

Effect of using Different Types of Sand on Workability, Mechanical and Durability Performance of High Strength Concrete

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Abstract : A rising need for alteration of conventional construction materials is encountered because of exploitation of the resources. There emerging technologies and alternatives that support change in material such as fine aggregate. The conventional fine aggregate used was river sand, as the crisis for river sand has increased, the alternate fine aggregate with remarkably relative properties of being used. This study mainly focuses on the comparison of parameter of the concrete similar grade of river sand, lateritic sand M-Sand and silica sand. This paper reported that fully replacement of river sand by silica sand, lateritic sand M-Sand. The fully replacement of river sand by alternative sand gives better hardened concrete, durability performance and special property of concrete compare with conventional concrete. The artificial sand such as silica sand, lateritic sand M-Sand, the compressive strength is increased about 33.572%, 30.572% and 27.904% in M20 Grade of concrete. The durability performance is better in silica and sand lateritic sand compare with conventional concrete. M-Sand is poor durability performance.

Key words : cement, concrete, lateritic sand, M – sand, River sand, silica sand, water absorption.

Introduction

River Sand or Natural Sand is being used as fine aggregate in concrete making and is preferred as fine aggregate. It is mainly mined from the river beds and random mining of sand has caused damages to the environment. We also see that reliance on this source has led to high material costs also. Now there is insufficiency of natural sand due to this lack of good eminence natural sand and a lot dependency on this for concrete manufacturing, there has been seen usage of poor quality natural sands for construction. Thus, it becomes almost compulsory to find alternatives to natural sand and estimate these alternatives for use in concrete production. Manufactured Sand is another form of crushed stone sand. M sand is man-made by any of the methods- by crushing of coarse aggregates (20mm & 10mm) in separate sand plants or using 3 stage VSI

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crushers. Then this material is supplementary processed either by washing with water or dry sieving, if required to improve the grading and reduce fine powder content. Thus, the properties of the concrete with different fine aggregate are analysed. The compressive and tensile strength is developed by optimization of partially replacement river sand with lateritic and lime stone filler. The lateritic sand lime stone filler various percentage of using about 0% ,25%, 50% and 75% and the 28 – days compressive and tensile strength is found 21.06 - 35.2 N/mm² and 10.06 -15.5 N/mm². The strength is achieved by the proportion of 25% laterite to 75% lime stone filler produced higher values of compressive and tensile strength (Jayaraman *et al* 2014). Another one literature survey studied above the same proportion but lateritic sand instead bottom ash used. In this paper reported partially replacement of river sand by bottom ash and lime stone filler using in various percentage and various grade of concrete mix. The compressive strength and tensile strength is achieved by 25% bottom ash to 75% lime stone filler produced higher values of compressive strength and tensile strength. The 25% bottom ash to 75% lime stone filler produce more flexural strength in M25 Grade of concrete compare with conventional and M20 Grade of concrete. In addition to 25% Bottom ash-75% lime stone filler concrete is high resistance low permeability and high durability of concrete compare with other mixes. 75% Bottom ash-25% lime stone filler gives more level water absorption and more permeability in M15 grade of concrete by (Jayaraman *et al* 2016). The percentage of bottom ash level increased the strength will be decreased due to more voids in bottom ash, increase the specific gravity level, low density and light weight. The ordinary Portland cement is moderately replaced with nano-silica by 0.25%, 0.5 %, 0.75% and natural sand is fully replaced with hydro sluiced bottom ash. The studies reveal that the increase in percentage of partial replacement of nano silica increased the compressive, tensile and flexural strength of concrete. It was found that 0.55 water/cement ratio produced higher compressive strengths, tensile Strength and better workability for partially replaced with nano-silica by 0.75 % mix, proportion. Specifically compressive and tensile strength ranged from 21.06 -35.2 N/mm² and 10.06 -15.5 N/mm² for the mixes considered by (Jayaraman 2014). Another one developed demand of sand increased by M –Sand (manufacturing sand). Concrete strength is developed by fully replacement of river sand with M –Sand, the workability is poor compare with river sand concrete. Hardened properties of concrete developed by M-Sand concrete, the compressive, tensile and flexural strength decreased compare with conventional concrete. M- Sand concrete only less than 50% of strength is achieved and durability performance also decreased compare with conventional concrete due to various particle size of sand and more voids. Further developed nano silica incorporating with cement, the strength is achieved. Addition of nano-Silica leads to a consequence raise in the typical strength and durability of concrete. Alternative of cement with 0.75% of nanosilica gives additional strength than the M-sand mix and in addition the durability has been increased compared to the M-Sand Mix. The self weight of the nano mix is lighter than the M-sand and the conventional mix. The workability decreases with the addition of Nano-Silica compared to the conventional mix and the M-Sand mix. The penetration level of chlorides and acids are less in Nano concrete compared to that of conventional and M-Sand mix by (Jayaraman *et al* 2013). The concrete are prepared using varying inside of M-Sand, lime stone powder as fine aggregate and ordinary Portland cement. The Samples of concrete are prepared in three different grades, namely: M15, M20 and M25. It was found that 0.50 water/cement ratio formed superior compressive strengths, tensile strength and better workability for M25 mix, proportion. Particularly compressive, tensile strength and flexural strength ranged from 18.14–36.72 N/mm², 10.76-18.5 N/mm² and 12.21- 40.08 N/mm² for the mixes considered. These results compare constructively with those of conventional concrete. The concrete was found to be suitable for use as structural members for buildings and related structures (Jayaraman 2014) this paper reported that M – Sand is has given better compressive , tensile and flexural strength compare with conventional concrete. The above literature survey fully replacement of river sand by M – Sand, the compressive strength has been achieved less than 50 % only, but in this paper reported M- Sand has given better strength due depending upon the particle size of sand.

