PROPERTIES OF COMPOSITE FIBER REINFORCED CONCRETE WITH PALM OIL FUEL ASH AS PARTIAL REPLACEMENT OF CEMENT

[1]Swati Gudagudi, [2]Shiva Malasree
[1]PG Student, Structural Engineering, [2] Asst.Professor,
[1]Department of Civil Engineering,
[1]RYMEC, Ballari, India.

Abstract: **In the production of palm oil various waste materials such as empty fruit bunches, palm kernel shells, palm leaves and fibers are produced. These wastes are used as fuel in palm oil industry in palm oil mill boilers. The combustion of these above by products produces ash. This palm oil fuel ash has the potential to be used as a partial replacement for cement as it has the pozzolanic properties, leading to reduction in the cost of construction, and a convenient means of disposal of wastes. In this experimental study the palm oil fuel ash is obtained by palm oil mill named Kalpataru near Harihar. The study deals with the properties of composite fiber reinforced concrete containing palm oil fuel ash as partial replacement of cement, and fibers (sisal and glass fibers) in different proportions. The palm oil fuel ash is used in the percentage of 0%, 10%, 20 % & 30%, for concrete having sisal fibers of various proportion i.e. 0%, 0.5 %, 1 %, 1.5 %, and glass fibers of 0 %, 0.1 %, 0.2 %, and 0.3% are used for mix. The study is carried to find out the compressive strength, split tensile, flexural strengths at the period of 7 and 28 days**

Index Terms **– Palm Oil Fuel Ash, Sisal fiber, Glass Fibers, Compressive Strength, Flexural Strength, Split Tensile Strength.**

1. INTRODUCTION

In the construction field the growing concern of resource depletion and global pollution is growing day by day so this is leading researchers to work and develop new materials relying on renewable resources. These include the use of by-products and waste materials for building construction from various industries and agriculture. The high cost of conventional building materials is a major factor affecting construction in India. In developing countries abundant agricultural and industrial wastes are discharged, these wastes can be used for various purposes in construction industry. These wastes have advantages, reduction in the cost of construction material and also as a means of disposal of wastes.

There are several causes of global warming, including CO_2 from cement. Approximately 5% of total CO_2 emission is released to atmosphere, with about 0.7–1.1 ton of CO_2 being emitted for every ton of cement production. In order to reduce the amount of CO_2 emission, cement manufactures can help by improving production process. For concrete production, the reduction of cement content in concrete can be achieved by utilization of supplementary cementitious materials such as fly ash, blast-furnace slag, natural pozzolans, palm oil fuel ash and biomass ash. Also, the generation of large quantities of industrial by-products every year by chemical and agricultural process industries has created environmental pollution as well as increasing the expenditure of the industry for disposing this waste. As a result, solid waste management has become one of the major environmental concerns in the world. Use of these materials not only helps in getting them utilized in cement, concrete, and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in land-fill cost, saving in energy, and protecting the environment form possible pollution effects. Further, their utilization may improve the microstructure, mechanical properties of concrete, which are difficult to achieve by the use of only ordinary Portland cement.

In the production of palm oil various waste product materials such as empty fruit bunches, palm kernel shells, palm leaves and fibers are produced. These wastes are used as fuel in palm oil industry in palm oil mill boilers and also used as a fuel to produce electricity generation in other counties. The combustion of these above by products produces ash. In most of the countries, these waste product materials are being disposed in open fields and thus it has negative impact on environment. This palm oil fuel ash has the potential to be used as a partial replacement for cement as it has the pozzolanic properties, leading to reduction in the cost of construction, and a convenient means of disposal of wastes.

