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# Strength Study On Fibre Reinforced Concrete Using Palmyra Palm Fibre Using FEM Software

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## Abstract

***Many types of natural fibres have been investigated for use in plastics including sunnhemp, jute, sisal, munj and banana. The main objective of this experimental study is to palmyra palm fibers reinforced concrete composites and to evaluate the mechanical properties such as flexural strength, tensile strength and compressive strength of the concrete.. Application of composite materials to structures has presented the need for the engineering analysis the present work focuses on the fabrication of polymer matrix composites by using natural fibres like sunnhemp, coir, banana, and sisal which are abundant nature in desired shape by the help of various structures of patterns and calculating its material characteristics (Flexural strength Tensile test, hardness number, % gain of water) by conducting tests . This report aims to investigate about the behaviour of palmyra palm fiber reinforced concrete under different circumstances. It contains the literature review of the palmyra palm fibers, and it will describe the different properties of concrete and what advantages could bring by mixing them with concrete. In addition, this report will discuss and compare the important properties of the palmyra palm fiber in detail.***

**Keywords:** Strength, Study, Fibre Reinforced Concrete, Palmyra Palm Fibre, FEM

## 1. INTRODUCTION

### 1.1 General

Since 2000, the population of the world increasing by 15.47% according to public data. The increase in population leads to higher demand of residential and official buildings. That fact leads construction companies constructing more buildings which means more material required for the construction. By the following facts, the engineers are looking different ways to reduce the material usage and the time spent constructing as well. In the recent years, more construction companies using different new types of construction to reduce the weight, the material used and the time construction. In the same way, engineer's goal is to keep the strength and stiffness of the structure. By cutting the weight of structure the energy, cost, time, money and carbon footprint will relatively reduce. The reinforcements in the structure has been used for a long time by using the steel reinforcement in the concrete, it will improve the weakness of the concrete which has low tensile strength. More recently, the new type of construction come which will decrease the amount of steel reinforcements required in the concrete and in the same way, the strength of beams or column remains the same or the structure will have a small reduction compared to its weight.

### 1.2 Aims And Objectives

The main aim and objective of this project is to find out, the possibilities of analysing fibers inside concrete in the real world (hand calculation) and the in Finite Element Software (ANSYS). However, there are more variables which need to be considered.

- Review the information which is already published.
- Review the information about the Palmyra palm fiber property.
- Review and investigate the detailed and the behaviour of Palmyra palm fiber under loads.
- Generate general formula for Palmyra palm fiber (how to analyse fiber in concrete).
- Generate a model and analyse it by software.
- Check the results with the experimental result.

### 1.3 Types Of Fibers

#### 1.3.1 Steel Fibres

Steel has high tensile strength. It improves strength, freeze-thaw, abrasion and impact resistance of the building. On the other hand, it is easy to shape the fibres. There are different types of steel fibres for different purposes. By adding these kinds of fibres the ductility and durability to undergo the pressures, impact forces will be gained. In addition, steel fibres help to control the cracks by trapping them in a small area and as a result the size of the cracks will be diminished. More information about the behaviour

of the steel fibers and property of it will be explain in the next chapter. Steel fibers usually use to increase the toughness and post crack load carrying capacity of the concrete. These fibers made from stainless steel or carbon.

**Specification:**

- ✓ Fibre diameters : 0.15-2 mm
- ✓ Fibre lengths : 7-75 mm
- ✓ High tensile strength : 0.5-2 GPa
- ✓ Modulus of elasticity : 200 GPa
- ✓ Most common steel fibre type : carbon steel (cheap)

**1.3.2 Glass Fibres**

Glass fibres are decent fibres to reinforce the concrete with, instead of using the bars which are heavy. GFRC (glass fibre reinforcement concrete) is made from soil; therefore it is not harmful for environment. Another strong point of these fibres is that they produce natural chemical reactions which makes GRFC very strong material and also flexible. It is eco-friendly because the fibre can be made from recycled glass and metal.

