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Durability Study of Lightweight Aggregate Concrete using Pumice Aggregate as Replacement of Coarse Aggregate

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Abstract

Lightweight concrete has less dead load as compared to the normal concrete. Most of the buildings are made in India using light weight aggregate/materials. In this experimental work, we need to focus on the light weight concrete using pumice aggregate and assessment of the result of compressive strength and reduction in dead load of the concrete. Four concrete mixes of M1, M2, M3 and M4 were prepared with the different replacement ratios (0, 15, 30 and 45%) of pumice aggregate with coarse aggregate respectively. Each set of concrete mix comprised of 9 cubes, tested at the age of 7, 14 and 28 days of curing period. It is concluded that with the increase in replacement of pumice stone by 15, 30 and 45%, the compressive strength decreases by 6.12, 14.25 and 22.84% respectively at 28 days of curing period.

Keywords: *Concrete, coarse aggregate, compressive strength, pumice aggregate, light weight concrete*

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INTRODUCTION

Lightweight concrete (LWC) is a versatile material for construction that has created great interest in many engineers, architects and contractors in recent years. LWC is generally used to reduce the dead weight of a structure as well as to reduce the risk of earthquake damages to a structure because the earthquake forces that will influence the civil engineering structures and buildings are proportional to the mass of those structures and buildings. Thus, reducing the mass of the structure or building is of utmost importance to reduce their risk due to earthquake acceleration. Lightweight aggregates (LWA) are used to make light weight concrete when the weights of aggregates are less as compared to the normal aggregate. However these types of aggregates are used for the making of LWAC using either artificial lightweight aggregates or natural lightweight aggregates. These various types of aggregates are available for commercial use, cover a wide range of properties such as elastic properties, tensile and compressive strength, time dependent properties, fire resistance, durability, etc. These materials are produced from raw materials in manufacturing plants. Naturally occurring lightweight aggregates such as pumice and scoria are mined from volcanic deposits but other light materials can also be used.

MATERIALS USED

Cement

The cement taken was ordinary Portland cement (OPC) of 43 grade of uniform consistency, conforming to IS 8112-1989. The test for specific gravity, standard consistency, initial and final setting time and 28 day compressive strength have been conducted (Table 1).

Table 1: *Physical Properties of Ordinary Portland Cement.*

Sr. No.	Characteristics	Values Obtained	Standard Values
1.	Specific Gravity	3.07	-
2.	Normal Consistency	2%	-
3.	Initial Setting Time	36 min	Not to be less than 30 min
4.	Final Setting Time	4 h 12 min	Not to be greater than 600 min

Fly Ash

In the investigation, Class C fly ash was used. Class C fly ash normally comes from coals which may produce an ash with higher lime content, generally more than 15%, often as high as 30%. Fly ash conforming to IS 3812 (part-1) has been used and uniform blending of fly ash with cement was ensured.

Fine Aggregate

The fine aggregate (river sand- *Badarpur*) used in the experimental work is locally procured. Sieve analysis of the fine aggregate was carried out in the laboratory as per IS 383-1970, and the results are tabulated in Table 2.

Coarse Aggregate

The aggregates which are retained over IS sieve 4.75 mm are called as coarse aggregate. The coarse aggregate used in the present study was locally available crushed stones of maximum size of 10 mm. Specific gravity and other physical properties of coarse aggregates are given in Table 3.

Pumice-Lightweight Aggregate

Pumice is one of the most common and the oldest of naturally occurring aggregates utilized lightweight coarse aggregates. Pumice is usually light colored or nearly white and has fairly even texture or interconnected cells. It is created when super-heated, highly pressurized rock is violently ejected from a volcano. The sieve analysis of these aggregates carried out individually for normal, medium and bigger size plastic aggregate and fineness modulus are as given in Table 4.

Table 2: *Physical Properties of Fine Aggregate.*

Characteristics	Type	Specific Gravity	Fineness Modulus	Grading Zone	Water Absorption
Value	Natural Sand	2.72	2.55	II	1.04%

Table 3: *Physical Properties of Coarse Aggregate.*

Characteristics	Colour	Shape	Maximum Size	Specific Gravity	Fineness Modulus	Water Absorption
Value	Grey	Angular	10 mm	2.63	6.61	.92%

Fig. 1: *Pumice Coarse Aggregate.*

Water

Tap water without any salts or chemicals was used in the study.

CONCRETE MIX DESIGN

The mix design of plastic coarse aggregate concrete is not different from that of conventional concrete and the same mix design procedure as per given in IS 10262:2000 was adopted for the M-30 grade of concrete. The ratio of the ingredients material is 1:1.34:1.7 and the water/cement ratio is 0.45 the for all the mix proportions. The concrete specimens are prepared with pumice aggregate using fly ash for the M-30 grade of concrete (Table 4). Three cubes of each variation of plastic aggregate are casted and the average of three test results is taken for the accuracy of the results.