II. Aim of the study

To compare the properties of fresh concrete hardened concrete, durability & quality of concrete specimen using silica sand .lateritic sand, manufactured sand and river sand.

Table 1: Physical and chemical properties of cement

Physical properties of cement		
Fineness, m ² /kg	316	Minimum 300
Initial setting time(minutes)	115	Minimum 30
Final setting time(minutes)	171	Maximum 600
Standard consistency	27.3	-
Soundness, Le Chatelier, mm	1.0	Maximum 10
Chemical properties of cement		
Component	Results (%)	Requirements of IS:1489
SiO ₂	21.8	-
Al ₂ O ₃	4.8	-
Fe ₂ O ₃	3.8	-
CaO	63.3	-
SO ₃	2.04	Maximum 3
MgO	0.91	Maximum 6
Na ₂ O	0.21	-
K ₂ O	0.46	-
Cl	0.06	Maximum 0.1
P ₂ O ₅	<0.05	-
Loss of ignition	1.36	Maximum 5
Insoluble residue	17.96	-

Table 2: Physical properties of Lateritic sand

Physical properties of Lateritic sand	
Liquid limit	28.76%
Plastic limit	13.4
Plasticity index	14
Moisture content	13.22%
Sieve analysis	0.53 mm to 4.2mm

Table 3: Physical and chemical properties of silica sand

Physical and chemical properties of silica sand	
CaO	20-25 %
Al ₂ O ₃	2-3 %
Iron	1-3 %
MgO	0.4-1 %
SiO ₂	58-60 %
Specific gravity	2.42
Fineness modulus	0.028

III Experimental Investigation

3.1 Material

3.1.1 Cement: Ordinary Portland cement 53 grade conforming to IS 8112 – 1989, and specific gravity of cement is found to be 3.15. The chemical and physical properties of cement given in **Table 1**

3.1.2 Lateritic sand: Lateritic sand is partially replacement of river sand .it is collected from BAG Groups Coimbatore, India. The bulk density of lateritic sand 1789 kg/m³ and the specific gravity 2.58 and fineness modulus of river sand is 2.73. The physical properties of lateritic sand given in **Table 2** and shown in **Figure 1(c)**.

3.1.3 Silicasand: Silica sand is partially replacement of river sand. it is collected from BAG Groups Coimbatore, India. The bulk density of silica sand 1760 kg/m² and the specific gravity 2.68 and fineness modulus of rive Sand is 2.76. The physical and chemical properties of lateritic sand given in **Table 3** and shown in **Figure 1(b)**.

3.1.4 M – sand: Manufactured sand: M-Sand is replaced is fully replacement of river sand .It is collected from BAG Groups Coimbatore, India. The bulk density of manufactured Sand 1680 kg/m² and the specific gravity 2.43 and fineness modulus of rive Sand is 2.62 and shown in **Figure 1(d)**.

3.1.5 Fine aggregate: Locally available river sand having bulk density 1800 kg /m³ is used and the specific gravity 2.71 and fineness modulus of river sand is 2.85 and shown in **Figure 1(a)**.

3.1.6 Course aggregate: Considering all the above aspects, blue granite crushed stone aggregate of 12 mm as maximum size and of typical particle shape “average and cubic” are used as the course aggregate for the present investigation. The aggregates are tested as per the procedure given in BIS: 2386- The bulk density of coarse aggregate 1700 kg/m² and the specific gravity 2.82 and fineness modulus of coarse aggregate 7.1



Figure: 1 Various type of sand

IV. Experimental Procedure

The mix ratio is prepared for M20 grade concrete for various sand such as conventional sand ,lateritic sand , silica sand also M-Sand. The Cube size of (150 x 150 x 150) mm Specimen is prepared for compressive strength. The cylinder of height 30 cm and 15 cm diameter is prepared for tensile strength. The specimens are tested for 7 days, 14 days and 28 days with each proportion of various sand mix. Totally there are 36 cubes and 36 cylinders are casted. The specimen size of (70x10x10) cm is used for flexural strength test. For durability test mortar specimen is prepared in a mix ratio of 1:3, the cube size of (50 x50 x 50) mm is prepared for water absorption test, the specimen is tested 28 days totally for 12 cubs and 9 cylinders.

V. Result and Discussion

5.1. Slump test

The results of Slump test shown in **Figure 2 and Table 4**. The slump test is for measuring consistency of concrete which can be employed either in laboratory or at site of work. It does not measure all factors contributing to workability, nor is it always representative of the placeability of the concrete. The advantage of slump cone suitable for field application, suitable for concrete of high and medium workability. The slump value for concrete with river sand, lateritic sand, silica sand and M – Sand are relatively same (± 5). As per IS 456 -2000 code provided the slump value range between (50 -100)mm ,the concrete suitable for reinforced slab ,beams foundations, footings , pumped concrete ,slip form work and wall. Shown in **Table 4**. The slump values are found to be river sand, lateritic sand, silica sand and M – Sand, all the sand mix are suitable for all types of work. As per IS 456 -2000 code provided the slump value range between (50 -100)mm ,the concrete suitable for reinforced slab ,beams foundations, footings , pumped concrete ,slip form work and wall.

