AN EXPERIMENTAL STUDY OF THE STRUCTURAL CAPACITY OF COMPOSITE BEAM (CONCRETE CAST C-BEAM)

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ABSTRAK

Kajian ini dijalankan untuk menentukan kekuatan muktamad rasuk keluli komposit. Objektif utama kajian ini adalah untuk menentukan beban muktamad, masa muktamad dan pesongan. Dalam kajian ini, tiga sampel telah digunakan untuk menentukan hasil purata yang tepat untuk memenuhi keperluan eksperimen. Menggunakan rasuk komposit dalam industri boleh mempercepatkan masa projek pembinaan kerana ia adalah mudah untuk dikendalikan dan tidak memerlukan kemahiran pakar dalam bidang pembinaan. ujian kekuatan mampatan telah dijalankan untuk memastikan kekuatan ciri konkrit yang dicapai. Magnus ujian bingkai telah dijalankan untuk menentukan keupayaan struktur muktamad bagi rasuk komposit dari segi beban muktamad, pesongan, tekanan dan ketegangan. Semua prosedur telah disediakan dengan sewajarnya, untuk memastikan objektif kajian akan dikenakan, dan untuk mendapatkan urutan yang betul dan kelancaran aliran keseluruhan, dari awal hingga akhir. Sampel telah disediakan dengan ciri-ciri yang sama. Ketiga-tiga sampel rasuk komposit telah dibuat di Makmal Struktur Berat, Universiti Malaysia Pahang (UMP) dan ujian kekuatan mampatan juga telah dijalankan di makmal sama. Data yang diterima menunjukkan bahawa objektif kajian berjaya dicapai. Dari ujian kekuatan mampatan, menunjukkan kepada kekuatan ciri-ciri konkrit telah digunakan untuk kajian ini adalah 23.95 Mpa yang hampir mencapai kekuatan yang dikehendaki. Dari ujian kerangka magnus, ia menunjukkan yang komposit rasuk segi empat tepat dengan saiz 150 x 300 x 2000 mm boleh menerima beban sehingga 113 kN. Manakala lenturan maksima berlaku antara tiga sampel hanya 7.42 mm. Hasil menunjukkan beban yang digunakan dan nilai ketegangan kedua-dua bahan yang konkrit dan keluli yang berkaitan. Di mana nilai tekanan meningkat bersama-sama dengan peningkatan beban yang digunakan untuk rasuk komposit sehingga ia gagal.

ABSTRACT

This study was conducted to determine the ultimate strength of a composite steel beam. The main objective of this study was to determine the ultimate load, deflection and the stress and strain value. In this study, three samples have been used to determine the average result that accurate for fulfilling the requirements of an experiment. Using composite beam in the industry can accelerate the time of a construction project because it is easy to handle and does not require the skills of an expert in the field of construction. Compressive strength test were conducted to ensure the characteristic strength of the concrete is achieve. Magnus frame test were conducted to determine ultimate structural capacity for composite beam in term of ultimate load, deflection, stress and strain. All the procedures are prepared accordingly, to assure the research objectives are applicable, and to secure proper sequence and smooth running of the entire flow, from start until end. The samples were prepared with same properties. All three samples of the composite beam have been cast at Heavy Structure Laboratory, University Malaysia Pahang (UMP) and compressive strength test also were conducted at same laboratory. The finding shows that the objectives of this study have been achieved. From compressive strength test, its shows the characteristic strength of the concrete have been used for this study is 23.95 Mpa which is nearly reached the required strength. From the magnus frame test, its shows the rectangular composite beam with size of 150 x 300 x 2000 mm can received load up to 113 kN. While the maximum deflection occurred among three samples only 7.42 mm. The result shows the load applied and the strain value of both material which are concrete and steel are related. Where the value of strain increase together with the increasing of load applied to the composite beam until it’s failed.

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LIST OF SYMBOLS

%	Percent
mm	Millimetre
mm^2	Millimetre square
m^3	Cubic metre
µm	Micro metre
g	Gram
kg	Kilogram
kg/m^3	Kilogram per cubic metre
N/mm^2	Newton per square millimetre
kN	Kilo newton
°C	Degree Celsius
°	Degree
kN/sec	Kilo newton per second
f_c	Compressive strength of concrete specimen
P	Maximum load carried by the specimen during testing
A	Area
l	Distance between the support
b	Net width
d	Depth

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Construction of composite steel and concrete structure is a well-known method because many advantages over conventional solutions. Composite construction has been mainly applied to bridges and multistory buildings, with the more traditional forms of composite beams and composite columns (J.Y. Richard Liew, 2003). The optimum combination of properties of two of the most popular construction materials consists of steel and concrete which is causing the structure more safe and economic. Composite steel beam combine the advantages of structural steel such as high strength, ductility and ease of erection while those of reinforced concrete such as high rigidity and low cost.

The reason why composite construction is often so good can be expressed in one simple way where concrete is good in compression and steel is good in tension. By joining the two materials together structurally these strengths can be exploited to result in a highly efficient and lightweight design. The reduced self-weight of composite elements has a knock-on effect by reducing the forces in those elements supporting them, including the foundations. Steel and steel-concrete composite construction provide a lighter structure with reduced foundation loads (J.Y. Richard Liew, 2003).Composite systems also offer benefits in terms of speed of construction.

1.2 Problem Statement

The construction industry has made impressive progress since reinforced concrete was introduced as structural material. Nowdays, construction industry all around the world is getting modern, advance and growing day by day. Inspite of the development, construction industry is dealing with one major problem such as building defects. Structural engineers are always striving to overcome challenge of defects in buildings but it is difficult to deal with it completely. A defect is a building flaw or design mistake that reduces the value of the building, and causes a dangerous condition. A construction defect can arise due to many factors, such as poor workmanship or the use of inferior materials. By using composite beam, the time of construction can be reduce and consequently the costs. These advantages of time reduce and cost happen due to elimination of formwork, elimination of excessive amounts of reinforcing steel and also unnecessary use of skilled labor.

1.3 Objectives of Study

There are three (3) main objectives for this project:-

i. To study the ultimate load of composite beam.

ii. To study the deflection of the composite beam.

iii. To study the stress & strain of the composite beam.

1.4 Scope of Study

This study is focused on the behaviour of composite beam in compression and tension state. Material that use in this beam is combination of concrete and steel C-beam. Type of beam for this study is simply supported beam with roller for both end connection. The size of the beam is fixed to 0.15m base x 0.3m height x 2m span dimension and for the cubes test, mould with size of 150mm x 150mm x 150mm will be use. For the curing process, the period of the concrete cube subjected to water is 28 days. The methods used for curing is water curing. While for the beam, the age of testing will be 28 days only with three sample for total. The test for compressive and flexural strength of the concrete cube is conducted after the process of curing for each specimen.

1.5 Importance of Study

This study provided all the information and knowledge regarding composite beam with using C-beam. The ultimate strength of the beam in term of load, deflection, strain and stress will be identified later on this study. The result from this study is expected to help increasing the sustainable of a beam over the traditional beam.

CHAPTER 2

LITERATURE REVIEW

2.1 Beam

2.1.1 Reinforced Concrete Beam

Reinforced concrete beam is the combination of using steel and concrete instead of using only concrete to offset some limitations. Concrete is weak in tensile stress with compared to its compressive stress. To offset this limitation, steel reinforcement is used in the concrete at the place where the section is subjected to tensile stress. According to Sella kumaraswamy A, the reinforcement is designed to resist maximum bending moment, shear force, torsion, and sometimes for compression as required. There are two shape of reinforced concrete beam which are rectangular beam and T beam. Usually the shape of beam is determined based on the location of beam and design load of structure.