Table 4: M-30 grade of concrete

Concrete Mix	Mix Content
M1: Control Mix	M30
M2	M30+20%fa+15%PA
M3	M30+20%fa+30%PA
M4	M30+20%fa+45%PA

RESULT AND DISCUSSION

Compressive Strength

The compressive strength tests results are the average of three measurements of the concrete cubes are presented in Tables 5–7after 7, 14 and 28 days. The compressive strength of the concrete cubes decreased with the increasing quantity of pumice aggregate content in concrete mixtures respectively. Further, the use of fly ash as partial replacement of cement; also to check the effect in the compressive strength whereas use of fly ash with pumice aggregate content give better compressive strength (Figure 2).

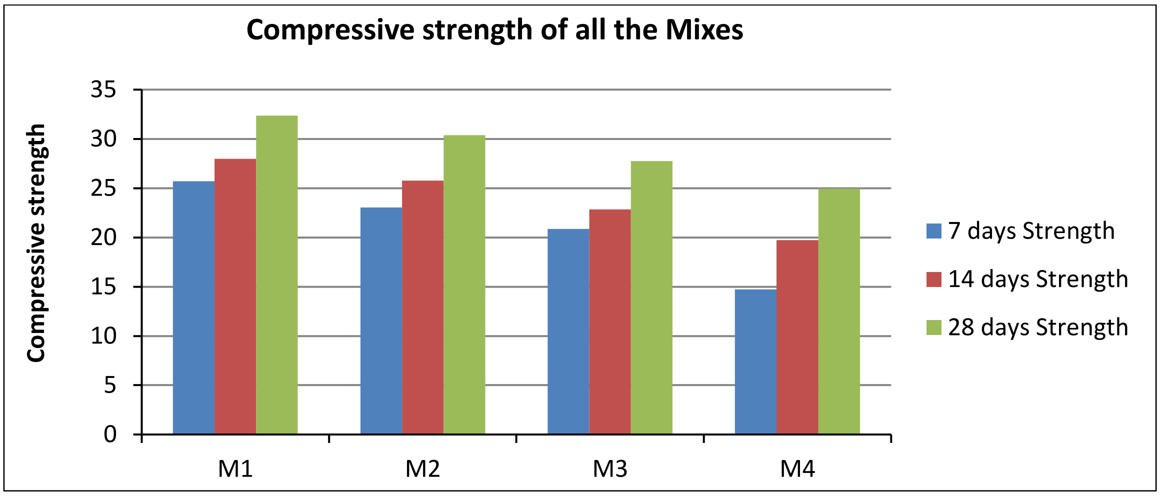

Fig. 2: *Compressive Strength on Hardened Cube Specimens by CTM.*

Table 5: *Compressive Strength of Cubes after 7 days.*

Sr. No.	M1	M2	M3	M4
Mix	Conventional	15%	30%	45%
7 days Strength	25.7	23.05	20.87	14.73

Table 6: *Compressive Strength of Cubes after 14 days.*

Sr. No.	M1	M2	M3	M4
Mix	Conventional	15%	30%	45%
14 days Strength	27.99	25.76	22.84	19.72

Table 7: *Compressive Strength of Cubes after 28 days.*

Sr. No.	M1	M2	M3	M4
Mix	Conventional	15%	30%	45%
28 days Strength	32.35	30.37	27.74	24.95

CONCLUSION

The following are the observations and conclusions on the basis of experimental results:

- The specific gravity of pumice (LWA) is 1.95; this value is 27% lower when compared to the specific gravity of NWA which is 2.68. Therefore, the usage of pumice aggregate can reduce the dead weight by 27%.
- On replacement of NWA with LWA in concrete mix M2 (15% replacement of NWA with LWA), M3 (30% replacement of NWA with LWA) and M4 (45% replacement of NWA with LWA), it is observed that the unit weight of LWAC reduces by 6.12, 14.25 and 22.84% respectively in comparison to control mix M1.
- The compressive strength by CTM (destructive testing technique) is found to decrease with increase in percentage of pumice stone a lightweight aggregate. The concrete mix M2, M3 and M4 showed reduction in compressive strength by 6.12, 14.25 and 22.84% at 28 day of curing period with respect to concrete mix M1. The compressive strength (by CTM) of concrete mix M2, M3 and M4 are 30.37, 27.74 and 24.95 MPa respectively, at curing period of 28 days. Hence the optimum value of strength M30 is achieved by replacing 30% of normal weight aggregate with lightweight aggregate.

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