EFFECT OF USED ENGINE OIL (UEO) AS CHEMICAL ADMIXTURES ON THE PROPERTIES OF HIGH STRENGTH CONCRETE (HSC)

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by

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Nasir Syafiq)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

Jan 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Athirah

NUR ATHIRAH MUSTAPHA KAMAL

ABSTRACT

High strength concrete was produced using locally available materials. Nowadays, there are many researches that include wastes as raw material in cement and concrete. This is a positive environmental impact due to the ever-increasing cost of waste disposal and sticker environmental regulation. The topic of **Effects of Used Engine Oil (UEO) as Chemical Admixtures on The Properties of High Strength Concrete (HSC)** is to produce high strength concrete with the usage of UEO as a replacement of superplasticizer and silica fume (SF) as cement replacement material. From the previous research, it shows that used engine oil have potential on increasing concrete strength and also acting as air-entraining chemical admixture to the concrete. The effect of using used engine oil in high strength concrete will be investigated and compared with concrete with superplasticizer. This report presents the results of experimental investigation on the effect of different amount of used engine oil and water to binder ratio on residual compressive strength of high-strength concrete up to 90 days. 10% silica fume was used as cement replacement material for six trial mixes. Based on the results mixes consists used engine oil do not obtained the compressive strength of 60MPa at 28 days which is the target strength for this study. This study can be concluded that silica fume do contribute to increase the concrete strength and used engine oil cannot replace superplasticizer as water reducer.

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LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENT

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

Concrete is a manmade building material that looks like stone. Combining cement with aggregate and sufficient water makes concrete. Water allows it to set and bind the materials together. Different mixtures are added to meet specific requirements. Concrete is normally reinforced with the use of rods or steel mesh before it is poured into moulds. Interestingly, the history of concrete finds evidence in Rome some 2000 years back. [1]

Concrete has been one of the most commonly used building materials in the world. The first invented concrete is the traditional normal strength concrete (NSC) which originally the ingredients composed are cement, water and aggregates. As a result of civil engineering demand, such as high-rise buildings and long-span bridges, a lot of research on concrete materials is conducted to produce higher compressive strength concrete.

High strength concrete is among the most significant ideal materials available in the market to rehabilitate and enhance the performance of the nation's crumbling infrastructure such as assisting the widespread problems of deteriorated bridge structures and tall buildings. In the precast and prestressed concrete industries, the use of high strength concrete has resulted in a rapid turnover of moulds, higher productivity and less loss of products during handling and transportation.

The main reasons for high strength concrete (HSC) development can be summarized as follows:

1. To put the concrete into earlier service
2. To build high-rise building by reducing column sizes and increase available spaces.
3. To build super structures and enhance its durability to 90-years of life span.
4. To satisfy specific needs of special applications such as durability, modulus of elasticity and flexural strength.

In HSC, admixtures and additives are added into the mix. Admixtures have long been detected as important materials of concrete used to improve its performance. Commonly, there are three kinds of admixtures, including silica fume, fly ash, and blast furnace slag. Before this, 42MPa concrete was enough categorized as high strength. Today, with silica fume, more than 105MPa compressive strength concrete can be produced. [16, 18]

For this project, the desired compressive strength is at least 60MPa with low cement content. This project is to study the behavior of fresh and hardened high strength concrete due to the effect of used engine oil.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

Various researches had been done to produce HSC that have the characteristics of high workability during its fresh state, but very strong and durable once it has hardened. For high-rise building or super structures construction, using HSC will be more efficient and indirectly minimize the cost due to smaller area and diameter of column used compared to normal strength concrete [16]. The previous research implies that HSC is made with a low water ratio, thus it requires a large amount of cement in the mixing process.

Large amount of cement not only may cause creep and shrinkage, but also costly and negatively affect the environment. Cement manufacturing is responsible for large emission of carbon dioxide (CO_2) into the atmosphere; approximately one ton of cement clinker releases a ton of CO_2. The number made nearly 7 % of the global

CO_2 emissions come from cement manufacturing. CO_2 in the air make the global warming [4]. Therefore by reduce cement content in concrete could save the environment.

Nowadays, there are a lot of nature and consumer products been tested to replace cement. From living process and industrial, there are tones of consumer wastes generated annually. Some of the products can be recycled or disposed, some are hard to eliminate. It is a good alternative to use some of the consumer wastes that are suitable and had been clarified as cement replacement after experiments. These products offer solution to reduce environmental impact. In this project, we use Silica Fume (SF) as cement replacer.

As for used engine oil (UEO), it is estimated that less than 45% of used engine oil is being collected worldwide while remaining 55% is thrown by the end user in the environment. Used oil affects both marine and human life [18]. Oil in bodies of water raises to the top forming a film that blocks sunlight, thus stopping the photosynthesis and preventing oxygen replenishment leading to the death of the underwater life. In addition, used oil contains some toxic materials that can reach humans through the food chain. Health hazards range from mild symptoms to death. The main source of contaminants in used oil is due to the break down of additives and the interaction of these substances with others found in nature. In this context, the proper management of used oil is essential to eliminate or minimize potential environmental impacts [22]. UEO as concrete chemical admixtures may reduce pollution.

1.2.2 Significance of the Project

In this project, combination the effect of UEP and SF to achieve a high strength concrete will be investigated. Used engine oil is used as an alternative to reduce superplasticizer and also act as an air-entrainment while silica fume is used as cement reducer.

1.3 OBJECTIVE AND SCOPE OF STUDY

1.3.1 The relevancy of the project

The main objectives of this project are:

1. To produce a concrete with compressive strength at 60MPa.
2. To produce high strength concrete by incorporating SF as cement replacement material and UEO as a replacement of superplasticizer.
3. To identify the effect of superplasticizer and UEO to a fresh and hardened properties of concrete

1.3.2 Feasibility of the Project within the scope and time frame

The feasibility study of the project within the scope is get desired HSC of at least 60MPa with the mixes of Portland cement, water, silica fume, fine and course aggregates, superplasticizer and used engine oil at specified percentage (Table 3.1). Prior to this, total of six concrete mixes including one control mix was conducted.

In addition, this project required several tests to be conducted during at fresh and hardened state. Slump test conducted in fresh state to determine the workability, while for hardened state, the tests will be conducted after 3,7,28, and 90 days of curing. The tests are:

1.Cube Crushing Strength Test

2.Porosity Test

3. Split Cylinder Test.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

Concrete in its simplest explanation is a composite construction material made from the combination of aggregates and cementations binder. Various types of concrete have been developed for specialist application. The exploring of research and applications on concrete materials seems never to cease. The regular type of concrete is normal strength concrete (NSC) and recently a lot of research had been made to produce high strength concrete (HSC) with minimum cost and better effect to environment. HSC is a very economical material to support vertical loads of high rise building and super structures [18].

The composition of concrete is determined initially during mixing and finally during placing of fresh concrete. The composition of concrete is usually made of cement, water, aggregates, admixtures, and additives. Significant improvements in durability through the use of additive as granulated blast-furnace slag, fly ash, silica fume, and densified cements will result in structures with longer life and lower maintenance costs [16].

2.2 HISTORY OF CONCRETE AND CEMENT

Concrete is a material used in building construction, consisting of aggregate made from different types of sand and gravel that is bonded together by cement and water. The oldest known surviving concrete is to be found in the former Yugoslavia and was thought to have been laid in 5,600 BC using red lime as the cement. [6]

The Assyrians and Babylonians used clay as the bonding substance or cement. The Egyptians used lime and gypsum cement. In 1756, British engineer, John Smeaton made the first modern concrete by adding pebbles as a coarse aggregate and mixing powered brick into the cement. In 1824, English inventor, Joseph Aspdin invented Portland Cement, which has remained the dominant cement used in concrete production. Joseph Aspdin created the first true artificial cement by burning ground limestone and clay together. The burning process changed the chemical properties of the materials and Joseph Aspdin created stronger cement than what using plain crushed limestone would produce. [6]

Concrete that includes imbedded metal (usually steel) is called reinforced concrete or ferroconcrete. 1849, reinforced concrete was invented by Joseph Monier. Reinforced concrete combines the tensile strength of metal and the compression strength of concrete to withstand heavy loads. In 1886, the first rotary kiln was introduced in England that made constant production of cement. By 1920s, concrete found major usage in construction of roads and buildings. [1]

Table 2.1 Historical Timeline of Concrete

12,000,000 BC	Reactions between limestone and oil shale during spontaneous combustion occurred in Israel to form a natural deposit of cement compounds.
3000 BC	Egyptians used mud mixed with straw to bind dried bricks. Also furthered the discovery of lime and gypsum mortar as a binding agent for building the Pyramids
300 BC	Romans used lime as a cementitious material. Pliny reported a mortar mixture of 1 part lime to 4 parts sand. Vitruvius reported a 2 parts pozzolana to 1 part lime. Animal fat, milk, and blood were used as admixtures
After 400 AD	The art of Concrete was lost after the fall of the Roman Empire
1678	Joseph Moxon wrote about a hidden fire in heated lime that appears upon the addition of water.
1756	John Smeaton, British Engineer, rediscovered hydraulic cement through repeated testing of mortar in both fresh and salt water
1779	Bry Higgins was issued a patent for hydraulic cement (stucco) for exterior plastering use.
1796	James Parker from England patented a natural hydraulic cement by calcining nodules of impure limestone containing clay, called Parker's Cement or Roman Cement.
1812 -1813	Louis Vicat of France prepared artificial hydraulic lime by calcining synthetic mixtures of limestone and clay.
1818	Maurice St. Leger was issued patents for hydraulic cement.
1818	Canvass White, American Engineer, found rock deposits in Madison, County, New York, that made hydraulic cement with little processing
1822	James Frost of England prepared artificial hydraulic lime like Vicat's and called it British Cement.
1825	Erie Canal created the first great demand for cement in the US
1902	Thomas Edison was a pioneer in the further development of the rotary kiln.
1916	Portland Cement Association founded
1919	Meis van der Rohe proposes concrete high-rises
1940s	Portland Cement Laboratories perfect air-entrained concrete
1970s	Fiber reinforcement in concrete was introduced.

2.3 CONCRETE PROPERTIES

The properties of concrete are its characteristics or basic qualities. The four main properties of concrete are:

1. Workability
2. Cohesiveness
3. Strength
4. Durability

2.3.1 Concrete State

Concrete has three different states which are plastic, setting and hardening. In each state it has different properties. [11]

Plastic State: When the concrete is first mixed it is like 'bread dough'. It is soft and can be worked or moulded into different shapes. In this state concrete is called plastic. Concrete is plastic during placing and compaction The most important properties of plastic concrete are workability and cohesiveness.

