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LABORATORY STUDY ON MECHANICAL PROPERTIES OF SELF COMPACTING CONCRETE BY USING SILICA FUMES, MARBLE WASTE & JUTE FIBER FOR MAKING ENVIRONMENT ECO- FRIENDLY CONCRETE

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Abstract: This laboratory study aimed to investigate the mechanical properties of self-compacting concrete (SCC) with the addition of silica fumes, marble waste, and jute fibers. SCC is a high-performance concrete that does not require vibration for compaction, making it more efficient and environmentally friendly. In this study, different proportions of silica fumes, marble waste, and jute fibers were added to SCC mixtures to determine their effect on the mechanical properties of SCC. The results showed that the addition of silica fumes and marble waste improved the compressive strength and flexural strength of SCC, while the addition of jute fibers improved the tensile strength and toughness. The optimal mixture proportions were identified, which could be used for future construction applications. The study demonstrates the potential for incorporating waste materials and natural fibers into SCC to improve its mechanical properties and reduce environmental impact. Self Compacting Concrete is able to compact under its own mass in thin sections and congested reinforced zones due to its high fluidity and cohesiveness. To produce a self compacting concrete , the marble waste is also used with partial replacement as 05,10 and 15% in natural fine aggregate and compared with the conventional mix. The marble sector has produced a large amount of waste in recent decades , which is increasing day by day. Marble waste is a highly polluting form of industrial waste , which has a significant health impact on the environment. Throughout the manufacturing process of the marble about 20-30% of marble waste is generated and created for disposal and land filling problems. Jute fiber is also used as additive material for making environmentally eco friendly concrete and also improved the split tensile strength and flexural strength of SCC. The optimum variety of Jute fiber is taken approximately 0.1 to 0.4% to produce a better quality of scc. A fine industrial by-product of silica fumes is used as a partial substitute for cement by replacing 5,7.5,10% for making eco-friendly concrete. When increasing the silica fumes quantity the results showed that the slump and air content of the concrete gradually increased . The experimental results of mechanical properties of SSC found better than conventional concrete and results are compared with the existing codal provisions.

Keywords: Self Compacting Concrete , Silica Fumes , Marble Waste , Jute Fiber , High performance Concrete

I. INTRODUCTION

The SCC is associated with the drive towards better quality of concrete pursued in Japan in late 1980's where the lack of uniform and complete compaction of concrete by vibration. It led to the development of the SCC by researchers Okamura & Ouchi at the University of Tokyo. The SCC doesn't require it to be vibrated to achieve full compaction. The main requirement of SCC is very high flow or slump spreads and very high segregation resistance. These two properties are most important for manufacturing of SCC. By the year 2000, the SCC has become popular in Japan for fabricated products and ready mix concrete. Several European countries recognized the significance and potential of SCC developed in Japan. SCC has been classified as powder type, viscosity agent type and the combination type. Each differs in the way such that segregation resistance is achieved. The Combination type of SCC uses a moderate powder content and a reasonable quantity of viscosity agent and is considered more robust for structural applications like local placement in tunnels.Current Indian scenario in the construction field, the construction of the Civil structure is large and complex which often leads to difficulty in concreting. Vibrating concrete in the congested location may cause some risk to labor in addition to noise stress. It is doubtful to achieve the required strength and durability in that location. To get HPC and SCC, the super plasticizers play a vast role. The max size of aggregate (10- 12 mm) and water cement ratio in the range 0.3-0.4 has been taken for SCC and it also plays an important role in manufacturing of SCC. Today, the SCC is widely used in the world and it reduces the time, skilled manpower cost , vibrating tools cost, noise level and also improves durability, workability of concrete.

Today, SCC is a necessity in the construction field for faster construction, safe working environment, better surface finishing. The SCC is used in the following structure given below:

- Bridges (anchorage, beam , girders, piers etc.)
- Box culvert
- Tunnel
- Dam
- Concrete Product like water tank, Slab and segment
- Concrete filled steel column
- Diaphragm wall

Increase in population in developing countries and rapid industrialization results in problems in disposal of industrial waste and by-products causing major issues in environment and ecological balance. The construction activities are increased manifolds to cater the need of increase in population. Such construction activities resulted in the depletion of natural resources like limestone and river sand and points to the sustainability issues to overcome and manage these problems, industrial by products like marble waste , silica fumes etc. are utilized by the various researchers for the production of the concrete .The use of the marble waste in normal concrete has showed improved mechanical properties. Millions of tons of waste are being generated from the marble industry causing various landfill problems to the environment. If it can be used as a partial substitute in the building industry, the volume of its landfill's occupancy is limited.A variety of additives are being used in construction to create various mixtures with properties that outperform many conventional concrete properties. Fibers are being employed as reinforcing material in concrete instead of steel.The natural fibers are lower in cost compared to synthetically prepared fibers such as jute fibers which can minimize splitting and enhance the tensile strength of concrete.The use of cement for concrete production has increased due to increase in construction activities. The manufacturing processes associated with production of cement are primary contributors to the increase in CO_2 emissions and many other adverse impacts on the global environment. Increase in CO_2 resulted in global warming , in order to tackle these impacts alternative materials and production methods are deemed necessary to minimize the environmental impacts while satisfying the growing infrastructure demands. SCC has been extensively used in infrastructure construction to minimize the vibration required to compact concrete , improve mechanical property of concrete and enhance the concrete workability and applicability in order to reduce the CO_2 emissions associated with the high demand of portland cement in SCC production. Pozzolans have been introduced as alternative cementitious materials in SCC mixtures. The performance of SCC depends not only on its workability during construction, but also on its load carrying behavior in hardened stages.