**Specifications:**

- ✓ Tensile strength 2-4 GPa
- ✓ Elastic modulus 70-80 GPa
- ✓ Brittle stress-strain characteristic (2.5-2.8% elongation at break)
- ✓ Up to 5% of concrete volume

**1.3.3 Propylene Fibres**

Concrete is not resistant against fire or heat. These fibres can cover this weakness of concrete very well. Propylene fibres have a reasonable price and can increase the compressive strength and thermal resistance. Propylene, just like other fibres decreases the permeability of concrete and curtails cracks. Propylene melts in 160□therefore during firing they melt and liquids inside the concrete will evaporate and decreases the pressure inside the concrete. By adding propylene fibres to concrete pump ability over long distances and impact resistance (to any force and plastic shrinkage during curing). Same as steel fibre, propylene fibre increase the freeze thaw of the concrete. As all the advantages and disadvantages mentioned, propylene fibres have many strong point as matter of strength and also the cost. However it reacts to fire quickly which is not suited in many cases therefore propylene fibres is not profitable to use.

**1.3.4 Synthetic Fibres**

Synthetic fibres are not create by nature or depending on animal farming or agricultural crop, but they made by humans in labs. This fact leads that these kinds of fibres become cheaper than any other fibres which have natural sources. In the same way, the availability of these fibres is better and also it should have easy maintenance. Synthetic fibres are durable however it dries fast. However, these fibres have many disadvantages which make some limitation to use them. Synthetic fibres have low melting temperature and will cause to melt before burning. As it mentioned before it is not natural, therefore it is also dangerous for environment. Other specification of this fibre is that they shrink easily and also their temperature changes easily (Depend on the temperature of area).

First of all synthetic fibres are not eco-friendly; however it is cheap and easily produced. The real disadvantages gained by the use of synthetic overrides its advantage. As a safety matter, the low melting temperature materials (as single or composites) could not be used in buildings. Mostly, synthetic fibers are used for slab one grade constriction to decrease to plastic shrinkage. On the other hand, it will improve and increase the impact and abrasion and toughness of the concrete.

**1.3.5 Carbon Fibres**

Carbon fibers is made from carbon graphite (CF) and their diameter are in the range of 5 to micro-meter. These fibers are very popular in civil engineering, motorsport and aerospace industry because of the spectacular properties they have. In general, the cost of the carbon fiber are quite high but in the recent years the cost carbon fibers has been manufactured.

**Specification:**

- ✓ High tensile strength (3.62GPa to 5.1GPa) and high elastic modulus (228GPa to 241GPa)
- ✓ High temperature tolerance
- ✓ High resistance against chemical reactions
- ✓ High strength/ weight ratio
- ✓ Low thermal expansion

**1.3.6 Acrylic Fibres**

These fiber are made from polymers and they are one form of be known as synthetic fibers. These fiber have up to 85% of acrylonitrile monomer and the remaining are made from modacrylic.

**Specifications:**

- ✓ Resistance to chemical
- ✓ Resistance to deterioration from sunlight exposure
- ✓ Very soft, very low tensile and compression strength not recommended for structure

**1.3.7 Aramid Fibres**

Aramid fibers are another form of synthetics fibers. These fiber are popular in military and aerospace industries. [12] [13][8]

**Specification:**

- ✓ No melting point, however aramid will start degradation from 500□C
- ✓ Good resistance to abrasion
- ✓ It has very low compressive and tensile strength ( not recommended for structure)
- ✓ Sensitive to acids and salts and ultra violet radiation

**1.3.8 Basalt Fiber**

Basalt fibers are natural fibers. These fibers are popular in military and aerospace industries. In general, basalt fibers are made from single material unlike most fibers which are

made from combinations of different material. The basalt fiber is made from quarried basalt rock which has been melted and extruded through small nozzles. These fibers are eco-friendly and there is no toxic in the processes. These fibers have high stability against high temperature and have insulating characteristics. Basalt fibers maintain their strength up to 1200 hours when exposed to water at $70^0$C whereas glass can withstand 200 hours at maximum. Tensile strength of basalt fiber is up to 200% more than the E-glass (strongest glass fibers) and the elasticity of it is about 15% to 30%. [14] [15][8]

**Specification:**

✓ High tensile strength (3 GPa to 4.84 GPa)
✓ High elastic modulus (79.3 GPa to GPa)
✓ Diameter of 9-17μm
✓ High thermal resistance from 700□C up to 1000□C