2.1.2 Steel Beam

Steel, and iron, are used widely in the construction of infrastructure like roads, buildings, bridges, railways, modern architecture like airports and skyscrapers, and also residential homes and recreational parks. Most structures are held up by steel skeletons, and concrete walls and pillars use steel bars to reinforce them. It is also used in power tools and cars despite the increase in the usage of aluminium. They are used for high-rise buildings, because of the strength, speed of construction, and its low weight; industrial and warehouse buildings, because it can be used to create large spaces at low cost; residential buildings for light gauge steel construction in place of wood framed construction; and temporary structures because they're easy to put up and remove.

The common reasons why steel products are widely used in construction because they are durable, versatile, and affordable. Because of its high strength to weight ratio, resistance to breakage, steel is very durable, making it ideal to use it for buildings. Aside from its durability, and flexibility, it's also environmentally friendly, as it is continuously recyclable. Laterally stable steel beams can fail only by flexure, shear or bearing, assuming the local buckling of slender components does not occur. These three conditions are the criteria for limit state design of steel beams. Steel beams would also become unserviceable due to excessive deflection and this is classified as a limit state of serviceability.

In construction, the use of high tensile steel can reduce the volume of steel needed but the steel needs to be tough at operating temperatures, and it should also exhibit sufficient ductility to withstand any ductile crack propagation. It is clear that the load-deflection response is affected significantly by changing the steel grade, with significant enhancements of the ultimate strengths but no distinct increases in the initial the stiffnesses. For example, when the steel grade rises from S345 to S960, the ultimate strength increases by 220% (from 155 kNm to 341 kNm), with the beams remaining ductile (Xinpei Liu, Mark A. Bradford and Abdolreza Ataei, 2016).

2.1.3 Composite Beam

Steel concrete composite beams consists of a steel beam over which a reinforced concrete slab is cast with shear connectors. In conventional composite construction, concrete slabs are simply rested over steel beams and supported by them. These two components act independently under the action of loads, because there are no connection between the concrete and steel beam. The basic concept of composite beam lies in the fact that the concrete is stronger in compression than steel and steel is stronger in tension. By using the composite action of these two, the advantages of both materials are utilized to the fullest. Strength of a material does not only depend on the material but also the shape in which the material is. Apart from the quantity and quality of steel used, cross sections (width and depth) of steel columns and beams is a major factor which decides the amount of load it can take. In other words, if the cross section is too thin, the beam or column will buckle. Using only steel to get the required cross-section will becomes too expensive. So steel is used to take the tension and concrete is used to take compression and as a filling material to obtain the desired cross section (Xinpei Liu, Mark A. Bradford and Abdolreza Ataei, 2016).

2.2 Material

2.2.1 Concrete

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement which hardens over time. In its simplest form, concrete is a mixture of paste and aggregates, composed of portland cement and water. Soon after the aggregates, water, and the cement are combined, the mixture starts to harden. All portland cements are hydraulic cements that set and harden through a chemical reaction with water call hydration. During this reaction, a node forms on the surface of each cement particle. The node grows and expands until it links up with nodes from other cement particles or adheres to adjacent aggregates.

Once the concrete is thoroughly mixed and workable it should be placed in forms before the mixture becomes too stiff. During placement, the concrete is consolidated to compact it within the forms and to eliminate potential flaws, such as honeycombs and air pockets. The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients. There are different ratio of mix design for difference grade. The quality of the paste determines the character of the concrete. The strength of the paste depends on the ratio of water to cement. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. High-quality concrete is produced by lowering the water-cement ratio as much as possible without sacrificing the workability of fresh concrete, allowing it to be properly placed, consolidated, and cured. Curing begins after the exposed surfaces of the concrete have hardened sufficiently to resist marring. Curing ensures the continued hydration of the cement so that the concrete continues to gain strength.

2.2.1.1 Ordinary Portland Cement

Cement is the most important binding construction material, which after mixing with water creates a workable paste with an ability to harden in the air and under water. Buildings, technical and industrial constructions, infrastructure facilities, dams, roads or bridges that surround us would not have been created without cement (Hewlett, 2004, Zetola, 2010 and Gao et al., 2015). In other word, cement can be defined as the bonding material having cohesive and adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly. Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. The raw materials required for the manufacture of Portland cement are calcareous material such as limestone or chalk and argillaceous materials such as shale or clay. A mixture of these materials is burnt at a high temperature of approximately 1400 0C in a rotary kiln to form clinker. The clinker is then cooled and grounded with a requisite amount of gypsum into fine powder known as portland cement.

It is important for the consumer to know the date of packing of the OPC. Fresher the cement, better is the performance. Cement being a hygroscopic substance, can lose strength if not stored properly or if stored for long periods of time. For concrete mix designing it is a must to know the strength of OPC and its variations from time to time. Often attempts are made to do mix designs without knowing the correct grade of OPC. This leads to either unsafe or over safe mix designs. An economical and technically viable concrete mix design can be achieved only if correct strength is known. For proper quality assurance and quality control of concrete works it is a must. (Matthew J. Heiser, 1998)

The setting time of concrete paste is defined by initial and final sets. The time at which initial set takes place is when the cement paste begin to stiffen considerably. In concrete, initial set is said to have occurred when it has reached a degree of stiffness beyond which it cannot be compacted using vibration means. The final set roughly indicate the time at which the bonding paste has started to harden just enough to support some load (Anniamma Chacko 2013).

2.2.1.2 Water

The amount of water in concrete controls many fresh and hardened properties of concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life.

Adding more water to the concrete increases workability but more water also increases the potential for segregation (settling of coarse aggregate particles), increased bleeding, drying shrinkage and cracking in addition to decreasing the strength and durability. Water is a key component in concrete. However, too much water can be detrimental to both the fresh and hardened concrete properties, especially strength, long term durability and potential for cracking. On your next job, be sure to know the water requirements for the concrete mixtures being used, especially the allowable water that can be added for slump adjustments.

2.2.1.3 Aggregate

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories which is fine aggregate and coarse aggregate. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large size gravel. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process.

In addition, aggregates are used in concrete for very specific purposes. The use of coarse and fine aggregates in concrete provides significant economic benefits for the final cost of concrete in place. It is commonly accepted that water demand and cement content in a concrete mixture increases as the maximum coarse aggregate size decreases. The required volume of paste in a concrete mixture must increase, due to the increased surface area of smaller aggregate sizes, to coat all of the aggregate particles. With this increase in paste quantity there is a reduction of volume of the aggregates per unit of concrete produced, thus the shrinkage of the mixture increases. Again, an increase in shrinkage potential combined with restraint of the concrete section may add substantially to the cracking potential of a concrete section. In short, the aggregates are used to improve economy, but more importantly do contribute significantly to the final properties of any concrete mixture.

2.2.2 Steel Beam

Concrete is strong in compression, as the aggregate efficiently carries the compression load. However, it is weak in tension as the cement holding the aggregate in place can crack, allowing the structure to fail. Because of that, in reinforced concrete beam will adds steel reinforcing bars so that it can carry tensile loads. This is because steel is an alloy of iron and other elements, commonly carbon that is widely used in construction and other applications because of its high tensile strength and low cost.

Steel is a versatile, popular material used in the construction of everything from skyscrapers to housing. Steel beams are composed mostly of iron with some alloying elements. Two types of steel beams that exist are cast iron and wrought iron beams. Cast iron beams are made by pouring molten iron into a mould and are strong in compression but brittle. Wrought iron beams are made by forming heated iron and are strong in tension. Steel has a very high strength-to-weight ratio. This means that a steel beam of a given mass is capable of resisting much higher stresses without fracture than an equivalent mass of wood or stone (Metallurgical Consultants, 2007).

2.3 Testing Method

2.3.1 Compressive Strength Test

Compressive strength of concrete testing is important because it gives an idea about all the characteristics of concrete. By this single test one judge that whether the concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete. Test for compressive strength will be carried out on cube sample. Various standard codes recommends concrete cylinder or concrete cube as the standard specimen for the test. American Society for Testing Materials ASTM C39/C39M provides Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

For cube test three types of cubes specimen of 15 cm X 15 cm X 15 cm will be cast. This concrete is poured in the mould and tempered properly to ensure not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine for 3, 7, 14 and 28 days after curing. Load should be applied gradually till the specimens fails and to calculate the compressive strength of the concrete, the load at the failure is divide by area of specimen. The strength of concrete increases with age.

