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Investigation of Lightweight Cellular Concrete using recycled Glass and Plastic waste

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Abstract: *Cellular Lightweight Concrete is one of the most significant type of concrete used for construction. Cellular Lightweight Concrete is also known as foamed concrete. This have many advantages and usages than traditionally produced concrete. The rapid urbanization has leads to increase in wastes & it is difficult task to dispose it. This paper identifying the possibility of using recycled materials of crushed glass and plastic wastes. In foam concrete, this recycled material use as a substitute filler.*

A protein based foaming agent was used for this study. The workability and strength of different mixes using powdered glass and plastic wastes were investigated. In this research foam concrete blocks were prepared according to the designed proportions to attain the maximum density of 1900 kg/m3. In this work, the mixing of recycled glass wastes 5%, 10%, 15% and recycled plastic wastes 1%, 3% & 5% were added as a filler in foam concrete. The 7, 14 and 28 days compressive strength, flexural strength, split tensile strength of each batch of concrete were studied and compared with conventional foam concrete. The study showed that the incorporation of recycled glass and plastic waste in conventional foam concrete is effective and it will be useful for load bearing wall applications...

Keywords: Cellular Lightweight Concrete

I. INTRODUCTION

Foam concrete is containing sand, cement, water and stable foam to perform the concrete. Mixing is carried out with proper precautions. The strength of foamed concrete is depends on cement content of the mix, Water & cement ratio, proportion of cement to sand and properties of the sand.

The rapid urbanization and industrialization all over the India has resulted in large deposition of waste polymer materials and waste glass materials. Accumulation of huge quantity of plastic and glass waste from various sources like household and commercial. It is one of major environmental problem in India. These wastes still have not been widely utilized for years. Most of these wastages such as plastic water bottles, plastic bottles & glass bottles are disposed in uncontrolled waste pits. To overcome this environmental issue, waste recycling into building and construction materials would be one of appropriate solutions to the environmental problems, as well as it help in reduction of costing building materials.

II. LITERATURE REVIEW

Classification of foamed concrete based on constituent materials, mix proportioning, production methods, fresh and hardened properties. He gives more attention to the important of foam stability. The drying shrinkage strains of foam concrete were high as would be expected in concrete with large paste phase volume. But this could be reduced by adopting autoclave method of curing by using light weight aggregates and by using Portland cement with fine fly ash which reduces the heat of hydration. The study shows that replacement of large volume of cement up to 75% by weight (using fly ash) will need a longer time to reach their maximum strength which was observed to be higher than that achieved by cement.

Sameer Shaikh et al., (2015) studied the behavior of concrete by replacing waste glass. Partially replacement of the cement as well as sand by waste glass powder and crushed glass particles carried out with equal combination by 5% interval up to 20% replacement. It resulting into replacement of glass powder in cement as well as crushed glass particles in sand by 5%, 10%, 15%, 20% increase the compressive strength. The split tensile strength after 28days by 5%, 10%, 15% increases the flexural strength after 28days.

Nursyami et al., (2017) discuss about utilization of poly ethylene Terephthalate (PET) plastic waste as a coarse aggregate. The results shows that the maximum compressive strength is achieved on sample using the maximum fineness modulus of PET Plastic waste aggregate. Nursyami presented a methodology to convert the PET Waste to coarse aggregate. The results shows that maximum compressive strength is 16.57Mpa.The study determines the gradation of coarse aggregate of PET plastic waste can affect the compressive strength of structural light concrete.

Lina et al., (2019) discussed about the influence the application of cellular concrete like raw materials, production methods and expected properties based on density. The use of raw materials for cellular concrete permit modifications on the physical and mechanical properties for construction applications. In a fresh concrete consistency, spread ability, yield stress, plasticity are the important characteristics for foamed concrete. In the hardened state, pore internal structure, voids size distribution, uniformity are the important characteristics of foamed concrete.

Amritha Raj et al., (2019) discussed about the fresh state and physical properties of concrete like consistency, stability, workability, drying shrinkage, air void system & mechanical properties like compressive strength, flexural strength & Elastic modulus. It resulting into a minimum water/cement ratio 0.30 is preferred for foam concrete.

