STUDY ON CHARACTERISTIC STRENGTH OF SELF COMPACTING CONCRETE ON PARTIAL REPLACEMENT OF CEMENT WITH MARBLE DUST AND SAND WITH IRON SLAG

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by

DEEPANSHU AGGARWAL

(11207626)

Supervisor

Mr PARIJAT HASIJA

Transforming Education Transforming India

School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA

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DECLARATION

I, Deepanshu Aggarwal (11207626), hereby declare that this thesis report entitled **“Study on Characteristic Strength of Self Compacting Concrete on partial replacement of cement with Marble Dust and sand with Iron Slag”** submitted in the partial fulfilment of the requirements for the award of the degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date:28-04-2017

Deepanshu Aggarwal
Registration no: 11207626

CERTIFICATE

Certified that this project report entitled "**Study on Characteristic Strength of Self Compacting Material on partial replacement of cement with Marble Dust and sand with Iron Slag**" submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara, carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

Supervisor
Mr. Parijat Hasija
Assistant Professor

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Signature of Student
Deepanshu Aggarwal

ABSTRACT

This research study examines the characteristic strength of self-compacting concrete on partial replacement of cement with marble dust and sand with iron slag. For this study, cement has replaced with marble dust by 20% kept constant and sand has replaced with iron slag at 10%, 15%, 20% and 25%. After then, on fresh concrete slump flow test and L-box test are conducted. After compressive strength, flexural strength and split tensile strength are conducted on hardened concrete at the end of 7, 14 and 28 days. From the test result, is was concluded that the compressive strength and split tensile strength is slight increased and then decreased and for flexural strength is decreased at the end of 7, 14 and 28 days.

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CHAPTER 1

INTRODUCTION

1.1 General:

Self-compacting concrete (SCC) is a flowing concrete mixture that can combine under its own particular weight. The highly mobile nature of SCC makes it suited for situating in difficult conditions and in sections with congested reinforcement. Utilization of SCC can also help minimize hearing-related damages on the work site that are caused by vibration of concrete. The other advantage of SCC is that the time taken to place large sections is considerably shortened.

When the construction industry in Japan saw a fall in the availability of skilled trade union movement in the 1980s, a demand was felt in a concrete that could master the problems of defective workmanship. This contributed to the development of self-compacting concrete, mainly through the work by Okamura. A council was made to examine the attributes of self-compacting concrete, letting in a fundamental investigation on the workability of concrete, which was taken out by Ozawa et al. at the University of Tokyo. The first operational rendition of self-compacting concrete was completed in 1988 and was named “High Performance Concrete”, and later mentioned as “Self-Compacting High-Performance Concrete”.

In Japan, the volume of SCC in construction has developed steadily over the years. Information shows that the share of application of SCC in the precast concrete industry is more than three times greater than that in the ready-mixed concrete industry. This is attributable to the greater cost of SCC. The calculated mean cost of SCC supplied by the RMC industry in Japan was 1.5 times that of the conventional concrete in the year 2002. Research operates in Japan are also promoting new types of applications with SCC, such as in lattice type structures, casting without a pump, and tunnel linings.

Since the development of SCC in Japan, many institutions across the world have carried out research on properties of SCC. The Brite-Euram SCC project was put up to encourage the use of SCC in some of the European nations. A state-of-the-art report on SCC was compiled by Skarendahl and Petersson summarizing the conclusions from the research studies sponsored by the Brite-Euram project on SCC.

A recent initiative in Europe is the establishment of the project – Testing SCC– involving a number of institutes in research works on various test methods for SCC. In summation, an organization with the participation from the specialist concrete product industry – EFNARC– has prepared specifications and guidelines for the use of SCC that covers a number of subjects, ranging from materials selection and mixture design to the significance of testing methods.

1.2 Current studies in Self-Compacting Concrete:

It can be break down into the following classifications: (a) use of rheometers to obtain information about flow behaviour of cement paste and concrete, (b) mixture proportioning methods for SCC, (c) characterization of SCC using laboratory test methods, (d) durability and hardened properties of SCC and their comparison with normal concrete, and (e) construction issues related to SCC. These will be relevant to the immediate demands.

In summation, the following questions also require particular consideration, from a long-term perspective: (a) development of mixture design guideline tables similar to those for normal concrete, (b) a shift to more 'normal' powder contents in SCC, from the existing high powder mixtures, (c) better understanding of the problems of autogenous and plastic shrinkage in the SCC, and (d) development of site quality control parameters such as in 'all-in-one' acceptance tests.

1.3 Materials for SCC:

Mix proportions for SCC alter from those of normal concrete, in that the previous has more powder substance and less coarse aggregate. Additionally, SCC consolidates high range water reducers (HRWR, superplasticisers) in bigger quantities and frequently a viscosity modifying agent (VMA) in low dosages. The questions that overwhelm the determination of materials for SCC are: (i) restrains on the amount of insignificantly improper totals aggregates that is, those deviating from ideal shapes and sizes, (ii) choice of HRWR, (iii) choice of VMA, and (iv) interaction and similarity between cement, HRWR, and VMA.

1.4 **Testing procedure for self-compactability**:

The methods introduced here are organized particularly for SCC. Existing rheological test methodology has not considered here, however the relationship between the consequences of these tests and the rheological attributes of the concrete is probably going to figure highly in future work, including institutionalization work. In considering these tests, there are a number of focuses which ought to be considered. (a). There is no clear relation between test outcomes and execution on site. (b). There is less exact information, therefore no clear guidance on consistence limits.

A concrete mix can only be classified as SCC if the prerequisites for all the following three workability properties are met.

- Filling ability,
- Passing ability,
- Segregation resistance.

Filling ability: It is the ability of the SCC to flow into all spaces within the formwork under its own weight. Tests, such as slump flow, V-funnel etc., are applied to regulate the filling ability of fresh concrete.

