

Studies on Structural Light Weight Concrete by Blending Light Weight Aggregates

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ABSTRACT

In this present experimental work, an attempt is made to study on the strength properties of structural light weight concrete produced replacing coarse aggregate by blending light weight aggregates such as Cinder and Leca for M20 grade of concrete. The light weight concrete is prepared by using Cinder and Leca as light weight aggregates which were blended in various percentage proportions 0:100, 10:90, 20:80; 30:70; 40:60, 50:50 and vice-versa by volume of concrete. By using this, the properties such as compressive strength, split tensile strength and density are studied by casting 33 no. of plain cube specimens of size 150 x150 x150mm and cylindrical moulds of 150x300mm. M20 grade light weight concrete with 60% Cinder and Leca 40% had an average compressive strength of 28.89N/mm² and split tensile strength of 1.67N/mm². The Ground Granulated Blast Furnace Slag (GGBFS) is used by replacing 20% of cement which enhanced the compressive to 30.68N/mm².

Keywords

Cinder, Leca, Compressive strength, Split tensile strength, Density

1. INTRODUCTION

Any structure ultimately transfers the load to the soil strata beneath; the increase in the shear number of structure has increased the stress on mother earth. The demand for construction space has increased many folds with increase in necessity of human beings. According to recent survey, the population density in world is around 54 persons per sq km, but in India it is around 400 persons per sq km. so, the developing country like India is having land scarcity. Hence vertical growth is preferred than horizontal growth, since more and more people are moving into urban areas lead to lot of land crunch. This land crunch and load increase demands the use of light weight structural concrete. The light weight structural concrete helps in decreasing load as the density is reduced substantially from ranges of 2400kg/cubic meter to 1800kg/cubic meter.

Light weight structural concrete is an enhanced version of concrete, with emphasis on decrease in density of concrete. When structural concerns require a minimum to the dead load, light weight concrete is used. It is ideal for roof deck repairs, stair pan fill, elevated floor slabs or over lays on existing floor decks .since it is light weighted it is ease in lifting and carrying which is an important advantage of light weight concrete. It also offers slower temperature transfer rates than standard concrete, resulting in improved insulation fact.

The concrete whose density is comparatively less than that of normal conventional concrete is termed as light weight concrete. The composition of light weight concrete is similar to that of

conventional concrete except the use of light weight aggregates or combination of both light weight aggregates & normal aggregates. In some cases the fine aggregates portion are replaced by light weight products. The bond between the cement and aggregates is strong in case of light weight concrete when compared to that of normal conventional concrete. With the increase of construction works, there is an increase in demand of light weight concrete due to its low density & improved strength. The cost of light weight concrete is expensive, it is not only due to cost of aggregates but it is an integration of various costs like labor, placing, transportation, reinforcements etc....For structural purposes the concrete should possess higher strength. Light weight aggregates used for structural light weight concrete are generally expanded shale, slate, cinder, pumice etc....

The use of light weight aggregates concrete in structures offers many advantages over the conventional normal weight concrete, including an increased strength weight ratio and improved thermal and sound insulation and fire resistances properties [K.Dhir and et.al,1984].

In concrete construction field, the concrete represents a very large proportion of the total load on the structure and there are clearly considerable advantages in reducing its density. One of the ways to reduce the weight of a structure is the use of light weight aggregate concrete [Mouli and Khelali 2008].

Light weight aggregate concrete (LWAC) has been used successfully for structural purposes for many years, because of their improved properties such as the workability, strength, less dead load and resistance to freezing and thawing of light weight concrete [V. Khonsari and et.al 2010]

The features of light weight, concrete are higher strength to weight ratio as compared with conventional concrete, enhanced in thermal and sound insulation, reduced dead load in the structure result reduce structural elements and minimize the steel – reinforcement [Jihad Hamad Mohammed and et.al.2014]

Light weight concrete has strength comparable to normal weight concrete, yet is typically 25 % to 35% lighter, structural light weight concrete offer & design flexibility and substantial cost savings by providing less dead load, improved seismic structural response, longer spans [Fatrizal Zulkarnain et. all in 2008]

Light weight concrete has vast applications in various fields due to its low density. The aim of experiment is to develop the light weight concrete for the mix design of conventional concrete such as M20 by full replacement of the portion of coarse aggregates (granite) by blending of light weight aggregates such as LECA & CINDER with different percentages & thereby achieving the target strength with low density of concrete. The concrete which

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is thus developed is then compared with the conventional M20 grade concrete & further the graphs are obtained for the above comparison.

