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# FLEXURAL CHARACTERISTICS OF OIL PALM STEM REINFORCED CONCRETE BEAMS

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**ABSTRACT**

*The potentials of Oil Palm Stem as a reinforcement material in concrete beams were investigated. The principal objective was to determine the flexural behaviour of Oil Palm Stem Reinforced Concrete Beams. Tensile strength tests were conducted on Oil Palm Stem Samples to assess their qualities as reinforcement material. Singly Steel Reinforced and Singly Oil Palm Stem Reinforced Concrete Beams of 750mm length having 150mm width and depth were compared with Plain Concrete Beam in this research work. The flexural strength, load carrying capacity and deflection characteristics of each beam were observed and compared. It was discovered that using Oil Palm Stem as reinforcement can increase the load carrying capacity of beams. It was also discovered for Singly Oil Palm Stem Reinforced Concrete Beam, the load carrying capacity increased by about 10% over that of the Plain Concrete Beam having the same dimensions while for Singly Steel Reinforced Concrete Beam, the load carrying capacity increased by about 3 times over that of the Plain Concrete Beam having the same dimensions. Further studies are also recommended on the use of Oil Palm Stem as reinforcement in concrete.*

***Keywords: Concrete, Beams, Steel, Oil Palm Stem***

## 1. INTRODUCTION

Steel is one of the most widely used and probably the most expensive of all the construction materials. Its strength and ductility properties have made it a choice for long span structures like bridges and tall buildings. Concrete is reinforced with steel because of its high tensile strength. Its high cost has however become a major challenge in the construction industry. In Nigeria and other developing countries where reinforced concrete in construction is widely used, the high and steadily increasing cost of steel has made construction very expensive. The search for a cheaper alternative has led to the exploration of abundant, naturally occurring material such as Oil palm fibre, Bamboo, Coconut fibre, Sisal etc. which can be obtained locally at low cost and low levels of energy using local manpower and technology.

Many research papers have indicated various advantages in the use of natural fibres in cement composites, among which are: increased flexural strength, post-crack load bearing capacity, increased impact toughness and improved bending strength (Do and Lien, 1995). Natural fibres exhibit many advantageous properties as reinforcement for composites (Toledo et al., 2003; Bilba et al., 2003; Asasutjarit et al., 2007; Olutoge 2009, Ahmad et al., 2010; Ofuyatan and olutoge, 2013).

In Nigeria, there are about 1.1 million hectares of oil palm trees that produce over 5 million tonnes of crude palm oil annually. The oil production represents only 30% and the remaining 70% consist of lignocellulose material of the total biomass produced by the industry (Okafor, 2005). Oil palm empty bunch and stem are one of the readily available, non woody natural fiber in Nigeria.

This paper presents the flexural behaviour of Oil Palm Stem Reinforced Concrete Beam compared with that of conventional Steel Reinforced Concrete Beam.

## 2. MATERIALS AND METHODS

### 2.1. Materials

#### 2.1.1. Oil Palm Stem

The Oil Palm used for this study was obtained from Iree, Osun State, Nigeria. The seasoned stem was cut into 10mm x 20mm x 700mm as required for the research work.

#### 2.1.2. Coarse Aggregate

The granite used for this research work was 12mm size. It was sourced from a quarry along Ibadan-Ile Ife expressway in Nigeria

#### 2.1.3. Fine Aggregate

The sand used for this research work was sourced from Iree, Osun state, Nigeria. The impurities were removed and it conformed to the requirements of BS 882 (1992).

#### 2.1.4. Steel Reinforcement

The reinforcement of size 16mm was obtained in Ikirun, Osun State, Nigeria. The reinforcement was cut into 700mm long.

#### 2.1.5. Cement

The cement used was Ordinary Portland Cement. It was sourced from Iree, Osun State, Nigeria and it conformed to the requirements of BS EN 197-1: 2000.

### 2.2. Concrete Mix Design

The concrete used in this research work was made using Ordinary Portland Cement, Sand and Gravel. The concrete mix proportion was 1:2:4 by weight and a water cement ratio of 0.50 was used.

### 2.3. Casting of Samples

#### 2.3.1. Beam Specimen

Concrete was poured into moulds 150 x 150 x 750mm in size. The different types of beam samples were:

. Plain Concrete Beam without any reinforcement.

. Singly Steel Reinforced Concrete Beam: Two 700mm long Steel Reinforcement Bars were placed on top of the first layer of 25mm which served as cover to reinforcement.

. Singly Oil Palm Stem Reinforced Concrete Beam: Two 700mm long Oil Palm Stems were placed on top of the first layer of 25mm which served as cover to reinforcement.

After 24 hours, samples were demoulded and submerged in open water tank for curing for 28 days as required for the test.