Passing ability: It is the ability of the SCC to flow through tight openings, for example, spaces between steel strengthening bars, under its own particular weight. Passing ability can be check by using U-box, L-box, Fill-box, and J-ring test methods.

Segregation resistance: The SCC must meet the filling ability and passing ability with uniform composition through the procedure of transport and placing.

1.5 Construction issues:

Utilization of SCC has been exhibited in various structures in Japan and Europe. An as often as possible refered to case is the construction of anchorages for the Akashi-Kaikyo bridge in Japan. Cases of different applications include: construction of a wall for a large liquefied natural gas tank in Japan, viaduct in Yokohama City, and a number of bridges in Sweden.

Experience in these projects brings to light certain construction issues relating to the role of SCC. One issue is that of comprehension the limit of flow distance of the concrete, in order to avoid segregation of coarse aggregate. Solutions from Japan indicate that for distances less than 10 m, segregation does not happen. Arima et al. suggested the use of automatic gate valves for discharging the concrete at many different stages, at intervals of 6-20 m.

CHAPTER 2

LITERATURE REVIEW

1. Ilker Bekir Topcua, Turhan Bilira and Tayfun Uygunoglub(2009):

According to this research paper, the author utilized the marble dust(MD) as a replacement of binder of SCC at certain contents of 0, 50, 100, 150, 200, 250 and 300 kg/m^3. After then, he performed the slump-flow test, L-box test, and V-funnel test on fresh concrete. At the end of 28 days, he determined the compressive strength, flexural strength, ultrasonic velocity, porosity, and compactness for the hardened concrete specimens. He additionally researched the impact of waste MD utilization as filler material on capillarity properties of SCC. As indicated by the test outcomes, he concluded that the workability of fresh SCC has not been influenced up to 200 kg/m3 MD content and the mechanical properties of hardened SCC have decreased by utilizing MD, particularly simply over 200 kg/m3 content.

2. A.S.E. Belaidia, L. Azzouzb and E. Kadric, S. Kenaia(2012):

According to this research paper, the author determined the effect of substitution of cement with natural pozzolana and marble powder on the rheological and mechanical properties of self-compacting mortar (SCM) and self-compacting concrete (SCC). He partially replaced Ordinary Portland Cement (OPC) by different percentages of pozzolana and marble powder (10–40%). After then, he performed the slump test, V-funnel flow time test, J-Ring, L-Box, and sieve stability tests for determining workability of fresh SCC. He determined the Compressive strength on prisms at the ages of 7, 28, 56 and 90 days. As indicated by the test outcomes, he concluded that the improvement in the workability of SCC with the utilization of pozzolana and marble powder. He also concluded that compressive strength of binary and ternary SCC decreased with the increase in amount of natural pozzolana and marble dust substance, but strength at 28 and 90 days shows that even with 40% (natural pozzolana + marble powder), suitable strength could be achieved.

3. Raharjo. D, Subakti. A, Tavio (2013):

According to this research paper, the author determined the SCC's optimal composition and the requirements of passing ability, filling ability, viscosity, and segregation. For this purpose, the author utilized some trial mixtures containing fly ash, policar boxilate, silica fume based of superplasticizer, and iron slag. The author conducted the slump cone, L-box, and V-funnel for determining the concrete's filling ability, viscosity, passing ability and segregation. The author also tested cylindrical sample of 20 cm in height and 10 cm in diameter of hardened SCC at 3.7, 14, 28 and 56 days of concrete age. The author tested the 33 variation of concrete mixture using 495 samples total mixture. Each composition contained various superplasticizer dose from 0.5 to 1.8% of cementitious weight. The dose of silica fume was additionally fluctuated at 0%, 10% and 20% of fly ash weight. The author expected from the study, to obtained the optimal material composition of the mixture that produced the maximum compressive strength but cheaper and competitive in price.

4. Tayfun Uygunoglu, Ilker Bekir Topcu and Atila Gurhan Celik(2014):

According to this research paper, the author investigated the utilization of marble waste (MW) and recycled aggregate (RA) from crushed concrete in the production of SCC. He made control series with crushed limestone aggregate (LS) in different water to binder ratios. After then, he replaced LS with MW or RA in proportion of 100%. Then, he performed the fresh concrete experiments such as slump-flow, the J-ring test, unit weight and air content. Moreover, he examined the compressive strength, splitting-tensile strength, modulus of elasticity, stress-strain relationship, and ultrasonic pulse velocity experiments on the hardened specimens, and compared the mechanical properties of all the concrete types. According to the results obtained, he concluded that the workability of SCC such as flow-ability, segregation resistance and blocking resistance is increased by utilization of pieces of MW rather than LS. Additionally, he did not observe important differences in the mechanical properties of SCC by utilizing MW and RA. For this reason, he also concluded that recycled coarse aggregates and crushed marble stone that were obtained using lower energy than that required for obtaining the LS, can be utilized in the SCC.

5. Ahmed S. Ouda , Hamdy A. Abdel-Gawwad(2015):

According to this research paper, the author investigated the effects of replacing sand by high percentages of iron slag on the compressive strength, bulk density and gamma ray radiation shielding properties of mortar. The author designed the cement mortar of mix proportion 1:3 including different proportion of iron slag. The proportion of replacement were 0%, 40%, 80% and 100% by weight of fine aggregate. The author prepared the mortar mixes with water cement ratio of 0.44 and cured in potable water for 90 days. The author performed the attenuation measurements, utilizing gamma spectrometer of NaI (Tl) detector. The utilized radiation sources included Cs and Co radioactive elements with photon energies of 0.662 MeV for Cs and two energy levels of 1.17 and 1.33 MeV for the Co. Then, he measured the half value layer (HVL), tenth value layer (TVL) and the mean free path (mfp) for the tested samples. From the outcomes of this investigation author concluded that the strength properties of mortars increased significantly upon replacing sand partially by iron slag. He also observed that the inclusion of iron slag as partially replacement with fine aggregates improves the bulk density of mortar. On the other hand, author also concluded that full sand replacement by iron slag has significant effects on shielding efficiency in thick shields, as it lessen the capture gamma rays better than normal mortar incorporating sand.

