Mechanical and Durability Properties of No Aggregate Concrete using Silica Fume

V Vamsi, GAVS Sandeep Kumar, Rakesh Siempu

Abstract*: India is a developing country which has been showing an enormous growth in different aspects like industrialization, urbanization and communication since 20th century. This development is leading to the decay of environment by polluting it. The huge disposal of various waste products from different industries is playing a prominent role in the rapid growth of pollution. No aggregate concrete (NAC) is another kind of concrete where the utilization of totals are completely maintained a strategic distance from for safeguarding the regular stone, hillocks and slopes. The utilization of sand is additionally maintained a strategic distance from to save the waterway beds. This is a regular research work serving the plan of economical advancement. To reduce the use of aggregates in concrete, No Aggregate Concrete for different grades of concrete is desired. The purpose of this project is to obtain mix design, understand Mechanical properties and Chemical durability properties of different mixes developed.

Keywords: no aggregate, economical advancement, mechanical properties, durability properties.

I. INTRODUCTION

Concrete is one of the widely used materials in the world. Based on the global usage it is placed at second position after water. It is a composite construction material which comprises of Cement, Coarse aggregate, Fine aggregate, Water, Admixtures. It hardens with time. Portland cement is one of the most common cement types used for concrete production. It is categorized into 3 types depending upon its particle size as grade 33, grade 43 and grade 53. The higher the grade, the better the fineness and strength of cement.River sand and Coarse Aggregates are the significant constituent utilized in the generation of regular cement. These have become profoundly costly and rare now a days. In the background of such a grim environment, there is a huge interest for elective materials from modern waste. Since the interest in the solid assembling is expanding step by step, the usage of fine total just as coarse totals prompts misuse of characteristic assets, loss of biodiversity, scarring of scene, bringing down of water table, sinking of the scaffold docks, and so on as a typical danger.

Due to Urbanization and Rapid growth across the world the need for concrete as a construction material has increased which results in increase in demand of its constituent materials. Aggregates are the major constituents of Concrete and based on the data obtained from various sources it has become clear that the demand will keep spiking up. Overcoming this problem and sustainably has taken priority. Use of various waste materials like Recycled Aggregates, GGBS, Gypsum, Slag, fly ash etc. to produce concrete has become a trend for research and development.

The excessive production of fly ash from industries like thermal stations, raw material manufacturing firms, power houses is depleting the earth scenario in its own degradation ways. The disposal of fly ash has always been troublesome. Fly ash has properties like cement and can be used as substitute for Aggregates as well. To safe guard the natural resources from exploitation in the name of concrete, eco-friendly researches and environmental trials have come up experimenting NO AGGREGATE CONCRETE. This is a new phase of concrete technology which eliminates the usage of coarse and fine aggregate in concrete matrix. This revolutionary phase is still in budding research stage and need a heavy boost up from various dimensions of structural engineering for social and practical implementation. As the proportion of aggregate is removed totally, the matrix comprises of major amount of cementitious materials such as Cement, fly ash, silica etc., It is also accompanied by admixtures such as super plasticizers.

II. REVIEW CRITERIA

This study deals with concrete which doesn't contain any aggregates (NAC). No Aggregate Concrete of different mixes were casted, keeping cement content fixed and varying silica fume and fly ash quantities, mix was casted. The main aim of this project is to attain different mix design by trial method and study the strength and durability characteristics of the obtained mix to provide an optimum mix for the desired grade of concrete. Strength test are performed for various proportions of the mix. RCPT test is performed to understand the durability of concrete and know about desired failure points.

III. MATERIALS

Materials like cement, fly ash, silica fume, water and master glenium sky 8233.

- **CEMENT:** Cement is a binding material that adheres to other materials and gets hardened on addition of water, cement used is penna OPC 53 grade which was
- bought from local supplier . Specific Gravity of cement is 3.13.
- **FLY ASH:** Fly ash is produced as a byproduct

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from burning pulverized coal in thermal and electric power generating plants. Fly ash used was of class-F which was bought from RANK ready mix concrete plant.
Specific gravity of fly ash is 2.3.

- **SILICA FUME:** Silica fume is a nebulous polymorph of silicon dioxide (SiO2), silica. It is a fine powder acquired as a side-effect during the generation of the silicon and ferrosilicon amalgam. It comprises of round particles with a normal molecule measurement of 150 nm (by and large ranges between 100-200 nm). Silica assumes an indispensable job when utilized in concrete. Its physical and synthetic characteristics which makes it significant when blended in with concrete. It is a receptive pozzolanic material as a result of its fineness and silica content. Silica fume is known to improve the mechanical characteristics of concrete.
Specific Gravity of Silica fume is 2.14. Silica fume has similar physical and chemical properties as of cement.
- **WATER:** water used was manjeera water obtained in concrete laboratory in college.
- **MASTER GLENIUM SKY 8233:** Master Glenium Sky 8233 is a superplasticizer that contains Poly-carboxylic ether. It is free from chlorine concentration and contains very little amount of alkali. It can combine with all types of cement available. This was bought from a distributor of BASF .

