



# Experimental Investigation on Concrete Strength with Marble Powder and Iron Ore

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**Abstract-** Concrete is a widely used construction material and plays a vital role in the development of infrastructure. However, its production consumes large quantities of natural resources such as cement and sand, leading to environmental concerns and increased costs. Rapid urbanization and industrial growth have further intensified the demand for these materials, making it necessary to explore sustainable alternatives. In this context, the use of industrial waste materials in concrete has gained significant attention. This study focuses on the utilization of waste marble powder (WMP) as a partial replacement for cement and waste iron powder (WIP) as a substitute for fine aggregate (sand). These materials are generated as by-products from industrial processes and are often disposed of in landfills, causing environmental pollution and health hazards. Their incorporation into concrete not only reduces waste but also conserves natural resources. In the experimental investigation, cement was replaced with marble powder at proportions of 5% and 10%, while sand was replaced with iron powder at 30%, 40%, and 50%. The performance of the concrete was evaluated based on compressive strength, flexural strength, and workability. The results indicated that the optimum combination was achieved at 10% marble powder and 50% iron powder replacement, where both compressive and flexural strengths were maximized. The findings suggest that the use of marble powder and iron powder can enhance the strength characteristics of concrete. Moreover, this approach provides an eco-friendly and cost-effective solution for sustainable construction by promoting the recycling of industrial waste materials.



## 1. Introduction

The extensive use of concrete in the construction industry makes it a significant concern for engineers. Concrete production also consumes a large amount of materials globally. However, with rapid urbanization and changing market demands, key factors such as energy cost, expansion of manufacturing capacity, and environmental issues have become increasingly important in the concrete industry. The present study focuses on the use of marble powder as a partial replacement for cement and iron ore as a substitute for sand to address problems related to pollution, as well as the high cost and limited availability of conventional materials.

Waste marble powder (WMP) and waste iron powder (WIP) are industrial by-products generated during the production and polishing of granite and are often discarded, posing risks to human health and the environment. In this study, marble powder was used as a cement replacement at 5% and 10%, while iron powder was used as a fine aggregate replacement at 30%, 40%, and 50%. The performance of concrete was evaluated based on compressive strength, flexural strength, and workability.

The results indicated that maximum compressive and flexural strength were achieved when 10% of cement was replaced with marble powder and 50% of sand was replaced with iron powder. The findings suggest that incorporating lower amounts of marble powder and higher amounts of iron ore can enhance the strength of concrete. Furthermore, recycling these waste materials for use in concrete is both economically beneficial and environmentally sustainable. It promotes the utilization of industrial waste in construction, reduces pollution, lowers material costs, and supports the development of new construction materials and sustainable practices in the industry.

## 2 Literature Review

Concrete technology has advanced significantly with increasing emphasis on sustainable materials. Researchers have explored the use of industrial by-products to partially replace conventional materials like cement and fine aggregates, aiming to reduce environmental impact and cost (Mehta & Monteiro, 2014).

Several studies have investigated the use of **marble powder** as a partial replacement for cement. Binici et al. (2007) reported that marble dust improves compressive strength and durability due to its filler effect and better particle packing. Similarly, Corinaldesi et al. (2010) observed that replacing cement with marble powder up to 10–15% enhances mechanical properties, while higher percentages may reduce strength due to dilution of cementitious compounds.

The use of **iron ore powder or waste iron powder (WIP)** as a replacement for fine aggregate has also been widely studied. Shettima et al. (2016) found that iron ore tailings improve compressive strength and density of concrete. Additionally, Ghorbani et al. (2019) reported that iron powder increases durability and mechanical performance due to its higher specific gravity, though excessive replacement can reduce workability.

Limited studies have explored the combined use of marble powder and iron ore powder. However, available research suggests a synergistic effect, where marble powder improves the microstructure and iron powder enhances density and strength (Aliabdo et al., 2014). This combination leads to improved overall performance of concrete.

Moreover, the utilization of waste materials such as waste marble powder (WMP) and waste iron powder (WIP) helps reduce environmental pollution and landfill waste. These practices support sustainable construction and align with circular economy principles (Siddique & Naik, 2004).

On the other hand, **marble powder (MP)** is widely recognized for its filler effect and ability to enhance the microstructure of concrete. Due to its fine particle size, MP improves packing density, reduces porosity, and contributes to early strength development. Studies indicate that replacement levels up to **10–15%** are optimal, beyond which strength decreases due to reduced cementitious content. Research also highlights that MP can enhance both compressive and flexural strength through improved particle bonding and hydration reactions.

Recent studies combining MP with iron-based materials (such as Fe<sub>2</sub>O<sub>3</sub> nanoparticles or iron tailings) demonstrate a **synergistic effect**, where MP improves workability and microstructure while iron materials increase density and strength. This combination leads to improved mechanical performance and durability of concrete.



Overall, the literature confirms that the use of WMP and IOT not only enhances concrete properties but also contributes to sustainable construction. It reduces dependence on natural resources, minimizes environmental pollution, and promotes the reuse of industrial waste materials. However, further research is still required to optimize mix proportions and address long-term durability aspects.

**Table 1.** Physical and Chemical properties of marble powder

| Chemical                       |      | Physical                      |              |
|--------------------------------|------|-------------------------------|--------------|
| Chemical                       | Test | Physical Properties           | Test Results |
| SiO <sub>2</sub>               | 13.8 | Loss of ignition              | 43.63        |
| CaO                            | 43.2 | Specific gravity              | 2.63         |
| MgO                            | 2.70 | Fineness (kg/m <sup>3</sup> ) | 350          |
| Al <sub>2</sub> O <sub>3</sub> | 2.50 | Colour                        | Light Gray   |
| Fe <sub>2</sub> O <sub>3</sub> | 1.9  | Water absorption              | 0.97%        |
| SO <sub>3</sub>                | 0.07 |                               |              |
| K <sub>2</sub> O               | 0.60 |                               |              |
| CL                             | 0.03 |                               |              |
| Na <sub>2</sub> O              | 0.90 |                               |              |

