

Strength and Durability Characteristics of Self Compacting Concrete Using Marble Powder and Silica Fume

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ABSTRACT: Self compacting concrete is one having excellent deformability in the fresh state and high resistance to segregation and can be placed and compacted under its self weight without applying vibration. Over the last ten years, significant amount of work has been carried out on self-compacting concrete all over the world. In this experimental work different percentages of marble powder and silica fume are added. Silica fume is very fine non crystalline silica produced in electric arc furnace as a byproduct of the production of elemental silicon or alloys containing silicon and marble powder are obtained during marble processing. This project covers experimental investigation for the possibility of effective replacement of cement with marble powder (5%, 10%, 15%, and 20%) and silica fume along with the optimum marble powder at (5%, 10%, 15%, and 20%) for M30 grade concrete. Tests such as Slump flow, V-funnel, L-box tests are carried out to determine optimum parameters for the self-compactability of mixtures. Tests done on Compressive strength, flexural strength and split tensile strength of the specimens shows that concrete strength is maximum improved by the replacement of cement by 10% marble dust and 10% silica fume. The Water absorption test, chloride penetration test, sulphate attack tests were also carried out for study its effect on durability. Both the materials improve durability characteristics of concrete.

KEYWORDS: Self compacting concrete; marble powder; silica fume; compressive strength; flexural strength; split tensile strength.

I. INTRODUCTION

Self-compacting concrete (SCC) is that concrete which has high flowing ability with no segregation. It is considered to be one of the revolutionary developments in concrete technology in recent times. It reduces noise at sites, precast factory and neighborhood. The mix proportions for self-compacting concrete were arrived at by performing mix design and then fine-tuning using EFNARC guidelines. It was first developed in 1988 by Professor Okamura in Japan.

SCC must satisfy the following workability performance criteria: 1) Flow ability: The ease of flow of fresh concrete when unconfined by formwork and/or reinforcement; 2) Viscosity: The resistance to flow of a material (e.g. SCC) once flow has started; 3) Passing ability: The ability of fresh concrete to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking; and 4) Stability: the ability of SCC to remain homogenous by resisting segregation, bleeding, and air popping during transport, placement, and after placement. Due to its characteristics, SCC provides several benefits such as: greater freedom in shape design, easier pumping and placing, improved consolidation around reinforcement, higher bond strength with reinforcement, uniform and complete consolidation, better surface finishes, improved durability, reduced noise levels caused by absence of vibration, labor savings, faster construction and also more spacious and safe working environment. Those characteristics of SCC can be achieved by implementing following basic principles in the mix design process; 1) lower coarse aggregate content, 2) increasing paste content, 3) lower water/powder ratio, (powder is defined as cement added with filler, such as: fly ash,

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silica fume, etc.), and 4) the use of super plasticizer. Considering lower water-cement ratio and higher content of cementitious materials compared to conventional concrete, SCC should have improved durability and strength. The project aims to study the properties of SCC in which silica fume and marble powder are used and also to study the effect in durability of SCC when silica fume and marble powder are used.

II. LITRATURE REIEW

Veena B., Sivakumar K (2016), studied about the experimental behaviour and durability property officer reinforced concrete with marble powder. And found that the compressive strength, split tensile strength, flexural strength increases with the increase of marble powder at 10% of marble powder & 0.1% of glass fiber and the concrete with marble powder is more durable, and it gives good resistivity to fire attack

Kishan P. Pala and Krunal J Dhandha(2015),studied, the Use of marble powder and fly ash in self compacting concrete and found that The Use of marble powder and fly ash by substitution to cement has no negative effect of workability of SCC. And the fresh property like Filling ability and passing ability is increase by use of 10% waste Marble Powder and 25% fly ash by replacement by cement in binder material.

Mr.Karthick.M (2016) et.al studied that use of silica fume and quarry dust in self compacting concrete as replacement of 20% by weight of cement and fine aggregate respectively shows good result of water absorption. When partial replacing 20% cement as silica fume and 20% fine aggregate as quarry dust shows very good resistance to alkaline attack, acid attack, sulphate attack and chloride attack than conventional concrete.

