

# To Study the Influence of Marble Waste on Strength Properties of Concrete

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**ABSTRACT:** The topic has been selected for the present study to determine suitability of marble powder (MP) in civil engineering. This will help in achieving economy in construction work as well as saving on environment degradation in term of reduced mining and less pollution. Construction and maintenance of buildings and roads involve millions of tonnes of aggregate, sand and cement. Considering the scarcity of fresh aggregate, sand and cement, in present study we replace cement with marble powder. Construction of the rigid road and heavy structure like dams is quite cost intensive. It is suggested to use marble powder in place of cement in construction of road, buildings and dams provide economy to the project. For making best use of by products, it is essential to study the suitability of these waste materials in various construction works.

**KEYWORDS:** Marble powder, Road construction, Cement.

## I. INTRODUCTION

Many by products and solid recyclable materials can be used in concrete mixtures as aggregates or cement replacement, depending on their chemical and physical characterization. The capacity of concrete for incorporating these secondary raw materials is very wide and the main limit is their availability, which has to be comparable with the cement stream, since it is not worthwhile to develop new cementations materials if their availability on the market cannot be guaranteed. Focus is being shifted on developments in concrete technology that are already underway and are revolutionary in the sense that the goal is not a special concrete type meeting a particular engineering need. Instead, the goal is to transform all concrete into a general purpose building material that is composed of eco-friendly components, and produce crack free and highly durable structures. There are different types of industrial waste or by product is used in concrete as a replacement material like fly ash, pond ash, foundry sand, red sand, copper slag, various types of plastic etc. . In the present study we use marble powder. Marble powder is used to replace with cement used in concrete.

## II. RELATED WORK

Several researchers have used different materials like marble powder, foundry sand, sawdust ash, rice husk ash, fly ash, cow dung ash as partial replacement of cement and foundry sand in concrete to find various physical property. It was observed that the strength of concrete different by product is different from that of concrete using natural aggregates. In present study we focus on replacing of cement with marble dust as partial replacement. There are some literature review explain below-

**Agarwal and Gulati (2006)** studied that the presence of MD in the matrix enhances the early compressive strength of the mortar, and the strength of the mortar decreases with the increasing MD content.

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**Binici H. (2007)** studied Mechanical properties of concrete mixtures containing marble dusts and limestone dusts and found that there were clear increases of the compressive strength, abrasion resistance, and sodium sulphate resistance with the increasing amount of marble dust.

**Almeida, N, Branco, F. & Santo, J.R. (2007)** found that there is technical viability to incorporate massive quantities of marble slurry as “Raw Material in the Production of Clinker Without any Previous Complex Treatment”.

**Topcu IB. (2009)** studied the effects of using natural pozzolana and marble powder on the fresh and hardened properties of self-compacting concrete and found there is increase in strength.

**Ali Ergun (2011)** studied the mechanical properties of concrete using dolomite and waste marble powder as partial replacement of cement and test results indicated that the optimize amount of dolomite and WMP (waste marble powder) as replacement by weight of cement had the best compressive and flexural strengths.

Research conduct at **MNIT, Jaipur (2012)** found that there is improvement in engineering properties of soil if we use marble slurry for soil stabilization in road works and bridge approaches.

### III. MATERIAL USED FOR STUDY

The objective of present study is to evaluate the strength suitability by using marble dust in concrete construction. So the material used for concrete construction must be having fully or partially replaced marble powder with cement.

A good concrete construction always has well graded particles of different sizes. In present study the composition of concrete considered as aggregate, fine sand and marble dust (replaced with cement). The present study is done on M-35 grade of concrete.

### IV. EXPERIMENTAL RESULTS

An Experimental study on the behaviour of marble powder and foundry sand based concrete has been conducted for various loading conditions. The results of the present investigation are compared with the other investigation. A good agreement between the compression, direct tension and flexural strength has been obtained. The results of the present investigation are discussed under the following heads:-

#### Consistency of Cement

Normal consistency tests, for the blended cements, were conducted, by Vicat apparatus, to observe the changes in water requirement of pastes due to the marble powder. Test result on cement paste replaced with marble powder is show in table1 given below with varying percentage of marble powder (MP) i.e MP 2.5,MP5, MP7.5 and MP10.

