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PARTIAL REPLACEMENT OF CEMENT BY FUMED SILICA AND COARSE AGGREGATE BY RECYCLED AGGREGATE IN WASTE CONCRETE

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Abstract - *The utilisation of recycled aggregates is undeniably a crucial stride towards achieving sustainable expansion in the concrete industry and in the management of construction waste disposal. Recycled aggregates (RA) are a lawful substitute for naturally occurring aggregates that aid in the conservation of the environment. The variability in aggregate qualities is the main factor that affects the use of recycled aggregates. The quality of the materials that are collected and transferred to the recycling facility directly impacts the quality of the recovered aggregate. Hence, the existing constraints of recycling facilities provide challenges in achieving a satisfactory production rate and quality of recovered aggregates. The consumers are worried about the durability of the production process and the uncertainty around the characteristics of the rock. The primary aim of this study project is to investigate the variability of aggregate qualities and its impact on concrete production. Therefore, it is crucial to assess the property prior to utilising the unit. Cementitious elements, like silica fume, possess cementitious qualities that enhance the strength of concrete. The use of silica fume in concrete and artificial sand results in higher strength compared to river sand, but at a higher cost. Pozzolanic materials contribute to the structural integrity of materials and also have significant implications for economic and ecological considerations. Silica fumes are a secondary product of silica alloys, which contribute to enhanced strength, stability, and function as fillers. The size of the cement particles is larger than the size of the particles.*

This investigation involved the preparation of 39 total number of samples using 13 different mix proportions. For this project, it is recommended to utilise M-25 grade concrete. In this case, the cement can be substituted with silica fume at varying percentages: 0%, 10%, 20%, and 30%. CA was substituted with RA at rates of 0%, 10%, 20%, and 30%. Concrete analysis testing is conducted in two stages: the workable stage and the hardening stage.

Key Words: **Recycled Aggregate, Properties of Concrete, Physical Properties of Concrete, and Mechanical Properties of Concrete**

1. INTRODUCTION

Conventional concrete mostly consists of Portland cement. The cement production process in the building sector emits substantial quantities of carbon dioxide and contributes to global warming. The cement production process depletes the natural resources of limestone due to its unsustainable nature. Novel pozzolan materials, such as silica dust and fly ash, that exhibit innovative properties. Introducing pozzolan material as a partial substitute for cement helps to decrease the excessive use of cement and enhances the organised use of resources and by-products in different sectors. The primary constituents of pozzolan utilised in this investigation consist of fly ash and silica fume. Fly ash is a residual substance that is produced when coal dust is burned in thermal power plants. Silicone fumes are a secondary outcome of the silicon or ferrosilicon production sector.

Concrete is the predominant construction material on a global scale. These are often used developer materials, encompassing a fixing agent, fineness, gross aggregate, and the necessary quantity of water. Stone has played a crucial role in the human pursuit of knowledge throughout much of history, and its use has grown since ancient times. The overall size is commonly employed as a rough estimate in high-density construction, and there has been a new focus in certain design nations on establishing a standard size to accommodate the increasing demands of infrastructure development. Specifically, there is a significant level of shared enthusiasm for establishing a state, mostly driven by the swift advancement of the infrastructure. Over the past several years, the availability of natural resources has significantly declined due to advancements in technology and the subsequent rise in consumption. Conversely, it is evident that extensive production leads to the generation of elements that harm the soil. The civil engineering sector, being a significant consumer of mineral resources, generates a substantial amount of solid waste in the form of stone separators. Stone is commonly utilised because of its unique aesthetic qualities. The Earth us many ordinary stone objects that we must throw away as extraordinary wealth.

1.1 Silica Fume:

1.2 Silicon powder is a residual substance generated by electric furnaces employed in the production of silicon or silicon metal alloys. Materials that have extremely small particles (with an average diameter of 0.1 m) and contain over 80% silica have a high level of pozzolanic activity. This product is appropriate for use as an adjunct to Portland cement. Aside from its economic potential and energy-saving properties, the incorporation of pozzolan additives in concrete offers other technical benefits, such as enhanced resistance to sulfuric acid and acidic water, as well as increased strength. Unlike other byproducts such as fly ash, CSF stands out due to its distinct and superior pozzolan action, which is both more effective and quicker.

