EFFECT OF PARTIAL REPLACEMENT OF SILICA FUME FOR CEMENT ON THE STRENGTH PARAMETERS OF PARTIALLY CINDER BASED LIGHT WEIGHT AGGREGATE CONCRETE

N. Sandhya Rani¹ and Dr.G.Vani ²
¹,²Civil Engineering, Intell Engineering College

Abstract—Lightweight concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. The main specialities of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs. In this connection an attempt has been made to use the light weight aggregate, cinder replacing of granite aggregate in proportion of 20, 40, 60, 80 and 100% for concrete works. In the present investigation the OPC cement has been replaced by an admixture silica fume in three percentages i.e. 5, 10, 15%. Here an attempt made to use the light weight aggregate, cinder in concrete to evaluate the density, workability, compressive strength, split tensile strength and flexural strengths with admixture with curing of 28 days. Among all the percentages the better strength obtained percentage is selected.

Keywords—Lightweight concrete, Cinder Aggregate, Silica fume, Compressive strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

1.1 LIGHT WEIGHT CONCRETE (LWC)

The advancement in the new construction materials has led to develop high strength materials, which are generally selected to reduce the weight of the construction. Also the developments in the stress analysis methods enable a more reliable determination of local stresses in the materials, which permit safety factors to be reduced resulting in further weight savings. 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. The coarser normal weight aggregate in conventional concrete can be replaced partially or fully with low density aggregates will produces light weight concrete that can reach a reasonably good compressive resistance. The advantages of lightweight concrete are its reduced mass, 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.

1.2 CINDER AGGREGATE

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

Properties of cinder:
1. The surface of the cinder is usually rough and highly porous due to mineral structure.
2. No physical testing is usually performed to quantify the angularity of the material, because it is visually classified as having 100% crushed face.
3. The water absorption for cinder is around 1.5%. This difference is thought to be the major reason of reduction in strength and durability of concrete made with cinder.
4. Low specific gravity of cinder in comparison with natural aggregate resulted in the concrete made with cinder to be lighter than normal concrete.

1.3 SILICA FUME:
Silica fume is an artificial pozzolana material having high pozzolonic activity. It is a by-product from an electric arc furnace used in manufacture of silicon metal or silicon alloy. It has a high silica content of more than 80%. It is excellent for use as a Portland cement supplement.

In the refractories world thirty-five years, nobody was working with silica smoke and few realized what it was. Within a couple of years, it was being utilized as an admixture to block. At the point when amount of substantial Alumina block, mullite was framed in the framework of the block on terminating, giving the block great volume quality, quality and synthetic resistance. At the time it was just conclusion that silica smoke would be utilized as a part of block not cast capable. Block were utilized for exceptionally imperative applications; nobody would have plausibility of utilizing thrown capable. Today's headstrong cast capable have gone past having "block like properties" to really out bit of work block in numerous applications. Silica smoke has assumed as greater part in this change.

1.4 SCOPE OF PRESENT WORK:
Based on availability of equipment in the laboratory, experimental work was conducted on cubes, cylinders and beams so that it leads to evaluate compression, split tensile and flexural strengths. Due to limitation of the equipments, it was confined to finding of above said strengths only.

1.5 OBJECTIVE OF THE TEST PROGRAM:
In the present investigation cinder aggregate is used as light weight aggregate and silica fume as admixture. For replacing cement with silica fume and normal coarse aggregate with cinder in various percentages, the light weight concrete designed as M20 grade to get structural light weight concrete using cinder aggregate. Compressive strength, Split tensile strength and Flexural strength are studied with replacement of cement in different percentages using silica fume.

A total of 144 specimens were cast which comprises of replacement of cinder aggregate and in percentages of 0, 20, 40, 60, 80 and 100% with 5%, 10%, 15% silica fume.

II. MATERIAL AND PROPERTIES

2.1 MATERIALS:
- Cement
- Fine aggregate
- Water
- Cinder aggregate
- Silica fume

| S.NO | Property                        | Numerical value          |
|------|--------------------------------|--------------------------|
| 1    | Fineness of Cement             | 225 m²/kg                |
| 2    | Specific Gravity               | 3.05                     |
| 3    | Normal Consistency             | 33 %                     |
| 4    | Setting Time                   |                          |
|      | 1. Initial Setting time        | 45 min                   |
|      | 2. Final setting time          | 6 10 Hours               |
### Table 2.2: Physical properties of Fine Aggregate

| S.NO | Property                      | Numerical value |
|------|-------------------------------|-----------------|
| 1    | Specific Gravity              | 2.7             |
| 2    | Fineness Modulus              | 2.8             |
| 3    | Bulk Density                  |                 |
|      | Loose State                   | 15.75 KN/m³     |
|      | Compacted State               | 17.05 KN/m³     |
| 4    | Grading of Sand               | Zone – II       |

