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Experimental Study on Use of Waste Marble Dust in Concrete

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Abstract
Concrete is the most important component used in the construction industry throughout the world, where the fine aggregate is generally natural sand. The use of sand in construction activities results in the excessive mining. Due to excessive mining, natural resources are getting exhausted, results in increase in scour depth and sometimes flood possibility. Thus, it is becoming inevitable to use alternative material in concrete.Marble is one of the important materials used in the construction industry. Marble powder is produced from processing plants during the sawing and polishing of marble blocks and about 20 - 25% of the processed marble is turn into powder form. Disposal of the marble powder material from the marble industry is one of the environmental problems worldwide today.The present study is aimed at utilizing Waste marble powder construction industry itself as fine aggregate in concrete, replacing natural sand. The replacement is done partially and fully in the proportion 0%, 25%, 50% and 100% and its effect on properties of concrete were investigated.

I. Introduction

Concrete is a widely used construction material consisting of cementing material, fine aggregate, coarse aggregate and required quantity of water, where the fine aggregate is usually natural sand. The use of sand in construction results in excessive sand mining which is objectionable. Due to rapid growth in construction activity, the available sources of natural sand are getting exhausted. Also, good quality sand may have to be transported from long distance, which adds to the cost of construction. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete.

Waste marble dust is one such material which can be used to replace sand as fine aggregate. The present study is aimed at utilizing Waste marble powder as fine aggregate in concrete, replacing natural sand. Marble is one of the most important materials used in buildings since ancient times, especially for decorative purposes. Marble powder is produced from processing plants during the sawing and polishing of marble blocks and about 25% of the processed marble is turn into powder form. Disposal of the marble powder material from the marble industry is one of the environmental problems worldwide today.

One of the logical means for reduction of the waste marble powder is utilizing them in building industry itself. Some attempts have been made to find and assess the possibilities of using waste marble powder in mortars and concretes and results about strength and workability were compared with control samples of conventional mortar/concrete.

The present study investigate the effects of using waste marble dust (WMD) as a fine material on the mechanical properties of the concrete. For this purpose four different series of concrete-mixtures will be prepared by replacing the fine sand with WMD at proportions of 0, 25, 50 and 100% by weight. In order to determine the effect of the WMD with respect to the curing age, standard mechanical properties of concrete are to be analyzed at the curing ages of 3, 7, 28 days.

II. Scope and Objective

1) To study the effect of use of waste marble dust on the mechanical properties of concrete.
2) To compare the compressive, flexural and tensile strength using WMD with the given design mix.
3) To establish alternative for sand with partial use of WMD in concrete.

III. Methodology

A total of four series of concrete specimens including the control specimen were prepared in order to examine the effect of substituting marble dust (0, 25, 50 and 100% by weight) in place of sand to investigate the basic strength properties of concrete.

Ordinary Portland cement (OPC), grade 43 confirming to IS 8112:1989 was used throughout the investigation. The marble dust obtained as an industrial byproduct directly from the deposits of

marble factories is used as a sand replacement material.

The coarse aggregate used in this investigation have a maximum size of 20 mm with grading confirming to IS-383-1970. The natural river sand passing through 4.75mm sieves is used throughout the process.

The design of concrete mix is done as per guidelines of IS 10262: 2009 with a grade of M25 concrete. The mixing of concrete is done using a standard mechanical mixer. The mixing is to be done for two minutes for all the ingredients to feed inside the mixer.

Compaction of all the specimen was done by using shake table vibrator. The top surface of concrete is leveled and finished smooth. After six hours, the specimen detail and date of concreting will be specified on top surface to identify it properly.