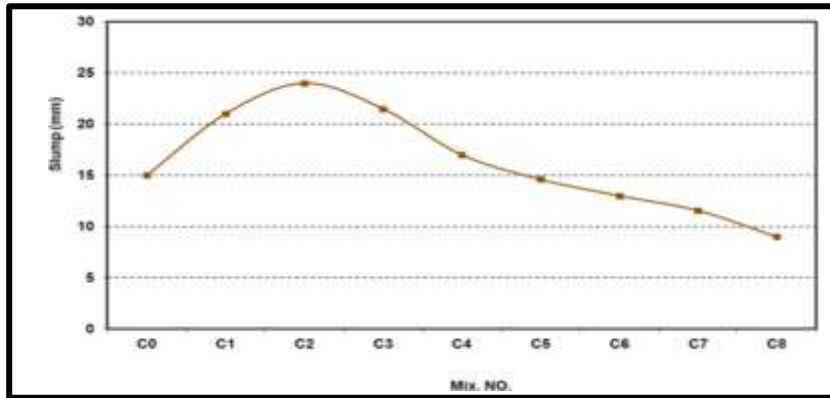
As studied by Soliman, N. M. (2013), the chemical composition of marble powder and cement was similar in most aspects, like lime, alumina, silica, and magnesia, as shown in Table 2.

**Table 2.** Percentages of cement and waste marble powder

| Component (%)     | Cement    | Waste marble powder |
|-------------------|-----------|---------------------|
| Lime              | 60% – 70% | 50.10%              |
| Alumina           | 3% – 8%   | 1.38%               |
| Silica            | 17% - 25% | 1.28%               |
| Magnesia          | 0.1%-0.4% | 1.72%               |
| Iron oxide        | 0.5%-0.6% | 0.54%               |
| Sulphur trioxide  | 1.3%-3%   | 0.21%               |
| Alkaline          | 0.4%-1.3% | 0.29%               |
| Calcium carbonate |           | 94.30%              |
| Loss of ignition  | 3%-4%     | 0.39%               |

According to the study conducted by Benabed et al. (2017), titled “*Strength and Durability of Low-Impact Environmental Self-Compacting Concrete with Waste Marble Powder,*” the incorporation of a small percentage of marble powder as a partial replacement for cement enhances the workability of fresh concrete. The presence of fine marble particles improves the flowability and compaction of the cement paste, which in turn contributes to better strength development. However, an excessive increase in marble powder content may lead to segregation between fine and coarse aggregates, thereby reducing the overall strength of concrete.

The study reported that when cement was replaced with marble powder at 2.5%, 5%, 7.5%, and 10%, the slump values increased by 40%, 60%, 36.7%, and 13%, respectively, indicating improved workability. Conversely, beyond the optimum level, a reduction in slump was observed, with decreases of 3.7%, 13.3%, 23.3%, and 40.0% at higher replacement levels, as illustrated in Figure 1. These findings suggest that while marble powder improves workability at lower percentages, higher replacement levels may adversely affect the consistency and performance of concrete.

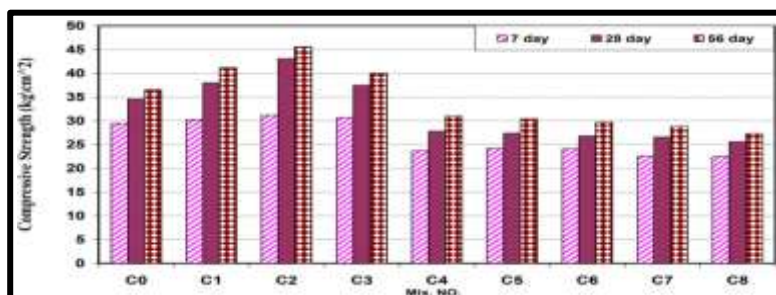


| Mix. Code | Compressive Strength (N/mm <sup>2</sup> ) |         |         | Indirect Tensile Strength (N/mm <sup>2</sup> ) |         |         | Modulus of Elasticity (E) (KN/mm <sup>2</sup> ) |         |         |
|-----------|---|---------|---------|--|---------|---------|---|---------|---------|
|           | 7 days                                    | 28 days | 56 days | 7 days   | 28 days | 56 days | 7 days  | 28 days | 56 days |
| C0        | 29.5                                      | 34.6    | 36.5    | 2.6  | 3.6     | 3.8     | 2.2   | 2.53    | 2.59    |
| C1        | 30.3                                      | 38      | 41.2    | 2.8  | 3.7     | 3.9     | 2.3   | 2.6     | 2.75    |
| C2        | 31.2                                      | 43.1    | 45.6    | 2.9  | 3.8     | 4       | 2.4   | 2.82    | 2.9     |
| C3        | 30.7                                      | 37.5    | 40      | 2.75   | 3.6     | 3.9     | 2.32  | 2.48    | 2.71    |
| C4        | 23.7                                      | 27.8    | 31      | 2.4  | 3.2     | 3.4     | 2.13  | 2.26    | 2.5     |
| C5        | 24.2                                      | 27.4    | 30.4    | 2.4  | 3       | 3.1     | 2.11  | 2.25    | 2.4     |
| C6        | 24.1                                      | 26.8    | 29.7    | 2.3  | 2.8     | 2.9     | 2.1   | 2.24    | 2.36    |
| C7        | 22.6                                      | 26.6    | 28.9    | 2.1  | 2.5     | 2.6     | 2.04  | 2.21    | 2.34    |
| C8        | 22.5                                      | 25.6    | 27.3    | 2  | 2.3     | 2.4     | 2.03  | 2.17    | 2.31    |

**Graph 1.** Slump values for different mixes

**Fig. 1.** Mechanical properties of the effect of the marble powder on different mixes

The compressive strength of the concrete was increased by 10%, 25%, or 8% after 28 days when marble powder was added at a concentration of 2.5%, 5%, or 7.5%. After 56 days of testing, the marble powder's compressive strength increased by 13%, 29%, and 10%. At 56 days, the compressive strength of the control mix was 354 kg/cm<sup>2</sup>.



