Effect of Steel Fibre and Marble Dust on the Mechanical Properties of High Strength Concrete (HSC)

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Abstract - *Using cement, coarse aggregates, and fine aggregates raises construction costs. Leaving trash outside can cause environmental problems. Thus,* ***recycling*** *is encouraged. Many industries produce waste materials that, due to their nature, can be used to partially replace fundamental resources. Concrete producers are continually looking for solutions to reduce solid waste disposal. Steel fibres are employed because concrete is weak in stress. There are experimental reuse and recycling alternatives for this industrial by product. These wastes are disposed nearby, destroying the soil's natural fertility. We discuss wastes' physical, mechanical, and chemical qualities.*

The research is done on ***M60*** *grade concrete with 0%, 15%, 30%, 45%, and 60% marble dust replacing sand and 0.8% steel fibres added to increase compressive, flexural, and split tensile strengths.*

Based on feasibility, replacing up to 45% marble powder and 0.8% steel fibres in concrete is appropriate. After 15% replacement, compressive strength and spilt tensile started falling.

1. INTRODUCTION

After food and water, humans use concrete. It has cement, fine, coarse, and water aggregates. River sand is fine aggregate. Cement dominates concrete. Cement, fly ash, and slag bind the aggregates. Aggregates include fine and coarse gravel, limestone, and granite. Many admixtures have unique properties. Water makes the dry combination firm and strong. Hydration strengthens and hardens. Water and cement combine to produce stone. Concrete needs reinforcements because it compresses well but stretches badly.

Concrete cracks from shrinkage and tension. Durable, fire-resistant, and increasing strength with time, it's great for building. Admixtures make high-strength concrete cost-effective and efficient.

Flexible concrete. Originally conceived as a steel cover, it's now a structural part. Concrete is strengthened by adding steel. Normal concrete is weaker than steel. High-strength concrete eliminated this problem (HSC).

Modern admixtures and concrete technologies can achieve 50 MPa in 12 to 18 hours and 70 MPa in 28 days.

MPa in 12 to 18 hours & 70+ MPa in 28 days.

1.1 Marble Dust

New technologies using artificial and waste materials minimise the load on natural resources. Replace concrete with sand to increase its mechanical characteristics. Marble dust is utilised instead. Marble dust is a construction material. Marble cutting and shaping creates it. Dumping causes pollution. Utilizing garbage reduces environmental problems. This research investigates utilising marble dust to substitute sand in concrete.

Marble dust has been utilised in construction since prehistoric times. Every year, the globe produces 7,000,000 tonnes of marble, of which 25% is transformed into dust or powder, a large amount whose disposal is a worry. Using discarded marble dust to increase the strength and other attributes of concrete by adding steel fibres solves the disposal problem and is beneficial

1.2 Steel Fibers Reinforced Concrete

Fibers-reinforced concrete is a mixture of four distinct systems, including cement, water, coarse particles, fine aggregates, and steel fibre dispersion. It is also possible to add admixture and pozzolans to the system of conservative concrete. Under ASTM guidelines, all admixtures suitable for usage in Steel Fiber-reinforced concrete are added to concrete (SFRC).

2. LITERATURE REVIEW

2.1 Compressive Strength

- **Dhawale et al. (2014)** researched concrete compression.
- These experiments were done using compression testing machines (CTM) utilising cubes with varied marble dust-to-sand ratios.
- 50% marble dust to sand produces stronger compressive strength than 100%.

Table-1: Compressive Strength at different proportions (Dhawale *et al.*, 2014)

M25 Grades	3days (N/mm²)	7days (N/mm²)	28days (N/mm²)
MD 0%	21.33	21.78	31.73
MD 25%	22.22	22.34	33.11
MD 50%	22.43	23.11	35.54
MD 100%	13.35	9.76	21.32

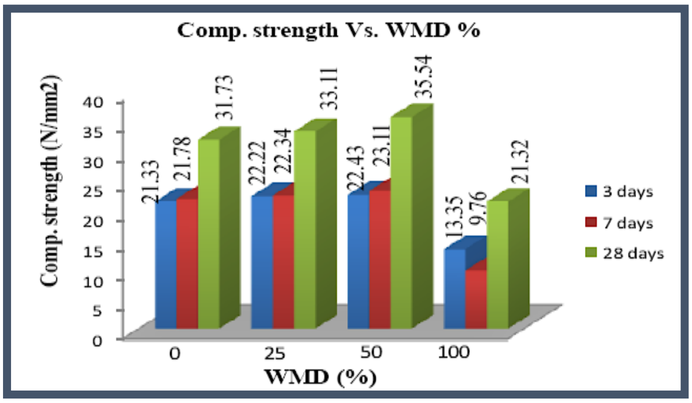

Chart -1: Compressive strength at different curing ages (Dhawale *et al.*, 2014)

2.2 Flexural Strength

- **Hameed et al. (2009)** evaluated the concrete's compressive strength.
- A 150 mm concrete cube and a 150 mm diameter, 300 mm tall concrete cylinder were utilised to evaluate compressive strength.
- To prevent environmental damage, he laboured on the creation of green concrete.