Juan He et al., (2019) studied the behavior of foam concrete by using Alkali activated cement & three different types of foaming agent with same foam stabilizer of silicone resin polyether emulsion FM-500 (MPs) were used to prepare foam. By comparing the three types of foaming agent, the compressive strength of sodium alpha olefin sulfonate gives high result. So AOS foaming agent is mostly preferred for Alkali Activated slag foamed concrete.

Sheelan Mahmoud Hama et al., (2019 investigated the effect of waste glass powder as a cement in concrete. It resulting into the ultimate load of specimens with 10% and 15% WGP demonstrated increasing capacity compared with that of reference beams. The load –deflection relationship shows that 10% of waste glass powder has a higher crack resistance capacity than that of reference beams. The usage of 15% of waste glass powder economizes 52.5kg of cement per cubic meter of concrete.

III. MATERIALS

BINDER

Locally available 53 Grade (OPC) Ordinary Portland Cement of specific gravity 3.13 used. It is conforming to IS 12269:1987.

FINE AGGREGATE

Fine aggregate retained on 600µm sieve, Zone II as per IS 383-1970.

The river sand passing through the 4.75mm sieve used as fine aggregate. (Free from impurities)

FILLER (RECYCLED GLASS AND PLASTIC WASTE)

Two types of recycled wastes in the powdered form were used. Recycled glass powder and recycled plastic scrap.

Recycled glass powder – crushed waste glass with particle size finer than 90µm and specific gravity 2.36.

Recycled plastic scrap – derived from waste (PET) plastic bottles. Its fineness modulus 2.8 and specific gravity 0.9

Figure 1. Glass powder.

FIGURE 2.PLASTIC SCRAP. FOAMING AGENTS

Foam generator process used for generation of foam by diluting the foaming agent with water. Then aeration process used to create the foam. Foaming agent of specific gravity 1.22 and pH value of 7.5 was used. For foam concrete, ASTM C 796 specifies the foam unit weight to be in the range of 35 to 70kg/m3. For evaluating the relative characteristics of foam produced with the foaming agent, a series of trials were carried out with two concentrations means foaming agent to water ratio like 1:35 & 1:45; and aeration pressure ranging from 150KPa to 350KPa. A stable foam density obtained by using the laboratory foam generator, is 40kg/m3 with a dilution of 1:35 and aeration pressure of 235KPa

III. METHODOLOGY

Specific gravity, Water absorption, Fineness modulus of the cement, Fine aggregate, Coarse aggregate have been tested. The cement tested as per IS. Fine aggregate tested for gradation, fineness modulus and specific gravity as per IS. Coarse aggregate tested for specific gravity and fineness modulus. The design mix for M25 grade of concrete derived by using IS (10262-2009). The mix proportions of materials required for M25 grade of concrete is 1:1.47:2.39 with water cement ratio of 0.45.

Foam concrete was prepared by adding of pre-formed foam with density 40 kg/m^3. The quantity of cement and filler was get by changing the foam volume for design density of foam concrete. Cement and filler were weighed and dry mixed in a mortar mixer, followed by water added for a homogeneous mix. The required quantity of foam added to the wet mixture and mixed till the foam get uniformly distributed throughout the mixture. The mix proportions of materials required for foam concrete is 1:2.5 for Cement & Fine aggregate with water cement ratio 0.35. Density of foamed concrete assumed as 1900kg/m3. The workability of the foam concrete tested by using the slump cone test by filling the mix in slump cone. Vertical settlement measured & recorded. The concrete cube of 150 mmx150mmx150mm for compressive strength test used. 150mm diameter & 300mm height for split tensile strength test used. 100mmx100mmx500mm size for flexural strength test used for cast concrete specimens. The compressive strength, tensile strength, flexural strength of foam concrete with different mix proportions of plastic & glass waste were compared.

The compressive strengths, Split tensile strengths and flexural strengths of the test sample were determined for 7, 14 and 28 days. The test were conducted as per IS 516:1959.

