ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.10

Features of Low Density Aggregate & It's Application

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Abstract:
Concrete is one of the most versatile and frequently used materials in construction and has been so since Roman times. India being a developing country will require concrete in huge proportions. Approximately three fourth of the volume of concrete is occupied by Coarse and Fine aggregate (sand). These Coarse aggregates are presently excavation from large mountains and crushed into the different sizes and similarly fine aggregates are mined from the river bed which has long term environmental impact. In order to augment our social responsibility towards preserving Earth to use of alternate Eco-friendly Coarse aggregates in concrete like Low Density Aggregates (LDA). LDA is commonly known worldwide by its generic name i.e. Light Weight Aggregate(LWA)/ Sintered fly ash coarse aggregate and is in wide precedence in UK,USA and the Middle East since last 3-4 decades. This paper highlights the Physical and Chemical properties of the Low Density Aggregate of two size 8-16 mm and 4-8 mm and its application in different areas as building materials. LDA is manufactured by M/s Indian Metals & Ferro Alloys Ltd (IMFA) and stand as the pioneer in India to producing LDA at state of art facility located at Choudwar nearby to Cuttack, Odisha, by utilizing of the fly-ash obtained from own thermal power plants.

Keyword: Concrete; Coarse; Fine; Aggregates; Density; Physical; Chemical; Environment; Sinter

Introduction:
Low Density Aggregate is the only known product in the world to possess the maximum capacity to utilize of Fly Ash as core raw material. It contributes manifold to safe guard the environmental conservation by reducing pollution created by quarrying of mountain to extract conventional stone chips and also by reducing the atmospheric hazards associated with dumping of fly ash in ash ponds and low land fillings. It also contributes to the concept of a greener tomorrow and adheres to the 3R's of waste management i.e. Reduce, Reuse and Recycle.
Apart from these environmental contributions it is an advanced replacement of natural aggregate/granite stone chips commonly used for concrete applications including PCC and RCC as well. It is very much beneficial to the new age construction industry because of its low bulk density, low thermal conductivity, internal curing, better compaction, easy pumpability, usage of less steel reinforcement etc. It has been used to make lightweight concretes and the reduction in concerete density has a significant effect on the dead load of the sturcture. Consequently foudation sizes can be reduced, additional floors can be consturcted, thinner section beams and columns can be used etc.

Manufacturing Process:-

The raw materials are **Fly Ash** which is a waste material from the coal based thermal power plant, **Powder Coal and Water**. It is made by pelletizing the fly ash by adding adequate quantity of powder coal and water in a specially designed disc pelletizing pans, rounded pellets are formed by adjusting the parameters of pelletizer, called as "Green Pellet". The green pellets are then heated on a sinter strand to temperature of around 1100ºC and similarly an adequate amount of suction pressure. The result is a hard, honeycombed structure of interconnecting voids within the aggregate. The particles formed are rounded in shape and range in size from 16mm down to fines. These sintered aggregate are subsequently screened as per required sizes and is ready for use as per the requirement.

Physical & Chemical Properties:-
The performance of concrete are dependent on the properties of the aggregate themselves. As three-fourth of the volume of concrete occupied by aggregate so, the performance of concrete depends on the quality of aggregate used. In general, an aggregate to be used in concrete must be clean, hard, strong, proper shaped and well graded. When determining the strength of normal concrete, most concrete aggregate are several times stronger than the other components in concrete. Not only may the aggregate limit the strength of concrete, as aggregate with undesirable properties cannot produce strong concrete but the properties of aggregate greatly affect the durability and performance of concrete.

Result Analysis:-
Size Gradation:- Size distribution of aggregate plays an important role because, if all the particles of an aggregate are of uniform size, the compacted mass will contain more voids and it will affect the strength of the concrete. The aggregate should be such that the smaller particles fill the voids between the larger particles, in general the aggregate should well graded for which produce better bond and more strong.

- The size distribution of LDA 8-16mm and LDA 4-8 mm confirms to the grading requirement for lightweight aggregate for structural concrete for coarse aggregate size designation 12.5 mm to 4.75 mm and 9.25 to 2.36 mm as per Table 1 of ASTM C 330-99: Standard Specification for Lightweight Aggregate For Structural Concrete.

Strength:-
It is difficult to find out the individual strength of the aggregate but we can get strength of the aggregate usually by some

indirect test: Crushing Value, Impact Value, Abrasion Value as per IS 2386 and Crushing Resistance as per BS EN 13055-2002.

Crushing Value:- The Crushing Value of LDA 8-16 and LDA 4-8 are 43% and 32% respectively and confirms to the IS 383: for the coarse aggregate used for concrete other than for wearing surface.

Impact Value:- The Impact Value of LDA 8-16 is 36 % it confirms to the IS 383: for the coarse aggregate used for concrete other than for wearing surface.

Abrasion Value:- The Abrasion Value of LDA 8-16 and LDA 4-8 are 33% and 32% respectively and confirms to the IS 383: for the coarse aggregate used for concrete other than for wearing surface.

Crushing Resistance :- The Crushing Resistance of LDA 8-16 and LDA 4-8 are 7 Mpa and 8 Mpa respectively.

Bulk Density:-
The Bulk Density of aggregate is defined as the mass of the material is required to fill in a given container in a unit volume it depends on the packing of aggregates i.e loosely or in compact.

- The oven dry loose bulk density of LDA 8-16 and LDA 4-8 are 810 Kg/m³ and 830 Kg/m³ respectively and confirms to the ASTM C330 and BS EN 13055-2002 as per which the maximum oven dry loose bulk density of light weight aggregate is 880 Kg/m³ and 1100 Kg/m³.

