Crushed Sand a Substitute for River Sand as a Fine Aggregate in Concrete

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Abstract— Concrete is a dominant part of construction industry. In India, ordinary concrete contains natural sand obtained from riverbeds as fine aggregates. In recent times with a boost in construction activities, there is a significant increase in the consumption of concrete causing the scarcity of natural sand. Because of several environmental issues thereby government imposing a ban on the uncontrolled use of natural sand. This has resulted in the significant rise in cost of natural sand. Therefore, to find a substitute to river sand has become the necessary in last two decades. The progressive use of crushed sand will conserve the natural resources for the sustainable development of the concrete in construction industry.

Key words: Crushed Sand, Fine Aggregate, Concrete, Compressive Strength

I. INTRODUCTION

With the progressive declination in the availability of construction sands along with the environmental pressures to reduce extraction of sand from rivers, the use of crushed sand as a replacement is increasing. Many states has ban on sand mining, and with the increasing demand for river sand for construction works, many civil engineers have expressed the need to promote use of crushed sand in the construction industry. As per reports, crushed sand is widely used all around the world and technicians of major projects around the world insist on the compulsory use of crushed sand because of its consistent gradation and zero impurity. from the point of view of durability of structures. Uncontrolled mining and quarrying is posing threat to the environment. As the demand for Natural River sand is surpassing the availability, has resulted in vanishing of natural sand sources. Crushed sand is the answer for this problem especially when some states have already banned the use of river sand for construction. This sand has been defined in IS 383-1970, under clause 2.0. There is a need to study shape characteristics of crushed sand, effect of micro fines on concrete characteristics such as modulus of elasticity, shrinkage, creep etc. concrete mix proportioning by resorting to particle packing approach is the need of the hour when it comes to use of crushed sand as a replacement to natural river sand.

II. NATURAL SAND VS. CRUSHED SAND

The sand from river due to natural process of attrition gets smoother surface texture and better shape. It also carries some moisture that is trapped in between the particles. These characters make concrete workability better. On the other hand, silt and clay carried by river sand can be harmful to the concrete. Another issue related with river sand is that of obtaining required grading with a fineness modulus of 2.4 to 3.1. It has been verified and found, at various locations across Western India, that it has become increasingly difficult to get river sand of consistent quality in terms of grading requirements and limited silt / clay content. It happens because we do not have any control over the natural process. In case of crushed sand, the process of attrition through (VSI) Vertical Shaft Impactor Crusher and washing makes the crushed stone sand particles good enough to be compared shape and surface texture of natural sand. With well-designed screening system the required grading (Zone II) and fineness modulus (2.4 to 3.1) can also be achieved consistently in the case of crushed sand. It must be noted that properly processed crushed sand can improve both compressive strength and flexural strength through better bond compared to river sand.

III. PROPORTIONING OF CONCRETE MIXES USING CRUSHED SAND

Concrete mix proportions should be select in such a way that the concrete is of adequate workability for the placing condition of the concrete and we can properly be compacted with the means available. In desensitized state concrete shall have required strength, durability and surface finish. Fine aggregate is one of the crucial ingredients of concrete. As natural sand deposits going to vanish near some areas of metropolitan growth, the use of crushed sands as a replacement fine aggregate in concrete gaining more attention. Designers, specifies, contractors and material suppliers need to understand the effects of crushed sand characteristics on concrete water demand and concrete durability.

As per IS 383 Revised on 1996, the % passing through 150 Micron sieve for crushed sand is of maximum limit = 20%, but For better result- Maximum % passing through 150 Micron should be within 15%.

Sieve size	Percentage Passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
100mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600Micron	15-34	35-59	60-79	80-100
300Micron	5-20	8-20	12-40	15-50
150 Micron	0-10	0-10	0-10	0-15

Table 1: Grading Zone of Sand as per IS 383, Clause 4.30- Table No – 4

Sieve size	Weight retained	Percentage weight retained	Percentage Cumulative	Percentage Passing	Remark
4.75mm	179.00	08.95	08.95	91.05	
2.36mm	225.00	11.25	20.20	89.80	As per IS 383-Sand in Zone I
1.18mm	582.50	29.13	49.33	50.67	

600Micron	460.00	23.00	72.33	27.67	Grading is OK.
300Micron	365.50	18.23	90.61	09.41	
150Micron	153.00	07.65	98.26	01.74	
Pan	33.00	01.65	99.91	0.01	

Table-2 Typical Sieve Analysis of River Sand Observed in Solapur city – (Sample Weight- 2kg)

Sieve size	Weight retained	% weight retained	% Cumulative	% Passing	Remark
4.75mm	48.00	24.00	24.00	97.60	
2.36mm	523.00	26.15	28.55	71.45	As per IS 383-Sand in Zone I
1.18mm	581.00	29.07	57.62	42.38	
600Micron	250.50	12.52	70.14	29.86	
300Micron	179.00	08.95	79.09	20.91	
150Micron	146.50	07.33	86.42	13.58	% Passing through 150Micron sieve is within 15 %. Hence ok.
Pan	267.50	13.37	99.78	6.22	

Table-3 Typical Sieve Analysis of Crushed Sand Observed in Solapur city – (Sample Weight- 2kg)

Batch	Concrete mix design for 100% river sand				
	Cement	Fine aggregate	Coarse aggregate	Water	Admixture
Per Cum	0.21 Cum	0.56 Cum	0.66 Cum	152.50litres	0.90Litres
Per 50kg	50kg (1 Bag)	168 kg	182 kg	25 liters	150 ml

A) Using 100% River Sand

Concrete mix design for 100% Crushed sand				
Cement	Fine aggregate	Coarse aggregate	Water	Admixture
0.23 Cum	0.53 Cum	0.67Cum	165Litres	1 liters
50 kg	158 kg	171kg	25litres	150ml

B) Using 100% Crushed Sand as Fine Aggregate

Table 4: Typical Concrete Mix Design for M-20 grade Made up with

Note: Admixture used is CONPLAST SP 430, manufacturer
M/s Fosroc Chemicals (India) Pvt.Ltd.

Grade of concrete	River sand Compressive strength(N/mm^2)		Crushed sand Compressive strength(N/mm^2)		Remark
M20	7 days	28 days	7 days	28 days	
	17.40	28.10	18.10	28.75	Crushed Sand gives satisfactory result over river sand.

Table 4: Compressive Strength of Cement Concrete Cubes

IV. COMPRESSIVE STRENGTH

1) The standard mix with 100% Manufactured sand has achieved maximum Compressive strength of 28.75 MPa.
2) The Mix design with 100% of river sand has achieved compressive strength of 28.10 Mpa, Crushed Sand gives 0.65 MPa higher than that of river sand.
3) The improved properties of crushed sand by the entire process of manufacturing could have resulted in reduced surface area and better particle packing. This will offer to good binding effect with the available cement paste and improved the compressive strength.

V. CONCLUSION

1) Compressive strength test on Crushed Sand gives satisfactory result over river sand.
2) As per IS 383:1996 gradation for Crushed sand gives positive result when we compare with river sand.
3) So we can use Crushed Sand as substitute for fine aggregate in concrete.

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