Effects of Oil Palm Fibre on the Compressive Strength of Mortar

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Abstract

Compressive strength development of mortar cube reinforced with Oil Palm Fibre (OPF) cured in water was investigated at different ages, using water /cement ratio of 0.5 and mix ratio of 1:6. OPF was introduced into the mortar at 0.2 %, 0.4 %, 0.6 %, 0.8 % and 1% by weight of cement. The result of the tests conducted showed that 0.6% is the optimal Oil Palm Fibre level both at 7 days and 28 days with compressive strengths of 1.4 N/mm$^2$ and 1.7 N/mm$^2$ respectively. These values are higher than the values for the control mortar mix for which the 7 days and 28 days compressive strengths were 1.2 N/mm$^2$ and 1.4 N/mm$^2$ respectively. These results show that 0.6 % is the most effective additive level of Oil Palm Fibre to mortar for greatest increase in compressive strength. This additive level of Oil Palm fibre as Self Compacting Mortar could satisfactorily replace concrete in area of repair and retrofit in concrete structures.

Keywords: oil palm fibre, compressive strength, mortar, water / cement ratio, curing.

INTRODUCTION

Improving mortar strength using available local materials is an effective way of overcoming the problem of low strength and failure in building construction as well as integrating indigenous knowledge in industrial sector. Flowability of mortar gave it an added advantage over concrete when inaccessibility comes into pictures in cases like congested reinforcement, narrow cracks or fissures and rehabilitation of structures. Self Compacting Mortar (SCM) easiness of application and improved mechanical advantages makes it preferable in repair works. Moreover, mortar plays a vital role in the workability properties of Self Compacting Concrete (SCC) therefore improvement on the properties of SCM will also bring about improvement in SCC (Kumar and Srikanth, 2008). Reinforcing mortar with different fibres would reduce plastic shrinkage and improves durability (Miguel, Kosa et al., Aly et al., 1997, 1991, 2010. Kumar and Srikanth (2008) reported that polypropylene and glass fibre would increase compressive strength of mortar specimen as well as increase the split tensile strength and flexural strength of mortars. SCM described as a new era of research (Sahmaran et al., 2006) is also applicable in the area of retrofit of both steel and concrete structures (Frosch et al. and Kanda et al. 1996, 1998). Brian and Ece (2010) also showed that the use of fibres in repair mortars improves the durability and flexural resistance of masonry structures while maintaining compatibility requirements and aesthetic appeal.

This study is an investigation into the compressive strength of OPF reinforced mortar. The fibre is derived from Empty Fruit Bunches of Palm oil tree as shown in plate 1.

Plate 1: Oil Palm Fibre

MATERIALS AND METHODS

The cement used in this research work was the Elephant brand of the Ordinary Portland Cement (OPC). The sand used as fine aggregates in this study complies with coarse, medium, and fine grading requirements of MS: 30 Part 8, 1995. The fine aggregate was air dried to obtain saturated surface dry condition to ensure the water cement ratio is not affected. Sieve analysis of the sand was done prior to using it to determine the fine aggregate passing 600 µm sieve. The result of the sieve analysis is shown in Fig.1.
The OPF used to reinforce mortar in this research was sourced within Akure. It is a by-product of oil palm nut whereby the oil in it was extracted and the fibre was manually separated from the nut by threshing, squeezing and washing process. The length of the fibre was around 12 mm. It was carefully measured and introduced into the mortar mixture as a percentage replacement of the OPC. Table 1 showed the chemical composition of the OPF.

