CHAPTER 1

1.0 INTRODUCTION

1.1 BACKGROUND

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens over time—most frequently in the past a lime-based cement binder, such as lime putty, but sometimes with other hydraulic cements, such as a calcium aluminate cement or with Portland cement to form Portland cement concrete (for its visual resemblance to Portland stone). Many other non-cementitious types of concrete exist with different methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concretes that use polymers as a binder.

When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials such as rebar embedded to provide tensile strength, yielding reinforced concrete.

High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a thermoplastic polymer produced from the monomer ethylene. It is sometimes called alkathene or polythene when used for HDPE pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geomembranes and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code.

HDPE is known for its high strength-to-density ratio. The density of HDPE can range from 930 to 970 kg/m^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/248 °F for short periods). High-density polyethylene, unlike polypropylene, cannot withstand normally required autoclaving conditions. The lack of branching is ensured by an appropriate choice of catalyst (e.g., Ziegler–Natta catalysts) and reaction conditions.

HDPE is resistant to many different solvents.

The physical properties of HDPE can vary depending on the molding process that is used to manufacture a specific sample; to some degree a determining factor are the international standardized testing methods employed to identify these properties for a specific process. For example, in Rotational Molding, to identify the environmental stress crack resistance of a sample, the Notched Constant Tensile Load Test (NCTL) is put to use.

Owing to these desirable properties, pipes constructed out of HDPE are ideally applicable for potable water, and waste water (storm and sewage).

1.2 PROBLEM STATEMENT

The production of plastic in Malaysia is increasing, 9.1 billion tonnes as of May 2018, 6.9 billion tonnes generated are plastic waste. Only 9% of said waste is recycled and expected to triple in the next 25 years.

1.3 OBJECTIVE

i. Produce concrete by using HDPE plastic fibres as additional material.
ii. Test the strength of concrete with HDPE plastic fibres.
iii. Compare the strength between the two design mixes.

1.4 PROJECT SCOPE

This study was conducted to investigate the strength of concrete by using HDPE plastic as an additive in concrete mix. In this study, the mixing ratios used was 1 : 2.5 : 0.3 : 3.4 (25% HDPE) representing, cement : sand : HDPE plastic fibres : aggregate for each value and mixture in light concrete. The test we will run on our concrete is a cube test for compressive strength.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is one of the methods of finding information. It describes the concepts used in the study and some of the literature that make up the background of analysis and understanding. This literary study aims to provide the background of the ongoing study and understanding of something in examining the techniques used in previous studies.

In this chapter, we will discuss the literature and studies behind producing concrete, the tests conducted to determine the strength and other characteristics of concrete.

2.2 CONCRETE

Concrete, an artificial stone-like mass, is the composite material that is created by mixing binding material (cement or lime) along with the aggregate (sand, gravel, stone, brick chips, etc.), water, admixtures, etc in specific proportions. The strength and quality are dependent on the mixing proportions.

The formula for producing concrete from its ingredients can be presented in the following equation:

Concrete = Binding Material + Fine & Coarse Aggregate + Water + Admixture (optional)

Concrete is a very necessary and useful material for construction work. Once all the ingredients -cement, aggregate, and water unit of measurement mixed inside the required proportions, the cement and water begin a reaction with one another to bind themselves into a hardened mass. This hardens rock-like mass is the concrete.

Concrete is powerful, easy to create and could be formed into varied shapes and sizes. Besides that, it is reasonable, low cost and is instantly mixed. It is designed to allow reliable and high-quality fast-track construction. Structures designed with the concrete unit of measurement plenty of durable and should be designed to face up to earthquakes, hurricanes, typhoons, and tornadoes. This is an incredible advancement. With all the scientific advances there are in this world, there still has not been the way of preventing nature's injury.

2.3 CHEMICAL COMPOSITION OF CONCRETE

Concrete is actually a mixture of cement (the binder), water and some form of aggregate (the filler). This means that concrete is a composite material. In addition to this, cement is also a compound material, as it is a mixture of limestone and clay. It is made by burning the two compounds together at extremely high temperatures ranging from 1400 - 1600°C.

While there is a range of cements available on the market - in addition to new research into sustainable alternatives - the most popular type of cement is known as Portland cement. Portland cement uses crushed CaCO3 (also known as limestone), mixed with clay, sand and iron ore to form a homogeneous powder.

This powder is heated to the high temperatures discussed previously. To achieve these temperatures, the mixture is poured into kilns which consist of long steel cylinders that are rotated on an incline. Depending on the size of the kiln, the materials can take up to 2 hours to pass slowly through the cylinder. The slow process allows the different elements of the material to react. The reaction of these materials involves the following processes:

1. Evaporation – the first stage of the process is the loss of water from the mixture due to evaporation.

2. Calcination – decomposition occurs in the dry mixture due to the loss of water and carbon dioxide.
3. Clinkering – the mixture then undergoes a transformation in which calcium silicates are formed. These are pieces that are the size of marbles.
4. Cooling – once the mixture leaves the kiln, it is allowed to cool to working temperatures.

The cooled clinker is then ground once more, and a compound known as gypsum is added to the mixture. This is in order to regulate the setting of the mixture. In Portland cement, 5% of its chemical composition is the gypsum mineral.

The major compounds that make up Portland cement are tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferrite and gypsum. Once this process is complete, the cement is packaged and stored for use in concrete at a later date.

Concrete can be created on site with the use of a rotating metal drum, known aptly as a cement mixture. The cement is rehydrated with water to make a thick consistency and large or fine aggregate is added depending on its intended use.

Aggregates are an important part of the concrete mixture as they determine the desired characteristics of the concrete. All aggregates are known to be chemically inert but vary in shapes, sizes and materials. The most commonly used are a mixture of fine sand and coarse stone. They also make up the largest portion of the concrete’s material composition, ideally between 70-80% of the volume. Concrete then must be vibrated, in order to release any air bubbles which may compromise the structural integrity of the material. Once poured, concrete needs at least 28 days to cure to full strength.

2.4 TYPE OF CONCRETE GRADES AND RATIOS

Grades of concrete are defined by the strength and composition of the concrete, and the minimum strength the concrete should have following 28 days of initial construction. The grade of concrete is understood in measurements of MPa, where M stands for mix and the MPa denotes the overall strength.

Concrete mixes are defined in ascending numbers of 5, starting at 10, and show the compressive strength of the concrete after 28 days. For instance, C10 has the strength of 10 newtons, C15 has the strength of 15 newtons, C20 has 20 newtons strength and so on.

Different mixes (M) come in various mix proportions of the various ingredients of cement, sand and coarse aggregates. For instance, M20 comes in the respective ratio of 1:1:5:3. You can see other examples below in the table.

