CHAPTER 1

BACKGROUND OF STUDY

1.1 Introduction

Concrete is a mixture of paste and aggregates. In order to get more strength in concrete, there are many of material that has been used in concrete mix design to increased shear. One of material that has been used in concrete mix is steel fibre reinforcement. So, the Fibre Reinforced Concrete will form.

The definition of Fibre Reinforced Concrete is the concrete made with hydraulic cement, containing fine or fine and coarse aggregate and discontinuous discrete fibre or concrete incorporating relatively short, discrete and discontinuous fibres.

Reinforcing the cement based matrix with fibers would contribute towards the following aspect:

a) Increase the tensile strength by delaying growth of cracks.
b) Increase the toughness by transmitting stress
c) Improves the impact strength and fatigue strength
d) Reduce shrinkage.

Among characteristic of fibers that has influence on the response of the composite are type of fibre, the length of fibre, the volume fraction of fibre and the bond of the fibre with the matrix.

There are so many advantages of fibers in concrete:

a) It reduces the bleeding
b) It improves the cohesion of concrete mix.
c) It provides a considerable amount of post-cracking “ductility” or toughness of Fibre Reinforced Concrete. When the fibre volume is increase, the toughness is also increase.

The usage of fibre in concrete is also will be affected to the workability. There are also having disadvantages. The workability of this type of concrete will be low due to integration of fibers. The loss of workability is proportional to the volume of concentration of the fibers in concrete. The other problem that will be appear to this concrete is more difficult to compact due to concrete that containing the fibre.

The types of fibers that always used in concrete mixing are:

a) Steel Fibers: It produced either cutting wire, by shearing sheets or from a hot melt extract. Crimped and deformed steel fibers are available both in full length or crimped at the ends only.
b) Asbestos Fibres
c) Synthetic Fibres
d) Natural Organic Fibres
e) Glass Fibres

1.2 Problem Statement

Steel Fibre Reinforcement Concrete (SFRC) materials are very attractive for use in civil engineering applications due to their high strength-to-weight and stiffness-to-weight ratios, corrosion resistance, light weight and potentially high durability. Their application is the most importance in the renewal of constructed facilities infrastructure such as building, bridge, pipeline, etc. Recently, their use has increased in the upgrading or retrofit of concrete structure. In some cases, it is necessary to change the existing structural system due to the change of usage rather than rebuilt a new structure.

A common example is removal of slab sections for staircase or lift core opening. As the opening take place, the strength capacity of the existing slab significantly reduced. Cracks occur at the edge of the opening with the increase of load due the strength concentration.

The applications of SFRC are able to overcome this problem. The SFRC will be function to overcome the problem of the concrete that has the weakness about the strength. The SFRC will be function to improve or increase the strength of the concrete due to the increase of the loading. This experimental will increase the strength of the concrete and also give the long life for the concrete itself. But, nowadays, engineers discover that by using the fibres, they can increase the strength of the concrete. SFRC is use all over the world to overcome the strength problem.

1.3 Research Objectives

The main objectives in this study are as follow:

a) To find the significant of shear due to a variation of steel fibre ratios in beam design.

b) To find out the value of compressive and bending stress of the specimen.

c) To compare and choose the optimum percentage of steel fibre contents in concrete structure respect to it shear strength.

1.4 Scope of study

In order to achieve the objective of this study, a compression test and bending test was implemented which was accordance to the ASTM C-78 respectively.

The concrete grade of 30 N/mm² was used during the preparation of the concrete mixture for the usage of normal concrete as the control sample and sample with 0.15%, 0.25%, 0.35%, 0.45% and 0.55% of steel fibre.

Adding fibres to concrete improves mechanical properties:

a) Increases toughness
b) Increases ductility and flexural resistance
c) Gets higher and more stable tensile strength
d) Increases shear resistance. (*Maccaferri, 2009*)

Steel fibre-reinforced concrete increases strain capacity and impact resistance, as well as energy absorption and tensile strength. (Nguyen *Van CHANH)*

Concrete design is the main scope for this study. First and foremost, the normal design will be use for the concrete mixing and the steel fiber will be the addition stuff that will be use in the concrete. The steel fiber will be adding in the concrete to archive the objective for this study.

