Study of Strength of Concrete with Palm Oil Fuel Ash as Cement Replacement

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Abstract— Palm oil fuel ash is the waste product obtained from palm oil manufacturing industry. The growing increase in amount of palm oil fuel ash is major concern for environment. The efficient disposal of palm oil fuel as is today's requirement. The use of palm oil fuel ash as replacement of cement in cement concrete has dual advantages as it contributes in effective disposal of fuel ash and it also contributes to the strength and other structural properties of concrete. In present study, palm oil fuel ash is studied for its effect on strength of concrete when used as partial replacement of cement.

Key words: Cement Concrete, Compressive Strength, Palm Oil Fuel Ash, Replacement in Concrete

I. INTRODUCTION

Coconut is considered as versatile fruit owing to its uses in different areas. In India, it is termed as "Nariyal" or "Khopra" and is considered the symbol of good luck and prosperity. Every auspicious work begins with breaking of coconut and offering it to gods [1].

Some of the products obtained from Coconut Water, Neera, Coconut Flower Syrup, Coconut palm jiggery, Coconut palm sugar, Copra, Coconut Oil, Raw Kernel, Coconut oilcake ,Coconut Shell Products, Coconut Wood Products, Coconut Leaves, Coir Pith etc. [2]. The coconut oil is an important product in India as India is one of the largest importer of coconut.

The two main exporter countries of palm oil are Indonesia and Malaysia which constitute about 85% of global output [3]. From palm oil industries large amount of palm oil fuel ash is obtained as by product. The pollution arising due to these ash particles is the primary motivation behind using palm oil fuel in concrete [4].

Besides, palm oil fuel ash also affects the strength and other structural characteristics of concrete. The palm oil fuel ash can then be used to replace the cement in concrete thereby contribution to reduction in pollution due to cement production also [5], [6].

It is observed in literature that replacement of cement by palm oil fuel ash by 20% contributed to compressive strength of concrete. [7]

The unit weight of palm oil fuel ash is very less, about 350 kg/m³ to 2000 kg/m³ hence are useful for lightweight concrete [8]–[10].

In present study, palm oil fuel ash is used as replacement of various type of concrete mixes and its effect on compressive strength is studied.

II. EXPERIMENTAL PROGRAM

A. Materials

The details of various materials used for experimental study is as given below.

1) Cement

The cement used is OPC 43 Grade obtained from suppliers and conforming to Indian standards.

2) Water

For mixing and curing of concrete water must be clean and free from inorganic and organic substances like oil, acid, alkali, salt, sugar, silt, organic matter as well as other elements which are deemed harmful to concrete. The chemicals, if present in water, may also react with ash particle and give undesirable effect. In general, tap water is feasible and is also used in this study for mixing and curing.

3) Fine Aggregate

Sand conforming to Zone-II is used as the fine aggregate, as specified in IS 383-1970 [11]. The sand is air dried and is found to be free from any foreign material, before mixing.

4) Coarse Aggregates

Coarse aggregate of nominal size 20 mm are used in present study. This is the standard type of coarse aggregate used.

5) Palm oil fuel ash

Palm oil fuel ash obtained from burning palm oil husk and palm oil shell in boilers of mill. The ash is found at the bottom where coarse are settled and fine ash escapes in air. The fine particles are settled using water. The ash is then pulverized before using in concrete

B. Batching and mixing of Specimen

Weight Batching is adopted using precise electronic weighing balance. Batching is performed for each individual mix proportion. The concrete is mixed by hand. The specimen is mixed until uniformity is achieved and the coarse and fine aggregates are mixed.

C. Casting of Specimen

The concrete is prepared and molded in cubes of size 150×150×150 for compressive strength tests. For flexural strength test, beams of 150×150×500 mm, which is sufficient for 20 mm coarse aggregate, is prepared. The fresh concrete is placed in molds in 3 layers, the vibrations are stopped as soon as the cement slurry appeared on the top of the mold.

The specimens are de-molded after 24 hrs. with care and are placed in the curing tank at ambient temperature. The ambient temperature for curing is specified as 27±20 °C.