2. OBJECTIVES

The main objectives of this project are as follows:

- The study deals with the properties of composite fiber reinforced concrete containing palm oil fuel ash as partial cement replacement used in the percentage of 0%, 10%, 20% and 30%.
- Palm oil fuel ash concrete consists of composite fibers, sisal of various proportion of 0%, 0.5%, 1%, 1.5%, and glass fibers of 0%, 0.1%, 0.2% and 0.3%respectively.
- The study is carried to find out the compressive strength, split tensile strength, flexural strengths of composite fiber reinforced concrete with palm oil fuel ash as partial replacement of cement at the period of 7 and 28 days.

3. LITERATURE REVIEW

General

Many researchers have carried out experimental investigation in the field of palm oil fuel ash concrete. Some of the research journal papers have been discussed here in order to support the objective of the present project work.

Literature survey:

[1] **A.S.M Abdul Awal and Warid Hussassin.** One of the most recent addition to the ash family is palm oil fuel ash, a waste material got from burning of palm oil husk and palm shell as fuel in palm oil plant boilers, which has been recognized as good pozzolanic material. This investigation is carried out to srudy the performance of palm oil fuel ash in reducing heat of hydration of concrete. Two concrete mix to be specific OPC concrete for example concrete with 100% OPC as control, and POFA concrete for example concrete with 30% POFA and 70% OPC were prepared, and the temperature rise because of heat of hydration in both the mix was recorded. It has been discovered that palm oil fuel ash decreased the absolute temperature rise as well as delayed the time at which the peak temperature occured. The results showed that partial replacement of cement by palm oil fuel ash is advantageous, particularly for mass concrete where thermal cracking due to excessive heat rise is of great concern

[2] Sooraj V. M. This study indicates effectiveness of agro waste ash by product called palm oil fuel ash as cement replacement. Strength properties of concrete containing 10% 20% 30% and 40%POFA with 0.45 water cement ratio is carried out. Properties of concrete such as compressive strength, flexural strength and split tensile strength are studied and compared with Conventional concrete. The study shows that replacement of OPC by POFA of 20% holds good strength in compressive test.

[3] **A. Krishnapriya et al.** In this study the palm oil fuel ash in different percentages of 5% 10% 15% 20% is used to replace cement for M25 grade concrete. The optimum point is obtained from above percentages of POFA. For this optimum point the glass fibers and steel fibers in different percentages of (0% 0.1% 0.2% 0.4%) and (0% 0.5% 1% 1.5% and 2%) are used respectively. Mechanical properties such as compression, flexural and split tensile tests for each set of fibers were studied. From test results the optimum percentage replacement of POFA was found to be 15%. And steel fibers and glass fibers of up to 1.5 % and 0.3% respectively can be used.

[4] **Gollapalle Priyankarni etal.** Experimental study is carried on effects of sisal fiber reinforced concrete. Sisal fibers are used in varying percentages of 0.5%, 1%, 1.5% , 2%and 3% for the concrete grade of M20. Compression test, split tensile test and flexural tests were carried out. Study indicate that there is increase in compressive strength, split tensile strength and flexural strength of specimens with increase in sisal fiber up to 1.5% compared to conventional concrete whereas further increase of fiber reduces the strength.

4. PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION OF OPC AND POFA

Table No 4.1 Physical properties of OPC and POFA

Test	Physical properties of OPC 43 grade	Physical properties of POFA	IS : requirements
Standard Consistency	32	34	With Vicat Apparatus
Initial setting time	52min	2h 15min	As per IS: 4031-1968 Min.:30 min.
Specific gravity	3.15	2.445	2.7-3.2

Table No 4.2 Chemical composition OPC and POFA

Oxide composition	OPC	POFA
Silicon dioxide (SiO_2)	20.1	41.34
Calcium oxide (CaO)	65	7.38
Aluminum trioxide (Al_2O_3)	4.9	17.35
Iron oxide (Fe_2O_3)	2.5	1.92
Magnesium oxide (MgO)	4.1	4.69
Sodium oxide (Na_2O)	0.2	0.25
Potassium oxide (K_2O)	0.6	1.81
Sulfur trioxide (SO_3)	2.4	1.38

