An Experimental Study on the Effect of Replacement of Natural Sand with Manufacture Sand

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Abstract- **Common River Sand is expensive due to excessive cost of transportation from natural Sources. Also large scale depletion of these sources creates environmental problems. As environment, transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. River sand used as fine aggregates in production of concrete poses the problem of acute shortage in all parts of country. The continuous use of this has started posing serious problem with respect to its availability, cost and environmental impact. In such a situation Manufactured sand (M. Sand) can be economical alternative to river sand. Manufactured Sand can be defined as all most residue, tailing or other non-valuable waste after the extraction and processing of rocks to form fine particles less than 4.75 mm. Manufactured Sand is used in large scale in the building work, highways as a surface finishing material, used for manufacturing of hollow blocks and light weight concrete prefabricated elements. Use of Manufactured Sand in concrete is drawing attention to researchers and investigators. The study of M. Sand presents the feasibility of usage of manufactured sand as substitute of Natural sand in concrete. Various mix designs have been developed for different grades using design codes like IS codes for both conventional concrete. In this paper we report various tests which were conducted on cubes, Cylinders and beams to study the strength of concrete made of M. Sand concrete and results were compared with Natural sand concrete. It was found that the compressive, flexural and tensile strength studies of concrete made of Manufactured Sand are nearly equal to the conventional concrete.**

I. INTRODUCTION

Currently, India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization. In recent years, concrete technology has made significant advances which have resulted in economical improvements in strength of concrete. This economic development depends upon the intelligent use of locally available materials. A huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced by using natural sand obtained from the riverbeds as fine aggregate. One of the important ingredients of conventional concrete is natural sand or river sand, which is expensive and scarce. However, due to the increased use of concrete in almost all types of construction works, the demand of natural or river sand has been increased. To meet this demand of construction industry, excessive quarrying of sand from river beds is taking place causing the depletion of sand resources. The scarcity of natural sand due to such heavy demands in growing construction activities have forced to find the suitable substitute. One of the cheapest and the easiest ways of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade [1]. The main cause of concern is the nonrenewable nature of natural sand and the corresponding increasing demand of construction industry. Therefore looking for another to river sand had become a necessity. The cheapest and easiest alternative to natural sand is manufacturing sand by crushing rocks/stones in desired amount and grade by suitable method. Sand produced by such means is called as manufactured/ crusher/artificial sand [2]. Priyanka A. Jadhav and Dilip K. Kulkarni puts forward the applications of manufactured sand as an attempt towards sustainable development. The effect of water cement ratio on hardened properties of cement mortar with partial replacement of natural sand by manufactured sand was also reported[3]. M. Prem Anand et. al. have reported the results of experimentally investigation on the effect of M-Sand in structural concrete by replacing river sand and develop a high performance concrete. They also determine and compare the differences in properties of concrete containing river sand and M-sand. They also use steel fibres and chemical admixtures to increase the strength and workability of concrete respectively. The investigations were carried out using several tests such as workability test, compressive test, tensile test, and flexural test etc [4]. Swapnil S. Fate has studied the effect of use of crushed sand on properties of concrete and review of various operational parameters viz. workability, durability and compressive strength was highlighted in the paper [5]. Martins Pilegis, Diane Gardner and Robert Lark have also reported the results of a laboratory study in which manufactured sand produced in an industry sized crushing plant was characterised with respect to its physical and mineralogical properties. The influence of these characteristics on concrete workability and strength, when manufactured sand completely replaced natural sand in concrete, was investigated and modelled using artificial neural networks (ANN). The results showed that the manufactured sand concrete made in this study generally requires a higher water/cement (w/c) ratio for workability equal to that of natural sand concrete due to the higher angularity of the manufactured sand particles [6]. Rameshwar S. etal. Had initiated to made the concrete economical by replacing the natural sand by crushed sand in the concrete. It was concluded that different Crushed sand gives different results for compressive strength depending on different quarries [7]. Akshay A. Waghmare Akshay G..Kadao, Ayushi R. Sharma and Sunil G. have reported the properties such as workability tensile strength and compressive strength of concrete prepared by replacing natural sand with artificial sand at different replacement level (0%, 20%, 40%, 60%, 80%, 100%).They have also reported the strength and durability performance of concrete made with natural sand and artificial sand[8]. Dr.S.Elavenil and B. Vijaya, have also reported that a well processed manufactured sand can be used as partial or full replacement to river sand and this is the need of the hour as a long term solution in Indian concrete industry until other suitable alternative fine aggregate are developed [9].