Various fiber types were selected and introduced as Reinforcement for SCC aiming to improve its tensile and flexural strength. Currently the common fibers are mostly made from inorganic polymers. Even though these fibers have good ability in enhancing the mechanical performance of SCC, they are non-degradable materials that impose adverse environmental effects in the future , also the production of inorganic polymers generates CO2 emissions that furtherly impacts the environment energy consumptions and end of life treatment . Recently natural fibers have attracted attention as good alternatives to manufactured fibers for their biodegradable ability and low cost. However it is noted that the inclusion of natural fiber in SCC could result in the loss of flow ability, which was attributed to the increased fiber binder frictional interaction, as well as the hydrophilic property of natural fibers in some cases. Jute Fibers are easy to obtain with low energy demands and CO2. They are considered one of the cheapest natural fibers that mainly contain cellulose and lignin. Jute fibers have high strength and stiffness and have recently being used as components for producing sustainable composite materials. Therefore the use of jute fibers in SCC could become an effective way for reinforcement . It was discovered that adding fiber in SCC improved the hardened properties. The addition of fibers to concrete provides various advantages including the avoid dense of rapid collapse, improved fracture energy, reduce crack width, decrease shrinkage and increased flexural and tensile strength and durability.The high surface area of fibers with small diameters decrease SCC work ability. Some researchers discovered that if the volume fraction of SCC exceeds 0.5 of the concrete volume , the fresh properties of SCC can negatively affect the optimum quantity used for better results.This analysis aims to assess the fresh and hardened property of SCC with silica fumes as a partial substitute for cement , marble waste as a partial substitute for natural fine aggregate and the addition of jute fibers. The workability properties of SCC are determined using Slump flow diameter, V funnel flow , L Box and U Box test. Furthermore split tensile strength , compressive strength and flexural strength tests were carried out to hardened properties.

II.Literature Survey

Mounir m. Kamal studied the optimum content of fibers (steel and polypropylene Fibers) used in scc. The Effect of different fibers on the fresh and hardened properties was studied. An experimental investigation on the mechanical properties,including compressive strength, flexural Strength and impact strength of fiber reinforced self-compacting concrete was performed. The results of the investigation showed that: the optimum dosage of steel and polypropylene fiber was 0.75% and 1.0% of the cement content, respectively. The impact performance was also improved due to the use of fibers. The control mix specimen failed suddenly in flexure and impact, the counterpart specimens containing fibers failed in a ductile manner, and failure was accompanied by several cracks.

A.S.E. Belaidi has studied 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).Ordinary portland cement (opc) was partially replaced by different percentages of pozzolana and marble powder (10–40%). The workability of fresh scc was measured using slump test, v-funnel flow Time test, j-ring,l-box and sieve stability tests. Compressive strength was determined on prisms at the ages of 7, 28,56 and 90 days. The results indicate an improvement in the workability of scc with the use of pozzolana and marble powder. Compressive strength of binary and ternary SCC decreased with the increase in natural pozzolana and marble dust content, but strength at 28 and 90 days indicate that even with 40% (natural pozzolan + marble powder), suitable strength could be achieved.

Prof. Shriram H. Mahure (2014) had studied about the fresh and hardened properties of self compacting concrete using Fly ash as partial replacement of cement in different percentages in addition to filler. The fresh properties have been determined by computing the Slump value, V-funnel value and L-box value and the hardened properties are determined by computing the Compressive strength, Flexural strength and Split tensile strength of the specimens. It is observed that the fresh properties of concrete shows an acceptable value up to 30% replacement of fly ash and also the hardened properties of concrete is significantly improved when compared to the conventional mix.

Sherif.A.Khafaga (2014) had investigated the fresh and hardened properties of self compacting concrete using recycled concrete aggregate as both coarse and fine aggregates. The concrete was prepared by replacing 25%, 50% and 75% of coarse and fine recycled aggregates. The study consisted of thirteen concrete mixes which reflect the key variables and their effects on the fresh and hardened properties of the produced SCC. The results indicated that the properties of the recycled aggregates SCCs have only a slight difference in their properties from the natural aggregates SCC. The recycled concrete aggregate as both coarse and fine aggregates can successfully be used for making of SCC.

Rafat Siddique (2013) investigated the strength and durability properties of Self-Compacting concrete which is obtained by partially replacing natural sand with waste foundry sand (WFS). He replaced the Natural sand with WFS by 0%, 10%, 15% and 20% in terms of weight. He studied the fresh properties of concrete before computing the strength parameters. Compressive strength and split tensile strength tests were obtained at the age of 7, 28, and 56 days and to determine the durability of the concrete, sulfate resistance was evaluated at the age of 7, 28 and 56 days and Rapid Chloride Permeability test was conducted at age of 28 days. Test results have shown that there is increase in compressive strength and split tensile strength of self-compacting concrete and also the durability properties have been improved by incorporating waste foundry sand as a replacement of Natural sand.

III.PROJECT BACKGROUND

Objective Of Study:

1. Silica fume and Marble Waste are waste that are generated in a huge quantity in India and create disposal and land filling problems. To minimize that problem and reduce the adverse environmental impact on Human Health, the use of silica fume and marble waste in concrete as partial replacement of cement and fine aggregate respectively.
2. To improve the Fresh and Hardened properties of concrete
3. To place the concrete in congested areas and congested reinforcement where the compaction of concrete is not possible properly and may cause risk to labor in addition to noise pollution.
4. To make environmental eco friendly and high strength concrete.
5. Easy to transport the concrete without any segregation
6. Easy to place concreting in underwater

Material:

Ordinary Portland Cement, 43 or 53 grade can be used for this study . Natural rivers and confirming to zone 2 and specific gravity 2.65 was used as conventional fine aggregate. Maximum size of coarse aggregate used in 10 mm to avoid blocking effect with the specific gravity of 2.60 and water absorption of 0.92% is used. Marble waste less than 4.75 mm which is utilized as a partial substitution of fine aggregate . The properties of marble waste are in Table 1. Portable water is used for drinking purposes and used for mixing and curing the concrete. Silica fume also known as micro silicon is used as pozzolanic material in this study. It has a specific gravity of 2.30.



