DEPARTMENT OF CIVIL ENGINEERING

DIPLOMA IN CIVIL ENGINEERING

DCC 5191 : CIVIL ENGINEERING PROJECT 1

SESSION : JUN 2019

NAME OF PROPOSAL PROJECT :

Performance of waste sludge in strength properties of mortar

NAME OF STUDENTS :

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CHAPTER 1

1. INTRODUCTION

1.1. Project Background

Sludge is semi-liquid residue from industrial processes and treatment of sewage and waste water.

1.2. Problem Statement

The increase in population indicates that more sewage sludge will be generated. Thus, disposal of domestic sewage sludge becomes a significant issue time by time and it is increasing the financial burden of wastewater treatment companies. Disposal of domestic sewage sludge would cause numerous environmental and health risk related issues. Thus, the disposal of sewage sludge must be mitigated to avoid causing serious problems in the country. In the year of 2020, it is predicted that 7 million metric tons of sewage sludge will be generated annually from current 3 million metric tons (Siti Noorain, 2013). Siti Noorain (2013) stated that the cost of managing the sewage sludge is about US$ 0.33 billion per year. Information from Indah Water Konsortium stated that Malaysia produces more than 4.5 million cubic meters of domestic sludge annually since 2005 and the volumes of sludge produced increases from year to year. Sewage sludge is one of the largest contributors of waste material in Malaysia, and it indirectly elevates local environmental problems. The general sludge treatment is processed before the sludge cake is transported to approval site for disposal. The waste products produced by domestic waste water sludge end up in sanitary landfills as practiced in Malaysia. One of the major challenges in the processing of domestic waste water sludge is highly connected to the management of high moisture content and its unstable organic substances in which decomposes to produce bad odours.

Due to the problems and limitations of sewage sludge disposal options, the use of sewage sludge as a non-conventional construction material has been studied and carried out by various researchers. The unprocessed sewage sludge is used as a filler and blended cement material for concrete and indirectly used as raw material to produce products such as bricks, lightweight aggregate, tiles and paving blocks, and cementitious material (Tay & Show, 1994). By the year of 2050, the demand for

Portland cement will rise to 200% from 2010 levels, and the usefulness of reusing SSA in concrete to reduce the amount of cement used in concrete mix is noted. An increase in the demand for cement shows that concrete structures are expected to increase in the similar trend (Jamshidi et al., 2012). The largest carbon dioxide emission source is the cement industry. Almost 5-7% of global CO_2 emissions are caused by cement plants, 900 kg of CO_2 is emitted to the atmosphere for producing one ton of cement (Benhelal et al., 2013)

Other research shows positive and negative results of using sewage sludge ash (SSA) as a cement component. The use of sewage sludge ash (SSA) faces problems in concrete mixtures since it has the effect of slightly retarding the setting time of concrete and increasing water demand. SSA shows evidence of being pozzolanic. However, it has been inferred that SSA concrete shows positive result frequently led to comparable or higher compressive strength than conventional concrete, although only at ages beyond 28 days, and the proportion of SSA replacement is more often at a level of less than 20% by the mass of the cement fraction (Dyer et al., 2011).

1.3. Objective of project

1.3.1. To investigate the strength properties of sludge bricks.

1.3.2. To determine the water absorption.

1.3.3. To produce sludge brick

1.4. Scope Of Project

1.4.1. Sludge will take from Lembaga Urus Air Selangor, Bukit Badung

1.4.2. Curing days :

I. 7 Days

II. 28 Days

1.4.3. Percentage of using sludge

I. 0%

II. 2%

III. 4%

IV. 6%

V. 8%

VI. 10%

1.5. Proposed mixture of concrete sludge brick

1.5.1. Mould size : 50 mm x 50 mm x 50 mm

1.5.2. Cement concrete ratio : (1:3), (1:6)

1.5.3. Testing to be carried out :

I. Density test

II. Compression strength test

III. Water absorption test

1.6. Significance of the study

It is expected that introduction of secondary wastewater treatment and the improvement of combined sewer system in Malaysia will increase the generation of sludge. Due to the presence of organic matter in sludge, the pathogenic, hygienic and nuisance factors must be considered first. In other words, this wastewater solid must always be properly treated prior to disposal. Considering the increasing difficulties in securing new disposal sites, innovative measures have to be prepared to utilize and recycle sludge safely for the future. From these thoughts, Polytechnic is repositioning sludge from a mere waste material to a valuable resource, and in some cases, has started to utilize and promote it, i.e. as compost.

This study, an effort from Polytechnic, details an innovative and constructive approach in which vitrified bricks were derived from a sludge- amended classical hand-moulding process. From an environmental engineering perspective, the use of sludge in brickmaking is an attractive concept since it is a neat way of recycling a waste material, thereby contributing to a reduction in the ever-growing sheer volume of this unwanted commodity in Malaysia. This process also extracts from the sludge its energy content with combustion of its constitutive organic matter, besides, conceivably destroying or nullifying pathogens and heavy metals, both of which are harmful constituents (Churchill, 1994), which ultimately transforms this unwholesome commodity into a useful product.

On the other hand, this study will also significantly contribute a few operational benefits to brick manufacturers in Malaysia as well. The previously mentioned combustion o f sludge organic matter may yield an exothermic heat release, which will consequently reduce the energy required for firing the bricks. In addition, combustion of this material may introduce small voids within the brick body that will prospectively improve the brick's bonding adherence to mortar besides making it lighter.

1.7. Conclusion

The conclusion of this chapter is to know about the project background, problem statement, objective of project, scope of project, proposed mixture of concrete sludge brick and significance of project.