**Graph 2.** Compressive strength graph for all concrete mixes with different ratios of marble powder

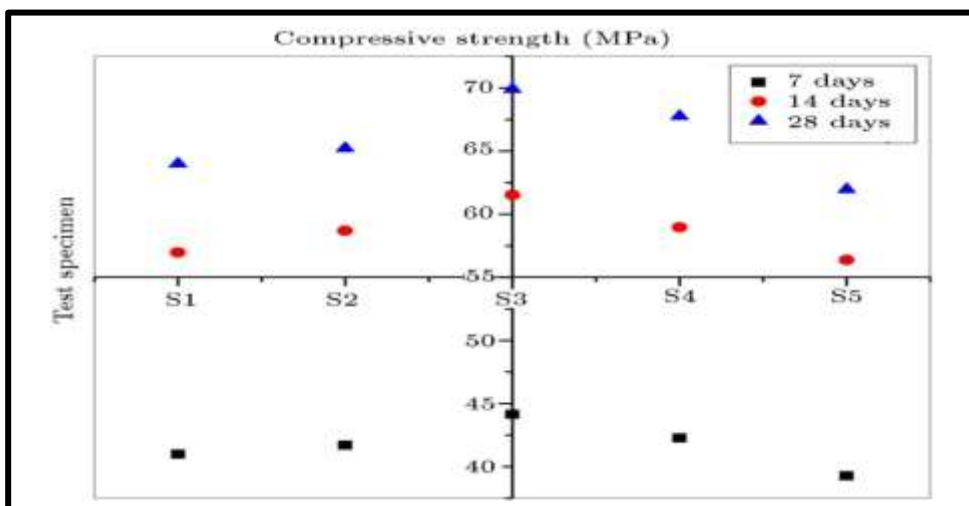


The behaviour and strength of R.C. concrete are affected by the use of marble powder in concrete mixtures.

The compressive strength of concrete at 28 days was observed to decrease by approximately 20%, 21.35%, 21.66%, 23.75%, and 26.6% as the proportion of marble powder increased from 10% to 20%. Table 5 presents the mix proportions used in experimental investigations to evaluate the suitability of marble powder as a partial replacement for cement in high-strength concrete (HSC). The primary objective of the study was to assess the influence of marble powder on the mechanical and durability properties of HSC. Marble powder was incorporated at replacement levels of 0%, 5%, 10%, 15%, and 20%.

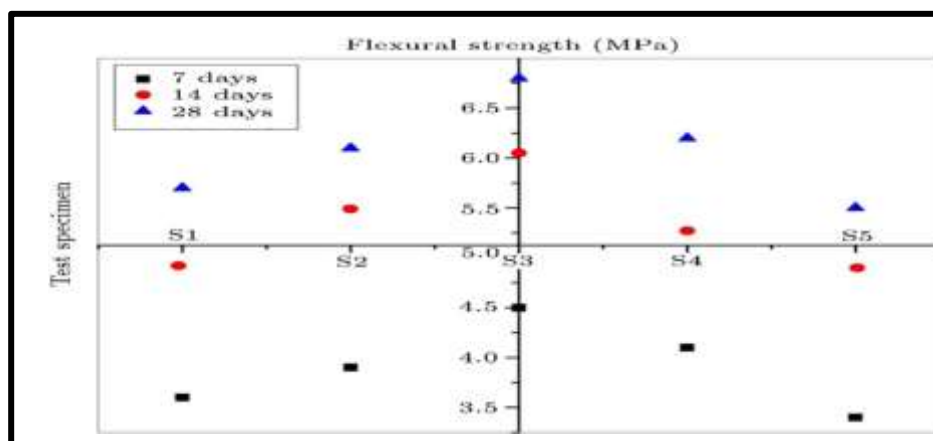
According to the findings of Raghunath P. N. et al. (2019), the compressive and flexural strengths of concrete improved when cement was replaced with marble powder at levels of 5%, 10%, and 15%. It was reported that mix S2 exhibited 1.90 times higher compressive strength compared to S1. Additionally, increases in compressive strength of 7.19%, 9.23%, and 5.89% were observed between mixes S2 and S4. However, at higher replacement levels (around 15% and above), a reduction in compressive strength was noted, which may be attributed to the decrease in available cementitious material required for proper bonding.

**Graph 3. Compressive Strength**



Raghunath P.N. et al.'s 2019 study on the mechanical and durability properties of marble- powder-based high-strength concrete The specimens S1, S2, S3, S4, and S5 had flexural strengths of 5.7 MPa, 6.1 MPa, 6.8 MPa, 6.2 MPa, and 5.5 MPa, respectively. With a 15% replacement level, a slight decrease was seen. The dearth of available support resources may help to explain this. (2018) (P.N. Raghunath et al.)

**Graph 4. Flexural strength of different specimens of concrete**



Raghunath P.N. et al.'s 2019 study on the mechanical and durability properties of marble- powder-based high-strength



concrete. Suresh, S. et al., 2019 started yet another study to investigate the viability of using marble powder in the production of concrete. Marble powder will be added to concrete M20 mixtures in varying amounts (0%, 5%, 10%, & 15% by weight) to determine the best replacement percentage.