1.3 Proposed study

This investigation involved the preparation of 39 total number of samples using 13 different mix proportions. Utilise M-25 grade of concrete with varying percentages of silica fume substitution, namely 0%, 10%, 20%, and 30%. The coarse aggregate was substituted with recycled aggregate at several percentages: 0%, 10%, 20%, and 30%. The analytical testing of concrete is conducted in two stages: the workable stage and the hardening stage.

2. OBJECTIVE

- To get the uses of silica fume and used aggregate in the concrete.
- To reduce additional stress of recycled waste on environment.
- Discover the properties of soft and hard concrete with silica fumes and aggregates.
- To find out the compressive strength of construction and demolition aggregates used to make concrete.

3. METHODOLOGY

3.1 Concrete

Concrete is a construction material composed of cement, fine aggregate (sand), and coarse aggregate. It is combined with water and allowed to solidify over a period of time. Portland cement is a prevalent variety of cement utilised extensively in the production of concrete. Concrete technology encompasses the examination of concrete's characteristics and its practical implementation. Concrete is used to weight foundations, pillars, beams, slabs, and other components in the construction of structures.

Aside from concrete, several adhesives are employed in road building, including lime for lime concrete and bitumen for asphalt concrete. The study utilised M-25 grade concrete to manufacture OPC 43 grade cement, sand, and aggregate, with a proportion of 1:1:2 (cement:sand:aggregate).

Common concrete tests:

1. Compression Test
2. Tension Test
3. Flexural Test
4. Rapid Chloride Penetration Test
5. Slump Test of concrete
6. Air Content Test of concrete
7. Water Permeability Test of concrete

Test used for concrete

a) Slump Test

b) Compressive Strength Test

3.2 Cement

The Portland cement utilised for the experiment was the Ultratech Cement brand. To safeguard concrete in enclosed containers from the effects of ageing, the focus is placed on locating the concrete in a single procedure. The concrete is thereafter examined in accordance with IS: 8112-2013 and authorised based on the organization's specifications.

Table -1: Properties of Cement

S. No.	Physical Properties	IS: 8112-2013
1.	Fineness of cement	✓ Minimum 225 (m^2/kg)
2.	Normal consistency of cement	✓ Not specified
3.	Initial timing of setting for cement	✓ Minimum of 30 min
	Final timing of setting for cement	✓ Maximum of 10 hr
5.	Cement Specific gravity (SG)	✓ {3.15}
6.	Compressive strength for cement	
	On 3rd day strength	✓ Min.27Mpa
	On 7th day strength	✓ Min. 33Mpa
	On 28th day strength	✓ Min. 43Mpa

Common Cement Tests:

1. Fineness Test
2. Consistency Test
3. Setting Time Test
4. Strength Test
5. Soundness Test
6. Heat of Hydration Test
7. Tensile Strength Test
8. Chemical Composition Test

Test used for concrete

1. **Fineness Test**
2. **Consistency Test**

3. **Test of Initial time setting**
4. **Test of final setting time**
5. **Compressive Strength Test**

3.3 Aggregate

The majority of the aggregate is captured by the 75mm IS sieve and is superior to the several kinds mentioned in this standard. According to the IS: 2386-1963 standard, many measurements are conducted, including aggregate weight, impact gradient, rate of water absorption, and density.

Common Aggregate Tests:

1. Crushing test
2. Abrasion test
3. Impact test
4. Soundness test
5. Shape test
6. Specific gravity and water absorption test
7. Bitumen adhesion test

Test used for Aggregate

1. **Abrasion test**
2. **Crushing Test**

3.4 Admixture

Super plasticizer refers to the latest iteration of concrete super plasticizers, known as the fourth generation. It fulfils the criteria for a high-quality water-reducing superplasticizer. It is sometimes referred to as FOS-Guard, Ether Polycarboxylate, or Concrete Plasticizer. Super plasticizer additives consist of specific compounds that aid in the reduction of water content in concrete and enhance its workability. This contributes to the formation of a cohesive concrete mixture.

