Utilization of Marble Dust in Pavement Quality Concrete

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Abstract— Concrete is highly versatile construction material in nature. Concrete's constituent materials are available naturally in all parts of the world. With more construction projects everywhere and due to the great utility of concrete in constructions, with each passing day these materials are getting deficient thus asking for the alternatives. Utilization of waste material in pavement quality concrete can be beneficial in order to find an alternative solution to reduce environmental pollution. The marble stone is most widely used in the construction and it generates marble dust through cutting and polishing of the stone. Marble dust is a waste material consisting of very fine powder and thus creating environmental problems worldwide today. Disposal of this marble waste leads to health hazards like respiratory and allergy problems to the people around. It also causes the pollution of air, water and soil. In this work, systematic experimental study has been carried out using marble dust to replace sand at various replacement levels in pavement quality concrete. This study has been carried out for w/c 0.40 and 0.42 and specimens have been cast to perform various tests (Compressive Strength Test and Flexural Strength Test), durability properties (Water permeability test, Abrasion resistance test), ultrasonic pulse velocity meter test and impact test.

Key words: Concrete, Durability Properties, Marble Dust, Pavement Quality Concrete, Strength Tests

I. INTRODUCTION

Rigid pavements or cement concrete roads are built with a top layer of high quality concrete called as Pavement Quality Concrete. It should have high strength so as to distribute the wheel load of the vehicles to the bottom layers without any deformation. It should minimize the skidding of vehicles. The use of good quality conventional materials in road construction is becoming increasingly expensive in India due to the increasing demand as well as its scarcity in nature. Further the development and use of new modified paving materials in road construction results in high performance pavement to meet the communities. So, attempts should be made to utilize industrial and agricultural wastes effectively in construction to address environmental and economic concerns. Recycling is the act of processing the used material for use in creating new product. Stone waste i.e. Marble and Granite waste has been commonly used as building materials.

A. Marble Dust

Today industry's disposal of stone waste is one of the environmental problems around the world. Stones are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, the original stone mass is lost by about 30% in the form of solid as well as powder form as dust. The waste is dumped in nearby pits and vacant spaces. This leads to serious environmental pollution an occupation of vast area of land. So it poses a severe threat on the environment, eco-system and the health of the people. So it is necessary to use this stone waste in construction industry. Marble processing units produce a huge amount of Marble waste in the form of powder during Marble cutting operations. This waste is rarely degradable and causes serious environmental issues. Marble industries dump marble waste in open fields or pits which causes water logging problems and reduces porosity of soils.

B. Research Aim

The aim of this research is to determine the suitability of marble dust as a partial replacement of sand in pavement quality concrete.

The following objectives have been considered for pavement quality concrete containing marble dust as partial replacement to sand:

1) To prepare pavement quality concrete containing marble dust using pre-compression technique of M30 grade for water cement ratio of 0.40 and 0.42.
2) To evaluate and compare the mechanical properties of the pavement quality concrete.
3) To investigate durability and impact resistance of the pavement quality concrete.
4) To determine the quality of the pavement quality concrete by non-destructive testing.
5) To compare the compressive, flexural and tensile strength using waste marble dust with design concrete mix.

C. Materials

In this systematic study, various types of materials used for the construction of modified pavement quality concrete are cement, fine aggregate, coarse aggregates and marble dust.

Fig. 1: Marble Dust Sample

S. No.	Name of Chemical	Percentage content of chemical in marble dust
1.	CaO	40.45
2.	SiO_2	28.35
3.	Al_2O_3	0.42
4.	Fe_2O_3	9.70
5.	MgO	16.25

Table 1.1: Chemical Properties of Marble Dust

II. PAVEMENT QUALITY CONTROL MIX PROPORTION

In this study, mix proportion of concrete was prepared with the help of concrete mix design method that has the mandatory desired properties. The concrete mix design of M30 grade is made as per the guidelines given in the Indian standards namely IS: 10262 (2009) and IS: 456 (2000). The marble powder is added to the mix by the weight of concrete and as the partial replacement of sand. The water to cement ratio maintained at 0.40 & 0.42. The mix proportion for the control and the other mixes at different percentage of marble dust are shown in Table 1.2