5. RESULTS AND DISCUSSION

5.1Compressive strength:-

Fig 5.1.1 Compressive test on Cube **Fig 5.1.2 Compression failure of Cube**

Table 5.1.1 Compressive strength at 7 and 28 days

Sl no	% of POFA	% of Fibers		Strength at 7 days (N/mm^2)	Strength at 28 days (N/mm^2)
		Sisal fibers	Glass fibers		
1	0%	0%	0%	20	28.5
2		0.5%	0.1%	21.5	31.5
3		1%	0.2%	23	33
4		1.5%	0.3%	24	35
5	10%	0%	0%	16.5	27.5
6		0.5%	0.1%	18	30
7		1%	0.2%	19	31.5
8		1.5%	0.3%	20	33
9	20%	0%	0%	15.5	25
10		0.5%	0.1%	17	26.
11		1%	0.2%	18.5	27.5
12		1.5%	0.3%	19.5	28
13	30%	0%	0%	12	22.5
14		0.5%	0.1%	13	23.5
15		1%	0.2%	14	24
16		1.5%	0.3%	14.5	24

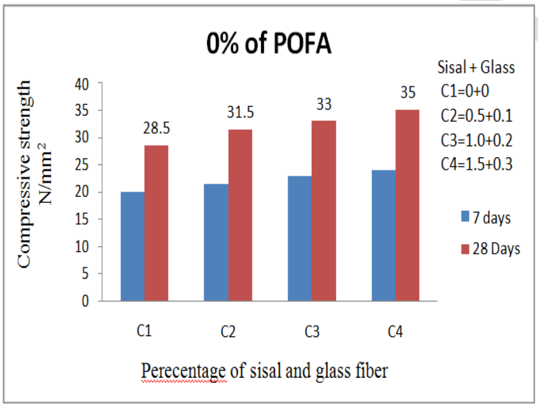

Fig 5.1.3 Compressive strength at 7 and 28 days for 0% POFA

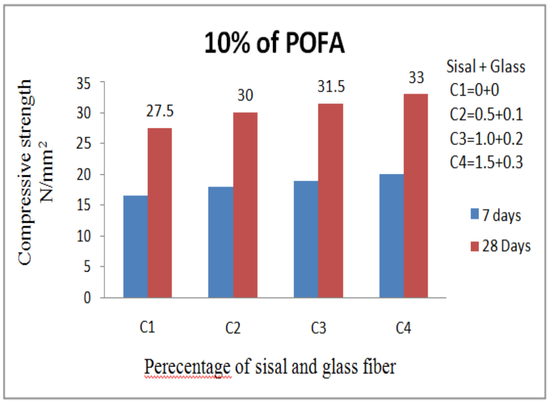

Fig 5.1.4 Compressive strength at 7 and 28 days for 10% POFA

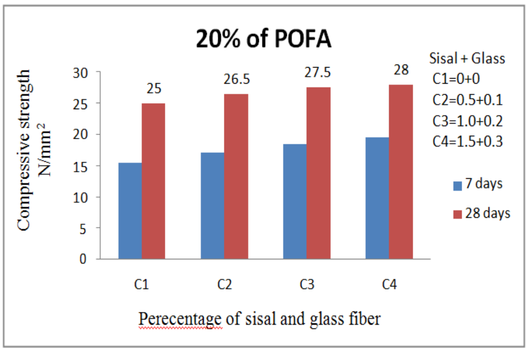

Fig 5.1.5 Compressive strength at 7 and 28 days for 20% POFA

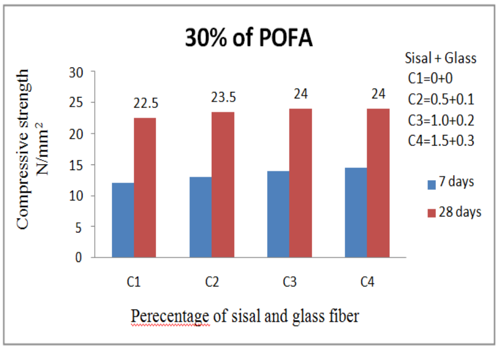

Fig 5.1.6 Compressive strength at 7 and 28 days for 30% POFA

- From table 5.1.1 and fig 5.1.3 it is observed that with 0% palm oil fuel ash Strength increase for 7 days is 7.5%, 15%, 20% and for 28 days is 10.52%, 15.78%, 22.8% with increase of fiber percentage respectively It is observed that with 0% palm oil fuel ash i.e. control mix the compressive strength increases with increase in percentage of fiber
