IMPROVING THE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT BY MARBLE POWDER & SAND WITH GLASS POWDER

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1. INTRODUCTION

1.1 ABOUT CONCRETE WITH MARBLE AND GLASS POWDER

Marble-glass powder concrete is the type of concrete that is made by partial replacement of cement with marble and sand with glass powder. One of the greatest environmental concerns in construction industry is the production of cement which emits large amount of CO_2 gas to the atmosphere. It is estimated that 1 tone clinker production releases 1 tone CO_2. Mixing of clinker to supplementary materials called blending is considered as a very effective way to reduce CO_2 emission. It is estimated that the Rajasthan Marble Processing Enterprise produces 1800m^3 (4500 tons) marble waste annually, which implies that using marble waste of The Rajasthan Marble processing enterprise as cement replacing material can indirectly reduce CO_2emission to the atmosphere by 4500 tons annually. Recycling marble waste powder in substitution of sand also indirectly can reduce environmental problem related with sand production. The design of concrete (M_{20}) was done with locally available materials. Cement was replaced with replacements levels of cement (0%, 10%, and 20%).

Cubes of size 150 X 150 X 150mm and cylinder 150 mm dia and 300 mm length and prism of size 150 x 150 x 700 mm were casted for each%age replacement. Hence cubes were casted for each compressive and split tensile strength. Thecompressive strength and split tensile strength of concrete of all mixes was determined at the ages of 7,14 and 28 days of curing for the various replacement level of cement and addition of cement and addition of waste marble powder (0%, 10%, 20%) at the end of different curing periods.

1.2 MARBLE AND GLASS POWDER IN CONCRETE

The main constituents of design concrete are source material which is partial replacement of cement with marble powder and sand with glass powder. In this concrete 10% of glass powder is commonly replaced by sand in optimum level and 0%, 10% & 20% of marble powder replaced with cement respectively. The most commonly used source materials are waste powders.

1.3 COMBINED EFFECT OF MARBLE & GLASS POWDER IN CONCRETE

Water/cement ratio is 0.45 and reference slump was 120±20mm. Marble powder has been used as a cement replacement material, because cement constituent are mostly same in marble powder, while pozzolanic material to enhance physical, chemical and mechanical properties of cement and concrete.similarly same as glass powder also have same properties of sand. The optimum use of glass powder in concrete is 10% and the effect of marble powder in concrete to be analyzed by adding 0%, 10% and 20% which is replaced to cement in concrete. This combination of marble and glass powder in concrete to increase the mechanical properties of compressive strength, split and flexural strength.

2. MATERIALS AND METHODS

2.1 Materials

The materials used in the projects for making concrete mixture are cement, Fine aggregate, coarse aggregate, Marble powder, are detailed describe below:

1) **Testing of Cement**: Cement is by far the primary element of concrete, in that it presents the binding material for the discrete elements. Cement naturally generating from raw supplies and sometimes blended or inter ground with in powdery wastes. The cement used in this experiment was Pozzolana Portland cement (PPC).

Table 1: Test of Cement

Tests Performed	Test process	Results
Consistency	Vicat Apparatus (IS: 4031 Part - 4)	32%

Initial setting time (min)	Vicat Apparatus (IS: 4031 Part -5)	110min
Final setting time	Vicat Apparatus (IS: 4031 Part -5)	180 min
Specific gravity	Specific. gravity bottle (IS:4031 Part - 4)	3.03
Fineness	Sieve test on sieve no.9 (IS: 4031 Part – 2)	2%
Compressive strength	(IS: 4031 Part-6)	22 N/mm²

2. **Fine Aggregate:** The fine aggregate used of a river sand that is, clear from all styles of natural contamination was utilized in this Investigational plan. The fine aggregate was moves through 4.75 mm sieve; the sand was most dried and without from any external material and had a specific gravity 2.6. The grading zone of fine aggregate was zone II as per IS specifications. However, it's currently well recognized that physical, chemical and thermal properties of aggregates considerably influence the properties and performance of concrete.

Table 2: Test of Fine aggregates

S. No.	Test	Result
1.	Zone	II
2.	Specific gravity	2.6
3.	Fineness Modulus	3.75
4.	Water Absorption	0.6%

3) **Coarse Aggregate:** Coarse aggregate is a substitute of concrete mixture used for building concrete material. They can be within the variety of unequal broken stone or naturally occurring gravel. Materials that are large to be maintained on 4.75mm sieve size are named coarse aggregates. Its highest size shall be up to 20 mm.

Table 3: Test of Coarse aggregates

4) **Marble powder:** Waste generated in the stone manufacturing industries during, shaping, cutting and cleaning of marbles stones. Through this process, about 20-25% of the procedure marble is turn into the powder variety. India being the third (about 10%) Prime most exporter of marble in the world, every year million tons of marble waste forms processing plants is released. Because of the accessibility of huge amount of waste formed in the marble plant, this assignment has been intended and preceded.

