POTENTIAL OF OLEOCHEMICALS WASTE TO SERVE AS PARTIAL SAND REPLACEMENT IN CONCRETE

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POTENTIAL OF OLEOCHEMICALS WASTE TO SERVE AS PARTIAL SAND REPLACEMENT IN CONCRETE

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ABSTRAK

Pengeluaran sisa oleokimia (*sludge*) dari minyak kelapa sawit melalui proses kimia semakin meningkat sejak kebelakngan ini. Pelupusan *sludge* telah membawa kepada masalah alam sekitar yang serius. Pada masa yang sama, peningkatan industri pembinaan telah membawa kepada peningkatan dalam aktiviti perlombogan pasir dan telah menimbulkan kesan buruk terhadap alam sekitar memandangkan ia mencetekkan sungai. Dalam usaha untuk memperbanyak kegunaan *sludge* dan untuk mengurangkan aktiviti perlombongan pasir, penyelidikan ini dijalankan dengan menggantikan separa pasir di dalam konkrit dengan *sludge*. Kajian ini dilakukan untuk menilai kekuatan dan kadar penyerapan air dalam campuran konkrit, dimana pasir diganti dengan 0%, 5% dan 10% *sludge* dari berat pasir. *Sludge* yang diterima daripada kilang akan dikeringkan menggunakan oven pada suhu 100°C dan tidak lebih daripada 24 jam. Kemudian, *sludge* yang kering akan dikisar dan diayak sebelum dibancuh. Semua campuran telah diacu dalam bentuk kiub dan prisma dan kemudian dikenakan pengawetan udara dan pengawetan air sehingga tarikh ujian. Hasil daripada kajian mendapati bahawa gabungan kandungan *sludge* akan mempengaruhi kekuatan dan kadar penyerapan konkrit. Sampel yang dihasilkan menggunakan 5% dan 10% *sludge* sebagai pengganti separa pasir tidak mencapai kekuatan optimum berbanding dengan konkrit kawalan kerana sampel konkrit terlalu rapuh dan mudah percah disebabkan *sludge* tersebut mengandungi polimer, manakala kadar penyerapan tidak dapat direkodkan kerana terdapat kesan terhakis pada permukaan sample apabila sampel direndam di dalam air.

ABSTRACT

The production of oleochemicals waste (sludge) from palm oil through chemical process is increasing over past few years. Disposal of sludge has brought towards serious environmental problem. At the same time, the growing of construction industry has lead towards the increasing in sand mining activities which pose adverse impact towards the environment as it lowers the stream bottom of the river. In an effort to use the sludge in large volume and to reduce sand mining activities, this research is carried out for its possible in making concrete containing sludge as partial sand replacement. The experimental investigation is performed to evaluate the strength and water absorption of concrete mixtures, in which sand is replaced with 0%, 5% and 10% of sludge by weight of sand. The sludge is oven dried at 100°C for not more than 24 hours after collected from the factory and then the dried sludge are grinded and sieved before mixing. All the mixes were cast in form of cubes and prisms and then subjected to air curing and water curing until the testing date. From the results, it is observed that the combination of sludge content would affect the strength and rate of absorption of the concrete. Samples produced using 5% and 10% sludge as partial sand replacement has not achieved optimum strength compared to control concrete due to the concrete sample are fragile and easily broken since there are presence of polymers in the sludge, while the rate of absorption cannot be recorded as there is corrosive effect on the surface of the sample when the sample is submerged in the water.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Green technology aims to conserve nature, remedy the negative impact, encouraging the use of renewable resources as well as preserving energy and natural resources while providing a healthy environment (Bhardwaj & Neelam, 2015). In this era globalization, development industry in Malaysia is growing quickly cause an increasing utilization of sand in concrete production to meet the continuous demand of the construction industry. The growing construction industry has lead towards increase of sand mining activities which causing adverse effects to the environment (Mehta & Monteiro, 2013). The way to reduce the continuous sand mining activity of natural sand is by doing the sand replacement in concrete production. One of the successful sand replacements was done by replaced with 20% of sand with sludge from waste water treatment plant in concrete (Vazhviniyan et al., 2016). Based on the investigation, reported that compressive and flexural strength increased with the addition of sludge.

At present, Malaysia has become a major producer of basic oleochemicals using the large supplies of indigenous raw material such as palm oil, palm kernel oil and also coconut oil which has almost 70% of the total oleochemical productions capacities (Abbas et al., 2016). Oleochemicals industry is one of major industries that produce effluent and affecting the water quality in the environment due to large consumption of mixture of water and chemicals for processing crude palm oil (Takemoto & Ichise, 2016). Oleochemicals waste or sludge that been used in this study is derived from sustainable resources that are majorly oils and fats of vegetable and animal origin through chemical process which produced glycerine, fatty acids and methyl esters (Elias et al., 2018). Sludge is a by-product of oleochemicals manufacturers and it has prime and critical environmental problem. Generally, oleochemicals waste requires more landfill area for dumping due to its large production, significantly affects the surrounding environment. Therefore, this study is conducted to investigate the use of oleochemicals waste as the partial sand replacement in concrete.

1.2 Problem statement

The growing construction industry has brought in the increasing of sand mining activities. It is reported that about nine billion tonnes of natural aggregates is annually consumes by concrete industry (Mehta & Monteiro, 2013). Sand mining activity where it was done by removing sand has cause environmental effects such as lowers the stream bottom, landslide and soil erosion (Bhardwaj & Neelam, 2015). It is not renewable sources and the source is decreased over the past few years. Simultaneously, oleochemicals wastes (sludge) also pose a significant environmental problem. Sludge is stored in landfills without any treatment. It is reported by Department of Environment, Malaysia that about 171.64 metric tonne of oleochemicals waste created in 2011. These sludge or disposal waste are disposed as landfill material without any reuse or recycling. Moreover, this sludge also is chemical wastes that contribute to the environmental pollution. Oleochemicals manufacturers has been facing difficulties in disposing this abundantly generated waste because more landfill site need to be provided and large cost need to be spend in order to place and manage this disposal waste. Hence, in order to overcome this problem, the invention of reuse oleochemicals waste as partial sand replacement in concrete is investigate, at the same time to build sustainable building.

1.3 Objectives

The aim of this research is to study the potential of oleochemicals waste to serve as partial sand replacement in concrete. The objectives of the study are:

i) To determine the effect of oleochemicals waste as partial sand replacement towards compressive strength and flexural strength at the age of 7 and 28 days.

ii) To determine the effect oleochemicals waste as partial sand replacement towards water absorption at the age of 28 days.

1.4 Scope of research

This study concentrated on investigation of compressive strength, flexural strength and water absorption of the concrete made by integrating oleochemicals waste as a partial sand replacement. The scopes of study are:

i) The testing is conducted in FKASA concrete lab at UMP Gambang.

ii) The oleochemicals waste is obtained from FPG Oleochemicals Sdn Bhd located at Gebeng Pahang.

iii) The oleochemicals waste is dried in an oven, grind and sieve before casting.

iv) The percentages of oleochemicals waste use as partial sand replacement are 0%, 5% and 10%.

v) The specimen is in the form of cube and prism which has size 100 x 100 mm x 100 mm and 100 x 100 x 500 mm respectively.

vi) There are three mixture of the concrete and the total sample is 45 which are 27 cubes and 18 prisms.

vii) The concrete design to be 25 N/mm2.

viii) Samples with 0% of sludge are cured using water curing, while samples with 5% and 10% of sludge are cured using air curing.

ix) The sample for compressive strength and flexural strength test are tested at the age of 7 days and 28 days, while the sample for water absorption test are tested at the age of 28 days.