Sumit Kumar (2015) et.al studied that self compacting concrete with silica fume exhibited satisfactory results in workability, because of small particle size and more surface area. 4 to 8 percent by mass replacement of silica fume for cement gives the highest strength for short and long terms and when silica fume is replaced by 12% the strength decreases.

III. MATERIALS USED

Cement: 53 grade Ordinary Portland cement of RAMCO, from local market is used. The properties of cement are given in Table 1.

Table 1 Properties of cement

Properties	Observed value
Specific gravity	3.15
Standard consistency	34%
Fineness modulus	8%
Initial setting time	33 min
Final setting time	360 min

Fine Aggregate: M sand conforming to zone II was used and its properties are given in table 2:

Table 2 Properties of fine aggregate

Properties	Observed Value
Specific gravity	2.76
Fineness modulus	3.21
Water absorption	2%
Moisture content	2.4%

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Coarse Aggregate: Aggregate of size of 10 mm was used and its properties are given in table 3.

Table 3 Properties of coarse aggregate

Properties	Observed Value
Specific gravity	2.8
Fineness modulus	7.02
Water absorption	0.5%
Moisture content	0.23%

Marble Powder: The advancement of concrete technology can reduce the consumption of natural resource and energy source and lessen the burden of pollution on environment .Presently Large amounts of marble dust are generated in natural stone processing plants with an important impact on environment and humans. This project describes the feasibility of using the marble dust in concrete production as partial replacement of cement. In India, the marble and granite stone processing is one of the most thriving industry the effects if varying marble dust content on the physical and mechanical properties of fresh and hardened concrete have been investigated. The marble powder collected from Reshmi Industries, Chalakudy.

Table 4 Properties of marble powder

Properties	Value
Specific gravity	2.6
Fineness modulus	2.1%
colour	White

Silica fume: It is an ultrafine powder obtained from the alloys of silicon and ferrosilicon production and consists of particle diameter of 150 nm with average spherical particles. It should have the high level of fineness have the property of good cohesion and improved resistance to segregation. It should be effective in eliminating bleeding.

Table 5 Physical properties of silica fume

Properties	Value
Specific gravity	2.14
colour	Light blue

Fly ash: Fly ash is obtained from Hindustan News Print Limited Kottayam, India. The physical properties of fly ash are given in table 5.

Table 6 Physical properties of fly ash

Properties	Value
Specific gravity	2.4
colour	Brownish

Water: The drinking tap water has been used for both mixing and curing of concrete.

Super plasticizer: The new generation of this kind of admixtures is represented by polycarboxylate ether-based super plasticizers (PCEs). With a relatively low dosage (0.15–0.3% by cement weight) they allow a water reduction up to 40%, due to their chemical structure which enables good particle dispersion. It is also called Glenium -51

IV. METHODOLOGY

A concrete mix of M30 grade is considered for the experimental work. The investigation is proposed to be carried out by replacing cement with marble powder (5%,10%,15%,20%) and silica fume (5%, 10%, 15%, and 20%).silica fume

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is obtained from RMC Plant Edayaar, and marble powder from Reshmi industries Chalakudy. The following tests were conducted on the hardened concrete:

1. Splitting Tensile Strength on cylinder
2. Flexural Strength on beam
3. Compressive Strength on cube
4. Acid resistance
5. Chloride resistance
6. Water absorption

V. MIX DESIGN

The SCC mix having a characteristic compressive strength of 30 MPa and water-cement ratio 0.38 was designed according to EFNARC guidelines.

Table 7 SCC mix proportions with marble powder

Mix	Cement kg	Fly Ash Kg	Marble Powder kg	Fine Aggregate kg	Coarse Aggregate K	Water L
SCC	375	225	0	980	770	190
MP5	375	225	25	980	770	190
MP10	375	225	50	980	770	190
MP15	375	225	75	980	770	190
MP20	375	225	100	980	770	190

VI. TEST RESULTS

Fresh properties of SCC replacing with Marble powder

The fresh properties of SCC using marble powder presented in table 8. They are Flow ability (Slump Flow Test), Viscosity (T 500 Slump- Flow Test or V Funnel Test) and passing ability (L Box Test). It shows that, the slump flow values for all mixes are in the range of 650-705mm. The European Guideline for Self-compacting Concrete has suggested that the slump flow range value should range from 650 to 800 mm.