Concrete Grade	**Mix Ratio (cement : sand : aggregates)**	**Compressive Strength MPa (N/mm2) psi**	
Grades of Concrete			
M5	1 : 5 : 10	5 MPa	725 psi
M7.5	1 : 4 : 8	7.5 MPa	1087 psi
M10	1 : 3 : 6	10 MPa	1450 psi
M15	1 : 2 : 4	15 MPa	2175 psi
M20	1 : 1.5 : 3	20 MPa	2900 psi
Standard Grade of Concrete			
M25	1 : 1 : 2	25 MPa	3625 psi
M30	Design Mix	30 MPa	4350 psi

M35	Design Mix	35 MPa	5075 psi
M40	Design Mix	40 MPa	5800 psi
M45	Design Mix	45 MPa	6525 psi

High Strength Concrete Grades			
M50	Design Mix	50 MPa	7250 psi
M55	Design Mix	55 MPa	7975 psi
M60	Design Mix	60 MPa	8700 psi
M65	Design Mix	65 MPa	9425 psi
M70	Design Mix	70 MPa	10150 psi

Table 1. Shows The Grades of Concrete

C10

Used for: Patio slabs, pathways and non-structural work

Type: Domestic & Commercial use

C15

Used for: Pavement curbs and floor blinding

Type: Domestic & Commercial

C20

Used for: Domestic floors and foundations (where the weight of structure will be lighter). Also good for workshop bases, garages, driveways and internal floor slabs.

Type: Domestic

C25

Used for: Construction in all areas. Multi-purpose concrete mix, usually used for foundations.

Type: Domestic & Commercial

C30

Used for: Pathways and roadways (this is the lowest grade concrete mix that can be used for this purpose). More durable than the grades that have come before, and thus is much more weather-resistant and can take heavy road traffic.

Type: Commercial

C35

Used for: Commercial structures. This heavy concrete mix is usually used for creating external walls and slabs, as well as for structural piling.

Type: Commercial

C40

Used for: Commercial construction sites, creating foundations and beams for structural support and roads. The most durable in this list, C40 can withstand chemical corrosion also, so is frequently used on farms where slurry could corrode structures, or in septic tanks.

Type: Commercial

2.5 MATERIALS USED IN CONCRETE

Concrete is made up of four main ingredients: water, Portland cement, aggregates, and air. The ratio of the ingredients changes the properties of the final product, which allows the engineer to design concrete that meets their specific needs. Admixtures are added to adjust the concrete mixture for specific performance criteria.

2.5.1 WATER

The water used for concrete mixtures is purely from materials that cause impurities such as silt, soil, organic acids and other organic substances such as salt, alkali and others. Substances such as silt and soil are easily separated by simply stamping processes.

The amount of mixing water used should be in minimum order for working status requirements for full compression of concrete.

2.5.2 CEMENT

The cement used in figure 1 is a type of artificial material produced with a mixture of limestone and clay or other suitable materials. These substances have two important properties, namely, clusters and adhesions. With this nature, the cement will act as a good binder to tie the rock into a solid and strong body.

A mixture of branched clay and clay that has been burned will become a charred stone rich in calcium silicates. This charred stone is then blended together with a bit of calcium sulphate into a fine powder. Sulphate acts as a material in controlling the solidification rate when the cement is mixed with water. Cement can be divided into several types based on the properties and contents of their chemical materials. The type of cement used for this mix is Portland cement.

Figure 1. Cement

2.5.3 AGGREGATES

The majority of a concrete mixture is made up of both coarse and fine aggregates, which help increase the strength of the concrete beyond what cement can provide on its own. Sand, gravel, and crushed stone are used as aggregates. Recycled materials, including blast furnace slag, glass (mostly for decorative purposes), and ground-up concrete are starting to be used as concrete aggregates.

2.6 TYPE OF AGGREGATES USED

2.6.1 COARSE AGGREGATE

Coarse aggregates have a wide variety of construction applications because they resemble standard rock particles, as opposed to fine aggregate, which more closely resembles sand. Coarse aggregates are an integral part of many construction applications, sometimes used on their own, such as a granular base placed under a slab or pavement, or as a component in a mixture, such as asphalt or concrete mixtures. Coarse aggregates are generally categorized as rock particulates that are greater than 4.75mm. The usual range employed is between 9.5mm and 37.5mm in diameter.

2.6.2 SAND

The sand used in Figure 2 to make concrete mixing has a shape that is rectangular and clean from dirt. Fine aggregates are usually sand or crushed stone that are less than 9.55mm in diameter.

Figure 2. Sand

2.7 PROPERTIES OF CONCRETE

Properties of concrete are influenced by many factors mainly due to mix proportion of cement, sand, aggregates and water. Ratio of these materials control the various concrete properties which are discussed below.

Different properties of concrete:

1. Grades (M20, M25, M30 etc.)
2. Compressive strength
3. Characteristic Strength
4. Tensile strength
5. Durability
6. Creep
7. Shrinkage
8. Unit weight
9. Modular Ratio
10. Poisson’s ratio

2.7.1 GRADES OF CONCRETE

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (fck) of 150mm cube at 28 days, expressed in N/mm2.

Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

2.7.2 COMPRESSIVE STRENGTH OF CONCRETE

Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

2.7.3 CHARACTERISTIC STRENGTH OF CONCRETE

It is defined as the value of the strength below which not more then 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same)

2.7.3.1 CHARACTERISTIC STRENGTH OF CONCRETE IN FLEXURAL MEMBER

The characteristic strength of concrete in flexural member is taken as 0.67 times the strength of concrete cube.

2.7.3.2 DESIGN STRENGTH (FD) AND PARTIAL SAFETY FACTOR FOR MATERIAL STRENGTH

The strength to be taken for the purpose of design is known is known as design strength and is given by

Design strength (fd) = characteristic strength/ partial safety factor for material strength

The value of partial safety factor depends upon the type of material and upon the type of limit state. According to IS code, partial safety factor is taken as 1.5 for concrete and 1.15 for steel.

Design strength of concrete in member = 0.45fck

2.7.4 TENSILE STRENGTH OF CONCRETE

The estimate of flexural tensile strength or the modulus of rupture or the cracking strength of concrete from cube compressive strength is obtained by the relations

fcr = 0.7 fck N/mm2. The tensile strength of concrete in direct tension is obtained experimentally by split cylinder. It varies between 1/8 to 1/12 of cube compressive strength.

2.7.5 CREEP IN CONCRETE

Creep is defined as the plastic deformation under sustained load. Creep strain depends primarily on the duration of sustained loading. According to the code, the value of the ultimate creep coefficient is taken as 1.6 at 28 days of loading.

2.7.6 SHRINKAGE OF CONCRETE

The property of diminishing in volume during the process of drying and hardening is termed Shrinkage. It depends mainly on the duration of exposure. If this strain is prevented, it produces tensile stress in the concrete and hence concrete develops cracks.

2.7.7 MODULAR RATIO

Short term modular ratio is the modulus of elasticity of steel to the modulus of elasticity of concrete.

Short term modular ratio = Es / Ec

Es = modulus of elasticity of steel (2 x 10 5 N/mm2)

Ec = modulus of elasticity of concrete (5000 x SQRT(fck) N/mm2)

As the modulus of elasticity of concrete changes with time, age at loading etc the modular ratio also changes accordingly. Taking into account the effects of creep and shrinkage partially IS code gives the following expression for the long term modular ratio.

