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Experimental Studies On Steel Fiber Reinforced Self Compacting Concrete By Partial Replacement Of Cement With Marble Dust

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ABSTRACT

The goal of this project is to investigate the characteristics of steel fibre reinforced self-compacting concrete made using marble dust instead of cement. In this research, we utilised various amounts of marble dust in place of cement, as well as steel fibres. M30 mix is utilised in this research, using conplast sp 430 as a chemical admixture. We utilised marble dust in place of cement (5 percent, 10 percent, 15 percent, and 20 percent) in proportions with steel fibres (0.2 percent) and evaluated mechanical characteristics for 7 and 28 days.

I.INTRODUCTION

Steel Cement, aggregates of various sizes, and fibres make up fibre reinforced self-compacted concrete (SFRSCC). Fiber reinforced concrete is defined as concrete with randomly arranged fibres throughout. Under tensile stress, concrete is brittle, however discrete fibres randomly placed to avoid and regulate fracture initiation, propagation, and merging may enhance mechanical characteristics. When suitable mechanical characteristics are added to the concrete mix, toughness, fatigue resistance, impact resistance, and reinforcing cover spalling are all enhanced. Flexural and shear strength has also been enhanced. The contribution of fibres to mechanical and durability properties is influenced by their kind, organisation, volume fraction aspect ratio, and other mixing factors.

1.1 Objective of Study

The purpose of this study is to look into the properties of steel fibre reinforced self-compacting concrete produced using marble dust rather than cement. We used different quantities of marble dust in place of cement, as well as steel fibres, in this study. In this study, M30 mix is used with conplast sp 430 as a chemical admixture.

1.2 Self Compacting Concrete

Professor Hajme Okamura's invention of Self Compacting Concrete (SCC) in 1986 had a significant effect on the building sector by eliminating some of the difficulties connected with new concrete. The SCC has been updated to handle numerous issues such as worker skill, reinforcing complexity, structural section type and shape, pumpability, segregation resistance, and, most importantly, compaction. Self-compacting concrete with a high fines content has been shown to be more durable. Since its inception in Japan, a slew of studies on the mix design of SCC, as well as its microstructure and durability, have been published throughout the globe. Despite considerable study by a variety of organisations and researchers to develop rational mix design processes and self compactibility testing methodologies, the Bureau of Indian Standards (BIS) has yet to provide a standard mix procedure. Self Compacting Concrete is made up of the same ingredients as regular concrete: cement, fine and coarse aggregates, water, mineral and chemical admixtures. SCC differs from regular concrete in that it contains additional particles, high-range water reduction agents (Super Plasticizers), and Viscosity Modifying Agents (VMA), all of which change the rheological characteristics to some degree.

Increased productivity, more uniform and cohesive material with few or no honeycombs, improved strength and durability characteristics, good finish, adaptability in congested reinforced sections, reduction in the size of structural members, and so on are some of the benefits of SCC over traditional concrete. SCC improves the workplace environment by reducing noise pollution and providing a safe environment for formwork owing to the reduction of compaction caused by vibration, resulting in a pleasant working environment. As a result, the Concrete Society describes the SCC as a "silent revolution" in the building sector. As a consequence, SCC is now widely used in the pre-cast product industry in Europe and worldwide. However, as compared to regular concrete, the increased fines content and use of admixtures make SCC more sensitive with lower robustness, necessitating additional knowledge and quality control.

SCC was developed in Japan in 1986, and large building projects there began utilising it in the late 1990s. As of now, the proportion of SCC in yearly Ready Mixed Concrete (RMC) and Pre-Cast Concrete production in Japan is estimated to be about 1.2 percent and 0.5 percent, respectively. In the first three months of 2011, the construction sector in the United States of America produced approximately 128,000 m3 of SCC each day. It accounts for approximately 1% of yearly RMC output. SCC's popularity increased dramatically over time all around the globe. However, despite extensive study into different elements of SCC's mechanical behaviour and structural applications, India is not in the forefront of its use. Despite the fact that SCC has proven to be an effective material, more research is needed to standardise self-compacting characteristics and their behaviour when used in various structural elements, paving the way for its acceptance in all hazardous and inaccessible project zones for better quality control.