In the present investigation workability, strength and durability of concrete with manufactured sand as change to natural sand in Proportions of 0%, 20%, 40%, 60% and 100% is studied. The experiments were conducted on M_{20} and M_{30} concrete grade with 450 specimens. Slump cone, compaction factor and vee-bee time tests were conducted to determine workability. Results obtained showed that as replacement of natural sand by manufactured sand is increased, there is a decrease in the workability. Compressive strength, split tensile strength and flexural strength tests were conducted to determine strength of concrete. The 60% replacement showed an increase in strength of about 20% and other changes to an order of minimum 0.93% in both the grades. The durability study is conducted by treating specimens for 30 days with 5% concentrated Hydrochloric Acid and the concrete mix with 60% replacement has given good durable properties.

II. ENVIRONMENTAL IMPACT OF SAND MINING

Large scale mining of sand and gravel several folds higher than the natural replenishments, has lead to irreparable damages to the land, water, biotic and social / human environments related to many of the world's river systems. The problem is severe in the case of the rivers in the southwest coast of India, especially in Kerala, where the rivers are small with limited river bed resources. At the equivalent time, the mining of sand is on the rise to meet its ever increasing demand in the construction sector. It is now widely realized that, in spite of the short term gain, the indiscriminate sand mining from the rivers is detrimental to these life sustaining systems, in the long run. Moreover, the effects of in stream sand mining may not be visible immediately because it requires regular monitoring and takes a decade or more to surface and propagate the effects along the river channel in measurable units. In other words, mining may go on for years without apparent effects upstream or downstream, only to have geomorphic effects manifest later during high flows. Similarly, rivers are often said to have 'long memories', meaning that the channel balancing to in stream extraction or comparable perturbations may persist long after the activity has ceased.

Sand mining disturbs the equilibrium of a river channel because it block material load moving within a dynamic system and triggers an initial morphological response to regain the balance between supply and transport.

Key Impact points on Envoirment due to Mining-

A. Changes in bed forms

The river channels are naturally modified into different bed forms depending on the changes in flow energy and sediment discharge.

B. Changes in sediment characteristics

Indiscriminate and continued mining of sand from the alluvial reaches of river systems could impose marked changes in the grain size characteristics of river beds, in the long run. As bed materials form an important abiotic component of a river ecosystem, changes in grain size characteristics may lead to changes in biodiversity of the system.

C. Changes in water quality / quantity

Indiscriminate mining for construction grade sand and gravel from the active channels and floodplains of river systems can impose serious problems in the surface and sub-surface (groundwater) water resources. High content of suspended particulates in the water column arising as a result of clandestine sand mining operations can cause severe impairments to the river ecosystems.Cases of water table lowering consequent to sand and gravel mining have been documented by several investigators.

D. Changes in biological environment

During the past 3-4 decades, river systems of the world have been altered significantly due to in discriminate sand mining. Sand mining has many deleterious direct and indirect effects on the physical, chemical and biological environments of river systems.

E. Environmental issues of Mining

The role of minerals and metals in economic development, mainly in the context of developing countries has recieved much attention.This is most important aspect while design the mine layout as it depletion of ground water, lesser availibility of water for industrial, agriculture land, fall of employment to farm workers, threat to livelihood, human rights violations and damage to roads and bridges. It also affects region's fragile ecosystem and rich biological and cultural diversity.

F. Air Quality

The main air quality issue with mining is dust particles. Large amount in concentration of dust can be health hazard, exacerbating respiratory disorders such as asthama and irritating the lungs and bronchial passages.

G. Noise & Vibration

Noise can be an issue because mines normally operate 24 hours a day and sound levels can fluctuate widely. Surface mines mainly generate noise from overburden, excavation and transport, while the major noise source from underground mines are ventilation fans, the surface facilities and product transport.

III. MATERIALS

Constituents of concrete: Cconcrete is to be suitable for a particular purpose, it is necessary to select the constituent materials and combine them in such a manner as to develop the special qualities required as economical as possible. Many variables affect the quality of the concrete produced, and both quality and economy must be considered.

A. Cement

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses.

Chemical compounds of Portland cement

The raw material used in the manufactured of Portland cement comprises four principal compounds. These compounds are usually regarded as the major constituents of cement and tabulated with their abbreviated symbols, in Table 1.

TABLE 1 TYPICAL COMPOSITION OF ORDINARY PORTLAND CEMENT

Name of compound	Oxide composition	Abbreviation
Tricalcium Silicate	$3CaO.SiO_2$	C_3S
Dicalcium Silicate	$2CaO.SiO_2$	C_2S
Tricalcium aluminate	$3CaO.Al_2O_3$	C_3A
Tetracalciumaluminoferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF

In addition to the main compounds, there exist minor compounds such as MgO, TiO_2, K_2O and Na_2O; they usually amount to not more than a few percent of the mass of the cement. Two of the minor compounds are of particular interest: the oxides of sodium and potassium, K_2O and Na_2O, known as the alkalis. They have been found to react with some aggregates, the products of the reaction causing disintegration of the concrete and have also observed to affect the rate of gain of strength of cement.

