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Experimental investigation of concrete using Silica Fume and Expanded Polystyrene

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***Abstract* — Concrete is the most important ingredient in the construction field. The increases quest for sustainable and eco-friendly materials in the construction industry has led to research on partial replacement of the conventional constituents of concrete by two selected waste materials. The attempt is made on replacing Silica Fume (SF) and Expanded Polystyrene (EPS) as replacement for cement and coarse aggregate in the M25 grade concrete. In this project, ordinary portland cement (OPC) is replaced by 10, 20, 30 percentage replacement of Silica Fume and 5 percentage of coarse aggregate is replaced by Expanded Polystyrene in M_{25} grade concrete**.

I. INTRODUCTION

Cement is responsible for about 3% of the greenhouse gas emission and for 5% of the CO_2 emission. As about 50% of the CO_2 released during cement production is related to the decomposition of limestone during burning, mixing of clinker with supplementary materials called blending is considered as a very effective way to reduce CO_2 emission. Thus it is very important to find a replacement material for cement. It is even good to use industrial by-product in the concrete. This not only reduces the production of CO_2 but also a very good idea to use those waste by-products. The demand for building material is increasing and increase in cost of building material is also a matter of concern. Thus this project utilizes the industrial by-product Silica fume and packaging waste expanded polystyrene in making concrete and the strength obtained is analyzed and compared with the conventional concrete.

II. OBJECTIVE

a. To investigate the strength of hardened concrete when the cement and coarse aggregate is partially replaced by Silica Fume and Expanded polystyrene aggregate in M25 grade concrete.
b. To investigate the properties of fresh concrete when the cement and coarse aggregate is partially replaced by Silica Fume and Expanded polystyrene aggregate in M25 grade concrete.

III. MATERIALS

a. Cement

In this work ordinary Portland cement (OPC) of grade 53 was used for casting cubes and cylinders. The cement was of uniform colour without any lumps. The following test have been conducted for cement and their results are given below.

Table 1 - Properties of cement

Fineness	6%
Consistency	32.5%
Initial setting time	34 minutes
Final setting time	12 hours
Specific gravity	3.154

b. Fine aggregate

The sand used for this project was locally procured and conforming to the zone II. The following test have been conducted on fine aggregate and the results are given below.

Table 2 - Fineness modulus of fine aggregate

Sieve No.	**Sieve size**	**Mass retained**	**% Retained**	**Cumulative % retained**	**% Passing**
4	4.75	8	0.53	0.53	99.47
8	2.36	12	0.80	1.33	98.67
16	1.18	90	6	7.33	92.67
30	0.600	360	24	31.33	68.67
50	0.300	430	28.66	59.99	60.01
100	0.150	405	27	86.99	13.01
Pan		190	12.66	99.65	0.15

Fineness Modulus

$$= \frac{[0.53+1.33+7.33+31.33+59.99+86.99++99.65]}{100}$$

= 2.87

Table 3 - Properties of fine aggregate

Specific gravity	2.78
Percentage voids	46%

c. Coarse aggregate

Locally available coarse aggregate of size 20mm has been used. The tests conducted on coarse aggregate are given below,

Table 4 - Properties of coarse aggregate

Specific gravity	2.78
Impact value	37.60%
Crushing value	32.24%

Table 4 - Fineness modulus of Coarse aggregate

Sieve no	Weight retained	% Weight retained	Cumulative % weight retained	% Weight passing
20	0	0	-	100
16	0	0	-	100
13.2	0	0	-	100
12.5	715	71.5	71.5	28.5
10	225	22.5	94	6
6.	43	4.3	98.3	1.7
4.75	6	0.6	98.9	1.1
pan	1	0.1	100	0

Fineness modulus = 665.36/100

= 6.65

d. Silica fume

Silica Fume is a by-product derived during the production ff elemental silicon or an alloy containing silicon and it is very fine non-crystalline silica produced in electric arc furnaces. The tests done on Silica fume are given below

Fig.1 – Silica fume

Table 5 - Properties of Silica fume

Fineness	3%
Consistency	32%
Initial setting time	36 minutes
Final setting time	10 hours
Specific gravity	2.5

e. Expanded polystyrene

The waste polystyrene are collected and scraped into small sizes, the following tests are conducted on polystyrene,

