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LDA, AN ECOFRIENDLY ALTERNATIVE TO NATURAL AGGREGATE IN STRUCTURAL CONCRETE FOR ENGINEERING CONSTRUCTIONS

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Abstract

Low Density Aggregate (LDA) made from fly ash, a waste product from the thermal power plant was used to replace the natural aggregate which turn out to be an efficient effort for green concrete. The process of creating LDA uses above 90% fly ash as major raw material mixing with small volume additives, carbonaceous solid fuel and water. The additives are clay and the coal which contributes the carbon percentage depending on the particle size and loss of ignition in the fly ash. After agglomeration and palletisation, the green pellets are transferred to a sinter machine for sintering. The physical characteristic of LDA product is found to be a superior aggregate than the natural aggregates. In this study, at first the concrete cubes were made using cement, sand and natural aggregate by mixing water. The materials were poured inside the 100 mm cube mould for making the samples. Secondly, the same procedure was followed to replace natural aggregate with the LDA keeping cement and sand content as the same. The LDA was collected from IMFA, Choudwar of two grades, one 4mm to 8mm and another 8mm to 16mm. The two aggregates were used in proportion of 40% to 60% respectively of the total LDA percentage. After de-moulding of the concrete cubes with LDA and natural aggregate, the samples were kept in two different curing conditions. One kept for moist curing for 28 days and another kept 28days in air-curing. After 28 days, both the cases of cubes were subjected to the compression test. It was observed that the concrete cube with natural aggregates had ultimate strength of 20.36 MPa, and the cube with LDA showed the ultimate strength of 16.69 MPa under the moist curing for 28days. However, the concrete cubes in air curing showed 17.93 MPa with natural aggregate and 18.3 MPa with LDA. The LDA cubes without curing or air curing showed higher compressive strength than the LDA cube with moist curing which is a positive result for places where curing is difficult to undertake. It was also observed that the compressive strength of the LDA concrete was about 10% less compressive strength than the concrete with natural aggregates under the same cement and sand content. The compressive strength of LDA concrete can be increased by changing the grading of the LDA and adding other admixtures. Due to limitation of time, it is recommended that for future study the LDA concrete should be made with different grades of LDA, 50:50 LDA and natural aggregate replacement, and at different cement content to achieve best results out of LDA.

I. INTRODUCTION

Concrete is the most widely used construction material with the ever increasing industrialization and urbanization, huge amounts of natural resources are required to make concrete. This means that large volumes of natural resources and raw materials are being used for concrete production around the world. To eliminate the negative environmental impact of the concrete industry and promote environmental sustainability, the use of wastes from industry as materials for concrete is considered as an alternative solution for preventing the excessive usage of raw materials. As aggregate represents about 70-80% of concrete components so it will be beneficial to recycle the aggregate for construction works and also to solve the environmental problems. To minimise the

problem of excess of waste material it is a good step to utilize the recycled aggregates provide that the desired final product will meet the standards. The cost of recycled concrete aggregate may be less than 20 to 30 % less than natural aggregate in some regions

By using the recycled aggregate the consumption of natural aggregate can be reduced. Indian construction industry today is amongst the five largest in the world and at the current rate of growth, it is slated to be amongst the top two in the next century. Work on recycled concrete has been carried out at few places in India but waste and quality of raw material produced being site specific, tremendous inputs are necessary if recycled material has to be used in construction for producing high grade concrete.

During the investigations for a civil works structure that incorporates low-density concrete (LDC), it is necessary to assess the availability and suitability of the materials needed to manufacture LDC with qualities meeting the structural and durability requirements of the specific project. Materials involved include cementations materials, fine aggregate (both normal- and low-density), coarse aggregate (both normal- and low-density), water for mixing and curing, and chemical admixtures. And lighter in weight than standard concrete, but just as strong, LDA offers significant dead load savings. This allows for long cantilevers, slimmer general sections and reduced foundations sizes, enabling designers to produce structures that would be very difficult to build in other materials.

Recycled aggregates are seldom utilized in structural applications; instead they have been used as fillers in road construction and in low-level applications due to material defects such as large water absorption capacity and their elongated and angular shape. The experimental results give an encouraging trend towards utilization of recycled aggregates from field demolished concrete by blending with natural aggregates in making recycled aggregate concrete for structural applications.

The compressive strength of recycled aggregate concrete generally decreases with increasing recycled aggregate contents. For a recycled aggregate replacement percentage equals 100%, the elastic modulus is reduced by 45% (Jianzhuang Xiaoa et al, 2004). The workability was good and can be satisfactorily handled for 0% recycled aggregate to 80% recycled aggregate and with more percentage replacement of recycled aggregate used in the concrete specimen, the percentage of tensile strength remained are gradually decreasing(Nelson, 2004).

