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Properties of concrete incorporating sand and cement with waste marble powder

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Abstract. Marble is a metamorphic rock used widely in construction which increases amount of marble powder obtained from it. Marble powder is a waste product obtained from marble during its processing. Marble waste is high in calcium oxide content which is cementing property but it creates many environmental hazards too if left in environment or in water. In this research, partial replacement of cement and sand by waste marble powder (WMP) has been investigated. Seven concrete mixtures were prepared for this investigation by partially replacing cement, sand with WMP at proportions of 0%, 10% and 15% by weight separately and in combined form. To determine compressive strength, flexural strength and split tensile strength of concrete made with waste marble powder, the samples at the curing ages of 7, 28 and 90 days was recorded. Different tests of durability were applied on samples like ultrasonic pulse wave test, absorption and sorptivity. For further investigation all the results were compared and noticed that WMP has shown good results and enhancing mechanical properties of concrete mix on partially replacing with sand and cement in set proportions. Moreover, it will solve the problem of environmental health hazard.

Keywords: waste marble powder; concrete; strength; pulse velocity; sorptivity; water absorption; durability; X-ray diffraction

1. Introduction

From ancient times marble has been used in construction of monuments as decorative material transformation of limestone. The purity and quality of marble can be identified by its color. Marble varies state to state with its mineral constituents too. The impurities of marble includes chemical as well as mineral like quartz, limonite, SiO_2 and Fe_2O_3 etc. But some impurities affects the properties of cement like magnesia, phosphate, leads, zinc, alkalis and sulfides. In India, Plenty of marble waste has been produced as a result of cutting and sawing process done in construction industries. But the waste marble powder is not easy to dispose off due to some of the impurities present which can't be handled easily. Such type of impurities, if mixed with soil reduces porosity and permeability

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permeability of soil results in infertility of land and if mixes with water, pollutes it making it unhealthy to use. So it is necessary to use waste marble powder in a functional manner.

However, concrete technology has reduced use of energy and natural resources which further reduces pollutants. But, due to rise in its cost waste should be used as constituents which will decrease the cost. Kushwah *et al.* (2015) presented in his paper that the marble can be utilized in concrete mix by replacement of fine aggregates. Mohammedan (2012) looks into the effect of marble powder and silica fume of different percentages as partial substitute for cement on mortar. Aruntas *et al.* (2010), Ergün *et al.* (2011), Hebhoub *et al.* (2011), Firat *et al.* (2012), Aliabdo *et al.* (2014) and Djebien *et al.* (2015), indicates marble dust, fly ash & waste sand have properties of additive materials, which enhances the material properties. Aliabdo *et al.* (2014) studied the replacement of cement or sand by marble powder for improvement in concrete properties. It shows that sand replacement gives better results as compare to cement replacement. Givi *et al.* (2010) studied that average particle size of rice husk provides positive effect on compressive strength and water permeability of hardened concrete. Hebhoub *et al.* (2014) studied the effect of marble wastes as replacement of sand (25, 50, 75, 100%) in the mortar. Aruntaş (2010), Ashish *et al.* (2016b) investigated the serviceability of waste marble dust as an additive material in blended cement.

Kumar *et al.* (2015a), Kumar *et al.* (2015b) and Wani *et al.* (2015) recommended the new and innovative building materials and eco-friendly technologies, covering waste material is the need of the hour. Prusty *et al.* (2015), Mukharjee and Barai (2015), Saini and Ashish (2015) and Saha and Rajasekaran (2016) investigation production of concrete with use of recycled coarse aggregates. Ashish *et al.* (2011), Thomas and Harilal (2014), Kumar *et al.* (2014), Kumar *et al.* (2015c), Chore and Joshi (2015), Sunil *et al.* (2015) and Dar *et al.* (2015) studied fly ash and its usage as construction material. Singh (2011), Chore and Joshi (2015), Tang *et al.* (2015) and Ashish *et al.* (2016a) examined and used ground granulated blast furnace slag (GGBFS) as a supplementary cementitious material. Verma and Ashish (2014) and Güneyisi *et al.* (2014) studied waste tyre as replacement of aggregate. Ganesan (2013), Shaikh (2014) and Patil *et al.* (2014) examined geopolymer concrete for its sustainable use. Parande (2013) investigated industrial by-product for high strength and high performance concrete.

The effect of partially replacing of cement and sand by marble powder waste can be determined easily. In this research mechanical and physical properties of concrete are investigated after replacing cement and sand with varying ratios.

2. Experimental methodology & investigation

For this research work marble powder was collected from nearby source Chandigarh for investigation. Concrete mixtures with varying percentages of marble powder were prepared like 0%, 10% (sand), 10% (cement), 15% (sand), 15% (cement), 20% {cement (10%) + sand (10%)} and 30% {cement (15%) + sand (15%)} as a partial replacement of cement and sand mix. At the curing ages of 7, 28 and 90 days the mechanical and physical properties were checked. .