The strength for the concrete in this study is 30 N/mm² at 28 days and proportion defective is 5%. For the standard deviation, the fair control with weight batching will be use. Two of different size of aggregate will be use. Referring to the standard table, the coarse aggregate will be crush to give the strength for the concrete and for the fine aggregate, uncrushed aggregate will be use to present the bonding between the aggregate. For the water cement ratio, the value is 0.62 will be use in this study.

By referring to the objective of this study, the material properties can be determined by doing some testing on the concrete. The testing are Compressive Strength Test, Flexural Test, Tensile Test and Stress and Strain Test. In the other hand, the physical properties of the concrete can be also determined by doing some testing such as Slump Test.

To determine the workability of the concrete, the Slump Test and Compacting Factor Test can be done. All of these tests can be called as Non-Destructive Test. It is because when doing this testing, the sample do not been crushed to get the result. Most engineers used Slump Test to determine the workability of the concrete.

Slump Test is carried out to measures the consistency of plastic concrete. This test is being used extensively on site. There are three types of slumps which is true slump, shear slump and collapse slump.

For the physical properties (Destructive Test), one of the tests is Concrete Flexural Test. The objective of this test is to prescribe and describe the flexural strength test of specimens of hardened concrete and demonstrate the method for determining the flexural strength of concrete beam by means of a constant moment in the centre zone (two-point loading).

Steel fiber will be use to the next step. This purpose of the steel fiber in this study is to increase the strength of the concrete structure. The percentage of the steel fiber in the concrete will be different between other concrete because from here the differential of the strength will be shown. But, the controller of the concrete also must be done to make a comparison between concrete with steel fiber and concrete without steel fiber. For the control, the steel fiber is not added to the concrete.

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Finally, the most important is the calculation part that must be correct because the amount of sand, aggregate, cement and steel fiber will be considered. The percentage of the steel fiber in the concrete is depending on the weight or volume of the concrete. But, for this study, the percentage of the steel fiber is depending on the weight of the concrete itself. The percentage of the steel fiber will be increase due to check the increasing of the strength of the concrete.

1.5 Significant of Study

The significant of this study is to improve the strength of the conventional concrete by using the steel fibre. When the strength of the concrete can be controlled, the long life of the building also can be controlled. Therefore, it easily can manage the life of the building for make it more safety and in good strength. In other words, the strength can be improved to be the highest as it can and can be controlled for the good safety factor.

The other significant is too involved in the new technology by using the steel fibre and used it in others way. Nowadays, the new technology must be learn to make someone life flow with the technology. Back to the old method that only uses concrete without fibre. This method make the strength of the concrete depend to the ratio of the concrete mix design. But, by using the steel fibre, the strength is depending on the percentage of the fibre and it also depend on the concrete mix design.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Fibre Reinforced Concrete (FRC) is defined as composite materials made by Portland cement, aggregate and incorporating discrete discontinuous fibers. The addition of fibre to concrete is one of the ways of increasing the strength of concrete. The real contribution of the fibres is to increase the toughness of the concrete (defined as some of function of the area under the load vs deflection areas), under any type of loading. That is, fibers tend to increase the strain at peak load and provide a great deal of energy absorption in post peak portion of the load vs. deflection curve. (*Nguyen Van CHANH*)

When the fibre reinforcement is in the form of short discrete fibers, they act as rigid inclusions in the concrete matrix. Physically they have same order of magnitude as aggregate inclusions; steel fibre reinforcement cannot therefore be regarded as a members. However, because of the inherent material properties of fibre in the body of concrete or the provision of tensile skin of fibre concrete can be cracking, deflection and other serviceability conditions.

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The fibre reinforcement may be used in the form of three, dimensionally randomly distributed fibers throughout the structural members when the added advantages of fibers to shear resistance and crack control can be further utilized. On the other hand, the fibre concrete may also use as a tensile skin to cover the steel reinforcement.

2.2 STEEL FIBRE

There are a number of different types of steel fibers with different commercial names. Basically, steel fibers can be categorized into four groups depending on the manufacturing process like cut wire, slit sheet, melt extract and mill cut.

Various notations, were previously used to nominate the specific type of the steel fibers like

a) (h x w x l) to nominate the straight rectangular section steel fibers. The letter h, w, l stands for section depth, width and the fiber length.

b) (d x l) was used to named circular or semi circular section straight or deformed steel fibers, d and l stand for diameter and length.

c) Hook ended steel fiber (i.e. 80/60 H means aspect ratio/length of steel fiber).

