BEHAVIOUR OF LIGHT-WEIGHT PUMICE CONCRETE WITH FLYASH AND WASTE GLASS POWDER

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Abstract – *This paper summarizes the research work on the experimental study on strength properties of light-weight pumice concrete with flyash and waste glass powder. The high self-weight of conventional concrete is not good from the point of view of damages caused by earthquake. So light-weight concrete is preferred in earthquake prone areas. But the light-weight concrete has less strength when compared to the conventional concrete. So while making the concrete of light-weight it is important to ensure that the same can satisfy the strength and serviceability criteria too. In the work conducted, light-weight concrete is made out of pumice aggregates and to makeover the strength properties flyash and glass powder is used and the compressive strength, split tensile strength and flexural strength of normal concrete and pumice concrete is compared.*

Key Words: Light-eight concrete, sustainability, flyash, pumice aggregates, waste glass powder, strength properties

1. INTRODUCTION

Conventional concrete is a mixture of Portland cement, coarse and fine aggregates and water. Coarse aggregate is responsible for the high self-weight of conventional concrete. While considering seismic prone areas, this high self-weight of conventional concrete is not a good one because heavy structures are more susceptible to damages caused by earthquake than light-weight structures and also heavy structures are more likely to collapse on a ground shaking than light-weight structures. So it is more preferable to use light-weight concrete for the construction works on earthquake prone areas. While using light-weight concrete, the main problem is that light-weight concrete has less strength when compared to conventional concrete. So while making light-weight concrete it is necessary to ensure that it has strength properties for to be satisfactorily used for construction purposes.

Pumice aggregates are natural light-weight aggregates of volcanic origin and formed during the volcanic eruption of viscous magma, mostly siliceous and rich in dissolved volatile constituents. By using pumice aggregates concrete which is up to one-third times lighter than conventional concrete can be produced. Flyash is a waste by-product of thermal power plants. Many million tonnes of flyash is produced every year in the world and the disposal of the same is a major issue on behalf of environmental pollution. Flyash have pozzolanic properties and its major constituents are silica and alumina. So it can be effectively used as a cementitious material. Glass powder is a waste material and it becomes granulated by sieving, by means of sieves after they are crushed in the beaker and milled. Clear as well as coloured glass powder have chemical composition similar to that of OPC and are declared as pozzolanic materials by ASTM standard.

In the work conducted pumice aggregates are used for making the concrete light-weight. To makeover the strength reductions that may have occur while making the concrete light-weight is makeover using flyash and waste glass powder. Incorporating waste materials in to concrete can be a solution for their disposal and make a step forward to sustainable construction practices.

2. MATERIALS USED

The materials collected were tested in the laboratory to check whether they satisfy the requirements for to be used in the production of concrete as per IS specifications. The materials used in the work are given below.

2.1 OPC 53 Grade

Ordinary Portland cement is the one used for normal constructions. In the work conducted, Ordinary Portland cement of 53 grade confirming to IS 12269: 2013 was used. OPC 53 grade is a high strength concrete and thus a higher grade concrete can be produced at economical cement grade.

2.2 M Sand

The fine aggregates used in the work is Manufactured sand confirming to IS 383: 1970. M sand gives good workability foe concrete. It has higher Fineness Modulus Index when compared to the natural river sand. M sand also has better abrasion resistance, higher unit weight and lower permeability since it is free from silt and clay.

2.3 Coarse Aggregates

Coarse aggregates increases the crushing strength of concrete and also provides bulk to concrete thus occupying the major volume of concrete. Use of largest permissible size of coarse aggregate can make a reduction in cement and water requirements. In the work conducted, good quality crushed stone of nominal size 20mm confirming to IS 383: 1970 is used as the coarse aggregates.

2.4 Flyash

In the work conducted class F flyash is used. Class F flyash is designated in ASTM C 618. It originates from anthracite and bituminous coals and it is mainly composed of silica and alumina. Class F flyash has higher LOI and lower calcium content. Flyash offers increased late compressive strength and increased resistance to alkali silica reaction. It also offers high resistance to sulphate attack and provides high pore refinement to concrete.

Fig- 1: Flyash

2.5 Pumice Aggregates

The pumice aggregates used in the work was good quality white aggregates. Pumice aggregates have superior resistance to harsh weather conditions. It also have better water absorption and desorption characteristics. But the moisture held in the interior of the pumice aggregate is not immediately available for chemical reaction with cement so is extremely beneficial in maintaining longer periods of curing, resulting in reduced permeability of the final concrete. Since pumice aggregates are light-weight aggregates, the use of pumice aggregates as partial replacement of coarse aggregtaes can result in reduction of dead load. Pumice aggregate also results in lower thermal conductivity and hence occurs less heat loss.

