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Structural Properties of Silica Fume Modified Light Weight Aggregate (Cinder) Concrete

N. Sivalinga rao[1], V. Bhaskar Desai[2] and B.L.P.Swamy[3]
[1]*Dy.Exe. Engineer, JNTUA*
[2]*Professor JNTUA Anantapur,*
[3]*Professor Vasavi College of Engineering, Hyd.*

Abstract: *Light weight concrete has become more popular in recent days owing to the tremendous advantages it offers over the conventional concrete but at the same time strong enough to be used for the structural purpose. Lightweight concrete has been successfully used since the ancient Roman times and it has gained its popularity due to its lower density and superior thermal insulation properties. Compared with normal weight concrete, Lightweight concrete can significantly reduce the dead load of structural elements. The most important characteristic of light weight concrete is its low thermal conductivity. This property improves with decreasing density. In the present experimental investigation, cinder, which is an industrial waste from steel manufacturing units, is used as a replacement of conventional aggregate. The conventional mix has been designed for M_{20} grade concrete and is adopted with a water cement ratio 0.50. From the experimental investigations, it is concluded that conventional aggregate replaced with 40% cinder aggregates by volume and cement is replaced with 10% silica fume by weight, it is reaches the target mean strength of conventional aggregate concrete. With 100% cinder aggregate in the normal coarse aggregate and cement replaced with silica fume in weight percentages of 0%, 5%, 8%, 10%, 15% and 20%, compressive strength, split tensile strength, flexural strength , moment carrying ,modulus of elasticity and strain energy stored capacity of concrete specimens increase up to 10% of silicafume and then decrease.*

Keywords: *strain energy, moment carrying, modulus of elasticity*

I. Introduction

1.1. Necessity of Light Weight Concrete

One of the disadvantages of conventional concrete is its high self weight. This heavy self weight of concrete makes it to some extent uneconomical structural material.

1.2. Design of Light -weight Aggregate Concrete Mix

Mix design methods applying to normal weight concrete are generally difficult to use with light weight aggregate concrete. The lack of accurate value of absorption, specific gravity, and the free moisture content in the aggregate make it difficult to apply the water/cement ratio accurately for mix proportioning. Light-weight concrete mix design is usually established by trial mixes.

1.3 Cinder Aggregate:

Cinder is the material with partly fused or sintered particles arising from the combustion of coal. Pulverized coal is more commonly used as light weight aggregate. It is an industrial waste. The cinder aggregates cannot be really brought under light weight aggregate because the concrete made with this aggregate will not come under the category of light weight aggregate concrete. However since the weight of such concrete will be less than the weight of normal concrete it is included here.

II. Literature Review

Takafumi Noguchi, et al., [1] conducted researches on light weight aggregate concrete and suggested a formula for modulus of elasticity. They have arrived at the formula from the test results of different light weight aggregate concrete specimens. The formula is,

$$E = K_1 \times K_2 \times 1.486 \times 10^{-3} \sigma_b^{1/3} \times \gamma^2$$

Where σ_b = Compressive strength in Mpa
γ = Density in Kg/m^3 of concrete
K_1 = 0.95 (Correction factor corresponding to coarse aggregates)
K_2 = 1.026 (Correction factor corresponding to mineral admixtures)

Chi JM, et al., [2] also stated that Commercially produced lightweight aggregates were used in concrete by many researchers to investigate the strength, stiffness and durability of concrete.

Campione, G., et al., [3] reported that the brittle nature of lightweight concrete greatly depends on the aggregates used and in particular on their density: in general, greater aggregate density improves the strength of the material to the detriment of the non-structural properties mentioned above. This disadvantage can be overcome by increasing the ordinary confinement transverse reinforcement and/or by adding reinforcing fibers to the concrete matrix, as has been shown in several recent studies.

Alduaij et al. [4] studied lightweight concrete using different unit weight aggregate including lightweight crushed bricks, lightweight expanded clay and normal weight gravel without the use of natural fine aggregate (no-fines concrete). They obtained a lightweight concrete with 22 MPa cylinder compressive strength and 1520 kg/m3 dry unit weight at 28 days.