4. RESULT AND DISCUSSION

In this section, perform the results of experimental work. The results are displayed in graph and tabular format. Results will vary for cement, coarse aggregate and concrete.

4.1 Result of Cement

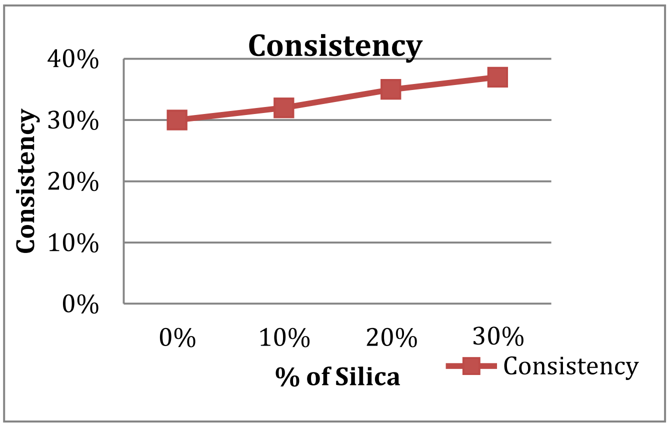

Fig. 1 Consistency Test of Cement Due to Replacement of Silica Fume

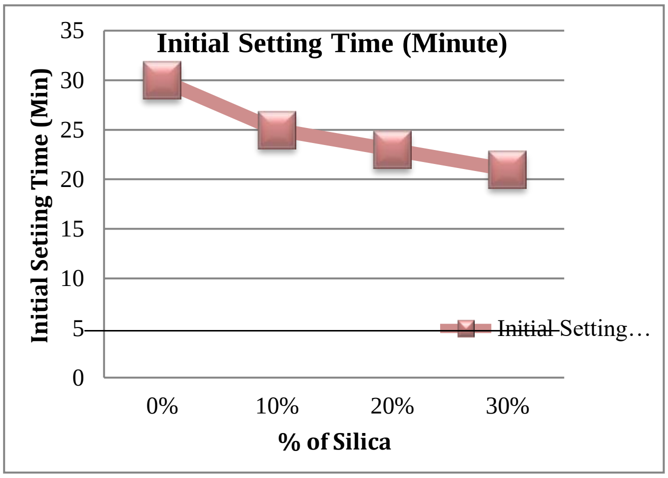

Fig. 2 (Initial) Setting Time of Cement Due to Replacement of Silica Fume

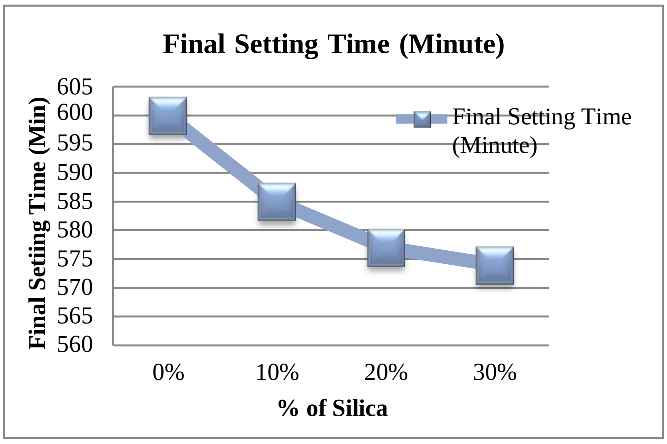

