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UTILIZATION OF MARBLE WASTES IN CEMENT BRICKS FOR AN ENVIRONMENTAL BENEFICIAL

J. K. Ranavasiya[1], S. C. Jain[2], J. V. Modi[3]

[1]J. K. Ranavasiya, Student of Dept. of Mining Engineering, C.T.A.E, Udaipur, Rajasthan, India
[2]S. C. Jain, Faculty of Dept. of Mining Engineering, C.T.A.E, Udaipur, Rajasthan, India
[3]J. V. Modi, Faculty of Department of Mining Engineering, G.E.C, Palanpur, Gujrat, India

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Abstract - *Marble is the world's largest natural stone, followed by granite, sandstone, limestone, slate, quartzite and more. Around 90% of the world's production of marble comes from India. The marble industry is one of the most environmentally unfriendly industries. It is estimated that 20 % to 50 % of the marble slabs are converted into powder when sawed. This waste is needed when developing some value-added products and reducing the impact on the environment. Marble wastes were collected from marble processing units in Gujrat, India and brick mortars were prepared with varying proportions of cement, sand and marble waste. In the present study attempts were made to find the suitability and reliability of marble waste in manufacturing bricks. Five different size marble waste MW1(10 mm), MW2(4.75 mm), MW3(2.36 mm), MW4 (2 mm) and MW5 (300 mic) were used for making bricks with four different proportions (60:20:20, 65:17.5:17.5, 70:15:15, 75:12.5:12.5). Six bricks specimen were prepared from each type of mix and were cured for four different curing period of 7, 14, 21 and 28 days. Laboratory test were conducted to assess the compressive strength and water absorption of bricks specimen. The results of study show that the MW1(10 mm) with proportion1 (60:20:20) had a highest compressive strength 40.5 N/mm^2 and water absorption 1.73 %.*

Key Words: **Marble waste, Bricks, Compressive strength, Water absorption.**

1. INTRODUCTION

The word marble comes from a Greek word, it means a shiny stone. The word marble is originated from the Latin 'Marmor', which itself comes from the Greek root 'Marmaros' It means a shiny stone. The industry's technical, operational and management practices are underdeveloped and also significantly increased waste generation. Marble is a very common building material. It is usually a rich source of calcium carbonate and it's had various applications. In India, most of the wastes from marble industries are being released from marble.

Cutting, polishing, processing and grinding. At the end of the cutting and polishing processes in marble factories, two types of waste material are obtained. First is the marble waste slurry (MWS) that consists of the marble dust mixed with water during the cutting and polishing process, second is the broken marble pieces that rupture from marble blocks and slabs. This process is illustrated in Fig.1.

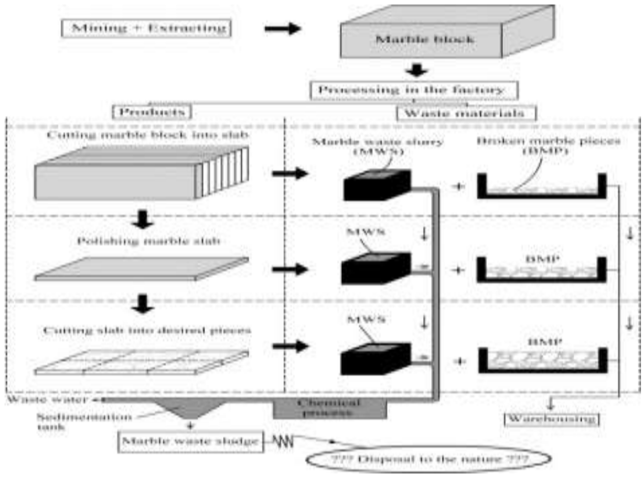

Fig -1: Formation process of marble waste sludge.

The amount of marble waste generated during the extraction of marble blocks is estimated to be 30 % to 40 % of the production (in a mechanized mine using wire saws, etc.), using conventional blasting techniques to produce 60 % to 70 % in the mine (Mehta and Mehta, 2015).

Exposing waste directly to the environment can cause environmental problems. Therefore, many countries are still studying how to reuse waste. This waste is dumped and left unattended, creating a dangerous problem. This waste is needed when developing some value-added products and reducing the impact on the environment.

Bricks are one of the most common masonry units used as building materials. The marble slurry is essentially chemical dolomite, composed of very fine particles. In view of chemical properties, it can be used as a fine aggregate in the production of bricks by using cement or lime as a binder. The results are very encouraging, the physical properties of the bricks produced in this process exceed the physical properties of ordinary bricks (Rajgor and Pitroda, 2013, Khandve and Rathi, 2015, Sadek et al., 2013, Hamza et al.,2011).