### Table 2.3: Physical properties of granite Coarse Aggregate

| S.No. | Property                      | Value           |
|-------|-------------------------------|-----------------|
| 1     | Specific Gravity              | 2.75            |
| 2     | Bulk Density                  |                 |
|       | Loose State                   | 14.13 kN/m³     |
|       | Compacted State               | 16.88 kN/m³     |
| 3     | Water Absorption              | 0.4%            |
| 4     | Flakiness Index               | 14.22%          |
| 5     | Elongation Index              | 21.33%          |
| 6     | Crushing Value                | 21.43%          |
| 7     | Impact Value                  | 15.5%           |
| 8     | Fineness Modulus              | 3.4             |

### Table No 2.4 : The physical properties of granite coarse aggregate and Cinder aggregate

| S. No. | Property Name                        | Normal coarse granite aggregate | Cinder aggregate |
|--------|--------------------------------------|---------------------------------|------------------|
| 1      | Specific gravity                     | 2.75                            | 2.05             |
| 2      | Fineness modulus                     | 4.6                             | 2.82             |
| 3      | Water absorption                     | 0.5                             | 1.6              |
| 4      | Maximum nominal size                 | 20 mm                           | 20 mm            |

### Table No 2.5 : Workability Test Values

| S.No | Nomenclature | Compaction facor value in mm |
|------|--------------|------------------------------|
| 1    | C A-0 SF5    | 0.89                         |
| 2    | C A-0 SF10   | 0.90                         |
| 3    | C A-0 SF15   | 0.92                         |
| 4    | C A-20 SF5   | 0.88                         |
| 5    | C A-20 SF10  | 0.89                         |
| 6    | C A-20 SF15  | 0.90                         |

Compressive Strength

- 3 days: 32 N/mm²
- 7 days: 46 N/mm²
- 28 days: 58 N/mm²
Compressive Strength:

Table No: 3.1: Compressive strength of concrete with replacement of cinder aggregate and Silica fume

| S.No. | Mix Designation | Compressive Strength, N/mm² | % Increase or decrease in strength |
|-------|-----------------|----------------------------|----------------------------------|
| 1     | CA-0 SF 0       | 26.85                      | -                                |
| 2     | CA-0 SF5        | 30.2                       | + 11.09                          |
| 3     | CA-0 SF10       | 32.2                       | + 16.61                          |
| 4     | CA-0 SF15       | 34.28                      | + 21.67                          |
| 5     | CA-20 SF5       | 29.8                       | + 9.90                           |
| 6     | CA-20 SF10      | 30.03                      | + 10.59                          |
| 7     | CA-20 SF15      | 30.33                      | + 11.47                          |
| 8     | CA-40 SF5       | 27.25                      | + 1.47                           |
| 9     | CA-40 SF10      | 30                          | + 10.50                          |
| 10    | CA-40 SF15      | 30.02                      | + 10.56                          |
| 11    | CA-60 SF5       | 23.4                       | - 12.85                          |
| 12    | CA-60 SF10      | 26.6                       | - 0.93                           |
| 13    | CA-60 SF15      | 27.3                       | + 1.65                           |
| 14    | CA-80 SF5       | 23.3                       | - 13.22                          |
| 15    | CA-80 SF10      | 25.3                       | - 5.77                           |
| 16    | CA-80 SF15      | 26.4                       | - 1.68                           |
| 17    | CA-100 SF5      | 21.4                       | - 20.30                          |
| 18    | CA-100 SF10     | 24.5                       | - 9.59                           |
| 19    | CA-100 SF15     | 26.2                       | - 2.42                           |

Fig 3.1 Compressive strength with different percentages of cinder aggregate with different percentages of silica fume
Fig 3.3 Testing of cube by compression

