

Concrete MIX DESIGN with Crusher Stone Dust as a Substitute for River Sand

Debabrata Paul¹, Shibasish Neogi²

Lead Engineer – Construction, M. N. Dastur & Company (P) Ltd., Kolkata, West Bengal, India¹

Assistant Manager, Larsen & Toubro Limited, Chennai, Tamil Nadu, India²

ABSTRACT: The aim of this study is to analyze the probability of using crushed stone dust as a substitute of fine aggregate (i.e. River Sand) in concrete at 3 MTPA Integrated Steel Plant Project by TATA Steel, Kalinganagar, Odisha, India. Accordingly, Trial Mix design of M25 grade concrete was carried out using crushed stone dust after fulfilling the physical properties as per the relevant standard. Several trials were conducted with crusher dust of different sources. Trials were also conducted with different admixtures. After conducting several trials, we have arrived at a workable proportion with crusher stone dust with higher compressive strength than the established mix design M 25 using river sand.

KEYWORDS: fine aggregate, Mix design, M25 grade concrete, admixtures, compressive strength.

I. INTRODUCTION

Concrete is the most ordinarily used artificial construction material on earth, composed of cement (commonly Portland cement) and different building materials like fly ash and slag cement, aggregate (generally a rough mixture fabricated from gravel or crushed rocks like sedimentary rock, or granite, and a fine mixture like sand), water, and chemical admixtures.

The word concrete comes from the Latin word "concretus" (meaning compact or condensed), the proper passive participial of "concrecere", from "con-" (together) and "crescere" (to grow).

Concrete solidifies and hardens once admixture with water and placement because of an action called hydration. The water reacts with the cement, that bonds the opposite elements along, eventually making a strong stone-like material.

Concrete is that the most generally used stuff these days and therefore the huge amount of concrete is consumed by construction industry everywhere the globe. Speedy increase in construction activities results in acute shortage of typical construction materials. In India, the standard concrete is made by natural sand (the watercourse deposits area unit the foremost common supply of the same), cement, coarse aggregate and water. For the last ten years, the increase in price of sand because of body restrictions in India, demands relatively larger price at around 2 to 3 times the price for crusher waste even in places wherever watercourse sand is offered close. Now-a-days sand is additionally not promptly appropriate, it ought to be transported from long distance. Those resources also are exhausting terribly speedily. With natural sand deposits the globe over dehydration, there's associate degree acute want for a product that matches the properties of natural sand in concrete. Within the previous couple of years, it's become clear that the provision of excellent quality natural sand is decreasing day by day. So, it is need of the time to search out some substitute to natural river sand and that may be Crusher Dust.

The role of the fine aggregate, that could be a very important ingredient of concrete, is to help in manufacturing workability and uniformity within the mixture, though this can be associate degree inert material within the concrete combine, its role can't be neglected. Followings area unit the necessary functions of fine aggregate in the concrete mix,-

- Offers requisite surface area for the film of binding material to stick and unfold.
- Will increase the quantity of mortar & consequently makes mortar additional economical.
- Well-graded fine aggregate adds to the density of mortars and concrete.
- Prevents excessive shrinkage of mortar.
- Since it's associate degree inert material, it renders structure additional resistant against atmospherically.



Crusher Stone dust is a fine waste material obtained from crusher plants. The grains area unit sharp and robust, and therefore impart higher strength to the concrete. Use of stone dust in concrete not solely improve the standard of concrete but additionally conserve the natural river sand for future generations.

A comparatively smart strength is predicted once sand is replaced by Crusher Dust, part or totally with or while not concrete admixtures and it's projected to check the chance of exchange sand with regionally obtainable Crusher Dust while not sacrificing the strength and workability of the concrete.

II. CONCRETE MATERIALS AND THEIR PROPERTIES

Coarse aggregate of 20 mm maximum size is used in Reinforced cement concrete work of every kind of structures. This can be obtained by crushing the stone boulders of size 100 to 150 mm in the stone crushers. Then it's sieved and the particles passing through 20 mm and retained on 10 mm sieve known as coarse aggregate. The particles passing through 4.75 mm sieve are known as Crusher Dust. Various physical properties of the concrete materials are tabulated in Table 1.

