

Effect of Marble and Granite Waste for the Partial Replacement of Coarse Aggregate in SCC

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ABSTRACT: Self compacting concrete (SCC) is one of the most important development in construction industry. One of the major property of SCC is its self compacting capability. Due to this property SCC is differ from normal concrete. They does not need any external vibration for placing and compaction. This study is dealing with the effect of marble and granite waste for the partial replacement of coarse aggregate in SCC. Marble and granite are commonly used flooring materials. Disposal of these stone wastes cause environmental problem. So marble and granite is partially replaced with coarse aggregate and produce modified self compacting concrete (MSCC).The test is carried out for M₄₀ gradeconcrete. Fly ash is used as mineral admixture. Super plasticizer is also used to get flowability. Fresh and hardened properties were checked. Based on the test results the fresh properties decreases with increases in marble and granite content. Hardened properties such as compressive strength, split tensile strength, and flexural strength are increases with increase in marble and granite content upto 21%, then decreases. Maximum results obtained at 21% replacement level. But at 40% replacement level the hardened properties are higher than that of control SCC mix. Based on strength point of view and economic point of view the optimum replacement level is 40%.

KEYWORDS: Self Compacting concrete, Modified self compacting concrete, Fresh property, Hardened property

I. INTRODUCTION

Self compacting concrete (SCC) is one of the most important development in construction industry. One of the major property of SCC is its self compacting capability. They does not need any external vibration for placing and compaction.They achieve full compaction underits own weight, even in the presence of congested reinforcement.

SCC was conceptualized in 1986 by Prof. Okamura at Ouchi University, Japan. The reduction in skilled workers in Japan's construction industry has led to a similar reduction in quality of construction work. The solution for the achievement of durable concrete structures independent of the quality of construction work is employment of SCC. SCC has been successfully used in France, Netherland, UK etc.Self compacting concrete also known as self consolidating concrete which is suitable for placing in difficult conditions and in sections with congested reinforcement.EFNARC (2002) has given the specification and guide lines for SCC mix design.

This study deals with fresh and hardened properties of SCC with partial replacement of coarse aggregate by stone wastes of marble and granite in equal proportions.Fly ash is used as the mineral admixture. Super plasticizer is also added to the mix. Fresh properties such as slump cone, U- box test and V-funnel tests. Hardened properties checked by conducting compressive strength test, split tensile strength test and flexural strength test.

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II. LITERATURE REVIEW

RoshanLalet.al (2014) [1] investigate strength characteristics of concrete containing waste marble and granite as coarse aggregate. The coarse aggregate is partially replaced with marble and granite from 0-40% at 10% interval. Physical properties of cement, fine aggregate and coarse aggregate etc. were explained. Based on this study the hardened properties is high at 20 % replacement. The hardened properties decreases due to grading effect.

R.Sivakumaret.al (2016) [2] conduct an experimental study on partial replacement for coarse aggregate by granite waste. In this study the water-cement ratio is fixed as 0.45. The concrete mix design is M₃₀. The granite waste is partially replaced as coarse aggregate from 0-50%. The hardened properties increased upto 40%.

Sudarshan D. Kore et.al(2016) [3] found out the marble waste is fully replaced as coarse aggregate. M₁₀ mix is prepared. The strength is increased with increase in marble content. The results shows that the compressive strength of C₄ specimens (80%) is higher than that of control mix.

R.K. Beheraet.al (2016) [4] investigate study on properties of SCC with slag as coarse aggregate. The scope of this project is to determine and compare the SCC by using different % of blast furnace slag as coarse aggregate (0-60%). M₃₀ mix is prepared for this study. The W/C is fixed as 0.43. There is an increase of 13.82% in compressive strength for SCC-60 over SCC-0. The flexural and split tensile strength also increase with increase in slag content. [4]

Karthick M (2016) [5] found out the durability properties of high strength SCC using silica fume and quarry dust. The SCC with 20% replacement of cement by silica fume and 20% replacement of fine aggregate by quarry dust. Master Glenium SKY 8233. Using silica fume and quarry dust 20% by weight of cement and fine aggregate respectively shows good result of fresh and hardened properties attack, water absorption, alkaline attack, acid attack and chloride attack than conventional concrete.