- From table 5.1and fig 5.1.4 it can be observed that for 10% palm oil fuel ash the strength increases with increase of fiber dosage. For 7 days strength increase is 9.09%, 15.15%, 21.21 and for 28 days is 9.09%, 14.54 %, 20%. The optimum level of 10% replacement of POFA is comparable to control mix and suggested.
- From table 5.1 and fig 5.1.5 it can be observed for 20% palm oil fuel ash strength increase for 7 days is 9.67%, 19.45%, 25.8% and for 28 days is 6%, 10%, 12% respectively. From the graph it can be seen that strength increases with increase in fiber percentage.
- From table 5.1 and fig 5.1.5 for 30% palm oil fuel ash strength increase for 7 days is 8.33%, 16.33%, 20.08% and for 28 days is 4.44%, 6.66%, 6.66%.From above results it is clear that compressive strength increases as the percentage of fiber added increases but decreases with increase in percentage of palm oil fuel ash.

5.2 Flexural strength:-

Fig 5.2.1 Flexural test on Beam

Fig 5.2.2Flexural failure of Beam

Table 5.2.1 Flexural strength results for 28 days

Sl no	% of POFA	% of Fibers		Strength at 28 days (N/mm^2)
		Sisal fibers	Glass fibers	
1	0%	0%	0%	6.75
2		0.5%	0.1%	7.5
3		1%	0.2%	8.25
4		1.5%	0.3%	9
5	10%	0%	0%	6.375
6		0.5%	0.1%	7.125
7		1%	0.2%	7.5
8		1.5%	0.3%	8.625
9		0%	0%	4.5
10		0.5%	0.1%	4.875

11	20%	1%	0.2%	5.25
12		1.5%	0.3%	5.625
13	30%	0%	0%	4.125
14		0.5%	0.1%	4.5
15		1%	0.2%	4.875
16		1.5%	0.3%	5.25