Table-2: Flexural strength at different Proportions (Dhawale *et al.*, 2014)

M25 grade	3Days (N/mm²)	7Days (N/mm²)	28Days (N/mm²)
MD 0%	2.94	3.30	4.43
MD 25%	3.04	3.56	4.70
MD 50%	3.15	3.74	5.10
MD 100%	2.21	2.43	3.51

2.3 Split Tensile Strength

Hashmi et al. (2014) investigated the concrete's split tensile strength. For different percentages of cement to marble powder, only three cylinders were produced. On substituting 10% of the cement with marble powder, the split tensile strength was shown to rise; however, the increase in split tensile strength is inhibited by the addition of more marble dust. As indicated in Table 3, substituting 10% of the cement with marble dust resulted in a 19.61% improvement in initial split tensile strength after 28 days.

Table-3: Split tensile strength of concrete (Hashmi *et al.*, 2014)

Sr. No.	Replacement of cement by MP (%)	Days of curing (days)	Split tensile strength (N/mm²)
1.	0	28	38.368
2.	5	28	41.093
3.	10	28	44.69
4.	15	28	36.769
5.	20	28	35.061

3. METHODOLOGY

- For casting, the inside of the mould was properly oiled so that the concrete wouldn't stick to it.
- Before casting, all of the parts must be bolted together correctly.
- Care was taken with the batching, mixing, and casting.
- The coarse and fine aggregates were weighed first to make sure they were correct.
- For each mix, or batch, the right amount of cement, coarse aggregates (20 mm and 10 mm), fine aggregates, marble dust, steel fibres, and water were weighed and tested.

4. EXPERIMENTAL PROGRAMMES

4.1 Slump Flow test

For casting, the inside of the mould was properly oiled so that the concrete wouldn't stick to it. Before casting, all of the parts must be bolted together correctly. Making batches, mixing, and pouring It is the most common way to figure out if something will work. The slump flow test needs to be done on High Strength Concrete. It is very helpful to do tests on-site to see how the materials that go into the mixes change from day to day.

Fig. 1: Slump Flow Test

4.2 Compressive Strength IS: 516-1959

The compressive strength is equal to the load written down from the CTM divided by the area. Then, take the average of the three values and compare it to IS: 516-1959."

Fig. 2: Compression testing machine (CTM) used for study

4.3 Split Tensile Strength, IS: 5816-1999

Having recorded the highest load, the following formula was applied:

$$f_{st} = \frac{2P}{\pi d l}$$

Where, f_{st} is measured split tensile strength, P is the maximum load at failure l and d is the length and diameter of the cylinder in mm.

5. RESULTS & DISCUSSIONS

5.1 Workability (Slump Flow Test.)

The slump flow test is a very common way to find out how easy it is to work with concrete. Different mixes have been made and tested to see how they affect the properties of fresh concrete. The best results were achieved by using 1% SP and 0.31 w/c ratio. Table-4 shows how the slump flow value changes with the amount of marble dust and steel fibres. When making different batches, different amounts of marble dust were used, but the amount of steel fibres was kept the same. The range of slump flow for HSC is between 500 and 700. It was seen that the slump flow value went down as the percentage of marble dust went up. Due to its tendency to soak up water, marble dust made the material less easy to work with. Chart-2 shows how the slump flow changes when different HSC mixes are used.

