An Investigation on the Impact of Industrial Wastes as A Replacement for Sand In Fiber-Reinforced M20 Grade Concrete

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Abstract**:** ***Waste disposal in environment due to rapid urbanization and industrialization is increasing day by day. Disposal of wastes in the environment is more difficult in the construction industry. Marble powder and quarry dust are the waste materials obtained from the dressing and processing unit of marble production and quarries respectively. These waste materials are dumped in the environment as a landfill, and they can be used as a viable substitute material to the ingredients of concrete to a great extent. This will result in the production of economically green concrete; this happens because of less usage of river sand, leading to reduction in damage to to the environment. In this paper, natural sand used in the fiber-reinforced concrete (FRC) of grade 20 was replaced by varying proportions (0%, 25%, and 50%) and combinations of quarry dust (QD) and marble powder (MP) with 0.5% of basalt fiber added to the mix in order to explore the impact of QD and MP on the mechanical properties of concrete. The strength properties were assessed at 3rd, 7th, 14th and 28th day and the obtained results are tabulated. It is observed that a particular proportion of QD and MP enhances the strength of FRC.***

Keywords: Marble powder, Quarry Dust, Fiber Reinforced Concrete, Basalt Fiber.

I. INTRODUCTION

Innovations are essential to meet the growing demand for new and high quality materials. For making concrete broken stones or gravel, river sand, cement and water are needed in abundance. Due to the rapid growth of the construction sector, the use of concrete is increasing every year. This leads to an over-exploitation of natural resources like river sand [1] [3]. Due to the existing high demand of river sand, our engineers are looking for an alternative material for to replace it in the concrete [4]. That is why the green building concept is emerging in the construction industry. As a result, engineers have succeeded in finding effective materials to replace sand in making concrete, namely fly ash, slag, lime stone, M-Sand, Marble dust, quarry dust, etc. Generally, marble is used for both for flooring and decorative purposes [7]. At present, large quantities of marble waste are produced in stone-processing plants, which generate huge volumes of waste that are very harmful to the environment. In India, tons of waste are produced by marble industry [9]. It is therefore necessary to use the waste effectively [8]. QD is a residue following the extraction and processing of rocks into finer particles. Natural sand is not properly classified in many parts of the country since it contains too much silt. On the other hand, QD does not have any sludge or organic contaminants and can be made in the preferred gradation and fineness as needed. As a result, it improves the strength of concrete [12]. Basalt fibers are typically used in concrete to control cracking due to plastic and drying shrinkage [15] [16]. They also reduce the permeability of the concrete and reduce bleeding.

So, in this study, the mix proportion is done to obtain M20 grade concrete made with 0.5% of Basalt fiber, and river sand is replaced by different percentages of QD and MP.

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II. MATERIALS USED

The lists of materials used in this study are as follows: [1] [3] [4]

- Cement
- Fine aggregate
  - Natural sand
  - Marble powder
  - Quarry dust
- Coarse aggregate (Gravel)
- Basalt fiber
- Water
- Super plasticizers

A) Cement

Throughout the study, the OPC grade 53 was used.

Table 1 Cement Properties

Property		Value	IS Code Ref.
Consistency (%)		29	4031 (Part 4):1988
Specific Gravity		3.15	4031 (Part 11)1988
Compressive Strength (MPa) @ days	3	27.4	12269: 2013
	7	37.8	
	28	53.5	

Setting time (Min.)	Initial	125	4031 (Part 5):1988

Table 2 Chemical Composition of Cement

Component	OPC 53
Na2O	0.4
K_2O	0.63
SO_3	1.35
MgO	2.07
Fe_2O_3	3.42
Al_2O_3	6.76
SiO_2	24.47
CaO	62.18

Fig. 1 Cement

B) Fine aggregate

i) River sand (RS)

Locally available river sand was used in this investigation.

Fig. 2 River Sand

ii) Marble powder

It was observed that the collected MP was firstly wet (Slurry form), used in the concrete mix and dried by exposure to the sun.

Fig. 3 Marble Powder

iii) Quarry dust

QD was obtained from nearby crushers and used without any processing.