Table 1 Consistency of Marble dust Blended Cement Pastes

S. No.	Code	Consistency (%)
1	MP 0 (OPC)	30
2	MP 2.5	32
3	MP 5	33
4	MP 7.5	34
5	MP 10	34

**Setting Time:-**Tests for setting time were conducted to compare the setting time of the blended cements with standards and also with the cement paste replaced with marble powder. The test result shows increase in initial setting time after addition of marble powder but decrease in final setting time. The test results are shown in table 2.

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Table 2 Initial and Final Setting Time of Marble dust Blended Cement Pastes

S. No.	Code	Initial setting Time (minutes)	Final Setting Time (minutes)
1	MP 0 (OPC)	40	262
2	MP 2.5	62	258
3	MP 5	84	250
4	MP 7.5	88	251
5	MP 10	90	254

**Soundness test result:-** Soundness of cement is determined by Le-Chatelier method as per IS: 4031 (Part 3) – 1988. Test is conducted by replacing the cement paste with marble powder at different percentage. Test show no variation in result after addition of marble powder in cement paste. The test results are show in table 3 given below.

Table 3 Soundness of cement paste with marble powder

S. No.	Code	Soundness (mm)
1	MP 0 (OPC)	1 mm
2	MP 2.5	1 mm
3	MP 5	1 mm
4	MP 7.5	1 mm
5	MP 10	1mm

**Sieve analysis:-** Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves. The test results of sieve analysis for marble powder are shown in table 4 given below.

Table 4 Sieve analysis of Marble powder

Sieve designation	Wt. retained on sieve	Cumulative wt. retained (gm)	Cumulative % retained	% passing	IS: 383-1970
4.75mm	0	--	0	100	90-100
2.36mm	110	110	11	89	75-100
1.18mm	530	640	64	36	55-90
600 $\mu$	275	915	91.5	8.5	35-55
300 $\mu$	40	955	95.5	4.5	8-30
150 $\mu$	17.5	972.5	97.25	2.75	0-10
Pan	27.5	1000		$\Sigma = 240.75$	

Fineness modulus of Marble powder =  $(240.75/100) = 2.40$

### Compressive Strength:-

The compressive strength was conducted on various specimens as per the guidelines given in IS 516-1959. The specimens were surface dried before testing the same on Universal Testing Machine of 100 tonnes capacity. The compressive strength of plane concrete and concrete made with varying percentage of marble powder and constant percentage of foundry sand content has been illustrated in Table 5 and 6 which shows the compressive strength after 7 and 28 days respectively. The compressive strength of plane concrete has been obtained as 18.83 N/mm<sup>2</sup> after 7 days and 34.41N/mm<sup>2</sup> after 28 days. This strength has been obtained as 19.13 N/mm<sup>2</sup>, 19.74 N/mm<sup>2</sup>,

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24.14 N/mm<sup>2</sup>, 27.33 N/mm<sup>2</sup> for 2.5, 5, 7.5, 10 percent of marble powder for 7 days and 35.26 N/mm<sup>2</sup>, 36.05 N/mm<sup>2</sup>, 37.43 N/mm<sup>2</sup>, 39.43 N/mm<sup>2</sup> after 28 days. In present study no. of sample casted are big in number so it is decided to nomenclature each sample with particular code. Variation of material is marble dust and foundry sand, so mix design code are suggested as M0, F0 which mean marble dust zero (0), foundry sand zero (0) in mix, which mean there is no replacement in marble dust and foundry sand with cement and sand. Likewise M-M2.5 and F10 stand for mix with replacement of marble dust as 2.5 % with cement and replacement of foundry sand with sand as 10 %.