### 2.4. Testing of samples

The tests were carried out at the Ministry of Works and Transport, Ibadan, Nigeria and Federal Polytechnic, Ado Ekiti , Nigeria.

The tensile strength test was performed on 16mm Steel Reinforcement samples as well as 10mm x 20mm size Oil Palm Stem samples. The specimens were placed in Technotest-Eurotronic machine and tensile load was applied until fracture.

The Flexural Test on the Concrete Beams was carried out on Universal Testing Machine in accordance with BS EN 12390-2. The sample was weighed before being put in the Flexural Machine. Each specimen was simply supported over an effective span of 450mm. The beams were tested in flexure under third point loading. The loads were applied at third points between the supports on top of the beam at a distance of 150mm from each support. The loads were applied on the beam until the first crack was noticed and the corresponding deflections were recorded until the final collapse of the beam was reached.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Tensile Strength of Oil Palm Stems and Steel Reinforcements

The results of the tensile strength test done on the Oil Palm Stem Samples and Steel Reinforcement Bars used are shown in Tables 1 and 2. The results revealed there was no significant difference in the stress values among the three Oil Palm Stem Samples and among the three Steel Reinforcement Bars.

*Table 1: Tensile Strength Test Results of Oil Palm Stem Samples*

| No | Sample size (mm) | Ultimate Load (kN) | Stress ($N/mm^2$) | Average Stress ($N/mm^2$) |
|---|---|---|---|---|
| 1 | 10x20 | 15.93 | 79.65 | |
| 2 | 10x20 | 16.40 | 81.98 | 80.03 |
| 3 | 10x20 | 15.69 | 78.47 | |

*Table 2: Tensile Strength Test Results of Steel Reinforcement Bars*

| Bar No | Bar size (mm) | Ultimate load (kN) | Stress ($N/mm^2$) | Average stress ($N/mm^2$) |
|---|---|---|---|---|
| 1 | 16 | 105.24 | 523.35 | |
| 2 | 16 | 101.14 | 502.96 | 513.05 |
| 3 | 16 | 103.13 | 512.85 | |

### 3.2. Compressive Strength of Concrete Cubes

The results of the Compressive Strength tests conducted on three 150mm concrete cubes after 28 days curing in water are shown in Table 3.

Table 3: Compressive Strength Test Results

| Sample No. | Compressive Strength ($N/mm^2$) | Average compressive strength ($N/mm^2$) |
|---|---|---|
| 1 | 28.14 | |
| 2 | 26.49 | 27.42 |
| 3 | 27.62 | |

### 3.3. Flexural Strength of Concrete Beams

#### 3.3.1. Plain Concrete Beam

In the plain concrete beam, the first crack occurred vertically from the point of load application. It was observed that the beam failed at the ultimate load of 40.9 kN. The beam failed suddenly which showed brittle failure.

#### 3.3.2. Singly Steel Reinforced Concrete Beam

The results of load versus deflection for the Singly Steel Reinforced Concrete Beam after 28 days curing in water is shown in Table 4. The corresponding graph is also shown in Figure 1. The results revealed that the ultimate load carrying capacity as 125kN and maximum deflection of 36mm. The maximum crack width was 5mm.

*Table 4: The result of loading Singly Steel Reinforced Concrete Beam*

| Deflection (mm) | Load (kN) |
|---|---|
| 2 | 29 |
| 4 | 59 |
| 6 | 92 |
| 8 | 96 |
| 10 | 99 |
| 12 | 102 |
| 14 | 104 |
| 16 | 107 |
| 18 | 110 |
| 20 | 112 |
| 22 | 113 |
| 24 | 116 |
| 26 | 119 |
| 28 | 120 |
| 30 | 121 |
| 32 | 122 |
| 34 | 124 |
| 36 | 125 |

#### 3.3.3. Singly Oil Palm Stem Reinforced Concrete Beam

The results of load versus deflection for the Singly Oil Palm Stem Reinforced Concrete Beam after 28 days curing in water are shown in Table 5. The corresponding graph is also shown in Figure 2. The results revealed that the ultimate load carrying capacity as 45 kN and maximum deflection of 16mm. The maximum crack width was 4mm.

*Table 5: The result of loading Singly Oil Palm Stem Reinforced Concrete Beam*

| Deflection (mm) | Load (kN) |
|---|---|
| 2 | 10 |
| 4 | 18 |
| 6 | 24 |
| 8 | 29 |
| 10 | 34 |
| 12 | 38 |
| 14 | 42 |
| 16 | 45 |

## 4. CONLUSION AND RECOMMENDATIONS

From the investigations carried out, the following conclusions can be made:

Using Oil Palm Stem as reinforcement can increase the load carrying capacity of beams having the same dimensions.