2. CHARACTERIZATION OF LIGHT WEIGHT AGGREGATES

Materials used

- 1) Cement-Ordinary Portland cement 43 grade confirming to IS 12269-1987.
- 2) Fine aggregates - Confirming to zone II passing through 4.75mm IS sieve.
- 3) Coarse aggregates - Locally available granites passing through 20mm IS sieve are used.
- 4) Light weight aggregates used in experimentation- In this study LECA and Cinder was selected as light weight aggregates to replace natural aggregates in concrete.

CINDER: Cinder is a naturally occurring light weight rock of igneous origin. It is a pyroclastic material which is similar to that of pumice and has many cavities with low density which can float in water. Cinder is generally black, brown or red in color depending on its chemical composition. Now a days it is also called by name Scoria. Volcanic cinders are uncemented, vitric, have bubble-like cavities, called vesicles, measure not less than 2.0 mm in at least one dimension the apparent specific gravity is between 1.0 and 2.0. Figure 1 shows the cinder used in study

LECA: It is abbreviated as LIGHT EXPANDED CLAY AGGREGATES. It is the special type of aggregate which are formed by pyroclastic process in rotary kiln at very high temperature. Since it is exposed to high temperature, the organic compounds burn, as a result the pellets expand & form a honeycombed structure. Whereas the outside surface of each granule melts and is sintered. The resulting ceramic pellets are lightweight, porous and have a high crushing resistance. It is environmental friendly, entirely a natural product incorporating same benefits as tile in brick form. LECA is non destructible, noncombustible & impervious to attack by dry-rot, wet-rot & insects. Figure 2 shows the LECA used in study.

Before deciding any material to be used as aggregate it has to possess some standards set by IS: 1343. As we are concerned with the mix design the basic tests were conducted the results were determined.

Based on the standard tests the results were as

Tests conducted on Leca were

Specific gravity = 0.51

Bulk density in Loose state % voids was 79.59% and Compacted state % voids was 68.94%;

Aggregate crushing test was 37.52%;

Water absorption was 16.42%

Fineness modulus was found to be 6.448.

Tests conducted on Cinder were

Specific gravity = 1.52

Bulk density in Loose state % voids was 67.84% and Compacted state % voids was 59.76%;

Aggregate crushing test was 32.01%;

Water absorption was 8.8%

Fineness modulus was found to be 7.414

3. METHODOLOGY

The concrete mix has been designed for M20 grade of concrete using ISI method. The design procedure had a mix proportion which is tabulated in Table 1.

Table 1: Mix Proportions for M20 grade of Concrete

1	Cement	383.0 kg/m ³
2	Water	191.6 kg/m ³
3	Fine aggregates	727 kg/m ³
4	Coarse aggregates	1103 kg/m ³
5	Water cement ratio	0.50



Fig 1: Cinder



Fig 2: LECA



Fig 3: Mixing



Fig 4: Slump



Fig 5: Casted Cubes



Fig 6: Casted Cylinders

In current test light weight aggregates like Leca and cinder were selected and their physical and chemical properties were tested. Based on the characteristics, design mix was arrived on ISI method. These aggregates are blended in a defined proportion starting from 0% to 100% for replacement of natural coarse aggregates. For each replacement ratio specimen's cubes and cylinders were cast as shown in figure 5 and 6. The elements were subjected to standard curing placing in water at ambient room temperature for 28 days. The cured cube specimens were subjected to compressive loadings and the corresponding strength characteristics were determined.