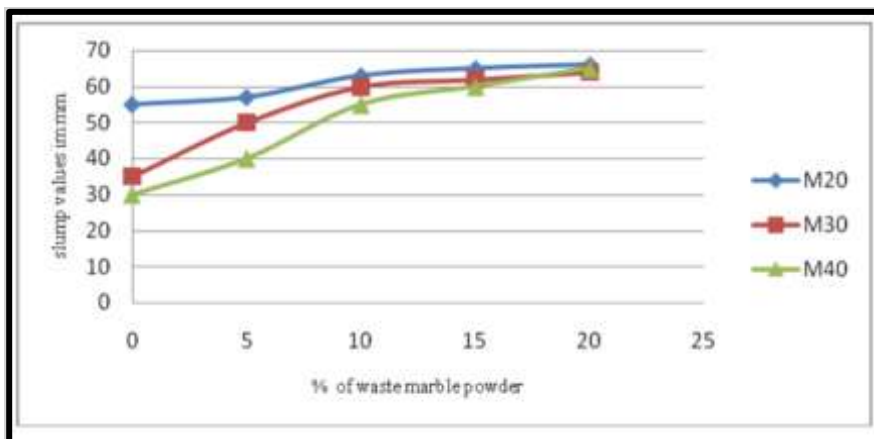
**Table 3.** Compressive strength for all mixes

| Sr No. | Test specimen | Marble powder dosage | Average compressive strength (N/mm <sup>2</sup> ) |         |
|--------|---------------|----------------------|---|---------|
|        |               |                      | 7 days  | 28 days |
| 1      | NSC 0%        | 0                    | 16.51   | 24.18   |
| 2      | NSC 5%        | 5                    | 24.99   | 27.4    |
| 3      | NSC 10%       | 10                   | 26.52   | 29.28   |
| 4      | NSC 20%       | 15                   | 15.21   | 21.52   |

Compressive strength changes when 5-10% of cement is substituted by marble powder in concrete, according to research by Suresh et al. (2019). S. Suresh et al. (2019). Flexural strength rose even though the specimen NSC dropped by 4.3% compared to the control NSC's 0%. Flexural strength is improved by 5%, 10%, or 15% marble powder in concrete, but decreased by 15%. The graph below demonstrates a clear decline in compressive strength, with NSC 10% and NCS 15% performing the best.

Latha et al. (2015) studied the effects of using leftover marble powder in place of some of the cement on the compressive, split, and tensile strengths of M 20, M 30, and M 40 concrete classes. Make sure you're using the right amount of marble powder in your concrete mix. The dust from marble blocks contributes to air pollution. Substituting marble powder for cement is one way to lessen environmental impact. Waste marble powder with a fineness of 13% and a specific gravity of 1.5 was sieved via an IS-90-micron sieve before being mixed into the concrete. Analysing the properties of powdered marble debris. Flexibility of newly placed concrete: After being mixed, concrete was tested using the slump and C.F. methods. The concrete batch used for the consistency test was combined with the others before test specimens were made. The workability of concrete is evaluated using a slump cone after it has been mixed.

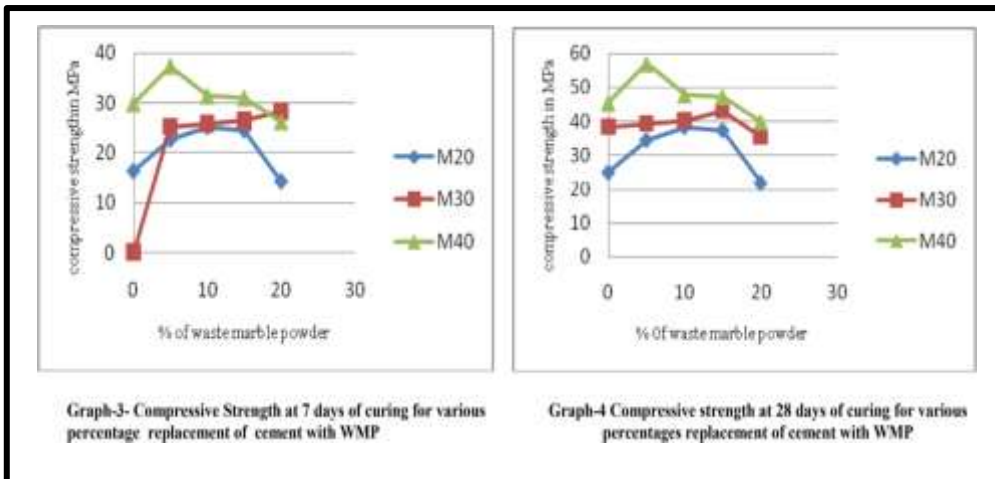
**Graph 5.** Various slump values for M20, M30 & M40 grades of concrete



Mixes like M20, M30, and M40 concrete became more workable when 20% cement replaced waste marble powder. Workability increases with 10% waste marble powder. WMP particles operate better due to their spherical shape, smooth texture, and higher surface area of contact. After 7 and 28 days in fresh water, the specimens were dried and tested for strength.



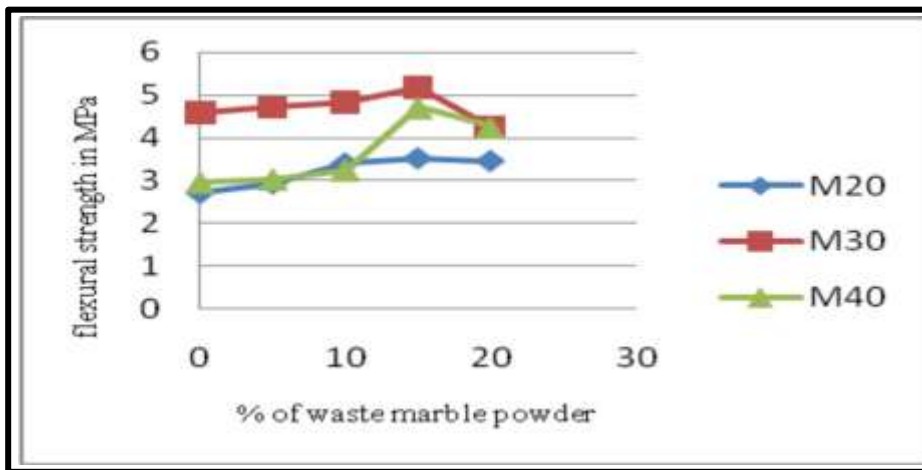
**Graph 6.** Compressive strength of concrete at 7 & 28 days



In 2015, G. L. et al. investigated the strength of concrete using discarded marble powder as cementitious material. Waste marble powder increases compression strength ratings for M20, M30, and M40-grade concrete by 10% to 20% at each curing age. Marble powder's calcium carbonate may improve concrete's strength. Marble powder-containing concrete mixes had 5–10% higher early strength. 20% replacement concrete has lower compressive strength.

