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EXPERIMENTAL INVESTIGATION OF FLOATING CONCRETE STRUCTURE USING LIGHT WEIGHT (NATURAL PUMICE STONE) AGGREGATE

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ABSTRACT

This Project deals with the development of Floating type of concrete by using lightweight aggregate (Pumice stone). In Design of concrete structures, light weight concrete plays a prominent role in reducing the density and to increase the thermal insulation. These may relate of both structural integrity & serviceability. The new sources of Structural aggregate which is produced from environmental waste is Natural aggregates and synthetic light weight aggregate. The use of structural grade light weight concrete reduces the self-weight and helps to construct larger precast units. In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M20 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Silica Fume. For this purpose, along with a Control Mix, 6 sets were prepared to study the compressive strength. Each set comprises of 3 cubes. Slump test were carried out for each mix in the fresh state. 7-days Compressive test were performed in the hardened state. The test results showed an overall strength & difference in weight for various ratios of mix and the best compressive strength is used for the floating structure.

KEYWORDS: Lightweight concrete, Natural aggregate, Pumice stone, Silica fumes, Floating structure.

I. INTRODUCTION

As the global warming possess a threat to human existence near coastal areas, new solutions are sort after. One such solution is by building floating concrete homes, which are being constructed in various parts of the world. In line with this thinking, I have endeavoured to construct a concrete structure with much less weight and has a strength similar to that of a conventional concrete by introducing pumice stone in place of gravels. Floating on water means there should be an upward force which is the buoyancy force of the liquid. PUMICE is a natural sponge-like material of volcanic origin composed of molten lava rapidly cooling and trapping millions of tiny air bubbles. Pumice is the only rock that floats on water, although it eventually becomes waterlogged and increases a little in weight. Worldwide, over 50 countries produce pumice products. The largest producer is Italy, which dominates pozzolonic production. Other major pumice producers are Greece, Chile, Spain, Turkey, and the United States. Pumice are used to make lightweight construction materials. About three-quarters of pumice and pumicite are consumed annually for this purpose. The use of light weight concrete permits greater design flexibility and, reduced dead load, improved cyclic loading, structural response, better fire ratings and lower foundations costs. Light Weight Aggregate is a relatively new material. In addition to the reduced dead weight, the lower modulus of elasticity and adequate ductility of light weight concrete may be advantageous in the seismic design of structures. Other inherent advantages of the material are its greater fire resistance, low thermal conductivity, low coefficient of thermal expansion and lower erection and transport costs for prefabricated members.

II. LITERATURE SURVEY

Floating platform: based on a concrete structure in 2013. This floating structure depends on the buoyancy force in order to keep the structure floating on water body. Here the weight of concrete is reduced by adding admixtures such as alumina powder to act as an air entering agent and cause the concrete platform to reduce in weight. Therefore, making it float in water.

Effect of silica Fumes on strength and durability parameters of concrete

This was done by Sree Narayana Gurukulam in the year 2012. Adding silica fumes to Concrete at different ratios of 5% 10% 15% 20% and the compressive strength was noted. The values of compressive strength were higher compared with control concrete. Even when this concrete is immersed in hydrochloric acid it can resist better than control concrete.

Influence of Silica Fume on Normal Concrete

This was done by D. Dutta in the year 2013. He stated that when silica fumes are added with concrete and Super plasticizer are added the water consumption reduces by 25% and still has good workability. The reduce in water increases the strength of concrete. Even though the super plasticizer helps in reducing the consumption of water the workability of concrete remains the same.

Concrete canoes was first discovered by an American scientist in the year 2000. The scientist stated that anything will float on water as long as the water dispersed should be higher in weight compared to the structural weight floating on water. When a concrete boat is constructed it is made to float by calculating the water displaced by the object. If the weight of water displaced is higher than the structure, then the boat will float in water.

III. OBJECTIVE AND SCOPE OF EXPERIMENTAL INVESTIGATION

3.1 Experimental Investigation

The experimental investigation consists of casting and testing of 6 sets along with control mix. Each set comprises of 3 cubes for determining the compressive strength. Pumice stone is used in the study with different percentages as a partial replacement to natural weight coarse aggregate along with the 5% percentages of the Silica Fume as admixture. Cube section dimension is of 15cmx15cmx15cm, the moulds are applied with a lubricant before placing the concrete. After a day of casting, the moulds are removed. The cubes are moved to the curing tank carefully. Here to different batches are made one for 7 days curing and the other for 28 days curing.

3.1.1 Materials

The constituent materials used in this study are given below:

1. Cement OPC.
2. Normal Weight Coarse Aggregate.
3. Fine Aggregate.
5. Silica Fume.
6. Pumice Stone (Light Weight Coarse Aggregate).