Wasserman and Bentur [5] had shown that the strength of the concrete could not be accounted for by the strength of the aggregates only and it was suggested that the absorption and pozzolanic activity of the aggregates could have an influence on the strength developed.

4.0. Experimental Investigation: Materials

4.1. Cement: O P C of 43 grade.

4.2. Silica fume: Surface area about 30,000 m^2/kg

4.3. Fine Aggregate: Conformed To Grading Zone-II

4.4. Coarse Aggregate: Conventional Granite

Fully compacted density of coarse aggregate is 1690 kg/m^3

Partially compacted density of coarse aggregate is 1466 kg/m^3

4.5. Light weight aggregate: cinder

Fully compacted density of Lightweight coarse aggregate is 1098kg/m^3

Loose density of Light weight coarse aggregate is 962kg/m^3

4.6. Water: Potable water

4.7. Super Plasticizer: SP-430, Fosrac

4.8. Mix Case Considered: M_{20}

4.9. Reinforcement details: Beams and Slabs: 8mm dia,Fe-415 grade Steel

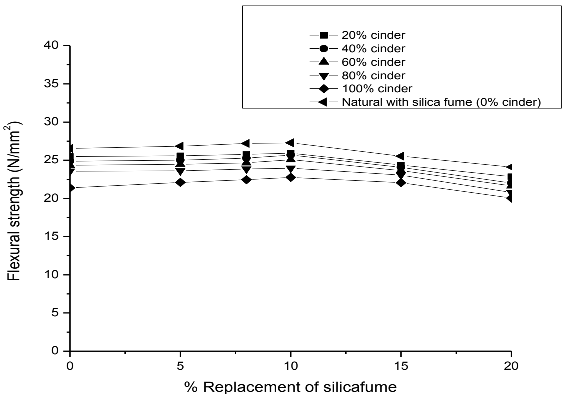

Fig.1. Super imposed variation of Flexural Strength Vs Replacement ofcement by silicafume

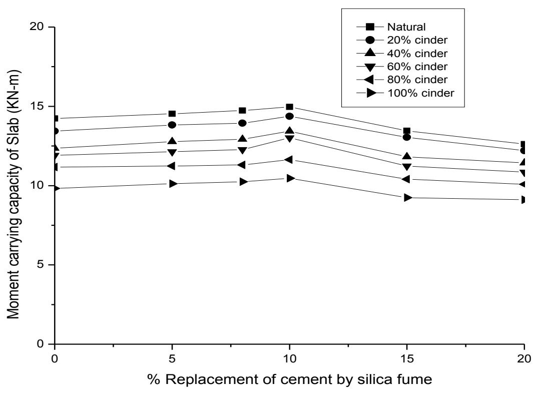

Fig.2. Super imposed variation of Moment carrying capacity of slab Vs Replacement of cement by silica fume

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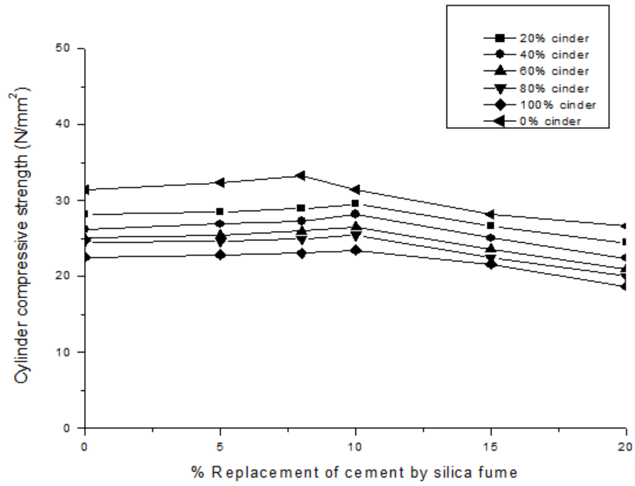

