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REPLACEMENT OF RIVER SILICA (OR) SAND WITH ROCK DUST AT HIGHER GRADES

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ABSTRACT - In such a situation the Quarry rock dust can be an economic alternative to the river sand. Quarry Rock Dust can be defined as residue, tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. Usually, Quarry Rock Dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements.

This paper presents the feasibility of the usage of Quarry Rock Dust as 100% substitutes for Natural Sand in concrete. Mix design has been developed for M40 grade using design approach IS for both conventional concrete and quarry dust concrete. Tests were conducted on cubes and beams to study the strength of concrete made of Quarry Rock Dust and the results were compared with the Natural Sand Concrete. It is found that the compressive and flexural strength of concrete made of Quarry Rock Dust are nearly 10% more than the conventional concrete. Tests were also conducted on cubes and beams which are exposed to temperatures of 300°C for 1hr, 3hr durations respectively.

The results show that at a dosage 1.3% of super plasticizer by weight of cement the concrete made of quarry stone dust as fine aggregate attained low strengths when compared with other dosages (1% and 1.6%) in compression and flexure.

KEYWORDS: concrete, fine particles, super plasticizers, compressive strength, flexural strength.

1. INTRODUCTION

This paper presents the feasibility of the usage of Quarry Stone Dust as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and beams to study the compressive, flexural strengths of concrete made of Quarry Stone Dust for two different grades of concrete M40.
Ordinary Portland cement (KCP) of 53 grade confirming to Bureau of Indian Standard is used in the present study. The stone dust is procured from locally available sources located at Kothavaluda, near Shamshabad, Hyderabad, Telangana samithi, India. The stone dust is tested for various properties like specific gravity, bulk density etc, in accordance with IS 2386-1968.Machine crushed angular metal from single source from available crusher located in village near Shamshabad, RangaReddy district is used as coarse aggregate. Super plasticizer by trade name Conplast SP-430 was used as water reducing agent to achieve the required workability.

1.1 OBJECTIVES:

The main objectives of the present work are:

1. To compare the properties of made of natural river sand and concrete made of quarry stone dust as fine aggregate.
2. To study the effect of super plasticiser on water-cement ratio.
3. To study the behaviour of concretes M40 grades when exposed to temperature.

1.2 MATERIALS:

1.2.0 Cement

Ordinary Portland Cement (53 Grade) with 32% normal consistency Conforming to IS: 8112-1989 was used. The properties of cement were given below:

Initial setting time: 118 min.;

Final setting time: 242min.;

Specific Gravity: 3.13

Fineness (IS sieve) : 2.00
Ultimate compressive strength of standard mortar cubes
a) At the age of 3-days (MPa) - 29.4
b) At the age of 7-days (MPa) - 40.0
c) At the age of 28-days (MPa) - 56.4

1.2.1 Quarry rock dust

The Quarry Rock Dust obtained from local resource Sri Kanaka Durga Fal-G Brick products, Hyderabad was used in concrete to cast test cubes and beams. The physical and chemical properties of Quarry Rock Dust obtained by testing the samples as per Indian Standards are listed in Tables 1 and 2, respectively.

TABLE I Physical properties of quarry rock dust and natural sand

Property	Quarry rock dust	Natural sand
Specific gravity	2.54-2.60	2.50
Relative density (kg/m^3)	1720-1810	1813.33
Sieve analysis	Zone II	Zone III

1.2.2 Fine aggregate (Natural river sand)

River sand having density of 1813.33 kg/m^3 and fineness Modulus (FM) of 2.015 was used. The specific gravity was found to be 2.5.

TABLE II Sieve analysis for sand

IS sieve size (mm)	weight retained (kgs)	cumulative weight retained (kgs)	cumulative % retained	cumulative % passing
10	0.005	0.005	0.5	99.5
4.75	0.005	0.010	1	99
2.36	0.01	0.02	2	98
1.18	0.075	0.095	9.5	90.5
0.6	0.16	0.255	25.5	74.5
0.3	0.43	0.685	68.5	31.5
0.15	0.260	0.945	94.5	5.5

1.2.3 Fine aggregate (Quarry stone dust)

Quarry Stone dust used in the laboratory investigations was procured from a local crushing plant.