III. MIX PROPORTIONS

The three type of mixes - M20, M25, M30 are prepared according to the provisions given in IS 456:2000 [12] and IS 10262:2009 [13]. In each mix the palm oil fuel ash is used to replace cement in increasing amount. The various mix proportions used are tabulated in Table 1.

Designation	Palm oil fuel ash (%)	Concrete Mix Type	Characteristic compressive strength (f_{ck})
MI-0	0	M20	20 N/mm²
MI-5	5	M20	20 N/mm²
MI-10	10	M20	20 N/mm²
MI-15	15	M20	20 N/mm²
MI-20	20	M20	20 N/mm²
MII-0	0	M25	25 N/mm²
MII-5	5	M25	25 N/mm²
MII-10	10	M25	25 N/mm²
MII-15	15	M25	25 N/mm²
MII-20	20	M25	25 N/mm²
MIII-0	0	M30	30 N/mm²
MIII-5	5	M30	30 N/mm²
MIII-10	10	M30	30 N/mm²
MIII-15	15	M30	30 N/mm²
MIII-20	20	M30	30 N/mm²

Table 1: Mix proportions details

IV. Results and Discussions

The results obtained from experimental test of concrete with palm oil fuel ash as partial replacement of cement is given in this section. The tests performed for this purpose are - slump test, tensile strength and flexural strength.

A. Workability

The slump test results are shown in Table 2 and Fig. 1. The slump value is found to increase uniformly as amount of fuel ash is increased.. It is due to the fine particles of fuel ash which contribute to enhancement in workability of concrete. The slump value in all three mixes i.e. M20, M25, M30 is observed to increase by 10% for every 5% replacement of cement with fuel ash.

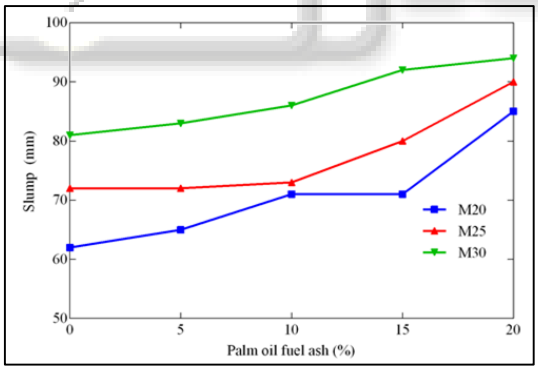

Fig. 1: Workability of concrete with varying amount of palm oil fuel ash

Designation	Palm oil fuel ash (%)	Slump (mm)
MI-0	0	62
MI-5	5	65
MI-10	10	71
MI-15	15	71
MI-20	20	85
MII-0	0	72
MII-5	5	72
MII-10	10	73
MII-15	15	80
MII-20	20	90
MIII-0	0	81
MIII-5	5	83
MIII-10	10	86
MIII-15	15	92
MIII-20	20	94

Table 2: Slump test results of concrete with palm oil fuel ash

B. Compressive Strength

The compressive strength test results of palm oil fuel ash is shown in Table 3, Fig. 2 and Fig. 3. The concrete with palm oil fuel ash shows increase in both 7 days and 28 days compressive strength which is due to pozzolanic action of palm oil fuel ash. The strength of concrete is found to increase uniformly with increase in amount of palm oil fuel ash.

Designation	Palm oil fuel ash (%)	7 days Compressive Strength (N/mm²)	28 days Compressive Strength (N/mm²)
MI-0	0	12.7	22.42
MI-5	5	13.23	25.50
MI-10	10	13.4	26.92
MI-15	15	14.14	28.91
MI-20	20	15.92	29.03
MII-0	0	15.58	30.775
MII-5	5	16.17	33.108
MII-10	10	16.31	33.218
MII-15	15	16.68	34.351
MII-20	20	17.93	35.086
MIII-0	0	19.07	35.34
MIII-5	5	19.6	36.33
MIII-10	10	20.84	38.68
MIII-15	15	21.01	39.36
MIII-20	20	21.38	41.72

