# COMPARISONS OF MIXED MODE PARAMETERS OF REPLACED CONCRETE WITH FIBER REINFORCEMENT.

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## Abstract:

**Green concrete capable for sustainable development is characterized by application of industrial wastes to reduce consumption of natural resources and energy and pollution of the environment. Marble sludge powder can be used as filler and helps to reduce the total voids content in concrete. Natural sand in many parts of the country is not graded properly and has excessive silt on other hand quarry rock dust does not contain silt or organic impurities and can be produced to meet desired gradation and fineness as per requirement. Waste from dismantled buildings can be recycled and can be used as coarse aggregate. Rice husk ash is used as a puzzolonic material in cement. Consequently, this contributes to improve the strength of concrete. Through reaction with the concrete admixture, marble sludge powder and quarry rock dust, recycled aggregate and rice husk ash improved puzzolonic reaction, micro-aggregate filling ,and concrete durability. This paper presents the feasibility of the usage of quarry rock dust and marble sludge powder as hundred percent substitutes for natural sand in concrete and recycled aggregate as coarse aggregate added fiber as reinforcement as it improves the tensile strength of concrete. An attempt has been made to durability studies on green concrete compared with natural concrete. It is found that the compressive , split tensile strength and durability studies of concrete made of quarry rock dust and other materials used are nearly 14% more than the conventional concrete. Application of green concrete is an effective way to reduce environment pollution and improve durability of concrete under severe conditions.**

## Introduction:

**Fiber reinforced concrete** (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Fibers are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural steel reinforcement. Indeed, some fibers actually reduce the strength of concrete. The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed volume fraction ($V_f$). $V_f$ typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fiber usually segments the flexural strength and



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toughness of the matrix. However, fibers which are too long tend to "ball" in the mix and create workability problems.

## Materials used:

RAW MATERIALS:

CEMENT:

Ordinary Portland Cement (43 Grade) with 28 percent normal consistency with specific surface 3300 cm2/g conforming to IS: 8112-1989 was used.

MARBLE SLUDGE POWDER:

Marble sludge powder was obtained in wet form directly taken from deposits of marble factories. It was observed that the marble sludge powder had a high specific surface area; this could mean that is addition should confer more cohesiveness to mortars and concrete. Specific gravity of the marble sludge powder is 2.212.

QUARRY ROCK DUST:

The specific gravity of the quarry rock dust is 2.677. Moisture content and bulk density of waste are less than the sand properties.

FINE AGGREGATE:

Medium size sand with a modulus of fineness = 2.20; Specific gravity 2.677, normal grading with the silt content 0.8%.

COARSE AGGREGATE:

Crushed stone with a size of 5-20 mm and normal continuous grading was used. The content of flaky and elongated particles is <3%, the crushing index ≤6% and the specific gravity 2.738.

RICE HUSK ASH:

Ash remained after burning of rice husk is used as a percentage replacement of cement.

WATER:

The qualities of water samples are uniform and potable.

SUPER PLASTICIZER:

A super plasticizer based on refined lingo Sulphonates, Roff Superplast 320‘ can be used to get and preserve the designed workability.

MIX PROPORTION OF CONCRETE:

For durability studies the Indian standard mix proportion (by weight) use in the mixes of conventional concrete and green concrete were fixed as (Cement(% of rice husk ash): River sand/marble sludge + stone dust: recycled aggregate) after several trials. Based on properties of raw materials, two different mix proportions were taken.

## Test on materials:

**A) FINENESS TEST:**

- The object of this test is to check the proper grinding of cement. The rate of hydration depends on the fineness of cement.
- Take 100 Gms of cement from sample and place it on a standard IS sieve No.9 continuously sieve the sample with a gentle wrist motion for 15 minutes.
- The mass of residue shall not exceed 10 Gms in case of ordinary Portland cement.
- Fineness = (weight of cement retained/weight of cement taken)*100

$$= (4/100)*100$$

$$= 4 \leq 10\% \text{ for OPC}$$

- The mass residue of our cement is 4grams

**B) SPECIFIC GRAVITY:**

- The specific gravity of solid particles is the ratio of the mass density of solids to that of standard fluid. It is determined in the laboratory using the relation.

