RECYCLED BR[illegible] :N HOLLOW SECTION BEAM

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ABSTRACT

This study is about using of recycled aggregates in reinforced hollow section concrete beam. Hollow section structures are widely used because it can help reduce the structure self weight and costs. Nowadays, the increases of demolition wastes have become serious in environmental problem and cause unpleasant view especially in urban area. Due to concerns in environmental safety and the increase in aggregate demand, the industry field is success to acknowledge recycle aggregate which is from the construction and demolition aggregate. In this study the recycled crushed brick aggregate is used as a replacement of coarse aggregate in concrete design. This study was conducted to determine the flexural strength and the best effect of cavity size in reinforced hollow section beam. This study includes, materials preparation, mixing and curing, and filling concrete to formwork. Beam concrete undergo curing process by using wet gunny curing for 28 days. After curing beam was test by using Magnus frame to know the flexural strength. Based on this study beam sample with cavity size 50mm x 100mm shows the highest ultimate loading 137.95kN followed by beam sample with cavity size 40mm x 100mm. While, beam sample with cavity size 60mm x 100mm shows the ultimate strength 136.34kN. Besides that, beam sample with cavity size 50mm x 100mm has the best effect to enhance the beam strength. This beam showed lower deflection for the same loading on each sample. From these result it shown that normal and reasonable strength concrete can produced using recycled aggregate. The replacement of natural aggregate with recycled aggregate can enhance the concrete performance to meet the industry needs.

ABSTRAK

Kajian ini berkaitan dengan penggunaan aggregat kitar semula dalam rasuk berongga yang diperkukuhkan. Penggunaan struktur berongga semakin banyak digunakan kerana dapat membantu mengurangkan berat struktur dan kos. Pada masa ini, peningkatan bahan buangan daripada runtuhan bangunan menyebabkan masalah alam sekitar yang serius serta menyebabkan pemandangan yang tidak menyenangkan terutamanya di kawasan bandar. Disebabkan kebimbangan terhadap keselamatan alam sekitar serta peningkatan permintaan terhadap aggregat, bidang industri telah berjaya mengenalpasti aggregat kitar semula iaitu daripada runtuhan bangunan. Dalam kajian ini, aggregat batu bata kitar semula yang dihancurkan digunakan sebagai gantian aggregat kasar semulajadi dalam konkrit. Kajian ini dijalankan adalah untuk mengetahui kekuatan rasuk dan kesan terbaik saiz rongga dalam rasuk berongga yang diperkukuhkan. Kajian ini merangkumi penyediaan bahan, pencampuran bahan dan pengawetan konkrit, proses mengisi konkrit ke dalam acuan rasuk. Proses seterusnya iaitu proses pengawetan rasuk dengan menggunakan guni basah selama 28 hari. Seterusnya, selepas rasuk menjalani pengawetan, kekuatan lenturan rasuk akan diuji dengan ujian lenturan menggunakan *Magnus Frame*. Berdasarkan kajian ini sampel rasuk dengan saiz rongga 50mm x 100mm menunjukkan beban yang tertinggi iaitu 137.95kN diikuti dengan sampel rasuk dengan saiz rongga 40mm x 100mm iaitu 137.78kN. Manakala sampel rasuk dengan saiz rongga 60mm x 100mm mencatatkan beban sebanyak 136.34kN. Selain daripada itu, sampel rasuk dengan saiz rongga 50mm x 100mm menunjukkan kesan yang baik terhadap peningkatan kekuatan rasuk. Rasuk ini menunjukkan lenturan yang rendah untuk beban yang sama bagi setiap sampel rasuk. Hasil kajian ini menunjukkan bahawa rasuk yang normal dan mempunyai kekuatan yang munasabah dapat dihasilkan dengan menggunakan aggregat kitar semula. Gantian aggregat semulajadi dengan aggregat kitar semula dapat meningkatkan prestasi konkrit untuk memenuhi keperluan industri.