Fig. 3 Final Setting Time of Cement Due to Replacement of Silica Fume

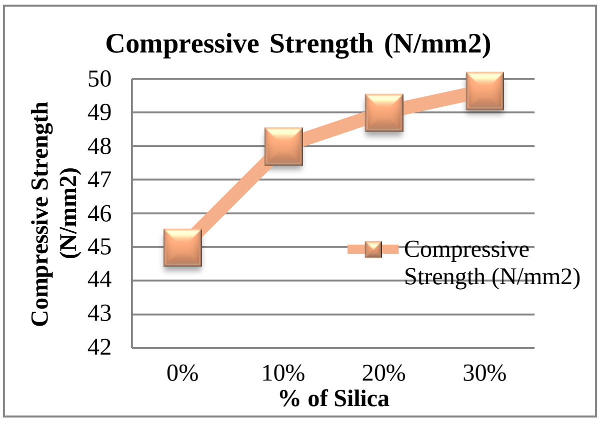

Fig. 4 Compressive Strength of Cement Due to Replacement of Silica Fume

4.2 Result of Aggregate

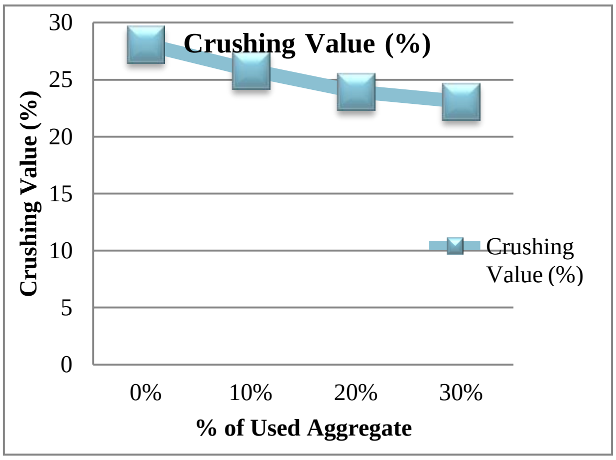

Fig. 5 Crushing Test of Aggregate Due to Replacement of Used Aggregates

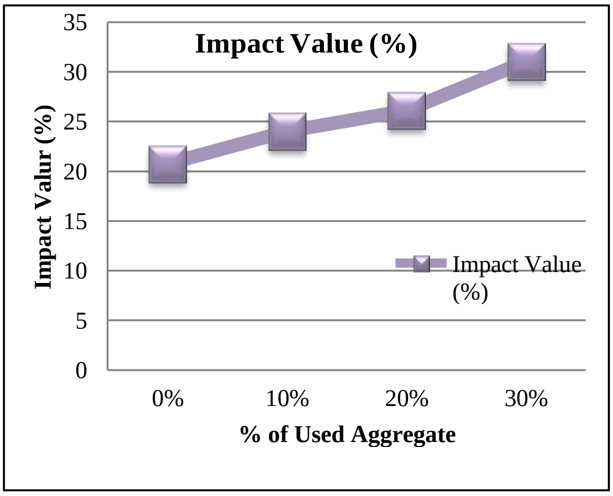

Fig. 6 Impact Test of Aggregate Due to Replacement of Used Aggregates

