EFFECT OF SHEAR REINFORCEMENT TO REINFORCED CONCRETE BEAM BEHAVIOR

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EFFECT OF SHEAR REINFORCEMENT TO REINFORCED CONCRETE BEAM BEHAVIOR

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ABSTRACT

The flexural strength is one of the mechanical properties of concrete. The flexural strength of concrete is needed to determine the maximum deflection and also maximum loads that concrete can maintain at certain times. Shear reinforcements, which are norally provided as vertical stirrups, are placed at varying intervals depending upon the shear conditions acting on a beam. The flexural failure in reinforced concrete beams does not happen suddenly but instead it shows some warning of distress that will occur in the near future. Contradictory to this, the shear failure is sudden, catastrophic and devastating. To avoid any such sudden shear failure, shear reinforcements are provided. Also, the shear reinforcement has a control over the shear strength of the beam. The shear stirrups and are used to increase the shear strength of concrete beams, to avoid the shear failure and to cause a flexural failure. The main aim of this research is to study the effects of shear reinforcement on flexural strength in concrete beam. The concrete mixture used in the present study consists of cement, course aggregates, fine aggregates and water. Two types of tests i.e. compressive and flexural were carried out. The samples for compressive strength included cubes with size of 150 mm x 150 mm x 150 mm, while the size of the beams used for flexural strength tests were 150 mm width x 150mm depth x 750mm length. The results show there is no difference in flexural capacity between 3 shear links and 4 shear links, but when add 5 shear links we notice slight increase in the flexural capacity, it is concluded that the addition of links as shear reinforcement slightly effect the flexural capacity.

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LIST OF SYMBOLS

N/mm^2	Newton per millimetre square
kN	Kilo Newton
N	Newton
mm	Millimetre
m	Metre
MPa	Megapascal

LIST OF ABBREVIATIONS

BS EN	British Standard European Norm
ASTM	American Standard Test Method
MS	Malaysian Standard
OPC	Ordinary Portland Cement

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Beam is a structural element that firstly resists the loads applied horizontally to the beam's axis. When we apply the loads to the beam it causes reaction forces at the packet support points and this happening because the position of deviation of this beam is primarily by bending. The overall effect of all the forces acting on the beam is to produce shear forces and bending moments through the beam, this stimulates the internal stresses, strains and deflections of the beam. So, beams can be described as members that are mainly subjected to flexure and it is essential to focus on the analysis of bending moment, shear, and deflection. When the bending moment acts on the beam, bending strain is produced. The resisting moment is developed by internal stresses. Under positive moment, compressive strains are produced in the top of beam and tensile strains in the bottom. Concrete is a poor material for tensile strength and it is not suitable for flexure member by itself. The tension side of the beam would fail before compression side failure when beam is subjected a bending moment without the reinforcement. For this reason, steel reinforcement is placed on the tension side. The steel reinforcement resists all tensile bending stress because tensile strength of concrete is zero when cracks develop

Beams are generally clarification of building or structural designing or civil engineering structural components. However, any structures, for example, car vehicle outlines, flying machine parts, machine outlines.

In engineering, there are several types of beams based on the supports which are Simply supported beam which a beam is supported on the ends that is allowed to rotate and have no moment resistance, fixed beam which a beam is supported on both ends and limited from rotation, over hanging which a simple beam extending toward its support on one side ,double overhanging which a simple beam with both ends extending beyond its supports on both ends, continuous beam or nonstop supports beam which a beam extending over more than two supports, cantilever beam which the beam is settled just toward one side and trussed beam which a beam is strengthened by adding a cable or rod to form a truss

Reinforced concrete is one of the modern building materials widely used. Concrete is an “artificial stone” obtained by mixing cement, sand, and aggregates with water. When aggregate is mixed together with dry Portland cement and water, the mix it forms fresh liquid of concrete that is easily poured and molded into any shape we want to get, which is an inherent advantage over other materials, the cement reacts chemically with the water and other components to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. After the production of Portland cement, concrete became very popular around the world; however, its limited resistance to tension prevented its widespread use in building construction, to overcome this weakness, steel bars are included in concrete to form a composite material called reinforced concrete. The modern reinforced concrete design and construction practice were developed by European engineers in the late 19th century, nowadays the reinforced concrete is widely used in many range of engineering applications such as building, bridges and dams

In the late nineteenth century, reinforcing materials, such as iron or steel rods, began to be used to increase the tensile strength of concrete. Today steel bars are used as common reinforcing material. Usually steel bars have over 100 times the tensile strength of concrete; but the cost is higher than concrete. Therefore, it is most economical that concrete resists compression and steel provides tensile strength. Also, it is essential that concrete and steel deform together and deformed reinforcing bars are being used to increase the capacity to resist bond stresses.

Good structural analysis and design must be completed with appropriate reinforcement detailing to make sure that the whole structure acts as it designed by the designer.so the process of details and arrangement of the bar should be in the best way, practical, cost-effective, and suitable for their intended use, otherwise you may suffer from ugly cracks, excessive deflection, or even collapse because the poorly detailed structure

Flexural strength, which also known as modulus of rupture, or bend strength, or transverse rupture strength is a substance property, which is defined as stress in a material before it is produced in a bend test (Michael Ashby 2011) .Most often transverse bending test is used, in which we employ a rectangular or circular cross section that is bent until breaking or yield by using a three-point rupture of modulus test technique, the flexural strength is the highest pressure occurs within the material at its moment of yield, this is measured in terms of stress.

when the shape of an any object is a single material such as steel bar or wooden beam, it is faces a range of pressures through its depth, the stress will be at its maximum pressure value if the state of the edge is concave face means that the edge of the object is on the inside of the bend, on the other hand the stress will be at its maximum tensile value if the pressure at the outside of the bend which means convex face, These internal and external edges of the beam or rod are known as the 'extreme fibers'. The majority of substances fail under tensile stress before they fail under pressure stress, so the transverse rupture strength (bend strength) is the maximum value of tensile stress that can be sustained before the beam fails.

The flexural strength of a material is defined as its ability to resist deformation under load. For materials that deform significantly but do not break, the load at yield, typically measured at 5% deformation/strain of the outer surface, is reported as the flexural strength or flexural yield strength. The test beam is under compressive stress at the concave surface and tensile stress at the convex surface.

1.2 PROBLEM STATEMENT

Flexural tests are highly sensitive to sample preparation, handling and processing procedure. Beam specimens are very heavy and can be damaged when handled and transported from the jobsite to the lab, allowing a beam to dry will yield lower strengths. Beams must be cured in a standard manner, and tested while wet. A short period of drying can lead to a sharp decrease in flexural strength. The concrete industry and inspection agencies are much more familiar with traditional cylinder compression tests for control and acceptance of concrete. but for accept the concrete the corresponding compressive strength should be used and so that Flexure can be used for design purposes .it must make both flexural and compressive tests so that a correlation can be developed for field.

Shear Reinforcement Concrete materials are very attractive for use in civil engineering applications because their high strength to weight and hardness 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 been increased in the improvement of concrete structure. In some cases, it is necessary to change the existing structural system because changing of use instead of rebuilding a new structure.