2. Literature Review

2.1 Introduction

Different industries produce sludge of different quality and in different qualities. This maybe due to difference in the manufacturing processes and treatment given to the waste water. Disposal of sludge has become a major issue. Efforts are being made to utilities the sludge for making useful material. Major research I being conducted in the field of utilization of sludge in brick manufacturing. The quality and type of brick made depends on various factors like composition of sludge, additives used, temperature at which the brick is fired, water content.

2.2 Concept and theory

According to P.Amsayazhi, waste may be defined as an unwanted material generated after the manufacturing process from industry, agriculture, or from house hold activity. Waste causes many nuisances in the environment. It produces many types of infection, for human and animal. The sludge from tannery effluent plants has problem of disposal. Dewatered sludge is disposed off by land filling. However, it is not an appropriate solution, due to the land limitation. The production of sludge in tannery effluent plant is about to increase every year. In addition, the constraint to treat sludge is very high in cost and time-consuming, which is the disadvantage to the responsible parties. Therefore, this study was carried out to utilize those sludge waste (SW) produced from the tannery effluent plant as a brick. The sludge brick (SB) mixtures were incorporated with many ratios of SW. Tests were conducted such as fineness test, specific gravity, water absorption and compressive strength. As the conclusion, brick with 20% utilization of SW is acceptable to produce good quality of brick. This study shows that the disposal of tannery sludge TSW would act as a suitable material for manufacturing of bricks with proportionate mix and design.

Chih-Huang Weng and Deng Fong Ling stated that bricks manufactured from dried sludge collected from an industrial wastewater treatment plant were investigated.

Results of tests indicated that the sludge proportion and the firing temperature were the two key factors determining the brick quality. Increasing the sludge content results in a decrease of brick shrinkage, water absorption, and compressive strength. Results also showed that the brick weight loss on ignition was mainly attributed to the organic matter content in the sludge being burnt off during the firing process. With up to 20% sludge added to the bricks, the strength measured at temperatures 960 and 1000 °C met the requirements of the Chinese National Standards. Toxic characteristic leaching procedure (TCLP) tests of brick also showed that the metal leaching level is low. The conditions for manufacturing good quality bricks is 10% sludge with 24% of moisture content prepared in the molded mixtures and fired at 880–960 °C.

NR Jianu, I C Moga, F Pricop and A Chivoiu , current world trends related to wastewater sludges are: reuse in agriculture, utilization as retaining material for petroleum products or utilization in construction. Bricks from sand-cement or autoclaved cellular concrete are commonly used in construction. The authors propose innovative receipts for bricks and plasters based on textile wastewaters sludge. Centrifuged sludge is mixed with cement to obtain bricks and plaster. For bricks, the mixture is represented by 45% cement and 55% sludge. The paper presents the obtained results and the new materials used for bricks fabrication.

Joo-Hwa Tay stated, sludge resulting from wastewater treatment plants creates problems of disposal. Generally, dewatered sludges are disposed of by spreading on the land or by landfilling. However, for highly urbanized cities, sludge disposal by landfilling might not be appropriate due to land limitation. Incineration might be an alternative solution. However, a substantial amount of ash will be produced after the burning process and must be disposed of by other means. This paper presents the results of the utilization of dried sludge and sludge ash as brick making materials. The maximum percentages of dried sludge and sludge ash that can be mixed with clay for brick making are 40% and 50% respectively. The compressive strength of the bricks are 87.2N/mm2 for 0% sludge, decreasing to 37.9N/mm2 for 40% dried sludge, and 69.4N/mm2 for 50% sludge ash.

2.3 Conclusion

By using literature view, we able to gain, get and access more information on our case study. Futhermore, article made by the previous reasearcher also allow us to futher our study their data references. It also gave us an overall image of project procurement.

2.4 References

Unit	References
1.	P Amsayazhi. Use of Sludge Waste as Ingredient in Making of Brick. - https://www.researchgate.net/publication/326703860_Use_of_Sludge_Waste_as_Ingredient_in_Making_of_Brick
2.	Chih-Huang Weng and Deng-Fong Lina. Utilization of sludge as brick materials. - https://www.sciencedirect.com/science/article/pii/S1093019102000370
3.	N R Jianu, I C Moga, F Pricop and A Chivoiu. Wastewater Sludge Used as Material for Bricks Fabrication. - https://iopscience.iop.org/article/10.1088/1757-899X/374/1/012061
4.	Joo- Hwa Tay. Bricks Manufactured from Sludge. - https://ascelibrary.org/doi/10.1061/%28ASCE%290733-9372%281987%29113%3A2%28278%29

3. Research Methodology

3.1. Introduction

This chapter will describe aspects of the research methodology used more clearly and in detail. These aspects are study design, population and sample study, data collection method, pilot study and data analysis. In addition to explaining the methodology of the study, this chapter will also explain the brick sludge innovated by Polytechnic students.

Methodology also gives an outline in order to choose a method to solve the problems and secondly gives planning to collect and analyze the data obtained.

3.2. Material

3.2.1 Cement

Figure 3.1

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete.

3.2.2 Sand

Figure 3.2

Sand is in very commonly use in construction, often providing bulk, strength and stability to other materials such as asphalt, concrete, mortar, render, cement, and screed.

3.2.3 Sludge

Figure 3.3

Sludge is used in the production of concrete as filling material because its benefits such as improving the compressive strength, freeze-thaw resistance and waterproofness.

3.2.4 Silica Fume

Figure 3.4

Silica fume is resulted from the processes of obtaining ferrosilicon industry, as a very fine powder which is recuperated by filters from furnaces.