1.5 Significance of research

The properties of concrete produced by utilizing oleochemicals waste as partial sand replacement are investigated in this study. The utilization of sludge from oleochemicals waste as partial sand replacement in concrete is able to reduce the amount of waste ending up at the landfill. The fundamental objective of disposal waste management is encouraging reuse of the wastes including diminishing environmental effects such as lowers the stream bottom, landslide and soil erosion. These is to guarantee that the replacement of oleochemicals waste in concrete production give a decent effect in the earth. Moreover, the use of sand in concrete production also is reduced thus assisting the industry to be environmental friendly (Ahmad Zawawi, 2018). At the same time, this study reduced sand mining activity which leads towards deforestation that include loss of animal habitats, climate change, soil loss and hydrological factor (Sulphey, 2016). Since the growing construction industry leads to the increase in natural sand demand, thus new materials from different sources are required as aggregate to cope with the demand of the construction industry in order to produce more quality construction material and good sustainable waste management in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, various types of topics and reading materials are discuss that help to study the potential of industrial waste to serve as partial sand replacement in concrete. Generally, the topics discuss about sand mining activities and the effect of sand mining toward the environment. Besides, this chapter also explained about the industrial waste products that have been used as partial sand replacement in concrete. At the end of this chapter, there are reviewed and described more detail about the oleochemicals and the negative impact of oleochemicals waste towards environment.

2.2 Fine aggregate

Fine aggregates used in concrete need to follow the required standard of BS EN 12620:2013. Properties of aggregate that affect properties of hardened concrete are ultimate strength, abrasion resistance, dimensional stability and durability (Koech, 2017). There are many types of fine aggregates used in concrete production and one of the famous sources is river sand (Mahendran et al., 2016). The appealed for raw materials by the construction industry, results in environmental damage and chronic deficiency of construction materials. The availability of good quality of natural river sand is decreased over past few years and also it is costly and hence there is necessity to find the substitute for natural sand (Ingale et al., 2016). There have been various researches conducted on the exploitation of waste products in concrete to diminish the exploitation of natural resources especially sand through sand mining activity.

2.2.1 Sand mining

Construction and concrete production in Malaysia is increased parallel with the developing construction industry. At the same time, the use of natural sand for construction also increased as result of rising market demand for larger quantity of sand supply (Torres et al., 2017). It has been a long time, human have taken pleasure in utilizing the natural benefits given by river without awareness on how the river ecosystem works and maintain its state of being strong and active. Based on Figure 2.1, Department of Minerals and Geosciences of Malaysia (2016), extraction of sand by sand mining activities have been increased from 37.3 million tonne in 2011 to 46.7 million tonne in 2016. Sand is obtained from sand mining where it done by removing sand from its natural resources such as river. Upon of this, the environmental impacts to river in term of water pollution, bank erosion, destruction of natural habitats and etc. are arise due to continuous, excessive and uncontrolled sand mining from natural resources in order to meet the demand of the construction industry (Ojos Negros, 2019). Therefore, this problems need to overcome in order to protect environment and avoid sand from depletion in the future.

Mineral	Tonnes (unless otherwise stated)	Value (RM Million)	Types of minerals group
Coal	2,414,765	316.11	Energy Minerals
Iron ore	1,914,232	443.35	Metallic Minerals
Gold (gm)	2,248,990	388.76	Metallic Minerals
Tin-in-concentrates	4,158	213.09	Metallic Minerals
Manganese	700,717	82.21	Metallic Minerals
Bauxite	343	35.49	Metallic Minerals
Ilmenite	4,316	1.51	Metallic Minerals
Rare earth minerals	1,880	14.13	Metallic Minerals
Struverite	77	1.49	Metallic Minerals
Rutile	3,810	7.62	Metallic Minerals
Zircon	653	1.63	Metallic Minerals
Silver (gm)	1,075,325	2.52	Metallic Minerals
Aggregates	133,072,882	2,263.17	Non-Metallic Minerals
Sand and gravel	44,944,336	819.94	Non-Metallic Minerals
Limestone (for cement)	25,431,150	351.39	Non-Metallic Minerals
Clay	5,794,833	62.36	Non-Metallic Minerals
Earth materials	25,490,877	259.81	Non-Metallic Minerals
Silica sand	5,408,814	249.3	Non-Metallic Minerals
Kaolin	392,932	35.52	Non-Metallic Minerals
Feldspar	441,857	25.76	Non-Metallic Minerals
Mica	4,701	2.82	Non-Metallic Minerals

Figure 2.1: Mineral extraction 2016

(Source: Department of Minerals and Geosciences of Malaysia)

2.2.2 The impact of sand mining

A construction material such as sand has become very important in the construction sector for a decade. Nowadays, the needs and demand of these materials become greater and continues that cause excessive in stream sand mining. However, these activities have created various environmental impacts results of excessive sand extraction. River sand mining causes the destruction of natural habitats and ecosystems results of soil erosion and sedimentation in the water bodies which reduce water quality of the river (Hashim, 2013). In addition, river sand mining leads to bank erosion by lowering the stream bottom (Mohd Salleh, 2017).

The destruction of natural habitats and ecosystems are included aquatic life and flora and fauna (Akmal et al., 2017). As results of soil erosion, sedimentation, dredging and extraction of sand from the river destroys natural habitats and ecosystem above and below ground surface, thus reduced in population of biodiversity (Ashraf et al., 2011). These also have caused real habitat interruptions that favoured some species over others and caused generally decreases in biological diversity and productivity. As the increase of turbidity levels caused by this activity, it reduces the visibility of certain fish that rely on vision to feed (Hashim, 2013). Other than that, noise generated from sand mining activity has been a disturbance of the habitat as well as interrupted nesting activities.

Naturally, excessive in stream sand mining causes the degradation of rivers which lowering the stream bottom and lead to bank erosion (Lawal, 2011). Uncontrolled sand mining activity is a threat to river banks and nearby structure and also affects the adjoining groundwater system. As results of bank erosion, it also harms public and private property which affects the stability of the structures (Mohammad Udin, 2017). The increasing in stream bank heights, it make the mechanical properties of the bank material cannot sustain the material weight when the bank failure due to channel section increases (Lawal, 2011). Other than that, reduction of sand in the stream bed and in coastal areas causes the deepening of rivers estuaries and the swelling of river mouths and coastal inlets (Kumar & Rastogi, 2017). Hence, sand mining activity triggered erosion of bed and banks.

Uncontrolled dredging and extracting sand, it leads the depth of river water decrease and then affects the water quality. Besides, sand mining activities contribute to an arising in erosion and loss of land which leads to flooding and landslide where it also brings to bad water quality of the river (Mohd Salleh, 2017). Not only increasing in turbidity level, but by doing this activity, it also raises the sedimentation concentration in the bottom of the river (Kumar & Rastogi, 2017). There is also possibility of oil spills or leakage from excavation machinery and other transportation vehicles used during conducted this activity, where it contributed to water pollution of the river (Madyise, 2013). Figure 2.2 shows the effect of sand mining activity which leads to pollution to the river and have bad water quality.

Figure 2.2: Sand mining activities pollute Sungai Sayong, Kota Tinggi

(Source: The Sun Daily, 2016)

2.3 Industrial waste products as replacement material

Generally, industrial activity produces abundantly of waste product materials such as hypo sludge, petrochemical waste, pond ash, sewage sludge ash and etc. In order to reduce the waste management problems such as lack of landfill area, various study have been conducted on reuse these waste as partial sand and cement replacement in concrete and brick.

2.3.1 Hypo sludge

Hypo sludge as shown in Figure 2.3 is a waste generated from paper mill industries that exist abundantly causing environment and dumping problems (Pandya et al., 2017). The material is a by-product of the deinking and re-pulping of paper (Kale, 2018). According to Anbu (2018), the optimum strength for concrete grade M20 is obtained at 20% replacement of hypo sludge as fine aggregate which is 3.9% more than the conventional concrete. The durability of hypo sludge concrete in term of acid attack, sulphate attack, rapid chloride penetration test and sorptivity test results are very low penetration (Anbu et al., 2018). There are many researches study the potential of hypo sludge as partial cement replacement in concrete, while for sand replacement, flexural strength and water absorption test remains unexplored.