B. Fly Ash

The fly ash is taken as Per IS-1489 code recommendation from Min. 15% to Max. 35% which includes pulverized coal fly ash from Thermal Power Plant. In Rajasthan Class I & II type is available.In this study the sample from Suratgarh Power Plant is taken and by passing 45 micron sieve it was found residue percentage lies in range of 12% to 15% which is in limit (Table 2).

TABLE 2 FLY ASH PROPERTIES

Property	Value	Requirement of IS:3812 (pt-1)-2003
Chemical Test		
$SiO_2 + Al_2O_3 + Fe_2O_3$, % By Mass	93.69	70 Min.
Silicon Dioxide, % By Mass	63.8	35 Min.
Magnesium Oxide, % By Mass	0.542	6 Max
Total Sulphur, % By Mass	0.111	3 Max
Available Alkalies as Na_2O, % By Mass	0.304	1.5 Max
Total Chlorides as Cl, % By Mass	0.025	0.05 Max
Less on Ignition	2.15	5 Max
Physical Test		
Fineness (M^2/Kg)	329 M^2/Kg	Not Less Than 320
Specific Gravity	2.20	
Soundness Auto Clave Expansion (%)	0.08	0.80 Max
Particle Retained on 45 Micron IS:Sieve, % By Mass (Wet Sieving)	23.25	34 Max

C. Aggregates

Type of aggregate use for concrete can have considerable effects on the plastic and hardened state properties of concrete. By selecting various sizes and types of aggregates and different ratios of aggregate to cement ratios, a wide range of concrete can be produced economically to suit different requirements. They can form 80% of the concrete mix so their properties are crucial to the properties of concrete. Aggregates can be broadly classified in four different categories: these are heavyweight, normal weight, lightweight and ultra-lightweight aggregates. However in most concrete practices only normal weight and lightweight aggregates are used. The other types of aggregates are for specialist uses, such as nuclear radiation shielding provided by heavyweight concrete and thermal insulation using lightweight concrete.

D. Manufactured sand

The term-manufactured sand is used for aggregate materials dimensionally less than 4.75mm that are processed from crushed rock or gravel and intended for construction use. The term sand refers to relatively small particles and there are little variations of sand with regard to particle size. Manufactured sands are made by crushing aggregate to size appropriate for use as a fine aggregate (< 4.75mm). The crushing process caused the manufactured sand to have an irregular particle shape. These fine particles and irregular shape of the aggregate have adverse effects on the workability and finish of the concrete. These negative effects have given manufactured sands a poor reputation in the construction industry. However this study affirms that in some other practical areas, these fine particles can be utilized to increase the compressive strength of the concrete [10].

E. Chemical Admixtures

PC based admixture-Fosroc Auramix 300 are shown in table 3[11].

TABLE 3 TESTS RESULTS OF CHEMICAL ADMIXTURE

S.No.	Test parameters	Observed results
1	Dry material content(%w/w)	19.27
2	Specific gravity	1.10
3	pH	7.28
4	Chloride(%w/w) (As per BS 5075)	NIL

Water Reducing Admixture (WRA): Naptha Based Admixture with used for concrete in residential & Commercial Projects. The doses were increased upto 1.2% for getting desired slump at long distance Pour.As per specification of IS code, the various types of admixture are there,like water reducing, retarder and water reducing and retarding admixture. When used in large dosage, it can have a negative effect on setting times.Due to problem in slump with Naptha the PolyCarboxylate(PC) based high range water reducing admixture which was used in majority of concrete mix in research Program.

High Range Water Reducing Admixture (HRWRA) PolyCarboxylate based admixture is high range water reducing admixture. The admixture meets IS-9103 for standard specification for chemical admixture. The recommended dosage range for PC based were 0.8 to 1.2%

by weight of cement. As compared to WRA, HRWRA generated the necessary workability for concrete mix containing high percentage of fines with only minor increase in setting time.

F. Water

Water is a key ingredient in the manufactured of concrete. Water used in concrete has to meet requirements of IS: 456-2000(Table 4). One of the most common causes of poor-quality concrete is the use of too much mixing water. Consequently “the strength of concrete is governed by the ratio of the weight of water to the weight of cement in a mix, provided that it is plastic and workable, fully compacted, and acceptably cured”.