3.2.5 Water

Figure 3.5

Water is one of the most important elements in construction but people still ignore quality aspect of this element. The water is required for preparation of mortar, mixing of cement concrete and for curing work etc during construction work.

3.3. Flow Chart Process Of Concrete Sludge Brick

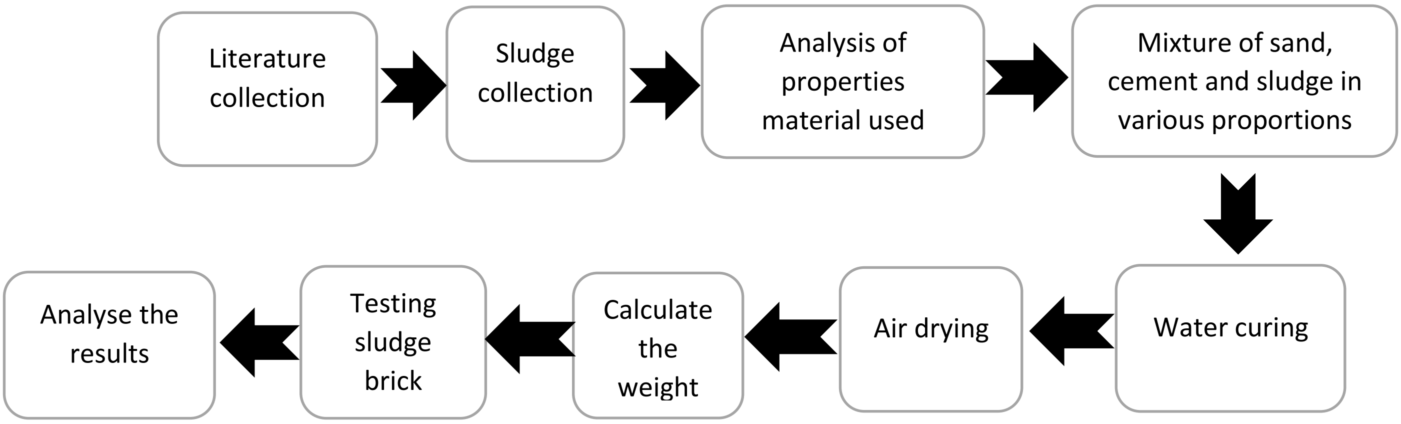


Figure 3.6 Machine of compaction test

Figure 3.7 Set the mould

Figure 3.8 Water curing

Figure 3.9 Dryed the cubes

Figure 3.10 Compaction test

Figure 3.11 Get the result

3.4. Testing To Be Carried Out

3.4.1. Compressive Strength

This test is to determine the compressive strength of the brick. In this testing a Compressive Test Machine will be used. Bricks are generally used for construction of load bearing masonry walls, columns and footings. These load bearing masonry structures experiences mostly the compressive loads. Thus, it is important to know the compressive strength of bricks to check for its suitability for construction.

3.4.2. Density

Our second test is brick density. Brick density is an important parameter. Density indicates the weight of the brickwork. Cores, Cells, and Frogs decrease the density and in turn, decrease the material cost. Apart from material density, brick density can be measured directly. The mass and volume of an oven-dried brick are measured. The bulk density can be determined by dividing the mass by volume.

3.4.3. Water Absorption

Lastly, water absorption. Water absorption test on bricks are conducted to determine durability property of bricks such as degree of burning, quality and behavior of bricks in weathering. A brick with water absorption of less than 7% provides better resistance to damage by freezing. The degree of compactness of bricks can be obtained by water absorption test, as water is absorbed by pores in bricks.

3.5. Conclusion

In this chapter**,** we outline the procedure for making our product. In addition, we also select laboratory tests on our products to determine the compressive strength and surface dimensions of bricks. Besides, we will find out the compressive strength and dimensions of our sludge cement bricks, whether they can be compared to existing cement bricks.

3.6. Gantt Chart

Activity/weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Breafing about research															
Submit proposal headings															
Briefing procedure															
Briefing 1- Introduction															
Preserve suggestions session															
Research literature review															
Preparation of recommendation report															
Presentation 1															
Meeting with Supervisor															
Briefing 2- Review of Literature & Methodology															
Meeting with Supervisor															
Methodological Studies															
Meeting with Supervisor															
Printed Project Report															
Presentation 2															
Sending Log Book & FYP 2 setup															

4. Data And Analysis

4.1. Introduction

Data analysis is a process of inspecting, cleansing, transforming and modelling data with the goal of discovering useful information, informing conclusion and supporting decision-making