Figure 2.3: Hypo sludge

2.3.2 Petrochemical waste

Petrochemical waste as shown in Figure 2.4 is derived from petrochemical industries which faced problems of the disposal of waste sludge from the refineries. Before mixing and casting, the sludge is dried and then sieved through 4.75mm sieve. Investigations proved by (Parvathy & Shrihari, 2017) shows that the optimum strength for concrete M20 and M25 are 25% and 20% of petrochemical sludge respectively. From the research, the density and workability is decreases, while the porosity is increases for both grades. At the same time, there is no total petroleum hydrocarbon released making it safe for replacement of fine aggregate in concrete. The research is lacked in term of flexural strength test and water absorption test, while the researchers recommended continuing study in term of effect of sludge on creep and shrinkage in concrete mixes.

Figure 2.4: Petrochemical sludge

2.3.3 Sewage sludge

Generally, there are numerous of water treatment plant generated abundant quantity of sewage sludge and having disposal problems which usually by land filling and incineration (Mathye, 2017). It was observed that raw sewage sludge contains mainly quartz (silicon dioxide, SiO2), phosphorus-pentoxide (P2O5) and iron oxide (Fe2O3) which obtained from XRF analysis (Nagar & Bhargava, 2016). Same like other replacement of sludge, the sludge is dried first before mixing and casting the concrete. Figure 2.5 shows sample of dried sludge that comes from water treatment plant and that sample is used in concrete production. It is recorded that the optimum strength for concrete grade M40 is 20% of sewage sludge (Vazhviniyan et al., 2016). Other researchers also obtained that concrete with 20% of sewage sludge ash and W/C=0.45 has a 28 day compressive strength of almost 30MPa (Jamshidi et al., 2012). However, it is not permissible using sewage sludge if there is present of harmful microorganisms (Subramani & Anbuchezian, 2017). It is recorded that the concrete containing sewage sludge can be used in making tiles, road bases and sub-bases and in non-structural element (Desai & Student, 2016). According to Ghannam (2016), the density is decreased when use treated water instead of tap water but doesn't strongly bad effect. The effect of sludge on creep and shrinkage in concrete mixes remains unexplored.

Figure 2.5: Sludge sample from waste water treatment plant

2.4 Oleochemicals

Oleochemicals is globally generated from plantation industry where it comes from the chemicals process derived from natural fats and oils, whether from animal, marine or vegetable oil sources (Elias et al., 2018). It is derived through breaking the oils or fats into corresponding constituents which mainly basic oleochemicals such as fatty acids, glycerol, fatty esters and etc., while the normal process involves of hydrolysis or trans-esterification (Yeong et al., 2012). Figure 2.6 shows the process involved in order to produce the basic oleochemicals.

Oleochemicals are used in several of applications, whether in industries or sector. For example, it is used as raw materials and being used directly or indirectly, as base materials, additives or as process aids. At the same time, oleochemicals manufacturers also generated oleochemicals waste while undergo the process in producing basic oleochemicals which finally produce consumer or industrial end products such as soap, shampoo, detergent, cosmetics and etc. (Qua, 2016). The oleochemicals waste is divided into three forms which are solid, semi-solid and liquid. There is abundant oleochemicals waste created since the demand of oleochemicals continues to increase from other countries day by day. Figure 2.7 and Figure 2.8 shows the number of oleochemicals plants and capacities in 2013 (tonne/year) and also Malaysian export volume of oleochemicals products in 2013 respectively.

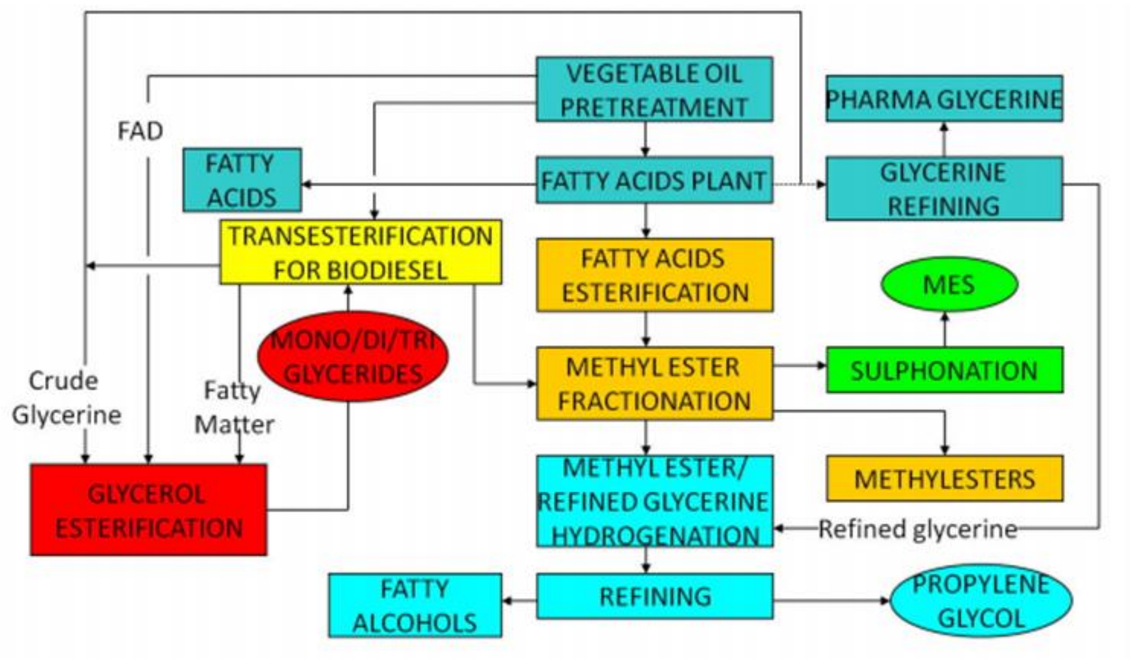

Figure 2.6: Generation of oleochemicals

(Source: MPOB)

State	In Operation		Not In Operation		Under Planning		Total	
	No	Capacity	No	Capacity	No	Capacity	No	Capacity
Johore	6	608,900	0	0	0	0	6	608,900
Penang	3	791,325	0	0	0	0	3	791,325
Selangor	6	817,746	0	0	0	0	6	817,746
Other States	1	365,000	1	16,000	1	60,000	3	441,000
Malaysia	16	2,582,971	1	16,000	1	60,000	18	2,658,971

Figure 2.7: Number of oleochemicals plants and capacities in 2013, tonne/year

(Source: MIDA & MPOB, 2014)

