Use of Silica Fume and Marble Dust as Partial Binding Material in Concrete

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ABSTRACT

The aim of this research work was to determine the characteristics of silica fume and marble dust for application in structural concrete. Silica Fume is a byproduct from the electrostatic extraction of iron silicate. Marble Dust is a grounded marble fine particles also another byproduct during process of marble cutting and finishing in marble industry. The scope of this project work is to determine the combined effect of silica fume and marble dust on concrete and comparing it by using various percentage replacements of silica fume and marble dust with cement in concrete. The research work was carried out by doing Abrasion Test, Slump Test, Compression Test and Flexure Test. The samples were divided into four groups based on partial replacement of cement. The workability of concrete was reduced comparatively with increase in the replacement with cement. The control sample were casted of concrete with 0% replacement, the marble dust replacement was kept constant to 30% of the cement for partially replaced samples and silica fume was replaced as 0%, 5% and 10% of cement of the partially replaced samples. The compressive strength and flexure strength of the samples was reduced with increase in partial replacement of cement.

1. Introduction

In the world of construction, concrete like other materials is playing an important role in development. Concrete is a composite material which is a mixture of cement, fine aggregates, coarse aggregates and water. The Cement among which plays an important role in strength of concrete. Other Pozzolanic materials such as marble dust, Silica Fume, Fly ash can also be used. It possesses many advantages including low cost, general availability, adaptability, no extra energy consumption, enhancement of concrete properties and utilization under different environmental conditions.

The goal of sustainable construction is to reduce the environmental impact of a constructed facility over its lifetime. Concrete is the main material used in the construction world. With the rapid development in the industrialization numerous industries are established and their rate is increasing day by day. Various industries such as Marble industry, steel mills e.t.c uses such materials that results in the production of various by-products such as silica fume, marble dust, fly ash and many others. In some countries these materials are dumped in open as of no use without knowing about their cementitious properties. Thus by doing so they are polluting the environment and also reducing the natural resources by cutting mountains. These by-products have cementitious properties, so they can be used as replacement with cement.

In the future it may be useful to find new source of binding material for the production of concrete due to increase in demand for and decrease in supply of cement. Partial replacement of cement is a viable option to decrease the demand on high quality natural resources and to limit the amount of waste excreted by industries. Partial replacement of cement with pozzolons has shown successful results in improving the strength of concrete and also helpful in producing low strength concrete at low cost than cement. The pozzolons contribute to material sustainability, reduce environmental impacts of pozzolons and can have positive financial implication for certain projects. The cost of project could decrease if cement replacement is done for gaining the high strength.

1.1. Scope

The main objective of the research includes the Use of pozzolons (Marble Dust and Silica fume) as replacement of cement. It reduces the production cost of concrete in terms of natural resources, energy and economical cost. It is modifying the mechanical and physical properties of concrete in the fresh and hardened state.

This aims to study and explore the effects of replaced material on properties of concrete both in fresh and hardened state. It requires examining the strength and workability of concrete with marble dust and silica fume as partial replacement with cement.

1.2. Significance

Replacement of cement with pozzolons (Silica Fume and Marble Dust) has significant effects on the workability, strength and other properties of concrete. However, limited research has been carried out studying the effects systematically and quantitatively. Also there is a little published data regarding cement replacement in concrete. The process of forming cement is rapidly increasing and the resources are not replenished at the rate are being used. In this research an attempt is made to study the combined effect of silica fume and marble dust on the physical and chemical properties of concrete.

Dilip Kumar Singha Roy, Amitava Sil, M. G. Avenue partially replaced some amount of cement studying its effect and properties in hardened concrete.

2. **Properties of Materials**

2.1. Silica Fume

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete. Silica fume is an ultrafine material with spherical particles less than 1 µm in diameter, the average being about 0.15 µm. This makes it approximately 100 times smaller than the average cement particle. The bulk density of silica fume depends on the degree of densification and varies from 130 (undensified) to 600 kg/m^3. The specific gravity of silica fume is generally in the range of 2.2 to 2.3. With the addition of silica fume, the slump loss with time is directly proportional to increase in the silica fume content due to the introduction of large surface area in the concrete mix by its addition. (B.B. Sabir, 1995).