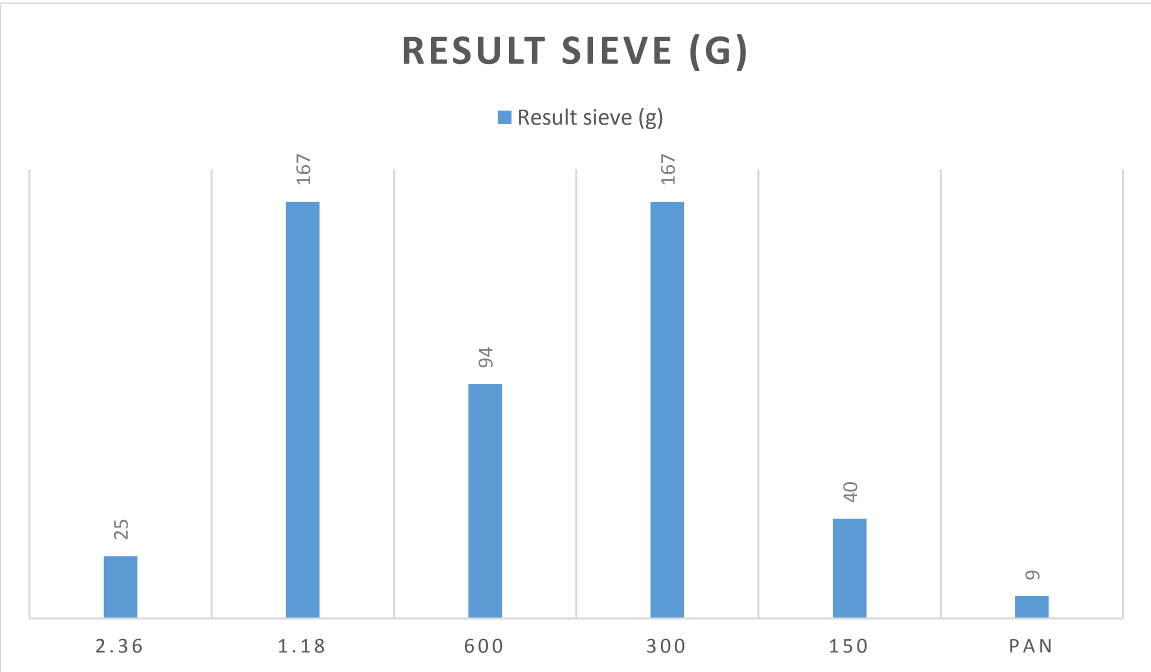
4.2 Material Characteristics

4.2.1 Sieve

Table 4.1

Sieve size	Before	After	Result
2.36	488 g	513 g	25 g
1.18	353 g	520 g	167 g
600	304 g	398 g	94 g
300	275 g	442 g	167 g
150	258 g	298 g	40 g
Pan	354 g	363 g	9 g

Figure 4.1 Result sieve



4.2.1.1 Calculation of mix propotion

Table 4.2

1:3	Sample	Days	Water (ml)	Cement (g)	Sand (g)	Sludge (g)
Control	1	7	463	625	1875	-
	2					
	3					
	1	28				
	2					
	3					
2% Sludge	1	7	463	625	1837	38
	2					
	3					
	1	28				
	2					
	3					
4% Sludge	1	7	463	625	1800	75
	2					
	3					
	1	28				
	2					
	3					
6% Sludge	1	7	463	625	1762	113
	2					
	3					
	1	28				
	2					
	3					
8% Sludge	1	7	463	625	1725	150
	2					
	3					
	1	28				
	2					
	3					
10% Sludge	1	7	463	625	1687	188
	2					
	3					
	1	28				
	2					
	3					
	2					
	3					

Table 4.3

1:6	Sample	Days	Water (ml)	Cement (g)	Sand (g)	Sludge (g)
Control	1	7	490	357	2143	-
	2					
	3					
	1	28				
	2					
	3					
2% Sludge	1	7	490	357	2100	43
	2					
	3					
	1	28				
	2					
	3					
4% Sludge	1	7	490	357	2057	86
	2					
	3					
	1	28				
	2					
	3					
6% Sludge	1	7	490	357	2014	129
	2					
	3					
	1	28				
	2					
	3					
8% Sludge	1	7	490	357	1972	171
	2					
	3					
	1	28				
	2					
	3					
10% Sludge	1	7	490	357	1929	214
	2					
	3					
	1	28				
	2					
	3					
	2					
	3					

4.2.2 Compression strength

4.2.2.1 Strength of bricks for 7 days

Result of strength of 7 days :

Table 4.4 Control bricks 1:3

Control Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	4.3
2	240	50	50	50	4.1
3	230	50	50	50	4.9

Table 4.4 Control bricks 1:6

Control Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	240	50	50	50	6.5
2	230	50	50	50	7.9
3	240	50	50	50	7.1