2. MATERIALS AND METHOD

2.1 Properties of Material

2.2.1 Specific gravity

Specific gravity is the ratio of the weight of a given volume of a material in air at a standard temperature to the weight in air of an equal volume of distilled water at the same stated temperature. Pycnometer is generally used for clay, smaller than 10 mm. The specific gravity of all materials was analysed according to the [IS:2386 (part III):1963].

Table 1 Specific gravity of the materials

Materials	Specific gravity
Cement	3.00
Sand	9.98
Marble waste 1 (MW1) (10 mm)	2.67
Marble waste 2 (MW2) (4.75 mm)	1.83
Marble waste 3 (MW3) (2.36 mm)	3.78
Marble waste 4 (MW4) (02 mm)	3.64
Marble waste 5 (MW5) (300 micron)	2.75

2.2.2 Bulk density (Unit weight)

The proportion of ingredient can be converted by mass to volume using bulk density of aggregates. Bulk density may be defined as the weight of aggregate required to fill a container of a given volume. Bulk density of aggregate can be calculated for loose weight or rodded weight.

Table 2 Bulk density of the materials

Materials	Bulk density (kg/m^3)
Cement	3100
Sand	1600
Marble waste 1 (MW1) (10 mm)	1600
Marble waste 2 (MW2) (4.75 mm)	1500
Marble waste 3 (MW3) (2.36 mm)	1500
Marble waste 4 (MW4) (02 mm)	1500
Marble waste 5 (MW5) (300 micron)	1100

2.2.3 Chemical analysis

The result of the chemical analysis of various materials are in Table 3. It depicts the concentration (in percentage) of elements in different ingredients mainly, silica, alumina oxide and calcium carbonate percentage were considered for preparing bricks. Table 3.1 shows that the percentage of calcium carbonate and silica in marble waste is 95.80 % and 1.94 % respectively. Other elements were also observed in traces inn the materials. It influences the better bonding in the product and give batter compressive strength of the bricks.

Table 3 Chemical analysis

Sr.no.	Major Elements (wt%)	Marble dust sample
1	SiO_2	1.94
2	TiO_2	0.01
3	Al_2O_3	0.07
4	Fe_2O_3	0.10
5	MnO	0.02
6	MgO	0.80
7	CaO	53.64
8	K_2O	0.02
9	P_2O_5	0.01
10	LOI	43.00
11	$CaCo_3$	95.80
12	$MgCo_3$	1.40

3. EXPERIMENTAL INVESTIGATION

3.1 Proportion of mixes

The proportion of the material was decided based on various studies (Ullas et al, 2010; Muduli et al, 2010; Yongliang et al, 2011; Zhao et al, 2012). Twenty types of mixture were prepared. All mixture was made of cement, sand and different grain size marble waste. Where cement was replaced with marble waste as mentioned in Table 4.

Table 4 Ratio of composition for marble waste bricks

Mixture (MW:C:S)		Ratio (in %)		
		Marble waste (W)	Cement (C)	Sand (S)
MW 1,2,3,4,5	proportion 1	60	20	20
	proportion 2	65	17.5	17.5
	proportion 3	70	15	15
	proportion 4	75	12.5	12.5

3.2 preparation and casting of bricks specimen

The ingredient for concrete mixture were weighed accurately to prepare the batch composition. Five different types of marble waste were taken and each size of marble waste have four different proportion so that twenty type of concrete mixture were prepared. The marble waste particles were allowed to pass through sieves and 10 mm, 4.75 mm, 2.36 mm, 2 mm and 300 microns & single size aggregate were used as coarse aggregate for modular bricks.

After preparation of concrete mixture, required amount of mixture was filled into the mould and after filling the mould, tamping rod was used for the tamp mixture evenly in the mould. After drying of brick specimen, they were extracted out from there mould and then their specimens were immersed in water for curing. Curing is a process which the brick specimens were kept in the water tank to facilitate hydration process, which increases compressive strength of bricks. In the study, curing was done for 7 days, 14 days, 21 days and 28 days, each having six bricks of each proportion.