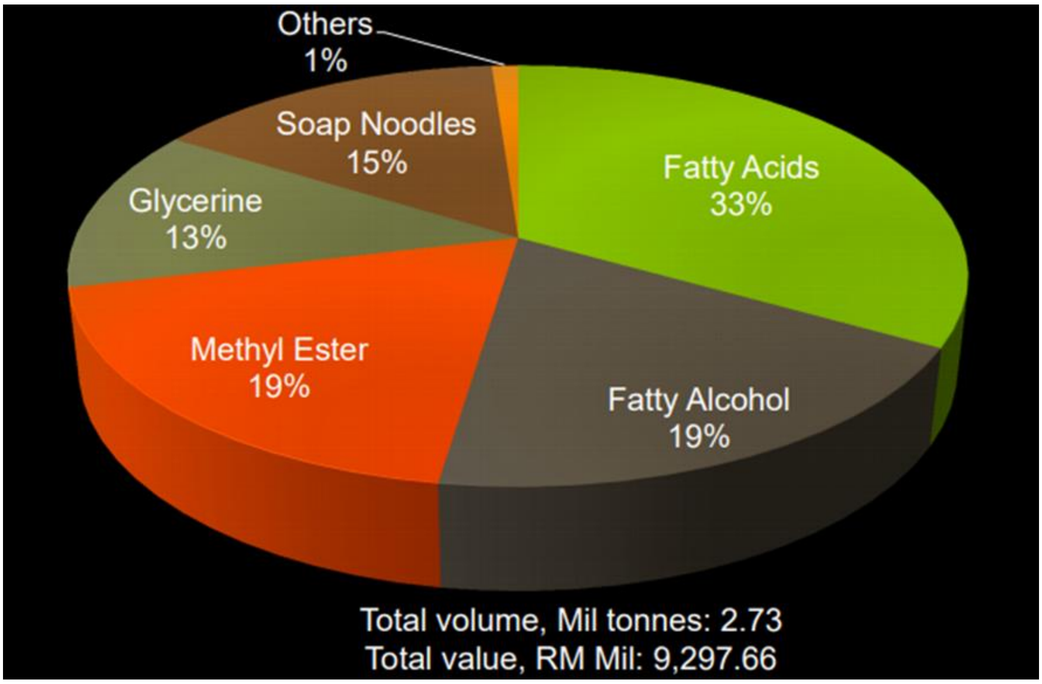

Figure 2.8: Malaysian export volume of oleochemicals products in 2013

(Source: MPOB)

2.4.1 Oleochemicals waste

The oleochemicals waste in the form of semi-solid or known as sludge is used in replacement partially of sand in concrete. It is used as partial sand replacement in order to reduce excessive sand mining activity in our country. Based on Figure 2.9, about 171.64 metric tonne of oleochemicals waste created in 2011 reported by Department of Environment, Malaysia (2012). As we know, disposal the solid waste to the dumping is one of the famous ways used by the industry nowadays (Abdel-shafy & Mansour, 2018). The sludge produced in the oil palm industry is dumped into open space without any profitable return resulting in massive solid disposal which causes negative impacts. Since there is abundantly generated waste, more landfill site need to be provided and large cost need to be spent in order to manage this disposal waste.

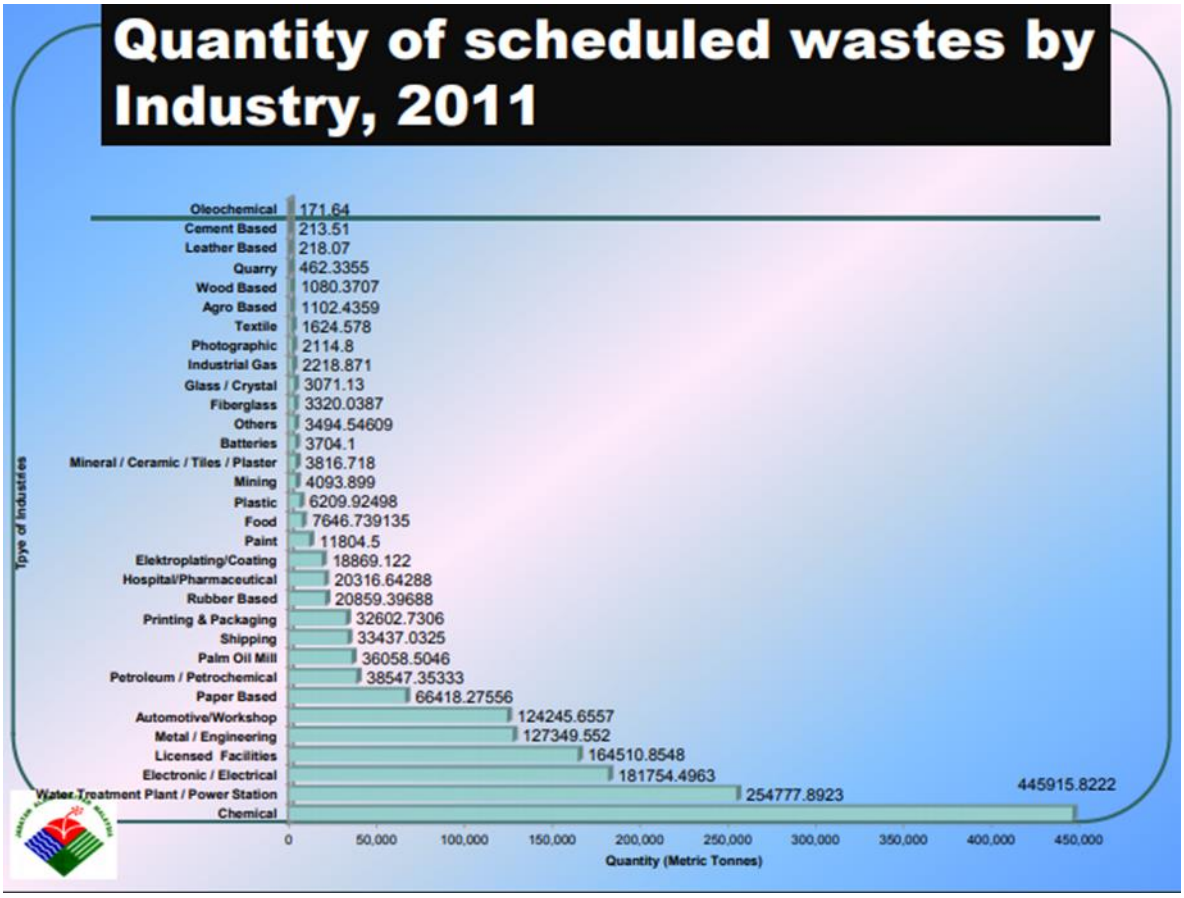

Figure 2.9: Quantity of waste in 2011

(Source: Department of environment, Malaysia)

2.5 Summary

As Malaysia is moving towards sustainability construction, there are many study conducted in order to reduce the usage of natural resources especially river sand. In this research, the study on potential of oleochemicals waste to serve as partial sand replacement in concrete. This study is conducted in order to reduce sand mining activities since it causes massive amount of environmental impacts such as water pollution, bank erosion, destruction of natural habitats and ecosystems and etc. to our country. At the same time, it helps in handling of waste management problems faced by oleochemicals manufacturers.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

A series of experiments need to be done to determine the mechanical properties of concrete using oleochemicals sludge as partial sand replacement. This experimental study is done by modifying a natural concrete mixture by using sludge as partial sand replacement. This chapter mainly discusses the procedure carried out in conducting the experimental work at the laboratory test to achieve the objectives. At the beginning of this chapter, the experimental process and preparation of materials used for mixing is presented. Then, a brief explanation of mix proportion used to produce concrete containing oleochemicals waste (sludge) is justified in this section. Lastly, the detailed method of mechanical properties testing conducted such as compressive strength test, flexural strength test and water absorption test are also discussed. There are two different aspects which are going to be tested which are the strength and water absorption of the concrete.

3.2 Flowchart of experimental process

Flowchart is a diagram that represents the process of the research in order to obtain the results for this research. The experimental process throughout this research are simplify in Figure 3.1 below.

