Experimentation on strength of concrete with different coarse aggregates

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Abstract - **The concrete being the most widely used construction material, the utilisation of concrete results in the depletion of natural resources that are to be used directly or indirectly as the ingredients of concrete. Such large scale depletion of natural resources create a negative impact on the environment. In order to reduce the use of natural resources as the ingredients of concrete, alternate materials like expanded clay and recycled concrete were used as coarse aggregates in concrete. The variation in the properties of the concrete containing different coarse aggregates were studied by performing the tests as per Indian Standard codes. It was found that the recycled concrete can be used as replacement for conventional coarse aggregates without much change in the properties of conventional concrete.**

keywords - **Structural lightweight concrete, Lightweight aggregate concrete, Light Expanded Clay Aggregates (LECA), Recycled concrete, Recycled concrete aggregates**

I. INTRODUCTION

The concrete has widespread applications in construction. Its advantages like high compressive strength, can be moulded into any shape, higher durability, etc., resulted in the increased use of concrete as a building material in the past decades. In spite of possessing such advantages, lower tensile strength, longer curing period, higher self-weight, etc., are few drawbacks of the concrete. The aggregates in concrete occupy maximum volume in concrete. Thus, to reduce the density of concrete, the density of aggregates must be reduced. This can be done by selecting the aggregates which possess lower density than conventional concrete. But, the density of aggregate depends on its crushing strength. Lower the density, lower is the crushing strength of the aggregate. In this study, Light Expanded Clay Aggregate (LECA) is chosen to be tested for the suitability of coarse aggregate in concrete.

The demolition of concrete structures create huge quantities of construction wastes that gets ended up in landfills. The demolition wastes, particularly used concrete can be crushed in crushers so that it can be used as aggregates in fresh concrete. This reduces the depletion of natural resources and also encourages recycling of concrete. But, the recycled concrete aggregates possess different physical properties in comparison with the conventional aggregates. Hence, the properties of concrete containing recycled concrete aggregates must be understood before use in real time construction.

The objective of the study is to identify the influence of expanded clay and recycled concrete aggregates on the properties of concrete.

II. REVIEW OF LITERATURES

Qazi Abu Haris Ateeq, Maneeth P.D, Brijbhushan S (2020) studied the influence of 40% replacement of conventional coarse aggregate with expanded clay aggregates. The properties of attained concrete were compared with the properties of conventional concrete. The workability of concrete containing expanded clay aggregates were less than conventional concrete. The compressive, split tensile and flexural strength of concrete containing LECA was more than the conventional concrete after 7 and 28 days of curing.

Nagashree B and Dr. S. Vijaya (2015) utilised LECA and cinder as complete replacement to coarse aggregate in concrete. The proportion of LECA and cinder were varied and the concrete mix was subjected to various tests. The replacement of conventional coarse aggregates with 40% LECA and 60% cinder resulted in increased workability. As the LECA content in concrete increased, the compressive strength and split tensile strength of concrete were reduced.

S. Muneera, A. Rupa (2016) studied the properties of M20 grade concrete in which the coarse aggregates were replaced with recycled concrete aggregate by 10%, 20%, 30%, 40%, 60%, 75% and 100%. It was observed that as the proportion of recycled concrete aggregate increased, the compressive strength and split tensile strength of concrete reduced after 7, 14, 28, 56 and 90 days of curing.

III. MATERIALS

The materials used for experimentation were cement, M sand, conventional coarse aggregate, expanded clay aggregate, recycled concrete aggregate and water. The cement used was OPC 53 grade cement satisfying the requirements as per IS 12269 (2013) - Ordinary Portland Cement, 53 Grade – Specification. Msand of fineness modulus 2.57, water absorption 1.11% and of zone II was used as fine aggregates. The coarse aggregates used for the study were conventional aggregates, expanded clay aggregates and recycled concrete aggregates. The size of coarse aggregates vary between 12.5 mm and 20 mm. The water absorption of conventional coarse aggregates, expanded clay and recycled concrete aggregates were 0.55%, 3.08% and 11.48% respectively. The bulk density of conventional coarse aggregates, expanded clay and recycled concrete aggregates were 1643 kg/m3, 339 kg/m3 and 1393 kg/m3 respectively. Potable water was used for casting and curing of concrete specimens.

IV. MIX PROPORTIONING

The concrete containing crushed aggregates and recycled concrete aggregates were conventional concrete. But, the use of expanded clay aggregates resulted in lightweight concrete. The mix design for M30 grade concrete using conventional coarse aggregates and recycled concrete aggregates was obtained using IS 10262 (2019). Also, the mix design for concrete using expanded clay aggregates was obtained using ACI 211.2 (1998). Mix M1 represents control mix with conventional coarse aggregates. The concrete with recycled concrete and expanded clay as coarse aggregates were designated as M2 and M3 respectively. The obtained mix ratio for each concrete mix and the required quantities are tabulated in table 1.