Table 5 Compressive strength test after 7 days

Mix designation	% of Marble powder	% of Foundry sand	Compressive load (KN)	Compressive Strength (N/mm <sup>2</sup> )	Average Compressive Strength (N/mm <sup>2</sup> )
M-MP 0	0	0	420	18.66	18.83
			460	20.44	
			395	17.55	
M-MP 2.5	2.5	2	430	18.90	19.13
			440	19.10	
			445	19.40	
M-MP 5	5	2	435	19.33	19.74
			450	20	
			448	19.91	
M-MP 7.5	7.5	2	525	23.77	24.14
			510	23.11	
			565	25.55	
M-MP 10	10	2	640	28.44	27.33
			595	26.44	
			610	27.11	

Figure 1 show the compressive strength of concrete in addition of marble dust after 7 days. The compressive strength is 18.83 N/mm<sup>2</sup> at marble powder is zero and 27.33 N/mm<sup>2</sup> at marble powder is 10 %. Graph is almost constant up to 5 % addition of marble powder and show high change after addition of more than 5 % marble powder.

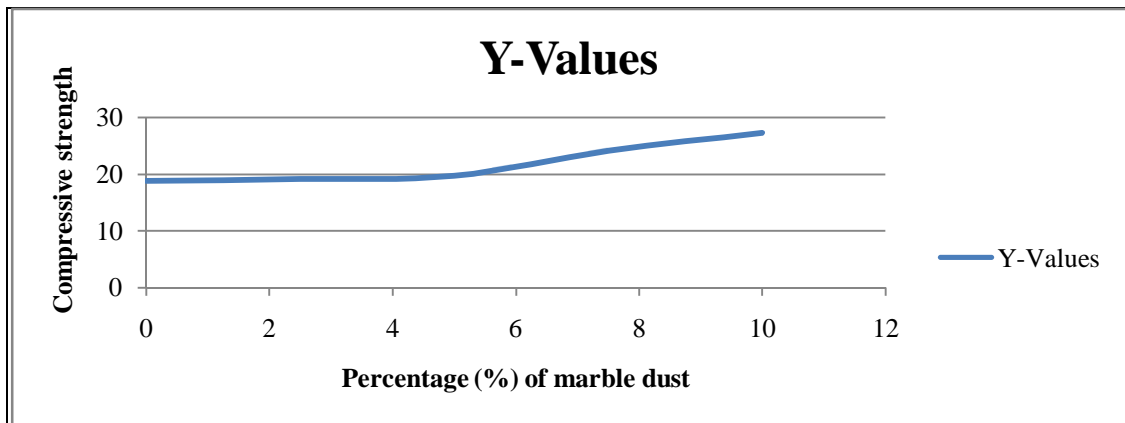


Fig. 1 Compressive strength after 7 days

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Table 6 which show the compressive strength after 28 days. The compressive strength of plane concrete has been obtained as 34.41N/mm<sup>2</sup> after 28 days and 39.43 N/mm<sup>2</sup> after addition of 10 % marble powder.

Table 6 Compressive strength test after 28 days

Mix designation	% of Marble powder	% of Foundry sand	Compressive load (KN)	Compressive Strength (N/mm <sup>2</sup> )	Average Compressive Strength (N/mm <sup>2</sup> )
M-MP 0	0	0	750	33.33	34.41
			795	35.33	
			778	34.57	
M-MP 2.5	2.5	2	780	35.10	35.26
			790	35.25	
			805	35.45	
M-MP 5	5	2	818	36.35	36.05
			805	35.80	
			810	36.00	
M-MP 7.5	7.5	2	845	37.55	37.43
			822	36.53	
			860	38.22	
M-MP 10	10	2	898	39.91	39.43
			874	38.84	
			890	39.55	

Figure 2 show the compressive strength of concrete after addition of marble dust after 28 days. The compressive strength is 34.41N/mm<sup>2</sup> at marble powder is zero and 39.43 N/mm<sup>2</sup> at marble powder is 10 %.

