EXPERIMENTAL STUDIES ON STEEL FIBRE REINFORCED SELF COMPACTING CONCRETE WITH MARBLE DUST AS PARTIAL REPLACEMENT OF CEMENT

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Abstract *Self-compacting concrete is the highly flow able, non-segregating concrete that can spread into place, fill formwork, and encapsulate even the most congested reinforcement by means of its own weight, with little or no vibration. It delivers these attractive benefits while maintaining or enhancing all of customary mechanical and durability characteristics of concrete. Adjustments to traditional mix designs and the use of super plasticizers create this concrete that can meet flow performance requirements. The self-compacting concrete is ideal to be used for casting heavily reinforced sections or be placed where there can be no access to vibrators for compaction and in complex shapes of formwork which may otherwise be impossible to cast, giving a far superior surface to conventional concrete. Self-compacting concrete, also referred to as self-consolidating concrete, is able to flow and consolidate under its own weight and is deaerated almost completely while flowing in the formwork. It is cohesive enough to fill the spaces of almost any size and shape without segregation or bleeding. This makes SCC particularly useful wherever placing is difficult, such as in heavily-reinforced concrete members or in complicated work forms.*

This study aims to focus on the possibility of using Marble dust and steel fibres in self compacting concrete (SCC) for M30 Grade prepared using additives of super plasticizer and viscosity modifying agent. The fresh and hardened properties in SCC (M30) are studied in laboratory experiments by replacing cement by using steel fibre of 0.2% by weight of concrete and marble dust with varying percentage of 0%, 10%, 20%, 30% and 40%.

Key words: *Self-compacting concrete, super plasticizers, heavily-reinforced concrete, steel fibres, marble dust.*

1. INTRODUCTION

Development of self-compacting concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. Self compacting concrete is not affected by the skills of workers, the shape and amount of reinforcing bars or the arrangement of a structure and, due to its high-fluidity and resistance to segregation it can be pumped longer distances (Bartos, 2000). The concept of self-compacting concrete was proposed in 1986 by professor Hajime Okamura (1997), but the prototype was first developed in 1988 in Japan, by professor Ozawa (1989) at the University of Tokyo. Self-compacting concrete was developed at that time to improve the durability of concrete structures. Since then, various investigations have been carried out and SCC has been used in practical structures in Japan, mainly by large construction companies. Investigations for establishing a rational mix-design method and self-compactability testing methods have been carried out from the viewpoint of making it a standard concrete.

Self-compacting concrete is cast so that no additional inner or outer vibration is necessary for the compaction. It flows like "honey" and has a very smooth surface level after placing. With regard to its composition, self-compacting concrete consists of the same components as conventionally vibrated concrete, which are cement, aggregates, and water, with the addition of chemical and mineral admixtures in different proportions. Usually, the chemical admixtures used are high-range water reducers (super plasticizers) and viscosity-modifying agents, which change the rheological properties of concrete. Mineral admixtures are used as an extra fine material, besides cement, and in some cases, they replace cement. In this study, the cement content was partially replaced with mineral admixtures, e.g. fly ash, slag cement, and silica fume, admixtures that improve the flowing and strengthening characteristics of the concrete.

Objectives of the study

The following are the main objectives for the self compacting concrete

1. To study the strength properties of self compacted concrete. To study the workability of self compacting concrete.
2. To compare the fresh and hardened properties of self compacting concrete made with different proportion of Marble dust and steel fibers.
3. To study the durability of self compacting concrete by using marble dust and steel fibers.

2. LITERATURE STUDIES

Russell et al., (1997) In his research, Russell (1997) found out that the use of slag cement lowers concrete permeability, thereby reducing the rate of chloride ion diffusion. Proper proportioning of slag cement can eliminate the need to use low alkali or sulfate-resistant Portland cements. Russell's results showed that BFS can be used to enhance the strength gain at later ages than 28 days, it replaces 20 to 30 percent by mass of the Portland cement.

Sobolev et al., (1999) Studied the effect of adding up to 50% by mass granulated blast-furnace slag in the cementitious material that resulted in the increasing of chemical and thermal resistance. The very low permeability of the concrete obtained, provided high resistance to chemical attack and to freezing and thawing cycles.

3. MATERIALS USED AND MIX DESIGN

Cement

Ordinary Portland cement of 53 grade from the local market was used and tested for physical and chemical properties as per IS: 4031 – 1988and found to be conforming to various specifications as per IS: 12269-1987.

OPC 53 grade cement

Fine aggregates

In the present investigation fine aggregate is natural sand from local market is used. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS :2386.

Fine aggregates (Sand)

Coarse aggregates

The crushed coarse aggregate of 12.5 mm maximum size rounded obtained from the local crushing plant, warangal is used in the present study. The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS ; 2386.