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LIST OF ABBREVIATIONS

kN	kiloNewton
kNm	kiloNewton meter
kN/m	kiloNewton per meter
kN/mm^2	kiloNewton per millimeter square
kN/sec	kiloNewton per second
kg/m^3	Kilogram per meter cube
mm	Millimeter
mm^2	millimeter square
m	Meter
m^3	meter cube
MPa	Mega pascal
N/mm^2	Newton per millimeter square
s	Second

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, construction was increase that led to the higher demand for construction materials and causing the materials sources become limited. Effect from that, alternatives way is needed to fulfill this necessity and one of the alternatives is by use hollow section structure. By using hollow section structure it can help to reduce the cost of construction material and also help to reduce the structure self-weight. Besides that, one of the properties of the hollow structure has in common is they are light. So this structure usually use in long span and other structure where the weight and cost are essential consideration (Zuhair Faruq Namiq,2012).

Normal concrete was produced by mixing of cement, fine aggregate, coarse aggregates and water. This mixed can be formed in various shapes according to the mould or formwork. In concrete aggregates element is the material that most required and comprises up to 60% to 75 % total volume of concrete. Nowadays, concrete is become one of the important material in a building construction. In addition, due to the rapid development in construction, the demand for concrete also increasing in order to fulfill the industry needed. Industrial field preferred concrete because it is always available, easy to handle as well as have lower costs (Khalaf. F. M, et. al, 2004).

As consequences, there is various alternative have been made to make concrete more flexible and to give benefits in the industry field. Among of the

alternative that was done is by produced components such as precast concrete, hollow slab, hollow beam and so on. However, as a result of the continued usage of natural resources it also cause problem which is shortage of raw material and cause the unreasonable price.

Effect of the natural resources shortage especially for coarse aggregate cause secondary aggregate or recycled aggregate was introduced. This secondary aggregate is obtained from the construction and demolition of building. In this study, the secondary aggregate that chose is recycled masonry brick from the building demolition. This recycled masonry brick was crushed to become an aggregate. With the large amount of rubble that produced every year cause this material had significant as replacement aggregate. Usually recycled aggregate used for low application, for example sub-base, capping layer and site filling (Ghazi. O. M, et. al, 2011). This recycled brick was crushed as needed either for coarse aggregate or fine aggregate.

Furthermore, by using recycled aggregate to replace the natural aggregate it can help to reduce the costs and more importantly it also help save our environment by reducing the rubble waste. Using this material is become common in area that natural aggregate is not available and because the aggregate source is scarce. Besides, the price of recycled aggregate is much lower than the natural aggregate. Next, by used this material in construction it helps reduce the costs for hauling, transport and to get rid this material in landfill. It also really helps in reduce the landfill area and waste disposal cost (De venny. A. S, 1999).

1.2 PROBLEM STATEMENT

Nowadays, our country was developed rapidly and construction was grown up gradually. Effect from this rapid development that required a lot of materials causes we faced problem in lack of materials sources. Other than that, impact from this development also causes various types of environmental pollution occurred such as underground pollution. One of the factors that lead to this pollution is rubble from the building demolition that dump in landfills

especially around the rivers and roads. This rubble also cause high costs to hauling, transporting and tipping this rubble in landfill area. So, by recycled this rubble, directly help reduce costs of waste management (Bazaz. J. B, et. al, 2012).

In order to save materials sources and costs and to make the structure more compatible hollow structure was made. This kind of structure helps to reduce the self-weight of structure and also improve the structure function such as increase the flexural rigidity (Chiad. S. S, 2013). Besides, by reduce concrete weight make work faster and easier due to less materials used.

Furthermore, by using recycled rubble can help to reduce environmental pollution. While recycled rubble such as concrete and brick can be used as aggregate in construction. This is very beneficial to provide material in order to fulfill industrial need and also to lower environmental pollution that becomes severe recently. In addition, this recycled rubble that used as replacement aggregate had potential to enhance the concrete quality and performance.

1.3 OBJECTIVES

Objectives in this study are:

i. To determine the strength of the hollow section beam with three different cavity sizes by using replacement recycled brick masonry aggregate.
ii. To determine the effect of cavity size in hollow section beam.

