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# A Study on Use of Steel Fibers and Marble Dust In Concrete-A Review

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***Abstract*** – Steel fiber and marble powder mix concrete is a relatively new material that has been gaining attention in the construction industry due to its improved mechanical properties and cost-effectiveness. This paper provides a comprehensive review of research studies on steel fiber and marble powder mix concrete, including its properties, benefits, and limitations**.**The conclusion is drawn out of the studies about the effect of marble powder and steel fiber in concrete. The conclusion was that the compressive strength was increase by using these materials also the split tensile and flexure strength.

*Keywords – Steel Fibre, Marble Dust, Split Tensile Strength, Compressive Strength, Flexural Strength*

## I. Introduction

Concrete has been a widely used construction material for centuries due to its strength and affordability. The use of lime and gypsum as binders in concrete was developed by the Egyptians, and lime remained the primary cement-forming agent until the early 1800s. In 1824, Joseph Aspdin invented Portland cement, which is still the dominant cementing agent used in concrete production today.

In recent years, there has been a growing interest among researchers to explore the potential of waste materials in concrete production. Among these waste materials is marble debris, sawdust, and fly ash. Marble has been used in construction for a long time, particularly in tiles and indoor flooring. It is found in many parts of the world, including Italy, Brazil, Spain, Sweden, Belgium, France, and Egypt, with Turkey alone holding 40% of the world's marble deposits. However, a significant amount of marble is wasted during quarrying and processing, with around 70% of the waste generated during cleaning and processing ending up in landfills or water bodies, leading to environmental problems.

To address these environmental issues, researchers have been exploring the use of waste marble powder (WMP) in construction. WMP has been found to be a potential stabilizing agent for improving the properties of weak clayey soils. Additionally, it can be used as a partial substitute for cement (up to 10%) in concrete production, resulting in improved properties. Studies by Aliabdo et al. and Corinaldesi et al. have shown that the filler effect of WMP in concrete improves its durability, resulting in denser concrete that is more resistant to chloride migration, absorption, and corrosion. Furthermore, the use of WMP in concrete production can lead to the development of affordable and eco-friendly concrete.

## II. Materials

Materals that are used are describe below,

1. **Cement**

Grade 53 cement.

2. **Coarse Aggregates**

Coarse aggregates are those that retained at 4.75 sieve

3. **Fine aggregates**

Aggregates passing through 4.75 mm sieve

4. **Marble Dust**

The powder left during cutting of marble.

5. **Steel fibres**

A short length steel wire

### 6. Water

Ordinary tape water.

## III. Steel Fibre And Marble Dust Use In Concrete

### A. Steel Fiber –Waste Marble Aggregate Concrete Mechanical Properties

The incorporation of white marble aggregate in concrete mix leads to improved mechanical properties compared to conventional concrete using coarse and fine aggregates. Adding steel fibers to concrete mix containing marble aggregate results in a favorable combination that enhances the mechanical behavior of concrete under load, allowing it to withstand higher loads before failure, especially in tension and elasticity with the addition of only a small amount of steel fiber. By utilizing waste marble in concrete production, it offers an eco-friendly solution to the growing problem of waste material accumulation, promoting sustainability while also reducing the cost of concrete production (Waseem H. AL-Baghdadi1, 2020)

| Mix Type | Compressive Strength, (MPa) | Tensile Strength (MPa) | Flexural Strength (MPa) |
|---|---|---|---|
| Reference Mix: 0% marble aggregate with 0% steel fiber | 41.43 | 3.21 | 4.17 |
| 10% Aggregate replacement with 0% steel fibers | 44.65 | 3.87 | 4.88 |
| 50% Aggregate replacement with 0% steel fibers | 46.87 | 4.10 | 5.34 |
| 100% Aggregate replacement with 0% steel fibers | 51.50 | 4.32 | 5.79 |
| 10% Aggregate replacement with 0.4% steel fibers | 51.90 | 5.26 | 6.97 |
| Aggregate replacement with 0.4% steel fibers | 53.09 | 5.70 | 7.90 |
| 100% Aggregate replacement with 0.4% steel fibers | 57.16 | 6.31 | 8.50 |
| 100% Aggregate replacement with 0.8% steel fibers | 60.77 | 7.15 | 9.87 |
| 100% Aggregate replacement with 1.2% steel fibers | 63.10 | 7.98 | 12.50 |
| 100% Aggregate replacement with 1.6% steel fibers | 65.14 | 8.24 | 14.90 |
| 100% Aggregate replacement with 2% steel fibers | 65.20 | 8.45 | 15.62 |