**1.4 Materials And Methods**

**1.4.1. Sample Collection And Preparation Of Composite**

Palm leaves of ten different aged trees (five of them are above 10 years and another five of them are below 10 years) were collected from Burura region of Comilla district. Dividing ends of the middle hard part of the leaves were hammered. Hard part of the leaves was im-mersed in water for 20 days to= rotten. Rotten materials were cleaned and fiber were then separated and dried under sun light. After that fiber was kept at 100˚C for 24 hours for partial removal of moisture. Acrylonitrile buta-diene styrene (ABS) was collected from local market of old Dhaka of Bangladesh. After measuring some proper-ties (Physical: Water absorption, Mechanical: Tensile strength and Thermal: TG/DTG) of palm fiber and ABS polymer, Palm fiber was cut to 1 - 2 mm in sized. ABS and small palm fiber were dried in dryer at 50˚C for 24 hours. Fined palm fiber and ABS polymer put into the injection moulding machine. This mixture was heated at 150˚C inside the injection moulding machine and molten mixture become composite and come out of the IMM. This composite was poured into different shape of die for different test. Three sets of composites samples (with 5%, 10% and 20% fiber content) were prepare to carry out this research.

**1.4.2 Characterization of PF-ABS Composite**

1) Tensile and Flexural Property of Composite Mechanical property such as TS and percentage of elongation-at break [EB(%)] of the samples were measured by a universal testing machine (Hounsfield UTM 10 KN; ASTM D 3039/D 3039 M-00) [9] at a crosshead speed of 2 mm/min, keeping a gauge length of 50 mm. FS and flexural strain (%) were also measured by the same apparatus [10], keeping a distance of 70 mm be-tween two supports on which the samples were placed to employ load.

The test samples were conditioned at 50˚C for 24 hours before testing. All the tests were performed under the same condition. 2) Hardness of Composite A software controlled Vicker's square based diamond indenter (Shimadzu, Japan) was employed to measure the micro hardness (H) from the residual impression on the sample surface after an indentation time of 6 seconds. Loads of 245.2 mN, 490.3 mN and 980.7 mN were used to derive a load indentation value of H in MPa by the following relation [11]. where $d(m)$ is the length of indentation diagonal, $P(N)$ is the applied load and $K$ is a geometrical factor equal to 1.891. Sample with flat and smooth surface immediately after their preparation were used for this measurement.

At least five imprints were taken on the sample surface for each load, and the $H$ was calculated from the average value of all impressions. Leeb's rebound hardness test is one of the most used methods for testing hardness. The portability of Leeb's tester can sometimes help to achieve higher testing rates without destruction of samples, which in most of the cases thus simplifies process and = saves costs [12]. It uses a carbide ball hammer that is spring rather than gravity powered. An electronic sensor measures the velocity of the hammer as it travels toward and away from the sur-face of the sample. The Leeb's value is the hammer's rebound velocity divided by the impact velocity times 1000. The result is Leeb's hardness from 0 to 1000 that can be related to other hardness scales such a Vickers.

## 2.METHODOLOGY

Figure.1 shows Methodology adopted in this study

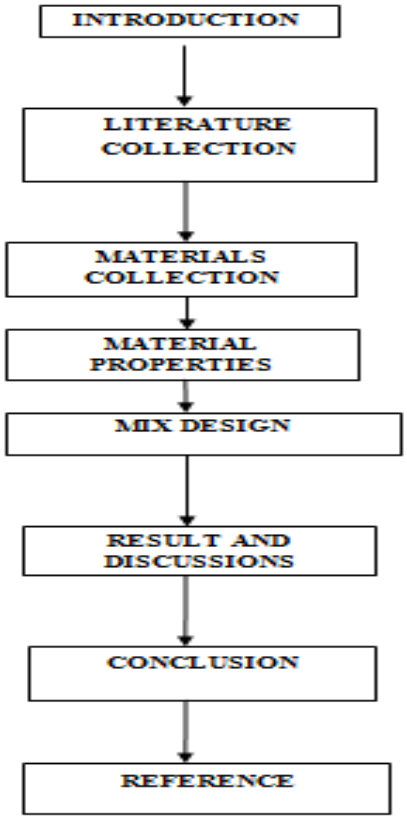


**Figure.1** Methodology

## 3.PROPERTIES OF MATERIALS

### 3.1 General

Concrete is an artificial material which is made up of cement, fine aggregate, coarse aggregate and water. In this project, an attempt has been made to replace fine aggregate by lathe scraps. Hence the properties of material have been arrived by conducting laboratory test results.

