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

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Abstract- *Rapid growth of infrastructure has led to the use of concrete almost everywhere, and one of the main products required in manufacturing concrete is cement, with the increase in the amount of cement used, heat of hydration increases which will lead to the formation of cracks in concrete accompanied by shrinkage effect. In order to control this, palm oil fuel ash, an agro waste which contains some amount of silica act as a pozzolanic material is being used as cement replacement and its strength is compared with conventional concrete of grade M25.*

Palm oil fuel ash which is obtained by burning palm fruit and dry leaves of palm oil tree in palm oil mills is also used to control heat of hydration effect on concrete, after pulverizing and making it into a fine powder. In this study cement is being replaced with palm oil fuel ash by 5%, 7.5%, 10%, 12.5%, 15%, 17.5% and the strength tests like compressive strength test, tensile strength test, flexural strength test are performed and are compared with the results of conventional concrete of grade M25 for 3,7 and 28 days. Satisfactory results have been found at a percentage of 12.5%. Increase in strength is found at this percentage.

Keywords- Compressive Strength, Tensile Strength, Flexural Strength.

I. INTRODUCTION

Background of Study:

Concrete is a very important material and widely used in construction material since an ancient time. Concrete is no doubt is important building material, playing a part in all building structure. It is must environmental friendly construction materials with offer the stability and flexibility in designing all building structures. Concrete are attractive for use as construction materials. Since, there are many advantages of concrete such as built-in-fire resistance, high. compressive strength and low maintenance. However, concrete also have a disadvantage which is the concrete are inherently brittle material.

On the other hand, concrete is also well known of its major problem associated with low tensile strength compared to compressive strength. Because of that, many new technologies of concrete and some modern concrete specifications approach were introduced. There have been many experimental works was conducted by introducing a new material or recycled material as a replacement to aggregate or cement in concrete.

Nowadays, the use of recycled materials as concrete ingredients is gaining Popularity and development because of increasingly stringent environmental legislation. Furthermore, there is significant research on many different materials for cement usage.

Objective of Study:

The objectives of the study are:

a) To study the effectiveness of palm oil fuel 'ash (POFA) and discover its potential as a partial replacement mixes in concrete.
b) To study the effect, of palm oil fuel ash (POFA) towards mechanical properties of concrete.
c) To study the effect, of palm oil fuel ash (POFA)) towards performance and durability of concrete.

Scope of Study:

This study concentrated on investigation of compressive strength and durability of palm oil fuel ash (POFA) concrete and plain concrete as a control mix. Each series of concrete were designed for grade 30 with constant water cement ratio (w/c) of 0.5 was conducted. The plain concrete compose of cement, water, aggregate and sand were considered as a control mix without replacing with POFA (POFA-0 0/o).. Three series of concrete mix design with POFA as cement replacement were composed as an unconventional mixes comprises of 5%,7.5%,10%,12.5%,15% and 17.5% from the total, weight of ordinary Portland cement The POFA concretes were labeled as POFA-10%, POFA-12.5% and POFA-17.5% respectively.

II. LITERATURE REVIEW

Concrete is a man-made material, is the most widely used building material in the construction industry. It consists of a rationally chosen mixture of binding material such as cement, well graded fme and coarse aggregates and water. Concrete has a high compressive strength, built-in-fire resistance, durability, and low maintenance. However, concrete is an inherently brittle materials with a relatively low tensile strength as compared to its compressive strength, requiring a lot of reinforcement.

Palm oil fuel ash is a by-product produced in palm oil mill. After palm oil is extracted from the palm oil fruit, both palm oil husk and palm oil shell are burned as fuel in the boiler of palm oil mill. Generally, after combustion about 5% palm oil fuel ash by weight of solid wastes is produced (Sata et al., 2004). The ash produced sometimes varies in tone of colour from whitish grey to darker shade based on the carbon content in it. In other words, the physical characteristic of POFA is very much influenced by the operating system in palm oil factory.

In practice, POFA produced in Malaysian palm oil mill is dumped as waste without any profitable return (Sumadi & Hussin, 1995). Either in 20th or 21st century, POFA is still considered as a nuisance to the environment and disposed without being put for any other use as compared to other type of palm oil by-product. Since Malaysia is continuous to increase production of palm oil, therefore more ashes will be produced and failure to find any solution in making use of this by-product will create severe environmental problems.

