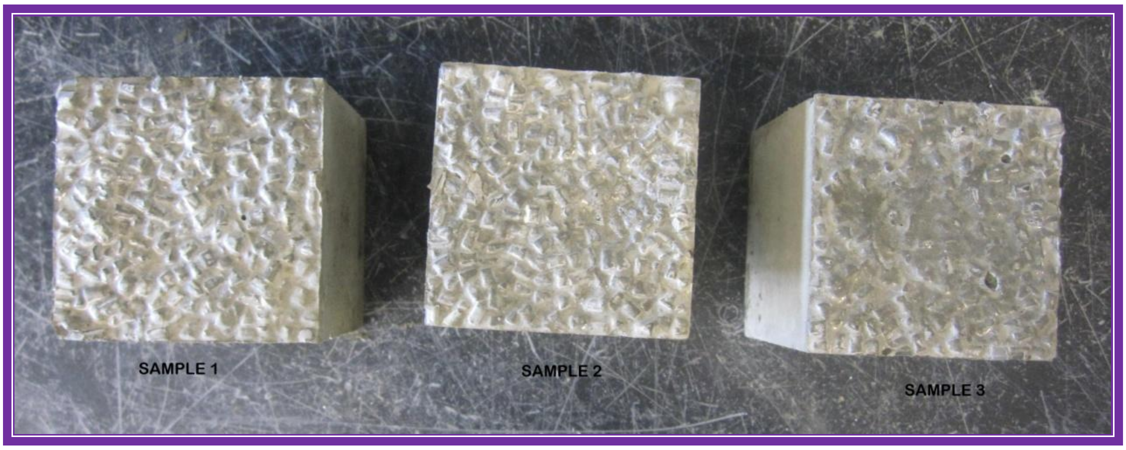


Figure 4.2: Batch 1 samples at day 1 after demoulding.

The second batch sampling is consisting of sludge + cement + water + RHA at 10%. Batch 2 is tested at various days (day 9, day 17, and day 28, respectively) for compressibility test. The Table 4.3 represents the data gathered from the test. The batch 2 samples are in comparison of the addition of 10% RHA from the batch 1 samples (sludge + cement + water).

Table 4.3: Batch 2 samples consisting of sludge + cement + water + RHA at 10%.

Batch 2: Sludge + Cement + Water + RHA (10%)			
Compressible Test for Batch 2 (Day 9)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	187.4	33.6	13.46
Compressible Test for Batch 2 (Day 17)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	184.0	42.8	17.12
2	192.1	37.8	15.14
Compressible Test for Batch 2 (Day 28)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	193.7	45.0	18.01

The Figure 4.3 below shows the batch 2 at day 2 after demoulding that consists of sludge + cement + water + RHA at 10%

Figure 4.3: Batch 2 samples at day 1 after demoulding.

The third batch sampling is consisting of sludge + cement + water + RHA at 15%. Batch 3 is tested at various days (day 8, day 16, and day 28, respectively) for compressibility test. The Table 4.4 represents the data gathered from the test. The batch 3 samples are in comparison of the addition of 15% RHA from the batch 1 sample (sludge + cement + water + RHA at 10%).

Table 4.4: Batch 3 samples consisting of sludge + cement + water + RHA at 15%

Batch 3: Sludge + Cement + Water + RHA (15%)			
Compressible Test for Batch 3 (Day 8)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	200.7	47.1	18.83
2	198.6	36.5	14.59
Compressible Test for Batch 3 (Day 16)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	213.0	56.7	22.67
Compressible Test for Batch 3 (Day 28)			
Sample	Weight (g)	Compressible Value	
		Sample peak load (kN)	Sample stress
1	202.7	62.3	24.91

The Figure 4.4 below shows the batch 3 at day 1 after demoulding that consists of sludge + cement + water + RHA at 15%

Figure 4.4: Batch 3 samples at day 1 after demoulding.