3.3 Specimen analyses

3.3.1 Compressive strength

The compressive strength test was carried out using a Universal Testing Machine (UTM) as shown in Fig. 3.10, which has a capacity of 3000 kN. The load was applied with a rate of 0.5 kN/s, uniformly, the load at which the specimens break was noted down and the compressive strength was obtained with the help of Equation 1. For the compressive strength calculation, the surface area of each brick was considered to be 190×90×90 mm.

$$Compressive\ strength = \frac{Maximum\ load\ at\ failure}{surface\ area} \quad (1)$$

Fig- 2: Universal testing machine to determine the compressive strength of bricks specimen

3.3.2 Water absorption

Figure 3 shows the bricks for different curing periods. To measure the water absorption capacity of brick specimen, the weight of dry bricks was measured and then these bricks were kept in the water tank for 24 hours at the room temperature. After 24 hours, the bricks were taken out from the tank and kept for 3 minutes and then their weight was taken as wet bricks weight. The water absorption capacity was calculated using the equation 2.

$$water\ absorption = \frac{[wet\ weight - dry\ weight]}{dry\ weight} \times 100 \quad (2)$$

Fig- 3: Bricks for different curing periods (7, 14, 21, 28 days)

4. RESULTS

4.1 Compressive strength of bricks prepared from MW

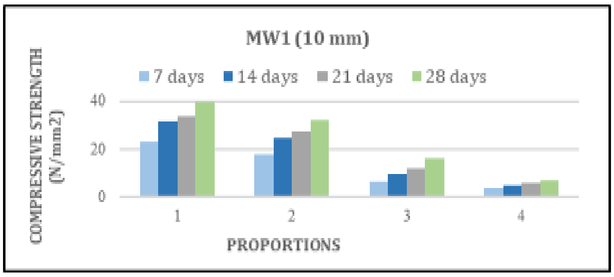

Chart –1: Average compressive strength of MW1 for all proportions

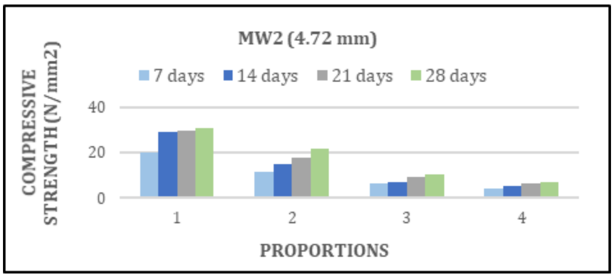

Chart -2: Average compressive strength of MW2 for all proportions

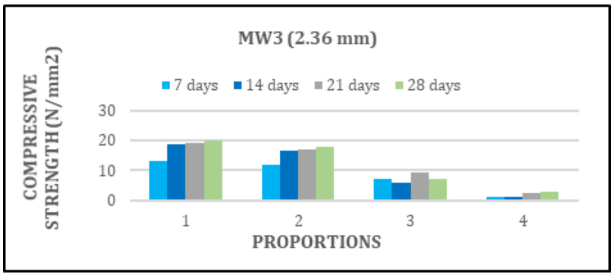

Chart -3: Average compressive strength of MW3 for all proportions

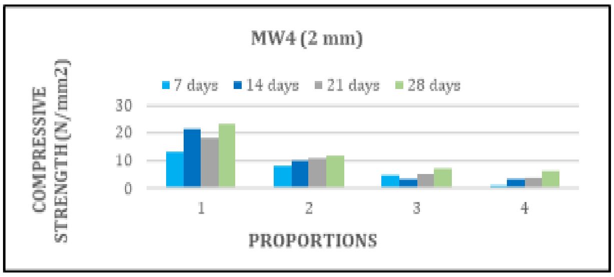

Chart -4: Average compressive strength of MW4 for all proportions

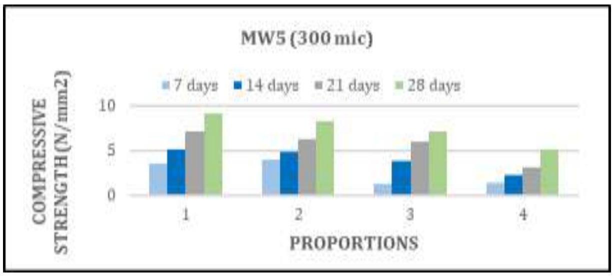

Chart -5: Average compressive strength of MW5 for all proportions

Table 5 Average compressive strength of MW

Average Compressive strength (CS) (N/mm2) (6 specimens)																
Marble waste (MW): Cement (C): Sand(S): (MW:C:S) Mixture for Single Size Aggregate																
Proportions	**60:20:20**				**65:17.5:17.5**				**70:15:15**				**75:12.5:12.5**			
Curing(days)	**7**	**14**	**21**	**28**	**7**	**14**	**21**	**28**	**7**	**14**	**21**	**28**	**7**	**14**	**21**	**28**
MW1(10mm)	23.23	31.93	33.92	**40.5**	17.57	24.83	27.23	32.08	6.72	9.92	11.92	16.30	3.70	5.00	6.00	7.03
