Experimental Analysis of Natural Sand with Crushed Sand of M20 Concrete Mix

Imam Korabu, Chetan Pise

Abstract*: Concrete itself as a mixture of water, cement, sand and aggregate in addition with admixtures.as the natural sources of aggregates are different the strength shows variation. There is shortage of natural sand due to heavy demand indifferent construction activities such as residential, commercial, bridges etc.it is very needful to find suitable substitute. The cost effective & simplest way to getting substitute to natural sand is by crushing natural stone to get manufactured sand i.e. M-sand of desired size & shape which would free from all deleterious materials. Now a day V.S.I. crusher is a cheapest machine for crushing stone in cubical shape & manufacture M-sand.in Maharashtra every city or town does not have V.S.I. crusher so artificial sand i.e. M-sand is not available at everywhere so we want to combine natural sand with artificial sand. For the purpose of testing concrete mixes are designed for M20 with 50% natural sand & 50% crushed sand and also all natural sand replaced by M-sand.to evaluate strength the compressive strength is taken on compressive testing machine.

***Keywords* : Crushed sand, manufactured sand, sieve analysis, coarse aggregate, compressive strength, V.S.I. crusher, environmental impact**.

I. INTRODUCTION

Natural sand wear away & break down the particles of rock with various grades or sizes depending upon the amount of wearing.in current sinario natural sand is not readily available. It makes available from different resources. These resources are also diminishing very fast. So it is essential to find supplementary substitute to natural sand. The M-sand produced by V.S.I crusher can be better substitute to natural sand. The sand can be classified in well graded sand as it contains particles of different sizes in proper proportion (particles from 150µ to 4.75mm).When sand classified as well graded sand then the sand will have minimum voids, due to which the quantity of cement required will be less which reduces the overall cost and becomes economical.as demand of natural sand increases day by day which cannot satisfy the demand of rising construction sectors. Natural river sand takes too much time to form. Because of its limited supply, the cost of river sand becomes too much high & also its supply is not constant. Due to these difficulties the artificial sand makes firm position in construction sector. River sand contains maximum silt & organic impurities which is harmful for durability of steel in concrete, but artificial sand has no silt content and organic impurities.But artificial sand cannot be available in ample amount in all over India. Crushed sand is easily available so crushed sand is used as supplementary for natural sand.
Several studies have been conducted in past to investigate the effect of partial replacement of natural sand with crushed rock sand. Ahu et al. (2003) observed that concrete made using crushed sand attained the comparable compressive strength. mudra et al. (2016) observed reduction in compressive was not increased at and beyond 50% of crushed sand. Rajput et al. (2018) gives compressive strength result of 20%,40%,60% 80%,100% replacement of crushed sand.
A survey of literature shows numerous studies has been conducted in past to utilize crushed sand as fine aggregate in concrete. The present study has attempted to show 100% replacement of crushed sand is feasible or not. Also covers the gap which all researchers are not shown about sieve analysis.

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II. MATERIALS AND METHODS

A. Concrete Mix Design of Grade M20 with Crushed Sand

Design Stipulations:

(i) minimum required strength	20 N/mm^2
(ii) Maximum size of aggregate	20 mm (angular)
(iii) Degree of workability	0.80 compacting factor
(iv) Degree of quality control	Good
(v) Type of Exposure	Mild

Test data for Materials:

(i) Specific gravity of cement	3.15
(ii) Compressive strength of cement at 7 days Satisfies the requirement of IS: 269–1989	
(iii) 1. Specific gravity of coarse aggregates	2.65
. Specific gravity of fine aggregates	2.65
(iv) Water absorption:	
1. Coarse aggregate	0.50%
2. Fine aggregate	1.0%
(v) Free (surface) moisture:	
1. Coarse aggregate	Nil
2. Fine aggregate	2.0%

(vi) Sieve Analysis is shown below

Coarse Aggregate confirming I.S 383-1970

Sieve Analysis				
I .S. Sieve Size	Sample-I	Sample-II	Sample-III	Average
20mm	87.56	87.93	82.72	86.07
10mm	4.53	5.28	4.63	4.91
4.75mm	0.49	0.18	0.08	0.086