Long term modular ratio (m) = 280/ (3fcbc)

Where, fcbc = permissible compressive stress due to bending in concrete in N/mm2.

2.7.8 POISSON’S RATIO

Poisson’s ratio varies between 0.1 for high strength concrete and 0.2 for weak mixes. It is normally taken as 0.15 for strength design and 0.2 for serviceability criteria.

2.7.9 DURABILITY OF CONCRETE

Durability of concrete is its ability to resist its disintegration and decay. One of the chief characteristics influencing durability of concrete is its permeability to increase of water and other potentially deleterious materials.

The desired low permeability in concrete is achieved by having adequate cement, sufficient low water/cement ratio, by ensuring full compaction of concrete and by adequate curing.

2.7.10 UNIT WEIGHT OF CONCRETE

The unit weight of concrete depends on percentage of reinforcement, type of aggregate, amount of voids and varies from 23 to 26 kN/m2. The unit weight of plain and reinforced concrete as specified by IS:456 are 24 and 25 KN/m3 respectively.

2.8 EFFECTS OF CONCRETE MIX

The presence of excessive water in a concrete mix although may facilitate the easy placement of concrete but it also lowers the quality of the overall product. The damage to concrete structures due to excessive water in a concrete mix is very common and the repercussions due to this are briefly explained.

Following are the effects caused by the presence of excess water in a concrete mix :

1. Strength Reduction
2. Drying shrinkage
3. Loss of abrasive resistance
4. Increase in permeability
5. Dusting and scaling
6. Reduced durability

2.8.1 STRENGTH REDUCTION

Compressive strength is the major property of hardened concrete and the superfluous quantity of water reduces the compressive strength of concrete. The excess water will not participate in the hydration process and retains in concrete even after hardening.

This water will evaporate when exposed to atmosphere and form voids in the concrete. These voids formed are therefore responsible for the reduction of compressive strength of concrete.

2.8.2 DRYING SHRINKAGE

Increase in water-cement ratio increases the drying shrinkage and concrete becomes weaker in tensile strength and as a result, cracks will form on the concrete surface.

2.8.3 LOSS OF ABRASIVE RESISTANCE

Abrasive resistance of concrete is directly proportional to its strength. When excessive water increases, the strength of the concrete decreases and therefore, the abrasive resistance also reduces.

2.8.4 PERMEABILITY

The concrete becomes porous after the evaporation of excess water in hardened concrete. The voids formed will absorb water and make the concrete structure permeable.

2.8.5 DUSTING

The excess water in concrete mix brings the fine aggregate to the top, as a result, after hardening- a fine loose powder will settle on the top of the concrete surface. This process is called dusting.

2.8.6 SCALING

Scaling of concrete also occurs due to excess water content in concrete. In this case, the top layer of the hardened concrete surface is removed. It is due to the reaction of water with freeze and thaw effects.

2.8.7 REDUCED DURABILITY

The above-explained effects finally lead to a reduction in the durability of concrete. Hence, to make durable concrete, water-cement ratio must be selected properly. Low water-cement ratio helps to get more durable concrete. With the addition of air entraining admixtures, the durability can be increased with low water content.

2.9 CONCRETE IN PRACTICE

Concrete is one of the most frequently used building materials worldwide. The distinctive characteristics like strength, durability, low-maintenance, energy-efficient, sustainability are the reasons for wide range usage of concrete in the field of civil engineering. Below, we discuss the different uses of concrete in the field of civil engineering.

2.9.1 CONCRETE DAMS

The characteristics of concrete such as high strength and unit weight make it a more suitable material for the construction of dams. Dams are used to store water and produce electricity. The loads imposed on the dam due to water pressure are very intense which makes concrete as a suitable material for dam construction.

2.9.2 RESIDENTIAL BUILDINGS

The construction of small buildings, villas, and even high-rise buildings are done using concrete with traditional or modern form-work as a method of construction of the skeleton from foundations to the slabs and of course columns and beams.

2.9.3 COMMERCIAL BUILDINGS

The use of concrete in commercial buildings makes it safer than using most other construction materials. It is mostly more economic than steel buildings and requires less maintenance. It is easy to control the heat transfer from inside to outside and vice versa which reduces the energy consumed.

2.9.4 ROADS AND DRIVEWAYS

Concrete streets, pavements, and driveways are more durable and stronger than asphalt roadways. The long-lasting service time and the less maintenance required for concrete roads make it the first choice of material for the construction of roads and driveways.

2.9.5 MARINE CONSTRUCTION

Concrete has had extensive use as a construction material for seawalls, jetties, groins, breakwaters, bulkheads, and other structures exposed to seawater. The performance record has generally been good.

2.9.6 CULVERTS AND SEWERS

Sewers and underground construction works need strong and durable building materials and concrete is the ideal one. Culverts, piers, foundation, abutments are constructed using special concrete mix.

2.9.7 FOUNDATIONS

The foundation of high-rise or low-rise buildings is usually constructed using reinforced cement concrete, as it is durable and has a huge load-carrying capacity.

2.9.8 FENCES

The development in the precast concrete industry has improved the industry of concrete fences. It is faster to produce and install the fence elements using precast than the traditional method of concrete fence construction. Moreover, it is beautiful and more attractive.

2.9.9 CONCRETE BRIDGES

Reinforced concrete strength, durability, ductility, weather resistance, fire resistance, and long-lasting life cycle makes the concrete the best solution for constructing the bridges. Pre-stressed concrete, post-stressed concrete, self compacted concrete are different types of concrete that may apply in bridges construction.

2.10 HIGH DENSITY POLYETHYLENE PLASTIC (HDPE)

Plastic High Density Polyethylene (HDPE), as shown in Figure 3 shows one of the types of plastics that are present in the world today, when visualized this type of plastic HDPE is thick, it is widely used as a bottle of milk. This type of plastic is symbolized by triangle and number 2. The type of plastic HDPE is easy to recycle, so this plastic is much sought after by businessmen for plastic recycling. This HDPE plastic is made from ethylene with the catalyst process. Most types of plastic HDPE are used for items such as plastic bottles, bottle caps and children's toys. Benefits for HDPE plastic users at low prices, resistant at temperatures -40^{o}C to 90^{o}C and resistant to chemicals.

Figure 3. HDPE Plastic Fibre

2.11 CHEMICAL COMPOSITION OF HDPE

High-density polyethylene (HDPE) is obtained under conditions of coordination polymerization initiated by a mixture of titanium tetrachloride (TiCl4) and triethylaluminum [(CH3CH2)3Al]. Coordination polymerization was discovered by German chemist Karl Ziegler. Ziegler and Italian chemist Giulio Natta pioneered the development of Ziegler-Natta catalysts, for which they shared the 1963 Nobel Prize for Chemistry. The original Ziegler-Natta titanium tetrachloride-triethylaluminum catalyst has been joined by a variety of others. In addition to its application in the preparation of high-density polyethylene, coordination polymerization is the method by which ethylene oligomers, called linear α-olefins, and stereoregular polymers, especially polypropylene, are prepared.