2.1 Materials

2.1.1 Cement

The experimental studies were conducted on cement was 43 grade OPC conforming to the specifications of Indian standard code IS: 8112 (1989) shows in Table 1. Fresh cement with no

Table 1 Physical properties of cement

Sr. No.	Characteristics	Specified value as per IS:8112(1989)	Experimental value
1	Consistency of cement (%)	---	31.5
2	Specific gravity	3.15	3.01
3	Initial setting time (minutes)	>30	40
4	Final setting time (minutes)	<600	380
5	Compressive strength (MPa)		
	(i) 3 days	>23	25.10
	(ii) 7 days	>33	36.00
	(iii) 28 days	>43	48.10
6	Soundness (mm)	10	1.05
7	Fineness of Cement (gm)	10	1.50

Table 2 Physical Properties of fine and coarse aggregates

Sr. No.	Physical Properties	Fine Aggregates	Coarse Aggregates
1	Specific Gravity	2.614	2.66
2	Free Moisture Content	2%	-
3	Water Absorption (%)	1.80	0.13
4	Fineness Modulus	2.86	2.65

Table 3 Physical Properties of marble powder

Sr. No.	Physical Properties	Values
1	Specific Gravity	2.210
2	Dry Moisture Content (%)	1.58
3	Bulk Density (kg/m^3)	1118
4	Fineness Modulus	2.03

Table 4 Chemical properties of marble powder

Sr. No.	Chemical Properties	Values
1	SiO_2	01.38
2	Al_2O_3	00.37
3	Fe_2O_3	00.24
4	CaO	53.12
5	MgO	00.38

lumps was used.

2.1.2 Aggregate

In this investigation locally available river sand confirming to Zone-II as per IS: 383(1970) as shown in Table 2 was used. The sand used in experiment has specific gravity 2.61 and coarse aggregates whose fineness modulus is 2.65. In experiment coarse aggregate used as 20 mm down size. The foreign materials and lumps of clay were separated out with care. Coarse aggregate and sand was washed and dried before testing.

2.1.3 Waste marble powder

For Investigations marble powder from marble industry was obtained. The fineness modulus is 2.03 with bulk density 1118 kg/m^3 and has specific gravity of 2.21 shown in Table 3. Chemical properties are shown in Table 4.

2.2 Concrete mix proportion

In these investigations, the concrete mix design is used as M30. Water binder ratio is used as 0.42. Refer to Table 5 (0%, 10%, 10%, 15%, 15%, 20% and 30%) namely MX0, MX1, MX2, MX3, MX4, MX5 and MX6 different mixes was prepared by using a different percentage of marble powder as a partial replacement in the cement and sand mix, where MX0 is control mix with no marble powder, MX1 with 10% marble powder as partial replacement of sand, MX2 with 10% marble powder as partial replacement of cement and MX3 with 15% marble powder as partial replacement of sand, MX4 with 15% marble powder as partial replacement of cement and also MX5 with 20% marble powder as partial replacement of cement and sand together and MX6 with 30% marble powder dust as partial replacement of cement and sand together as shown in Table 6.

Table 5 Mixture proportions of concrete mixes

Sr. No.	Mix Designation	Percentage of WMP (%)	Water (lt/m^3)	Cement (kg/m^3)	Coarse Aggregates (kg/m^3)	Fine Aggregate (kg/m^3)	Marble Powder (kg/m^3)
1	MX0	0	186	432.00	1123.57	648.46	0
2	MX1	10	186	432.00	1123.57	583.62	64.84
3	MX2	10	186	388.80	1123.57	648.46	43.20
4	MX3	15	186	432.00	1123.57	551.20	97.26
5	MX4	15	186	367.20	1123.57	648.46	64.80
6	MX5	20	186	388.80	1123.57	583.62	108.04
7	MX6	30	186	367.20	1123.57	551.2	162.06

Table 6 Terminology for all concrete mixes

Mix Designation	Designation
MX0	Control concrete mix
MX1	10% sand replacement with marble powder
MX2	10% cement replacement with marble powder
MX3	15% sand replacement with marble powder
MX4	15% cement replacement with marble powder
MX5	10% sand and 10% cement replacement (combination) with 20% marble powder
MX6	15% sand and 15% cement replacement (combination) with 30% marble powder

2.3 Methods

2.3.1 Workability

In accordance with IS 7320 (1974), slump test was performed for workability, Different samples of concrete mix were tested for slump values. It was tested by partially replacing sand and cement in ratios of 0%, 10% and 15% and in combined form by marble powder.