1.3 Fiber Reinforced Self Compacting Concrete

With the availability of different grades of cements and mineral admixtures, concrete technology has experienced revolutionary developments in recent years. Even though there have been significant advances, certain issues persist. These issues may be considered disadvantages for this cementatious material when compared to materials like steel. Concrete, being a quasi-fragile material, has a low tensile strength and virtually no ductility. The inclusion of fibres may help with these two issues to some degree. Apart from bridging fractures and slowing their propagation, this is shown to improve energy absorption. Fiber Reinforced Concrete (FRC) has been popular since the 1960s, and considerable research has been done on it. Bridge decks, pre-cast elements, pavements, industrial floors, critical zones in RCC components, and shotcreting are just a few of the uses for FRC.

1.4 Backdrop regarding self-compacting concrete

Cement-based goods are the most abundant of all man-made products, and they are extremely important design items; in fact, they are quite likely to have comparable importance in the future. These design and anatomist goods, on the other hand, must satisfy new and bigger needs. When faced with issues of manufacturing, general economics, top quality, and also environment, weather resistant take on other design goods such as plastic, material, and also wood. Self-compacting concrete (SCC), a better product that passes and consolidates simply by its own weight without the need for extra compaction energy, is one route in this development.

Self-compacting concrete is defined as a kind of concrete that can be placed and compacted with its own weight without the use of vibration, providing complete formwork coverage even when accessibility is limited by filter gaps between reinforcing plates. The growing industry has a problem in realising that will should not be vibrated. To achieve this behaviour, the new concrete must exhibit both significant fluidity and advantageous cohesion at the same time.

For many years, self-compacting concrete (SCC) has been regarded as one of the most significant advancements in concrete engineering. Limited homogeneity on solid concrete due to poor compaction or segregation may reduce the efficacy of fully formed concrete in-situ significantly. SCC was created to provide adequate compaction and to assist in the placing of concrete in crowded reinforcing and in limited areas. SCC began in the late 1980s in Japan, where it was primarily used for highly crowded reinforced setups in seismic areas.

1.5 REQUIREMENT FOR SCC

Foundry fine sand, as well as reddish coloured sand, have pozzolanic homes, which increase the holding houses and offer better quality durability while also reducing charge issues. Furthermore, Foundry waste disposal is minimised. During the process of disposing of property, it turns out to be ineffective. It begins to pollute the groundwater. As a result, it should be put to good use in some way. This might be appealing in a few of ways. Assist in improving the top quality of concrete. For many years, the issue of concrete set ups' sturdiness has been a significant concern for designers. Compaction is required to produce long-lasting concrete structures. Vibratory compaction is used to finish normal concrete compaction. Segregation may be caused by more than just vibration. It's difficult to provide uniform product quality and also advantageous density in heavily reinforced areas using ordinary concrete. When material isn't properly encased by concrete, it adds to sturdiness issues. Here's the problem, which is mostly associated with heavily reinforced areas where a significant amount of reinforcement traffic is seen. The solution to the issue may be a kind of concrete that can be compressed straight into every nook and cranny of varied work and also gap between materials just by its own weight and without the need for compaction. To overcome these problems, the SCC idea was required.

This SCC idea may be described as concrete that meets particular efficacy and homogeneity criteria that cannot always be fulfilled by using conventional components, standard mixing procedures, and standard curing processes. This SCC is a designed product made up of bare cement, aggregates, water, and admixtures, as well as several new constituents such as colloidal silica, pozzolanic products, and compound admixtures to meet specific requirements such as high-flowability, compressive durability, substantial workability, superior resistance to compound or kinetic stresses, and so on. This home, for example, provides fluidity and a high degree of resistance to segregation, allowing for the installation of concrete free of vibrations in less time, with less noise, and with much less tool wear. The use of

SCC solves the issue of concrete placement in heavily reinforced sections while also reducing design time.

Self-compacting concrete is gaining popularity, particularly in the pre-cast sector, where its benefits are well-known and widely used. Excellent plasticizer increases deformability as the degree of resistance to water/powder segregation decreases. Restricting the amount of rough blends typically results in a high degree of deformability and also a high level of segregation resistance. However, the large dose of super-plasticizer used to lower the fluid limit and improve workability, the large powdery written content used as a ‘lubricant' with the rough aggregates, and the use of viscosity-agents to increase the viscosity of the concrete should all be considered. Today, in our challenge, I'm working on replacing bare cement with volume using Soar Ash and GGBFS. Foundry waste is usually subject matter (contains) that is consistently measured, as well as a number of organic and natural binder. If any fresh fine sand and also binder is usually placed into maintain the quality of sending your line and also make-up fine sand that has been lost while working. It is also used as an alternate component in blends and as a kiln give in the production of Portland bare cement. It has a low ingestion rate and is free of plastic stuff. In comparison to normal fine sand, it leaches a little proportion and takes the stove from thirty-three to forty-five degrees in terms of shear level of resistance.

