# Use of Marble Powder and Tile Powder as Cementitious Materials in Concrete

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*Abstract*—**The use of agricultural and industrial waste products as raw materials in the construction industry is investigated extensively. These products are inexpensive and help in environmental sustainability, as environmental pollution is thus reduced. This study focused in investigating the properties of fresh, physical and hardened concrete blended with marble (MP) and tile powder (TP) of several proportions, such as 0%, 5% (2.5%MP + 2.5%TP), 10% (5%MP + 5%TP), 15% (7.5%MP + 7.5%TP), and 20% (10%MP + 10%TP) by weight. A total of 60 concrete cylinders were cast with 0.45 water/cement ratio, 1:1.96:2.14 mix ratio, and were cured for 7 and 28 days. These cylinders were used for checking the compressive and splitting tensile strength of concrete. The experimental results showed that compressive and splitting tensile strengths were increased by 8.90% and 8.30% respectively for the 2.5%MP + 2.5%TP sample after 28 days.**

***Keywords-marble powder; tile powder; utilizing waste products; reducing environmental pollution; increasing strength of concrete***

## I. INTRODUCTION

Cement concrete is a widely used material in constructions [1]. Concrete consists of paste and aggregates. The paste consists of water and cement, while the aggregates consist of sand and coarse aggregates, with cement being the most important component, which in contact with water forms a paste, binding the aggregates together into a solid mass [2, 3]. Cement production emits large amounts of $CO_2$, which has adverse effects on the environment [4]. The production of 1 ton of cement emits 1-1.25 tons of $CO_2$, contributing significantly to global warming. Thus, for environmental protection, immediate action is required to minimize the production and use of cement [5-9]. Many methods have been proposed on the use of industrial or agricultural waste as partial cement substitutes [10]. Industrial waste includes waste from marble powder, blast furnace slag, tile powder [11], fly ash and silica fume, while agricultural waste includes rice husk ash [12, 13], corn cob ash [14], wheat straw ash, ground coal bottom ash [15, 16], coconut waste, and bagasse ash, which are used to replace partially the cement in concrete [17, 18]. The use of these wastes as substitutes for cement not only reduces the cost of concrete, but it also minimizes the negative environmental impacts associated to their disposal, and the release of $CO_2$ during cement production [19, 20].

Marble powder is a by-product of the marble industry. Sludge or wet powder is formed during polishing, finishing and cutting marble stone. Fine marble powder, left after processing, polishing, and cutting of marble, is poured into landfills, catchment areas, rivers, dead wells and seasonal rivers, affecting negatively the soil, reducing soil fertility, and subsequently annual crop yield [21-24]. Marble waste mainly consists of boulders, which are used as aggregates, and fine powder which is dumped. Waste marble powder utilization could reduce environmental degradation and $CO_2$ emissions from cement production [25, 26]. About 100 million tons of tiles are produced annually. The 15-30% of the total tile production is converted into waste, without processing. Tile powder utilization has many advantages, such as energy saving, cost and environmental risk reduction [29]. Tile waste could be utilized in concrete to enhance some of its properties, such as strength. The construction industry could consume waste tile powder, helping to solve this environmental problem [27, 28]. Many studies have been conducted on the use of tile by-products in concrete to increase its effectiveness [30, 31]. The current study investigated the properties of fresh, physical and hardened concrete, blended with several percentages of Marble Powder (MP) and Tile Powder (TP) as partial substitutes of cement in concrete.

## II. RESEARCH METHODOLOGY

This study's purpose was to investigate and evaluate the properties of fresh, physical and hardened concrete, by using 0%MP + 0%TP, 2.5%MP + 2.5%TP, 5%MP + 5%TP, 7.5%MP + 7.5% TP, and 10%MP + 10%TP as partial substitutes of cement in concrete. Sixty concrete cylinders were cast, with mix ratio of 1:1.96:2.14, at 0.45 water/cement ratio (w/c). After casting, all specimens were kept in a curing tank,

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and they were tested after 7 and 28 days in a Universal Testing Machine (UTM). Standard cylinders, with 4in diameter and 8in height, were used for casting the specimens, under the ASTM C 192 code procedure. These concrete cylinders were used to obtain compressive and indirect tensile strengths. Moreover, concrete samples were tested for density and water absorption after 28 days. Three concrete samples were cast for each ratio, and the final result was considered as their mean. This study was conducted in the laboratory of Concrete Technology, in H.C.S.T. Hyderabad, Sindh, Pakistan.

TABLE I. CONCRETE MIXES

| Mix ID | RHA + FA (%) | F.A & CA (%) | Cement (%) | Mix ratio | w/c ratio |
|---|---|---|---|---|---|
| 01 | 0%MP+0%TP | 100 | 100 | 1.1.96:2.14 | 0.45 |
| 02 | 2.5%MP+2.5%TP | 100 | 95 | 1.1.96:2.14 | 0.45 |
| 03 | 5%MP+5%TP | 100 | 90 | 1.1.96:2.14 | 0.45 |
| 04 | 7.5%MP+7.5%TP | 100 | 85 | 1.1.96:2.14 | 0.45 |
| 05 | 10%MP+10%TP | 100 | 80 | 1.1.96:2.14 | 0.45 |

## III. MATERIALS USED

### *A. Cement*

The cement used was ordinary Portland, cement locally available in the market of Hyderabad, Sindh, Pakistan. The experimental results of cement are shown in Table II.

