Effect of partial replacement of cement with marble dust powder using steel fiber on strength parameters of self compacting concrete

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ABSTRACT

Self-Compacting concrete is a type of concrete that gets compacted under its self-weight. It's commonly abbreviated as SCC and defined as the concrete which can placed and compacted into every corner of a formwork; purely means of its self-weight by eliminating the need of either external energy input from vibrators or any type of compacting effort. In this study, the effect of replacing the cement by marble dust powder with (5%,10%,20%) respectively and steel fibers (2%) their combinations of various proportions on the properties of Self compacting concrete has been compared. Properties of compressive strength, split tensile strength and flexural strength of Concrete were determined. However, the results of this study suggest that MARBLE DUST powder (10%),steel fibers (2%) combinations can improve the workability of Self compacting concrete, more than conventional concrete and while their using separate.

Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its colour and appearance: it is white if the limestone is composed solely of calcite (100% $CaCO_3$). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are the major mineral impurities whereas SiO_2, limonite, Fe_2O_3, manganese, $3H_2O$ and FeS_2 (pyrite) are the major chemical impurities associated with marble.

KEYWORDS: Different types of steel fibers proportions, M40 grade concrete, Mechanical properties of concrete.

Scope of project

The scope of the work is the study of self compacting self curing concrete with steel fibers and Marble dust powder. Already by many researchers as thought the steel fibers increases the tensile strength and Marble dust powder increases the compression strength for concrete. Specimens are going to cast such as cubes, cylinders, and beams by introducing limestone powder at (5%,10%,20%) replacement of cement and steel fibers (2%) with 50 aspect ratio and self curing period of 3, 7and 28 days. The strength is measured by testing compressive test, split tensile and flexural test, Rapid chloride permeability test.

PROPOSED METHODOLOGY AND DISCUSSION

The present research aims at studying the effect of straight fiber, crimped fiber and hooked fiber on strength parameters of self compacting concrete for M-40 grade of concrete having a mix proportion of 1:1.79:2.54 and maintaining water cement ratio =0.35.The mix design was carried out using IS:10262-2009 and modified Nansu Method was also implemented. Cubes, Cylinders and Prisms were casted and tested at 7 and 28 days in order to study the compressive strength, Split tensile strength, flexural strength, of steel fibre reinforced concrete (SFRC) containing this fibers at a varying percentage of 1%, 2% and 3% by volume of cement

MATERIALS USED:

The various materials used in the preparation of Self Compacting concrete are as follows.

1. Cement.
2. Coarse aggregate.
3. Fine aggregate.
4. Steel Fibres(Straight, Crimped, Hooked)
5. Super plasticizer.
6. Water.

PROPERTIES OF MATERIALS

3.1 Cement

The most common cement currently used in construction is 53 grade Ordinary Portland cement.

1.2.1 Coarse aggregate:

The coarse aggregate chosen for Marble dust powder should be well graded and smaller in terms of the maximum size than that used for conventionally vibrated concrete. For typical conventional concrete the coarse aggregate size may be 20 mm and even more in general. The rounded aggregates and smaller size of aggregate particles improves the Flowability, deformability and segregate resistance of MDP. The gradation is an important factor in choosing a coarse aggregate, where, highly congested reinforcement patterns are used and where, very small dimensional elements are to be produced. In case of conventional concrete, the size of the coarse aggregate depends upon the type of the construction. Like in case of conventional concrete, size of aggregate has a key note to play in MDP designs also. Hence, studies are needed to assess the maximum size of aggregate for a particular grade of concrete. Usually, the maximum size of the coarse aggregate used in production of MDP, ranges approximately between10mm and 20mm.

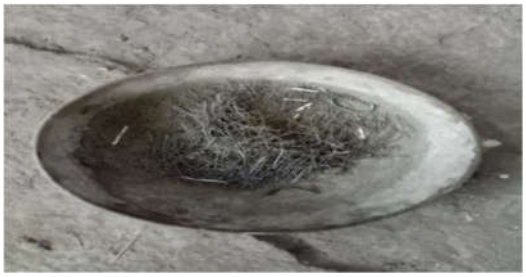
1.2.2 Fine Aggregate:

All normal river sands are suitable for MDP. Both crushed an rounded sands can be used. Siliceous and calcareous sands can be used for production of MDP. The amount of fines less than 0.125mm is to be considered as powder which is very important for the Rheology of MDP. A minimum amount of fines must be maintained to avoid segregation. The amount of fines has a very significant effect on MDP mix proportions. Fine sand requires more water and Super Plasticizer (SP), but less filler than coarse sand. The SP dosage, water content and cement/filler content could be adjusted by treating

the fines (>150 um) in sand as part of the filler. We are using Godavari river sand. Its is best suitable for this experiment.