Fig 1(results)

### B. Waste Marble Aggregate Concrete Reinforced With Local Steel Pins As Steel Fibers

The research findings suggest that utilizing waste marble aggregates can enhance the mechanical properties of concrete while reducing production costs. Furthermore, the incorporation of locally-sourced steel pins as steel fibers can significantly improve the flexural strength of waste marble concrete. The cost of steel fiber-reinforced waste marble concrete was more than double that of waste marble concrete without steel fibers. The high strength of marble aggregates (over 270 MPa) makes it a unique waste material for use in construction and minimal absorption, making it highly valuable in improving the mechanical properties of concrete. This highlights the significance of utilizing waste marble aggregates to enhance the mechanical performance of concrete compared to other waste materials such as waste concrete aggregates, plastic, glass, or rocks. (Zwain, 2019)

| Mix type | Compressive strength | Tensile strength | Flexural strength |
|---|---|---|---|
| 1:1.1:2.2 normal aggregates | 50.89 | 3.10 | 3.58 |
| 1:1.1:2.2 , marble aggregates | 57.07 | 3.84 | 3.96 |
| 1:1.1:2.2 Steel pins = 0.1% by volume | 59.29 | 3.94 | 4.20 |
| 1:1.1:2.2 , steel pins 0.2% by volume | 60.77 | 4.28 | 4.96 |
| 1:1.1:2.2 Steel pins = 0.3% by volume | 61.34 | 4.71 | 5.39 |
| 1:1.1:2.2 Steel pins = 0.4% by volume | 62.24 | 4.89 | 5.72 |
| 1:1.1:2.2 Steel pins = 0.5% by volume | 64.76 | 5.02 | 5.90 |
| 1:1.1:2.2 Steel pins = 0.6% by volume | 65.59 | 5.45 | 6.34 |
| 1:1.1:2.2 Steel pins = 0.7% by volume | 66.20 | 5.69 | 6.71 |
| 1:1.1:2.2 Steel pins = 0.8% by volume | 68.13 | 5.76 | 7.17 |
| 1:1.1:2.2 Steel pins = 0.9% by volume | 70.55 | 5.80 | 7.80 |
| 1:1.1:2.2 Steel pins = 1% by volume | 72.14 | 5.98 | 8.67 |

Fig 2(results)

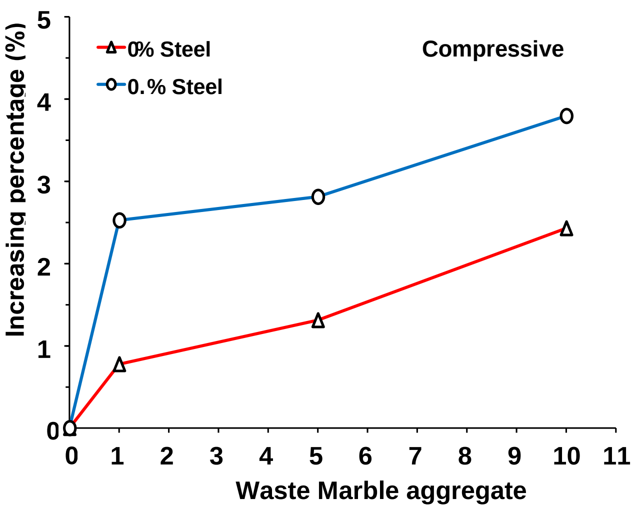


Fig 3(compressive strength)