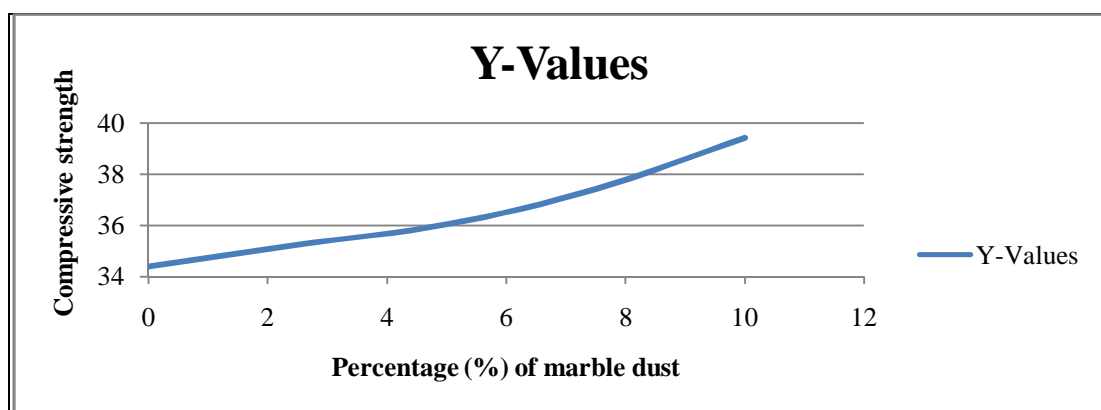


Fig. 2 Compressive strength test after 28 days

### Flexural strength

Flexural strength of plane concrete and marble powder based concrete has been investigated by testing beams of 150mm×150mm×700mm under two-point load because of small span between the supports. In this flexural strength, the effective length of the beam was 640 mm. The flexural strength of plane concrete and concrete based on varying percentage of marble powder and constant percentage of foundry sand content has been illustrated in Table 7 and 8, which shows the flexural strength after 7 and 28 days respectively. The flexural Strength has been obtained as 1.55 N/mm<sup>2</sup> for plane concrete and 1.34 N/mm<sup>2</sup>, 1.48 N/mm<sup>2</sup>, 2.58 N/mm<sup>2</sup> and 2.56 N/mm<sup>2</sup> for varying percentage of

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marble powder and constant percentage of foundry sand for 7 days and 2.7 N/mm<sup>2</sup> for plane concrete and 1.73 N/mm<sup>2</sup>, 2.36 N/mm<sup>2</sup>, 3.50 N/mm<sup>2</sup>, 3.44 N/mm<sup>2</sup> for concrete with varying percentage of marble powder and constant percentage of foundry sand for 28 days. In present table M-MP show the mix of marble powder with varying percentage like 2.5, 5, 7.5 and 10.

Table 7 Flexural strength test after 7 days

Mix designation	% of Marble powder	% of Foundry sand	Flexural load (KN)	Flexural Strength (N/mm <sup>2</sup> )	Average Flexural Strength (N/mm <sup>2</sup> )
M-MP 0	0	0	9.30	1.76	1.55
			6.80	1.30	
			8.50	1.61	
M-MP 2.5	2.5	2	6.30	1.27	1.34
			6.45	1.32	
			6.60	1.45	
M-MP 5	5	2	7.20	1.37	1.48
			7.50	1.42	
			8.80	1.67	
M-MP 7.5	7.5	2	14.30	2.71	2.58
			12.50	2.37	
			14.00	2.66	
M-MP 10	10	2	14.50	2.75	2.56
			12.80	2.43	
			13.20	2.50	

Figure 3 show the flexural strength of concrete after addition of marble dust after 7 days. The flexural strength is constant up to 5 % addition of marble dust but high change after addition of more than 5%. The flexural strength is 1.55 N/mm<sup>2</sup> at marble powder is zero and 2.56 N/mm<sup>2</sup> at marble powder is 10 %.