Setting State: Concrete then begins to stiffen. The stiffening of concrete, when it is no longer soft, is called setting. Setting takes place after compaction and during finishing. Concrete that is sloppy or wet may be easy to place but will be more difficult to finish.

Hardening State: After concrete has set it begins to gain strength and harden. The properties of hardened concrete are strength and durability.

2.3.2 Workability

Workability means how easy it is to place, handle, compact and finish a concrete mix. Concrete that is stiff or dry may be difficult to place, handle, compact and probably will not be as strong or durable when finally hardened. A slump test can be used to measure the workability of concrete. Workability is affected by:

1. The amount of cement paste: The cement paste is the soft or liquid part of the concrete mix. The more paste mixed with the coarse and fine aggregates, the more workable a mix.

2. The aggregate grading: Well-graded, smooth, rounded aggregates improve the workability of a mix.
3. Add more cement paste
4. Use well graded aggregates
5. Use an admixtures

2.3.3 Strength and Durability

Well made concrete is a naturally strong and durable material. It is dense, reasonably watertight, able to resist changes in temperature, as well as wear and tear from weathering. Strength and durability are affected by the density of the concrete. Denser concrete is more watertight (or less permeable). Concrete durability increases with strength. Well made concrete is very important to protect the steel in reinforced concrete. [11]

Strength of concrete in the hardened state is usually measured by the compressive strength using the compression test. Strength and durability are affected by :

1. *Compaction*: Removing the air from concrete. Proper compaction results in concrete with an increased density which is stronger and more durable.
2. *Curing*: Keeping concrete damp for a period, to allow it to reach maximum strength. Longer curing will give more durable concrete.
3. *Weather*: Warmer weather will cause concrete to have a higher early strength.
4. *Type of cement :* Different types of cement will affect concrete properties
5. *The water cement ratio:* Too much water and not enough cement means concrete will be weaker and less durable. The water to cement ratio (W/C) is the weight of the water divided by the weight of cement. The lower the ratio, the stronger the concrete.

2.3.4 Cohesiveness

Cohesiveness is how well concrete holds together when plastic. Cohesiveness is affected by the aggregate grading and water content. Graded aggregate means that there is a range of size of aggregates, from large rocks to small sands; well-graded aggregates give a more cohesive mix, too much coarse aggregate gives a boney mix. A mix that has too much water will not be cohesive and may separate and bleed.[11]

2.3.5 Other Properties

Typical properties of normal strength Portland cement concrete are indicated below: [6]

1. Density : 2240 - 2400 kg/m^3 (140 - 150 lb/ft^3)
2. Compressive strength : 20 - 40 MPa (3000 - 6000 psi)
3. Flexural strength : 3 - 5 MPa (400 - 700 psi)
4. Tensile strength : 2 - 5 MPa (300 - 700 psi)
5. Modulus of elasticity : 14000 - 41000 MPa (2 - 6 x 10^6 psi)
6. Permeability : 1 x 10^{-10} cm/sec
7. Coefficient of thermal expansion : 10^{-5} °C^{-1} (5.5 x 10^{-6} °F^{-1})
8. Drying shrinkage : 4 - 8 x 10^{-4}
9. Drying shrinkage of reinforced concrete : 2 - 3 x 10^{-4}
10. Poisson's ratio : 0.20 - 0.21
11. Shear strain : 6000 - 17000 MPa (1 - 3 x 10^6 psi)'
12. Specific heat capacity : 0.75 kJ/kg K (0.18 Btu/lb$_m$°F (kcal/kg°C))

Concrete is an artificial conglomerate stone made essentially of Portland cement, water, and aggregates. When first mixed the water and cement constitute a paste which surrounds all the individual pieces of aggregate to make a plastic mixture. A chemical reaction called hydration takes place between the water and cement, and concrete normally changes from a plastic to a solid state in about 2 hours. Thereafter the concrete continues to gain strength as it cures. [21]

During the first week to 10 days of curing it is important that the concrete not be permitted to freeze or dry out because it would be very detrimental to the concrete strength. Theoretically, if kept in a moist environment, concrete will gain maximum strength, however, in practical terms; about 90% of its strength is gained in the first 28 days. [21]

Concrete has almost no tensile strength, and for this reason it is almost never used without some form of reinforcing. Its compressive strength depends upon many factors, including the quality and proportions of the ingredients and the curing environment. The most important indicator of strength is the ratio of the water used compared to the amount of cement. Basically, the lower this ratio is, the higher the final concrete strength will be. A minimum water-to-cement ratio of about 0.3 by weight is necessary to ensure that the water comes into contact with all cement particles. Practically, typical values are in the 0.4 - 0.6 range in order to achieve a workable consistency so that fresh concrete can be placed in the forms and around closely spaced reinforcing bars. [4]

Most structural concretes have f'c values in the 3000- 5000 psi range. However, lower-story columns of high-rise buildings will sometimes utilize concretes of 12,000 or 15,000 psi to reduce the column dimensions which would otherwise be inordinately large. [4]

2.4 CONCRETE TESTING

There are tests should be conducted to concrete at fresh and hardened state. Testing should always be done carefully. Wrong test results can be costly. The first step is to take a test sample from the large batch of concrete. This should be done as soon as discharge of the concrete commences. The sample should be representative of the concrete supplied. The sample is taken in one of two ways: For purposes of accepting or rejecting the load: Sampling after 0.2 m3 of the load has been poured. For routine quality checks: Sampling from three places in the load. [11]

The tests conducted, amongst others include:

1. Slump Test
2. Porosity Test
3. Compressive strength of concrete cubes, concrete cylinders, concrete cores and bricks
4. Flexural strength of concrete beams
5. Tensile splitting strength of concrete cylinders
6. Microstructural properties of cementitious based materials

However the two main tests usually conducted in concrete construction are slump test and compression test, but in our project we also add one extra test which is porosity test.

2.4.1 Test for consistency

Slump test has been conducted to check for the consistency or workability of concrete. It determine how fluid or stiff a material is. It is important because the fluidity affect the concrete characteristic. Too much stiffness makes it too difficult or impossible to work the concrete into the forms and around reinforcing steel. On the other hand, too fluid a mixture however is also detrimental. The measured slump must be within a set range, or tolerance, from the target slump.

Workability is a simple word to cover how easy the mix is to place, handle, compact and finish. The observed slump will depend on the type of concrete mix used, how wet it is, the types and proportions of the aggregate in it and how far the setting process has gone. Low water to cement ratio leads to high strength but low workability. High water to cement ratio leads to low strength, but good workability.

What we usually got while doing the slump test on site was 'true slump'. True slump is a general reduction in height of the mass without any breaking up. There are also two other slumps that can be obtained from the slump test; the 'shear slump' and the 'collapse slump' .Figure below show the differences between each slump.

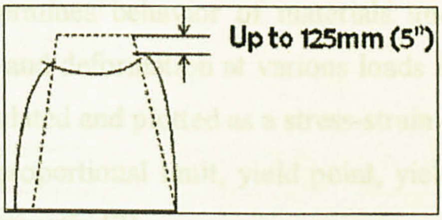

Figure 2.1 : True Slump

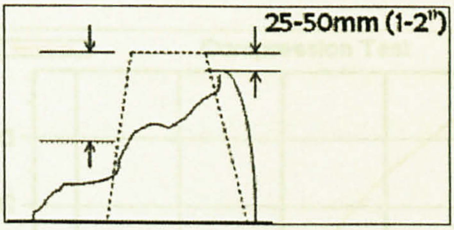

Figure 2.2 : Shear Slump

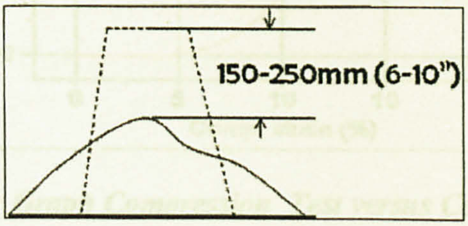

Figure 2.3: Collapse Slump

Shear slump indicates a lack of cohesion and tends to occur in harsh mixes. Concrete is not suitable for placement. Collapse slump generally indicates a very wet mix. Slump can be increased by adding chemical admixtures such as mid-range or high-range water reducing agents (super-plasticizers) without changing the water/ cement ratio. It is bad practice to add extra water at the concrete mixer.

Lower slump concrete is very stiff, and higher slump concrete is more fluid. Usually decorative concrete applications would be in the 4- to 5-inch range, but it could be anywhere from 1 to 10 inches depending on what you're doing. If you're paving a road, you need a much stiffer material that can stand on its own. If you're doing a wall, the flow needs to be much more fluid.

2.4.2 Test for strength

The Compression Test

Cube tests are most commonly used for determining concrete strength. The purpose of the test is to determine the compressive strength of concrete or its ability to resist a crushing force.

A compression test determines behavior of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. Compressive stress and strain are calculated and plotted as a stress-strain diagram which is used to determine elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength. [7]

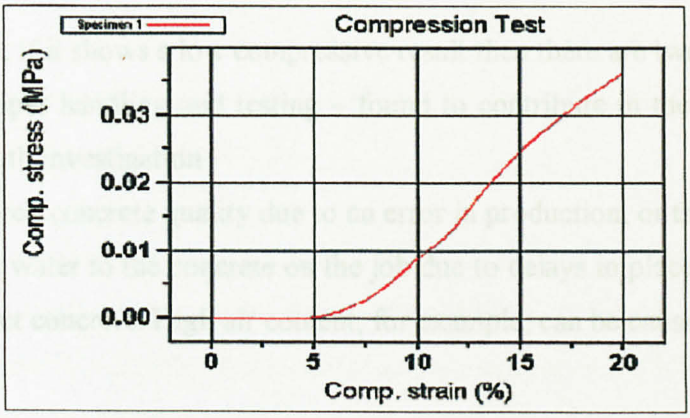

Figure 2.4: Graph Compression Test versus Comp. Strain

The ASM Handbook' Volume 8, Mechanical Testing and Evaluation states that axial compression testing is a useful procedure for measuring the plastic flow behavior and ductile fracture limits of a material. Axial compression testing is also useful for measurement of elastic and compressive fracture properties of brittle materials or low-ductility materials. [7]

Figure 2.5 illustrates the modes of deformation in compression testing.

1. Picture (a) : Buckling
2. Picture (b) : Shearing
3. Picture (c) : Double barreling and friction is present at the contact surfaces
4. Picture (d) : Barreling and friction is present at the contact surfaces
5. Picture (e) : Homogenous compression
6. Picture (f) : Compressive instability due to work-softening material.