TABLE 4 WATER PROPERTIES

Property	Result	Requirement of IS:456-2000
Test		
Volume of 0.02 N NaoH Required to Neutralize 100ml Sample of Water using phenolphthalein as indicator, ml	2.6	5 Max
Volume of 0.02 N H_2 SO_4 Required to Neutralize 100ml Sample of Water using Mixed indicator, ml	8.8	25 Max
Solid Contents mg/l		
a. Organic	62.5	200 Max
b. Inorganic	813	3000 Max
c. Sulphate	8.60	400 Max
d. Chloride	332.18	2000(PCC)/500(RCC)
e. Suspended Matter	240	2000 Max
pH Value	7.39	Not Less then 6.0

Material Summary: Manufactured Sand (From Kotputli) were used in testing during the research program. The coarse aggregate was composed of two sized of Chandwaji Area.The Cementing material was ordinary Portland Cement as per IS-8112 along with Suratgarh Thermal Power Plant fly ash. High range water reducing and water reducing admixture were incorporated into the mix to reach required workability.

IV. EXPERIMENTAL PROGRAM

The materials were tested during an experimental Program that was divided in two distinct parts.The first portion of the experimental program was devoted to examine the effects of fine aggregate type, grading and 100 percentage manufactured sand on fresh and hardened concrete properties. The second part of the experimental program focused on optimization of selected mixture.

Aggregate Gradings

1 Fine Aggregate grading- As per IS-383 [12] and Morth Table, the Banas Sand of zone - II was recommended for optimization of concrete mix.The Sieves recommended for Gradation of Banas Sand are 4.75mm, 2.36mm, 1.18mm, 600 micron, 300 micron and 150 micron.

2 Manufactured Sand Grading- As per IS-383 [12] & IS-2386 [13] two samples were taken from Kotputli stone sand for gradation with the same size sieve. The main aim was to find percentage of silt and clay in finer particles and

3 Manufactured Sand Grading- Various grading curve were drawn in study of gradation as per Zone-II requirement and need to optimize the concrete mixture.

4 Combined Coarse and fine aggregate grading- The Aggregate in each test consisted of 39% caorse aggregate (20mm) and 25.7% coarse aggregate(12.5mm) and 35.3% fine aggregate.

A. Mix Proportioning

1 Control Mix

For comparision the concrete mix was based on a single univeral mix called control mix.The control mixes were expected to achieve the target workability for all types of concrete with min. slump of 100-120mm in pumpable concrete. It accomodates the wide range of aggregate (well shaped natural sand to poorly shaped crushed stone sand) and reach the appropriate compressive strength for residential & commercial concrete.The control mix was established through several trial mix.The paste contents for the trial mixes were based on the void contents of the combination of coarse, intermediate and fine aggregates.The IS-2386 [13] Part-3, 1963 is Standard to determine the voids & Bulk density. Each mix needed enough paste to fill the voids between aggregate and provide adequate lubrication of the aggregate particles.Various trial mixes were tested in order to establish a suitable control mix. Water reducing admixture was added to the trial mixtures as needed to increase the workability without increasing water content(Table 5).

TABLE 5 TRIAL MIX PROPORTION

Trial Mixture No.	W/c ratio
1.M-20(OPC+PFA)	0.55
2.M-25(OPC+PFA)	0.50
3.M-30(OPC+PFA)	0.45
4.M-35(OPC+PFA)	0.45

2 Mix With 100 Percentage Natural Sand for Study-

The control mix served as the basis for comparision of the test mix in both parts of experiemental program. The first part of Experiemental Program the mix with N.sand study was devoted to examining the how fresh and hardened concrete properties behave when sand type in natural.Including the control mixes 20 trials were tested in the study.The mix proportion based on these control mix are given in Table 6.

TABLE 6 MIX PROPORTION (M-20 TO M-35 GRADE OF CONCRETE)WITH NATURAL SAND

Mix Name	Ce me nt	Fl y As h	Coarse Aggregate		Natu ral Sand	M.Sa nd	W ate r	Admix ture PC Based
	(kg)	(k g)	20 mm (kg)	10m m (kg)	(kg)	(kg)	(k g)	(kg)
M-20 (OPC+P FA)	217	93	651	434	779	0	17 1.0	2.480
M-25 (OPC+P FA)	238	10 1	643	428	769	0	16 9.6	2.714
M-30 (OPC+P FA)	267	10 7	633	422	758	0	16 8.0	2.987
M-35 (OPC+P FA)	300	10 0	626	418	749	0	16 8.0	3.200

Note- All Materials are taken in kg for 1 cum. of concrete

3 Mix With 100 Percentage M. Sand Replaced By N. Sand For Study

The Ideal mix for a particular M. sand mix may not match the mix proportions of the universal mix design. The latter portion of the research project was devoted to the Design of the concrete mix with 100 Percentage M.Sand.[14] The mixes tested in optimization study were redesigned by holding the same w/c. By the combined aggregate Grading we came to know the proportion of Coarse & Fine Aggregates. With W/c ratio we take cement & Fly ash part & Design the trial mix with different different cement content & by that study we approches to proper design mix. In M.Sand mixes we have to use the PC based admixture due to require workability(Table 7).