The graph below indicates that adding discarded marble powder up to 15% cement weight boosts flexural strength. Waste marble powder reduced the strength of the concrete somewhat. 10%–15% marble powder replacement in cement is good. Thus, residual marble powder improves hardened concrete's performance by 15%.

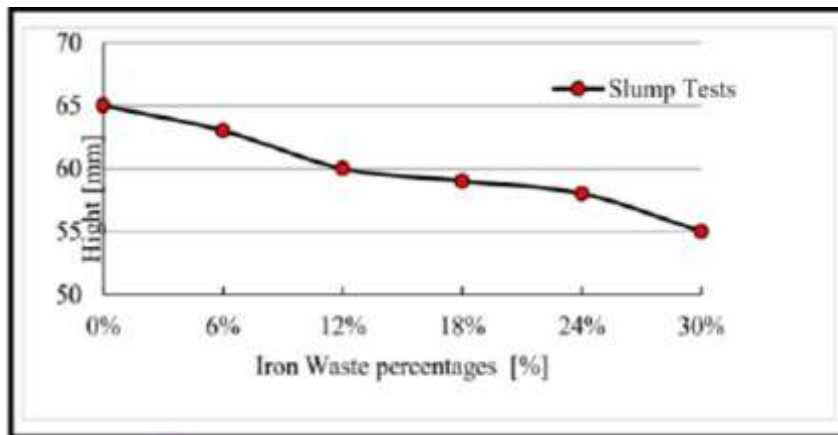
**Graph 7.** Flexural strength for various grades with varying percentages of marble powder



KIM, J. et al. (2015), studied the effect of Iron Powder on Inhibition of Carbonation Process in Cementitious in which the iron ore was replaced with different percentages of sand. The paper also shown that the chemical makeup of iron powder is largely the same as that of cement compounds. This classification makes it possible to use iron powder in concrete mixes in place of sand to good effect.

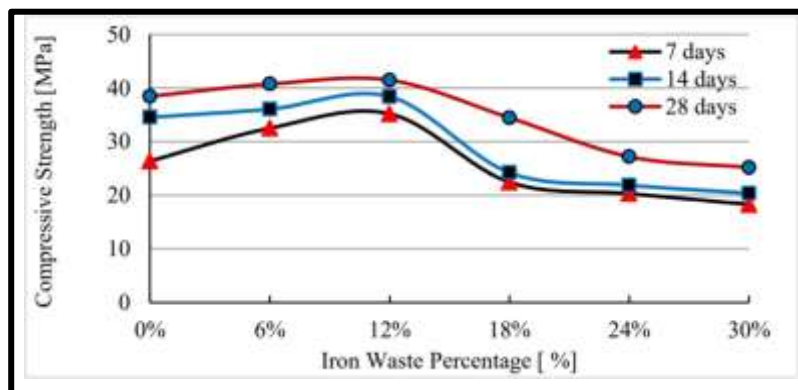


**Graph 8.** Slump con for all mixing ratios of Iron powder



Noori, K., et al.'s (2018) studied the mechanical Properties of Concrete Using Iron Waste as a Partial Replacement of sand. The results show that the slump gradually and slightly lessened as iron waste increased. This shows that concrete is workable within a reasonable range and has good durability. (2018) (Noori, K., et al.)

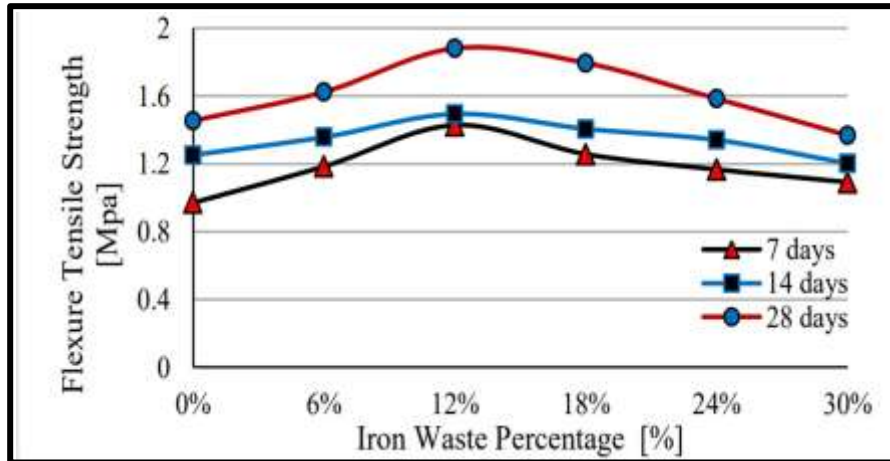
**Graph 9.** Compressive strength with different percentages of waste iron waste.



The above graph is based on data from Noori, K., et al. (2018), Mechanical Properties of Concrete Using Iron Waste as a Partial Replacement of Sand, and it shows how increasing the iron waste content leads to a steady rise in compressive strength. The purpose of this study was to examine the effect of iron waste content on the strength development of concrete after 7, 14, and 28 days of curing. The results show that a composition of 12% iron waste produces the strongest concrete; beyond this point, adding more iron waste degrades the concrete. Adding 12 percent iron waste to concrete immediately boosts its compressive strength by 15 percent compared to control concrete after only 28 days.