Fig- 2: Pumice aggregates

2.6 Glass Powder

The glass powder used in the work is silica based waste glass powder. Glass powder can act as an excellent mineral admixture and has good heat resistance, chemical resistance and also offers good pressure and breakage resistance. The pozzolanic nature of glass powder made glass powder to have a strong gain in the construction industry.

Fig- 3: Glass powder

2.7 Water

Water plays an important role in the production of concrete. Water used for construction should be free from impurities because strength of concrete also depends on the purity of water. In the work conducted, potable water is used as per IS 456: 2000 recommendations.

3. METHODOLOGY

For the work the materials were collected and tested in the laboratory. Mix design is done for M40 grade concrete. Cement is replaced by flyash at 30%, coarse aggregate is replaced with pumice aggregates at varying proportions of 10%, 20%, 30% and 40% and glass powder is added at 6% by mass of cement. Cube, cylinder and beam specimens are cast using moulds of standard dimensions and are subjected to curing for 7, 14 and 28 days. The specimen taken out from curing tank after completion of specified curing periods were tested for finding the compressive strength, split tensile strength and flexural strength and the results obtained for normal concrete and the light-weight pumice concrete is compared.

Table- 1: Mix designation

NOMENCLATURE	COMPOSITION		
	FLYASH	PUMICE AGGREGATES	GLASS POWDER
F0P0G0	0%	0%	0%
F30P10G6	30%	10%	6%
F30P20G6	30%	20%	6%
F30P30G6	30%	30%	6%
F30P40G6	30%	40%	6%

4. RESULTS AND DISCUSSIONS

4.1 Cube Compressive Strength

Table- 2: Compressive strength values for different mixes

MIX	COMPRESSIVE STRENGTH AFTER CURING OF		
	7 Days (N/mm²)	14 Days (N/mm²)	28 Days (N/mm²)
F0P0G0	26.44	35.6	41.86
F30P10G6	22.82	32.41	38.2
F30P20G6	24.95	33.9	40.44
F30P30G6	25.73	35.34	41.95
F30P40G6	23.12	32.88	39.46

Normal concrete mix exhibited a compressive strength of 41.86 N/mm² after 28 days of curing. Then pumice aggregate was added in varying percentages from 10% to 40%, by keeping the percentages of flyash and glass powder as constant, that is, 30% and 6% respectively. With the addition of 10% pumice aggregate, the compressive strength reduced to 38.2 N/mm² and then increased to 40.44 N/mm² and 41.95 N/mm², with the addition of 20% and 30% pumice aggregates. Later on with the addition of 40% pumice aggregates, the compressive strength after 28 days curing is decreases again to 39.46 N/mm². The variation in compressive strength values for different mixes is shown in chart 1.

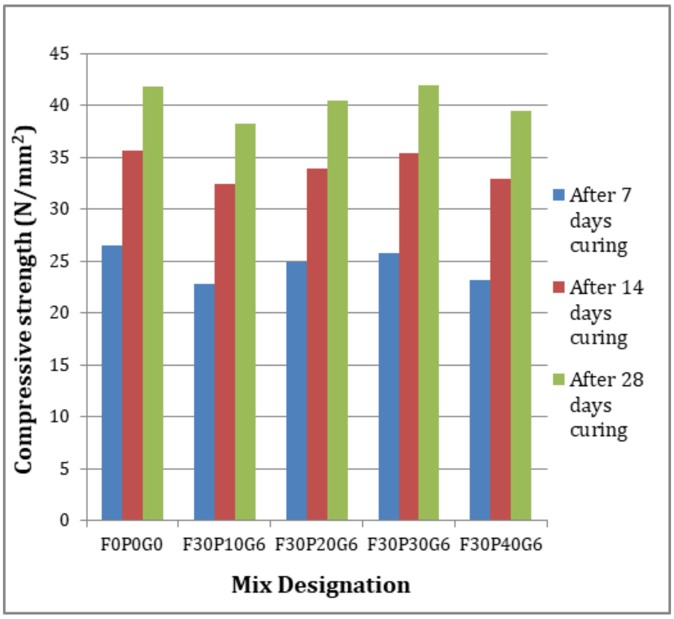

Chart- 1: Variation in compressive strength values

4.2 Split Tensile Strength

Table- 3: Split tensile strength values for different mixes

MIX	SPLIT TENSILE STRENGTH AFTER CURING OF		
	7 Days (N/mm²)	14 Days (N/mm²)	28 Days (N/mm²)
F0P0G0	2.59	3.28	5.40
F30P10G6	1.98	2.91	4.86
F30P20G6	2.24	2.95	5.10
F30P30G6	2.54	3.40	5.42
F30P40G6	2.12	2.53	4.98

Split tensile strength test is done for cylinder specimens after 7, 14 and 28 days of curing periods. The maximum split tensile strength obtained for the control mix is 5.40 N/mm² and that for the mixes with pumice aggregate is 5.42 N/mm². The result obtained with the mix F30P30G6 with 30% flyash, 30% pumice aggregate and 6% glass powder, is slightly greater than that obtained with the control mix for after a curing period of 28 days. Split tensile strength is observed to be increased as the percentage of pumice aggregate added is increased from 10% to 30%. But then, a reduction in the split tensile strength is observed with the addition of 40% pumice aggregate. Variation in split tensile strength for different mixes is shown in chart 2.