$$G = \frac{(M2-M1)}{(M4-M1)-(M3-M2)}$$

Where,

M1 = Mass of empty Density Bottle

M2 = Mass of Bottle and Cement

M3 = Mass of bottle, cement & kerosene

M4 = Mass of bottle with kerosene

M1 = 34 Gms

M2 = 83 Gms

M3 = 114 Gms

M4 = 80 Gms

**Specific Gravity of cement = 3.15**



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**C) INITIAL SETTING TIME:**

- When water is added to cement and mixed properly the chemical reaction soon starts and the paste of cement remains plastic for a short period. During this period, it is possible to remix the paste. This period is called initial setting time.
- Weight of water taken = 0.85*p*weight of cement. Where, p=normal consistency.
- The initial setting of the cement is 90 minutes.

**D) NORMAL CONSISTENCY TEST:**

- This test determines the quantity of water required to produce a cement paste.
- The consistency of standard cement paste is expressed as the amount of water as percentage by mass of dry cement.

Standard consistency, $\rho = m2/m1$

Where,

m1 - mass of cement taken

m2 – mass of water added when the plunger has penetration of 5 mm to 7 mm from the bottom of the mould. Usually standard consistency lies between 26 to 33%.

- Normal consistency is 29 %.

**2.1.3 TESTS ON COARSE AGGREGATE:**

Crushed stone chips of maximum size of 20mm available the local quarries were obtained.

The following tests were made for this 20mm aggregate:

(a) Specific gravity

(b) Bulk density

(c) Sieve Analysis

**A) SPECIFIC GRAVITY:**

$$G = \frac{M2-M1}{(M4-M1)-(M3-M2)}$$

M1=Mass of empty pyconometer bottle

M2=Mass of bottle and Coarse Aggregate

M3=Mass of bottle, Coarse Aggregate, water

M4=Mass of bottle with water

M1=638gm

M2=1136gm

M3=1847gm

M4=1530gm

Specific gravity of Coarse Aggregate (G)=2.74

**B) BULK DENSITY:**

$$\text{Bulk density of coarse aggregate (Y)} = \frac{(W3-W1)}{(W2-W1)}$$

W1=Weight of empty cylinder

W2=Weight of empty cylinder with water

W3=Weight of empty cylinder with coarse aggregate

(W2-W1)=Volume of cylinder

(W3-W1)=Net weight of coarse aggregate

W1=3.7kg

W2=8.5kg

W3=8.9kg

W2-W1=4.8kg

W3-W1=5.2kg

Bulk density of coarse aggregate (Y) = 1733.3kg/m³

**C) SIEVE ANALYSIS:**

Weight of sample taken: 5 kgs

**TABLE NO: 6 SIEVE ANALYSIS FOR COARSE AGGREGATE:**

| Sieve Size (mm) | Weight Retained (gms) | Total Weight Retained (gms) | %Cumulative Weight Retained | %Passing Through | Fineness Modules |
|---|---|---|---|---|---|
| 80 | 0 | 0 | 0 | 100 | |
| 40 | 485.5 | 9.71 | 9.71 | 90.29 | |
| 20 | 2785.5 | 55.71 | 65.42 | 34.58 | 7.64 |
| 10 | 1200.5 | 24.01 | 89.43 | 10.57 | |
| 4.75 | 528.5 | 10.57 | 100 | 0 | |



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## Test on recycled aggregate:

| Sl.No | Test conducted | Results |
|---|---|---|
| 1 | Specific Gravity | 2.65 |
| 2 | Field moisture content | 2% |
| 3 | Water absorption | 2.00% |
| 4 | Fineness modulus | 3.87 |

**Mix design:**

**CASTING AND TESTING OF CONCRETE**

Cubes and beams were casted by replacing the fine aggregate with quarry rock dust and marble sludge powder, coarse aggregate with recycled aggregates and cement with some percentage of rice husk ash with different proportions. A total of 171 cubes and 57 beams including 57 cylinders were casted i.e., 9 cubes, 3 beams and 3 cylinders for each proportion and reinforced with reliance fiber to get more tensile strength.