Major efforts have been made recent years to optimize the shape and size of the steel fibers to achieve improved fiber-matrix bond characteristics and to enhance fiber dispensability. It found that SFRC containing hook-ended stainless steel wires has better physical properties than that containing straight fiber. In addition, the high tensile stresses localized at cracks necessitate that steel fibers have high tensile strength. A typical steel fiber tensile strength is ranged between 1100 and 1700 Mpa.

Apart from other mix constituents, there are four important parameters found to affect the properties of, namely, type, and shape of fibers, dosage, aspect ratio, and orientation of fibers in the matrix.

2.3 CONCRETE MIX DESIGN

The main objective in designing a structural fiber concrete mix is to produce adequate workability, ease of placing and efficient use of fibers as crack arrestors, besides the others objectives desired in any normal concrete.

Preliminary trial mixes indicated that the addition of steel fibers to a properly designed concrete mix reduced the slump. To maintain the level of workability and to ensure adequate bond of the fibers to the concrete matrix, it was concluded that the addition of steel fiber to the concrete mix should be accompanied by the addition of cement paste. The amount of added cement paste depends on three principal factors as follows:

a) Amount of fibers

b) Shape and surface characteristics of the fibers

c) Flow characteristics of the cement paste.

Normal concrete mix proportioning criteria's can be used for the designing of trail mix there after the workability can be adjusted when adding steel fibers.

The mechanistic mix proportioning design method, introduced by the Portland Cement Association in 1977 was based on three principles:

a) The addition of steel fibers should be accompanied by the addition of an amount of cement paste sufficient to coat the fibers and to ensure their bond in the concrete mix.

b) The added fibers and cement paste should be treated as a replacement for an equivalent volume of the plain concrete mix.

c) Water cement ratio in both plain and SFRC mixes remains unchanged.

A holistic mix proportioning approach does not exist yet and the reason for this could be the large variety of steel fiber types available, as well as the high number of parameters influenced by the use of SFRC. In practice an indication of the mix proportionally is given. It has recommended that large aggregates (38mm) are suitable for SFRC pavement bearing in mind that the steel fibers should have length greater than the largest aggregates.

The ACI committee has given the following guidelines to serve the purpose of SFRC mix design:

a) Coarse aggregates should be limited to 55% of the total aggregates.

b) W/C should be kept below 0.55 (0.35bis recommended).

c) Minimum cement content of 320 kg/m^3 should be used.

d) Reasonable sand content of 750 – 850 kg/m^3 is recommended.

e) The workability could be improved by increasing the cement paste, which is possible by addition of slag or fly ash to replace the cement.

f) Maximum aggregate size is to be 19mm.

2.3 ADVANTAGES AND DISADVANTAGES

Generally, the increases of ductility, toughness, strength, fatigue endurance, deformation characteristics are the reason for the major saving in time, cost and materials when using SFRC.

Despite of SFRC excellence and superiority, drawbacks exist. Loose fibers at the hardened surface might be blown onto aircraft engines or tire, which leads to unsafe operations. Injury to personnel being scraped or cut by and exposed fiber while working on the concrete surface is also possible. Packard et al reported that the residential street project was overlaid due to complaints from some residents because children suffered skin abrasions from falls on the pavements. Safety equipment is recommended to protect the personnel during construction, magnetic fields can be used to collect the loose fiber prior to opening the traffic and finishing techniques can be applied to knock fibers down while surfacing. Corrosion of the surface could take place, eventually influencing the appearance of the surface.

2.5 MECHANICAL PROPERTIES

2.5.1 Shear Strength

Shear strength capacity is important for pavements. Corner and edge break off might occur as the result of exceeding the shear capacity of concrete , storage racking or raised storage legs can also punch on the floor. The k knowledge of the shear capacity and behaviour of materials should therefore be applied to pavements