- Flexural strength:

| S.No. | Mix Designation | Flexural Strength, N/mm² | % Increase or decrease in strength |
|-------|-----------------|--------------------------|-----------------------------------|
| 1     | CA-0 SF 0       | 3.82                     | -                                 |
| 2     | CA-0 SF5        | 4.1                      | + 6.83                            |
| 3     | CA-0 SF10       | 4.5                      | + 15.11                           |
| 4     | CA-0 SF15       | 4.8                      | + 20.42                           |
| 5     | CA-20 SF5       | 3.6                      | - 5.76                            |
| 6     | CA-20 SF10      | 3.62                     | - 5.24                            |
| 7     | CA-20 SF15      | 3.64                     | - 4.71                            |
| 8     | CA-40 SF5       | 3.48                     | - 8.90                            |
| 9     | CA-40 SF10      | 3.5                      | - 8.38                            |
| 10    | CA-40 SF15      | 3.66                     | - 4.19                            |
| 11    | CA-60 SF5       | 3.42                     | - 10.47                           |
| 12    | CA-60 SF10      | 3.47                     | - 9.16                            |
| 13    | CA-60 SF15      | 3.55                     | - 7.07                            |
| 14    | CA-80 SF5       | 3.33                     | - 12.83                           |
| 15    | CA-80 SF10      | 3.4                      | - 10.99                           |
| 16    | CA-80 SF15      | 3.54                     | - 7.33                            |
| 17    | CA-100 SF5      | 3.2                      | - 16.23                           |
| 18    | CA-100 SF10     | 3.33                     | - 12.83                           |
| 19    | CA-100 SF15     | 3.52                     | - 7.85                            |

Table No:3.2: Flexural strength of concrete with replacement of cinder aggregate and Silica fume

Fig 3.2 Flexural strength with different percentages of cinder aggregate with different percentages of silica fume
Fig 3.4 Beam under universal testing machine

Split tensile strength

Table 3.3: Split tensile strength of concrete with replacement of cinder aggregate and silica fume

| S.No. | Mix Designation | Split tensile strength, N/mm² | % Increase or decrease in strength |
|-------|----------------|------------------------------|----------------------------------|
| 1     | CA-0 SF 0      | 3.16                         | -                                |
| 2     | CA-0 SF5       | 3.5                          | + 9.71                           |
| 3     | CA-0 SF10      | 3.85                         | + 17.92                          |
| 4     | CA-0 SF15      | 3.7                          | + 14.59                          |
| 5     | CA-20 SF5      | 3                            | - 5.06                           |
| 6     | CA-20 SF10     | 2.72                         | - 13.92                          |
| 7     | CA-20 SF15     | 2.68                         | - 15.19                          |
| 8     | CA-40 SF5      | 2.8                          | - 11.39                          |
| 9     | CA-40 SF10     | 2.6                          | - 17.72                          |
| 10    | CA-40 SF15     | 2.38                         | - 24.68                          |
| 11    | CA-60 SF5      | 2.75                         | - 12.97                          |
| 12    | CA-60 SF10     | 2.4                          | - 24.05                          |
| 13    | CA-60 SF15     | 2.33                         | - 26.27                          |
| 14    | CA-80 SF5      | 2.42                         | - 23.42                          |
| 15    | CA-80 SF10     | 2.21                         | - 30.06                          |
| 16    | CA-80 SF15     | 2                            | - 36.71                          |
| 17    | CA-100 SF5     | 2.2                          | - 30.38                          |
| 18    | CA-100 SF10    | 2.16                         | - 31.65                          |
| 19    | CA-100 SF15    | 2.01                         | - 36.39                          |

Fig 3.5 Testing of cylinder by split tensile
IV. CONCLUSIONS AND FUTURE RECOMMENDATIONS

4.1 CONCLUSIONS

From the current experimental work the following tentative conclusions can be drawn.

- The compaction factor decreases with the increase in percentage of cinder aggregate at each constant percentage replacement of cement by silica fume.
- From the study it is observed that the densities have decreased continuously with the increase in percentage of cinder aggregate for silica fume replacement for cement.
- It is observed that concrete with silica fume replacement for cement achieved higher strength than the conventional concrete.
- With 15% silica fume replacement, 21.67% increase in cube compressive strength is found to achieve when compared to conventional concrete.
- It has been observed that the cube compressive strength with replacement of cement by 15% silica fume, for 20% cinder aggregate replacement gave a maximum strength of 30.33 N/mm² which is 11.47% greater than the conventional concrete.
- From the study it is seen that the cube compressive strength has decreased continuously with the increase in percentage of cinder with replacement of cement by silica fume. However with 60% replacement of conventional aggregate by cinder aggregate with replacement of cement by 15% silica fume more than target mean strength of concrete is achieved.
- From the study it is observed that the compressive strength at 15% silica fume is giving the better results when compared to 5% and 10% silica fume.
- It can be observed that due to porous nature cinder aggregate's quality is low in comparison with normal aggregate.
- It has been observed that the split tensile strength is decreased continuously with increase in percentage of cinder.
- It is also observed that with 100% natural aggregate in concrete and 0%, 5%, 10%, 15% replacement levels of silica fume the split tensile strength increased slightly. At 10% silica fume replacement an increase in split tensile strength by 17.92%.
- In case of silica fume replacement for cement with the increase in cinder aggregate percentages the split tensile strength decreased at a drastic phase.
- It is observed that the concrete with silica fume replacement for cement achieved higher flexural strength than the conventional concrete.
With 15% silica fume replacement, 20.02% increase in flexural strength is found to achieve when compared to conventional concrete.