Table 8 Fresh properties of SCC replaced with marble powder

Test	MC	MP5	MP10	MP15	MP20	Acceptance Range
Slump flow test (mm)	650	670	675	695	705	650-800
T500(sec)	4.5	4	3.7	3.2	3	2-5
L-Box	0.81	0.82	0.85	0.90	0.92	0.8-1
V-Funnel (sec)	10	9.6	8.7	7.9	7.5	6-12

The sample without marble powder shows the lowest value of slump flow with 650mm. The value increases gradually with the increase of marble powder up to 15 %. The time taken by concrete to reach a slump flow of 500 mm was also recorded and designated as T50 cm slump flow. As per EFNARC guide lines states 2 to 5 seconds as satisfactory range. All mixes satisfied the above mentioned limit. T500 value decreased with the increase of marble powder in the

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mixture. It can be seen from results that all mixes shows satisfactory results for passing-ability using L-Box test. Table 8 shows that the V-funnel time of all mixes was in EFNARC satisfactory range i.e. 6 seconds to 12 seconds.

Hardened Properties of SCC Using Marble powder

The figures below show that the value of compressive strength gradually increases and the maximum value obtained is at 10% replacement and the value is 37.22N/mm^2 . The Flexural strength and split tensile strength exhibit the same behaviour as compressive strength. Even if there is a decrease in strength, each mix meets its target value. Hence replacement cement with marble powder can be done up to 20%

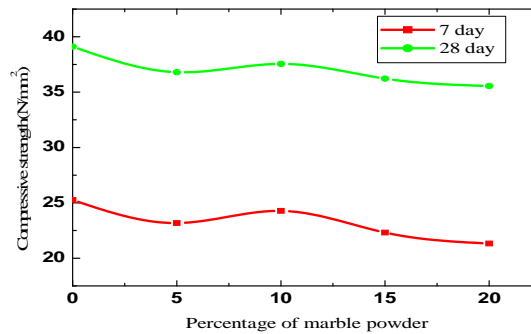


Fig 1 Compressive strength of SCC using marble powder

Figure 1 shows the variation of compressive strength with percentage of marble powder. From these results the optimum percentage of marble powder found as 10%. The test results shows the compressive strength of the specimens gradually decrease with the increase in the percentage of replacement of marble powder.

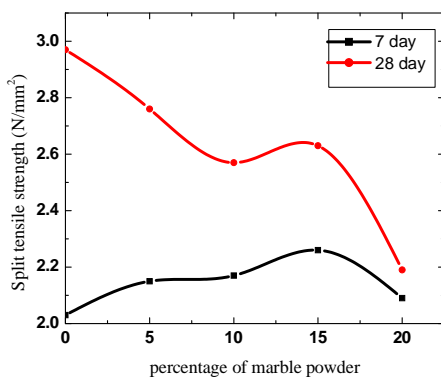


Fig 2 Split tensile strength of SCC using marble powder

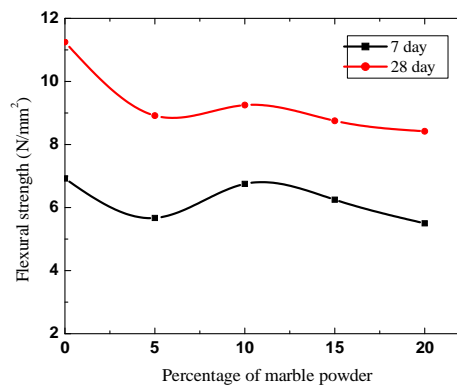


Fig 3 Flexural strength of SCC using marble powder

Figure 2 and figure 3 shows split tensile strength and flexural strength of SCC using marble powder. From these figures it shows that flexural strength maximum at 10% replacement. And split tensile strength maximum at 15%

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replacement. From the test results the optimum marble powder found as 10%. With this optimum cement is replaced with silica fume.