Compressibility Test

Compressibility test in a simple definition is the ability to be compressed by pressure. It is the capacity of a material to withstand loads tending to reduce size. The test is measured by plotting applied force against deformation using compression machine. Samples can have fractures at their compressive strength limit and others deform irreversibly that is considered as the limit for compressive load. Compressibility test is one of the key values for design structure.

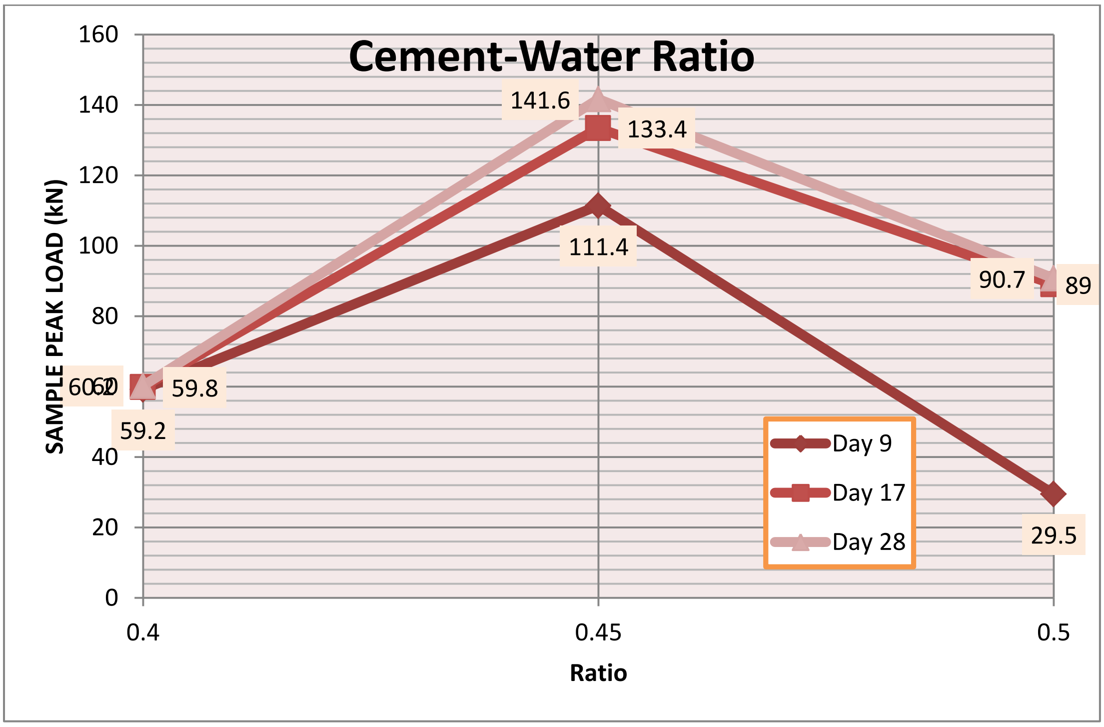
Figure 4.5: Compressibility Test. Top left: Compression Machine. Top middle: Sample tested inside compression machine. Top right: the direction of the compression with respective to the sample. Bottom: Sample crushed after testing.

4.2 <u>Results & Discussion</u>

Mixture design

Lead (Pb) Sludge from Yokohama Reclamation Sdn Bhd is the industrial waste used for the experiment. It has the specific gravity of 0.915. The mould used for the experiment has the dimension of 50mm x 50mm x 50mm which is equivalent to 1.25 x $10^{-4}m^3$. Each set of the mould has 3 cubes and there are 4 set of moulds which sum up the total volume of 1.5 x $10^{-3}m^3$. The mass of waste is then calculated by using the density formula which will give 1.3725kg. Then, the mass of cement is calculated by using the ratio of cement to waste as 4:1, giving the mass of cement as 5.49kg. Mass of water is obtained by using the ratio of water to cement as 0.5:1, giving the value of 2.745kg. RHA ratio is then decided to be 0.15 giving 0.8235kg.