Figure 1. Silica Fumes **Figure 2.(Stone aggregate)** **Figure 3.(Jute Fiber)**

Table 1: PROPERTIES OF MARBLE WASTE

Proportion	Results
Colour	White
Specific Gravity	2.64
Form	Fine Chips
Fineness Modulus	2.75
Water absorption	1.75%

Table 2: CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES OF SILICA FUME AND CEMENT

Chemical Name	Cement	Silica Fume
SiO2	21.14%	85.32%
Al2O3	5.38%	0.84%
Fe2O3	3.2%	0.91%
CaO	63.26%	0.56%
MgO	1.19%	0.45%
Na2O	0.29%	1.05%
K2O	0.53%	1.00%
SO3	2.33%	0.67%
Specific gravity	3.25	2.17
Blain fineness	3420	168000

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Jute Fiber : Jute fiber is composed mainly of cellulose, hemicellulose, and lignin, along with small amounts of pectin and other materials. The composition of jute fiber can vary depending on factors such as the age of the plant, the growing conditions, and the processing method used.

Cellulose is the most abundant component of jute fiber, accounting for around 65-75% of the fiber's total weight. Hemicellulose is the second most abundant component, making up about 15-20% of the fiber's weight. Lignin is present in smaller amounts, comprising around 10-15% of the fiber's weight. Jute fiber is also rich in other important elements such as potassium, magnesium, calcium, and sulfur, which contribute to its strength and durability. These elements are important in the formation of the cellulose and lignin components of the fiber

Chemical Admixture: Superplaseizers are an essential component of SCC to provide necessary workability. The new generation of superplasticizers termed poly-carboxylated ethers (PCE) is particularly useful for SCC. Other types may be incorporated as necessary, such as Viscosity Modifying Agents (VMA) for stability, air entraining agents (AEA) to improve freeze-thaw resistance, and retarders for Control of Setting.

IV. PROPERTIES OF SCC

Fresh SCC should have the filling ability, passing ability & segregation resistance at required levels. The filling ability means the ability of SCC to flow into each corner of the form work by its own weight. It should be able to fill all space of formwork without vibration of concrete. The flow of SCC should be easy in the horizontal and vertical direction. The ability to flow through heavily congested reinforcement under it’s own weight. The passing ability of SCC means the ability of SCC to flow through tight openings such as spaces between steel reinforcing bars under it’s own weight. The resistance of segregation means resistance of components of SCC to migration or separation and remains uniform and homogeneous throughout the process of transport and placing. To satisfy these conditions the European Federation of Specialist Construction Chemical and Concrete System (EFNARC) gave the same test method, guidelines and specifications for workability of SCC. In the situation where the reinforcement is congested and vibration of concrete is not possible the SCC will be used.

Table 3. List of Test methods for workability properties of SCC

Sri No.	Method	Property
1.	Slump flow by Abrams cone.	Filling ability
2.	$T_{50\ cm}$ Slump flow	Filling ability
3.	J-ring	Passing ability
4.	V-funnel	Filling ability
5.	V-funnel at T_5 minutes	Segregation resistance
6.	L-box	Passing ability
7.	U-box	Passing ability
8.	Fill-box	Passing ability
9.	GTM Screen Stability Test	Segregation resistance
10.	Orimet	Filling ability

Fig 4.Congested Reinforcement in Raft

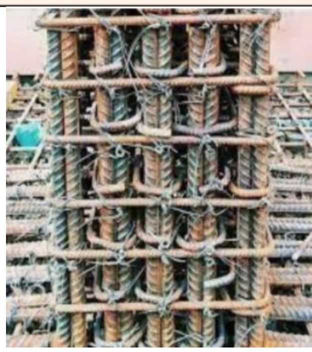


Fig 5.Congested reinforcement in column

Viscosity Modifying Agent (VMA):

VMA is the most important material for producing SCC. One of the methods of improving the stability of flowing SCC is to increase the paste content by using a large amount of filler active or insert. However attempts are being made to reduce the fine content (the paste content) with a view to reduce shrinkage and creep by using VMA for stability.VMAs have been in use for a long time for underwater concreting in the past. Now their use is extended to SCC. Most VMAs contain polysaccharides as active ingredients. Some starches could also be used for control of viscosity. Diutan gum and welan gum Diutan gum and welan gum are often Diutan gum and welan gum become part of certain viscosity modifying admixture. It is claimed that such VMA becomes compatible with all superplasticizers. One must be careful about the sequence of addition of VMA and superplasticizer into SCC. VMA should be added after a superplasticizer is added and mixed with cement particles. If VMA is added before a superplasticizer, it swells in water and dispersion of the superplasticizer in concrete becomes difficult. Usually VMA is added in a small dose of 0.2 to 0.5 per cent by weight of the binder content.

Super Plasticizers: Superplasticizers constitute a relatively new category and improved version of plasticizer, the use of which was developed in Japan and Germany during 1960 and 1970 respectively. They are chemically different from normal plasticizers. Use of superplasticizers permit the reduction of water to the extent upto 30 percent without reducing workability in contrast to the possible reduction up to 15 per cent in case of plasticizers. The use of superplasticizer is practiced for production of flowing, self leveling, self compacting and for the production of high strength and high performance concrete. The mechanism of action of superplasticizers are more or less same as explained earlier in case of ordinary plasticizers. Only thing is that the superplasticizers are more powerful as dispersing agents and they are high range water reducers. They are called High Range Water Reducers in American literature. It is the use of superplasticizer which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 Mpa or more. It is the use of superplasticizer which has made it possible to use fly ash, slag and particularly silica fume to make high performance concrete. The use of superplasticizer in concrete is an important milestone in the advancement of concrete technology. Since their introduction in the early 1960 in Japan and in the early 1970 in Germany, it is widely used all over the world. India is catching up with the use of superplasticizer in the construction of high rise buildings, long span bridges and the recently become popular Ready Mixed Concrete Industry. Common builders and Government departments are yet to take up the use of this useful material. Superplasticizers can produce: " at the same w/c ratio much more workable concrete than the plain ones, " for the same workability, it permits the use of lower w/c ratio, " as a consequence of increased strength with lower w/c ratio, it also permits a reduction of cement content. The superplasticizers also produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding.