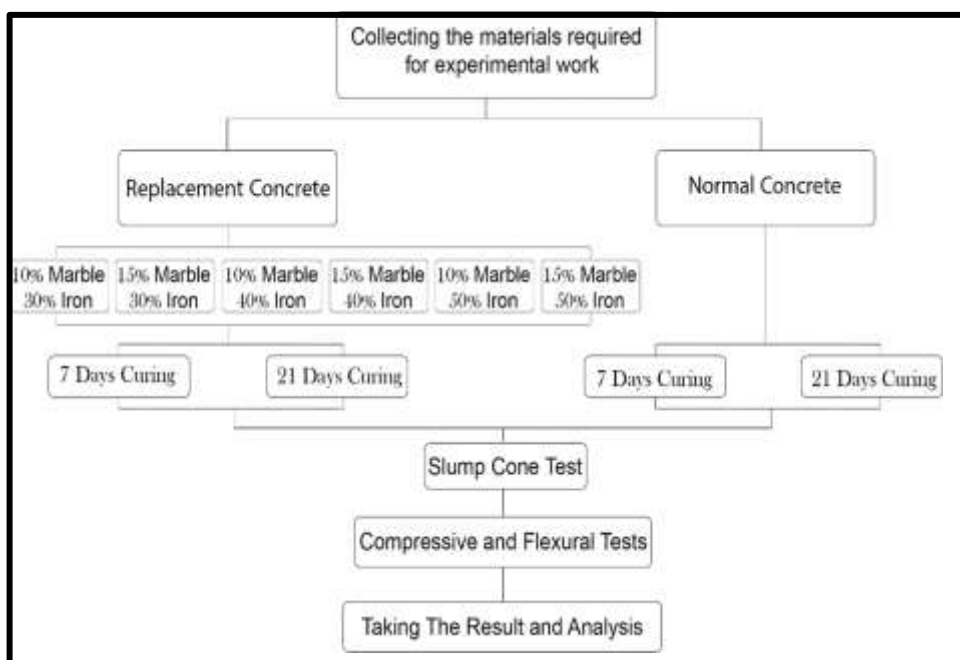
**Graph 10.** Flexural strength with different percentages of Iron waste



The graph demonstrates that the flexural tensile strength decreases with an increase of iron waste of more than 12%. Therefore, it may be argued that the strength of concrete can be increased by using a tiny amount of iron waste in place of sand. (2018) Noori, K., et al.

The rising global demand for steel and the subsequent extraction of valuable ore generates IOT, as explained in the 2018 article "Experimental study on strength properties of concrete replacing cement by marble dust and sand by iron ore tailings" by Kumar, N. et al. Since IOT is a byproduct of slurry extraction and has very fine material properties, it can be utilised in place of fine aggregate. The decorative usage of marble dust is widespread in the building industry. Over twenty percent to thirty percent of all waste generated from quarry to finish consists of fine particles. If dumped outside, it could contribute to air pollution, which would have negative effects on human health and soil fertility. Recent research has investigated using marble dust as a partial cement replacement due to its high quality. Partial substitution of fine aggregate (natural sand) at 10%, 20%, 30%, and 40% and normal Portland cement (OPC) at 5%, 10%, 15%, and 20% was used to examine the behaviour of iron ore tailings (IOT) and marble dust when being carried across fresh concrete. Adding more IoT devices has been demonstrated to decrease the system's usability. The superplasticizer admixture "CONPLAST-SP340" was used to maintain the material's workability. A combination of 10% IOT and 5% marble dust was found to be the best option based on the strength characteristics.

### 3Methodology



**Figure 2.** Flowchart of the experimental research



### 3.1 Design of concrete:

The mix design was carried as per BS 8110 and BS 8500. Table 4 and table 5 shows the mix design properties and quantities respectively.

**Table 4.** Mix design used in the experiment.

| Used material                              | Quantity/ rate                |      |      |       |      |      |
|--|-------------------------------|------|------|-------|------|------|
| Cube                                       |                               |      |      |       |      |      |
| Cement type                                | OPC- Ordinary Portland cement |      |      |       |      |      |
| W/C ratio                                  | 0.45                          |      |      |       |      |      |
| Density of the cement (kg/m <sup>3</sup> ) | 2400(kg/m <sup>3</sup> )      |      |      |       |      |      |
| Wight of water (L)                         | 1.18 L                        |      |      |       |      |      |
| Mass of cement (kg)                        | 21 Kg                         |      |      |       |      |      |
| Marble powder percentage (%)               | 10%                           |      |      | 15%   |      |      |
| Wight of Marble powder (kg)                | 2.17                          |      |      | 3.186 |      |      |
| Iron powder percentage (%)                 | 30%                           | 40%  | 50%  | 30%   | 40%  | 50%  |
| Wight of Iron powder (kg)                  | 7.8                           | 9.44 | 11.8 | 7.8   | 9.44 | 11.8 |
| Mix proportion                             | 2                             | 2    | 2    | 2     | 2    | 2    |
| Beam                                       |                               |      |      |       |      |      |
| Cement type                                | OPC- Ordinary Portland cement |      |      |       |      |      |
| W/C ratio                                  | 0.45                          |      |      |       |      |      |
| Density of the cement (kg/m <sup>3</sup> ) | 2400(kg/m <sup>3</sup> )      |      |      |       |      |      |
| Wight of water (L)                         | 1.18                          |      |      |       |      |      |
| Mass of concrete (kg)                      | 9.5                           |      |      |       |      |      |
| Marble powder percentage (%)               | 10%                           |      |      | 15%   |      |      |
| Wight of Marble powder (kg)                | 2.17                          |      |      | 3.186 |      |      |
| Iron powder percentage (%)                 | 30%                           | 40%  | 50%  | 30%   | 40%  | 50%  |
| Iron powder percentage (%)                 | 30%                           | 40%  | 50%  | 30%   | 40%  | 50%  |

**Table 5** Quantities of the materials

| Mix code | Cement (kg) | Coarse Aggregate (Kg) | Fine aggregate (Kg) | Marble (kg) | Iron ore (kg) | Water (L) |
|----------|-------------|-----------------------|---------------------|-------------|---------------|-----------|
| M1       | 21.25       | 53                    | 24                  | -           | -             | 10.2      |
| M2       | 19.12       | 53                    | 17                  | 2.2         | 7             | 10.2      |
| M3       | 19.12       | 53                    | 14                  | 2.2         | 9.5           | 10.2      |
| M4       | 19.12       | 53                    | 12                  | 2.2         | 11.9          | 10.2      |
| M5       | 18.06       | 53                    | 17                  | 3.19        | 7             | 10.2      |
| M6       | 18.06       | 53                    | 14                  | 3.19        | 9.55          | 10.2      |
| M7       | 18.06       | 53                    | 12                  | 3.19        | 11.9          | 10.2      |

The necessary quantity of each material (coarse aggregate, cement, sand, and water) was prepared. The mixer machine initially received the dry materials and began mixing them. Water was gradually incorporated during the mixing process.