Table 1 shows the properties of materials used:

Sr.no	Physical properties	Cement	Fine aggregate	Coarse aggregate
1.	Specific Gravity	3.02	2.62	2.61
2.	Fineness Modulus	-	2.90	6.67
3.	Water Absorption	-	0.45%	0.17%
4.	Consistency	25%	-	-
5.	Setting Time	30min	-	-

Table 2 shows Proportioning of the Mortar Mixtures used:

Notation	Cement	Water	Foam	Sand
Concrete	20.50	9.25	-	30.00
Foam concrete	25.00	8.38	0.37	65.19
FPG-1	25.00	8.38	0.37	61.20
FPG-2	25.00	8.38	0.37	56.67
FPG-3	25.00	8.38	0.37	52.68

Notation	Glass powder	Coarse aggregate (% by Weight)	Plastic scrap (% by Weight)
Concrete	-	50.20	-
Foam concrete	-	-	- -
FPG-1	3.25	-	0.65
FPG-2	6.5	-	1.75
FPG-3	9.75	-	3.20

3.1 Samples Test

Five different types of concrete samples are shows in table 2. Concrete & foam concrete were casted as per IS. For CFPG-1(foam concrete with plastic &glass waste- sample 1), the sand is replaced by 1% plastic waste and 5% glass waste, For FPG-2, the sand was replaced by 3% plastic waste and 10% glass waste. For FPG -3, the sand was replaced by 5% plastic waste 15% glass waste. Total 45 samples were cast and cured at different days.

IV. RESULTS AND DISCUSSION

To measure workability of concrete, Slump test is the most commonly used?

For Concrete Water cement ratio is 0.45 & slump value 30 mm.

For Foam Concrete Water cement ratio is 0.35 & slump value 125 mm.

Based on the test results, the workability of concrete was optimum and the workability of foam concrete was high.

Compression strength

The compressive strength results of the test samples at 7, 14, 28 days are shows in Table 4. The average compressive strengths of foam concrete mixed with plastic and glass waste were lower compressive strength than the compressive strength of concrete. The average compressive strength of foam concrete mixed with the plastic and glass waste increasing with increasing days.

It was observed that the compressive strength increased for sample FPG-2 than sample FPG-1. But the compressive strength decreased for sample FPG-3 than FPG-2. Figures 3 and 4 shows that Compressive Strength relations between Concrete and Foam Concrete Samples. Compressive strength relations between FPG-1, FPG-2 & FPG-3 Samples respectively

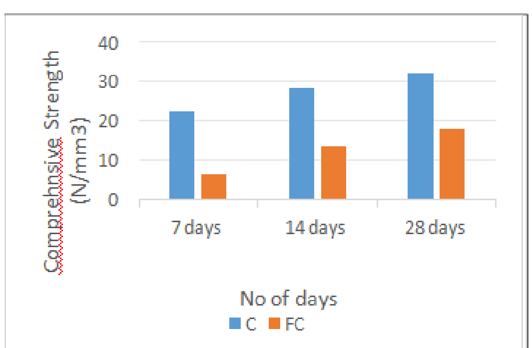

Figure 3. Compressive Strength of C and FC with days.

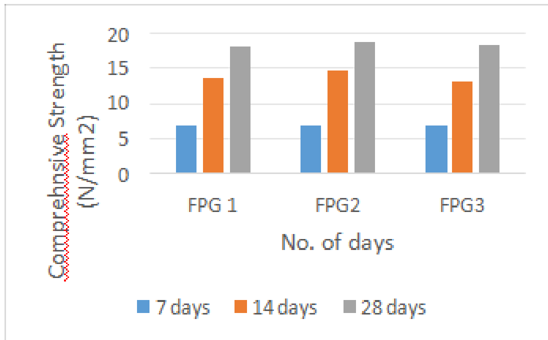

Figure 4. Compressive strength of FPG-1, FPG- 2 & FPG-3 Samples with days

Table 4. Compressive strength of samples

Notation	Average compressive strength		
	7-days	14- days	28 -days
C	22.51	28.21	31.84
FC	6.68	13.5	18.01
FPG-1	6.82	13.64	18.14
FPG-2	6.81	14.72	18.65
FPG-3	6.79	13.17	18.30