2.12 PROPERTIES OF HDPE

HDPE is known for its high strength-to-density ratio. The density of HDPE can range from 930 to 970 kg/m^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/248 °F for short periods). High-density polyethylene, unlike polypropylene, cannot withstand normally required autoclaving conditions. The lack of branching is ensured by an appropriate choice of catalyst (e.g., Ziegler–Natta catalysts) and reaction conditions.

HDPE is resistant to many different solvents.

The physical properties of HDPE can vary depending on the molding process that is used to manufacture a specific sample; to some degree a determining factor are the international standardized testing methods employed to identify these properties for a specific process. For example, in Rotational Molding, to identify the environmental stress crack resistance of a sample, the Notched Constant Tensile Load Test (NCTL) is put to use.

Owing to these desirable properties, pipes constructed out of HDPE are ideally applicable for potable water, and waste water (storm and sewage).

Thermophysical properties of High Density Polyethylene (HDPE)

Density	940 kg/m^3
Melting Point	130.8 °C.
Temperature of crystallization	111.9 °C.
Latent heat of fusion	178.6 kJ/kg.
Thermal conductivity	0.44 W/m.°C. at °C.
Specific Heat Capacity	1330 to 2400 J/kg-K
Specific heat (solid)	1.9 kJ/kg. °C.
Crystallinity	60%

Table 2. Thermophysical Properties of HDPE

CHAPTER 3

3.0 METHODOLOGY

3.1 INTRODUCTION

Methodology is a study or analytical theory of a method or technique. Methods based on research and observation to achieve manufacturing level. In the methodology, what is expected or the answer being sought is the result of observation. In addition, this methodology chapter serves as an indicator of the steps for the study to be conducted and helps to issue solution options to perfect the objectives presented in the study. The purpose of this methodology is to obtain the study data. The study continued with a study on hard concrete aimed at assessing the strength properties and concrete durability. This study covers the preparation of concrete specimens that are preserved by water curing. Hence, in this way, the methodology this time discusses more details about the stages to be carried out. We will do some tests ie strength test and water absorption in concrete. Tests conducted to achieve the desired objectives, sources of information and data to be obtained. The curing process is carried out as concrete tests 3, 7, 14, 21 and 28 days. All test methods conducted in laboratory studies are based on specifications and regulations set out in Malaysian (MS) and British (BS) standards.

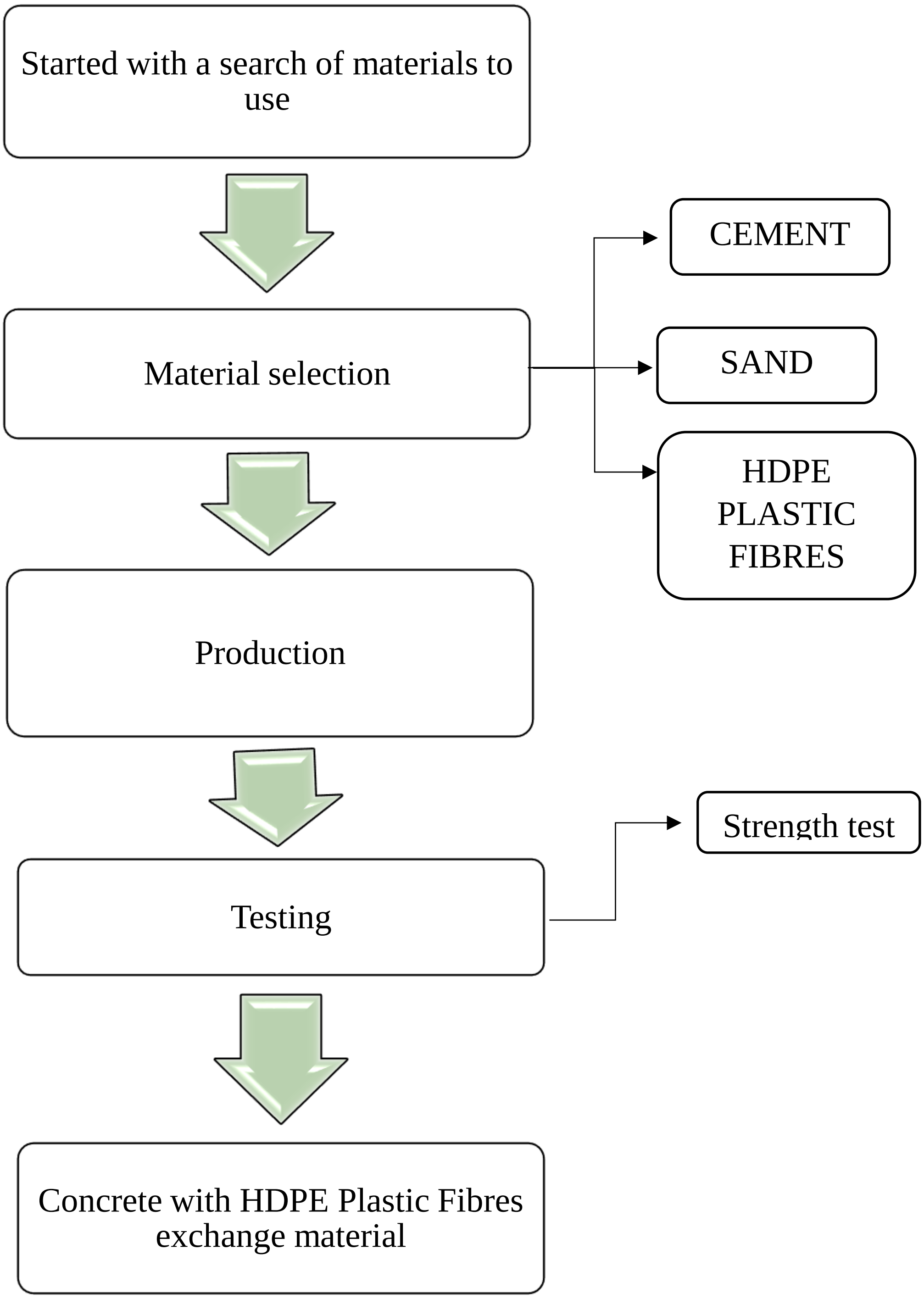

Figure 4. Preparation flow chart makes lightweight concrete with additive HDPE

3.2 CONCRETE SAMPLING

Making, curing and testing cubes should be carried out in the correct manner. Even small deviations from the standard procedures will usually lead to compressive strength results which are lower than the true strength of the concrete. For example, for each 1% air entrapped there will be a 4 to 5% loss of strength. The procedures for concrete cube making are given in British Standard (BS) 1881:1983 Testing Concrete.

3.2.1 EQUIPMENT

- Sample tray
- Mould for making test cube
- Scoop
- Trowel
- Compacting bar
- Cleaning rags
- A bucket or barrow for transporting the samples
- Curing tank

3.2.2 DESIGN MIX CALCULATION

For the design mix, the Volumetric Method was used to achieve the design of the concrete. This method was recommended by an engineer from YTL Cement that I approached to enquire about the design mix. To calculate the amount of materials needed the density, mass and volume for each of the materials need to be taken into account. The amount of Ordinary Portland Cement needed to produce 1m³ of concrete is 300kg. The rest of the calculations used to get the design mix are based on 1m³ of concrete.