Fine Aggregate confirming to grading Zone-I

Sieve Analysis of crushed sand

I.S Sieve Size	Sample-I	Sample-II	Sample-III	Average
4.75mm	99	98.5	97.2	98.23
2.36mm	76	70.25	56.2	67.48
1.18mm	32.8	23.2	11	22.33
600 Microns	18.75	10.65	4	11.13
300 Microns	11.2	6.5	3	6.9
150 Microns	8.3	4.8	2.65	5.25

A) Target mean Strength of concrete

fck = fck + 1.65 s

where fck= characteristic compressive strength at 28

s is the standard deviation. From Table 8 in I.S.456-2000 for M20 concrete S=4

Therefore, target mean strength = 20+ 1.65 x 4 = 26.6N/7mm^2

B) Selection of W/C ratio

Water cement ratio is the ratio of weight of water to weight of cement used. W/C ratio directly affect strength of concrete, if more water is used then it minimizes the strength of concrete & if minimum water is used then it reduces the workability of concrete.in such cases we find out the optimum water content.

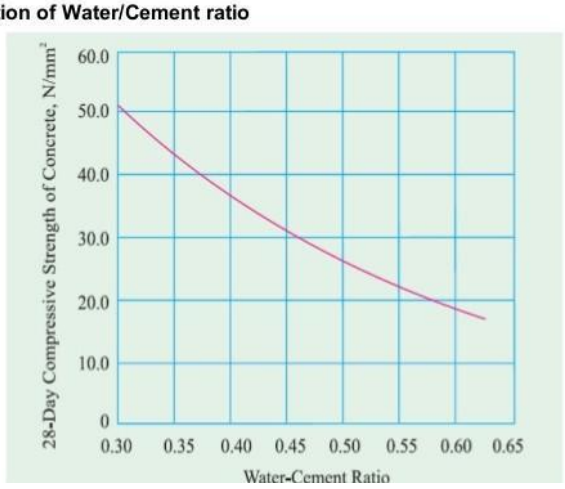

Fig.No.1

From above graph the water-cement ratio required for the target mean strength of 26.6 MPa is 0.50. This is lower than the maximum value of 0.55 prescribed for 'Mild' exposure. Take W/C ratio of 0.50

C) Entrapped Air in concrete:

Concrete is heterogeneous material containing different ingredients due to which it contains air bubbles. Smaller air bubbles called entrained air & large as entrapped air. Due to entrapped air friction between aggregate reduces & allowing lower water content thereby reducing bleeding & segregation.

The air content is estimated from the normal maximum size of aggregate used.As size of aggregate is 20mm so select entrapped air is 2.0 %

d) Determination of water & sand content

from table 2 of I.S10262-2009 the maximum water content per cubic meter of concrete for 20mm aggregate is 186Kg and maximum sand content by volume as 35% applicable upto M35 concrete.

Sr.no	Change in Condition	Adjustment in (%) required	
		Water Content	Sand Content
1	For decreasing in w/c ratio by 0.05	0	+1.5%
2	For increase in compaction factor (0.9-0.8)	+3%	0
3	For sand confirming to zone-I	0	-1%
4	TOTAL	**+3%**	**+0.5%**

From above adjustment the corrected final water & sand content is as below

a) final Water content = 186 +(186x3/100) =191.58 kg/m^3

b) final Sand as percentage of total aggregate by absolute volume = 35 + 0.5=35.5%

e) Determination of cement content

water cement ratio= 0.5

final water content =191.58 litre

cement=191.58/0.5=383.16 kg/m^3

f) Determination of coarse aggregate & fine aggregate

the maximum size of aggregate is 20mm & amount of entrapped air is 2 percent.

$V=[W+C/S_c+ 1/P\ f_a/S\ f_a]\ 1/1000$

$0.98=[191.58 + 383.16/3.15 + 1/0.355*f_a/2.65]\ 1/1000$

$F_a=628.58$ Kg/m^3

$C_a=(1-P)/P\ *f_a*S_{ca}/S_{fa}$

$C_a=(1-0.355)/0.355*\ 628.58*2.65/2..65$

$C_a=1137.72$ Kg/m^3

The final mix proportions of M-20 grade of concrete with crushed sand: -

WATER	CEMENT	F.A	C.A
191.58 Lit	383.16Kg	628.58Kg	1137.72Kg
0.52	1	1.87	3.11

B Concrete Mix Design – M 20 Grade of Concrete with 50% sand & 50% Crushed Sand

Design Stipulations:

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(iii) Degree of workability 0.80 compacting factor

