Exploratory Study on Mix Design & Properties of Concrete when Waste Marble Powder Partial Replaced in Cement Sand Mix

Harpinder Kaur[1], Tapeshwar Kalra[2]
[1]Research Scholar,Department of Civil Engineering, MRS Punjab Technical University, Bathinda, India
[2]Asst Professor ,Department of Civil Enginnering, MRS Punjab Technical University, Bathinda, India

***Abstract* - The attention of the world towards sustainable development is one of the major concerns from the past few years. This may be due to use of natural resources in bulk quantity in construction sector or any other industrial sector. This act of using huge volume of natural aggregates in construction industry leads to the shortage of natural aggregate in construction process. The latest trend in construction industry is to use alternate materials which can be best substitute of natural aggregates so that there is no compromise in terms of strength and durability considerations of structure. Reusing waste materials as an alternative to natural aggregates can help in reducing environmental problems, pollution, waste disposal and global warming. From the last few years, it has been found that the waste generated from demolition of construction site and old structures is increasing at more rapidly. Thus, reusing and recycling these wastes may reduce the usage of natural aggregates and thus contribute in reducing environmental hazards.**

Marble powder creates environmental problems but due to presence of high oxide calcium content, which is cementing property, marble can be used as in the partial replacement of cement in cement sand mixAs nowadays, marble is widely used in structures which increase the amount of waste that obtained from it. As marble powder is the waste product which is obtained during the process of sawing and shaping of marble by parent marble rock, contains heavy metals which makes the water unfit for use.. It is also useful because marble waste is a by-product of marble production and also creates environmental pollution in large scale. Therefore, it could be possible to prevent the environmental pollutionIn this research work, the effects of using waste marble powder (WMP) as a partial replacement of cement and sand on the mechanical properties of the concrete have been investigated. For this purpose seven different series of concrete-mixtures were prepared by partially replacing cement, sand with WMP at proportions of 0, 10 and 15% by weight separately and in combined form. In order to determine the effect of the WMP on the compressive strength, split tensile strength and flexural strength, strengths of the samples were recorded at the curing ages of 7 and 28 days. Finally, all of the data were compared with each other & it was observed that the addition of WMP such that would partially replace the sand and cement separately at particular proportions has displayed an enhancing effect on the mechanical properties of concrete mix.
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Keywords: **Waste marble powder, concrete, compressive strength, flexure strength, split-tensile strength.**

I. INTRODUCTION

In general, large amount of marble powder dust are obtained during the cutting and forging process. In India, tons of waste has been produced from the industries. But there are some impurities present in the waste that cannot be easily disposed off. Such type of impurities mixed with soil and water.Marble is obtained from the transformation of pure lime stone. The purity of marble depends upon the colour of the marble. Since the ancient times marble is widely used in monuments and historical buildings for decorative purpose. The various types of constituents present in marble, some of which varies from origin to origin. There are some chemical as well as mineral impurities which are associated with marble like quartz, SiO_2, limonite, Fe_2O_3. But some impurities like magnesia, phosphate, leads, zinc, alkalis and sulfides affect the properties of cement. When they mix with soil, it reduces the porosity and permeability of soil and also reduces the fertility of soil. Also if it mixes with water it pollute the water and make the water unfit for use. So it is necessary to use the waste in functional manner. Usually this type of waste can be utilized by using it as a raw material or as constituent in a material because they had a different chemicals present in it that causes a harmful effects on the environment.

Nowadays, concrete has a great advancement in concrete technology in which it can reduce the consumption of natural resources as well as the energy sources and that can further reduce the impact of pollutants on the surroundings. Due to hike in price, waste should be used in the constituents to decrease the cost and make the project cost effective. Raj P. Singh Kushwah et al. (2015) , presented in his paper that the marble can be utilized in concrete mix by replacement of fine aggregates. Hassan A. Mohammedan (2012) , looks into the effect of marble powder and silica fume of different percentages as partial substitute for cement on mortar. S.Firat, indicates marble dust, fly ash & waste sand have properties of good additive materials, which enhances the material properties. According to Ali. A. Aliabdo et. al., 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. Also, Alireza Naji et al. , studied that average particle size of rice husk provides positive effect on compressive strength and water permeability of hardened concrete.

In this experimental study we had experimental effect of marble waste powder on the concrete mix by partially replacing cement and sand with the marble powder waste. In this project, we check the effect on mechanical and physical properties of concrete mix with varying marble powder waste partially replaced in concrete mix.