Figure 4.2 Result compression strength control bricks using 1:3

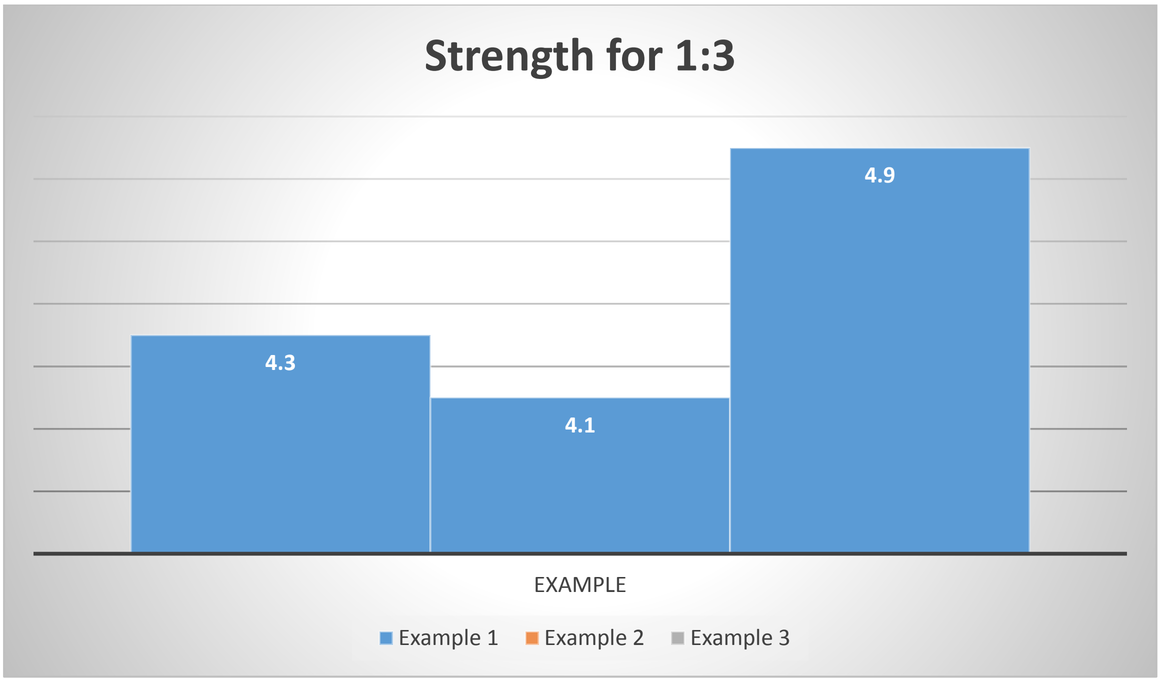
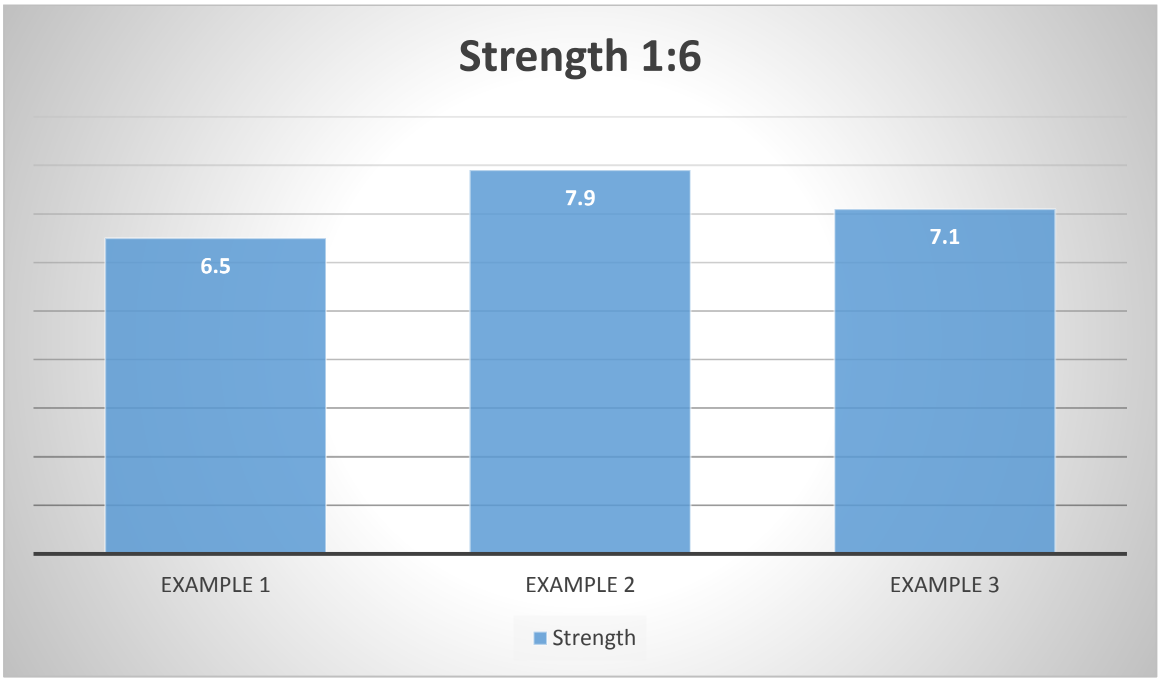


Figure 4.3 Result compression strength control bricks using 1:6



4.2.2.2 Compression strength of bricks using sludge for 7 days

Data of using 1:3

Table 4.5 Using 2% sludge

Sludge Bricks 2%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	240	50	50	50	9.0
2	270	50	50	50	8.9
3	270	50	50	50	7.8

Table 4.6 Using 4% sludge

Sludge Bricks 4%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (Mpa)
1	230	50	50	50	7.6
2	230	50	50	50	6.6
3	220	50	50	50	6.2

Table 4.7 Using 6% sludge

Sludge Bricks 6%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (Mpa)
1	240	50	50	50	5.6
2	240	50	50	50	5.5
3	240	50	50	50	5.4