V. METHODOLOGY

Test Method For Fresh Self Compacting Concrete:

Srl No.	Method	Unit	Typical ranges of values Minimum	Maximum
1.	Slump flow by Abrams cone.	mm	650	800
2.	$T_{50\ cm}$ Slump flow	sec	2	5
3.	J-ring	mm	0	10
4.	V-funnel	sec	8	12
5.	V-funnel at T_5 minutes	sec	0	+3
6.	L-box	(h_2/h_1)	0.8	1.0
7.	U-box	$(h_2 - h_1)$mm	0	30
8.	Fill-box	%	90	100
9.	GTM Screen Stability Test	%	0	15
10.	Orimet	sec	0	5

5.2 Material Testing:

Sieve Analysis of 10 mm Coarse Aggregate:

Weight of sample: 3000 gm

S no	Sieve Size (in mm)	Weight of coarse aggregate retained	Percentage of weight retained	Cumulative percentage of weight retained(A)	Percentage Passing (100 - A)	Permissible percentage passing as per IS code 383
1.	12.5	0	0	0	100	100
2.	10.00	411	13.7	13.7	86.3	85-100
3.	4.75	2237	74.57	88.26	11.74	0-20
4.	2.36	325	10.83	99.09	0.91	0-5
5.	Pan	27	0.009	100	0	0

Table 4. Sieve Analysis of 10 mm Coarse Aggregate

Water Absorption & Specific Gravity Test of Coarse Aggregate:

S no.	Description	Sample 1	Sample 2
1	Weight of sample (in gm)	1000	1000
2	Weight of Vessel + Sample + water (A) (in gm)	3372	3162
3	Weight of Vessel + water (B) (in gm)	2754	2552
4	Weight of saturated and surface Dry sample (C) (in gms)	990	995
5	Weight of Oven Dry Sample (D)	982	985
6	Specific gravity (D / C-(A - B))	982/372 = 2.64	985/385 = 2.56
	Average value of Specific Gravity	(2.64+2.56)/2=2.60	
7	Water Absorption (C- D) / D x 100	0.81	1.02
	Average value of Water Absorption	(0.81+1.02)/2=0.92	

Table 5. Water Absorption & Specific Gravity Test of Coarse Aggregate

Sieve Analysis of Fine Aggregate:

Weight of Sample = 1000 gm

S no	Sieve Size (in mm)	Weight of coarse aggregate retained	Percentage of weight retained	Cumulative percentage of weight retained (A)	Percentage Passing (100 - A)	Permissible percentage passing as per IS code 383 (Zone 2)
1.	10	0	0	0	100	100
2.	4.75	11	1.1	1.1	98.9	90-100
3.	2.36	39	3.9	5.0	95.0	75-100
4.	1.18	312	31.2	36.2	63.8	55-90
5.	0.6	210	21	57.2	42.8	35-59
6.	0.3	274	27.4	84.6	15.4	8-30

7.	0.15	114	11.4	96.0	4.0	0-10
8.	0.075	18	1.8	97.8	2.2	
9.	Pan	22	2.2	100	0	

Table 6. Sieve Analysis of Fine Aggregate

Silt Test of Fine Aggregate:

Silt content (in %) : Volume of Silt / Total Volume of fine aggregate x 100

1. Silt content = 2/ 84 x 100 = 2.38 % < 8% (It's Okay)
2. Silt content = 3/ 90 x 100 = 3.33 % < 8% (It's Okay)
3. Silt content = 5/ 88 x 100 = 5.68 % < 8% (It's Okay)

Average = 3.79 % < 8% (It's Okay)

Mix Proportioning:

In a study a mix ratio 1:1.80:1.35:0.38 was arrived at with constant w/p ratio for SCC mixes. SCC requires the optimum amount of Powder content and superplasticizer. The powder content can be achieved by fixing the percentage of coarse aggregate in the volume of concrete. The optimum superplasticizers dosage taken 1% by weight of cement. Master Sky Glenium 8233 beyond 1% of mix proportion affects the strength. The cement content is partially replaced by silica fumes for 5%, 7.5%, 10% by weight . The fine aggregate is replaced by marble waste for 5%,10% & 15% and the fiber ratio is 0.30% for these mixes taken constant by its concrete volume.

S. No	Mix ID	Cement (kg/m^3)	FA Fine aggregate (kg/m^3)	CA Coarse Aggregate (kg/m^3)	Water (in kg)	SP% Super Plasticizer	Silica fume (kg/m^3)	Marble Waste (kg/m^3)	Jute Fiber (%)
1	CC	490.00	882.00	661.50	186.20	1.25	0	0	0.30
2	S05MW05	465.50	837.90	661.50	186.20	1.25	24.50	44.10	0.30
3	S05MW10	465.50	793.80	661.50	186.20	1.25	24.50	88.20	0.30
4	S05MW15	465.50	749.70	661.50	186.20	1.25	24.50	132.30	0.30
5	S7.5MW05	453.25	837.90	661.50	186.20	1.25	36.75	44.10	0.30
6	S7.5MW10	453.25	793.80	661.50	186.20	1.25	36.75	88.20	0.30
7	S7.5MW15	453.25	749.70	661.50	186.20	1.25	36.75	132.30	0.30
8	S10MW05	441.00	837.90	661.50	186.20	1.25	49.00	44.10	0.30
9	S10MW10	441.00	793.80	661.50	186.20	1.25	49.00	88.20	0.30
10	S10MW15	441.00	749.70	661.50	186.20	1.25	49.00	132.30	0.30

Table 7: The details of the mix proportions for the 10 combination of SCC mixes

Fresh Concrete Test:

To evaluate the workability and rheological properties behavior of SCC , fresh concrete testing techniques are used. The performance of SCC in the fresh stage is specified by its passing ability , filling ability and segregate resistance.

Slump flow is a technique for determining the free flow of concrete. The slump cone was filled with fresh concrete immediately after it had been mixed. The cone was then pulled upward to allow the concrete to settle on the floor . When the flow stopped , the average final diameter of spread concrete was measured. The end diameter of a concrete circle was approximate in two directions D1 and D2 and the mean was determined in this fest.

To determine the flowability of SCC , V funnel testing is conducted.This involves filling the funnel with concrete then opening the bottom outlet to allow the concrete to flow.The time required for the concrete to flow was measured.

L box test was used to determine the passing ability after mixing the concrete , the vertical portion of the box was instantly filled and the gate was opened to allow the concrete to fill the Horizontal areas. The filling ability of concrete was determined by H2/H1. The V box test was used to assess the filing capacity of SCC.