Table 1 Mix proportion

Mix	Mix ratio	Cement (kg)	Msand (kg)	Coarse Aggregate (kg)	Water (ltr)
M1	1: 1.56: 2.62 (w/c – 0.40)	25.08	39.12	65.71	10.03
M2	1: 1.56: 2.26 (w/c – 0.42)	25.08	39.12	56.68	10.53
M3	1: 1.89: 0.61 (w/c – 0.45)	23.99	45.34	14.63	10.80

V. CASTING AND CURING

The ingredients of concrete pertaining to each mix were mixed separately in a pan mixer until a homogeneous mixture were obtained. Six cubical moulds and six cylindrical moulds per mix were cleaned and greased. The concrete was filled in the respective moulds in three layers with each layer tamped 25 times using a tamping rod. After 24 hours, the hardened concrete were removed from the moulds and cured for 7 and 28 days after which the specimens were subjected to corresponding strength tests.

VI. RESULTS AND DISCUSSIONS

Workability test

The workability of the concrete was determined using slump cone test. The variation in the workability of each concrete mix was shown in figure 1.

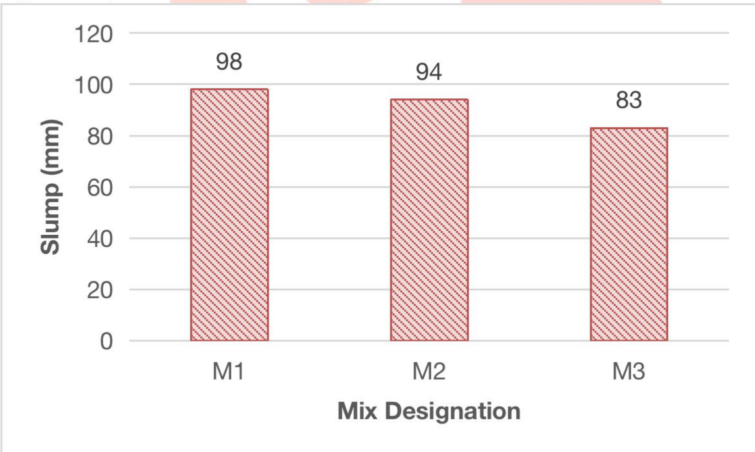

Figure 1 Workability test results

From fig 1, it can be identified that the use of various coarse aggregates affected the workability of the concrete. The decrease in slump of M2 and M3 concrete mix were 4% and 15.3% respectively. The workability of mix M1 and M2 were identical. Though the water absorption of expanded clay aggregates was high, its round nature contributed to the high workability of concrete.

Density test

The concrete cube was weighed using a weigh balance. The weight of concrete cube divided by the volume of concrete cube represents density of hardened concrete. The variation in density of hardened concrete containing various coarse aggregates is shown in figure 2.

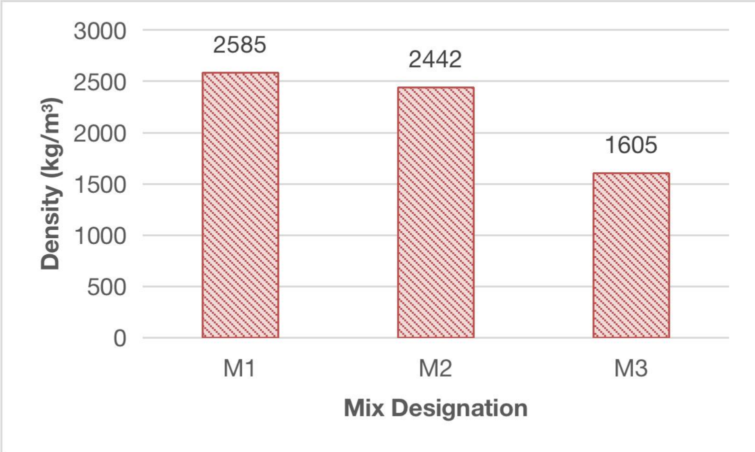

Figure 2 Density test results

From fig 2, it can be observed that the use of expanded clay aggregate resulted in the reduction of hardened density by about 38%. The density of hardened concrete containing recycled concrete aggregate (M2) was similar to conventional concrete (M1).

Compressive strength test

Three concrete cubes of 150 mm size were tested per mix after 7 and 28 days of curing, by subjecting the cube to uniaxial compressive load. The compressive strength of concrete mix was obtained by dividing the failure load by the cross sectional area of the concrete cube. The variation in average compressive strength of each mix is represented in figure 3.