Tensile strength

The tensile strength of test samples at 7, 14, 28 days are shows in Table 5. The average tensile strengths of foam concrete and foam concrete mixed with plastic and glass waste were low tensile strength than the tensile strength of concrete. The sample FPG-2 have higher tensile strength value than FPG-1 and FPG-3. Similarly FC and FPG -1, FPG-2, FPG-3 have low tensile strength than conventional concrete. Figures 5 and 6 shows that tensile Strength of C and FC Samples and tensile strength of FPG- 1, FPG-2 & FPG-3 Samples respectively.

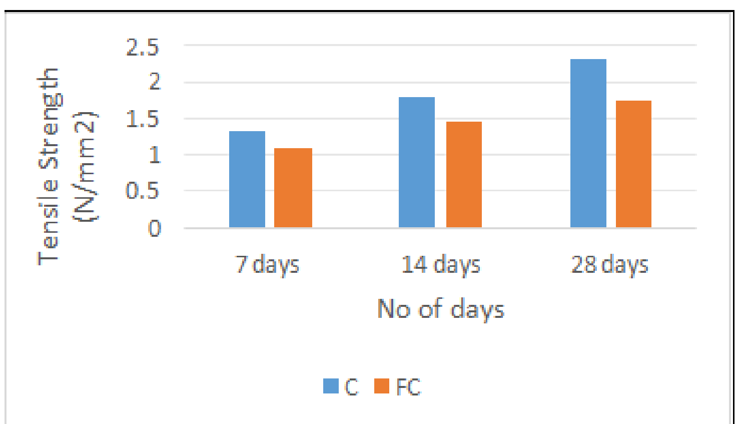

Figure 5. Tensile strength of C and FC with day

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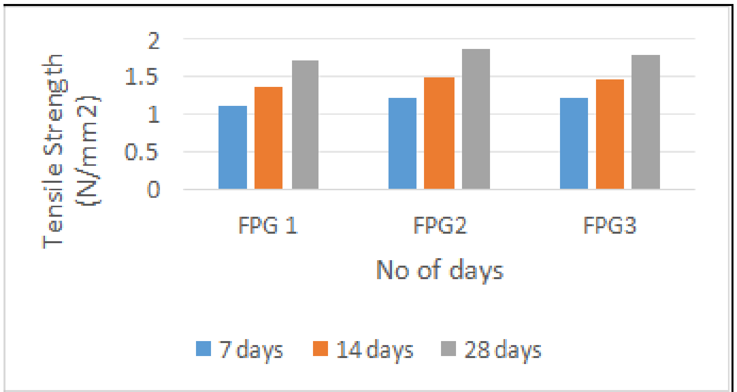

FIGURE 6 TENSILE STRENGTH OF SAMPLES

Table 5. Tensile strength of Samples

Notation	Average tensile strength (MP)		
	7-days	14- days	28 -days
C	1.32	1.79	2.31
FC	1.1	1.45	1.74
FPG-1	1.12	1.37	1.7
FPG-2	1.21	1.5	1.88
FPG-3	1.2	1.46	1.79

Flexural strength

Flexural strength or modulus of rupture or bend strength is defined as a material's ability to resist deformation under load. The flexural strength results of samples at 7, 14, 28 days are shows in Table 6. The flexural strength of concrete was high than foam concrete and foam concrete with Plastics and glass waste. But sample FPG- 2 have high flexural strength than FPG-1 and FPG-3. Figures 7 and 8 shows flexural Strength relation of C and FC Samples and flexural strength of FPG-1, FPG-2 & FPG-3 Samples respectively.