Okonkwo and Arinze EE (2016) [6] investigate properties of concrete in fresh and hardened stage using different aggregates size and mix design was investigated. The sizes of coarse aggregates varies from 25mm, 20mm, 12mm and 6mm. The mixes prepared for this study was 1:2:4, 1:1.5:3, and 1:3:6. The coarse aggregate size of 20mm performed best slump test for 1:2:4 and 12mm coarse aggregate performed best for 1:1.5:3. The coarse aggregate size 20mm shows better hardened properties.

Er.Kuldeep Kumar et.al (2015) [7] conduct an investigation on strength characteristics of concrete containing recycled aggregates of marble waste. Replacement conduct from 0-40%. Sieve analysis of both marble and natural coarse aggregate were done. The hardened properties such as compressive strength and flexural strength is high at 20% replacement level.

N.Anandet.al (2014) [8] A mix design procedure for the design of SCC mixes has been developed by modifying the mix proportions arrived from Indian Standard mix design method for different grades of concrete. Flow and strength properties were determined by experimental investigation. An attempt has been made to study the effect of elevated temperature on SCC specimens heated from 27°C to 900°C under hot condition. Compressive strength of SCC was found to decrease by 70.60%, 75.31%, 78.57% and 81.76% respectively for M₂₅, M₃₀, M₃₅ and M₄₀ concrete when exposed to a temperature of 900° compared to reference specimen. It is found that as the temperature increases, compressive strength, tensile strength and flexural strength of Self Compacting Concrete was found to decreases.

EFNARC (2002) [9] has given the specification and guide lines for SCC mix design. Each mix design should be tested by more than one test method for different workability parameters. For the initial mix design of SCC all the workability parameters need to ensure that all aspects are fulfilled.

Nan Su et.al (2001) [10] introduce a new mix design method for SCC. Initially the quantity of aggregates required is determined, and the paste of binders is then filled into the voids of aggregate to ensure that the concrete thus obtained has desired SCC properties. The results of fresh and hardened properties indicate that the proposed method could produce successful SCC of high quality.

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III.MATERIALS AND METHODS

3.1 Cement

OPC 53 grade cement (Bharathi) is used throughout the work. The physical properties of are shown in table 1.

Table 1. Physical properties of cement

Sl No.	Property	Result
1	Standard consistency	30%
2	Initial setting time	71 minutes
3	Final setting time	310 minutes
4	Specific gravity	3.17
5	Compressive strength at 28 days of curing	56.56 N/mm ²

3.2 Fly ash

Class F fly ash is used for this study. Older anthracite and bituminous coal typically produces class F fly ash. This fly ash is pozzolanic in nature, and contains less than 10% lime. The glassy silica and alumina of class F fly ash requires a cementing agent, such as Portland cement, quick lime etc. In this study fly ash is replaced 30% by weight of cement. Physical properties of fly ash is shown in table 2.

Table 2. Physical properties of fly ash

Sl No.	Property	Result
1	Standard consistency	31%
2	Initial setting time	180 minutes
3	Final setting time	324 minutes
4	Specific gravity	2.89



Fig.1 Fly ash

Fig.1 shows class F fly ash.

3.3 Fine Aggregate

M-sand is used as fine aggregate. Properties of M-sand is shown in table 3.

Table 3. Properties of fine aggregate

Sl No.	Property	Result
1	Sieve analysis	Zone II
2	Specific gravity	2.79
3	Water absorption	2.8 %
4	Moisture content	3.09 %
5	Silt content	14 %

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3.4 Coarse Aggregate

In this study three types of aggregates are used and they are 12.5mm normal aggregate, marble aggregate and granite aggregate of same size. Marble and granite aggregates are replaced in equal proportions. Properties of these aggregates are shown in table 4.

Table 4. Properties of coarse aggregate

Sl No.	Properties	12.5mm normal aggregate	Granite	Marble
1	Specific gravity	2.7	2.66	2.66
2	Water absorption	0.4 %	0.2 %	0.2%

3.5 Admixture – Master Glenium ACE 30IT

Glenium ACE 30IT is an admixture with highly early strength gains. It is compatible with all types of cements. Glenium ACE 30IT is the combination of Master matrix 2 capable of self compaction, even in the presence of dense reinforcement without the aid of vibration, for making precast elements. Table 5 shows the properties of admixture.