Table-4: Slump flow values for various HSC Mixes

HSC Mixes	Slump Flow values	Admixture (%)
Mix 1	610	1
Mix 2	597	1
Mix 3	580	1
Mix 4	556	1
Mix 5	525	1

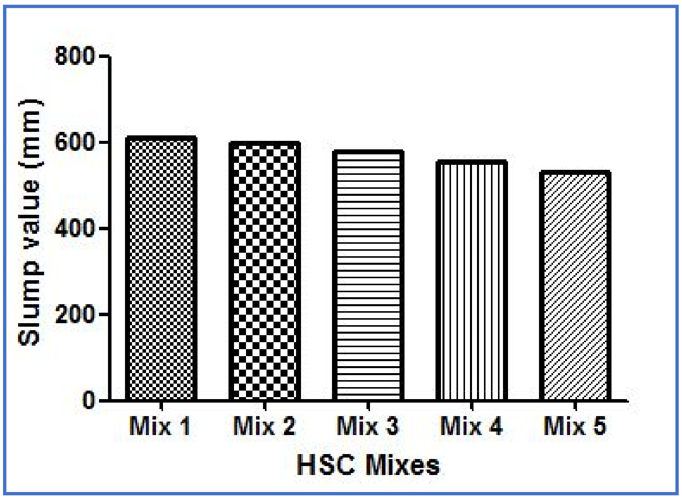

Chart -2: Variation of slump flow with respect to different HSC mixes

5.2 Compressive Strength

To find out what would happen to the compressive strength of concrete if sand was replaced with marble and steel fibres were added, concrete cubes were made and tested after 7 and 28 days. Table 5 shows the results of the compressive strength at 7 days and 28 days after curing. The test was done on a 2000 KN ASTM capacity. For the control mix, samples were made and compared to the %age replacements. For each age, three samples were used to make moulds. After 7 days and 28 days, the samples were put through tests.

All of the mixes were tested for compressive strength at different percentages of replacement. After 28 days, the compressive strength of Mix 4 is 8.10% higher than that of Mix 1 (the control mix). The curve and bar chart of compressive strength show that the compressive strength of concrete cubes at a water-to-cement ratio of 0.31 increased as the replacement percentage went up. The cubes were found to be the strongest when mix 4 (45% sand instead of marble dust and 0.8% fibres) was used. But as more cubes were added, the cubes' compressive strength went down.

Table-5: Compressive Strengths for various HSC mixes

HSC Mix	**7 Day**		**28 Day**	
	Comp. Strength(N/mm²)	**Avg. Comp. Strength(N/mm²)**	**Comp. Strength(N/mm²)**	**Avg. Comp. Strength (N/mm²)**
Mix 1	58.93	59.85	64.78	64.18
	61.45		65.19	
	59.17		62.57	
Mix 2	60.64	62.15	67.93	66.23
	62.09		65.84	
	63.72		64.92	
Mix 3	64.91	65.06	65.53	67.18
	66.34		68.21	
	63.93		67.80	
Mix 4	67.24	66.29	70.15	69.38
	65.71		68.45	
	65.92		69.54	
Mix 5	60.78	58.92	64.76	63.18
	56.86		63.10	
	59.12		61.68	

5.3 Split Tensile Strength

To find out what happened to the split tensile strength of concrete when sand was replaced with marble dust and steel fibres were added, concrete cylinders were made and tested after 7 and 28 days. Table 6 shows the results of the split tensile strength test after 7 days and 28 days of curing. Split tensile strength kept going down as the amount of marble dust went up.

Table-6: Split Tensile Strengths of various HSC mixes

HSC Mixes	**7 Days**		**28 Days**	
	STS (N/mm²)	**Avg. STS (N/mm²)**	**STS (N/mm²)**	**Avg. STS (N/mm²)**
Mix 1	6.17	6.24	6.48	6.56
	6.57		6.25	
	5.98		6.95	
Mix 2	6.53	6.60	7.04	6.84
	6.40		6.83	
	6.87		6.65	
Mix 3	6.12	5.94	6.59	6.22
	5.71		5.82	
	5.89		6.25	
Mix 4	5.32	5.46	5.63	5.83
	5.65		6.09	
	5.41		5.77	

Mix 5	4.78	4.98	5.80	5.91
	5.34		5.73	
	4.82		6.20	

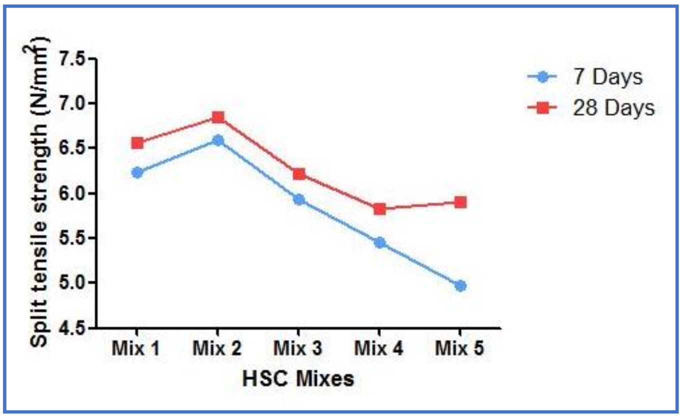

Chart -3: Variation of Split tensile strengths with respect to ages

5.4 Flexural Strength

To find out what would happen to the flexural strength of concrete if sand was replaced with marble dust and steel fibres were added, concrete beams were poured and tested after 7 days and 28 days. Table 7 shows the results of the flexural strength test. As the percentage of marble dust went up, the bending strength kept going down.