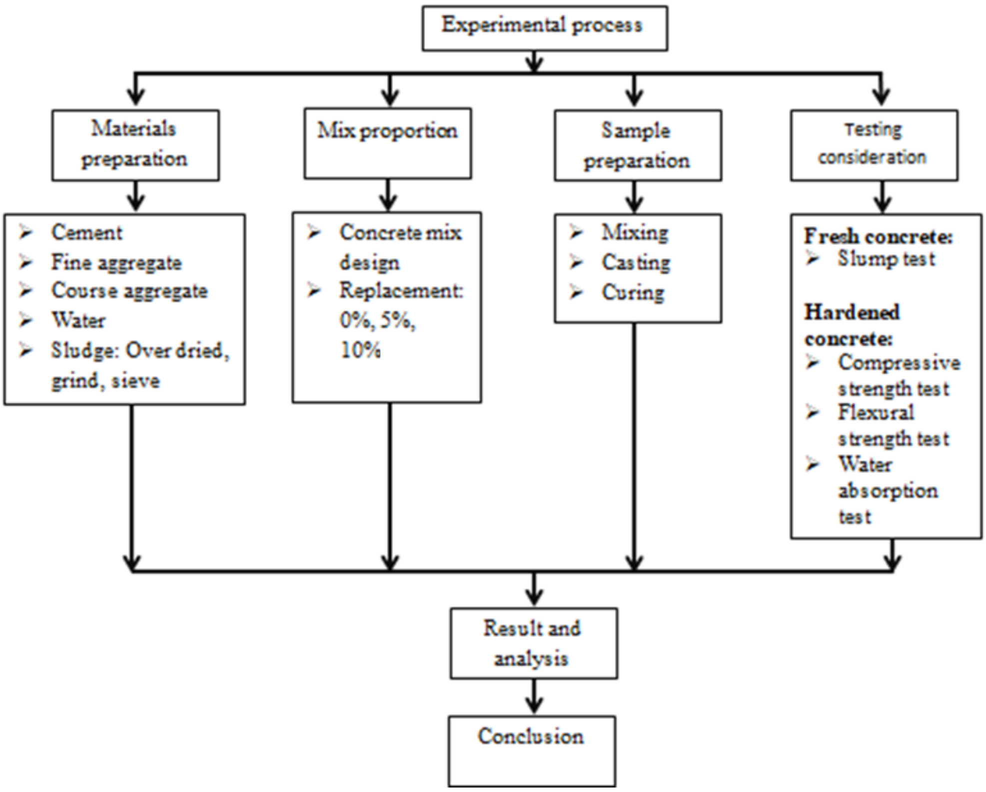

Figure 3.1: Flowchart of experimental process

3.3 Materials preparation

In this study, the materials that will be used in production of concrete mixtures are cement, water, sand, gravel and sludge. All the materials used are taken from FKASA concrete lab because the materials are available there except sludge. The sludge used is obtained from FPG Oleochemicals Sdn. Bhd. and it act as partial sand replacement in the concrete production. The following sub-sections elaborate each of the materials used throughout this study.

3.3.1 Cement

Cement is the basic ingredient in concrete production which acts as a binder for fine and coarse aggregate and also to fill the air void between those two particles to form a compact mass. Cement mixed with fine and course aggregate produces concrete which will form strong building material. Figure 3.2 show the Orang Kuat Ordinary Portland Cement (OPC) produced by YTL Cement Berhad is brand used throughout this experimental study. This type of cement complies with Type 1 Portland cement conforming to Malaysia Standard MS 522: Part1: 2007 for Portland cement specification which is suitable for all general purpose applications.

Figure 3.2: Orang Kuat Ordinary Portland Cement (OPC)

3.3.2 Fine aggregate

Usually, sand acts as the fine aggregate in most of concrete production to fill voids that exists between coarse aggregate. In production of concrete mixing, uncrushed fine aggregate is considered. The fine aggregate is classified when the sand pass through 4.75 mm sieve and the sand is placed under closed area to prevent effect on the specimen if there is excess in moisture content. River sand as shown in Figure 3.3 is used as fine aggregate in this study. The standard for the sand used in this experiment is BS EN 12620:2013.

Figure 3.3: River sand

3.3.3 Course aggregate

Figure 3.4 shows the crushed gravel that is used as coarse aggregate to produce concrete mixture throughout this experimental study. The maximum size of coarse aggregate considered is 20 mm following BS EN 12620:2013.

Figure 3.4: Crushed gravel

3.3.4 Water

Concrete is produced from reaction between water and cement through hydration. The quality of concrete is determined from the quality and quantity of water. In order to avoid adversely affect the strength and moisture content of the concrete, water that free from impurities is used. Thus, water tap that obtained from concrete laboratory in UMP is used. The amount of water used is depends on the mix design.

3.3.5 Oleochemicals waste (sludge)

Figure 3.5 illustrates the oleochemicals waste (sludge) used as partial sand replacement to produce concrete in this study. The sludge is collected from an oleochemicals manufacturer owned by FPG Oleochemicals Sdn. bhd. located at Gebeng, Pahang. The sludge obtained is dried in an oven at 121°C for not more than 24 hours to remove any unwanted moisture content. Figure 3.6 shows the dried sludge. The dried sludge then is grinded by using grinding machine until the texture is like sand and then sieve by using sieve shaker. The sludge that passed through 4.75mm is used as partial sand follow BS EN 12620:2013.

Figure 3.5: Oleochemicals waste (sludge)

Figure 3.6: Dried sludge

3.4 Mix proportion

Mixing process of the concrete is done by referring standard design of normal concrete, Department of The Environmental (DoE) HMSO, 1988. All the materials used are weighted according to the mix design before mixing. The sludge used is act as partial sand replacement in the concrete. The following sub-sections present the mix proportion that is used throughout this study.

3.4.1 Concrete mix design

There are three mixture of the concrete, which are 0%, 5% and 10% by the weight of the sand and the water-cement ratio of 0.64 is used. Besides, the concrete design to be 25 N/mm2, while the volume for one cube and prism are 0.001 m3 and 0.005 m3 respectively. The detail of mix proportion of the materials used and the total sample for each mixture are shown in Table 3.1 and Table 3.2 respectively.

Table 3.1: Mix proportion of the materials used

Sample (%)	**Cement (kg/m^3)**	**Sand (kg/m^3)**	**Sludge (kg/m^3)**	**Gravel (kg/m^3)**	**Water (kg/m^3)**
0	360	1135	0	1125	230
5	360	1080	55	1125	230
10	360	1020	115	1125	230

Table 3.2: Total sample for each mixture

Sample (%)	**Types of testing**					**Total no. of sample**
	Compressive strength		**Flexural strength**		**Water absorption**	
	No. of sample by curing days					
	7	**28**	**7**	**28**	**28**	
0	3	3	3	3	3	15
5	3	3	3	3	3	15
10	3	3	3	3	3	15

3.5 Sample preparation

The preparation of the sample is started by preparing the sludge which already dry, grind and sieve. Then, other mixing ingredients consist of cement, sand, gravel and water is prepared for the process to produce concrete mixture. After that, the materials undergo the flow of the sample preparation; mixing, casting and curing. Figure 3.7 shows flow of sample preparation involve in this research.

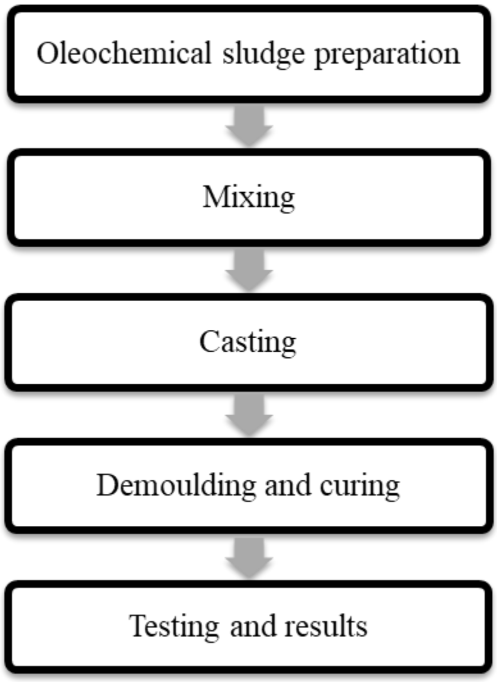

Figure 3.7: Sample preparation flow

3.5.1 Mixing

After all the materials such as cement, sand, gravel, water and sludge are weighed to the required amount accurately, the mixing process is carried out. All the materials are mixed by using concrete mixer as shown in Figure 3.8 until the uniform and well mix is acquired in order to achieve concrete grade of 25 N/mm2. Then, the slump test was conducted simultaneously with casting process to measure the workability of concrete. By conducting the slump test, the consistency of fresh concrete is measured before its sets.