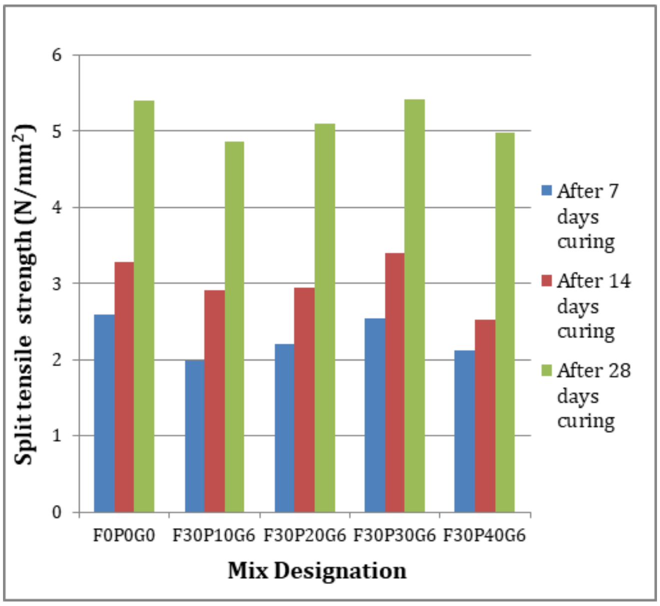

Chart- 2: Variation in split tensile strength values

4.3 Flexural Strength

Table- 3: Flexural strength values for different mixes

MIX	FLEXURAL STRENGTH AFTER CURING OF		
	7 Days (N/mm²)	14 Days (N/mm²)	28 Days (N/mm²)
F0P0G0	2.54	5.2	8.49
F30P10G6	2.5	4.4	6.75
F30P20G6	2.514	4.56	7.98
F30P30G6	2.56	5.16	8.54
F30P40G6	2.52	4.48	7.66

The normal mix exhibited its highest flexural strength of 8.49 N/mm² after 28 days of curing period. Later with the addition of 10% pumice aggregates, the flexural strength reduced to 6.75 N/mm² and with the addition of 20% and 30% of pumice aggregates, the flexural strength is increased to 7.98 N/mm² and 8.54 N/mm² and later on with the addition of 40% pumice aggregates, the flexural strength is again decreased to a value of 7.66 N/mm². The value of flexural strength obtained with the mix F30P30G6 is slightly greater than that obtained with the control mix after 28 days of curing. The variation in flexural strength for different mixes is shown in chart 3.

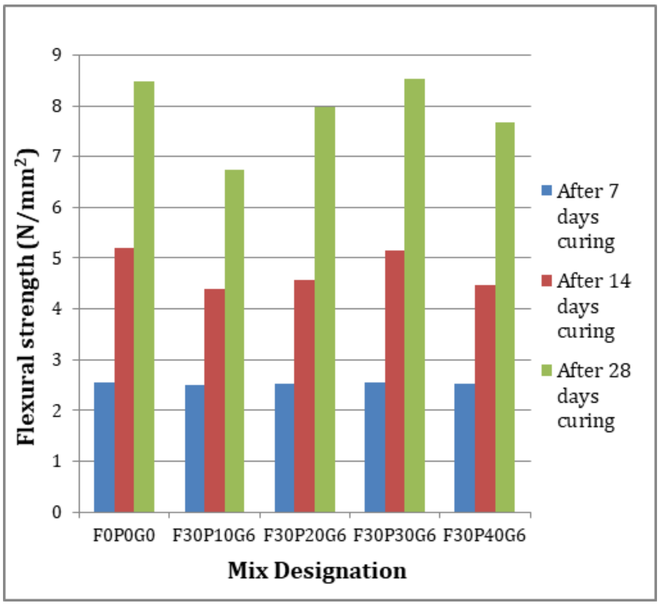

Chart- 3: Variation in flexural strength values

5. CONCLUSIONS

- Light-weight concrete can be satisfactorily produced out of pumice aggregates along with the addition of flyash and glass powder.
- Flyash and glass powder strongly helped in maintaining the desirable strength properties of the light-weight concrete.
- The addition of flyash increased the workability of concrete.
- Pumice aggregates are easier to be handled than conventional coarse aggregates and cause lesser damages to equipment.
- Glass powder can be effectively used for the makeover of the strength properties of light-weight concrete.
- The optimum percentage of pumice aggregates in concrete is 30%.

- Introduction of flyash and glass powder to concrete can make some improvements in the desired properties of concrete as weel as reduce and can be a solution for the environmental pollution problems related with their disposal.

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