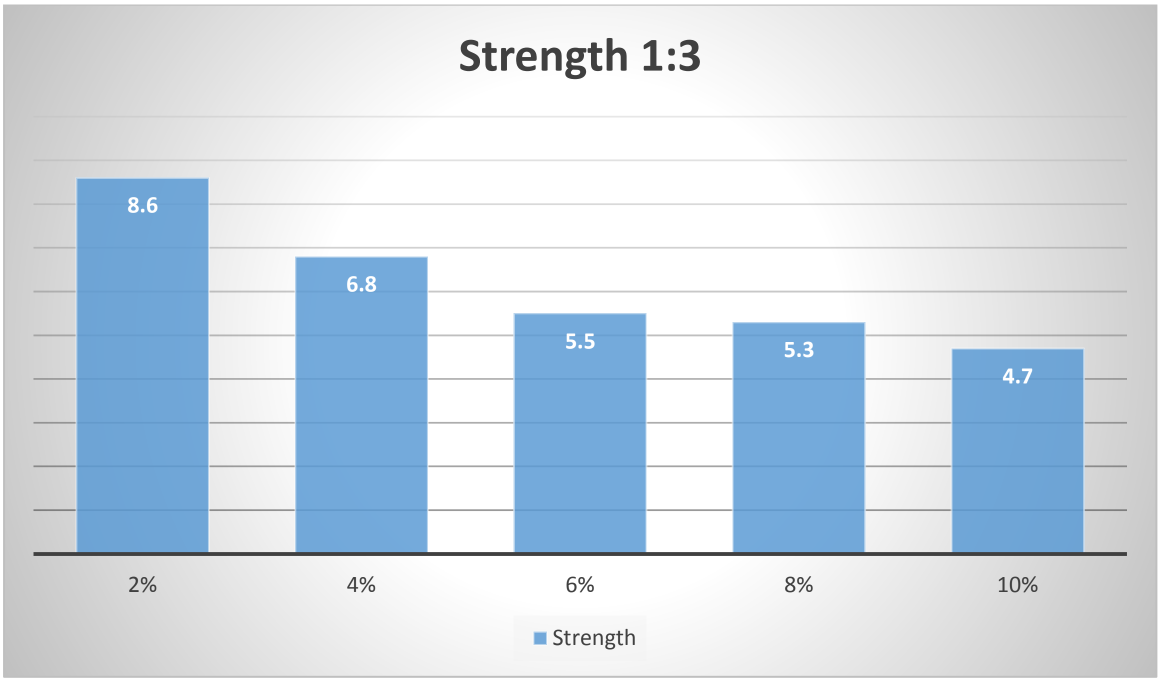
Table 4.8 Using 8% sludge

Sludge Bricks 8%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (Mpa)
1	240	50	50	50	5.5
2	240	50	50	50	5.7
3	240	50	50	50	5.2

Table 4.9 Using 10% sludge

Sludge Bricks 10%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (Mpa)
1	230	50	50	50	4.5
2	240	50	50	50	4.8
3	240	50	50	50	4.8

Figure 4.4 Graph of using sludge



Data of using 1:6

Table 4.10 Using 2% sludge

Sludge Bricks 2%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	220	50	50	50	2.6
2	220	50	50	50	2.3
3	240	50	50	50	2.4

Table 4.11 Using 4% sludge

Sludge Bricks 4%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	220	50	50	50	1.7
2	220	50	50	50	1.7
3	210	50	50	50	1.8

Table 4.12 Using 6% sludge

Sludge Bricks 6%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	250	50	50	50	1.0
2	240	50	50	50	1.0
3	240	50	50	50	1.6

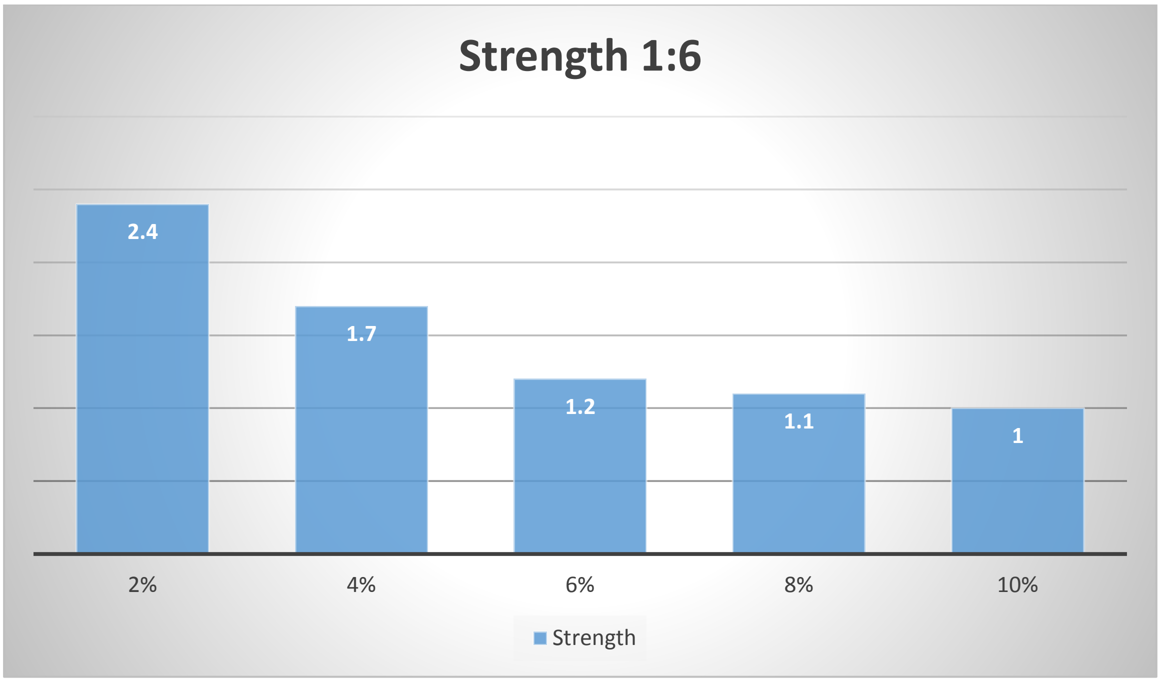
Table 4.13 Using 8% sludge

Sludge Bricks 8%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	1.5
2	220	50	50	50	1.7
3	190	50	30	50	0.2

Table 4.14 Using 10% sludge

Sludge Bricks 10%	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	1.0
2	220	50	50	50	0.8
3	190	50	50	50	1.2

Figure 4.5 Graph of using sludge



4.2.2.3 Strength of bricks for 28 days

Result strength of using sludge for 28 days using 1:3

Table 4.15 Control bricks

Control Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	6.3
2	240	50	50	50	6.6
3	240	50	50	50	6.0

Table 4.16 Using 2% sludge

Sludge Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	250	50	50	50	14.3
2	270	50	50	50	13.9
3	250	50	50	50	14.2