TABLE II. PHYSICAL PROPERTIES OF CEMENT

| S. N. | Tests | Results |
|---|---|---|
| 01 | Normal consistency | 30% |
| 02 | Initial setting time | 48min |
| 03 | Final setting time | 240min |
| 04 | Specific gravity | 3.15 |

### *B. Fine and Coarse Aggregates*

The aggregates used are locally available in the region of Hyderabad. Hill sand was used as fine aggregate (FA). It was passed through #4 sieves, and 20mm crushed stone was used as coarse aggregates (CA). The properties of the laboratory test results of the aggregates are shown in Table III.

TABLE III. PROPERTIES OF AGGREGATES

| S.No | Properties | FA | CA |
|---|---|---|---|
| 01 | Fineness modulus | 2.80 | --- |
| 02 | Water absorption | 1.10% | 0.75% |
| 03 | Specific gravity | 2.61 | 2.65 |
| 04 | Bulk density | 128lb/ft$^3$ | 106lb/ft$^3$ |

### *C. Marble Powder (MP)*

MP was collected from the region of Hyderabad. After its collection, it was sieved through #300 sieves and could be utilized as partial substitute of cement in the mix concrete.

### *D. Tile Powder (TP)*

Tile powder was collected from the region of Hyderabad, it was sieved through #300 sieves in order to be used as partial cement replacement in concrete mixes [11].

## IV. RESULTS AND DISCUSSIONS

### *A. Workability of Fresh Concrete*

Fresh concrete was measured for workability in terms of slump losses. As shown in Figure 1, slump value improves as marble powder and tile powder increases, as in [11]. It was observed that the demand of water in the concrete mix declined as the amount of MP and TP increased. The slump value was increased at 3in on the 10%MP + 10TP, while the minimum recorded value was 1.6in on the control sample.

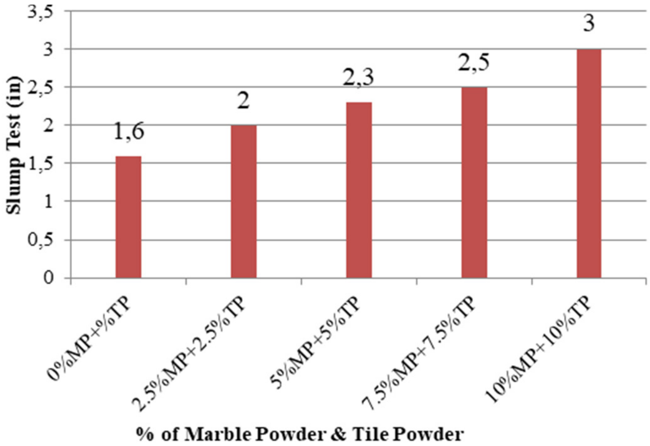


Fig. 1. Slump test

### *B. Density of Concrete*

The concrete specimens were used to analyze the density of the hardened concrete. Figure 2 indicates that the density of the conventional concrete is greater than of the mixes produced with various proportions of MP and TP. The density value of the control mix was 144.90lb/ft$^3$, while a minimum density value of 140lb/ft$^3$ was noticed on the 10%MP + 10%TP sample. Density reduced as MP and TP increased.

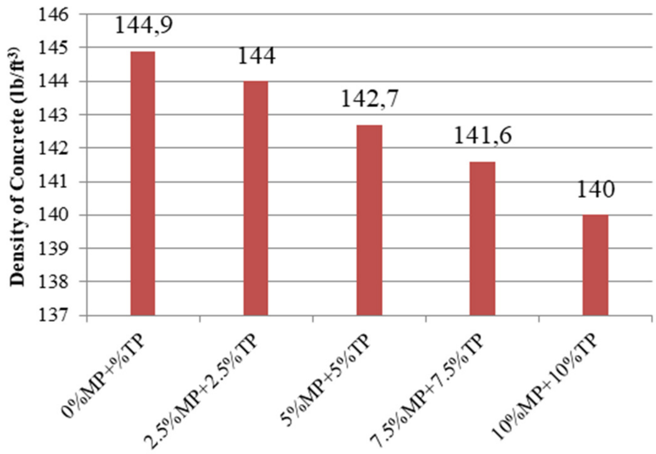


Fig. 2. Density of concrete

### *C. Water Absorption of Conctrete*

Water absorption of the hardened concrete specimens was measured. Figure 3 shows that the water absorption is greater on the conventional concrete than the mixes prepared with various proportions of MP and TP. The water absorption of the control mix was 3.41%, while the lowest (2.87%) was measured on the 10%MP + 10%TP sample. Water absorption value reduced as the content of MP and TP increased.