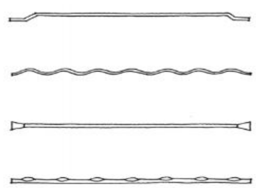
Marble Dust

Marble dust should be white in color and should be in particular air dried of all moisture content. The Marble dust powder was collected from the locally available manufacturing unit in Lucknow, Uttar Pradesh, India. Specific gravity of marble dust powder is 2.64 and water absorption is 0.97%. It was sieved by IS-90 micron sieve before mixing in concrete.

Marble dust powder

Steel fibers

Many years of the experience had prompted the generation of the five most productive steel fiber sorts. The proficiency of the at present created fiber depends on the two its adequacy in solid framework and the effortlessness of its generation, which thusly affects its cost. These five most prevalent sorts of steel fiber are: customary straight, snared, pleated, coned, and mechanically twisted.



Fiber Profiles: Hooked, Crimped, Coned, and Mechanically Deformed

Super plasticizer

The super plasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observant that with the use of large quantities of finer material (fine aggregate + cement + fly ash) the concrete is much stiff and requires more water for required workability hence, in the present investigation SP430 is used as water reducing admixture.

Sodium chloride (NaCl)

Sodium chloride commonly known as salt is an ionic compound with the chemical formula NaCl, representing a 1:1 ratio of sodium and chloride ions. With molar masses of 22.99 and 35.45 g/mol respectively, 100 g of NaCl contains 39.34 g Na and 60.66 g Cl. Sodium chloride is the salt most responsible for the salinity of seawater and of the extracellular fluid of many multi cellular organisms.

Sodium chloride (NaCl)

Sulphuric acid (H2So4)

Sulfuric acid (alternative spelling sulphuric acid), also known as vitriol, is a mineral acid composed of the elements sulfur, oxygen and hydrogen, with molecular formula H_2SO_4. It is a colorless, odorless, and syrupy liquid that is soluble in water and is synthesized in reactions that are highly exothermic.

Its corrosiveness can be mainly ascribed to its strong acidic nature, and, if at a high concentration, its dehydrating and oxidizing properties. It is also hygroscopic, readily absorbing water vapor from the air. Upon contact, sulfuric acid can cause severe chemical burns and even secondary thermal burns; it is very dangerous even at moderate concentrations.

Mix design of Concrete

The following table shows the mix proportions of M30 grade concrete used in this study