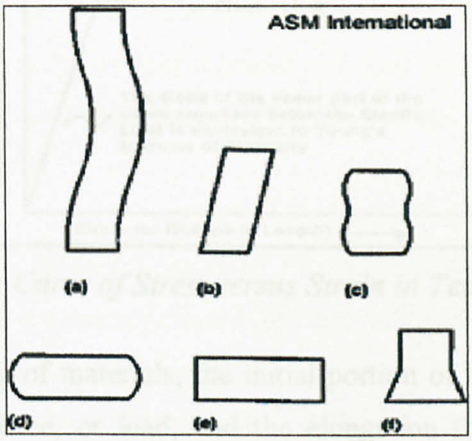

Figure 2.5: Various Mode of Deformation in Compression Testing

From the test, if it shows a low compressive result then there are two major reasons:

1. Improper handling and testing – found to contribute in the majority of low strength investigation
2. Reduced concrete quality due to an error in production, or the addition of too much water to the concrete on the job due to delays in placement or requests for wet concrete. High air content, for example, can be cause of low strength. [4]

The Tensile Test

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on material. Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on something, the material will react to forces being applied in tension and the strength along with how much it will elongate can be determined. [8]

When the material breaks, a good, complete tensile profile can be obtained. A curve will result showing how it reacted to the forces being applied. The point of failure is of much interest and is typically called its "Ultimate Strength" or UTS on the chart.[8]

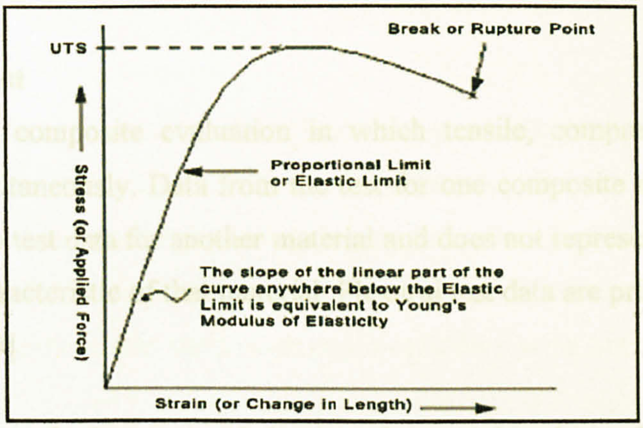

Figure 2.6: Curve of Stress versus Strain in Tensile Testing

For most tensile testing of materials, the initial portion of the test, the relationship between the applied force, or load, and the elongation the specimen exhibits is linear. In this linear region, the line obeys the relationship defined as "Hooke's Law" where the ratio of stress to strain is a constant, or $\frac{\sigma}{\varepsilon} = E$. E is the slope of the line in this region where stress (σ) is proportional to strain (ε) and is called the "Modulus of Elasticity" or "Young's Modulus".[8]

The modulus of elasticity is a measure of the stiffness of the material, but it only applies in the linear region of the curve. If a specimen is loaded within this linear region, the material will return to its exact same condition if the load is removed. At the point that the curve is no longer linear and deviates from the straight-line relationship, Hooke's Law no longer applies. This point is called the "elastic, or proportional, limit". From this point, the material reacts plastically to any further increase in load or stress. It will not return to its original if the load were removed. A value called "yield strength" of a material is defined as the stress applied to the material at which plastic deformation starts to occur while the material is loaded.[8]

One of the properties you can determine about a material is its ultimate tensile strength (UTS). It is the maximum load the specimen sustains during the test. The UTS may or may not equate to the strength at break. This all depends on what type of material you are testing and sometimes a material may be ductile when tested in a lab, but, when placed in service and exposed to extreme cold temperatures, it may transition to brittle behavior.[8]

The Flexural Test

A test used for composite evaluation in which tensile, compressive and shear stresses act simultaneously. Data from the test for one composite material may not be comparable to test data for another material and does not represent a fundamental performance characteristic of that material. Flexural test data are primarily useful for quality control.[9]

The flexure test method measures behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. Maximum fiber stress and maximum strain are calculated for increments of load. Results are plotted in a stress-strain diagram. Flexural strength is defined as the maximum stress in the outermost fiber. This is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve to determine slope. [10]

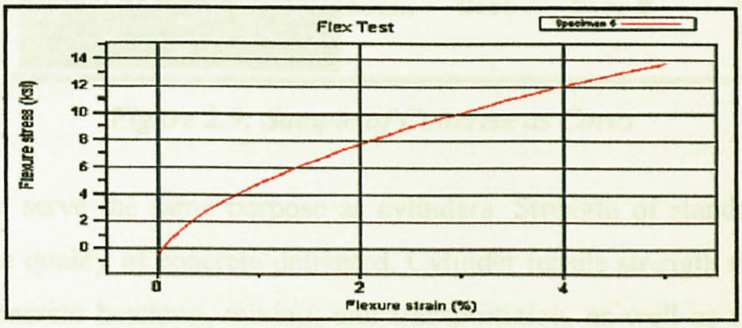

Figure 2.7: Graph of Flexure Stress versus Flexure Strain

There are two test types; 3-point flex and 4-point flex. In a 3-point test the area of uniform stress is quite small and concentrated under the center loading point. In a 4-point test, the area of uniform stress exists between the inner span loading points.[10]

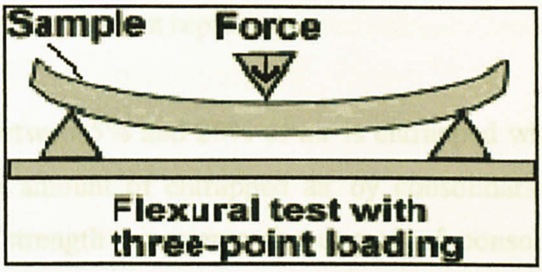

Figure 2.8: Simple Beam in Three-point Loading Test

The Porosity Test

Sometimes after concrete testing, the cylinder compressive strength test results are low or below expectation when it should be otherwise. To aid the investigation, cores will be taken and tested. Knowing the in-place characteristics of the concrete and how they affect the measured compressive strength of the cores can go a long way toward establishing that the low-strength cylinders were not the result of bad concrete.

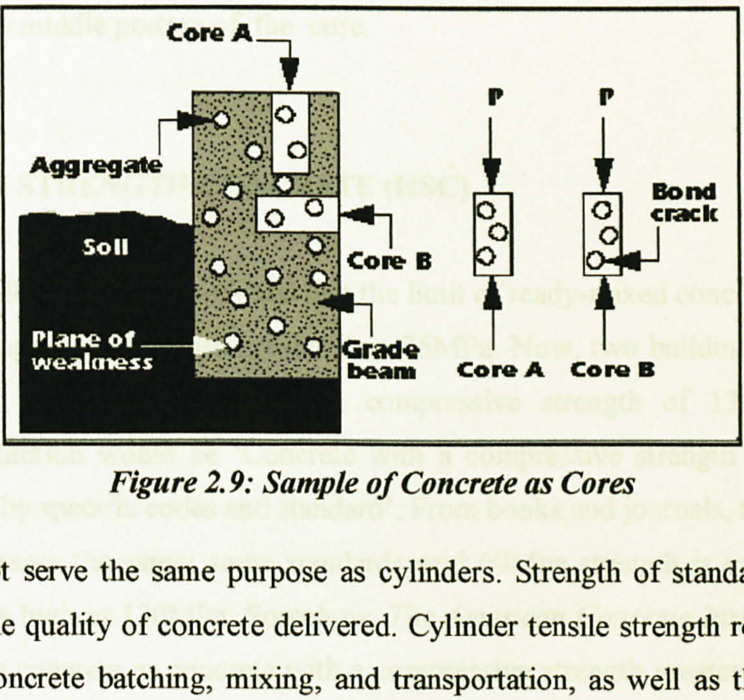

Figure 2.9: Sample of Concrete as Cores

Cores do not serve the same purpose as cylinders. Strength of standard cylinders represents the quality of concrete delivered. Cylinder tensile strength represents the quality of concrete batching, mixing, and transportation, as well as the sampling, preparation, handling, curing, and testing of the cylinders. Strength of cores represents the in place concrete strength. In addition to concrete batching, mixing, and transportation, core compressive strengths represent the quality of placement, consolidation, and curing, and the techniques for obtaining and testing cores. Therefore, the relationship between core and cylinder strength varies because of the characteristics that each specimen represents.

It is estimated that between5% and 20% of air is entrapped while placing concrete. Vibrators reduce the amount of entrapped air by consolidating the concrete. The core's compressive strength represents the degree of consolidation achieved by workers and their equipment.

The thermal history and curing of cores is quite different than for standard cylinders. The structure's thermal environment might be better or worse than that provided by laboratory curing. Field concrete may be subjected to cold- or hot-weather curing conditions. High temperatures can lower concrete strength but lower temperatures could actually produce stronger concrete at later ages. Curing dramatically affects the concrete surface, but has less of an effect on the interior concrete. The outer concrete protects the inner concrete's humidity and temperature conditioning. When cores are tested, the restraint of the testing procedure makes most concrete cores fail within the middle portion of the core.

2.5 HIGH STRENGTH CONCRETE (HSC)

In the early 1970s, experts predicted that the limit of ready-mixed concrete hardly to exceed a compressive strength greater than 76MPa. Now, two buildings in Seattle, Washington, contain concrete with a compressive strength of 131MPa. HSC adequate definition would be 'Concrete with a compressive strength greater than that covered by specific codes and standard'. From books and journals, the standards are not necessary the same; some standards said 60Mpa strength is enough, while some need as high as 130MPa. Somehow, *The American Concrete Institute* defines high-strength concrete as concrete with a compressive strength greater than 41MPa [14].