Table 4: Physical properties of marble dust powder

S. No.	Properties	Result
1.	Specific gravity	3.03
2.	Colour	white
3.	Form	Powder
4.	Odour	Odourless
5.	Fineness	3%

5) Glass powder: In order to make concrete industry sustainable, the use of waste materials in place of natural resources is one of the best approaches. In India, 0.7% of total urban waste enervated comprises of glass. UK produces over three million tons of waste glass annually. Waste glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, sand cover for sport turf and sand replacement in concrete. If fine aggregate is replaced by waste glass by specific percentage and in specific size range, it will decrease fine aggregate content and thereby reducing the ill effects of river dredging and thus making concrete manufacturing industry sustainable.

Table 5 Properties of Glass powder

S.No	Properties	Glass Powder	Sand
1.	Colour	White	brownish
2.	Specific gravity	2.56	2.6
3.	Bulk density	2.53 (gm/cc)	1.46 (gm/cc)
4.	Moisture content	NIL	1.5
5.	Fineness	3.36	2.70
6.	Sieve analysis	Zone	Zone

6) **Concrete mix Design**: M 20 design mix of concrete has

S.no	Test	Result
1.	Water absorption	0.22%
2.	Specific gravity	2.94
3.	Fineness Modulus	7.17

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been used for the present work. The concrete mix proportion was 1:1.925:3.547 and water cement ratio was 0.50.

3. EXPERIMENTAL PROCEDURE

The estimation of concrete with marble powder and Fine aggregates used as substitute of aggregate materials is completed during concrete specimen testing. Concrete include cement, water, fine aggregate, coarse aggregate. Concrete is replaced with alternative materials by varying percentage of replacement. The waste powder of marble is used as partial replacement for Cement in the range Of 5%, 10%, 15%, 20%, and 25% by cement as per its weight and its optimum level is to be found. For analyzing the power of normal and other variation mix totally 54 cubes of size 150x150x150mm were casted for compression strength test. Then 6 beam of size 700x150x150mm is casted for flexural strength testing. Once 24hours completed from casting the concrete specimens are opened and allowed for continuous curing in a tank with portable water. The specimen are taken and tested at required 3rd day, 7th day & 28th day from curing for compression test at 3rd day, 7th day & 28th day and flexural test at 28th day from curing. Then compare the Strengths of M_{20} design mixes.

4. MIX PROPORTIONING FOR M_{20}GRADEOF CONCRETE

1) STIPULATIONS FOR PROPORTIONING

Grade designation : M_{20}

Type of cement : OPC 43 grade

Size of coarseaggregate:

(i)20mm= 60%

(ii)10mm =40%

Minimum cement content : 260 kg/m^3

Maximum water – cement ratio : 0.45

Workability : (50-75) mm

Exposure condition : mild

Degree of supervision : good

Type of aggregate : crushed angular aggregate

Maximum cement content : 450 kg/m^3

2) TEST DATA FOR MATERIALS

Cement used : OPC 43 grade (conforming to IS 8112)

Specific gravity of cement : 3.15

Specific gravity of:

1) Coarse aggregate :

20mm = 2.64

10mm = 2.57

2) Fine aggregate : 2.5

Water absorption:

1) Coarse aggregate : 0.3%

2) Fine aggregate : 1.0%

Free (surface) moisture:

1) Coarse aggregate : NIL

2) Fine aggregate : 2.0%

3) TARGET STRENGTH FOR MIX PROPORTIONING

5% of risk factor = 1.65

As per IS456, M_{20}Standard deviation

S = 4

Therefore,

target strength = 20+ 1.65 x 4

= 26.60 N/mm^2

4) SELECTION OF WATER CEMENT RATIO

Maximum water cement ratio = 0.45

Based on experience, adopt water cement ratio as 0.45

0.45 =0.45

Hence ok.

5) SELECTION OF WATER CONTENT

Maximum water content = 189litre

Estimated water content =189+(6/100)x189

=200.34 Kg/cu.m

Water content = 0.75 x 200.34

= 150.255 Kg/cu.m

6) CALCULATION OF CEMENT CONTENT

Water cement ratio = 0.45

Cement content = 150.255/ 0.45

=333.9Kg/m^3

260Kg/m^3<333.9Kg/m^3

Hence ok

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7) MIX CALCULATION

a)Volume of concrete = $1m^3$

b)Volume of cement

=(mass of cement / specific gravity of cement)× (1/1000)

= (333.9 / 3.15) x (1/1000)

= 0.106 m^3

c) Volume of water

= (mass of cement / specific gravity of cement)×(1/1000)

= (150.255/1) x (1/1000)

= 0.150 m^3

d) volume of super plastisizer

= (1.2 x 333.9)/(100 x 1.2)