III. METHODOLOGY

With the development of cities and their infrastructure and the advancements of tools the usage of concrete is gaining importance. Due to advancements in material technology concerts up to 100Mpa are used, generally these high strength concrete requires high amount of cement which leads to increase in the heat of hydration leading to formation of cracks. This higher usage of cement leading to increase in heat of hydration can be tackled by reducing the amount of cement with some other cementing agents, and one such among is PALM OIL FUEL ASH. This palm oil fuel ash is the agro waste produced in manufacturing palm oil, this is produced by burning palm oil fruit and its leaves. This is being disposed in huge amount which is becoming a threat to environment.

This palm oil fuel ash which we get after burning is of not uniform size and of different colour, but after pulverizing it turns in to grey colour with uniform size, this pulverized palm oil fuel ash is said to have cementing properties with cement and hence is used as cement replacement. India stands in 3rd position in producing this palm oil fuel ash as its main production happens in tropical countries. By using this palm oil fuel ash as replacement for cement many things can be achieved like reduction in cost of concrete as the utilization of cement is replaced with palm oil fuel ash, environmental damage can be minimized as the freely disposed palm oil fuel ash is being used in manufacturing concrete also the durability, appearance and strength of concrete can be increased by eliminating the formation of cracks.

MATERIAL SELECTION:

CEMENT

According to IS 456:2000 the cement 43Grade Ordinary Portland Cement conforming to IS 8112

In present day concrete, cement is a mixture of lime stone and clay heated in a kiln to 1400-1600c. The types of cement permitted by IS:1343-1980(clause 4.1) for pre-stressed applications are the following. The information is revised as per IS:456-2000, plain and reinforced- concrete code of practice.

FINE AGGREGATE

Nominal size is less than 4.75mm sand. Along with cement paste it forms mortar grout and fills the voids in the coarse aggregates River sand having density of 1460 kg/m3 and fineness Modulus (FM) of 2.51 was used. The specific gravity was found to be 2.52. Fineness Modulus is given by division of the summation of cumulative retained fractions for standard sieves up to 150-micron sieve size by 100. The fineness modulus of sand varies from 2.0 to 4.0, higher the FM coarser is the sand.

COARSE AGGREGATE

Gravel aggregates are stones that have nominal size larger than 4.75mm. It is the basic building component of concrete. Coarse aggregate can be obtained from natural sources or synthetic. Natural resources generally were from the granite and limestone (BS812: Part 1:1975). Groupings were used for the construction of comparative density of normal and stone aggregates typically are in the range of 2500-2700kg/m3.

PALM OIL FUEL ASH

Palm kernel shells along with fiber wastes are burned together in chimneys to produce heat at a temperature of 450o. After burning the ash generated tries to escape due to less weight, to avoid this water is sprinkled from top and then this is collected, pulverized and passed through IS 90mm sieve.

Palm oil fuel ash is the byproduct of burnt palm oil husk and palm oil shell in the boiler of palm oil mill. In this study, POFA have been collected from Sime Darby Plantations palm oil processing factory from Kilang Kelapa Sawit Mills, Negeri Sembilan. The ash was found at the shaft of the tower where all the fine ashes are trapped when escaping from the burning chamber of the boiler. Among the available ashes, only the grayish ash will be sorted out and collected. Firstly, the dried ashes will be sieved through a 300µm sieve in order to remove bigger size of ash particles and impurities. Secondly, only the fine ashes passing through 300µm will be used

IV. RESULTS AND DISCUSSIONS

SLUMP CONE TEST

It is the test performed to know the workability of concrete. It is mostly using in laboratory and in sites. Slump test is used to determine the workability of fresh concrete.

Reporting of Results

The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, which collapses or shears off laterally, gives incorrect result and if this occurs, the test should be repeated with another sample. If, in the repeat test also, the specimen shears, the slump should be measured and the fact that the specimen sheared, should be recorded.

Table 1. Slump cone results

Composition with POFA replacement	Water-cement ratio	Slump (mm)	Average slump (mm)
0%	0.5	61.40	60.13
		60.29	
		58.80	
5%	0.5	65.49	66.16
		68.00	
		65.00	
7.5%	0.5	68.50	69.33
		70.00	
		69.50	
10%	0.5	70.00	71.16
		71.50	
		72.00	
12.5%	0.5	72.40	73.69
		74.88	
		73.80	
15%	0.5	74.50	76.00
		76.00	
		77.50	
17.5%	0.5	78.40	79.49
		80.59	
		79.50	