2.3.2 Magnus Frame Test

Magnus frame tests are generally used to determine the flexural modulus or flexural strength of a material because it is using same method with flexural strength test. This test is less affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is the flexural strength of that particular sample. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen. Flexural modulus is calculated from the slope of the stress vs. strain deflection curve. These two values can be used to evaluate the sample materials ability to withstand flexure or bending forces.

The two most common types of magnus frame test are three point and four point flexure bending tests. A three point bend test consists of the sample placed horizontally upon two points and the force applied to the top of the sample through a single point so that the sample is bent in the shape of a “V”. A four point bend test is roughly the same except that instead of the force applied through a single point on top it is applied through two points so that the sample experiences contact at four different points and is bent more in the shape of a “U”. The three point flexure test is ideal for the testing of a specific location of the sample, whereas, the four point flexure test is more suited towards the testing of a large section of the sample, which highlights the defects of the sample better than a 3-point bending test. Generally a flexure test is run until the sample experiences failure and is therefore ideal for the testing of brittle materials. The actual approach shows that the influence of the displacement of the contact points and that of the horizontal forces is more critical in four-point bending than in three point bending (Faustino Mujika, Ainhoa Arrese, Itziar Adarraga, and Usue Oses, 2016).

2.4 Structural Strength

2.4.1 Deflection

Deflection is the distance that an object bends, twists from its original position. I would generally assume that an objects deflection does not include rigid movement of the object. Deflection also generally used where there is involvement of external force that causes part of the member or material to move in one direction. According to Shiyun Xiao, Wenbo Cao & Haohao Pan, the yield displacement and the ultimate displacement of RC beams increased distinctly with the increasing loading rate.

2.4.2 Stress

The term stress (s) is used to express the loading in terms of force applied to a certain cross-sectional area of an object. From the perspective of loading, stress is the applied force or system of forces that tends to deform a body. From the perspective of what is happening within a material, stress is the internal distribution of forces within a body that balance and react to the loads applied to it. The stress distribution may or may not be uniform, depending on the nature of the loading condition. For example, a bar loaded in pure tension will essentially have a uniform tensile stress distribution. However, a bar loaded in bending will have a stress distribution that changes with distance perpendicular to the normal axis.

Simplifying assumptions are often used to represent stress as a vector quantity for many engineering calculations and for material property determination. The word "vector" typically refers to a quantity that has a "magnitude" and a "direction". For example, the stress in an axially loaded bar is simply equal to the applied force divided by the bar's cross-sectional area.

2.4.3 Strain

Strain is the response of a system to an applied stress. When a material is loaded with a force, it produces a stress, which then causes a material to deform. Engineering strain is defined as the amount of deformation in the direction of the applied force divided by the initial length of the material. This results in a unit less number, although it is often left in the unsimplified form, such as inches per inch or meters per meter. For example, the strain in a bar that is being stretched in tension is the amount of elongation or change in length divided by its original length. As in the case of stress, the strain distribution may or may not be uniform in a complex structural element, depending on the nature of the loading condition.

If the stress is small, the material may only strain a small amount and the material will return to its original size after the stress is released. This is called elastic deformation, because like elastic it returns to its unstressed state. Elastic deformation only occurs in a material when stresses are lower than a critical stress called the yield strength. If a material is loaded beyond it elastic limit, the material will remain in a deformed condition after the load is removed. This is called plastic deformation.

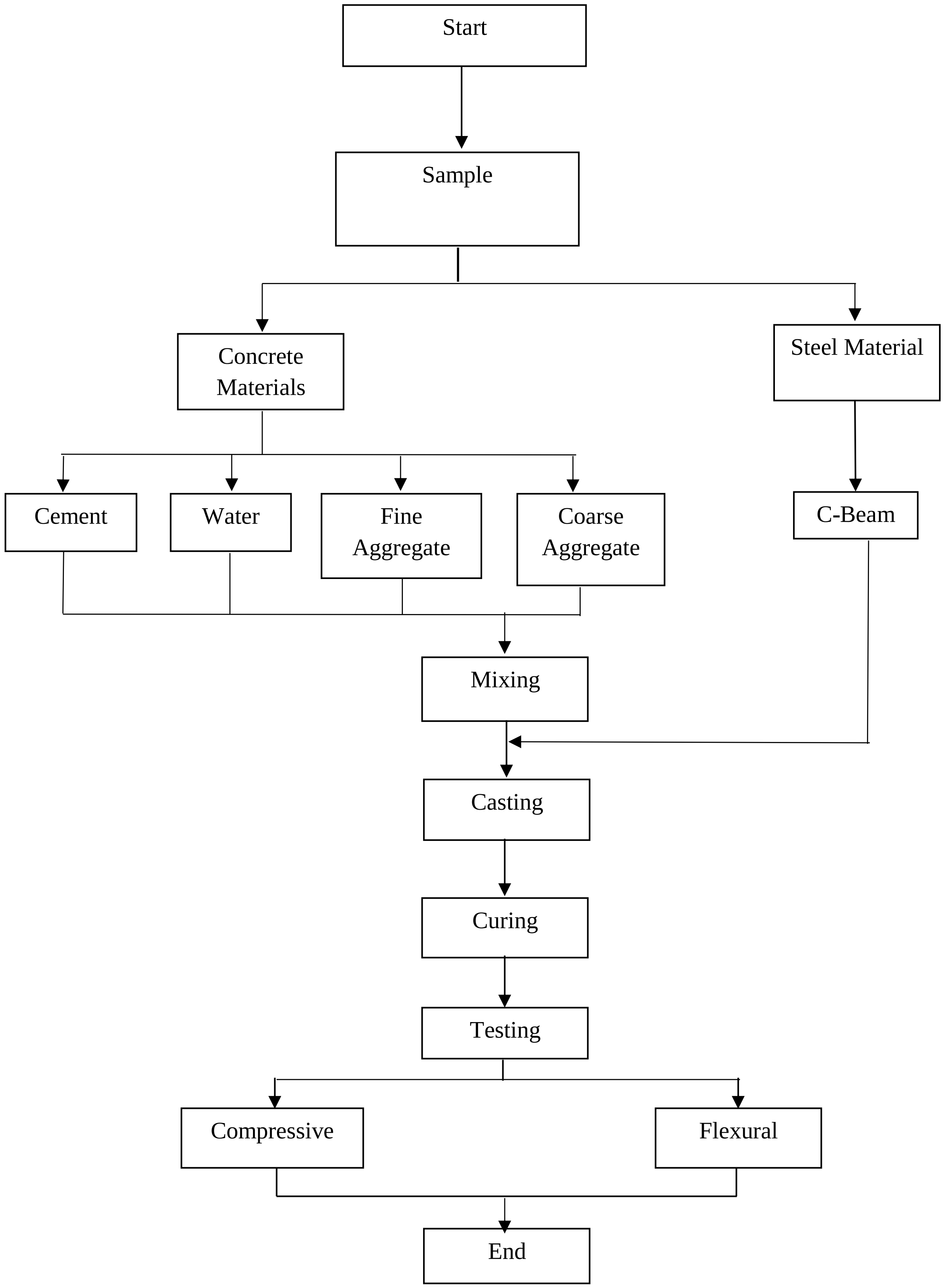
CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The type of beam that have been used in this research is rectangular composite beam. The materials that have been used in this study are divided to two categories which are concrete materials and steel material. For concrete material, its consist of Ordinary Portland Cement (OPC), water, cement, fine and coarse aggregate where all the material were completely mixing at the batching plant. While for the steel material it just has only steel beam. The beam is composite beam because it composed of two dissimilar structure joined together to act as a unit which are concrete beam and steel beam. The whole research is about structural strength of the composite beam in term of load, deflection, and stress and strain.