2.3.2 Compressve strength, flexural and split tensile strength

In accordance with IS 516 (1959), compressive strength tests were conducted on all the concrete mixes at the curing ages of 7, 28, and 90 days. The cube specimen were tested for determining compressive strength and 100 mm×100 mm×100 mm, a cylindrical specimen were tested for determining the split tensile strength of size 150 mm (diameter)×300 mm (length) and beams of size were tested for determining flexural strength 100 mm (width)×100 mm (depth)×500 mm (length).

2.3.3 Water absorption

In accordance with BS EN 12390-8 (2000), water penetration test was performed. The test was conducted at curing ages 28 days. The specimens used were of size 150 mm×150 mm×150 mm and kept under water pressure of 500 ± 50 kPa for 72 ± 2 h. The specimens were split into two halves and kept perpendicular to water pressure. When split face get dried and front of water penetration is visible, water front was marked. The nearest millimeter shows maximum depth of water penetration.

2.3.4 Sorptivity

In accordance with ASTM C1585 (2004), capillary suction test was performed at 28 days curing ages. This test determines water absorption; increase in mass of specimen was analyzed as function of time, at a time only one surface of specimen is exposed to water. Discs were cut from the cylinders of 100 mm × 200 mm into 100 mm diameter and 50 mm thickness and left for oven drying till constant mass analyzed. The specimens were cooled at room temperature than kept in desiccator. They were sealed from sides. The end of specimen was sealed with loose plastic sheet. The precision balance was used to record mass of specimen. During testing, exposed ends of all specimens were in touch of water. According to ASTM code the mass of specimens were tested at suitable intervals with Initial rate of absorption (IRA).

2.3.5 Pulse velocoty

According to ASTM C597 (2004), pulse velocity of concrete were determined on all concrete mix at the curing ages of 28 days.

2.3.6 X-ray diffraction

X-ray diffraction (XRD) analyses was performed at 28 days of curing ages to analyze broken samples and change in microstructure on addition of marble powder. This test was performed on hardened concrete prepared with marble powder replacement in place of sand, No replacement, for phase’s identification. The investigations of XRD for diffraction angle 2θ ranged between 0° to 90° were performed.

Table 7 Mixture proportions of concrete mixes

Sr. No.	Mix Designation	Slump (mm)
1	MX0	140
2	MX1	135
3	MX2	130
4	MX3	138
5	MX4	130
6	MX5	135
7	MX6	135

3. Experimental test result & discussion of mechanical and workability properties

3.1 Workability of concrete

According to IS 7320 (1974), workability was evaluated through slump cone test for cement/binder concrete incorporating marble powder at 10% and 15% proportions in replacement of cement, sand and combined form. Table 7 depicts replacement level, mix designation slump value of mixes. No effect on workability was observed with the use of additive moreover it was noticed that slump value decreased with the replacement of cement. As compare to Portland cement marble powder has higher specific area which results in increased friction and lower workability. But due to fine filler effect of marble powder slump value was increased with the replacement of sand by marble powder.

3.2 Compressive strength test results of concrete

It can be observed from Table 8 & Fig. 1, on partially replacing 10% cement by marble powder, at the curing ages of 7, 28 & 90 days, compressive strength decreased by 4.72%, 2.8% & 4.16% respectively. On partially replacing 10% sand by marble powder, at the curing ages of 7, 28 & 90 days, compressive strength increased by 10.81%, 11.24% & 15.64% respectively. On replacing 15% cement by marble powder compressive strength decreased by 12.42%, 11.24% & 14.06% at 7, 28 & 90 days of curing respectively. On replacing 15% sand by marble powder compressive strength increased 26.06%, 23.24% & 16.24 at the curing ages of 7, 28 and 90 days respectively. On replacing both 10% cement and 10% sand in combined form by marble powder, compressive strength increased by 0.57% at 7 days of curing and decreased by 3.11% & 6.34% at 28 & 90 days of curing respectively. On replacing both 15% cement and 15% sand in combined form by marble powder, compressive strength decreased by 2.03%, 11.33% & 8.51% at the curing ages of 7, 28 & 90 days. It can be noticed that on replacing 15% of sand by marble powder shows high compressive strength where as replacing cement with marble powder shows decrease in strength.