1.2.3 Steel Fibres:

i. Straight Steel Fibres: These Steel fibers are nothing but the pieces of steel wire from 0.3 to 1.1 mm in dia and these are having length 50 mm. These steel fiber are used in three-dimensional reinforcement of concrete and replaces steel mesh.



Straight Steel Fibres

ii.Crimped Steel Fiber: Crimped Steel Fiber is used as a piece of either dry or wet process shotcreting to enhance Flexibility, quality and impact resistance.

Crimped Steel Fibre

iii. Hooked Steel Fiber: Hooked Steel Fiber can be used with any concrete mix and high concrete density is less mandatory then for undulated or for flat-end fibers. Load transfer in the crack is very good with this fiber shape

Hooked Steel Fiber

1.2.4 Cement:

All types of cements conforming to Bureau of Indian standards are suitable as per Indian conditions. Selection of the type of the cement is made depending on the overall requirements of MDP such as strength, durability etc. The cement content can be 350 – 450 kg/m^3. The usage of cement more than 500 kg/m^3 may increase the shrinkage in the hardened state of concrete, whereas, the quantity less than 350 kg/m^3 may decrease the durability of MDP. Hence, cement content shall be judged properly.

1.2.4 Water:

Potable water shall be used for the production of MDP. In case of conventional concretes (NC), the water is proportionate only with the cement content. It is called as the water-cement ratio. This influences the mix and thereby workability. But, in the case of MDP, instead of water-cement ratio the term water binder-ratio will be used. This means the content of water mixed in the MDP is proportionate to the total binders such as cement, fly ash etc.

1.2.5 Chemical admixtures:

Super Plasticizer:

Generally, in order to increase the workability, the water content is to be increased provided a corresponding quantity of cement is also added to keep the water cement ratio constant, so that the strength remains the same. Portland cement, being in fine state, has a tendency to flocculate in wet concrete. This flocculation entraps certain amount of water used in the mix and there by all the water is not freely available to increase the fluidity of mix. On the other hand, to avoid the use of excess quantity of water and cement, SP is used to increase the fluidity of the mix and improve the workability of concrete. When plasticizers are used, they get absorbed on cement particles. The absorption of charged polymer on cement particle creates particle to particle repulsive forces, which over come the attractive forces.

This repulsive force is called zeta potential which depends on the base, solid contents and quality of super plasticizer used. Then, the cement particles are deflocculated and the water trapped inside the flocks gets released and the water is available to fluidity the mix.

The job of super plasticizer is to impart a high degree of flowability and deformability which are essential for the development of MDP. However, the higher dosages of SP can lead to a high degree of segregation. Super plasticizer is a chemical compound used to increase the workability without adding more water. It has the property of spreading the given water in the concrete throughout the concrete mix resulting in a uniform mix. Thus, super plasticizer is essential for the creation of MDP.

EXPERIMENTAL RESULTS

4.1 COMPRESSIVE STRENGTH (IS 516-1959)

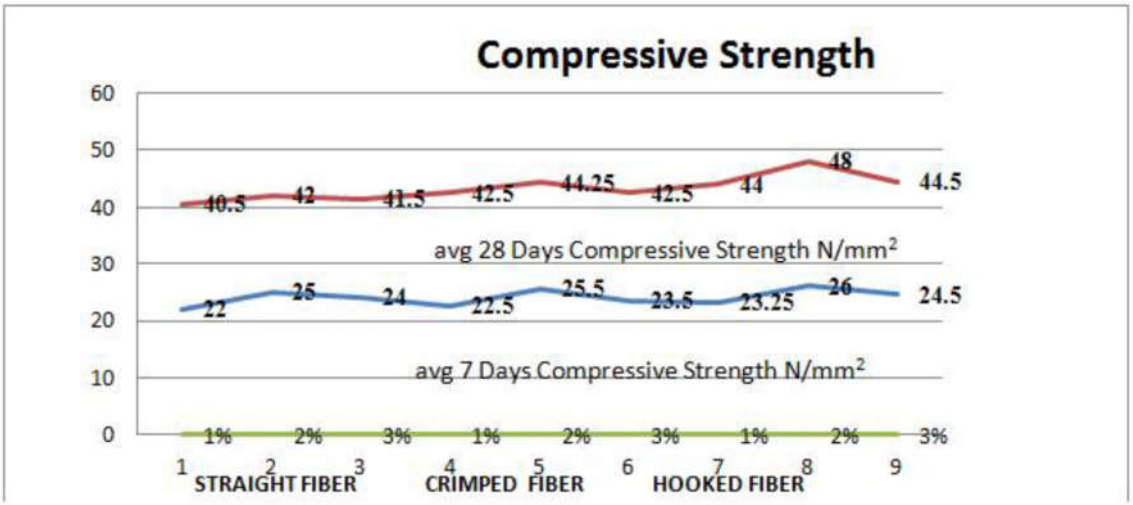
Cubes of size (150 x 150 x 150mm) were casted and tested for determining compressive strength at 7 and 28 days The
concrete cubes were cured at ambient temperature.