W	Cement	Fine aggregates	Coarse aggregates
186	440	472	611.11
0.42	1	1.07	1.38

Tests to be conducted on the concrete

The following are the various tests to be conducted on M30 grade SCC

Workability of concrete

1. Slump cone test
2. Compaction factor test

Strength of concrete

1. Compressive strength of concrete
2. Split tensile strength of concrete
3. Flexural strength of concrete

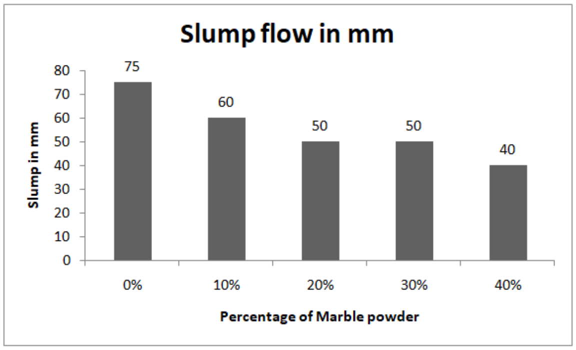
Durability of concrete

1. Acid attack test
2. Sulphate attack test

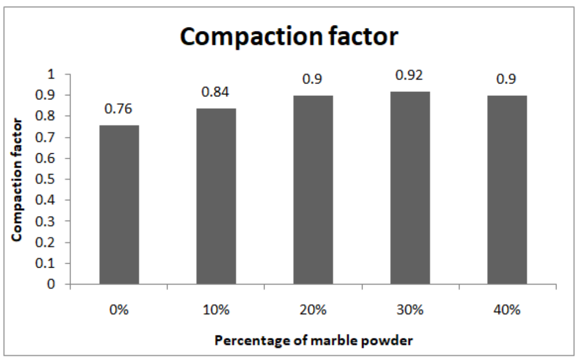
4. EXPERIMENTAL RESULTS

Workability of concrete

Slump cone test with 0.2% steel fibers

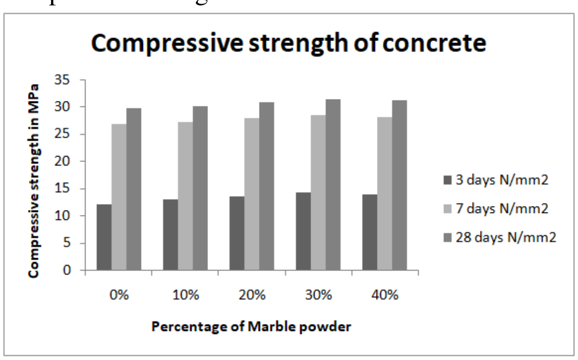


Compaction factor test with 0.2% steel fibers

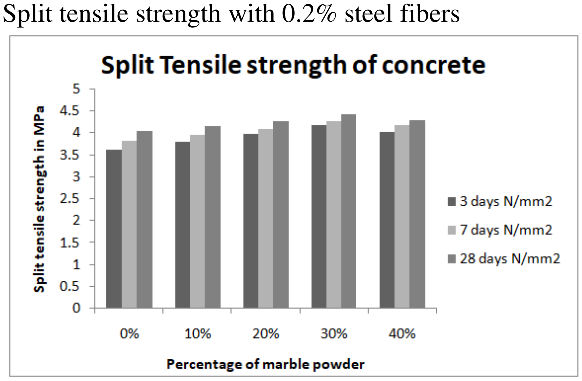


Strength of concrete

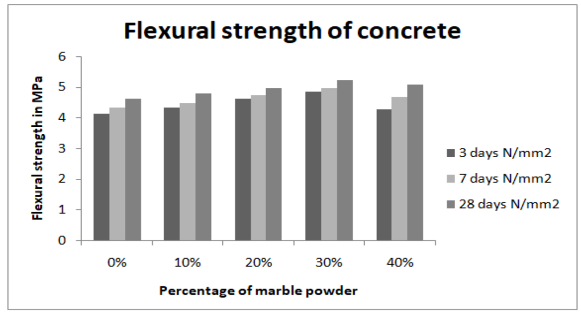
Compressive strength with 0.2% steel fibers



Split tensile strength with 0.2% steel fibers

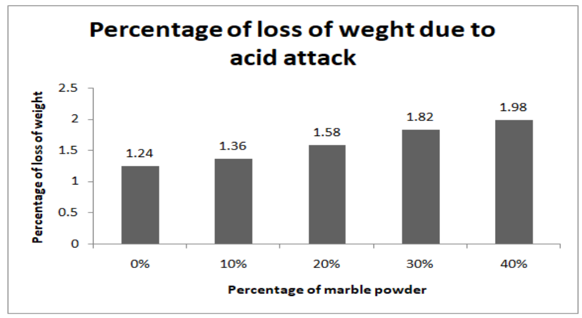


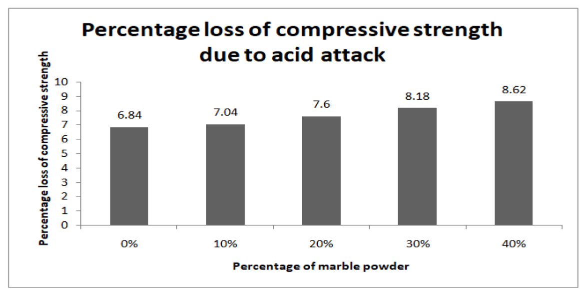
Flexural strength with 0.2% steel fibers



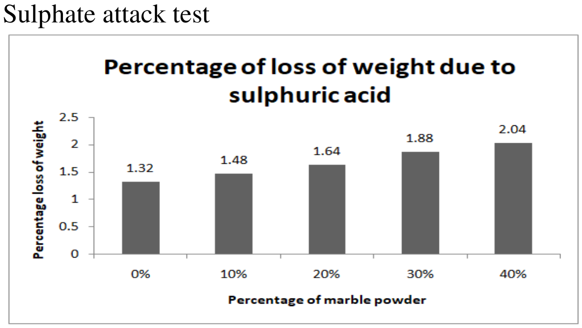
Durability of concrete with 0.2% steel fibers

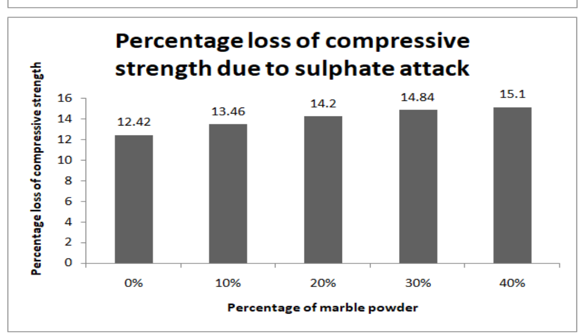
Acid attack test





Sulphate attack test





5. CONCLUSIONS

From this study the following conclusions were made

1. Self-compacting concrete can be obtained in such a way, by adding chemical and mineral admixtures, so that its splitting tensile and compressive strengths are higher than those of normal vibrated concrete.
2. The slump flow value for the SCC by using marble powder decreases with increasing the percentage.
3. The compaction factor for the SCC by using marble powder Increases with increasing the percentage.
4. The optimal value of compressive strength, split tensile strength and flexural strength of SCC was observed at 30% of marble powder. The value of strengths increases with increase in the percentage of marble powder up to 30%.
5. In addition, self-compacting concrete has two big advantages. One relates to the construction time, which in most of the cases is shorter than the time when normal concrete is used, due to the fact that no time is wasted with the compaction through vibration.
6. The second advantage is related to the placing. As long as SCC does not require compaction, it can be considered environmentally friendly, because if no vibration is applied no noise is made.
7. Due to effect of acid and sulphate on concrete by using marble dust the value of percentage loss of weight, and percentage loss of compressive strength increases.

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