The proportions are:

1. Cement + 100% stone dust as fine aggregate + coarse aggregate
2. Cement + 100% marble sludge as fine aggregate + coarse aggregate
3. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + coarse aggregate
4. Cement + (30% stone dust + 70% marble sludge) as fine aggregate + coarse aggregate
5. Cement + 100% stone dust as fine aggregate + coarse aggregate + 0.71% fiber
6. Cement + 100% marble sludge as fine aggregate + coarse aggregate + 0.71% fiber
7 Cement + (50% stone dust + 50% marble sludge) as fine aggregate + coarse aggregate+ 0.71% fiber
8. Cement + (30% stone dust + 70% marble sludge) as fine aggregate + coarse aggregate+ 0.71% fiber
9. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + 20% recycled aggregate as coarse aggregate
10. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + 40% recycled aggregate as coarse aggregate
11. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + 60% recycled aggregate as coarse aggregate
12. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + 80% recycled aggregate as coarse aggregate
13. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + 100% recycled aggregate as coarse aggregate
14. Cement + (50% stone dust + 50% marble sludge) as fine aggregate + 80% recycled aggregate as coarse aggregate +0.71% fiber
15. Cement replaced with 5% rice hush ash+ (50% stone dust + 50% marble sludge) as fine aggregate+ 80% recycled aggregate as coarse aggregate
16. Cement replaced with 10% rice hush ash+ (50% stone dust + 50% marble sludge) as fine aggregate+ 80% recycled aggregate as coarse aggregate
17. Cement replaced with 15% rice hush ash+ (50% stone dust + 50% marble sludge) as fine aggregate+ 80% recycled aggregate as coarse aggregate
18. Cement replaced with 20% rice hush ash+ (50% stone dust + 50% marble sludge) as fine aggregate+ 80% recycled aggregate as coarse aggregate
19. Cement replaced with 15% rice hush ash+ (50% stone dust + 50% marble sludge) as fine aggregate+ 80% recycled aggregate as coarse aggregate+0.71% fiber

**DETAILS OF MIX DESIGN AS PER IS: 10262-2009:**

**A) DESIGN STIPULATIONS FOR PROPORTIONING:**

a. Grade designation : M30
b. Type of cement : PPC 53 grade, IS 8112
c. Max. Nominal size of agg. : 20 mm
d. Minimum cement content: 300 kg/m³
e. Maximum water cement ratio : 0.55
f. Workability : 75-100 mm (slump)



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g. Exposure condition : moderate

h. Degree of supervision: Good

i. Type of agg. : Crushed angular agg.

j. Maximum cement content : 450 kg/m3

k. Chemical admixture : Not used

l. Method of concrete placing: pumping

m. Fiber used: reliance fibers

**B) TEST DATA FOR MATERIALS**

a. Cement used : OPC 53 grade

b. Specific gravity of cement : 3.15

c. Specific gravity of Coarse aggregate : 2.68

d. Specific Gravity of Fine aggregate : 2.66

e. Specific gravity of recycled aggregate aggregate : 2.59

f. Sieve analysis

g. Coarse aggregate : Conforming to Table 2 of IS 383

h. Fine aggregate : Conforming to Zone III of IS 383

**C) TARGET STRENGTH FOR MIX PROPORTIONING:**

$$f_{ck} = f_{ck} + t \times s$$

From Table 1 standard deviation, $s$ = 4.6 N/mm²

Therefore target strength = 30 + (1.65 x5)

= 38.25 N/mm²

**D) SELECTION OF W/ C RATIO**

From Table 5 of IS 456:2000, maximum water cement ratio = 0.5 (Mild exposure)

Based on experience adopt water cement ratio as 0.45

0.45 < 0.5

Hence ok

**E) TOTAL MIX DESIGN CALCULATIONS: (FOR ONE PROPORTION)**

V = 3*(0.15*0.15*0.15)

= 0.010125m3

Ratio = 1: 1.81: 2.04

$$f_{ck} = f_{ck} + t \times s$$

= 30 + (1.65 x5)

= 38.25 N/mm²

w/c = 0.55

20mm- agg

W= 186 kg / m3

1 m3 ----------186 kg

0.0101 ------------ x

1/ 0.0101 = 186/x

W = 1.883 kg

w/c = 0.55

Total vol V= [1.883 + (3.424/3.15) + (1/.47)*(6.197/2.65)]