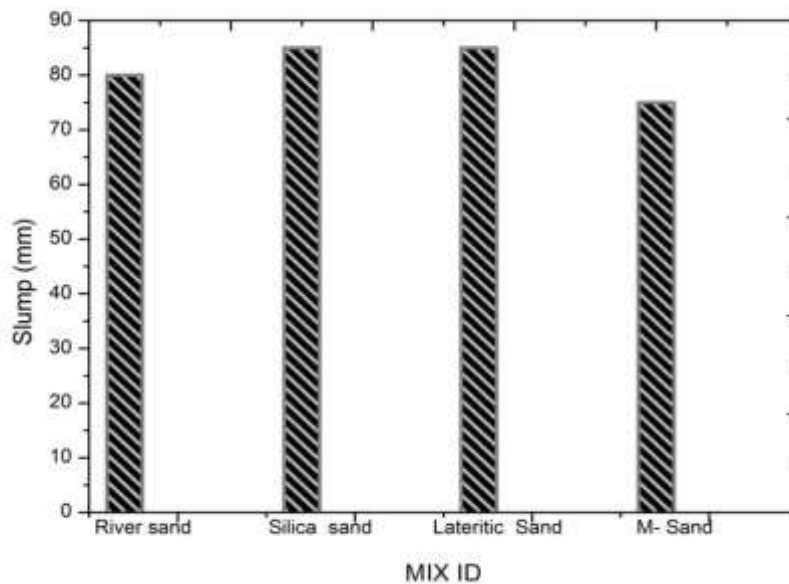


Figure: 2 Slump test in mm

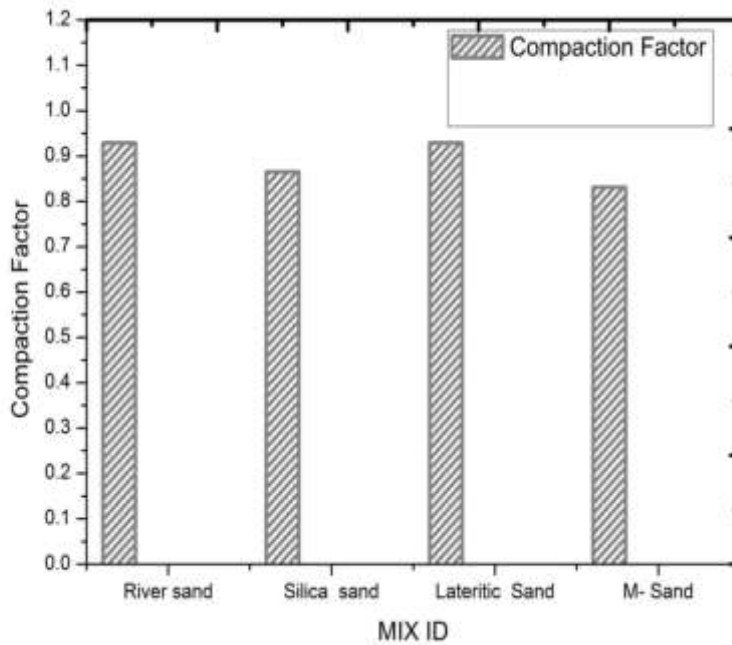


Figure: 3 Compaction factor test

Table: 4 Properties of Fresh Concrete

Workability of concrete	River Sand	Silica sand	Lateritic Sand	M- Sand
Slump	80	85	85	75
Compaction Factor	0.929	0.865	0.929	0.831
Vee Bee Time	5	9	5	3

5.2. Compacting factor test

The result of compacting factor test is show in **Table4 and Figure 3**. The test is considered mainly for use in the laboratory but it can also be used in the field. It is more specific and responsive than the slump test and is mostly useful for concrete mixes of extremely low workability as are usually used when concrete is to be compacted by vibration. The compaction factor of river sand and lateritic sand is found to be greater when compared to that of silica sand and M -Sand. Even though, the compaction factor is lower than River sand, Eco sand mix is also comfortable workable. As per IS 456 -2000 code provided the compacting factor value range between (0.85 -0.92)mm ,the concrete suitable for reinforced slab ,beams foundations, footings , pumped concrete ,slip form work and wall. The compaction factor value are found to be river sand, lateritic sand, silica sand and M – Sand, all the sand are suitable for all types of work.

5.3. Vee Bee test

The results of Vee Bee test shown in**Figure 4 and Table 4**.Vee bee is a good laboratory test to measure indirectly the workability of concrete. The latest IS 456 recommends the values of workability in terms of Vee Bee time in seconds. This method of test is used for very dry concrete whose slump value cannot be measured by slump test. The slump is measured in terms of Vee Bee seconds. It is the time required in seconds for concrete to change its shape from slump cone shape to cylindrical shape and is known as Vee Bee degree. The Vee Bee degree of mix of with river sand is lower than Vee Bee degree of mix with silica sand and higher than the M –Sand. This shows that mix with silica sand is highly workable than river sand.