These results are in agreement with those achieved by (Shirule *et al.* 2012, Aliabdo *et al.* 2014). It can be noticed that on partial replacement of sand with marble powder there is significant rise in compressive strength. The strength of mix is enhanced due to filler effect of marble powder as it is micro fine filler. It is noticeable that on partial replacement of cement with marble powder there is

Table 8 Comparison of compressive strength of concrete at the curing ages of 7, 28 & 90 days

S.N.	Mix Designation	Average Compressive Strength (N/mm^2) at 7 days curing	% Increase Average Compressive Strength at 7 days curing	Average Compressive strength (N/mm^2) at 28 days curing	% Increase Average Compressive Strength at 28 days curing	Average Compressive strength (N/mm^2) at 90 days curing	% Increase Average Compressive Strength at 90 days curing
1	MX0	21.18	0	32.82	0	50.5	0
2	MX1	23.47	10.81	36.51	11.24	58.4	15.64
3	MX2	20.18	-4.72	31.90	-2.80	48.4	-4.16
4	MX3	26.70	26.06	40.45	23.24	58.7	16.24
5	MX4	18.55	-12.42	29.13	-11.24	43.4	-14.06
6	MX5	21.30	0.57	31.80	-3.11	47.3	-6.34
7	MX6	20.75	-2.03	29.10	-11.33	46.2	-8.51

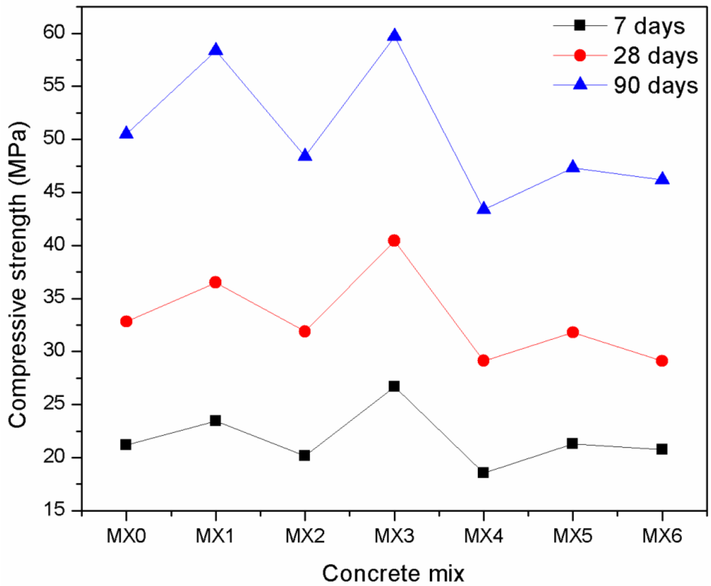

Fig. 1 Compressive strength of concrete at the curing ages of 7, 28 & 90 days

a slight decrease in compressive strength of concrete. The strength of mix is decreased due to decrease in cementing materials tricalcium silicate (C_3S) and dicalcium silicate (C_2S). It can be concluded that partial replacement of sand by marble powder is more efficient as compare to replacement of cement.

3.3 Split tensile strength test results of concrete

It can be observed from Table 9 & Fig. 2, on partially replacing 10% cement by marble powder, at the curing ages of 7, 28 & 90 days, split tensile strength increased by 6.54%, 7.57% & 4.49% respectively. On partially replacing 10% sand by marble powder, at the curing ages of 7, 28

Table 9 Comparison of split tensile strength of concrete at the curing ages of 7, 28 & 90 days

S. N.	Mix Designation	Average split tensile strength (N/mm^2) at 7 days curing	% Increase average split tensile strength at 7 days curing	Average split tensile strength (N/mm^2) at 28 days curing	% Increase Average split tensile strength at 28 days curing	Average split tensile strength (N/mm^2) at 90 days curing	% Increase Average split tensile strength at 90 days curing
1	MX0	2.14	0	3.70	0	4.45	0
2	MX1	2.34	9.35	4.10	10.81	5.00	12.35
3	MX2	2.28	6.54	3.98	7.57	4.65	4.49
4	MX3	2.18	1.87	3.79	2.43	4.62	3.82
5	MX4	2.17	1.40	3.75	1.35	4.60	3.37
6	MX5	2.14	0.00	3.75	1.35	4.58	2.92
7	MX6	2.12	-0.93	3.58	-3.24	4.42	-0.67

