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THE IMPACT OF HYBRID FIBRES ON FRESH AND HARDENED STATE PROPERTIES OF FOAM CONCRETE

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Abstract - *In this experimental exploration, the impact of hybrid fibres mainly copper fibres and aluminum fibres (dosage 0.5%,1%,1.5% by weight of cement) on fresh and hardened state properties of foam concrete of density 900 kg/m³, 1000 kg/m³, 1300 kg/m³ is studied. The synthetic foam used is generated with the help of mechanical air compressor with cylinder, from the experimental work and analysis done, it is clear that the impact of hybrid fibres on the flexure strength is significant and the increase of fibre dosage lead to an incremental increase in flexure strength, however in case of compressive strength density played vital role than the fibres. The spread test value mainly depended on the volume of foam and water content, with the increase in volume of foam and water content the flow ability property of foam concrete increased. Also the correlation between compressive strength and flexure strength in accordance with Indian standard is not same and a relationship is developed between flexure strength and compressive strength of foam concrete by regression anaylsis.The porosity value increased with decrease in density and increase in porosity destined increase in water absorption and with the help of regression analysis, a relationship is developed between water absorption and porosity.*

Key Words: Foam concrete, Hybrid fibres, Compressive strength, Silica fume, Fly ash, Flexure strength, Water absorption, Porosity.

1. INTRODUCTION

Foam concrete is nothing but ultra-light weight concrete whose densities may vary from mere 300 to 1700 kg/m³.this concrete is self-compacting and has a great workability [1]. Foam concrete produced can be used in non-structural elements, bridge abutments, void filling, decorative purpose and precast construction. In the present study, foam used is generated by mechanical air compressor with cylinder.

From the researches it is clear that there has been a less amount of work done in fibre reinforced foam concrete especially the impact of hybrid fibres on foam concrete. Hence the present experimental exploration focuses on the impact of hybrid fibres on the fresh and hardened state of foam concrete.

2. Materials and Methodology

The ingredients used in the foam concrete were primarily synthetic foam, silica fume, fly ash, cement, hybrid fibres, and water.

2.2 Generation of foam by mechanical air compressor with cylinder

This is the steadiest way of foam generation, the foam formed by this process is stable for quite amount of time and also the pores in foam are not visible to naked eye. The foam formed by this process looks like a shaving foam or crème from the bakery. The foam can be formed in few minutes without any hassle. The foam generated has a higher viscosity and displacement, the foam agent is mixed with potable drinking water in the ratio 1:3.

2.3 Hybrid fibres

Hybrid fibres used are mainly copper and aluminum fibres, the properties of hybrid fibres are shown in Table-1

Table -1: Physical properties of hybrid fibres

Gauge size	36
Diameter in (mm)	0.193
Length in (mm)	20
Aspect ratio	104

2.3 Mix proportion

In the present study the density of foam concrete used were 900 kg/m³, 1000 kg/m³, 1300 kg/m³, the effect hybrid fibres on the fresh and hardened state of foam concrete is studied on this densities, the fibre dosages used were 0.5%,1%,1.5% by weight of cement. The mix proportion is developed after enormous trail mixes undertaken on these densities and by interpreting the previous results. The Table-2 shows the mix proportion of foam concrete for the above densities

Table -2: Mix proportions for various densities

Particulars	Units	Quantity		
Volume of concrete	m^3	1	1	1
Target density	Kg/m^3	900	1000	1300
W/c ratio	-	0.4	0.38	0.35
Cement content	Kg/m^3	220	240	330
Silica fume	Kg/m^3	110	120	165
Fly ash	Kg/m^3	110	180	165
Foam (by volume)	%	70	60	50
Water	Liters	162	180	225
Foam	Kg	38	40	32

Table -3: Fibre percentages by weight of cement in kg/m^3

Density (kg/m^3)	900	1000	1300
0.5 %	1.1	1.2	1.65
1%	2.2	2.4	3.3
1.5%	3.3	3.6	4.95

2.3 Mixing process

With the help of this mix design the materials were weighted separately, then the foam chemical and water was mixed and placed into the mechanical air compressor with cylinder and it is kept under observation, here firstly water is added in tilting mixer machine and then dry mix is prepared of the various materials like silica fume, fly ash, cement and hybrid fibres and then part by part they were added into the tilting mixer. And at the later stage the foam was taken out from the cylinder and poured into the tilting mixer and then for about 2-3 minutes the materials and foam were mixed and then taken out and poured into the standard beam and cube specimen.