### 3.2 Material Used.

#### 3.2.1 Cement

In the most general sense of the word, cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The word "cement" traces to the Romans, who used the term opus caementicium to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick additives that were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cimentum, cement and cement.

#### 3.2.2 Aggregates

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are a component of composite materials such as concrete and the aggregate serves as reinforcement to add strength to the overall composite material.

#### 3.2.3 Water

Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

### 3.3 Properties Of Palm Fibers

#### 3.3.1palmyrafibre

Palmyra fibre is a natural fibre that derives from treatment of the leaf sheats of the Palmyra Palm and is produced in souther and eastern India. Bassine is inexpensive and durable, and its sweeping qualities are fair, but it is not resilient and may distort in use especially when wet. As with most of the other vegetable fibres it has good resistance to heat and most chemicals. Bassine is shipped in bundles ready to use in a brush-making machine, which makes it very attractive to the brush manufacturer. It is used in cheaper warehouse brooms, in mixtures for scrubbing brushes, and in cheaper household brushes and brooms. The fiber is sorted in grades, such as:

- Medium stiff
- Prime stiff
- Extra prime stiff

Palmyra Fibre is very strong and hardwearing, making it ideally suitable for semi-stiff sweeping brooms. It is also suited to the manufacture of scrub brushes. However, its properties can be markedly improved by the addition of a second material, either Mexican Tampico Fibre to produce a completely natural filling material, or PVC/PPN to create a semi-synthetic Union Mixture. The addition of Tampico Fibre increases the liquid carrying properties of Palmyra Fibre quite dramatically. Palmyra Fibre is very light in density, and is relatively low cost making it the perfect choice for low cost domestic brush ware.It is degrades completely naturally, with no harm to the environment, and is harvested from a renewable source, making it one of the "greenest" fibres available. It has good resistance to friction and heat, and will withstand many chemicals and solvents. We hold good stocks of all lengths of Palmyra Fibre in both Natural and Dyed grades. We can, of course ,fully dress and lubricate the fibre for use in high speed filling machines, and mix the fibre with a wide range of other Natural and Synthetic Fibres to make it suitable for almost any application This material is derived from the stalks of the Palmyra palm in Southern India mainly in Kerala State. The best material comes from an area around Palakkad, and is available in various grades of stiffness .Bassine is inexpensive and durable, and its sweeping qualities are fair, but it is not resilient and may distort in use especially when wet. As with most of the other vegetable fibres it has good resistance to heat and most chemicals. Bassine is shipped in bundles ready to use in a brush-making machine, which makes it very attractive to the brush manufacturer .It is used in cheaper warehouse brooms, in mixtures for scrubbing brushes, and in cheaper household brushes and brooms. The natural colour of Palmyra fibre is a dark brown, that can be dyed, and when is black dyed is usually called Bassine Palmyra fiber is obtained from the palmyra (palm) tree, which is 10 to 15 metre high plant. If used as reinforcing constituent in some matrix, it will result in a cost-effective and eco-friendly composite .Palmyra fibre is easily and abundantly available in India, Srilanka, etc. It is not only cheaper but also possesses high specific strength and modulus. Due to its low specific weight, it can be a better alternative to existing synthetic fibre reinforced composites. In this work, the raw palmyra fibres (botanical name is boralessus flabellifer) have been extracted from the tissues of primary stem of palm (toddy) plant, processed, prepared, and tested to determine their physical and mechanical properties. Ten individual fibres have been tested in natural (usually wet) condition and straight configuration. Density of different individual fibres of 200 mm length having mean diameter of 0.20 to 0.21 mm, and weight varying from 0.018 gm to 0.022 gm is obtained SIt varies from 606.7 kg/m3 to 789.3 kg/m3 (i.e. 0.606 gm/cm3 to 0.789 gm/cm3). The tensile tests have been performed on Hounsfield ten so meter using a scale of 0–30 kg (0–300 N) with a least count of 0.2 kg (2 N).