Fig. 4 Quarry Dust

Table 3 Properties of Fine Aggregate

Property	RS	MP	QD	IS Code Ref.
Shape	Spherical	Spherical	Spherical	2386 (Part III): 1963
Max. Size (mm)	4.75	4.75	4.75	
Specific Gravity	2.58	2.8	2.54 – 2.6	
Bulk Density (kg/m^3)	1460	1418	1750	
Moisture content (%)	1.5	1.6	2.15	
Fineness Modulus	2.65	2.09	2.4	
Gradation	Zone II	Zone II	Zone II	383: 2016

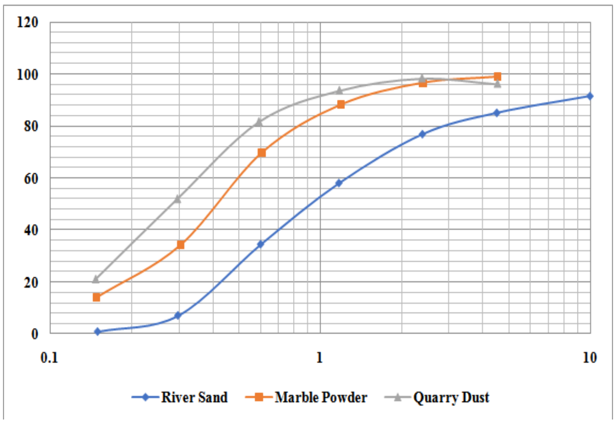

Fig. 5 Sieve Analysis Report

C) Coarse Aggregate

Locally available crushed granite stones were used in this study which were retained on 4.75mm IS sieve conforming to the specifications mentioned in IS 383:2016.

Table 4 Coarse Aggregate Properties

Property		Value	IS Code Ref.
Type and Shape		Crushed & Angular	2386 (Part I):1963
Size (mm)	Max.		
	Min,		
Fineness Modulus		6.41	
Specific Gravity		2.71	2386 (Part III): 1963
Bulk density (kg/m^3)		1653	
Water absorption (%)		0.92	
Impact value (%)		10.15	2386 (Part IV): 1963
Crushing value (%)		13.5	

Fig. 6 Coarse Aggregate

D) Basalt Fiber

Commercially available Chopped basalt fibers were used uniformly mixing them in the concrete mix [15] [16].

Table 5 Properties of Basalt Fiber

Property	Value
Young's Modulus (GPa)	88.5
Tensile Strength (MPa)	3200
Specific Gravity	2.68

[*As per Manufacturers result]

Figure 7 Basalt Fiber

III. EXPERIMENTAL PROGRAMME

M20 grade fiber-reinforced concrete mix was prepared by keeping the basalt fiber addition at 0.5%, and the fine aggregate was partially replaced by QD and MP under various proportions of replacement percentage [1] [2] [5] [8]. The experimental programme followed in this study is described in Table 6. Mix proportion was made as per the guidelines prescribed in IS 10262:2009 i.e., 1:1.59:3.34 (see Figure 9).

Table 6 Fine Aggregate Replacement Percentage (%)

Mix ID	RS	MP	QD
CC	100	-	-
FRC1	75	25	-
FRC2	50	50	-
FRC3	75	-	25
FRC4	50	-	50
FRC5	50	25	25
FRC6	-	50	50

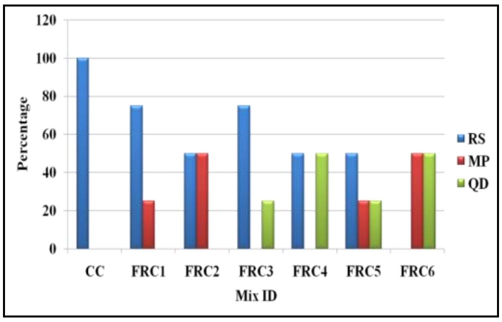

Fig. 8 Fine Aggregate Replacement Percentage (Experimental Programme)

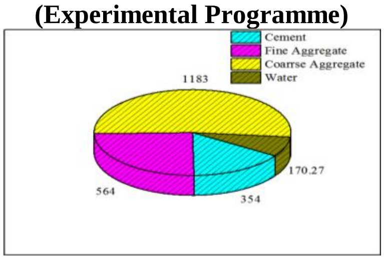

Fig. 9 Mix Proportion (kg/m^3)

IV. MECHANICAL STRENGTH PROPERTIES

Strength properties of FRC mix were assessed on 3rd, 7th, 14th and 28th days. The details of test results are tabulated in Tables 7 and 8.