Hardened Concrete Test:
Compressive strength , flexural and split tensile strength tests were conducted at a water curing interval of 7 & 28 days to determine the hardened state characteristics of SCC. Samples were prepared with one control mix and three samples with silica fume , marble waste and jute fiber. For compressive strength test 150mm*150mm*10mm size specimen were used , for flexural 500mm*100mm*100mm sample used and evaluated in a standard two point loading test and for split tensile 150mm*a 300mm sized cylinder sample/specimen was used. All tests were conducted as per standard code IS 516:1959.
The hardened properties of SCC can be evaluated using the same tests that are used for conventional concrete, although some specific tests may be necessary to measure the flowability and segregation resistance of SCC. Here are some of the key tests that can be used to evaluate the hardened properties of SCC:

Compressive strength test: This is the most commonly used test to evaluate the strength of concrete. It involves crushing a cylindrical or cubical sample of concrete in a compression testing machine. The compressive strength of SCC is typically higher than that of conventional concrete due to the higher cement content and reduced porosity resulting from the absence of vibration.

Flexural strength test: This test is used to evaluate the ability of SCC to resist bending forces. It involves placing a prismatic or beam-shaped sample of concrete in a bending frame and applying a load until the sample fails. SCC typically exhibits higher flexural strength than conventional concrete due to the improved homogeneity and reduced cracking tendency.

Durability tests: SCC can be evaluated for its resistance to various environmental factors such as freeze-thaw cycles, chloride penetration, carbonation, and sulfate attack. These tests involve exposing concrete specimens to simulated environmental conditions and measuring their deterioration over time. Ultrasonic pulse velocity test: This test is used to evaluate the homogeneity and integrity of concrete by measuring the speed of sound waves passing through it. It can be used to detect any defects or voids that may exist within the SCC.

VI. Result And Conclusions

Fresh Concrete test Result:
Fresh Concrete properties of SCC containing Silica fumes, Marble Waste and jute fiber are discussed in this sector . The minimum slump flow requirement as per EFNARC guidelines is 650 mm. It is noted that the mix S75MWO5 is more workable with a slump flow of 680 mm. Whereas S05MW15 possesses the least flow of 685 mm. Figure 1: The variation in slump flow with marble waste for constant silica fume and fiber value that increases in Marble waste to reduce the flowability of SCC mixes.This could be higher water absorption capacity of Marble Waste. Even though the slump flow gets decreased with the increase of marble waste percentage. The quantity of SP used was varied to keep the diameter of slump flow steady at 690+-30 mm. It is also found that the silica fumes absorb some SP on its surface due to its fine particle size. Marble waste has lower stiffness when compared to silica fumes and this decreases the flowability hence affecting the workability of the mixture. It is also noted that the marble waste quantity is increased in SCC mix then the required SP dose value increases significantly probably due to increased substantial friction between cement and marble waste particles. When a large amount of Marble waste is used the passing and filling ability has also decreased as the segregation resistance decreases. Also the fresh concrete properties were negatively affected by the large surface area of the fiber,obstructing the movement of Fresh Concrete.

Slump Flow Test :
The fresh property (flowability) of fresh SCC mixtures were evaluated based on the slump flow test . The slump flow test can be determined by slump cone and J Ring test. The Slump flow diameter of control cement , concrete without the addition of the jute fiber and marble waste powders was 650mm. Regarding the specimens without any fiber modification,the slump flow and J ring diameter were in ranges from 600 to 680 mm and from 400 to 550 mm respectively. The slump flow and J ring diameter reduced with increased fiber content. When the fiber content increased from 0.10% to 0.35% the slump flow and J ring diameter increased instead of decreasing . Thereafter the further increase in fiber content reduced the slump flow and J ring diameter since large surface area and friction inside the mixture with more fiber.

Figure 6: Slump flow test at field

Fresh concrete properties of SCC containing silica fume and marble waste are discussed in this study in the variation of the slump flow and the J ring test value for all mixes are observed. The minimum slump flow requirements as per EFNARC guidelines is 650 mm. It is observed that the mix SF7.5MW05 is more workable with a slump flow of 680mm whereas SF10MW15 possesses least value 630mm.The variation of slump flow with Marble Waste with constant value of jute fiber. If the increase of % of marble waste tends to reduce the flowability of SCC mixes . This could be due to higher water absorption capacity of marble waste . Hence the optimum % should be taken for preparation of mix. It is also found that the silica fumes absorb some super plasticize on its surface due to its finer particle size and marble waste has lower stiffness . When compared to silica fumes, this decreases the flowability hence affecting the workability of the mix.When a large amount of marble waste is used the filing and passing ability decreases as the segregate resistance decreases . Also the fresh concrete properties was negatively affected by the large surface area of the fiber.

Line Graph Value

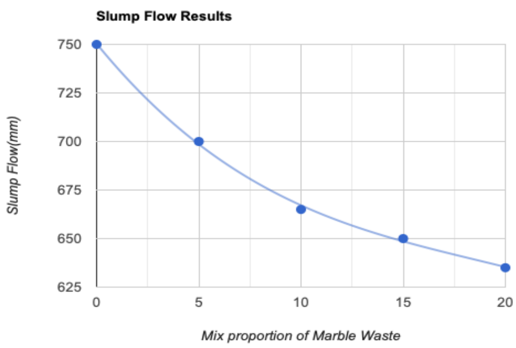
Mix proportion of Marble Waste X axis(in %)	Slump Flow (mm) Y axis
0	750.00
5	700.00
10	670.00
15	650.00
20	630.00

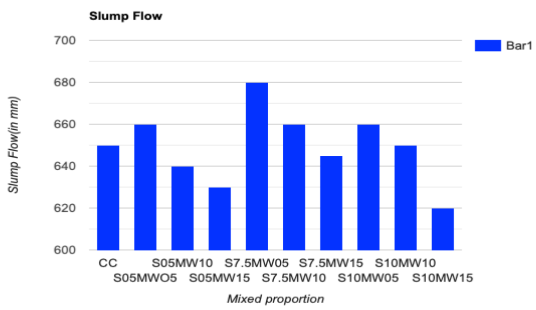
Table 8: for Slump Flow Results

Bar Graph Value

S.No	Mixed Proportion	Slump value (in mm)
1	Cement Concrete	650
2	S05MW05	660
3	S05MW10	640
4	S05MW15	630
5	S7.5MW05	680
6	S7.55MW10	660
7	S7.5MW15	645
8	S10MW05	660
9	S10MW10	650
10	S10MW15	620