Table 1: Quantities of Starch, Glucose, Lignin, and Carbohydrate in every 2 grams of OPF

<table>
<thead>
<tr>
<th>OPF Contents</th>
<th>Weight (kg)</th>
<th>Maximum Load (N)</th>
<th>Cross Sectional Area (mm²)</th>
<th>Average Compressive Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 % (Control)</td>
<td>0.289</td>
<td>2481</td>
<td>2500</td>
<td>0.99</td>
</tr>
<tr>
<td>0.2 %</td>
<td>0.282</td>
<td>2575</td>
<td>2500</td>
<td>1.03</td>
</tr>
<tr>
<td>0.4 %</td>
<td>0.282</td>
<td>2540</td>
<td>2500</td>
<td>1.16</td>
</tr>
<tr>
<td>0.6 %</td>
<td>0.268</td>
<td>3100</td>
<td>2500</td>
<td>1.22</td>
</tr>
<tr>
<td>0.8 %</td>
<td>0.248</td>
<td>2989</td>
<td>2500</td>
<td>1.20</td>
</tr>
<tr>
<td>1.0 %</td>
<td>0.236</td>
<td>2925</td>
<td>2500</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Potable water was used in the mixing and curing processes.

Mixing was done manually with cement/sand mix ratio of 1:6. The OPF were added to the mix at 0 %, 0.2 %, 0.4 %, 0.6 %, 0.8 % and 1.0 % by weight of cement. The mortar sample was cast in 50 mm x 50 mm x 50 mm cube mould. They were demoulded after 24 hrs and cured in water for 7 days and 28 days. The cube was crushed after 7 days and 28 days with ELE International ADR 1,500 compressive testing machine shown in plate 2 in accordance with ASTM C 109-12 (1996). The test was done in the material and testing laboratory of the Civil Engineering Department, Federal University of Technology, Akure. A total of 36 cubes were cast and crushed.

RESULT AND DISCUSSION

Tables 2 and 3 show the results of the compressive strength of OPF reinforced mortar and that of the control experiment.
Table 3: Average compressive strength of mortar cured in water for 28 days

<table>
<thead>
<tr>
<th>OPF Contents</th>
<th>Weight (kg)</th>
<th>Maximum load (N)</th>
<th>Cross Sectional Area (mm²)</th>
<th>Average Compressive Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 % (Control)</td>
<td>0.289</td>
<td>3252</td>
<td>2500</td>
<td>1.30</td>
</tr>
<tr>
<td>0.2 %</td>
<td>0.283</td>
<td>3375</td>
<td>2500</td>
<td>1.35</td>
</tr>
<tr>
<td>0.4 %</td>
<td>0.273</td>
<td>3475</td>
<td>2500</td>
<td>1.39</td>
</tr>
<tr>
<td>0.6 %</td>
<td>0.266</td>
<td>3600</td>
<td>2500</td>
<td>1.44</td>
</tr>
<tr>
<td>0.8 %</td>
<td>0.248</td>
<td>3528</td>
<td>2500</td>
<td>1.41</td>
</tr>
<tr>
<td>1.0 %</td>
<td>0.236</td>
<td>3425</td>
<td>2500</td>
<td>1.37</td>
</tr>
</tbody>
</table>

Fig. 4 compared the results of 7 days with 28 days compressive strength of the mortar.

![Average Compressive Strength against Curing Age](image)

Figure 4: Average Compressive Strength against Curing Age

The results for 7 days show that OPC i.e. 0 % OPF gives 0.99 N/mm² while OPF as an additive to cement gives the highest strength of 1.22 N/mm² at 0.6 % OPF which corresponds to 23.23 % increment in strength. For 28 days results OPC i.e. 0 % OPF gives 1.30 N/mm² while OPF as an additive to cement gives the highest compressive strength value of 1.44 N/mm² at 0.6 % OPF which corresponds to 10.77 % increment in strength.

CONCLUSIONS

These results show that 0.6 % partial replacement of cement with OPF which gives an increment of 10.77 % is an effective method of increasing the compressive strength of mortar. The compressive strength increment make it suitable to be used as Self Compacting Mortar in areas where inaccessibility comes into pictures in cases like congested reinforcement, narrow cracks or fissures. It also promotes integration of indigenous knowledge in industrial sector. The results also show that strength development of mortar increases with age if cured. However, durability test, split tensile strength and flexural strength tests could further be carried out on the mortar.

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