Table 7 Compressive Strength (MPa)

Mix ID	Compressive Strength at varying curing period in days				Strength Attainment Ratio (Based on Target Mean Strength) %			
	3	7	14	28	3	7	14	28
CC	12.8	19.3	26.4	29.8	45.31	68.32	93.45	105.49
FRC1	13.1	19.7	27.3	30.2	46.37	69.73	96.64	106.90
FRC2	12.9	19.5	26.6	30.1	45.66	69.03	94.16	106.55
FRC3	13.9	20.4	28.1	30.9	49.20	72.21	99.47	109.38
FRC4	14.7	21.6	29.3	32.4	52.04	76.46	103.72	114.69
FRC5	14.9	21.9	29.8	33	52.74	77.52	105.49	116.81
FRC6	11.9	18.1	25.3	27.9	42.12	64.07	89.56	98.76

Table 8 Split Tensile and Flexural Strength (MPa)

Mix ID	Compressive Strength at varying curing period in days				Strength Attainment Ratio (Based on Target Mean Strength) %			
	3	7	14	28	3	7	14	28
CC	12.8	19.3	26.4	29.8	45.31	68.32	93.45	105.49
FRC1	13.1	19.7	27.3	30.2	46.37	69.73	96.64	106.90
FRC2	12.9	19.5	26.6	30.1	45.66	69.03	94.16	106.55
FRC3	13.9	20.4	28.1	30.9	49.20	72.21	99.47	109.38
FRC4	14.7	21.6	29.3	32.4	52.04	76.46	103.72	114.69
FRC5	14.9	21.9	29.8	33	52.74	77.52	105.49	116.81
FRC6	11.9	18.1	25.3	27.9	42.12	64.07	89.56	98.76

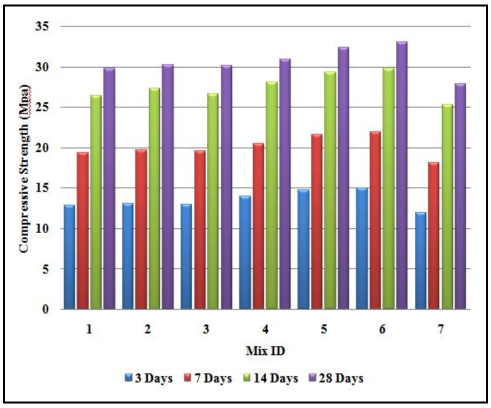

Fig. 10 Compressive Strength

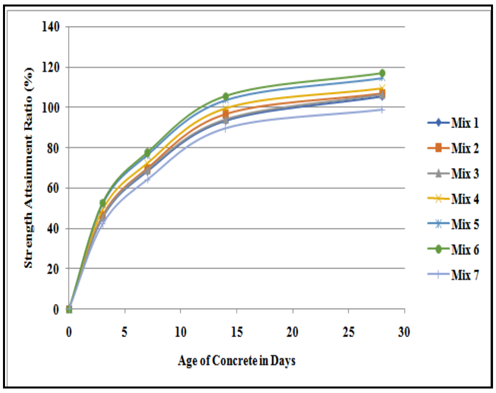

Fig. 11 Strength Attainment Ratio

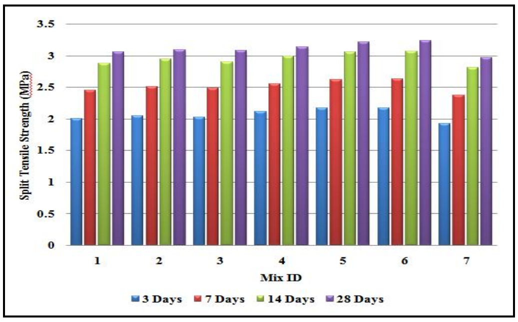

Fig. 12 Split Tensile Strength

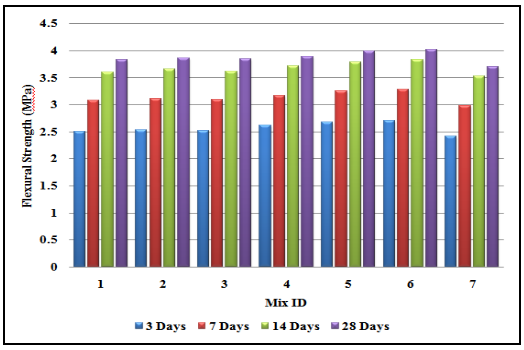

Fig. 13 Flexural Strength

V. CONCLUSION

The results of the experimental study are as follows:

- Waste materials like QD and MP, the industrialized waste products, can be used in concrete to obtain durability deriving economic and environmental benefits.
- Test results show that these waste materials can improve the performance of concrete at hard state and that they produce excellent strength and quality.
- Basalt fiber addition in the mix enhances the strength of concrete by reducing the shrinkage and drying effects.
- Replacement of RS with QD at 50% shows better results than that mix produced with 50% of MP.
- FRC5 (RS:50%, MP:25%, QD:25%) shows better results than the other concrete mixes and increases the strength properties by 10.74%, 5.9% and 5.24%, which is better than the concrete mix without any waste materials.
- It is concluded that the replacement of RS with QD and MP is achievable and economical when compared to conventional concrete.

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