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Investigations on Properties of Light Weight Cinder Aggregate Concrete

E.Hanuman Sai Gupta[1], V.Giridhar Kumar[2]
E. Hanuman Sai Gupta (M. Tech(Structural Engineering) student, G.Pulla Reddy Engineering college. Kurnool)
V. Giridhar Kumar (Assistant Professor of Civil Engineering, G. Pulla Reddy Engineering College. Kurnool)

Abstract:- With the advent of Industrial development and mass constructions in various parts of the world, the pollution levels as well as scarcity of construction materials have reached the peak level. Iron manufacturing companies produce large amounts of by - product namely Cinders. It is named as artificial light weight aggregate as it produces low density concretes. In the present day construction, it is used as a bottom or sub grade aggregate in floorings as well as washrooms in buildings and pavement construction. The present investigations involve the use of cinder aggregate in making conventional concrete by replacing the conventional granite and fine aggregate in partial or full amounts. In this paper, the effects of cinder aggregate and cinder powder on mechanical properties of concrete are presented. Cinder aggregates being light in weight, the dead loads of the structure are significantly reduced. Investigations are carried out by replacing the granite coarse aggregate with different percentages of cinder aggregate with water-cement ratio 0.47. Similarly fine aggregate (sand) is replaced by cinder powder partially. A 20 mm nominal size cinder coarse aggregate along with cinder powder were used at different percent replacement levels in conventional M25 grade design mix concrete. Cubes, cylinders and beam specimens of standard sizes are casted and tested for compression, split and flexural tension at 28 days respectively. Test results conclude that cinder is one among the best alternatives for coarse and fine aggregates for making conventional concrete in respect of the properties like density and workability, though the strength development is low at different replacement levels.

Keywords:- Cinder aggregate, cinder powder, Light weight aggregate concrete, Density, workability.

I. INTRODUCTION

Concrete is one of most versatile material used in building construction. In structural applications, the self-weight of the structure is quite important as it represents a major portion of its dead load. Replacing partially or entirely the coarser normal weight aggregate in conventional concrete can be replaced partially or fully with low density aggregates will produces lightweight concrete that can reach a reasonably good compressive resistance. The advantages of lightweight concrete are its reduced mass and improved thermal and sound insulation properties, while maintaining adequate strength. The reduced self-weight of LWC will reduce the gravity load as well as seismic inertial mass which leads to decreased member sizes as well as forces on foundation can be reduced . Aggregates contribute an important role in concrete volume as they contribute to 60 to 70 percent of the total volume. Thus they have an major influence on the different material properties like density, specific gravity, water absorption etc.,

Cinder is the material comes under the category light weight aggregate and it is a byproduct of steel, iron manufacturing companies. The surface of cinder aggregate is usually rough and highly porous due to mineral structure. The cinder material visually classified as having 100% crushed face.

Cinder aggregates are used for making building blocks for partition walls, for making screeding over flat roofs and for plastering purposes because of its less weight. linear coeff. Of thermal expansion is about 3.8* 10-6 c. Cinder contains large percentage of air, so it is naturally a better material with respect to sound absorption, sound proofing and thermal insulation. Due to its low density it helps in reduction of dead load, increases the progressing of building, and lowers handling costs. The most important characteristic of light weight concrete is the relatively low thermal conductivity. Due to its low specific gravity, the concrete made with it is lighter than natural concrete.

II. REVIEW OF LITERATURE

Dr.Bashkar Desai et al., describes experimental investigation an attempt is to be made to study the strength properties of light weight cinder aggregate cement concrete in different percentage proportions of 0, 25, 50, 75 and 100 by volume of light weight aggregate concrete can be prepared. By using this properties such as compressive strength, split tensile strength, modulus of elasticity, density and shear stress.

N. Siva lingaRao, et.al ., concluded that 60 percent replacement of conventional aggregate with cinder by volume along with cement replaced by 10 percent of silica fume by weight, yields the target mean strength of M20 concrete. It is worth to be noted that there is a slight increase in strength and other properties due to extended curing periods and the unit weight of the cinder concrete is varying from 1980Kg/m³ to 2000Kg/m³ with different percentages of cinder. It is also noted that there is a decrease in density after extended curing periods.