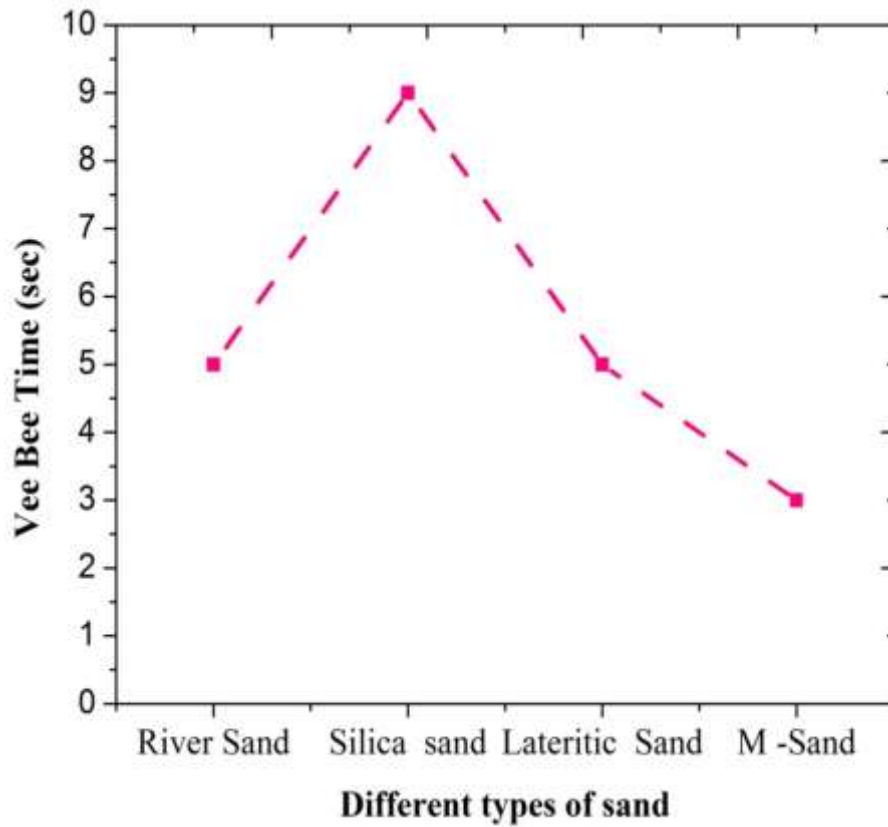


Figure: 4 Vee Bee Test in sec

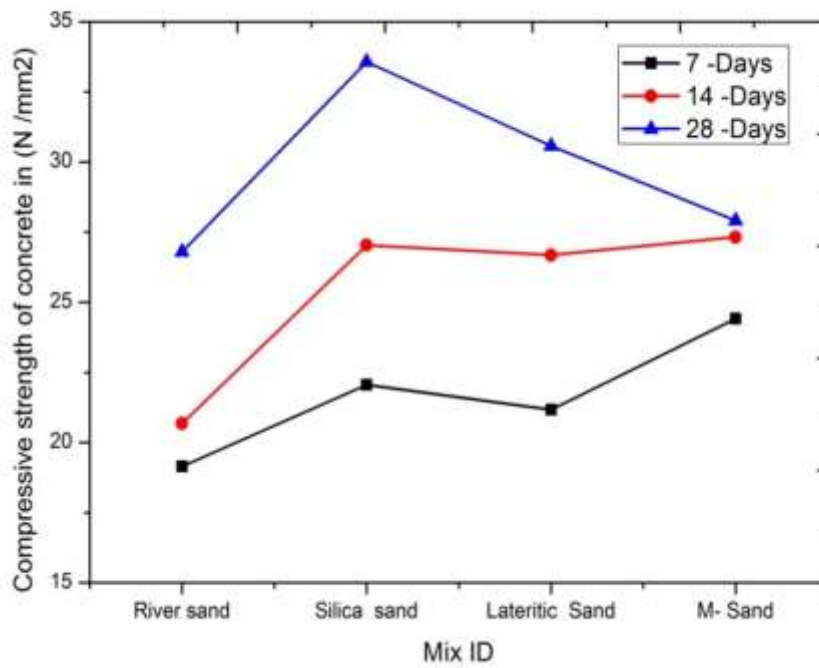


Figure:5 7, 14 and 28 Days compressive strength of concrete

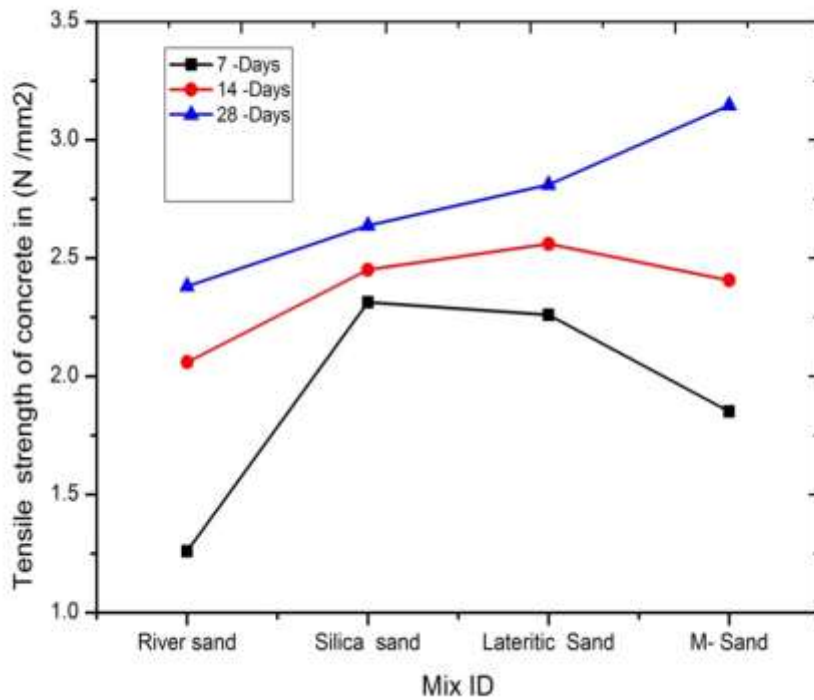


Figure: 6 7, 14 and 28 Days tensile strength of concrete

5.4. Compressive strength of concrete.

The test is carried out conforming to IS 516 -1959 to obtain compressive strength and tensile strength of concrete at the 7days, 14 days and 28 days. The cubes and cylinders are tested using 400 tonne capacity HELICO compressive testing machine (CTM).