3.2 Methodology Flowchart



3.3 Ready Mix Concrete

Ready mixed refers to concrete that is batched for delivery from a central plant instead of being mixed on the job site. Each batch of ready-mixed concrete is tailor-made according to the specifics of the contractor and is delivered to the contractor in a plastic condition, usually in the cylindrical trucks often known as "cement mixers”. Even though the concrete that were used in this study is ready mix that come from batching plant, it still need to ensure the characteristic by doing compressive strength. For this test, the characteristic strength of the concrete that have been chose is grade C20/25. Ready mix concrete that was ordered need achieve the compressive strength of 25 N/mm2. The others properties that have been used in the ready mix are 20mm for maximum size aggregate and 70 – 90 mm for the slump type.

3.4 Beam and Design Properties

The type of beam that were used in my research is rectangular beam. The materials that have been used in my research is Ordinary Portland Cement (OPC), steel beam (C-Beam), and aggregates. The concrete grade for the beam is C20/25. The whole research is about the ultimate structural capacity that can sustain by the composite beam.

3.5 Sample Preparing and Procedure

The size of the beam is 0.15m base x 0.3m height x 2.0m long of the span with 3 sample only. Each sample are same sample to test. The steel beam that were used is hot rolled 100 x 50 x 5 mm for it cross section. And after undergo the normal process of construction beam which is including mixing the concrete, pouring the concrete, vibrating, curing and then the beam will be tested.

3.6 Compressive Strength Test

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Test for compressive strength will be carry out on concrete cube. For this test, 15 x 15 x 15 cm size cube has been choose to be cast. The wet concrete will be pour in the mould and temper properly to prevent any voids. After 24 hours these moulds are remove and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. Total for test specimens are 9 samples which are 2 samples for each testing age.

These specimens will be test by compression testing machine after 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the specimens fails. The equipment that will be use for the testing is shown in figure 3.1.

Figure 3.1 Machine Compression

3.6.1 Procedure

I. Remove the specimen from water after specified curing time and wipe out excess water from the surface.

II. Take the dimension of the specimen to the nearest 0.2m

III. Clean the bearing surface of the testing machine

IV. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.

V. Align the specimen centrally on the base plate of the machine.

VI. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

VII. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails

VIII. Record the maximum load and note any unusual features in the type of failure.

For calculate the compressive strength of concrete, the load at the failure divided by area of specimen given.

$$\sigma = \frac{F}{bd}$$

This stress is not the true stress, since the cross section of the sample is considered to be invariable (engineering stress).

- F is the axial load (force) at the fracture point
- b is width
- d is the depth or thickness of the material

3.7 Magnus Frame Test

Load on each specimen was monotonically increased through the force control protocol during the test. The load increment was selected to be 40 kN per step at speed of 40 kN/min up to the elastic limit of each specimen. Then, the load increment reduced to 20 kN per step till the ultimate state. The load was sustained for 3 min at the end of each loading step to allow observation and recording the progressively developed damages in each specimen.

Displacement transducers were put under the beam and strain gauges were attached to each specimen for both steel and concrete. As shown, each specimen was instrumented to record the following response quantities of interest: strains on concrete slab. Size of composite beam that will be cast is 150 x 300 x 2000 mm and total of beams have been used for this test are 3. The age of testing is 28 days only.

Figure 3.2 Magnus Frame machine

3.7.1 Procedure

I. Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.

II. Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.

III. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

IV. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centred with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.

V. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter concentrates towards results obtained from laboratory test including compressive cube test and flexural strength test. The results were analysed as well as discussed in tables and figures forms. Every test in which have different types of data need to analyse turning it is easier to present and understand. The specimens were cured and tested at 28 days. There are 2 type of test that had been conducted which are compressive strength test and magnus frame test which is 4-point loading test.

4.2 Compressive Strength Test

Strength of concrete is generally tested after 28 days as concrete cube strength. The reason for testing concrete strength after 28 days is because the concrete gains strength with time after casting. It takes much time for concrete to gain 100% strength. The rate of gain of concrete compressive strength in higher during the first 28 days of casting and then it slows down.

From the compressive test that were conducted, table 4.1 shows the result for the concrete cube strength of 150 mm3 for 28 days.

Table 1 Compression Strength of 150 x 150 mm of grade 25Mpa for 28 days

Days	**Sample**	**Weight (kg)**	**Compressive Strength (Mpa)**
28	A	2.20	25.02
	B	2.25	23.99
	C	2.20	22.85
		***Average**	**23.95**

Based on data obtained for the sample, the average strength for three sample is 23.95 Mpa. Its shows that the result doesn’t meet the requirement of the characteristic strength design for the concrete. But it’s still can be accepted because it nearly reach 25 Mpa. There are several aspects that affected to the result. Some of the aspect may be from the quality of the water when curing process which not clean enough.

One of the part that causing insignificant result was the mixture of concrete. During the mixing process, the mixture was not mixed or merges together. When this happens, concrete will be not complete mix with one another and the strength of the concrete become low. It should mix carefully due to large volume of concrete to be use and if not mix properly maybe the certain amount of cement or aggregate can be outcast during the mixing.

4.3 Magnus Frame Test

4-point loading test have been used in this test because its can produces peak stresses along an extended region of the specimen surface. Hence, exposing a larger area of the specimen is possible with more potential for defects and flaws to be highlighted. The purpose of this test are to determine the ultimate load, deflection, stress and strain of the composite beam.

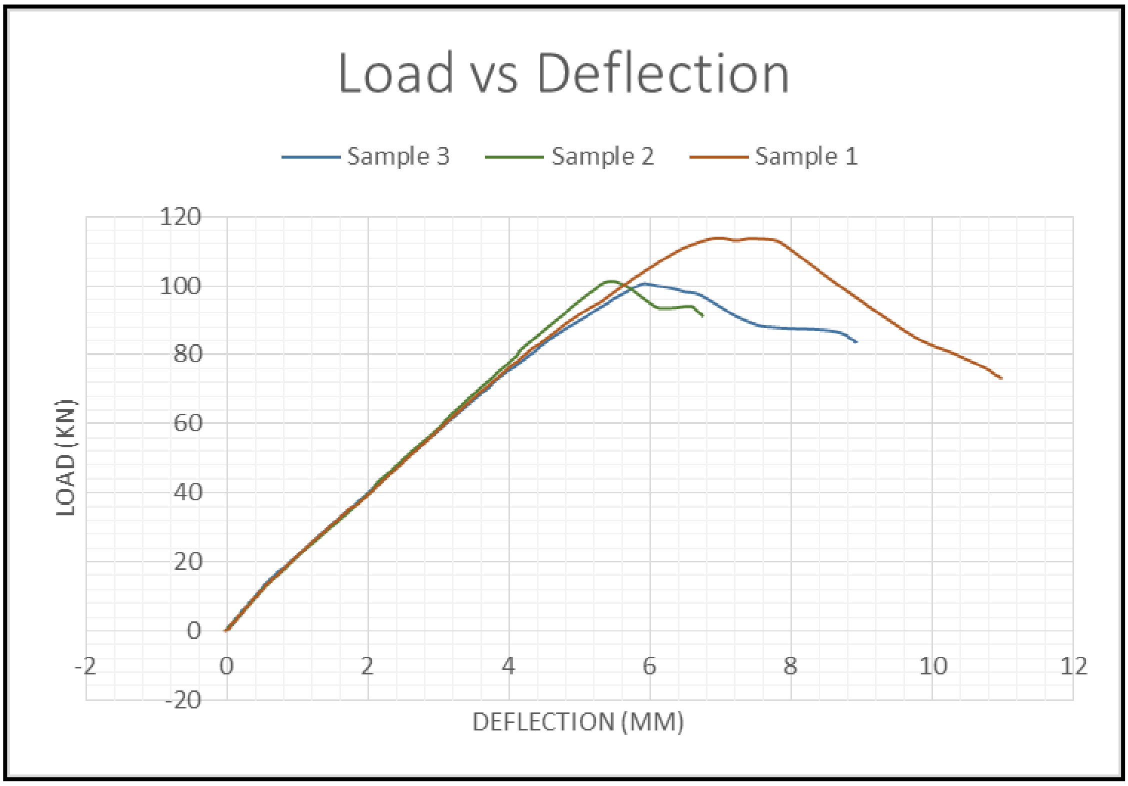


Figure 4.1 Load vs Deflection for all sample

From the observation the sample 1 had the highest load applied before its failed which the load is 113.7 kN, followed the sample2, 101.2 kN and lastly sample 3 which is 100.6 kN. The graph shows that the sample 1 had the highest deflection which is 7.42 mm right before it's failed. Then followed by sample 3, 5.93 mm and sample 2, 5.4 mm. This shows that the deflection is directly proportionally increase with load.