Concrete made with recycled aggregate produced from construction and demolition waste has a compressive strength (28days) about 27% - 30% less than the strength of the concrete made with natural aggregates (Austin et al, 1995). Concrete results showed that 25MPA and 30MPA strength can be reached using recycled aggregate as a coarse material. Using more than 35% of fine recycled aggregate causes an obvious weakness in the concrete strength.

II. MATERIALS AND METHODS

The laboratory test was conducted in the Structure Lab of the College of Agricultural Engineering & Technology, OUAT .First of all the ingredients for preparing the blocks were collected. The materials were cement, aggregates, sand, water etc. The LDA were collected from IMFA, Choudwar. Other accessories like belcha, cement pan, sieve etc. were in the laboratory of the college. The aggregates were first graded according to the required size and separating the unnecessary waste materials. The desired sized aggregates are kept separately in a bucket and the oversized aggregates were kept aside.

Figure. 1 & 2. Preparation of concrete mix and moulding

A thorough mix of the pre-sample was made by adding cement, sand and water in the ratio 1:2:3. The figures showed the mixing of sand, cement and water until proper proportion is achieved. Representative proportion of sample of concrete was taken for casting cubes. The concrete was filled into the moulds in layers appx. 5cm deep. It was distributed evenly and compacted either by vibration or by hand tampering. After the top layer has been compacted, the surface of concrete was levelled with the top of the mould using a trowel, and covered with glass plate to prevent evaporation.

The specimen was stored at site for 24+1/2h under damp matting or sack. After that, the samples were kept in clean water at $27+2^0$ C, until the test time. The specimen was tested immediately after removal from water and still in wet condition. The bearing surface of the testing specimen was wiped clean and any loose material was removed from the surface. In the case of cubes, the specimen should be placed in the machine in such a manner that the load cube as cast, that is not to the top and bottom. Then the testing was done after aligning the specimen with the steel plates, and no packing was used.

The load was applied slowly without shock, and increased continuously at a rate of appx. $140kg/cm^2/m$ till the resistance of the specimen to the increased load. Then it broke down and greater load could not be sustained. The maximum load applied to the specimen was recorded and the unusual factors marked at the time of failure. Each test specimen was a standard concrete cube ($100mm^3$). A total of 12 no of cubes were made for testing. Concrete cubes were prepared using both natural aggregates and LDA. After filling of mould, it is subjected to vibrator table to eliminate air voids and homogeneous distribution, which indirectly affected the strength of the concrete.

After 24 hours, the cube was demoulded, and cured in lime water for 28 days and the air cured for at least another week at room temperature.

Figure.3. Compression test in the UTM

Theory:

The compressive strength is calculated by using the formula

C (kg/cm^2) = W_f /A_p, where
W_f = Max. applied load just before load (kg)
A_p = Plan area of cube mould (mm^2)

III. RESULTS AND DISCUSSIONS

Concrete cubes are prepared and the specimen taken into consideration for the testing of the load displacement variation of two types of materials. i.e. LDA and NA with curing and without curing process. Various mix properties were like this.

Table.1.MIX PROPORTION:

	LDA (gm.)	NA (gm.)
CEMENT	**300**	**300**
SAND	**663**	**663**
NA	**0**	**1356**
LDA(4-8mm)	**336**	**0**
LDA(8-16mm)	**504**	**0**
WATER	**150**	**150**

The specimens were subjected to moisture curing and another batch of same mix proportion specimens were subjected to air curing for both 14 days and 28 days. All the specimens were subjected to compression test and results were tabulated below.

Table.2.Moist curing:

	14 Days (Mpa)			28Days (Mpa)		
SAMPLES	1	2	3	1	2	3
NA	16.39	__	__	19.71	19.64	20.36
LDA	13.93	__	__	16.69	16.29	16.51

Table.3.Air curing:

	28Days (Mpa)	
SAMPLES	1	2
NA	17.94	18
LDA	16.11	18.3

After comparing both tables we came to know that incase of moist curing NA shows higher ultimate strength. But in case of air curing the LDA has greater ultimate strength. To know more about the characteristics we can obtain LOAD vs DISPLACEMENT graphs.