The results of 7 days, 14 days and 28 days compressive strength test is show in **Table. 5 and Figure 5**.The 7 days compressive strength of Silica sand, Lateritic Sand and M-Sand concrete are found to be 15.18 %, 10.54 % and 27.49% of compressive strength is increased when compared to the normal river sand concrete. (Jayaraman *et al.* 2014)reported that the fully replacement of river sand with M – sand concrete the compressive strength is 20.35% decreased when compare with river sand at 28 days. The 14 days compressive strength of Silica sand, Lateritic Sand and M-Sand concrete are found to be 30.71%, 29.68 % and 32.11 % of compressive strength is increased when compared to the normal river sand concrete. Similarly 28 days compressive strength are found to be 25.26%, 14.07% and 4.119 % of compressive strength is increased when compared to the normal river sand concrete ,it may be the pores is less and density is more in M- Sand. Finally silica sand has been increased better compressive strength compare with other sand mix, it may fill the voids and density is more.

Table: 5 Compressive Strength of Concrete

Compressive strength of concrete in N /mm ²			
Mix ID	7 –Days	14 –Days	28 –Days
River Sand	19.15	20.68	26.80
Silica sand	22.06	27.032	33.572
Lateritic Sand	21.17	26.68	30.572
M- Sand	24.416	27.322	27.904

Table: 6 Tensile Strength of Concrete

Tensile strength of concrete in N /mm ²			
Mix ID	7 –Days	14 –Days	28 –Days
River Sand	1.26	2.06	2.38
Silica sand	2.313	2.45	2.637
Lateritic Sand	2.26	2.56	2.810
M- Sand	1.851	2.406	3.146

5.5. Tensile strength of concrete.

The results of 7 days, 14 days and 28 days tensile strength of test are show in **Table. 6 and Figure 6**.The 7 days tensile strength of Silica sand, Lateritic Sand and M-Sand concrete are found to be 83.57 %, 79.36 % and 46.90 % of tensile strength is increased when compared to the normal river sand concrete. (**Jayaraman et al. 2017**)reported that the partially replacement of 50 % bottom ash and 50 % lateritic sand with 0.5 % nano silica have given better tensile strength compare with other mix and conventional concrete.The 14 days compressive strength of Silica sand, Lateritic Sand and M-Sand concrete are found to be 18.93%, 24.27 % and 16.79 % of tensile strength is increased when compared to the normal river sand concrete. Similarly 28 days tensile strength are found to be 10.79%, 18.06 % and 32.18 % of tensile strength is increased when compared to the normal river sand concrete ,it may be the pores is less and density is more in M- Sand concrete.. M –Sand concrete mix have better tensile strength compare with other sand mix at 28 –days. It may the M – Sand have more ductility. The silica sand and Lateritic Sand have been gradually increased initially and finally decreased at 28 –days strength.

5.6. Flexural strength of concrete

The results of 7 days, 14 days and 28 days flexural strength of test are show in **Table.7 and Figure 7**.The enhancement 3, 7& 14 days flexural strength of Silica sandmixis increased about 83.57 %,18.93 % and 10.79 % compare with normal river sand mix. The 7, 14 and 28 days flexural strength of Lateritic Sand mix is increased about 79.36 %, 24.27 and18.06 % compare with conventional river sand mix.The 7, 14 and 28 days flexural strength of M-Sand concrete are found to be 46.90%, 16.79 % and 32.18 % of flexural strength is increased when compared to the normal river sand concrete. M –Sand concrete mix have better flexural strength compare with other sand mix at 28 –days. It may, the silica sand have more flexural properties. The M - sand and Lateritic Sand, the flexural strength have been gradually increased initially and finally decreased at 28 - days. The mix of partially replacement of M- Sand and 10 % ash with 10 % PVA has gives better flexural strength compare with other mix concrete and conventional concrete by (**Jayaraman et al. 2018**)

Table: 7 Flexural Strength of Concrete

Flexural strength of concrete in N /mm ²			
Mix ID	7 –Days	14 –Days	28 –Days
River Sand	4.04	4.81	5.62
Silica sand	5.52	7.62	9.99
Lateritic Sand	5.89	6.2	7.4
M- Sand	4.46	5.41	6.49