The use of high strength concrete has become a common practice in many applications throughout the world for many decades, especially for high-rise buildings, long span bridges and repair and rehabilitation works. Moreover, during the last decade, developments in mineral and chemical admixtures have made it possible to produce concrete with relatively much higher strength than was thought possible. High strength concrete is not a revolutionary material; rather, it is a development of normal strength concrete. [5]

For high strength concrete, the content of cementitious material is high and the water/cement ratio is low; the maximum size of aggregate is small. High strength concretes are also sensitive to changes in constituent material properties than conventional concretes. Hence, special attention and detail considerations are required to produce high strength concrete. [5]

A commentary to the definition states that a high strength concrete is one in which certain characteristics are developed for a particular application and environment. [4] Examples of characteristics that may be considered critical for an application are:

1. Ease of placement
2. Compaction without segregation
3. Early age strength
4. Long-term mechanical properties
5. Permeability
6. Density
7. Heat of hydration
8. Toughness
9. Volume stability
10. Long life in severe environments

Most high strength concretes have a high cementitious content and a water-cementitious material ratio of 0.40 or less. However, the proportions of the individual constituents vary depending on local preferences and local materials. Many trial batches are usually necessary before a successful mix is developed. For this project, several measures will be conducted to obtain optimal result in term of concrete strength of at least 60Mpa with minimal cement content. [4]

2.6 NORMAL STRENGTH CONCRETE (NSC) AND HIGH STRENGTH CONCRETE (HSC).

Figure 2.9.1 below shows normally resultant plotted graph of difference of compressive strength achieved by high strength concrete and normal strength concrete. High strength concrete leads normal strength concrete even from day one test. So to achieve high strength concrete over normal strength concrete with minimal cost is desired to any construction joiners. [3]

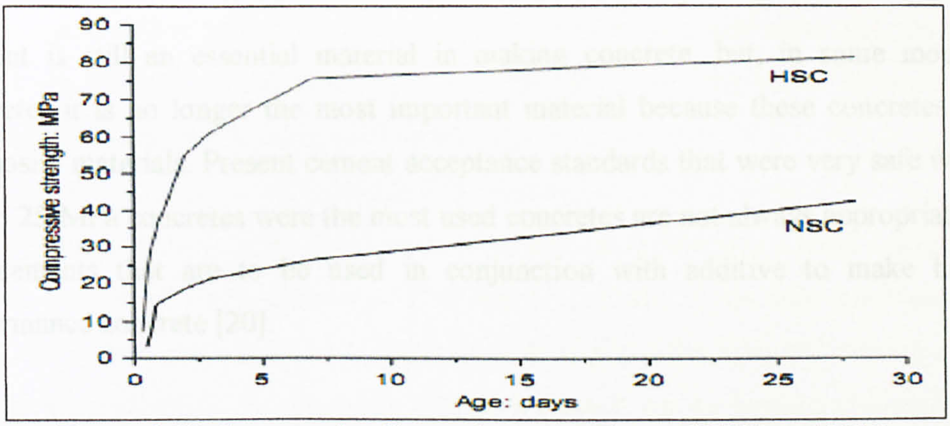

Figure 2.10 Compressive Strength versus Time of HSC and NSC

High strength concrete seems to have become the key word in today's concrete technology. In the early 1940s, 30 N/mm^2 was considered to be the representative of high strength concrete. This level jumped to 50 N/mm^2 in the late 1950s and early 1960s. Concrete strengths of 100-130 N/mm^2 is now being viewed as the criteria for high strength. Just how far we can go to reach an ultimate in strength in the future is nobody's guess. [6]

With many lab tests, it is found that the strength development depends on many parameters, some are noticeable and specified by theories like compositions, proportions and some are hidden practices and experience like time of mixing, way of mixing and more. Table 2.2 shows various categories of high strength concrete. [3]

Table 2.2 Classification of high strength concrete

Normal High Strength Concrete (HSC)	50-100 N/mm 2
Very High Strength Concrete (VHSC)	100-150 N/mm 2
Ultra High Strength Concrete (UHSC)	150-200 N/mm 2
Super High Strength Concrete (SHSC)	Exceeding 200 N/mm 2

2.7 CEMENT

Cement is used to bond the aggregates together with the concrete. It has the adhesive and cohesive properties. The common cement used is the Ordinary Portland Cement (OPC). The main compositions of the cement are mortars and plasters.

Cement is still an essential material in making concrete, but, in some modern concretes it is no longer the most important material because these concretes are composite materials. Present cement acceptance standards that were very safe when 20- to 25-MPa concretes were the most used concretes are not always appropriate to test cements that are to be used in conjunction with additive to make high-performance concrete [20].

2.8 SILICA FUME AS CEMENT REPLACEMENT

Silica fume arrive as cementitious materials that will produce a very high strength and durable concrete. It consists primarily of amorphous silicon dioxide (SiO_2). Each particles are approximately 1/100th the size of an average cement particle which make them extremely small. Its chemical and physical properties make it a very reactive pozzolan. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307 [17].

Silica fume is also beneficial in other aspects and due to this, it is an expensive material. The other advantage of silica fume is reduced permeability due to its small size able to fill the void between cement particles which reduce potential liquid solutions percolate and attack aggregates. As a result, the durability of the concrete is improved [12, 15].

Silica fume ontain some form of vitreous reactive silica which, in the presence of water, can combine with lime, at room temperature, to form calcium silicate hydrate of the same type as formed during the hydration of Portland cement. Pozzolanic reaction can be written in the following manner:

Pozzolan + lime + water → calcium silicate hydrate

It must noted that at room temperature this reaction is generally slow and can take several months for completion. However, the finer and the more vitreous the pozzolan, the faster its reaction with lime [23].

As has been previously seen, Portland cement hydration liberates a large amount of lime as a result of the hydration of C3S and C2S (30% of the anhydrous cement mass). Such lime contributes very little to the strength of the hydrated cement paste and can be responsible for durability problems since it can be leached out easily by water. This leaching action results in an increase in the porosity of the cement paste matrix, and thus in a higher leachability. The only positive feature of this lime in concrete is that protects and passivates the reinforcing steel [23].

2.9 USED ENGINE OIL (UEO) AS SUPER PLASTICIZER

Used engine oil can be define as any oil refined from crude oil or synthetic oil that as a result of its use, storage, or handling has become unsuitable for its original purpose, but which may be suitable for further use. Used oil includes crankcase oil, compressor oil, cutting oils, synthetic oils, etc.

UEO behave as an air-entraining agent to concrete by improving the slump and fluidity and enhance the air content. Other than the fact that UEO is an abundant and cheap source, the reduction in the concrete strength is also not as significant as when a chemical air-entraining admixture was used [13,14].

Air entrainment is recommended principally to improve the freeze–thaw resistance of hardened concrete [20]. Entrained air voids act as empty chambers in the paste for the freezing and migrating water to enter, thus relieving the pressures described above and preventing damage to the concrete. In this project, UEO is used as an alternative of superplastisizer and also be used as same as air entrainment.

CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

This project is to study on used engine oil potential to increase concrete strength and also act as air-entraining chemical admixture to the concrete. Before starting the lab work and concrete testing, some literature review through journals and readings material has been done regarding the used engine oil which affects the concrete characteristics such as the strength, durability and a lot more as discussed in before.

3.2 PROJECT IDENTIFICATION

The methodologies that have been followed through finishing this project are as shown below:

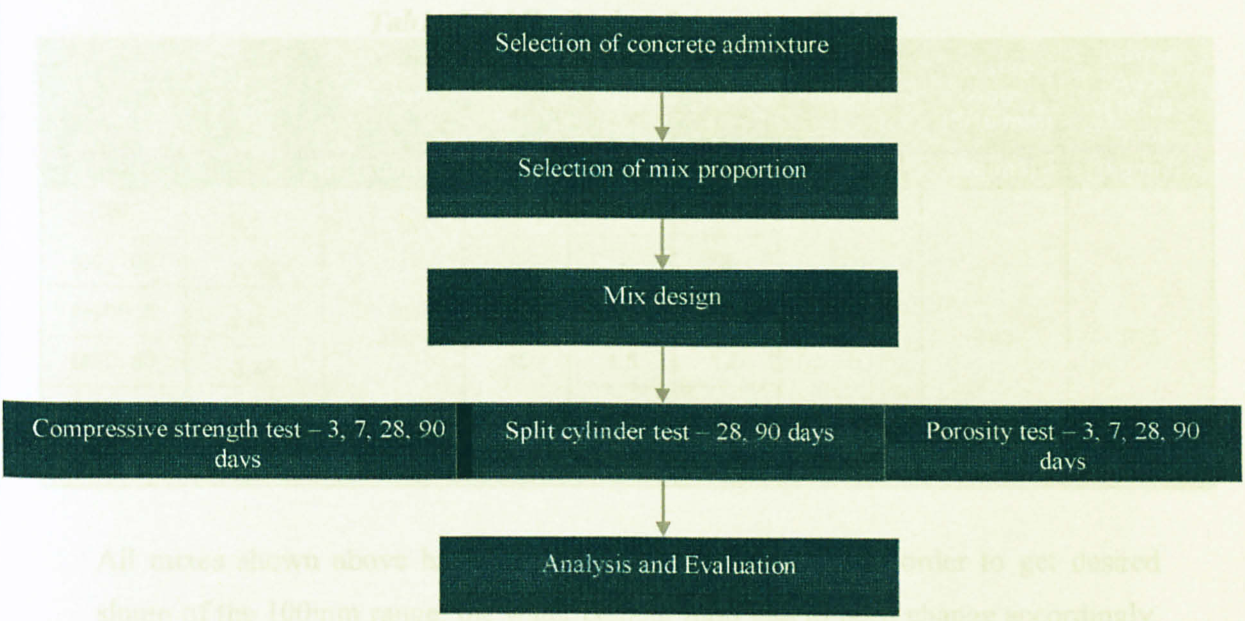

Figure 3.1 Flow chart of activities

3.2.1 Literature review

Literature review was conducted to expose to the previous studies that has been done on the topic of the project. Literature review is a research based on the journals, publications and also reference books from the library. The idea on how to conduct the project was planned from the knowledge gained from the literature review.

3.2.2 Discussion

Weekly meeting with the supervisor was conducted to ensure that the project is going on the right path. The meetings lead to a better understanding besides in depth researches. Ideas were exchange at the meetings.

3.3 MIX DESIGN PROPERTIES

This project includes six types of mixes in order to achieve the compressive strength of more than 60MPa. Materials used are Portland cement, silica fume, used engine oil, superplasticizer, aggregates, sand and water. Table below shows each type of mixes that are going to be cast in 3, 7, 28 and 90 days for cubical crushing strength test and porosity observation and as well as for split cylinder test in 28 and 90 days.

Table 3.1 Mix Design Proportion Table

<table>
<tr><th>Mix</th><th>w/b</th><th>Cement
(kg/m^3)</th><th>SF
(%)</th><th>UEO
(%)</th><th>SP
(%)</th><th>Fine Agg.
(kg/m3)</th><th>Coarse Agg.
(5-10 mm)
(kg/m3)</th><th>Coarse Agg.
(10-20 mm)
(kg/m3)</th></tr>
<tr><td>CM</td><td>0.51</td><td rowspan="6">315</td><td>-</td><td>-</td><td>-</td><td rowspan="6">700</td><td rowspan="6">700</td><td rowspan="6">525</td></tr>
<tr><td>M0_100</td><td>0.36</td><td rowspan="5">35</td><td>-</td><td>3</td></tr>
<tr><td>M100_0</td><td>0.41</td><td>3</td><td>-</td></tr>
<tr><td>M50_50</td><td>0.41</td><td>1.5</td><td>1.5</td></tr>
<tr><td>M30_70</td><td>0.41</td><td>0.9</td><td>2.1</td></tr>
<tr><td>M70_30</td><td>0.41</td><td>2.1</td><td>0.9</td></tr>
</table>

All mixes shown above have various water/cement ratio. In order to get desired slump of the 100mm range, the water/cement ratio had to been change accordingly.