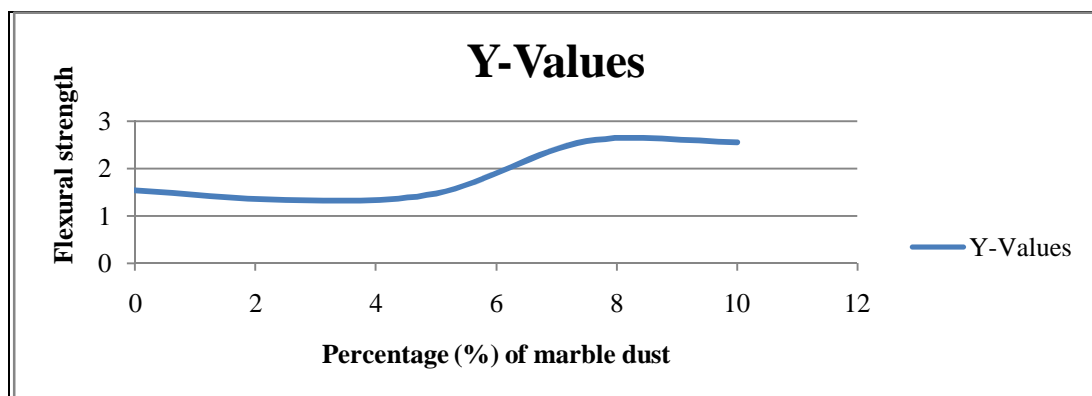


Fig. 3 Flexural strength test after 7 days

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Table 8 which show the flexural strength after 28 days. The flexural strength of plane concrete has been obtained as 34.41N/mm<sup>2</sup> after 28 days and 3.44 N/mm<sup>2</sup> at 10 % addition of marble powder in concrete.

Table 8 Flexure Strength test after 28 Days

Mix designation	% of Marble powder	% of Foundry sand	Flexural load (KN)	Flexural Strength (N/mm <sup>2</sup> )	Average Flexural Strength (N/mm <sup>2</sup> )
M-MP 0	0	0	16.00	3.04	2.7
			13.50	2.56	
			13.20	2.50	
M-MP 2.5	2.5	2	8.35	1.60	1.73
			8.44	1.72	
			8.90	1.88	
M-MP 5	5	2	11.00	2.09	2.36
			11.50	2.18	
			14.80	2.81	
M-MP 7.5	7.5	2	16.50	3.13	3.5
			19.80	3.76	
			19.00	3.61	
M-MP 10	10	2	18.20	3.45	3.44
			18.80	3.57	
			17.50	3.32	

Figure 4 show the flexural strength of concrete after addition of marble dust after 28 days. The flexural strength is 2.70 N/mm<sup>2</sup> at marble powder is zero and 3.44 N/mm<sup>2</sup> at marble powder is 10 %.