The compressive strength and flexure strength were conducted in accordance with *IS 516 1959* [4]. Water absorption and porosity are conducted on cube specimen after 28 days of precise curing , firstly all the specimen were taken out and with dry cloth they were wiped and then the surface saturated weight of each specimen is taken and then the specimen is submerged in to water and the submerged weight of the specimen is taken and after that, the specimen are kept in oven dry for a period of 12 hours , after that the specimen are removed and oven dry weight is taken and then with the help of formula we can determine the physical properties of foam concrete. The equations below are used to determine the porosity, water absorption and density of foam concrete.

$$\text{Porosity [P]} = \frac{Wsat - Wdry}{Wsat - Wsub} * 100 \quad \text{.....2.1}$$

$$\text{Water absorption [W]} = \frac{Wsat - Wdry}{Wdry} * 100 \quad \text{.....2.2}$$

Wsat = Surface saturated weight of the specimen in kgs
Wdry= Oven dry weight of the specimen in kgs
Wsub = Submerged weight of the specimen in kgs

3. Results and discussion

3.1 Spread test

The Table -4 show the various spread test value for foam concrete of density 1300 kg/m^3, 1000 kg/m^3, 900 kg/m^3, it can be easily noticeable that the effect of hybrid fibres can alter the spread value and also it should be noted that there will be significant increase in the spread value with the decrease in density this is mainly because of the volume of foam and the water content. This indicates that the flow ability of foam concrete increases with decrease in density. The spread test was conducted in accordance with ASTM C 1611 [5].

Table -4: Spread test values for various densities

Density (kg/m3)	Fibre Dosage (%)	Spread Test Value (cm)
1300	0	59.6
1300	0.5	58.4
1300	1	57.1
1300	1.5	55.8
1000	0	60.9
1000	0.5	59.68
1000	1	58.42
1000	1.5	57.4
900	0	62.2
900	0.5	60.9
900	1	59.6
900	1.5	59.2