I. RESEARCH SIGNIFICANCE

In this experimental study fine marble powder dust were collected from the nearby source for the investigation. Different concrete mixtures were prepared by using different percentages of marble powder 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. The mechanical and physical properties were checked on the 7 & 28 days.

II. EXPERIMENTAL METHODOLOGY & INVESTIGATION

Concrete Mix Constituents

Cement

The cement use for the experimental studies was 43 grade OPC conforming to the specifications of Indian Standard Code IS: 8112-1989 shows in table 1. It was fresh and without any lumps.

Aggregate

Normal river sand which is locally available in the market and confirming to Zone II as per IS 383 1970 as shown in table 2 and specific gravity of fine sand is 2.614 and coarse aggregates were used in this experiment whose fineness modulus is 2.65. Coarse aggregate used as 20 mm down size. The lumps of clay and other foreign materials were separated out carefully. Sand was washed and dried before testing. The coarse aggregates were washed to remove dirt, dust and then dried to surface dry conditions.

Table 1.Characterstics Properties of Cement

S.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 (N/mm^2)		
	(i) 3 days	>23	25.10
	(ii) 7 days	>33	36
	(iii)28days	>43	48.10
6	Soundness (mm)	10	1.05
7	Fineness of Cement (gm)	10	1.5

Table 2.Physical Properties of Fine and Coarse Aggregates

Sr.No.	Physical Properties	Fine Aggregates	Coarse Aggregates
1	Specific Gravity	2.69	2.96
2	Free Moisture Content	2%	-
3	Water Absorption	1.46%	0.73%
4.	Fineness Modulus	2.66	2.85

Table 3.Physical Properties of Marble Powder

Sr.No.	Physical Properties	Values
1	Specific Gravity	2.610
2	Dry Moisture Content	1.52%
3	Bulk Density(kg/m^3)	1188
4.	Finess Modulus	2.09

Table 4. Chemical Properties of Marble Powder

Sr.No.	Chemical Properties	Values
1	SiO_2	1.48
2	Al2O3	0.67
3	Fe2O3	0.44
4.	CaO	51.12
5.	MgO	0.58

Supplementary Cementitious Materials

The marble powder was obtained by crushing marble powder forms in a marble industry. The bulk density was 1118.01 kg/m^3 and fineness modulus is 2.03 and has specific gravity of 2.21.

Concrete Mixture Proportion

In this experimental study, the mix design is taken as M30. Water binder ratio is taken as 0.43. Different mixes was prepared by using a different percentage of marble powder (0%, 10%, 10%, 15%,15%, 20% and 30%) namely MX0,MX1,MX2, MX4,MX5 & MX6 as a partial replacement in the cement sand mix, where MX0 is control mix with no marble powder dust,MX1with 10% marble powder as partial replacement of sand, MX2 with 10% marble powder dust as partial replacement of cement and MX5 with 20% marble powder dust as partial replacement of cement and sand together and also MX3 with 15% marble powder as partial replacement of sand, MX4 with 15% marble powder dust as partial replacement of cement and MX6 with 30% marble powder dust as partial replacement of cement and sand together.

Figure 1.Marble Powder

Casting Detail

A Cube specimen of size 150mm×150mm×150mm and 100×100×100mm were tested for determining compressive strength and durability respectively, a cylindrical specimen of size 150mm (diameter) ×300mm (length) were tested for determining the split tensile strength and beams of size 100mm (width)×100mm (depth)×500mm (length) were tested for determining flexural strength.

Curing of Specimen

After the hardened of specimen in about 24 hours then the casted concrete specimens were cured under water which is free from chlorides and sulphates are placed for curing and tested after required curing.

Figure 2.Curing of Specimen

Table 5: Marble Dust Based Concrete Mix

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(Control)	0	186	432	1123.57	648.46	0
2	MX1 (Sand)	10	186	432	1123.57	583.62	64.84
3	MX2(Cement)	10	186	388.80	1123.57	648.46	43.2
4.	MX3 (Sand)	15	186	432	1123.57	551.2	97.26
5.	MX4(Cement)	15	186	367.2	1123.57	648.46	64.8
6.	MX5(Cement and Sand)	20	186	388.80	1123.57	583.62	108.04
7.	MX6 (Cement and Sand)	30	186	367.2	1123.57	551.2	162.06

III. EXPERIMENTAL TEST RESULT & DISCUSSION

Workability

Slump values of concrete sample have been tested for different sample of mix with different percentages of marble powder as replacement of cement and sand in a mix. The result showed that the workability of a concrete mix was decreases with increase in the marble powder dust content.