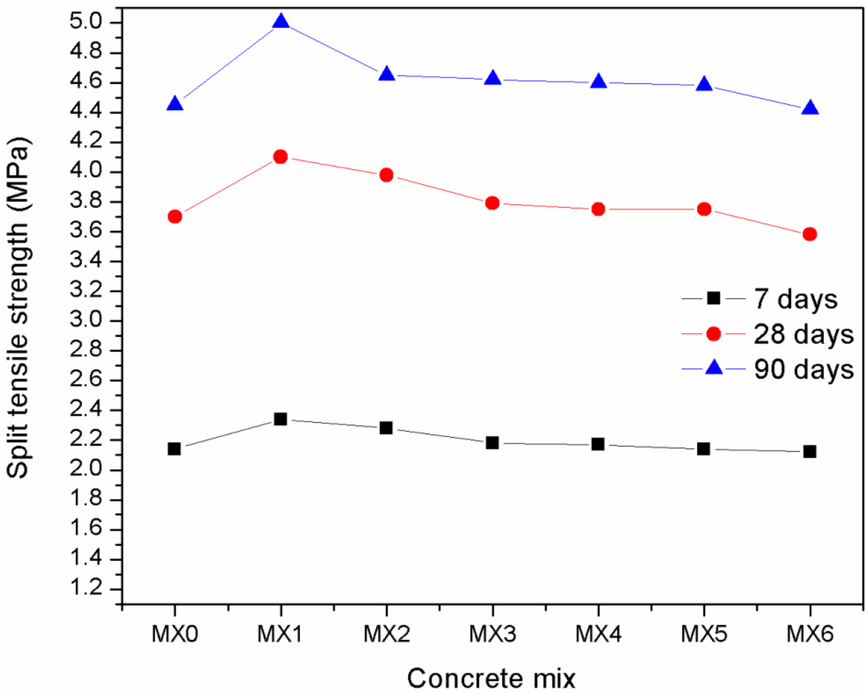

Fig. 2 Split tensile strength of concrete at the curing ages of 7, 28 & 90 days

& 90 days, split tensile strength increased by 9.35% 10.81% & 12.35% respectively. On replacing 15% cement by marble powder split tensile strength increased slightly by 1.4%, 1.35% % & 3.37% at the curing ages of 7, 28 & 90 days respectively. On replacing 15% sand by marble powder split tensile strength increased 1.87%, 2.43% & 3.82% at the curing ages of 7, 28 and 90 days respectively. On replacing both 10% cement and 10% sand in combined form by marble powder, split tensile strength increased by 0%, 1.35% & 2.92% at the curing ages of 7, 28 & 90 days respectively. On replacing both 15% cement and 15% sand in combined form by marble

Table 10 Comparison of flexural strength of concrete at the curing ages of 7, 28 and 90 days

S. N.	Mix Designation	Average flexural strength (N/mm^2) at 7 days curing	% Increase average flexural strength at 7 days curing	Average flexural strength (N/mm^2) at 28 days curing	% Increase Average flexural strength at 28 days curing	Average flexural strength (N/mm^2) at 90 days curing	% Increase Average flexural strength at 90 days curing
1	MX0	2.88	0	4.50	0	5.42	0
2	MX1	3.09	7.29	4.82	7.11	5.78	6.64
3	MX2	3.19	10.76	4.77	6.00	5.72	5.53
4	MX3	2.98	3.47	4.60	2.22	5.55	2.40
5	MX4	2.93	1.74	4.57	1.55	5.47	0.92
6	MX5	2.85	-1.04	4.32	-4.00	5.17	-4.61
7	MX6	2.71	-5.90	4.25	-5.55	5.00	-7.75

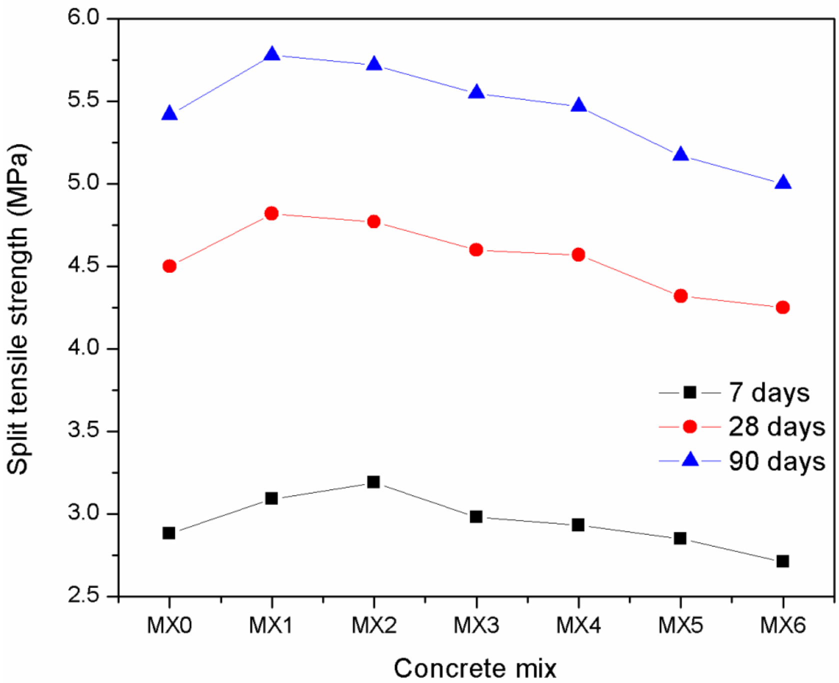

Fig. 3 Flexure strength of concrete at the curing ages of 7, 28 and 90days

powder, it shows low split tensile strength in comparison to replacement of marble waste in cement and sand individually. Increase in split tensile strength was noticed due to low porosity for blended cement concrete incorporating marble powder as a micro fine filler product. The sand substitution shows improved split tensile strength as compare to cement substitution with use of marble powder in concrete. Same results were achieved by (Shirule *et al.* 2012, Aliabdo *et al.* 2014). It can be noticed that due to decrease in porosity there is significant increase in split tensile strength.