For cubical concrete, its dimension is $100mm^3$ and 100mm in diameter x 200mm in length for cylinder concrete to be cast in this project

Materials

Ordinary Portland Cement (OPC) Type 1 was used in this research, conforming to BS EN 197-1 2000 with the physical and chemical properties listed in Table 1. OPC Type 1 was preferred because the observation on concrete properties can be done in normal hydration process hence the advantages of silica fume usage in concrete can be optimized. Aggregate used to prepare concrete are confirming to BS 882: 1992. In this experimental program, used engine oil was used as superplasticizer. Chemical composition and physical properties of Portland cement, silica fume and used engine oil were given in Table 2.

The used engine oil (UEO) content and water to binder ratio were obtained concrete that could be compacted easily. After casting, they were left for 24 hours before been removed and were cured with water bath at room temperature the desired age of testing at 3, 7, 28, 90 and 120 days for testing.

Table 3.2 Chemical compositions of OPC, silica fume and used engine oil

Chemical Composition	Ordinary Portland Cement (%)	SF (%)	Used Engine Oil (%)
SiO_2	21.98	91.7	-
Al_2O_3	4.65	1	-
Fe_2O_3	2.27	0.9	0.43
CaO	61.55	1.68	15.9
MgO	4.27	1.8	-
SO_3	2.19	0.87	37.0
K_2O	1.04	-	-
Na_2O	0.11	0.1	-
CaO	-	-	15.9
P2O5	-	-	8.95
ZnO	-	-	17.7
Cl-	-	-	15.9

3.4 CONCRETE MIXING

A concrete is designed to produce concrete that can be easily placed at the lowest cost. The concrete must be workable and cohesive when plastic, then set and harden to give strong and durable concrete. The mix design must consider the environment that the concrete will be in; ie exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold. As known, proportioning of concrete is a mixture of cement, water, coarse and fine aggregates and admixtures. The unique of our concrete mix is addition of used engine oil to reduce water content and beneficially produce high strength concrete.

The proportions of each material in the mixture affect the properties of the final hardened concrete. These proportions are best measured by weight. Measurement by volume is not as accurate, but is suitable for minor projects. A basic mixture of concrete can be made using the volume proportions of 1 water : 2 cement : 3 sand.

As the cement content increases, so does strength and durability. Therefore to increase the strength, increases the cement content of a mix. Adding water to a mix gives a weaker hardened concrete. Always use as little water as possible, only enough to make the mix workable. When the water to cement (w/c) ratio increases, the strength and durability of hardened concrete decreases. Too much water results in weak concrete. Too little water results in a concrete that is unworkable. And as for aggregates too much fine aggregate gives a sticky mix. Too much coarse aggregate gives a harsh or boney mix.[11]

Mixing concrete must be mixed so the cement, water, aggregates and admixtures blend into an even mix. Concrete is normally mixed by machine. *Machine mixing* can be done on-site or be a Pre-Mixed concrete company. Pre-Mixed concrete is batched (proportioned) at the plant to the job requirements.[21] For this project, we are not in need of large amount of concrete mixing, small site mixing is enough then.

Site Mixing begins by loading a measured amount of coarse aggregate into the mixer drum. Add the sand before the cement, both in measured amounts. Mix the dry ingredients and slowly add half of the water until the concrete is workable. This mixture may need to be modified depending on the aggregate used to provide a concrete of the right workability. The mix should not be too stiff or too sloppy. It is difficult to form good test specimens if it is too stiff. If it is too sloppy, water may separate (bleed) from the mixture. The mixes then been left for 8minutes to let the aggregates absorb the water before pour cement and mix for 1minute. Finally add the rest of water, silica fume and used engine oil and mixed for 3minuts. Finally perform hand mixing until the mix is in uniform stage. The mixer was stopped and slump test was done before it can be use for casting.

Figure 3.2: Mixer Machine

Be careful not to overload the mixer. Too much concrete in the mixer means each batch takes longer to be properly mixed, which causes costly delays in the long run or it will not mix at all. Avoid delays between batches to get maximum output. [21]

3.5 CONCRETE CASTING

Fresh concrete will then poured into cube, slab and cylinder. Compaction then is done by shaking or vibrating, the concrete which liquefies it, allowing the trapped air to rise out. Compaction must be done as concrete is placed, while it is still plastic. Never let concrete dry-out and stiffen because it will be too hard to compact. Properly compacted concrete is more dense, strong and durable and can prevent from honey comb, Off-form finishes will also be better. [21]

The compaction to be easy is done with a mechanical vibrator or poker vibrator. The poker is put into concrete and vibrates it from the inside. Put the poker into the concrete quickly. Take the poker out very slowly otherwise a hole, or weak spot, may be left in the concrete. Below are the details on how to make sample concrete in cube and cylindrical form for testing purpose:-

3.5.1 Concrete Cube

1. Place the mould on a firm, level surface.
2. Form the test sample by placing concrete in the mould in three layers of approximately equal volume.
3. Move the scoop around the top edge of the mould to ensure a symmetrical distribution of the concrete within the mould.
4. Vibrating or rod each layer with 25 strokes of the tamping rod
5. After the top layer has been rodded, the surface will be struck off with a trowel and covered with saran wrap to prevent evaporation.
6. Store the specimen undisturbed for 24 hours in such a way as to prevent moisture loss and to maintain the specimen within a temperature range of 15^0C to 27^0C.
7. Remove the test specimen from the mould between 20 and 48 hours and transfer carefully to the place of curing and testing. If moulds are being shipped it is permissible to leave specimen in cardboard mould during transit.
8. Place the specimen in the water bath and store for the curing period designated in the contract.
9. Specimens will be kept moist until time of test.

3.5.2 Cylinder

1. Clean the cylinder mould and coat the inside lightly with form oil, then place on a clean, level and firm surface, i.e. the steel plate. Collect a sample.
2. Fill 1/2 the volume of the mould with concrete then compact by rodding 25 times or vibrate with vibrator.
3. Fill the cone to overflowing and rod 25 times or vibrate into the top of the first layer, then top up the mould till overflowing and level off with steel float.

4. Cap, clearly tag the cylinder and put it in a cool dry place to set for at least 24 hours.
5. After the mould is removed the cylinder is sent to the laboratory where it is cured and crushed to test tensile strength.

Table 3.3 Samples of test

Test	Item per mixed	Age (days)			
		3	7	28	90
Compression Stress 100mm x 100mm x 100mm	3	●	●	●	●
Porosity 200mm x 300mm x 40mm	3	●	●	●	●
Split Cylinder Test 100mm (d) x 200mm	3			●	●

3.6 CONCRETE CURING

Curing means to cover the concrete 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. Concrete keeps getting harder and stronger over time. Household concrete jobs must be cured for at least 28 days. For better strength and durability, cure concrete for 7 days. The longer concrete is cured, the closer it will be to its best possible strength and durability. Compressive strength of properly cured concrete is 80 to 100 per cent greater than the strength of concrete which has not been cured at all [11,21] Figure3.1 below shows different strength of cured and not cured concrete.

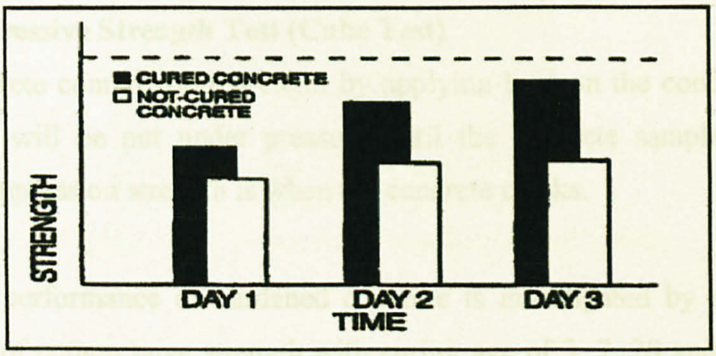

Figure 3.3 Graph Strength over Time of cured and uncured concrete

3.7 TESTING PROGRAM

Tests that are going to be conducted for this project were conducted during fresh and hardened concrete.

3.7.1 Slump test

The test was proposed for testing workability and deformability. No compaction energy must be applied during the test so that the HSC flows only under the influence of gravity. The desired slump result of this project is 100-150mm.

Tools : Standard slump cone, small scoop, bullet-nosed rod, ruler, slump plate.

Method:

1. Clean the cone and the slump plate. Collect a sample.
2. Fill 1/3 the volume of the cone with the sample. Compact the concrete by 'rodding' 25 times. Then fill to 2/3 and again rod 25 times, just into the top of the first layer.
3. Fill to overflowing, rodding again this time just into the top of the second layer. Top up the cone till it overflows and level off surface with the steel rod using a rolling action.
4. Carefully lift the cone straight up making sure not to move the sample.
5. Turn the cone upside down and place the rod across the up-turned cone.
6. Take several measurements and report the average distance to the top of the sample.
7. If the sample fails by being outside the tolerance (ie the slump is too high or too low), another must be taken. If this also fails the remainder of the batch should be rejected.

3.7.2 Compressive Strength Test (Cube Test)

Test the concrete compression strength by applying load on the concrete surfaces. The concrete will be put under pressure until the concrete samples crack. The maximum compression strength is when the concrete cracks.

Comparative performance of hardened concrete is investigated by measuring the development of compressive strength with curing age of 3, 7, 28 and 90 days. The compressive strength was taken as the maximum compressive load it could carry per unit area.

Procedure:

1. The specimen is removed from curing tank and the surface water is wiped and the specimen is grit off.
2. Each specimen is weight to the nearest kg.
3. The top and lower platens of the testing machine are cleaned. The sample is carefully centered on the lower platen and it is ensured that the load will be applied to two opposite cast faces of the sample.
4. The data is been set up depends on the size of the sample tested and the pace rate automatically set constantly.
5. Without shock, the load is applied and increased continuously at a nominal rate within the range of 0.2 N/mm^2 to 0.4 N/mm^2 until no greater load can be sustained. The maximum load applied to the cube is recorded.
6. The stress of each is calculated by dividing the maximum load by the cross sectional area. For automatic machine the stress is already stated.

The compression test shows the best possible strength concrete can reach in perfect conditions of hardened state. The testing is done in a laboratory off-site. The only work done on-site is to make a concrete cubes for the compression test. The strength is measured in Megapascalderneds (MPa). [11]

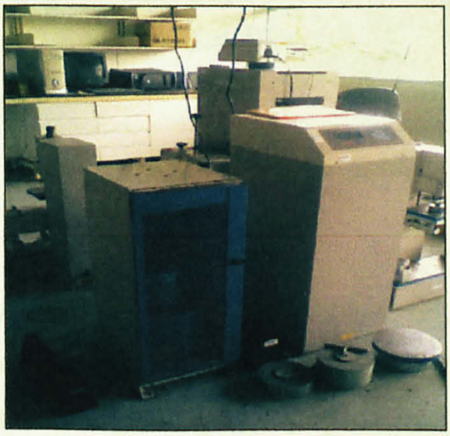

Figure 3.4: Compression machine (ADR 1500)

3.7.3 Split Cylinder Test

Comparative performance of hardened concrete is investigated by measuring the development of its split cylinder test with curing age of 28 and 90. This test is similar to the compression test in order to obtain its maximum tensional strength by using the compression machine (ADR 1500). It differs to the compression test by locating the cylinder into its holder then only places it into the machine.