TABLE 7
DESIGN MIX WITH M.SANDM-20 TO M-35 GRADE

Mix Name	Cement	Fly Ash	Coarse Aggregate		Natural Sand	M.S and	Water	Admixture PC Based
	(kg)	(kg)	20mm (kg)	10mm (kg)	(kg)	(kg)	(kg)	(Kg)
M-20 (OPC+PFA)	220	110	708	466	0	633	179.90	2.640
M-25 (OPC+PFA)	255	102	702	462	0	627	178.50	2.856
M-30 (OPC+PFA)	284	108	691	455	0	613	176.70	3.141
M-35 (OPC+PFA)	325	105	681	449	0	605	174.15	3.440

B. Concrete mixing Procedure

The aggregate is added in mix first for a short period of time before adding the cementing materials. The cementing materials were then added and mixed again untill the dry mix appeared uniform. The mixing water was then added while the mixture was rotating. The concrete was mixed for a period of 3 min. left to rest for 3 min. and then mixed again for 2 min. The mix was visually examined and if necessary, high range water reducing admixture was added toward the end of rest period. A slump test [15] was made after the last 2 min. mixing period. If the Ideal Slump has not been met, additional high range water reducing admixture was added to the concrete and the concrete was mixed again for a short period of time. Another slump test was made and the procedure was repeated untill the target slump was achieved.

C. Fresh Concrete Testing Procedure

Workability- The Slump as per trial mix when done as per IS-7320 was 100mm to 120mm in range which was satisfactory for pumping at site. The slump was achieved by adding high range water reducing admixture to the concrete mix and performing a slump test. The slump test is however not useful for extremely stiff or extremely fluid concretes.The test is valid mainly for concrete with medium plastic highly plastic consistency. The water reducing admixture demands can also be an indicator of workability. High HRWRA demand indicates a stiff mixture and low HRWRA demand indicates a more fluid mix.

D. Hardened Concrete Testing Procedure

1 Compressive Strength- The compressive strength of every mix was measured with 150mm cube.The specimen were tested after curing in chamber for 3,7 days and 28 days as per IS-456 standard code for plain & reinforced cement concrete[16].

2 Density, Absorption and Voids

The density, water absorption and voids content are determined as per IS-2386 [4] for all the mixtures in optimization study(Table 8 & 9). As per IS-2386 [4] density pot is taken for determining the compacted and uncompacted density[16]. Similarly water absorption is determined by taking saturated sample in gas for having lid wetting them with water.

TABLE 8 GRADING AND FINES CONTENT
(Determined in accordance with IS : 383 & IS : 2386)

Sieve Size	Weight Retained gm		% Retained		Cumulative % Retained		% Passing		Limits (IS-383)	
	20 MM	10 MM	20 MM	10 MM	20 MM	10 MM	20 MM	10 MM	20 MM	10 MM
40 mm	0	0	0.00	0.00	0.00	0.00	100	100	100	100
20 mm	235	0	11.75	0.00	11.75	0.00	88.25	100.00	85-100	100
12.5 mm	1515	97.50	75.75	9.75	87.50	9.75	12.50	90.25	——	85-100
10 mm	204	854.50	10.20	85.45	97.70	95.20	2.30	4.80	0-20	0-20
4.75 mm	44	45.00	2.20	4.50	99.90	99.70	0.10	0.30	0-5	0-5
Pan	2	3.00	0.10	0.30		100.00				0
Total wt.	2000.0gm	1000.0gm								
Comments:	Material O.K.,									
Equipment Used	IS Sieves, Weigh Balance,									

TABLE 9 GRADING AND FINES CONTENT
(Determined in accordance with IS : 383 & IS : 2386)
TEST DETAILS OF M. SAND

Sieve Size	Weight Retained gm	% Retained	Cumulative % Retained	% Passing	Limits (IS-383) ZONE II
10 mm	0	0.00	0.00	100.00	100
4.75 mm	40	8.00	8.00	92.00	90-100
2.36 mm	20	4.00	12.00	88.00	75-100
1.18 mm	30	6.00	18.00	82.00	55-90
0.6 mm	120	24.00	42.00	58.00	35-59
0.3 mm	165	33.00	75.00	25.00	8-30
0.15 mm	90	18.00	93.00	7.00	0-10
0.075 mm	35	7.00		0.00	
Pan	0	0.00			
Total Wt.	**500gm**		248		
			Fineness Modulus	248/100	**2.48**
Comments :	Material O.K., 2.2 - 3.2				
Equipment Used :	IS Sieves, Weigh Balance,				

Flakiness Index & Elongation Index were also determined in accordance with IS: 383 & IS : 2386 (Table10).