It is observed that the concrete mixes with 0% cinder aggregate and silica fume replacement from 0% to 15% indicated an increase in flexural strength.

As the percentage of cinder aggregate increases, and for all percentages of silica fume the flexural strength decreased.

From the study it is observed that the usage of light weight cinder aggregate to some extent (40%) and granite aggregate (60%) using admixture as silica has proved to be quite satisfactory considering the compressive strength when compared to other strengths studied.

At 60% cinder aggregate replacement for natural coarse aggregate, target mean strength is found to achieve.

The cinder aggregate is no way inferior to the natural aggregate.

4.2 RECOMMENDATIONS FOR FUTURE INVESTIGATIONS:
1. Good scope of many research works to understand the performance under impact loading.
2. Mathematical / Empirical methods can be developed for the light weight aggregate concrete.
3. Studies can be conducted by inclusion of other admixtures.
4. Also durability studies such as resistance to sulphate attack, Acid resistance etc., can be performed on light weight aggregate concrete with admixtures.

V. REFERENCES

[1] Ganesh Babu. K investigations on “Behaviour of lightweight polystyrene cement containing silica fume “Journal of materials in Civil engineering, May 2003.

[2] M. A. Caldarone and R.G.Burg, “Development of very low density structural lightweight concrete”, ACI journal, vol.218, February 2004, pp.177-188.

[3] Nataraja M C et al., investigations on “Proportioning cement based composites with burnt coal cinder” Journal of materials in Civil engineering, 2007.

[4] P.S. Raghuprasad, R. Satish, A.V. Pradeepkumar, Experimental Investigation on “Solid concrete blocks with partial replacement of coarse aggregate with Cinder aggregate” Journal of materials in Civil engineering, 2007.

[5] Niyazi Ugur Kockal journal on “Strength and elastic properties of structural lightweight concrete” Journal of materials in Civil engineering, 2011.

[6] Rathish Kumar P. et al, A study on the “Sorptivity characteristics of High Performance Mortars”, Journal of Institution of Engineers, 83, 1-7 (2002) .

[7] N.K Amudhavalli, Jeena Mathew journal on “Effect of silica fume on strength and durability parameters of concrete” International Journal of Engineering Sciences & Emerging Technologies, August 2012, Volume 3, Issue 1, pp: 28-35 ©IJESET

[8] N. Siva linga Rao, investigations on “Properties of lightweight aggregate concrete with cinder”, International Journal of Earth Sciences and Engineering, Vol. 4, No. 6, 2013, pp. 907-912.

[9] Dr.V.Bhaskar Desai, A.Satym, ‘Some studies on strength properties of Light weight cinder aggregate concrete’, “volume 4 issue 2, Feb 2014 , ISSN 2250-3153

[10] Sivakumar, S.Muthukumar journal on “Experimental studies on high strength concrete by using recycled coarse aggregate”, Journal of materials in Civil engineering Jan 2014.

[11] B. Veerash, B.B.C.O. Prasad, and K. Satheesh Kumar journal on “Strength and characteristics of concrete with cinder based light weight aggregate”, International Journal of Scientific Engineering and Technology Research Volume.04, IssueNo.23, July-2015, Pages: 4437-4442

[12] V. Giridhar Kumar investigations on “Strength and sorptivity characteristics of concrete made with cinder “ International Journal of Engineering Research and Development, Volume 11, Issue 07 (July 2015), PP.50-59 .

[13] KRISHNA RAJU, N., Design of concrete Mixes, CBS publishers and Distributors, New Delhi.

[14] M.S. Shetty - Concrete Technology (Theory and Practice)

[15] Concrete Technology - A.R. Santhakumar.

[16] N. Krishna Raju - Design Of Concrete Mixes