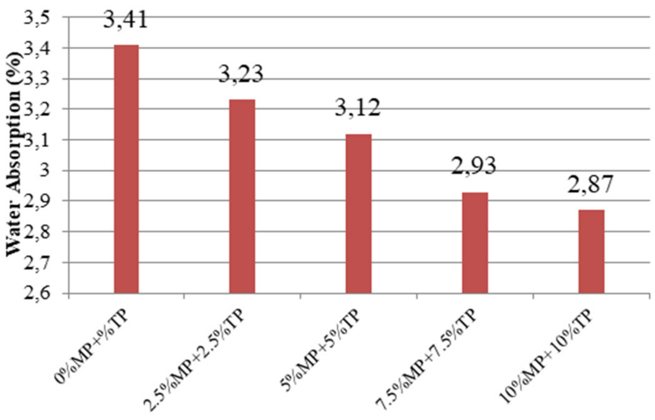


Fig. 3. Water absorption of concrete

### *D. Compressive Strength of Concrete*

The cylindrical samples were used for investigating the compressive strength of the concrete blended with several ratios of MP and TP. Figure 4 shows that maximum compressive strength was improved by 0.6% and 8.9% on the 2.5%MP + 2.5%TP sample, while it reduced about 17.9% and 8.95% on the 10%MP + 10%TP sample, after 7 and 28 days respectively. This trend was also noted in [32].

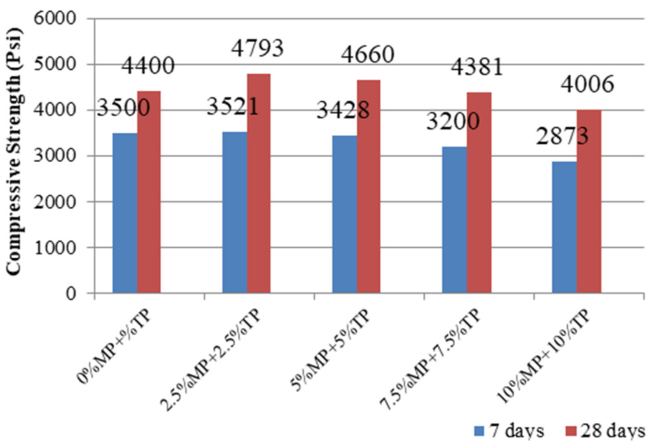


Fig. 4. Compressive strength of concrete

### *E. Indirect Tensile Strength of Concrete*

The cylinder specimens were tested on a UTM for discovering their tensile strength, following the ASTM code. Figure 5 shows that maximum splitting tensile strength improved by 6.80% and 8.30% on the 2.5%MP + 2.5%TP, while it reduced by 23.40% and 19.60% on the 10%MP + 10%TP sample, after 7 and 28 days respectively. This trend was also noted in [11, 33].

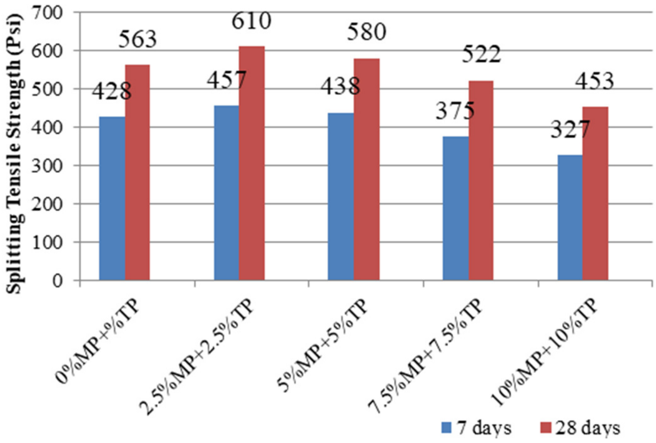


Fig. 5. Split tensile strength of concrete

## V. CONCLUSIONS

On the basis of the experimental results obtained, it is concluded that:

- The slump value was enhanced for the 10%MP + 10TP, while the minimum slump value was recorded on the control mix.
- The water absorption value of the control mix was 3.41%, while the lowest water absorption was 2.87% on the 10%MP + 10%TP mix.
- The density value of the control mix was 144.90lb/ft$^3$, while the minimum density value was 140lb/ft$^3$ on the 10%MP + 10%TP mix.
- Maximum compressive strength increased by 0.6% and 8.9% on the 2.5%MP + 2.5%TP mix, while it reduced by 17.9% and 8.95% on the 10%MP + 10%TP mix, after 7 and 28 days respectively.
- Maximum splitting tensile strength increased by 6.80% and 8.30% on the 2.5%MP + 2.5%TP mix, while it reduced by 23.40% and 19.60% on the 10%MP + 10%TP mix, after 7 and 28 days respectively.

## VI. FUTURE WORK

The use of chemical admixtures along with marble and tile powder may give better results and reduce cost in construction works, so in the future this prospect should be investigated.

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