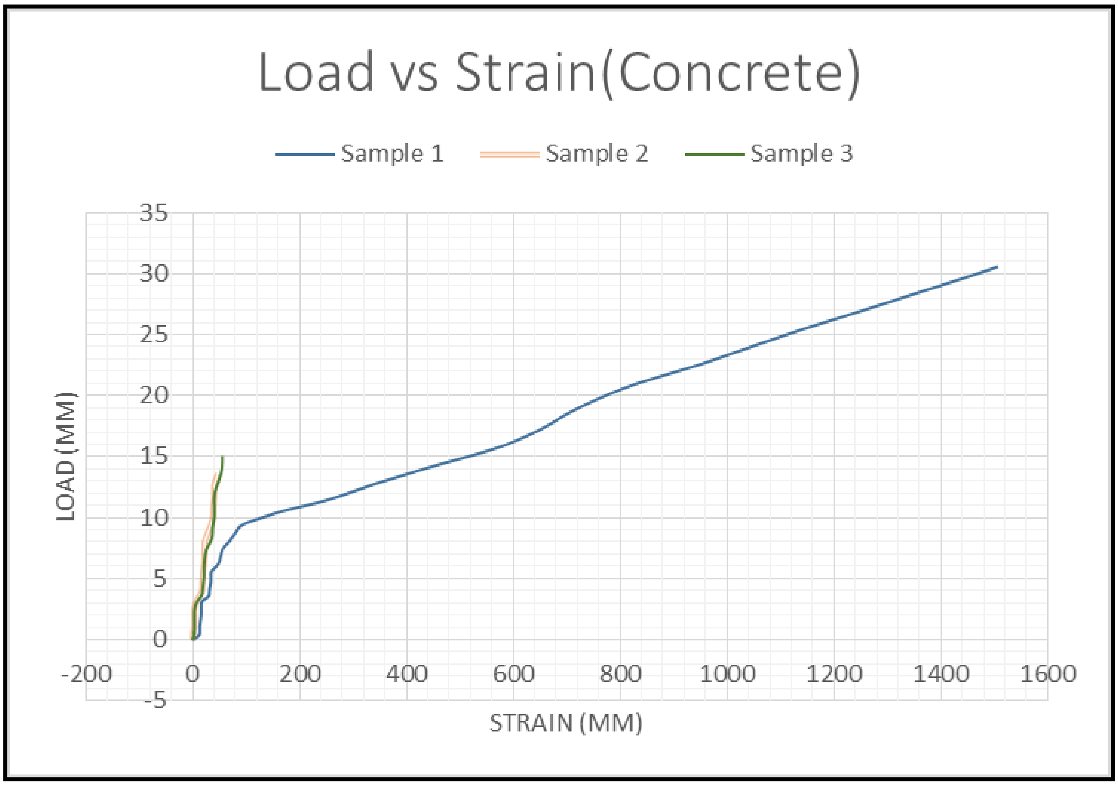


Figure 4.2 Stress vs Strain of the concrete

From the graph shown in figure 4, the strain reading of concrete for sample 1 have the highest strain value at with 1507mm, followed by sample 3 at 56mm, and lastly sample 2 at 47mm. Its shows that the strain value increase when the load also increase. From the observation during test, the strain reading become failure due to crack occur at the beam sample even though the beam still not fail yet.

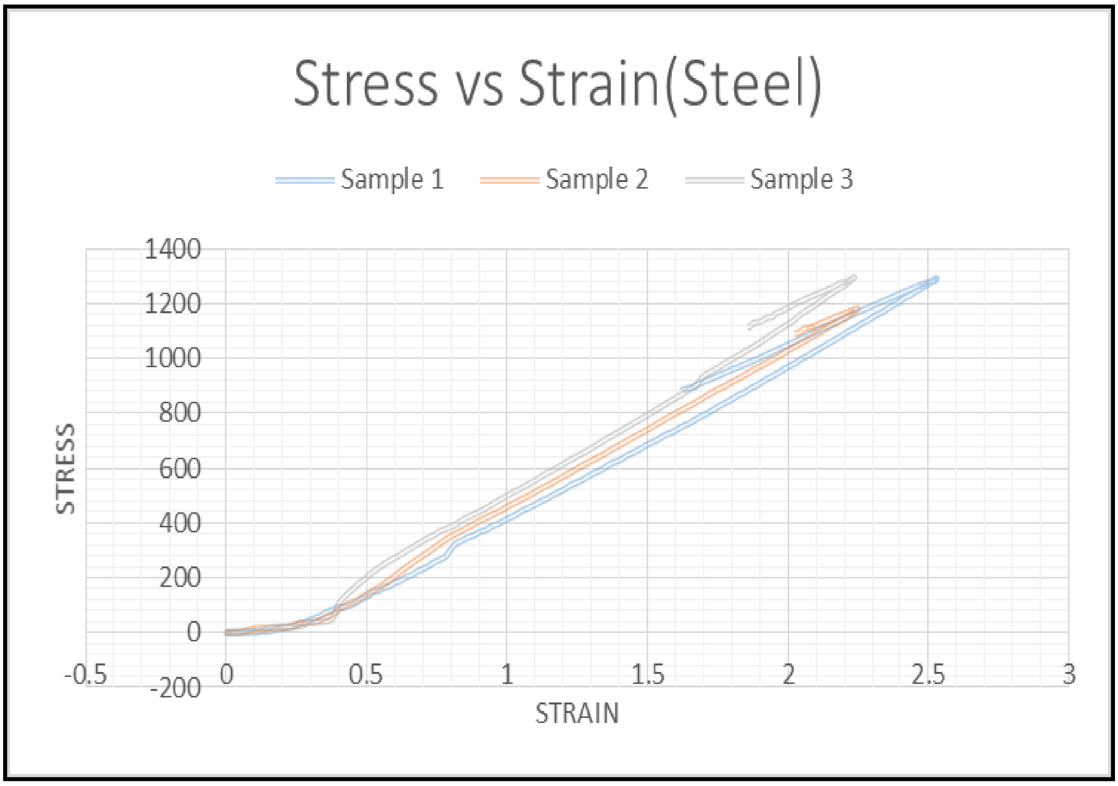


Figure 4.3 Stress vs Strain for steel

From the figure 4.3, the strain reading from steel beam of sample 3 were having the highest strain reading with 1296mm, followed by sample 1 at 1293mm, and lastly sample 2 at 1181mm. Its shows that all sample get quite similar reading with average around 1200.