Cement-to-water ratio



From the Graph shown above it is evident that the optimum ratio cement-to-water is at 0.45. At cement-to-water ratio 0.45, the strength is at the peak of 133.4 kN and 111.4 kN, respectively. While at 0.4 ratio, the strength is 59.2 kN & 59.8 kN, and for 0.5 ratio, the strength is 29.5 kN & 89 kN.

Batch sampling

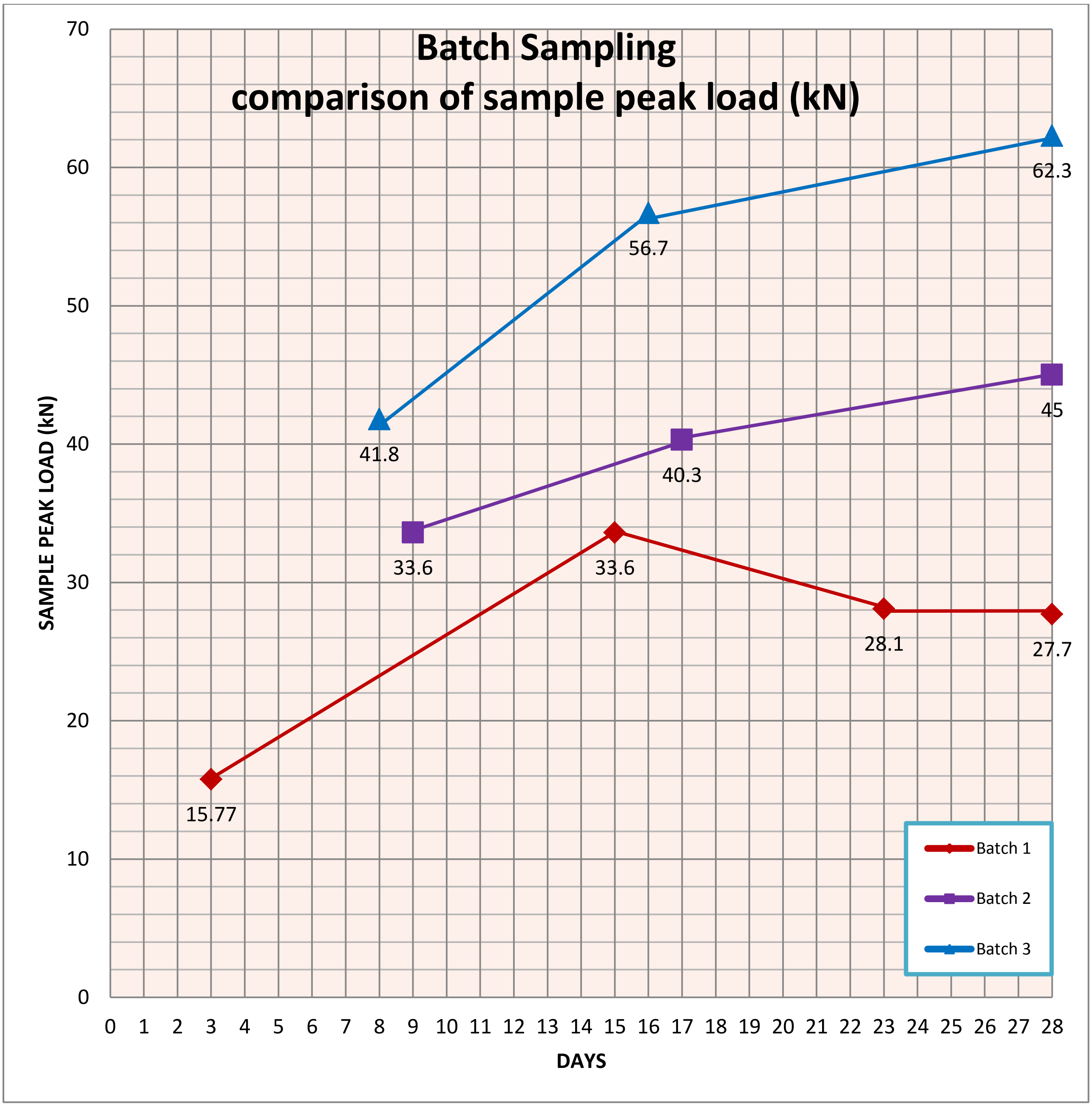


Figure 4.6: Graph showing batch sampling comparing the sample peak load in kN through the compressibility test.