Table 5. Properties of admixture

Parameter	Specification(IS 9103-1999)	Results
Physical state	Reddish brown liquid	Reddish brown liquid
Chemical name of active ingredient	Polycarboxylate Polymers	Polycarboxylate Polymers
Relative density at 25 ⁰ C	1.110 ±0.01	1.108
p ^H	Min.6	7.09
Chloride ion content	Max 0.2	0.0081
Dry material content	38 (± 5%)	37.09

3.6 Mix Design

Mix proportion of SCC for this study was based on the EFNARC. Dosage of super plasticizer was fixed as 0.8. Mix design results are shown in table 6.

Table 6. Mix design

Mix designation	cement	Fly ash	Fine aggregate	Coarse aggregate			Water	Super plasticizer (%)
				Marble	Granite	Normal		
SCC – C	350	150	1000	0	0	730	220.0	0.8
M + G – 5	350	150	1000	18.25	18.25	693.50	215.6	0.8
M + G – 10	350	150	1000	36.50	36.50	657.00	223.0	0.8
M + G – 15	350	150	1000	54.75	54.75	620.50	219.0	0.8
M + G – 20	350	150	1000	73.00	73.00	584.00	215.7	0.8
M + G – 21	350	150	1000	76.65	76.65	576.70	221.0	0.8
M + G – 22	350	150	1000	80.30	80.30	569.40	198.0	0.8
M + G – 23	350	150	1000	83.95	83.95	562.10	225.9	0.8
M + G – 24	350	150	1000	87.60	87.60	554.80	230.1	0.8
M + G – 25	350	150	1000	91.25	91.25	547.50	211.4	0.8
M + G – 30	350	150	1000	109.50	109.50	511.00	199.0	0.8
M + G – 35	350	150	1000	127.75	127.75	474.50	199.4	0.8
M + G – 40	350	150	1000	146.00	146.00	438.00	188.9	0.8
M + G – 41	350	150	1000	149.65	149.65	430.70	192.1	0.8

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M + G – 42	350	150	1000	153.30	153.30	423.40	220.3	0.8
M + G – 43	350	150	1000	156.95	156.95	416.10	199.5	0.8
M + G – 44	350	150	1000	160.60	160.60	408.80	213.0	0.8
M + G – 45	350	150	1000	164.25	164.25	401.50	224.0	0.8
M + G – 50	350	150	1000	182.50	182.50	365.00	221.7	0.8

3.7 Methods

3.7.1 Fresh properties

A concrete mixture may be called as SCC only if the mix have shown three properties such as filling ability, passing ability and segregation resistance. To check these requirements slump flow, U-box and V-funnel tests were performed according to EFNARC guidelines. The test results are shown in Table 7.

3.7.2 Mechanical properties

Compressive strength (150 x 150 x 150mm cubes), split tensile strength (cylinder 100 x 300mm) and flexural strength (100 x 100 x 400 mm) was determined at the age of 7 and 28 days.

IV. EXPERIMENTAL RESULTS

4.1 Fresh properties

Fresh properties of SCC is shown in table 7. The fresh properties of SCC is decreased with increase in percentage addition of marble and granite. The results of fresh properties is within the allowable limits of EFNARC.

Table 7. Fresh properties of SCC

Mix designation	Slump flow(mm)		U-box (mm)		V-funnel (seconds)	
	min	max	Min	max	min	max
	650	800	0	30	6	12
SCC-C	693		5		11.20	
M+G -5%	730		8		7.60	
M+G -10%	723		11		8.20	
M+G -15%	700		14		8.80	
M+G -20%	698		18		9.60	
M+G -21%	690		19		9.80	
M+G -22%	686		19		10.07	
M+G -23%	683		18		10.21	
M+G -24%	680		18		10.40	
M+G -25%	678		17		10.80	
M+G -30%	675		20		11.05	
M+G -35%	672		23		11.34	
M+G -40%	667		25		11.37	
M+G -41%	666		25		11.45	
M+G -42%	665		26		11.56	
M+G -43%	663		26		11.62	
M+G -44%	662		26		11.71	
M+G -45%	660		27		11.85	
M+G -50%	653		29		12.00	

Figure (Fig.2 and Fig.3) shows V-funnel test and slump flow test. These tests shows the fresh properties of SCC. Slump flow test describes the flowability and V-funnel describes the filling ability.

