# Experimental Study on the Properties of Hardened Concrete Using Palm Oil Clinker as Repalcement Material for Fine Aggregate

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**Abstract**— The present experimental study revealed the effect of using Palm Oil Clinker as a replacement material for fine aggregate on the mechanical properties of structural concrete. Natural river sand is the most preferred choice as a fine aggregate material. It is mined from the river beds and sand mining has disastrous environmental consequences. The availability of natural sand for concrete production is facing challenges in the past few decades and has lead to a search for a replacement material.Palm oil clinker is obtained as a waste material in the palm oil industries is normally being dumped and treated as disposal waste thus creating environmental pollution. In this study, fine aggregate is replaced with palm oil clinker by 5%, 10% 15%, 20% and 25% by weight and compared with the control mix prepared without palm oil clinker. Compressive strength, split tensile strength and flexural strength test were conducted for each sample.The test results showed an increase in strength upto 20% inclusion of palm oil clinker and then it got reduced for 25% inclusion of palm oil clinker.Based on the overall observations, it can be suggested that palm oil clinker can be effectively utilized as fine aggregate in all concrete applications.

**Index Terms**— Concrete, Environmntal pollution, Fine aggregate,Mechanical properties,Palm oil clinker,Replacement material, Waste material.

## 1 INTRODUCTION

Concrete is a dense matrix composed of cement, sand , coarse aggregate and water. In India there is growth in infrastructure projects for which consumption of concrete will be very high. Concrete is used extensively all over the world and is the most widely used material in the world after water.

Production of cement and concrete, both require consumption of natural resources. Considering the effect of over exploitation of natural sand from river beds for ever ever increasing concrete production, alternatives to natural sand are being explored. One such alternative discussed in this paper is Palm Oil Clinker waste which has been used as a replacement material for natural sand. Palm oil clinker is obtained as a by product waste produced from burning of palm oil fibre and palm oil shell inside the boiler under high temperatures. Generally these wastes are being dumped near the palm oil mill thus resulting environmental pollution.The use of fine aggregates from waste generated from the palm oil industry in the production of structural concrete has therefore being studied as a useful alternative from the perspective of both environmental protection and the sustainability of natural river sand.

However, in order to make public this an alternative within the construction section, it is necessary to ensure quality and safety, in addition to providing a clear understanding of the performance of concrete containing fine aggregates from palm oil industry wastes.

M. Soundar Rajan [1] studied the effect of using steel slag as a partial replacement material for fine aggregate. The study evaluated the strength of M20 grade concrete made with steel slag as replacement for fine aggregates for varying percentages such as 10%, 20%, 30%, 40%, and 50% by weight of sand. Compressive strength and flexural strength tests were conducted to evaluate the strength properties. Maximum strength development was observed at 30% of steel slag replacement.

Pranshu Saxena [2] conducted experiments to study the effect of using silica fume and copper slag as a partial replacement material for cement and fine aggregate respectively. In this study, the amount of silica fume was fixed as 10% and the varying proportion of copper slag 10%, 20%, 30%, 40% and 50% were replaced with cement and fine aggregate respectively. Compressive strength, flexural strength and split tensile strength tests were conducted on M30 concrete to study the properties of hardened concrete. The study concluded that the maximum strength development was obtained at 40% replacement of fine aggregate by copper slag.

G.Balamurugan [3] studied the effect of using quarry dust as replacement material for fine aggregate. The work was carried out to study the variation in the strength of concrete when replacing sand by quarry dust from 0% to 100% in steps of 10%.Split tensile strength and flexural strength test was conducted at 28 day.The result indicated that quarry dust can be effectively used in concrete mixtures as a substitute for natural river sand at 50% replacement with additional strength than control mix.

Vanchai Sata et.al [4] studied the use of palm oil fuel ash as a replacement material for Portland cement. Palm oil fuel ash was used to replace Portland cement by 10%, 20% and 30% by weight of cementitious materials in order to make high strength concrete. Compressive strength test revealed that the concrete specimen with 20% replacement of ground palm oil

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fuel ash had the highest strength.

Bashar S. Mohammed et.al [5] conducted durability test on light weight concrete produced from oil palm clinker aggregates. The durability test that was conducted in this study was rapid chloride permeability test. In this study, light weight concrete specimens were prepared by utilizing palm oil clinker as full replacement for fine and coarse aggregate.

