International Journal on Emerging Technologies **9**(1): 50-54(2018)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

An Experimental Investigation of Properties of Cement with Waste Marble Powder in Cement

Er. Nishant Punia[1] and Er. Sunil Kumar[2] and Er. Vikram[3]
[1]Research Scholar, Department of Civil Engineering, JCDMCOE, Sirsa, (Haryana), India
[2]Assistant Professor, Department of Civil Engineering, JCDMCOE, Sirsa, (Haryana), India
[3]Assistant Professor and H.O.D, Department of Civil Engineering, JCDMCOE, Sirsa, (Haryana), India

(Corresponding author: Er. Nishant Punia)
(Received 10 April, 2018 accepted 14 June, 2018)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Waste marble powder has been taken for detailed study as a lot of research work has already been done on other waste materials and there is a lot of scope for research on WMP as a replacement to cement, sand or both. Here in this case, cement has been partially replaced with in varying proportions from 0% to 50% and its effect was analysed on the standard consistency, soundness, setting times of cement and compressive strength of cement mortar mixes.

The study shows that Standard consistency of cement paste made with cement partially replaced with WMD has slightly decreased. It decreases gradually from 28.5% for controlled mix to 26% for 50% replacement of cement. The initial setting time and final setting time of cement pastes although increases to some extent by the use of waste marble powder but remain well within the permissible limits as per code provisions. Compressive strength of cement mortar decreases. However, from the general requirements of strength for 43 Grade ordinary Portland cement, waste marble powder can successfully be used upto 20% of replacement of cement. Utilize waste marble powder, which is a humanitarian issue, requiring urgent attention to safeguard against environmental pollution.

I. INTRODUCTION

It is generally known that, the fundamental requirement for making concrete structures is to produce good quality concrete. Good quality concrete is produced by carefully mixing cement, water, and fine and coarse aggregate and combining admixtures as needed to obtain the optimum product in quality and economy for any use. Waste marble powder is generated as a by - product during cutting of marble. The waste is approximately in the range of 20% of the total marble handled [1, 3].

In general, the industry of dimensional stone marble has contributed to the development of major environmental problems due to waste generation at different stages of mining and processing operations. [2] Waste generation continues from mining process to finished product and is about 50% of mineral mined; the dried slurry product is quiet fine. 90% of the particles are below 200 µm. Depending on the kind of process involved, the sludge generated is equal to between 20% and 30% of the weight of the stone worked. Among these waste materials, waste marble dust is a byproduct of marble processing factories. Some references estimate that 20-25% of the marble/granite produced results in powder in the form of slurry, as for each marble or granite slab of 20 mm produced; 5 mm is crushed into powder during the cutting process [6]. This powder flows along with the water forming marble slurry. Waste marble dust can be used as an additive material in production of cement and cost of the cement production can be reduced by this application [4].

Major component of chemical composition in waste marble powder is calcium oxide (CaO) as reported by various researchers. Chemical composition is given in Table 1.

Table 1: Chemical Composition.

Chemical	Marble Powder (%)
SiO_2	1
CaO	52.6
MgO	2.1
Al_2O_3	0.2
Fe_2O_3	0.2
SO_3	0.07
K_2O	0.04
TiO_2	0.01
Na_2O	0.06
CL	-
MnO	-
LOI	43.63

Physical Properties: Some researchers say that Blaine fineness for WMP is much more than for portland cement i.e. 5960 cm^2/g against 4375cm^2/g . Due to high degree of fineness of WMP, it has resulted to be very effective in providing very good cohesiveness of mortar and concrete. It also results in decreasing the porosity. However, the fineness reported by other researchers is comparable to sand and can be used as replacement of sand [5].

II. MATERIALS AND METHOD

The properties of materials used for making cement mortar mixes were determined in the laboratory as per relevant Indian Standard codes and under controlled conditions. The material characterization was carried out for all the major ingredients of cement mortar. The purpose of the characterization is to check their acceptability as per the relevant Indian Standards so as to enable an Engineer to design a concrete mix for a particular required strength. The properties of various materials which are required in this study are Ordinary Portland Cement (grade 43), waste marble powder, standard sand of grade 1, 2 and 3 and water.

A. Waste Marble Powder

The marble dust in powder form was collected from locally available source in Sirsa. It was white in color; air dried and was packed in bags in powder form as shown in Fig.1.

Fig.1.

B. Tests Performed

The tests that were performed in order to study the efficiency of waste marble powder as partial replacement of cement included fresh state and harden state tests

Standard Consistency. This test is performed to know the amount of water to be added to the cement so as to get a paste of normal consistency i.e. the paste of a certain standard solidity. The consistency of fresh pastes, with or without partial replacement of cement were tested according to IS 9597:1989. The material used for performing the tests for different mixes is presented in Table 2.