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Fig.2 V-funnel test



Fig.3 Slump flow test

4.2 Hardened properties

The compressive strength of control SCC mix is 42.40N/mm² and 50.46N/mm² at 7 and 28 day of curing. The compressive strength is increases with increase in marble and granite content upto 40%. Maximum result was obtained at 21 percentage replacement level and the values are 54.60 N/mm² and 63.34 N/mm². At 40% replacement level the compressive strength values are 43.30 N/mm² and 50.55 N/mm². Compressive strength at 40 replacement level is higher than that of control mix.

The flexural strength of control SCC mix is 3.64 N/mm² and 4.26 N/mm² at 7 and 28 day of curing. The flexural strength is increases with increase in marble and granite content upto 40%. Maximum result was obtained at 21 percentage replacement level and the values are 7.74 N/mm² and 8.68 N/mm². At 40% replacement level the compressive strength values are 3.94 N/mm² and 4.95 N/mm².

The split tensile strength of control SCC mix is 3.17 N/mm² and 4.42 N/mm² at 7 and 28 day of curing. The flexural strength is increases with increase in marble and granite content upto 42%. Maximum result was obtained at 21 percentage replacement level and the values are 7.46 N/mm² and 8.96 N/mm².

Table.8 shows the test results of compressive strength, flexural strength and split tensile strength at 7 and 28 days of curing.

Table 8.Hardened properties of control SCC and MSCC

Mix	Average compressive strength (N/mm ²)		Average flexural strength (N/mm ²)		Average split tensile strength (N/mm ²)	
	7 th day	28 th day	7 th day	28 th day	7 th day	28 th day
SCC-C	42.40	50.46	3.64	4.26	3.17	4.42
M+G-5%	45.60	52.40	3.90	4.80	4.28	5.62
M+G-10%	45.85	55.56	4.26	5.26	4.38	5.82
M+G-15%	49.50	57.63	5.25	6.90	4.71	5.91
M+G-20%	52.26	59.20	6.24	7.26	6.30	7.72
M+G-21%	54.60	63.34	7.74	8.68	7.46	8.96
M+G-22%	53.80	61.38	7.46	8.08	6.32	8.93
M+G-25%	51.30	57.18	5.71	6.33	8.56	8.57

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M+G-30%	47.30	53.40	4.31	5.10	5.93	7.52
M+G-35%	45.70	51.50	4.72	5.83	5.83	7.32
M+G-40%	43.30	50.55	3.94	4.95	5.66	6.95
M+G-41%	40.22	50.41	3.81	4.82	5.34	6.74
M+G-42%	43.42	49.57	3.63	4.53	4.76	5.85
M+G-45%	41.16	47.52	3.14	4.14	2.45	3.53
M+G-50%	37.46	42.53	2.51	3.62	2.12	3.33

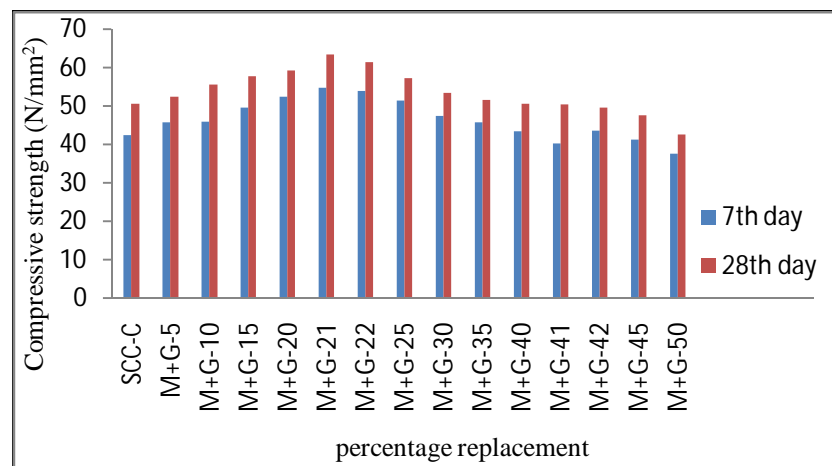


Fig.4 shows the variation of compressive strength for different percentage replacement

Fig.4 shows the variation of compressive strength for different percentage replacement of marble and granite content. In this maximum strength is obtained at 21% replacement level.