Compressive strength test was conducted on palm oil clinker concrete specimens.The result indicated that the compressive strength was approximately 60% higher than the minimum strength required for structural light weight concrete.The test results of density, splitting tensile strength and modulus of elasticity results indicate that palm oil clinker concrete was comparable to ordinary concrete and are suitable to be used as structural light weight concrete. Rapid chloride permeability test was conducted at 7day, 28day and 90 day. A high value of chloride ion penetration was observed at 7 day and 28 day whereas moderate value was observed at 90 day.The paper concluded that palm oil clinker concrete can be used for the production of structural light weight aggregate concrete.

A Mansoor Ali [6] studied the use of crumb rubber as a replacement material for fine aggregate. In this study, mechanical and durability properties of concrete with crumb rubber replacing fine aggregate and cement with silica fume were conducted.The test results indicated that the addition of rubber crumb caused a reduction in compressive strength and splitting tensile strength compared to the control concrete. An increase in flexural strength was obtained by limiting the replacement amount to only 10% of the fine aggregate. As a durability test, acid curing test including the sulphuric acid and hydrochloric acid were conducted for 28 days.On sulphuric acid and hydrochloric acid curing, a slight increase in the strength value was observed.Thus the durability properties on acid attack showed good results compared to conventional concrete.The study concluded that the concrete with fine rubber crumb can be used for non structural elements where the strength is not required.

This experimental work sought to study the properties of hardened concrete including the compressive strength test, split tensile strength test and flexural strength test on using palm oil clinker as a replacement material for fine aggregate in structural concrete.

## 2 Experimental Investigation

### 2.1 Materials

Ordinary Portland Cement of 43 grade was used for this experimental study. The test results on various physical properties are demonstrated in Table 1. Msand was used as fine aggregate and tests results on various physical properties are indicated in Table 2. Palm oil clinker used in this study was collected from palm oil mill located at Bharatheepuram of Kollam district, India.The tests results on various physical properties of palm oil clinker are indicated in Table 3.

Locally available granite type coarse aggregates were used and tests were conducted to determine the physical properties. The test results are summarized in Table 4.

TABLE 1
Physical Properties of Ordinary Portland Cement

| Particulars | Value |
|---|---|
| Grade | OPC43 |
| Specific gravity | 3.2 |
| Standard consistency(%) | 33 |
| Fineness(%) | 1 |
| Initial setting time(min) | 60 |
| Final setting time (min) | 360 |

TABLE 2
Physical Properties of Msand

| Property | Value |
|---|---|
| Fineness modulus | 3.15 |
| Specific gravity | 2.61 |
| Sieve analysis | Zone of aggregate –Zone I |

TABLE 3
Physical Properties of Palm Oil Clinker

| Property | Value |
|---|---|
| Fineness modulus | 2.59 |
| Specific gravity | 2.75 |
| Sieve analysis | Zone of aggregate –Zone II |

TABLE 4
PHYSICAL PROPERTIES OF COARSE AGGREGATE

| Property | Value |
|---|---|
| Fineness modulus | 0.92 |
| Specific gravity | 2.88 |
| Bulk density(g/cc) | 1.64 |
| Porosity(%) | 43 |
| Void ratio | 0.75 |

## 3 EXPERIMENTAL PROCEDURE

Concrete mix design for M30 grade concrete was prepared and is indicated in Table 5. Water cement ratio was fixed as 0.45. Palm oil clinker was introduced into concrete mix at varying percentages of 5%, 10%, 15%, 20% and 25% by weight of fine aggregate.

TABLE 5
MIX DESIGN FOR M30 GRADE CONCRETE

| Material | Cement | Fine aggregate | Coarse aggregate | Water |
|---|---|---|---|---|
| Weight ($Kg/m^3$) | 438 | 695 | 1107 | 197 |
| Ratio | 1 | 1.586 | 2.527 | 0.45 |

Mixes without palm oil clinker were also made to serve as control mixes. Specimens to be used for evaluating the hardened concrete properties were casted in moulds and compacted using a vibrating table. The details regarding the type, size and total number of specimens casted during the experimental work are indicated in Table 6.

TABLE 6
SPECIMENS PREPARED FOR 7 DAY AND 28 DAY STRENGTH TESTS

| Properties of hardened concrete | Type of specimens used | Size of specimens | Total number of specimens casted |
|---|---|---|---|
| Compressive strength | Concrete cube | 150mmX150mmX150mm | 36 |
| Split tensile strength | Cylinder | 150mm diameter and 300mm height | 18 |
| Flexural strength | Beam | 150mmmX100mmX100mm | 18 |

## 4 EXPERIMENTAL RESULTS AND DISUSSIONS

### 4.1 Compressive Strength Test

Compressive strength tests on cubes were determined at the age of 7day and 28day. Average reading of 3 specimens was recorded as the strength at respective age of concrete. The recorded values of average compressive strength at 7 day and 28 days interval are interpreted in Table 7.