The compressive test and the flexural strength test are performed as per IS 516 : 1959 and split tensile test is performed as per IS 5816 : 1970. Various tests on the concrete ingredients that were required, given by -

Sr. No.	Tests	Result
1	Specific gravity of cement	3.15
2	Consistency	32 %
3	Initial setting time	74 min
4	Final setting time	255 min
5	Specific gravity of sand	2.61
6	Specific gravity of aggregate	2.8
7	Aggregate impact value	5.26%
8	Aggregate crushing value	15.09%

Waste marble dust

Marble powder is produced from the marble processing plants during the cutting, shaping and polishing. During this process, about 20-25% of the process marble is turn into the powder form. India being the topmost exporter of marble, every year million tons of marble waste form processing plants are released. The disposal of this waste marble on soils causes reduction in permeability and contaminates the over ground water when deposited along catchment area**.**

Thus, utilizing these marble waste in construction industry itself would help to protect the environment from dumpsites of marble and also limit the excessive mining of natural resources of sand.

Physical properties

- Colour - White
- Form - Powder
- Odour - Odourless
- Specific gravity - 2.68 gm/cm^3

Chemical properties

OXIDES	OPC – 43 (%)	WMD (%)
CaO	60 – 67	40.45
SiO_2	17 – 25	28.35
Al_2O_3	3.0 – 8.0	0.42
Fe_2O_3	0.5 - 6.0	9.70
MgO	0.1 – 4.0	16.25

IV. Concrete Mix Design

A mix M25 grade was designed as per Indian Standard method (IS 10262-2009) and the same was used to prepare the test samples.

Material	M 25 Grade
Cement	350 kg/m^3
Sand	860 kg/m^3
Aggregate	1096 kg/m^3
Water	168 lits.
w/c ratio	0.48

Thus, for the given design mix, the proportion of the material for the replacement sand with the marble powder is done as per following quantities (kg/m^3) –

Specimen M25 grade	Cement (Kg)	Sand (Kg)	Aggregate (Kg)	Water (Kg)	Marble dust (Kg)
MD 0%	350	860	1096	168	0
MD 25%	350	645	1096	168	215
MD 50%	350	430	1096	168	430
MD 100%	350	0	1096	168	860


Fig. 1 Weighing and mixing of materials

Slump Test

The slump of the concrete is defined as the vertical settlement of the unsupported fresh concrete flows to the sides when sinking in height takes place.

The slump is the measure indicating the consistency or workability of the cement concrete. It is the measure of the water content needed for concrete to be used for different works. Concrete is said to be workable if it is easily mixed, placed and compacted.

Fig. 2 Slump of concrete

Specimen M25 grade	Slump Value (mm)
M D 0 %	5 4
M D 2 5 %	6 2
M D 5 0 %	7 8
M D 1 0 0 %	9 5

V. Results

Compressive strength

Compressive strength tests were performed on compression testing machine using cube samples. Three specimens for each mix were prepared and tested. The average failure load and the strengths obtained are given by –

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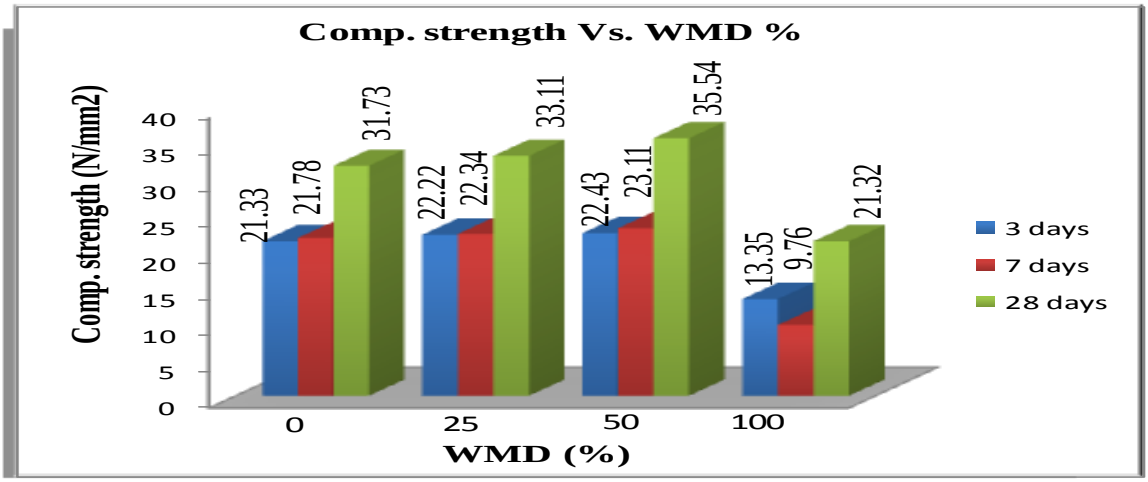
Fig. 3 Testing of concrete cubes