Rathish Kumar P. et al ., has studied the strength and sorptivity characteristics of concrete made with cinder-based lightweight aggregates. Prior to this the size of cinder based light weight aggregate was optimized. The mechanical properties , compressive strength and split tensile strengths were studied at the end of 3, 7 and 28 days for medium grade concretes with different sizes of aggregate. It was noted that with 12.5mm size aggregate and 30% fly ash replacement, the mechanical properties were superior in 20Mpa Light weight Concrete, while 10 mm size aggregate with a 30% fly ash replacement improved the properties of 30Mpa concrete.

P.S. Raghuprasad et al., as studied the coarse aggregates in the conventional solid concrete blocks were replaced partially with Cinder (12mm) and tested for compressive strength at the age of 3days, 7days and 21days. From the results of the investigation, it can be concluded that solid concrete block with 15% replacement of coarse aggregate by cinder records more strength than the conventional one.

Owens, P.L. et al., had stated that Light weight aggregate concrete was used for structural purposes since the 20th century. As per this study, the Light weight aggregate concrete is a material with low unit weight and often made with spherical aggregates. The density of structural Light weight aggregate concrete typically ranges from 1400 to 2000 kg/m³ compared with that of about 2400 kg/m³for normal weight aggregate concrete.

M. A. Caldarone and R. G. Burg et al., Structural lightweight concrete is defined as concrete made with low- density aggregate having an air-dry density of not more than (1850 kg/m³) and a 28-day compressive strength of more than (17.2 MPa). This paper presented the test results of very low- density structural lightweight concrete mixtures developed in the laboratory for the purpose of finding a suitable mixture for use on a historic building rehabilitation project. Mixture parameters included a specified compressive strength of 3000 psi at 28 days and an air-dry density approaching 70 lb/ft3. Various constituent materials, mixture proportions and curing methods were examined. The result of this research exemplifies the feasibility of achieving very low densities with structural concretes.

Nataraja M C et al., : studied to advance a step-wise procedure to proportion plain and slag concrete mixes with burnt coal cinder waste as coarse aggregate. The mix design can be economized by using significant amount of GGBS as replacement to cement. Concrete mixes are designed with cement alone and with cement and GGBS at 30% and 60% replacement levels using burnt coal cinder. Concrete with conventional granite aggregate is also cast and tested for comparison.

III. MATERIAL PROPERTIES

Ordinary Portland cement of 53 - grade conforming to IS: 12269 -1987 with a specific gravity of 3.13 with initial setting time of 50 minutes has been used in present investigations. Well graded locally available river sand passing through IS 4.75 mm sieve with specific gravity 2. 57 and fineness modulus 2.68 is used. Natural granite aggregate passing through I.S 20-mm sieve with specific gravity 2.75 and cinder aggregate passing through I.S 20 - mm sieve with specific gravity 2.05 is also used. Tests on physical properties like bulk density, specific gravity, water absorption, and fineness modulus were conducted for fine and coarse aggregates respectively in the laboratory and the results are tabulated. These results are used in concrete mix design. The mix proportions are also tabulated in Table 3

PHYSICAL PROPERTIES OF MATERIALS

The properties of cement were: specific gravity 3.13, Normal consistency 32%, compressive strength of standard mortar cubes = 55.6 MPa.

The physical properties of fine aggregate (river sand) are indicated in table 1.

Table No.1

Property Name	River Sand (F.A)
Specific gravity	2.57
Fineness modulus	2.68
Free surface moisture (%)	2.0
Water absorption (%)	1.1

The physical properties of Coarse aggregate (Crushed granite) are indicated in table 2.