Table 9: Bar Graph Value for Slump Flow Results





L Box Test:

The blocking behavior of SCC mixes by reinforcing bars is indicated by the L-box height ratio parameters, which are smaller if the step height is less and the height ratio equal to or greater than 0.80-1 is an acceptable one. The agglomeration between powdered particles over a certain amount of substitution might have raised particle friction , resulting in lower passing ability as compared to control mixes. Also the surface area of fiber affects the passing ability. The passing ability of SCC decreases as the proportion of marble waste increases. SCC's passing ability is typically between 0.80 to 1.00. All the mix with marble waste and fiber had an L-Box ratio of 0.80 to 1.0. All the mix with marble waste and fiber had L-Box ratio of 0.80 to 1.0. Indicating that all of the mixes are within the range of limits and have an acceptable range of concrete passing ability when compared to standard values.

Line Graph Value

Mix Proportion of Marble Waste(in %)	L-Box Test Ratio
0	0.90
5	0.88
10	0.86
15	0.85
20	0.83

Table 10: L-Box Test Result

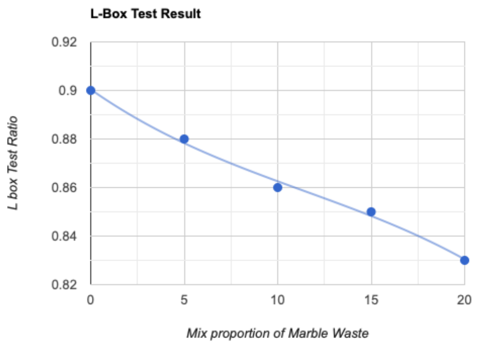


Fig 7: L Box Test Apparatus

U Box Test:

The acceptable limit of the U Box test is 0-30 mm according to EFNARC guidelines.Passing ability is lower for Marble waste and jute fiber replaced mixes as compared to control SCC,because of fiber surface area and raised friction between particles that reduced passing ability.The test results are typically reported as the distance traveled by the SCC in the U box after a specified time (usually 10 seconds or 30 seconds). The distance traveled by the SCC can be used to evaluate the ability of the mixture to flow and fill complex shapes without segregating or clogging. The U box test results are often compared to the specifications or requirements of a particular project or application. The results can be used to optimize the mixture proportions to achieve the desired flowability and passing ability or to adjust the mix design to meet project specifications.It's worth noting that the U box test is only one of several tests used to evaluate the properties of SCC, and the results of the U box test should be considered in conjunction with other test results to provide a comprehensive assessment of SCC's properties.

Line Graph Value

Mix Proportion of Marble Waste(in %)	U Box Test(in mm)
0	28.5
5	28.7
10	29.4
15	29.6
20	30

Table 11: U-Box Test Result

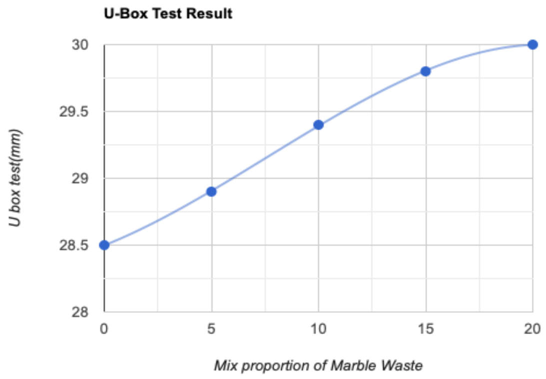


Figure 8: U Box test practical

V funnel Test:

The V funnel test was used to determine SCC flowability of the increase the % of marble waste with constant % of fiber then the flow ability time increases as compared to conventional concrete because of the fibers large surface area which slows the flow of concrete. Concrete with jute fibers took the longest to pass through the V funnel. The flowability is affected by the percentage of marble waste and the constant percentage of fiber but it was within the acceptable range of 8-12 second according to EFNARC guidelines. It is observed that the drawback of marble waste is that the flowability of concrete is compensated by silica fumes, which has shown good results in improving workability properties.The results of the V-funnel test are typically reported as the time it takes for the SCC to flow through the funnel. The time can be used to classify the SCC as either "pass" or "fail" based on the specified project requirements or specifications. A shorter time indicates a more fluid mixture with higher flowability, while a longer time indicates a more viscous mixture with lower flowability. The specific pass/fail criteria for the V-funnel test can vary depending on the project specifications or industry standards.

In summary, the V-funnel test result for SCC is typically reported as the time it takes for the SCC to flow through the funnel, and it can provide valuable information about the workability, flowability, and stability of the mixture.

Line Graph Value

Mix Proportion of Marble Waste	V Funnel Test (in second)
0	8.1
5	8.3
10	8.5
15	8.65
20	8.75

Table 12: V Funnel Test Result

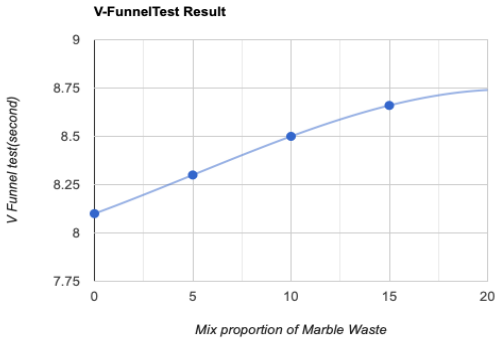


Figure 9 : V Funnel Test on field

Hardened Concrete test/Properties of SCC:

Compressive strength was determined at 7 and 28 days curing in 150 mm size cubes. Compressive strength values varied from 21.20MPa to 22.90MPa for 7 days period and 36.80MPa to 37.60MPa for 28 days curing period. It does seem that in comparison to a control mix prepared without marble waste and silica fumes. The compressive strength is initially improved with addition 5% Silica and 7.5% Marble Waste as fine aggregate but then decreased as the marble waste content increased. Previous research found that marble waste increased compressive strength by producing more C-S-H gel as a result of mixing silicon dioxide in marble reacting with calcium hydrate in cement to produce more cementitious material.At a higher percentage of marble waste , silica fume and fibers compaction is little bit difficult due to low workability while the addition of marble waste was replaced in fine aggregate. It refines the pore structure . So microstructures of the concrete mix were increased. Another side improved strength of mixes is due to lower W/P ratio which indicates that very few pores and strong bonds are in between the interfaced transition zone. Increasing the percentage of marble waste the compressive strength of the mix started to decrease due to the low workability and harsh mix which affect the packing of the materials that may reduce the compressive strength. It is also noted that the compressive strength linearly decreases for the mixes S05MW05,S05MW10, S05MW15 in these mix we observed the silica fume is 5% in all three mix and Marble waste increases 5% simultaneously in each mix resulting increases , marble waste decreases compressive strength but it also observed the increase the quantity of silica fume 7.5% and make three mixes S7.5MW05, S7.5MW10,S7.5MW15% . The compressive strength comes from the mix S7.5MW05% is found increased by 2%-3% because of the silica fume has enhanced cement hydrate- as a result of which the strength has increased . But the increase is of high percentage and it also decreases compressive strength. The reasons may be due to the presence of unreacted hydration products of silica fumes with voids. Obviously the increase in percentage of silica fume increases the water requirement, forming more voids and there is a drop of compressive strength. The highest compressive strength is S7.5MW15 and the lowest compressive strength S10MW15.

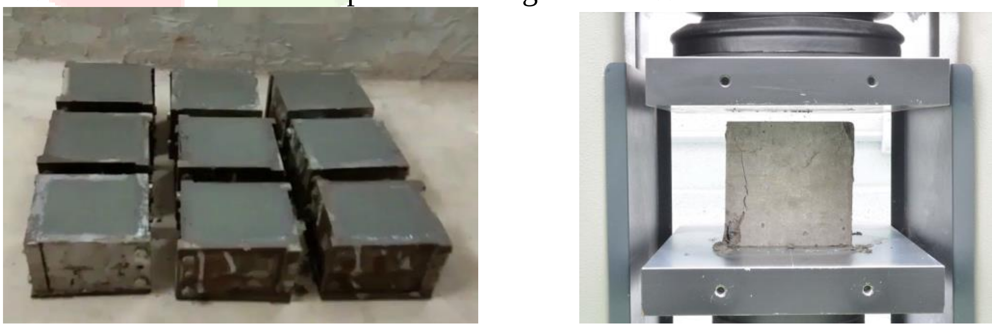
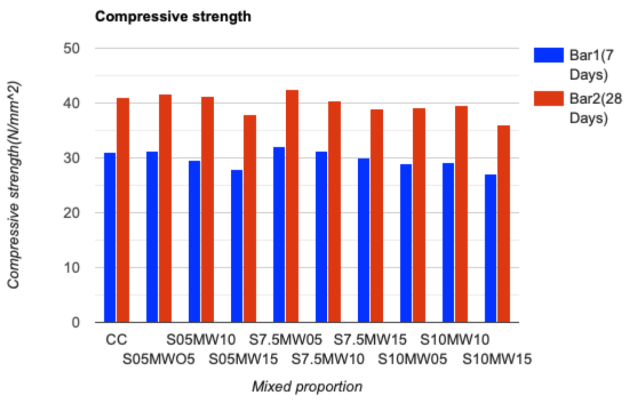


Figure 10: Filling C.C cube at site

Bar Graph Values

S.No.	Mixed Proportion	Compressive Strength(7 days)N/mm^2	Compressive Strength(28 days)N/mm^2
1	Cement Concrete	31	41
2	S05MW05	31.2	41.8
3	S05MW10	29.5	41.3
4	S05MW15	28	38
5	S7.5MW05	32	42.6
6	S7.55MW10	31.3	40.5
7	S7.5MW15	30	39.0
8	S10MW05	29	39.2
9	S10MW10	29	39.5
10	S10MW15	27	36

Table 13:for Compressive Strength



Split Tensile Strength:

Split tensile strength is significantly increased from 3MPa to 4.10MPa after 7 days and 4.40MPa to 5.10MPa for 28 days curing period. The split tensile strength increases 10 to 30% approx. After using silica fume, marble dust and jute fiber in concrete when compared with conventional concrete. The split tensile strength increases gradually which shows the better strength of cement paste matrix mix and interfacial transition zone. Increased strength as a result of Marble Waste acting as a filler material and making the aggregate more dense. The angular marble particles and in the formation of a stronger bond along the crack path forming during the split tensile strength test. The addition of fibers also increased the tensile split strength. The addition of fibers to concrete provides various advantages including the avoidance of rapid collapse , improved fracture energy , reduced crack width, decreased shrinkage and increased durability and flexural strength of concrete. The silica fumes give a good bond bet aggregate and cement paste and increase the S.T.S. When the optimum quantity of Silica fumes and Marble Waste is used for C.C then it increases the compressive strength and S.T.S but increases the quantity of silica fumes and marble waste from optimum quantity of silica fume and marble waste. The S.T.S of S7.5MW05 was the highest while it was the lowest in S10MW15 mixes the S.T.S of S05MW05 , S7.5MW10, S10MW10 and conventional concrete is almost the same.