For the first batch of samples, mixture of cement + water + sludge, it demonstrates that on the day 3 of compressibility test, it shows 15.77kN of strength and follows as on day 15 gives 33.60kN and on the 23rd and 28th day of maturity gives 28.10kN and 27.70kN, respectively.

On the other hand for the second batch with the same mixture design and an addition of 15% Rice Husk Ash (RHA), it reveals that the addition of RHA strengthens the samples. On day 9, it gives compressibility value of 33.6kN and as follows on 17th and 28th day, it gives values of 40.3kN and 45.0kN, respectively. Comparing it to the first batch, it is evident that the presence of RHA in the mixture gives higher value of compressibility.

For the 3rd batch same ratio of the mixture and RHA additive, gives more evidence and confirmation of the values obtained in the second batch. On 8th and 16th day gave 41.8kN and 56.7kN compressibility values.

From Figure 4.6, it shows the trend of the compressibility values of the three batches. It is evident that the addition of RHA in the 2nd and 3rd batch gives higher strength of compressibility.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 CONCLUSION

According to the mix design proportion of water-to-cement, the optimum ratio (W/C) was found at 0.45 having the highest strength compared to the ratio of 0.4 and 0.5, and with cement-to-sludge (C/S) ratio at 4 found the best performance of the sample. By integrating the peak strength ratios of W/C and C/S with Rice Husk Ash (RHA), it was found that it increases the strength value. The effective RHA content is at 15%, higher fraction causes reduction in strength of cementation. The pozzolanic reaction of RHA reduces toxic attacks which improves the resistance to immobilize the contaminant which is the lead (Pb). Silica present in RHA combines with the calcium hydroxide results to an excellent resistance of the material to mobility of the contaminants.

5.2 RECOMMENDATION

Improvement in testing of batch samples on the same day of maturity is better for comparison purposes. Additional batch samples for more mixture design ratio can be done for wide evaluation and study of the workability and performance in relation to the proportions of the raw materials. Altering of additive binders aside from RHA such as Fly ash, etc. or including chemical admixtures such as accelerators, water reducers/plasticizers, etc. can build up better performance of the sample material.

In recommendation from the examiner during the poster presentation, to change the title and the objectives of the project due to unavailability of the equipment and machine to measure the rheological properties of the paste, the main topic of the project. It is highly recommended to have at least available equipment to measure the rheological properties and can be incorporated into the testing of the matured sample material.

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APPENDIX A

GANTT CHART

Details (FYP I)	1	2	3	4	5	6	7		8	9	10	11	12	13	14
Research Work								Mid-semester Break							
-Reading Journal, Report and other related materials															
Submission of Extended Proposal															
Proposal Defense															
Project Work															
-Compiling relevant research materials															
-Purchasing chemicals and raw materials															
-Pre-testing materials and equipment															
Submission of Interim Draft Report															
Submission of Interim Report															

