USED MARBLE WASTE AGGREGATE: OPPURUNITIES FOR PRODUCTION OF ECO-FRIENDLY CONCRETE

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Abstract: *The waste generated from the marble industries during the process of cutting and polishing of marble stone is increasing day by day all over the world. So the reuse of the marble waste is necessary because this marble waste results in the accumulation of landfills, environmental and pollution problems. These problems can be reduced by considering the marble waste as a non-primary aggregate in structural concrete. This research describes the feasibility of using marble waste in concrete production by partial replacement of coarse aggregate. The aim of the research is to replace the recycled marble waste aggregate (RMWA) by weight of natural aggregate according to the range of 0%, 25%, 50%, 75% and 100%. The investigation was carried out on different concrete mixes and was tested in terms of workability and compressive strength test. The slump test result shows that as the percentage of RMWA increases the workability increases due to the smooth surface of recycled marble waste aggregate. From the compressive strength test results it was concluded that as the percentage of RMWA increases the strength significantly decreases. The reason for the reduction of compressive strength was the smooth surface of RMWA which results in the weak bond.*

Keywords: Marble industries, marble waste aggregate (RMWA), workability, compressive strength

1. INTRODUCTION

All over the world due to advancement of technologies the amount and different type of waste is generated which lead to the crisis of waste disposal. To overcome these crises the waste material should be reuse by recycling it [1]. Recycling is a process by which we can convert the waste materials into a new product. In the construction infrastructure areas, due to the advance development the use of marble has getting more and more severe [2]. To reduce this problem recycled marble should be used as replacement material. Recycled marble comprises of crushed and graded particle obtained from that material which is used in demolition and construction debris [3]. Marble is metamorphic rock mainly composed of dolomite and calcite, or combination of two carbonate minerals which are formed from limestone due to heat and pressure in earth crush [4]. Due to these force it cause the limestone to change its make- up and texture. This process is known as Re-crystallization. The initial process for changing the demolition and construction debris in to recycled marble is crushing. In this process the marble debris is crushed into the pieces. The equipment used for crushing and rising marble has two crushers i.e. Jaw and cone crusher. The primary Jaw crusher break the marble debris up to 3 inches and the secondary cone crusher break the material up to the maximum required size which varies from ¾” to 2” [5]. Now days the engineering performance of a material is analyzed and measured on the basis of effect on environment. Greece, Spain, Italy, Egypt, USA, France, Belgium, Brazil and Portugal are among the countries which have the marble reserves [6]. All over the world about 40% of total marble reserves are presented in turkey. Annually 7 million tons of marble is produced in turkey [6]. During the last five years the recycled marbles is widely used in the construction era. There are many advantages of using the recycled marble i.e. environment gain, save energy and cost. Environmental gain is the major advantage. The 40% of the total waste generated each year which is estimated 14 million tons is going to land fill according to CSIRO construction and demolition waste [7]. To overcome this problem the reuse of this waste material is necessary and it will also save the natural aggregate quarries. Recycling is a process that can also be done on site. Japan has development a method with in-site recycling system used on the construction site. This method also saved the energy of transporting the materials to the recycling plant. The in-site recycling system method was developed by Kajima Technical and Research Institute (2002). The cost of recycled aggregate is half of cost of natural aggregate which is used in construction.

2. RESEARCH SIGNIFICANCE

The aim for this project is to determine the strength characteristic of recycled marble. The objective of this research work is to investigate possible uses of marble waste in a proposal for transformation from a polluting industrial cluster to an environmental friendly cluster and to reach a community of zero waste.

The proposed research work encompasses the following areas:

1. To review and research of recycled marble waste aggregate (RMWA) concrete.
2. Production and investigation of concrete specimens by using RMWA.
3. To perform the laboratory tests on materials and concrete incorporating with RMWA.
4. The Analysis of the results and finding for the strength characteristics.

3. EXPERIMENTAL METHODOLOGY

3.1 Materials

According to ASTM C50, type-1 cement (Ordinary Portland Cement, OPC) was used throughout the research. Bestway cement was used as binding material. The Lawrencepur sand was used as fine aggregate and Margalla crush was used as coarse aggregate in this research. The marble waste was obtained from an industry located on raiwand road Lahore.

3.2 Physical tests on materials

*3.2.1 Sieve Analysis of Fine Aggregate (*ASTM *C136 - 06)*

Table 1 shows the results of fine modulus of fine aggregate and gradation curve for fine aggregate is presented in Figure 1.

Total Sample weight = 1000 gm.