Table-7: Flexural Strengths of various HSC mixes

HSC Mixes	7 Days		28 Days	
	FS (N/mm²)	Avg. FS (N/mm²)	FS (N/mm²)	Avg. FS (N/mm²)
Mix 1	7.43	7.33	8.32	8.21
	7.32		8.05	
	7.24		8.28	
Mix 2	8.4	8.38	9.84	9.82
	8.52		9.76	
	8.22		9.86	
Mix 3	8.15	8.12	9.34	9.46
	8.25		9.40	
	7.93		9.64	
Mix 4	8.05	7.82	8.66	8.53
	7.86		8.37	
	7.55		8.56	
Mix 5	5.95	5.95	6.02	6.23
	6.08		6.35	
	5.82		6.32	

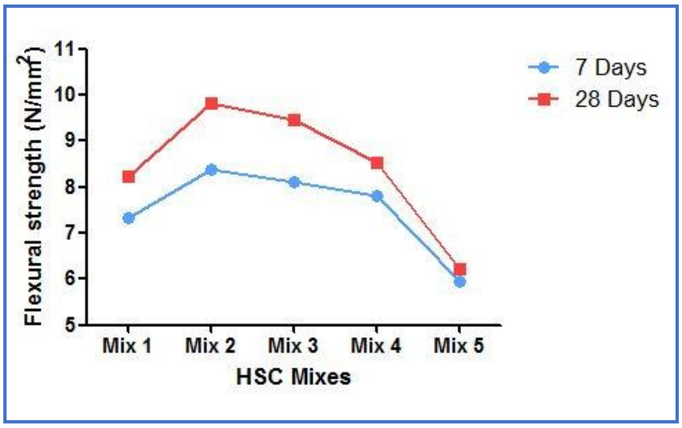

Chart -4: Variations of Flexural strength of HSC mixes with respect to age

6. CONCLUSION

6.1 General

The goal of this study was to find out how the flexural strengths, split tensile strengths, and compressive strengths of concrete changed when different amounts of sand were replaced with marble dust and steel fibres were added. Sand was replaced in part by marble dust (0%, 15%, 30%, 45%, and 60%), and steel fibres were added to all of the batches at a rate of 0.8%. All HSC mixes contained 1% by weight of cement of the super plasticizer BASF-PCE BASE 50. Recent research shows that adding waste materials to concrete makes it stronger and more durable.

6.2 Fresh Concrete Properties

The slump flow of the HSC mixes is between 500 and 700 mm. As more things were thrown away, the slump got worse. The amount of marble powder in the concrete makes it harder to work with. But it's good to know that the needed workability of the concrete can be achieved both with and without chemical additives.

6.3 Compressive Strength

The compressive strengths went up until it reached 45% replacement, and then it started going down. With a lower w/c ratio, marble dust worked better than sand when it was used to replace sand. At 28 days of curing, adding 0.8% of steel fibre made the most difference. This was when 45% of the marble dust was replaced with it. After

45% of the cement was replaced with marble dust, the compressive strength went down. This is because marble dust has a pozzolonic property that changes the way cement works.

6.4 Split Tensile Strength

The curve and the bar chart of the split tensile strengths test show that the concrete's split tensile strength went up to 15%, then started going down. The w/c ratio stayed the same for all mixes, which is 0.31. Due to the lower fineness modulus of the marble dust, the material sticks together better, so the split tensile strength goes up. At 28 days of curing, the highest increase was at 15% marble dust and 0.8% steel fibre, which was almost 4%.

6.4 Flexural Strength

The curve and the bar chart of the flexural strength test show that the concrete's flexural strength went up to 15%, then started going down. The most improvement was seen when 15% of the marble dust was replaced and 0.8% of steel fibre was added. After 28 days, the improvement was almost 20%. Concrete's flexural strength goes up because its fineness modulus is lower, which makes the material stick together.

7. FUTURE SCOPE

- For further research, if we increase the amount of fibres in the concrete mix, the engineering properties of the concrete show that its strength has increased significantly.
- In future research, we think it would be helpful to look at how high temperatures affect the mechanical properties of concrete with marble dust.
- There needs to be research on the microstructure.

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