The average compressive strength are tabulated in Table 2

Table 2: Average Compressive Strength

SL. No	Light Weight Aggregate		Density (kg/mm ³)	Avg Compressive Strength (N/mm ²)	
	% Leca	%Cinder		7 days	28 days
1	0	100	2325.92	22.560	30.910
2	10	90	2257.77	22.240	30.082
3	20	80	2219.26	21.110	29.330
4	30	70	2139.26	21.073	28.644
5	40	60	1837.00	19.475	28.892
6	50	50	1777.77	15.260	22.266
7	60	40	1751.11	14.969	20.856
8	70	30	1697.78	14.243	19.848
9	80	20	1629.63	13.952	19.443
10	90	10	1540.74	12.498	17.408
11	100	0	1454.81	12.208	17.018



Fig 7: Curing



Fig 8: Testing in CTM

The average tensile strength are tabulated in Table 3

Table 3: Average Tensile Strength

SL. No	Light Weight Aggregate		Slump (mm)	Average Tensile Strength (N/mm ²)	
	% Leca	%Cinder		7 days	28 days
1	0	100	27	1.87	2.64
2	10	90	31	1.85	2.62
3	20	80	33	1.85	2.61
4	30	70	48	1.78	2.52
5	40	60	55	1.66	2.43
6	50	50	53	1.45	2.05
7	60	40	50	1.34	1.89
8	70	30	46	1.10	1.56
9	80	20	42	0.96	1.36
10	90	10	39	0.85	1.20
11	100	0	37	0.83	1.1

4. RESULTS AND DISCUSSIONS

The comparison of experimental results and analyzing were done in graphical way.

Analysis of slump results of fresh concrete mix: Here the slump test carried out for various proportions of fresh concrete mixes of M20 grade are compared.

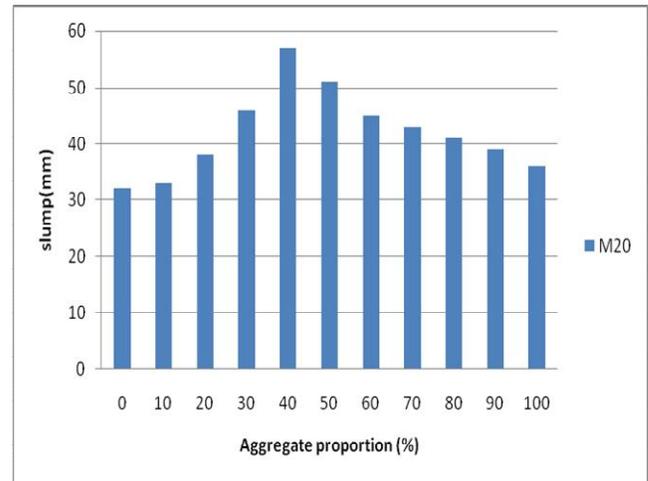


Fig 9: Comparison of %Aggregate proportion V/S Slump(mm)

Analysis of compressive strength of hardened concrete: Here the compressive strength of various proportions of M20 for different curing periods such as 7 days and 28 days are analyzed.

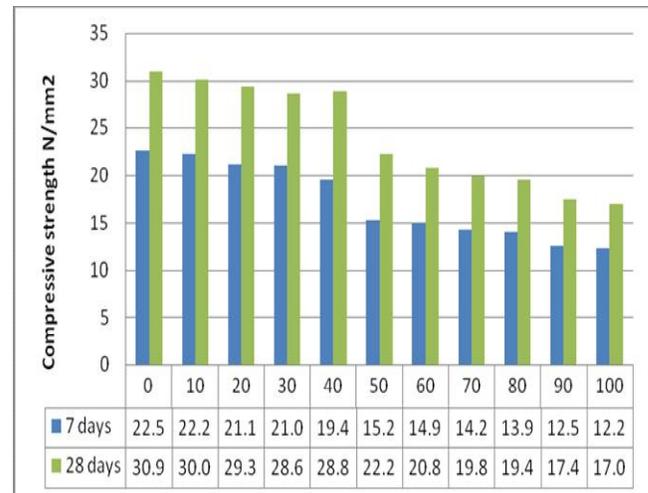


Fig 10: Comparison of %Aggregate proportion V/S Compressive strength

Analysis of split tensile strength results of hardened concrete: Here the split tensile strength of various proportions of both M20 for different curing periods such as 7 days and 28 days are analyzed.