Table No. 2

Property	Coarse aggregate	Cinder
Specific gravity	2.75	2.05
Fineness modulus	4.6	2.82
Water absorption (%)	0.5	1.3
Maximum nominal size	20mm	20mm

Table 3: Materials requirement for one cubic meter of concrete

Material	Granite aggregate	Cinder aggregate
Cement (kg/m^3)	419	419
Fine Aggregate(kg/m^3)	643	513
Coarse Aggregate(kg/m^3)	1152	859
Water(lit)	197	197

IV. EXPERIMENTAL PROGRAMME

The basic constituents of concrete mixes are cement, fine aggregates (sand and cinder powder) , coarse aggregates (granite and cinders – 20 mm nominal size), and water. Fine aggregate has been procured from nearby river Tungabhadra , conventional granite coarse aggregate(20mm machine crushed) has been procured from local quarry available near Dinnedevarapadu Kurnool, and pure portable water is used for making concrete mixes. Concrete Mix has been designed for M25 grade concrete mix has been designed according using IS code. A water cement ratio of 0.47 has been adopted for both granite and cinder concrete mixes. Concrete has been placed in standard moulds in three layers and the each layer is compacted by tamping rod and vibrated on table vibrator for 10 to 15 seconds for full compaction. The top surfaces of concrete specimens were finally finished for smooth surface. Cubes (150 x 150 x 150), cylinders (150 x 300), beams (100 x 100 x 500) mm of standard sizes were casted and tested for 28 days curing period and results for compressive strength, split tensile strength and Flexural strength of concrete are tabulated in tables 6, 7 and 8 for cinder aggregates as replacement and Table 9 for cinder powder for as replacement respectively. Results for Density for concrete mixes are tabulated in table no.10 respectively.

TABLE 4: MIX PROPORTIONS FOR CINDER AS COARSE AGGREGATE

Mix Designation	Natural Aggregate (%)	Cinder Aggregate (%)
M-0	100	0
M-1	80	20
M-2	60	40
M-3	40	60
M-4	20	80
M-5	0	100

Table 5: MIX PROPORTIONS FOR CINDER POWDER AS FINE AGGREGATE

Mix Designation	Fine Aggregate (%)	Cinder powder (%)
M-6	100	0
M-7	90	10
M-8	80	20
M-9	70	30
M-10	60	40
M-11	50	50

V. RESULTS AND DISCUSSIONS

Compressive strength of Cinder Aggregate Concrete:-

Figure 1 shows the variation of compressive strength with percent replacement of cinder aggregate in conventional concrete. The results for compressive strength for the replacement levels 20%, 40%, 60%, 80%, and 100% of cinder aggregate are shown in table 6. Results show that 40 % replacement level of cinder aggregate will give maximum compressive strength of 32 MPa which is above the target mean strength of 31.6 MPa for M25 design mix. This shows that this replacement level will not affect the desired target strength. However the compressive strength decreases for mixes with replacement levels above 40%. The results are shown in fig.1.

Table 6: cube compressive strength results (average of three cubes)

Mix Designation	Percentage Replacement Of C.A(%)		Compressive strength (MPa)	Percentage decrease in compressive strength
	Granite Aggregate	Cinder Aggregate		
M-0	100	0	36.0	0
M-1	80	20	33.5	6.94
M-2	60	40	32.0	11.11
M-3	40	60	31.3	13.05
M-4	20	80	29.7	17.50
M-5	0	100	27.6	23.33