Table 1. PHYSICAL PROPERTIES OF CONCRETE MATERIALS

SPECIFIC GRAVITY OF CEMENT	2.956
INITIAL SETTING TIME OF CEMENT	125 Minutes
FINAL SETTING TIME OF CEMENT	400 Minutes
CONSISTENCY OF CEMENT	35 %
COMPRESSIVE STRENGTH OF CEMENT (3, 7 & 28 DAYS)	24.08 N/ mm ² , 32.5 N/ mm ² , 44.81 N/ mm ²
SPECIFIC GRAVITY OF 20 mm SIZED COARSE AGGREGATE	2.826
SPECIFIC GRAVITY OF 10 mm SIZED COARSE AGGREGATE	2.776
SPECIFIC GRAVITY OF THE COMBINED COARSE AGGREGATE (50:50)	2.801
ZONE OF CRUSHER STONE DUST	II
SPECIFIC GRAVITY OF CRUSHER STONE DUST	2.678
SILT CONTENT OF CRUSHER STONE DUST	7.20 %
AGGREGATE IMPACT VALUE	19.14 %
CRUSHING STRENGTH	18.55 %
FLAKINESS INDEX	18.31 %
SPECIFIC GRAVITY OF ADMIXTURE [AT CARPOL 200 (HE)] (PCE based)	1.10

III. CONCRETE MIX DESIGN TRIAL WITH TESTING PROCEDURE

Total 8 nos. of trial mix have been conducted from the various crushers and seventh trials found the most satisfactory trial out of 8 trials. We can see different outcomes for different trials in Table 2 & 3.

Table 2. CONCRETE MIX DESIGN TRIAL WITH CRUSHER STONE DUST (M25 GRADE)

SL.NO.	DATE	W/C	CEMENT	WATER	CA: FA	DUST STOCK
1st Trial	01.06.2015	0.48	347.2	167	56:44	AVAILABLE
2nd Trial	01.06.2015	0.47	355	167	59:41	AVAILABLE
3rd Trial	02.06.2015	0.48	347	167	61:39	KONARK
4th Trial	02.06.2015	0.47	355	167	59:41	BAGHUA
5th Trial	03.06.2015	0.45	370	167	59:41	BAGHUA
6th Trial	04.06.2015	0.45	370	167	59:41	BAGHUA
7th Trial (FINALMIX)	05.06.2015	0.45	370	167	59:41	BAGHUA
8th Trial	06.06.2015	0.48	338	162	59:41	BAGHUA

Table 3. CONCRETE MIX DESIGN TRIAL WITH CRUSHER STONE DUST (M25 GRADE)

SL.NO.	SPECIFIC GRAVITY (DUST)	DUST	20 mm:10 mm	20 mm	10 mm	ADMIXTURE	REMARKS
1st Trial	2.67	836	60: 40	675	450	AT-PLAST201 (I) @ 0.6% Dosage	Homogeneous mixing not observed
2nd Trial	2.67	782	60: 40	705	470	AT-PLAST201 (I) @ 0.6% Dosage	Segregation and bleeding
3rd Trial	2.578	739	70: 30	856	367	AT-PLAST201 (I) @ 1.1% Dosage	Segregation and bleeding
4th Trial	2.678	784	60: 40	705	470	AT CARPOL 200 (HE) Pure Pce Based @ 0.6% Dosage	Segregation and bleeding
5th Trial	2.678	771	50: 50	586	586	AT CARPOL 200 (HE) Pure Pce Based @ 0.6% Dosage	Initial Slump: 150 mm 30 min Slump: 80 mm 1-hour Slump: 50 mm Mix found cohesive but retention required
6th Trial	2.678	771	50: 50	585	585	AT CARPOL 200 (HE) Pure Pce Based @ 0.7% Dosage	Initial Slump: 150 mm 30 min Slump: 100 mm 1-hour Slump: 60 mm Mix found cohesive but retention required
7th Trial (FINAL MIX)	2.678	771	50: 50	585	585	AT CARPOL 200 (HE) Pure Pce Based @ 0.8% Dosage	Initial Slump: 170 mm 30 min Slump: 145 mm 1-hour Slump: 125 mm
8th Trial	2.678	799	50: 50	593	593	AT CARPOL 200 (HE) Pure Pce Based @ 0.7% Dosage	Segregation and bleeding and coating of cement with aggregate not found

TRIAL 7. CONCRETE MIX DESIGN GRADE M-25 CIVIL WORK

A) DESIGN STIPULATIONS

- 1 Grade Designation - M 25
- 2 Type of Cement - PSC Conforming to IS: 455- 1989
- 3 Maximum Nominal Size of Aggregate - 20mm
- 4 Minimum Cement Content - 300 kg/ m³ (As per IS: 456- 2000)
- 330 kg/ m³ (As per Dastur Technical Specification)
- 5 Maximum Water Cement Ratio- 0.50 (As per IS:456- 2000)
- 6 Degree of Workability - Slump required 150 mm
- 7 Exposure Condition - Moderate

- 8 Degree of Supervision - Good
- 9 Type of Aggregate - Crushed Aggregate
- 10 Chemical Admixture Type - Super plasticizer