TABLE III Sieve analysis for quarry stone dust

IS sieve size (mm)	weight retained (kgs)	cumulative weight retained (kgs)	cumulative % retained	cumulative % passing
10	0	0	0	100
4.75	0	0	0	100
2.36	0.25	0.25	25	75
1.18	0.215	0.465	46.5	53.5
0.6	0.095	0.56	56	44
0.3	0.175	0.735	73.5	26.5
0.15	0.235	0.97	97	3

The specific gravity of stone dust was 2.63 and fineness modulus was 2.67

1.2.4 Coarse aggregate

Natural granite aggregate having density of 2700kg/m^3 and fineness modules (FM) of 7.26 was used. The specific gravity was found to be 2.60. (Conforming to IS 2386-1963)

1.2.5 Admixture

Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. The very high levels of water reduction possible allow major increases in strength to be obtained. Conplast SP430 is compatible with other types of Fosroc admixtures when added separately to the mix. Site trials should be carried out to optimize dosages. Cohesion is improved due to dispersion of cement particles thus minimizing segregation and improving surface finish. This mechanism provides flow able concrete with greatly reduced water demand. The dosages of admixtures used are 1%, 1.3% and1.6% by weight of cement.

II MIX DESIGN

The method mix design proposed by IS was first employed to design the Conventional Concrete mixes and finally natural sand was fully replaced by Quarry Rock Dust to obtain Quarry Rock Dust concrete mixes.

2. 1 Mix Design for M40-Grade Concrete

- Grade Designation: M40
- Type of cement: OPC 53 grade KCP
- Maximum size of Aggregate: 20mm
- Minimum cement content: 250Kg/m^3
- Maximum Water-Cement ratio: 0.5
- Workability: Slump
- Type of Exposure: Severe
- Degree of Quality Control: Good
- Type of Aggregate: ANGULAR aggregate
- Max. Cement content: 450Kg/m^3
- Chemical Admixture type: SP 430 CONPLAST

Test Data For Materials

- Cement used: OPC 53 grade KCP
- Specific Gravity of Cement: 3.03
- Chemical Admixture type: SP 430 CONPLAST
- Specific Gravity of Coarse Aggregate: 2.7
- Specific Gravity of Fine Aggregate: 2.5

SIEVE ANALYSIS

1) Coarse aggregate: 20mm passed 10mm retained
2) Fine aggregate: Confirming to Zone III of Table 4 of IS: 383.

2.2 TARGET STRENGTH FOR MIX PROPORTIONING

For a tolerance factor of 1.65 and using table 1, the obtained target mean strength for the given grade of concrete

$$\mathbf{f`_{ck} = f_{ck} + 1.65s}$$

From table I, standard deviation, s = 5N/mm^2
Therefore, target strength = 40 + 1.65 x 5 = 48.25N/mm^2

Selection of water – cement ratio

From table 5 of IS 456, maximum water-cement ratio = 0.5
Based on experience, adopt water-cement ratio as 0.43.
0.43<0.5 hence OK.

Selection of Water content

From Table 2, maximum water content for 20mm aggregate = 186litre (for 25 to 50mm slump)
Estimated water content for 180mm slump = $186 + \frac{130\ X\ 3}{25\ X\ 100}$ x 186 = 215.016 lit.
Adopting cement c=430kg
As super plasticizer is used,
The water content can be reduced up to 5% for 1% & 1.3% sp

The water content can be reduced up to 20% for 1.6% sp
Calculation of cement content
Water-cement ratio = 0.43
Water content = $(0.43 * 430) = 189.4$lts
From Table 5 of IS 456, minimum cement content for `severe' exposure condition = 250kg/m^3
375kg/m^3 > 250kg/m^3, hence O.K.