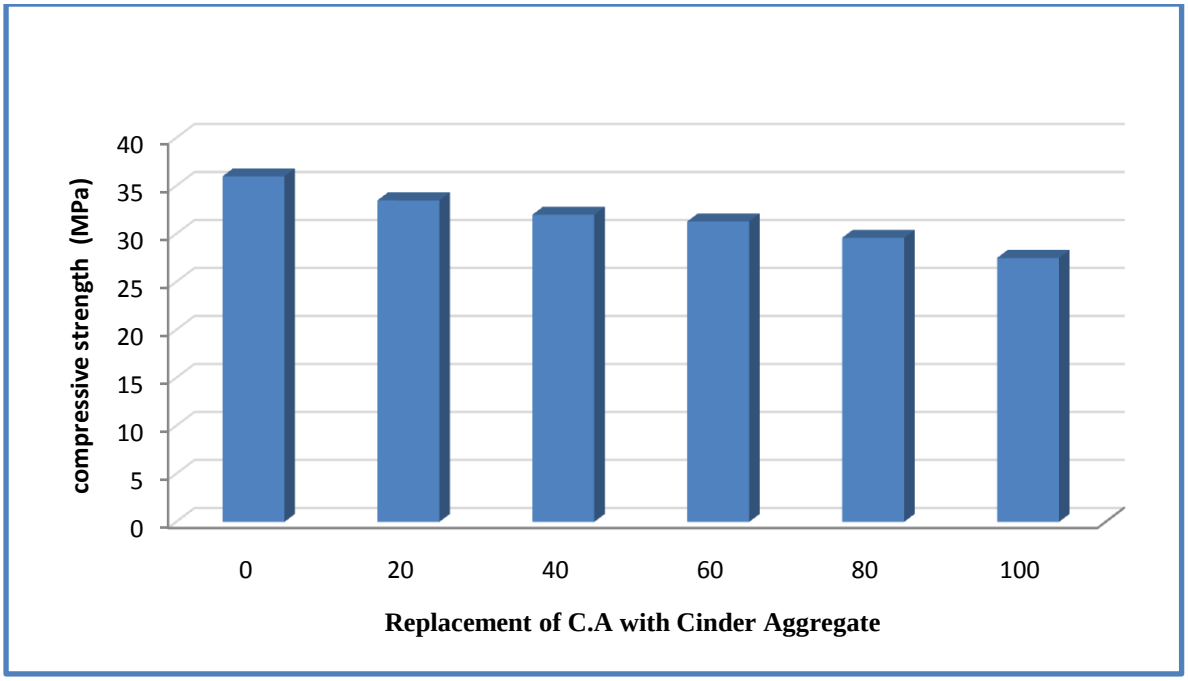

Fig.1 : Variation of Compressive strength with percent Replacement of cinder aggregate

Figure 2 and 3 shows the variation of tensile strength with percent replacement of cinder aggregate in conventional concrete. The results for split tensile strength for the replacement levels 20%, 40%, 60%, 80%, and 100% of cinder aggregate are shown in table 7. The results conclude that the tensile strength in split and flexural decrease gradually with increasing replacement levels of cinder aggregate. Further investigations are carried for improving tensile strength of mixes y incorporating fibers at some percentage into the concrete. The results are graphically shown in fig2 and fig.3.

Table 7: split tensile strength results

Mix Designation	Percentage Replacement Of C.A(%)		split tensile strength (MPa)	Percentage decrease in Tensile Strength
	Granite Aggregate	Cinder Aggregate		
M-0	100	0	3.9	0
M-1	80	20	3.6	7.69
M-2	60	40	3.5	10.25
M-3	40	60	3.3	15.38
M-4	20	80	3.0	23.07
M-5	0	100	2.8	28.20