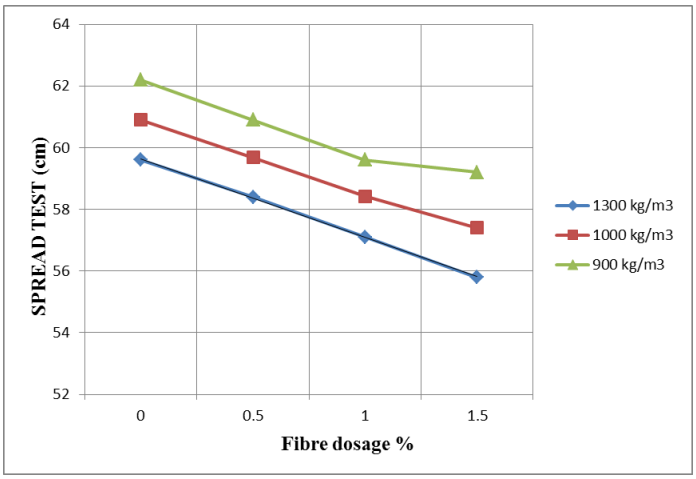

Fig -1 Deviation of Spread test value with fibre content

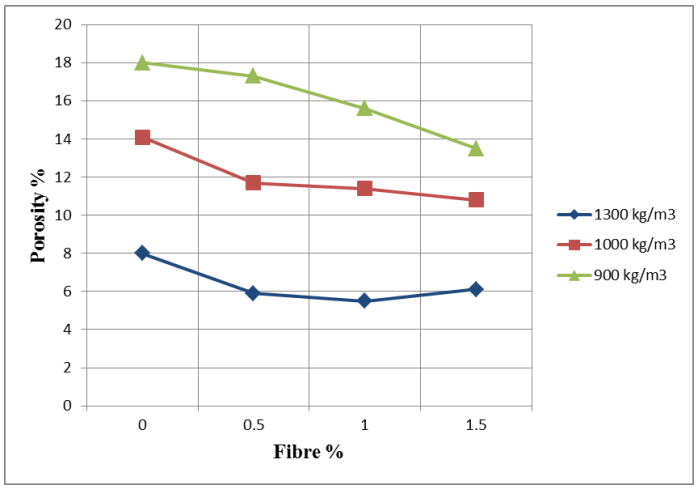

Fig -3 Deviation in porosity with fibre %

3.1 Porosity and water absorption

Deviation in porosity with fibres is as shown in the Fig -3, from the figure it is clear that deviation is not steep with respect fibres and Fig -2 shows the deviation in porosity with density it is clear from this that the deviation is steep and withal the porosity increases with decrease in density of foam concrete. A relationship is developed between porosity and water absorption by regression analysis, it is clear from this analysis that the increase in porosity will increase the water absorption; hence they are directly proportional to each other, the fig -4 shows the deviation in water absorption with density. It is clear from the graphs that the hybrid fibres do not play any part in the physical properties of foam concrete.

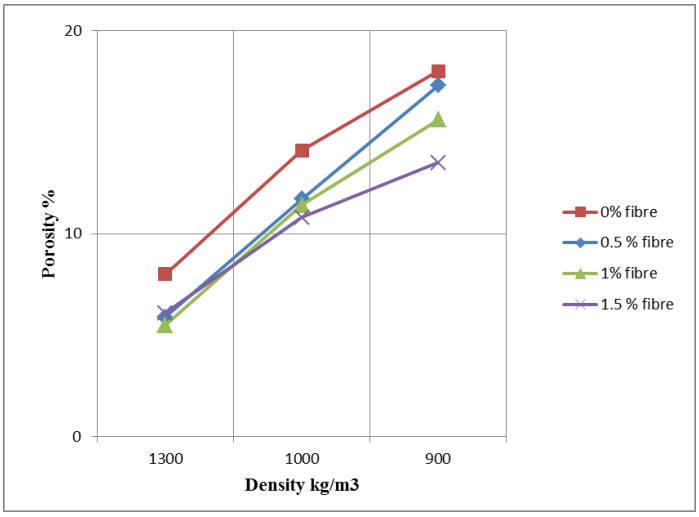

Fig -2 Deviation in porosity with density

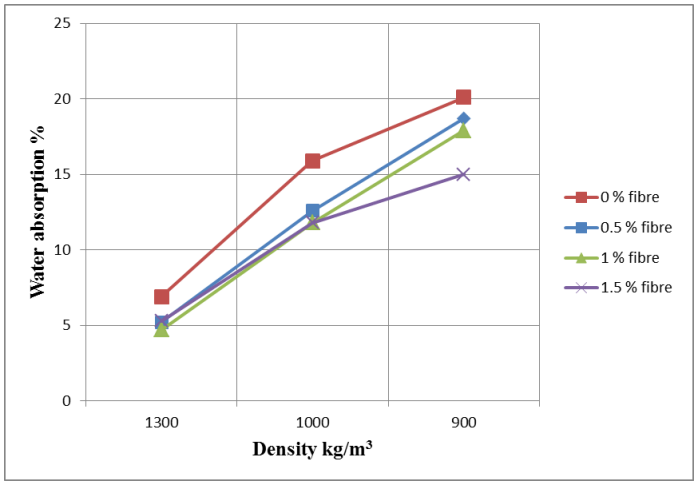

Fig -4 Deviation in water absorption with density

3.2 Correlation between water absorption and porosity

A correlation is established between the values of average porosity and average water absorption using regression analysis. From the regression analysis it is clear that a relationship exists between the two parameters.The Fig -5 correlation between avg water absorption with avg porosity