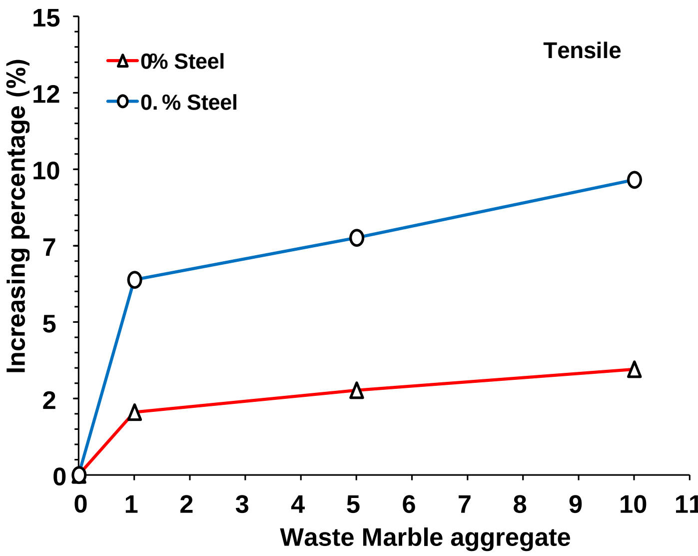


Fig 4 (Tensile strength)

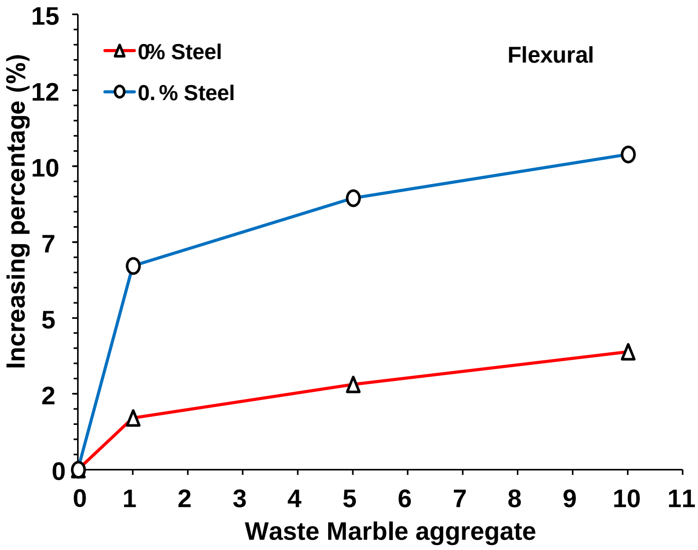


Fig 5(flexure strength)

### C. Waste Marble Powder And Wheat Straw Ash In Steel Fiber Reinforced Concrete

The mechanical strength of concrete strengthened by WSA, WSA, and steel fibres increased by 43%, 59%, and 45.96% in compressive, split tensile, and flexural strength, respectively. Since water absorption and porosity fell by 15.9% and 29%, respectively, WSA, WMP, and steel fibres also markedly improved durability. The inclusion of WMP, WSA, and steel fibres significantly decreased the workability of concrete. The value of the concrete sample was lower than that of the control sample. By increasing the dosage of WSA and WMP, it was also discovered that sorptivity and porosity had decreased. The addition of steel fibres raised the cost, according to a cost-benefit study. By increasing the dosage of WSA and WMP, a reduction in porosity was also seen. According to the cost-benefit analysis, the cost of the steel fibre addition was 7.9% more than it was for the control samples. With concrete's greatly better mechanical characteristics and several environmental advantages. (Osama Zaid, 2021)

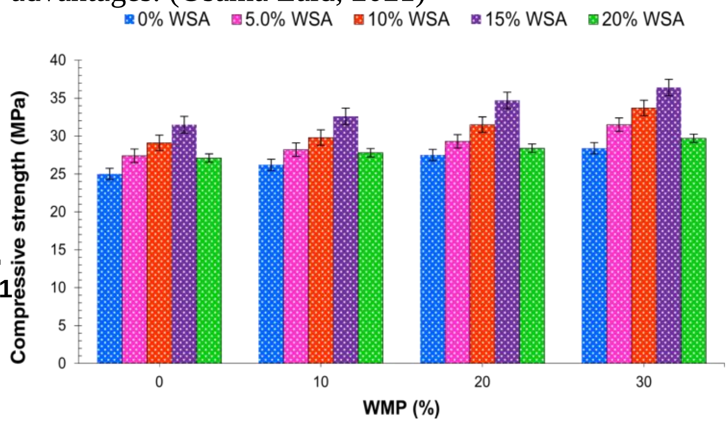


Fig 6 (compressive strength without steel fiber)