B) TEST DATA FOR MATERIAL

- 1 Cement- Konark Portland Slag Cement- Conforming to IS: 455- 1989
- 2 Specific gravity of Cement – 2.956
- 3 Chemical Admixture AT - CARPOL 200(HE) (PCE based) conforms to IS: 9103-1999 and ASTM C 494
- 4 Specific gravity of Fine Aggregate (Stone Dust)-2.678
- 5 Specific gravity of Coarse Aggregate- 2.801
- 6 Specific gravity of Admixture- 1.10
- 7 Water Absorption of Fine Aggregate- 1.300 %
- 8 Water Absorption of Coarse Aggregate- 0.535 %
- 9 Free (Surface) Moisture in Coarse Aggregate- NIL
- 10 Free (Surface) Moisture in Fine Aggregate- NIL
- 11 Sieve Analysis of Coarse Aggregate- As per IS: 383- 1970
- 12 Sieve Analysis of Fine Aggregate- Conforming to grading zone 2 of table 4 of IS: 383- 1970.
- 13 Gradation of All-In-Aggregate- As per IS: 383- 1970 Table No. 5.

C) TARGET MEAN STRENGTH OF CONCRETE

$$f'_{ck} = f_{ck} + 1.65 s$$

Where

f_{ck} = characteristics of compressive strength at 28 days, and
 s = standard deviation

From IS: 456- 2000 Table 8 Page 23, Standard deviation, $s = 4 \text{ N/mm}^2$
Therefore, target strength = $25 + 1.65 \times 4 = 31.60 \text{ N/mm}^2$

D) SELECTION OF WATER CEMENT RATIO

Maximum Water Cement Ratio as per Technical Specification 0.50
Based on experience, adopt water-cement ratio as 0.45
 $0.45 < 0.50$, Hence O.K

E) SELECTION OF WATER CONTENT

From IS: 10262- 2009 Table 2 Page 3, maximum water content= 186 Lit. (For 25 to 50 mm slump range)
For 20 mm Aggregate
Estimated water content for 150 mm slump = $186 + \{[(150-50)/25] \times 3\} / 100 \times 186$
Therefore, Estimated water content for 150 mm slump = 208.32 Ltr/m³
As super plasticizer is used, the water content can be reduced up to 20.0 % and above.
Based on trials with super plasticizer water content reduction of 20.0 % has been achieved.
Hence, the arrived Water Content = $208.32 \times 0.80 = 166.656 \text{ Liter}$

F) CALCULATION OF CEMENT CONTENT

Water-Cement ratio = 0.45
Cement Content = $166.656 / 0.45 = 370.347 \text{ Kg/m}^3$
 $370 \text{ Kg/m}^3 > 330 \text{ Kg/m}^3$, Hence O.K

G) PROPORTION OF VOLUME OF COARSE AGGREGATE & FINE AGGREGATE

From IS: 10262- 2009 Table 3 Page 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone 2) for water cement ratio of 0.50 = 0.620



In the present case water cement ratio is 0.45 Therefore, volume of coarse aggregate is required to be increased to decrease fine aggregate content. As the water-cement ratio is lower by 0.05, the proportion of volume coarse aggregate is increased by 0.010 (at the rate of +/- 0.01 for every +/- 0.05 change in water- cement ratio).

Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.45= 0.630

For pumped concrete this value should be reduced by 6%

Therefore, volume of coarse aggregate= 0.630 X 0.94= 0.5922

Volume of fine aggregate content = 1 - 0.5922 = 0.4078

H) MIX CALCULATION

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

a) Volume of concrete= 1 m³

b) Volume of Cement = (Mass of Cement/ Specific Gravity of Cement) X (1/1000)

$$= (370/ 2.956) X (1/1000)$$

$$= 0.1252 \text{ m}^3$$

c) Volume of Water = (Mass of Water/ Specific Gravity of Water) X (1/1000)

$$= (166.656/ 1) X (1/1000)$$

$$= 0.1667 \text{ m}^3$$

d) Volume of chemical Admixture (Superplasticizer) @ 0.8 percent by mass of cementitious material)

$$= (\text{Mass of chemical Admixture} / \text{Specific Gravity of chemical Admixture}) X (1/1000)$$

$$= (0.8 \% \text{ of } 370 / 1.1) X (1/1000)$$

$$= 0.0027 \text{ m}^3$$

e) Volume of all in Aggregate = a-(b+c+d)

$$= 1-(0.1252+0.1667+0.0027)$$

$$= 0.7054 \text{ m}^3$$

f) Mass of Coarse Aggregate = e x Volume of coarse aggregate x specific gravity of coarse aggregate x 1000

$$= 0.7054 \times 0.5922 \times 2.801 \times 1000$$

$$= 1170.084 \text{ Kg.}$$

$$= 1170 \text{ Kg.}$$

g) Mass of Fine Aggregate = e x Volume of fine aggregate x specific gravity of fine aggregate x 1000

$$= 0.7054 \times 0.4078 \times 2.678 \times 1000$$

$$= 770.359 \text{ Kg.}$$

$$= 770.3 \text{ Kg.}$$



IV. TESTING AND ANALYSIS OF TEST RESULTS

A) Casting of specimens

150 x 150 x 150 mm size of mould was used to cast specimens for Compressive Strength testing. Combination of 20 mm and 10 mm sizes of coarse aggregates were used. The specimens were cast, tested in a compression-testing machine at the age of 7 and 28 days after curing.