1.4 SCOPE OF STUDY

In this study, the replacement coarse aggregate used is crushed recycled brick masonry aggregate. This replacement aggregate obtain from a demolition site that located near to the University Malaysia Pahang area. While, granite will be use for the natural coarse aggregate. The maximum coarse aggregate size that will be use is 20mm. Hence, natural coarse aggregate will replace by 30% of beam volume of recycled aggregate. For fine aggregate, natural river sand that

passing through 5mm sieve opening will be use. Furthermore, Portland composite cement and ordinary tap water will be use during the mixing process.

Beam size that design for this study is 250mm x 300mm x 2000mm. Steel reinforcement bar and links also design in this study. The diameter for reinforcement bar and link that will be used is 16mm and 8mm respectively. This beam is design according to MS EN 1992: Eurocode 2 – design of concrete structures. There will be three different cavity sizes in this study which are 40mm x 100mm, 50mm x 100mm and 60mm x 100mm. This cavity size will be form by using polystyrene block that will be inserted to the beam during the casting process according to the design. The mixing process will be done by using drum mixer.

After the hardening process and the formwork is removed beam will undergo next process namely curing process. Wet gunny curing will be use in this study. This curing use because, beam size is too large and cannot load to the water curing compartment. This beam will be cured for 28 days. Then, test will be conduct which is flexural strength test. Beams sample will test until failures occur.

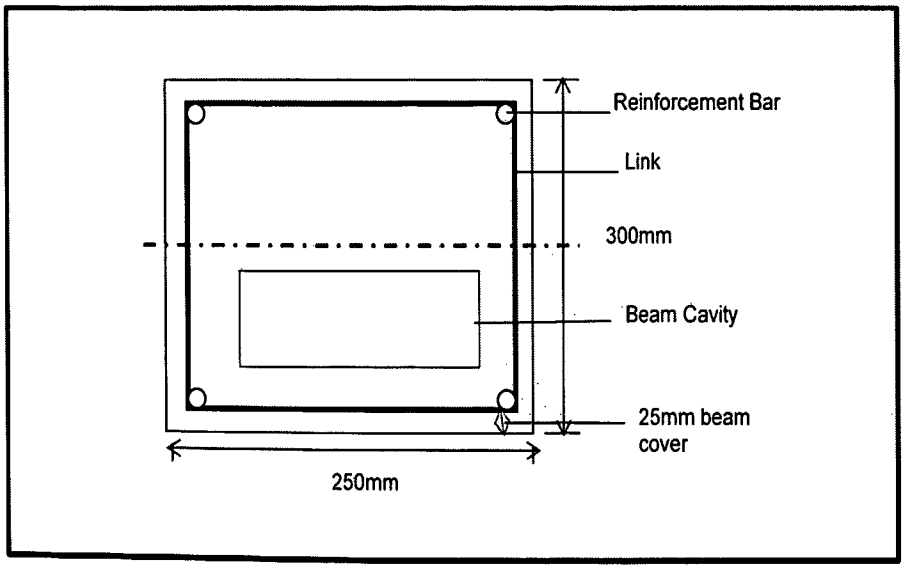

Figure 1.0: Hollow beam cross section.

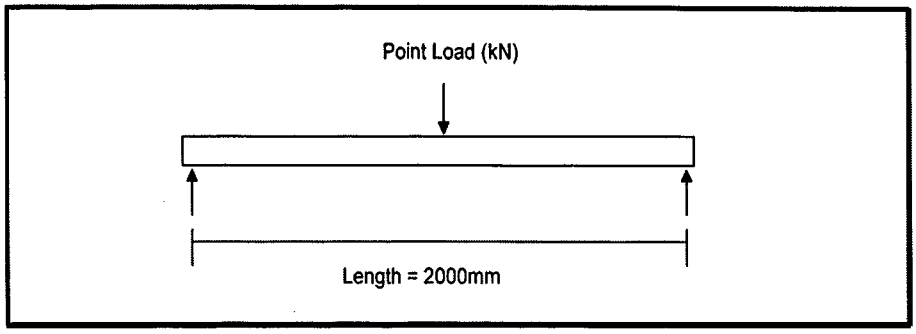

Figure 1.1: Schematic of flexural beam test.