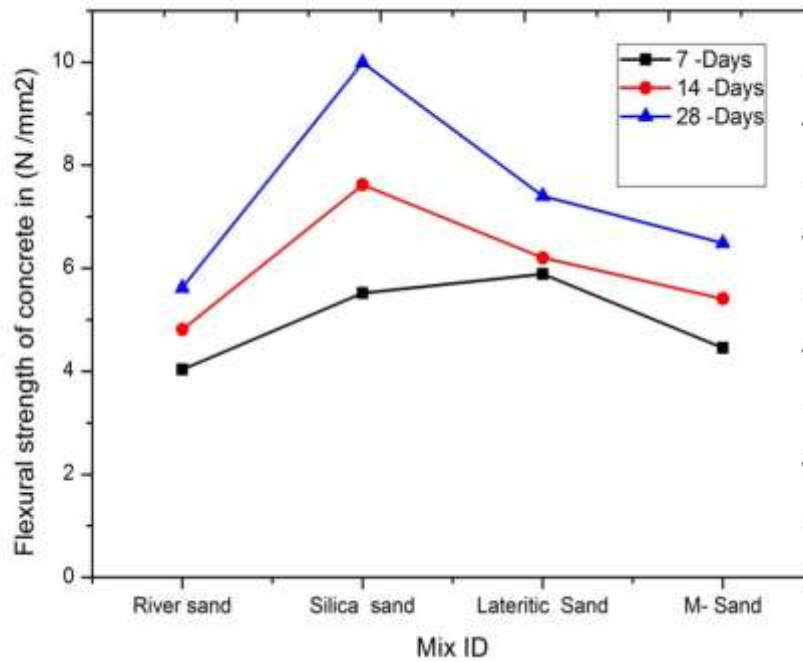


Figure: 7 7, 14 and 28 Days flexural strength of concrete

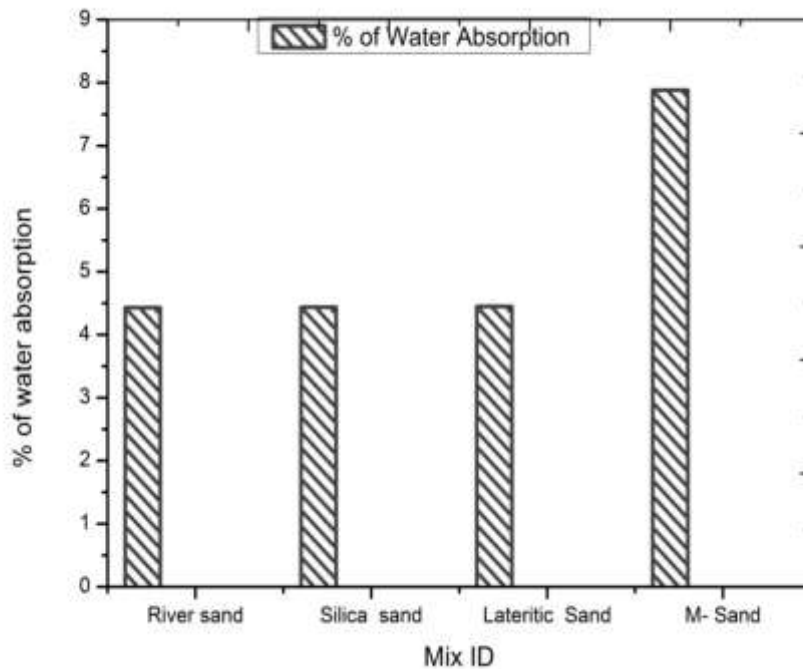


Figure.8 % of water absorption test

Table: 8 Durability of Concrete

Mix ID	% of Water Absorption	Permeability	Total Voids
River Sand	4.43	8.234	15.68
Silica sand	4.437	4.117	6.34
Lateritic Sand	4.45	7.987	14.189
M- Sand	7.88	11.012	18.104

Durability of Concrete

5.7. % of Water Absorption, Permeability and Total Voids

The results of percentage of permeability test for the various sand mix combinations are given in **Table 8** and **Figure 9**. The permeability of the Silica sand, Lateritic Sand mixtures at 28 days shows better combinations, since lowest percentage of permeability level of about 99 % and 3.09 % respectively with reference to the conventional concrete. The M –Sand shows the highest percentage of permeability level of 33.73 %, higher than the control concrete specimen. The results of water absorption tests for the different sand mix combinations are given **Table 8** and **Figure 8**. The mixtures Silica sand, Lateritic Sand shows that more or less equal compare with control concrete specimen, and M –Sand , concrete specimen level 77.876 % higher than the control specimens.