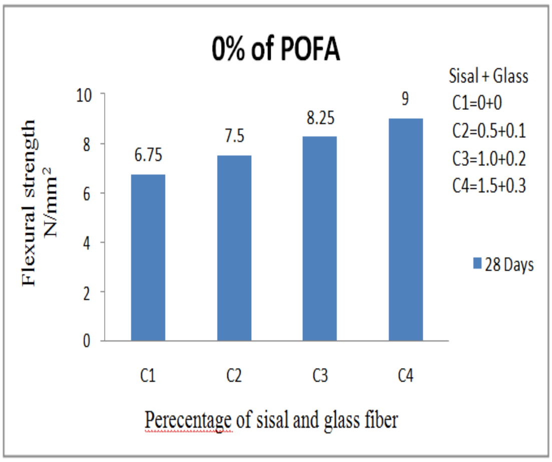

Fig 5.2.3 Flexural strength at 28 days for 0% of POFA

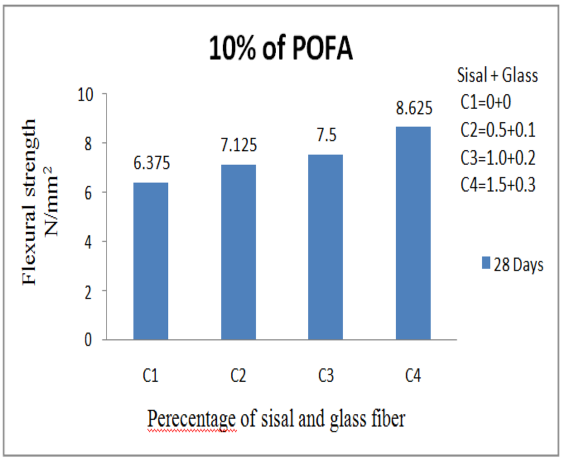

Fig 5.2.4 Flexural strength at 28 days for 10% of POFA

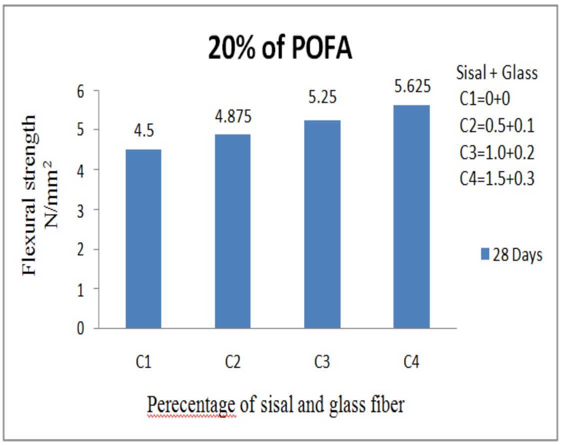

Fig 5.2.5 Flexural strength at 28 days for 20% of POFA

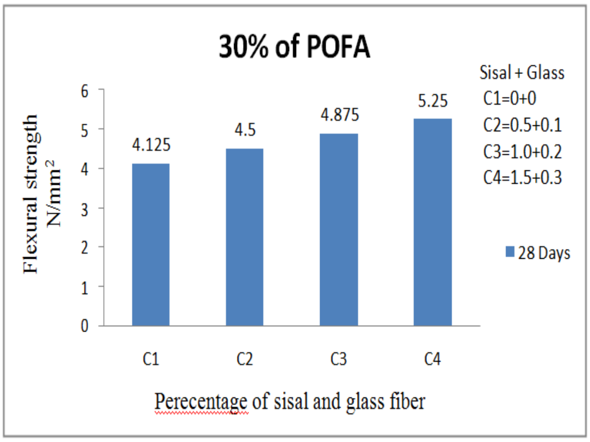

Fig 5.2.6 Flexural strength at 28 days for 30% of POFA

- From table 5.2.1 and fig 5.2.3 it is observed that with 0% palm oil fuel ash flexure Strength increase for 28 days is 11.1%, 22.3%, 33.3% with increase of fiber percentage with increase of fiber percentage respectively
- From the table 5.2.1and 5.2.4 for 10% palm oil fuel ash the strength increases with increase of fiber dosage for 28 days is 11.76%, 17.64%, 35.29%.
- From the table 5.2.1 and fig 5.2.5 For 20% palm oil fuel ash strength increase for 28 days is 8.33%, 16.66%, 25%.%. From above results it is clear that flexure strength increases as the percentage of fiber increases
- From table for 5.2.1 and fig 5.2.6 for 30% palm oil fuel ash strength increase for 28 days is 9.09%, 18.18%, 27.27%. From above results it is clear that flexure strength increases as the percentage of fiber increases but decreases with increase in percentage of palm oil fuel ash.

5.3 Split Tensile strength:-

Fig 5.3.1 Split tensile test on Cylinder

Fig 5.3.2Split tensile failure of Cylinder

Table 5.3.1 Split Tensile strength results for 7 days and 28 days

Sl no	% of POFA	% of Fibers		Strength at 7 days (N/mm^2)	Strength at 28 days (N/mm^2)
		Sisal fibers	Glass fibers		
1	0%	0%	0%	2.23	2.547
2		0.5%	0.1%	2.568	2.886
3		1%	0.2%	2.72	3.2
4		1.5%	0.3%	3.02	3.5
5	10%	0%	0%	1.9	2.22
6		0.5%	0.1%	1.98	2.35
7		1%	0.2%	2.38	2.86
8		1.5%	0.3%	2.7	3.18
9	20%	0%	0%	1.453	1.93
10		0.5%	0.1%	1.902	2.22
11		1%	0.2%	2.08	2.54
12		1.5%	0.3%	2.22	2.56
13	30%	0%	0%	1.6	1.92
14		0.5%	0.1%	1.743	2.22
15		1%	0.2%	1.902	2.22
16		1.5%	0.3%	2.38	2.86