AVG 7 Days Compressive Strength (N/mm2)at 0% Fiber Content =21.4 N/mm2

AVG 28 Days Compressive Strength (N/mm2) at 0% Fiber Content =40.3 N/mm2

Mix Proportion of different Steel Fibers of M40 grade of MDP

Replacement	0%	5%	10%	15%	20%	25%	30%
Mix proportion	1:1.68:2.4	1:1.7:2.21: 0.052	1:1.81:2.38:0.11	1:1.88:2.44: 0.176	1:1.93:2.51:0.25	1:2.02:2.63: 0.3	1:2.06:2.67:0.4
Cement	23.4	22.28	20.72	19.57	18.92	17.22	15.59
Marble powder	0	1.168	2.27	3.42	4.58	5.54	6.74
Fine aggregate	39.16	37.84	37.87	36.72	34.94	34.78	32.6
Coarse aggregate	53.84	49.22	49.2	44.66	46.08	44.92	42.9
Water	9.24	8.77	8.3	7.86	7.32	6.88	6.32
Super plasticizer	0	111.4	144.76	184.2	201.82	215.24	225.12



Type of Steel Fiber	Type of Steel Fiber	AVG 7 Days Compressive Strength N/mm2	AVG 28 Days Compressive Strength N/mm2
Straight Fiber	1%	18	30.5
	2%	19	42
	3%	17.5	41.5
Crimped Fiber	1%	20	32
	2%	22.5	32.5
	3%	221.25	30.25
Hooked Fiber	1%	22.25	31.5
	2%	23	30
	3%	22.5.	29.5

Splitting Tensile Strength Test

Cylinders of size (150 x 300mm) were casted and tested for determining Splitting Tensile Strength at 7 and 28 days
The concrete Cylinders were cured at ambient temperature.
AVG 7 Days split tensile Strength (N/mm2) at 0% Fiber Content =1.95 N/mm2
AVG 28 Days split tensile Strength (N/mm2) at 0% Fiber Content =3.8 N/mm2

Table VI: Average Split Tensile Strength in N/mm2 at 7 and 28 Days for different fibers at varying percentages

Curing days	0%	5%	10%	15%	20%	25%	30%
7 days	3.67	3.83	5.9	6.4	5.5	4.55	3.8
28 days	5.4	7.5	11.4	14.	10.4	7.1	5

Conclusions

In this study, different types of steel fibers were used to produce fiber reinforced self-compacting concrete. A strict mixing procedure is followed in this study, in terms of time of mixing, addition of components, and sequence of material addition. In order to achieve high quality SCC and SFR-SCC mixes, it is essential to strictly follow the recommended mixing procedure. This procedure with the given mix proportions has led to an SCC mix that was able to flow and fill the molds without any need of vibration.The following conclusions were obtained from this study.

1. The 7 and 28 days compressive strength of self-compacting concrete with hooked steel fibres is maximum at a fibre percentage of 2%
2. The 7 and 28 days splitting tensile strength of self-compacting concrete with hooked steel fibres is maximum at a fibre percentage of 2% The 7 and 28 days flexural strength of self-compacting concrete with hooked steel fibres is maximum at a fibre percentage of 2%
3. The variation of 28 days splitting tensile strength of self-compacting concrete with different type of steel fibre percentage is moderate.
4. Up to 15% replacement of cement with Marble dust powder there is a increase in all mechanical properties.
5. The replacement of 15% of cement with marble dust powder attains maximum compressive and split tensile strength.
6. The optimum percentage for replacement of marble powder with cement and it is almost 15% cement for both cubes and cylinders.
7. To minimize the costs for construction with usage of marble powder which is freely or cheaply available; more importantly.
8. To realm of saving the environmental pollution by cement production; being our main objective as Civil Engineers.
9. To increase the workability of concrete and increases the strength

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