4.4 Experimental vs Theoretical

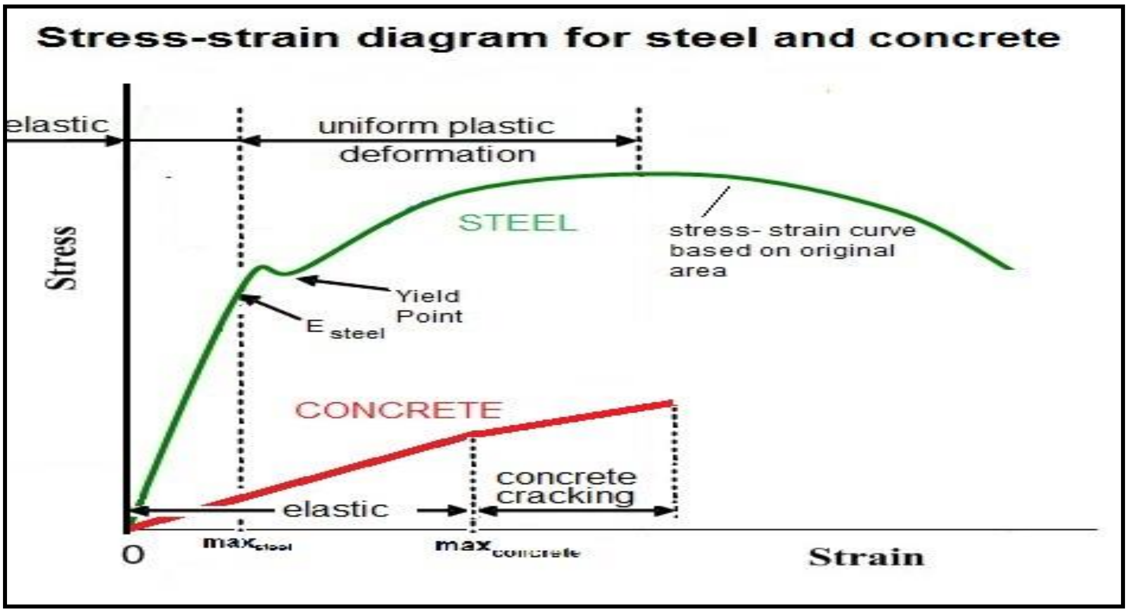


Figure 4.4 Typical stress-strain curve diagram for concrete and steel material

Figure 4.4 shows typical stress-strain curve diagram for concrete and steel material. For steel material, there are 4 stage that occur during testing conducted which are elastic deformation, plastic deformation, strain hardening and necking. While concrete only have two stage occurred during test which are elastic and concrete cracking. Considering that steel and concrete are two different material but both still having elastic phase. Because both can be deformed in an elastic way, steel can be deformed in its elastic area and return to its original form after the applied forces are taken away. Also concrete can be bend elastically. The difference between the steel and the concrete is that concrete doesn't have a yield point elongation or plastic deformation and therefore will break at its yield point.

From figure 4.2, the graph shows that the result obtained followed the same pattern with the theory of typical stress strain curve diagram for concrete. Where the strain increase together with increasing in load. While from figure 4.3, the graph shows a little bit different pattern with the theory stress strain curve diagram for steel. Where there are no necking phase in the experimental graph. But they still have others phases where its start with elastic deformation, plastic deformation and strain hardening. After it reached the maximum load, the strain become decrease together with the load.

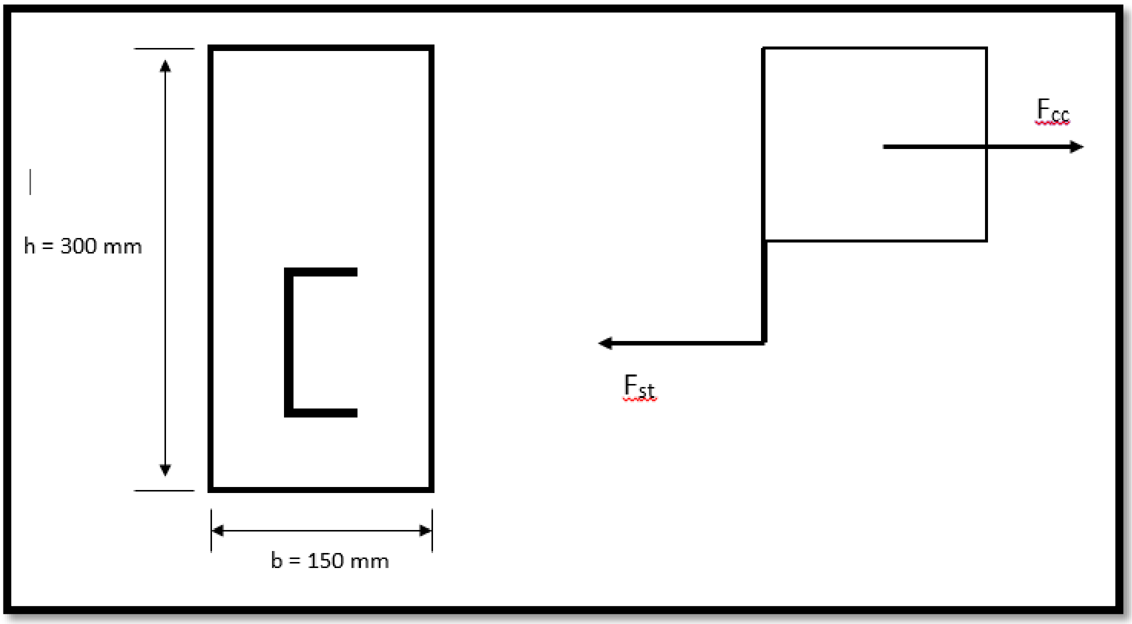


Figure 4.5 Stress block diagram for composite beam

In figure 4.5 shows the stress block diagram for composite beam that were used for this study. In the appendix 1 shows the theory calculation for stress block diagram of the composite beam. From the calculation, the maximum load its can support is up to 194 kN compare to experimental result that only can support up to 113 kN only. This possibility indicate that there are error in certain part during testing was conducted. Errors can come from environment, and calibration of the equipment. The result from compressive strength that show that the concrete doesn't reach 25 Mpa also can be cause that the strength capacity of the beam is different with theoretical.

4.5 Cracking Pattern

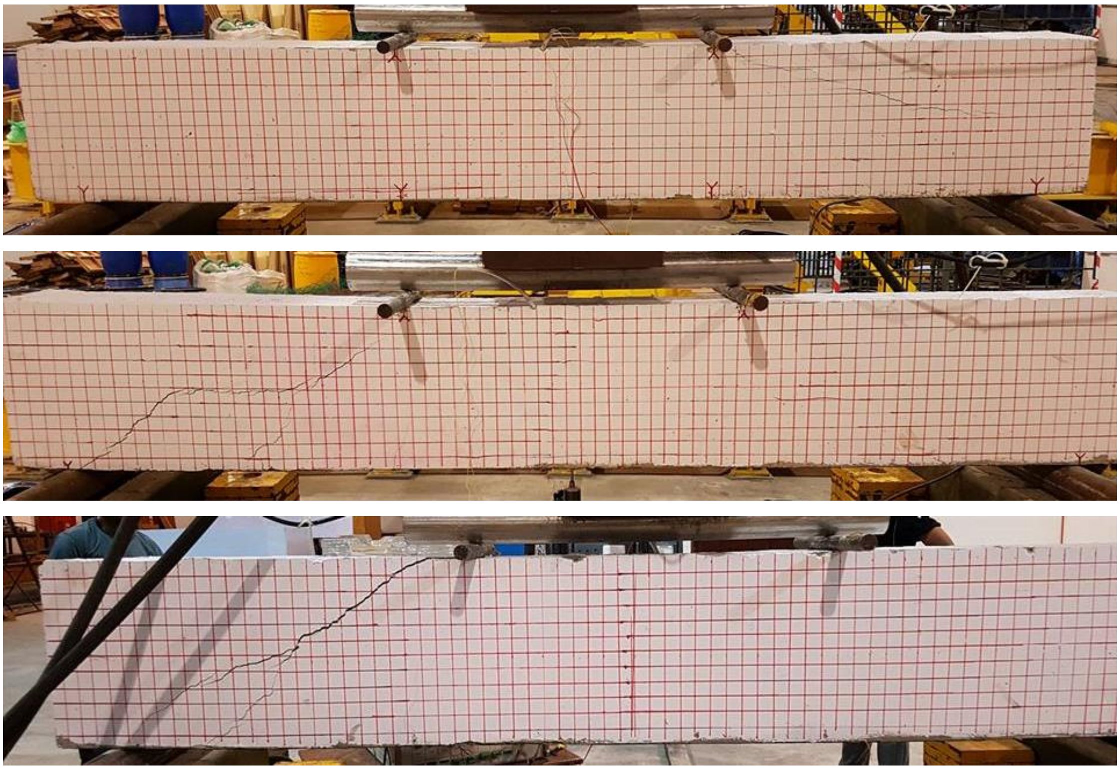


Figure 4.6 Cracking pattern for all sample

From the observation on the figure 4.4, sample 2 and 3 have the most crack occur on the surface on the beam compare to the sample 1 beams which are less. From the figure shown, all the sample having same cracking pattern. The cracking starting occur at the location of point load of the beam. From the figure it shows that sample 3 has the biggest crack but data that obtained from crack gauge shown that each sample having same maximum crack value with 0.4mm.