IV. MATERIAL PROPERTIES

4.1 Cement

The cement used was ordinary Portland cement of 53- grade conforming to IS 12269. The cement should be fresh and of uniform consistency. Where there is evidence of lumps or any foreign matter in the material, it should not be used. The cement should be stored under dry conditions and for as short duration as possible.

4.2 Aggregates

A) Fine Aggregates

Sand shall be obtained from a reliable supplier and shall comply with ASTM standard C-33 for fine aggregates. It should be clean, hard, strong, and free of organic impurities and deleterious substance. It should inert with respect to other materials used and of suitable type with regard to strength, density, shrinkage and durability of mortar made with it. Grading of the sand is to be such that a mortar of specified proportions is produced with a uniform distribution of the aggregate, which will have a high density and good workability and which will work into position without segregation and without use of high water content. The fineness of the sand should be such that 100% of it passes standard sieve The fine aggregate which is the inert material occupying 60 to 75 percent of the volume of mortar must get hard strong nonporous and chemically inert. Fine aggregates conforming to grading zone II with particles greater than 2.36 mm and smaller than 150 mm removed are suitable.

B) Normal Weight Coarse Aggregate

Machine crushed hard granite chips of 67% passing through 20mm sieve and retained on 12 mm sieve and 33% passing through 12 mm and retained on 10 mm sieve was used a coarse aggregate throughout the work.

C) Light Weight Coarse Aggregate

Pumice Stone

Pumice called pumicite in its powdered or dust form, is a volcanic rock that consists of highly vesicular rough textured volcanic glass, which may or may not contain crystals as shown in fig 3.2.2.C.

Fig. 3.2.2.C Pumice Stone.

4.3 Water

Water used in the mixing is to be fresh and free from any organic and harmful solutions which will lead to deterioration in the properties of the mortar. Salt water is not to be used. Potable water is fit for use mixing water as well as for curing of beams.

Admixtures

4.4 Silica Fume

Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolonic. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor. Silicon metal and alloys are produced in electric furnaces. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being landfilled. Perhaps the most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle.

V. Moulds and Equipments

Moulds of required size and shape were prepared for casting process. The dimensions of the moulds for casting cubes are 150mm x 150mm x 150mm as shown in fig.5 All the moulds are applied lubricant before concreting. After a day of casting moulds are de moulded and then cubes are moved to the curing tank carefully for curing.

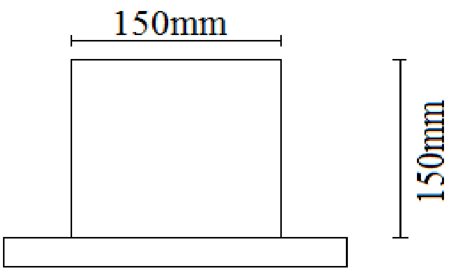


Fig. 5. Mould.

VI. Mix Design

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. Mix design for each set having different combinations are carried out by using **IS: 10262 – 2009** method. The mix proportion obtained for normal M20 grade concrete is **1:1.5:3** with a water-cement ratio of **0.45.**

Preparation Of Concrete Cubes

Metal moulds, preferably steel or cast iron, strong enough to prevent distortion is required. They are made in such a manner as to facilitate the removal of the moulded. Specimen without damage and are so maintained that, when it is assembled, the dimensions and internal faces are required to be accurate.

Compacting

The testing cube specimens are made as soon as possible after mixing and in such a manner to produce full compaction of the concrete with neither segregation nor excessive bleeding.

Curing

The test specimens are stored in a place free from vibration in moist air of at least 90% relative humidity and at a temperature of 27^{o}C for 24 hours from the time of addition of water to the dry ingredients. After this period, the specimens are marked and removed from the moulds.

Testing

Compressive Strength

After 7 days curing, cubical specimens are placed on compression testing machine having a maximum capacity of 3000 KN and a constant rate of loading of 40 kg/m2 per minute is applied on test specimen. Ultimate load at which the cubical specimen fails is noted down from dial gauge reading. This ultimate load divided by the area of specimen gives the compressive strength of each cube.

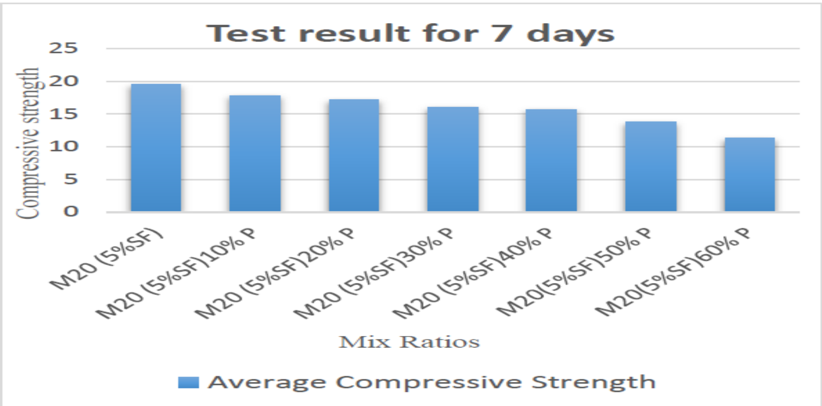
VII. TEST RESULTS AND DISCUSSIONS

Table 6.1: Compressive strength for control concrete.