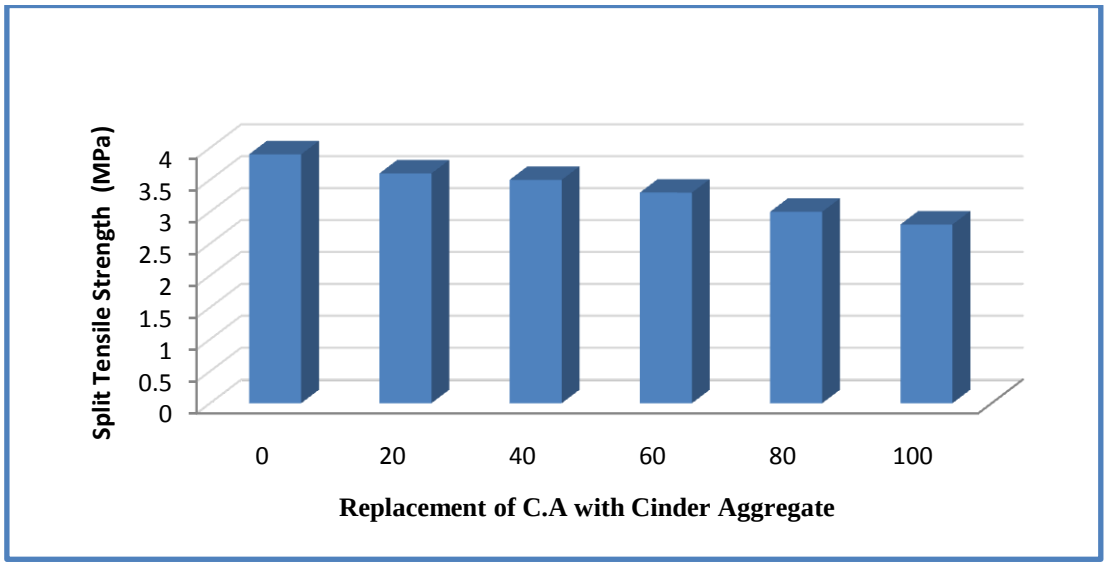

Fig.2: Variation of Split Tensile strength with percent Replacement of cinder aggregate

Table 8: Flexural strength results

Mix Designation	Percentage Replacement Of C.A(%)		Flexural Tensile strength (MPa)
	Granite Aggregate	Cinder Aggregate	
M-0	100	0	7.8
M-1	80	20	7.1
M-2	60	40	6.0
M-3	40	60	5.7
M-4	20	80	5.6
M-5	0	100	5.2

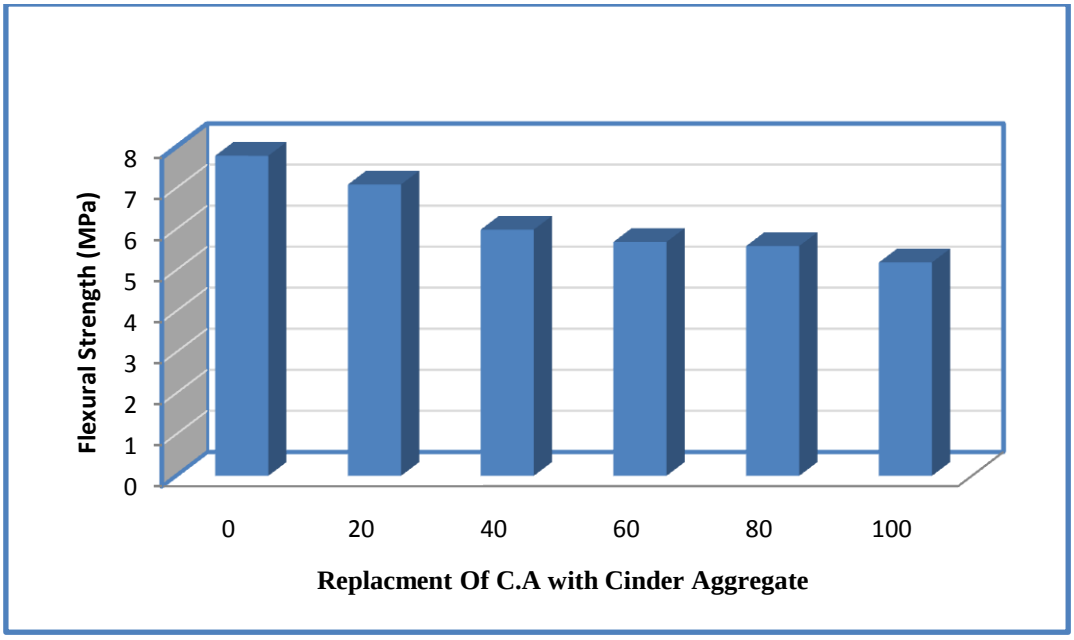

Fig.3: Variation of Flexural strength with percent replacement of cinder Aggregate

Fig.4,5,6 will show the variation of compressive strength and tensile strength for various percent replacement levels of cinder powder in cinder aggregate concrete. Tests on cinder aggregate concrete revealed that the maximum compressive strength more than target mean strength be achieved at 40% replacement of cinder aggregate. Table 9 shows the results of variation of compressive and tensile strengths of cinder aggregate concrete with partial replacement of fine aggregate with cinder powder at 10 % to 50 % respectively. These mixes are designated as M-6 to M-11 with cinder powder 0 to 50 % respectively. For all these mixes the 40 % cinder aggregate is taken as optimum level as it attains maximum compressive strength. Results shows that the strength values will decreases gradually with the increase of cinder powder percentage. Results graphically shown in fig. 4,5,6 respectively.