2.3 MIX CALCULATIONS:
The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1m^3
b) Volume of cement $= \frac{Mass\ of\ cement}{specific\ gravity\ of\ cement} \times \frac{1}{1000}$
$= \frac{430}{3.03} \times \frac{1}{1000} = 0.142\text{m}^3$
c) Volume of water $= \frac{Mass\ of\ water}{specific\ gravity\ of\ water} \times \frac{1}{1000}$
$= \frac{184.9}{1.0} \times \frac{1}{1000} = 0.185\text{m}^3$
d) Volume of Super Plasticizer $= \frac{Mass\ of\ chemical\ admixture}{specific\ gravity\ of\ chemical\ admixture} \times \frac{1}{1000}$
$= \frac{4.30}{1.145} \times \frac{1}{1000} = 0.00375\text{m}^3$
e) Volume of all in aggregate = a- (b+c+d) = 1-0.142-0.1849-0.00375 = 0.66935m^3
f) Mass of coarse aggregate = e x volume of coarse aggregate x specific gravity of coarse aggregate x 1000 = 0.66935 x 0.654 x 2.7 x 1000 = 1181.320kg
g) Mass of fine aggregate = e x volume of fine aggregate x specific gravity of fine aggregate x 1000 = 0.66935 x 0.346 x 2.5 x 1000 578.685kg.

MIX PROPORTIONS
Cement = 430kg/m^3
Water = 180kg/m^3
Coarse aggregate = 1181.320kg/m^3
Fine aggregate = 578.685kg/m^3
Chemical admixture = 3.75kg/m^3
Water-cement ratio = 0.43

The above mix designs are used for casting concrete specimens. The water-cement ratio changes for different dosages of super plasticizer. Usage of super plasticizer reduces the water requirement and new w/c ratios are obtained. The following tables show the details of w/c ratios obtained at various dosages of super plasticizer for M40 concrete.

III . COMPRESSIVE STRENGTH (M40)

The compressive strength of M40 grade concrete cubes made with natural sand and those made with quarry stone dust as fine aggregate are tested under compression testing machine and results are tabulated in table-IV shown below.

TABLE IV Strength comparison for M40 grade cubes

S.No	Sp %	OPC + SAND		OPC + QUARRY STONE DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	46.67	51.775	34.445	51.11
2	1.30	32.28	53.333	33.335	48.88
3	1.60	47.55	56	31.555	49.77

3. 1 M40 GRADE-COMPRESSIVE STRENGTH OF CUBES (Mpa)
From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the compressive strengths of normal concrete are slightly higher when compared with Quarry stone dust concrete. There is no significant difference in the strengths with variation in dosage of super plasticizer. At 1.3% dosage of super plasticizer the strengths were observed to decreasing. The following figures show the compressive strengths.