Different fibres of 0.42 mm to 0.60 mm diameter have sustained widely varying maximum load of 1.2 kg to 2.2 kg (12 N to 22 N) and have undergone an elongation of 8 mm to 20 mm.The recorded strains vary from 0.082 to 0.189. The tensile strength is found to vary from 500 kg/cm2 to 1923 kg/cm2 (50 MPa to 192.3 MPa).The stress-strain behaviour is plotted in figures. Its nature is widely varying

from linear to non-linear. The cause of variation in properties of different fibres is their different age and growth. Finding of this work has been compared with other natural fibres like flax, hemp, jute, coir, sisal and cotton. It is concluded that the density of palmyra is least among all known fibres. It is 0.7 only as compared to 1.25 for coir, 1.33 for sisal, 1.40 for flax, 1.46 for jute, 1.48 for hemp and 1.51 for cotton fibres. This is highly favourable property from the view point of light weightness. Hence, the palmyra fibres are most suitable for making reinforcement in composite materials.

Palmyra Brush Fibre and Stalks are extracted from palm trees. Fillers are compounding ingredients added to rubber compounds for the purpose of reinforcing them and/or cheapening their cost.

Traditional fillers include carbon black, silica, calcium carbonate, calcium silicate and clay. Carbon black is the most popular filler added to the rubber compounds due to its ability to enhance certain properties, especially mechanical properties Carbon black is derived from petro-chemical sources but the unstable price of crude oil has led to the search for filler that are derived from other sources. Agricultural by-products, maize cobs, cocoa pod husk, sugarcane chaff, rice husk, plantain peel, Palmyra palm fiber etc., are low cost materials, readily available and can be used in place of carbon black in natural rubber vulcanization. The growing environmental awareness is another driving force that leads to this research since fibers from agricultural byproducts are biodegradable and does not cause any environmental hazards. They can be easily recycled. The regulations on using synthetic materials are also a serious factor to consider which make the use of bio fibers an advantage over other types of fillers Palmyra palms are economically useful and widely cultivated in tropical regions.

The Palmyra palm has long been one of the most important trees of Cambodia and India, where it has over 800 uses. The leaves are used for thatching, mats, baskets, fans, hats, umbrellas, and as writing materials. Palmyra palm trees are in great abundance in Awka, Anambra state of Nigeria as well as the Northern part of Nigeria. Palmyra palm fruits are not used for any purpose and hence they constitute solid waste. This research work is aimed at harnessing the potential of Palmyra palm fiber as a filler additive which can be used as an alternative or in partial replacement to the commonly used commercial carbon black filler in natural rubber vulcanizate with a consequent reduction in cost of product.(Figure.2)


**Figure 2** Type Of Palm Fiber

## 4.ABOUT SOFTWARE

### 4.1 Finite Element Analysis

In mathematics, the finite element method (**FEM**) is a numerical technique for finding approximate solutions to boundary for equations. In this method the large problem domain is subdivided into number of smaller parts to reduce error and get more appropriate result.

The subdivision of a whole domain into simpler parts has several advantages

- Accurate representation of complex geometry
- Inclusion of dissimilar material properties
- Easy representation of the total solution
- Capture of local effects.

## 5.ANALYSIS RESULTS

A non –linear finite element analyses were done using ANSYS 14.5. The following are the properties assigned for the specimens.

### 5.1 ELEMENT TYPES

Solid65, Eight-node solid element was used to model the concrete. Steel reinforcement and steel plates were modeled using link180 element. Solid185 elements are used to model the FRP.

### 5.2 Material Properties

#### 5.2.1 For M30 Concrete

Modulus of elasticity= 30000N/mm$^2$
Poisson's ratio =0.2

#### 5.2.2 For Steel And Steel Plates

Modulus of elasticity=200000 N/mm$^2$
Poisson's ratio = 0.30
Yield stress =415N/mmm$^2$
Tangent modulus =20MPa

**5.2.3 For Palmyra Palm Fiber**

Figure.3,4,5,6,7,8 & 9 shows the Anmaterial properties alysis result of the Palmyra palm fiber used in this study.Table.1 & Figure 10 Graphs shows load vs deflection