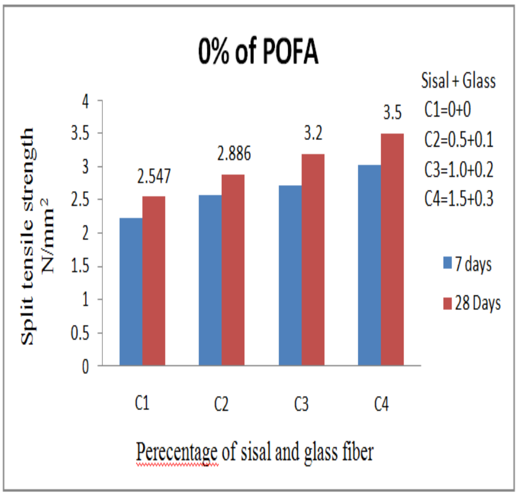

Fig 5.3.3 Split tensile strength at 7 and 28 days for 0% of POFA

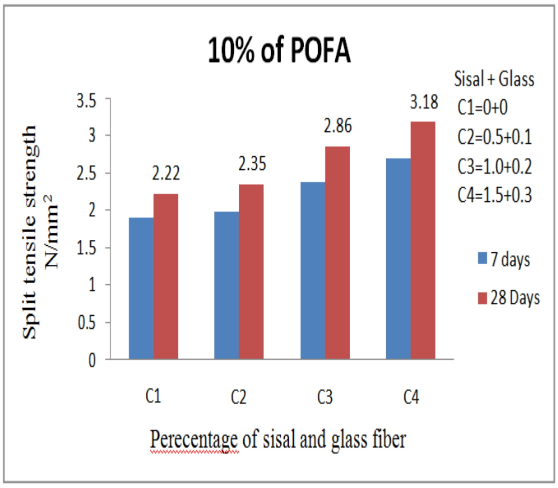

Fig 5.3.4 Split tensile strength at 7 and 28 days for 10% of POFA

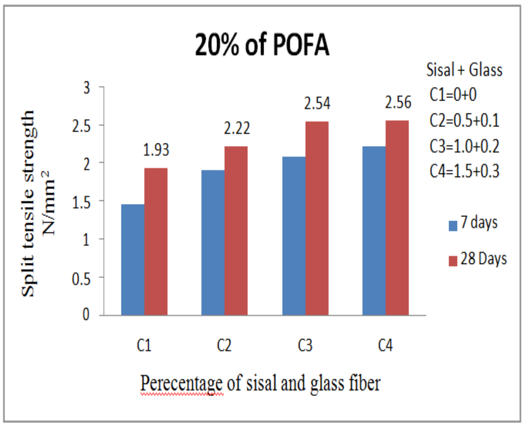

Fig 5.3.5 Split tensile strength at 7 and 28 days for 20% of POFA

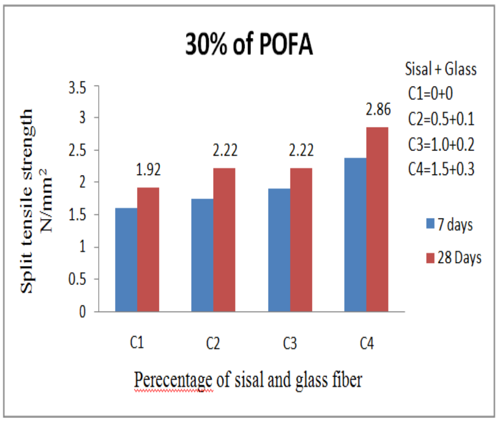

Fig 5.3.6 Split tensile strength at 7 and 28 days for 30% of POFA

- From table 5.3.1 and fig 5.3.3 it is observed that with 0% palm oil fuel ash split tensile Strength increase for 7 days is 15.15%, 21.97%, 35.42% and for 28 days is 13.3%, 24.67%, 37.41% with increase of fiber percentage respectively From the observation with 0% palm oil fuel ash i.e. control mix the split tensile strength increases with increase in percentage of fiber.
- From the table 5.3.1 and fig 5.3.4 it can be observed that for 10% palm oil fuel ash the strength increases with increase of fiber dosage. For 7 days strength increase is 4.57%, 25.26%, 32.1 and for 28 days is 5.85%, 28.8%, 33.24%.
- From the table 5.3.1 and fig 5.3.5 for 20% palm oil fuel ash it can be seen that strength increase for 7 days is 30.9%, 43.15%, 52.78% and for 28 days is 15.02%,31.6%, 32.6%.
- From table 5.3.1 and fig 5.3.6 for 30% palm oil fuel ash strength increase for 7 days is 8.93%, 18.8%, 48.75% and for 28 days is 14.5%, 14.5%,46.95%.Split strength increases as the percentage of fiber added increases but decreases with increase in percentage of palm oil fuel ash.

6. CONCLUSION

Based on the experimental study carried out in this project the following conclusions have been drawn.

1. The optimum level of 10% replacement of POFA with cement is comparable to control mix and is suggested.
2. The compressive strength of concrete increases with increase in the percentage of fibers
3. Like the compressive strength flexural strength of concrete increases with increase in the percentage of fibers