S. No	Replacement of sand	W/C ratio	Cement (Kg)	Fine aggregate (Kg)	Coarse aggregate (Kg)	Marble dust (Kg)
1.	Control mix (0%)	0.40	478.95	640.78	1157.18	0.00
2.	10%	0.40	478.95	576.70	1157.18	23.95
3.	15%	0.40	478.95	544.66	1157.18	45.50
4.	25%	0.40	478.95	480.58	1157.18	61.43
5.	Control mix 0%	0.42	478.95	640.78	1157.18	0.00
6.	10%	0.42	478.95	576.70	1157.18	23.95
7.	15%	0.42	478.95	544.66	1157.18	45.50
8.	25%	0.42	478.95	480.58	1157.18	61.43

Table 1.2: Mix Proportion of Concrete per m^3 Containing Marble Dust

A. Testing Methods of Concrete

After curing, the specimens are taken for following tests:

1) Compressive strength test
2) Flexural strength test
3) Workability test
4) Water permeability test
5) Abrasion resistance test
6) Ultrasonic pulse velocity test
7) Impact test

The three number of specimens in each sample are tested and the average value is calculated. The results are compared and analyzed with that of control mix

B. Compressive Strength Test

The compressive strength is the capacity of a material to withstand loads while being contracted or pushed before failure or breaking. The compressive strength of concrete is the most important property of hardened concrete which determine for deciding not only the ability of the concrete to withstand load, but also the quality of the hardened concrete. The compressive strength has a specific relationship with all the other properties of concrete i.e. the other properties of concrete enhanced with improvement in compressive strength. In this investigation, the specimens size of 150 mm × 150 mm × 150 mm concrete cubes (three for each mix) were cast for compressive strength. The compressive strength test is conducted on cubes at 7 days, 28 days, and 90 days as per the IS: 516-1959.The digital Compression Testing Machine (CTM) shown in Fig. 3.2 is used for testing specimens. All the specimens are subjected to the compressive axial load without shock and increased continuously with the rate of approximately140 kg/cm^2 per minute until the failure of specimen and no greater load can be sustained.

Fig. 2: Compression Testing Machine

III. DATA ANALYSIS & DISCUSSION

A. Workability

The value of the slump was obtained from the distance between the underside of the round tamping bar and the highest point on the surface of the slumped concrete sample. Table 1.3 shows the results of the slump test for the concrete paving block mix with or without marble dust waste at w/c ratio of 0.40 and 0.42.

S.N0.	Specimen number	Water cement ratio	% Replacement of marble dust	Slump value
1.	A1	0.40	0%	60
2.	A2	0.40	10%	60
3.	A3	0.40	15%	55
4.	A4	0.40	25%	50
5.	B1	0.42	0%	65
6.	B2	0.42	10%	65
7.	B3	0.42	15%	60
8.	B4	0.42	25%	60

Table 1.3: Workability of Concrete (Slump Result)

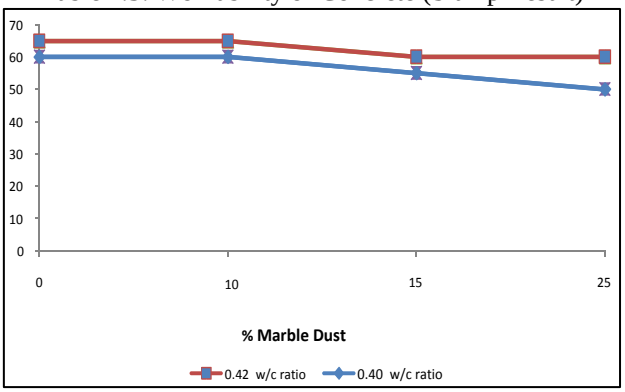

Fig. 3: Slump Value of Different Concrete Mix

B. Compressive Strength

The compressive strength of concrete containing marble dust as partial replacement of sand for 0.40 and 0.42 w/c ratios at 7 days, 28 days, and 90 days curing had been shown in Fig. 4.2 and Fig.4.3 respectively.