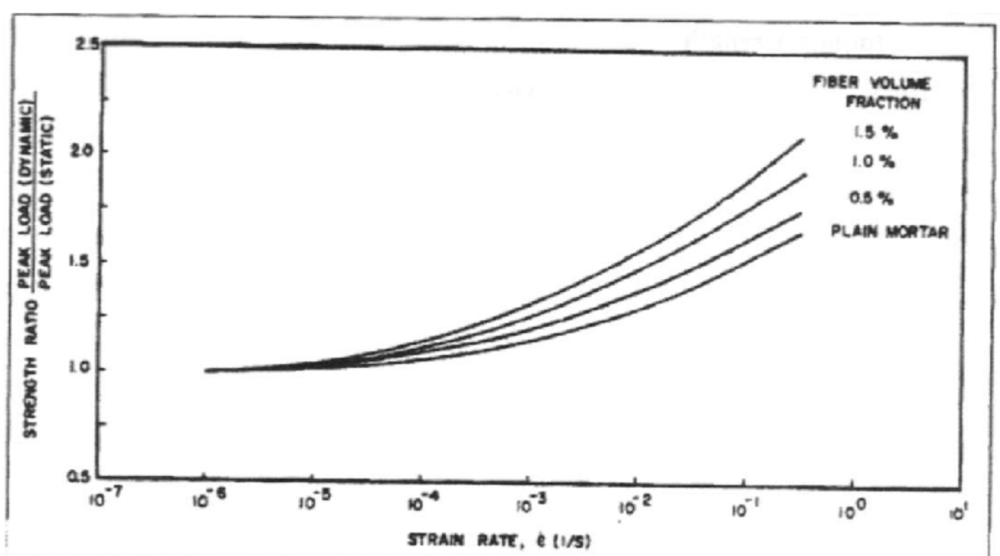

Figure 2.1 S-N relationship based on First Crack Strength from ASTM D6916

2.5.2 Flexural Strength

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol σ.

The flexural strength would be the same as the direct tensile strength if the material was homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to direct tension then all the 'fibers' in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore it is common for flexural strengths to be higher than direct tensile strengths for the same material. Conversely, a homogeneous material with defects only on it might have a higher direct tensile strength than flexural strength.

There are several calculations to measuring the flexural strength:

For a rectangular sample under a load in a three-point bending setup:

$$\frac{3LP}{2bd^2}$$

- *P* is the load (force) at the fracture point
- *L* is the length of the support span
- *b* is width
- *d* is thickness

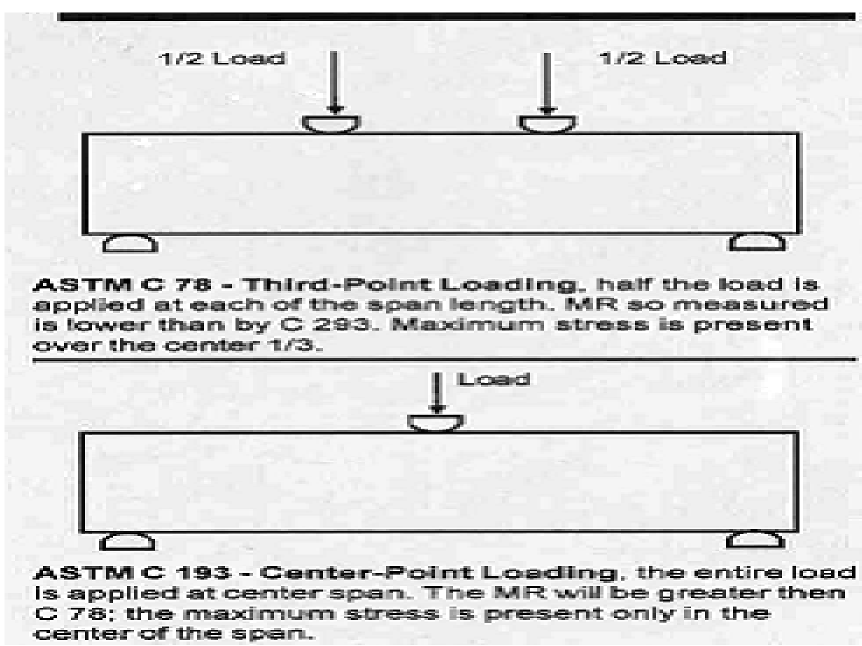

Figure 2.2: Flexural test from ASTM C 78 and ASTM C 193

2.5.3 Compressive Strength

It has been found by many researches that the inclusion of steel fibre in concrete increases it is compressive strength value relative to the fibre content. Their findings ranged between marginal and significant increases in compressive strength.

Maximum stress a material can sustain under crush loading. The compressive strength of a material that fails by shattering fracture can be defined within fairly narrow limits as an independent property. However, the compressive strength of materials that do not shatter in compression must be defined as the amount of stress required to distort the material an arbitrary amount. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compression test.