TABLE 7
COMPRESSIVE STRENGTH TEST RESULTS

| Mix | Palm oil clinker (%) | Average 7 day strength (Mpa) | Average 28 day strength (Mpa) |
|---|---|---|---|
| 1 | 0 | 21.11 | 38.15 |
| 2 | 5 | 24.15 | 42.11 |
| 3 | 10 | 25.63 | 45.63 |
| 4 | 15 | 26.81 | 49.97 |
| 5 | 20 | 27.85 | 54.96 |
| 6 | 25 | 23.26 | 40.15 |

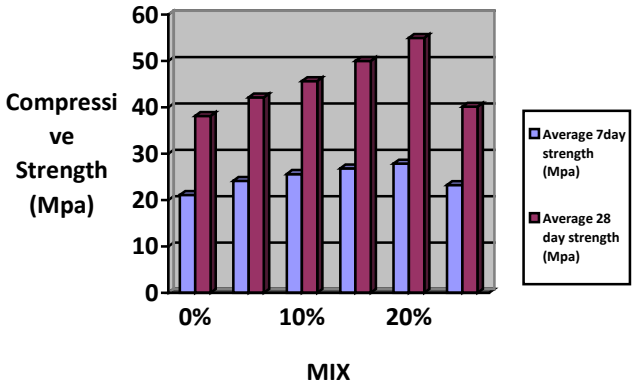


Fig. 1. Average compressive strength test results.

From Fig. 1 ,it can be seen that compressive strength of the new concrete mixes with 5%,10%,15%20% and 25% fine aggregate replacement with palm oil clinker were higher than the control mix at all stages. The compressive strength of all mixes continued to increase with the increase in age. The highest average 7 day compressive strength was achieved by 20% replacement of palm oil clinker, which was found about 27.85Mpa compared with 21.11Mpa for the control mix. This means that there is an increase in the strength of almost 32% compared to the control mix at 7 days. The highest average 28 day compressive strength was achieved by 40% replacement of palm oil clinker, which was found about 54.96Mpa compared to 38.15Mpa for the control mix. This means that there is an increase in strength of almost 45% compared to control mix at 28 days.

### 4.2 Split Tensile Strength Test

Splitting tensile strength is an indirect method to determine the tensile strength of concrete. In this test, a cylindrical specimen is subjected to a uniform line load along the length of the specimen. The tensile strength of cylindrical specimens were determined at 28 days and the average reading of 3 specimens were taken as the strength corresponding to 28 days.The test results are interpreted in Table 8. The variation of splitting tensile strength values are shown in Fig. 2.

The highest average 28 day splitting tensile strength was achieved by 20% replacement of palm oil clinker, which was found about 4.14 Mpa compared to 3.47Mpa for the control mix. This means that there is an increase in the 28 day strength of almost 20% compared to the control mix.

TABLE 8

SPLITTING TENSILE STRENGTH TEST RESULTS

| Mix | Palm oil clinker (%) | Average 28 day split tensile strength(Mpa) |
|---|---|---|
| 1 | 0% | 3.47 |
| 2 | 5% | 3.93 |
| 3 | 10% | 3.96 |
| 4 | 15% | 4.07 |
| 5 | 20% | 4.14 |
| 6 | 25% | 3.61 |

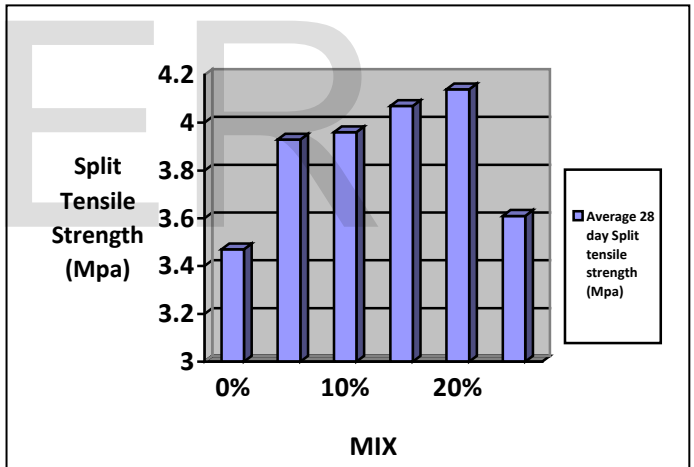


Fig. 2. Average 28 day Split tensile strength test results.