Type of Material	Density (g/cm^3)
Ordinary Portland Cement	3.12
Water	1
Coarse Aggregate	2.64
Sand	2.64
HDPE Plastic Fibre	0.95

Table 3. Density (g/cm^3) of Materials Used

$1m^3$ is equivalent to 1000ℓ. The following is an example of the calculations used:

Ordinary Portland Cement

Volume = Mass / Density

$= 300kg / 3.12g/cm^3$

= 96.15ℓ

The Water Cement Ratio used is 0.4

Water

300kg x 0.4 = 120kg

=120ℓ

Take into consideration the airation of 20%

Air

1000ℓ x 20% = 20ℓ

The Sand to Aggregate Ratio used is 1:1

1000ℓ - 96.15ℓ - 120ℓ - 20ℓ = 763.85ℓ

763.85ℓ / 2 = 381.925ℓ

In this study, the HDPE plastic fibre is used as an additional material to substitute sand at 25% and 50% of their respective values.

HDPE Plastic (25%)

381.925ℓ x 0.25 = 95.481ℓ

HDPE Plastic (50%)

381.925ℓ x 0.5 = 190.962ℓ

After calculating the volume, the volume of each respective material is multiplied by their respective density. The mass is then multiplied by a value of 0.05m³ to produce 15 cubes with 150mm x 150mm x 150mm dimensions

Type of Material	Volume (ℓ)	Density (g/cm^3)	Mass for $1m^3$ (kg)	Mass for $0.05m^3$ (kg)
Ordinary Portland Cement	96.15	3.12	300	15
Water	120	1	120	18
Coarse Aggregate	381.925	2.64	1008.28	50.41
Sand	286.44	2.64	756.2	37.81
HDPE Plastic Fibre (25%)	95.841	0.95	91.05	4.55

Table 4. Calculation for Mass of Materials Needed To Produce 15 Cubes of Concrete With 25% of Sand Replaced by HDPE Fibre

Type of Material	Volume (ℓ)	Density (g/cm^3)	Mass for $1m^3$ (kg)	Mass for $0.05m^3$ (kg)
Ordinary Portland Cement	96.15	3.12	300	15
Water	120	1	120	18
Coarse Aggregate	381.925	2.64	1008.28	50.41
Sand	190.963	2.64	504.14	25.21
HDPE Plastic Fibre (50%)	190.962	0.95	181.41	9.07

Table 5. Calculation for Mass of Materials Needed To Produce 15 Cubes of Concrete With 50% of Sand Replaced by HDPE Fibre

3.2.3 MAKING TEST CUBES FROM FRESH CONCRETE

After the sample has been remixed, immediately fill the cube moulds and compact the concrete, either by hand or by vibration. Any air trapped in the concrete will reduce the strength of the cube. Hence, the cubes must be fully compacted. However, care must also be taken not to over compact the concrete as this may cause segregation of the aggregates and cement paste in the mix. This may also reduce the final compressive strength. Compacting with Compacting Bar.

150 mm moulds should be filled in three approximately equal layers (50 mm deep). A compacting bar is provided for compacting the concrete. It is a 380 mm long steel bar, weighs 1.8 kg and has a 25 mm square end for ramming. During the compaction of each layer with the compacting bar, the strokes should be distributed in a uniform manner over the surface of the concrete and each layer should be compacted to its full depth. During the compaction of the

first layer, the compacting bar should not forcibly strike the bottom of the mould. For subsequent layers, the compacting bar should pass into the layer immediately below. The minimum number of strokes per layer required to produce full compaction will depend upon the workability of the concrete, but at least 35 strokes will be necessary except in the case of very high workability concrete. After the top layer has been compacted, a trowel should be used to finish off the surface level with the top of the mould, and the outside of the mould should be wiped clean.

3.3 COMPACTION OF CONCRETE

Compaction of Concrete is an operation in which fresh concrete is compacted in forms and make it encircle reinforcements and other embedded objects such as tubes in the mold.

There are various problems that might arise if compaction of concrete is not carried out properly such as honeycomb and trapped inside concrete paste. Moreover, poor compaction of concrete could to permeability problems and therefore steel corrosion and decreasing ultimate capacity of hardened concrete.

3.3.1 COMPACTION METHOD

Hand compaction was used to compact the concrete into the mold. Reasonably workable and flowable concrete mixtures are consolidated by hand employing a rod. The bar should adequately reach the bottom of the form work and rode diameter need to compact concrete between reinforcement spacing and mold.

The concrete is tamped by the rod tool repeatedly, approximately 35 times according to British Standard, to consolidate it. Mixtures with low slump value could be consolidated by hand if superplasticizers are added to decrease slump and make the concrete workable.

Furthermore, tools such as spade is used to provide good surface appearance and hitting formwork sides make way to repel entrapped air out of the concrete.

Mechanical consolidation is not recommended to use if the mixture is designed to compact by hand to avoid segregation.

3.4 CURING OF CONCRETE

Curing means to cover the concrete with a layer of water, so it stays moist. By keeping concrete moist, the bond between the paste and the aggregates gets stronger. Concrete doesn't harden properly if it is left to dry out. Curing is done just after finishing the concrete surface, as soon as it will not be damaged. The longer concrete is cured, the closer it will be to its best possible strength and durability. Concrete that is cured sufficiently is less likely to crack.

3.4.1 CURING METHOD

Test cubes should be demoulded between 16 and 24 hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable demoulding without damaging the cube then the demoulding should be delayed for a further 24 hours. When removing the concrete cube from the mould, take the mould apart completely. Take care not to damage the cube because, if any cracking is caused, the compressive strength may be reduced.

After demoulding, each cube should be marked with a legible identification on the top or bottom using a waterproof crayon or ink. The mould must be thoroughly cleaned after demoulding the cube. Ensure that grease or dirt does not collect between the faces of the flanges, otherwise the two halves will not fit together properly and there will be leakage through the joint and an irregularly shaped cube may result.

Cubes must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after demoulding in the curing tank or mist room.

The curing temperature of the water in the curing tank should be maintained at 27-30°C. If curing is in a mist room, the relative humidity should be maintained at no less than 95%. Curing should be continued as long as possible up to the time of testing.

CHAPTER 4

4.0 ANALYSIS AND DATA RESULT

4.1 INTRODUCTION

Plastic have become an inseparable and integral part of our lives. Its low density, strength, user-friendly designs, fabrication capabilities, long life, light weight, and low cost are the factors behind such phenomenal growth. Plastics have been used in packaging, automotive and industrial applications, medical delivery system, artificial implants, other healthcare application, water desalinations, land/soil conservation, flood prevention, preservation and distribution of food, housing, communication materials, security systems, and other uses.

