International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 10 | Oct 2020 www.irjet.net p-ISSN: 2395-0072

Effect of Lightweight Aggregates on RCC Beams

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Abstract - *This experimental scenario deals with the investigation on the development of light weight concrete by combining two types of light weight aggregates of which, one is naturally occurring and the other is artificially occurring. Light expanded clay aggregates (LECA) is the natural aggregate and cinder is the artificial aggregate. This experimental study includes the study on strength properties of partially replaced light weight concrete is produced by replacing coarse aggregate with LECA (30% by volume) & fully replaced light weight concrete which is produced by replacing coarse aggregates by blending LWA namely cinder(70% by volume) and LECA (30% by volume) for M25 grade of concrete. The properties such as compressive strength, split tensile strength & flexural strength are studied by casting specimens. The test results obtained are compared with Normal concrete. Also the investigation of the flexural behaviour of reinforced lightweight concrete beams made is conducted. From the results we can analyze that with replacement of LECA and Cinder aggregates in place of normal coarse aggregates have given better results with high strength, less weight and low density.*

Key Words: **CINDER, LECA, LOW DENSITY, FLEXURAL STRENGH, RCC BEAMS**

1. INTRODUCTION

This Light-weight concrete is often defined as a kind of concrete which incorporates an expanding agent therein it increases the quantity of the mixture while giving additional qualities like lessened dead weight. It's lighter than the conventional concrete. The required properties of the light-weight concrete will have an impact on the simplest sort of Light Expanded Clay aggregate to use. The Structural light weight concrete as we call is a concrete whose density varies from 1400 to 2000 kg/m3. It reduces the weight of concrete and cost of concrete by reducing the aggregate cost and produces economic infrastructure system. The present work is intended to provide experimental information on the strength properties of RC beams made of LWAC. It is based on a comparative study of the results obtained from tests in which specimens made of LWAC and NC are subjected to the applied loading. All specimens are designed in compliance with the provisions of current codes for RC structures made from NC. The LWAC selected for the specimens is designed so as to have a compressive strength similar to that of the NC used in spite of being lighter by about 30%.

2. LITERATURE REVIEW

Various technical papers on assessment of concrete using Lightweight Aggregates are presented below:

Prof Ivan Tomicic (2012) aimed at analyzing improved properties of lightweight aggregate concrete and its practical use in his research. Sufficient data were provided for the verification of ductility, stiffness, and cracking of lightweight aggregate beams. The results showed that lightweight aggregate concrete structures are very similar to those exhibited by normal-weight concrete, which is why they can almost be used in circumstances when standard structures are normally used.

This paper describes an experimental study on the flexural ductility of lightweight-aggregate concrete beams including concretes with compressive strengths between 22.0 and 60.4 MPa and dry densities between 1651 and 1953 kg/m3. Ductility was studied by defining ductility indexes. The main variables are the concrete compressive strength and the longitudinal tensile reinforcement ratio. It is shown that the parameter with higher influence on ductility is that the longitudinal tensile reinforcement ratio. It also showed that for approximately constant values of concrete compressive strength, beams suffer a reduction in ductility with increasing longitudinal reinforcement ratio. **Miguel et al (2013)**

Anil Kumar R and Dr.P.Prakash (2015) administered aims to review on the strength properties of structural light weight concrete produced replacing coarse aggregate by blending light weight aggregates like Cinder and Leca for M30 grade of concrete. The light weight aggregates like Cinder and Leca were blended in various percentage proportions. The properties like compressive strength, split lastingness and density are studied. M30 grade light weight concrete with 60% Cinder and Leca 40% with addition of Ground Granulated Blast Furnace Slag (GGBFS) of 20% enhanced the compressive strength.

T Sonia and R Subhashini (2015) examined the structural behaviour of Lightweight concrete (LWAC) using lightweight aggregates (Light expanded clay aggregates LECA) and normal weight aggregates, to investigate on concrete mix M25 by the effect of partially and fully replacement of the coarse aggregate by Leca with various percentage such as 20%, 40%, 60%, 80% and 100% and fly ash percentage such as 15%, 20%, 25% used as partial replacement for cement in concrete. This paper concentrated on performance parameters such as compressive strength, splitting tensile strength of the light weight concrete using LECA. In strength performance of 15% replacement of fly ash content with 40% replacement of coarse aggregates concrete for better results to ensure its optimal proportions.