### 6.1 Flexural Tensile Strength Test

A flexure test is the most common procedure used to measure the tensile strength of concrete. Although concrete is not normally designed to resist direct tension, the knowledge of tensile strength is of importance in estimating the load under which cracking will develop. The test is very useful especially in relation to the design of road slabs and runways because the flexure tension is a critical factor in these cases.

The flexural tensile strength test was conducted on plain cement concrete beam and the average reading of 3 specimens

were taken as the strength corresponding to 28 days. The specimens were subjected to two point loading and the failure load of the specimen was noted down. The test results are summarized in Table 9 and the graphical variation is indicated in Fig. 3.

TABLE 9
FLEXURAL TENSILE STRENGTH TEST RESULTS

| Mix | Palm oil clinker (%) | Average 28 day flexural tensile strength(Mpa) |
|---|---|---|
| 1 | 0% | 4.1 |
| 2 | 5% | 6.1 |
| 3 | 10% | 6.45 |
| 4 | 15% | 6.75 |
| 5 | 20% | 7.9 |
| 6 | 25% | 6.5 |

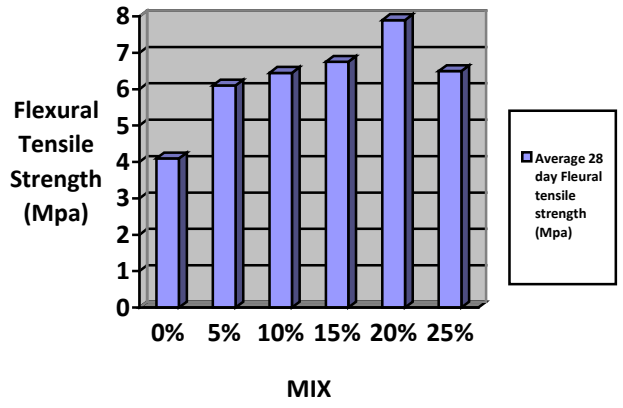


Fig. 3. Average 28 day Flexural tensile strength test results.

The 28 day highest average flexural strength was achieved by 20% replacement of palm oil clinker, which was found about 7.9Mpa compared with 4.1Mpa for the control mix. This means that there is an increase in the strength of almost 92% compared to the control mix at 28 days.

## 5 CONCLUSION

Based on the results of the experimental investigations conducted, the following conclusions were made.

1. The 28 days average compressive strength obtained for 20% palm oil clinker concrete mix shows 44% increase in compressive strength compared to control mix
2. The 28 day average split tensile strength obtained for 20% palm oil clinker concrete mix shows 20% increase in split tensile strength when compared to control mix.
3. The 28 day average flexural tensile strength obtained for 20% palm oil clinker concrete mix shows 92% increase in flexural tensile strength when compared to control mix.
4. Optimum level of replacement of palm oil clinker was found to be 20% and the results were better than that of control mix.
5. Beyond the replacement level of 20% of fine aggregate with palm oil clinker in concrete, a decrease in strength was observed.

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## REFERENCES

[1] M.Soundar Rajan, "Study on Strength Properties of Concrete by Partially Replacement of Sand by Steel Slag," *International Journal on Engineering Technology and Sciences*, vol 1, no 6, pp. 96-99, Oct. 2014.

[2] Pranshu Saxena,"Experimental Study on Mechanical Properties of M30 Concrete With Partial Replacement of Cement and Fine Aggregate with Silica Fume and Copper Slag,"*International Journal of Research in Engineering and Technology*,vol 4, no 5, pp.283-286, May 2015.

[3] G.Balamurugan and Dr.P. Perumal, "Behaviour of Concrete on the Use of Quarry Dust to Replace Sand-An Experimental Study,"*IRACST- Engineering Science and Technology: An International Journal, vol* 3, no 6, pp.776-781, Dec.2013.

[4] Vanchai Sata, Chai Jaturapitakkul and Kraiwood Kiattikomal,"Utilization of Palm Oil Fuel Ash in High Strength Concrete,"*Journal of Materials in Civil Engineering*, vol 16,no 6,pp. 623-628,Dec.2004.

[5] Bashar S. Mohammed, Khandaker M. Anwar Hossain, W. L.Foo and M. Abdullahi, "Rapid Chloride Permeability Test on Light Weight Concrete Made with Oil Plam Clinker," *International Journal of Engineering Research and Applications*, vol 1, no 4, pp.1863-1870, 2011.

[6] A. Mansoor Ali and A. Saravanan,"Experimental Study on Concrete by Partial Replacement of Fine Aggregate with Crumb Rubber,"*International Conference on Engineering Trends and Science and Humanities*, pp.60-65, 2015.