Table 9

Mix designation	Fine aggregate Replacements (%)		Coarse Aggregate Replacement (%)	Compressive Strength (MPa)	Split Tensile Strength(MPa)	Flexural Strength (MPa)
	Sand	Cinder powder	Cinder Aggregate			
M-6	100	0	40	32.8	3.63	6.5
M-7	90	10	40	32.0	3.54	6.12
M-8	80	20	40	31.7	3.46	6.04
M-9	70	30	40	31.3	3.41	5.64
M-10	60	40	40	30.9	3.32	5.33
M-11	50	50	40	30.7	3.29	5.13

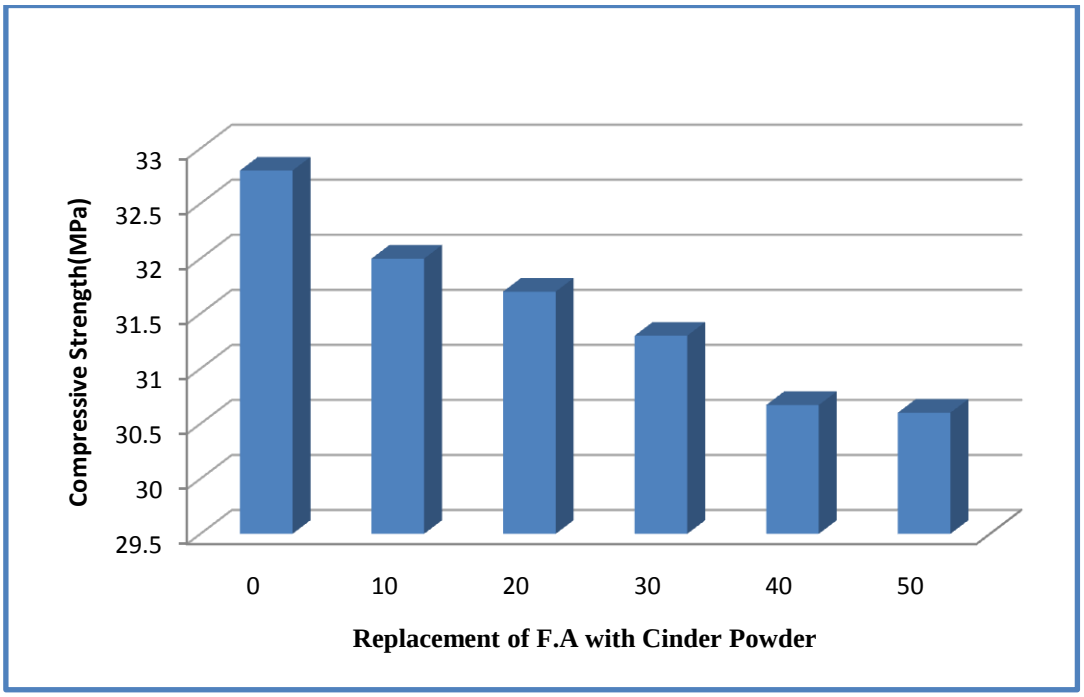

Fig.4 : Variation of Compressive Strength with percent replacement of Cinder Powder and cinder aggregate