Table 1 Fineness modulus of fine aggregate

Sieve No.	Sieve Size	Mass Retained (gm.)	Percentage Retained (%)	Cumulative Percentage Retained (%)	Cumulative Percentage passing (%)
#4	4.75mm	45.07	4.507	4.507	95.493
#8	2.36mm	55.52	5.552	10.059	89.941
#16	1.18mm	105.75	10.575	20.634	79.366
#30	600µm	235.83	23.583	44.217	55.783
#50	300µm	241.60	24.160	68.377	31.623
#100	150µm	280.83	28.083	96.46	5.54
Pan	Pan	35.4	3.54	100	0

Fineness Modulus =

$$\frac{\sum(\text{Cumulative \% Retained on Standard Sieves of } 150\mu\text{m or above})}{100}$$

Fineness Modulus = 2.62

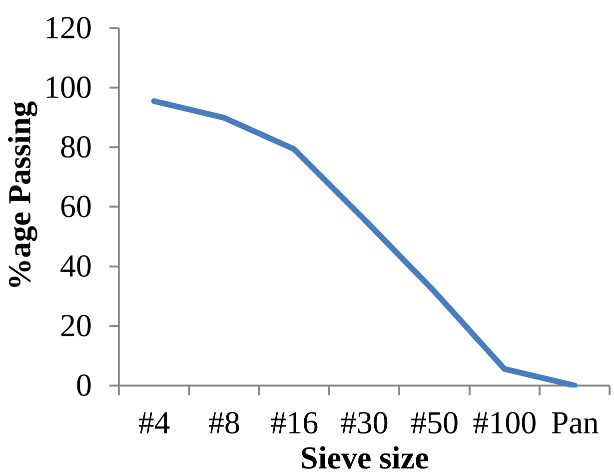

Figure 1 Gradation curve for fine aggregate

3.2.2 Rodded Bulk Density (ASTM C29/C29M-09)

The aggregate bulk density is the total mass of aggregates which is required to fill a unit volume of container after aggregates are batched based on volume.

Cylinder diameter = 6 inches

Height = 1 inches

Volume = 5.56×10^{-3} m^3

Empty weight of cylinder = 5.9 kg

Cylinder + aggregate =13.44 kg

Bulk density= $\frac{13.44-5.9}{\text{Volume}}$ =1655.34 kg/m^3

3.2.3 Los Angeles Abrasion Test (ASTM C-131):

It is defined as the "resistance of a material against scratching, wear, or degradation." And can be find by using the formula given below. The Los Angeles abrasion testing machine is shown in Figure 2.

Los Angeles Abrasion Value = Original Weight – Final Weight/Original Weight x 100

Where,

Final weight = Weight retained on sieve #12

For Marble

Original weight of the sample, W1 (kg) = 5 kg

Final weight after test (retained on sieve #12), W2 (kg)=3.58 kg

Los Angeles Abrasion Value = Original Weight – Final Weight/Original Weight x 100

= 5 – 3.58 / 5 × 100 = 28.4 %

For Crush

Original weight of the sample, W1 (kg) = 5 kg

Final weight after test (retained on sieve #12), W2 (kg)=3.85 kg

Los Angeles Abrasion Value = Original Weight – Final Weight/Original Weight x 100

= 5 – 3.85 / 5 × 100 = 23.4 %

Figure 2 Los Angeles abrasion testing machine

3.3 Mixing of Concrete

The mixing of concrete was done in the concrete mixer as shown in the Figure 3. The performance of RMWA was influence by mixing which means that a good and proper practice mixing will results in good quality of RMWA concrete. Another factor which should be considered is the homogeneity of mix which can lead a better strength and bonding of cement with aggregate.

Figure 3 Concrete Mixer

3.4 Placing, Compaction and Casting of Concrete Specimens

After mixing the fresh concrete is placed into the concrete moulds which were oiled before placing concrete [8]. After placing the fresh concrte in the moulds the compaction was done to avoid the entrapped air. Then the leveling of concrete was done on the surface and left the moulds for 24 hours to set.

3.5 Curing of Concrete Specimens

After 24 hours the concrete cylinders were placed into the curing tank as shown in Figure 4 in further for 7, 14 and 28 days for the hardened properties test of recycled marble concrete.

Figure 4 Curing Tank

4. RESULTS AND DISCUSSIONS

4.1 Slump Test

Slump cone test was performed to determine the workability of fresh concrete shown in the Figure 5. The Table 2 shows that the value of slump increases as the percentage of RMWA increases which results in the good workable concrete. The workability increases due to the smooth surface of RMWA and the result is presented in Figure 6.