Figure 3.8: Concrete mixer machine

3.5.2 Casting

After mixing process, the mixture is immediately casted in the concrete cube and prism mould with size of 100 mm x 100 mm x 100 mm and 100 mm x 100 mm x 500 mm respectively. The concrete is poured in three layers in the mould and then switch on the vibrator for each layer in order to ensure there is air void in the concrete mould. After that, the sample is ready for curing process.

3.5.3 Curing

The samples are demoulded and cured after 24 hours of casting. The methods of curing that are involved in this study are air and water curing. The samples of concrete containing 0% of sludge are using water curing while samples of concrete containing 5% and 10% of sludge are using air curing. The concrete sample is cured for 7 and 28 days before undergo testing.

3.6 Testing considered

The following sub-sections present brief details of explanations for sieve analysis test, slump test and mechanical properties of concrete containing sludge which are compressive strength test, flexural strength test and water absorption test. All the testing is carried out in FKASA concrete laboratory at UMP Gambang.

3.6.1 Sieve analysis

Sieve analysis is important to make sure the size of the aggregate used for concrete mixture where the aggregate is weighted for required weight to conduct this test. Before conducting the test, prepare a stack of sieves whereby sieves having larger opening sizes are placed above the ones having smaller opening sizes. The sample is placed inside on the sieve with the largest opening which located on top of the rest of sieves and shake around 10 to 15 minutes by using sieve shaker machine as shown Figure 3.10. Then the weight of the sample is weighed. The sample of sand and sludge are used in this sieve analysis and the comparison for gradation of fine aggregate between sand and sludge is plotted as shown in Figure 3.9. The data for the gradation are in Appendix A.

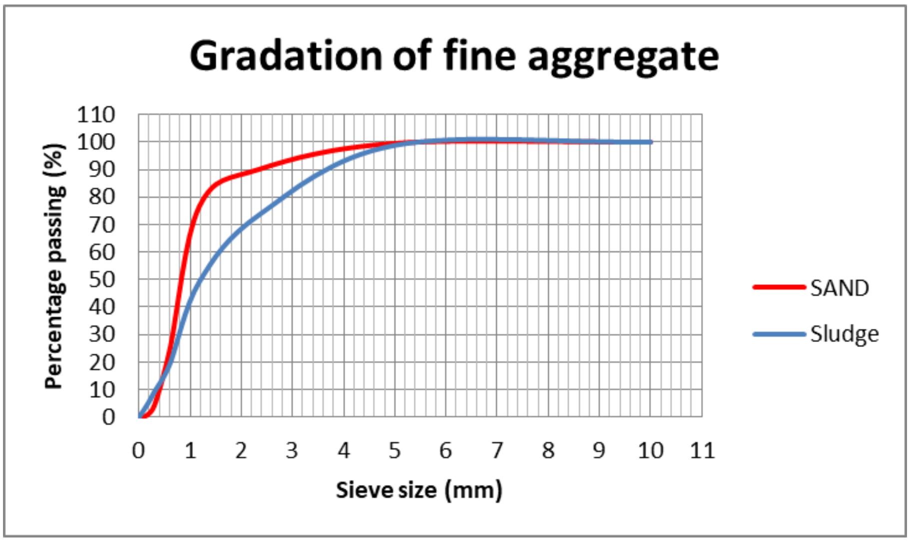

Figure 3.9: Comparison of fine aggregate between sand and sludge

Figure 3.10: Sieve shaker machine

3.6.2 Slump test

Slump test is conducted to investigate the workability of the fresh concrete mix which refers to BS EN 12350: Part 2 (2009). The cement-water ratio is depends on type and maximum size of the aggregate to give a concrete of 30 – 60 mm slump. During the filling process, the mould is held firmly in place by standing on the two-foot pieces provided in the slump cone. Then, the concrete is poured in three layers in the mould of truncated metal cone shape and each layer is tamped with 25 strokes. Then, the height of the mould and the highest point of the sample are measured after removing the mould.

3.6.3 Compressive strength test

Compressive strength test is conducted to analyse the compressive strength of hardened concrete specimen which refers to the BS 1881:Part1 16:1983 and ASTM C 39 – 03. This test is tested by using compressive testing machine as shown in Figure 3.11. The test is done for the concrete cube with size of 100 mm x 100 mm x 100mm and the samples are tested at the age of 7 days and 28 days after air curing process. During the compression test, the sample surface is subjected to the compression load to determine its strength and maximum load achieved. The compressive strength of the concrete sample is calculated as follow:

$$\textit{Compressive strength, } fc = P / A \qquad 3.1$$

Where,

P = maximum load carried by the sample during test

A = average cross sectional area of the sample

Figure 3.11: Compressive strength machine

3.6.4 Flexural strength test

Flexural strength test is carried out to study the flexural strength of hardened concrete specimen which refers to the BS 1881:Part1 18 and ASTM C 78 – 02. This test is tested by using flexural testing machine as shown in Figure 3.12 with third point loading and the samples used in this test are tested at the age of 7 days and 28 days after air curing process. The test is carried out for the prism with size of 100 mm x 100 mm x 500 mm. After the prism split up, the maximum load is recorded.

Figure 3.12: Flexural strength machine

3.6.5 Water absorption test

This test is conducted to determine the percentage of water absorbed under specified condition which refers to the BS 1881 – 122:1983 and ASTM C55 (2011). The samples used in this test are tested at the age of 28 days after curing process for cube concrete with size 100 mm x 100 mm x 100 mm. After curing process, the specimen is weighed of wet concrete sample and placed in an oven for drying process within 24 hours. Figure 3.13 shows the oven to store the samples for water absorption test. After 24 hours, the weight of the dry sample is recorded. The percentage of water absorption is calculated as follow:

$$Water\ absorption\ (\%) = 100\ (W_s - W_d)\ /\ W_d \qquad 3.2$$

Where,

W_s = weight of sample after submerged in the water

W_d = weight of dry sample

Figure 3.13: Oven to store the samples for water absorption test

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This research is conducted to study the potential of oleochemicals waste to serve as partial sand replacement in concrete. In this chapter, the results presented include slump test, compressive strength test, flexural strength test and water absorption test for all the samples. Concrete mixture grade 25 is used as benchmark in order to compare with the modified mixture. The details results obtained for each test are showed in table and graph form. Hence, the results obtained from this research are presented and discussed in this chapter for further recommendation and application.

4.2 Slump test

The slump test is one of the rapid methods that are widely used in construction site nowadays. It is conducted to measure the workability for fresh control concrete and concrete containing sludge. The classification used by Malaysia for slump test is follows British Standard (BS 1881: Part 102) which states the degree of workability within range of 10mm up to 50 mm is considered into low workability as shown in Table 4.1.

The effect of sludge as partial sand replacement in concrete mixes towards slump is illustrated in Table 4.2 and Figure 4.1. All the mixtures are considered as true slump since the fresh concrete remained in the shape of a symmetric cone shape (Ahmad Zawawi, 2018). From the result, the highest height of slump is obtained by mixture that containing 0% of sludge, which is control mixture. For this research, the result of the slump test for all the mixture are within range of slump limits as described in Standard. The results indicated that the workability of the concrete considerably decreased on increase in the percentage of the sludge added to the concrete. These are due to high water absorption of the sludge when the sludge content increased hence resulting in low workability of the fresh concrete. The influence of sludge content on the properties of concrete is linked to the characteristic of sludge particle. Figure 4.2 shows slump value at 10% of sand replacement.