This method consists of molding a concrete cylinder with an installed steel tube or reinforcing bar through its center upon which strain gages are mounted. The tensile strength of a material is the maximum amount of tensile stress that it can be subjected to before failure. The definition of failure can vary according to material type and design methodology. There are three typical definitions of tensile strength:

1. Yield strength: The stress at which material strain changes from elastic deformation to plastic deformation, causing it to deform permanently.
2. Ultimate strength: The maximum stress a material can withstand.
3. Breaking strength: The stress coordinate on the stress-strain curve at the point of rupture

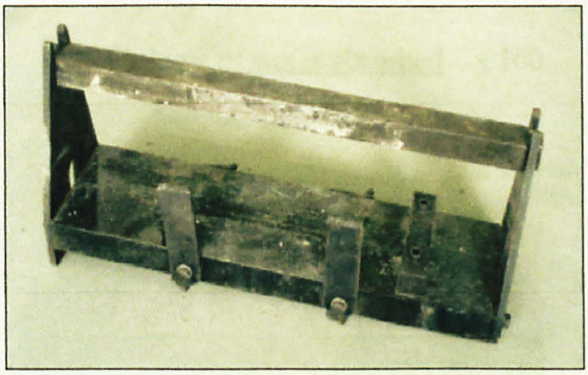

Figure 3.5: Cylinder holder

3.7.4 Porosity Test

Porosity determines the durability of the concrete. Concrete of a low porosity will afford better protection to reinforcement within it than concrete of high porosity. High porosity does not necessary will give high permeability.

There are no vacuum absorption tests in the British Standards, although an earlier version of BS 3921 did contain such a test.

The porosity test for this project is using vacuum saturation method. Vacuum saturation is a method of assessing the total water absorption porosity of a material. Porosity can be determined by measuring its weight gain and expressing this as a percentage of the mass of the sample. To determine the porosity of each samples, the procedures are as below :

1. Select sample to core and take out three cores of each sample
2. Put in your sample without water and vacuum for about 30 minutes
3. Fill in water, submerge the cores and then vacuum in for 6 hours
4. Close the vacuum container and Leave the samples for 24 hours
5. After 24-hours soaked in water, the samples were dried at 100 ±5°C.
6. Take the samples out and weight it, both in water and air by using buoyancy balance. Record the weight as W_{sat} and W_{water}
7. Put the samples in the oven for 24 hours to enforce the water out of the samples
8. Weight the samples again as W_{oven}. Record the values
9. After collecting values of W_{sat}, W_{water} and W_{oven} of each samples; then The vacuum saturation porosity, P can be calculate from:

$$P = \frac{\text{Volume of water absorbed}}{\text{Volume of sample}} \times 100$$

$$P = \frac{W_{sat} - W_{oven}}{W_{sat} - W_{water}} \times 100$$

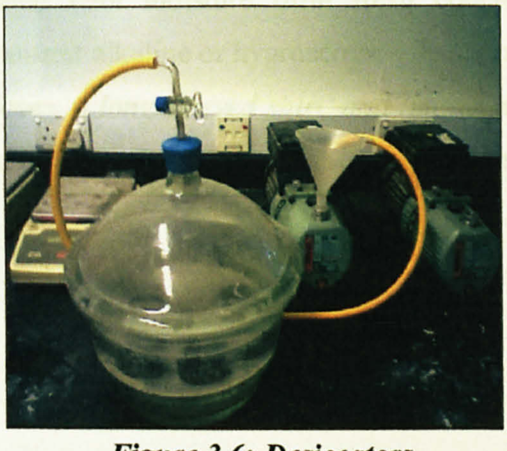

Figure 3.6: Desiccators

3.8 HEALTH, SAFETY AND ENVIROMENT EFFECT

Concrete is easy to work with, versatile, durable, and economical. By observing a few basic precautions, it is also safe-one of the safest building materials known. Outlined below are some simple suggestions-protection, prevention, common sense precautions-useful when working with Portland cement and concrete:

1. *Protect Your Head and Eyes* - Construction equipment and tools represent constant potential hazards to busy construction personnel. It is therefore recommended that some sort of head protection, such as a hard hat or safety hat
2. *Proper eye protection* - Eyes are particularly vulnerable to blowing dust, splattering concrete, and other foreign objects. On some jobs it may be advisable to wear full-cover goggles or safety glasses with side shields.
3. *Protect Your Back*- All materials used to make concrete-portland cement, coarse aggregate, sand, and water-can be quite heavy even in small quantities. When lifting heavy materials, your back should be straight, legs bent, and the weight between your legs as close to the body as possible.
4. *Protect Your Skin* -. Prolonged contact between fresh concrete and skin surfaces, eyes, and clothing may result in burns that are quite severe, including third-degree burns. For deep burns or large affected skin areas, seek medical attention immediately.
5. *Clothing* - worn as protection from fresh concrete should not be allowed to become saturated with moisture from fresh concrete because saturated clothing can transmit alkaline or hygroscopic effects to the skin.
6. *Waterproof gloves, a long-sleeved shirt, and long pants should be worn* - If you must stand in fresh concrete while it is being placed.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 INTRODUCTION

Concrete properties can be divided into two which is fresh and hardened concrete. In this study, slump test was conducted to measure the workability of concrete in fresh state. Hardened concrete measured by conducting compressive strength test, split cylinder test and porosity test. These parameters are required in order to establish the performance of concrete containing used engine oil and silica fume.

4.2 SLUMP TEST

Slump test is a very simple test of apparatus and procedures required, therefore it become one of the test that most widely used in measuring the workability of fresh concrete. The slump test is useful in ensuring the uniformity among different batches of supposedly similar concrete under field condition.

In this study, the workability was set to be high which is around slump of 100-150 mm in order to produce high fluidity concrete that is easier and faster for vibrating, pouring and transfer at site. Low workability concrete could be difficult to vibrate at site which resulting of voids and honeycomb to concrete and reduce the concrete strength.

Prior to that, the water to bind ratio was manipulated to achieve the target slump. Comparison between the slump of mixes and water to bind ration are illustrated in Figure 4.1.

From the result obtained, Mix M100_0 (100% UEO) needs 13.8% of water to bind ratio more than Mix M0_100 (100% SP) to get the same slump value. For all other mixes; the water to bind ratio are same, which show that UEO in concrete mixes increase the workability of concrete up to 20% compare to normal concrete. It also shows that water demand of concrete mixes consists of UEO and superplasticizer are almost the same. M0_100 is the best proportion because of the lowest water to bind ratio of 0.36

Table 4.1: Result of Slump Test

Mix	UEO (%)	SP (%)	w/b	Slump (mm)
CM	-	-	0.51	100
M0_100	-	3	0.36	100
M100_0	3	-	0.41	110
M50_50	1.5	1.5	0.41	100
M30_70	0.9	2.1	0.41	125
M70_30	2.1	0.9	0.41	110

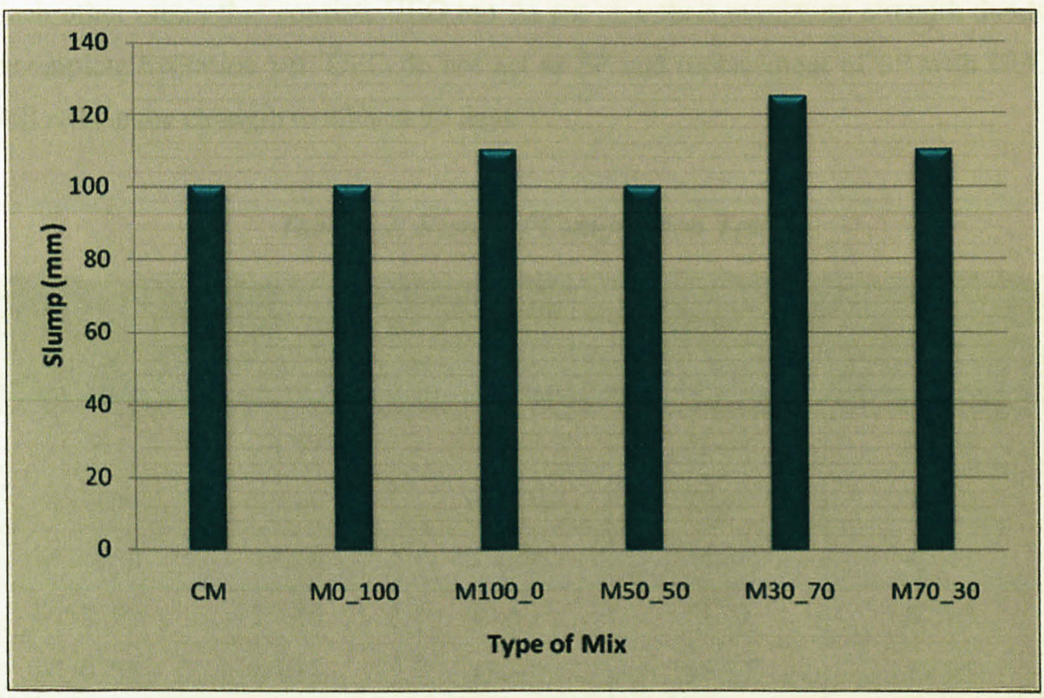

Figure 4.1: Bar Chart of Slump (mm) versus Type of Mix

4.3 COMPRESSTION TEST

For the purpose of this study, concrete with characteristic compressive strength greater than 60 MPa will be considered as 'high strength'.

Compressive strength of each mix was measured at the age 3, 7, 28 and 90 days and the result is shown in Figure 4.2. From the result obtained, the highest compressive strength for concrete can achieve a maximum strength to 70.60 at 90 days age by mix M0_100. Referring to Table 4.2, the maximum increment of compressive strength from 7 to 28 days is 17% while there is no increment of compressive strength from 28 to 90 days show that the concrete produce high early age strength. The concrete hydration had completed by day 28 and would not develop strength anymore.

The concrete strength for 90 days is increasing with SP contents, the concrete strength of mix M30_70 is high due to 2.1% of SP. Somehow, the increment of compressive strength for mix M100_0 from day 28 to 90 days is 18% which is still a high increment and show that the concrete did not yet achieve its peak strength. Each other mixes that consists UEO too do not give their maximum strength due to incomplete hydration yet. UEO do not act as SP and replacement of SP with UEO will reduce the strength to 43% at 90 days.