Omkar S. Gangatire and Yogesh R. Suryawanshi (2016) gave the review and analysis of sunshine weight concrete with conventional concrete. The lightweight concrete is produced by mixing air entraining agent Kemilite-pr in conventional concrete in 0%, 10%, 20%, 30% and 20% cement is replaced by fly ash to make it cost effective. The analysis program focuses on tests such as Compressive test, Flexural test, Split Tensile test, water absorption test and Density test, Pull out test & Rebound Hammer Test (NDT). Ultimately there is reduction of dead load, faster building rate in construction and lessen haulage and handling costs.

3. MATERIALS

The raw materials which are used for the experiment are discussed below:

- Cement-Ordinary Portland Cement of 43 grade.
- Fine aggregates –Aggregates of size between 4.75mm and 2.36mm are taken.
- Coarse aggregates – Normal coarse aggregates of size between 12 mm and 10 mm are taken.
- LECA & CINDER as replacement to normal coarse aggregates
- Water

Fig. 1. LECA and CINDER

Mix proportions for M25 Grade of light weight AGGREGATE concrete (1:1.41:2.46)

INGREDIENTS	MIX PROPORTION
WATER	197 litres
CEMENT	438 kg/ m3
FINE AGGREGATES	620.63 KG
COARSE AGGREGATES	1077.63 KG
W/C RATIO	0.45
CINDER	754 kg (of CA replaced by volume)
LECA	323 kg (of CA replaced by volume)

4. METHODOLOGY

Batching of concrete: It includes measuring of concrete mix ingredients & introducing them into the mixture. Here cement, fine aggregate, coarse aggregate, LECA & Cinder are measured and batched. Water is measured in volumetric quantity as litre.

Mixing of concrete: It is defined as complete blending of the materials to make a homogeneous product. All ingredients are loaded into mixture & water is added.

Casting: Moulds were cleaned and fitted. The fresh concrete was casted into the specimen using tamping rod with three layers of compaction. The process of placing and compaction are independent and are carried out simultaneously. The mould is compacted using vibrator.

Curing: The specimen were cured under three different conditions such as water curing, air curing & gunny bag curing at ambient temperature. For curing purpose, after 24 hours, one set of specimens are marked and removed from the mould and were immediately submerged in fresh water for water curing and second set of specimens were kept in a gunny bag which is always wetted for gunny bag curing and the third set of specimens were kept in a clean dry place for air curing until testing.

5. EXPERIMENTAL RESULTS

TESTS ON CEMENT

OPC (43 grade) is used in the experimental work. Several experiments are conducted on cement to make sure that it satisfies the all requirements of 4031-1968 specification. The table below shows the test results on cement.

DESCRIPTION	VALUE
SPECIFIC GRAVITY	3.12
INITIAL SETTING TIME	45 MINUTES
FINAL SETTING TIME	330 MINUTES
FINENESS	4%
NORMAL CONSISTENCY	32%

TESTS ON FINE AGGREGATES

The size of the aggregates used was less than 4.75mm and was in accordance with zone 3. River sand was used for this study which was oven dried and devoid of any unwanted material. The specific gravity of sand was found to be 2.61 when obtained. The following table shows the test results on fine aggregates.

EXPERIMENTS	VALUES OBSERVED
SPECIFIC GRAVITY TEST	2.53
WATER ABSORPTION TEST	20.12%
FINENESS MODULUS TEST	4.59

TESTS ON COARSE AGGREGATES

Coarse aggregate are those whose size is more than 4.75 mm. Locally available crushed stones are used as coarse aggregate in this experiment. Size of aggregates varied from 10 mm and 20mm used in the concrete mix.

Properties of these nominal sized aggregates are presented below.