Table 11 Comparison of ultrasonic pulse wave of concrete at the curing ages of 28 days

S. N.	Mix Designation	Average ultrasonic pulse wave (km/s)	% Increase average ultrasonic pulse wave
1	MX0	4.132	0
2	MX1	4.694	13.6
3	MX2	4.545	10
4	MX3	4.773	15.5
5	MX4	4.290	3.8
6	MX5	4.420	6.97
7	MX6	4.220	2.13

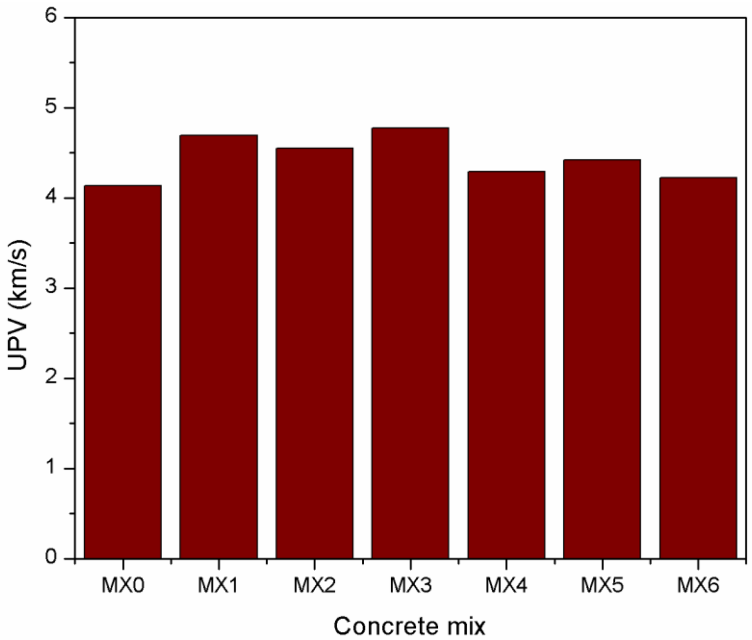

Fig. 4 Ultrasonic pulse wave of concrete at the curing ages of 28 days

3.4 Flexural strength test results of concrete

It can be observed from Table 10 & Fig. 3, on partially replacing 10% cement by marble powder, at 7, 28 & 90 days of curing, flexural strength increased by 10.76%, 6% & 5.53% respectively. On partially replacing 10% sand by marble powder, at the curing ages of 7, 28 & 90 days, flexural strength increased by 7.29%, 7.11% & 6.64% respectively. On replacing 15% cement by marble powder flexural strength increased slightly by 1.74%, 1.55% & 0.92% at the curing ages of 7, 28 & 90 days respectively. On replacing 15% sand by marble powder flexural strength increased 3.47%, 2.22% & 2.4% at the curing ages of 7, 28 and 90 days respectively. On replacing both 10% cement and 10% sand in combined form by marble powder, flexural strength decreased by 1.04%, 4% & 4.61% at the curing ages of 7, 28 & 90 days respectively. On replacing both 15% cement and 15% sand in combined form by marble powder, compressive strength decreased by 5.9%, 5.55% & 7.75% at the curing ages of 7, 28 & 90 days.The improvement of results was due to good strength and low porosity of both the interfacial transition zone (ITZ) and cement paste matrix. Similar results were achieved by (Aliabdo *et al.* 2014; Rana *et al.* 2015).

4. Experimental test result & discussion of durability properties

4.1 Pulse velocity test results of concrete

All the mixes containing the waste marble powder has high ultrasonic pulse wave as compare to control mix presented Table 11 & Fig. 4. So there is a slightly increase in the durability of

Table 12 Comparison of water absorption of concrete at the curing ages of 28 days

S. N.	Mix Designation	Average water absorption %	% decrease average Water absorption
1	MX0	5.20	-
2	MX1	4.50	13.0
3	MX2	4.55	12.5
4	MX3	4.43	15.0
5	MX4	4.60	11.0
6	MX5	4.90	5.7
7	MX6	5.10	2.0