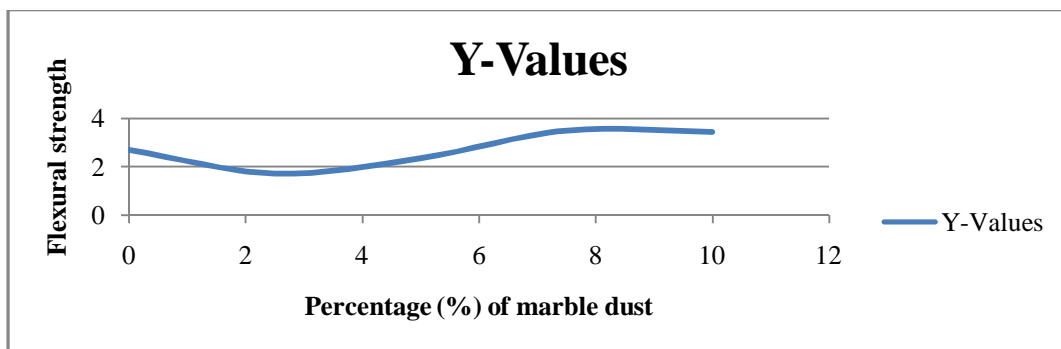


Fig. 4 Flexural strength test after 28 days

### Split tensile strength

Split tensile strength of plane mortar and Marble powder and foundry sand based concrete has been investigated by testing cylinders of 300mm × 150mm under Compression Testing Machine of 100 tonnes capacity. The cylinder has been tested by placing the cylinder in vertical position. The split tensile strength of plane concrete and Marble dust and foundry sand based concrete for various percentages has been illustrated in Table 9 and 10 which shows the split tensile strength after 7 and 28 days respectively. The tensile Strength has been obtained as 3.16 N/mm<sup>2</sup> for plane concrete and 3.27 N/mm<sup>2</sup>, 3.52 N/mm<sup>2</sup>, 3.31N/mm<sup>2</sup> and 2.71N/mm<sup>2</sup> respectively for marble

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powder and foundry sand based concrete for 7 days and 3.16 N/mm<sup>2</sup> for pane concrete and 3.27 N/mm<sup>2</sup>, 3.52 N/mm<sup>2</sup>, 3.31N/mm<sup>2</sup>, 271N/mm<sup>2</sup> respectively for marble dust and foundry sand based concrete for 28 days. In present table M-MP show the mix of marble powder with varying percentage like 2.5,5,7.5 and 10.

Table 9 Split strength test after 7 days

Mix designation	% of Marble powder	% of Foundry sand	Tensile load (KN)	Tensile Strength (N/mm <sup>2</sup> )	Average Tensile Strength (N/mm <sup>2</sup> )
M-MP 0	0		225 202 245	3.18 2.86 3.46	3.16
M-MP 2.5	2.5	2	230 235 242	3.22 3.28 3.32	3.27
M-MP 5	5	2	241 242 265	3.40 3.42 3.75	3.52
M-MP 7.5	7.5	2	255 220 228	3.60 3.11 3.23	3.31
M-MP 10	10	2	188 195 192	2.66 2.76 2.72	2.71

Figure 5 show the split tensile strength of concrete after addition of marble dust after 7 days. The tensile strength is 3.16 N/mm<sup>2</sup> at marble powder is zero and 2.71 N/mm<sup>2</sup> at marble powder is 10 %.

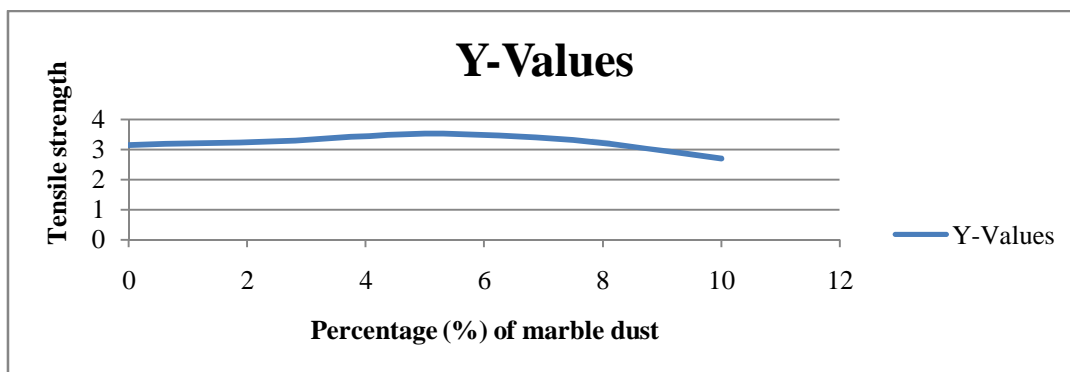


Fig.5 Split tensile strength test after 7 days

Table 10 show the flexural strength after 28 days. The flexural strength of plane concrete has been obtained as 4.42 N/mm<sup>2</sup> and 4.59 N/mm<sup>2</sup> after addition of 10 % marble powder after 28 days.