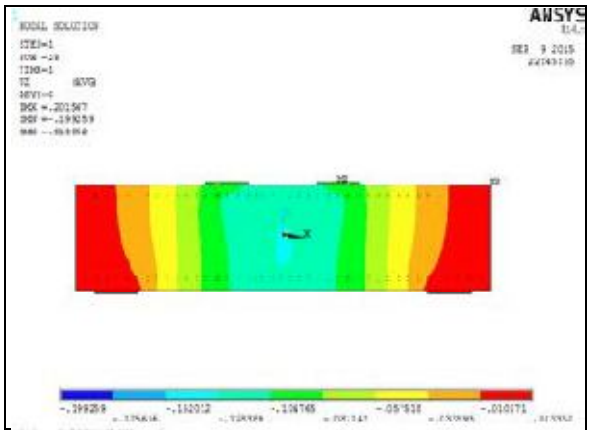

**Figure 3** The Displacement Of Palmyra Fibre

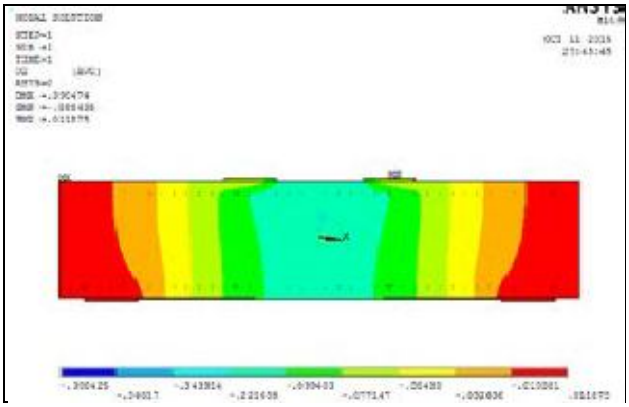

**Figure 4** The Displacements In The Model After Non-Linear Finite Element Analysis For CB

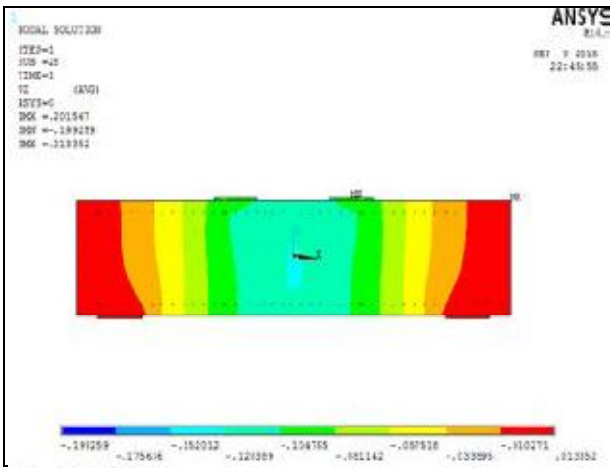

**Figure 5** The Displacements In The Model After Non-Linear Finite Element Analysis For SB1A

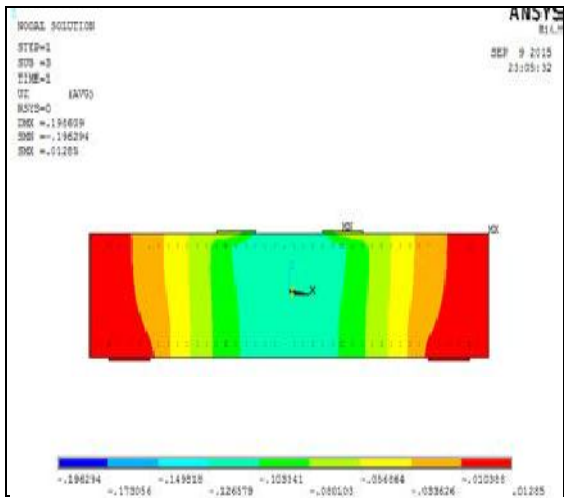

**Figure 6** The Displacements In The Model After Non-Linear Finite Element Analysis For SB2A

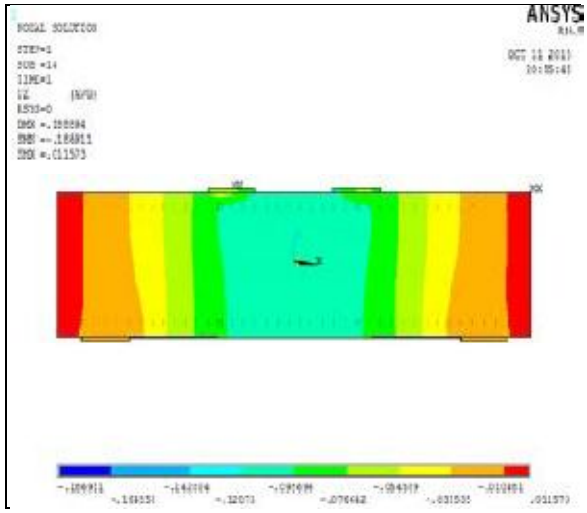

**Figure 7** The Displacements In The Model After Non-Linear Finite Element Analysis For SB3A

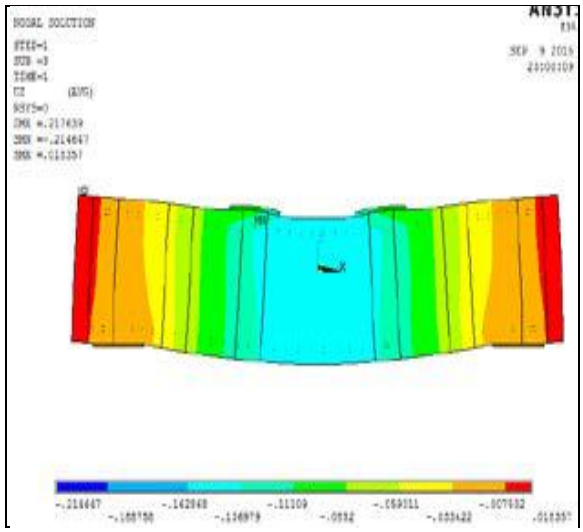

**Figure 8** The Displacements In The Model After Non-Linear Finite Element Analysis For SB4A

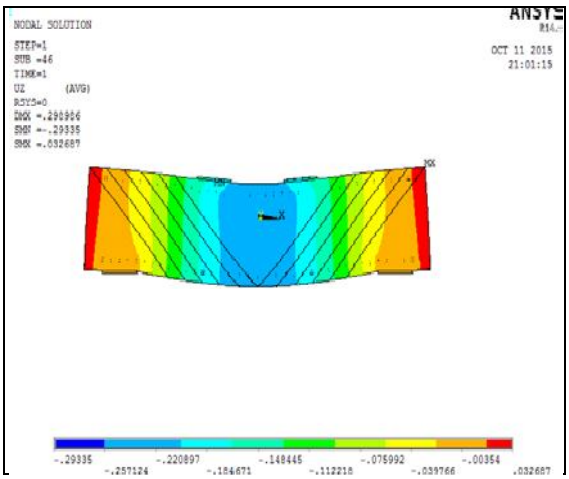


**Figure 9** The Displacements In The Model After Non-Linear Finite Element Analysis For SB5A

**Table.1** Load vs deflection

| *Beam code* | *Max. Deflection (in mm)* | *Ultimate Load (kN)* |