Table 10

				FLAKINESS GAUGE		LENGTH GAUGE	
	Sieve Size	**Weight Retained gm**	**% Retained**	**Weight Passing**	FLAKINESS INDEX((M2 / M1) * 100)	**Weight Retained**	ELONGATION INDEX((M3 / M1) * 100)
Test Details of 20 mm	14.0 mm	2000.0gm (M1)	100.0	390 (M2)	19.75	415(M3)	20.75
Test Details of 10 mm	6.3 mm	500.0 gm (M1)	0.00	90 (M2)	18	95(M3)	19

On the basis of above table it can be predicted that material is ok.

Impact Value and crushing value for coarse aggregate were found 16.83% and 15.48% respectively which was in accordance with IS : 383 & IS : 2386. Particle density (Table 11) & bulk density (Table 12) were also determined.

TABLE 11 PARTICLE DENSITY & ABSORPTION
(Determined in accordance with IS : 383 & IS : 2386)

	20 MM	**10 MM**	**M.Sand**
Particle Density (Oven Dry)	2.61	2.58	2.55
Particle Density (S.S.D.)	2.62	2.61	2.63
Particle Density (Apparent)	2.65	2.65	2.78
Water Absorption (%)	0.50	0.91	3.24
Comments:	Material is O.K.		
Equipment Used :	Gas Jar, Weigh Balance, Oven.		

TABLE 12 BULK DENSITY
(Determined in accordance with IS : 383 & IS : 2386)

	20 MM	**10 MM**	**M.Sand**
Mean Weight of Sample (A) :	14.21 kg	9.45 kg	4.64 kg
Volume of Container (B) :	0.0098 m3	0.007 m3	0.0029 m3
UNCOMPACTED BULK DENSITY (A/B) :	1450.00 kg/m3	1350.00 kg/m3	1600.00 kg/m3
	20 MM	**10 MM**	**M.Sand**
Mean Weight of Sample (C) :	15.288 kg	10.15 kg	4.8575 kg
Volume of Container (D) :	0.0098 m3	0.007 m3	0.0029 m3
COMPACTED BULK DENSITY (C/D) :	1560.00 kg/m3	1450.00 kg/m3	1675.00 kg/m3
Comments:	Material is O.K.		
Equipment Used :	Density Pot, Weigh Balance, Tamping Rod.		

Chemical analysis of coarse, fine aggregates and water were also determined (Table13,14 & 15).

TABLE 13 CHEMICAL ANALYSIS OF COARSE AGGREGATES

Characteristic	**Observations**		**Reference**
	Material 1	**Material 2**	
pH	7.00	7.00	
Chlorides (%)	0.01	0.02	IS 456:2000 Clause 8.2.5.2 Table 7
Sulphates (as SO_4) mg/ltrs	40	40	IS 456:2000 Clause 8.2.5.3 Table 4
Deleterious materials (%)	NIL	NIL	IS 383 Table 1
Alkali aggregate reactivity	--	--	IS 2386 (Part VII)
Organic impurities (%)	NIL	NIL	IS 383 Note 2 under table 1
Soundness Test % Loss in weight after 05 cycle by Na_2So_4 method		--	IS 383 Clause 3.6

TABLE 14 CHEMICAL ANALYSIS OF FINE AGGREGATES

Characteristic	Observations M. Sand	Reference
pH	7.60	
Chlorides (%)	0.02	IS 456:2000 CLAUSE 8.2.5.2 Table 7
Sulphates (as SO_4) mg/ltrs	60	IS 456:2000 CLAUSE 8.2.5.3 Table 4
Deleterious materials (%)	NIL	IS 383 Table 1
Alkali aggregate reactivity	--	IS 2386 (Part VII)
Organic impurities (%)	NIL	IS 383 Note 2 under Table 1
Soundness Test % Loss in weight after 05 cycle by Na_2So_4 method	--	IS 383 Clause 3.6

TABLE 15 CHEMICAL ANALYSIS OF WATER

Characteristic	Observations	Permissible Limit as per IS 456-2000	
		Mixing & Curing (Clause 5.4 Table 1)	Ground (Clause 8:2:2:4 & Table 4)
pH	6.90	Not less than 6	From 6 to 9
Chlorides(mg/ltrs)	332	Max. 2000 (Plain concrete) 500 (Reinforced concrete)	---
Sulphates (as SO_4) mg/ltrs	8.6	Max 400	Refer Table 4
Organic Impurities (mg/ltr)	62.5	Max 200	
Inorganic Impurities (mg/ltr)	813	Max 3000	
Suspended matter (mg/ltr)	240	Max 2000	
Alkalinity (mg/ltr)	--	--	
Total Hardness (mg/ltr)	--	--	
Dissolved solid (mg/ltr)	--	--	