Process

Suggested Milestone

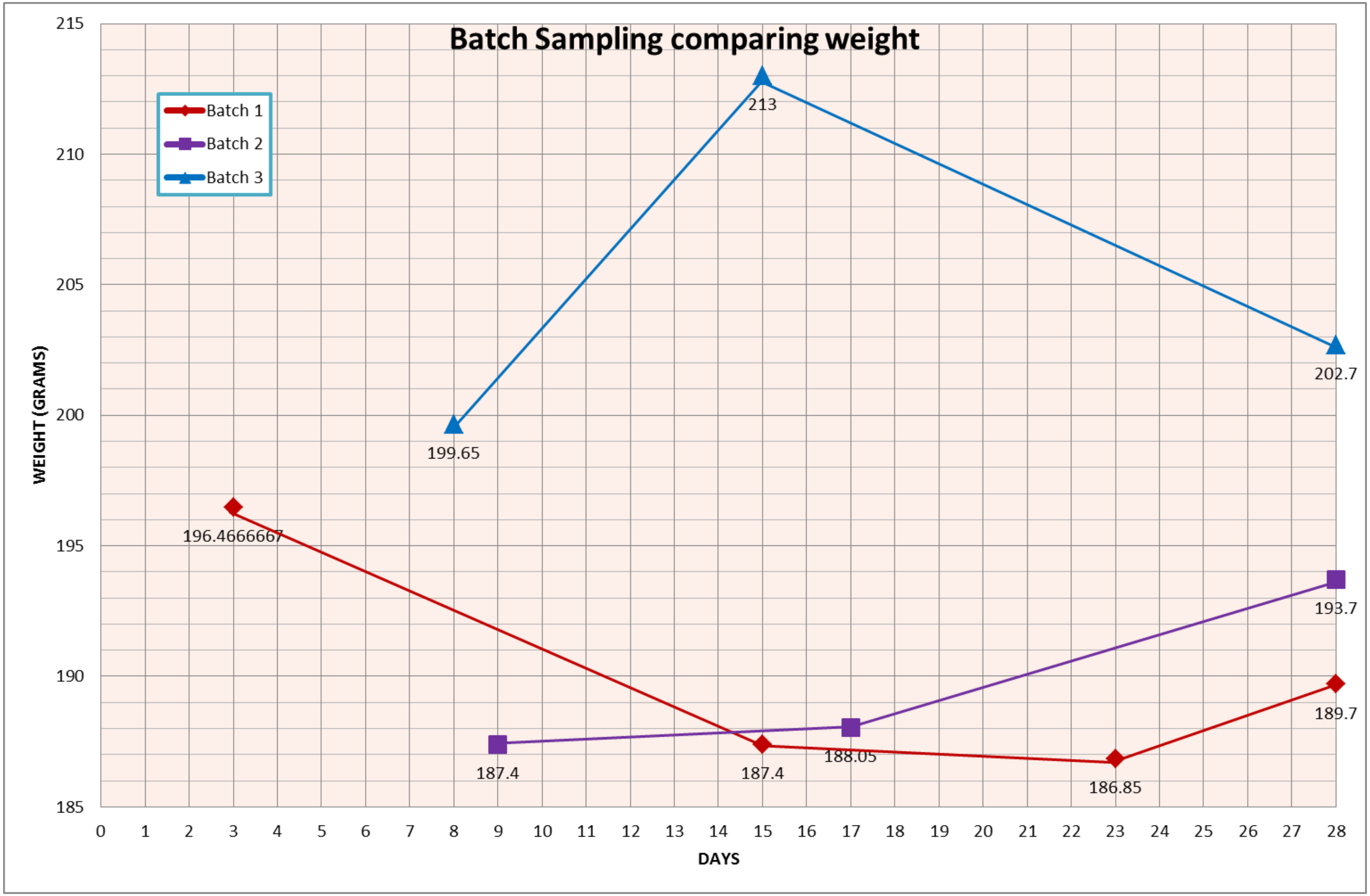
Details (FYP II)	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1. Project work (experimental)								Mid-semester Break								
2. Submission of Progress report																
3. Project work (experimental)																
4. Pre-SEDEX																
5. Submission of Draft Report																
6. Submission of Dissertation (soft bound)																
7. Submission of Technical Paper																
8. Oral Presentation																
9. Submission of Project Dissertation (hard bound)																