Table 4.2: Result of Compression Test

Mix	Compressive Strength (Mpa)			
	3	7	28	90
CM	18.89	26.9	31.34	34.36
M0_100	56.12	60.15	70.45	70.60
M100_0	15.56	25.39	34.36	40.47
M50_50	29.45	40.57	51.11	57.65
M30_70	40.11	45.87	48.27	61.95
M70_30	23.96	26.03	29.83	37.81

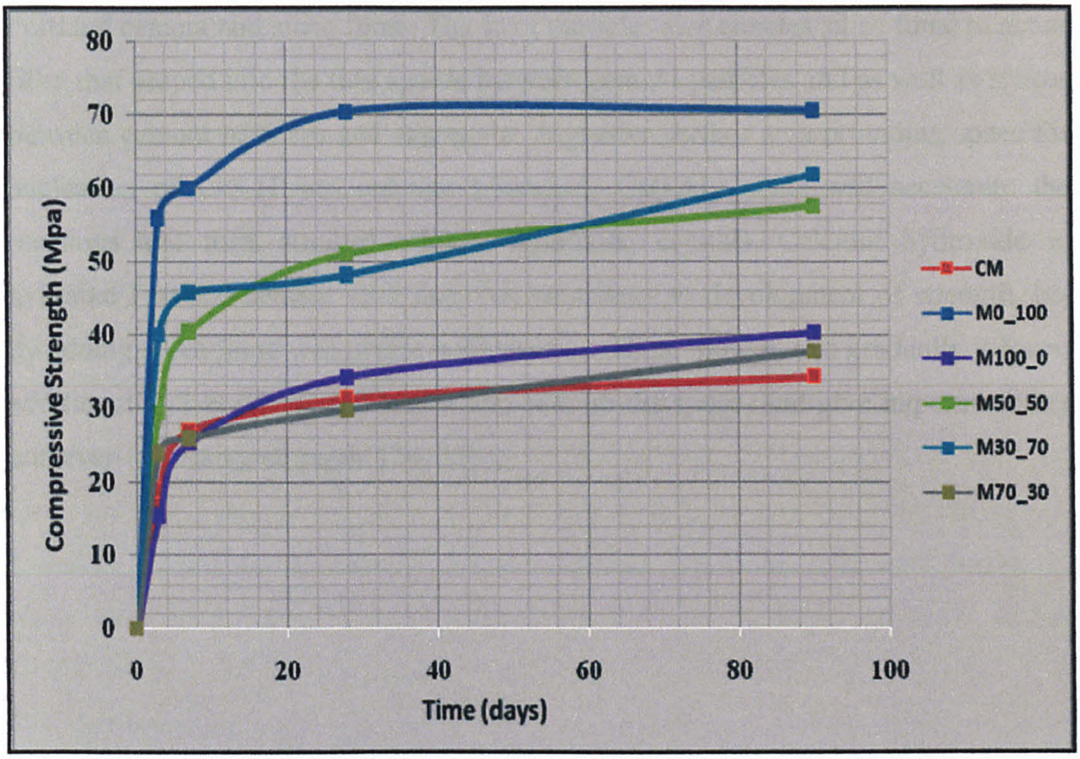

Figure 4.2: Graph of Compression Strength (Mpa) versus Time (days)

The use of superplasticizer contributes to producing result such mix M0_100. Superplasticizer act as water reducer so that can improve the workability with low water to binder content. It performs their function by deflocculating the agglomerations or lumps of cement grains. In the normal stage the surface of cement grains contain a combination of positive and negative chargers. As they are agitated and bump into each other, they are repealed if same chargers approach each other and attracted if opposite chargers approach. On the other hand, superplasticizer consist of very large molecules (colloidal size), which dissolve in water to give ions with a very high negative chargers (anions). These anions adsorbed on the surface of cement particles in sufficient number to form a complete monolayer around them to become predominantly negatively charged. Thus they repeal each other and flocs in released and can then contribute to the mobility of cement paste and hence to the workability of concrete. [23]

The improvement of compressive strength is due to the pozzolanic reaction between Portland cement and silica fume. The finer particles size enables silica fume to act as filler that seeped into the tiny spaces between cement particles and as well as spaces between cement particles and aggregate. A greater surface area providing space for nucleation of C-S-H and calcium hydroxide $Ca(OH)^2$. This will accelerate the reactions and form smaller calcium hydroxide crystals. Calcium hydroxide in hydrated Portland cement such does not contribute to development of strength, but by adding silica fume will utilize with reactive silica. Slowly, and gradually it forms additional C-S-H which is a binder and fills up the space, and give impermeability and ever-increasing strength. [24, 25]

4.4 TENSILE TEST

The tensile strength governs the cracking behaviour and affects other properties such as stiffness, damping action, bond to embedded steel, and durability of concrete. It is also of importance with regard to the behaviour of concrete under shear loads. The tensile strength is determined either by direct tensile tests or by indirect tensile tests such as flexural or split cylinder tests.

For this experiment, the tensile strength test is determined by indirect tensile tests which are used split cylinder test. Tensile strength test was measured for every 28 and 90 days. Tensile strength was been tested using Compressive Strength Test Machine by constant pace rate 0.94. Each result for tensile strength is the average of three test values. Three cylinders were tested for splitting tensile strength (ASTM C496-96).

Table 4.3: Result of Tensile Test

Mix	Tensile Strength (Mpa)	
	28	90
CM	**2.51**	**2.57**
M0_100	**4.52**	**4.78**
M100_0	**2.89**	**3.72**
M50_50	**3.89**	**3.94**
M30_70	**3.76**	**4.64**
M70_30	**2.53**	**3.27**

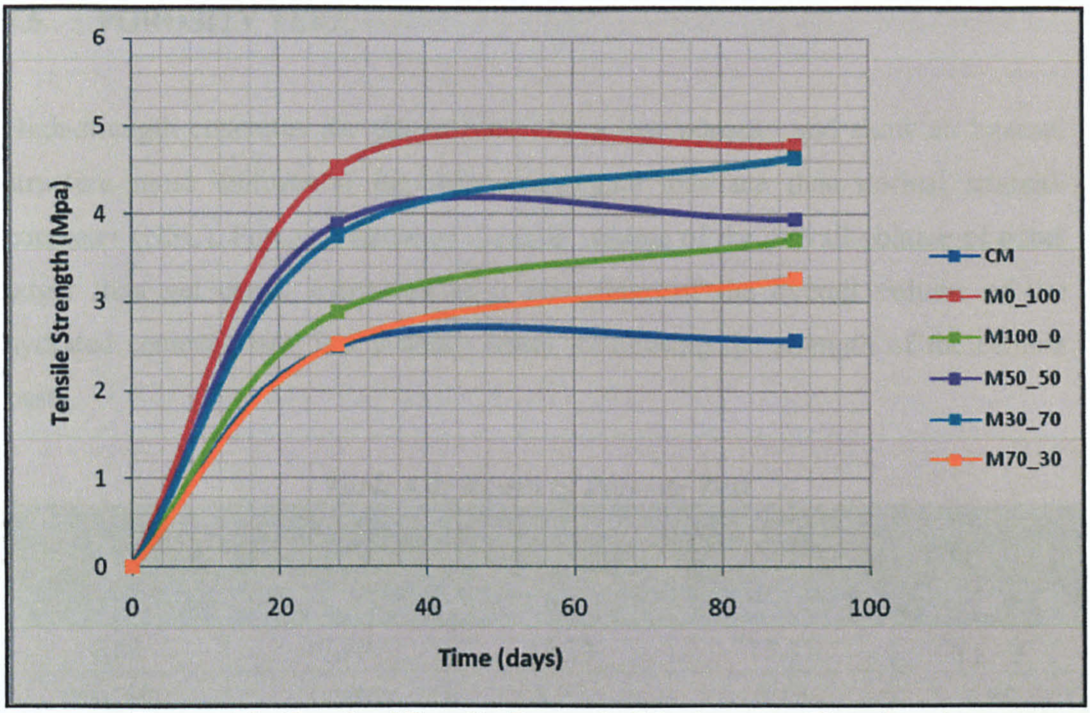

Figure 4.3: Graph of Tensile Strength (Mpa) versus Time (days)

From figure 4.3, it showed that mix M0_100 gained the highest tensile strength compared to other mixes. On the other hand, mix M100_0 and M70_30 give the lowest results of all mixes shows the lower the compressive strength the lower the tensile strength. From table 4.3, the increment of tensile strength for mix M100_0 is 30% compared to mix M0_100; the increment is below 10% which tells that mix contains UEO develop strength at slower rate.

Despite the results, there are several factors that contribute to affect the values obtained such as the mixture was not compacted well and cause cracking inside the cylinders. If the mixes were not well compacted, air bubbles or void will occur. Air bubbles in the moulds will become weak points during strength tests. Other reasons could be as the materials were not in a good condition such as the wet aggregate, and there was others wastes mix with the materials that can affect the quality of the strength. Sometimes it might caused by the machine error when the reading was taken.

4.5 POROSITY TEST

High-strength concretes are characterized by a low porosity and show an internal structure more uniform at the matrix-aggregate interface than normal strength concretes (NSC). Porosity define as the total volume of the overall volume of pores larger than gel pores, expressed as a percentage of the overall volume of the hydrated cement paste, is a primary factor influencing the strength of the cement paste.