IV. MIX DESIGN

The aim of the project was to design a M40 grade of concrete with ingredients of concrete being cement, fly ash, Silica fume, water and admixture . Cement content was fixed at 20% and the concentration of Fly ash and silica fume was altered for the rest 80 % varying the composition of silica fume from 0 to 6 %. In this mix design a total of four mixes were casted, all of them having cement content as 343 kg/m^3 , water content as 311 kg/m^3, admixture content as 6.82 kg/m^3 . Table 1 shows the proportions of mix design in kg/m^3.

Table- 1: Mix Design in kg/m^3

Sample	Cement	Fly ash	Silica Fumes	Water	Admixture
S0	343.7	1375.2	0	311.11	6.82
S1	343.7	1340.82	34.38	311.11	6.82
S2	343.7	1306.44	68.76	311.11	6.82
S3	343.7	1268.06	103.14	311.11	6.82

V. METHODOLOGY

As the mix doesn't contain any aggregates this mix needs a high speed mixer to achieve the workability. Blending of concrete is done by using concrete pan mixer and high speed mixer. The contents of the mix were weighed and placed in the concrete pan mixer. The dry mix was done by hand, adding water periodically the mix was started. The admixture was added by mixing with 1litre of water for every 100 ml.Then high speed mixer was used to achieve more workability. For every mix, 15 cm x 15 cm x 15 cm cubes were casted to test for compressive strength, 10 cm x 10 cm x 50cm prisms were casted to test for flexural strength, 30 cm x 15 cm diameter cylinders were casted to test for split tensile strength , 10 cm x 10 cm x 10 cm cubes have been casted to test for acid-attack test and rapid chloride ion permeability test.(RCPT)

VI. RESULTS AND DISCUSSION

A. COMPRESSIVE STRENGTH

From the Concrete Mixes it has been seen that there was an uplift in Compression Strength of Concrete as the amount of Fly Ash replaced with Silica Fumes has increased. The sample S0 had a compressive strength of 14 MPa, whereas it has been on a rise with sample S1 achieving 38 MPa, sample S2 achieving 42 MPa and finally sample S3 achieving 52 MPa.

Table-2: Characteristic compressive strength at 28 days.

Mix Designation	Strength(MPa)
S0	14
S1	38
S2	42
S3	52

B. SPLIT TENSILE STRENGTH

From the Concrete Mixes it has been seen that there was an uplift in Tensile Strength of Concrete as the amount of Fly Ash replaced with Silica Fumes has increased. The sample S0 achieved 0.64 MPa, whereas the sample S1 achieved 1.63 MPa, sample S2 achieved 1.87 MPa and finally sample S3 achieving 1.98 MPa.

Table-3: Split Tensile strength at 28 days.

Mix Designation	Strength(MPa)
S0	0.64
S1	1.63
S2	1.87
S3	1.98

C. FLEXURAL STRENGTH

From the Concrete Mixes it has been seen that there was an uplift in Tensile Strength of Concrete as the amount of Fly Ash replaced by Silica Fumes has increased.
The sample S0 achieved 0.5 MPa, whereas the sample S1 achieved 1.25 MPa, sample S2 achieved 1.5 MPa and finally sample S3 achieving 1.75 MPa.

Table-4: Flexural strength at 28 days.

Mix Designation	Strength(MPa)
S0	0.5
S1	1.25
S2	1.5
S3	1.75

D.RAPID CHLORIDE PERMEABILITY TEST

This test measures the concrete's ability to avoid penetration caused by chloride ion penetration . This test is conducted for six hours by passing constant voltage through the specimen. From the mixes it has been seen d that the RCPT values of all the specimens are very low and low.

Table-5: Rapid Chloride Permeability Test

Mix Designation	Charge passed in coloumbs
S0	1278.34
S1	634.56
S2	757.22
S3	1193.27

The graphs explaining these tests are shown below as figure 1 representing compressive strength, figure 2 representing split tensile strength, figure 3 representing flexural strength, and figure 4 representing rapid chloride ion permeability test.