|---|---|---|
| CB | 0.390 | 139.5 |
| SB1A | 0.201 | 188 |
| SB2A | 0.198 | 178 |
| SB3A | 0.188 | 149 |
| SB4A | 0.217 | 178 |
| SB5A | 0.298 | 184 |

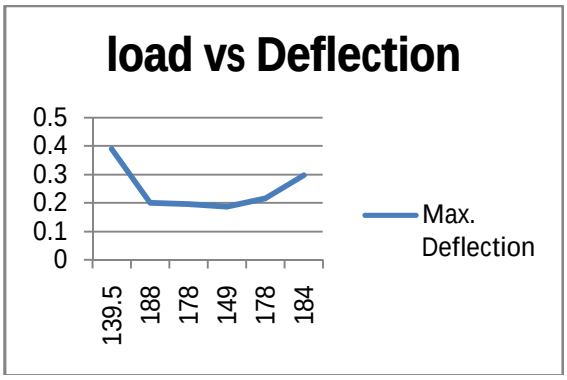


**Figure 10** Graphs shows load vs deflection

## 6. CONCLUSION

This study was an investigation of the effect of Palmyra palm fiber on natural rubber vulcanizates. A different composition of PPF was used to replace the commercial carbon black in natural rubber compound. The work has shown that Palmyra palm fiber can replace carbon black up to 57% and still have a good effect on the compound formed. This study showed that Palmyra palm fiber can be employed in natural rubber vulcanization as well as in other engineering works. Further research can be exploited by controlling particle size and particle distribution, improving filler dispersion, its surface functionality and also other methods of vulcanization can be employed using Palmyra palm fiber.

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