II.MATERIALS

The following are some of the materials that were utilised to complete this project:

2.1 Cement

In this job, ordinary Portland cement of grade 53 was utilised. Because of its optimal particle size distribution and excellent crystalline structure, 53 Grade OPC offers exceptional strength and durability to constructions. As a high-strength cement, it offers a number of benefits in applications where high-strength concrete is needed, such as skyscrapers, bridges, flyovers, chimneys, runways, concrete highways, and other heavy-load-bearing constructions. This kind of cement is not only stronger but also more durable than other varieties. Furthermore, by replacing OPC 53 for lower-grade cement, total savings may be realised due to the decreased amount of cement needed. When 53 Grade OPC is used instead of any other grade, a savings of 8-10% may be realised.

2.2 Fine aggregate

In this project, manufactured sand was utilised in lieu of fine aggregate. Crushed hard granite stone is used to make manufactured sand. Crushed sand is cubical in form with grounded edges, cleaned, and graded for use as a building material. It's more angular than river sand, and it has somewhat different characteristics. Manufactured sand may be manufactured in locations closer to building sites, lowering transportation costs and ensuring a constant supply. Natural sand contains silt and clay particles, while manufactured sand has a denser particle packing than natural sand. It also has a greater flexural strength, superior abrasion resistance, a lower permeability, and a larger unit weight

Figure 2.1 Manufactured sand

2.3 Coarse aggregate

The coarse aggregate in this research was crushed granite stone chips (angular) with a diameter of 12.5mm. The more coarse the aggregate, the more cost-effective the mixture. Larger chunks have less surface area of the particles than smaller ones of the same volume. The use of coarse aggregate with the highest permitted maximum size allows for a decrease in cement and water use. When coarse aggregates are used in excess of the maximum size allowed, they may interlock and create arches or obstacles inside the concrete form. As a consequence, the region below becomes a vacuum, or at most, only fills with finer sand and cement particles, resulting in a weaker area.

Figure 2.2 coarse aggregate

2.4 Super plasticizer

In the combination, Conplast SP 430 was employed as a super plasticizer. Conplast SP430 is a superplasticizing admixture made from sulphonated naphthalene polymers that is chloride-free. It comes as a dark solution that dissolves quickly in water. Conplast SP430 disperses tiny particles in the concrete mix, allowing the concrete's water content to function better. The very high levels of water reduction achievable allow for significant strength gains. The admixture will enable water to be removed from the mix while preserving its workability.

Figure 2.3 Conplast SP430 super plasticizer

2.5 Steel fibers

Steel fibres with hooks were included in the mix. Steel fibre is a discrete short length of steel with a length-to-diameter ratio (i.e. aspect ratio) ranging from 20 to 100. The random distribution reduces efficiency, improves concrete toughness and tensile characteristics, and aids crack management. Further research and development showed that adding SFs to concrete improves its flexural toughness considerably.

Figure 2.4 steel fibers

2.6 Marble dust

Marble Dust Powder is a metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite. Marble may be foliated. Marble is commonly used for sculpture and as a building material.

Figure 2. 5 Marble Dust

III. METHODOLOGY

3.1 Mix Design

Mix design using Nan-Su method: Nan Su and colleagues suggested a simple mix design method for SCC, with the primary goal of using binder paste to fill gaps in weakly packed aggregate. For aggregate, they developed a factor called Packing Factor (PF). It's the mass of aggregates in a densely packed state divided by the mass of aggregates in a loosely packed state. The process is completely reliant on the Packing Factor (PF). A greater PF number implies that the aggregate content is bigger, requiring less binder and having less flow ability. The packing factor, it was determined, affects the aggregate content and influences characteristics such as flow ability, self-consolidation ability, and strength. The volume of FA to mortar in his mix design was in the range of 54–60 percent, and he discovered that the PF value would be the regulating element for the U– box test.