Although the slump decreases, the mix remains highly cohesive. Silica fume reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the silica fume and hence the free water left in the mix for bleeding also decreases.

2.1.1. Applications

Because of its extreme fineness and high silica content, silica fume is a very effective pozzolanic material. Standard specifications for silica fume used in cementitious mixtures are ASTM C1240. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. (H.A. Toutanji, T. El-Korchi, 1996)

Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions and those of humid continental roadways and runways (because of the use of deicing salts) and saltwater bridges. Effects of silica fume on different properties of fresh and hardened concrete include.

2.2. Marble Dust

Marble Dust is crushed or ground marble particles. These marble particles can still be used to make a solid object. Dry grinding reduces it to a powder without destroying its particle structure, which is important in making strong grounds and providing tooth on the surface of the grounds. In painting grounds it makes a durable surface with tooth for egg and casein tempera, distemper, encaustic and oil paint. Marble dust is often times added to concrete or synthetic resin to make counters or building stone.

2.2.1. Applications

Marble Dust is used as a replacement of cement in concrete. It is mixed with cement and concrete in the production of building stone.

Marble dust has various contemporary uses, both in the arts and in industry.

Marble from certain areas of the world is more prized for fine art use than others results from the elemental makeup of the original rock mass.

3. Needs for cement replacement.

There are following major factors which highly impact the environment on the basis of cement during any type of construction

3.1. Environment

There has been evidence that leach ate with characteristics harmful to the surrounding ecosystem may be generated from Silica Fume. Leaching issues are particularly problematic with unweathered slag. These problems include increases in pH, oxygen depletion, release of metals, sulphur and precipitation of drain clogging Tufa, as well as occurrence of color and odor nuisances.

3.2. Safety issues

Risk of serious damage to eyes. Contact with wetted Hydrated Lime, wetted Natural Hydraulic Lime, wetted Hydraulic, Lime Mortar, Lime Putty or Fine Lime Plaster may cause irritation, Dermatitis or burns. Contact between Hydrated Lime, Natural Hydraulic Lime or Hydraulic Lime Mortar powder and body fluids (e.g. sweat and eye fluid) may cause skin and respiratory irritation, Dermatitis or burns.

3.3. Awareness

More work is needed in this field. Contractors should be educated so that they can fully utilize the potential of Silica Fume and Marble Dust.

3.4. Lack of Facilities

As both Silica Fume and Marble Dust requires proper crushing before it could be used in soil. The lack of crushers is a big hurdle. Most of the Material produced from factories is either wasted or is exported on minimal price.

3.5. No Proper guidelines

No proper guidelines have yet been established in Pakistan. For the use of Silica Fume and Marble Dust as a partial binding material in concrete.

4. Methodology.

4.1 Material Procurement

The materials used during research work were:
Kohat cement, Sand used was from Nizampur, Coarse aggregate was from Basai khwar, Silica Fume was brought from Sica Paints, Islamabad, Marble Dust was brought from a Marble Factory on Warsak road. The parent rock was Malagori Hills.

4.2 Sample Casting

The Samples were casted with replacement of cement in various percentages by silica fume and marble dust. 3 cube specimens were prepared for each day and each replacement of samples. 2 beam specimens were prepared for each day and each replacement of samples. 36 cubes and 16beams were casted as a whole. The cubes were tested for 7, 28 and 90 compressive strength under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol σ.

5. RESULTS COMPARISION AND DISCUSSION

5.1 Abrasion Test

The result form the Los Angeles Abrasion Test gave the Abrasion 18.55%

5.2 Slump Test

The results from the slump test for various percentage replacement of cement are tabulated as follow

Table 5.1 Slump Test Result

Samples	Slump (in)
Control Samples (0% Replacement)	3
30% Marble Dust, 70% Cement	2
30% Marble Dust, 5% silica Fume, 65% Cement	2
30% Marble Dust, 10% silica Fume, 60% Cement	0.2

Fig 5.1(a) Slump Test of CS

Fig 5.1(b) Slump Test of PRS

5.3 Compression Test

The result of 7 Days compression test is:
$f_c' = P/A$
Where
P = Load in tons
A = Area of cube