Process

Suggested Milestone

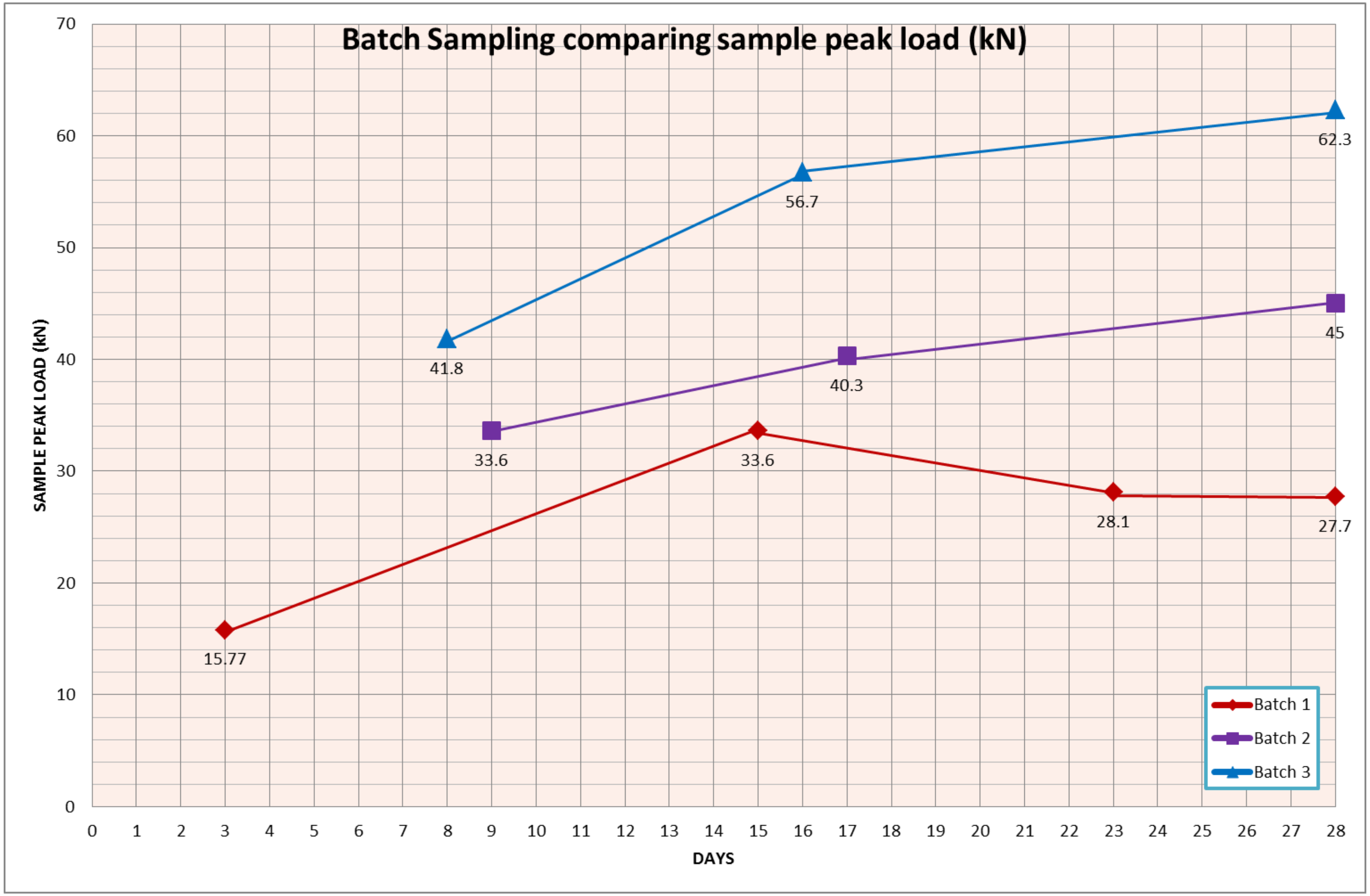
APPENDIX B

BATCH SAMPLES COMPARING WEIGHT


Batch Sampling comparing weight
Batch 1
Batch 2
Batch 3
213
202.7
199.65
196.4666667
193.7
189.7
187.4
187.4
188.05
186.85
215
210
205
200
195
190
185
WEIGHT (GRAMS)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
DAYS