MW2(4.75 mm)	20.28	29.10	29.93	31.08	11.70	14.95	18.02	21.53	6.58	7.20	9.25	10.23	4.15	5.42	6.63	7.00
MW3(2.36 mm)	13.18	18.63	19.17	19.93	11.88	16.68	17.23	18.00	7.11	6.02	9.	7.27	**1.17**	1.33	2.28	3.00
MW4(2 mm)	13.13	21.60	18.30	23.18	8.23	9.93	10.80	12.00	4.70	3.63	5.52	7.07	1.28	2.33	3.68	6.05
MW5(300 mic)	3.45	5.02	7.02	9.03	3.88	4.80	6.20	8.28	1.18	3.80	5.95	7.02	1.40	2.23	3.12	5.08

Table 6 Average water absorption of MW

Average Water absorption (WA) (%) (12 specimens)				
Proportions	**60:20:20**	**65:17.5:17.5**	**70:15:15**	**75:12.5:12.5**
MW1 (10 mm)	1.73	1.59	0.93	1.36
MW2 (4.75 mm)	**0.52**	1.02	1.92	1.94
MW3 (2.36 mm)	3.84	2.79	2.61	3.32
MW4 (2 mm)	2.43	2.10	2.84	2.97
MW5 (300 micron)	5.43	6.20	**10.31**	6.03

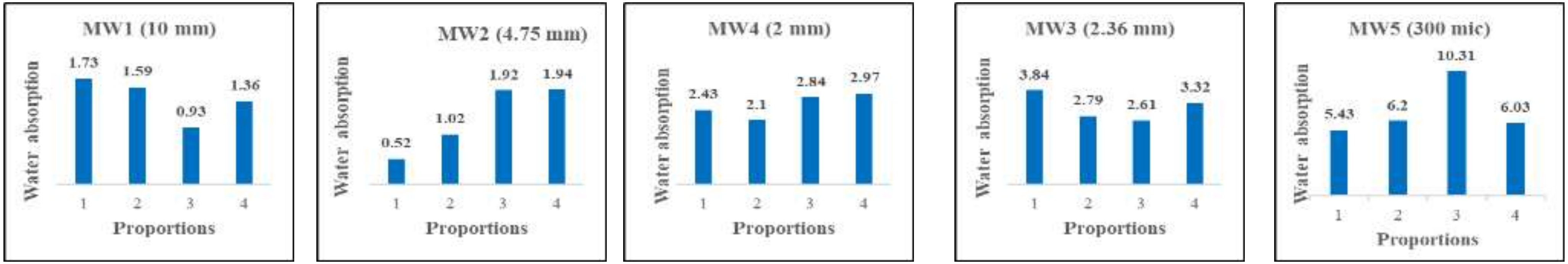

Chart -6: Water absorption of MW

5. CONCLUSIONS

- After analysis of results of compressive strength, it defined that proportion 1 (60:20:20) is the best proportion for the manufacturing bricks because proportion 1 gave a higher compressive strength.
- It is observed from the results that by increasing weight in percentage of marble powder, compressive strength of bricks decreased. These bricks can be used in areas where higher strength is not a concern especially in shelter for people of earthquake and flood affected areas.
- The average water absorption of all marble waste bricks is less than 20% and it is also satisfied the bureau of Indian standards (IS-2180:1988 and IS-1077:1992)
- From the environmental point of view, these bricks are made without firing, which is an advantage over fired bricks in terms of low embodied energy bricks. Hence, study demonstrates that the marble waste can be utilized as aggregate in manufacturing of non-fired bricks, without conforming to its quality/standards.
- By utilizing these kinds of marble waste which are threat for the environment so minimizing the land water and air pollution.
- Manufacturing of building bricks without burning of solid fuel is one of the options for reducing the emission of CO_2 gas

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AUTHORS

Ranavasiya jyoti k

Student of M.Tech final year

Mining engineering C.T.A.E, Udaipur. Rajasthan

Dr. S.C.Jain

Faculty of mining Engineering Department C.T.A.E, Udaipur. Rajasthan

Jimesh Modi

Faculty of mining Engineering Department G.E.C, Palanpur, Gujrat.