= 0.0079

=0.016 m3

W = 1.883 lt

C = 3.424 kg

F.A = 6.197 kg

C.A = 6.984 kg

**Test on concrete:**

**TESTS ON CONCRETE:**

a. Slump Test

b. Compaction Factor Test

**c.** Fresh Density

**A) SLUMP TEST:**

The slump test is carried out with a mould called slump cone whose top diameter is 10 CMs, Bottom diameter is 20 CMs and height is 30 CMs. The test may be performed in the following steps:

1. Required quantity of water is taken.
2. Place the mixed concrete in the mould to about one-fourth of its height
3. Compact the concrete by giving 25 blows with the help of a tamping rod uniformly all over the area
4. Place the mixed concrete in the mould to about half of it's height and compact it again.
5. Similarly, place the concrete up to its three-fourth height and then up to its top. Compact each layer 25 times with the help of tamping rod uniformly for the second and subsequent layers the tamping rod should penetrate into under laying layers.
6. The top surface of mould shall be leveled with a trowel or tamping rod so that mould is filled to it's top
7. Remove the mould immediately; by lifting in vertical direction

When the settlement of concrete stops, measure the subsidence of the concrete in millimeter, which is the required slump of the concrete.



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**B) COMPACTION FACTOR TEST:**

The slump test is carried out by using compaction factor apparatus, graduated cylinder and a balance to weigh.

**PROCEDURE:**

1. Keep the compaction factor apparatus on a level ground and apply grease on the inner surface of the hoppers and cylinder.
2. Fasten the flap doors. Weigh the empty weight of cylinder accurately and note down the mass as W1 kg.
3. Fix the cylinder on base with fly nuts and bolts in such a way that the central points of hoppers and cylinder lie on vertical line.
4. Fill the concrete in upper hopper gently and carefully with hand scoop without compacting.
5. After two minutes, release the trap door so that the concrete may fall into the lower hopper bringing the concrete into standard compaction.
6. Remove the excess concrete above the top of cylinder by a pair of trowels and clean the cylinder from all sides properly. Find mass of partially compacted cylinder as W2 kg.
7. Refill the cylinder with same concrete in 4 layers, compacting each layer with 25 blows.
8. Level the concrete and weigh the cylinder with fully compacted concrete. Let the mass be W3 kg.

**PREPARATION OF TEST SPECIMENS FOR CUBES:**

Cube size: 150mm*150mm*150mm

Concrete Mix 1:1.81: 2.04

**APPARATUS :**

150mm cube moulds, weighing machines, platform vibrator, compression testing machine, tamping rods, trays.

**PROCEDURE :**

- Required quantities of cement, plastic aggregates, and fine aggregate and coarse aggregate were weighed batched.
- Measured quantities of fine aggregate and coarse aggregate were spread out over dry mix of cement and plastics and mixed thoroughly in dry state until uniformity of color was achieved. Water was measured exactly and added to the dry mix and it was thoroughly mixed to obtain homogeneous concrete.
- The 150*150*150mm cube moulds were cleaned and the inner side and bottom of the moulds were coated with waste oil for easy removal of moulds after casting. The mix was placed in three layers. Each layer was compacted using a tamping rod of 600mm in length and 16mm diameter with 25 blows.
- The cubes were removal after 24 hours and put to curing Cubes were immersed in a clean water tank till the date of testing.

**TESTING PROCEDURE FOR CUBES:**

- Concrete specimens are removed from curing pond and wiped clean. Then they are placed under compression testing machine, load is applied continuously. The load is increased until the specimen fails and the maximum load is recorded for each specimen.
- Compressive strength = Average load / Area of cross section

**PREPARATION OF TEST SPECIMENS FOR BEAMS:**

**Apparatus:**

Beam moulds of 100*100*600 mm size, weighing machine, tapping rod, testing machine, tray.

**Procedure for casting cylinders:**

- The material that will be sufficient for casting of 1 beam must be taken. Mix them thoroughly in a mechanical mixer until uniform color concrete is obtained.
- Pour the concrete so separated in the moulds which have been oiled with medium viscosity oil in 3 layers each of approximate 50 mm each layer shall be rammed more than 30 times over the surface, the blow shall be evenly distributed on layer. In place of hand ramming plate vibrator may be used.
- Remove the specimens from the mould after24 hours immerse them in water for the final curing. The tests are usually conducted at age of 7 & 28days. The age shall be calculated from the time of addition of water to dry ingredients.