=3.339 x (1/1000)

=0.003339 cu.m

e) Volume of all in aggregate = [a-(b+c+d)]

=1(0.106+0.150+0.00339)

= 0.74061m^3

W/C RATIO	CEMENT	F.A	C.A	S.P
0.45	1	1.9	3.4	0.01

8) MIX PROPORTION

Cement = 333.9 Kg/m^3

Coarse aggregate :

(i)20mm =727.33 Kg/m^3

(i)10mm =472.035 Kg/m^3

Fine aggregate = 703.57 Kg/m^3

Water = 150.255 Kg/m^3

Super plastisizer =3.339Kg/m^3

Water cement ratio = 0.45

5. RESULTS AND DISCUSSION

In this study the casted concrete is related to different tests to calculate the strength and other properties of the casted concrete. The main aim of the project is to monitor the developed strength attained by the concrete at various testing days from curing. Generally proper casting and curing of concrete will augment the strength of the concrete. For this project each test is carried out with 3 Samples for every mix ratio and tested at required curing time. Then the average values are used for the investigations. The series of testing actions are detailed below:

5.1 TEST RESULTS ON FRESH CONCRETE

TABLE 6 Test Results on Fresh Concrete

S. No	Name of the test	Observation	Test result	Remarks
1	Slump test	Slump value	120mm	The test results shows that the concrete is workable and easy to flow
2	Compaction factor test	Compaction factor	0.89	
3	Vee-Bee consistometer test	Vee-Bee seconds	25 Sec	
4	Flow test	Flow value	400mm	

The slump test, compaction factor test, Vee-Bee consistometer test and flow test are the tests which are carried out to determine the workability and the flow ability of the concrete.

5.2 TEST RESULT OF HARDENED CONCRETE

5.2.1 Compressive Strength Test

Concrete is weak in tension and strong in compression so the concrete should be strong to attain high compression. In this study for each mix 3-samples were tested and the average strength is compared with nominal mix of M20 Mix. The results of compressive strength at the age 3rd day, 7th day & 28th day are shown in table 7.

Table 7: Compressive Strength on Concrete M_{20} Cubes

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Percentage Replacement of Marble powder	Compressive Strength (N/mm²)		
	3 Days	7 Days	28 Days
0%	12.50	18.9	28.10
5%	14.12	19.21	28.90
10%	14.37	21.77	30.15
15%	15.71	23.83	31.27

5.2.2 Flexural strength

Flexural strength also called as modulus of rupture. In concrete flexure is the bending moment caused by the applied load, in which a concrete beam has compression at top and tensile stress at the bottom side. Beams on testing will fail In tension due to its property and shear will appear on concrete. This experimental works totally 6-beams of size 700 x 150 x 150 mm are casted of M20 design mix concrete and other percentage of replacements as for 5%, 10%, 15%, 20% and 25% by weight of Marble powder with cement. Then compare the values of both design mixes. The flexural values of various mixes are displayed in Table.8.

Table.8: Flexural Strength of Concrete at 28 days

Percentage Replacement of Marble powder	Flexural Strength (N/mm²)
0%	3.8
5%	3.84
10%	3.87
15%	3.94
20%	3.85
25%	3.6

6. ***Waste Management:*** Marble powder or dust is mixed in the concrete as replacement material of Cement. It is the waste product of marble stone produces from surface finishing or stone in construction buildings or industries. The safe disposal of this waste requires sufficient area which is costly and will cause environmental pollution. The construction industry is the only area where the safe use of Marble powder or dust is possible. When it is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete. Many researchers had already establish, Marble Powder or dust achievable use as a replacement material in concrete. In this Experimental study Marble dust is used in concrete in the form of replacement material of Cement. For this study, M20 grade of concrete is prepared and the test are conducted for various substitute of cement using Marble dust as 0%, 5%, 10%, 15%, 20% & 25% in concrete ready with Cement.

7. CONCLUSION

The following conclusions are drawn from the detailed experimental investigations conducted on the behavior of M20 grade conventional and high performance concrete.

a. The basic properties of materials are tested and results were tabulated.
b. The concrete with marble and glass powder is achieved by Cement, sand, Coarse aggregate, Fine aggregate, super plasticizer, water, marble powder and glass powder.
c. The fresh concrete tests like slump, flow tests were conducted and the test result satisfies the standard values.
d. The experimental investigation for mechanical properties like compressive strength, split tensile strength and flexural strength are carried out.
e. The optimum value of marble and glass powder replaced in concrete is 10 % .i.e., cement replaced by 10% of marble powder and sand replaced by 10% of glass powder.
f. The compressive strength of design concrete is increased by 38.3%
g. The flexural strength concrete is increased by 35.9%
h. Use these waste materials leads to sustainable development in construction industry
i. To minimize the cost for construction with the usage of marble powder which is freely or cheaply available and more importantly.

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