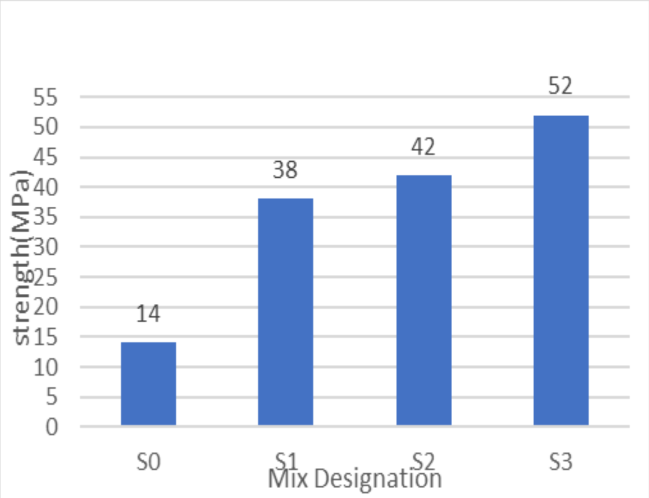

Fig. 1.Compressive strength in MPa at 28 days.

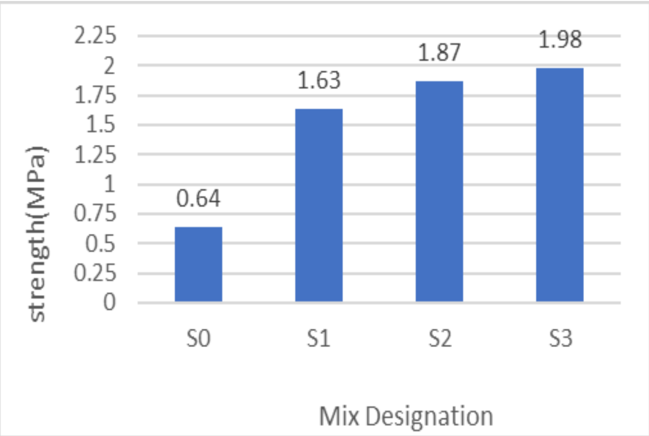

Fig.2.Split Tensile Strength in MPa at 28 days.

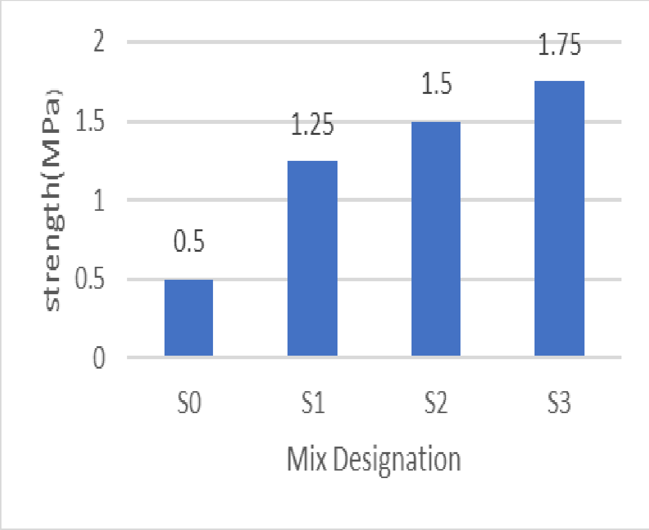

Fig. 3.Flexural Strength in MPa at 28 days

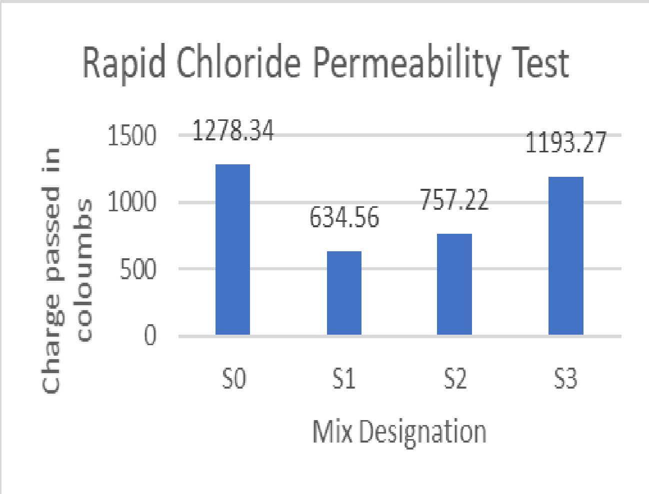

Fig. 4. Rapid Chloride Permeability Test

VII. CONCLUSIONS

- Compressive strength of mix S3 is 52 MPa which is more than all mixes at 28 days.
- Split Tensile strength of mix S3 is 1.98 MPa which is more than all the mixes at 28 days.
- Flexural strength of mix S3 is 1.75 MPa which is more than all the mixes at 28 days.
- Best strength properties were achieved in mix S3 where Fly Ash was replaced by Silica Fumes at 6% of Cementitious material and the desired mix of M40 was achieved.

Fibres can be used to increase split-tensile strength and flexural strength. Using Basalt fibres and steel fibres may increase the strength of no aggregate concrete. Study on the no aggregate concrete should go on further.

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