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Table 10 Table for Split tensile strength test after 28 Days

Mix designation	% of Marble powder	% of Foundry sand	Tensile load (KN)	Tensile Strength (N/mm <sup>2</sup> )	Average Tensile Strength (N/mm <sup>2</sup> )
MX0	0	0	315	4.31	4.42
			320	4.52	
			315	4.43	
MX2.5	2.5	2	380	5.70	5.76
			370	5.78	
			375	5.80	
MX5	5	2	395	5.59	5.52
			386	5.46	
			390	5.52	
MX7.5	7.5	2	370	5.23	5.18
			368	5.20	
			362	5.12	
MX10	10	2	340	4.81	4.59
			312	4.44	
			320	4.52	

Figure 6 show the split tensile strength of concrete after addition of marble dust after 28 days. The split tensile strength is 4.42 N/mm<sup>2</sup> at marble powder is zero and 4.59 N/mm<sup>2</sup> at marble powder is 10 %.

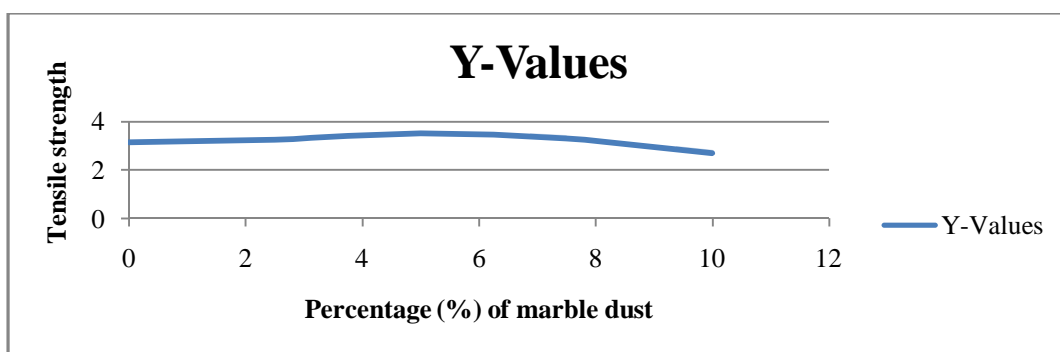


Fig.6 Split tensile strength test after 28 days

### V. CONCLUSION

- The results obtained in the present study indicates that it is feasible to replace the cement by marble powder for improving the strength characteristics of concrete, thus the marble powder can be used as an alternative material for the production of concrete to address the waste disposal problems and to minimize the cost of construction with usages of marble powder.
- The Experimental work shows that properties of concrete M35 gets improved up to some extent due to incorporation of marble powder.

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- M35 concrete produced from cement replacement up to 10% marble powder leads to increase in compressive strength of concrete at the end of 7 days i.e 27.33 N/mm<sup>2</sup> & 28 days i.e 39.43 N/mm<sup>2</sup> respectively in case of compressive strength of concrete.
- M35 concrete produced from cement replacement up to 10% marble powder leads to increase in flexural strength of concrete at the end of 7 days i.e 2.56 N/mm<sup>2</sup> & 28 days i.e 3.44 N/mm<sup>2</sup> respectively in case of flexural strength of concrete.
- M35 concrete produced from cement replacement up to 10% marble powder leads to decrease in tensile strength of concrete at the end of 7 days i.e 2.71 N/mm<sup>2</sup> & 28 days i.e 4.59 N/mm<sup>2</sup> respectively in case of tensile strength of concrete.
- Consistency of cement paste increases by adding different % of marble powder i.e by replacing of cement by marble powder.
- Initial setting time of cement increase by adding different % of marble powder in a cement paste.
- Soundness of cement will not change so much by adding different % of marble powder in a cement paste.

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