(iv) Degree of quality control Good

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(iv) Water absorption:
1. Coarse aggregate
0.50%
2. Fine aggregate 1.0%
(v) Free (surface) moisture:
1. Coarse aggregate Nil
2. Fine aggregate Nil

Fine Aggregate confirming to grading Zone-I

Sieve analysis of 50 % sand & 50% crushed sand				
I.S Sieve Size	**Sample-I**	**Sample-II**	**Sample-III**	**Average**
4.75mm	96.7	96.2	97.9	95.95
2.36mm	81.15	75.7	85.15	88.61
1.18mm	53.8	43.3	57.85	69.6
600 Microns	34.7	25.15	36.9	32.25
300 Microns	17.9	11.65	18.85	17.8
150 Microns	11	6.95	11.75	6.35
75Microns	8.32	5.2	8.55	7.35

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Fig No. 1 Water Content Vs Compressive Strength

From above graph the water-cement ratio required for the target mean strength of 26.6 MPa is 0.50. This is lower than the maximum value of 0.55 prescribed for 'Mild' exposure. Take W/C ratio of 0.50

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$F_a=628.58$ Kg/m^3
$C_a=(1-P)/P\ *f_a*S_{ca}/S_{fa}$
$C_a=(1-0.355)/0.355*\ 628.58*2.65/2..65$
$C_a=1137.72$ Kg/m^3

The final mix proportions of M-20 grade of concrete with 50% crushed sand & 50% natural sand: -

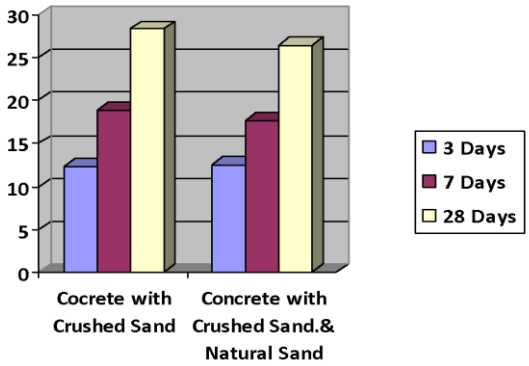
Water	**Cement**	**F.A (sand)**	**F.A (crushed sand)**	**C.A**
191.58 Lit	383.16Kg	314.29Kg	314.29Kg	1137.72Kg

Compressive Strength of Concrete at Various Ages:

Target Mean Strength	Nominal mix	trial no	W/C Ratio	date of casting	date of testing	compressive load	compressive strength	Avg.
26.6N/mm2	M20	1	0.50	24/12/2017	27/12/2017	330KN	14.67	12.28 N/mm2
						290KN	13.8	
						190KN	8.44	
				24/12/2017	31/12/2017	374KN	16.62	18.87 N/mm2

						459KN	20.4	
						441KN	19.6	
				24/12/2017	21/01/2018	633KN	28.13	28.29 N/mm2
						685KN	30.44	
						592KN	26.31	

Target Mean Strength	Nominal mix	trial no	W/C Ratio	date of casting	date of testing	compressive load	compressive strength	Avg.
26.6N/mm2	M20	2	0.50	01/01/2018	01/04/2018	320	14.22	12.56 N/mm2
						285	12.66	
						247	10.97	
				01/01/2018	01/08/2018	380	16.88	17.80 N/mm2
						380	16.88	
						442	19.64	
				01/01/2018	28/1/2018	554	24.62	26.44 N/mm2



III. CONCLUSION

From the above experimental work following points are concluded

1. The fine aggregates (crushed sand) are not confirming to any of the zones specified in I.S.383-1970. It is not recommended as to use fine aggregate (crushed sand) which was used for concreting.
2. The combined fine aggregates (50 % river sand + 50% crushed sand) are confirming to the zone-II specified in I.S.383-1970. It is recommended as to use fine aggregate (50 % river sand + 50 % crushed sand) which was used for concreting.
3. Crushed sand can be used as supplementary option for natural sand as it is cheap & reduces cost of construction.
4. As per visual observation the mix is non-cohesive which reduces the workability.
5. The magnitude relation of fines below 600 microns in sand ought to be below 30%.
6. Crushed sand incorporates a potential to supply supplementary different to natural sand.
7. the strength of concrete with crushed sand is higher than strength of concrete with crushed sand & river sand.

AUTHORS PROFILE

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