Strength

Compressive Strength

It can be noted that when cement is partially replaced by the marble powder up to 10% then the compressive strength of the mix after 7 days increased upto 9% and after 28 days it increase upto 9.3% and when partially replace it with sand then again compressive strength after 7 days increased up to 10% after 28 days it increase upto 11% but when marble powder dust is partially replaced by cement (15%), compressive strength after 7 & 28 days increases slightly 1.7% and 0.9% respectively and when partially replaces it with sand then it increases up to 2.45% & 2% after 7 & 28 days respectively also when together replaces by 20%(10%+10%) by marble powder then its compressive strength after 7 & 28 days decreased upto 8.8% & 9% respectively and 11.5% & 11.33% when partially replaces both cement and sand by 30%(15%+15%) marble waste. Hence result shows that marble powder when mixes with sand and cement up to 10% has high compressive strength and thereafter its strength decreases.

Table 6.Comparison of Compressive Strength After 7 & 28 Days

S.No.	Mix Designation	Average Compressive strength (N/mm^2) in 7 Days	% Increase Average Compressive Strength in 7 Days	Average Compressive strength (N/mm^2) in 28 Days	% Increase Average Compressive Strength in 28 Days
1	MX0	21.18	0%	32.82	0%
2	MX1	23.47	10%	36.51	11%
3	MX2	23.18	9%	35.90	9.3%
4	MX3	21.70	2.45%	33.45	2%
5	MX4	21.55	1.7%	33.13	0.9%
6	MX5	19.30	-8.8%	29.80	-9%
7	MX6	18.75	-11.5%	29.10	-11.33%