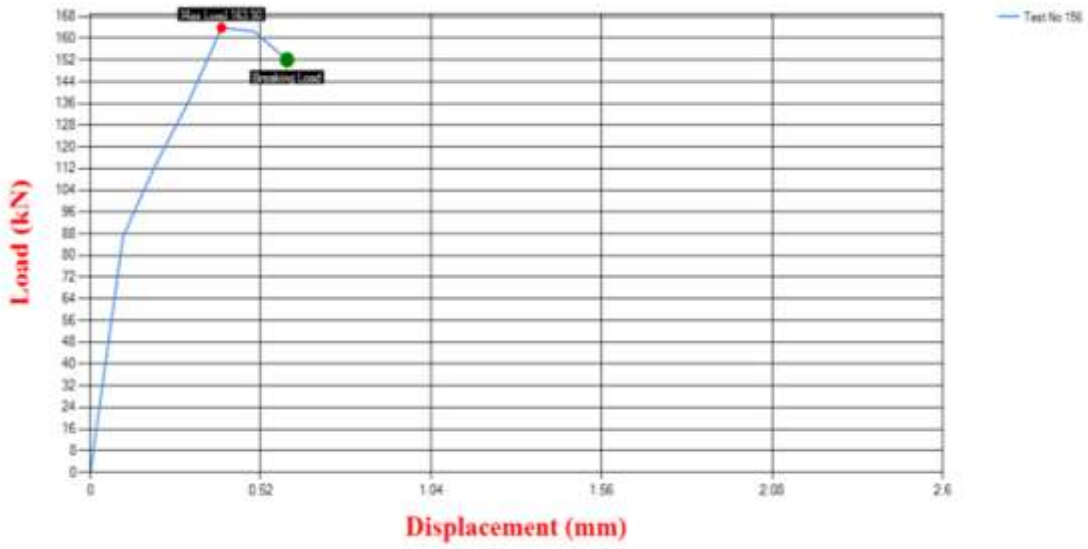

Figure.5.Graph showing the Load-Displacement variation of cube using natural aggregate (After 14days moist curing)

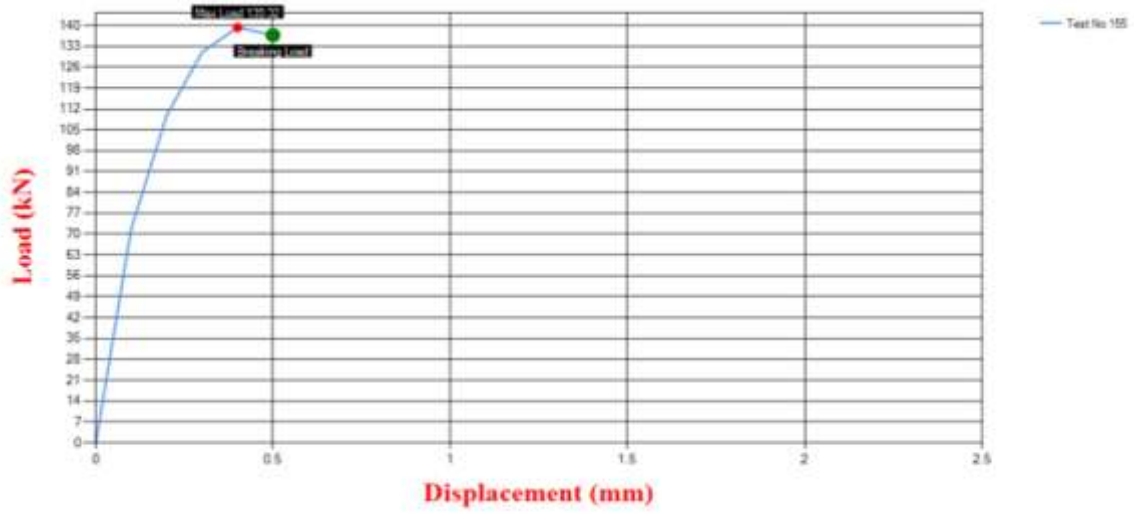

Figure.6.Graph showing the Load-Displacement variation of cube using low density aggregates (After 14 days moist curing)