Fresh properties using Silica fume

Using these results with optimum percentage of marble powder and replacing cement with silica fume. The fresh properties of SCC using silica fume is given in table 9. The addition of silica fumes lower the flow ability .which also affects the passing and filling ability

Table 9 Fresh properties of SCC using silica fume

Tests	MOSF5	MOSF10	MOSF15	MOSF20	Acceptance range
Slump flow test (mm)	690	700	675	655	650-800
T500(sec)	4	3.2	3.7	3.2	2-5
L-Box	0.89	0.87	0.85	0.83	0.8-1
V Funnel (sec)	8.9	8.7	8.6	8.3	6-12

Hardened Properties of SCC Using Silica fume

From test results it shows that the compressive strength maximum attained with the addition of 10% silica fume replacement. The flexural strength exhibits same behaviour as compressive strength. The split tensile strength maximum value obtained with 15% replacement of silica fume. Fig 4, fig 5, fig 6 are shows the compressive strength, split tensile strength, flexural strengths of SCC using silica fume. The optimum value is obtained wth 10% of replacement with silica fume . the maximum value of compressvie strength attained is 40.88N/mm².

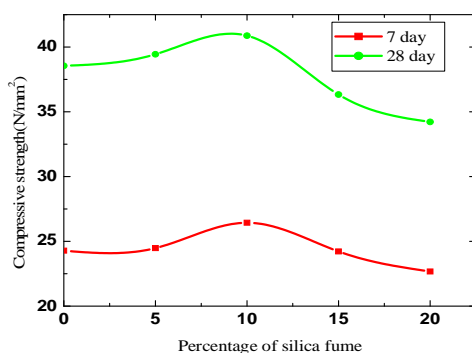


Fig 4 Compressive strength of SCC using silica fume

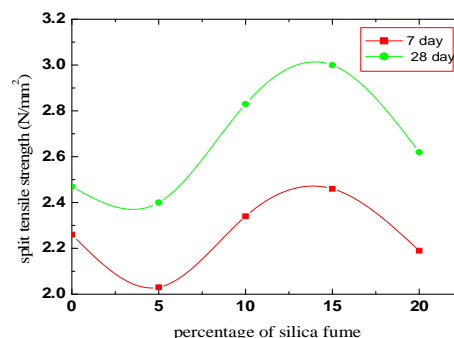


Fig 5 Split tensile strength of SCC using silica fume

From fig 4 it is obtained that the compressive strength increases with silica fume and maximum at 10% replacement. From fig 5 the split tensile strength maximum obtained at 15% of replacement.

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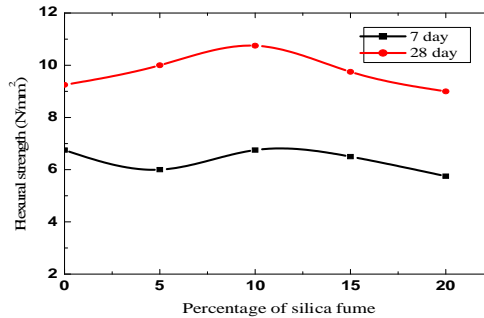


Fig 6 Flexural strength of SCC using silica fume

From fig 6 the flexural strength increase with silica fume and optimum value obtained at 10% replacement with silica fume. From these test results the optimum value of replacement is taken as 10%.

Durability results

a) Acid resistance: - Table 10 and 11 shows the obtained test results.

Table 10 Acid resistance of SCC with marble powder

Mix	Loss in weight (%)		Loss in strength (%)	
	28day	56 day	28 day	56 day
MC	3.56	4.22	10	13.59
MP5	2.6	3.55	9.3	12.23
MP10	2.02	3.10	8.5	10.25
MP15	2.20	3.41	8.7	11.21
MP20	2.75	3.75	7.23	11.21

From the test results it shows that the marble powder increases the resistance to acid attack. The weight loss and strength loss decreases using marble powder. It will give good resistance to acid attack than conventional mix.