Fineness modulus = 492.7/100

= 4.92

Table 6 - Properties of Expanded polystyrene

Specific gravity	1.1
Impact value	36%
Crushing value	20.32%

IV. EXPERIMENTAL WORK

a) *Compressive Strength*

Concrete cubes (150x150x150mm) of M25 grade concrete have been casted, the conventional cubes and the cubes with replacement of cement by 10%, 20%, 30% Silica fume and 5% of coarse aggregate by expanded polystyrene have been tested. The results have been given below,

Fig.2 – Compression test

Table 7 – Compressive strength

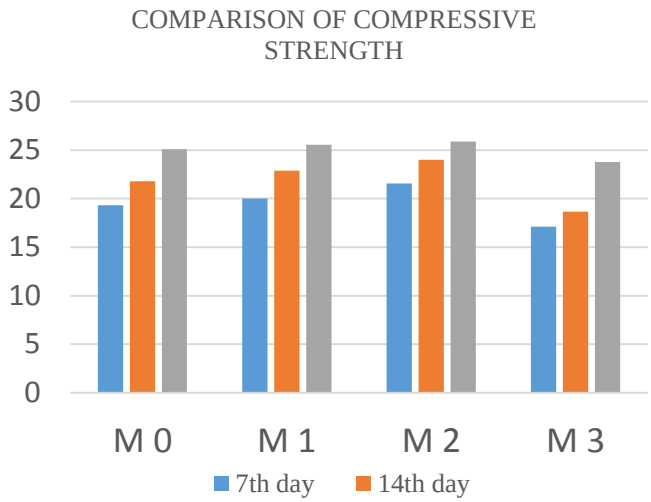
Mix	Compressive strength		
	7th day	*14th day*	***28th day***
M 0	19.33	21.78	25.78
M 1	20	22.89	26.13
M 2	21.56	24	26.40
M 3	17.11	18.67	23.11

M 0 – Control mix

M 1 – 10% Silica Fume and 5% Expanded polystyrene

M 2 – 20% Silica Fume and 5% Expanded polystyrene

M 3 – 30% Silica Fume and 5% Expanded polystyrene

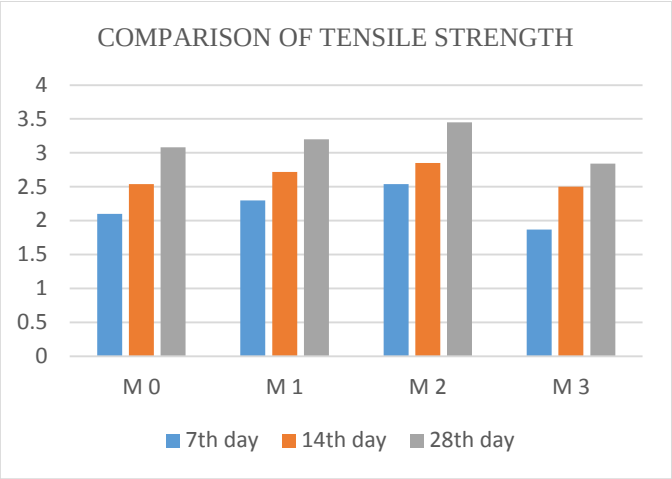


a) *Split tensile strength*

Concrete cylinders (dia-150mm, height-300mm) of M25 grade concrete have been casted, the conventional cylinders and the cylinders with replacement of cement by 10%, 20%, 30% and 5% of coarse aggregate by expanded polystyrene

Table 8 – Split tensile strength

Mix	Split tensile strength		
	7th day	***14th day***	***28th day***
M 0	2.10	2.54	3.08
M 1	2.30	2.72	3.20
M 2	2.54	2.85	3.45
M 3	1.87	2.50	



V. CONCLUSION

In this paper the effect of Silica fume and expanded polystyrene in the compressive strength and split tensile strength was determined and the following observations are made during this experiment

1. The compressive strength increases upto 20% replacement of cement by Silica fume and 5% replacement of coarse aggregate by expanded polystyrene.
2. The split tensile strength also increases upto 20% replacement of cement by Silica fume and 5% replacement of coarse aggregate by expanded polystyrene.
3. The compressive strength and tensile strength increases due to good packing nature of Silica fume
4. 5% replacement of coarse aggregate by expanded polystyrene does not cause any decrease in strength since the replacement level is low.
5. The optimum percentage of replacement is 20% cement by Silica fume and 5% coarse aggregate by expanded polystyrene in M25 grade concrete

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