Table 4.4: Result of Porosity Test

Mix	Porosity (%)			
	3	7	28	90
CM	**17.99**	**17.22**	**15.01**	**11.77**
M0_100	**6.89**	**6.07**	**5.15**	**4.88**
M100_0	**11.99**	**11.52**	**10.08**	**9.89**
M50_50	**7.87**	**7.45**	**6.97**	**6.85**
M30_70	**9.4**	**9.27**	**9.03**	**8.13**
M70_30	**7.74**	**7.59**	**7.32**	**7.1**

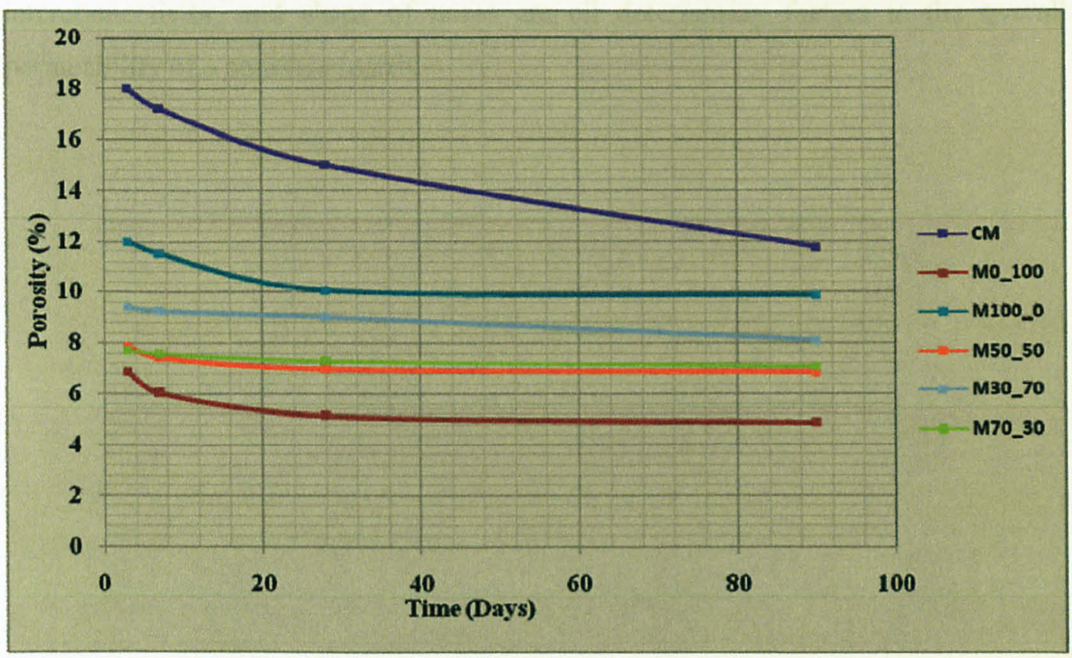

Figure 4.4: Graph of Porosity (%) versus Time (days)

Porosity of each mix was measured at the age 3, 7 and 28 and 90 days and the result is shown in Figure 4.4. From the result obtained, porosity of all samples decreased with increasing of time. The more lower the porosity, the more good of the concrete itself; concrete with lower porosity afford better protection from environmental attack compare to concrete of high porosity. As shown in Table 4.4, mix M0_100 gained the lowest porosity after 90 days while mix M100_0 gained the highest porosity compared to other mixes. Theoretically, the higher the compression and tensile strength the lower the porosity.

Although aggregates are porous, it should be noted that their pores are normally discontinuous in a concrete matrix, being completely enveloped by cement paste. Detached voids or pores in concrete, including entrained air bubbles that are discontinuous similarly do not contribute significantly to concrete permeability. Concrete porosity is usually expressed in terms of percentage by volume of concrete. It is the interconnectivity of pores, rather that total porosity that determines a concrete's permeability. A concrete with a high proportion of disconnected pores may be less permeable that a concrete with a much smaller proportion of connected, or continuous pores. With greater particularity, it is the overall nature of the matrix pore structure that ultimately affects its permeability. The size, distribution, interconnectivity, and shape of pores are all determining factors in the overall permeability of a concrete matrix.

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

This project presented the results of a research study on the effect of high strength concrete by using used engine oil. From the tests that have been carried out, it was found that used engine oil did not adversely affect the strength development process of concrete, 28 days strength of at least 60MPa. On the other hand, silica fume in concrete design shows the opposite. High strength concrete can be produced with addition of SF such 10%. It showed that concrete mix M0_100 of water content 0.36 is the best proportion since it achieved the highest compressive strength with high tensile strength and low porosity.

5.2 RECOMMENDATION

As for recommendation, this mix design cannot yet be applied by the industries to solve the problems stated above before any extended research (ex: 1year curing duration or other additional type of concrete test such as compaction factor test as another way to measure concrete workability) so that we can evaluate the results of UEO effect to concrete strength development though it is possible to use a little amount of UEO in concrete because it do work to increase the workability of concrete with low water to bind ratio other than the fact we would have a solution to dispose UEO and turn the waste into value.

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APPENDICES

APPENDIX 1

Lab Procedures

LAB PROCEDURES

MIXING CONCRETE

1. Weigh out proportions as per specific for the batch of concrete.
2. Divide the water into two buckets, one with about 3/4 of the water. Put the superplasticizer and used engine oil in the 3/4 water bucket.
3. Put about half the coarse aggregate and the 3/4 bucket of water with air entraining in the mixer.
4. Start the mixer.
5. Add the rest of the coarse and fine aggregate.
6. Carefully add all the cement with the mixer running. Mix until all the cement is blended in.
7. Add enough water from the final quarter of the water to produce a workable mix.
8. Mix for three minutes, followed by a three minute rest, followed by a two minute final mixing. Cover the mixer opening with a damp towel while not running.
9. Perform a slump test. If results are satisfactory, skip to the next step.

   If the slump is less than required, return the concrete to the mixer, add the remaining water, and mix for one minute.

   Perform a second slump test. If results are satisfactory, go on to step 10.
10. Record the final slump.
11. Record the actual weight of water and cement used

APPENDIX 1-2

SLUMP TEST

1. Dampen the slump test mold and place it on a flat, moist, nonabsorbent, rigid surface, like a steel plate.
2. Fill the mold to 1/3 full by volume (about 2 1/2 inches), and rod the bottom layer with 25 evenly spaced strokes.
3. Fill the mold to 2/3 full (about 6 inches), and rod the second layer with 25 strokes penetrating the top of the bottom layer.
4. Heap the concrete on top of the mold, and rod the top layer with 25 strokes penetrating the top of the second layer.
5. Strike off the top surface of the concrete even to the top of the mold.
6. Remove the mold carefully in the vertical direction (take about five seconds).
7. Immediately place the mold beside the slumped concrete and place the rod horizontally across the mold, and measure the slump, in inches, to the nearest 1/4 inch. The slump test should take approximately 2 1/2 minutes.

CASTING CYLINDERS

1. Place the casting molds on the concrete floor.
2. Fill the mold to 1/3 full by volume (4 inch depth) and rod the bottom layer with 25 strokes evenly spaced.
3. Fill the mold to 2/3 full (8 inch depth) and rod the second layer with 25 strokes penetrating the top of the second layer.
4. Heap the concrete on the top of the mold and rod the top layer with 25 strokes penetrating the top of the second layer.
5. Tap the sides of the mold lightly to close the voids left by the rod.
6. Strike off the top surface of the concrete using a sawing action with the rod. Take special care to smooth the surface. Be sure to mark the cylinders with name, cylinder number, mix number, and date.
7. Carefully move the cylinders to temporary storage.
8. Cover the cylinders with a cap or plastic bag.
9. After 20 to 48 hours, remove the molds and place them in the curing tank
10. Transfer your identifying marks from the molds to the top of the cylinders.

STRIPPING CYLINDERS

1. Drive the stripping tool (looks like a large screwdriver with a 3-way head) down between the plastic cylinder mold and the cylinder, splitting the mold.
2. Split the opposite side of the cylinder mold
3. Stack up the split cylinder molds in the trash
4. Label the cylinders with a marker
5. Place the cylinders in the curing tank

APPENDIX 2

Figures

Figure 1: Photographs taken during the project :(From left to right)
a. Mixing the concrete
b. Take out the samples from curing tank for testing purpose
c. Test the compressive strength of the concrete
d. Vacuum the cores for porosity test
e. Weight the cores for porosity test

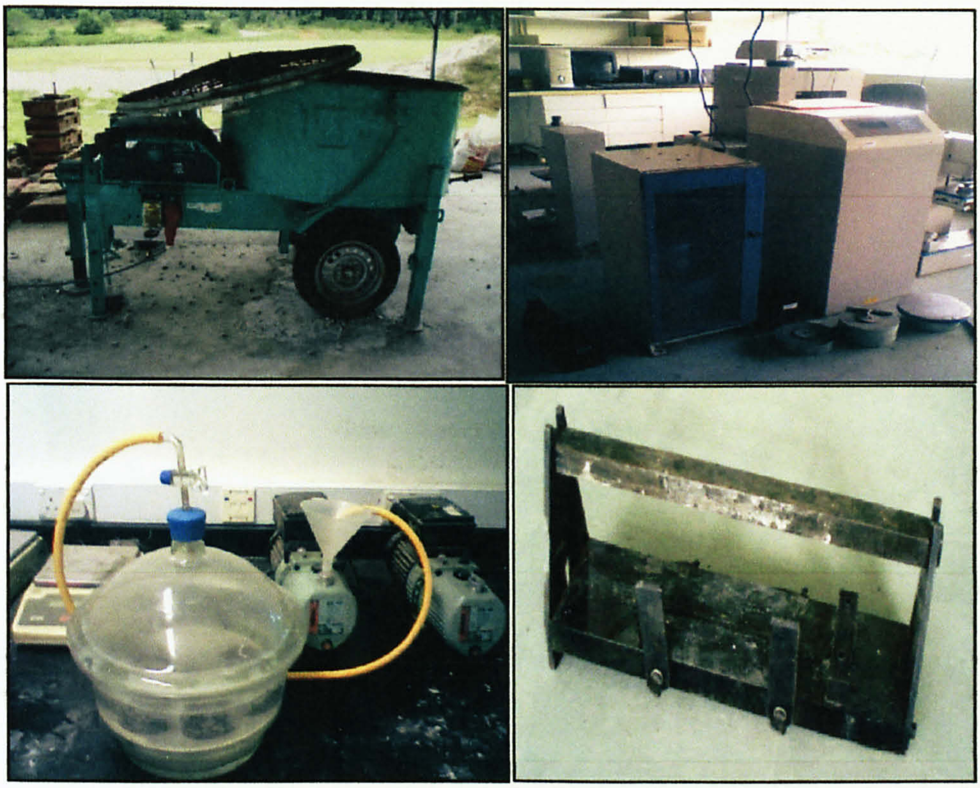

Figure 2: Photographs taken of instrument and lab materials :(From left to right)
a. Mixer machine
b. Compression machine (ADR 1500)
c. Desiccators
d. Cylinder holder

APPENDIX 3

Gantt Chart : Progress Flow

Gantt Chart for FYP I

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic											Mid-semester break			
2	Literature Review and Seminars														
3	Submission of Preliminary/Progress Report							●							
4	Concrete Mixing and Curing														
5.	Concrete Testing														
6.	Submission of Interim Report Final Draft												●		
7.	Oral Presentation														

● Milestone

Process

APPENDIX 3-1

Gantt Chart for FYP II

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue	■	■	■					Mid-semester break							
2	Submission of Progress Report 1				●											
3	Project Work Continue				■	■	■	■								
4	Submission of Progress Report 2									●						
5	Seminar (compulsory)										■	■	■			
5	Project work continue									■	■	■	■			
6	Poster Exhibition											●				
7	Submission of Dissertation (soft bound)													●		
8	Oral Presentation														●	
9	Submission of Project Dissertation (Hard Bound)															●

● Milestone

■ Process

APPENDIX 3-2