Table 5.2 7 Days Compression Test

Samples	**Compression Strength, fc'(psi)**
Control Sample	2050
30% Marble Dust, 70% Cement	1135.65
30% Marble Dust, 5% Silica Fume, 65% Cement	872
30% Marble Dust, 10% Silica Fume, 60% Cement	1507

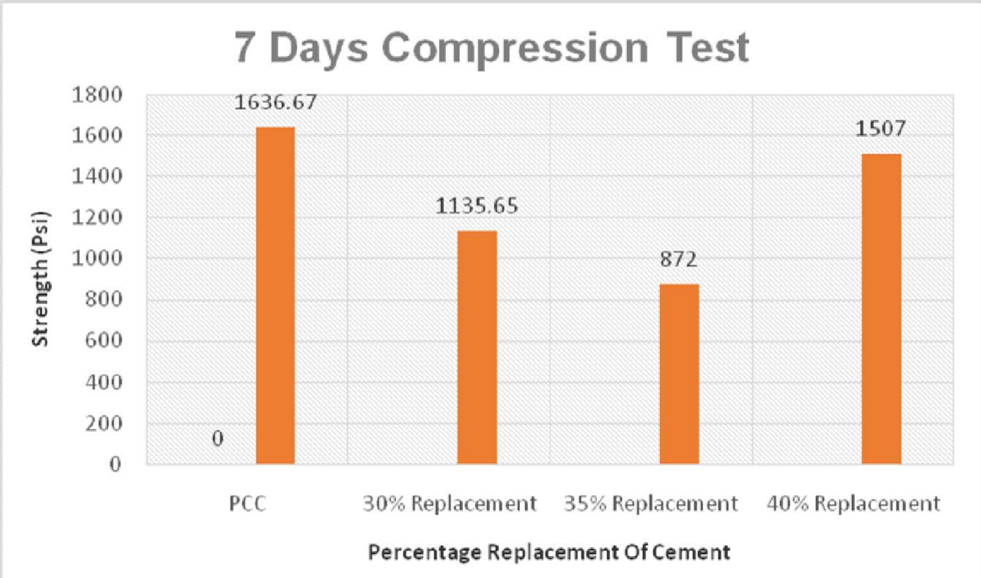


Table 5.3 28 Days Compression Test

Samples	Compressive Strength, fc'(psi)
Control Sample	3103.33
30% Marble Dust, 70% Cement	1910.13
30% Marble Dust, 5% Silica Fume, 65% Cement	1261.17
30% Marble Dust, 10% Silica Fume, 60% Cement	2038.7