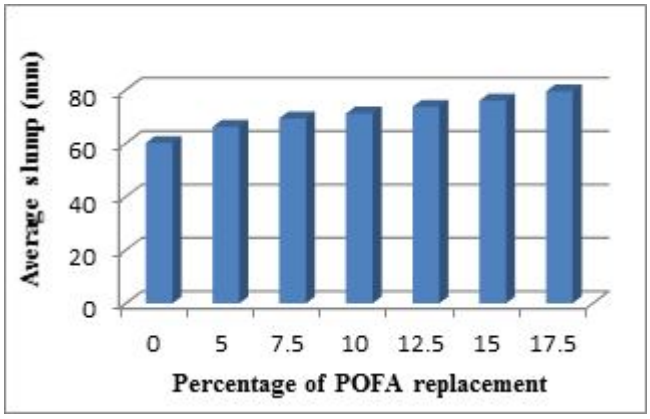

Figure 1. Graph:4 X-Axis is % of POFA Y-Axis is Average slump of slump cone test.

COMPACTING FACTOR TEST:

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus are trowel, hand scoop, balance, and tamping rod.

Table 2. Compaction factor test results

Composition with POFA replacement	Water-cement ratio	Compaction factor	Average compacting factor
0%	0.5	0.93	0.93
		0.94	
		0.92	
5%	0.5	0.94	0.93
		0.93	
		0.93	
7.5%	0.5	0.94	0.94
		0.93	
		0.94	
10%	0.5	0.93	0.94
		0.94	
		0.95	
12.5%	0.5	0.94	0.943
		0.94	
		0.95	
15%	0.5	0.95	0.953
		0.96	
		0.95	
17.5%	0.5	0.96	0.963
		0.97	
		0.96	

COMPRESSIVE STRENGTH TEST RESULTS:

It is one of the most important test conducted on hard concrete. The compressive strength tests are conducted on POFA concrete for different mixes. The test is conducted for 3, 7 and 28 days under compressive strength testing machine. The results obtained after conducting tests are shown in the below table it can be noted that at 12.5% of mix it shows higher strength.

Table 3. Compressive strength of concrete with various percentages of palm oil fuel ash

S.No	% of Palm Oil Fuel Ash	Compressive Strength at Age of 3days, MPa	Compressive Strength at Age of 7days, MPa	Compressive Strength at Age of 28days, MPa
1	0	18.5	23.03	37.04
2	5	19.2	24.36	37.55
3	7.5	18.7	23.48	37.22
4	10	19.5	24.16	37.60
5	12.5	21.8	28.75	42.05
6	15	19.89	26.53	39.86
7	17.5	18.6	23.9	37.16

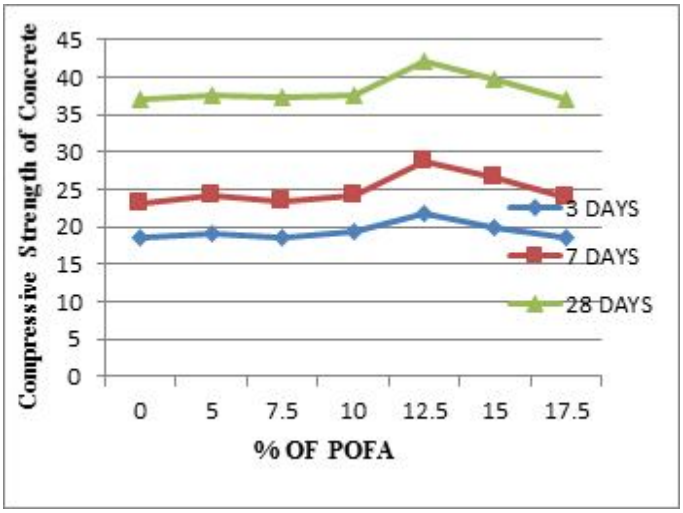

Figure 2. Graph. X-Axis is % of POFA, Y-Axis is Compressive strength of concrete

SPLIT TENSILE STRENGTH TEST RESULT:

Tensile strength of concrete is one of the basic and important property of the concrete, it is determined by conducting tests on concrete cylinders. Split tensile strength conducted on different mixes of POFA are tabulated below

Table 4. Tensile strength of concrete by the addition of various % of palm oil fuel ash

S.No	% of Palm Oil Fuel Ash	Split Tensile Strength at Age of 3days, MPa	Compressive Strength at Age of 7days, MPa	Compressive Strength at Age of 28days, MPa
1	0	1.27	1.94	2.98
2	5	1.38	2.14	3.63
3	7.5	1.41	2.5	3.6
4	10	1.20	1.9	2.98
5	12.5	2.13	2.94	4.45
6	15	1.70	2.01	3.02
7	17.5	1.73	2.44	3.3