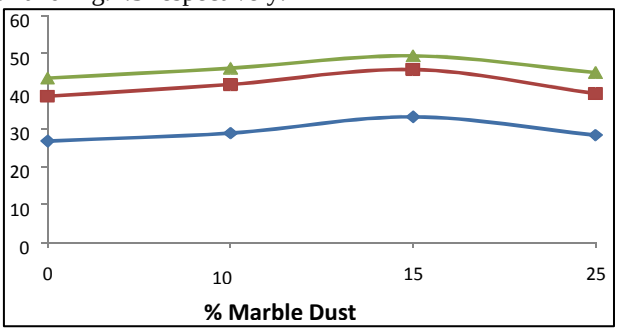

Fig. 4: Compressive Strength at w/c ratio 0.40

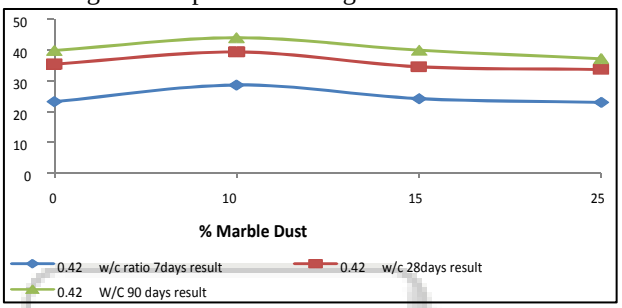

Fig. 5: Compressive Strength at w/c ratio 0.42

C. Abrasion Resistance

Abrasion resistance has been calculated as the depth of surface wear. The graph shows the variation in the depth of wear with respect to the varied percentage of 0%, 10%, 15%, and 25% of marble dust as partial replacement of sand at w/c ratio of 0.40 and 0.42.

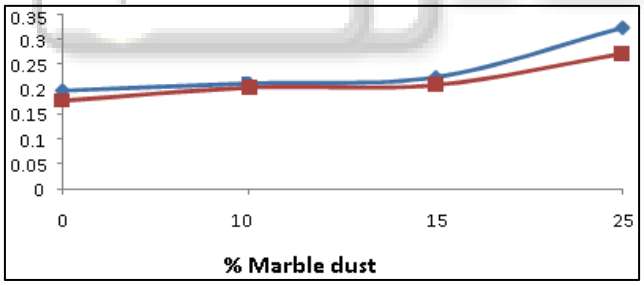

Fig. 6: Abrasion Resistance of Concrete Paving Blocks Containing Marble Dust for Varied w/c Ratio

IV. CONCLUSIONS

Following conclusions were drawn from the discussion of results of marble dust pavement quality concrete in the previous chapters:

1) The workability of concrete gets decreased when sand has been replaced by marble dust (replacement level 25%) as compared to control mix (replacement level 0%) for w/c 0.40 & 0.42.
2) For marble dust concrete paving blocks, the compressive strength of concrete increased depending upon replacement level and w/c ratio. For w/c ratio 0.40, the improvement in compressive strength has been observed at replacement level of 15% whereas the corresponding increase was at the replacement level of 10% for w/c ratio 0.42.
3) The flexural strength of marble dust concrete paving blocks increased depending upon replacement level and w/c ratio for modified concrete containing marble dust. For w/c ratio 0.40, the increase in flexural strength is observed at replacement level of 15% whereas for w/c ratio 0.42, the corresponding increase is at the replacement level of 10%.
4) The value of water penetration depth as compared to control mix (replacement level 0%) increased gradually for the both w/c ratio 0.40 and 0.42. Maximum water penetration depth is observed as at 25% replacement level of marble dust at w/c of 0.40 and 0.42.
5) The value of abrasion loss was gradually increased with addition of varied replacement level (10% to 25%) of marble dust as partial replacement of sand. It was also seen that the maximum loss of Abrasion was 0.32 mm (less than permissible abrasion loss for concrete paving block). So, this type of concrete samples can be used in concrete paver block
6) For w/c ratio 0.4, energy absorbed by the concrete samples was increased at replacement level of 15% whereas for w/c ratio 0.42, the corresponding increase at the replacement level up-to 10%.
7) Ultra-sonic pulse velocity result shows that quality of marble dust pavement quality concrete blocks (for both w/c ratio of 0.40 and 0.42) was of good category as per IS 13311(Part1).

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