The applications of Shear Reinforcement Concrete are able to overcome this problem. The Shear Reinforcement Concrete will be function to overcome the problem of the concrete that has the weakness about the strength. The Shear Reinforcement Concrete 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. Shear Reinforcement Concrete is use all over the world to overcome the strength problem

1.3 RESEARCH OBJECTIVES

The following are the objectives of this research:

i) To study the effect of shear reinforcement variation on the flexural strength of reinforced concrete beam.

ii) To investigate the structural behavior of reinforced concrete beam.

1.4 SCOPE OF STUDY

The aim of this research is to understand the factors effect of shear reinforcement on modulus of rupture in concrete. In this study the, beams with same geometrical dimension [150mm (width) x 150mm (height) x 750mm (length)] and reinforcement detailing categorized into B1, B2 and B3 were tested to evaluate the effect of flexural strengthening using different number of links, the total of the beams designed will be nine specimens so every beam will conducted as three specimens .The beams B1 were designed as specimens with five links implemented where the distance between one link and the other is 116 mm, the beams B2 were designed as specimen with four links implemented where the distance between one link and the other is 140mm, the beams B3 were designed as specimen with three links implemented where the distance between one link and the other is 175 mm. The detail are given in table 1.

Table 1.1 Detail about beams design

Category	Specimens	Spacing
B1	3	116 mm
B2	3	140 mm
B3	3	175 mm

In order to achieve the objective of this study some of the tasks were conducting which includes slump test on fresh concrete to measure the workability of concrete, compression testing of concrete cube (6 cubes, 3 after 7days and 3 after 28 days) to determine the compressive strength of hardener concrete specimen with reference to the standardized method, and flexural testing of concrete beams strengthened to study the load deflection behavior of all beams and evaluating the failure modes. The result was also compared in between the beam specimens in order to determine the better model

1.5 SIGNIFICANT OF STUDY

The significance of this study is to improve the flexural design of reinforced concrete by taking into account the effects of links as shear reinforcement. Furthermore, the addition of shear links may have positive effect on the modulus of rupture. It can be improving the strength of the conventional concrete by using the shear reinforcement. 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.

Alternatively, the increased modulus of rupture can lead towards using small cross-sections for beams with high shear and flexure values resulting in more environment friendly structures, as well as the increased modulus of rupture value can lead towards saving in terms of the longitudinal reinforcements.

With no doubt, the most importance thing of the design of reinforced concrete beams is safety. Sudden failure due to shear low strength is not desirable mode of failure. The reinforced concrete beams are designed primarily for flexural strength and shear strength. Beams are structural members used to carry loads primarily by internal moments and shears. In the design of a reinforced concrete member, flexure is usually considered first, leading to the size of the section and the arrangement of reinforcement to provide the necessary resistance for moments. For safety reasons, limits are placed on the amounts of flexural reinforcement to ensure ductile type of failure. Beams are then designed for shear. Since shear failure is frequently sudden with little or no advanced warning, the design for shear must ensure that the shear strength for every member in the structure exceeds the flexural strength. The shear failure mechanism varies depending upon the cross-sectional dimensions, the geometry, the types of loading, and the properties of the member.

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

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review was a preliminary survey to view related overall study. The literature review is made to understand and to obtain background of the research topics beginning of the subject title. There are several papered that have been recently discussed the methods and strategies used in concrete structures. In the construction industry, the important part is safety in the field, in this industry have to avoided any sudden failure which may happened because low strength in shear. In reinforced concrete design, beam is designed primarily to resist moments and shears. However, in the reinforced concrete design, the flexure is one of the main aspect to be consideration first, leading to the size of the section and the arrangement of reinforcement to provide necessary resistance for moments. For the safety purposes, limits are placed on the amounts of flexural reinforcement in order to achieve ductility failure

Reinforced concrete is widely accepted material for quick preparation. It is widely used in the construction industry all over the world. The use of reinforced concrete has increased due to its noticeable advantages like high modulus of elasticity, chemical resistance, shrinkage and permeability. Besides these advantages, there is various mode of failure exist in reinforced concrete structure. The most common failure in the concrete beams and other structural component is shear failure which give no pre-attention to his user.

In members with shear reinforcement, a large portion of the shear is carried by the shear reinforcement after diagonal cracking occurs. Shear reinforcement also provides a certain level of restraint against the growth of inclined cracks and thus helps to ensure a more ductile behavior. Finally, shear reinforcement provides dowelling resistance to shear displacements along the inclined crack. For these reasons, the presence of shear reinforcement changes the relative contributions of the different shear resisting mechanisms. The minimum amount of shear reinforcement required to affect such changes becomes important and that minimum amount is taken as a function of the concrete strength in most major design codes. Such is the case in both the AASHTO Standard and LRFD specifications

2.2 FLEXURAL STRENGTH

The other terms of flexural strength or bending strength, modulus of rupture of fracture strength. The flexural strength is one of the mechanical properties of concrete. The flexural strength of concrete is needed to determine the maximum loads that concrete can maintain at certain times. Theoretically, there are limits of concrete in receiving the loads apply before it yields or rupture. The flexural strength will be the same as tensile strength if the material used is standardized

The flexural strength is likewise recognized as the material's ability to resist deformation under loads applied. The flexural strength is almost 10 to 20 % at the same as compressive strength that depending on type, size and volume of aggregates used in concrete production. Generally, a beam is used to determine the strength of modulus of rupture. This is due beam will have a larger in size that make it easier to find the maximum point of stress also are calculated on incremental load applied. The flexural strength result also is used nowadays to control the properties of concrete instead of compressive strength.

2.3 DUCTILITY

Ductility is a desirable structural property because it allows stress redistribution and provides warning of impending failure. Steel-reinforced concrete beams are under-reinforced by design, so that failure is initiated by yielding of the steel reinforcement, followed, after considerable deformation at no substantial loss of load carrying capacity, by concrete crushing and ultimate failure. This mode of failure is ductile and is guaranteed by designing the tensile reinforcement ratio to be substantially below (ACI 318 requires at least 25 % below) the balanced ratio, which is the ratio at which steel yielding and concrete crushing occur simultaneously. The- reinforcement ratio thus provides a metric for ductility, and the ductility corresponding to the maximum allowable steel reinforcement ratio provides a measure of the minimum acceptable ductility.

2.3.1 Yield Deformation

Definition of the Yield Deformation When calculating ductility factors the definition of the yield deformation (displacement, rotation or curvature) often causes difficulty since the force-deformation relation may not have a well-defined yield point. This may occur, for example, due to nonlinear behavior of the materials, or due to longitudinal bars at different depths in a reinforced concrete section reaching yield at different moment levels, or due to plastic hinges in different parts of a structure forming at different load levels.

2.3.2 The Maximum Available (Ultimate) Deformation

The Maximum Available (Ultimate) Deformation is the maximum available (ultimate) deformation has also been estimated using various assumptions by investigators. The displacement corresponding to a particular limiting value for the concrete compressive strain, the displacement corresponding to the peak of the load displacement relation, the post-peak displacement when the load carrying capacity has undergone a small reduction, and the displacement when the transverse or longitudinal reinforcing steel fractures or the longitudinal compression reinforcement buckles. When considering the most appropriate definition it should be recognized that most structures have some capacity for deformation beyond the peak of the load-displacement relation without significant reduction in strength.