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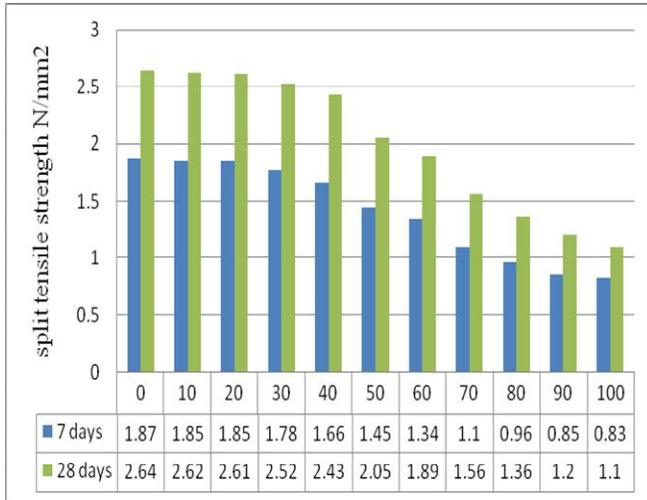


Fig 11: Comparison of %Aggregate proportion V/S Split Tensile strength

Based on the results of the experimental investigation carried out, 60% of cinder & 40% of Leca has found to be optimum design mix for obtaining the designed concrete mix. In order to improve the compressive strength, for the same mix the 20% of cement was replaced by Ground Granulated Blast Furnace Slag which improved the compressive strength from 28.89N/mm² to 30.20N/mm². The mix proportions and results are tabulated in Table 4 and 5 respectively

Table 5: Mix Proportions for M20 grade of Light weight Concrete with 20% GGBFS

1	Cement	306.4 kg/m ³
2	GGBFS	76.6 kg/m ³
3	Water	191.6 kg/m ³
4	Fine aggregates	727 kg/m ³
5	Coarse aggregates	1103 kg/m ³
6	Water cement ratio	0.50

Table 6: Compressive Strength of M20 grade of Normal aggregates concrete & LWC with 60% Cinder, 40% Leca as aggregates with 20% GGBFS

Compressive Strength of Normal Concrete (N/mm ²)		Compressive Strength of Light weight concrete (N/mm ²)	
7 days	28 days	7 days	28 days
23.54	34.62	21.90	30.34
23.05	34.28	21.87	30.27
22.96	34.05	21.69	31.45

4. CONCLUSIONS

Based on the results of the experimental investigation carried out and in scope of work carried out, the conclusions are drawn,

- Cinder and Leca can be used as a light weight aggregate in replacement of normal coarse aggregate.
- Increasing the percentage of light weight aggregate decreases the cubes weight from 8.5kg to 5.15kg. But simultaneously there was decreasing strength. Blending of aggregates showed better performance in this case
- The concrete mixes are blended in various proportions like (50;50 ,60;40 ,70;30 ,80;20 ,90;10 ,fully 100%) vice versa in cinder and Leca.
- 60% of cinder and 40% of LECA with 20% of GGBS replaced for cement gave a good low weight structural concrete.
- Cinder and LECA can be used as light weight aggregate in replacement of normal coarse aggregate. M20 grade light weight concrete had an average compressive strength of 30.68N/mm² respectively which was almost nearer to the compressive strength of normal aggregate concrete which was 34.32N/mm².
- The density of light weight aggregate concrete varied from 1750 to 1850 kg/mm³ which were lesser than that of normal weight concrete having a density of 2651 kg/mm³.
- There was significant cost reduction when compared to normal concrete. The batching of concrete work is done in volume wise, 1kg of LECA replaced 3.5 kg of normal aggregate by mass.

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