Table 2: Quantity of Materials Used for Standard Consistency.

S.NO.	Cement (gm)	WMP (gm)	Water (gm)
1	500	0% (0)	142.5
2	450	10% (50)	140
3	400	20% (100)	137.5
4	350	30% (150)	137.5
5	300	40% (200)	132.5
6	250	50% (250)	130

Initial and Final setting time. Mass of cement and waste marble powder (as per replacement %) taken= 500 gm Mass of water taken= 0.85P x 500 gm.

The amount of materials taken for measuring the setting times for all the mixes is presented in Table 3.

Table 3: Setting Time Results.

S.No.	WMP (%)	Consistency (%)	Sample Mass		Water(Gm)
			Cement (Gm)	WMP (Gm)	
1	0	28.5	500	0	121.1
2	10	28	450	50	119
3	20	27.5	400	100	116.9
4	30	27.5	350	150	116.9
5	40	26.5	300	200	112.6
6	50	26	250	250	110.5

Soundness. Soundness of all the mixes with or without waste marble powder were measured as per IS 269- 1976. The quantity of materials required for performing the soundness tests are listed in Table 4.

Table 4: Quantity of Materials Required for Soundness Test.

S. No	%age WMP	Standard Consistency (%)	Water 0.78P (gm)	Mass Of Sample	
				Mass Of Cement (gm)	Mass of WMP (gm)
1	0	28.5	22.23	100	0
2	10	28	21.84	90	10
3	20	27.5	21.45	80	20
4	30	27.5	21.45	70	30
5	40	26.5	20.67	60	40
6	50	26	20.28	50	50

Compressive Strength of Concrete Mixes. For casting of cement paste samples, the quantities of cement, each size of aggregate and water for each batch were determined by weight. The ingredients were mixed in the DIGI mortar mixer. Standard sand grade 1 being coarser was added first, then grade 2 and lastly grade 3 sand is added. Cement was then added along with WMP. The period of mixing should be not less than two minutes after all the materials are in the drum and had to continue till the resulting mix is uniform in appearance. Then water was slowly introduced and mixing was continued till uniform mix was obtained. The entire procedure as laid down above was diligently followed for preparation of all the concrete mixes.

Table 5: Qty of Materials Required for Compressive Strength.

S. N	Mix	WMP (%)	Consistency (%)	Cement (gm)	WMP (gm)	Standard Sand (gm)			Water (gm)
						Grade 1	Grade 2	Grade 3	
1	M1	0	28.5	200	0	200	200	200	81
2	M2	10	28	180	20	200	200	200	80
3	M3	20	27.5	160	40	200	200	200	79
4	M4	30	27.5	140	60	200	200	200	79
5	M5	40	26.5	120	80	200	200	200	77
6	M6	50	26	100	100	200	200	200	76

III. RESULTS AND DISCUSSION

Tests were conducted for finding the effect on consistency, soundness and initial and final setting times of cement by changing the replacement levels of cement with waste marble dust. The strength characteristics of mortar containing marble dust are also discussed. The tests were performed on the hard cement mortar under standard laboratory conditions and compressive strength of cement mortar cubes was observed at curing ages of 3, 7 and 28 days respectively.

A. Standard Consistency Test

Table 6: Standard Consistency Results.

WMP (%)	Cement (gm)	WMP (gm)	Water (gm)	Standard Consistency (%)
0	500	0	142.5	28.5
10	450	50	140	28
20	400	100	137.5	27.5
30	350	150	137.5	27.5
40	300	200	132.5	26.5
50	250	250	130	26

From above results, it is seen that standard consistency decreases with increase in replacement percentage of cement with waste marble powder. It illustrates that need of water for WMP is less? The reason for this is that specific surface of WMD is less than the specific surface of cement. As a result of this, the water requirement value decreases related to the control cement by increasing the WMD ratio in cement.

B. Initial and Final Setting Times

Table 7: Setting Time Results.

S.No.	WMP (%)	Consistency (%)	Setting Time		Δt (minute)
			Initial (Minute)	Final (Minute)	
1	0	28.5	90	280	190
2	10	28	124	301	177
3	20	27.5	174	335	161
4	30	27.5	196	367	171
5	40	26.5	207	398	191
6	50	26	229	419	190

It can be observed from the table that both IST and FST increase with increase in percentage of WMP. However, the values still remain in the permissible limit as presented by IS 4031- (Part 5)- 1988, i.e the IST of all the mixes is greater than 30 min; FST is less than 600 min. The increase in settle time can be attributed to change in chemical composition of cement. Although the fineness of WMP is almost similar to cement, the chemical composition Indicates lesser amount of CaO & SiO_2. Hence, the percentage of cement hydration compounds formed will decrease, which are responsible for setting of cement.