Figure 5 Slump test

Table 2: **Slump value against percentage replacement of RPWA concrete**

Percentage Replacement	Slump (mm)
0 %	48
25 %	55
50 %	63
75 %	70
100 %	78

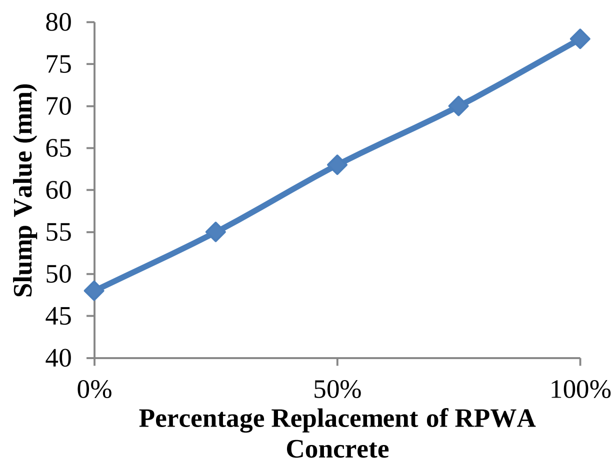

Figure 6 Graph between percentage replacement and Slump Value

4.2 Compressive Strength Test

Addition of recycled marble resulted in a significant reduction in concrete compressive strength as compared with the control concrete. Compression test was performed on 7, 14 and 28 days on pair of 3 cylinders [9] .Increasing percentage of RMWA causes reduction in strength and at 100 % replacement this reduction is quite significant. Cylinders were tested by compression testing machine and readings were noted shown in Figure 7 and Figure 8.

Figure 7 Compression testing machine

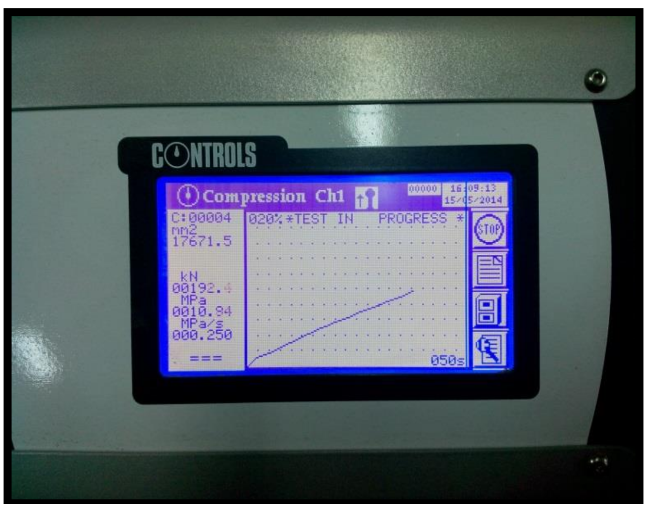

Figure 8 Reading observed

Compressive strength decreases when the percentage of RMWA is increased this can be seen in Figure 9. The value of Compressive strength test values obtained at different ages is shown in Table 3.

Table 3 Average Compressive Strength of RMWA concrete at different percentage replacement

Concrete age	A (0 %)	B (25 %)	C (50 %)	D (75 %)	E (100 %)
7 days	2535 psi	2488 psi	2457 psi	2399 psi	2343 psi
14 days	3272 psi	3200 psi	3121 psi	3002 psi	2879 psi
28 days	4111 psi	4035 psi	3989 psi	3914 psi	3821 psi

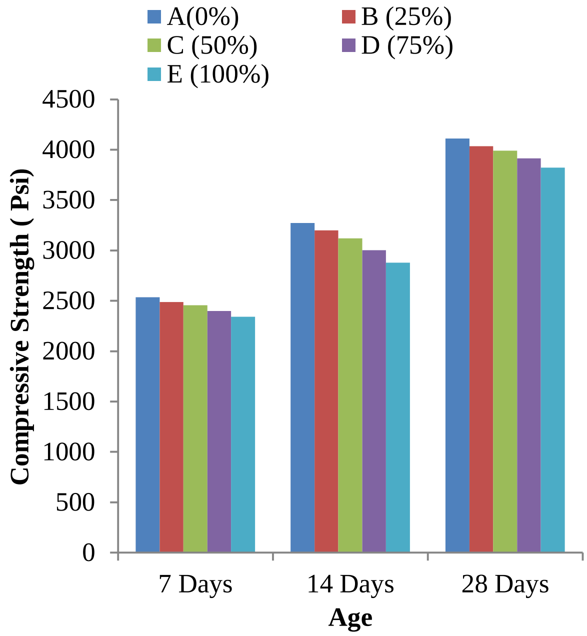

Figure 9 Relation between Age and Strength of Recycled Marble at different percentage of Marble

As the recycled marble percentage increases, more reduction of compressive strength was observed and relation between age and strength of RMWA concrete can be seen in Figure 9**.** The results show that recycled marble does not show exhibit typical failure behavior. Compressive strength test was also performed for concrete samples containing 100% recycled marble. The average compressive strength at 28 days was noted to be 3821 psi.

5. CONCLUSION

The use of Marble waste as an aggregate helps in solid waste management as the marble is excessively available waste.

At 100 % replacement Unit weight was around 2520 kg/m^3 which is about 5 % higher than that of normal weight concrete.

At the same water cement ratio the workability of Recycled Marble concrete is higher than that of control concrete due to the smooth impervious surface of RMWA.

In comparison with the control concrete the compressive strength is found to be 7% less at 100 percent replacement.

The compressive strength decreases due to weak bond between aggregates and marble waste because of smooth surface of RMWA.

6. REFERENCES

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