6. Mohsen Tennicha, Abderrazek Kallela and Mongi BenOuezdoua(2015):

According to this research paper, the author evaluated the incorporation of wastes from marbles and tiles factories as mineral added substance to self-compacting concrete (SCC) and to substitute at 100% the known additions (limestone filler, fly ash, …). The author believed that the purpose of these wastes can help produce economical self-compacting concretes (SCCW) and cut down the quantity of wastes dumped into landfills. The impact of these wastes on the behavior of SCC in the fresh state is highlighted in contrast with a reference self-compacting concrete (SCCR) made with limestone filler while their consequences for mechanical strength and ultrasonic testing are assessed in the hardened state in contrast with the properties of both SCCR and an ordinary vibrated concrete (OVC). He formulated the compositions of the different concretes which considered in the present review and after that he is utilizing the "Concrete LabPro2" software. He tested the outcomes from the slump flow test, V-funnel test, L-Box test, and sieve stability test on fresh concretes represent that the incorporation of wastes from marbles and tiles factories gives a satisfactory smoothness to the SCCW and their resistance to segregation, approaching those of the SCCR. He tested the mechanical properties of the concretes by ultrasonic testing and by basic compressive testing and tensile splitting of cylindrical specimens (160 mm × 320 mm) at the curing ages of 3, 7, 14 and 28 days. From the outcomes, he concluded that the speed of wave proliferation through the concrete and the compressive and tensile strengths are clearly adequate for the self-compacting concretes incorporating wastes from marbles and tiles factories contrasted with those of the SCCR and OVC.

7. Gurpreet Singh, Rafat Siddique Ph.D. (2016):

According to this research paper, the author investigated the durability characteristics of self-compacting concrete (SCC) made with iron slag (IS). For this purpose, the author initially designed a control SCC, and then fine aggregates were partially replaced with iron slag in a proportion of 0, 10, 25 and 40%. The author performed the different tests for fresh SCC properties, durability properties and compressive strength, such as rapid chloride permeability, resistance to sulphate attack, water absorption and ultra-sonic pulse velocity up to the age of 365 days. The author also performed the Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD) analysis test. As indicated by the test outcomes, he concluded SCC incorporating iron slag gives better durability and strength than control mixture of SCC, and can be suitably utilized in SCC.

8. Gurpreet Singh, Rafat Siddique Ph.D. (2016):

According to this research paper, the author explored the possibility of utilization of iron slag as partial replacement of fine aggregate (sand) in self-compacting concrete (SCC). The author designed SCC mixes and replaced fine aggregates with 0%, 10%, 25%, and 40% of iron slag. The author performed the tests such as slump flow, V-funnel, L-box, U-box, compressive strength, splitting tensile strength, flexural strength and modulus of elasticity to assessed the fresh properties, strength properties and micro-structural analysis of SCC. From the results, the author concluded that splitting tensile strength, compressive strength, and flexural strength of self-compacting concrete improved with incorporation of iron slag at all the curing ages. The author also performed the Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD) analysis test to examine the microstructure, which showed that utilization of iron slag made the microstructure of SCC denser.

CHAPTER 3

SCOPE AND RATIONALE OF THE STUDY

3.1 Scope of the study:

Self-compacting concrete was made for experimental work. The cement has replaced with marble dust by 20% kept constant and sand has replaced with iron slag at 10%, 15%, 20% and 25%. After then, on fresh concrete slump flow test and L-box test are conducted. The various mechanical properties like compressive strength, split tensile strength and flexural strength for various mixes are being examined for the different proportions of the marble dust and iron slag at the end of 7, 14 and 28 days. Normal specimen i.e. without replacement of cement are also casted. The results are compared for the normal without replacement of Marble dust specimen and the experimented specimen with replaced proportions of Marble Dust and iron slag are compared and the best result is used further for practical applications.

3.2 Objective of the study:

The objective of the study is to get self-compacting concrete with different percentage replacement of cement with marble dust and sand with iron slag. The main objective of the project is: -

1. To study the effect on compressive strength of concrete by replacement of cement with marble dust and sand with iron slag for different proportions.
2. To study the effect on split tensile strength of concrete by replacement of cement with marble dust and sand with iron slag for different proportions.
3. To study the effect on flexural strength of concrete by replacement of cement with marble dust and sand with iron slag for different proportions.

CHAPTER 4

MATERIALS AND RESEARCH METHODOLOGY

4.1 General:

The main objective is to check the properties of materials used for testing. The main materials which are used are Ordinary portland cement, aggregates, sand, marble dust and iron slag. The materials are used to check the mechanical properties of concrete mix.

4.2 Materials:

4.2.1 Ordinary Portland Cement:

Ordinary Portland cement of Grade 43 was used. The various physical properties of cement are examined i.e. fineness, specific gravity, consistency and initial and final setting of cement and soundness as shown in Table 1.

Table 1: Properties of OPC 43 grade Cement

S. no.	**Characteristics**	**Value obtained Experimentally**	**Values Specified by IS8112:1989**
1.	Fineness (retained on 90-µm sieve)	4.5g	<10% of 300g
2.	Normal Consistency	29.5%	-
3.	Initial Setting Time	32 minutes	Should not be less than 30 minutes
4.	Final Setting Time	278 minutes	Should not be greater than 600 minutes
5.	Soundness	3mm	<10 mm
6.	Specific Gravity	3.15	-

Figure 1: Ordinary Portland cement

4.2.2 Aggregate:

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having colour, specific gravity and fineness modulus as given in Table 2 and crushed stone with 12mm maximum size having colour,shape specific gravity and fineness modulus as given in Table 3 was used as coarse aggregate. Both fine aggregate and coarse aggregate conformed to Indian Standard Specifications IS: 383-1970.