2.4 SHEAR AND ITS IMPORTANCE

The study of shear behavior in concrete structures has been going on since a century. It was until the year 1955, when the shear failure of beams that took place in the warehouse at Wilkins Air Force Depot in Shelby, Ohio, researchers were of the view that shear was simple problem to deal with. Then they realized that shear in concrete beams cannot be designed as traditionally as it was done earlier. There has been a feeling among researchers to go back and rethink about the fundamentals of shear design. Going back, the work done by Talbot (1909) during the year 1909 was considered to give a clear and significant way to analyze the shear for designing concrete structures. Talbot's results confirm that the shear stress is a function of longitudinal reinforcement, length of the beam and the stiffness of the beam

It is only since the last four decades, researchers have been focusing their work to evolve a common and a rationalized consensus on design for shear which could be globally acceptable. As a result, many theories have been developed to explain the shear behavior in beams and also to estimate its shear capacity.

2.5 FACTORS INFLUENCING THE SHEAR BEHAVIOR AND CAPACITY OF REINFORCED CONCRETE BEAM

2.5.1 Factors influencing the shear behaviour

Shear failure in concrete beams are brittle in nature and are catastrophic, which is completely contrary to flexural failure where ductility is dominant. In the concrete beams since the shear failure precedes the flexural failure, the shear strength is designed to be greater than the flexural strength at all points along the beam. Shear behavior of a beam without shear reinforcement is mainly determined by four factors: the ratio of shear span to effective depth, the longitudinal reinforcement ratio, the tensile strength of the concrete and the existence of axial forces Mac Gregor (1988). Shear forces in a beam occur wherever the applied moment changes along its length

The main assumption in the ACI 318 code specification is that the shear capacity is proportional to the depth of the member. To discover the fact about this assumption, many experimental investigations were conducted by Shioya in which they tested reinforced concrete members that ranged in depth from 100 to 3000 mm. All members were simply supported without any shear reinforcement and were reinforced in flexure. The results prove that the shear stress at failure decreases as the depth of the member increases.

The influence of size has a significant role in shear carrying capacity in Reinforced Concrete beams was found by Bazant, Z.P,&Kim,J.K.(1984) who worked on “size effect” in concrete beams. He demonstrated that the shear stress at failure de-creases as the depth of the member increases. Assuming the contribution of concrete strength in design is a common practice, where the shear resistance is assumed to be proportionate to the square root of the maximum cylinder 15 compressive strength. But, the latest research has proved that high cylinder strengths do not result in high shear strength.

The presence of the longitudinal reinforcement also affects the crack by reducing its size and modifies resistance performed by the total interlock. The length and depth of the crack decreases significantly in the presence of larger amount of longitudinal reinforcement. The decrease in the size of cracks helps to prevent the beam from increasing crack spread. Thus, by providing greater amount of longitudinal reinforcement, the shear capacity can be increased to an extent.

2.5.2 Factors influencing the shear capacity

In case of concrete beams without shear reinforcement, the load at cracking determines the capacity of the member. However, in the case of beams with shear reinforcement, even after cracking there seems to be some resistance to shear due to the presence of tensile stresses in concrete. This fact about the increased capacity was found by Collins et al (1996). The design capacity of these beams depends on the load at cracking.

Concrete beams without stirrups, having a longitudinal reinforcement ratio between 0.75 to 2.5 percentage, fail only due to shear. In this range, beams with Lower reinforcement ratios tend to fail at lower shear stresses. Beams that fail in shear have greater amount of reinforcement than what is minimum required for a flexure. Beams with very low ratios of longitudinal reinforcement generally fail in flexure earlier before the shear 17 capacity is reached. The axial compression produced due to applied load, serves to increase the shear capacity of a beam. Opposing this, the axial tension greatly decreases the shear capacity this has been proved by MacGregor and Wight (2005).

2.6 EFFECT OF SHEAR REINFORCEMENTS ON FLEXURAL STRENGTH

The flexural failure in reinforced concrete beams does not happen suddenly but instead it shows some warning of distress that will occur in the near future. Contradictory to this, the shear failure is sudden, catastrophic and devastating. To avoid any such sudden shear failure, shear reinforcements are provided. Also, the shear reinforcement has a control over the shear strength of the beam. The shear stirrups and are used to increase the shear strength of concrete beams, to avoid the shear failure and to cause a flexural failure.

Shear reinforcements, which are normally provided as vertical stirrups, are placed at varying intervals depending upon the shear conditions acting on a beam. Different configurations of stirrups are being used, such as an open or closed stirrup, or stirrups with multiple legs which depends upon the amount of applied shear. Shear reinforcement are also provided as inclined bars in some cases. Shear reinforcement comes into effectiveness only after the formation of diagonal cracks either crossing them or in its vicinity.

At the instance of diagonal cracks formation, the stirrups come to effect and the stirrups offer more resistance to the shear when the cracks cross them. This controls the growth of the cracks and reduces the penetration of the crack further. Furthermore, stirrups are tied to the longitudinal reinforcement and due to this confinement effect the splitting of concrete along the longitudinal main bars is controlled more effectively. The extent and amount of shear resisted by the shear stirrups and concrete depends upon the design procedure which is being adopted

2.7 SUMMARY

Significant progress has been made in the past century in the design of reinforced concrete members subjected to shear. Some of the important contributions to study the shear behavior such as Kani's model, modified compression field theory, variable truss angle model, rotating angle softened truss model have been discussed.

Despite the huge number of works done on shear behavior of beams, there is still no uniform solution to predict the shear strength of a beam regardless of whether it is slender, short or deep beam. Still, research work on shear behavior of slender beams is currently carried out to find a unified expression for shear strength that could be accepted and adapted commonly.

The role of shear reinforcement in concrete beams which are placed in the form of stirrups contributes to the strength of the shear mechanisms and enhances the shear capacity. A stirrup effectively confines the longitudinal reinforcement and resists the crack. This in turn increases the contribution to shear by effective dowel action. In the presence of stirrups, the cracks are minimized and due to which the shear transfer through aggregate interlocking can be considerably reduced.

By providing stirrups with sufficient spacing, the concrete can be confined with its region and this can enhance the compressive strength and thus increasing the shear capacity. The shear reinforcement used in concrete beams keeps the concrete contribution to shear and allows the development of additional shear force.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology is an important procedure in securing that the project is handled smoothly and well while ensuring that the aims that have been proposed are achieved with satisfactory. The planning of methodological work is also very important to assure that this work will be carried out with an organized and successful. For the completion of this research writing, some of the best methods of research are studied and chosen based on significance towards the study carried out. This chapter will describe the overall procedure of the study carried out in this project.

In starting a study, a flow chart plays an important role to ensure the study progressing according to plan and to avoid any confusion during lab preparation. It's also important to organize the thing that we want to do according's to the order. Therefore, the flow chart will make the studies more systematic.

3.2 THE MATERIALS USED IN CONCRETE MIXING

The concrete mixing materials consist of cement, course aggregates, fine aggregates and water. Use the materials in concrete mixing must achieves the requirement which has been described. This is to make sure that the concrete that will be produce is according the specifications and not fail. The necessary precautions should be taken during mixing the materials that must according to the ratio of materials provided according to the standard.

3.2.1 Cement

For this study, the Portland cement has been chosen due to it is commonly being used spread in our construction industry and its availability in the laboratory. It also most suitable in our country atmosphere and its hardening rate are very suitable to be used for concrete works.

Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and non-specialty grout. It is a fine powder, produced by heating limestone and clay minerals in a kiln to form clinker, grinding the clinker, and adding small amounts of other materials. Several types of Portland cement are available. The most common, called ordinary Portland cement (OPC), is grey in color, but white Portland cement is also available.

The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Concrete can be used in the construction of structural elements like panels, beams, street furniture, or may make cast-in situ concrete for building superstructures like roads and dams. These may be supplied with concrete mixed on site, or may be provided with 'ready-mixed' concrete made at permanent mixing sites.

Figure 3.1 Portland cement

3.2.2 Aggregates

Aggregates play an important role in concrete as aggregate is one of the materials instead of water, cement and other additive in concrete production due to aggregate compose 75% of production of concrete. It likewise means that concrete production, largely depending on aggregate properties. The properties of aggregates are compressive and bond strength, shape and surface, size, permeability and rarefaction of chemicals, other than that, the physical properties of aggregates such as relative density, density loam, porosity and moisture absorption, soundness and resistance to acid and alkali attack also affect the strength of aggregate in concrete production. The choice of aggregates for concrete mix is something very significant due to the properties that will bear upon the strength, toughness mixing ratio, and so thus it economical to the concrete producing

In general, a good aggregate is an aggregate containing details of stability and durability and do not contain ingredients that will bring adverse effects to the concrete such as dust, mud, salt and others. With a high demand of aggregate due to increase in the construction industry, it will make the shortage of aggregate in market to occur.

3.2.2.1 Coarse aggregate

Coarse aggregate comes from an aggregate production process that has been separated into a specific class. The size of coarse aggregate is usually more than 5 mm or specifically the coarse aggregate is aggregate that not passing sieve size 4.75 mm. Coarse aggregate that has been practiced in concrete mixing normally consists of three normal sizes such as 10 mm, 20 mm, and 40 mm. Furthermore, coarse aggregate consists of following types such as hard rock or gravel which are crushed by grinding process and rock that has been derived from natural breakdown.

For the coarse aggregate, the preparation process consists of many stages such as provision of natural aggregates that are often used for concrete mixing. The selection of the types of coarse aggregate is based on the accessibility of the aggregate at the lab. Coarse aggregate was weighed until it reaches the required amount. Then, the coarse aggregate that has been weighed was piled in the lab in an open area. This procedure is done for drying process of the coarse aggregate. This is very vital to ensure that the water content in the aggregate has been removed entirely because it can affect the strength of the concrete.

Furthermore, coarse aggregate must free from any impurities such as bark and clay. Then, coarse aggregate needed to be strained to obtain the needed size. The size of coarse aggregate is between 4.75 to 20 mm, 1t is important to conduct the sieve analysis to differentiate each size and maintain the quality of coarse aggregate.

Figure 3.2 example of coarse aggregates

3.2.2.2 Fine aggregate

The fine aggregate that has been used in concrete mixing is sad that passing the specification during the grading process. Usually the sand that is used consists of the type of not ground. Before mixing process is done. The sand needs to be heated at least one day before the mixing is conducted. This is to prevent a significant humidity in the sand and thus able to influence the water cement ratio content in the concrete mix.

Fine aggregate is containing rougher material that has been approved in conformity with stipulations. Sand is one of fine aggregate that has a smaller in limit size equal to 0.07 mm. Particle size ranging from 0.06 millimeter to 0.02 mm can be classified as sediment and clay. Fine aggregate may consist of the following characters, natural sand of fine aggregate resulting from breakdown process and sand obtained by grinding natural gravel, other than that, sand from hard rock that has been fine-grained.

For this study, the sand is select from laboratory availability. The size of fine aggregate or sand must lower than 4.75 mm. fine aggregate is also required to adopt the same procedure as coarse aggregate that is sieve analysis to produce the wanted size.

Figure 3.3 Example of fine aggregate

3.2.3 Water

Water is the essential source for producing concrete. It plays the important role in the work of the spreading cement concrete so that each detail of aggregates closely covered with cement and also will easily for the concreting work process. Furthermore, water is a substance for a chemical reaction in the cement to bind all of the aggregates during concrete mixing.

Water cement ratio, (w/c) is unitary of the main factors that determine the strength of concrete. The ratio of (w/c) that is lower will produce a lot stronger concrete, while higher ratio of (w/c) will raise a concrete with lower intensity, water applied to make concrete, which that has plastic behavior and well made, and also provide the hydration of the cement. Strength, resistance, and waterproof properties of concrete are dependent on the quantity of water applied, only if amount of water is used more than the prescribed boundary, the durability and density of the concrete will be shortened, otherwise, if too little water use, the concreting process work will be difficult and the hydration process will be imperfect.

The water used during curing and mixing of concrete should be free from harmful chemicals and water cleanness must be taken into consideration because it is very important in ensuring a good quality of concrete.

The water used during the concreting process is tap water. This is due to by the use of tap water the cleanness of water is guaranteed compared to waters. Other than that, the tap water is easily available. The measure of water content is utilized depending on the water cement ratio used. The water cement ratio for all the cement mix process was performed for this study is set at 0.45.

3.3 PRE-MIXING EXPERIMENTS

The concrete production process is done after all the materials for mixing are prepared. There are three stages in producing concrete sample such as:

3.3.1 Mixing process

The mixing process is made by using a concrete mixer machine at the laboratory. By using concrete mixer, the quality and ratio of materials can be controlled. Furthermore, the shorter time is necessitated for the merging process to be performed by using mixing machine.

The amount of water added during concrete mixing needed to be poured gradually to produce uniform concrete compounds. 0.12 m3 per trial mix of each material is used in the preparation of concrete. The ratio of concrete mix for cement coarse aggregate, fine aggregate and water are l: 2.5: 2: 0.45 for each mixing.

3.3.2 Compacting process

After the concrete mixed is ready, the next step was to pour the concrete into mold that has been set up in the lab. At the same time, compaction process needed to be performed as soon as the concrete casting made. The concrete compaction process consists of three layers where each layer has to be compacted first. For every layer the concrete will be blow 35 times with tamping bar. After the compacting process is done, the surface of concrete was flattened.

3.3.3 Curing process

This process is the final stages in concrete production. Generally, curing process functions is to ensure the hydration occur properly where humidity in the concrete can be prohibited. The curing process can only be performed after the concrete that has compacted after 24 hours at room temperature. Then, the concrete mold was removed the hardened concrete produce added into the water tank. The hardened cubes concrete was immersed in water for 7 days for the three first cubes and 28 days for the other three, and the all beam samples were air-dried for 28 days for curing. After the curing process completed according to the days required, then the concrete is ready for tested

3.4 SAMPLE PREPARATION

The sample consists of cubes and beams for concrete mixing. The sample is prepared using materials used for concrete mixing stated in sub topic 3.3. Table 3.2 and 3.3 shows the number of samples that will be used for beams and cubes testing. The only flexural test will use beam as a sample, while others tests will use cube as samples. For the flexural test, there were 9 samples of beam prepared while 6 samples for slumps, compressive strength and water penetration tests. Thus, a total of 15 samples were prepared for this study.

Table 3.1 Sample of beams for testing

Category	Specimens	Spacing	Duration
B1	3	116 mm	28 days
B2	3	140 mm	28 days
B3	3	175 mm	28 days

Table 3.2 Sample of cubes for testing

The Number of cubes	Duration Sample for testing
3 samples	7 days
3 samples	28 days

3.5 DETERMINATION OF CONCRETE PERFORMANCE

In determining the performance of concrete, the test will be done. The test will analyses the performance of concrete using a natural coarse aggregate and fine aggregate. The test will be conducted to identify performances of concrete based on workability and strength of concrete. The tests will be performed in accordance with the standard requirement in the British Standard.

3.5.1 Concrete workability test

The workability test is the measurement of the convenience of air content release trough compaction. There are several factors that influence the workability of concrete such as water and cement ratio, aggregate shape, ratio of aggregate, humidity, and temperature. The tests will be conducted in the laboratory.

3.5.1.1 Slump test

Slump test is done to test in roughly the uniformity of concrete mixing to ensure it's not too melted and not too dry. However, in this test, is so sensitive in getting the different consist of mixing. The most suitable concrete to be used is a concrete that have a higher and a medium workability during this test.

The equipment used in this test is a conical mold made from pieces of metal G16 and a steel rod with a diameter of 16 mm with a ruler. During the slump test process, there are three types of slump that can occur. The types of slump that will occur are true slump, rich slump and collapse slump. Figure 3.4 shows the types of slump occur, in every the conducted, there will be one of that slump that will occur.

True slump shows a good workability of concrete and suitability for used. However, rich slump and collapse slump is showing that the concrete mixing experienced deficiencies in cohesive characteristics or the concrete is too wet. The slump test is conducted in accordance with BS1881: Part 102: 1983.

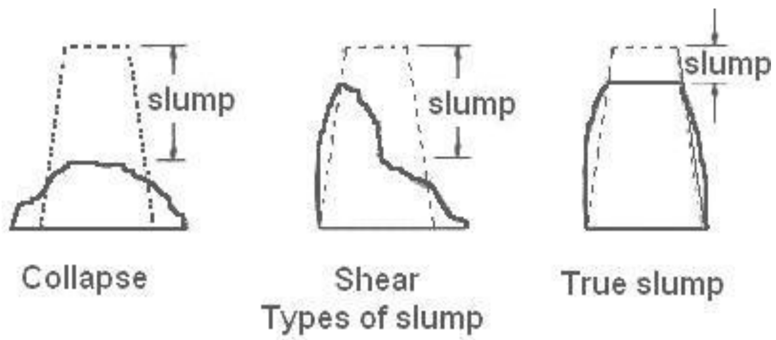

Figure 3.4 Types of slump

In a collapse slump the concrete collapses completely. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate. In a shear slump the top portion of the concrete shears off and slips sideways. Or If one-half of the cone slides down an inclined plane, the slump is said to be a shear slump. 1. If a shear or collapse slump is achieved, a fresh sample should be taken and the test is repeated. 2. If the shear slump persists, as may the case with harsh mixes, this is an indication of lack of cohesion of the mix.

In a true slump the concrete simply subsides, keeping more or less to shape. 1. This is the only slump which is used in various tests. 2. Mixes of stiff consistence have a Zero slump, so that in the rather dry range no variation can be detected between mixes of different workability. However, in a lean mix with a tendency to harshness, a true slump can easily change to the shear slump type or even to collapse, and widely different values of slump can be obtained in different samples from the same mix; thus, the slump test is unreliable for lean mixes.

3.5.2 Concrete strength test

The strength of concrete is one of the most important criteria in determining a good concrete. The strength of concrete depends on the ability of concrete to sustain and maintain its condition during testing. The test conducted such as compressive, and flexural.

3.5.2.1 Compressive strength test

Through this test, as it is shown in (Figure 3.5) The quality of good concrete will be identified. The value result of this test will provide the overview of the strength of tensile, bending, durability, permeability, and the modulus of elasticity. For a good concrete, it is difficult to be permeable and can be exposed to severe exposure and also durability from wear out. Figure 3.6 shows a machine used in compressive strength test. The test is accordance to BS EN 12390-3:2002. The cube size 150 mm x 150 mm x 150 mm is used. The compressive strength is expressed in N/mm^2.

The compressive strength test is used to get the value, compressive strength of hardened concrete at specific an age that is 7 and 28 days. A cube sample is inserted in the middle of the machine and a metal plate is placed above the cube sample that is between the cube and the surface of the applied load

It is important to make sure that the surface of cube sample is smooth before the test is conducted. The reading value shows in the digital meter are recorded and it will give the value of the maximum load can be sustained by the sample cube concrete before it fails. The load value is recorded and the compressive strength can be calculated by the following formula;

Compressive strength=P/A 3.5

Where:

P= is the Maximum load (in N)

A=is the cross-sectional dimension of specimen (Surface area of cubes) (in mm^2)

Figure 3.6 Compressive strength test equipment

3.5.2.2 Flexural Test

The flexural strength of beams can be identified when the fails to occur in the tension part. Flexural strength also known as modulus of rupture is the one that measure the tensile strength of concrete. It is a measure of a reinforced beam to resist failure in bending. The flexural strength depends on load distribution, sample size, rate of humidity and rate of strain stress. It is measured by loading concrete beams with a span length at least three times the depth. This test also involves the use of beams sample size of 100 mm x 100 mm x 500 mm. In this test, the one-point loading method is used and it is determined by British Standard (1881: Part 118: 1983). The formula for the flexural strength is;

$$\text{Modulus of rupture, } F=3FL/bd^2 \qquad 3.6$$

Where,

F =Maximum applied load

L= Beam length (500 mm)

b= Beam width (100 mm)

d=beam depth (100 mm)

a= Distance from Maximum applied load to support

Figure 3.7 Flexural test equipment

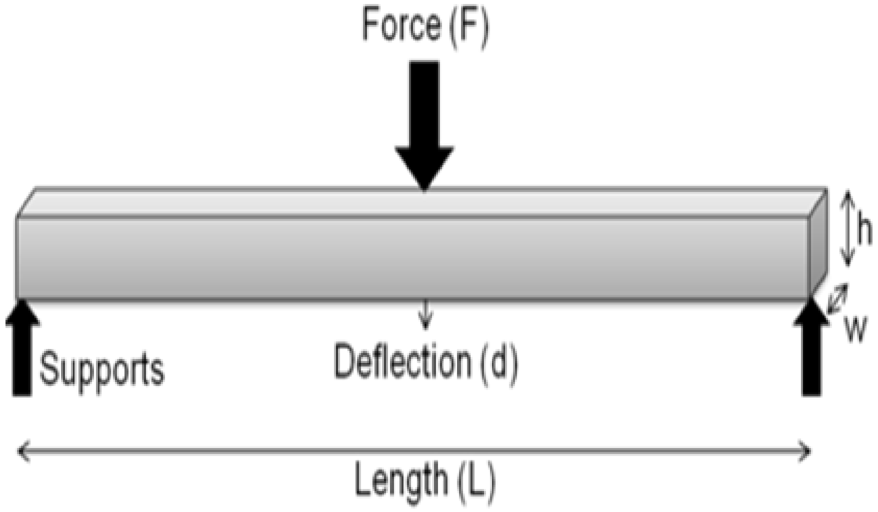

Figure 3.8 loading arrangement on the specimen

CHAPTER 4

DATA ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the experimental program done for this research would be put with its discussions and results. This chapter will mainly focus on the discussion of the effect of shear reinforcement on modulus of rupture in concrete. The shear reinforced would be used as the control sample to discuss the variations in results throughout this study. In this research two main test were conducted; these tests are Compressive Strength Test and Flexural Strength Test.

4.2 CONCRETE 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.

The compressive strength of any material is defined as the resistance to failure under the action of compressive forces. Especially for concrete, compressive strength is an important parameter to determine the performance of the material during service conditions. Concrete mix can be designed or proportioned to obtain the required engineering and durability properties as required by the design engineer.

Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. The ages shall be calculated from the time of the addition of water of the dry ingredients. For number of specimen test At least three specimens. Preferably from different batches. Shall be made for testing at each selected age.

Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting find removed specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2mm and their weight shall be noted before testing.

Placing the specimen in the testing machine the bearing surface of the testing machine shall be wiped clean and any loose sand or other material removed from the surface of the specimen. Which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axes of the specimen shall be carefully aligned with the center of thrust of the spherically seated platen.

4.3 FLEXURAL STRENGTH TEST

For the Flexural Strength Test, it includes a total of 9 samples with the beam size of 150mm x 150mm x 750mm; to investigate the load and deflection displacement of the beam samples. The testing for the beams was done after the age of 28 days of by water spray curing. In Flexural Strength Test, it also quantifies that the reinforcement concrete sample has an ability to withstand a certain amount of loading or deflection displacement. Modulus of rupture testing was implemented at 350mm in vary to the 750mm full-size of the sample. The three-point loading method is used and determined by British Standard (1881: Part 118) and a Linear Variable Differential Transformer which is a deflection sensor to record the mid-span displacement is also utilized. Generally, by connecting the LVDT (Linear Variable Differential Transformer) to a data logger the deflections and the force could be recorded up to every single second. All these samples were placed in the center of the two supports under the loading of hydraulic machine and the data were collected and tabulated through required calculation in Microsoft Excel.

4.4 ANALYSIS OF SLUMP TEST RESULT

The slump test usually conducted to identify roughly the uniformity of mixing concrete and thus be able to know whether the concrete is not highly sleet or too dry. Furthermore, the test was conducted during fresh phase of concrete and through the range value of slump test the workability of concrete can be measured and analyze. Fresh concrete, as many materials in nature or industry behaves as yield stress fluids. An evolution of the material rheological behavior is frequently observed during this stage. The types of slump tests can be categorized into three, such as collapse slump, true slump and rich slump.

Based on the workability of concrete mix design the value of 60 to 180 mm has been chosen as the slump test standard, and from the result obtained in this experiment the slump get the collapse condition which mean high workability, so we can say that the concrete is well mixed and it is without drying

4.5 ANALYSIS CONCRETE COMPRESSION TEST

The Compressive Strength Test includes a total of 6 samples with the cube size of 150mm x 150mm x 150mm; to investigate the characteristics of concrete. The test is conducted in the FKKSA laboratory at University Malaysia Pahang accordance to BS 1881: Part 116: 1983. The testing for the cubes was done after the age of 7 days for 3 cubes and after 28 days for the other 3 cubes.

Table 4.1 Compressive strength for Cubes after 7 days

Specimens	Max load (kN)	Max strength (Mpa)
Cube1	664.336	29.526
Cube2	686.154	30.496
Cube3	652.681	29.008
Average	667.7	29.68

Based on the analysis, the samples for cubes were tested after 7 days in Table 4.1 has recorded a lower value of maximum load result which is 686.154 kN with weight 7.806 kg in comparison to samples were tested after 28 days in table 4.2 which has maximum load result which is 910.846 kN with weight 7.967 kg. For the average load, cubes after 7 days in table 4.1 also records the lowest value result of average load which is 667.7 kN with average weight 7.8 kg in compare to the average value of cubes after 28 in table 2.4 which is 885.694kN with average weight 7.81 kg. From the results showed in table 4.1   in this study can notice that there was no significant difference in between the load values recorded for the samples tasted after 7 days, and also there was no significant difference in between the load values recorded for the samples tasted after 28 days.

Table 4.2   Compressive strength for Cubes after 28 days

Specimens	Max load (kN)	Max strength (MPa)
Cube1	910.846	40.482
Cube2	865.778	38.479
Cube3	880.458	39.131
Average	885.694	39.364

Next, from table 4.2, we see that, concrete gains 39.364 MPa average of maximum compressive strength in 28 days which is considered as a highest value compere to 29.68 MPa average in 7 days in table 4.1. Thus, it is clear that concrete gains its strength rapidly in the initial days after casting, i.e. 50% in only 7 days. When, its strength has reached 75% in 28 days, from this result we can say that the strength for cubes after 28 days curing is higher than strength for cubes after 7 days curing by 25 %, still concrete continues to gain strength after that period, but that rate of gain in compressive strength is very high compared to that in 28 days. Concrete gains strength with time after casting. It takes much time for concrete to gain 100% strength and the time for same is still unknown. The rate of gain of concrete compressive strength in higher during the first 28 days of casting and then it slows down. So, since the concrete strength is 99% at 28 days, we can say that the strength of concrete increases with age, and it's almost close to its final strength, thus we rely upon the results of compressive strength test after 28 days and use this strength as the base for our design and evaluation.

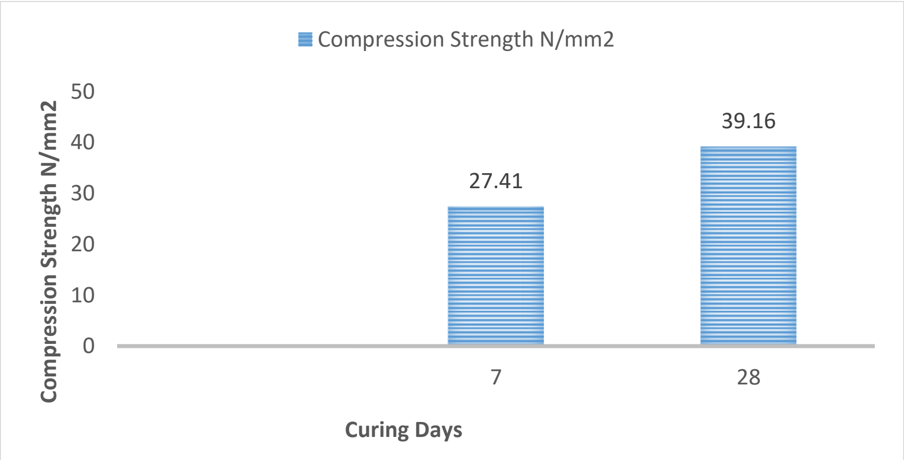

Figure 4.1 Compressive strength for cubes tested after 7 and 28 day.

Figure 4.1 shows the average maximum strength for the cubes tasted after 7 days and 28 days in which the blue histogram represents the maximum strength. From the graph, we can say that the highest value of average maximum strength is 39.364 MPa for the samples tasted after 28 days, and 29.68 MPa of average maximum strength for the samples tasted after 7 days. In brief, we can conclude that the average maximum load for samples tasted after 28 days has shown a tremendous increase compared to the sample of cubes tasted after 7 days. Thus, the usage of cubes after 28 days curing has shown a positive impact for this study.

4.6 ANALYSIS OF FLEXURAL STRENGTH TEST

Based on the analysis, Figure 4.3 represents the graph of flexural strength for three specimens of 3 shear links beam. The graph proves that beam2 line has a sharp increment and gives the highest value of load which is144.78 KN with a deflection value of 6.281mm compared to the other two specimens in the test, followed by beam1 which has recorded the second highest value of maximum load of 139.771 KN with a deflection value of 4.196mm. While the beam3 has the lowest value of load in all beams specimens which is 103.988 kN with a deflection value of 4.444mm. The flexural strength test for 3 shear links has proven to show that beam1 and beam2 has steeply increase and recorded the highest peak load value in comparison to beam 3.

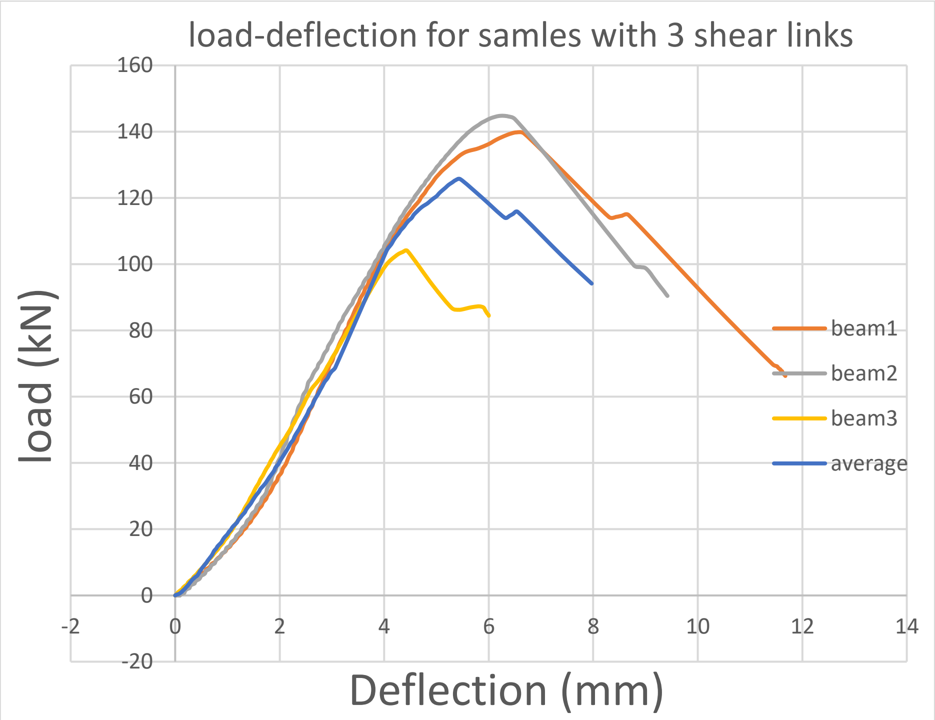

Figure 4.2 Flexural strength of samples with 3 shear links

Next, Figure 4.4 represents the graph of flexural strength for three specimens of 4 shear links beam. In this graph beam42 line has shown the highest increment of load which is 139.633 KN with a deflection value of 6.745 mm compared the beam1 and beam3.In addition, beam43 has recorded closed value to beam42 which considered as the second highest value of maximum load 130.456 kN with deflection value 6. 997mm. moreover, beam41 has the lowest value of load in between all beam's specimens which is 111.347 kN with deflection 5. 284mm. The average value for these three specimens get a maximum load 118.33 kN with a deflection 5.14 mm.

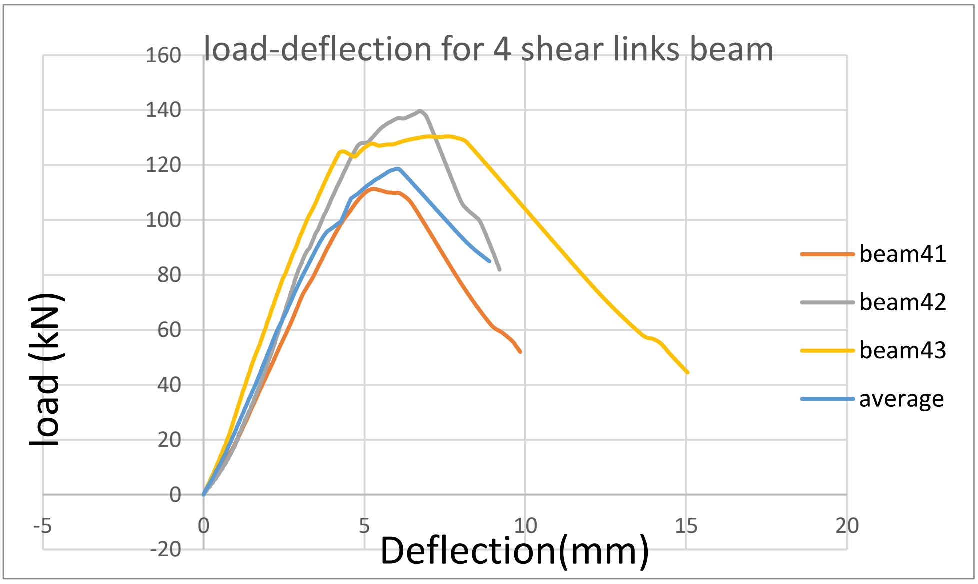

Figure 4.3 Flexural strength of samples with 4 shear links

After that, Figure 4.5 represents the graph of flexural strength for three specimens of 5 shear links beam. In this graph we can see slightly increase in flexural capacity compared to beam with 3 shear links and 4 shear links beams. Here beam52 and beam53 lines have shown the highest increment of load which is approximately 158 compared the beam51 that has shown the lowest value of approximately 135 KN

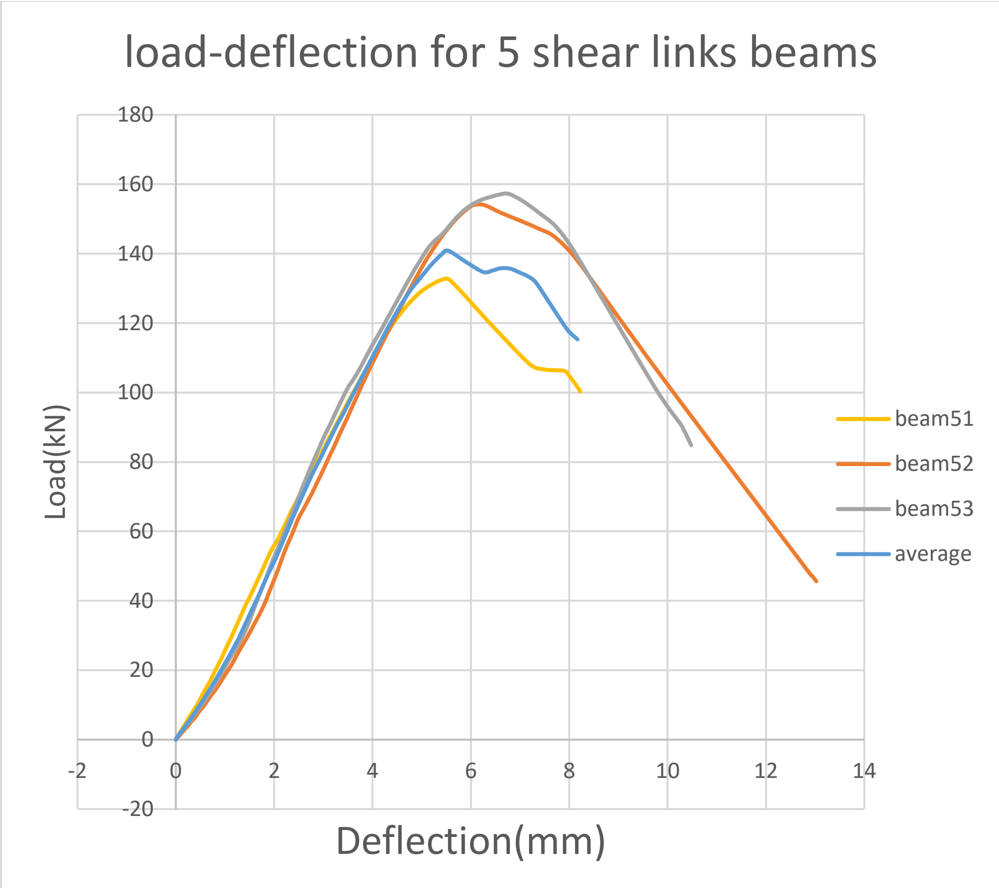

Figure 4.4: Flexural strength of samples with 5 shear links

The flexural strength analysis was also done by using the average of samples result; Figure 4.6 was produced and shows the graph of flexural strength for the average load-deflection lines for the samples beam of different links number used as a shear reinforcement. Basically, the samples that were used 5 shear links shows the highest value of modulus rapture which is 140.86 kN load and its deflection is 5.538 mm in comparison to the sample of 4 shear links and sample of 3 shear links which their maximum value are 118.33 kN load with its deflection 5.914 mm and 125.63 kN load with its deflection 5.4575mm respectively. In comparison to the results from the various graphs in this analysis, the samples with 3 shear links used proved to have not much slippage in comparison to the samples with 4 shear links used. Not only has that, but the remarkable increment of 5 shear links samples used showed the improvement in the flexural capacity. So, for the flexural capacity in this research as we get in the results there is no difference in flexural capacity between 3 shear links and 4 shear links, but when add 5 shear links we notice slight increase in the flexural capacity, it is concluded that the addition of links as shear reinforcement slightly effect the flexural capacity as shown in Figure 4.5.

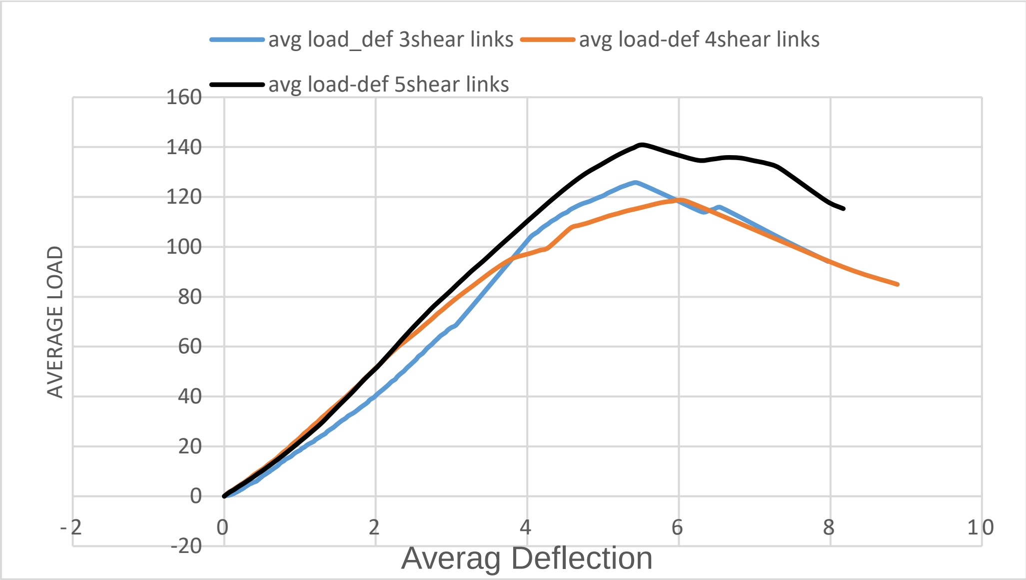

Figure 4.5: Flexural strength average of samples with 3, 4 and 5 shear links

4.7 Ductility

Table 4.3: The Deflection of the maximum load and the Yield

Type of shear link	Max load (kN)	Deflection of the maximum load (mm)	Deflection of Yield (mm)
3 shear links	125.63	5.46	3.79
4 shear links	118.33	6.1	4.57
5 shear links	140.86	5.54	3.44

Table 4.4 The Ductility analysis and Mode of failure.

Type of shear link	Max load (kN)	Ductility (mm)	Mode of failure
3 shear links	125.63	1.44	Shear failure
4 shear links	118.33	1.33	Shear failure
5 shear links	140.86	1.61	Bending failure

The samples that were used 5 shear links shows the highest value of ductility which is 1.61mm and the two values 5.54mm and 3.44mm are the deflection of maximum load and deflection of yield respectively. in comparison to the sample of 4 shear links and sample of 3 shear links, the 3 shear links ductity is 1.15mm with its deflection of maximum load 6.1mm and its deflection of Yield 4.57mm, also the 4 shear links ductity is 1.15mm with its deflection of maximum load 6.1mm and its deflection of Yield 4.57mm.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 INTRODUCTION

A 3-point bending test has been conducted to validate the effectiveness of the links as shear reinforcement in reinforced concrete beam and also to find the effect of shear reinforcement variation on the modulus of rupture of concrete beam, flexural test has been observed including the flexural strength, deflection and cracking behavior. The compression test has been conducted to test the cube samples to obtain the strength of the concrete. The first and second beams were after 7days and after 28 days respectively.

5.2 CONCLUSION

This study provided a structural building for developing the standard of care applied to the application of links as shear in reinforcement concrete and hence the development of this material can be adopted and implemented in more upcoming structures and projects.With no doubt, the addition of links as shear reinforcement can significantly increase the shear capacity. Initially there is no difference in flexural capacity between 3 shear links and 4 shear links, but when add 5 shear links. There is slight increase in the flexural capacity, The effectiveness of shear links as shear reinforcement has been validated. Moreover, it is concluded that the addition of links as shear reinforcement slightly affects the flexural capacity.

5.3 RECOMMENDATION

In this research, there are several recommendations for the future study, the recommendation will be based on observations made and personal opinions. However, there are needs for the recommendations to been made for the improvement of the result and quality of this study in the future such as:

i) A suitable add mixture need to be found out to improve the workability of the concrete mixture fastens the work and improve the quality of the mixture.
ii) Addition of 6, 7 and 8 shear links can also improve the flexural capacity.
iii) The research should be conducted for a longer duration of time to determine the flexural to find the effect of shear reinforcement variation on the modulus of rupture of concrete beam.
iv) Use Tensile steel bar (T); Diameter = 14 mm and Round steel bar (R); Diameter = 8 mm with spacing 116 mm for 5 shear link beams ,116 mm spacing for 4 shear link beams and 175 mm spacing for 5 shear link beams.
v) Use vibrator machine for compacting while casting the concrete.

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APPENDEX A

THE SAMPLES DURING FLEXURAL TEST AND COMPRESSIVE TEST

APPENDEX B

THE SAMPLES AFTER FLEXURAL TEST AND COMPRESSIVE TEST