S. No.	Mixed proportion	Split Tensile Strength(N/mm^2)
1	Cement Concrete	4.8
2	S05MW05	4.85
3	S05MW10	4.72
4	S05MW15	4.60
5	S7.5MW05	5.10
6	S7.55MW10	4.74
7	S7.5MW15	4.70
8	S10MW05	4.68
9	S10MW10	4.72
10	S10MW15	4.40

Table 14: Split Tensile Strength

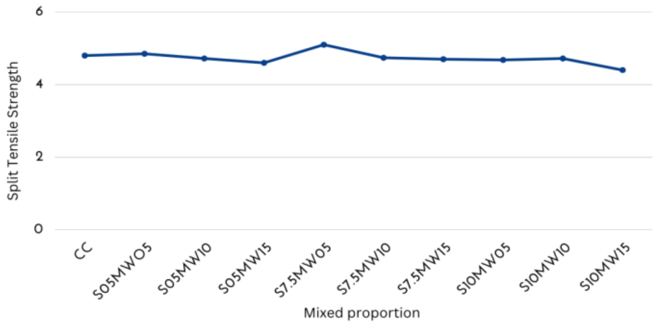


Figure 11: Split tensile strength

Flexural Strength:

The Flexural strength almost follows the similar pattern as the compressive strength does. The flexural strength result for control mix (SCC) was 4.3 MPa and the other 5%,10%,15% mix 4.25,4.35,4.60,4.11 MPa and it varied 4.1 to 4.6 MPa for 28 days . The flexural strength with a Marble Waste replacement of 5%,10%,15% and jute fiber was increased when compared to control mix. The flexural strength's highest value is SF7.5MW05 while it is lowest value in S10MW15 mix. The flexural strength of S05MW10, S7.5MW15 and S10MW10 was almost the same. The flexural strength of concrete increases 5 to 10% after mixing of Silica Fumes , Marble Waste and jute fiber in concrete when compared to its conventional concrete. Due to the pozzolanic reaction of marble waste , it has been observed that the marble waste replacement increases flexural strength. Also it is because of particles rough surface and angular from morphology , might have produced rigid packing between aggregate and cement process, resulting in increased flexural strength. There is a significant increase of strength by mixing / Adding fibers in concrete. The adding of fibers improved the hardened property of scc and provided various advantages including the avoidance of rapid collapse , improved fracture energy , reduced cracks width , decreased shrinkage and increased flexural strength. It is shown that the uses of fibers in concrete decreased SCC workability due to fibers having large surface area and small diameter . If the fibers quantities increased it may result in more air voids content and finally reduces the flexural strength.

S. No.	Mixed proportion	Flexural Strength(N/mm^2)
1	Cement Concrete	4.30
2	S05MW05	4.35
3	S05MW10	4.42
4	S05MW15	4.25
5	S7.5MW05	4.60
6	S7.55MW10	4.34
7	S7.5MW15	4.25
8	S10MW05	4.30
9	S10MW10	4.15
10	S10MW15	4.10

Table 15: Flexural Strength Result

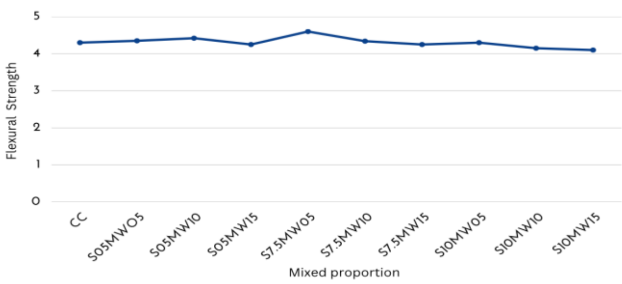


Figure 12: Flexural Strength test

Conclusion:

The study presented and investigated the mechanical properties of SCC with replacement of Silica Fumes, marble waste and mixing as additive jute fiber. The successful use of jute fiber and waste material/ mineral in SCC has improved the mechanical properties. It enhances the split tensile strength and flexural strength of fresh concrete, hardens the concrete properties reducing the CO2 emission making it environment eco friendly. The following conclusions may be drawn:

1. The addition of silica fumes to the cement can increase the fluidity and strength. If the silica content increases, the mortar fluidity increases while decreasing the water requirement.
2. The addition of silica fume increases the setting time and reduces the heat of hydration.
3. For the fresh concrete properties, all the values were in acceptable limits by EFNARC guidelines.
4. The passing and filling capability had reduced compared to the controlled mix (SCC). This is due to friction between the marble waste powder and fiber surface area.
5. Generally, fiber content increases the flexural and tensile strength of concrete.
6. Partial use of marble waste in concrete increases the flexural and split tensile strength because the waste acts as a filler material and makes the aggregate more dense.
7. The use of jute fiber and mineral powder in SCC increases the mechanical property of SCC. The jute fiber reinforced SCC mixes with marble waste would become an ecological construction material with lower CO2 emission as compared to conventional SCC mixture. The environmental issues related to portland cement production as well as landfills related to waste mineral powder and jute could also be relieved with the application of this sustainable material.
8. Silica fume is a by-product waste which creates disposal problems. The disposal of SF in landfills may lead to a lack of reusable land and generate difficulties for waste management organizations. Furthermore when silica fumes come in contact with water bodies, the water becomes contaminated. In addition, SF has considerably small particles easily combined with air and contribute to air pollution. Consequently dumping of SF endangers both natural environment and human health hence SF is to be used as SCM(Supplementary cementitious Material) in cementitious composites. The utilizing SF in cementitious composite would be a more sustainable practice and it also reduces the CO2 emission in the environment.
9. When the percentage of Silica fume is increased beyond 7.5% the compressive strength is found to decrease and this may be due to increase in voids present in coarse off matrix formed by unhydrated S.F.
10. The compressive strength tends to decrease when the % of Marble waste is increased with constant S.F content. The Marble waste acts as an inert material.When the replacement % is increased beyond 5% the strength properties are reduced.The splitting tensile strength and flexural strength almost follows the same trend as the 28 days compressive strength does.
11. The optimum level of addition of silica fume and Marble waste was found to be 7.5% and 5% by weight of cement and fine aggregate respectively.
12. It is the way of making concrete environmentally eco-friendly by using Silica fumes, Marble Waste and Jute fiber and best ways to dispose of the waste and mitigate the environmental impact on Human Health.
13. The compressive strength enhancement of 1% to 4% was observed for the mixes S05MW05 and S7.5MW05 compared to the conventional concrete CC. The increase in percentage of tensile strength of S7.5MW05 was found to be up to 6% more than the C.C the marginal increase in percentage of flexural strength of S7.5MW05 was found to be 6.90 more than C.C.

VII. ACKNOWLEDGMENT

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