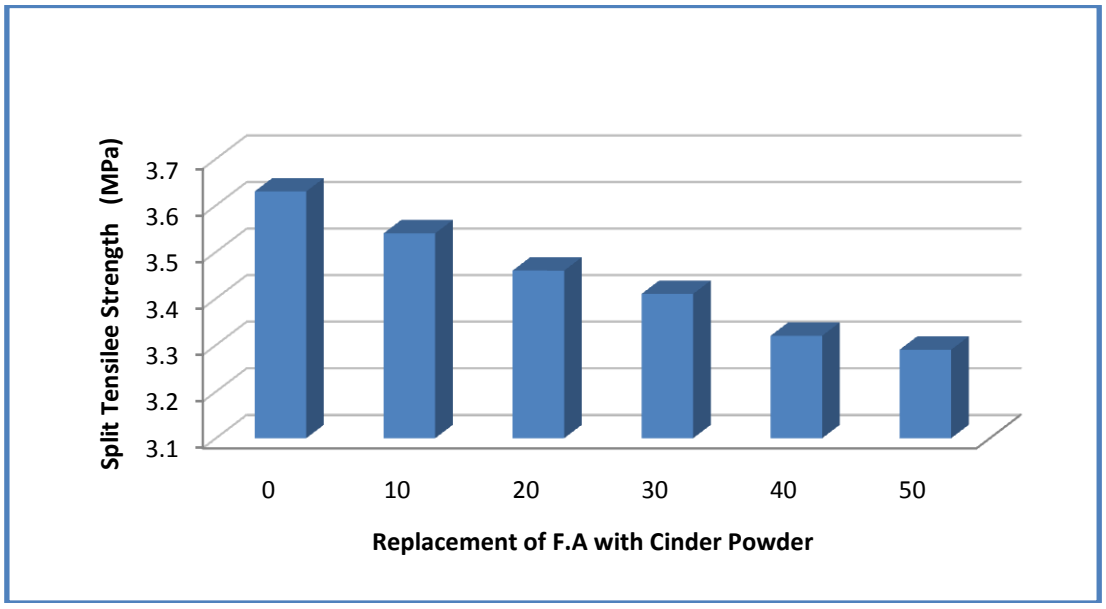

Fig.5 : Variation of split tensile Strength with percent replacement of Cinder Powder and cinder aggregate

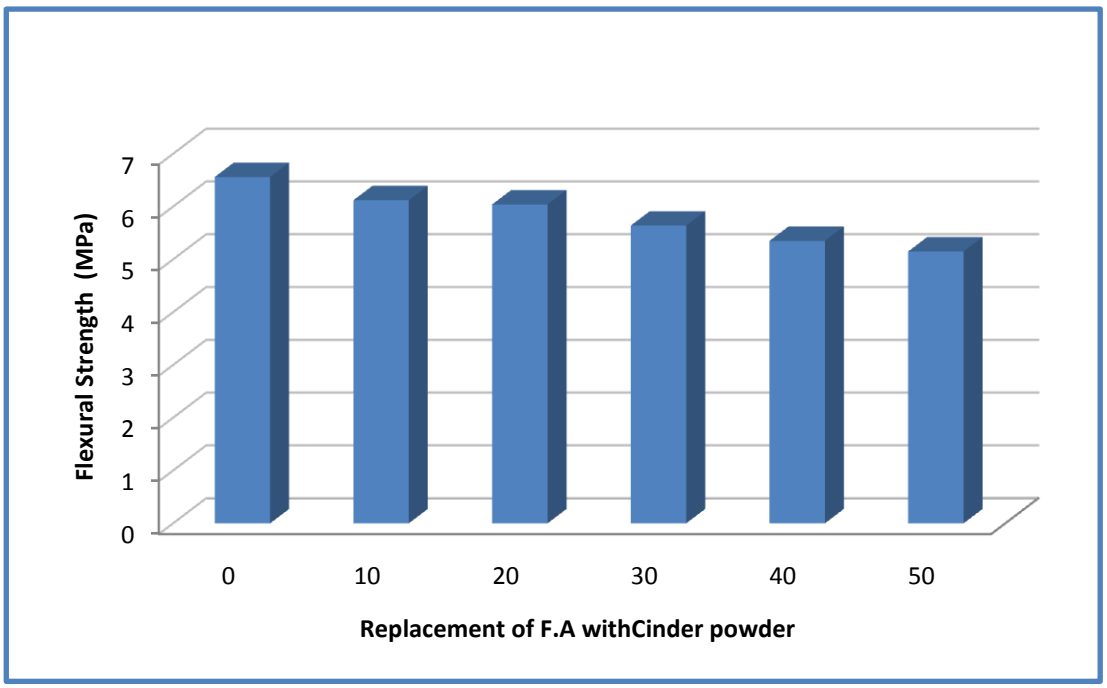

Fig.6: Variation of Flexural Strength with percent replacement of Cinder Powder and cinder aggregate