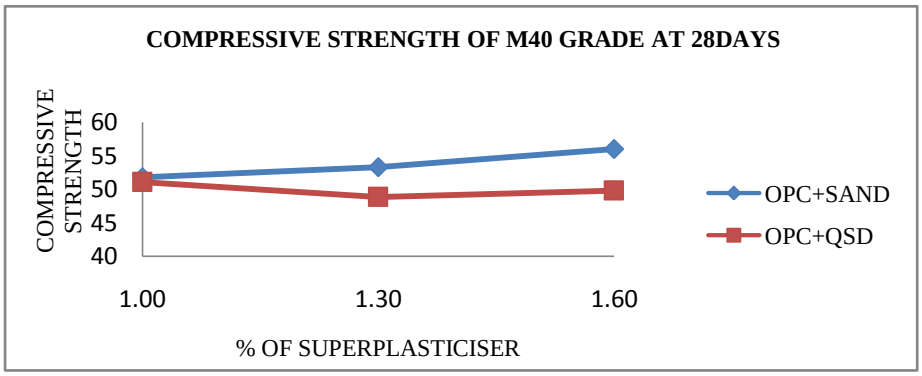

Fig: 1.0 compressive strength of m40 grade at 28days

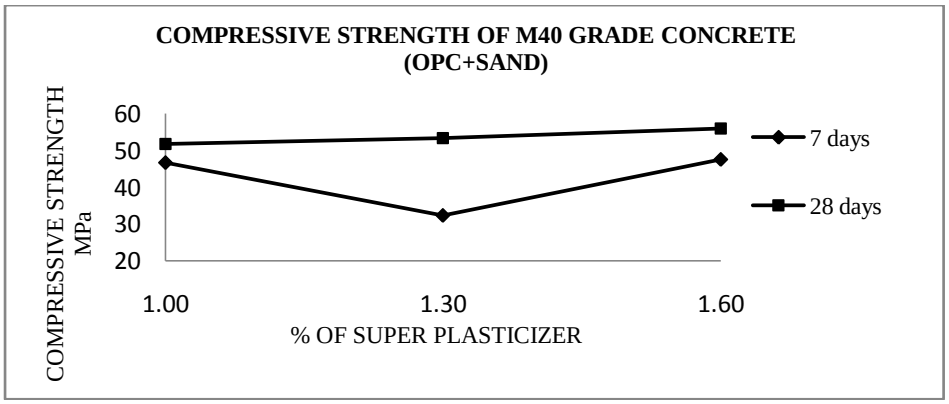

Fig:1.1 compressive strength of m40 grade concrete (opc+sand)

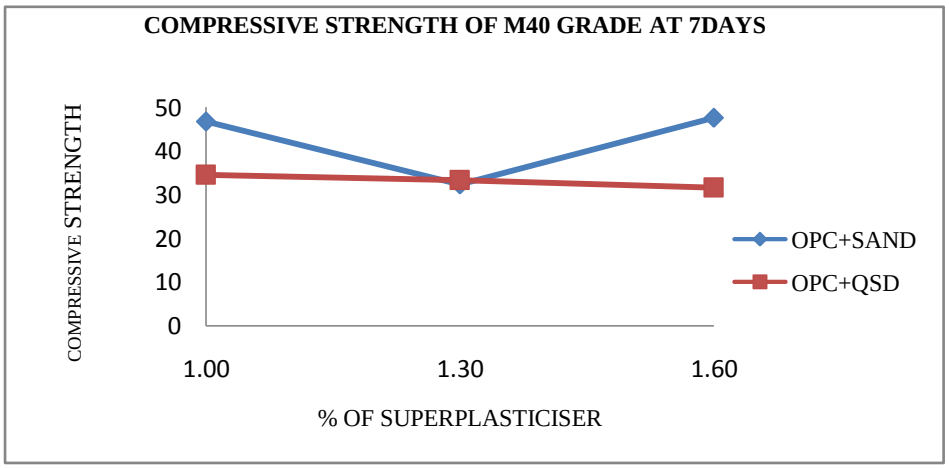

Fig:1.2 compressive strength of m40 grade at 7days

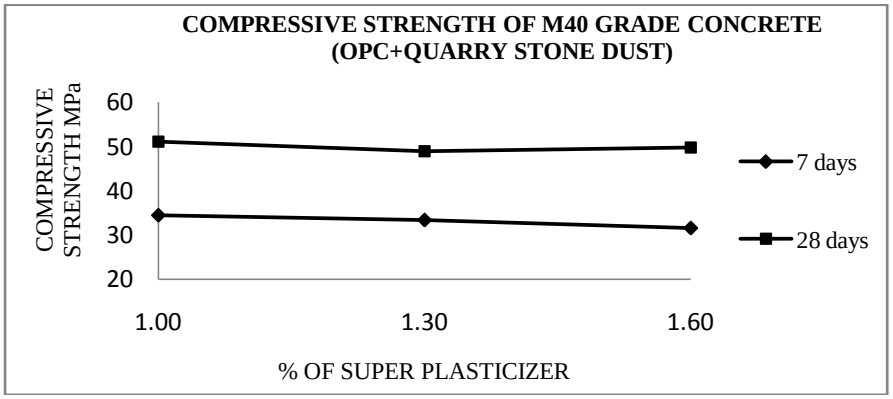

Fig:1.3 compressive strength of m40 grade concrete (opc+quarry stone dust)

IV. FLEXURAL STRENGTH (M40 GRADE):

The flexural strength of M40 grade concrete beams made with natural sand and those made with quarry stone dust as fine aggregate are tested under universal testing machine and results are tabulated below:

TABLE VI: Strength Comparision For M 40 Grade Beams

S.No.	Sp %	OPC + SAND		OPC + CRUSHER DUST	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	5.027	6.16	5.415	5.77
2	1.30	3.295	6.38	5.455	5.455
3	1.60	5.14	6.635	4.825	5.81

From the table it is observed the strengths that both the concretes are achieving the target strengths at the age of 28 days. But of normal concrete are slightly higher when compared with Quarry stone dust concrete.

