Research Paper

# The Effect of Using Waste Marble Fine Aggregate On Physical and Mechanical Properties of the Concrete

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**In this research study, I showed the effect and efficiency of using marbles waste instead of aggregate on the properties of concrete. These properties include compression, flexural and tensile strength.**

**In this research, I will test 3 samples of concrete in the cubic shape with (10x10x10) cm. These tests will depend on curing and time, that the samples were tested in 7, 14, and 30 days with three different distributions of the marbles in the mixture of the concrete**

**The distribution of the aggregate and the marbles were the same in both the samples at the end, the two different tests are compared together. The overall purpose of the test is to use the waste of marbles in construction and prevent environmental pollution, especially in the regions with lots of usage of marbles and mines.**

Keywords: Waste marble, aggregate, concrete, compressive strength, tensile strength, flexural strength

## 1.1 Introduction:

Marble is mostly used in building materials and design because it has a beautiful view and has properties that vary from other types of stone, which has very low temperatures on hot sunny days.

The mining and using of marbles in the construction have much waste with no usage (Corinaldesi et al., 2019). The marbles stone in the mines have very disordered shapes and for making them usable for transferring and construction they should be turned into desirable shapes in this process there will be produced lots of waste including large to fine marbles. This amount of waste is about 20-30 percent of the overall amount of marbles that are mined. This amount of waste is a large unusable material in the environment with a large amount of pollution (Karasahin and Terzi, 2007).

Using marbles in construction and the concrete mixture can prevent environmental pollution and this can increase the efficiency of using

materials in the environment (Demirel and Yazicioglu 2008, 2006).

There are many research and studies in the field of waste marble whose aim is to show the efficiency of using this material for construction to better clean the environment.

This research is about the usage of marble waste which is the by-product and waste material in the process of sawing and shaping marble stone. The researchers are not reached their aim of effectively using this material instead of aggregate and there should be more research and investigation to achieve the goal of effectively using this material in construction.

This study is going to add an investigation in this field and can prevent pollution in its part for saving the environment.

*Table 1 (Grain size distribution of the aggregate)*

| Sieve size (mm) | Passing (%) |
|---|---|
| 16 | 100 |
| 8 | 67 |
| 4 | 53 |
| 2 | 44 |
| 1 | 32 |
| 0.50 | 19 |
| 0.25 | 10 |

## 1.2 Materials and methods for the test

There are 5 tests to examine the effects of using fine and coarse marble waste on concrete for construction and improving the mechanical efficiency of the concrete mixture.

### 1.2.1 Cement

The cement used in this mixture was the type I of Portland cement according to the ASTM Code which is the normal cement used in the east middle.

### 1.2.2 Marble waste

This material used in the mixture was crashed marbles that were the byproduct of the factories' mining marbles. The marble used in this mixture was sieved through sieve analysis and was matched exactly with the amount of aggregate used in the mixture.

### 1.2.3 Aggregate

The concrete mix in this experiment was produced with coarse and fine aggregate sizes, Maximum size was 16 mm and the density was 2750 kg/$m^3$The following table shows the grain size and other properties of aggregate used in this experiment.

The 0, 50, and 100 % proportions of the sieve analysis materials changed with the marble waste. Also, the waste marble grain size distribution table is as follows

## 1.3 Mix design properties

For every experiment there were 20 concrete specimens were made and for every curing time, there were 5 specimens (7, 14, 21, and 30 days). And in the end, there were 80 cubic specimens (10 x 10 x 10 cm) to find the mechanical properties of Waste marble used in concrete mixture and find the Compressive strength, Sorptivity, and Porosity.

### 1.3.1 Compressive strength

All other values including porosity Sorptivity, modulus of elasticity, and unit weight were determined before the compressive strength of concrete after 30 days (ASTM C39, 1994).

There were five specimens for each period of time to find the compressive strength of concrete and there were 20 cubes for all periods to find the accurate compressive strength of concrete.

### 1.3.2 Sorptivity (water absorption)

All calculations of capillary Sorptivity were found using a pre-conditioned oven at about 50 degrees Celsius until the full original was achieved. After that concrete cubes were cooled down to 25 degrees Celsius (room temperature). Then the cubes were set in a pan with 5mm of water height and four sides are coated with paraffin to achieve unconditional flow to find the exact water flow in the cubes, then during exact times of 0, 5, 10, 20, 30, 60, 180, 360, and 1440 minutes to find the Sorptivity coefficient at the day of 28th.