Fig.3. Super imposed variation of Cylinder compressive strength Vs Replacement of Cement by Silicafume

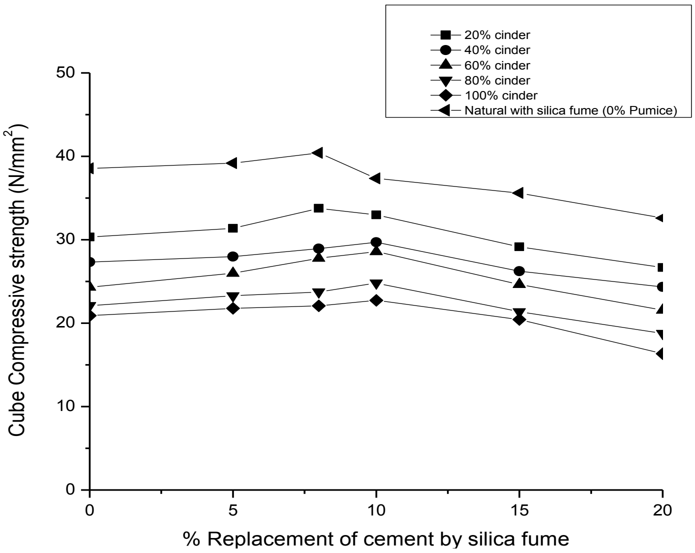

Fig.4. Super imposed variation of Cube compressive strength Vs Replacement of Cement by Silica fume

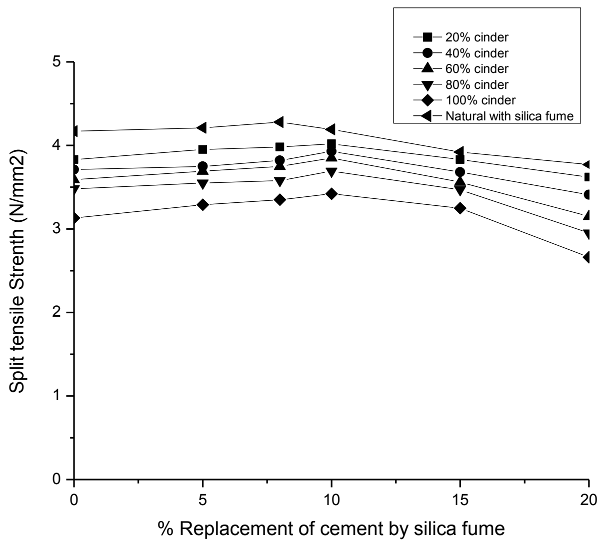

Fig.5. Super imposed variation of Split tensile strength Vs Replacement of Cement by Silicafume

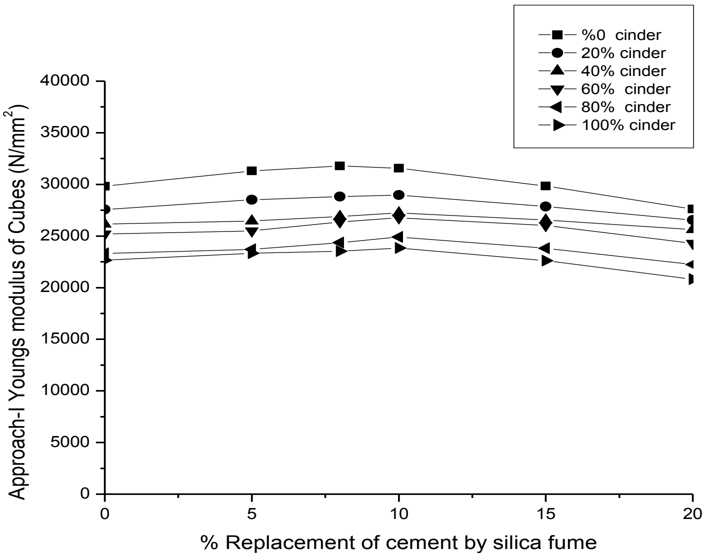

Fig.6. Super imposed variation of Approach-I Youngs Modulus Vs Replacement of cement by silicafume