Self-compacting concrete (SCC) has been dubbed "concrete's most significant breakthrough in decades." The most significant benefit of self-compacting concrete is that it reduces construction time and ensures compacting inside buildings, especially in restricted areas where vibration and compaction are problematic. Professor Hajime Okamura of Japan invented the self-compacting concrete in 1986, while the prototype was first constructed in 1988 in Japan by Professor Ozawa of the University of Tokyo. The standards and instructions for testing fresh compacting concrete included within this document are derived from “Specification and guidelines for Self-compacting concrete” issued by EFNARC in February 2002. The European Organization for Specialist Construction Chemicals and Concrete Systems (EFNARC) is a federation devoted to specialist construction chemicals and concrete systems. High quality cementitious material, mineral admixtures such as ash, silicon oxide fume, GGBFS, stone powder, and chemical admixtures such as high vary water reducers (HRWR or super plasticizer) and consistency modifying admixtures are required to induce engineering characteristics and smart performance (VMA). It requires concrete with a limited aggregate concentration of around 59 percent by volume. The following are the functions of those additives:

• It fills and shuts holes or changes the kind of pore structure, in addition to the filling action of micro aggregate.

Marble Dust Replacement with cement for cubes

Table:3.1

Opc 53 grade (100%)	**MD(0%)**	2.26 kg	2.26kg
Opc 53 grade (95%)	**MD(5%)**	2.26x5%	113gm
Opc 53 grade (90%)	**MD(10%)**	2.26x10%	226gm
Opc 53 grade (85%)	**MD(15%)**	2.26x15%	339gm
Opc 53 grade (80%)	**MD(20%)**	2.26x20%	452gm

Marble Dust Replacement with cement for cylinder

Table:3.2

Opc 53 grade (100%)	**MD(0%)**	3.47kg	3.47kg
Opc 53 grade (95%)	**MD(5%)**	3.47x5%	173gm
Opc 53 grade (90%)	**MD(10%)**	3.47x10%	347gm
Opc 53 grade (85%)	**MD(15%)**	3.47x15%	520gm
Opc 53 grade (80%)	**MD(20%)**	3.47x20%	694gm

Marble Dust Replacement with cement for prism

Table:3.3

Opc 53 grade (100%)	**MD(0%)**	3.47kg	3.47kg
Opc 53 grade (95%)	**MD(5%)**	3.47x5%	173gm
Opc 53 grade (90%)	**MD(10%)**	3.47x10%	347gm
Opc 53 grade (85%)	**MD(15%)**	3.47x15%	520gm
Opc 53 grade (80%)	**MD(20%)**	3.47x20%	694gm

3.3 Casting and curing of test specimens

The specimens of standard cubes (150mm x 150mmx 150mm), Standard prisms (100mm x 100mm x500mm) and standard cylinders (150mm diameter x300mm height) were casted.

3.4 Mixing of concrete

On an impermeable concrete floor, measured amounts of coarse aggregate, fine aggregate, and cement were laid out. Steel fibres are thrown in at random while the concrete is being mixed. Repeat the process until the colour is consistent; the mixing time should be between 10-15 minutes.

Figure 3.1 concrete mixing

3.5 Placing and compacting

To guarantee that no water escapes during the filling, the mould sections were coated with mould oil, and a similar layer of mould oil was placed between the contact surfaces of the bottom of the moulds and the base plate. The concrete is then poured into the moulds, layer by layer, and compacted properly. Finally, after the moulds have been completely filled, they are levelled.

Figure 3.2 Compaction of prism mould

3.6 Workability Tests

To examine the SCC fresh properties, recent properties such as the slump flow test, the L-box test, J ring test, V- funnel test were carried out. For better flowability super plastisizers was added to the mix.

Description of Mix	Slump flow (mm)	T50 Slump flow(sec)	v-funnel test (sec)	J-ring test H1-H2(mm))	L-box test H1/H2
Opc 53 grade (80%) MD(20%)	796	2.57	8.2	4	0.93
Opc 53 grade (80%) MD(20%) S.F(0.2%) Admixture (0.6%)	645	6.6	13.9	18	1.55

3.7 Curing

The test specimen cubes, prisms, and cylinders were kept in a vibration-free environment with 90% relative humidity and a temperature of 27°C for 24 hours 12 hours after water was added to the dry components. The concrete cubes, prisms, and cylinders are then taken from the moulds and put for 3 days, 7 days, or 28 days of curing.

Figure 3.3 Test specimens kept for curing

IV. TESTING AND RESULTS

4.1 Compression strength test on concrete cubes

Compressive Strength Definition

The capacity of a material or structure to bear stresses on its surface without cracking or deflection is known as compressive strength. When a substance is compressed, it shrinks, while when it is stretched, it lengthens.

Compressive Strength Formula

The load applied at the point of failure to the cross-section area of the face on which the load was applied is the compressive strength formula for any material.