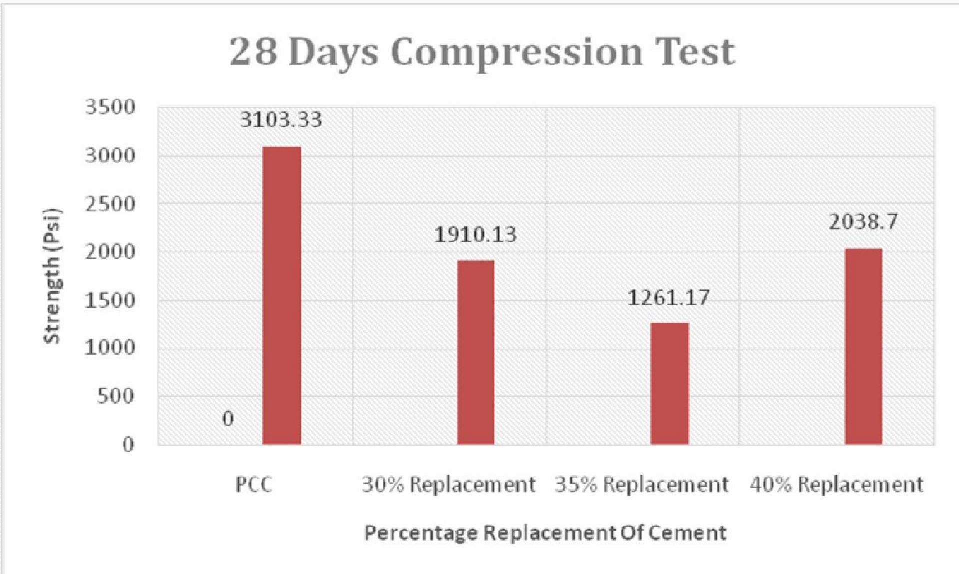
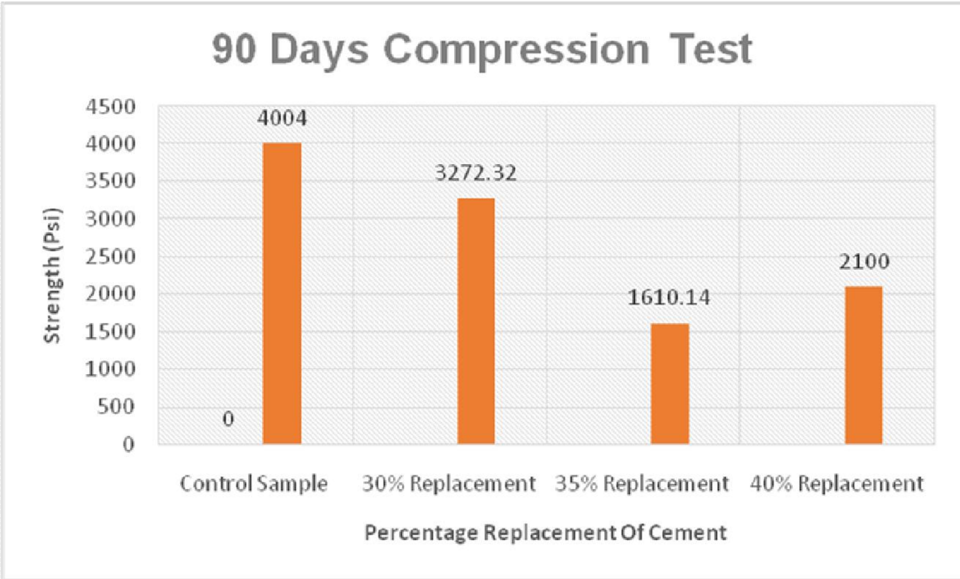


Table 5.4 90 Days Compression Test Result

Samples	Compressive Strength, fc'(psi)
Control Sample	3103.33
30% Marble Dust, 70% Cement	1910.13
30% Marble Dust, 5% Silica Fume, 65% Cement	1261.17
30% Marble Dust, 10% Silica Fume, 60% Cement	2038.7



5.4 Flexure Test

The Result of 28 days flexure test was:
$R = PL/bd^2$
Where P = load in tons
L = Length of Beam in inches
b = Breadth of Beam in inches
d = Depth of Beam in inches

Table 5.5 28 Days Flexure Test

Samples	Modulus Of Rupture, R(psi)
Control Sample	557.07
30% Marble Dust, 70% Cement	437.05
30% Marble Dust, 5% Silica Fume, 65% Cement	355.12
30% Marble Dust, 10% Silica Fume, 60% Cement	451.52