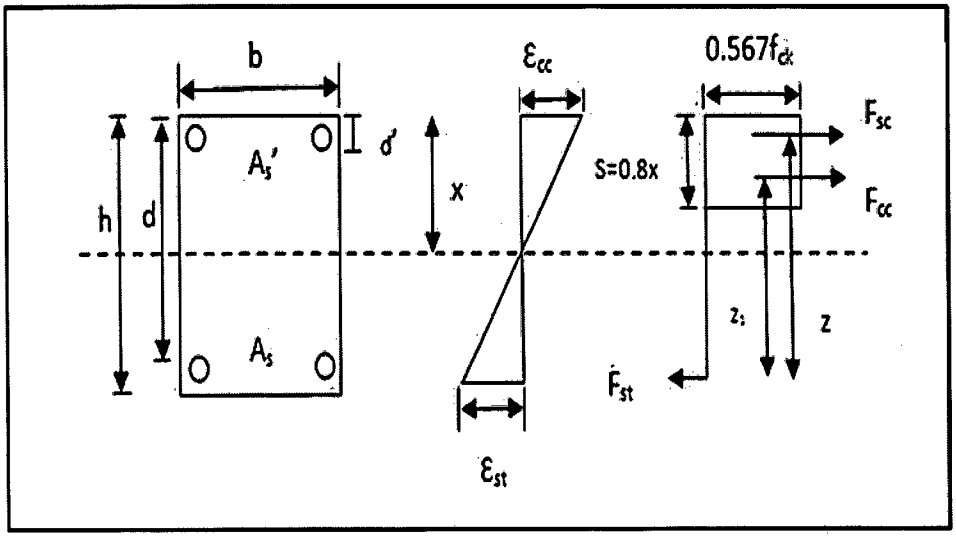

Figure 1.2: Section, strain and stress diagram.

1.5 EXPECTED OUTCOME

In this study, there is some target that should be achieved. First, the crushed recycled brick aggregate concrete can achieve the strength at least equivalent to the strength of conventional concrete. Second, the different cavity opening in the hollow section beam will produce different ultimate strength.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Rapid construction in our country that led to higher demand for construction materials and cause materials source are limited. Consequences, alternatives way was required to meet this demand and one of the alternatives is by use hollow structure. By using hollow structure it can help to reduce the structure self weight and cost of construction materials and. Hollow structure was widely used nowadays because it is lighter, flexible and save costs (Namiq. Z. F, 2012).

Hollow section beam can define as closed thin wall beam section and the walled beam is characterized by the relative magnitude of its dimensions. Hollow section beam has small wall thickness than other linear dimensions of the cross section. Hollow section structure designed to resist great torsional rigidity such as box girders (Namiq. Z. F, 2012). Besides that, the strength of concrete in tension is roughly one-tenth of the compressive strength, and the tensile force in the concrete below the neutral axis is small compared with the tensile force in steel. The contribution of the tensile stresses in the concrete to the flexural capacity of the beam is small and can be neglected (Yassin. M. S, 2012)

Hollow section structure is usually designed to reduce self weight and to increase the flexural rigidity. Hollow section structure is the structure that used less volume of materials than conventional structure due to reduction in cross

section area. Hollow section structure is usually used for the long span of structure such as bridge where the weight and cost are in high considerations (Inoue. S et. al, 1998).

Nowadays, concrete is one of the important materials that used in construction development. However, by time passes the ingredients to make concrete is decreasing due to the high demand. The alternative way has been discovered to overcome this problem by using recycles materials from construction and demolition of building. The using of recycles aggregates in concrete from building construction and demolition is not a new things. It was practice and known long time age since the Roman times. By using this recycles aggregate as a replacement aggregate can help in economic and environmental stability term. Other than that, this recycles aggregate can be used in various types of construction such as building and roadway.