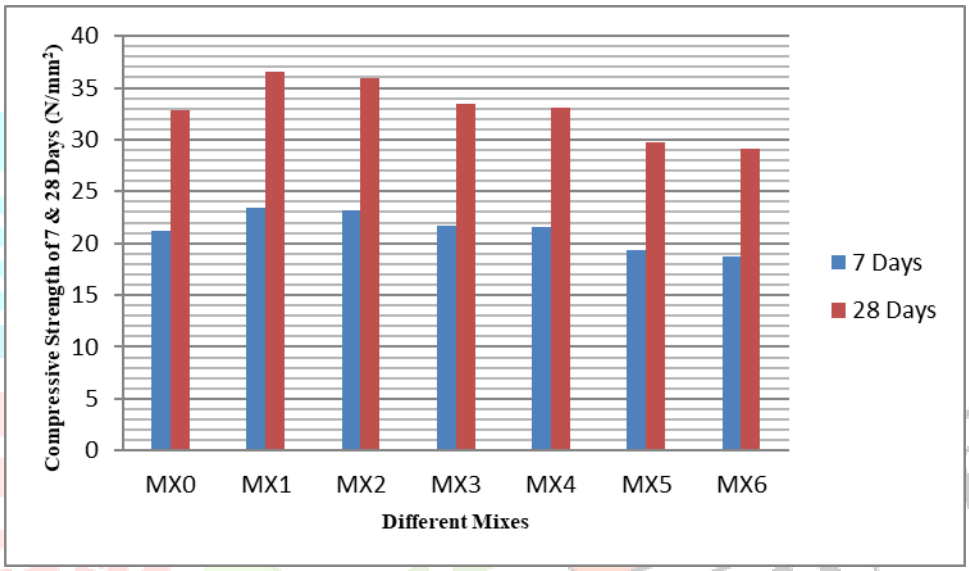

Figure 3. Graph Between Different Mixes and Compressive Strength of 7 & 28 Days

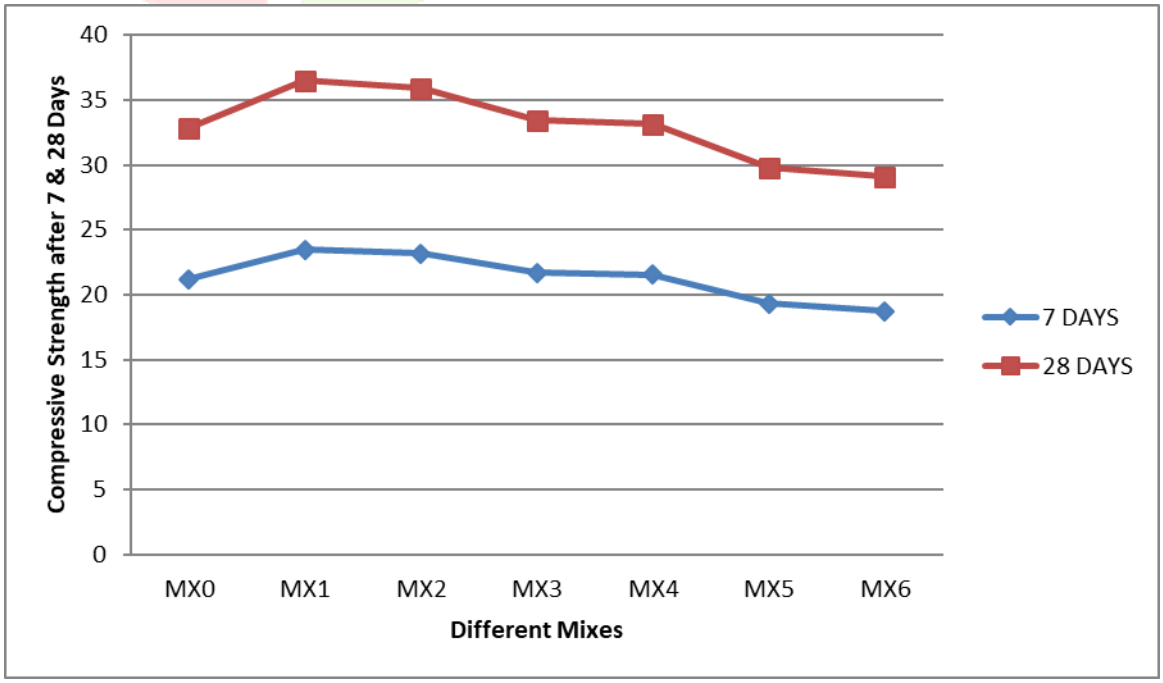

Figure 4. Comparison of Different Mixes of Compressive Strength after 7 & 28 Days