Table 2: Physical properties of Fine aggregates

Characteristics	Description
Colour of fine aggregates	Brown
Specific gravity	2.66
Fineness modulus	2.41

Figure 2: Fine Aggregate

Table 3: Physical properties of Coarse aggregates

Characteristics	Description
Colour of coarse aggregates	Grey
Shape of aggregates	Angular
Maximum Size of aggregates	12mm
Specific gravity	2.71
Fineness modulus	6.64

Figure 3: Coarse Aggregate (12mm)

4.2.3 Water:

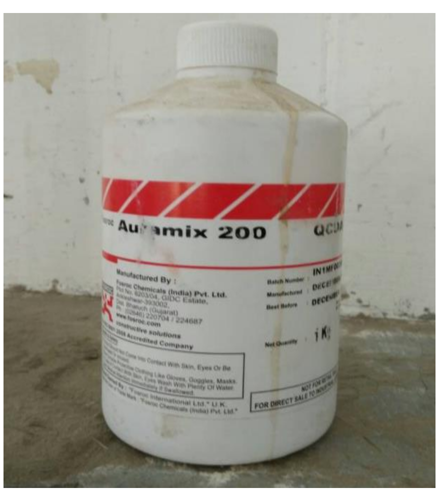
The potable water is usually measured reasonable for mixing and curing of concrete. Potable water was used for making concrete and its available in Material Testing laboratory. This was free from any detrimental contaminants and was good potable quality.

Figure 4: Curing of Specimen

4.2.4 Admixtures:

Fosroc Auramix V200 is a chloride free was used liquid admixture. It is a high performance concrete rheology modifying agent based on a unique polymer which is designed to be used with Fosroc's polycarboxylate based Structure and Auramix admixtures for high fluid concrete.

Figure 5: Auramix V200



4.3 Test Method:

Self- Compacting Concrete is characterized by filling ability, passing ability and resistance to segregation. Many different methods have been developed to characterize the properties of SCC. No single method has been found until date, which characterizes all the relevant workability aspects, and hence, each mix has been tested by more than one test method for the different workability parameters. Table 4 gives the recommended values for different tests given by different researchers for mix to be characterized as SCC mix.

Table 4: Recommended Limits for Different Properties

S.NO.	Property	Range
1.	Slump Flow Diameter	500-700 mm
2.	T_{50cm}	2-5 sec
3.	L-Box H2/H1	≥ 0.8

4.3.1 Slump Flow Test:

The slump flow test is used to assess the horizontal free flow of SCC in the absence of obstructions. On lifting the slump cone, filled with concrete, the concrete flows. The average diameter of the concrete circle is a measure for the filling ability of the concrete. The time T50 cm is a secondary indication of flow. It measures the time taken in seconds from the instant the cone is lifted to the instant when horizontal flow reaches diameter of 500mm.

Figure 6: Slump Test of Concrete

4.3.2 L-Box Test:

The passing ability is determined using the L- box test [10] as shown in Fig 3. The vertical section of the L-Box is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. The height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1). This is an indication of passing ability. The specified requisite is the ratio between the heights of the concrete at each end or blocking ratio to be ≥ 0.8.

Figure 7: L-Box Test of Concrete

4.3.3 Compressive Strength of Concrete:

Cube specimens of size 150 mm x 150 mm x 150 mm were taken out form the curing tank at the ages of 7, 14 and 28 days and tested immediately on removal from the water (while they were still in the wet condition). Surface water was wiped off, the specimens were tested. The position of cube when tested was at right angle to that as cast. The load(P) as applied gradually without shock till the failure of the specimen occurs and thus the compressive strength was found. The magnitude of compressive stress (C) acting uniformly on cube of applied loading is given by formula:

C = P/A

where: P = Applied load

A = Area of cube

Figure 8: Compressive Test of Cube

4.3.4 Split Tensile Strength of Concrete:

The split tensile strength of concrete is determined by casting cylinders of size 100 mm x 200 mm. The cylinders were tested by placing them uniformly. Specimens were taken out from curing tank at age of 7, 14 and 28 days of moist curing and tested after surface water dipped down from specimens. This test was performed on compression Testing Machine. The magnitude of tensile stress (T) acting uniformly to the line of action of applied loading is given by formula

T= 0.637P/DL

Where,

T = Split Tensile Strength in MPa

P = Applied load,

D = Diameter of Concrete cylinder sample in mm.

L =Length of Concrete cylinder sample in mm.

Figure 9: Split Tensile Test of Cylinder

4.3.5 Flexural Strength of Concrete:

The flexural strength of concrete is determined by casting beam of size 100 mm x100 mm x 500mm. The beams were tested by placing them uniformly. Specimens were taken out from curing tank at age of 7, 14 and 28 days of moist curing and tested after surface water dipped down from specimens. This test was performed on compression Testing Machine on beam attachment. The beams are tested for two-point loading. At 1/3rd from support from both ends.

Formula used for flexural strength 'fb'

fb = PL/bd2

(when a > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen) or

fb = 3Pa/bd2 (when a < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.) Where,

a = the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen

b = width of specimen

d = failure point depth

L = supported length

P = max. Load

Figure 10: Flexural Test of Beam

4.3.6 Design Mix:

Researchers have mentioned that the most popular mix design method for SCC has been introduced by Okamura. To proceed towards achieving SCC,

TR 1-First cement was taken as 480kg/m3, Sand was taken as 977kg/m3 and 10mm aggregates was taken as 570kg/m3 at water cement ratio 0.4 and admixtures 1% and but the slump flow and L-box were not obtained.

TR 2-Therefore, cement was increased to 500kg/m3 and water cement ratio to 0.43 and others kept contant but the slump flow and L-box were not obtained.

TR 3-Therefore, cement was again increased to 530kg/m3 and water cement ratio to 0.45 and others kept contant. Now the slump flow and L-box were obtained. Mix proportions for various trial mixes are given in Table 5.

Table 5: Mix proportions for various trial mixes.