4. Tensile strength also increases with increase in fiber dosage and lower compared to compressive strength.
5. Palm oil fuel ash is a product of industrial waste & which has no further use in any production process, which remains as waste & should be disposed off. But these products have cementations properties which can replace cement to some extent.

7. REFERENCES

1. **Abdul Munira,*, Abdullahb, Huzaimb, Sofyana, Irfandia, Safwana,** Utilization of palm oil fuel ash (POFA) in producing lightweight foamed concrete for non-structural building material ,science direct Procedia Engineering 125 (2015) 739 – 746
2. **Belal Alsubari [a], Payam Shafigh [b, *], Mohd Zamin Jumaat** [a], Utilization of high-volume treated palm oil fuel ash to produce sustainable self-compacting concrete, Science direct, Journal of cleaner production 137(2016)
3. **A.S.M. ABDUL AWALa and M. WARID HUSSIN**, Effect of Palm Oil Fuel Ash in Controlling Heat of Hydration of Concrete, science direct Procedia Engineering 14 (2011) 2650–2657
4. **Mohammad Momeen Ul Islam, Kim Hung Mo, U. Johnson Alengaram*, Mohd Zamin Jumaat**, Durability properties of sustainable concrete containing high volume palm oil waste materials, Journal of cleaner production 2016
5. **Sooraj V.M**. Effect of Palm Oil Fuel Ash (POFA) on Strength Properties of Concrete, International Journal of Scientific and Research Publications, Volume 3, Issue 6, June 2013 1 ISSN 2250-3153
6. **A. Krishna priya, V. Kanaka Durga**, A Study on Strength of Fiber Reinforced Concrete with Palm Oil Fuel Ash as Partial Replacement of Cement IJESC Volume 7 Issue No.7
7. **Gollapalle Priyankarani, Dr .P. Srichandana**, Experimental Study on Effects of Sisal Reinforced Concrete, International Journal & Magazine of Engineering, Technology, Management and Research ,ISSN No: 2348-4845
8. **CONCRETE TECHNOLOGY**, Theory and practice by **M S Shetty**