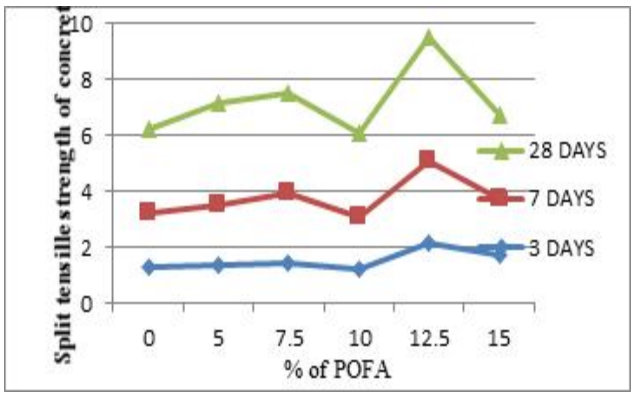

Figure 3.

FLEXURAL STRENGTH TEST RESULT:

The flexural strength tests are conducted on POFA concrete for different mixes. The test is conducted for 3, 7 and 28 days under flexural strength testing machine. The results obtained after conducting tests are shown in the below table it can be noted that at 12.5% of mix it shows higher strength.

Table 5. Flexural strength of concrete by the addition of various % of palm oil fuel ash

S.No	% of Palm Oil Fuel Ash	Flexural Strength at Age of 3days, MPa	Flexural Strength at Age of 7days, MPa	Flexural Strength at Age of 28days, MPa
1	0	10.1	11.41	11.96
2	5	10.3	11.83	12.22
3	7.5	10.3	12.16	12.65
4	10	11.66	13.5	14.1
5	12.5	13.0	14	15.32
6	15	10.83	11.66	12
7	17.5	10.16	11.25	11.85

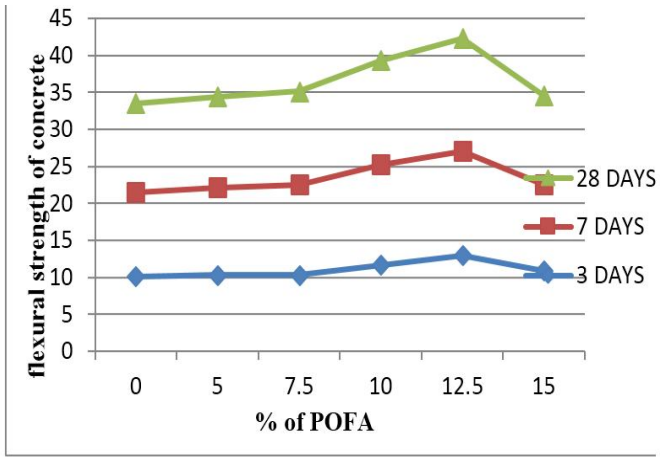

Figure 4.

V. CONCLUSION

After careful experimentations done on concrete of grade M25 with varying percentage of palm oil fuel ash from5-17.5%,by conducting tests like slump, workability, compressive strength and split tensile strength test, the following conclusion are obtain

1. In making this no advanced tools are required and it is easy to use this also it reduces the cost of concrete as there is replacement of cement with palm oil fuel ash.
2. With this there will be also reduction in the damage of environmental disturbances created by the spread of palm oil fuel ash.
3. From the above results it has been drawn that at 12.5% of palm oil fuel ash there is increase in the strength.
4. By using POFA tensile strength is slightly higher than opc at 12.5% of mix and tensile strength also increases accordingly.
5. When super plasticizer is added to POFA concrete, there is improvement in workability. Therefore the effect of the super plasticizer also increases the workability of POFA concrete.
6. The effect of super plasticizer on concrete exhibits a higher value for slump compared to the slump of OPC concrete. Also the result of the compacting factor can be correlated to the slump. The higher percentage of replacement exhibited higher workability. Hence POFA has higher workability when super plasticizer is added.
7. The results showed that the ultimate compressive strength of concrete could be improved by using up

to 12.5 % of POFA to replace Portland cement in the concrete mix.

8. Compressive strength of POFA shows its optimum compressive strength is when the cement is replaced with 12.5% POFA giving a higher compressive strength than OPC.
9. Consuming POFA as cementing materials in construction industry will reduce the environmental problems associated without disposing it in landfill.
10. The flexural strength of POFA is slightly higher than that of OPC by replacing cement with 12.5% POFA. Similar to flexural strength, the tensile strength of concrete containing POFA develops in the similar way.

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