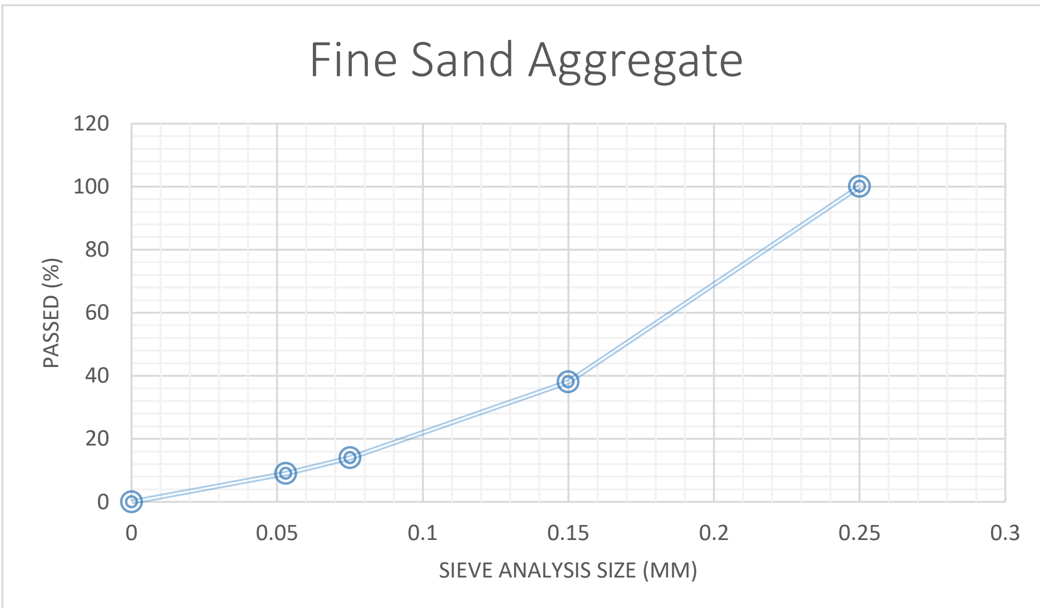


*Figure 1 (Grain size distribution of fine sand aggregate)*

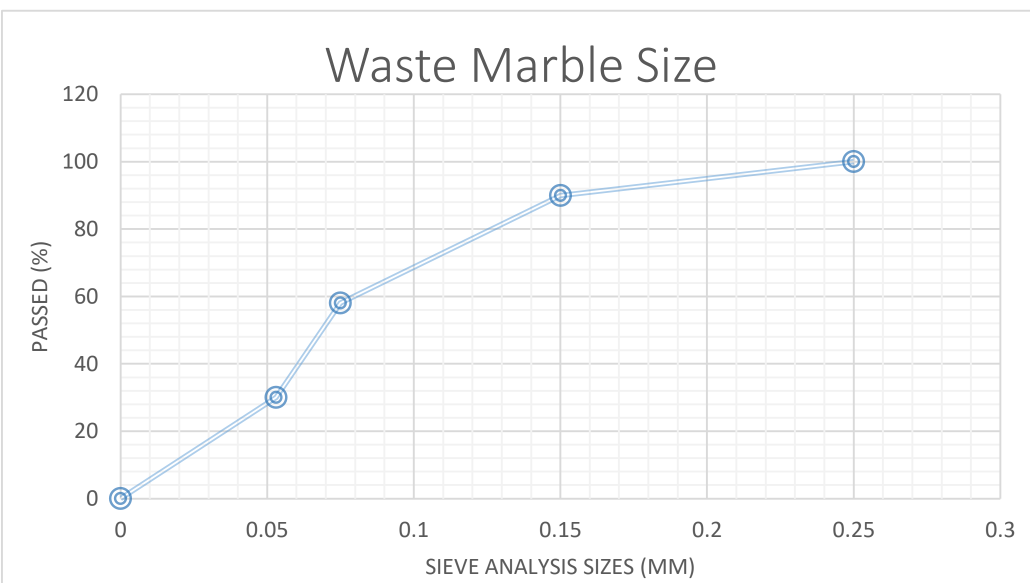


*Figure 2 (Grain size distribution of waste marble dust)*

| Specimen | Water | Fine Aggregate | | Coarse aggregate | Cement | Marble dust |
|---|---|---|---|---|---|---|
| | | (0-025)mm | (0.25-4)mm | (4-16)mm | | |
| MD 0 | 250 | 150 | 650 | 750 | 500 | - |
| MD 50 | 250 | 80 | 650 | 750 | 500 | 90 |
| MD 100 | 250 | - | 650 | 750 | 500 | 180 |
| | | | | | | |

*Table 2 (Details of concrete mixes (kg/m3).)*

The coefficient of Sorptivity has achieved from the following equation:

$$\frac{Q}{A} = k\sqrt{t} \quad \text{Equation 1}$$

Q= the water absorbed by the cubes ($cm^{3-}$)

A= cross-section of the specimen (cubes)

t= time in sec

k = Sorptivity coefficient of the specimen cm/$s^{1/2}$)

(Tasdemir, 2003; Tukmen, 2003)

Porosity

Archimedes principle is the weight of the saturated specimens in the air and water and the dry weight (oven dry 110 degrees Celsius) and porosity were determined in the cubes with 10 cm on each side, the porosity was calculated with this equation (Gonen and Yazicioglu, 2007)

$$P = \frac{(W_{sat} - W_{dry})}{W_{sat} - W_{water}} \quad \text{Equation 2}$$

Dynamic Modulus of Elasticity

The formula for finding the Dynamic Modulus of Elasticity is as follows (Erdogan, 2003)

$$E_d = \frac{V^2 n(1+\mu)(1-2\mu)}{1-\mu}(10^{-6})3 \quad \text{Equation 3}$$

Where $\mu$ = poisson, n = unit weight (kg/m3)

and V =ultrasonic pulse velocity (m/s).

According to the Erdogan (2003), the value of the

Poisson is considered 0.3 at the low quality concrete and 0.15 at the high quality concrete.

A value of 0.2 is generally used for Poisson. In this study m is 0.2.

## 1.4 Results and discussion

Mechanical and physical properties of concrete Mixture