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- The mix design and the process is same as that for cubes.

**Split tensile strength (cylinder)**

A concrete cylinder of size 150mm dia×200mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner .The cylinder is subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.

Horizontal tensile stress=2P/πDL

Where P=the compressive load on the cylinder.

L=length of the cylinder

D=dia of cylinder

**Standard beam test**

Standard beam test or modulus of rupture carried out on the beams of size (100mm×100mm×500mm), by considering the material to be homogeneous .The beam should be tested on a span of 400 mm for 100mm specimen by applying two equal loads placed at third points .To get these loads, a central point load is applied on a beam supported on steel rollers placed at third point. The rate of loading shall be 1.8 KN/minute for 100 mm specimens the load should be increased until the beam failed .Note the type of failure, appearance of fracture and fracture load.

Let a‟ be the distance between the line of fracture and the nearer support. Then for finding the modulus of rupture, these cases should be considered.

1. When a>133mm for 100mm specimen

Fcr =PL/bd2

Where P=total load applied on the beam.

| Comparison set | Compressive strength (n/mm2) | Tensile strength(n/mm2) | Slump(mm) |
|---|---|---|---|
| 1 | 44 | 4.4 | 146 |
| 2 | 46 | 4.4 | 135 |
| 3 | 44 | 2.4 | 140 |

**Test results:**

For cubes:

| TRAIL | 7 days (N/mm2) | 28 days (N/mm2) | 56 days (N/mm2) |
|---|---|---|---|
| 1 | 28 | 46.5 | 49 |
| 2 | 18.25 | 25.5 | 27 |
| 3 | 24 | 44 | 46 |
| 4 | 25.5 | 36.8 | 49 |
| 5 | 24 | 42 | 56 |
| 6 | 18 | 26 | 31 |
| 7 | 14 | 24 | 29 |
| 8 | 29.5 | 38 | 42 |
| 9 | 28 | 33 | 36 |
| 10 | 26 | 40 | 42 |
| 11 | 24 | 42 | 44 |
| 12 | 25.6 | 46 | 45 |
| 13 | 32 | 42 | 42 |
| 14 | 35 | 46 | 46.5 |
| 15 | 29 | 42 | 43 |
| 16 | 28 | 41.5 | 42 |
| 17 | 27 | 44 | 42 |
| 18 | 26 | 37 | 40 |
| 19 | 25 | 45 | 48 |

**Strength variation between normal concrete and fiber reinforced concrete**

**NORMAL CONCRETE:**

**Fiber reinforced concrete:**

| Comparison set | Compressive strength(n/mm2) | Tensile strength(n/mm2) | Slump(mm) |
|---|---|---|---|
| 1 | 46 | 5.4 | 140 |
| 2 | 46 | 5.2 | 135 |
| 3 | 45 | 4.4 | 130 |

## CONCLUSIONS



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All the experimental data shows that the addition of industrial wastes improves the physical and mechanical properties. These results are of great importance because this kind of innovative concrete requires large amounts of fine particles. Due to its high fineness of the marble sludge powder it provided to be very effective in assuring very good cohesiveness of concrete.

1. The chemical composition of quarry rock dust and marble sludge powder such as fe2o3, mno, na2o, mgo, k2o and sio2 are comparable with that of cement.
2. The replacement of fine aggregate with that of marble sludge powder and rock dust in equal proportion of 50% gives excellent strength. It has high compressive strength, high split tensile strength. If marble sludge powder content is increased further, it improves workability but affects the compressive and split tensile strengths.
3. Green concrete induced higher workability and it satisfy the self compacting concrete performance which is the slump flow is 657mm without affecting the strength of concrete.
4. Water absorption is slightly higher than conventional concrete.
5. Durability is more and permeability is less.
6. It can be used for architectural concrete mixes containing white cement. Thus this green concrete exhibited excellent performance.
7. Rice husk ash served good at 15% replacement with cement.
8. Recycled aggregate is the best material to replace the coarse aggregate material in concrete which in turn impart more strength.
9. It is echo friendly product as it is from nature and economical too.
10. It improves tensile strength of the concrete. Fibers improve the tensile strength of concrete.

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