Avg WA (28 days) =
-0.23 (Avg P % 28 days)2+1.32(Avg P % 28 days)-2.7362

……..3.1

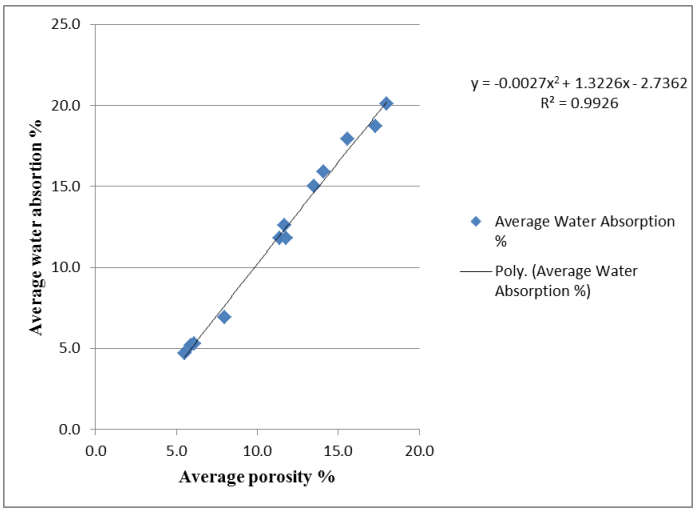

Fig -5 Correlation between avg water absorption with avg porosity

3.3 Flexure strength and compressive strength

The hybrid fibres play a very improtant role in the flexure strength of foam concrete, the Fig -6 show devaition in flexure strength with fibre %, it is clear from the graph, that there is incremental increase in the flexure strength with increase of fibre dosage, however in case of compressive strength the density play vital role in strength than the fibres, the Fig -7 show the devaition of compressive strength with density of foam concrete