B) Fresh concrete workability

For the determination of the consistency of concrete, Slump test had been conducted with varied water content and a selected water cement ratio (w/c) which supplies the slump values are mentioned below as per the seriatim,

- Initial Slump: 170 mm
- 30 min Slump: 145 mm
- 1-hour Slump: 125 mm

C) Compressive Strength Test

For determining of the Compressive Strength at the end of 7 days and 28 days, the cube specimens had been tested. The same specimens were tested once surface of the specimen dried. The load was applied on the smooth sides while not shock and redoubled unceasingly till the failure of the cube specimens. The maximum load resistivity by the specimens is noted, mean compressive strength is determined and bestowed below as per the seriatim,

- 7 Days Cube Testing Result Value (Avg.): 30.22 N/mm²
- 28 Days Cube Testing Result Value (Avg.): 40.89 N/mm²

D) ANALYSIS OF TEST RESULTS

It is ascertained that each of the 7 days and 28 days compressive strength results for the concrete mixing with Crusher Dust give most end in compressive strength compared to the conventional concrete mixing with River Sand.



V. CONCLUSIONS AND SUGGESTIONS

From this experimental study, it's over that the Crusher Stone Dust may be used as a replacement for the River Sand. It's found that replacement of River Sand by Crusher Stone Dust provides most end in compressive strength compared to the traditional concrete.

Thus, the environmental effects and waste may be considerably reduced.

Based on higher than discussions, following suggestions are drawn,

- The value of concrete may be attenuated by increasing the number of Crusher Stone Dust in place of River Sand.
- Besides being an economical different, use of Crusher Stone Dust as fine aggregates in concrete helps in sustaining the ecological balance.

ACKNOWLEDGEMENTS

The authors acknowledge the research enabling environment created by the Navayuga Engineering Company Limited at their Laboratory at the project site of 3 MTPA Integrated Steel Plant Project by TATA Steel, Kalinganagar, Odisha, India.

We would like to thank M. N. Dastur and Company (P) Ltd. team especially Mr. Partha Bandyopadhyay, Technical Director and Head – Construction; Mr. Pritam Kumar Chatterjee, Technical Director and Site-in-charge; laboratory technicians and local contractors to help us find the way of doing the study.

REFERENCES

- [1] IS: 0262- 2009 Indian standard code of concrete mix proportioning – Guidelines
- [2] IS: 383- 1970 Indian standard code of coarse and fine aggregate for concrete- Specification
- [3] IS: 456- 2000 Indian standard code of practice for plain and reinforced concrete
- [4] IS: 2386 (Part I) – 1963 Indian standard code of METHODS OF TEST FOR AGGREGATES FOR CQONCRETE- PARTICLE SIZE AND SHAPE
- [5] IS: 2386 (Part III) – 1963 Indian standard code of METHODS OF TEST FOR AGGREGATES FOR CQONCRETE- SPECIFIC GRAVITY, DENSITY, VOIDS, ABSORPTION AND BULKING
- [6] IS: 2386 (Part IV) – 1963 Indian standard code of METHODS OF TEST FOR AGGREGATES FOR CQONCRETE- MECHANICAL PROPERTIES
- [7] IS: 4031 (Part I) – 1996 Indian standard code of METHOD OF PHYSICAL TESTS FOR HYDRAULIC CEMENT - DETERMINATION OF FINENESS BY DRY SIEVING
- [8] IS: 4031 (Part IV) – 1988 Indian standard code of METHOD OF PHYSICAL TESTS FOR HYDRAULIC CEMENT - DETERMINATION OF CONSISTENCY OF STANDARD CEMENT PASTE
- [9] IS: 4031 (Part V) – 1988 Indian standard code of METHOD OF PHYSICAL TESTS FOR HYDRAULIC CEMENT - DETERMINATION OF INITIAL AND FINAL SETTING TIMES
- [10] IS: 455-1989 Indian standard code of PORTLAND SLAG CEMENT- SPECIFICATION
- [11] IS: 9103-1999 Indian standard code of CONCRETE ADMIXTURES – SPECIFICATION
- [12] ASTM C 494 Standard Specification for Chemical Admixtures for Concrete
- [13] IS: 10262- 2009 Indian standard code of CONCRETE MIX PROPORTIONING - GUIDELINES
- [14] M.S. Shetty, Concrete Technology Theory and Practice, S.Chand& Co. Ltd., New Delhi