Economic and environmental term is factors that contribute the increasing of use this material rather than just discard it as waste in landfill area. One way to produce recycle material from this construction and demolition waste is by crushing and grading it become aggregate and used it during the concrete production. Consequences, it helps to reduce waste material in landfill area and also help reduce the demand on natural aggregate. The natural aggregate can be saved for the high quality applications construction (De Venny. A. S, 1999).

The potential use of recycle aggregate for future construction was widely discussed on a local as well as in national scale. Due to increasing price of natural aggregate the use of recycled aggregate from construction and demolition building will become increase. Besides that, it also widely use in place where the natural aggregate is scarce. Concrete with recycled aggregate usually used as low level applications such as sub-base, site fill, capping layer or as a pipe bedding. It also used in new concrete structure construction either in horizontal and vertical applications. In other hand, a recycled aggregate is more affordable compared than natural aggregate in term of economic. The

construction and demolition waste that used as aggregate are including the crushed aggregate, crushed brick masonry as well as mixed rubble such as from roadways and building (Cavalline. T. L, 2012)

Furthermore, there is study shows that concrete produced with recycled aggregate have strength at about the same as concrete that produced with natural aggregate. Not only that, the mechanical and durability characteristics of concrete with recycled aggregate are can be compared similar properties of concrete with the natural aggregate (Cavalline. T. L, 2012). Besides that, to save concrete material it was advisable to construct the beam as hollow beam.

2.2 CONCRETE

Concrete is mixing of cement, fine aggregate, coarse aggregate and water. Concrete can be molded into various types of shape according to the mould shape. Concrete is filled about 70% to 80% by aggregate which is lead to the major volume of concrete. However, due to limited of natural aggregate source it is necessary to find others and new sources alternatives that can be use as substitute as aggregate.

Concrete that produce with recycle brick aggregate shows the performance that extensive and satisfactory for ordinary concrete (Dey. G. et. al, 2013). According to Ahmad. S, (1998) the quality and strength of concrete not only depend on the ingredients it also involves the preparation method, curing, placing and also environment condition to produce the high quality concrete.

2.2.1 Cement

Cement act as a binder in concrete to bind fine and coarse aggregate together and can hardens independently. Cement is one of the important ingredients in production of concrete and mortar. The combination of cement, fine and coarse aggregate will produce strong building materials. Cement is not a simple chemical compound, it is contain four main compound that is; Tricalcium

Silicate (C_3S), Dicalcium Silicate (C_2S), Tricalcium Aluminate (C_3A) and Tetracalcium Alumino Ferrite (C_4AH).

This chemical compound has own function in order to produce high quality concrete. Tricalcium silicate hydrates fast contribute for early strength development, while Dicalcium Silicate hydrates slower because it is contribute for belated strength development. Furthermore, Tricalcium Aluminate contributes slightly too early strength and Tetracalcium Aluminoferrite responsible to give colour to the cement. During the study only one type of cement is use because, by use one types of cement the effect of various type of aggregate in concrete can be observe (Khalaf. F. M, 2006).

2.2.2 Aggregates

Aggregates either fine aggregate or coarse aggregate is the main ingredients in concrete that almost 60% to 75% occupied the concrete volume. The quality selection of aggregates is very important and compulsory because it is influence the concrete physical and mechanical characteristics. The hardened concrete strength is depends on aggregates use which is the source for the fine and coarse aggregate. The different types of aggregates use will produce different strength of concrete (Bazaz.J. B, et. al, 2012).

2.3 RECYCLED AGGREGATES

Recycled aggregate is found from the reprocessing of waste materials where the main source is from the construction and demolition site. There are several types of waste that produced from the construction and demolition site such as, concrete rubble, tiles and bricks, sand, timber and metals. Usually, concrete rubble is contributing the largest quantities from the construction and demolition waste.