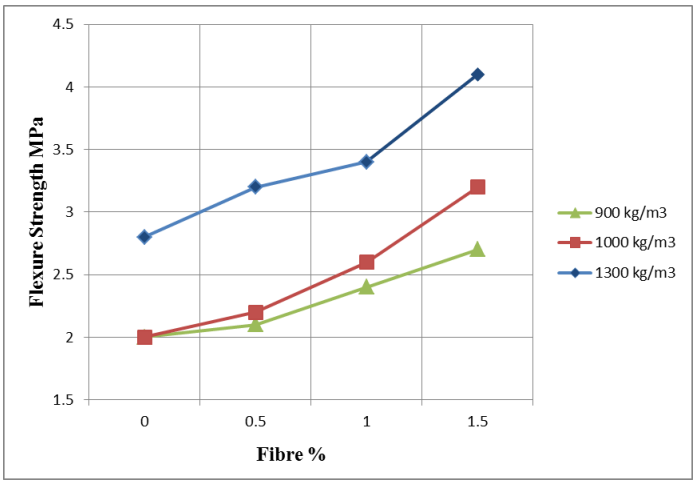

Fig -6 Deviation in flexure strength with fibre %

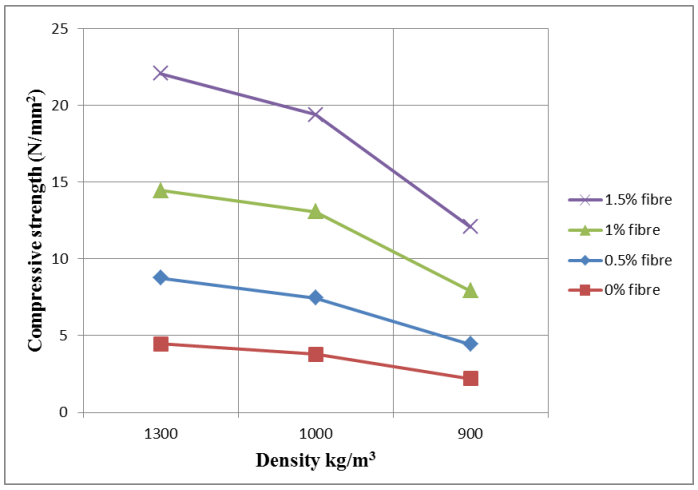

Fig -7 Deviation in Compressive strength with density

3.4 Correlation between compressive strength and flexure strength

Correlation between compressive strength and flexure strength is be developed with the help of the regression analysis and the equation given in *IS 416 2000*. Table -5 shows the values of experimental compressive strength, experimental flexure strength and analytical flexure strength, the analytical flexure strength can be developed by equation 3.2.It is clear that the experimental flexure strength is 50 % more than the analytical flexure strength and withal the equation 3.3 shows the relationship between compressive strength and flexure strength after 28 days of curing.

$$\text{Analytical flexure strength} = 0.7 \sqrt{fck\ (28\ \text{days})} \quad \text{.....3.2}$$

Regression equation

$$Fs\ (28\ \text{days}) = 1.3088\ Fck\ (28\ \text{days})^{0.5188}] \quad \text{.....3.3}$$

Fs= flexure strength after 28 days.
Fck= compressive strength after 28 days.

Table -5: Results of analytical flexure strength and experimental flexure strength

28 days Compressive Strength(Mpa)	28 days Flexure strength (Mpa)	Analytical Flexure strength (Mpa)	Error in Percentage (%)
4.6	2.8	1.5	46.8
4.0	3.2	1.4	56.3
5.5	3.4	1.6	51.7
7.6	4.1	1.9	52.7
3.7	2.0	1.3	32.7
3.3	2.2	1.3	42.2
4.9	2.6	1.5	40.4
6.2	3.2	1.7	45.5
2.0	2.0	1.0	50.5
2.2	2.1	1.0	50.1
3.4	2.4	1.3	46.2
3.8	2.7	1.4	49.5

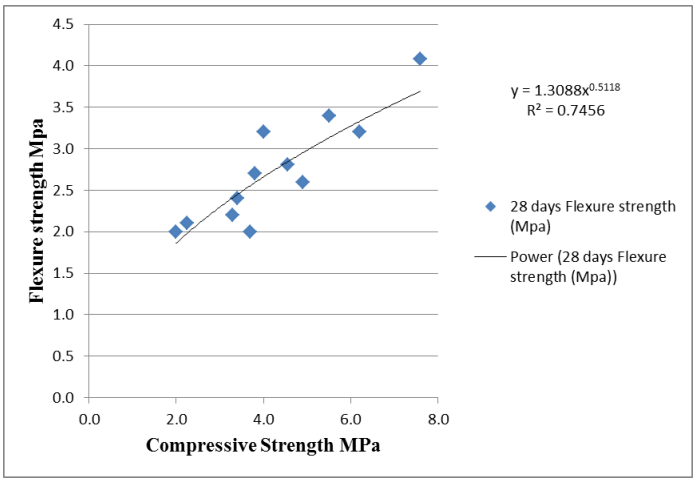

Fig -8 Correlation between compressive strength and flexure strength

4. CONCLUSIONS

In this experimental investigation hybrid fibres were used to study the impact on fresh and hard state properties of foam concrete, based on the enormous amount of experimental work and analysing results, the following conclusions were made.

- There is a significant effect of water content and volume of foam on the flow ability property of foam concrete and withal the fibre content alter the spread value to some extent.
- A relationship is developed between the water absorption and porosity by regression analysis. Porosity increases with decrease in the density from 1300 to 900 kg/m^3.
- The compressive strength increases with the increase in density of concrete, fibre content have no significant impact on the compressive strength.
- The hybrid fibres have a larger impact on the flexure strength of foam concrete.
- The relationship is proposed between the flexure strength and compressive strength after 28 days of curing using regression analysis.
- The relation between experimental flexure strength and analytical flexure strength according to Indian standards is not same.

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