Table 4.1: Slump classification (BS 1881: Part 102)

Class of slump	Slump (mm)	Degree of workability
S1	10 to 50	Low
S2	50 to 90	Medium
S3	100 to 150	High

Table 4.2: Slump test result

Sample	Slump value (mm)	Degree of workability
0%	30	Low
5%	21	Low
10%	18	Low

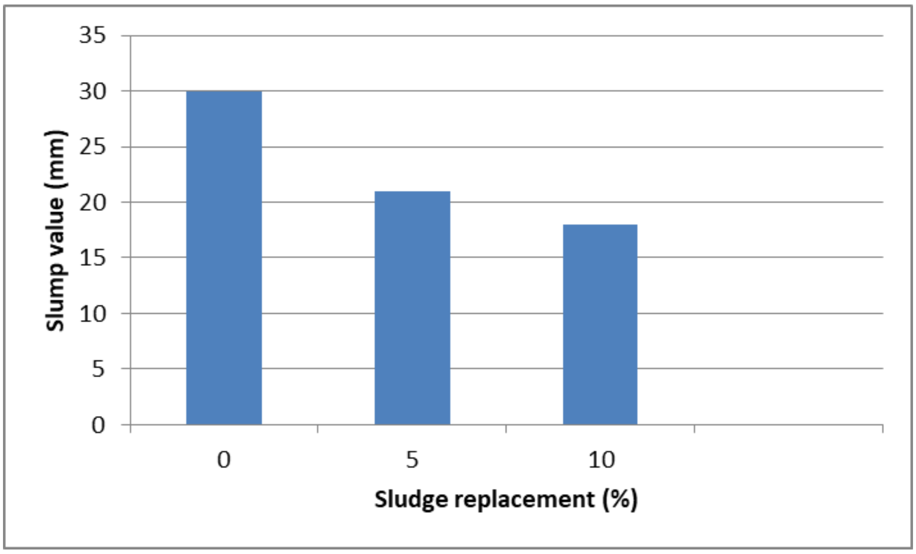

Figure 4.1: The effect of sludge content on workability of concrete

Figure 4.2: Slump value at 10% of sand replacement

4.3 Compressive strength test

The compressive strength test is one of the methods that are widely used in construction site in order to measure the compressive strength of hardened concrete sample by the use of cube with size 100 mm x 100 mm x 100 mm. The standard used by Malaysia is follows BS 1881: Part1 16:1983. The concrete sample is subjected to the compression load at the specified rate and tested to its failure. Hence, the maximum load reached is considered as the ultimate load for future strength calculation.

From Table 4.3, Table 4.4 and Figure 4.3, the results indicated that the compressive strength of the concrete becomes zero when the percentage of the sludge added to the concrete. Although the test is done, but there are no strength achieved for the sample with 5% and 10% sand replacement. The reading on compressive machine does not rise and it is remain +0.00.

Obviously, the use of sludge as partial sand replacement in concrete influenced the strength of concrete. The compressive strength does not achieved the maximum load when applied load on the samples. Since there is polymers exist in the sludge, thus the materials in the concrete mixture do not bind together especially between sludge and cement which causing a fragile sample and decreased the strength as shown in Figure 4.4 . For this case, the compressive strength when 5% and 10% content of sludge added in the concrete is 0 N/mm2. Based on standards, the control concrete sample is classified in satisfactory failures while samples with present of sludge are classified in unsatisfactory failures.

Table 4.3: Compressive strength result at the age of 7 days

Percentage of sludge (%)	**Compressive strength (N/mm^2)**			
	1	**2**	**3**	**Average**
0	24.70	23.45	22.34	23.50
5	0	0	0	0
10	0	0	0	0

Table 4.4: Compressive strength result at the age of 28 days

Percentage of sludge (%)	**Compressive strength (N/mm^2)**			
	1	**2**	**3**	**Average**
0	28.74	28.11	32.42	29.76
5	0	0	0	0
10	0	0	0	0

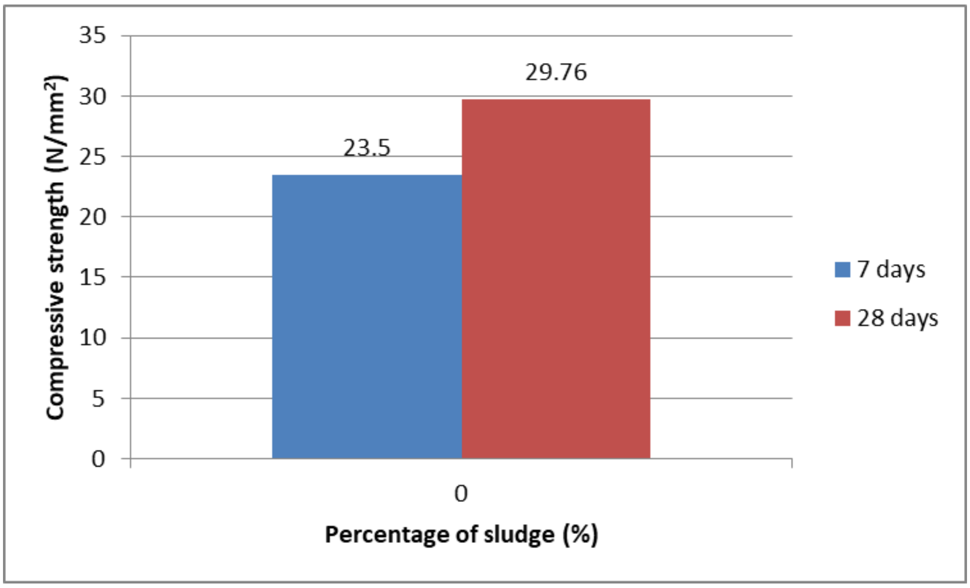

Figure 4.3: The effect of sludge content on compressive strength of concrete at the age of 7 and 28 days

Figure 4.4: Cube sample with 5% of sludge after testing

4.4 Flexural strength test

The flexural strength test is conducted to determine the flexural strength of hardened concrete sample by the use of prism size 100 mm x 100 mm x 500 mm with reference to the standardized third point loading. The standard used by Malaysia is follows BS 1881: Part1 18. The concrete sample is subjected to the loading at the specified rate until failure occurs.

From Table 4.5, Table 4.6 and Figure 4.5, the results indicated that the flexural strength of the concrete becomes zero on increase in the percentage of the sludge added to the concrete. Literally, the result of flexural strength is about 10% to 20% from result of compressive strength. If the compressive strength low, the flexural strength also low. For this case, the flexural strength when 5% and 10% content of sludge added in the concrete is also 0 N/mm2. This is because the flexural strength is related to poor bonding between the sludge and the cement due to low workability and presence of polymer in the sludge. Figure 4.6 shows when the load is applied to the samples, the sample continues to break within a short period of time.

Table 4.5: Flexural strength result at the age of 7 days

Percentage of sludge (%)	**Flexural strength (N/mm^2)**			
	1	**2**	**3**	**Average**
0	5.38	5.89	5.56	5.61
5	0	0	0	0
10	0	0	0	0

Table 4.6: Flexural strength result at the age of 28 days

Percentage of sludge (%)	**Flexural strength (N/mm^2)**			
	1	**2**	**3**	**Average**
0	7.38	6.37	6.29	6.68
5	0	0	0	0
10	0	0	0	0