The results in Table 2 show that as long as the amount of waste marble increases the unit weight of specimen cubes increases. This is normal because the unit weight of the Waste marble is more than the coarse and fine aggregate. This is because it has finer particles than aggregates.

Table 2 shows that compressive strength has increased when the waste marble increase and this increase for MD100 is about 5-10% at 21 and 30 days as compared to the MD0. It also shows that when curing time increases the compressive strength is reduced. And as curing increases the waste marble compressive strength decreases. The change of compressive strength with the increase of curing time can be better observed in the Table 2. The highest compressive strength of marble dust concrete is with MD100 which is on days 7, 14, 21, 30 days (Binici et al, 2007).

In the experiment using the Marble waste, an increase in the marble dust decrease the compressive strength. Turker et al. (2002),

has said that the decrease of the compressive strength comes from dilution of $C_2S$ and $C_3S$

*Table 3 (Results of mechanical and physical tests of the specimens.)*

| Code | F'c (MPa)) | | | | Unit Weight(kg/m$^3$) | Porosity(%) | Sorptivity (cm/s$^{1/2}$) | $E_{din}$ (GPa) |
|---|---|---|---|---|---|---|---|---|
| | 7d | 14 | 21 | 30 | | | | |
| **MD 0** | 15.2 | 36.5 | 42.9 | 55.9 | 2235 | 7.2 | 1.26 | 37.2 |
| **MD 50** | 19.4 | 36.7 | 50.8 | 56.2 | 2285 | 6.5 | 1.17 | 41.2 |
| **MD 100** | 22.3 | 39.0 | 54.1 | 56.9 | 2310 | 6.4 | 1.11 | 45.1 |

which are the main cause of cement strength. This experiment shows that using marble dust instead of fine and coarse aggregate will cause the rising of compressive strength in all curing times.

Figure 4 shows the change in porosity with the use of marble dust. The porosity of the concrete mixture decreases as marble waste is added to the mixture.