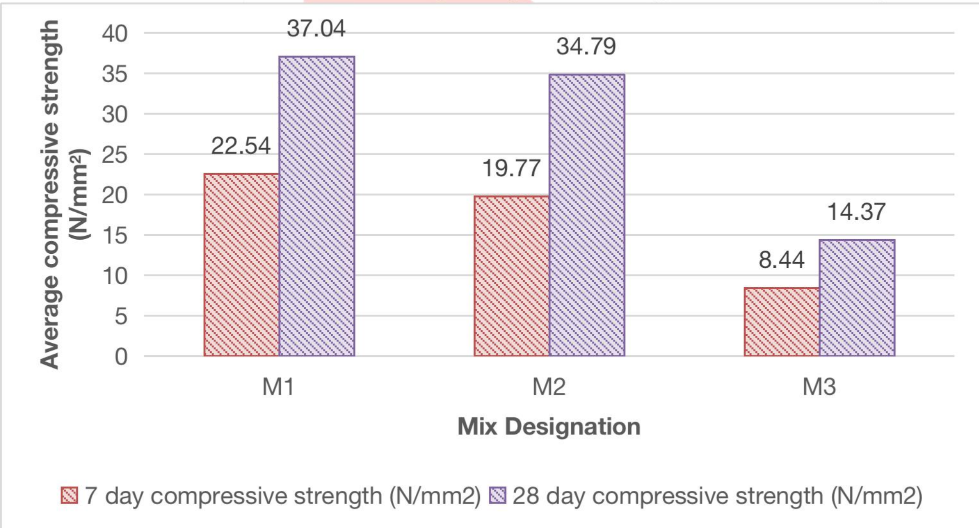

Figure 3 Compressive strength test results

From fig 3, it can be seen that the reduction in early compressive strength of concrete for mix M2 and M3 were 12.3% and 63% respectively. Similarly, the reduction in 28 days average compressive strength of concrete mix M2 and M3 were 6% and 61% respectively. The reduction in compressive strength of M2 was considerable. But the use of expanded clay aggregates resulted in higher loss of compressive strength of concrete. The strength attained by M3 concrete was so less. Thus, M3 mix cannot be used as structural concrete.

Split tensile strength test

The tensile strength of concrete was measured indirectly by subjecting the cylindrical concrete specimens of diameter 150 mm and length 300 mm to uniaxial compressive load with its axis perpendicular to the direction of loading. The variation in the split tensile strength of concrete mixes is shown in figure 4.

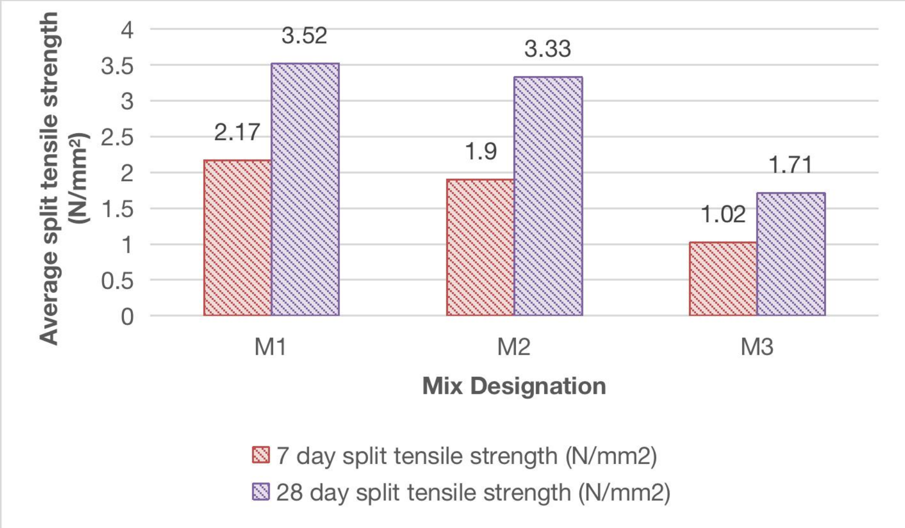

Figure 4 Split tensile strength test results

From fig 4, it can be observed that the split tensile strength of concrete containing recycled concrete aggregate was 12.5% and 5% less than the conventional concrete after 7 and 28 days of curing. The strength of M3 mix concrete was much lesser than the M1 mix.

VII. CONCLUSION

The conclusions obtained from the experimental study are as follows:

- The effect of recycled concrete aggregates on the properties of concrete like slump, density, compressive strength and split tensile strength were negligible. The use of recycled concrete as aggregates must be encouraged to reduce the exploitation of natural resources and recycling of demolition wastes.
- The use of expanded clay aggregates resulted in the decrease of compressive and split tensile strength of concrete. Thus, the concrete containing expanded clay aggregates cannot be used for the construction of structural members.

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