Table 3: Compressive strength test results of concrete with palm oil fuel ash

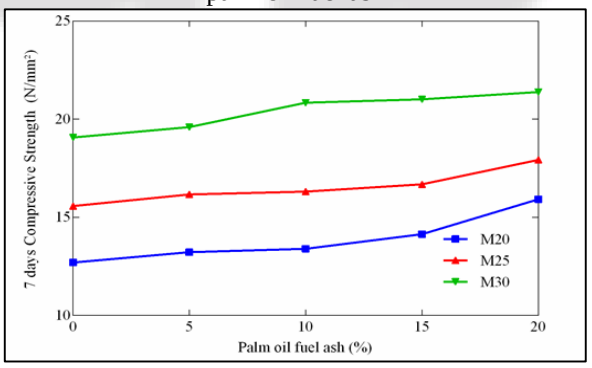

Fig. 2: 7 days Compressive strength results of concrete with palm oil fuel ash

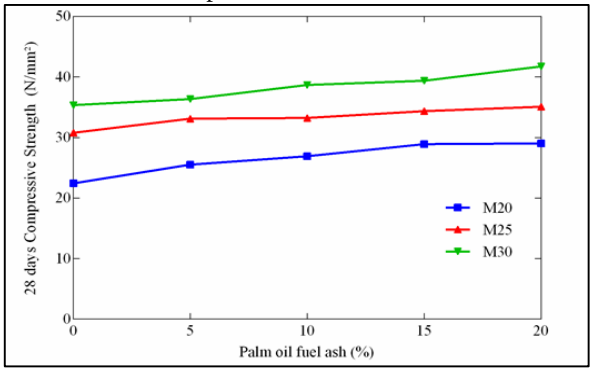

Fig. 3: 28 days compressive strength of concrete with varying amount of palm oil fuel ash

C. Flexural Strength

The flexural strength test results are given in Table 4 and Fig. 4 which show that there is slight enhancement in flexural strength of concrete as amount of palm oil fuel ash is increased.

Designation	Palm oil fuel ash (%)	Flexural Strength (N/mm²)
MI-0	0	2.22
MI-5	5	2.23
MI-10	10	3.13
MI-15	15	3.34
MI-20	20	4.04
MII-0	0	2.18
MII-5	5	2.64
MII-10	10	3.15
MII-15	15	4.14
MII-20	20	4.89
MIII-0	0	2.26
MIII-5	5	2.28
MIII-10	10	2.30
MIII-15	15	3.09
MIII-20	20	3.25

Table 4: Flexural strength test results of concrete with palm oil fuel ash

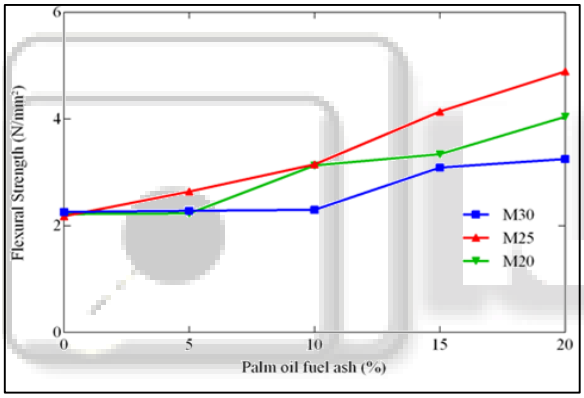

Fig. 4: 28 days flexural strength of concrete with varying amount of palm oil fuel ash

V. CONCLUSION

The palm oil fuel ash is precarious issue for environment and its efficient disposal is essential need of today. The use of palm oil fuel ash as pozzolanic material to replace cement in concrete provides effective disposal of palm oil fuel ash. The pozzolanic action of ash also contributes to strength of concrete as well as workability.

In present study, the palm oil fuel ash is used as a replacement of cement in concrete and its effect on strength is studied. It is concluded that increasing amount of palm oil fuel ash contributes significantly to workability and compressive strength of concrete. The flexural strength of concrete, though, is only slightly affected by presence of palm oil fuel ash.

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