Water Absorption:-
The water absorbed by the dry aggregate when immersed in water for 24 hour. The aggregate water absorption is very important for concrete mix design.

- The 24 hour water absorption of LDA 8-16 and LDA 4-8 are 14 % and 13% respectively. As per A. M Neville the 24 hour absorption of lightweight aggregate ranges from 5 to 20 percent by mass of dry aggregate but, for good quality aggregate for use in structural concrete, it is usually not more than 15 percent.

Specific Gravity:-
The specific gravity of an aggregate is defined as the ratio of the mass of solid in a given volume of sample to the mass of an equal volume of water at the same temperature. This is required during concrete mix design.

- The specific gravity of LDA 8-16 and LDA 4-8 are 1.5 and 1.51 respectively in dry condition.

Deleterious Materials and Organic Impurities Content:-
The materials whose presence may adversely affect the strength, workability and long term performance of concrete. These are considered undesirable as constituent because of their intrinsic weakness, softness, fineness or other physical or chemical characteristics harmful to the concrete behavior.

Table -1
Deleterious Materials and Organic Impurities Content

Sl. No.	Parameters	LDA 8-16 mm	LDA 4-8 MM	Requirements As per IS-383
1	Coal and Lignite, percent by mass	Nil	Nil	Max. 1.00%
2	Clay lumps, percent by mass	Nil	Nil	Max. 1.00%
3	Material finer than 75 micron I.S Sieve, percent by mass	0.36	0.33	Max. 3.00%
4	Mica, percent by mass	Nil	Nil	--
5	Organic Impurities	Passes the test	Passes the test	Shall pass the test
6	Total Deleterious materials, percent by mass	0.36	0.33	Max. 5.00%

From the table-1 the deleterious materials and organic impurities content result of LDA 8-16mm and LDA 4-8 mm are 0.36% and 0.33 % respectively and confirms to the IS-383 requirement of maximum 5%.

Alkali Aggregate Reaction :-
The reaction can be disruptive and manifest itself as cracking in concrete which directly affect to the strength of the concrete and eventually failure of concrete structure.

- The alkali reactivity test result for both fraction of LDA is Innocuous as per ASTM C 1260 and IS 383.

Soundness :-
The soundness indicates the ability of the aggregate to resist excessive changes in volume due to changes in environmental conditions and by the chemical reactions between the aggregate and the alkalis in cement, result in deterioration of the concrete.

- The soundness of LDA 8-16mm and 4-8 mm are 1.64% and 0.66% and confirm to the IS 383 requirement of maximum 12%.

Loss on Ignition:-
Loss on ignition indicates the present of unborn carbon in the aggregate. Excessive presence of carbon in aggregate can deteriorate the concrete.

- The loss on ignition of LDA 8-16mm and 4-8 mm are 2.15 % and 2.02 % which confirm to ASTM C 330 requirement of maximum 5%.

Sulphate (So_3):-
Sulphate is harmful to concrete which shall yield in the homogeneous nature of the concrete getting deteriorated subsequently, it may hamper the concrete by manifold cascading effects like Weak Cohesiveness, lagging behind in attaining strength, durability etc.

- The sulphate (So_3) present in LDA 8-16 is 0.1% and is very less.

Table No. 2
TEST RESULT OF LOW DENSITY AGGREGATE

Sl. No.	Name of the Parameters	Size of Low Density Aggregate	
		8 - 16 MM	4 - 8 MM
1	Crushing Resistance (Mpa)	7	8
2	Crushing Value (%)	42	35
3	Impact Value (%)	38	N/A
4	Abrasion Value (%)	32	31
5	Bulk Density (Loose) Kg/m³	815	830
6	Bulk Density (Compact) Kg/m³	860	880
7	Water Absorption 24 hr (%)	14	13.5
8	Specific Gravity	1.51	1.53
9	Deleterious Materials and Organic Impurities Content	0.36	0.33
10	Alkali Aggregate Reactivity Test	Innocuous in Nature	Innocuous in Nature
11	Soundness (Sodium Sulphate, 5 cycles) (%)	1.64	0.66
12	Loss on Ignition (%)	2.15	2.02
13	Sulphate (So_3)	0.1	--

Application:-
As a secondary aggregate manufactured from the by-prodcucts of an industrial process, not only diverts waste from landfill but also reduces demand for natural quarried material. From the sustainability point of view LDA has distinct advangates over natural materials. Low Density Aggregate is an advanced replacement of natural aggregate/granite stone chips commonly used for all sort of concrete applications. Apart from its manifold environmental contributions it is very much beneficial to the new age construction industry because of its low bulk density, low thermal conductivity, internal curing, better compaction, easy pumpability, usage of less steel reinforcement etc. Lighter in weight than normal concrete, but as strong, structural light weight concrete made with LDA. This allows for long cantilevers, slimmer general sections and reduced foundations size. Moreover LDA can reduce the dead load of the concrete structure by 20-23% because of it is comparatively lighter in weight. LDA can be used in all sort of concrete applications including PCC and RCC as well. LDA is best suitable to be applied in the construction of Green buildings, Precast Structures, Landscaping, Floor and Roof Screed, Arrester Bed, Filter madia and as a filling material. It is highly essential for tall rise building where every addion load play a vital role for the building, moreover there is the potentieal additional benefit of reducing project cost. .

Conclusion:-
The physical and chemical test results of LDA shows that the LDA 8-16 mm and 4-8 mm coarse aggregate can be used for concrete applications including PCC and RCC as well. As the Crushing value, Impact Value and Abrasion value of LDA is more than 30% it is advisable that LDA should avoided for using in wearing surface. However various codal provision needs to amended with proper specification. Once the guide lines and the codes of practices are available, then its becomes more easy to use in concrete by purcheser.

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