S.No.	Mix	Cement (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)	S.P. (%)	W/c ratio	Slump Flow (mm)	L-box Blocking ratio(H2/H1)
1.	TR 1	480	977	570	1%	0.4	420	-
2.	TR 2	500	977	570	1%	0.43	490	-
3.	TR 3	530	977	570	1%	0.45	660	0.1
F.A: Fine Aggregate, C.A: Coarse Aggregate, S.P: Superplasticizer								

After obtained the trial mix, different mix proportions were made by replacement of cement with marble dust by 20% kept constant and sand has replaced with iron slag at 10%, 15%, 20% and 25% with a water-cement 0.45 and admixture 1% kept constant. Mix proportions for various mixes are given in Table 6.

Table 6: Mix proportions for various mixes.

S.No.	Mix	Cement (Kg/m^3)	Marble Dust (Kg/m^3)	F.A (Kg/m^3)	Iron Slag (Kg/m^3)	C.A (Kg/m^3)	W/c ratio	S.P. (%)
1.	CM	530	0	977	0	570	0.45	1%
2.	M1	424	106	873.3	97.7	570	0.45	1%
3.	M2	424	106	830.45	146.55	570	0.45	1%
4.	M3	424	106	781.6	195.4	570	0.45	1%
5.	M4	424	106	732.75	244.25	570	0.45	1%
F.A: Fine Aggregate, C.A: Coarse Aggregate, S.P: Superplasticizer, M.D: Marble Dust, I.S: Iron Slag, CM: Control Mix M1: 20 M.D +10 I.S, M2: 20 M.D + 15 I.S, M3: 20 M.D + 20 I.S, M4: 20 M.D + 25 I.S.								

Figure 11: SCC Mix in mould

Table 7: Workability for various mixes.

S.No.	Mix	Slump Flow(mm)	T_{50cm} (sec)	L-box Blocking ratio(H2/H1)
1.	CM	660	3.4	0.1
2.	M1	672	3.5	0.1
3.	M2	655	3.9	0.1
4.	M3	647	4.3	0.1
5.	M4	634	4.6	0.1

CHAPTER 5

RESULT AND DISCUSSION

5.1 General:

This chapter deals with the presentation of results got from different tests conducted on the material utilized for developing self-compacting concrete. In order to achieve the objectives of present study, an experimental program was planned to investigate the effect of Marble Dust and Iron Slag on flexural strength, compressive strength and split tensile strength of concrete so as to assess its feasibility for use in structure building. The experimental program consists of casting, curing and testing of controlled, marble dust and iron slag concrete specimen at different ages.

5.2 Compressive Strength of Concrete:

In most structural applications, concrete is employed primarily to resist compressive stresses. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical crack occurs due to lateral tensile strains. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strains. The 150 mm x 150mm x 150 mm cubes are used for testing the compressive strength after 7 days,14 days and 28 days. Specimens has been made for control mix and compared with replacement of cement with MD at 20% kept constant and sand with iron slag at 10%, 15%, 20%, and 25%. Three samples have been casted for each percentage i.e. three for 7 days, three for 14 days and three for 28 days testing. Specimens tested after 7 days,14 days and 28 days age of curing and average results are shown in Table 7.

Table 8: Compressive Strength of Cubes:

Compressive Strength (MPa)										
Curing age (days)	CM 0%MD+0%IS		M1 20%MD+10%IS		M2 20%MD+15%IS		M3 20%MD+20%IS		M4 20%MD+25%IS	
7	21.02	22.22	25.73	26.93	22.07	23.47	21.74	21.74	19.16	19.56
	22.42		27.13		23.87		21.24		19.56	
	23.22		27.93		24.47		22.24		19.96	
14	29.26	30.66	33.38	34.68	28.56	28.96	24.22	25.42	21.48	22.68
	30.76		34.98		28.96		25.62		22.88	
	31.96		35.68		29.36		26.42		23.68	
28	34.22	35.82	35.13	36.53	32.22	33.62	27.48	27.68	26.64	27.04
	36.42		36.93		33.62		27.68		27.04	
	36.82		37.53		35.02		27.88		27.44	

Figure 12: Variation in the Compressive Strength.