Table 4.17 Using 4% sludge

Sludge Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	240	50	50	50	10.4
2	240	50	50	50	10.5
3	230	50	50	50	9.9

Table 4.18 Using 6% sludge

Sludge Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	240	50	50	50	10.4
2	250	50	50	50	10.0
3	240	50	50	50	9.6

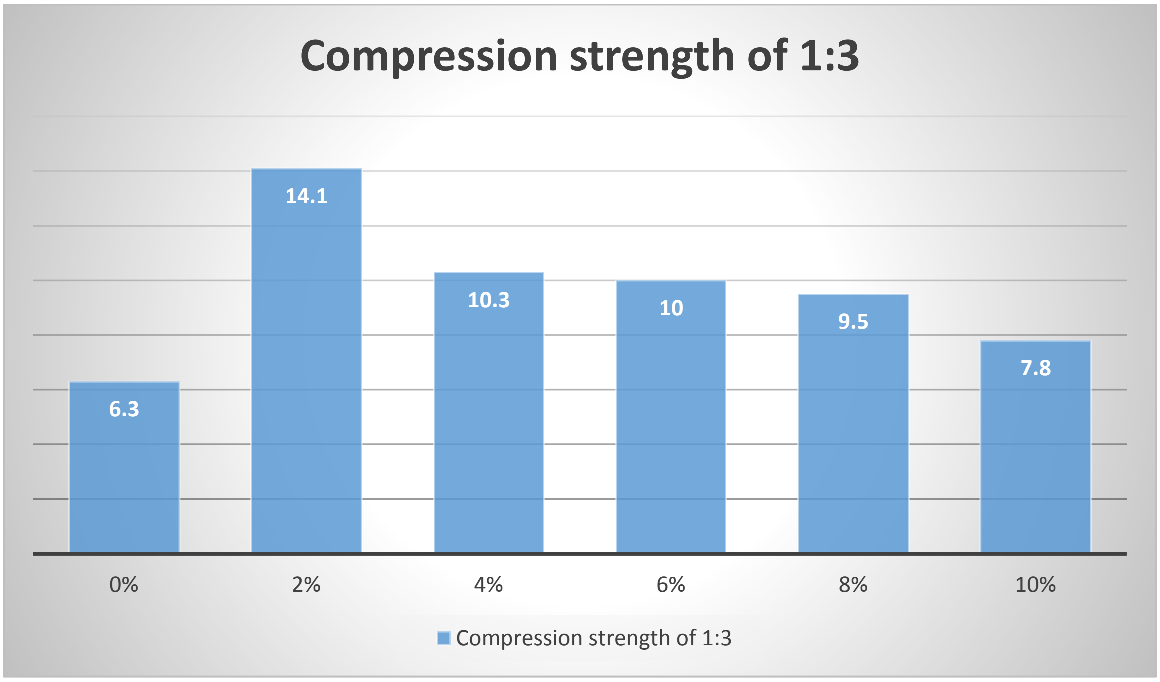
Table 4.19 Using 8% sludge

Sludge Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	240	50	50	50	9.7
2	240	50	50	50	9.8
3	240	50	50	50	8.9

Table 4.20 Using 10% sludge

Sludge Bricks (1:3)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	260	50	50	50	8.5
2	260	50	50	50	7.1
3	270	50	50	50	7.7

Figure 4.6 Graph of compression strength using 1:3



4.2.2.4 Strength of bricks for 28 days

Result strength of using sludge for 28 days using 1:6

Table 4.21 Control bricks

Control Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	11.5
2	240	50	50	50	11.3
3	230	50	50	50	12.1

Table 4.22 Using 2% sludge

Sludge Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	3.1
2	220	50	50	50	2.9
3	220	50	50	50	3.1

Table 4.23 Using 4% sludge

Sludge Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	2.7
2	220	50	50	50	2.4
3	240	50	50	50	2.8

Table 4.24 Using 6% sludge

Sludge Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	2.5
2	220	50	50	50	2.6
3	220	50	50	50	2.3