Table 11 Acid resistance of SCC with silica fume

Mix	Loss in weight (%)		Loss in strength (%)	
	28day	56 day	28 day	56 day
MOSF0	1.21	4.4	8.5	10.25
MOSF5	0.9	2.81	5.10	8.18
MOSF10	0.75	2.23	3.30	7.69
MOSF15	0.8	2.76	4.35	8.02

From the test results it is found that the acid resistance increases with increase of silica fume. It will provide good results than the use of marble powder. From these results obtain the minimum loss of strength occurs at 10% replacement of silica fume with optimum quantity of marble powder. Thus replacement of silica fume is found to have increased the durability against acid attack.

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b) Chloride resistance

The obtained results are shown in table 12 and table 13.

Table 12 Chloride resistance of SCC with marble powder

Mix	Loss in weight (%)		Loss in strength (%)	
	28day	56 day	28 day	56 day
MC	0.90	1	6.2	7.52
MP5	0.85	0.95	5.10	6.85
MP10	0.62	0.84	3.74	4.9
MP15	0.70	0.88	4.10	4.92
MP20	0.72	0.88	5.2	6.9

The table 12 shows the chloride resistance of self compacting concrete when it replaces cement with marble powder. The loss in weight and loss in strengths for 28 days and 56 days are shown. From these results it is found that the usage of marble powder shows good in chloride resistance. Usage of marble powder increases the resistance of chloride. The obtained weight losses are 0.90, 0.85, and 0.62 etc are for 28 days. And 1, 0.95, 0.84 for 56 days

Table 13 Chloride resistance of SCC with silica fume

Mix	Loss in weight (%)		Loss in strength (%)	
	28day	56 day	28 day	56 day
MOSF0	0.62	0.84	3.74	4.9
MOSF5	0.50	0.62	3.62	4.75
MOSF10	0.45	0.62	3.30	4.31
MOSF15	0.54	0.76	2.96	3.42

From the results it is found that chloride resistance of silica fumed SCC is higher than that of conventional mix. The weight loss and strength losses are comparatively lesser than conventional SCC used. The weight losses are 0.62%, 0.50%, 0.45% etc. With the increase in percentage of silica fume the chloride resistance also increases. The strength loss decreases. The strength loss obtained as 3.74%, 3.62%, 3.30% etc.

c) Water absorption

Table 16 Water absorption results with marble powder

Mix	Percentage of water absorbed (%)	
	28 days	56 days
MC	0.215	0.35
MP5	0.206	0.32
MP10	0.189	0.30
MP15	0.156	0.28
MP20	0.132	0.213

The water absorption of conventional SCC is 0.215% and 0.398 % is for 28 and 56 days. From the above table it is found that the water absorption is reduces with the replacement of marble powder. The amount of marble powder increases the water absorption reduces.

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Table 17 Water absorption results with silica fume

Mix	Percentage of water absorbed (%)	
	28 days	56 days
MOSF0	0.189	0.30
MOSF5	0.133	0.230
MOSF10	0.113	0.150
MOSF15	0.090	0.110

From the test results the mix without silica fume shown high amount of water absorption than the mix with silica fume. The water absorption percentage decreases with increasing the amount of silica fume. This is mainly due to particle size of silica fume.

VII. CONCLUSIONS

- In Fresh property such as Filling ability and Passing ability is increase by use of 10% Marble Powder
- The increase of Marble powder in SCC decreases both T50 test time and V –funnel time.
- Increase of Marble Powder in SCC increase passing ability.
- In hardened property such as compressive strength, flexural strength and split tensile strength would be taken into account; marble powder can be used up to 10% i.e. the optimum percentage of marble powder obtained 10%.
- Using silica fume the flowing parameters re same as of conventional self compacting concrete.
- It has been indicated that SCC having Silica Fume have higher compressive strength .The silica fume has contributed to large extent in development of strength.
- Maximum compressive strength obtained is 40.88N/mm^2 , which is greater than conventional mix is 39.11N/mm^2 .
- The silica fume percentage for better replacement of cement is obtained as 10%
- Using marble powder and silica fume also increases durability.
- Water absorption decreases for both marble powder and silica fume.
- Good resistance to acid attack maximum at 10% marble powder and 10% silica fume.
- Good resistance to chloride attack at 10% marble powder and 10% silica fume.

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