	3 days		7 days		28 days	
M25 grade	Failure load (KN)	Comp. strength (N/mm2)	Failure load (KN)	Comp. strength (N/mm2)	Failure load (KN)	Comp. strength (N/mm2)
M D 0 %	480	21.33	490	21.78	714	31.73

M D 2 5 %	5 0 0	2 2 . 2 2	5 0 2 . 6 7	2 2 . 3 4	7 4 5	3 3 . 1 1
M D 5 0 %	**5 0 4 . 6 7**	**2 2 . 4 3**	**5 2 0**	**2 3 . 1 1**	**7 9 9 . 6 7**	**3 5 . 5 4**
M D 1 0 0 %	3 0 0 . 3 3	1 3 . 3 5	2 1 9 . 6 7	9 . 7 6	4 7 9 . 6 7	2 1 . 3 2



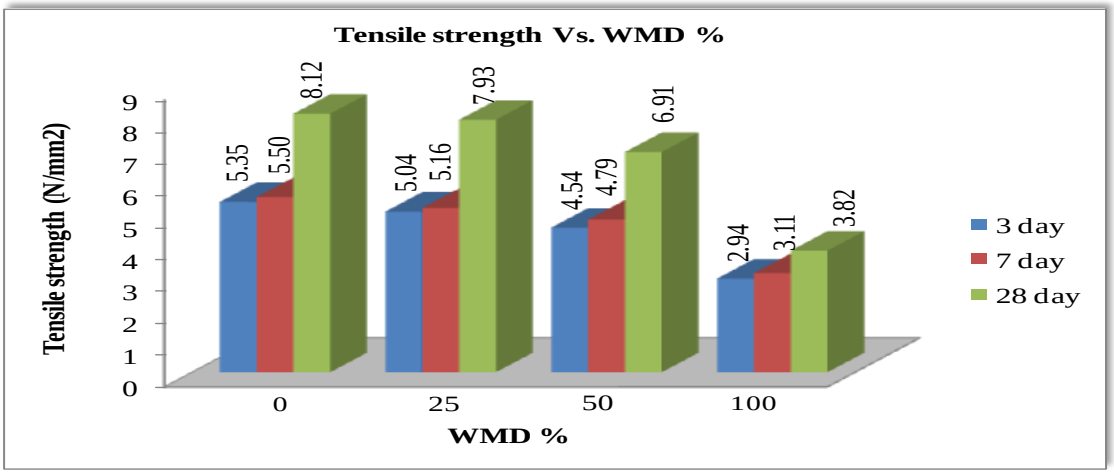
It is observed that 50 % WMD mix is the maximum optimum % of WMD and again further increasing the WMD% the compressive strength is gradually decreases.

Split Tensile Strength

The average failure load and the split tensile strength obtained after 3, 7 and 28 days of curing for cylindrical specimen is given by –

Fig. 4 Testing of cylinder speciman.

	3 d a y s		**7 d a y s**		**2 8 d a y s**	
M 2 5 g r a d e	Failure load (KN)	Slit tensile strength (N/mm2)	Failure load (KN)	Slit tensile strength (N/mm2)	Failure load (KN)	Slit tensile strength (N/mm2)
M D 0 %	**3 7 7 . 6 7**	**5 . 3 5**	**3 8 8 . 3 3**	**5 . 5 0**	**5 7 3 . 3 3**	**8 . 1 2**
M D 2 5 %	3 5 6 . 3 3	5 . 0 4	3 6 4 . 3 3	5 . 1 6	5 6 0 . 0 0	7 . 9 3
M D 5 0 %	3 2 0 . 6 7	4 . 5 4	3 3 8 . 3 3	4 . 7 9	4 8 8 . 3 3	6 . 9 1
M D 1 0 0 %	2 0 7 . 6 7	2 . 9 4	2 1 9 . 6 7	3 . 1 1	2 6 9 . 6 7	3 . 8 2