Study has shown that recycled aggregate from construction and demolition waste has potential used as substitute for natural aggregates in

concrete. This waste can be used either for fine or coarse aggregate. Apart from being used in concrete this recycled aggregate also suitable used in base layer and sub-base layer in pavements (Kou. S. C, 2006).

The strength of recycled crushed brick masonry aggregate is different according to the manufacturing methods and impurities on the recycled brick before it re-process as crushed aggregate. An impurity is one of the issues that cannot be avoided in recycled aggregate. Furthermore, the strength of concrete that used recycled crushed brick aggregate as substitute for natural aggregate will depends on the original strength of brick (Adamson. M. B, 2012).

2.3.1 Properties of Recycled Crushed Brick Aggregate

The recycled crushed brick aggregate has high water absorption compared to natural aggregate. As consequences, the aggregate should be immersed in water before use in mixing process to ensure it is in saturated condition to ensure the concrete mixing has good workability. Besides that, recycled crushed brick masonry aggregate has high porosity characteristics that cause it has high permeability. However, these characteristics potentially improve the free-thaw resistance performance (Adamson. M. B, 2012).

2.4 NATURAL AGGREGATE

Natural aggregate is aggregate that the sources is cannot be renewed. Natural aggregate is aggregate that used in concrete with their natural state or after the aggregate is crushing and sizing. Gravel and sand, and crushed stone is two of main source of natural aggregate where it is can be use directly without any process in construction or as a raw materials for bituminous road. There is various types of natural aggregate such as; Limestone, Sandstone, Gritstone, Basalt and also Granite. The chemical composition of natural aggregate is vary considerably while use in construction.

The strength and density of natural aggregate and recycled aggregate is different. Study has shows that natural aggregate has high density than recycled aggregate. Concrete that produced from natural aggregate has good strength however, the concrete strength that produced from recycled aggregate is still can be considered (Khalaf. F. M, 2006).

2.5 WORKABILITY OF CONCRETE

Workability of concrete is the behavior of concrete which is involving mixability, mouldability, transportability and also compactibility. In concrete construction all the mixtures workability is measured by using slump test. The mixture workability is should not segregate. Concrete mixture that content recycled crushed aggregate is has low workability. The mixture is stiffer and coarser which contribute to the low slump compared to the concrete mixture content natural aggregate that has same water cement ratio. The high friction of recycled aggregate surface is the main cause of low slump compared to the natural aggregate (Bazaz. J. B, 2012).

2.6 CONCRETE CURING

Curing is essential to ensure concrete achieve it optimum strength. Adequate curing is compulsory to ensure concrete can complete hydration process faster to make concrete harden in order to achieve desired durability and strength. As the result, the continuous curing is required until the concrete obtain the design strength that specified.

There are various types of curing method such as; water curing, air curing, drying curing, wet gunny curing and many more. The ultimate strength of concrete was highly affected by curing condition. Concrete may loss it strength due to absence of curing especially in early stage and it is irrecoverable. Study shows the 7 days moist curing will ensure concrete get eventual strength. While, for 28 days continuous of moist curing will allow the concrete to get strength about 75% to 80% in range (Ahmad. S, 1998).

2.7 HOLLOW SECTION

Hollow section structure is usually designed to reduce the self weight and to increase the flexural rigidity. However, for hollow section of reinforced concrete is have potential do not have enough energy dissipation and plastic deformation capacity because it is hard to ensure deterioration of shear resistance because of thinner web. However, concrete structure is has advantages in terms of stiffness and compressive strength (Inoue. S, et. al, 1996).

One characteristics of hollow section have in common is there are light compared to the alternative structure. Therefore, hollow section structure usually uses in long span structure and construction that weight and cost is highly under considerations (Namiq. F. Z, 2012).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This study is proposed to determine the flexural strength of reinforced recycled brick masonry aggregate hollow section beam. Besides that, this study also conducted to identify the effect cavity size in hollow section beam.

There are several processes to produce the hollow section beam by using recycle coarse aggregate as replacement before it tested to fulfill the objectives of this study. In this study, the hollow section beam produced by including material preparation, mixing of material, curing and then followed by testing. After the beam is ready and have been test, all the characteristics or any advantages and problems that encountered were discussed.