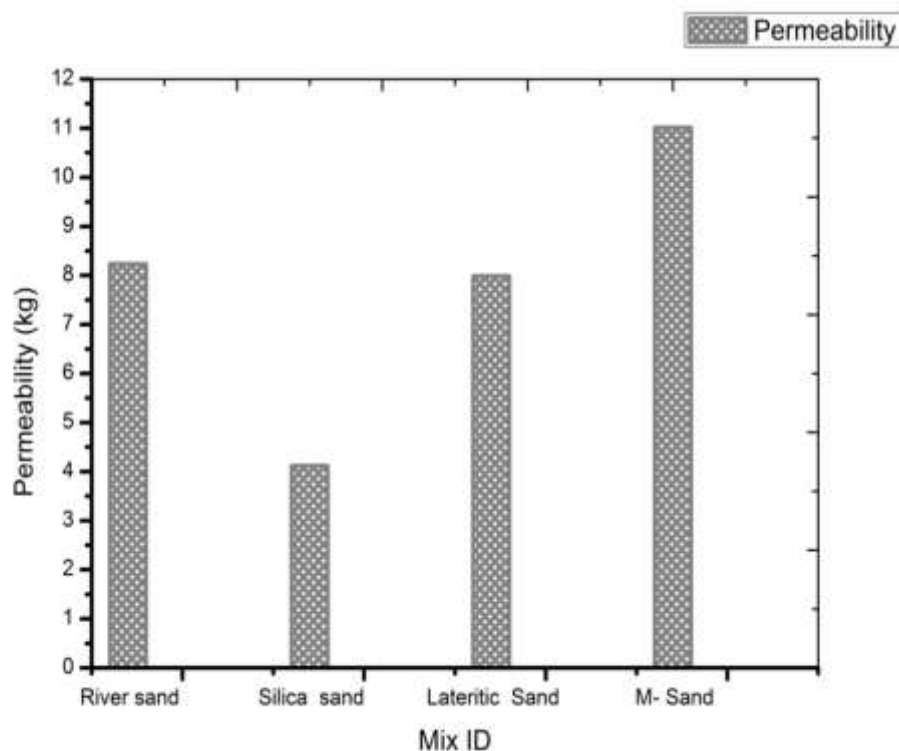


Figure .9 permeability of concrete

The results of percentage of total voids test for the various sand mix combinations are given in **Table 8** and **Figure 10**. The total voids of the Silica sand, Lateritic Sand mixtures at 28 days shows lowest percentage of total voids level of about 59.56 % and 10.50 % respectively with reference to the conventional concrete. The M –Sand shows the highest percentage of total voids level of 15.45 %, higher than the control concrete specimen.

Finally silica sand and lateritic sand is better durability performance compare with conventional concrete mix. The M – sand is not better for durability performance compare with conventional concrete mix.

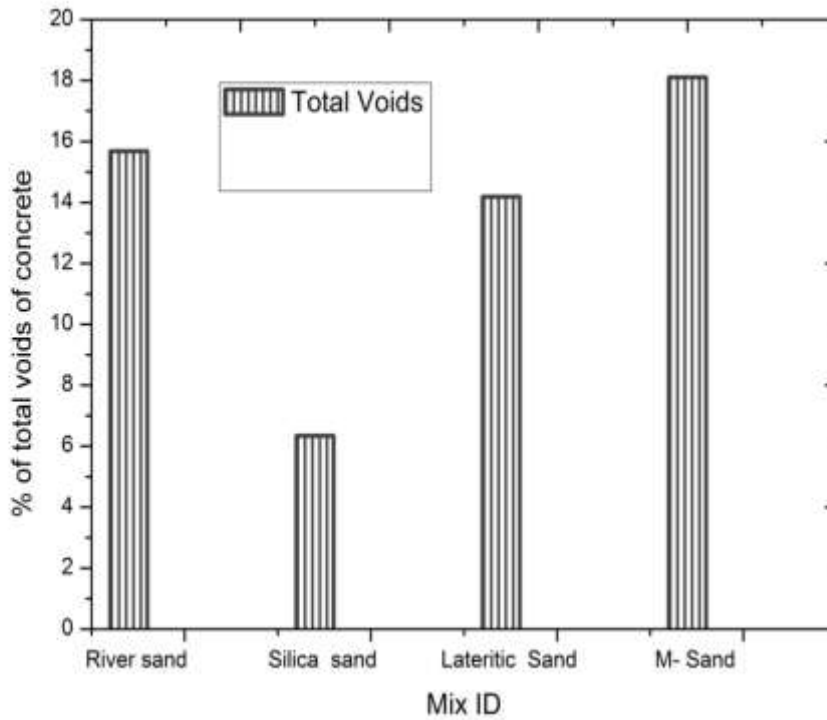


Figure .10 Total voids of concrete

Table: 9 Accelerated Curing

Mix ID	R _a	R ₂₈
River Sand	7.84	20.94
Silica sand	9.592	23.82
Lateritic Sand	8.054	21.04
M- Sand	8.72	22.391

Table: 10 Quality of Concrete – Ultrasonic plus velocity

Mix ID	Direct Method	Indirect Method	Surface Method
River Sand	4.516	5.93	10.89
Silica sand	4.261	7.641	5.357
Lateritic Sand			
M- Sand	4.504	7.075	6.849

5.8. Special property of concrete:

The results of accelerated curing special property test are show in **Table. 9 & 10 and Figure 11 & 12.**On account of special parameter accelerated curing strength and quality using ultrasonic pulse velocity method were analysed.

Curing can be described as keeping the concrete moist and warm enough so that the hydration of cement can continue. More elaborately, it can be described as the process of maintaining satisfactory moisture content and a favourable temperature in concrete during the period immediately following placement, so that

hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service. Methods of curing and accelerated curing. Accelerated curing strength is higher for sample with silica sand, lateritic sand and M –Sand has attained 11.84%, 4.77% and 6.92% higher than the compressive strength of concrete with mix using river sand.