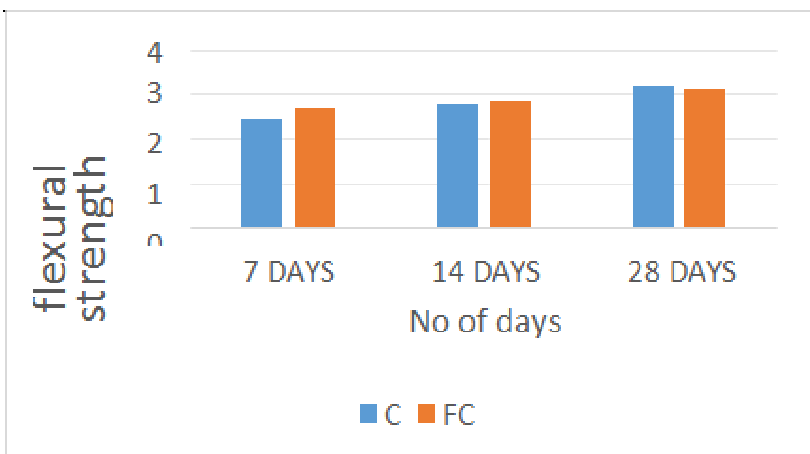

Figure 7. Flexural strength of C and FC Samples With Days.

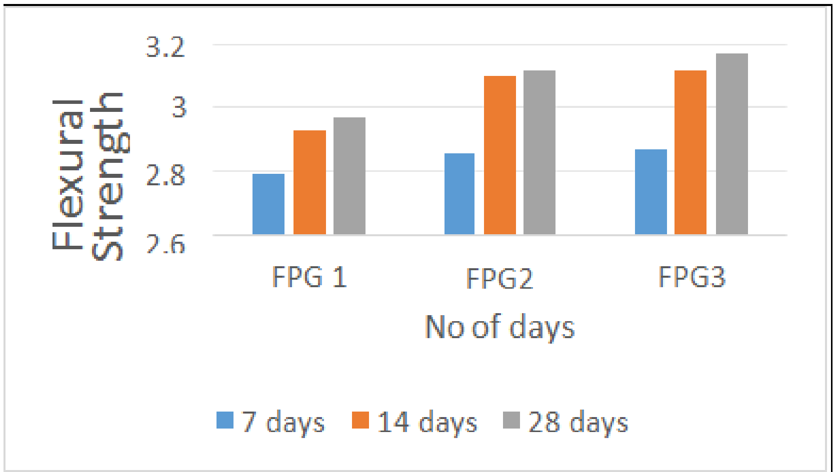

Figure 8. Flexural strength of FPG-1, FPG-2 & FPG-3 samples with days.

Table 6. Flexural strengths of Samples

Notation	Average flexural strength (MPa)		
	7-days	14-days	28-days
C	2.42	2.81	3.2
FC	2.7	2.87	3.1
FPG-1	2.79	2.93	2.97
FPG-2	2.86	3.1	3.12
FPG-3	2.87	3.12	3.17

V. CONCLUSION

This research study on compressive strength, tensile strength, and flexural strength of the foam concrete mixed with the combination of recycled glass and plastic waste. Based on experimental results as well analytical investigations 1) FPG-2 gave the better compressive strength. The compressive strength of concrete mix (FPG-2) is higher than concrete mix 1. (FPG-1) and Concrete mix 3 (FPG-3). The compressive strength of concrete mix (FPG-1) is lower than concrete mix 2 (FPG- 2).

2. The compressive strength and durability of foam concrete increases with the days. But the compressive strength of this concrete mixes (i.e. FPG-1, FPG-2 & FPG-3) is lower than concrete at 28 days.

3. The tensile strength and flexural strength of this concrete mixes increases with days. Replacement of plastic & glass as a filler in foam concrete have lesser tensile strength compared to concrete at 28 days. Other hand the concrete mix (FPG-2) gives higher tensile strength than the foam concrete.

4. The flexural strength of concrete mix (FPG-2) is lower than concrete. The sample FPG-2 have higher flexural strength than FPG-1 and FPG-3.

5. FPG-2 have higher compressive strength, tensile strength and flexural strength than FPG-1 & FPG-3. Other hand FPG-2 have less compressive strength, tensile strength and flexural strength than concrete.

6. Combination of recycled glass and plastic waste can be used as a filler in foam concrete. The use of recycled glass and plastic in foam concrete reduce the consumption of fresh raw materials. It help to sustainable use of raw material.

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