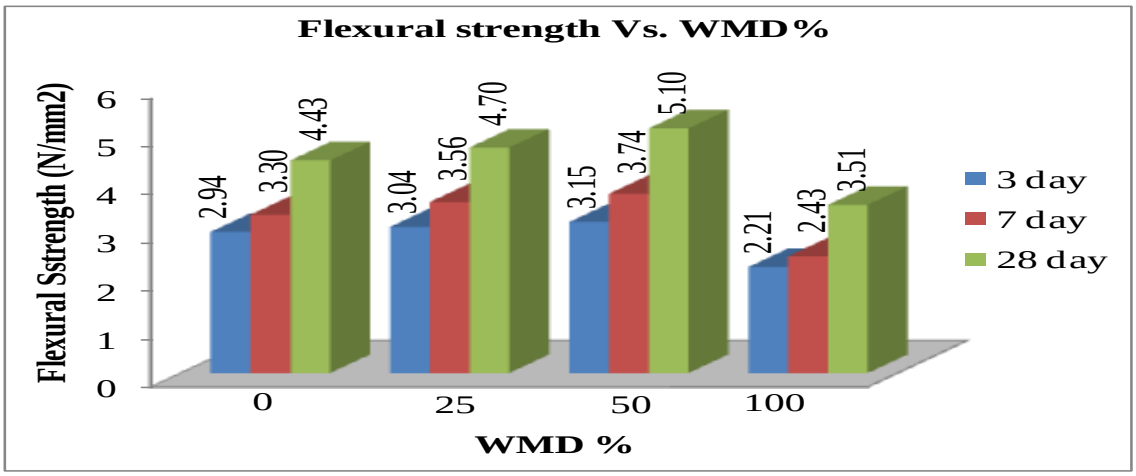
The maximum tensile strength is obtained at 0% WMD mix. However, the tensile strength at 25% WMD mix is coming nearly equal to the tensile strength at 0% WMD. Thus, 25% WMD mix can also give better tensile strength.

Flexural Strength

The average failure load and the flexural strength obtained after 3, 7 and 28 days of curing for beam specimen is given by –

Fig. 5 Testing of concrete beam

	3 days		7 days		28 days	
M 25 grade	Failure load (KN)	Flexural strength (N/mm2)	Failure load (KN)	Flexural strength (N/mm2)	Failure load (KN)	Flexural strength (N/mm2)
MD 0 %	15.27	2.94	17.13	3.30	23.00	4.43
MD 25 %	15.80	3.04	18.50	3.56	24.40	4.70
MD 50 %	**16.33**	**3.15**	**19.40**	**3.74**	**26.47**	**5.10**
MD 100 %	11.47	2.21	12.63	2.43	18.20	3.51



The maximum flexural strength is achieved at 50% WMD mix, at all thecuring ages. Thus, 50% WMD mix gives the optimum percentage of WMD.

VI. Discussion

- With the inclusion of Marble powder the compressive and flexural strength of concrete gradually increases upto a certain limit but then gradually decreases.
- With the inclusion of Marble powder upto50%, there is 10.72% increase in compressive strength and 13.13% increase in flexural strength for 28 days curing.
- The maximum tensile strength is obtained at 0% substitution of marble powder and with the addition of WMD the strength gradually decreases.

VII. Conclusion

1. The compressive strength of concrete is increased with addition of waste marble powder up to 50% by weight in place of sand and further any addition of waste marble powder the compressive strength decreases.
2. The split tensile strength of cylinders is decreased with addition of waste marble powder, from control mix to 100% replacement of sand.
3. However, the tensile strength at 25% replacement of sand is coming nearly equal to the tensile strength at control mix. Thus, 25% sand replacement with WMD can also give better tensile strength.
4. The flexural strength of beams is also increased with addition of waste marble powder up to 50% sand replacement and then gradually decreases.
5. Thus, we found out the optimum percentage for replacement of sand with marble powder in concrete is almost 50%.

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