Effect of pH Solutions on Using Waste Marble powder to Enhance Mortar Compressive Strength

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Abstract
The aim of this study is to improve the compressive strength of mortar by adding a recycled material (marble powder) at different weights gradually to the mortar. The samples were prepared and treated with different pH solutions to investigate how can effect compressive strength. The results showed that after preparing the sample of mortar by adding different weights of marble powder, the Compressive strength of the sample of (4 gm) weight of marble powder had the highest value comparing with other samples. The compressive strength for the samples were treated with different pH showed that it decreased with increasing acidity (pH from 1 to 6), but the other sample’s compressive strength increased with increasing alkalinity (pH from 8 to 14). At (pH from 1 to 14), the compressive strength was increasing gradually.

Key Words. Mortar, Compressive Strength, Waste Marble Powder, pH solutions.

1. Introduction
The applied cement that used to bind structure such as concrete stonework units together is mortar. It is cover and fill the breaks between them, and sometimes enhance nice-looking designs in stonework walls. In addition, mortar consist of clay or soft sludge that used between mud bricks. When cement mortar cures, it becomes tough which result in a rigid construction. The mortar is proposed to be weaker than the structure blocks because it is easier and cheap to reparation than the building blocks. Mortars are typically made from a mixture of sand, cement, and water. The common binder since the early 20th century is Portland cement. Because of, it is significant to the reparation supplies are being similar to the advanced materials; gypsum and Lime are mainly used in the repair and repointing of structures and constructions. The kind and proportion of the overhaul mortar is originated by analyzing a mortar [1,6].

Marble is a rock collected to carbonate crystals (carbonate calcium), most usually calcite or dolomite.
Geologists procedure the word "marble" to state to transformed granite; even though, stonemasons use the term generally to incorporate unmetamorphosed sandstone. As a building material, Marble is usually used for sculpture [2,3].

Before starting the compressive strength test, the cross sectional area of a specimen should be calculated. After taking the ultimate load, the concrete compressive strength value can be got by equation (1) [5]:

\[
\text{Compressive strength} = \frac{\text{Ultimate load (N)}}{\text{cross sectional area (mm}^2)}
\] ………………(1)

The unit of compressive strength will be N/mm².

The pH of a solution is an amount of the molar concentration of hydrogen ions in the solution and also is a measure of basicity or acidity of the solution. The mathematical value that defined as the negative base 10 logarithm of the molar concentration of hydrogen ions is the pH or "power of hydrogen" as following

\[
\text{pH} = -\log_{10}[\text{H}^+]
\]

As in the conventional procedure for determining standard electrode potentials, the quantity of the pH of a sample can be accomplished by figuring the cell potential of that sample in reference to a standard hydrogen electrode. This procedure would provide a value of zero for a (1) Molar solution of H⁺ ions, so that states the zero of the pH scale. The cell potential for any other value of H⁺ concentration can be got with the use of the Nernst equation [8, 10].

Er. Raj P. Singh Kushwah, et.al (2015) Presented in the paper that the marble can be utilized in concrete mix replacement of fine aggregates. Different mechanical by properties of marble slurry are determined like specific gravity, fineness modulus was founded and showed that utilization of marble slurry by replacing it with sand up to 30%, which shows equal strength as of conventional concrete 1:2:4 cement concrete ratio with 0% marble slurry. It concludes that marble slurry can easily be utilized in cement concrete mix [1].

Veena G. Pathan, and Md. Gulfam Pathan (2014) premeditated feasibility of marble powder as the basic of concrete mix. He studied that the compressive strength and tensile strength of concrete can be increases as the addition of waste marble powder as the extra of cement by 10%. This paper also investigates that the marble dust had a great influence on the properties such as consistency, settling time, insoluble residue and soundness. The use of cheaper component such as wastes can solve the ecological problems as well as environmental problems. Therefore, there is a scope for more researches in the field of durable concrete with this waste [4].

2. Experimental Details

2.1. Materials and Equipment

Sand, Marble dust powder, Cement, Mold, Sieve, Water, Hydrochloric Acid solution (HCl 0.1 N), Sodium Hydroxide Solution (NaOH 0.1 N), Beakers, pH meter, Balance, Compressive Strength Machine.