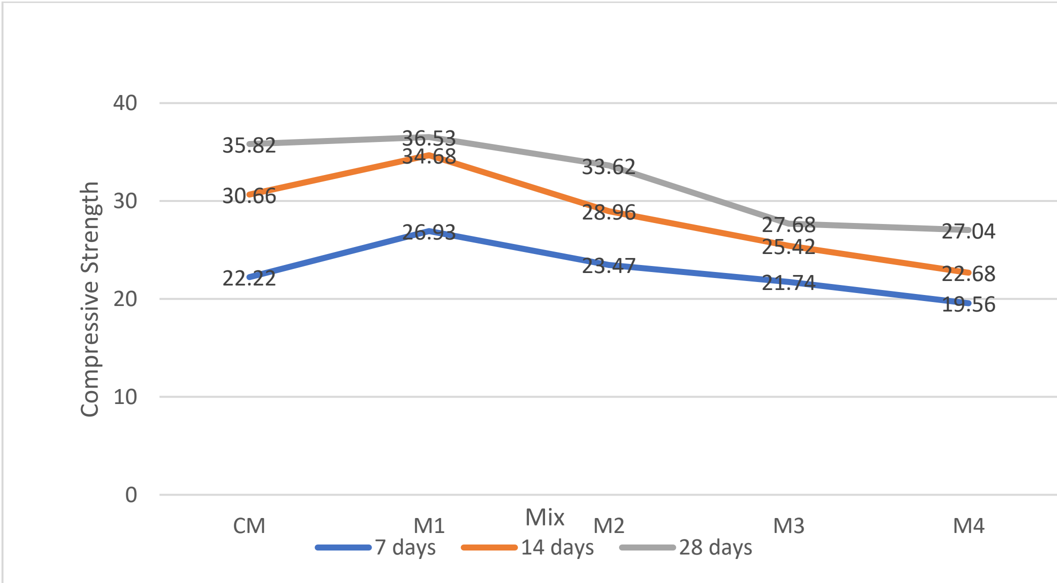
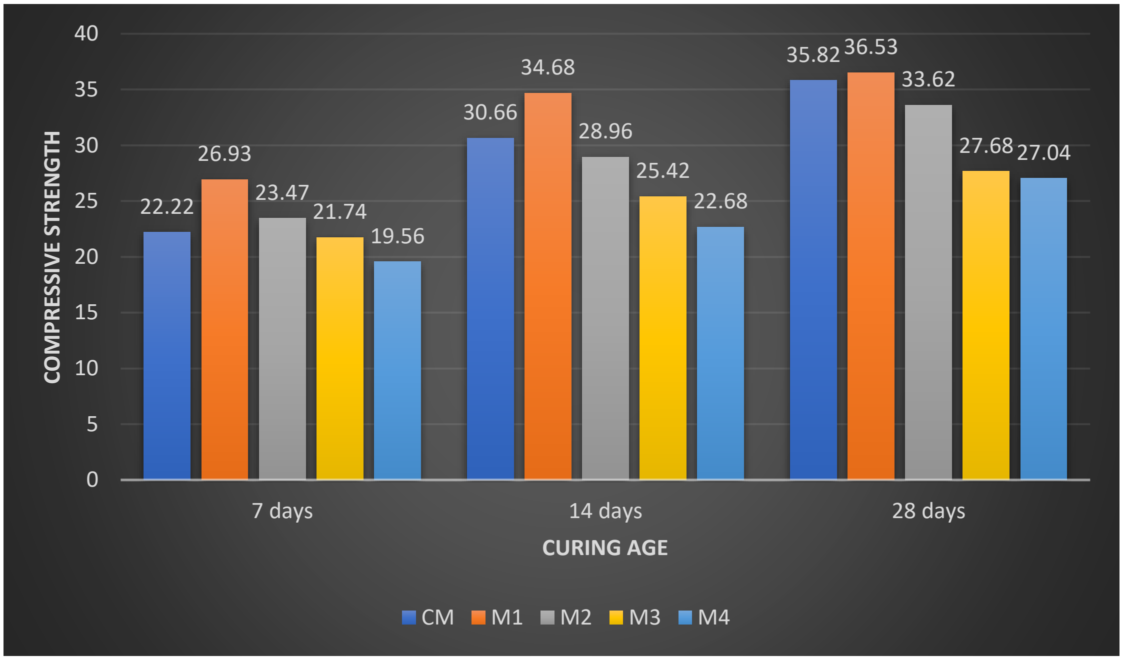


Figure 13: Variation in the Compressive Strength with increase in curing age



From the graphs and bar chart of compressive strength depicts that compressive strength is increased for M1 as compared to control mix but after there is a decreased in strength for M2, M3, M4 with the increase of iron slag content with marble dust kept constant. With the increased of curing age, compressive strength is increased for M1 as compared to control mix. Therefore, the maximum compressive strength of the cubes is found on M1 as compared to others.

5.3 Split Tensile Strength of Concrete:

The 200mm x 100 mm cylinders were used for testing the split tensile strength after 7 days,14 days and 28 days. Specimens has been made for control mix and compared with replacement of cement with marble dust at 20% kept constant and sand with iron slag at 10%, 15%, 20%, and 25%. Three samples have been casted for each percentage i.e. three for 7 days, three for 14 days and three for 28 days. The split tensile strength of all the mixes was determined at the age of 7 days,14 days and 28 days for various replacement levels of marble dust and iron slag in concrete mix. The results of split tensile strength of concrete are reported in Table8.

Table 9: Split Tensile Strength of Cylinder

Split Tensile Strength (MPa)										
Curing age (days)	CM 0%MD+0%IS		M1 20%MD+10%IS		M2 20%MD+15%IS		M3 20%MD+20%IS		M4 20%MD+25%IS	
	2.98		3.17		2.85		2.38		2.31	
7	2.99	2.99	3.24	3.21	2.86	2.86	2.70	2.58	2.36	2.35
	3		3.22		2.87		2.66		2.38	
	3.37		3.50		3.19		2.76		2.59	
14	3.39	3.39	3.49	3.51	3.18	3.18	2.83	2.81	2.64	2.63
	3.41		3.54		3.17		2.84		2.66	
	3.81		4.06		3.59		3.41		3.21	
28	3.91	3.86	4.02	4.05	3.97	3.79	3.49	3.47	3.24	3.23
	3.86		4.07		3.81		3.51		3.24	

Figure 14: Variation in the Split Tensile Strength.