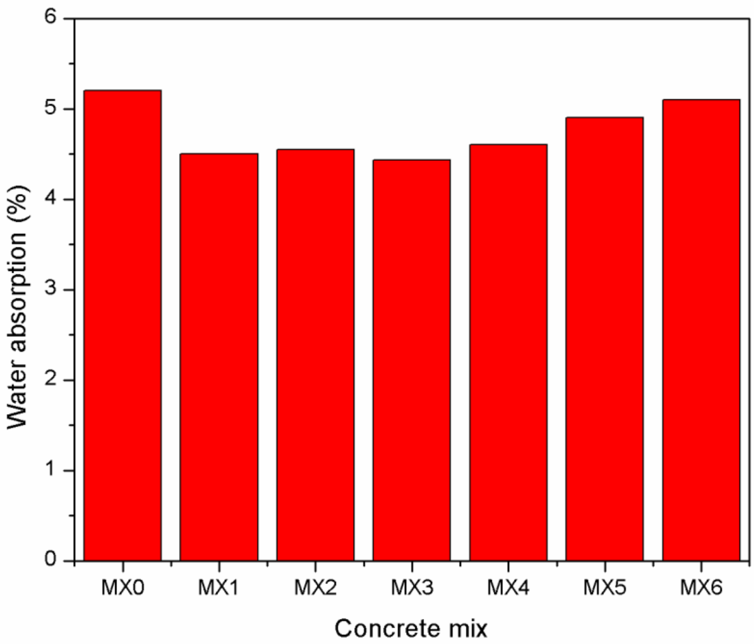

Fig. 5 Water absorption of concrete at the curing ages of 28 days

Table 13 Comparison of sorptivity of concrete at the curing ages of 28 days

S. N.	Mix Designation	Sorptivity value in 10^{-4} mm/sec0.5	% Decrease in sorptivity value
1	MX0	1.25	-
2	MX1	1.09	12.8
3	MX2	1.12	10.0
4	MX3	1.04	16.0
5	MX4	1.15	8.0
6	MX5	1.19	5.0
7	MX6	1.22	2.4

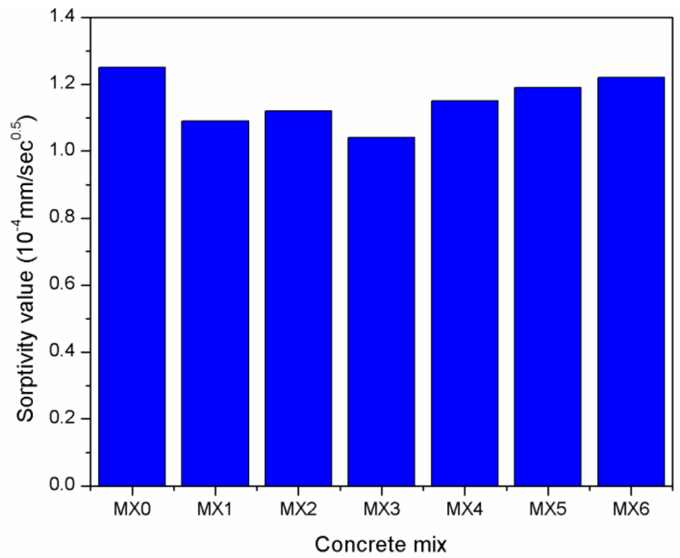

Fig. 6 Sorptivity of concrete at the curing ages of 28 days

concrete. No considerable effect was noticed on the value of UPV by the use of marble powder as cement and sand replacement. The variation noticed because of the ultrasonic pulse velocity proportional with the fourth root of concrete compressive strength as stated by Aliabdo *et al.* (2014).

4.2 Water absorption test results of concrete

All the mixes containing the waste marble powder absorbs less water as compare to control mix are presented in Table 12 & Fig. 5. So there is a slightly increase in the durability of concrete. MX1 absorbs 13% less water as compared to control mix (MX0). Similarly MX2, MX3, MX4, MX5 and MX6 absorbs 12.5%, 15%, 11%, 5.7% and 2% less water as compared to MX0. Low water absorption was noticed in blended cement concrete with the use of marble powder as it is micro fine filler, due to which low porosity can also be observed. It was noticed that the sand replacement was more effective than the cement replacement in controlling water penetration in

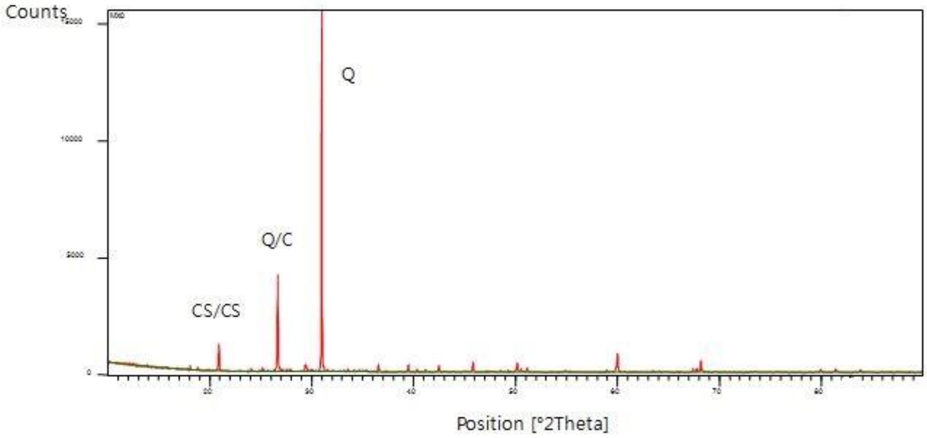

Fig. 7 X-Ray Diffraction of MX0 at the curing ages of 28 days (Q = quartz; CS = calcium silicate; CSH = calcium silicate hydrate)