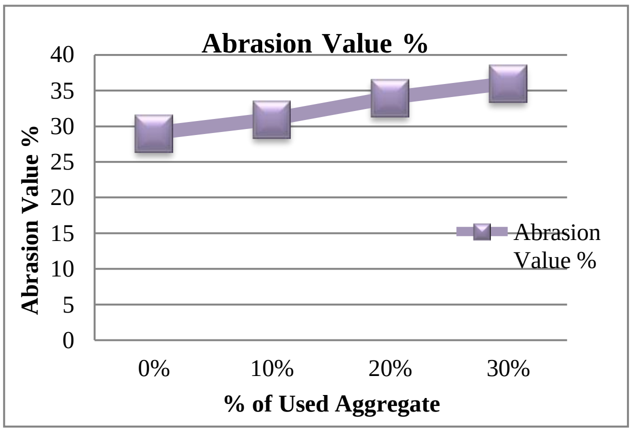

Fig. 7 Abrasion Test of Aggregate Due to Replacement of Used Aggregates

4.3 Result of Concrete:

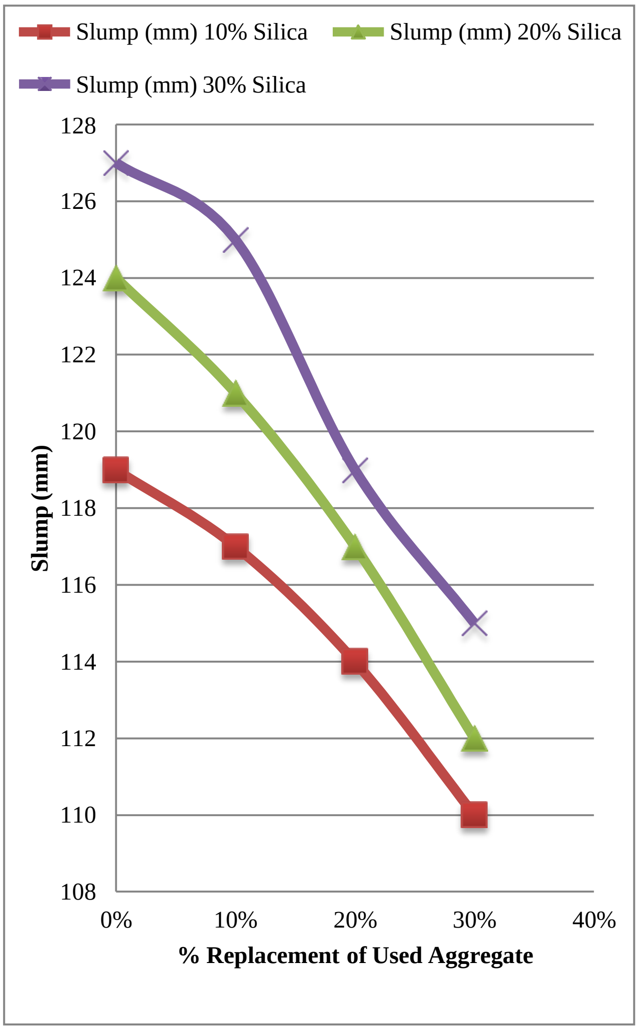

Fig. 8 Slump Test for 10%, 20% and 30% substitute of Cement with Silica and Varying % of Aggregate replacement with Used Aggregate

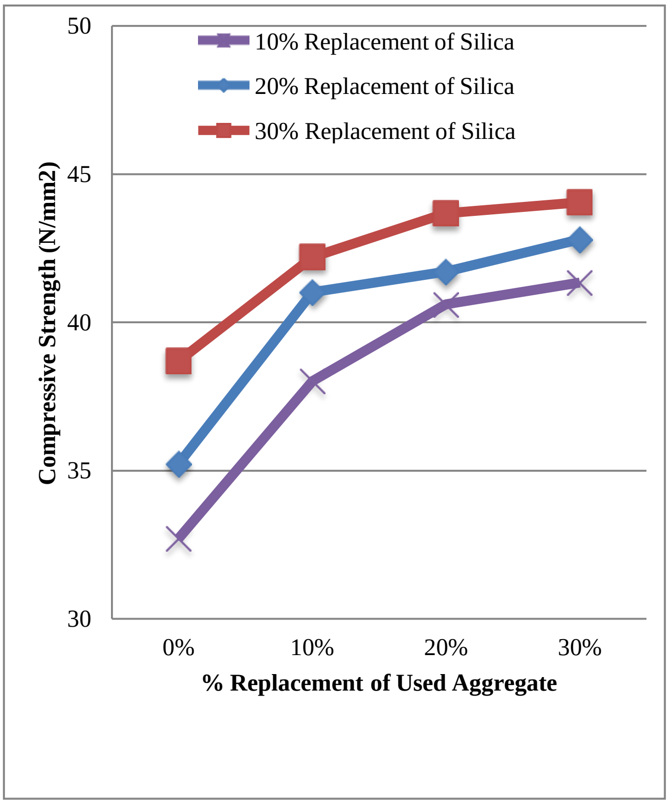

Fig. 8 Compressive Strength for 10%, 20% and 30% Substitute of Cement with Silica and Varying % of Aggregate Substitute with Used Aggregate