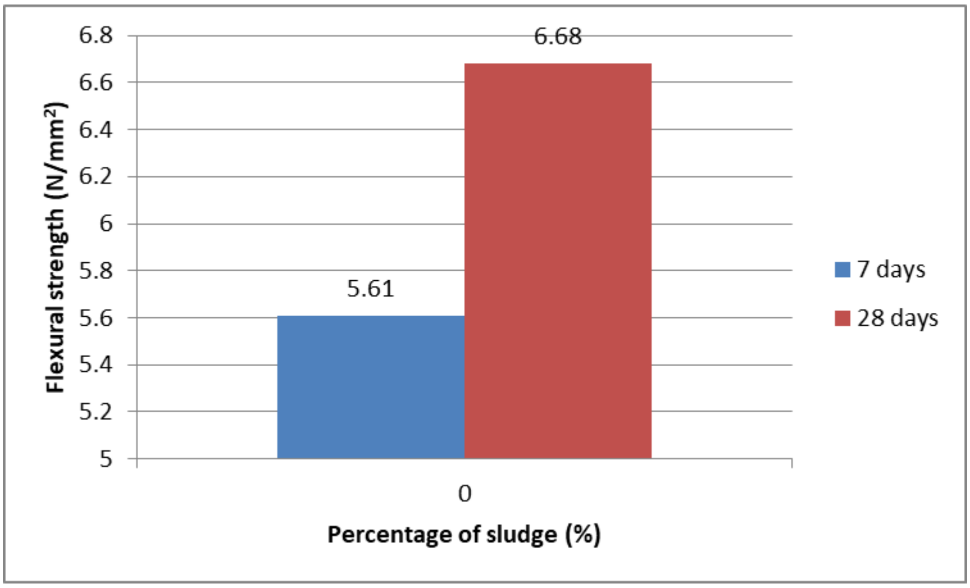

Figure 4.5: The effect of sludge content on flexural strength of concrete at the age of 7 and 28 days

Figure 4.6: Prism sample after testing of 5% of sand replacement

4.5 Water absorption test

The water absorption test is conducted to determine the rate of absorption of water by concrete cube with size 100 mm x 100 mm x 100 mm which content sludge as partial sand replacement. The standard used by Malaysia is follows BS 1881-122: 1983. It is determined by measuring the increase in the mass of sample generated from absorption as a function of time when the sample is exposed to water.

Table 4.7, Table 4.8 and Figure 4.7 show the result of water absorption of plain concrete at the age of 28 days. Water absorption test is conducted for plain concrete only because containing sludge undergoes air curing, not water curing. There are corrosive effects on the surface of concrete when the sample is submerged in the water as shown in Figure 4.8.

Table 4.7: Weight of dry and wet sample

Percentage of sludge (%)	Weight of the sample (kg)	
	Wet	Dry
0	2.346	2.286
5	2.345	2.289
10	2.254	2.196

Table 4.8: Water absorption result

Percentage of sludge (%)	Water absorption (%)			
	1	2	3	Average
0	2.62	2.45	2.64	2.57

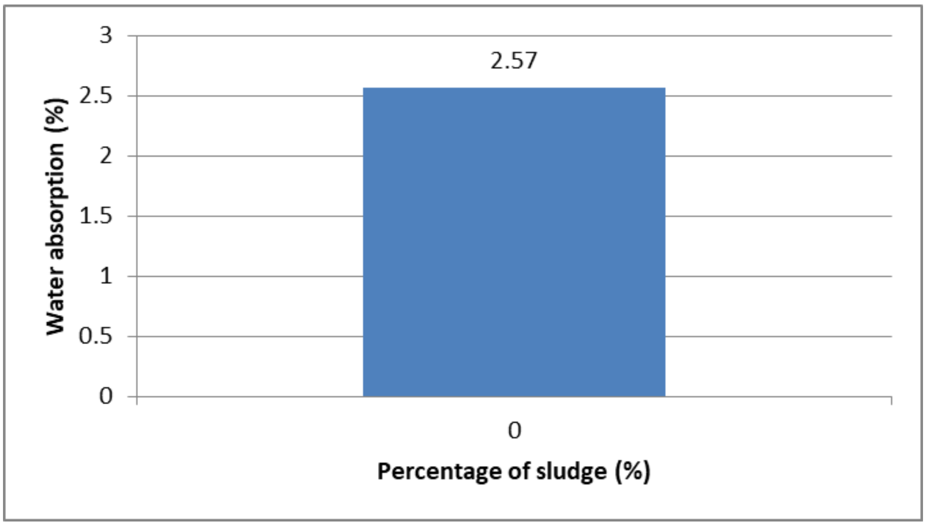

Figure 4.7: The effect of sludge content on water absorption of concrete at the age of 28 days

Figure 4.8: Cube sample when submerged in the water after few seconds

4.6 Summary

This study identified the potential of oleochemicals waste (sludge) to serve as partial sand replacement in concrete, compared to conventional concrete. The characteristic of sludge is majorly affected the behaviour of concrete with present of sludge replacement. The properties of sludge which are high absorber of water influenced the strength and the appearance of the concrete because no hydration process occur which make the concrete fragile when added of sludge. Based on the results obtained, the more content of the sludge within the concrete caused reduction in compressive and flexural strength of the concrete. However, there is no comparison for water absorption test result is made due to the concrete containing sludge have corrosive effect when submerged in water. In summary, the objectives for this study are not achieved and the recommendation regarding to this results is discussed in the next chapter.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

In conclusion, the objectives from this study cannot be achieved. The aim of this research is to determine the potential of oleochemicals waste (sludge) to serve as partial sand replacement in concrete in terms of compressive strength, flexural strength and water absorption. The sludge are used as partial sand replacement from the ratio of 0%, 5% and 10% Despite that, the percentages of sludge replacement have effect on concrete properties. This chapter concludes the overall experimental studies obtained based on the objectives listed in Chapter 1. Moreover, several suggestions and recommendations made for improvement are also included in this chapter.

5.2 Conclusion

Based on the results obtained and discussion in Chapter 4, several conclusions are drawn as follows:

i) The decrease of slump value is related by the characteristic of sludge as high water absorption. As the sludge content increases, the slump value is decreases. The slump value falls in the range of 10 mm to 50 mm with the water cement ratio of 0.64.

ii) In terms of compressive and flexural strength, the concrete containing 5% and 10% of sludge as partial sand replacement did not achieved the optimum strength compared to plain concrete. This is due to the present of polymer in the sludge made the particles in the mixture have poor bonding between sludge and cement and also high amount of water absorption affected the strength in concrete.

iii) In terms of water absorption, there is no comparison is made because when the concrete containing sludge is submerged in the water, there is corrosive effect occurs on the surface of the sample.

5.3 Recommendation

Study on the others performances are needed in order to develop these waste material products is more applicable material in the construction industry. From the discussions and observations made during this study, several recommendations and suggestions are made for future work the research of concrete containing oleochemicals waste (sludge) as partial sand replacement:

i) To obtain better results, changing the method of preparation of the oleochemicals waste (sludge).

ii) To improve performances of the concrete, ensure there is none of chemical addictive in sludge such as polymer that has mix together with sludge.

iii) Adding hardener to help concrete mixture quickly hardened and adding charcoal to help reduced the odour of the sludge.

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APPENDIX A

RESULT FOR SIEVE ANALYSIS TEST

Sand:

Sieve size (mm)	Weight of sieve (g)	Sieve and sample (g)	Weight of sample (g)	% Cumulative	% Passing
10.00	688.7	688.7	0.0	0.00	100.00
5.00	957.7	959.7	2.0	0.46	99.54
2.36	681.3	722.5	41.2	9.83	90.17
1.18	974.0	1033.7	59.7	23.41	76.59
0.60	901.2	1130.5	229.3	75.58	24.42
0.30	770.1	856.3	86.2	95.19	4.81
0.15	755.4	773.8	18.4	99.38	0.62
0.00	466.3	469.0	2.7	100.00	0.00
		Total sample	439.5		

Sludge:

Sieve size (mm)	Weight of sieve (g)	Sieve and sample (g)	Weight of sample (g)	% Cumulative	% Passing
10.00	688.6	688.6	0.0	0.00	100.00
5.00	957.8	963.7	5.9	1.19	98.81
2.36	680.4	805.4	125.0	26.31	73.69
1.18	973.1	1095.0	121.9	50.81	49.19
0.60	900.1	1049.3	149.2	80.97	19.21
0.30	772.1	822.2	50.1	90.86	9.14
0.15	755.5	780.2	24.7	95.82	4.18
0.00	466.4	487.2	20.8	100.00	0.00
		Total sample	497.6		