2.2. Mortar Preparation steps

In this stage, different samples were prepared. The first sample is a mixture of sand and cement, while the other samples contain (marble dust powder) in different weights. The powder weights gradually increased from (2gm) to (16 gm) by increasing (2 gm) gradually. Steps of work as follows [7,9]:

1. Materials mixed (sand, cement, water, and marble dust powder).
2. Add 100gm of water to the mixture.
3. Pour the mixture inside the mold.
4. Leave the mold (24 hours) until the samples dry.
5. Samples were taken out of the mold.
6. Place the samples in a water for 28 days.
7. Take the samples out of the water.
8. Samples are ready for compressive strength test.

Figure (1) showed mortar cubes.

2.3. Compressive Strength Test

The test was performed in the device (ADR 3000) Figure (2). The device measured the compressive strength test for the samples after preparation. The maximum load for this device is (300 KN.). After measuring the highest load for each sample, it divided on the cross sectional area of the mortar cube to find the compressive strength value.

The result that got from testing device is the ultimate load to break the concrete sample. The load unit is generally in (lb.) to convert it in newton (N), multiply by acceleration (9.8 m/s²), the purpose is, to know the concrete compressive strength. Compressive strength is equivalent to eventual load divided by cross sectional area of concrete sample. The concrete specimen's dimensions were taken before starting the test and cross sectional area was calculated. The compressive strength value was found depending on the eq. (1) as referred before.

All cubic samples had the same cross sectional area, which was (50 mm x 50 mm = 2500 mm²) [5]. It is noticed that the best compressive strength value was for the sample, which had the marble weight of (4 gm).

The test repeated for other samples that prepared with equal weight of marble powder, which was (4gm) and left for (28) days in different pH solutions (pH from 1 to 14) acidic, neutral and Alkaline. As shown in Figure (3).
3. Results and Discussion

The results of compressive strength test for the samples of mortar, which had marble dust powder by different weight, showed that the highest and best compressive strength value was at weight of (4 gm) marble dust powder as shown in table (I) and Figure (4).

| Sample no. | Marble wt. (gm.) | Load Applied (KN) | Compressive strength (MPa) |
|------------|------------------|-------------------|---------------------------|
| 1          | 0                | 61                | 24.4                      |
| 2          | 2                | 63                | 25.2                      |
| 3          | 4                | 89.7              | 35.9                      |
| 4          | 6                | 59.3              | 23.7                      |
| 5          | 8                | 52.6              | 21.04                     |
| 6          | 10               | 44.3              | 17.7                      |
| 7          | 12               | 28.8              | 11.5                      |
| 8          | 14               | 20.3              | 8.12                      |
| 9          | 16               | 19.6              | 7.8                       |

Figure 3. Mortar Samples in Different pH solutions

Figure 4. The relation between compressive strength and Marble wt.
The results of compressive strength test for the samples of mortar, which had the same weight of marble dust (4 gm) and treated with different pH solutions (pH= 1 to 14), showed that the compressive strength values decreased with increasing acidity and increased with increasing alkalinity and the best value was at (pH=14) which was the highest value as shown in table (II) and Figure (5).

| Sample no. | pH Values | Load Applied (KN) | Compressive strength (MPa) |
|------------|-----------|-------------------|----------------------------|
| 1          | 1         | 64                | 25.6                       |
| 2          | 3         | 86.4              | 34.6                       |
| 3          | 5         | 97.8              | 39.1                       |
| 4          | 6         | 99.5              | 39.8                       |
| 5          | 7         | 123.3             | 49.3                       |
| 6          | 8         | 124.5             | 49.8                       |
| 7          | 10        | 124.9             | 49.9                       |
| 8          | 12        | 125.6             | 50.2                       |
| 9          | 14        | 127.1             | 50.8                       |

Figure 5. The relation between compressive strength and pH Values

4. Conclusion

The aim of this study is to enhance compressive strength of mortar by using marble dust powder and immersed in different pH solutions. The results showed that after preparing the samples of mortar by adding different weights of marble dust and immersed in water for (28) days. Compressive strength test was tested on all the samples. The sample of (4 gm) weight of marble dust had the highest compressive strength value comparing with other samples.

After preparing the samples that have the same weight of marble dust, which was (4 gm). These samples treated with different (pH) solution (from 1 to 14) and left for (28) days.
The sample were dried and tested by using compressive strength device. The compressive strength results showed that it decreased with increasing acidity (pH from 1 to 6), but the other sample compressive strength increased with increasing alkalinity (pH from 8 to 14). At (pH from 1 to 14), the compressive strength was increasing gradually. As marble is consist of calcium carbonate, it is extremely vulnerable to passion by acidic media, even when the solution is a very weak acid.

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