4.6 Conclusion

Compressive strength test and magnus frame test are very important in order to get this study done. From compressive strength test, it can show the characteristic strength of the concrete sample that were used in composite beam. And magnus frame test was used to get data in order to achieve the objective's study. Comparison between theoretical and experimental somewhat giving different value in maximum load capacity with 42% of error. But based on graph that have been plotted above shows that the result obtained from the experiment followed the shape and pattern result almost same with theoretical graph.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter will discuss the conclusion of this study that is about compressive, flexural strength and the cracking pattern of the composite beam. According to result and analysis from the experimental laboratory testing this chapter will discuss about the result, discussion and conclusion that follows research's objective in Chapter 1.

5.2 Conclusion

Based upon the test results obtained from this investigation, the following significant conclusions were drawn:

I. From the experimental investigation it is observed that the load carrying capacity of the composite beam were reached more than 100 kN where sample 1 (113.69 kN), sample 2 (101.17 kN), and sample 3 (100.63 kN).

II. From the test carried out, sample 1 give the maximum deflection is 7.42mm and sample 2 is 5.4mm and sample 3 is 5.93mm.

III. From the observation, its shows that maximum crack for all beam are not more than 0.04mm.

IV. From data obtained, the value of strain for concrete are 1507 for sample 1, 47 for sample 2 and 56 for sample 3.

V. From data obtained, the value of strain for steel are 1290 for sample 1, 1182 for sample 2, and 1296 for sample 3.

5.3 Recommendation

In accomplishing this study, lots of effort has been delivered in order to strive towards goal. It is a normal to face challenges and obstacles during undergoing a study. Many new experiences and knowledge will be acquired through these challenges. In return, we ourselves will be enhanced.

In order to accomplish objective, a number of solution has been figured out to resolve the problem arise. For the future studies several recommendation are proposed for this study. The followings are the recommendations relevant to this topic are:

I. Create a proper manufacturing formwork such as steel formwork in order to come out we better shape and dimension during casting.

II. Use several type connector such as headed stud connector, perfobond ribs connector, T-rib connector, T connector and others in other to provide the necessary shear connection for composite action in flexure between steel beam and concrete.

III. Ensure all the preparation of work like put on strain gauge on concrete and steel beam with appropriately to avoid any parallax error during testing.

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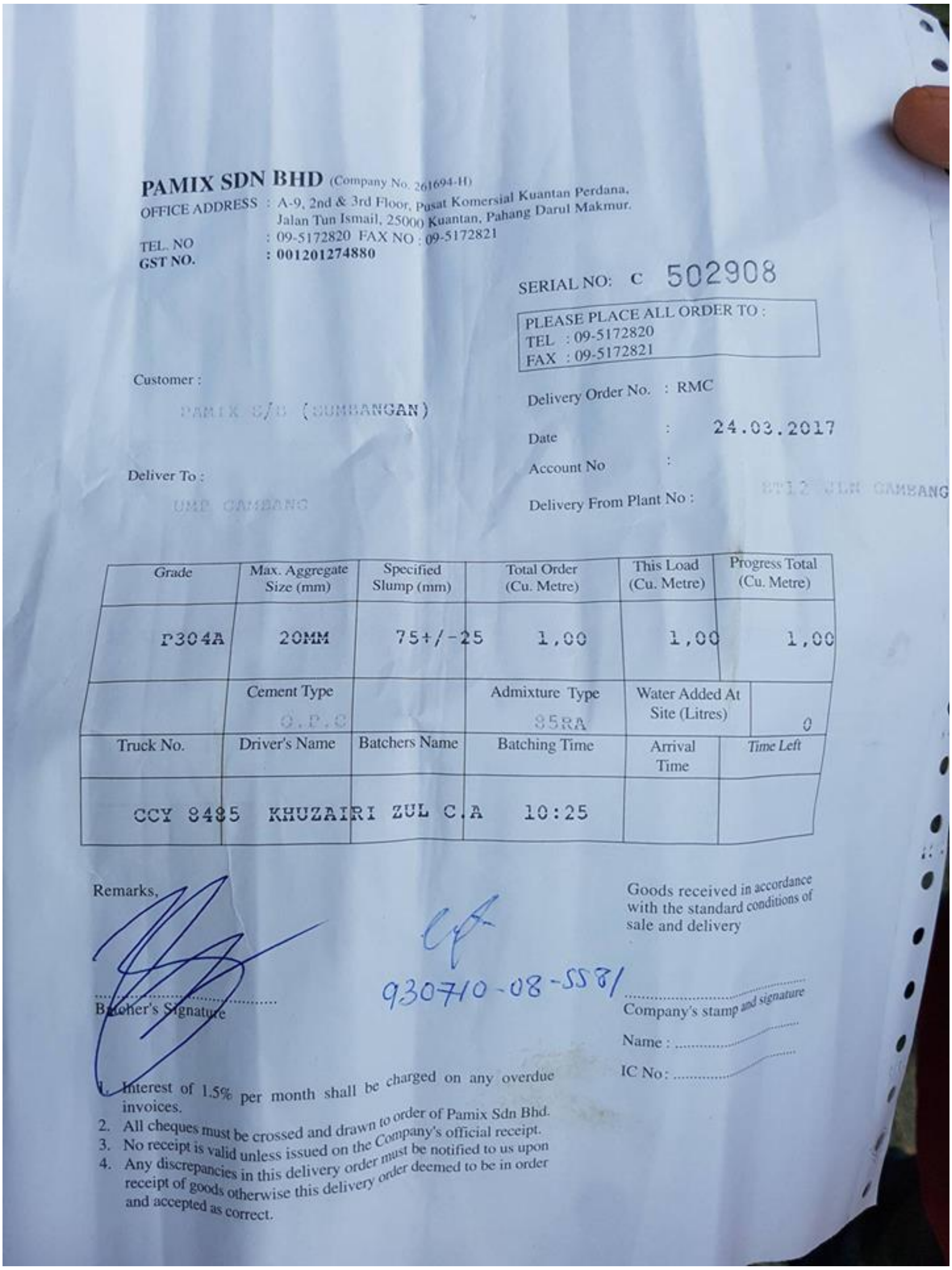
APPENDIX 1

DELIVERY ORDER OF READY MIX CONCRETE GRADE 25



PAMIX SDN BHD (Company No. 261694-H)
OFFICE ADDRESS : A-9, 2nd & 3rd Floor, Pusat Komersial Kuantan Perdana, Jalan Tun Ismail, 25000 Kuantan, Pahang Darul Makmur.
TEL. NO : 09-5172820 FAX NO : 09-5172821
GST NO. : 001201274880

SERIAL NO: C 502908

PLEASE PLACE ALL ORDER TO :
TEL : 09-5172820
FAX : 09-5172821

Customer :
PAMIX S/B (SUMBANGAN)

Delivery Order No. : RMC
Date : 24.03.2017
Account No :
Delivery From Plant No : BT12 JLN GAMBANG