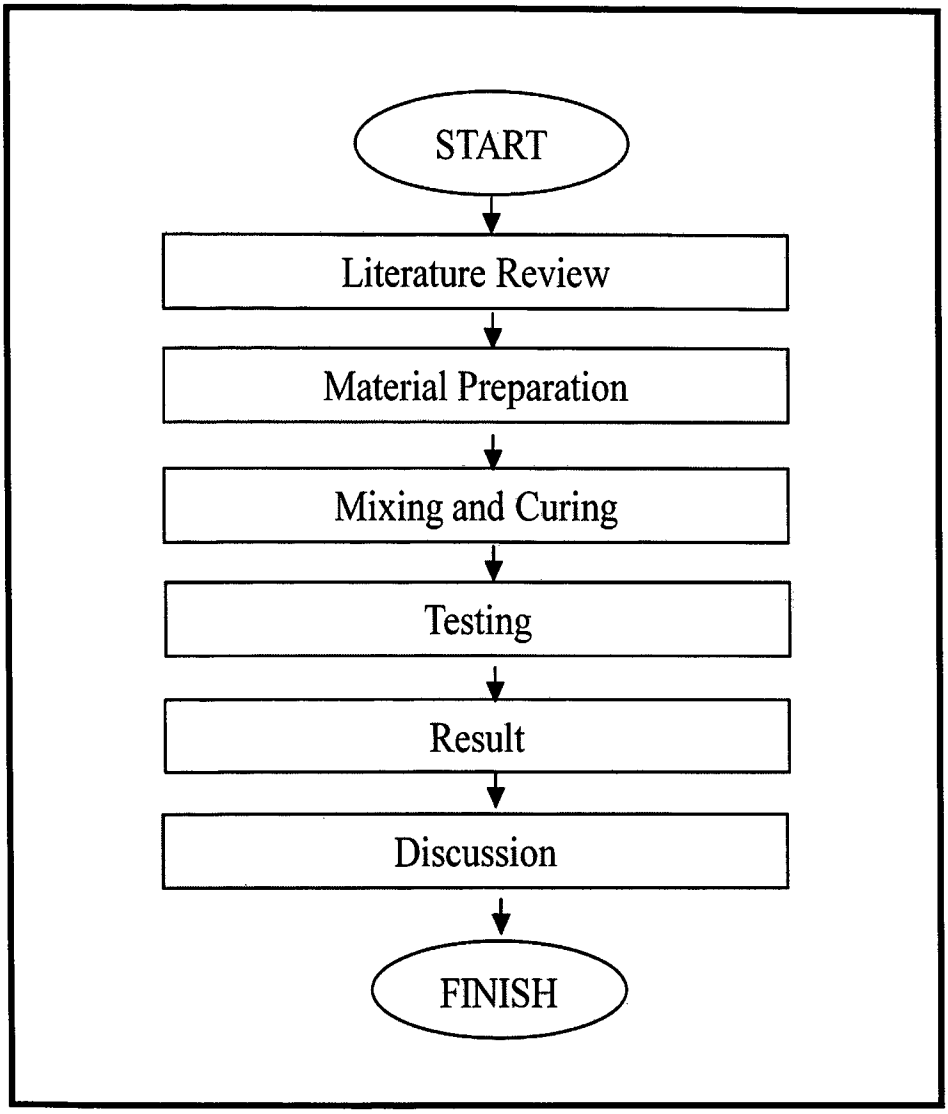

Figure 3.0: Flowchart of work.

3.2 MATERIAL PREPARATION

Materials preparation was done before concrete mixing process started to facilitate laboratory works. Steel reinforcement bar and polystyrene spacer, concrete materials and formwork were checked to ensure it is ready to use, enough in quantity and in good condition.

Materials that required to produce concrete are cement, fine aggregate, coarse aggregate and water. In this study type of cement that used is Portland Composite Cement (PCC). Steel reinforcement bar and link also required with