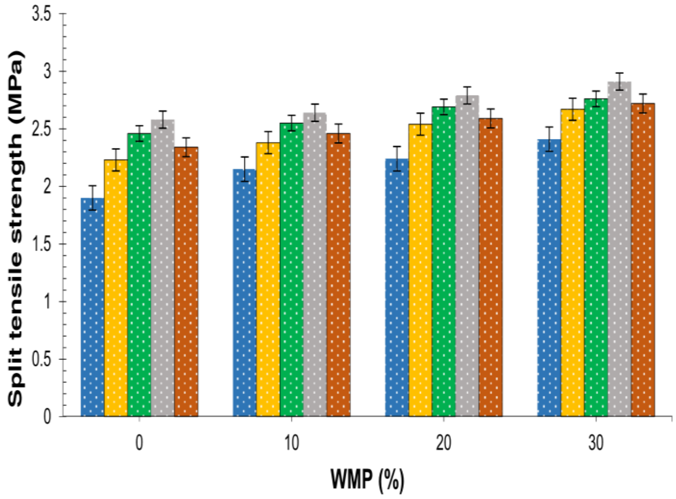


Fig 7 (split tensile strength without steel fiber)

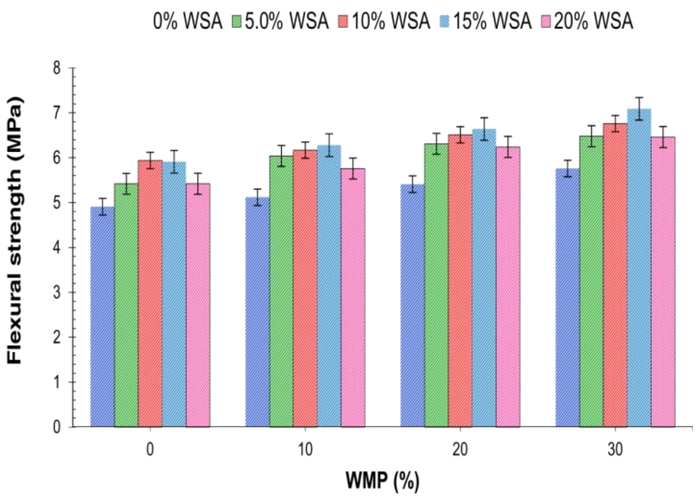


Fig 8 (flexure strength without steel fiber)

### D. Marble Dust And Glass Fiber In Concrete

The experimental findings suggest that substituting some of the very fine sand in mortar with marble dust increases its compressive strength while reducing its porosity. This is because the marble dust particles act as micro fillers, filling the gaps in the aggregate and cement paste. The addition of glass fibers to the mortar samples, however, reduced their compressive strength and increased their porosity, likely due to poor adhesion between the fibers and the mortar. The porosity of the mortar samples also increased when exposed to high temperatures, due to the release of water bound by the cement paste and the formation of air voids. The reduction in compressive strength was more pronounced at temperatures above 400 C, as the loss of crystallization water caused changes in the mortar's structure and the formation of micro-cracks. The addition of marble dust improved the high temperature resistance of the mortar, likely due to the reduction in voids and modification of the aggregate/cement paste and/or fiber/mortar interface. The A4B1C1 parameter settings were found to be the most effective in terms of both compressive strength and porosity value at high temperatures. According to ANOVA, marble dust had a highly significant effect on both compressive strength (92.94%) and porosity value (96.33%) of the cement mortar samples at high temperatures.(BihterGökçerb, 2014)