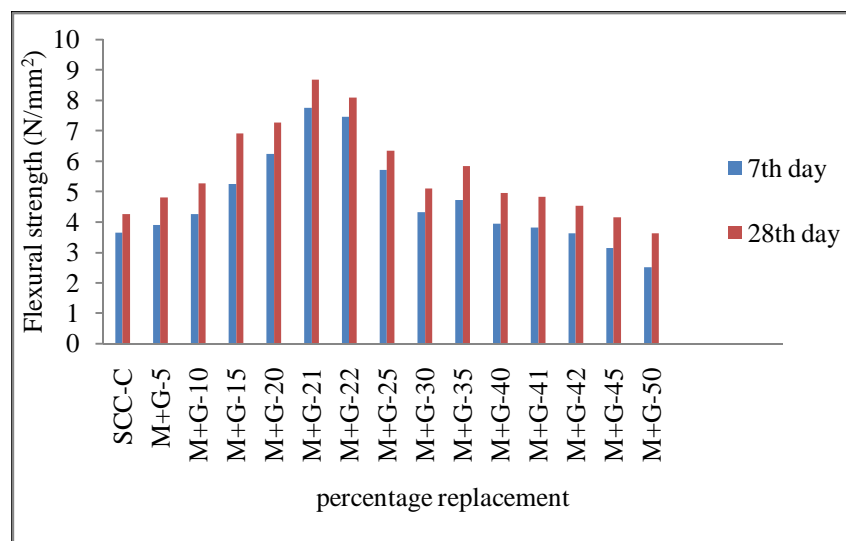


Fig.5 Variation of flexural strength for different percentage replacement of marble and granite aggregate

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Fig.5 shows the variation of flexural strength for different percentage replacement of marble and granite content. In this maximum strength is obtained at 21% replacement level.

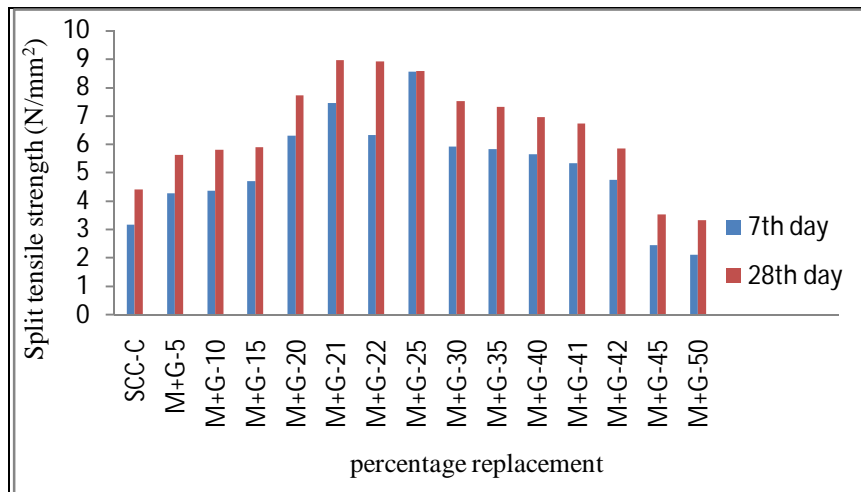


Fig.6 shows the variation of split tensile strength for different percentage replacement

Fig.6 shows the variation of split tensile strength for different percentage replacement of marble and granite content. In this maximum strength is obtained at 21% replacement level.

V. CONCLUSIONS

Marble and granite waste as coarse aggregate for making MSCC, the physical properties satisfy the IS code specifications. So marble and granite waste can be used as coarse aggregate in MSCC. The fresh properties of control SCC mix conforms with EFNARC code specifications and hardened properties of control SCC mix satisfies IS code specifications. The fresh properties such as flowability and filling ability, that decreases with increases in percentage content of marble and granite waste as coarse aggregate.

Hardened properties such as compressive strength, split tensile strength and flexural strength increases with increase in marble and granite content upto 21%, then decreases. The hardened properties of MSCC is higher than that of control mix upto 40%. Concluding the observations the optimum percentage replacement of marble and granite waste as coarse aggregate in MSCC is 40%.

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