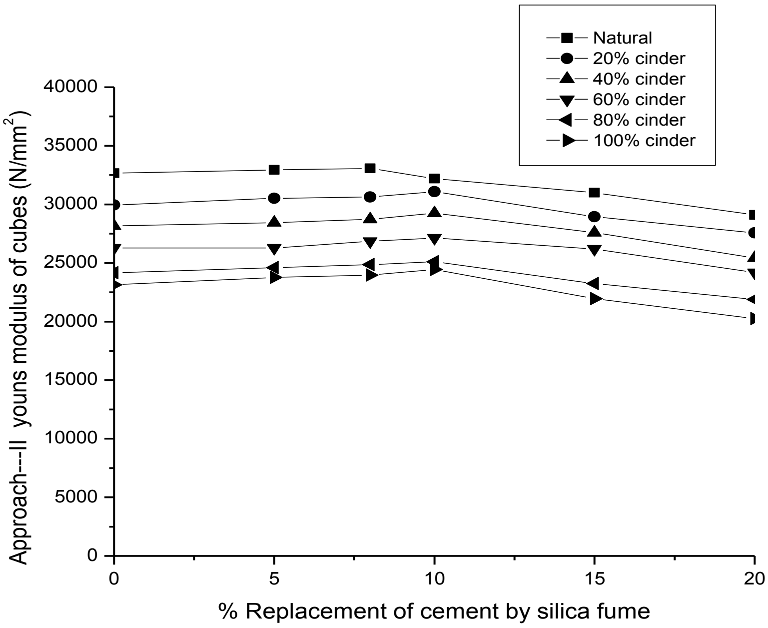

Fig.7. Super imposed variation of Approach-II YoungsModulus Vs Replacement of cement by silicafume

Table.1. Strain Energy Stored In Beams

S No	Id	Percentage Of Granite Aggregate	Percentage Of Cinder Aggregate	Percentage replacement Of cement by silicafume	Strain Energy Stored in Beams (mm^2)
1	**B3**	**60**	**40**	**10**	28910.07
2	**E3**	**0**	100	10	**25870.07**

Table.2. Strain Energy Stored In Slabs

S No	Id	Percentage Of Granite Aggregate	Percentage Of Cinder Aggregate	Percentage replacement Of cement by silicafume	Strain Energy Stored in Slabs (mm^2)
1	**B_3**	**60**	**40**		120483.62
2	**E_3**	**0**	**100**		90576.69

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Plate 1. Crack Pattern of Beam

Plate 1. Crack Pattern of slabs

III. Conclusions

1. More than the target mean strength of concrete is obtained with 40 percent replacement of conventional aggregate by cinder aggregate and with 10 percent of cement replaced with silica fume. Also the compressive strength of cinder concrete with 60% cinder content and 10%silica fume is seen to have achieved a strength more than tangent mean strength of M20 grade concrete.
2. The Young's modulus values of cinder concrete calculated from Approach-I are found to have satisfactory agreement with those calculated by Approach-II up to 20% replacement of natural aggregate by cinder. The optimum recommended combination for this strength is 40% cinder and 60% natural aggregate along with 10% silica fume.
3. The moment carrying capacity of slabs is found to vary from 14.23KN-m to 9.82KN-m with the replacement of natural aggregate by cinder from 0 to 100 percent. Between 8 to 10 percent replacement of cement with silicafume gives the optimum values of moment carrying capacity. The optimum recommended combination for this strength is 40% cinder and 60% natural aggregate along with 10% silica fume.
4. With the increase in cinder contents the deflections of beams, slabs etc., are found to increase.
5. Based on the experimental investigations it is concluded that cinder light weight aggregate is no way inferior to other manufactured, developed aggregate like cold bonded, sintered artificial aggregates.

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