Deliver To :
UMP GAMBANG

Grade	Max. Aggregate Size (mm)	Specified Slump (mm)	Total Order (Cu. Metre)	This Load (Cu. Metre)	Progress Total (Cu. Metre)
P304A	20MM	75+/-25	1,00	1,00	1,00

	Cement Type		Admixture Type	Water Added At Site (Litres)	
	O.P.C		85RA		0
Truck No.	**Driver's Name**	**Batchers Name**	**Batching Time**	**Arrival Time**	**Time Left**
CCY 8485	KHUZAIRI	ZUL C.A	10:25		

Remarks,

930710-08-5581

Batcher's Signature

Goods received in accordance with the standard conditions of sale and delivery

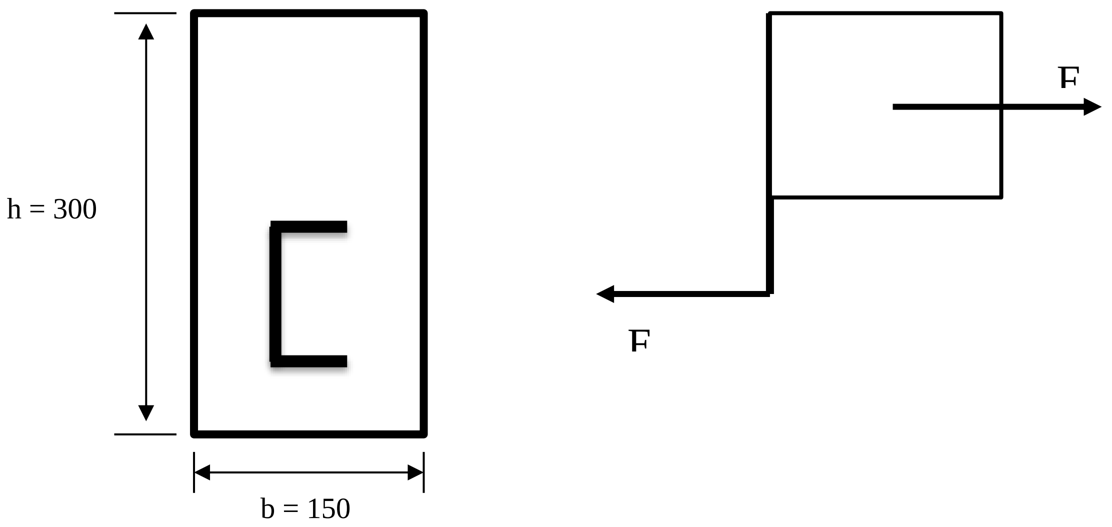
Company's stamp and signature
Name :
IC No :

1. Interest of 1.5% per month shall be charged on any overdue invoices.
2. All cheques must be crossed and drawn to order of Pamix Sdn Bhd.
3. No receipt is valid unless issued on the Company's official receipt.
4. Any discrepancies in this delivery order must be notified to us upon receipt of goods otherwise this delivery order deemed to be in order and accepted as correct.

APPENDIX B
COMPRESSIVE STRENGTH OF CONCRETE FOR 28 DAYS

SAMPLE	WEIGHT (KG)	MAXIMUM LOAD (kN)	MAXIMUM STRENGTH (Mpa)	AVERAGE STRENGTH (Mpa)
SAMPLE 1	7.6	562.95	25.02	
SAMPLE 2	7.68	539.83	23.99	**23.95**
SAMPLE 3	7.6	514.18	22.85	

APPENDIX C
THEORETICAL CALCULATION OF STRESSBLOCK DIAGRAM



$F_{cc} = 0.567fyk(b \times 0.8x) = 0.454fyk\ bx$

$F_{cc} = 0.87fykA_s$

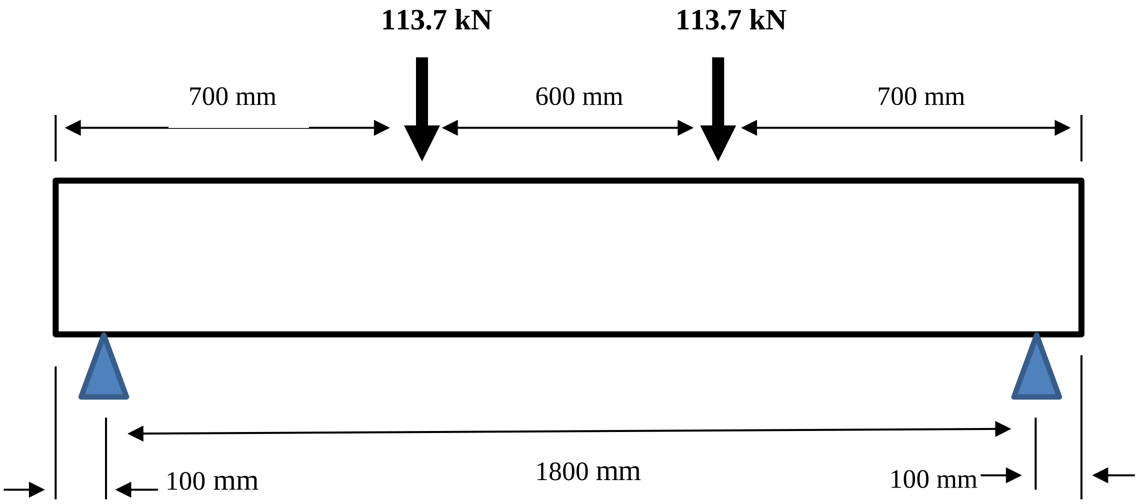
$F_{cc} = F_{st}$

$0.454(25)(150)x = 0.87(235)(950)$

$x = 114.1\ mm$ (Neutral axis)

$F_{cc} = F_{st} = 0.454(25)(150)(114.1) = \mathbf{194.26kN}$

APPENDIX D
CALCULATION OF LOAD AT SUPPORT



$$\begin{aligned} selfweight\ beam &= selfweight\ concrete + selfweight\ steel \\ &= (0.13 \times 0.3 \times 25) + (9.36 \times 9.81 \div 1000) \\ &= 0.975 + 0.092 \\ &= 1.07\ kN/m \end{aligned}$$

$$V_A = V_B = \frac{(1.07 \times 1.8 \times 0.9) + (113.7 \times 0.6) + (113.7 \times 1.2)}{1.8}$$

$$= \mathbf{114.7\ kN}$$

APPENDIX E
PICTURES OF SAMPLE PREPARATION

Completion of formworks with size of 150 mm x 300 mm x 2000 mm for 3 samples.

Installation of strain gauge at the middle of bottom steel beam.

Steel beam have been put in the formwork.

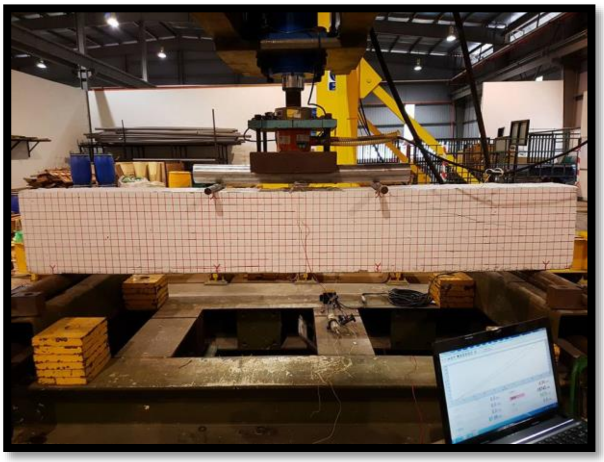
APPENDIX F
PICTURES OF COMPRESSIVE STRENGTH TEST PROCESS

The cube were filled with ready mix concrete and vibrated

The cube were in the curing process

The cube were tested using compressive machine.

APPENDIX G
PICTURES OF COMPRESSIVE STRENGTH TEST PROCESS



Sample were setup on the magnus frame machine.

Testing were on progressing