TABLE 16 CEMENT TESTING (DETERMINED IN ACCORDANCE WITH IS : 4031)

Particulars of Test	Results	IS Requirements	
Normal Consistency	29.5%	--	--
Setting Time			
a) Initial	210	< 30 minutes	
b) Final	280	> 600 minutes	
Specific Gravity	3.12		
Specific Surface (Fineness), Blaine's air permeability Method	240.56	Limits Min. 225 M^2/Kg	

TABLE 17 COMBINED AGGREGATE GRADATION (AS PER MORTH TABLE 1000-1)

Sieve Size mm	20 mm				10 mm				Combined Gradation	Specification Limits	
	60.00%				40.00%				100.00 %	Lower Limit	Upper Limit
	Rt. Wt. Grams	% of Rt. Wt.	100.00%	50.00%	Rt. Wt. Grams	% of Rt. Wt.	100.00%	50.00%			
40.00	0	0.00	100.00	60.00	0	0.00	100.00	50.00	100.00	100.00	100.00
20.00	199	6.07	93.93	56.36	0	0.00	100.00	50.00	96.97	95.00	100.00
10.00	3009	97.95	2.05	1.23	438	21.36	78.64	39.32	40.35	25.00	55.00
4.75	63	99.87	0.13	0.06	1606	99.70	0.30	0.15	0.21	0.00	10.00

Manufactured Sand Concrete Mix Results

The purpose of study was to determine how sand type, grading affect fresh and hardened concrete properties.The Manufacturer sand grading and grading of M.S. with Natural Sand is taken as per IS-2386 [13] and IS-383 [12] Codal Provision.The replacement of M.S. has been done from 100%, including the control mixes. 20 concrete mixes were tested during the phase of experimental procedure.

V. RESULT OF FRESH CONCRETE

A. Workability

1 Slump: The Slump for the mixes tested are tabulated in Table 18 and the slump record with min. value of 110mm and a maximum value of 145mm in laboratory condition when trials were done. The avg. slump was 120mm slightly above the target value of 110mm. The slump was highly dependent on the amount of High Range Water Reducing Admixture (HRWRA) added in the mix. Lower slump was associated with mix containing poorly shaped natural sand along with Manufacturedr sand. The angularity of the sand decreased the slump and higher paste content may be necessary for these mixtures.Without increasing the Paste content the mix required higher dosage of high range water reducing admixture to produce slumps with in the acceptable range of 100mm to 120mm

2 HRWRA Demand: The high range water reducing admixture demand is to achieve a specified slump. In order to identify the correct doses, HRWRA was added incrementally to each mix. Mix with high dosage may have stayed in the mix for a longer period of time.Regardless of sand type or grading or crushed stone sand, the HRWRA demand increased with increasing proportions of crushed stone sand.

In this paper we have reported the Naphtha as well as PolyCarboxylate based admixture, but due to high fines in manufacturedr sand we have taken up trials with PC based due to slump problem associated in Naphtha based admixture.Similarly the concrete mix plants or batching plants need more HRWRA demand if site is far away to do the job maintaining slump in well defined limits.

TABLE 18 SLUMP STUDY ON NAPHTHA & PC BASE ADMIXTURE (M-20)

Slump in mm	1 % Nephta	0.8 % Mid PC	1 % Mid PC	1.1 % Mid PC	1.2 % Mid PC
Initial	30	90	150	150	180
30 Minute	0	30	100	120	170
60 Minute	0	0	60	110	160
90 Minute	0	0	30	100	150
120 Minute	0	0	0	80	130
150 Minute	0	0	0	70	120

B. Hardened Concrete Properties

1 Compressive Strength

The compressive strength for 7 days and 28 days are tabulated (table 19). All mixes achieved the target strength. Although with use of VSI crusher, screening and proper washing arrangement can be more fruitful to attain good M.Sand as well as higher compresive strength. The use of PC based admixture is also helpful to get desired compressive strength of sand blend concrete.In this study the sample from Kotputli source were taken for M. sand. The use of proper sieves, well graded stone with proper crushing followed by dust collector and washing technique can be helpful to get desired strength.

2 Density, Water Absorption & Voids

As per sample taken for crushed stone aggregate from different source of crusher the data for particle density and water absorption is taken in calculation sheet (table 22 & 23) and also bulk density is calculated shown in proper format. All data of density and water absorption are shown in table as Per IS-383 [12] -1970 and IS-2386[13]. The water absorption is somewhat in range of 3% to 3.5% which is at higher side. So HRWRA was used for making good workability.