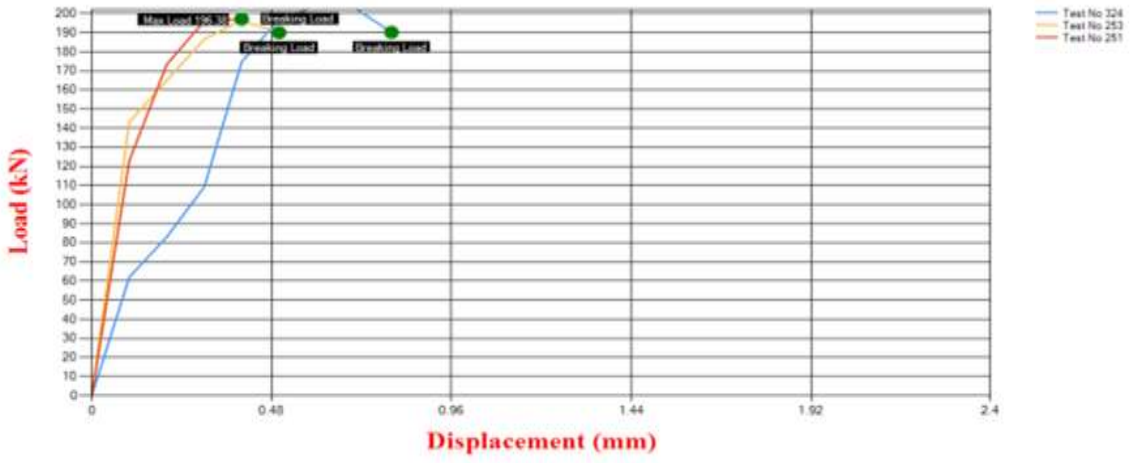

Figure. 7.Graph showing the Load-Displacement variation of cube using natural aggregate (After 28 days moist curing)

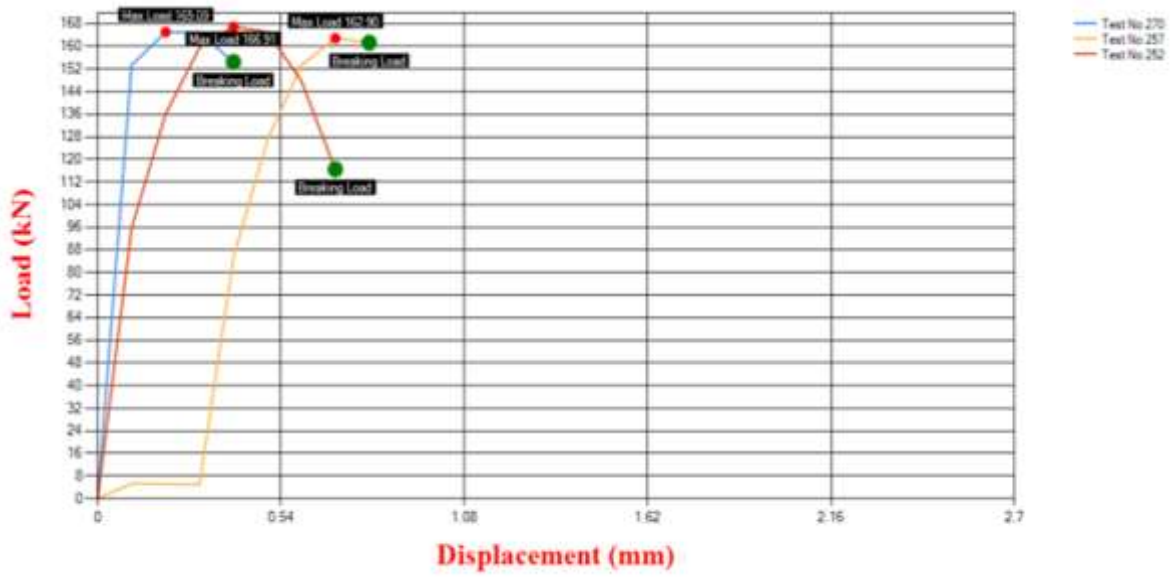

Figure .8.Graph showing the Load-Displacement of cube using low density aggregate (After 28 days moist curing)

Figure .9. Cubes after compression test

IV. CONCLUSION

Low density Aggregates (LDA) are made out of fly ash can play an important role for the future construction industries. It was observed that the comparison between the compression test results obtained from the cube of samples made out of natural aggregate and low density aggregates showed positive results to replace natural aggregates. The cubes of low density aggregate concrete showed 18.3 N/mm^2 compressive strength at 28 days without curing, where as the cubes of natural aggregates showed 18 N/mm^2 compressive strength at the same day. However it was observed that when moist curing was done in the cubes of natural aggregate, showed 19.71 N/mm^2, while the cubes with LDA showed less compressive strength 16.69 N/mm^2, which was not significant. So it is concluded that the LDA, which is made out of waste product of thermal power plant can be replaced with the natural aggregate to keep the ecological balance and can be used as a green building material. LDA concrete can also be used in the places, where moist curing is difficult to achieve.

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