Compressive Strength = Load / Cross-sectional Area

Apparatus for Concrete Cube Test

Compression testing machine

Sampling of Cubes for Test

1. Oil the moulds after cleaning them.

2. Pour about 5 cm thick layers of concrete into the moulds.

1. Using a tamping rod, compact each layer with at least 35 strokes each layer (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)

2. Using a trowel, level and polish the top surface.

Procedure for Concrete Cube Test

1. After the required curing time has passed, remove the specimen from the water and wipe away any excess water from the surface.

2. Round the specimen's size to the closest 0.2m.

3. Clean the testing machine's bearing surface.

4. Place the specimen in the machine in such a way that the load is given to the cube cast's opposing sides.

5. Place the specimen in the centre of the machine's base plate.

6. Gently rotate the moveable part so that it contacts the specimen's top surface.

7. Gradually increase the weight without causing shock until the specimen fails.

8. Make a note of the maximum load and any unique characteristics in the kind of failure.

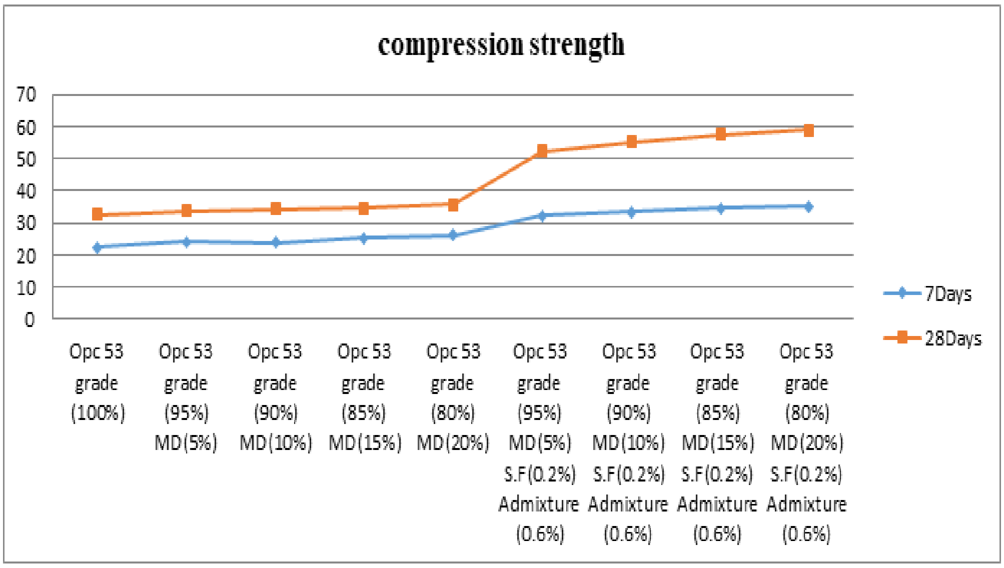

Figure 4.1 compression test of cubes

Compression Test results

Table: 4.1

SI.NO	Mix	Description of Mix	7Days	28Days
1.	**M1**	**Opc 53 grade (100%)**	22.4	32.5
2.	**M2**	**Opc 53 grade (95%) MD(5%)**	24.2	33.8
3.	**M3**	**Opc 53 grade (90%) MD(10%)**	23.8	34.2
4.	**M4**	**Opc 53 grade (85%) MD(15%)**	25.4	34.6
5.	**M5**	**Opc 53 grade (80%) MD(20%)**	26.2	35.8
6.	**MD5**	**Opc 53 grade (95%) MD(5%) S.F(0.2%) Admixture (0.6%)**	32.2	52.4
7.	**MD10**	**Opc 53 grade (90%) MD(10%) S.F(0.2%) Admixture (0.6%)**	33.4	55.2
8.	**MD15**	**Opc 53 grade (85%) MD(15%) S.F(0.2%) Admixture (0.6%)**	34.5	57.4
9.	**MD20**	**Opc 53 grade (80%) MD(20%) S.F(0.2%) Admixture (0.6%)**	35.2	59.1

4.2 Split tensile test on concrete cylinders

One of the most fundamental and essential characteristics of concrete is its tensile strength, which has a significant impact on the amount and size of cracking in buildings. Furthermore, owing to its brittle nature, the concrete is extremely weak in tension. As a result, it is unlikely to withstand direct strain. As a result, when tensile pressures surpass the concrete's tensile strength, fractures appear. As a result, the tensile strength of concrete must be determined in order to calculate the load at which the concrete members may fracture.