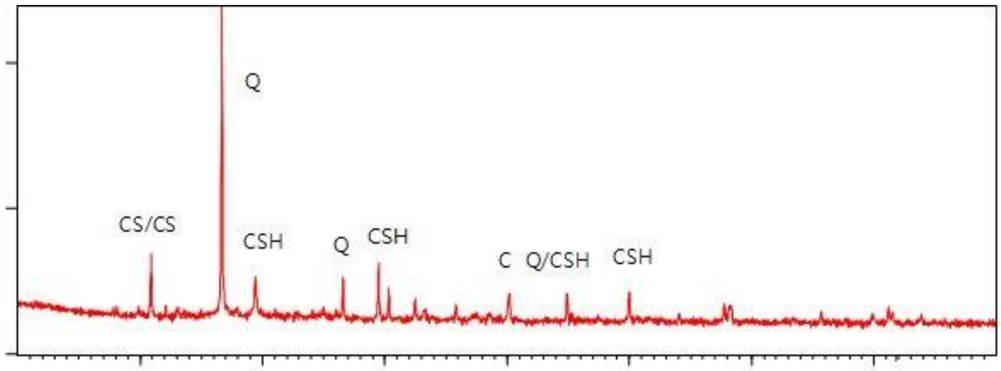

Fig. 8 X-Ray Diffraction of MX1 at the curing ages of 28 days (Q = quartz; CS = calcium silicate; C = calcite; CSH = calcium silicate hydrate)

the concrete mixes. Similar results were achieved as André *et al.* (2013). It can be noticed that low water absorption was seen because of less water absorption by waste marble powder.

4.3 Sorptivity test results of concrete

All the mixes containing the waste marble powder absorbs less water as compare to control mix are presented Table 13 & Fig. 6. So there is a slightly increase in the durability of concrete. MX1 absorbs 12.8% less water as compared to control mix (MX0). Similarly MX1, MX2, MX3, MX4, MX5 and MX6 absorbs 10%, 16%, 8%, 5% and 2.4% less water as compared to MX0. It can be noticed that low sorptivity was seen because of less water absorption by waste marble powder. This trend is similar to the one observed with other durability properties in this investigation.

Fig. 6 shows that the sorptivity values of the concrete mixes containing marble powder. It was observed that in the concrete mixes, sand replacement was very effective in lowering the IRA values in comparison of cement replacement. However, compared to the cement replacement, sand replacement was more effective in controlling capillary suction of the concrete mixes.

4.4 X-Ray diffraction of concrete

Since from the experiments it has been revealed that certain amount of waste marble powder as a replacement of sand by 10% & 15% enhances the strength characteristics of concrete, therefore, to analyze the composition difference in control concrete and concrete with waste marble powder XRD was conducted accordingly shown in Figs. 7-8. The main phases present in the mortar paste are, calcium silicate hydrate (CSH), calcium silicate (CS) and calcite (C). Remnants aggregate in the form of quartz (Q) were also observed in the XRD spectrums of mortar paste powdered. The weak diffraction peaks of calcium silicate hydrate tend to be swamped by the diffraction peaks from calcium silicate and diffraction peaks of aggregates. It is seen that there was no change in the phase composition qualitatively on use of marble powder as replacement of cement in mortar mixtures. Though, the change in proportions of phases was observed on incorporation of marble powder in mortar. Clearly indicates that marble powder is an inert material and does not lead to much change in the phase composition of the resultant mix.

5. Conclusions

Experimental investigation showed the following conclusions.

• The investigations shows increase in compressive strength on 15% replacement of sand by marble powder and it decreases on replacement of 15% cement.

• Maximum split tensile strength was achieved on 10% sand replacement but on replacement of 15% sand and 15% cement in combined form shows decrease in split tensile strength.

• In comparison to the control concrete, flexural strength shows improved results for 10% replacement of sand and cement individually by marble powder.

• The ultrasonic pulse velocity shows improved results upto 15% replacement of sand with marble powder.

• The water absorption of concrete mix was slightly increased upto 15% replacement of cement and sand individually by marble powder.

• The sorptivity test shows increase in durability upto 15% replacement of cement and sand individually by marble powder.

So finally it can be concluded that sand replaced with marble powder shows better results as compare to cement.

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