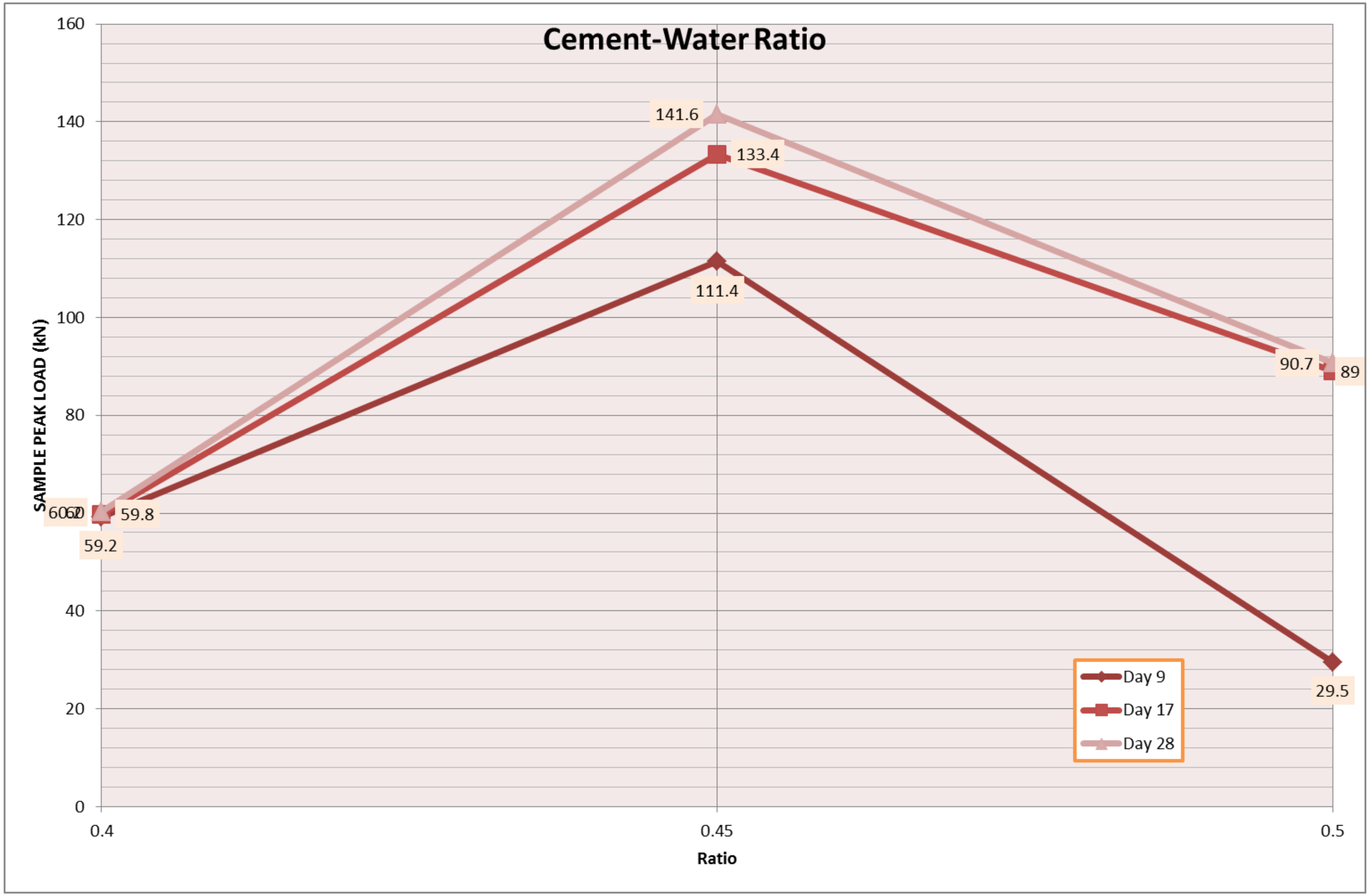
APPENDIX C

BATCH SAMPLES COMPARING SAMPLE PEAK LOAD (kN)