### E. Rigid Pavement Concrete with Use of Steel Fibers and Marble Dust:

Based on the available research, it can be concluded that incorporating steel fibers, marble dust, and other additives can significantly increase the strength and durability of concrete. Despite being commonly considered waste products, these additives can enhance the compressive strength, flexural strength, and cube strength of concrete. Additionally, they improve the stability of concrete mixes. By partially replacing cement with marble dust, substantial cost savings can be achieved, making it an economically feasible option. The combination of 20% marble dust and 0.5%-1% steel fibers has been found to be ideal for a rigid pavement that exhibits high distributed tensile strength, flexible strength, compressive power, long-term durability, and high load carrying capacity. Therefore, the use of these materials should be considered to maximize the benefits of concrete in terms of strength, durability, and cost-effectiveness.(Aquib Sultan Mir, 2016)

### F. Steel Fiber Size On The Properties Of Fresh And Hardened Self-Compacting Concrete Incorporating Marble Powder

It Structural concrete can incorporate marble powder and steel fibers, but this requires low water addition and good workability. Marble powder can replace limestone powder effectively. The addition of steel fibers changes the failure mode of self-compacting concrete (SCC) to a more complex one. Experimental tests show that small steel fibers act as a bridge to reduce micro-cracks, but have little effect on the post-load response compared to Prism displacement in Mid-Spain. Large steel fibers in high volume lead to better rigidity and toughness of the SCC compared to small fibers. The change in marble powder has a slight effect on ultrasonic pulse speed (UPV) and steel fibers. Fiber geometry affects SCC properties both in fresh and hardened conditions. The inclusion of steel fibers increases mechanical properties, especially the distribution of tensile strength, flexibility, and fracture energy, with improvements increasing as the share of large fiber volume increases. LSF has no significant effect on preventing micro cracks formation, but it does affect the peak response section after the load compared to the displacement curve, leading to higher fracture energy cost.. (Naima Haddadou M. B.,2021)

| Mix ID | Compressive strength (MPa) | | | Splitting tensile strength (MPa) | | Flexural strength (MPa) | | Ultrasonic pulse velocity (m/s) | | Fracture energy (N/m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 d | 28 d | 56 d | 28 d | 56 d | 28 d | 56 d | 28 d | 56 d | 56 d |
| SCC1 | 39.35 | 49.56 | 54.33 | 2.42 | 2.75 | 4.45 | 4.79 | 4178 | 4297 | 81.42 |
| SCC2 | 37.18 | 49.02 | 52.87 | 2.35 | 2.83 | 4.37 | 4.71 | 4158 | 4269 | 79.04 |
| RSCC1 | 36.63 | 47.72 | 52.02 | 2.56 | 3.11 | 4.6 | 4.89 | 4432 | 4598 | 502.14 |
| RSCC2 | 40.45 | 47.85 | 49.36 | 2.85 | 3.38 | 5.08 | 5.28 | 4342 | 4443 | 570.95 |
| RSCC3 | 33.82 | 45.38 | 47.54 | 3.32 | 3.82 | 5.43 | 5.81 | 4322 | 4577 | 657.14 |
| RSCC4 | 34.08 | 45.33 | 48.08 | 3.48 | 4.02 | 5.69 | 5.97 | 4411 | 4549 | 727.38 |
| RSCC5 | 35.49 | 49.22 | 48.35 | 3.63 | 4.23 | 5.93 | 6.29 | 4424 | 4558 | 914.76 |

Fig 9 (results)

## IV. Conclusion

After reviewing various research studies, it can be inferred that incorporating steel fibers, marble dust, and other additives into concrete can significantly enhance its strength. Despite being commonly treated as waste byproducts, these additives can play a crucial role in increasing the compressive strength, flexural strength, and cube strengths of concrete. Partial replacement of cement with marble dust can also result in cost savings, while achieving a concrete mix with superior properties such as higher split tensile strength, flexural strength, compressive strength, longer service life, and greater load carrying capacity. Based on these findings, a concrete with 20% marble dust and 0.5%-1% steel fiber gives good results

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