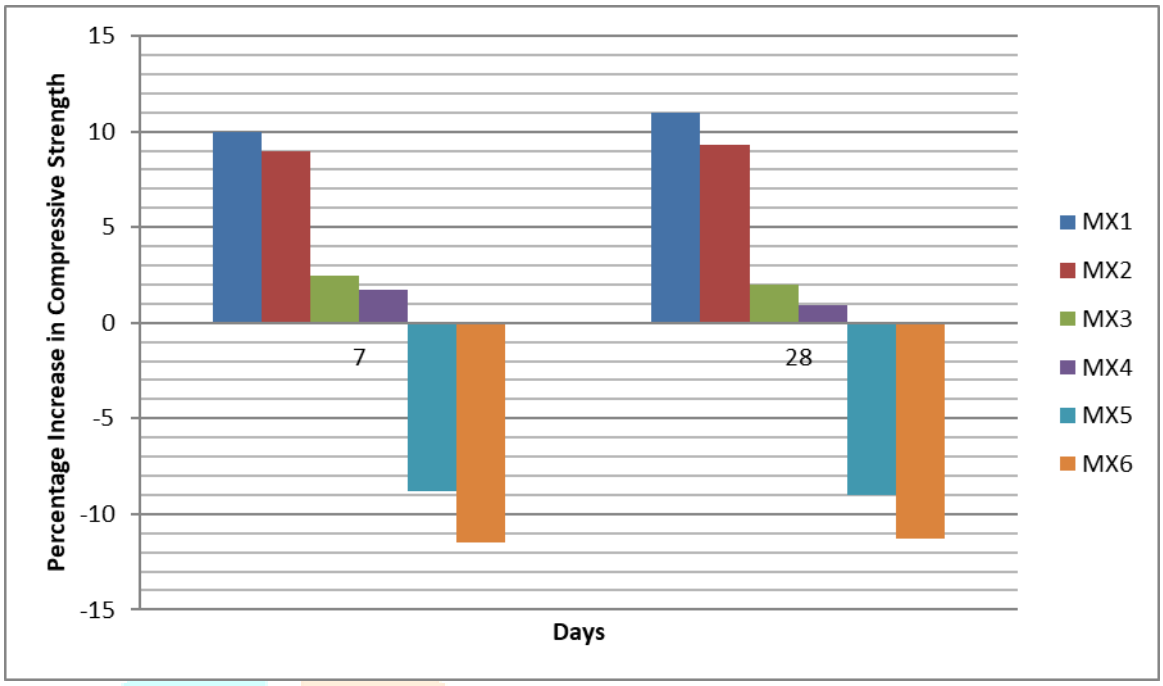

Figure 5. Percentage (%) increase in Compressive Strength by using marble waste

Split Tensile Strength

It can be noted that the split tensile strength for concrete mix increased with 7% & 7.5% when partially replaced by 10% marble powder dust against cement in 7 & 28 days respectively and also increased by 11% & 11% as in the partial replacement with sand having 10% marble dust powder in 7 & 28 days respectively. But the split tensile strength increased slightly for the mix which contains 15 % marble powder dust against cement by 1.4%& 1.3% in 7 & 28 days respectively and 2% & 2.4% when partially replaces with 15% sand in 7 & 28 days respectively. Also when sand and cement together partially replaces up to 20%and 30% they have low split strength as compare to the replacement of marble waste in cement and sand individually.

Table 7. Comparison of Split Tensile strength after 7 & 28 days

S.No.	Mix Designation	Average Split Tensile strength in 7 Days (N/mm^2)	% Increase Average Split Tensile Strength in 7 Days	Average Split Tensile strength (N/mm^2) in 28Days	% Increase Average Split Tensile Strength in 28Days
1	MX0	2.14		3.70	
2	MX1	2.39	11%	4.10	11%
3	MX2	2.28	7%	3.98	7.5%
4	MX3	2.18	2%	3.79	2.4%
5	MX4	2.17	1.4%	3.75	1.3%
6	MX5	2.04	-4.6%	3.55	-4%
7	MX6	1.91	-10%	3.30	-11%

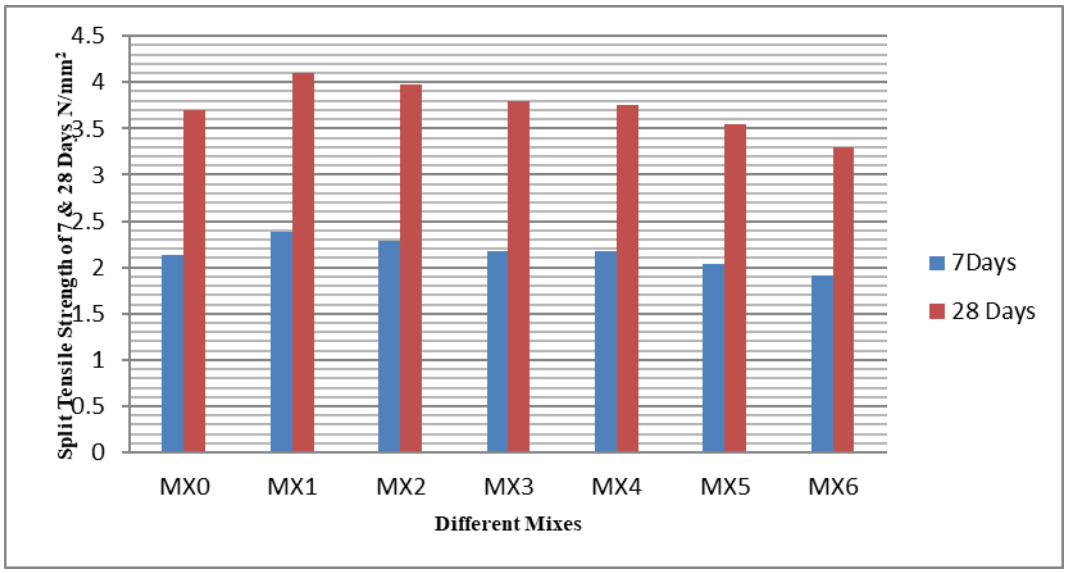

Figure 6. Graph Between Different Mixes and Split Tensile Strength of 7 & 28 Days