As said in the literature review marble waste has fine materials and it affects the hydration of cement which is the cause of the reduction in porosity (Kristuloviç,1994). The Below graph provides the provision for the compressive strength of our mixture using marble dust.

Also, the Sorptivity coefficient has been decreased as waste marble increases this claim also has been reported by Topc et al. (2009). Also, the Sorptivity coefficient of the concrete decrease as the compressive strength has decreased. This literature also said by Tasdemir (2003) that the Sorptivity coefficient of concrete will decrease slightly as compressive strength increases (Topcu et al, 2009).

The relation between the compressive strength and the dynamic modulus of elasticity at day 30 is shown in figure 3.

Figure 3 shows the positive correlation between modules of elasticity and the compressive strength of the concrete (Topcu, 2006). At the end of the analyzing the curve the

equation and regression of coefficient ($R^2$) are determined as

$y = 0.025x^2 – 1.4546x + 67.426.$ *Equation 4*

in this formula, the y is compressive strength x is the dynamic modulus of elasticity. When the dynamic modulus of elasticity is calculated by non-destructive testing the compressive strength of a material can be calculated by the above formula.

As the Table 3 shows that the highest modulus of elasticity got from the MD100 sample, has the highest compressive strength, and also has the highest unit weight. This finding is said by Topcu and Isikdag (2008), who said that concrete has a higher modulus of elasticity as a result of the higher compressive strength. And we can say that the using of marble dust decreases the porosity in concrete which is hardened.