5. CONCLUSION

This investigation involved the preparation of 39 total number of samples using 13 different mix proportions. Utilise M-25 grade of concrete in which the cement is substituted with SF at varying percentages of 0%, 10%, 20%, and 30%. CA was substituted with RA at rates of 0%, 10%, 20%, and 30%. Concrete analysis testing is conducted in two stages: the workable stage and the hardening stage. Additionally, do research on the properties of cement and aggregates when combined with silica fume and separate aggregates.

5.1 Cement with Silica Fume

- Normal Consistency of cement without silica fume it will be 30% and after the replacement of silica fume by 10%, 20% and 30% consistency of cement is 30%, 32%, 35% and 37% respectively increases.
- Initial Setting time of cement without silica fume it will be 60 minute and after the replacement of silica fume by 10%, 20% and 30% Initial Setting time of cement is 58, 50 and 47 respectively decreases.
- Initial Setting time of cement decreases as increase in % replacement of silica fume.
- Final Setting time of cement without silica fume it will be 600 minute and after the replacement of silica fume by 10%, 20% and 30% Final Setting time of cement is 585, 577 and 574 respectively increases.
- Final Setting time of cement increases as increase in % replacement of silica fume.
- Compressive Strength of cement without silica fume it will be 45N/mm2 and after the replacement of silica fume by 10%, 20% and 30% consistency of cement is 48N/mm2, 49N/mm2 and 49.65N/mm2 respectively increases.

5.2 Aggregate with Used Aggregate

- Crushing value of aggregates without used aggregates it will be 28.09% and after the replacement of used aggregates by 10%, 20% and 30% crushing value of aggregates is 225.81%, 23.94% and 23.06% respectively decreases.
- Impact Value of aggregates without used aggregates it will be 20.75% and after the replacement of used aggregates by 10%, 20% and 30% Impact Value of aggregates is 24.03%, 26.12% and 31.05% respectively increases.
- Abrasion Value of aggregates without used aggregates it will be 29% and after the replacement of used aggregates by 10%, 20% and 30% Abrasion Value of aggregates is 31%, 34% and 36% respectively increases.

5.3 Concrete with Silica Fume and Used Aggregates

- Mix proportion with 10% silica fume and coarse aggregates are replaced with used aggregates by varying % slump value decreases 119mm to 110mm.
- Mix proportion with 20% silica fume and coarse aggregates are replaced with used aggregates by varying % slump value decreases 124mm to 112mm.
- Mix proportion with 30% silica fume and coarse aggregates are replaced with used aggregates by varying % slump value decreases 127mm to 115mm.
- Effect on slump due to increase in % of silica fumevalue of slump also increases.
- Mix proportion with 10% silica fume and coarse aggregates are replaced with used aggregates by varying % compressive strength increase 32.72N/mm2

to 41.35 N/mm2.

- Mix proportion with 20% silica fume and coarse aggregates are replaced with used aggregates by varying % compressive strength increase 35.23 N/mm2 to 42.80 N/mm2.
- Mix proportion with 30% silica fume and coarse aggregates are replaced with used aggregates by varying % compressive strength increase 38.70 N/mm2 to 44.06 N/mm2.
- Increase in % of silica fume value of compressive strength also increases.

6. FUTURE SCOPE OF WORK

- This study can be carried out with other more resistant and durable types of concrete (egg M40 and M50).
- This Study can also be carried out with 2% increment in silica fume with self-compacting concrete.
- The studio is broken down into other common types of clay, glass and wood dust. This means that almost any closed construction project and demolition work can be done from waste, but construction glass can be powdered glass along with construction debris. Use glass boxes and cut wood instead of glass boxes and sticks
- Further evidence of alternative wave comparisons between the use of aggregates and all used aggregates for M25 cement.
- Comprehensive pollution counter and soft cut glass powder.

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