PROPERTIES	VALUES
TYPE	CRUSHED
WATER ABSORPTION	0.1%
SPECIFIC GRAVITY	2.58
FINENESS MODULUS	7.35
AGGREGATE IMPACT VALUE	26.28%
AGGREGATE CRUSHING VALUE	25.07
ABRASION TEST VALUE	24.2%

TESTS ON WATER

Water used for the mixing process is fresh and is free from any organic matter and harmful solutions that lead to the declination in the cement mortar and its characteristics. Salt water generally not used. Water which is potable is used for mixing water as well as for curing of cubes and beams. The following table represents the tests on water

PROPERTIES	VALUES OBSERVED
PH VALUE	7.5
DISSOLVED SOLIDS	280
SUSPENDED SOLIDS	NIL
CHLORIDE CONTENT	22

TESTS ON FRESH CONCRETE

Various tests were conducted on fresh concrete to determine its workability. Workability of concrete is defined as the degree of ability to flow. Higher the slump value; better is the workability of concrete. The following tests were conducted for determining the workability of fresh concrete:

- Slump Test
- Compaction Factor Test

The results of the above tests are represented in the below table

Type of Concrete	Slump Cone Value	Compaction factor
Normal Concrete	10	0.896
Partially Replaced Concrete	50	0.940
Fully Replaced Concrete	55	0.960

TESTS ON HARDENED CONCRETE

Testing of hardened concrete plays an important role in controlling and confirming the quality of concrete. The main purpose of testing hardened concrete is to confirm that concrete has developed the required strength. Some of the tests performed are:

- Compressive Strength Test
- Splitting Tensile Test
- Flexural Test.

These tests were conducted as per IS: 516- 1959. The specimens were caste, cured and the tests were conducted at ambient room temperature after 7 and 28 days. Different specimens were casted by replacement of coarse aggregate with Light weight aggregate such as:

1. Normal Concrete (Control Specimens)
2. Partially replaced concrete (About 30% of coarse aggregate is replaced with LECA by volume).
3. Fully replaced concrete (Coarse aggregate is completely replaced with 70% cinder & 30% LECA by volume).

The results of these tests are represented in the following tables:

Average Compressive Strength Values

Type of Concrete	7 days (MPa)	28 days (MPa)
Normal Concrete	17.12	29.5
Partially Replaced Concrete	16.02	26.12
Fully Replaced Concrete	16.64	27.40

Average Split tensile Values

Type of Concrete	7 days (MPa)	28 days (MPa)
Normal Concrete	1.4	2.2
Partially Replaced Concrete	1.05	1.74
Fully Replaced Concrete	1.28	2.05

Average Flexural Strength Values

Type of Concrete	7 days (MPa)	28 days (MPa)
Normal Concrete	2.86	4.21
Partially Replaced Concrete	2.60	3.35
Fully Replaced Concrete	2.84	3.92

DENSITY OF SPECIMENS:

The measurement of concrete's solidity is called density in concrete. The mixing process of concrete can be modified to form a higher or lower density of concrete. The density of concrete varies depending upon the type of aggregates used in it. Hence, for Light weight concrete, the density is lesser compared to normal conventional concrete. The following table represents the density values

Type of Concrete	Density (kg/m3)
Normal Concrete	2522
Partially Replaced Concrete	2286
Fully Replaced Concrete	2171

FLEXURAL TEST OF REINFORCED LWC BEAMS

Specimen of dimension 120mm×200mm×1950mm were cast according to the above mentioned mix design. The beams were de-mould after 24 hours and kept for curing. The cured beams were subjected to flexure test after 28 days in a compression testing machine. The beam specimens were tested under two-point loads, which were kept at 600 mm apart on a span of 1800 mm under a load control mode with 10 to 15 KN increments until failure. The results of the test are given in the following table

Type of Concrete	28 days (MPa)
Normal Concrete	66.887
Partially Replaced Concrete	64.696

6. CONCLUSIONS

The Lightweight aggregates (LECA and Cinder) can be used as an alternative for conventional coarse aggregates for production of concrete. It develops high durability, high strength and also reduces development of stress cracks. The Compressive test, split tensile test and flexural strength test showed that both the partially and fully replaced LWAC are found to be on par with the control specimen. The light weight aggregate concrete is found to be lesser than the conventional concrete in terms of density. Further, the reinforced Lightweight aggregate beam used in this study closely resembles that of a Normal weight concrete equivalent Beam in terms of flexure. If the concrete strength is increased, the first cracking load also increases. Hence, from these obtained results it can be showed that the coarse aggregates can be replaced by Lightweight aggregates for production of good strength low weight structural concrete.

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