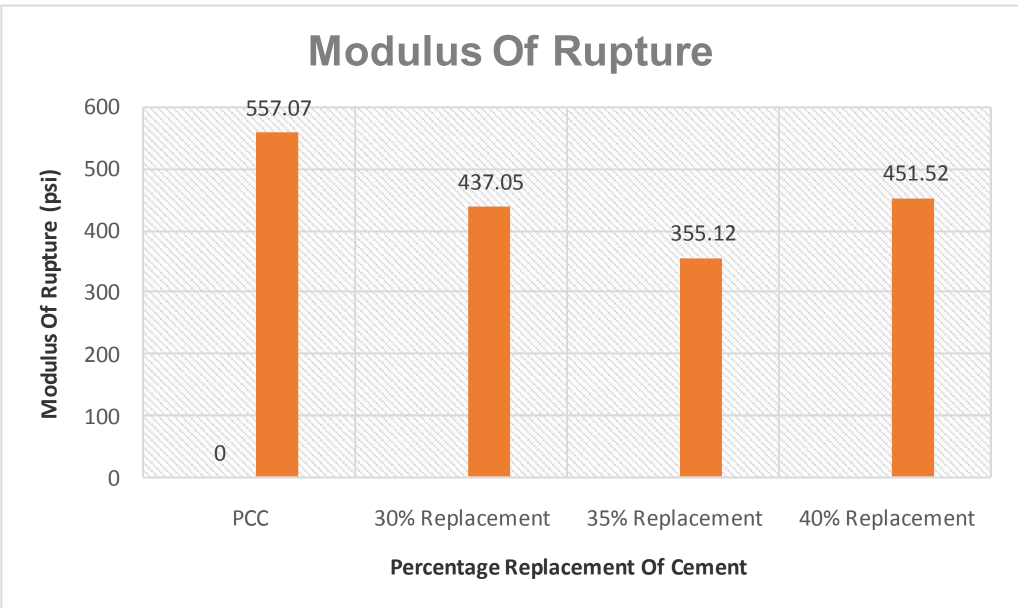
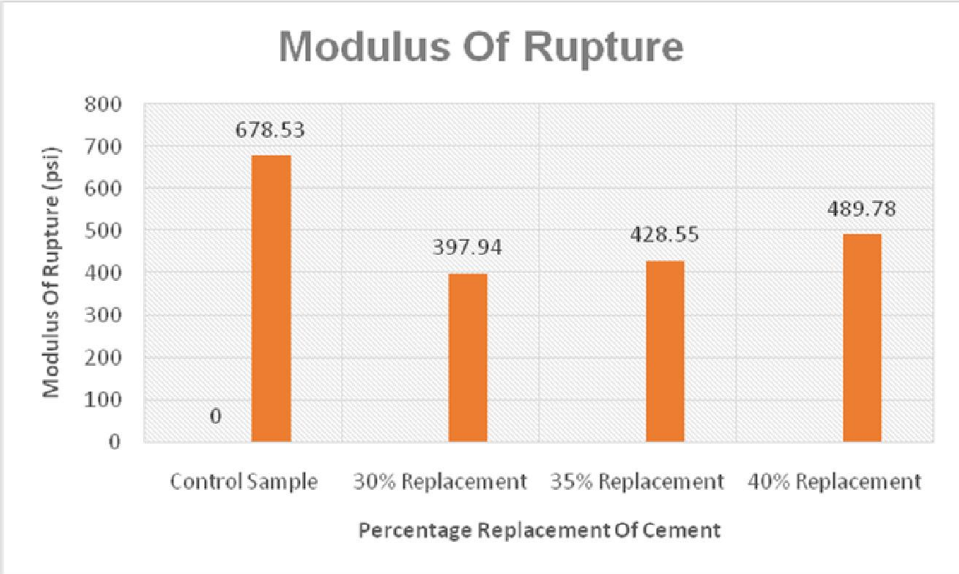


Table 5.6 90 Days Flexure Test

Samples	Modulus Of Rupture, R(psi)
Control Sample	678.53
30% Marble Dust, 70% Cement	397.94
30% Marble Dust, 5% Silica Fume, 65% Cement	428.55
30% Marble Dust, 10% Silica Fume, 60% Cement	489.78



6. CONCLUSIONS AND RECOMENDATION

6.1 Conclusions

6.1.1 Workability

The workability of the CS was first determined, then by keeping it the standard the workability of other PRS were determined and compared with the standard. The workability of PRS was reduced compared to CS.

6.1.2 Compressive Strength

The compressive strength of CS was determined for all the tests and was kept as standard. The compressive strength of PRS was determined and was compared with CS. There was decrease in the first two replacements (30% Marble dust, 70% Cement and 30% Marble Dust, 5% Silica Fume, 65% cement) but for the third replacement there was increase in the degree of decrease of strength i.e. the strength was increased compared to the other two replacements.

6.1.3 Flexure Test

The Flexure strength trend was the same as that of the compressive strength.

6.2 Recommendations

In this research work Kohat Cement (Type-1) was used, the other type of cement can also be used.
The effect in varying the w/c ratio can also be carried out in further research.
The effect of various mix design ratio can also be investigated in further research.
In this research locally available materials were used, the materials from any other source can also be used in further research.

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