According to Edginton et al, fibres in SFRC compacted by means of table vibration have a tendency to align themselves in planes at right angles to the direction of vibration. This indicates that the method of compaction can be an important parameter influencing the compressive strength of SFRC.

Perrie argued that, since the failure is initially due to breakdown at the aggregate interface, fibres are expected to have little effect on compressive strength of concrete. The influence of steel fibre on compressive strength should be taken as insignificant and the increase in compressive strength developed as the result of the presence of steel fibres should be considered to compensate for the vi\variation of the testing results due to variation of fibre orientation and content in different specimens. Thus, the compressive strength of the parent plan mix should be considered as the target compressive strength.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

There are several stages to finish this study. First stage for this study was material preparation. After that, the sample preparations for cube and beam mould were ready for concrete preparation. Concrete mix design were use to prepare the concrete and curing process were take place after all the concrete were casted into the moulds. For concrete cubes, there was a test after 7 and 28 days. Compressing test was done to the cubes while flexural test was done to the concrete beam after 28 days cured.

The final stage for this study was collect and analyzed the data. There were calculation and formula that were used to analyze the data. From the data, the report was compiled for this study.

3.2 SAMPLE PREPARATION

The Project Stages

a) Materials preparation (including formwork)
b) Sample preparation
c) Mixing Process
d) Curing
e) Testing
f) Data Collection

Types of mould that will be use:

a) Beam mould for bending test
b) Cube mould for compression test

Grade concrete 30 was designed in order to prepare the samples for testing. Portland cement was used in preparing samples for testing is accordance to ASTM C 150-04 (Standard Specification for Portland Cement).Fine aggregates used granular material which is passing 5 mm sieve and retained on 74-micron sieve. Granular material passing 20 mm sieve and retained on 5 mm sieve was used as a coarse aggregates. The range of size for the steel fibre used in this study is between 10 mm – 75 mm.

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3.3 SAMPLE TESTING

To determine the workability of the concrete, the Slump Test and Compacting Factor Test can be done. All of these tests can be called as Non-Destructive Test. It is because when doing this testing, the sample do not been crushed to get the result. Most engineers used Slump Test to determine the workability of the concrete. Slump Test is carried out to measures the consistency of plastic concrete.

For the physical properties (Destructive Test), one of the tests is Concrete Flexural Test. The objective of this test is to prescribe and describe the flexural strength test of specimens of hardened concrete and demonstrate the method for determining the flexural strength of concrete beam by means of a constant moment in the centre zone (two-point loading).

3.3.1 Slump Test

The Concrete slump test (or simply the slump test) is an in situ test or a laboratory test used to determine and measure how hard and consistent a given sample of concrete is before curing. The concrete slump test is, in essence, a method of quality control. For a particular mix, the slump should be consistent.

A change in slump height would demonstrate an undesired change in the ratio of the concrete ingredients; the proportions of the ingredients are then adjusted to keep a concrete batch consistent. This homogeneity improves the quality and structural integrity of the cured concrete.

Procedures of Slump Test

a) Place the mixing pan on the floor and moisten it with some water. Make sure it is damp and no free standing water remains.

b) Firmly hold the slump cone in place using the 2 foot holds.

c) Fill the bottom one-third of the cone with the concrete mixture. Then rodding the layer 25 times using a hemispherical tip 5/8-inch steel rod in a circular motion, making sure not to stir.

d) Add more concrete mixture to the two-thirds mark. Repeat rodding the layer 25 times again. Rodding just barely into the previous layer(1")

e) Fill up the whole cone up to the top with some excess concrete coming out of top, and then repeat rodding 25 times. (If there is not enough concrete from tamping compression, stop tamping, add more, then continue tamping at previous number)

f) Remove excess concrete from the top of the slump cone by striking off the top using the rod in a rolling motion until the concrete surface is flat with the top of the cone.

g) Slowly and carefully remove the cone by lifting it vertically (5 seconds +/- 2 seconds), making sure that the concrete sample does not move.

h) Wait for the concrete mixture as it slowly slumps.

i) After the concrete stabilizes, measure the slump-height by turning the slump cone upside down next to the sample, placing the rod on the slump cone and measuring the distance from the rod to the original displaced centre of the slumped concrete.