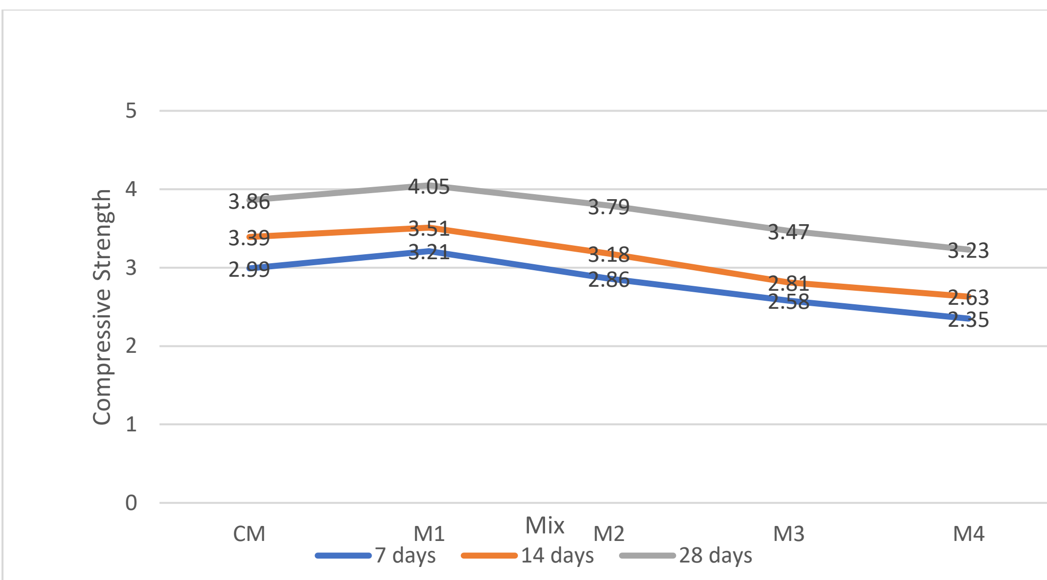
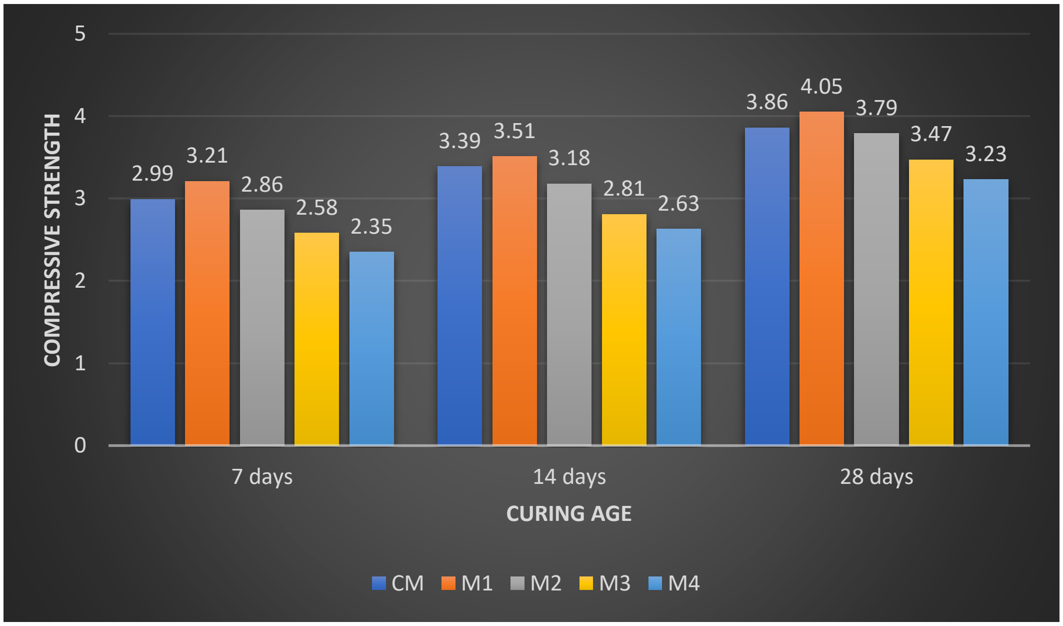


Figure 15: Variation in the Split Tensile Strength with increase in curing age



From the graphs and bar chart of Split Tensile Strength depicts that Split Tensile Strength is increased for M1 as compared to control mix but after there is a decreased in strength for M2, M3, M4 with the increase of iron slag content with marble dust kept constant. With the increased of curing age, Split Tensile Strength is increased for M1 as compared to control mix. Therefore, the maximum Split Tensile Strength of the cubes is found on M1 as compared to others.

5.4 Flexural Strength of Concrete:

When beam is subjected to flexure in a structural building is commonly evaluated by means of bending tests. When concrete is subjected to bending, then tensile and compressive stresses and in many cases direct shear stresses are developed. The 100 mm x 100mm x 500 mm beams were used for testing the compressive strength after 7 days,14 days and 28 days. Specimens has been made for control mix and compared with replacement of cement with marble dust at 20% kept constant and sand with iron slag at 10%, 15%, 20%, and 25%. Three samples have been casted for each percentage i.e. three for 7 days, three for 14 days and three for 28 days testing. The results of flexural strength of concrete are reported in Table 9.

Table 10: Flexural Strength of Beam

Flexural Strength (MPa)										
Curing age (days)	CM 0%MD+0%IS		M1 20%MD+10%IS		M2 20%MD+15%IS		M3 20%MD+20%IS		M4 20%MD+25%IS	
7	7.23	7.52	6.38	6.39	5.74	5.76	5.07	5.09	4.3	4.32
	7.62		6.37		5.76		5.08		4.32	
	7.71		6.42		5.78		5.12		4.34	
14	8.22	8.24	7.44	7.47	6.51	6.53	6.07	6.08	5.12	5.13
	8.24		7.48		6.53		6.08		5.13	
	8.26		7.49		6.55		6.09		5.14	
28	9.83	9.86	8.77	8.78	7.87	7.88	7.01	7.02	6.38	6.39
	9.87		8.78		7.88		7.02		6.39	
	9.88		8.79		7.89		7.03		6.4	

Figure 16: Variation in the Flexural Strength.