C. Soundness

From above results, it is observed that expansion values are not influenced due to replacement of cement with marble powder. Expansion values comply with the IS codal provisions where it is recommended that expansion is not to increase more than 10 mm.

Table 8: Soundness Test Results.

S.No	%age WMP	Sample Cement+WMP (Gm)	Water 0.78p (Gm)	Distance Between Indicator Points		Cement Expansion (D_2 - D_1) (Mm)
				Initial $D_{1(Mm)}$	Final $D_{2(Mm)}$	
1	0	100+0	22.23	25	27	2
2	10	90+10	21.84	26	27	1
3	20	80+20	21.45	36.5	37.5	1
4	30	70+30	21.45	39	40.5	1.5
5	40	60+40	20.67	20	21.5	1.5
6	50	50+50	20.28	20.5	22.5	2

Similar results were found by Aliabdo *et al.* (2013) while making a maximum replacement of 15% by WMP. Soundness depends on presence of free line and magnesia. Although the percentage of free lime in WMP (30%) is lower than cement (60-65%), which could have reduced the value of soundness. Its effect was compensated by higher amount of magnesia in WMP (15%) as compared to corresponding value in cement (1-4%). This indicate that changed chemical composition of cement due to a replacement by WMP has no detrimental effect on soundness of cement.

D. Compressive Strength

Table 9 shows the results of compressive strength after 3 days, 7days and 8 days.

Table 9: Compressive Strength Test Results.

S.No.	WMP (%)	3 Days		7 Days		28 Days	
		Compressive Strength (N/Mm2)	% Rate Increase/Decrease	Compressive Strength (N/Mm2)	% Rate Increase/Decrease	Compressive Strength (N/Mm2)	% Rate Increase/Decrease
1	0	28.9	-	32.21	-	48.17	-
2	10	29.14	(+) 0.83	32.33	(+)0.37	48.26	(+)0.19
3	20	26.29	(-)9.03	28.75	(-)10.74	43.33	(-)10.06
4	30	23.35	(-)19.20	25.37	(-)21.24	32.73	(-)32.06
5	40	20.75	(-)28.20	23.49	(-)27.07	29.06	(-)39.68
6	50	16.43	(-)43.15	18.56	(-)42.38	26.69	(-)44.602

IV. CONCLUSION

The following findings have been made from this study:

(i) Standard consistency of cement paste made with cement partially replaced with WMD has slightly decreased. It decreases gradually from 28.5% for controlled mix to 26% for 50% replacement of cement. The reason for this is that specific surface of waste marble powder is less than the specific surface of cement. As a result of this, the water requirement value decreases by increasing the amount of waste marble powder in mix.

(ii) The initial setting time and final setting time of cement pastes although increases to some extent by the use of waste marble powder but remain well within the permissible limits as per codal provisions.

(iii) Soundness of cement was checked and is well with permissible limits in all the cases where cement has been partially replaced with waste marble powder. It shows that the continued effect of changed chemical composition of cement due to addition of waste marble powder has no detrimental effect on soundness of the resultant mix.

(iv) Compressive strength of cement mortar decreases. However, from the general requirements of strength for 43 Grade ordinary Portland cement, waste marble powder can successfully be used upto 20% of replacement of cement.

REFERENCES

[1]. A Umoh, (2012). Recycling demolition waste sandcrete blocks as aggregate in conc, *ARPN Journal of Engineering and Applied Science*s, Vol. **7**, 1111-18

[2]. Chandana Sukesh, Katakam Bala Krishna, P. Sri Lakshmi Sai Teja and S.Kanakambara Rao, (2013). Partial replacement of sand withquarry dust in concrete, *International Journal of Innovative Technology and Exploring Engineering* (IJITEE), Vol. **2**, 254-58.

[3]. Dr. G. Prince Arulraj , Mr. A. Adin and Mr. T. Suresh Kannan, (2013). Granite powder IRACST - *Engineering Science and Technology: An International Journal (ESTIJ),* ISSN: 2250-3498, Vol. **3**, No.1, February 2013.

[4]. H. Hebhoub , H. Aoun ,M. Belachia , H. Houari and E. Ghorbel (2011). Use of waste marble aggregates in concrete *Construction and Building Materials,* **25:** 1167-1171.

[5]. Khalifa S Al-Jabri, Makoto Hisada, Salem K Al-Oraimi, Abdullah H Al-Saidy (2009). Copper slag as sand replacement in concrete, *Cement and Concrete Composites,* Vol. **31**, 483-488.

[6]. Pareek S. (2007). Gainful utilization of marble waste - an effort towards protection of ecology & environment. Centre for Development of Stones 2007,http://www.cdos-india.com/Papers%20technical.htm.