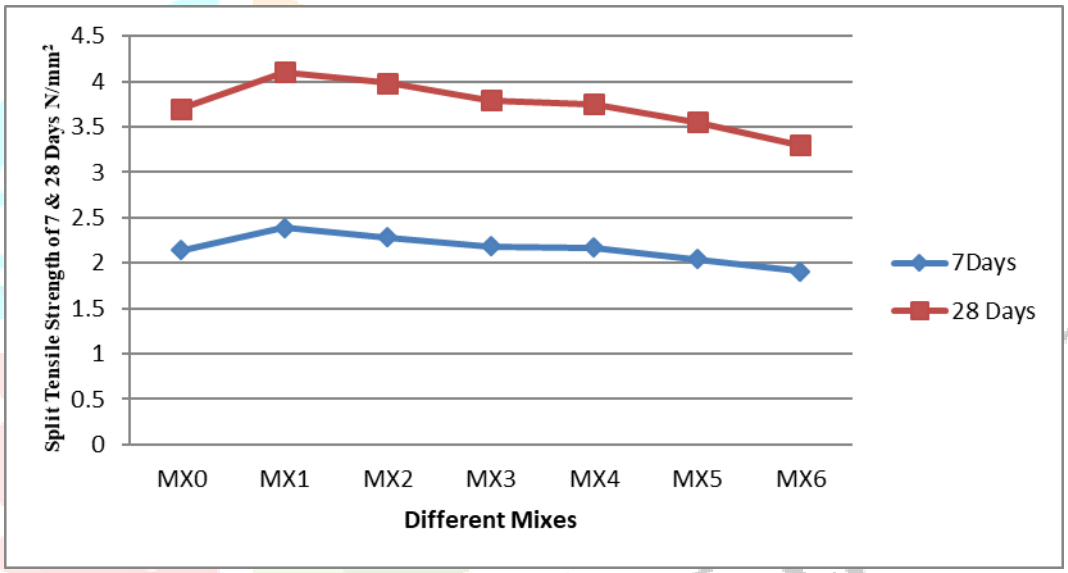

Figure 7. Comparison of Different Mixes of Split Tensile Strength after 7 & 28 Days

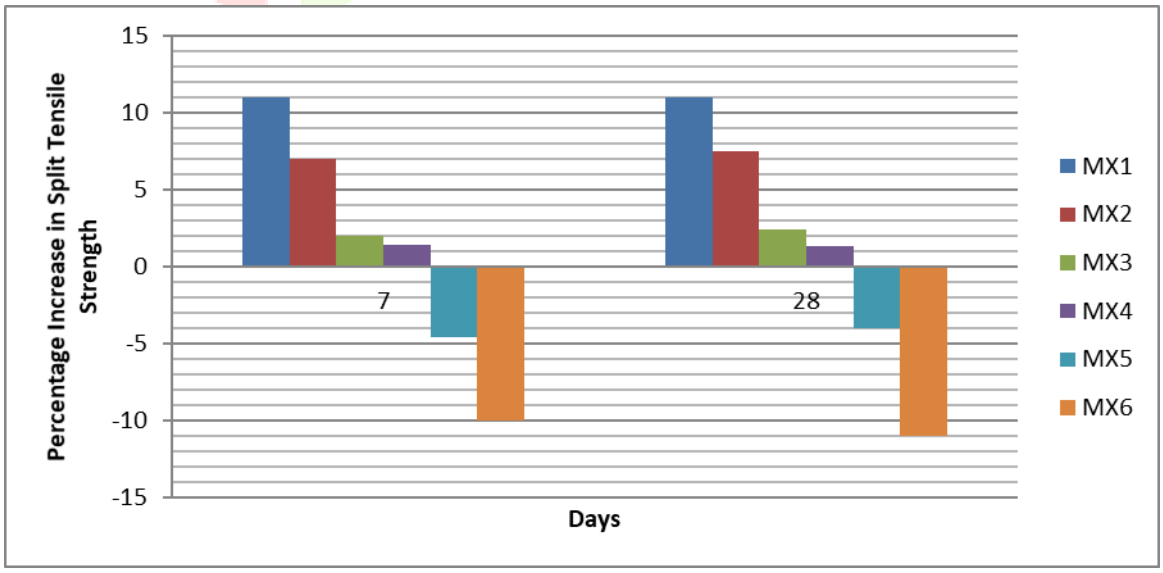

Figure 8. Percentage (%) increase in Split Tensile Strength by using marble waste

Flexural Strength

It can be observed that the flexure strength for the concrete mix containing 10% of marble powder dust in cement got increased by the value of 5.9% & 6% in 7 & 28 days respectively and for 10% replacement with sand the flexure strength also got increased about 7.3% & 7.1% in 7 & 28 days respectively but it increased slightly when the mix contains 15% marble powder dust against cement about 1.7% & 1.5% in 7 & 28 days respectively and 2.4% & 2.2% when mix contains 15% marble powder dust against sand in 7 & 28 days respectively. Also when sand (10%) and cement (10%) were partially replaced with marble powder dust it decreases the strength about 3.8% & 4% in 7 & 28 days respectively and 5.9% & 5.5% when sand (15%) and cement (15%) were partially replaced with marble powder dust in 7 & 28 days respectively. Hence result shows that marble powder when mixes with sand and cement together has low flexural strength, and individually it enhances the strength upto some proportion.