Now **split tensile strength = 2P/πLD**

Where P = load , L = length of the cylinder

D = diameter of cylinder

Procedure of Splitting Tensile Test

1. After 7, 28, or any appropriate age at which tensile strength is to be measured, remove the wet specimen from the water.

2. Wipe the water from the specimen's surface.

3. Then, on both ends of the specimen, draw diametrical lines to verify that they are in the same axial position.

4. Next, note the specimen's weight and dimensions.

5. Adjust the compression testing machine's range to the necessary value.

6. Place the specimen on the plywood strip on the bottom plate.

7. Center the specimen over the bottom plate with the lines indicated on the ends vertical and centred.

8. Place the second piece of plywood on top of the specimen.

9. Lower the top plate until it touches the plywood strip.

10.Continue to apply the load without becoming shocked.

Finally, make a note of the breaking load (P).

Figure 4.2 Split tensile test on concrete cylinder

Split Tensile Test results

Table:4.2

SI.NO	Mix	Description of Mix	7 Days	28Days
1.	M1	Opc 53 grade (100%)	2.52	3.63
2.	M2	Opc 53 grade (95%) MD(5%)	3.17	3.48
3.	M3	Opc 53 grade (90%) MD(10%)	3.32	3.72
4.	M4	Opc 53 grade (85%) MD(15%)	3.28	3.84
5.	M5	Opc 53 grade (80%) MD(20%)	3.36	3.96
6.	MD5	Opc 53 grade (95%) MD(5%) S.F(0.2%) Admixture (0.6%)	3.70	4.05
7.	MD10	Opc 53 grade (90%) MD(10%) S.F(0.2%) Admixture (0.6%)	3.81	4.26
8.	MD15	Opc 53 grade (85%) MD(15%) S.F(0.2%) Admixture (0.6%)	3.94	4.34
9.	MD20	Opc 53 grade (80%) MD(20%) S.F(0.2%) Admixture (0.6%)	4.09	4.47

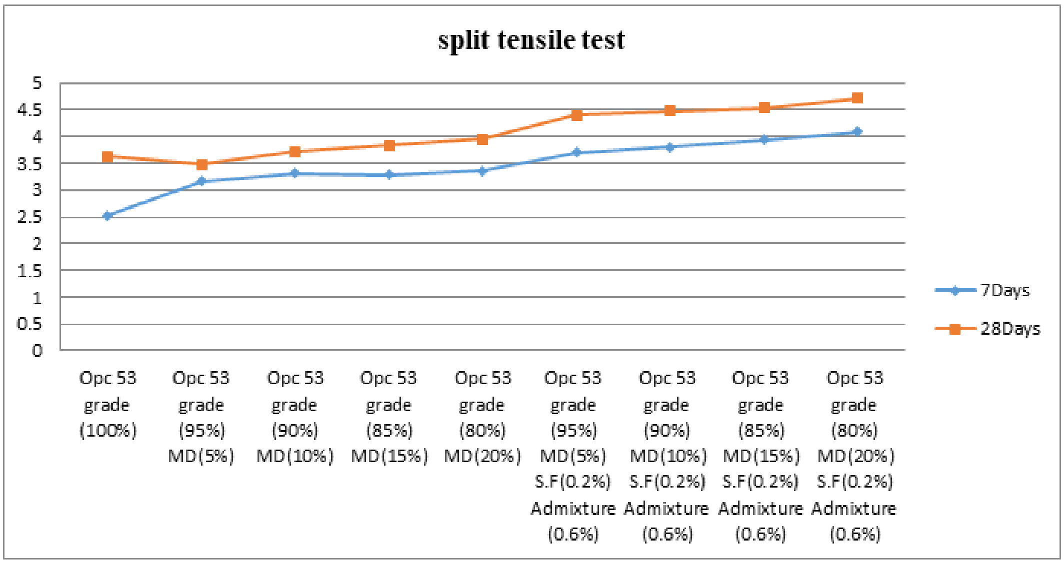

Figure 4.3 Graphical Representation for tensile strength of cylinders

V.CONCLUSION

M30 mix is utilised in this research, using conplast sp 430 as a chemical admixture. The findings of tensile strength, compression strength, and flexural strength were obtained, and it was discovered that up to 20% of marble dust may be substituted with cement, and 2% steel fibre can be added in concrete since the strength of the concrete increases dramatically after 28 days.

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