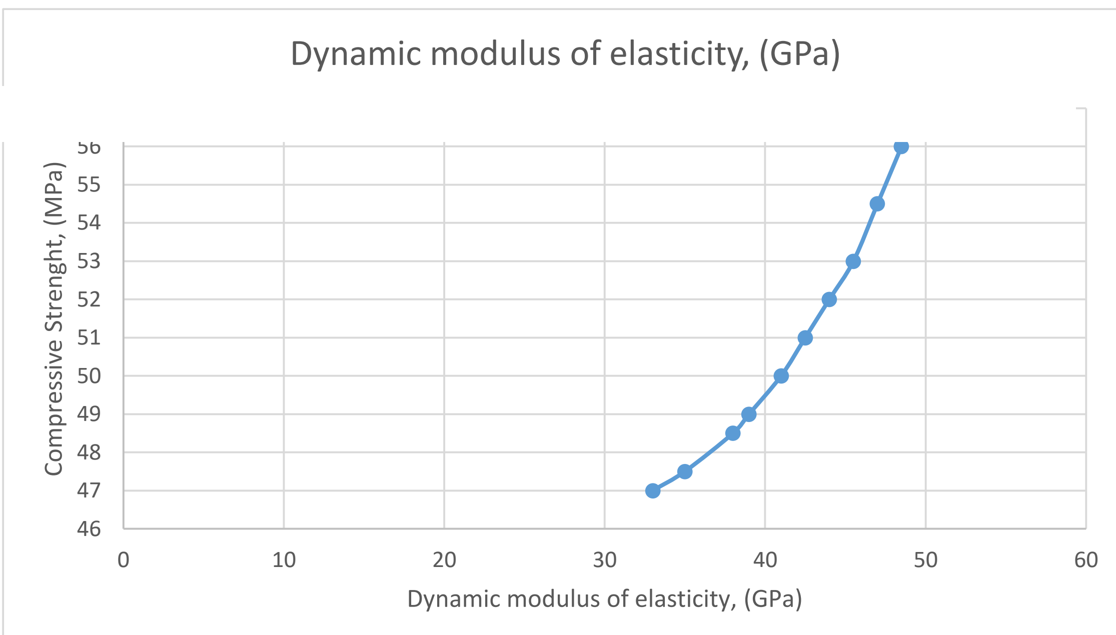


*Figure 3 (Dynamic modulus of elasticity, (GPa).)*

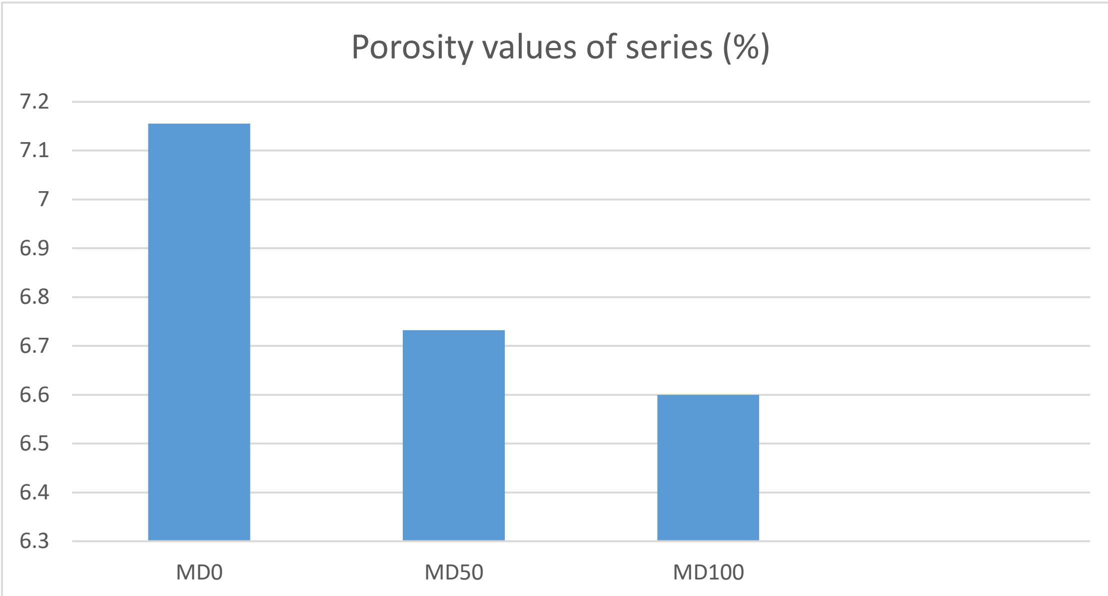


*Figure 4 (Porosity Values in %)*

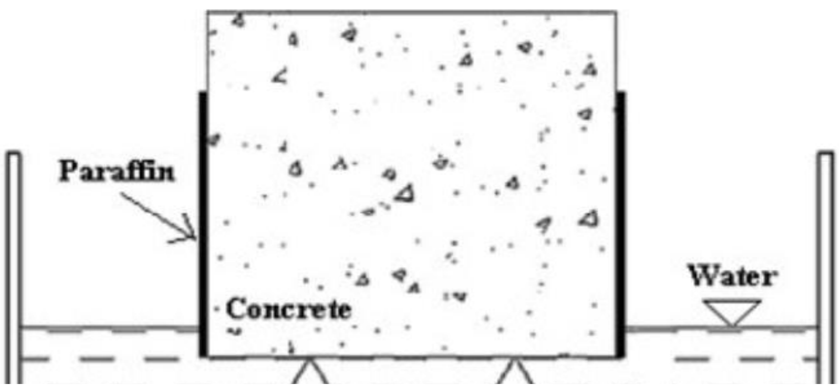


*Figure 5 (The measurement of water capillary sorption)*

## 1.5 Conclusion

After this study and experimentation these conclusions can be got:

I. The test shows that the unit weight of the concrete increased as a proportion of Waste marble decreased because the marble dust has very fine particles.

II. The compressive strength of cement has been increased with the increase of the marble waste in all curing times. And the highest compressive strength of the concrete has been got by MD100 specifically at the early curing times.

III. Series with using fine waste marble with passing 0.25mm sieve got a very better compressive strength than those that hadn't fine marble waste. Because marble waste has very finer

IV. materials than aggregate and plays a good role in the curing and hydration process. (the cement proportion was constant at all series)

The porosity of the concrete decreased with the increase of waste marble. The filler effects of marble waste on cement curing is associated with reducing the porosity.

Using the marble waste effectively decreases the amount of porosity in the concrete mixture.

The highest dynamic modulus of elasticity of concrete has been got from the MD100 series which has the highest compressive strength.

And at the last, this study shows that

Waste Marble can be used effectively in the concrete mixture to improve the physical and mechanical properties of the concrete mixture. Using fine and coarse Waste marble can be an alternative to using aggregate in the concrete mixture.

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