4.1 M40 GRADE - FLEXURAL STRENGTHS OF BEAMS (MPa)

From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the strengths of normal concrete are slightly higher when compared with Quarry stone dust concrete.

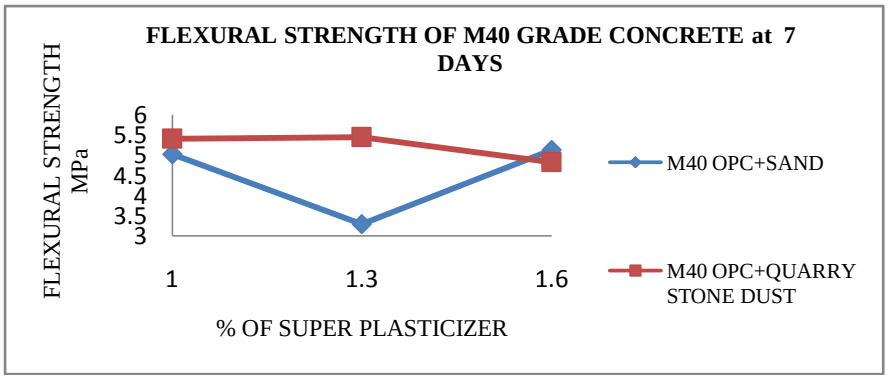

Fig. 1.4(A) Flexural Strength of M40 Grade Concrete At 7 Days

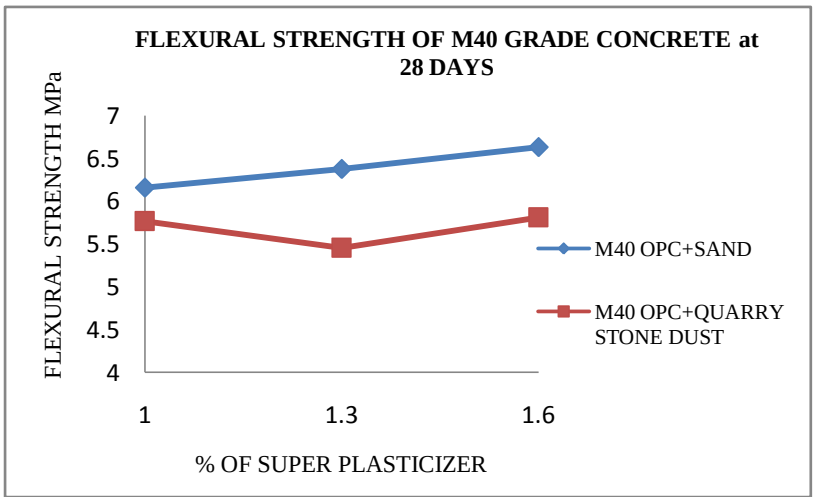

Fig. 1.4(b)

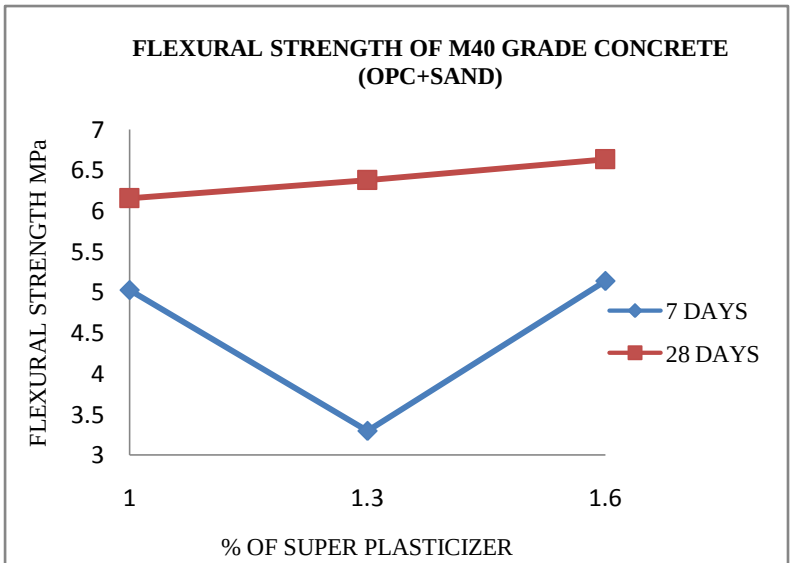

Fig. 1.4(c)