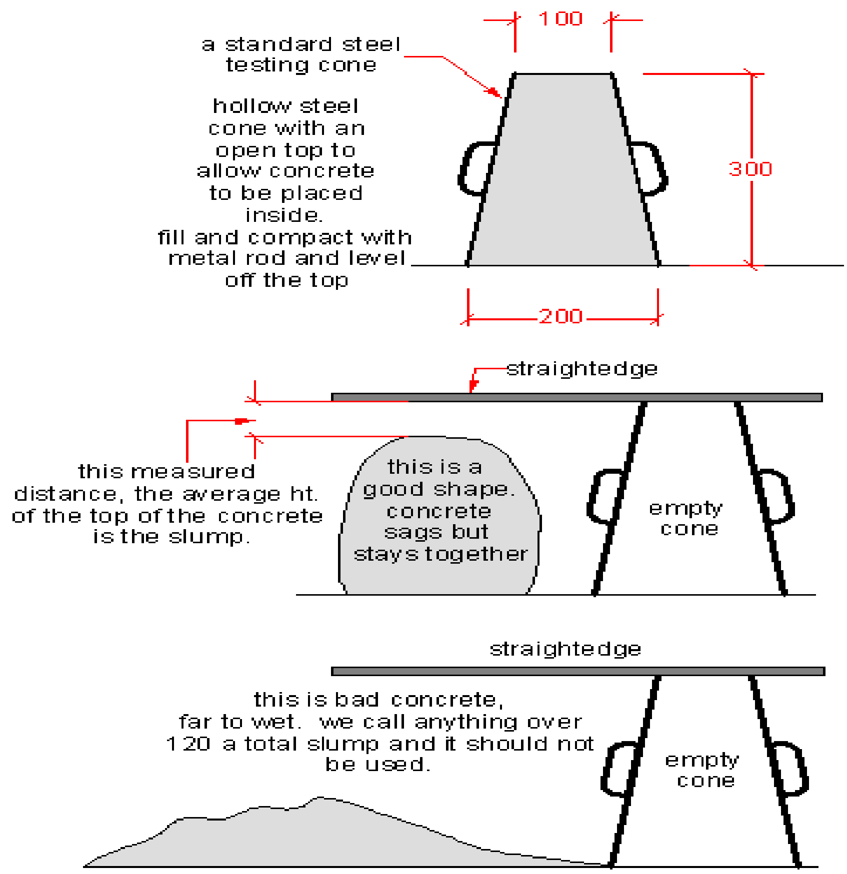

Figure 3.1: Procedure of Slump Test

Figure 3.2a: Slump Test

Figure 3.2b: Slump Test

Figure 3.2c: Slump Test

3.3.2 Concrete Compression Test

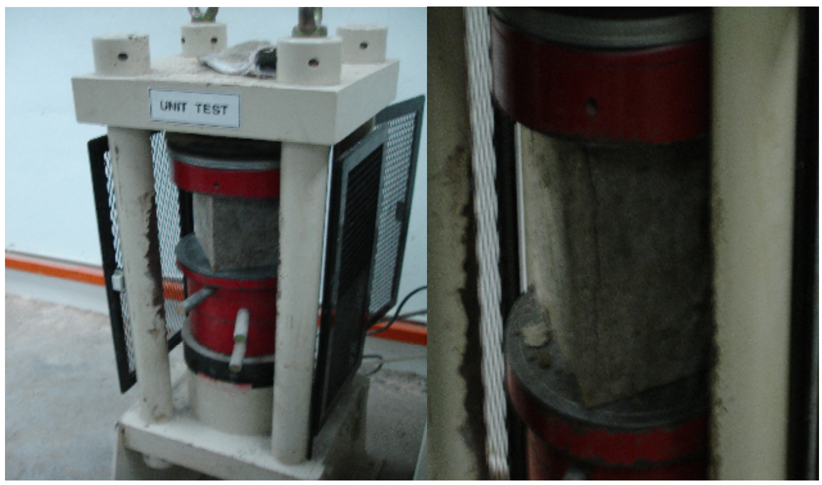

Figure 3.3: Compression Test.

Compressive strength is the primary physical property of concrete, and is the one most used in design. It is one of the fundamental properties used for quality control for lightweight concrete. Compressive strength may be defined as the measured maximum resistance of a concrete specimen to axial loading.

The ‘concrete cube test' is the most familiar test and is used as the standard method of measuring compressive strength for quality control purposes (Neville, 1994).