Table 10 shows the results of densities of concrete mixes from M-1 to M-5 with cinder aggregate replacement levels of 0 to 100 %. The percent decrease in density is observed as 18 % for M-5 mix similarly the density of concrete mix M-6 to M-11 in table no.11 . These densities are with reference to the replacement level of 40 % in conventional concrete. Densities are measured with cinder powder replacement levels of 0 to 50%. Results clearly declared that cinder aggregate best alternate to produce light weight low density concrete with densities varying from 2580 to 2100 kg/m^3

Table 10: Density Results of cinder aggregate

Mix Designation	Percentage Replacement Of C.A (%)		Density (kg/m^3)	Percentage decrease in Density
	Natural Aggregate	Cinder Aggregate		
M-0	100	0	2580	0
M-1	80	20	2536	1.70
M-2	60	40	2400	6.9
M-3	40	60	2282	11.5
M-4	20	80	2193	15.0
M-5	0	100	2103	18.5

Table 11: Density results of cinder powder

Mix Designation	**Percentage Replacement of F.A (%)**		**Density (kg/m^3)**	**Percentage decrease in density (%)**
	Fine Aggregate	**Cinder powder**		
M-6	**100**	**0**	**2385**	**0**
M-7	**90**	**10**	**2341**	**1.84**
M-8	**80**	**20**	**2311**	**3.10**
M-9	**70**	**30**	**2266**	**4.98**
M-10	**60**	**40**	**2223**	**6.80**
M-11	**50**	**50**	**2207**	**7.46**

Plate: Specimen under Flexural Strength Test

VI. CONCLUSIONS

The following conclusions were drawn from experimental investigations:

1 Cinder aggregates are light in weight with low specific gravity (G= 2.05). it is considered as best alternative to conventional coarse aggregate to produce light weight concrete. From the above test results it is concluded that the crushing (quality) Strength is low when compared with Normal granite Aggregate.

2. Densities of concrete mixes with increase in cinder percentages are observed as smaller than conventional normal aggregate concrete. Use of cinder aggregate reduces the dead weight of structure considerably compared to that when conventional concrete is used.

3. Cinder aggregate concrete has good workability properties compared to conventional concrete without cinder. structural light weight concrete with compressive strength above 17 MPa can be produced using cinder aggregate with considerable maximum slump values ranging from 75 to 100 mm. this shows that cinder aggregate concrete have good flow value when used in Congested steel environment.
4. The use of cinder powder doesn't cause serious effect on strength properties of concrete. The percent decrease of strength is comparative low with partial replacement of fine aggregate with cinder powder.
5. Cinder aggregate concrete with replacement level of 40% of cinder achieved the equal target mean strength as conventional concrete(32 MPa).This shows that granite aggregate can be replaced with 40 % Cinder aggregate to achieve target mean strength at 28 days. The strength of light weight concrete may also varies from about .3 MPa to 40 MPa
6. Structural light weight concrete is a concrete having 28 days compressive strength more than 17 MPa. From test results it is concluded that cinder aggregate is effectively used as coarse aggregate replacement up to 100 %. It produces structural light weight concrete.

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V.Giridhar Kumar is presently working as Assistant Professor in the Department of Civil Engineering, G.Pulla Reddy Engineering College (Autonomous), Kurnool A.P. He has 13 years experience in teaching and in construction. He worked earlier as Site Engineer (Civil), Reynolds Engineers and consultants, Hyderabad and as Assistant Engineer (civil), CES (India) limited, Hyderabad for 3 years. His interested research areas include the Finite Element Methods and Modeling, material composites in concrete applications research. He is member of The Institution of Engineers (India), Kolkata.

E.Hanuman Sai Gupta is currently pursuing M.Tech (Structural Engineering) in Civil Engineering at G.Pulla Reddy Engineering College (Autonomous), Kurnool A.P. He is presently investigating the feasibility of light weight cinder aggregate as replacement material in light weight concrete mixes as a part of the intended course work for the completion of M.Tech degree.