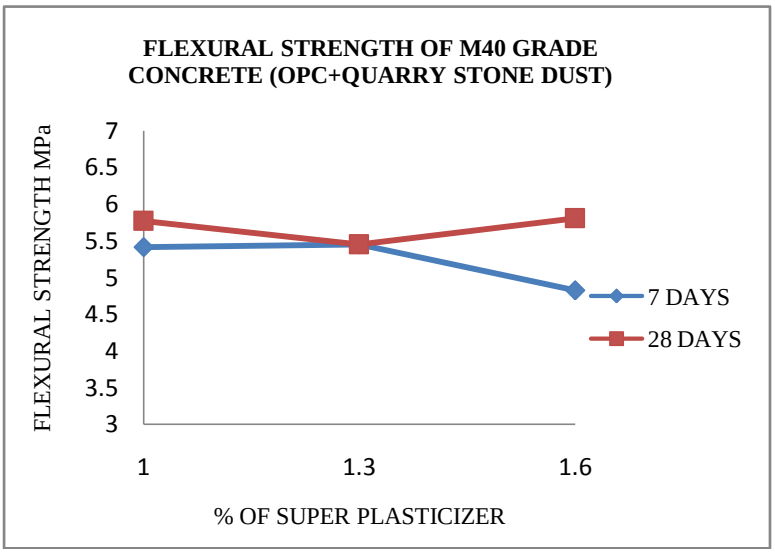

Fig. 1.4(d)

4.2 TEMPERATURE:

The test results of M40 grade cubes which are exposed to a temperature of 300°C using furnace for 1hour and 3hr durations are tabulated below:

TABLE –VII M40 Grade Beams Temperature Study

S.No	Details	Time Duration	Weight before heating (in kg)	Weight After heating (in kg)	% reduction in weight	Flexural Strength (Mpa)
1	OPC+SAND	1hr	13.11	12.69	3.2	3.69
2	OPC+QUARRY STONE DUST	1hr	13.44	12.99	3.3	4.71
3	OPC+SAND	3hr	13.22	12.81	3.1	3.37
4	OPC+QUARRY STONE DUST	3hr	13.53	13.09	3.3	4.24

The percentage reduction of weight is more in QSD beams. The flexural strength decreases at 1hr heating when compared to 3hrs duration both for OPC+SAND and OPC+QSD. The strength is more for OPC+QSD when compared to OPC+SAND. The resistance to fire is more in QSD concrete when compared with normal concrete.

V. SUMMARY OF RESULTS

From the results tabulated in earlier chapter the following statements can be derived:

1. For the designed mix proportions of M40 grade of concrete the desired characteristic strengths for cubes are achieved in both conventional concrete and Quarry Stone dust concrete.
2. The strength achieved in concrete made with sand as fine aggregate achieved high strengths when compared with Quarry stone dust concrete. However, in both the cases strengths were falling at a super plasticiser dosage of 1.3% by weight of cement. Similar behaviour was also observed in cubes of M40 grade cubes.
3. In M40 grade cubes it was observed that at 1.3% dosage of super plasticizer the compressive strength is decreased.
4. At 28 days QSD concrete with a super plasticiser dosage of 1.3% by weight of cement exhibits has low strength compared to other dosages.
5. For M40 grade concrete the strength gradually increases for 1% to 1.6% super plasticizer whereas in quarry stone dust the strength decreases from 1% to 1.3% super plasticizer and then increases at 1.6% super plasticizer.

SCOPE FOR FUTURE WORK

1. The same work can be carried out by blending quarry stone dust from one or more sources.
2. Alternative materials other than quarry stone dust such as artificial sand, robosand, waste copper slag, marble sludge powder can be used for replacement.
3. Super plasticiser of different type can be used and water reduction can be determined.

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