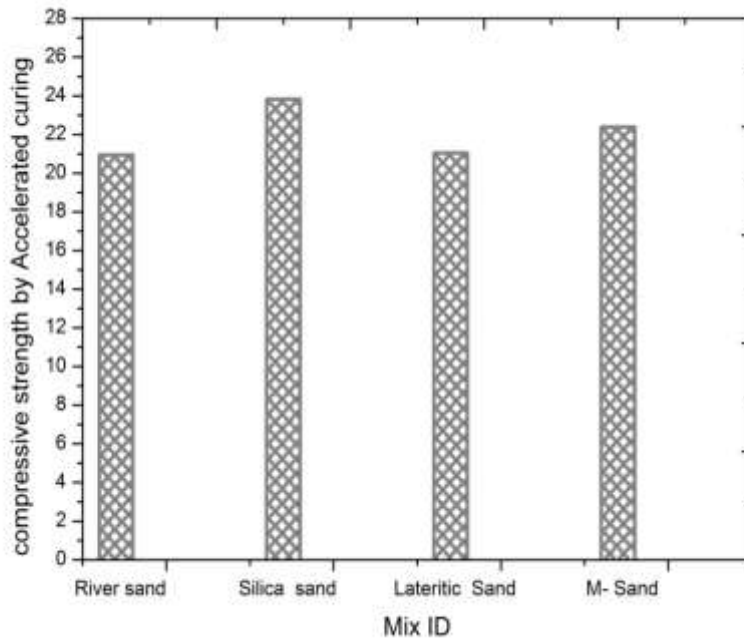


Figure: 11 compressive strength of concrete by accelerated curing

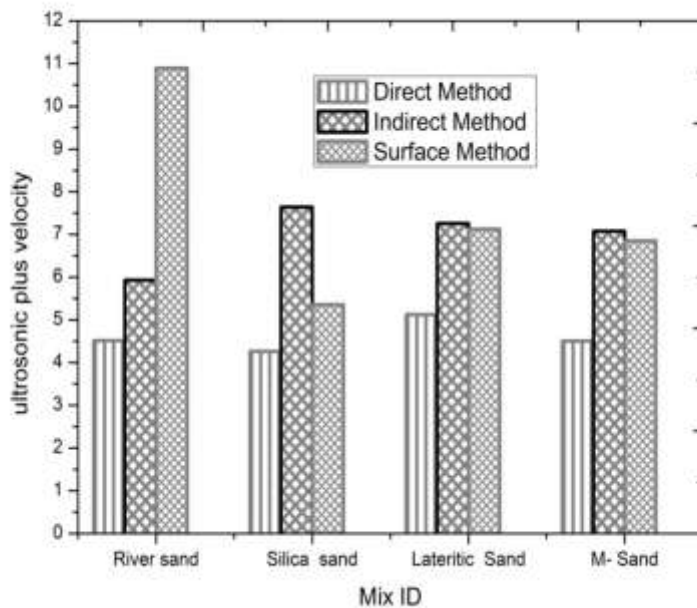


Figure: 12special properties of concrete

The ultrasonic pulse velocity method is used for non-destructive testing of plain, reinforced and pre-stressed concrete whether it is precast or cast in-situ

- The homogeneity of the concrete
- The attendance of cracks, voids and other imperfections
- Changes in the structure of the concrete caused by the revelation condition, corrosion,

Wear etc. which may occur with time,

- The excellence of the concrete in relation to the particular standard requirements.
- The excellence of one element of concrete in relation to another.
- The values of the dynamic elastic modulus of the concrete.

River sand has shown better properties. Direct and surface method on contrary to semidirect method. Thus the quality is fairly acceptable in both cases and has proven to be excellent.

VI Conclusions:

- The silica sand and lateritic sand has been increased better compressive strength, and tensile strength compare with other sand mix, it may fill the voids and density is more.
- The M - sand and Lateritic Sand, the flexural strength have been gradually increased initially and finally decreased at 28 -days.
- Accelerated curing strength is higher for sample with silica sand, lateritic sand and M –Sand has attained 11.84%, 4.77% and 6.92% higher than the compressive strength of concrete with mix using river sand.
- The durability properties of Silica sand, Lateritic sand shows that more or less equal compare with control concrete specimen, and M –Sand , concrete specimen level 77.876 % higher than the control specimens.
- On study of various parameters and properties, it found that silica sand, lateritic sand manufactured sand is challengeable alternative to river sand and hence be used in all types of constructions and is proving itself in current practices.

References

1. Jayaraman (2014), “Fully Replacement of Natural Sand With hydro Sluiced Bottom Ash in High Performance Concrete with Nanosilica”, International Journal of ChemTech Research issue, Vol.6, No.2, pp 938 – 947 April-June 2014.
2. Jayaraman (2016), “Experimental Study on Fully Replacement of River Sand by Bottom Ash and Lime Stone Filler”, International Journal of ChemTech Research, issue Vol.9, No.5, pp870 – 886 April-June 2016.
3. Jayaraman (2014), “Experimental Study on Partial Replacement of Natural Sand with M- Sand and Cement with Lime Stone Powder ”, International Journal of ChemTech Research, issue Vol.6, No.2, pp948 – 954 April-June 2014.
4. Jayaraman (2017), “Eco Friendly Building Materials Used for High strength andhigh performance Concrete”, International Journal of ChemTech Research, issue Vol.10, No.11, pp23 – 38 April-June 2017.
5. Jayaraman (2018), “Experimental Studies on Corrosion and Durability Analysis in Building Materials”, International Journal of ChemTech Research, issue Vol.11, No.7, pp202 – 213June 2018.
6. Jayaraman (2013), “Optimization of fully replacement of natural sand by m-sand In high performance concrete with nanosilica”, International Journal of Emerging Technology and Advanced Engineeringissue Vol.3, No.4, November 2013.
7. Jayaraman (2014), “compressive and tensile strength of concrete using lateritic sand and lime stone filler as fine aggregate ”, International Journal of Research in Engineering and Technology, issue Vol.3, No.1, pp 79 – 84 JAN 2014.