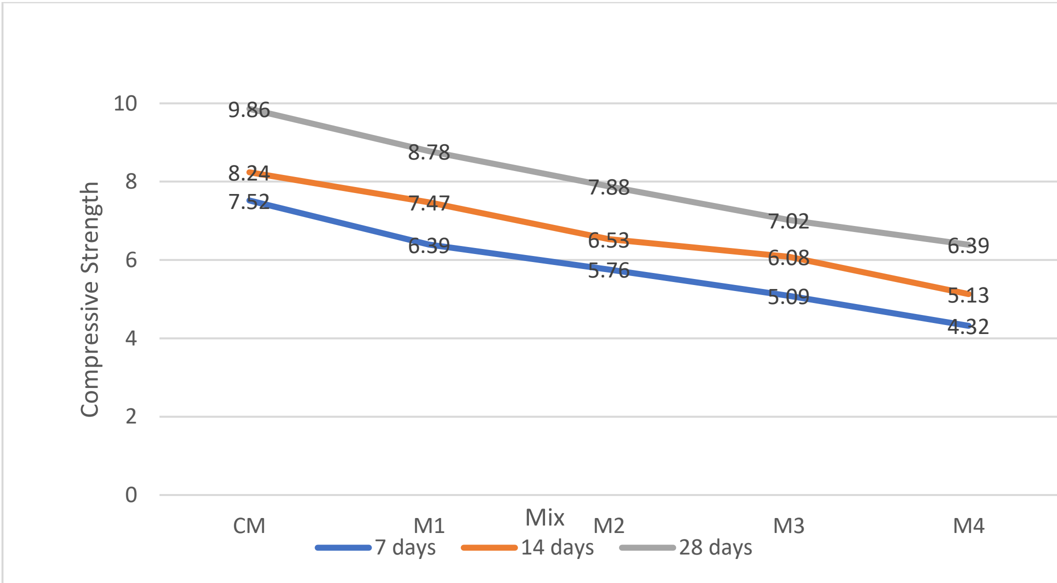
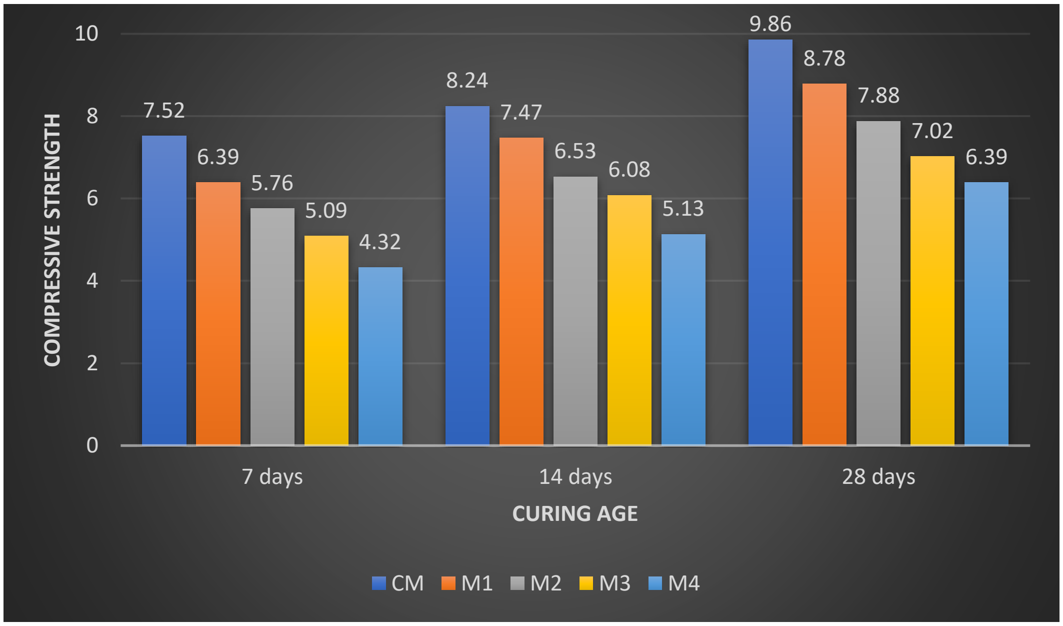


Figure 17: Variation in the Flexural Strength with the increase in curing age



From the graphs and bar chart of Flexural Strength depicts that Flexural Strength is decreased for M1, M2, M3, M4 as compared to control mix with the increase of iron slag content with marble dust kept constant. With the increased of curing age, Flexural Strength is decreased as compared to control mix. Therefore, the maximum Flexural Strength of the cubes is found on control mix only as compared to others.

CHAPTER 6

CONCLUSION

6.1 General:

The present study was undertaken to investigate the compressive strength, flexure strength, and split tensile strength of concrete with replacement of cement with marble dust at 20% kept constant and sand with iron slag at 10%, 15%, 20%, and 25%.Tests were performed after 7,14 and 28 days of curing of concrete. 27 samples of reference mix i.e. with 0% (marble dust and iron slag) and 108 samples of Marble Dust and iron slag in concrete with different percentage were prepared for determining compressive strength, flexure strength and split tensile strength of concrete with 0.45 water-cement ratio. Super-plasticizer "Fosroc Auramix V200" was used in all the mixes at 1% level by weight of cementious material.

6.2 Conclusion:

6.2.1 Analysing Compressive Strength:

The graphs and bar chart of compressive strength depicts that ,with the replacement of cement with marble dust and sand with iron slag, there is an increase in the compressive strength of the concrete cubes at the water- cement ratio of 0.45. The maximum compressive strength of the cubes is found at by replacing 20 % of cement with Marble dust and 10% of sand with iron slag. But further compressive strength of cubes decreases on replacement of cement with marble dust and sand with iron slag.

6.2.2 Analysing Split Tensile Strength:

The graphs and bar chart of split tensile strength depicts that, with the replacement of cement with marble dust and sand with iron slag, there is an increase in the split tensile strength of the concrete cylinder at the water- cement ratio of 0.45. The maximum split tensile strength of the cylinder is found at by replacing 20 % of cement with marble dust and 10% of sand with iron slag. But further split tensile strength of cylinder decreases on replacement of cement with marble dust and sand with iron slag.

6.2.3 Analysing Flexural Strength:

The graphs and bar chart of flexural strength depicts that, with the replacement of cement with marble dust and sand with iron slag, there is an decrease in the flexural strength of the concrete beam at the water- cement ratio of 0.45. The maximum flexural strength of the beam is found in control mix only. Further flexural strength of beam decreases on replacement of cement with marble dust and sand with iron slag.

6.3 Estimation and Costing:

S.no	Materials	Materials used(kg)	No of bags	Cost / bag	Total cost
1	Cement	306.6	7	300	2100
2	Marble Dust	46.8	1	350	350
3	Iron slag	75.12	-	-	-
4	F. A	458.1	10	12	120
5	C.A(10 mm)	307.13	7	12	84
6	Admixture	2.85 lt.	3 lt	100	300
8				Total = 2954=3000	
Transportation Cost = 1000				Total Cost = Rs. 4000	

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