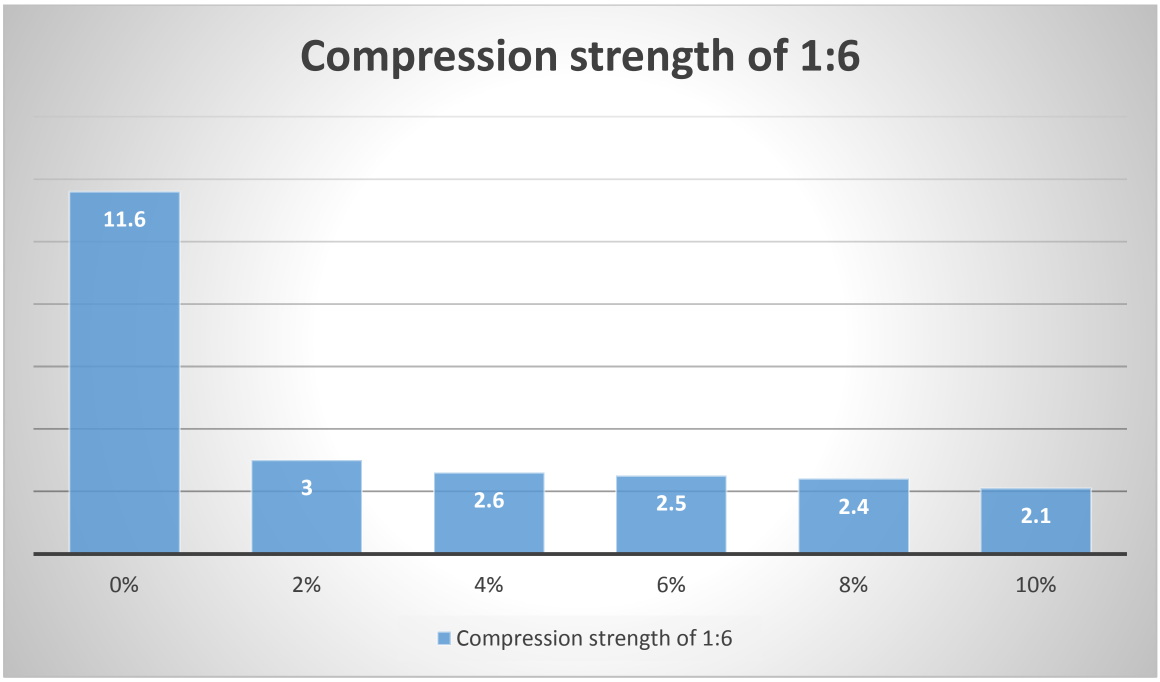
Table 4.25 Using 8% sludge

Sludge Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	2.6
2	220	50	50	50	2.4
3	220	50	50	50	2.1

Table 4.26 Using 10% sludge

Sludge Bricks (1:6)	Weight (g)	Length (mm)	Width (mm)	Depth (mm)	Strength (MPa)
1	230	50	50	50	2.2
2	220	50	50	50	2.1
3	220	50	50	50	2.1

Figure 4.7 Graph of compression strength using 1:6



5. DISCUSSION AND CONCLUSION 5.1 INTRODUCTION

5.1. Introduction

The laboratory test of the project has been made of sand cement brick using sludge. The bricks are made by adding sludge by 0%, 2%, 4%, 6%, 8%, 10% in sand percentage. The results of this test are in accordance with the percentage and procedure of MS 1972. Based on the findings of this study, this chapter will discuss the improvements and suggestions on sludge as additives in sand cement bricks.

5.2 DECISION IMPLICATIONS

Refer to the strength and absorption tables of bricks, which are types of engineering bricks, loadbearing bricks and damp-proof bricks refer to MS 76: 1972. A good brick is a brick with a smooth surface, size and a good angle. Based on the tests performed on these 3 sets of brick samples, bricks with sludge mixtures are able to reach specifications and achieve a specified compressive strength. As such, sludge as an additive in sand cement bricks is ideal for lightweight construction such as one or two storey houses, walls and many other uses.

From the tests and data obtained from the project findings, it is shown that the value of compressive strength of sand cement brick decreases as the percentage of sludge increases. The 2% sludge bricks have the highest compressive strength. The sludge control brick reached the second highest compressive strength. It shows an increase in strength.

5.3 DECISION APPLICATIONS

Based on the value obtained from the compressive strength of the brick, it is found that the higher the percentage of sludge added, the lower the value of the brick strength.

5.3 Conclusion of the study

Based on the problem statement presented, the results and analysis of the data are obtained from laboratory tests. Some conclusions can be drawn from this study. Sand added cement sand can be used in the construction industry in Malaysia. This is because the compressive strength of the brick meets the specification specified by the Malaysian Standard (MS 76: 1972) of 5.2 MN / m ^ 2. Sand cement bricks with a 2% percentage of sludge are only suitable for one and two storeys in Malaysia because of their compressive strength.

The 5% sludge composition used in brick is the most suitable. Overall, the compression strength obtained was 9 MN / m ^ 2 for 2% sludge.

5.4. Chapter Summary

In this chapter, it can be concluded that the use of sludge as the optimum additive is 2%. Therefore, the discussion and suggested improvements need to be made in order for the product to be developed to reach a higher percentage of sludge use. The whole project showed satisfactory results in terms of compressive strength, water absorption and density.

References

Shamrul-Mar Shamsudin et. al, (2017), The Effect o Sludge Water Treatment Plant Residuals on the Properties of Compressed Brick, IOP Conference Series: Materials Science and Engineering, Volume 271 (1), 012052.

Abdul Kadir et. al, (2015), Utilizayion of Polishing Sludge and Body Mill Sludge Incorporated into Fired Clay Brick, Journal of Engineering and Applied Sciences, 10 (15).

Yousif Algamal et al, (2018), Usage of the Sludge from Water Treatment Plant in Brick-Making Industry, Journal of Chemical Technology & Metallurgy, 53 (3), pages 504-510.

Mohammed O. Ramadan et. al, (2008), Reusse of Water Treatment Plant Sludge in Brick Manufacturing, Journal of Applied Sciences Research, Volume 4 (10), pages 1223-1229.

Mohd Asri Md Nora et. al, (2015), Properties and Perfomance of Water Treatment Sludge (wts)-clay Bricks, Jurnal Teknologi (Sciences & Engineering), Volume 77 (32), 83-93.

Ertugul Esmeray et. al, (2019), Utilizatin of Sewage Sludge, Oven Slag and Fly Ash in Clay Brick Production, Construction and Building Materials, Volume 194, pages 110-121.

CH Weng et. al, (2019), Use of Sewage Sludge Ash as Brick Material, Teknologi Sipil Volume 1, page 2.

Ravindra K. Dhir et. al, (2015), Sewage Sludge Ash Characteristic and Potential for Use in Concrete, Constrution and Building Materials, Volume 98, pages 767-779.

Ertugul Esmeray et. al, (2019), Utilizatin of Sewage Sludge, Oven Slag and Fly Ash in Clay Brick Production, Construction and Building Materials, Volume 194, pages 110-121.

Gaurav Goel et. al, (2017), An Investigation on Use of Paper Mills Sludge in Brick Manufacturing, Construction and Building Materials, Volume 148, pages 334-343.