At Ultimate load, the Oil Palm Stem Reinforced Concrete Beam crushed under load followed by the rupture of the Oil Palm Stem whereas the Steel did not rupture but lost its elasticity.

For Singly Oil Palm Stem Reinforced Concrete Beam, the load carrying capacity increased by about 10% over that of the Plain Concrete Beam having the same dimensions.

For Singly Steel Reinforced Concrete Beam, the load carrying capacity increased by more than 3 times over that of the Plain Concrete Beam having the same dimensions.

The maximum deflection of Singly Steel Reinforced Concrete Beam is about 1.25 times than that of the maximum deflection of Singly Oil Palm Stem Reinforced Concrete Beam

Both Singly Oil Palm Stem and Steel Reinforced Concrete Beams showed elastic behaviour while performing flexural tests on them.

Singly Steel Reinforced Concrete Beam has better elastic behaviour than Singly Oil Palm Stem Reinforced Concrete Beam.

The following are recommended from this study:

Durability studies should be carried out on the use of Oil Palm Stem as reinforcement.

The creep and shrinkage properties of Oil Palm Stem should be investigated.

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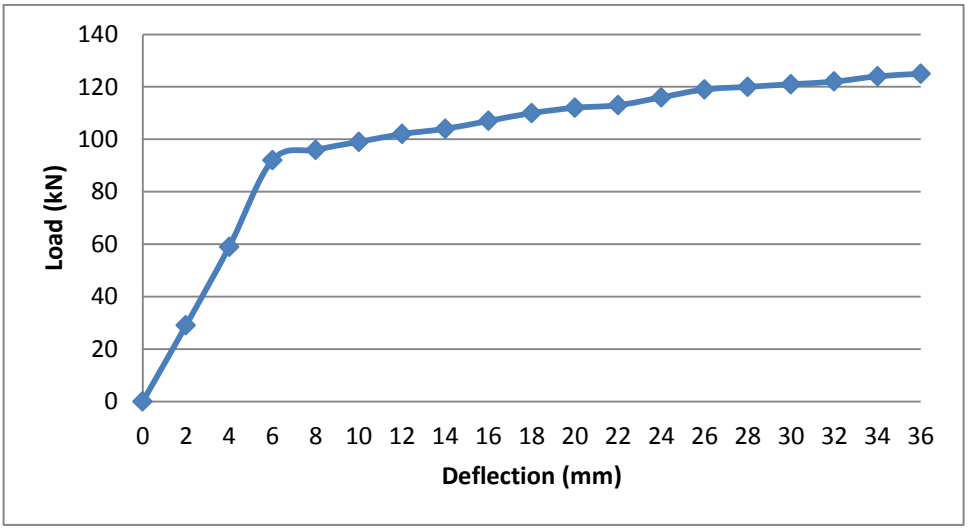


*Figure 1: Load-Deflection Curve for Singly Steel Reinforced Concrete Beam*

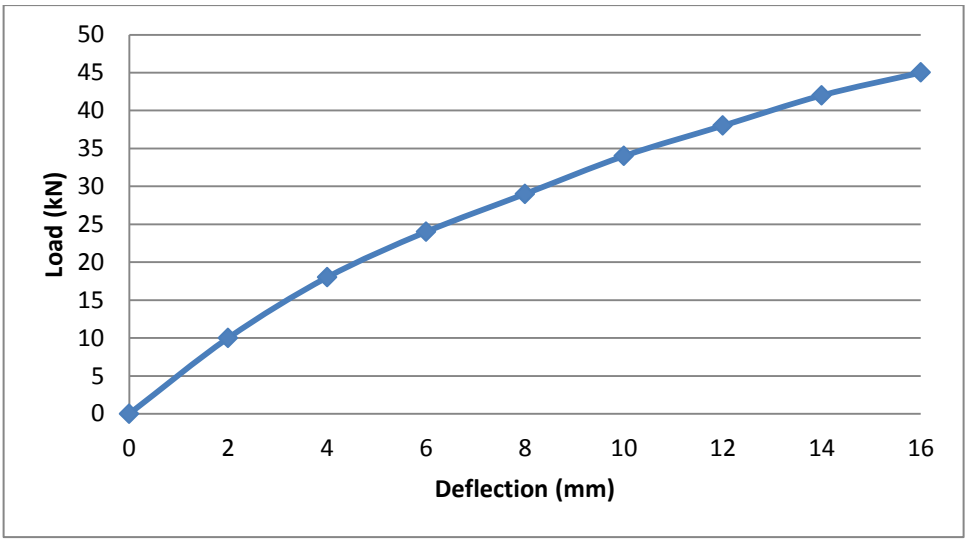


*Figure 2: Load-Deflection for Oil Palm Stem Reinforced Concrete Beam*