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# Comprehensive Evaluation of Properties of Sands in and around Goa

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## ABSTRACT

Until recently, river sand was the only fine aggregate widely accepted in the construction industry. This material dominated the industry for a long time. This is supported by literary history. Although researchers were working on alternative materials to replace fine aggregates, it gained traction with the construction industry's resource crunch. The industry was looking for substitute materials for river sand. The current study delves into the physical properties of available sands in and around Goa. Specific gravity, particle size distribution, form, and surface roughness are all factors that influence the properties of fine aggregates. Mineralogical composition, toughness, elastic modulus, and other factors frequently influence the chemical properties of fine aggregates. The rheological and mechanical properties of concretes and mortars have a significant impact on their compressive strength and durability. Five different sand types were investigated, and their suitability was evaluated using physical and mechanical properties. The materials used in the study include coarse silica sand, fine silica sand, river sand, manufactured sand, and standard (as defined by IS650) sand. The properties are compared to those of standard sand. The construction industry necessitates such a thorough investigation. The extensive data is more applicable to the construction industry. In this study, a comparison of 7-day compressive strength will be carried out for each type of sand.

**Keywords -**Fine aggregates, Construction industry, Mechanical properties, Compressive strength.

## 1. INTRODUCTION

Although the term "concrete aggregates" comprises a wide variety of materials, the most popular ones are stone and sand, in coarse and fine grades, respectively. Fine aggregates are essentially any naturally occurring sand fragments that have been extracted from the earth. These are composed of broken stone or natural sand. Any constituent of concrete that falls within the 4.75 mm to 20 mm range for coarse aggregate is taken into consideration. any aggregate that is retained in a #4.75mm sieve and passes through a 6 mm sieve is considered grit. Any particle that goes through a 4.75 mm sieve but is retained on a #0.150 mm sieve is considered a fine aggregate.

Aggregates constitute 60–80% of the volume and 70–85% of the mass of concrete. Perhaps the most crucial element in the manufacture and control of concrete is the cost. By utilizing aggregate as a filler, concrete manufacturers can significantly reduce costs. Cement usually costs seven to eight times as much as CA and FA. Cement is only required to bind these constituents. The strength can be maintained by combining low-cost well-graded aggregates with high-quality fine aggregates.

Aggregate is also important for the strength, thermal and elastic properties, as well as the dimensional and volume stability of concrete. Shrinkage in cement is more likely when too fine FA is used or when bleeding occurs. Shrinkage can be controlled and cracking can be avoided by using properly graded aggregates in the mix.

## 2. LITERATURE REVIEW

Several research investigations on sands were undertaken by researchers, and their contributions representing specific outcomes and techniques were noticed and recorded.

Praveen Kumar K et.al (2015) [1], carried out a study in which they compared the strength and workability of cement mortar with two different sands. They examined the strength and workability of 1:6 cement mortar with natural sand and m sand as fine aggregate, along with different replacement amounts. Ordinary Portland Cement 53 grade was utilized as the cement. Zone II was constructed using locally available river sand and M sand. Physical properties of cement were tested (such as Fineness, soundness, Initial setting time, final setting time, standard consistency, and specific gravity). In addition, physical properties of fine aggregate were tested (such as specific gravity, moisture content, and Fineness modulus) Cement mortar with a W/C ratio of 0.8 to 1.2 was made. The flow test was carried out by substituting natural sand with M sand (Replacement by

20, 40, 60,80, and 100 percent ). