# BEHAVIOR OF KENAF FIBER REINFORCED RECYCLED AGGREGATE CONCRETE BEAM

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# ABSTRACT

Disposal and treatment of construction and demolition (C&D) wastes are often costly and hazardous to the environment. Their recycling could lead to a greener solution to the environmental conservation. This study utilizes demolished concrete as coarse aggregate often termed as recycled coarse aggregate (RCA) for producing industry quality concrete. Large scale recycling can substantially reduce the consumption of natural aggregate and help preserve the environment. However, in near future, it can raise new challenges. The use of "repeated recycled coarse aggregate" in concrete production can be a viable solution to the growing problem regarding the Construction & Demolition waste disposal. During the development of new generation product like recycled and repeated recycled coarse aggregate concrete, it is essential to investigate the fresh, hardened, and durability properties of concrete to promote and escalate its application in the construction industry. Through adding kenaf fiber into the mixture, it may have prospect to prevent the cracking beams. Four beams are constructed in this research, which are the control beam and the rest beams replaced with 25% of recycled concrete as coarse aggregate added with (0%,1%,2%) volume of kenaf fibers. Kenaf fiber had potential to delay the cracking compared to control beam. However, kenaf fiber reinforced recycled aggregate concrete beams has potential to become more ductility compare with control beam.

# ABSTRAK

Pelupusan dan rawatan pembinaan dan perobohan (C & D) sisa selalunya memerlukan kos yang tinggi dan berbahaya kepada alam sekitar. Kitar semula bahan pembuangan boleh membawa kepada penyelesaian yang lebih mesra kepada pemuliharaan alam sekitar. Kajian ini menggunakan konkrit yang dibongkar sebagai agregat kasar yang sering disebut sebangai kitaran agregat kasar (RCA) yang dikitar semula untuk menghasilkan industry konkrit yang berkualiti. Kitar semula berskala besar boleh mengurangkan penggunaan agregat semulajadi dan membantu memelihara alam sekitar. Walau bagaimanapun, pada masa akan datang, ia dapat menimbulkan cabaran baru. Penggunaan "agregat kasar yang dikitar semula" dalam pengeluaran konkrit boleh menjadi penyelesaian yang berdaya saing kepada masalah yang semakin meningkat mengenai pelupusan sisa Pembinaan & Perobohan. Semasa pembangunan produk generasi baru seperti konkrit agregat kasar kitar semula dan berulang yang dikitar semula, adalah penting untuk menyiasat ciri-ciri konkrit baru, kekerasan, dan ketahanan untuk meningkatkan dan meningkatkan penggunaannya dalam industri pembinaan. Melalui proses menambah serat kenaf ke dalam campuran, ia mungkin mempunyai prospek untuk mencegah rasuk retak. Empat rasuk dibina dalam kajian ini, iaitu yang merupakan rasuk kawalan dan dan rasuk lain digantikan dengan 25% daripada konkrit kitar semula sebagai agregat kasar ditambah dengan isipadu kenaf (0%, 1%, 2%). Serat Kenaf berpotensi untuk melambatkan retak berbanding rasuk kawalan. Bagaimanapun, serat kenaf yang diperkuat dengan rasuk konkrit agregat dikitar semula mempunyai potensi untuk menjadi lebih banyak kemuluran berbanding dengan rasuk kawalan.

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# LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| X | Times |
| / | Divided |
| F | Maximum Applied Load |
| L | Beam Length |
| b | Beam Width |
| b | Beam Depth |
| a | Distance From Maximum Applied Load To Support |
| δu | Associated Deflection For Ultimate Load |
| δy | Corresponding Deflection For Yield Load |
| δmax | Related Deflection For |
| µ | Ductility Ratio |
| Pmax | Maximum Load |
| Pu | Ultimate Load |
| Py | Yield Load |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| BS | British Standard |
| mm | Millimetre |
| EN | English |
| $N/mm^2$ | Newton per Millimetre Square |
| MPa | Mega Pascal |
| Kg/$m^2$ | Kilogram per Metre Square |
| W/C | Water To Cement Ratio |
| $m^3$ | Metre Cube |
| NAC | Natural Aggregate Concrete |
| RAC | Recycled Aggregate Concrete |
| 1%KF | 1% Kenaf Fiber |
| 2%KF | 2% Kenaf Fiber |

# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND OF STUDY

Recycled concrete aggregate is an engineering term that has been used to denote both fine and coarse aggregate reused in various engineering application (Hansen, 2000). These aggregates are obtained from a multitude of sources pertaining to industrial waste, construction and demolition waste. The properties of these recycled aggregates vary based on many factors such as characteristic strength of old concrete, the size of gravel used, the percentage of sand and gravel fraction in the concrete mix and amount of lime in the sand fraction of the old mix. They can be substituted with different percentages of replacement for fine and coarse aggregates in new mixes (Kotrayothar, 2012).

In general, it is considered as inert materials that generated from construction and demolition waste (CDW). In addition, the CDW can be obtained from broken concrete in demolition sites. Therefore, its use is increasing proportionately with the development of the towns and the countries. Thus, finding an appropriate procedure so as to get rid of this waste is a must. Reducing, reusing and recycling is appeared to be the best option for this purpose (Skevik, 2013). As a rule of thumb, the use of recycled aggregates in concrete is a promising and can pose many possibilities in the reuse of materials in the building industry (Vytlačilová, 2010). Hence, the implementation of recycled aggregates in structure and construction is a good solution to the problem of an excess of waste material. This obviously reduces the consumption of the natural resources as well as the consumption of the landfills required for waste concrete. Recycling is the act of processing the used material for use in creating new product. As technology has significantly developed so far, the usage of natural aggregate is getting more and more intense with the advanced development in infrastructure are (Zuhud, 2008).

In Malaysia, the waste generated from construction and demolition activities is the major component that contributes to solid waste. Moreover, the increasing growth of the construction industry potentially generates substantial construction waste in Malaysia. Thus, this kind of waste can pose serious effects to the environment and cause social problems in local communities (Mohammad, 2013). Recently, there is a huge amount of waste generated in construction sites and estimated to be around 27,068.40 tons. In term of characterization perspective, the RAC promotes poor mechanical properties which are flexural strength and compressive strength. Previous studies have highlighted the benefits of large-scale recycling of concrete waste. These benefits are Controlling the over-discharge of construction and demolition wastes that otherwise would have been disposed in landfills and Decreasing the dependence of the construction industry on natural aggregates, thereby preserving natural resources, provides savings from the treatment of waste disposal, and yields alternative sources for urban areas facing shortage of natural aggregates (Chuan, 2010).

Therefore, it can be modified with natural fibers so as to enhance its properties. In this research, kenaf fiber is taken into consideration for this purpose.

Fiber as an additive to the RAC increases its structural integrity and strength (Omar, 2011). In general, some fiber is lower in the strength of recycled aggregate and some fiber provides greater impact, abrasion and shatter resistance. However, this can refer to the type of fiber reinforced with the RAC. In fact, there are many types of fiber can be used such as steel, glass, synthetic and natural fibers. Natural fibers have the potential to improve the usage of material related to environmental friendly. Natural fibers are considered as one the easier to be utilized for this purpose. It is cheaper compare to other fiber and low in energy level using the technology and local manpower (Ismail, 2015). However, the utilization of natural fibers is less popular in construction fields. Many types of natural fibers can be used such as sisal, coconut coir, bamboo, jute, and sugarcane bagasse. The natural fibers used in this investigation are kenaf fibers as known as Hibiscus cannabjnus.

Nowadays, kenaf has been famous fiber used in the recycled aggregate concrete. kenaf is suitable to be grown in a tropical country like Malaysia and Indonesia due to its weather condition (Tezara, 2016). Recently, there are many new usages of kenaf including building material, absorbents, animal feeds and paper product. Kenaf is very good in mechanical properties and can grow very quick, rising with height of 4-5 in in within 4-5 month growing season and the diameter is around 25-35mm (Udoeyo, 2012). In this research, kenaf fiber is used to enhance the recycled aggregate properties such as flexural and compressive strengths and also to increase the toughness of the desired product that will be implemented in structure field.

## 1.2 PROBLEM STATEMENT

At the present, the use of recycled aggregates from construction and demolition wastes is showing prospective application in construction as alternative to primary (natural) aggregates. It conserves natural resources and reduces the space required for the landfill disposal. By recycling of construction and demolition wastes the environmental impact can be minimized to the lowest level and natural resource of aggregates will be saved (Zuhud, 2008). Recently, the natural resource protection is one of the important parts of environmental issues. Therefore, recycling will help to conserve natural resources for next generations. And this is the major challenges that our society communities face in today.

The recycling of concrete waste into recycled aggregate concrete (RAC) has been investigated as a potential source of construction concrete. RAC can be obtained through the demolition of the concrete elements of buildings and other construction. In addition, some countries, which are subjected to a political, global conflicts and war case, most of their structural buildings and infrastructures are destroyed and thus generating millions tons of aggregate waste. This is the current case in some of Middle East countries such as Syria, Yemen, Iraq and etc. however, in the most developed countries, the local authorities destroy the old building in order to construct new modernized buildings leading to originating a huge amount of construction waste. Therefore, the wastes from construction and demolition works are of large volume and increasing over time. To overcome this issue, sustainable concrete construction is one of the strategies to be considered by the construction industry. One way of achieving this is to introduce recycled aggregates from these wastes of construction and demolition works into the production of concrete.

In Malaysia, the great amount of concrete waste that cause a serious impact to the local environment is due to the renovation of many buildings and the limitation of disposal sources. The replacement of the natural aggregates at the concrete production through the use of recycled aggregates, have become a popular topic among researchers nowadays. Thus, coming up with new methods and strategies for replacement is so important. One of these methods is to use a proper additive such as natural fibers. (Rabadiya, 2015) stated that natural fibers have an excellent potential to enhance the properties of materials, and could be used effectively to improve the engineering performance of recycled aggregate concrete. (Safiuddin, 2011) has illustrated that natural fiber are the best additives working with the RAC. This is because of their fabulous advantages in enhancing the engineering properties of RAC.

In this research, Kenaf fiber (KF) is proposed to be used as an additive. This is because that Kenaf fiber is considered as important natural fibers that has high modulus of elasticity for effective long term, it has also high flexural strength depending on addition rate and greater retained toughness in conventional concrete mix (Awang, 2015). Therefore, it can be taken highly into consideration to be treated as a natural additive. Later on the next stages, an investigation will be conducted on the behavior of recycled aggregate concrete treated with kenaf fiber.

## 1.3 AIM AND OBJECTIVES

This research aims to reduce the environmental problems generated from dumping the construction and demolition wastes which can be achieved by recycling the construction and demolition wastes to produce concrete standard. However, the two main objectives have been listed as shown below to complete the aim of this study:

- To investigate the flexural and compressive strength of the recycled aggregate concrete replacement with 25% to the mix and added with length 30mm of kenaf fiber.
- To study the effects of kenaf fiber content on reinforced recycled concrete beam.

## 1.4 SCOPE OF STUDY

The flexural strength and compressive strength will be conducted to determine the effectiveness of RAC and kenaf fiber. Regardless of the limitations of the available laboratory facilities of recycled aggregate concrete (RAC), the scope of this research is as follows:

- The beam size considered is 150mm x 150mmx 1500mm.
- The cube size considered is 150mm x 150mm x 150mm.
- The fibers used are kenaf fibers with diameter at range of 0.1 - 2.5rmn and length of 25mm.
- The structure beam design is according to BS EN and the tension reinforcement is 2H12 and the compression reinforcement is to 2H8.
- Using formwork for beam and plastic moulds for cube sample.
- The total samples for beam is four which are
  - Beam 1 will contain 100% natural aggregate with 0% kenaf fiber.
  - Beam 2 will contain 25% of recycled aggregate concrete with 0% kenaf fiber.
  - Beam 3 will contain 25% of recycled aggregate concrete with added 1% of kenaf fiber.
  - Beam 4 will contain 25% of recycled aggregate concrete with added 2% of

kenaf fiber.

- The total samples for cubes is 24 which six samples for each beam concrete mix. However, three cube samples are testing for 7 days and remain is testing for 28days.
- The location of the research will be held in concrete laboratory, University Malaysia Pahang (ump).
- The testing related to the research are compressive strength and four points bending test.
- Slump test to determine the slump of cohesive concrete of low to high workability of concrete.

## 1.5 SIGNIFICANCE STUDY

Leaving aside the recent economic crisis, the concrete production is very important. This fact approves that the aggregates, the main component of concrete, are much demanded. Due to the fact that, in some countries, the natural aggregates are a scarce resource, it is necessary to find a new source of aggregates by adopting of recycling to enhance the concrete production. The recycling of aggregate has come into sight to achieve the two main goals:

- To maintain the price of concrete, which until now was the cheapest construction material?
- To preserve the environment, without creating piles of waste over the world.

In this research, Kenaf fiber is proposed to be used as a natural additive so as to enhance the quality of recycled aggregate. This can be done through conducting certain tests for this purpose. Durability, performance, toughness and strength of the final products will be investigated on the next stages. In a nutshell, it is hoped that this research will be a small contribution in the advance of the utilization of the recycled aggregates as construction material in the future.

## 1.6 EXPECTED OUTCOMES

The expected outcome from these studies are

- Kenaf fibers added with recycled aggregate concrete mixture will be more strength in flexural strength and compressive strength.
- The potential of kenaf fibers to control crack propagation.
- The used of kenaf fibers and recycled aggregate concrete to promote as a green building materials

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 RECYCLED AGGREGATE CONCRETE

### 2.1.1 GENERAL

Concrete generated from solid scheduled waste is called recycled aggregate concrete (RAC). In general, it is derived from the materials that used in a product or in construction industry such as construction demolition. Therefore, recycled aggregate concrete are used as a replacement of the natural aggregate concrete since long decades. Also recycled aggregate concrete is excellent a way of recycled materials through keeping it from being as disposed in landfall. Reprocessing of aggregate concretes is an effective path to relieve the burden on the landfill area. Since recycled aggregates are producing from concrete debris which has bear undergo years of services, the resulting RAC bear that the shrinkage and creep are increase and it decrease of flexural and compressive strength compare by natural aggregate concrete.by the other words, the quality of product recycled aggregates concretes is lower than the natural aggregate concrete (Adnan, 2010). Recently, many countries have adopted the utilization of construction and demolition waste to be treated as a new construction material involved in construction activities (Kotrayothar D. , 2012). Therefore, the literature review presents the current state of knowledge and examples of successful uses of alternative materials in concrete technology, and in particular the use of Recycled Concrete (RC) aggregate as a coarse aggregate fraction in non-structural and structural concrete. Many researchers have made many efforts in order to investigate the characterization of these kinds of aggregate, the minimum requirements for their utilization in concrete and the properties of concretes made with recycle aggregates. It also presents a review of available literature on physical, mechanical and durability properties of RC aggregates, and mechanical, durability and structural properties of RCA concrete. This study is concentrating on recycling of concrete waste as an aggregate in structural concrete in flexure and punching shear.

### 2.1.2 Constituent Materials in Concrete

Concrete is the major materials of structures current days. In developing countries, it has been mentions that the concrete is very advantageous. This is due to its adequate tensile strength and its fire and weather fair resistance. It is made from local cheap materials and concrete suitable to be cast in the required shape and has good compressive strength. Thus, it is not so much affected by humidity. Moreover, it cannot be burnt and never be attacked by insects. So this is the reason for high demand of concrete in construction field.

Advanced concrete is appeared to be a complicated composited material which is significantly undergoing enhancement and modification process (Sahoo, 2016). (Nelson, 2004) has stated that there are other materials such as chemical admixtures including super plasticizers, water reducers and air-entertainers that can be used to modify the characteristics of OPC concrete. Since the past decades, the utilization of various alternative fine and coarse aggregates in the productions of concrete have been investigated, including the use of RC aggregates. Concrete can made up from fine and coarse aggregate, cement, water and occasionally with admixtures added in it. The rate of using materials in the mix are depending on the concrete mix design based on the requirement of a structure. Concrete is low in tensile strength because that the cracking or failure of the structure can be occurred when the load is applied on it and has limited ductility (CHUAN, 2010).

Aggregate are the important component in concretes. aggregate is desirable materials which is come from the natural rocks, crushed stones also from gravels and sands. Aggregate mostly occupied 70% to 80% of concrete volume. Therefore, aggregate has important impact of fresh and hardened concrete of their properties. However, aggregate have many types first is coarse aggregates which is particles greater than 4.75mm, also mostly range between 9.5mm to 73.5mm in diameter and can occupy 2/3 of aggregate volume. Also, coarse aggregate is produced from natural disintegration and stone or crushed gravel. In addition, coarse aggregate has many types such as basalt, granite, calcareous and marble. Second, fine aggregates have particles smaller than the coarse aggregate with less 4.75mm and it is equal to 75um or larger. Fine aggregate generally contains of manufactured particles or natural with ranging size from 1.50mm to 4.75mm and occupy 0 to 15% of overall volume of aggregate. Also fine aggregate has few types such as sea sand, pit and river sand.

### 2.1.3 Concrete Waste and Concrete Recycling

In general, concrete waste that is related to the Construction and Demolition (C & D) waste is originated and developed once construction of new, or modifications occurred to existing urban infrastructure such as transportation systems (Syazwani, 2016). As the world's population increases, the amount of C & D waste is also increases. This is the fact that cannot be denied specially in urban communities.

Moreover, there is an increased social request to governmental department and industries in developed countries so as to find out alternative materials and reduce the waste in order to enhance environment protection and to understand that the depletion of natural resources is a serious threat. Therefore, there is a general awareness that recycled C & D waste including RC aggregates can be treated, enhanced and utilized used for the purpose of construction.

As a rule of thumb, the major source of raw material for recycling of concrete waste comes from demolition of concrete structures. The quality and purity of the raw material affect the quality of recycling products and ultimately commercial acceptance of concrete recycling products. The process of manufacturing concrete recycling products is relatively simple. To produce high quality concrete recycling products that satisfy commercial and technical specifications, it is crucial to segregate concrete waste at source eliminating any low and high density and friable contaminants. Recycling process and plant setup depends on desired grading and quality of the final product. In situations when crushed concrete waste is to be used as fill material, the use of a mobile crusher is usually sufficient. However, when crushed concrete waste is used to produce RC aggregates for road sub-base or as a concrete aggregate, a proper plant with at least two crushers, vibrating screens, magnets and conveyor belts have to be established. Once concrete rubble has been deposited at a recycling plant it is then broken by a pulverize mounted on an excavator. Pieces of concrete waste broken to a suitable size are then crushed in a primary jaw crusher and then passed via conveyor belts into a cone crusher. The crushed material is passed through a set of vibrating screens and sieved on the way to a stock pile. After each crusher, the rotating magnets remove remains of steel reinforcement whereas pickers manually remove other contaminants (Abukersh, 2007).

a) concrete waste b) recycled aggregate

**Figure 2.1:** concrete waste and recycled aggregate

### 2.1.4 BENEFIT OF USING RAC

There are many of benefit of using recycled aggregate concrete which will be shown in below:

1. **Environmental considerations.**

In this decade of increasing attention to environmental influence of construction and sustainable development, and Portland concrete cement (PCC) have much to offer:

- it is resources efficient minimizing depletion of natural resources
- it is inert making it an ideal medium in which to recycle waste or industrial by products.
- It is energy efficient, it is superior to wood and steel.
- It is durable, continuing to gain strength with time/
- It is recyclable, fresh concrete is used on an as-needed basis (whatever is left over can be reused or reclaimed as aggregate), and old hardened concrete can be recycled and used as aggregate in new concrete or as fill and pavement base material.

**2. Economic factors.**

Recycling concrete is an attractive option for governmental agencies and contractors alike. Most municipalities impose tight environmental controls over opening of new aggregate sources. In many areas, increase of the cost of starting new quarries is increased. For demolition contractors, landfill space is limited and can be far away, especially in urban areas. Hence, the disposal of old concrete and masonry is costly. Also, dumping fees will most likely rise as construction debris increases and the number of accessible landfills decreases. Furthermore, the cost and transport distances of conventional aggregates could continue to increase as sources grow scarce.

**3. Other uses**

Unprocessed RCA is useful to be applied as many types of general bulk fill, bank protection, sub-basement, road construction, noise barriers and embankments. Processed RCA can be applied to new concrete for pavements, shoulders, median barriers, sidewalks, curbs and gutters, and bridge foundations. It also can be applied to structural grade concrete, soil-cement pavement bases, lean concrete and bituminous concrete (PCA 2008). Also, it has been used to produce high strength concrete (Qasrawi, 2013)

### 2.1.5 Sources of material for the production of recycled aggregate

The main source of concrete comes from the demolition of demolition construction. (CHIU, THE USE OF RECYCLED CONCRETE AGGREGATE IN STRUCTURAL CONCRETE AROUND SOUTH EAST QUEENSLAND, 2006) has stated that the material supplied to the recycling plant will usually come from within a 20-30-kilometer radius of the recycling plant. According to research conducted by recycling queens land, the composition of demolition material will generally be a mix of 21% concrete ,20% plaster card board-paper-glass mix,19% timber,16% brick,9% steel and other metals,6% soil,5% general wastes and 4% plastics. recycled aggregate quality depend on how the material is clean when it inters the crusher that cleanliness refers to how much materials are removed.

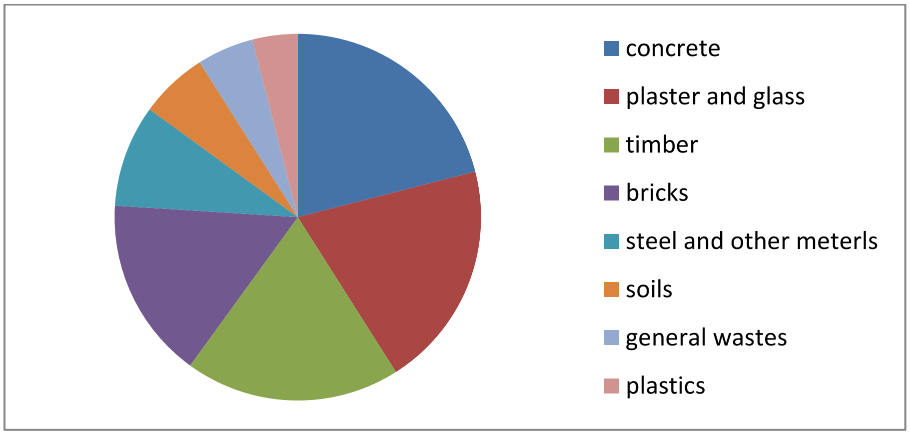


**Figure 2.2:** Mixture of crushed material from a building construction according to QLD Recycling

Miss K w ong (2006) .

## 2.2 FIBER

Fiber is materials that used to be added in concrete structural integrity.

### 2.2.1 GENERAL

Recycled concrete is relatively brittle and its tensile strength is typically lower than the compressive strength. For many applications, it is becoming increasingly popular to recycled aggregate concrete with small, randomly distributed fibers. The main purpose of fibers is to increase the flexural strength. In addition, also help to increase in toughness of the material. Fiber is a composite concrete material consisting of a cement matrix reinforced with discontinuous discrete fibers (metal, glass, or other synthetic or natural fiber material). The modern development of fiber reinforced cement composites dates back to the 1960s. Since then, fibers used as reinforcement materials have diversified. More research studies now focus on the natural fiber reinforcement. A unique aspect of these fibers is the low amount of energy required to extract these fibers (Sharafaddin, 2013). Only a low degree of industrialization is required for their processing. Therefore, the applications of natural fibers in recycled aggregate concrete have provided an exciting prospect to the construction industry.

Nowadays, there are many studies have been conducted to improve the properties of the recycled aggregate concrete such as producing the fiber. In addition, the small fibers are dispersed and distributed randomly in the recycled aggregate concrete during mixing, and thus improve recycled aggregate concrete properties in all directions. Fibers help to improve the post peak ductility 'performance, pre-crack tensile strength, fatigue strength, impact strength, shrinkage cracks and flexural strength. According to Li et al., (2004), reported that to utilize natural fibers as reinforcement in recycled aggregate concrete, it is important that the fibers have appropriate physical and mechanical properties for an application. Work on the behavior of recycled aggregate concrete with kenaf, jute fiber, rice straw, sugar cane fiber and wood fiber has also been reported. It can be concluded that the addition of these natural fibers does not improves compressive strength significantly compared to flexural strength in recycled concrete. (YUSOFF, 2012).

### 2.2.2 NATURAL FIBER

The use of natural fibers (NF) has been studied quite heavily over the past 40 years. Natural fibers are prospective reinforcing materials and their use so long has been more traditional than technical. They have long served many useful purposes but the application of the material technology for the utilization of natural fibers as the reinforcement in recycled concrete took place in comparatively recent years. Economics and other related factors in many developing countries where natural fibers of various origins are abundantly available, demand construction engineers and builders to apply appropriate technology to utilize these natural fibers as effectively and economically as possible to produce good quality fiber recycled concrete materials for housing and other needs (YUSOFF, 2012).

Applications of NF for large-scale structural purposes have traditionally been limited to special applications which are practically and economically justified. One of the most promising fields for their application is that of composite construction in which the NF forms a permanent strong and tough covering over a weaker core. NF further provides architectural and ornamental features. Sisal fiber reinforced concrete tiles, corrugated roofing sheets, pipes, gas tanks, water tanks and silos are also being used extensively in some African countries (YUSOFF, 2012).

Salehudin (2013) has stated that the major properties of natural fiber are depending on factors such as the length that used of fiber also the volume fraction and types of fibers. Study of kenaf fiber stated that the addition of fibers will not affect the compressive strength due to its density while tensile and flexural strength and toughness will increase. Also said the study indicated that the minimum fibers volume fraction required to provide significant improvement in the mechanical properties of cement composited was approximately 3%. However, there is many types of natural fiber as shown in figure 2.3.

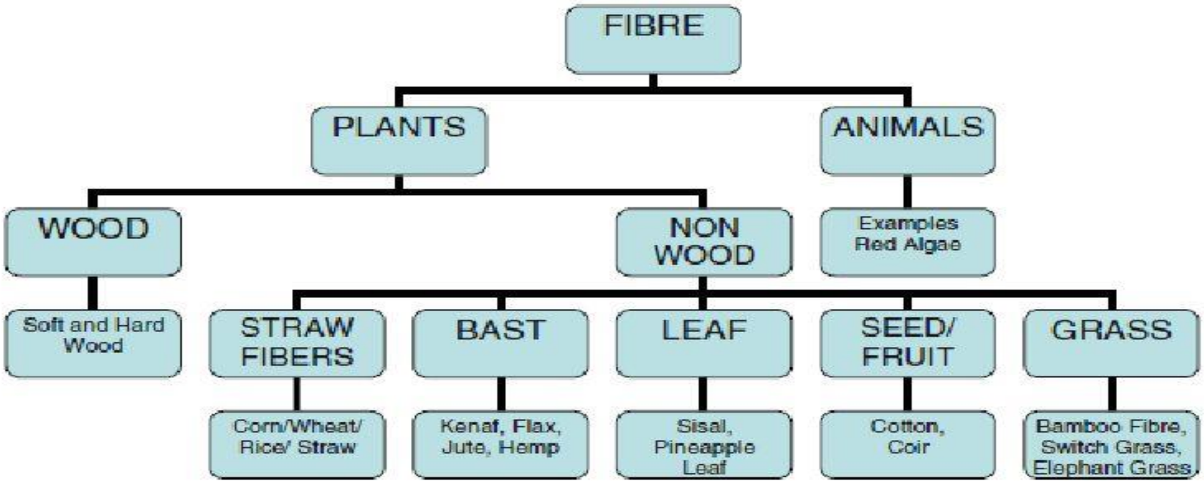


**Figure 2.3**: types of natural fiber
Salehudin *(2013)*

Therefore, there are many advantages and disadvantages for natural fiber as shown in below table 2.1:

**Table 2.1:** advantage and disadvantage of fiber

| Advantages | Disadvantages |
|---|---|
| Producible with low investment at low cost, which makes the material an interesting product for low-wage countries | Lower durability fiber treatments can improve this considerable. |
| It is renewable resources; the production required little energy co2 is used while the oxygen is given back to the environment. | Moisture absorption, which causes swelling of the fibers. |
| Low specific weight, which result in a higher specific strength and stiffness than glass | Lower strength properties, particularly its impact strength. |
| | Price can fluctuate by harvest result or agricultural politics. |

### 2.2.3 KENAF FIBER

Kenaf or its scientific name Hibiscus cannabin's have started to plant so much in Malaysia. According to Malaysian Agricultural Research and Development Institute (MARDI), governments of Malaysia are planning to expand the plantation of kenaf in Kelantan and Terengganu.

In addition, it will be the main sources for the country in the future. Regarding to MARDI, the kenaf grows quickly, rising to heights of 3.66m-4.27m (12-14 feet) in as little as 4 to5 months. Besides that, the other study shows that kenaf yields of 6 to 10 tons of dry fiber per acre per year are generally 3 to 5 times greater than the yield for pine trees which can take from 7 to 40years to reach harvestable size. Upon harvest, the whole kenaf plant is processed in mechanical fiber separator similar to a cotton gin.

**Table 1.2:** Tensile strength and young's modulus for five type of natural fiber

| TYPE OF FIBER | DIAMETER(mm) | Tensile strength(MPa) | Young's modulus(MPa) |
|---|---|---|---|
| Kenaf | 0.04-0.81 | 18-250 | 430 |
| JUTE | 0.082-0.04 | 29-345 | 2200 |
| OIL PALM | 0.25-0.447 | 58-71 | 478-1703 |
| COIR | 0.04-0.45 | 15-175 | 400-600 |
| BANANA | 0.08-0.25 | 54-754 | 7700-20000 |

SALEHUDIN (2013)

Kenaf fibers as one of natural fibers source will be more deeply to investigate in this research Local organic such as most of natural fibers represent an available resource for fiber reinforced materials are relatively expensive, and make.

It difficult to provide adequate solutions to the housing needs of such areas of the world. Therefore, the feasibility of natural fibers as one of the source of fibers would be investigated (SALEHUDIN, 2013).

Recently, kenaf is used as a raw material to be alternative to wood in pulp and paper industries for avoiding destruction of forests and also used as non-woven mats in the automotive industries.in addition, Kenaf is an herbaceous annual plant that is grown commercially in the United States in a variety of weather conditions, and it has been previously used for rope and canvas. Kenaf has been deemed extremely environmentally friendly for two main reasons:

(a) kenaf accumulates carbon dioxide at a significantly high rate.

(b) kenaf absorbs nitrogen and phosphorous from the soil. (AZIZ, 2011).

However, kenaf fiber has many advantages such as low densities and cost, low energy consumption, high specific properties, wide variety of fibers available through the world, generation of a rural/agricultural-based economy and nonabrasive nature. And the two main disadvantages for kenaf fiber are high moisture absorption of the kenaf fibers and composites and low processing temperatures permissible (OSMAN, 2010).

Salehudin (2013) has stated that the characterize the basic tensile properties of kenaf fiber have been studied in the past. The result indicates that the average tensile strength of kenaf fibers range from 157 MPa to 600MPa. Meanwhile, the average ultimate tensile strain and elastic modulus of the fibers range from 0.015 to 0.019 and 12,800MPa to 34,200 MPa respectively. A part from these, the location along the stalk from which the fibers are taken is depended by the mechanical properties of the fibers.

## 2.3 The Importance of Concrete Properties

The attributes of concrete are playing an important part in projecting a sound concrete and it's critical for controlling the character of good concrete in the process of designing the concrete mixture. The properties of recycled aggregate concrete that must focus of this study is the compressive strength and flexural strength test.

### 2.3.1 Compressive Strength

Compressive strength is an important material property of concrete and is often related to the quality of the concrete. Compressive strength is commonly used in material specification as it can be easily tested and other properties of concrete can be correlated to the compressive strength. As such, most RCA studies have included the effects of RCA addition on the compressive strength of concrete. Concrete is essentially a two-phase material that consists of aggregate and mortar. The compressive strength of concrete depends on the inherent strength of these two phases as well as that of the zone between the two, often referred to as the Interfacial Transition Zone (ITZ). In low strength concretes (below 40 MPa), the aggregate is typically stronger than the paste and does not control the compressive strength. In high strength concretes, the paste's strength can exceed that of the aggregate and at that point the aggregate strength can govern. When the ITZ is weak it can form a failure plane that can reduce the overall strength of the concrete in either case. In all situations, aggregate can initiate and arrest the propagation of cracks in the paste. Generally, the addition of coarse RCA coincides with a reduction in compressive strength, though some RCAs have been observed to cause an increase. The severity of this reduction has been observed to depend on a large number of variables, which include mix design strength, natural aggregate replacement level, RCA saturation, RCA source material, concrete mixing procedure, curing conditions, and several other factors. Each of these variables can affect the two phases of concrete and the ITZ in a number of different ways. With such a high number of 31 variables, it is difficult to present any results without several qualifying statements. Across this scope of variables, concretes produced using RCA have exhibited compressive strengths ranging from approximately 60%-160% of the control concrete's compressive strength. Generally, the ITZ in RCA concrete is considered to be the weak point of the material. This is often attributed to weak pre-existing mortar on the RCA and localized water/cement ratio fluctuations due to the absorptive nature of the aggregate. RCA is inherently angular because it is produced through crushing. It is thought that this could provide some benefit in terms of compressive strength, however mainly in low w/c content concretes. It has also been hypothesized that the superficial pores on the surface of RCA could allow for penetration of new hydration products, which could result in a “nailing effect” that could benefit the ITZ of RCA concrete. This further supports the need for an accepted framework for classifying RCA as discussed by Butler. Determining and standardizing the best practices for RCA use in concrete is an important step for widespread acceptance of such a framework (Pickel, 2014).

Previous study stated that the compressive strength results are presented in Table 3.2. Each presented value is the average of three measurements. Compressive strength of RAC is lowered compared to Natural Aggregate Concrete (NAC). For w/c ratio 0.4 and 0.5, the concrete mixtures prepared with 25, 50, 75 and 100 % replacement of RA had a decrease of 21.9, 23.7, 43.3, 32.7 % and 13.2,7.7,19.1,13.2 % in the compressive strength at 28-day compared to NAC. Then, the concrete mixtures with w/c ratio 0.6 that prepared with 25, 50, 75 and 100% replacement of RA had a decrease of 11.85, 17.1, 31.3, 22.3 % in compressive strength than that of NAC.it also found that RA100 obtained higher compressive strength than that of RA075. Normally as RA replacement increased, compressive strength will decrease. The higher compressive strength may be attributed to the greater bonding force and strength when same type of aggregates was used. Otherwise, RAC still obtained lower compressive strength compared to NAC (ADNAN, 2013).

**Table 2.3:** Result of Compressive Strength for Different W/C Ratio

Adnan (2013).

| SERIES | W/C RATIO | 7-DAYS | 28-DAYS |
|---|---|---|---|
| **RA00** | 0.4 | 34.4 | 56.6 |
| | 0.5 | 20.3 | 30.2 |
| | 0.6 | 15.9 | 21.1 |
| **RA025** | 0.4 | 29.9 | 44.2 |

| | | | |
|---|---|---|---|
| | 0.5 | 19.2 | 26.2 |
| | 0.6 | 13.4 | 28.6 |
| **RA0.50** | 0.4 | 27.1 | 43.2 |
| | 0.5 | 15.5 | 25.1 |
| | 0.6 | 12.3 | 17.5 |
| **RA075** | 0.4 | 23.2 | 32.1 |
| | 0.5 | 16.1 | 22.0 |
| | 0.6 | 11.4 | 14.5 |
| **RA100** | 0.4 | 21.8 | 38.1 |
| | 0.5 | 16.5 | 23.6 |
| | 0.6 | 10.3 | 16.4 |

### 2.3.2 Flexural Strength

The other term of flexural strength is bending strength, modulus of rupture or fracture strength. The flexural strength is one of the mechanical attributes of concrete. The flexural strength of concrete is needed to identify the maximum loads that the concrete can sustain 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. Thus, the selection of aggregates is a vital in determining the strength of concrete. Generally, a beam is used to identify 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 and strain in beams compared to cube specimen. The max strain and stress also are calculated on the incremental load applied. The flexural strength result also is used nowadays to control the properties of concrete instead of compressive strength. The typical strength of flexural strength of concrete using Portland cement is between 3 to 5 MPa (300 to 700Psi).

## 2.4 SUMMARY

From the literature review has shown that the properties of aggregates come from construction waste have vital effects in influence the good concrete production. This is based on the previous studies that have been done from many waste materials as coarse aggregate either in partially of fully replacement has shown a good advantage such as marble, copper slag and ceramic waste. However, there are some materials that seem not suitable to be used as a coarse aggregate replacement, for example, ared-orage laterite aggregate. The use of construction waste has been proven a useful way for treatment of a country in managing and controlling the construction waste from keeping increasing trough those previous researches.

Thus, the selection of construction waste from sand brick will give good advantages in producing a good concrete. Even though the use of sand brick waste as coarse aggregate partial replacement of coarse aggregate in concrete producing has not been done before this, the ability of sand brick waste shows that is can be a good alternative to the bright future prospect. In japan, for examples, that has already been made the standard requirement in using waste materials in construction sector. This shows that the ideas in using waste materials a part of the construction industry is a possible way.

# CHAPTER 3

# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

The research methodology is an important procedure to ensure that the project is going proceed smoothly and very good while securing that the aims which have been proposed are accomplished with satisfactory. Work planning of systematic is so important to confirm that this work will be carried out with an organized and successful. The procedure adopted by this study is in progress to illustrate the overall process achieving the objective target involved in such project.

In starting a research, a flow chart is playing an important role to securing the research progressing according to plan and to avoid any embarrassment during lap preparation. However, it is so important to organize the thing that we want to do according's to the order. So, the flow chart will make the research systematic. Below is a chart flow of the research methodology.

Laboratory studies;

- Preparation and selection of study materials
  - Collection of recycled aggregate from laboratory concrete (ump)
  - Collection for the others materials (cement, coarse and fine aggregate, steel bar and kenaf fiber)
- Samples preparations
- Cubes and beams

Testing samples

compressive strength and flexural strength

- Result and analysis;
- Data analysis

drawing graph



Project presentations

## 3.2 PREPARATION OF RECYCLED AGGREGATE FROM CONCRETE LAB

The preparation of recycled aggregate is the preliminary stage of the study, the used aggregate is taken from concrete lab. The concrete waste consists of used coarse and fine aggregate that mostly been gathered up from cubes after the concrete compressive strength tests performed from previous experiment students in laboratory lab concrete (ump).

The aggregate concrete waste will be gathered to undergo a crushing process. The crushing machine used is crusher located at concrete lab. The machine is simply applied to crush the aggregate concrete waste into small aggregate, like the size of coarse aggregate required. In addition, during the crushing process, all materials have to be removed.

The next procedure is to crush the aggregate concrete chunks by using hand tools such as hammers. The crushing process is controlled to get the desired size of aggregates. in this research, the size of aggregates required for concrete mixing is between 14 to 20 mm. Moreover, for the separation size of every aggregate, the crushed aggregate concrete need to be sieved analysis. The sieve analysis process is to accomplish the specific size of aggregate required. Finally, the aggregate should be washed to make sure that is clean from any other materials.


**Figure 3.2:** Crusher Machine

## 3.3 THE MATERIALS USED IN CONCRETE MIXING

The concrete mixing materials of this study will consist of cement, coarse aggregate, sand, water and kenaf fiber. However, utilize the materials in concrete mixing have to achieve the specific requirement to confirm that the concrete will be produce is according to the specifications and not fails. The precaution ought to be taken during mixing the materials which have to according to the ratio of materials provided according to the standard.

### 3.3.1 WATER

The water use during the concreting process is tap water. This water should be drinkable if it is possible, but water have to not be dirty or saline. Other than that, tap water is easily available. The measure of water content is utilized depending on the water cement ratio used. Moreover, the water cement ratio for all the cement mix process will be performed for this study is set at 0.60.

However, river or groundwater can be the source for water which are suitable for making mixtures.in addition, the function of water is chemical reaction with cement and other materials.

Also, water can contribute the workability that can be affected by the water content water is very important because water distribute every single particle of cement so every crushed rock is covered tightly and water make the mixture of concrete easy to handle.

### 3.3.2 CEMENT

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

The raw materials utilized to produce Portland cement are lime, silica, alumina, and iron oxide. It is made by heating a mixture of limestone and clay till it almost fuses and then mashing the clinker to a fine powder. moreover, maximum size of the cement particles is 0.09 mm and the average diameter of the particles are smaller than 0.045 mm.

### 3.3.3 COARSE AGGREGATE

For the coarse aggregate, the preparation process consists of two stages. The first stage involves the 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 will be weighed till it get 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 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.

Moreover, it is important to remove all the materials from coarse aggregate as wood and clay. Then, coarse aggregate must be strained to get the required size. The size of coarse aggregate is 14 to 20 mm. sieve analysis for coarse aggregate is so important procedure to separate each size of coarse aggregate and preserve the quality of coarse aggregate.

Whilst, the second stage is the preparations of use recycled aggregate which has been recycled from concrete lab waste. The preparation of recycled aggregates is shown at figure 2. However, the recycled aggregate concrete should pursure the same steps as natural aggregate for a drying process. However, due to retain the quality of the aggregate based on size and surface roughness the size of the recycled aggregate has been controlled.

**Figure 3.3:** Recycled Aggregate After Sieve

### 3.3.4 FINE AGGREGATE

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

For this research, the sand is select from laboratory availability that is sand from the river. 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 required size.

### 3.3.5 KENAF FIBER

The samples of kenaf will be prepared by cutting the samples in 25 mm in length. It will be added with amount 1% and 2% of total volume to concrete mix respectively.

**Figure 3.4:** Kenaf Fiber

### 3.3.6 REINFOREMENT BAR

For the reinforced concrete beam, the reinforcement which will be used is steel bar 12 for major reinforcement. All the steel bar will be cut according to require length using the cutter machine. The requirement for having the reinforcement to improve the strength of the beam in term of flexural strength.

## 3.4 CONCRETE MIX DESIGN

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

### 3.4.1 MIXIING 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. However, table3.2 show concrete mix design for all mix.

**Table 3.1:** Concrete Mix Design

| Materials ($kg/m^3$) | NC | RAC | 1% | 2% |
|---|---|---|---|---|
| Cement | 310 | 310 | 310 | 310 |

| | | | | |
|---|---|---|---|---|
| Aggregate | 1085 | 1085 | 1085 | 1085 |
| Sand | 890 | 890 | 890 | 890 |
| Water | 170 | 170 | 170 | 170 |
| W/C ratio | 0.6 | 0.6 | 0.6 | 0.6 |
| Superplastcizer (l/m3) | 4.65 | 4.65 | ~~4.72~~ | ~~4.72~~ |
| $kenaf\ \boldsymbol{fiber}(\boldsymbol{kg}/\boldsymbol{m3})$ | 0 | 0 | 6.2 | 12.4 |

### 3.4.2 COMPACTING PROCESS

After the concrete mixed is ready, the next step was to pour the concrete into mould 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 must be compacted first. For every layer the concrete will be blow 35 times with tamping bar. After the compaction process is done, the surface of concrete was flattened.

### 3.4.3 CURING PROCESS

This process is the final stages in concrete production. Generally, curing process function 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 is added into the water tank. The hardened concrete was immersed in water for 7 and 28 days for curing. After the curing process completed according to the days required, then the concrete is ready for tested. The curing process is based on BS 1881-3:1970.

### 3.4.4 SAMPLE PRAPERATION

The sample consists of cubes and beams for concrete mixing. Table 3.2 shows the rate of replacement of coarse aggregate with recycled aggregate and kenaf fiber added to the mix in percent. The only flexural test will use beams as sample, while compressive test will used cube as sample. For flexural test, there will be 4 samples of beams, while 24 sample of cubes for compressive test

### 3.4.5 FORMWORK

Plywood will utilize to construct the formwork for beams. four formworks will be provided to cast aggregate concrete beam with added kenaf fiber. The formwork's surface must be oiled before concrete mixture is placed. Meanwhile for cube samples, the plastic mould will be utilized and it can get it from lab concrete. The formwork will be designed based on the dimension of 1500mm x 200mm x 150mm. The timbers in sizes of 2 inches and plywood were used to form the formwork.

## 3.5 TEST METHODS

In this study will include three tests, which is slump test,compressive strength and flexural strength test:

### 3.5.1 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 consistency of mixing. The most suitable concrete to be used is a concrete that have a higher and a medium workability during this test. The ideal height of slump test is approximately 75-+25 mm.

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. Figure3 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 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.

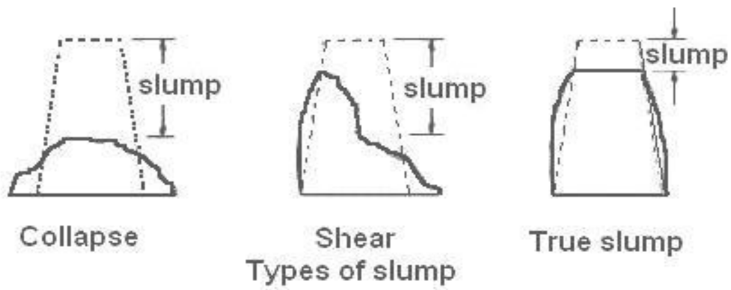


**Figure 3.5:** Types of slump test

### 3.5.2 COMPRESSIVE STRENGTH TEST

The quality of good concrete will be identified through this test. Also, the value result of this test will be provided the overview of the bending, modulus of elasticity, durability, permeability and strength of tensile. For getting good concrete, it is difficult to be permeable and can be exposed to severe exposure and also durability from wear out. In Figure 3.5, shows a machine utilized in compressive strength test. The test is accordance to BS EN 12390-3:2002. The cube size 150 mm x 150mm x 150 mm is used. 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. The total of 6 samples of cubes is prepared for each proportion replacement of recycled aggregate concrete. 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 compressive strength is expressed in MPa $\left(\frac{N}{mm^2}\right)$ and the load value is recorded and the compressive strength can be calculated by the following formula:

Compressive strength $=\frac{maximum\ load(N)}{surface\ areao\ fcube(mm^2)}$

**Figure 3.6:** Compressive Strength Machine

### 3.5.3 FLEXURAL STRENGTH TEST

Flexural strength is known as modulus of rupture. The modulus of rupture of beam is identified the fails to occur in the tension part. Moreover, it measures the tensile strength of concrete and measure of a reinforced beam to resist failure in bending. it is measured by loading concrete beams with a span length at least 3 times of depth. This test also includes the use of beams sample size 150 mmx 150 mmx 1500mm.this test, the three points loading method are utilized and it is determined by British standard (1881: part118:1983). The formula for the flexural strength is: modulus of rupture, $F = \frac{3FL}{bd^2}$.

Where

F= maximum applied load

L= beam length (1500mm)

b=beam width (150mm)

d=beam depth (150mm)

A= distance from maximum applied load to support

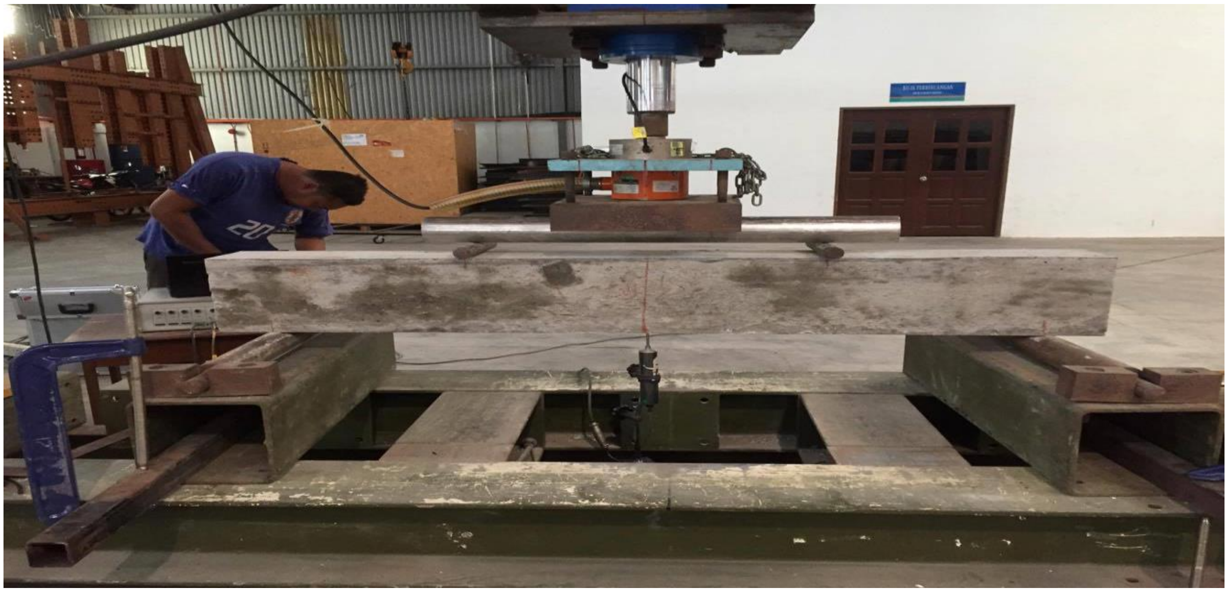

**Figure 3.7:** Flexural strength machines

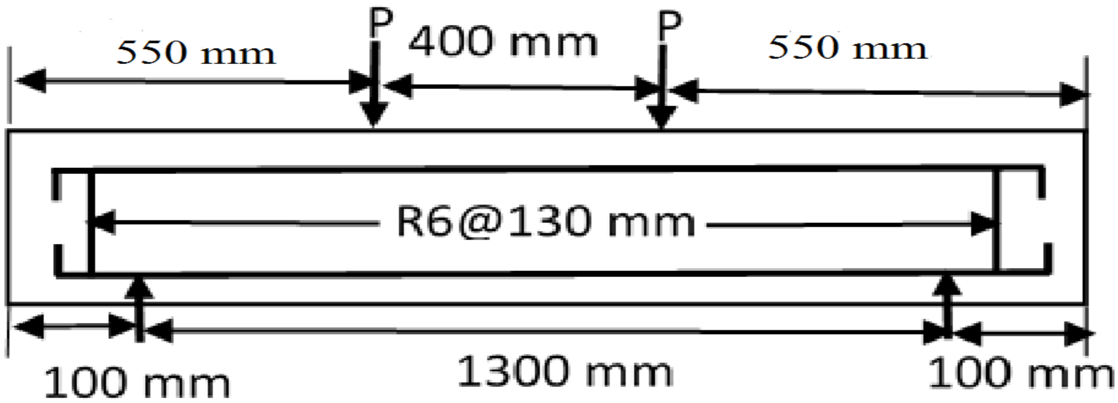


**Figure 3.8:** Loading arrangement on the specimen

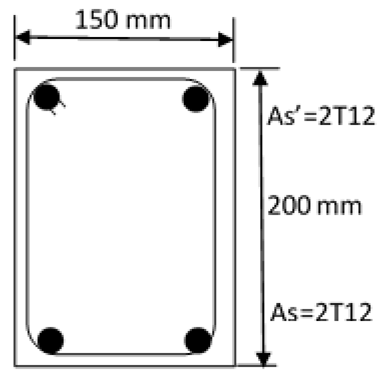


**Figure 3.9:** cross-section of beam detailing

# CHAPTER 4

# 4 RESULT AND ANALYSIS

## 4.1 INTRODUCTION

In this chapter, analyzing and discussing about the result for all samples after conducting test. All the laboratory test result was analyzed and examined to study about the mechanical properties of recycled aggregate concrete beam added with kenaf fiber and compare to normal concrete beam. The result of compression test also will discuss in this chapter. The purpose of this study is to be as a guideline to recognize and improve the characteristic of the samples for any recommendation in the future study. Four type of concrete mix which are normal concrete (NC), 25% of recycled aggregate concrete, also RAC add with 1% of kenaf fiber and RAC add with 2% kenaf fiber were analyzed and make a comparison based on the result obtained.

## 4.2 BEHAVIOR OF CONCRETE MIXTURE

The behavior of concrete mixture is discovered through the slump test and compressive strength test as shown below:

### 4.2.1 RESULT AND DISCUSSION OF WORKABILITY TEST

The workability of the concrete can be defined as the case that can be mixed, transported, placed, and compacted wisely in position without any problem happen. The Slump test is performed as a workability test for this research.

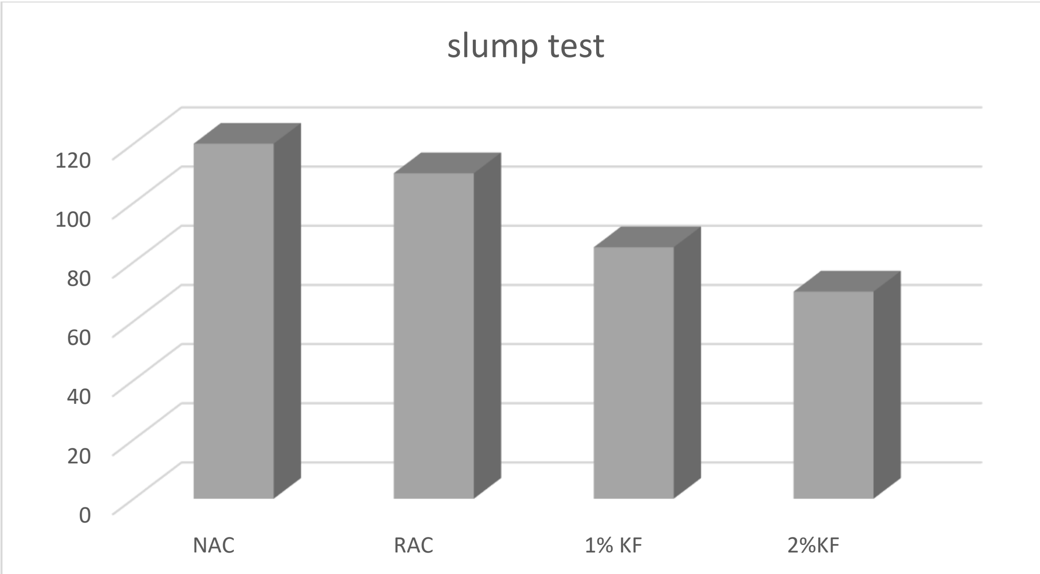


**Figure 4.1:** Bar chart for slump test

**Table 4.1:** Slump Test Between Different Type of Concrete

| Samples | Concrete type | Height of slump(mm) | Type of slump |
|---|---|---|---|
| 1 | NAC | 105 | True slump |
| 2 | RAC | 95 | True slump |
| 3 | 1% KF | 84 | True slump |
| 4 | 2%KF | 67 | True slump |

The workability of the fresh concrete was measured by slump test according to BS 1881 part 102(1983). The slump designed was 60- 125mm.after testing the slump test, the workability of the samples can be determined by the classification of the type of slump. For sample 1 and sample 2 which is normal concrete and recycled aggregate concrete, the type of the slump is true slump that is similar to the design mix approved. Meanwhile for the samples 3 which is contain of 1% kenaf fibers in the samples is true slump and it is similar to the samples 4 which is contain of 2%. However, the present of RAC and kenaf fibers in fresh concrete make the concrete become stiff and reduces the workability values. The highest of kenaf fibers content in concrete mix are the lowers in workability observed. These happen because the concrete contains of kenaf fiber look more dry compare to normal concrete and RAC. This reason is the characteristic of fibers is absorption of the water. It may cause kenaf the reduction of water from fresh concrete. The way to improve the workability of the concrete mix, the super plasticizer has been added to the concrete mix. The amount of the additional plasticizer was calculated based on the 0.1% of the weight of cement content. Some journal stated that more can be added to improve the cement workability. Meanwhile, regarding to the Portland Association, the amount of cement and water reducer must be increased to obtain the same workability, slump and water-cement ratio to normal concrete. In conclusion, the normal concrete has higher workability compare to the concrete contain RAC and kenaf fibers.

### 4.2.2 COMPRESSIVE STRENGTH TEST

Concrete cube compression test was completed to determine the concrete mix satisfied their target compressive strength. It was determined for different type of concrete after 7 days and 28 days. The purpose of having this test is to fulfill the objective of the research to study the compressive strength of the RAC with kenaf fibers added. For this research, the target compressive strength that wants to obtain is 30 MPa.

**Table 4.2:** Compressive strength for cubes sample

| $compressive\ strength(N/(mm^2\ )$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NC | | RAC | | 1%KF | | 2%KF | |
| **No** .of | 7D | 28D | 7D | 28D | 7D | 28D | 7D | 28D |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| cubes | | | | | | | | |
| Cube 1 | 34.80 | 43.92 | 28.74 | 37.80 | 15.46 | 19.33 | 7.75 | 9.69 |
| Cube 2 | 33.79 | 42.75 | 28.31 | 35.77 | 15.13 | 18.92 | 5.89 | 7.068 |
| Cube 3 | 33.34 | 41.66 | 28.16 | 38.65 | 15.21 | 19.01 | 6.79 | 8.46 |
| Mean | 33.98 | 42.78 | 28.40 | 37.41 | 15.27 | 19.09 | 6.81 | 8.40 |

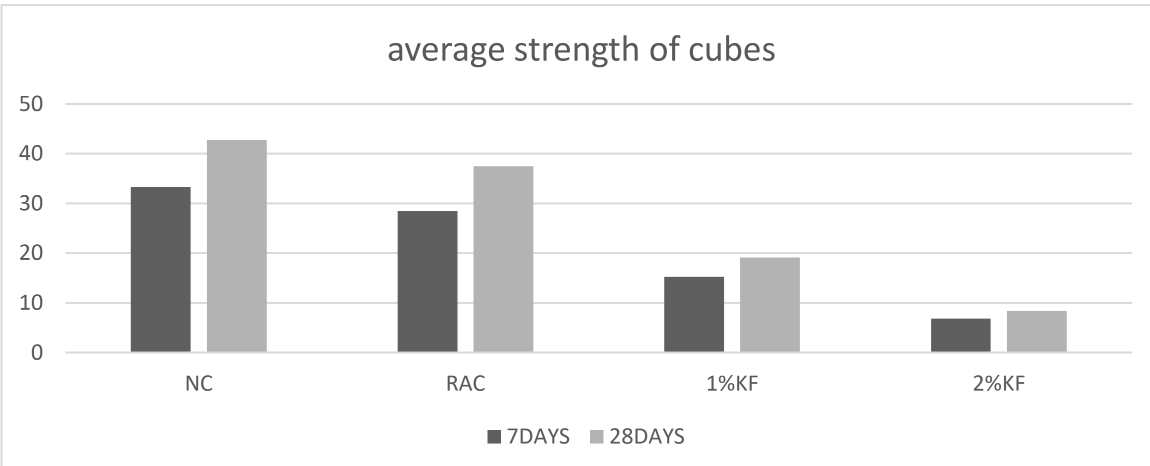


**Figure 4.2:** Bar chart of compressive strength for all samples

#### 4.2.2.1 Normal concrete (NC)

The compressive strength of the normal concrete samples is shown in table 4.2 for age 7days and 28 days. The differences of the concrete strength can be seen when comparing the age of the concrete. The average of compressive strength value of normal concrete for 7 days and 28 days after curing are 33.98 N/mm2 and 42.78 N/mm respectively.

Figure 4.2 indicated the comparison of the result compressive strength between the different ages of concrete. Based on the figure, the result indicated that the increasing of compressive strength is proportional to increasing of ages. The strength of 28 days curing increases about 25.89% from the strength of 7 days curing. This is because the hydration process of concrete was happened rapidly until maturity time of concrete. However, figure 4.3 is shown pictures for control cubes after testing.

**Figure 4.3:** Cubes of Control Mix After Testing

#### 4.2.2.2 25% OF RECYCLED AGGREGATE CONCRETE WITH 0% OF KENAF FIBER

The compressive strength results for 25% of recycled aggregate concrete are presented in table 4.2. It is shown in figure 4.2 that the compressive strength of RAC is lowered compared to natural aggregate concrete. the replacement of RAC for 7 days is 28.40N/mm and 37.41N/mm for 28 days after curing. As shown on the figure 4.2, the result indicated that increasing of compressive strength is proportional to increasing of ages. In addition, the compressive strength of 28 days curing increases about 31.725% from strength of 7 days curing. This is because the hydration process of concrete was happened rapidly until maturity time of concrete. Moreover, the pictures in figure 4.4 is cubes of RAC.

**Figure 4.4:** Cubes of RAC mix after testing

#### 4.2.2.3 Concrete consist of (1%) of kenaf fibers

Table 4.2 indicates the average result of compressive strength for concrete added with 1% kenaf fiber at the ages of 7 days and 28 days. Observably, it shows that the increasing of strength proportional the day increases. The result shows the 1% of kenaf fiber for 7 days curing is 15.27N/mm2 followed by 19.09N/mm2 for 28 days. The percentage increase is 20.01%. Figure 4.2 shows the visual of the difference of compressive strength value for these samples. Similar to normal concrete, the compressive strength of this type of concrete gained with increasing of ages curing but still the strength of 28 days is lower than normal concrete and RAC. From the previous study stated that by adding the kenaf fibers cannot enhance the improving of compressive strength. Furthermore, figure 4.5, is presented the cubes of 1% of kenaf fiber after testing.

**Figure 4.5:** Cubes of 1% KF

**4.2.2.4 concrete consist of (2%) kenaf fibers**

Table 4.2 shows the result of compressive strength for concrete added with 2% kenaf fibers at the ages of 7 days and 28 days after curing. Apparently, it shows that the increasing of strength proportionate the ages increase. The result shows the 2% of kenaf fiber for 7 days curing is 6.81N/mm2 followed by 8.40 N/mm2 for 28 days. The percentage increase is 18.93 %. Figure 4.2 shows the difference of compressive strength value for these samples. Similar to samples 2 concrete, the compressive strength of this type of concrete increased with increasing of ages curing but the strength of 28 days is lower than normal concrete and RAC. Also the result shows the strength of 2% of kenaf fiber is lower than 1% of kenaf fiber. However, figure 4. is provide picture for sample 2% of kenaf fiber is shown in figure 4.6 below.

**Figure 4.6:** Cubes of 2% KF

#### 4.2.2.5 compressive strength between different types of concrete

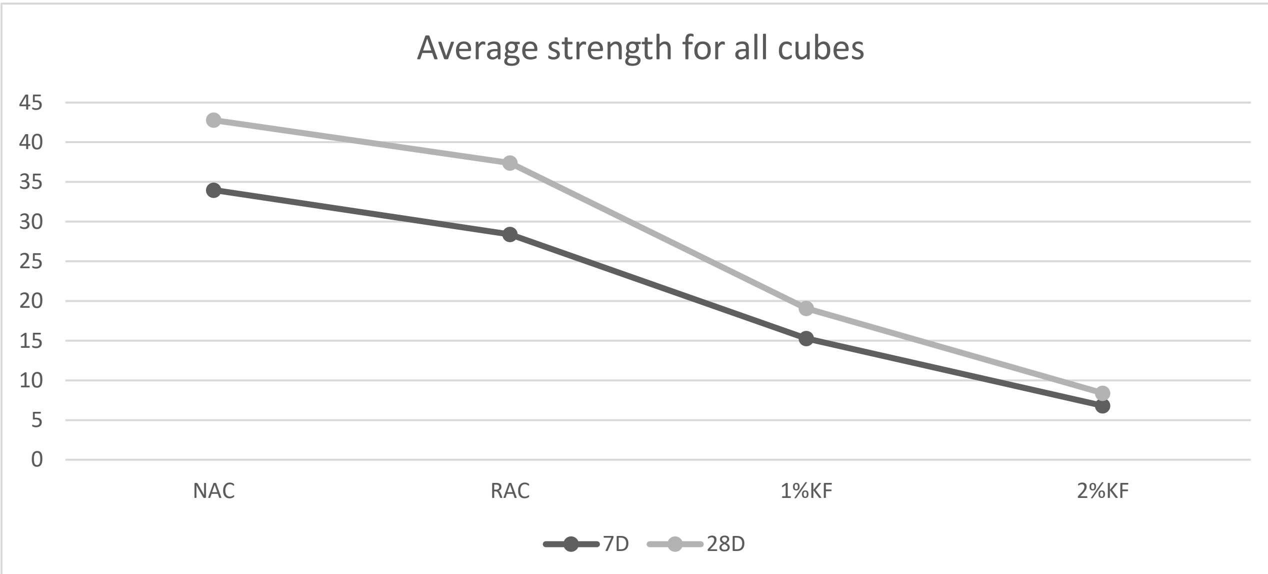


**Figure 4.7:** Combination Result Of Compressive Strength

Figure 4.7 indicates the average compressive strength result with different amount of concrete mix for 7 days and 28 days of curing. The graph shows normal concrete performed the highest compressive strength compare to other three different amounts of concrete for 7 days curing period. The percentage decreasing in term of compression from normal concrete to sample contain recycled aggregate concrete was 16.42%. Meanwhile for sample contain 1% and 2% of kenaf fibers was decreased 55.06% and 79.96%. The development of compression strength after 28 days of curing process indicated that sample of normal concrete which was normal concrete was still possessed highest strength compare to the other three concretes. Concrete with 25% of recycled aggregate concrete was decreased 12.55% from normal concrete. Meanwhile for concrete with 1% and 2% of kenaf fiber was decreased 55.38% and 80.36% from normal concrete. As expected, sample contains kenaf fibers still produce lower compression strength from normal concrete sample and recycled aggregate concrete. Also, at the same time, RAC still produce lower compression strength from normal concrete.

The compressive strength of concrete is slightly decreased due to the addition of recycled aggregate concrete and kenaf fibers in the concrete mix design. additive material did not enhance the improvement of the strength. It may cause the density of kenaf fiber with RAC is lower than other materials. Other than that, RAC and kenaf fiber were determined as absorption materials which it absorb water from the concrete. It may disturb the hydration process in the concrete. It can be seen when the mixing process of kenaf fibers in term of workability. Besides that, the kenaf fibers did not mixed well in mixing process because the condition of kenaf fibers which was too dry. It was hard to obtain well mix with the condition like that. Having super plasticizer will enhance to avoid from the mix become dry quickly. The effect of did not mixed well can caused segregation in the concrete. This happens when the fresh concrete component separated and resulting in a non-uniform mix. It will affect the strength of the concrete. Overall the result of compressive strength has been similar to the previous study by (SALEHUDIN, 2013) mentioned that the increasing kenaf fibers content would decrease the compressive strength. As a conclusion, the study of the kenaf fibers added in concrete have lower result compare to normal concrete and recycled aggregate concrete compressive strength. The NAC and RAC attained the design grade of the concrete 30 MPa.

## 4.3 Structure Behavior of Recycled Aggregate Concrete Beams Added with Kenaf Fiber

### 4.3.1 LOAD DEFLECTION

The figure 4.8 below shows the load -deflection of the samples at midspan.

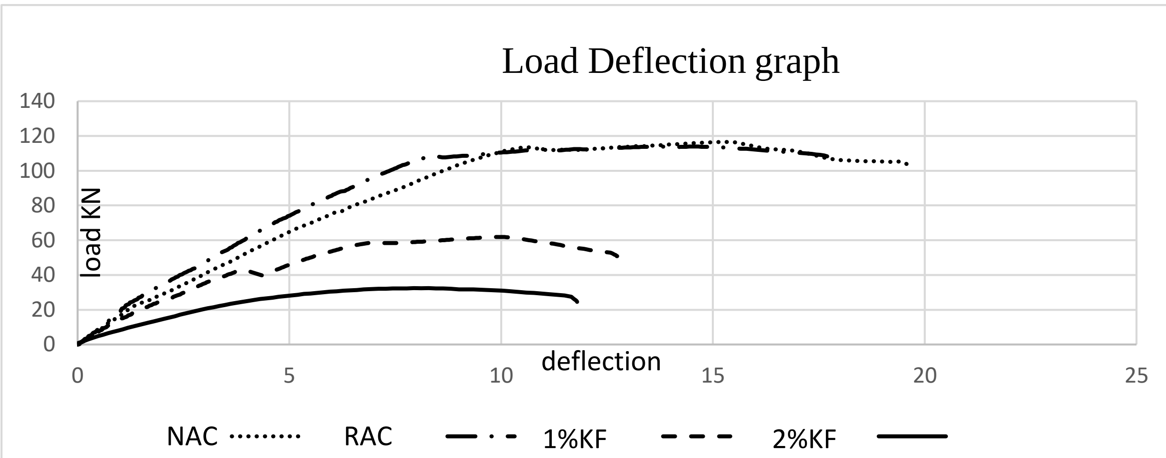


**Figure 4.8:** Load-deflection graph

**Table 4.3:** Summary of the significant values in the load-deflection curves for beams

| Sample | NAC | RAC | 1%KF | 2%KF |
|---|---|---|---|---|
| $Py\ (KN)$ | 75.350 | 72.891 | 38.052 | 20.76 |
| $\delta y\ (mm)$ | 6.026 | 4.911 | 3.369 | 3.073 |
| $Pmax\ (KN)$ | 116.552 | 112.619 | 61.859 | 32.366 |
| $\delta\text{max}(mm)$ | 15.311 | 11.148 | 9.960 | 8.11 |
| $Pu\ (KN)$ | 99.069 | 95.72 | 52.850 | 27.511 |
| $\delta u\ (mm)$ | 8.571 | 6.947 | 5.875 | 4.898 |
| $\mu = \delta u/\delta y$ | 1.422 | 1.414 | 1.744 | 1.594 |

In this section, the results of flexural test to examined the effect of adding RAC added with kenaf fiber into reinforced concrete beams. All samples are tested for flexural at the age of 28 days. The experimental test results are plotted by load deflection curves of beams. The main parameters included load at yield (Py) and its corresponding deflection (δy), the maximum load (Pmax) representing the load-carrying capacity and related deflection (δmax), the ultimate load (Pu) and its associated deflection (δu) as well as the ductility ratio (U) defined as $\mu = \delta u/\delta y$.

The load deflection curves in figure4.8 showed that there was no significant deference in the maximum load (Pmax) and yield loading (Py) between control beam and 25% of RAC when it changed from 116.552N/mm2 to112.619 N/mm2 and 75.350N/mm2 to72.891N/mm2, respectively. the decreased of RAC is due to the amount of recycled concrete aggregate used in concrete mixture which has low density compare to NA. The beam of RAC was become more drier and not fully harderden due to recycled concrete aggregate absorb more water compared to natural coarse aggregate. This may affect the binding between cement and recycled concrete aggregate become weaker (Orie, 2014). While, for 1% and 2% of kenaf fiber beams with recycled coarse aggregate decreased up to 46.93% and 72.23% respectively as compared to the control beam for maximum load(Pmax) while, it is decreased up to 49.449% and 72.45% for yield loading (Py). However, the weakening of the load at yield (Py) and maximum load (Pmax) of KF beams is considerably significant. the load deflection curve demonstrates that the kenaf fibers beams failed earlier as compare to beams with 0% of fiber and RAC. However, this result is agreement with the study reported by (Orie, 2014) They aid that the reason of decreased the flexural strength is due to the high amount of kenaf fiber in the beam, which absorbs the water this may lead the beams to become honeycomb beams which have low strength and stiffness in load carrying capacity and the kenaf fibers did not mixed well in mixing process because the condition of kenaf fibers which was too dry as shown in figure 4.13. Additionally, this is also may due to amount of RAC in the beams as discussed above. Consequently, the strength of the beam with the 2% amount of fiber is lower than the one with 1% of fiber content, that is similar with study reported by (Yatim, September 2014) Moreover, beams added with kenaf fiber should be tested on the 56th day to allow the beam to be fully dried and hardened as reported by (Mohsin, 2014). the main effect of the kenaf fiber is to prevent and control the crack propagation. from figure4.8 inspection indicates that the high fiber content in concrete reduced the flexural strength of KFRC. However, the additional of fiber with the appropriate amounts slightly increased the yield load (Py) and maximum load (Pmax) of the KF beam as observed in beam with 1% of kenaf fiber.

In terms of ductility, the ductility ratio (u) is calculated based on ultimate deflection (Pu) with respect to yield deflection (δu). The ductility ratio listed for beams in table 4.1. In general, a high ductility ratio indicates that ta structural member is capable of undergoing substantial deflections prior to failure. The ductility of reinforced concrete structures is of importance because any member should be capable of undergoing substantial deflection at near maximum load carrying capacity and providing ample waring when structure reached close to failure. In this investigation, satisfactory ductility is observed for beam 25% of RAC the ductility is very closed to control beam, whereas with 1% of KF in which the ductility increases up to 22.64% as well as, with 2% of the ductility increase 12.09 % as compared to control beam. It is observed that the ductility increases up to certain point before reducing upon the addition of more fiber. Similar pattern was observed, by (AZIMI, 2015) where the addition of more fiber into the beam caused the beam to be failed with less ductility. As crack initiates, kenaf fiber prohibited crack growth and created multiple cracking, eventually increases the ductility. Since the control beam is less ductility than KFRC beams, hence the ductility showed significant improvement in the structure properties of beams with the incorporation of kenaf fiber. Presence of kenaf fiber in concrete beam structure exhibited the ability to delay cracks propagation and significantly ductility of structures.

### 4.3.2 CRACKING BEHAVIOUR

Cracking pattern can be observed by analyzing the cracking pattem formed after the sample stretched fail. The cracking pattern can be analyzed by sketching the pattern of crack and numbering the propagation of crack when the load was acted on the beam samples. The crack usually start appears from the bottom of the beam samples during loading and will increase the crack propagation as load was increased. Theoretically, the top of surface will be in the compression meanwhile it will be in the tension at the bottom of the surface. Other than that, the crack will start from bottom since the concrete is weak in tension.

**Table 4.4:** Characteristic of the cracks pattern

| Type of concrete | Load at first crack(KN) | Type of failure |
|---|---|---|
| **NAC** | 73.395 | Flexural crack |
| **RAC** | 59.148 | Flexural crack |
| **1%KF** | 36.461 | Flexural crack |
| **2%KF** | 16.294 | Flexural crack |

As theoretical, higher initial crack will gain the higher resistance for cracking Based on the table the value of initial cracking was observed for NAC and RAC samples which were control beam obtain 73.394 KN and59.148 KN. meanwhile for sample 3 and sample 4 which contain 1% and 2% of kenaf fibers were 36.461 and 16.294 kN respectively. As for the result, the highest loading initial cracking was from NAC, followed by RAC. The sample of contain kenaf fibers were showed the lower initial crack reading due to its weight, density and strength of the concrete.

Regarding to the table 4.10, for the sample NAC and RAC, the crack was appearing when the load reached 73.395KN and 59.148 KN respectively. Meanwhile for the sample 3 which contains 1% kenaf fibers only crack when the load was reached 36.461 kN. Sample 4 which contain 2%kenaf fiber was reached the crack at 16.294 kN loading. Moreover, the failure mode and crack pattern of samples beams after flexural test are shown in Figure,4.9, Figure 4.10, Figure 4.11 , Figure 4.12  and Figure 4.13.

**Figure 4.9:** Failure mode and crack pattern of control beam

**Figure 4.10:** Failure mode and crack pattern of RAC beam

**Figure 4.11:** Failure mode and crack pattern of 1% kenaf fiber beam

**Figure 4.12:** Failure mode and crack pattern of 2% kenaf fiber beam

**Figure 4.13:** honeycomb of kenaf fiber beams after casting

## 4.4 SUMMARY

Overall the result showed that the amount of RAC and kenaf fibers gave affected in term of workability, compressive strength, flexural strength and the cracking pattern appeared. The result had shown by comparing the different amount of kenaf with NAC and RAC for the cube samples and beams. The compressive strength for kenaf fibers increased as the increased of ages but it obtains lower strength compare to normal concrete and RAC. It is similar to the testing of beam sample in term of flexural strength.

# Chapter 5

## CONCLUSION AND RECOMMENDATIONS

### 5.1 INTRODUCTION

A 4-point bending test has been conducted to study the effectiveness of RAC and kenaf fibers in the beam structure in term of flexural strength. The compression test has been conducted to test the cube samples. The first and second beams were NAC and RAC. Also, the third and fourth beams were 1% and 2% of kenaf fiber were tested for comparison between the control beam and two amounts of kenaf fibers. 24 cubes samples have been tested for 7days and 28 days for compression test to obtain the strength of the concrete. Flexural test has been observed including the flexural strength, deflection and cracking behavior.

### 5.2 CONCLUSION

As conclusion, kenaf fiber show potential of improving the strength and ductility of the beams if the amount of the fiber used is below than 1%. In addition, kenaf fiber beams show potential reducing the crack propagation in the beam. However, there is many of pointed which show the summary of this study

- Concrete added with 25% of recycled aggregate concrete give lower compressive strength result compare with normal concrete due to lower density of RAC but it is achieved the grade of compressive strength design at 28 days.
- Concrete added with kenaf fiber display lower compressive strength result as compare with normal concrete.
- The low of KF cubes is due to the lower density of kenaf fiber which is absorb more water.
- Flexural strength of RAC is slightly lower than the control beam.
- Flexural strength of kenaf fibers beams are Significantly lower than the control beam due to added kenaf fiber which made honeycomb in the beams and lead the stiffness lower than control beams.
- Beam with 1% of kenaf fiber is shown improvement for flexural strength compare with Beam which has 2% of kenaf fiber.
- Beam with kenaf fiber make honeycomb
- The ductility ratio of all kenaf fiber reinforced recycled concrete beams obtained higher ductility compare to the control sample.

## 5.3 RECOMMENDATION

There are several recommendations to improve the study fibers beam of recycled aggregate concrete beams added with kenaf fiber in concrete in the future. These recommendations can be used as a guideline for future research.

- Use the amount below than 1% of kenaf fibers.
- Use kenaf fiber with other fiber composite.
- Use the superplasticizer to improve the workability of the concrete added with kenaf fibers.
- Increase the sand in concrete mix design because may that lead to bond kenaf fiber with sand and prevent kenaf fiber to chunk during mix concrete.
- Use vibrator machine for compacting while casting the concrete.

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## APPENDIX

In table below is shown some pacture for beams and cubes during casting and after casting. In addition, there is some pacture shows the test for flexural test and compressive test before and after testing.

**Figure A:** beams before and after testing


**Figure B:** cubes after testing with its result