### 3.2 Concrete Mix procedure with replacement of marble powder and iron ore

The coarse aggregate and fine aggregate (sand) were then added to the mixer machine, with the sand being partially replaced with iron powder (30%, 40%, or 50% depending on the mix). Cement was added to the mixture when marble powder was largely replaced (by 10% or 15%, respectively). The components were blended by gradually adding water. The same process was repeated multiple times, each time with a different proportion of marble to iron powder. Applying oil to the cube and prism moulds required a brush. The mixture was put in three stages, or layers, in the moulds, then tamped down 25 times between each stage. Excess material was scraped off the surface of the mould with a tamping rod. The compacting machine was used to compact the mixture in moulds, eliminating air pockets. The concrete prisms and cubes were permitted to dry in their moulds for 24 hours before being removed. After curing for seven and twenty-eight days, respectively, concrete prisms and cubes were placed in the water tank.



Figure 4. Concrete mix placement.

### 3.3 Slump test:

At implementation sites and mixing stations, this test is considered one of the best and simplest ways to guarantee product quality. For testing, the concrete was poured into a mould in the shape of an elliptical cone manufactured from thick metal (at least 1.5 mm). It can be entered from both above and below. It stands at 30 centimetres tall, with a 10-centimetre-wide top opening and a 20-centimetre-wide bottom one. The tamping rod used was 60 centimetres long and 15 millimetres in diameter. The mould's interior was polished and coated with oil. Assuming that each layer was compressed 25 times with the compaction rod, the mould was filled in three layers, with each layer's height being about equivalent to one-third of the mould's height. The edge of the mould was lined up with the top of the mixture after it had been tamped down firmly. After the mould was filled vertically, it was lifted gradually and in a straight line. After the mould was lifted, the slump was calculated by comparing the mould's height to that of the concrete's centre.

### 3.4 Compressive and flexural strength test

The compressive and flexure test were carried out for 7 and 21 days as per the EN 12350 and EN 13791 on fresh and hardened concrete test procedure requirements.



Figure 5. Compressive machine

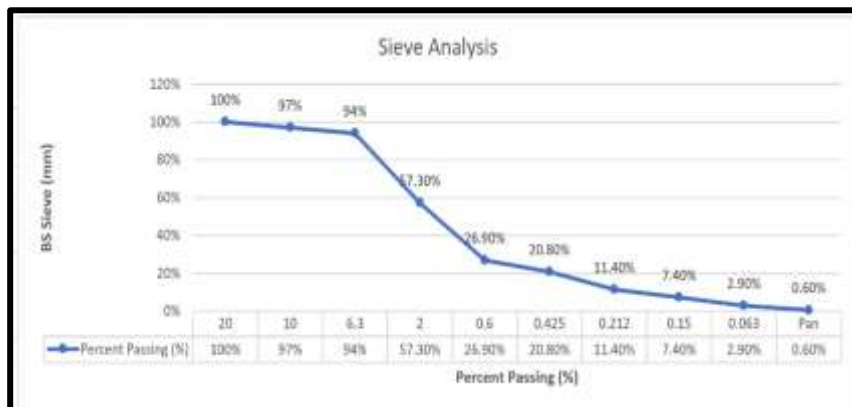


Figure 6. Flexure machine

## 4 Results & Discussion

### 4.1 Sieve Analysis:

Graph 11. Relation between soil and Sieving Analysis

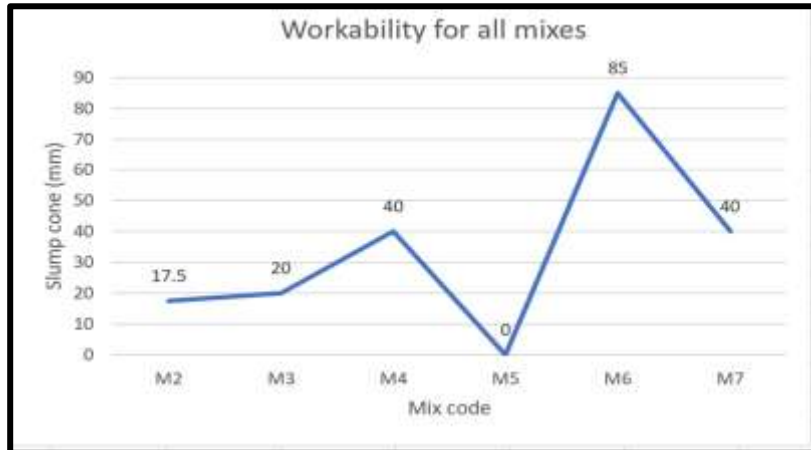


### 4.2 Workability results (Slump test)

The horizontal flow of concrete is examined in this test with no obstacles in the way. Slump cones are used to evaluate the workability of freshly mixed concrete. In the accompanying table, we can see the results for every possible mixture of marble powder and iron powder in concrete, albeit with different replacement ratios. Slump test results for mixtures with 30% (M2), 40% (M3), and 50% (M6) iron powder substitution for sand were raised by 22.5% and 45%, respectively, when 10% of the cement was replaced with marble powder. As can be seen in the table below, which compares mixes M3 and M5, the slump values reduced by as much as 20% when using a 15% marble ratio with varying iron levels. As the iron powder ratio rises, the slump cone values tend to fall, suggesting a correlation between the two. Mixes with a 10% marble ratio are more workable than those with a 15% marble ratio, demonstrating that increasing the replacement ratio of marble and iron powder reduces the mix's workability. Mix M6, with its appropriate replacement of 50% iron and 10% marble, increases concrete workability in comparison to the control mix.