S.N.	Grade	Different Ratios	Curing Days	Weight of Cube	Failure Load in (KN)	Average Compressive Strength
1.	M20	Conventional concrete	7	8.635	376	16.72
2.	M20	Conventional concrete + 5% Silica fumes	7	8.692	439	19.55
3.	M20	100% pumice stone	7	5.453	118	5.27

Table 6.2: Compressive strength for different ratios of pumice stone with 5% of silica fumes.

S.N.	Mix Designation	Compressive Strength
1	M20 (5%SF)	19.55
2	M20 (5%SF)10% P	17.825
3	M20 (5%SF)20% P	17.165
4	M20 (5%SF)30% P	16.035
5	M20 (5%SF)40% P	15.705
6	M20(5%SF)50% P	13.761
7	M20(5%SF)60% P	11.31



VIII. Floating Structure.

The best mix ratio for the floating concrete structure is M20 with 5% of silica fumes and replacing coarse aggregate by 50% with pumice stone. The compressive strength obtained for this Mix is 13.76N/mm2 for 7 days which is acceptable value for M20 grade of concrete mix. Hence with the above mix a concrete structure is made.

8.1 Structural dimension

Our main structure is for :517 sq.ft.

The real structure dimension is :8mx6mx4m.

Which is reduced to a ratio of :(1:13.3).

The reduced ratio structural dimension is :0.6x0.45x0.3m.

which is :2x1.5x1ft.

The mix design ratio :1:1.5:3 (M20).

8.2 The total amount needed for the construction

The volume of concrete to be applied: 0.0245 M3.

Cement: 8.02kg.

Fine aggregate: 13.28kg.

Coarse aggregate (pumice stone 50%): 5.35kg.

Coarse aggregate 50%: 23.27kg.

Volume of water used (theoretical): 3.6lit.

Water/cement ratio: 0.45.

8.3 Design of the structure

The structure is constructed from the basics of Archimedes principle. Which states that any structure will float on water as long as the weight of water displaced by the structure is more than the structural weight. Keeping that in mind the structure is constructed with the modified concrete for the ground floor alone. Here the entire ground floor will be constructed with concrete which includes the floor and the 4 walls. They are constructed at a single stretch to make one single structure.

8.4 Total weight of structure

After considering the factor of safety for the total weight of the structure the total weight calculated for the structure is 63kg.

8.5 How much will it sink for reduced structure

Volume of the structure = 63cm x 46cmx h.

Mass = density x volume.

63000gms = 1 x (63 x 46 x h).

h = 63000.

63 x46.

Therefore, the total Height of structure below water

= 21.739cm.

Fig: 8.5.1 Floating structure.

Fig: 8.5.2 Floating structure.

In the above figure 8.5.2 the three lines shows the distance from the bottom that is 20cm, 22.5cm & 25cm respectively. Hence the structure sinks according to the designed and calculated depth.

Fig: 8.5.3 Floating structure.

8.6 Calculating the total weight at which the structure will sink for the reduced structure

Volume of the structure = 60cm x 45cm x 30 cm.

Mass = density x volume.

x = 1 x (60 x 45 x 30).

X = 81,000gms.

Therefore, the total weight the structure can hold is= 81kg.

8.7 Calculating the total weight at which the large structure (8mx6mx4m) will sink

Volume of the structure = 800 x 600x 400 cm.

Mass = density x volume.

x = 1 x (800 x 600 x 400).

x = 192,000,000gms.

Therefore, the total weight at which the structure will sink

=192,000kg.

Which is =211.64 tons.

Calculating the different weights of the large structure

x=192,000kg – Reinforcement weight – weight of ground floor.

x=192,000 – 1044 – 94000.

x=96,956kg.

Therefore, the total weight of the super structure should be below:

=96,956 kg.

Which is =106.87 tons.

Hence proved, that the structure floats above water.

IX. CONCLUSION

Consistency of cement depends upon its fineness. Silica fume is having greater fineness than cement and greater surface area so the consistency increases greatly. The optimum 7 days' compressive strength have been obtained in the range of 5% silica fume for different replacement of coarse aggregate by pumice stone for 10%, 20%, 30%, 40% and 50%. Thus by comparing the compressive strength we can conclude that any structure can be built with 50% replacement of coarse aggregate with pumice stone with the addition of silica fumes by 5%.

Thus the construction of floating concrete structure was built and it is kept in Civil Engineering lab for further study and improvements.

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