Batch Sampling comparing sample peak load (kN)
SAMPLE PEAK LOAD (kN)
DAYS
0
10
20
30
40
50
60
70
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
15.77
33.6
28.1
27.7
33.6
40.3
45
41.8
56.7
62.3
Batch 1
Batch 2
Batch 3

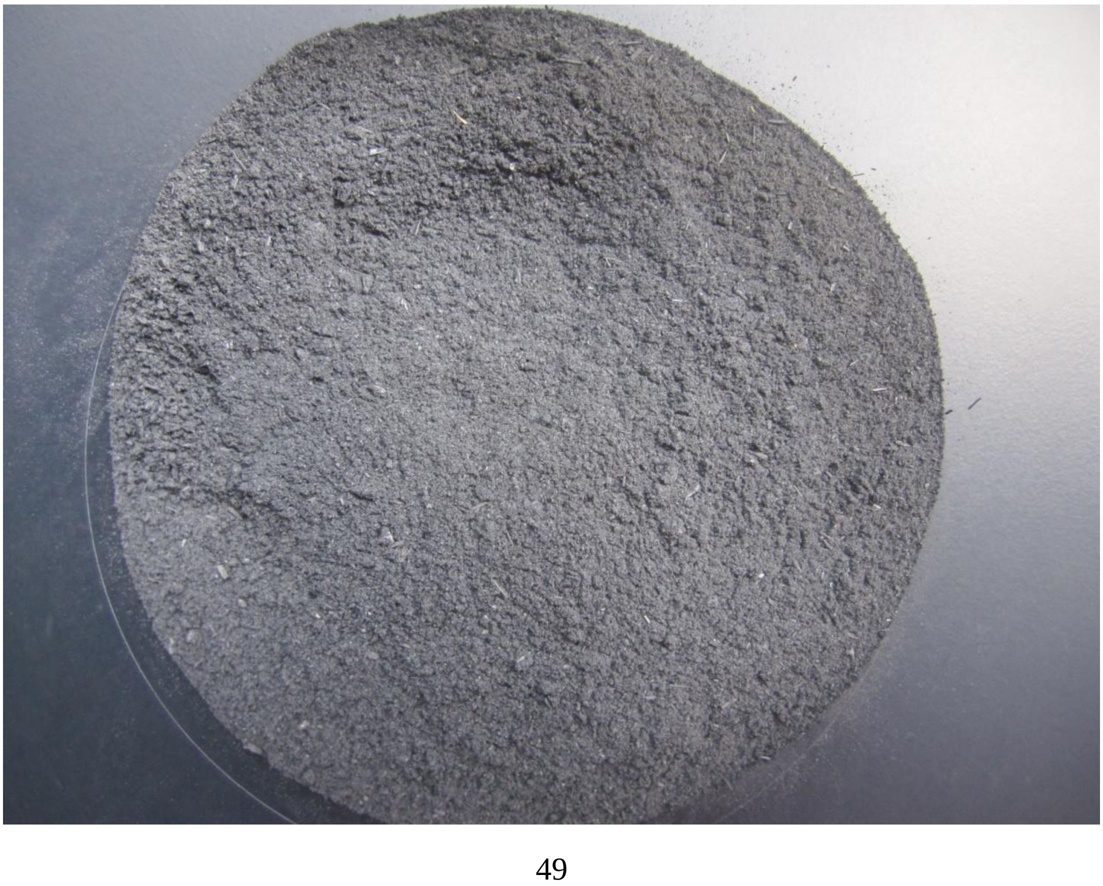
APPENDIX D

CAMENT-TO-WATER RATIO OPTIMUM GRAPH


Cement-Water Ratio
160
140
120
100
80
60
40
20
0
SAMPLE PEAK LOAD (kN)
141.6
133.4
111.4
90.7
89
60.2
59.8
59.2
29.5
Day 9
Day 17
Day 28
0.4
0.45
0.5
Ratio

APPENDIX E

PHOTOS TAKEN DURING EXPERIMENTAL WORK




PLATEN
SERIAL Nº
To Your SAMPLE is 40mm.


Your SAMPLE is