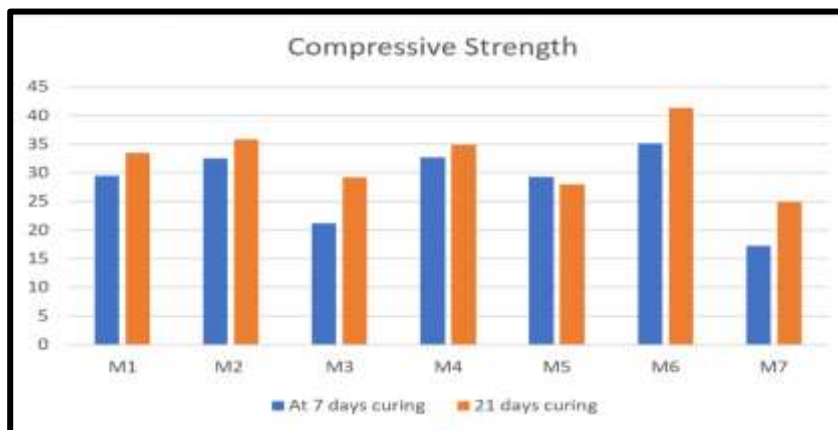
**Graph12.** Slump test results for different mixes



The results were consistent with those found in the article "Effect of Using Marble Powder in Concrete Mixes on the Behaviour and Strength of R.C. Slabs"; increasing the amount of marble powder to cement from 2.5% to 5% to 7.5% to 10% raised the slump values by 40%, 60%, 36.7%, and 13%. N. M. Soliman (2013) Overall, replacing 10% of the cement with marble powder enhanced the fresh concrete's workability. As the iron replacement ratio increased, the slump cone values also rose.

### 4.3 Compressive strength

**Graph 13.** Values Compressive and Flexural strengths for all mixes

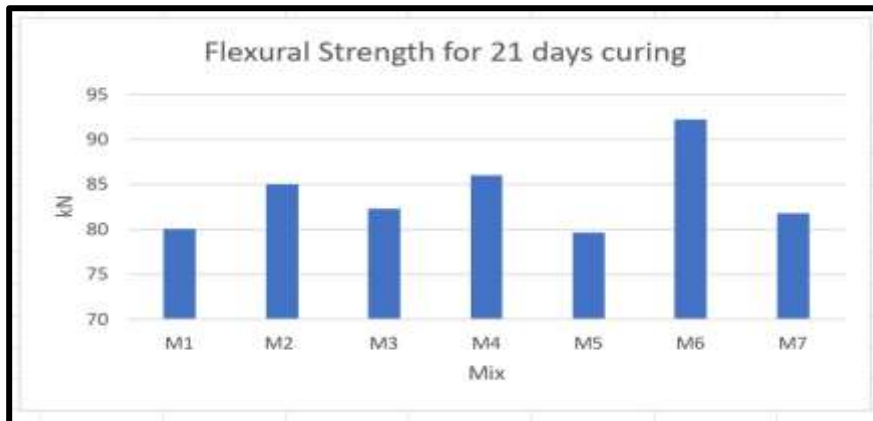


Therefore, the compressive strength values of all specimens with 10% marble as a partial replacement of cement increased, unequivocally demonstrating M2, M4, and M6. After curing for seven days, the cubes had values of 32.5 MPa, 32.7 MPa, and 35.1 MPa, respectively. After curing, the values for 21-day-cured cubes were 35.83 MPa, 34.90 MPa, and 41.291 MPa, respectively. The cubes containing 15% WMP were found to be weaker than the control cube containing 0% WMP. In addition, as shown in M6, the optimal replacement ratio to boost compressive strength is 10% marble with 50% iron.

When we compare the outcomes of the variant mixtures (M2, M3, M4, M5, M6, and M7) to the reference variant (M1), we see that the compressive strength diminishes as the proportion of substitution with marble increases. The research in "An Experimental Examination on Mechanical and Durability Properties of Cement Replacing with Marble Powder" (Suresh, S. et al., 2019) lends credence to this conclusion. Because reducing the amount of cement in a combination reduces its compressive strength, using marble is analogous to this practice. And after 7 days, we found that iron contributed more to the overall compressive strength improvement than marble did. This finding is in line with that found in "Mechanical Properties of Concrete Using Iron Waste as a Partial Replacement of Sand" by Noori, K., et al., 2018.



#### 4.2.2. Flexural strength



**Graph 14.** Graph Flexural Strengths for all mixes

Samples with 10% marble powder had flexural strengths of 84.99 kN, 86.05 kN, and 92.18 kN. Additionally, the increase in flexural strength was proportional to the amount of iron powder employed in the procedure. Despite this, a 1.6% drop can be seen between the control specimen M1 and the WMP 15%-treated specimen M5. Flexural strength was enhanced when marble powder replaced 10% of the cement but was diminished when the proportion was increased to 15%. In addition, M6 (10% marble and 50% iron) was shown to be the greatest replacement ratio for enhancing flexural strength.

#### 5 Conclusion

Based on the results of the study, it was determined that self-compacting concrete containing marble powder as a replacement for 10–15% of Portland cement outperformed concrete without marble in its composition. The accumulation of marble garbage contributes to environmental pollution, yet this result is helpful because it reduces that pollution. Concrete made using scrap marble is considered "green" concrete since it contributes to a reduction in carbon dioxide emissions from the concrete manufacturing process. It helps keep pollutants at bay and achieves environmental sustainability. Because the presence of such a process creates an environmental problem that cannot be disposed of when not in use, slag, one of the industrial byproducts of the local slag, which until now has been an excess material and there are currently no efforts to use it in industry, was used in the production process. In this experiment, slag was added to concrete by replacing sand at various amounts (30, 40, and 50%).

When marble powder can be collected and repurposed, it is a terrific way to use industrial waste. Larger facilities are encouraged to employ self-compacting concrete made with marble powder to prevent the usual compaction concerns that come with ordinary concrete, reduce expenses, and protect the environment. To decrease environmental damage caused by local slag's occupation of broad regions and to promote its uses, crushing facilities for slag blocks of the correct sizes to be used as aggregates in concrete, roads, and railways must be made available.

#### 6 Scope for further studies

The use of slag or iron ore tailings in the production of concrete and pavement design.



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