In case of natural sand the normal water absorption is 1% to 2%. So different trials for comparison purpose were taken. The bulk density in case of M. Sand is almost equal or in some cases is lower than the Natural sand mix. But again particle size & shape of well graded & further use of processed in VSI crusher with proper screening may give the same result as natural sand. The result obtained in M. Sand have some-how equal with Natural Sand. Well graded particles of M.Sand along with less water absorption may give good packing density and the result will be somewhat higher than natural sand. Due to higher packing density in use of M.Sand the more impermeable layer is obtained, which is less affected by chemical effect & Chloride ingress, provide durable structure. Cost of N-sand and M-sand weas also compared and both are in approximately same range (table 24).

TABLE 19 COMPRESSIVE STRENGTH TREND COMPARISON FOR M-20

	Comp. Strength M-20		Comp. Strength M-25		Comp. Strength M-30		Comp. Strength M-35	
	M. Sand in Mpa	N. Sand in Mpa	M. Sand in Mpa	N. Sand in Mpa	M. Sand in Mpa	N. Sand in Mpa	M. Sand in Mpa	N. Sand in Mpa
3 Days	16.75	15.45	19.25	18.5	20.95	19.45	24.85	21.75
7 Days	21	21.25	24.75	25.95	27.62	28.25	31.6	31.25
28 Days	28.75	29.25	33.85	34.6	38.25	38.56	43.25	44.15

TABLE 20 FLEXURE STRENGTH TREND COMPARISON

	Ave. Flexure Strength on 28 day's in Mpa			
	M-20	M-25	M-30	M-35
N. Sand	2.24	2.88	3.45	4.15
M. Sand	2.42	2.95	3.55	4.08

TABLE 21 TENSILE STRENGTH TREND COMPARISON

	Ave. Tensile Strength on 28 day's in Mpa			
	M-20	M-25	M-30	M-35
N. Sand	1.84	2.34	3.08	3.46
M.Sand	1.95	2.44	3.15	3.54

TABLE 22 PARTICLE DENSITY TREND COMPARISON

	M. Sand	N.Sand
M-20	2349	2364
M-25	2357	2368
M-30	2362	2374
M-35	2370	2381

TABLE 23 WATER ABSORPTION TREND COMPARISON

	Water Absorption on 28 day's in Percentage			
	M-20	M-25	M-30	M-35
N. Sand	4.25	4.1	3.91	3.85
M.Sand	3.76	3.56	3.35	3.26

TABLE 24 COST COMPARISON

	Cost of Concrete	
	N.Sand	M.Sand
	(Rs Per Cu-m)	
M-20	2518	2513
M-25	2629	2686
M-30	2778	2842
M-35	2932	3053

VI. CONCLUSIONS

The above studies helps to meet the construction Industry strategic goal of environmental study such that Manufactured sand (MS) can replace natural sand in concrete mix. Using less natural sand leads to a decrease in river dredging and the disruption of river environments. As mentioned the areas used for aggregate mining can be reclaimed and developed for new purposes such as residential, commercial or recreational usage. The results of the hardened properties of the mix have shown that the concrete mix with proportion of manufactured and natural

sand achieved a almost Similar compressive strength almost at all tested age of concrete.
Manufactured sands are made by crushing aggregate to sizes appropriate for use as a fine aggregate. During the crushing case the manufactured sand have irregular shapes and more fine particles contributing to improved compressive strength, compared to natural sand control mix. Due to the irregular particle shape of the manufactured sand, in addition to the reduced amount of water cement ratio, manufactured sand is more important for high strength concrete mixes. Analysis made on the influence of manufactured sand in the cost of the concrete revealed that no significant cost variation is observed for mixes with fully replacement of the manufactured sand with natural one. Manufactured sand offers important economic advantages in regions where the availability of natural sand is scarce or in cities where transportation cost is high. The use of manufactured sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources. Manufactured sand offers a viable alternative to the natural sand if the problems associated with the workability of the concrete mix can be resolved by using super plasticizer. The addition of super plasticizer to a concrete mix with manufactured sand allows the mix to have a better workability. The Manufactured needs to use clean washed coarse aggregates generally 6 mm to 10 mm size for getting good quality of crushed sand having combination of fines with some percentage of 2 mm to 4 mm coarse particles for producing effective concrete mix. Environment friendly approach is most important aspect and is touched due to understanding of earth life balance along with pollution free society. The requirement of cement has been observed to be very reasonable for all the mixes. The same content of cement was adequate for the same grade of mix with different admixtures. The mechanical properties of M. Sand depend upon the source of raw material. Hence the selection of quarry is very important for obtaining quality fine aggregates. This study shows minimum void content in M. Sand as compare to natural sand which further gives lesser drying shrinkage & less cavitations in structure, provide high durability in all types of concrete work.

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