Table 8. Comparison of Flexural Strength After 7 Days & 28 Days

S.No.	Mix Designation	Average Flexural Strength (N/mm^2) in 7 Days	% Increase Average Flexural Strength in 7 Days	Average Flexural Strength (N/mm^2) in 28 Days	% Increase Average Flexural Strength in 28 Days
1	MX0	2.88		4.50	
2	MX1	3.09	7.3%	4.82	7.1%
3	MX2	3.05	5.9%	4.77	6%
4	MX3	2.95	2.4%	4.60	2.2%
5	MX4	2.93	1.7%	4.57	1.5%
6	MX5	2.77	-3.8%	4.32	-4.0%
7	MX6	2.71	-5.9%	4.25	-5.5%

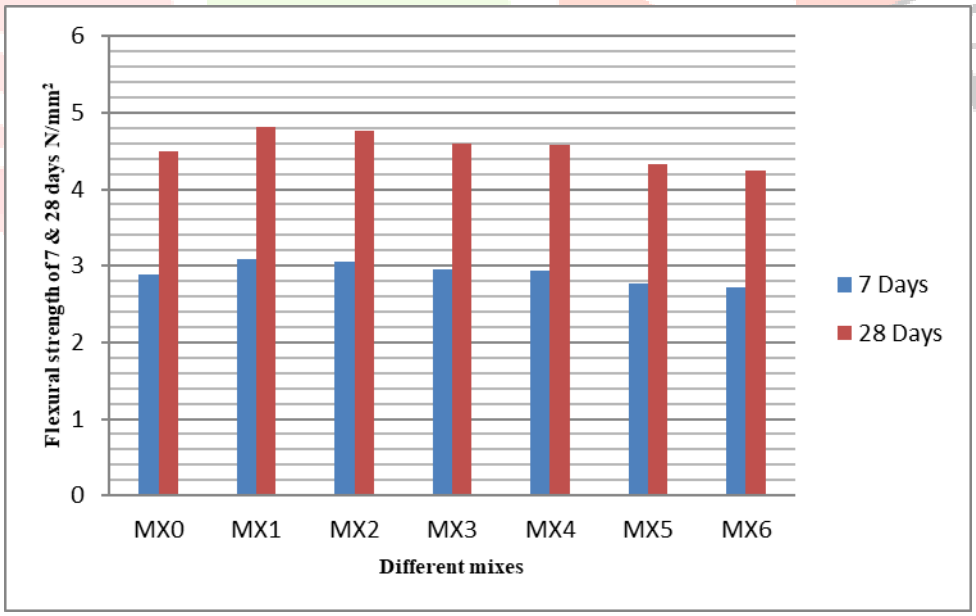

Figure 9. Graph Between Different Mixes and Flexural Strength of 7 & 28 Days

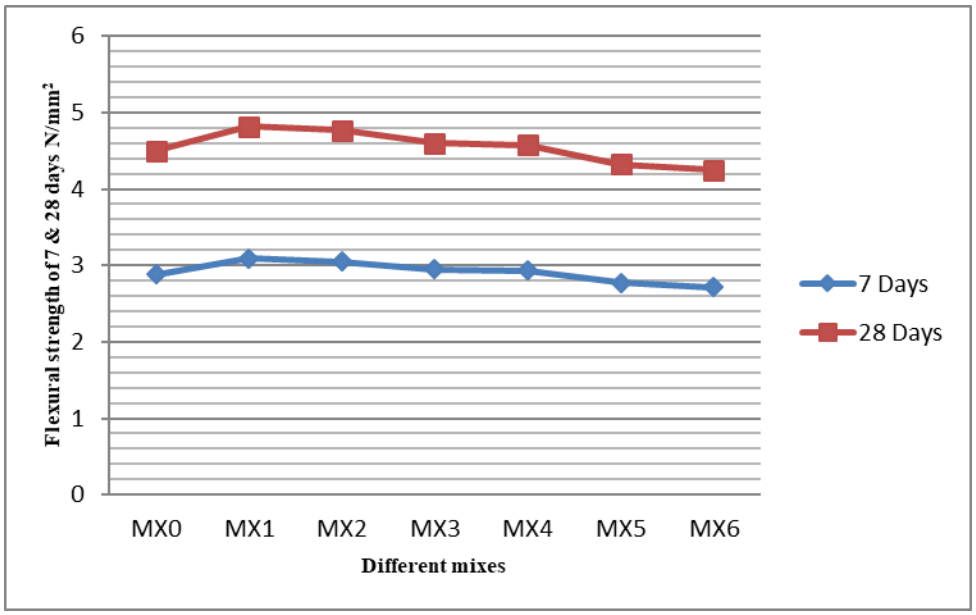

Figure 10. Comparison of Different Mixes of Split Tensile Strength after 7 & 28 Days

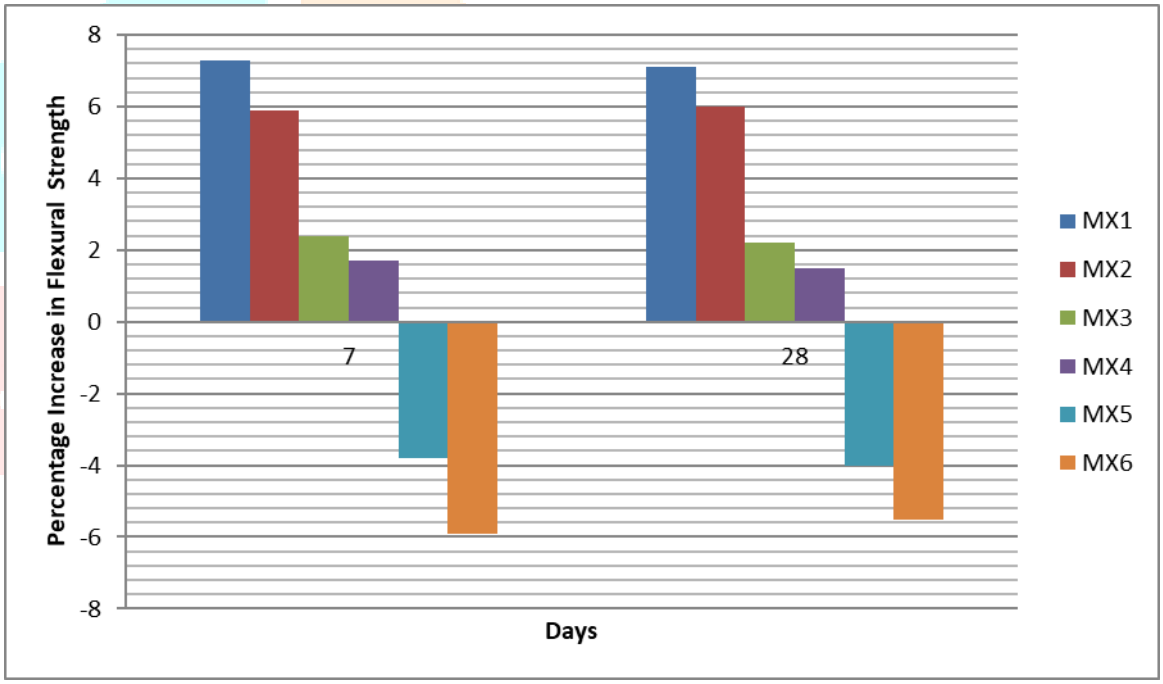

Figure 11. Percentage (%) increase in Flexural Strength by using marble waste

IV. CONCLUSION

Experimental investigation showed the following conclusions:

1. When cement is replaced with marble powder upto 10% weight a high strength concrete was achieved.
2. Based on the experiment result it showed that replacement of cement and sand by marble powder upto 15% increases the compressive strength but above 15% content of marble powder decreases the compressive strength.
3. Split tensile strength increases with increase in marble powder dust upto some proportion.
4. Compared to the control concrete flexural strength is maximum when replace with fine aggregate upto 15%.
5. In mix MX1 where, marble dust partial replacement with sand 10% by weight, its void become less as compare to other mixes due to the presence of calcite.

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