The common materials, using waste plastic granules as sand in the production of concrete has attracted much attention from the researchers. Nowadays, there are many concrete applications made with natural or artificial aggregates are found in the literature. The researches have been carried out to investigate the use of recycled High Density Polyethylene (HDPE) as sand aggregates, used HDPE in concrete. The result founded that, as the volume proportion and the particle of HDPE, the concrete showed a decrease in compressive strength. Moreover, the water absorption was increased. The specimen were made with different percentages of HDPE Plastic Fibres as a replacement for sand. Rheological characterization on fresh concrete and mechanical tests at the ages of 28 days were performed on the HDPE concrete as well as on reference concretes containing only natural sand aggregates in order to investigate the influence of the substitution of HDPE to the sand aggregates in concrete. He found that the HDPE concrete display similar workability characteristics and compressive strength.

The present work attempted to utilize the waste HDPE as partial replacement of conventional sand aggregate in making concrete. The influences of plastic on concrete properties have also been analysed and discussed.

4.2 COMPRESSIVE STRENGTH TEST

The compressive strength of the reference concrete specimen and other specimens containing 25% and 50% of plastic HDPE fibre was determined at 3, 7, 14, 21 and 28 days of curing. Figure 6 shows the result of compression tests on various concrete specimens. From Figure 6, an accelerated increase in resistance can be noticed and the strength value of concrete containing 50% plastic fibre was about similar to 25% plastic fibre at 14 and 28 days. It can also be seen that the HDPE Plastic Fibres addition decreased the concrete compressive strength when compared to the concrete at different curing ages, since the HDPE Plastic Fibres does not contribute to the strength of the concrete as does the natural sand aggregates.

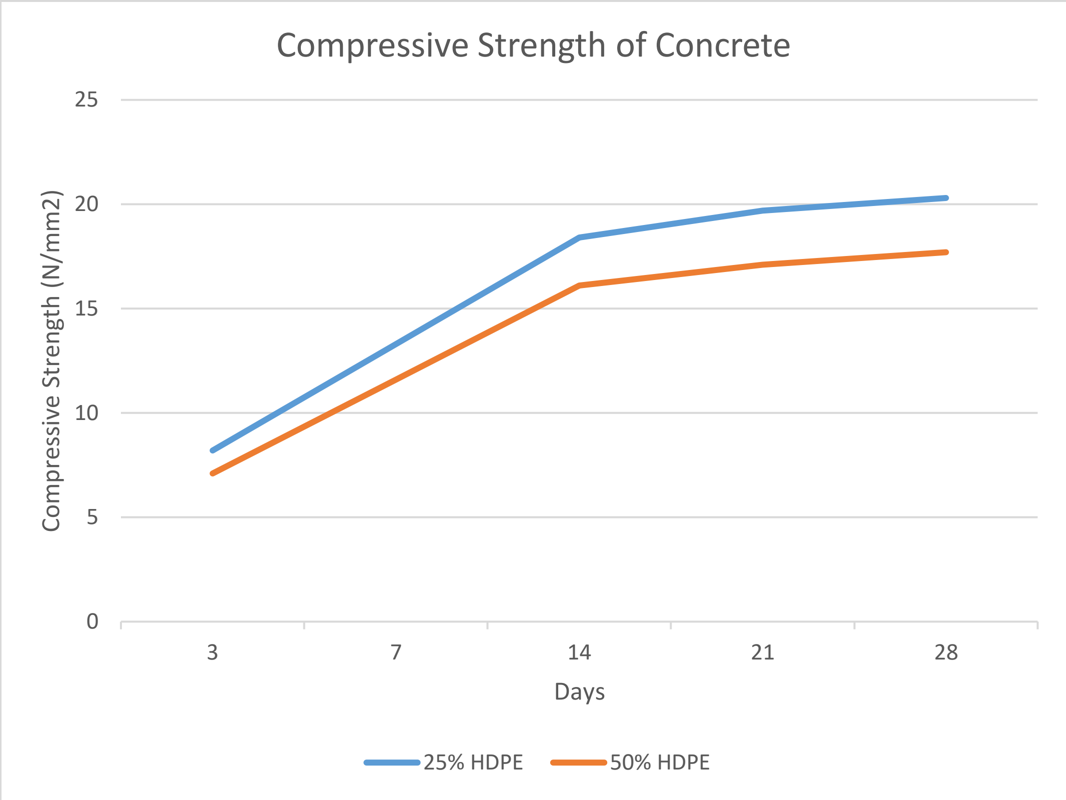

Figure 5. Graph of Compressive Strength of HDPE Concrete Against The Number of Days of Curing

Cube Marking	Date Cast	Date Tested	Cube Age (Day)	Cube Weight (kg)	Compressive Strength (N/mm²)	Load (kN)
25%	3/2/2020	6/2/2020	3	5.36	7.8	175.5
25%	3/2/2020	6/2/2020	3	5.48	8.6	193.5
25%	3/2/2020	6/2/2020	3	5.23	8.2	184.5
50%	3/2/2020	6/2/2020	3	5.01	7.4	166.5
50%	3/2/2020	6/2/2020	3	4.98	7.1	159.8
50%	3/2/2020	6/2/2020	3	5.12	6.8	153

Table 6. Compressive Strength Results on Day 3

Cube Marking	Date Cast	Date Tested	Cube Age (Day)	Cube Weight (kg)	Compressive Strength (N/mm²)	Load (kN)
25%	3/2/2020	10/2/2020	7	5.11	13.3	299.3
25%	3/2/2020	10/2/2020	7	5.08	14.1	317.25
25%	3/2/2020	10/2/2020	7	5.15	12.5	281.25
50%	3/2/2020	10/2/2020	7	4.82	10.1	227.25
50%	3/2/2020	10/2/2020	7	4.91	13.1	294.75
50%	3/2/2020	10/2/2020	7	4.95	11.6	261

Table 7. Compressive Strength Results on Day 7

Cube Marking	Date Cast	Date Tested	Cube Age (Day)	Cube Weight (kg)	Compressive Strength (N/mm²)	Load (kN)
25%	3/2/2020	17/2/2020	14	5.01	17.4	391.5
25%	3/2/2020	17/2/2020	14	5.08	18.4	414
25%	3/2/2020	17/2/2020	14	4.99	19.4	436.5
50%	3/2/2020	17/2/2020	14	4.88	16.1	362.3
50%	3/2/2020	17/2/2020	14	4.70	15.5	348.75
50%	3/2/2020	17/2/2020	14	4.71	16.7	375.75

Table 8. Compressive Strength Results on Day 14

Cube Marking	Date Cast	Date Tested	Cube Age (Day)	Cube Weight (kg)	Compressive Strength (N/mm²)	Load (kN)
25%	3/2/2020	24/2/2020	21	5.00	19.6	441
25%	3/2/2020	24/2/2020	21	4.92	19.8	445.5
25%	3/2/2020	24/2/2020	21	4.93	19.7	443.2
50%	3/2/2020	24/2/2020	21	4.73	17.1	384.7
50%	3/2/2020	24/2/2020	21	4.92	17.4	391.5
50%	3/2/2020	24/2/2020	21	4.80	16.8	378

Table. 9 Compressive Strength Results on Day 21

Cube Marking	Date Cast	Date Tested	Cube Age (Day)	Cube Weight (kg)	Compressive Strength (N/mm²)	Load (kN)
25%	3/2/2020	2/3/2020	28	4.83	20.3	456.8
25%	3/2/2020	2/3/2020	28	5.03	20.9	470.25
25%	3/2/2020	2/3/2020	28	5.02	19.7	443.25
50%	3/2/2020	2/3/2020	28	4.71	17.7	398.3
50%	3/2/2020	2/3/2020	28	4.89	17.2	387
50%	3/2/2020	2/3/2020	28	4.62	18.2	409.5

Table 10. Compressive Strength Results on Day 28

BSEN Test Sdn. Bhd.

...STOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

...stomer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment

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Receipt No. ....

Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	6/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
190021	1 (25%)	6/02/2020	3	5.36	150	150	150	175.5	7.8
190022	2 (25%)	6/02/2020	3	5.48	150	150	150	193.5	8.6
190023	3 (25%)	6/02/2020	3	5.23	150	150	150	184.5	8.2

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :

Mode of Cube failure (Refer to Figure and circle an appropriate)

Satisfactory A B C

Un-Satisfactory 1 2 3 4 5 6 7 8 9

[ ] -

Age	Witness by
3	

Signature only required when customer witness

Age	Tested by
3	

Age	Checked by
3	

Attachment 1. Data of Test Results for Concrete with 25% HDPE at Day 3

BSEN Test Sdn. Bhd.

...STOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

...stomer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment

CREDIT

CASH

Receipt No. ....

Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	6/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
190024	1 (50%)	6/02/2020	3	5.01	150	150	150	166.5	7.4
190025	2 (50%)	6/02/2020	3	4.98	150	150	150	159.8	7.1
190026	3 (50%)	6/02/2020	3	5.12	150	150	150	153	6.8

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :

Mode of Cube failure (Refer to Figure and circle an appropriate)

Satisfactory A B C

Un-Satisfactory 1 2 3 4 5 6 7 8 9

[ ] -

Age	Witness by
3	

Signature only required when customer witness

Age	Tested by
3	

Age	Checked by
3	

Attachment 2. Data of Test Results for Concrete with 50% HDPE at Day 3

BSEN Test Sdn. Bhd.

CUSTOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

Customer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment
CREDIT
CASH
Receipt No. ....
Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	10/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
191257	4 (25%)	10/02/2020	7	5.11	150	150	150	299.3	13.3
191258	5 (25%)	10/02/2020	7	5.08	150	150	150	317.25	14.1
191259	6 (25%)	10/02/2020	7	5.15	150	150	150	281.25	12.5

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES
1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :
Mode of Cube failure (Refer to Figure and circle an appropriate)
Satisfactory A B C
Un-Satisfactory 1 2 3 4 5 6 7 8 9
[ ] -

Age	Witness by	Age	Tested by	Age	Checked by
7		7		7	

Signature only required when customer witness

Attachment 3. Data of Test Results for Concrete with 25% HDPE at Day 7

BSEN Test Sdn. Bhd.

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

USTOMER CUBE SUBMISSION FORM

ustomer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment
CREDIT
CASH
Receipt No. ....
Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	10/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
191260	4 (50%)	10/02/2020	7	4.82	150	150	150	227.25	10.1
191261	5 (50%)	10/02/2020	7	4.91	150	150	150	294.75	13.1
191262	6 (50%)	10/02/2020	7	4.95	150	150	150	261	11.6

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES
1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :
Mode of Cube failure (Refer to Figure and circle an appropriate)
Satisfactory A B C
Un-Satisfactory 1 2 3 4 5 6 7 8 9
[ ] -

Age	Witness by	Age	Tested by	Age	Checked by
7		7		7	

Signature only required when customer witness

Attachment 4. Data of Test Results for Concrete with 50% HDPE at Day 7

BSEN Test Sdn. Bhd.

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

ɔSTOMER CUBE SUBMISSION FORM

ɹstomer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment

CREDIT

CASH

Receipt No. ....

Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	17/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
192539	7 (25%)	17/02/2020	14	5.01	150	150	150	391.5	17.4
192540	8 (25%)	17/02/2020	14	5.08	150	150	150	414	18.4
192541	9 (25%)	17/02/2020	14	4.99	150	150	150	436.5	19.4

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :

Mode of Cube failure (Refer to Figure and circle an appropriate)

Satisfactory A B C

Un-Satisfactory 1 2 3 4 5 6 7 8 9

[ ] -

Age	Witness by	Age	Tested by	Age	Checked by
14		14		14	

Signature only required when customer witness

Attachment 5. Data of Test Results for Concrete with 25% HDPE at Day 14

BSEN Test Sdn. Bhd.

CUSTOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

Customer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment

CREDIT

CASH

Receipt No. ....

Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	17/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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WITNESSED

CONCRETE CUBE TESTING REPORT

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
192542	7 (50%)	17/02/2020	14	4.88	150	150	150	362.3	16.1
192543	8 (50%)	17/02/2020	14	4.70	150	150	150	348.75	15.5
192544	9 (50%)	17/02/2020	14	4.71	150	150	150	375.75	16.7

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :

Mode of Cube failure (Refer to Figure and circle an appropriate)

Satisfactory A B C

Un-Satisfactory 1 2 3 4 5 6 7 8 9

[ ] -

Age	Witness by
14	

Signature only required when customer witness

Age	Tested by
14	

Age	Checked by
14	

Attachment 6. Data of Test Results for Concrete with 50% HDPE at Day 14

BSEN Test Sdn. Bhd.

CUSTOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

Customer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment

CREDIT

CASH

Receipt No. ....

Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	24/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
193902	10 (25%)	24/02/2020	21	5.00	150	150	150	441	19.6
193903	11 (25%)	24/02/2020	21	4.92	150	150	150	445.5	19.8
193904	12 (25%)	24/02/2020	21	4.93	150	150	150	443.2	19.7

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :

Mode of Cube failure (Refer to Figure and circle an appropriate)

Satisfactory A B C

Un-Satisfactory 1 2 3 4 5 6 7 8 9

[ ] -

Age	Witness by
21	

Signature only required when customer witness

Age	Tested by
21	

Age	Checked by
21	

Attachment 7. Data of Test Results for Concrete with 25% HDPE at Day 21

BSEN Test Sdn. Bhd.

...STOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

...stomer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment
CREDIT
CASH
Receipt No. ....
Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	24/02/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

☑ WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
193905	10 (50%)	24/02/2020	21	4.73	150	150	150	384.7	17.1
193906	11 (50%)	24/02/2020	21	4.92	150	150	150	391.5	17.4
193907	12 (50%)	24/02/2020	21	4.80	150	150	150	378	16.8

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :
Mode of Cube failure (Refer to Figure and circle an appropriate)
Satisfactory A B C
Un-Satisfactory 1 2 3 4 5 6 7 8 9
[ ] -

Age	Witness by
21	

Signature only required when customer witness

Age	Tested by
21	

Age	Checked by
21	

Attachment 8. Data of Test Results for Concrete with 50% HDPE at Day 21

BSEN Test Sdn. Bhd.

ʋSTOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

ʋstomer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment

CREDIT

CASH

Receipt No. ....

Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	2/03/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

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CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
195124	13 (25%)	2/03/2020	28	4.83	150	150	150	456.8	20.3
195125	14 (25%)	2/03/2020	28	5.03	150	150	150	470.25	20.9
195126	15 (25%)	2/03/2020	28	5.02	150	150	150	443.25	19.7

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES

1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :

Mode of Cube failure (Refer to Figure and circle an appropriate)

Satisfactory A B C

Un-Satisfactory 1 2 3 4 5 6 7 8 9

[ ] -

Age	Witness by
28	

Signature only required when customer witness

Age	Tested by
28	

Age	Checked by
28	

Attachment 9. Data of Test Results for Concrete with 25% HDPE at Day 28

BSEN Test Sdn. Bhd.

CUSTOMER CUBE SUBMISSION FORM

File No. : 19091121

Pro Code : POLI (HDPE FIBRE)

Customer : Politeknik Sultan Salahuddin Abdul Aziz Shah, Shah Alam

Project : Project Concrete with HDPE Fibre

Structure & Elements: Site Mix

Terms of Payment
CREDIT
CASH
Receipt No. ....
Date ....

Date Cast	3/02/2020	Cement	N.A	Date Receive	2/03/2020
Grade MPa	SM	Cour. Agg.	N.A	Job Code	19-07509
Slump (mm)		Fine Agg.	N.A	Supplier	Site Mixed
Samples	Submited	Admixture	N.A	Remarks	N.A

Test Machine (Tick) BSEN 001 / [A] [B] [C] [D]

COPY EMAILED FAXED

Lab Use Only

CONCRETE CUBE TESTING REPORT

WITNESSED

Lab Mark	Client Marking	Date Test	Age Test	Weight (Kg)	Dimension (mm) L	B	H	Load (kN)	Strength N/mm^2
195127	13 (50%)	2/03/2020	28	4.71	150	150	150	398.3	17.7
195128	14 (50%)	2/03/2020	28	4.89	150	150	150	387	17.2
195129	15 (50%)	2/03/2020	28	4.62	150	150	150	409.5	18.2

TEST METHOD : (BS EN 12390-3:2009) - Compressive Strength of Test Speciments

NOTES
1. Cubes were tested "as received / saturated" condition.
2. Method of Testing BS EN 12390-3:2009 / MS EN 12390-3:2012
3. The cubes were tested at local ambient room temperature

REMARKS :
Mode of Cube failure (Refer to Figure and circle an appropriate)
Satisfactory A B C
Un-Satisfactory 1 2 3 4 5 6 7 8 9
[ ] -

Age	Witness by	Age	Tested by	Age	Checked by
28		28		28	

Signature only required when customer witness

Attachment 10. Data of Test Results for Concrete with 50% HDPE at Day 28

CHAPTER 5

5.0 RECOMMENDATION AND CONCLUSION

5.1 INTRODUCTION

This chapter is the final chapter of this study and it will generally discuss in depth the findings of the study that have been analysed. This finding is supported by the opinion that it may strengthen the results of the research project. In conclusion, it is based on discussion of the findings of the project and some suggestions are also available for use in future projects.

5.2 DISCUSSION

For our product, concrete with HDPE plastic fibres, we tested it's compressive strength on different days as well as it's workability. Cube test for compressive strength is was done on the 3^{rd}, 7^{th}, 14^{th} , 21^{st} and 28^{th} day after the concrete was cast. The main objective of this project was to make concrete using waste materials and we managed to achieve that. We then carried out tests to study the characteristics of the concrete that was produced with the additional materials. Our focus was on the compressive strength of the concrete. This is because one of the main characteristics of concrete is that it has to be strong and be able to withstand a certain amount of stress when applied and not break under pressure. After the results from both studies were obtained, the data collected was used to compare the strength of both design mixes and determine which is more suitable to be used in practice. 15 cube samples were produced for each design mix and three cubes were tested at a time for each respective design mix. The data from the tests were then totaled up and divided by the number of cubes to obtain the average compressive strength of the design mix at each given day.

During the mixing process, the 50% HDPE design mix was slightly less workable, so some water was added to the mixture to allow a better consistency. The cubes were left to cure in water for up to 28 days. The cubes were taken out from the water approximately an hour before the test was done as it was recommended by many sources to cure it for as long as possible before testing. Throughout the curing process, the water was changed quite frequently, about once every week to avoid contamination from the water. While testing was being done, it was found that the compressive strength of the concrete increased linearly as the days passed. However the difference in the compressive strength between the two samples were quite significant as the sample with 25% HDPE plastic fibre had a much higher compressive strength as compared to the sample with 50% HDPE plastic fibre. This could be due to the fact that HDPE plastic is far less dense as compared to sand and is less suitable to be used as fine aggregate but the results were still in favour of the design mix to be used in construction. It was found that on the 28th day, the sample with 25% HDPE plastic fibres achieved a compressive strength of 20.3 N/mm^2 whereas the sample with 50% HDPE plastic fibres achieved a compressive strength of 17.7 N/mm^2. This means that it cannot be used in the industry but can be used for small scale projects that do not require concrete with high compressive strength and can be compared to grade M15 concrete for the sample with 50% HDPE, meaning it can be used for domestic and commercial use in making pavement curbs and floor blinding as well as patio slabs, pathways and non-structural work, whereas the sample with 25% HDPE plastic achieved a greater compressive strength and can be classified as grade M20 concrete that can be used in construction to produce domestic floors and foundations (where the weight of structure will be lighter). Also good for workshop bases, garages, driveways and internal floor slabs. This shows that we manged to achieve our objective to produce concrete using HDPE plastic fibre as an additional material and also succeeded in testing the physical properties of the concrete produced.

5.3 CONCLUSION

In conclusion, the study conducted was a success because all of the objectives were achieved. From this study we can agree that recyclable waste is something that can be used in construction and should be practiced. This is due to the possibility of being able to reach industry standards with more research done on the materials that are used. We managed to produce the concrete which proves that recyclable materials can be put to use in the construction industry. In addition, the concrete that was produced achieved a high enough compressive strength that it can be categorised in the grade M15 and M20 concrete classes. From this we learned that there are more ways of applying eco-friendly solutions in construction and can help reduce our carbon footprint as well as utilising waste materials that usually end up in landfills and pollute our planet.

5.4 RECOMMENDATIONS

We feel that using waste materials in construction is a very good way to reduce the amount of waste produced, but there is a lack of research on creating such products. We recommend that more studies should be done about using waste materials in construction. Instead of only using one source of material, other waste materials can also be used such as glass, cardboard, sawdust, aluminium shavings. Also, these materials can be combined together in different combinations to see the difference in strength, as well as other characteristics that might be affected due to the different densities and other qualities of the materials. In addition, other methods of curing can also be tested to observe if there are any effects on specific materials used because different materials have different properties

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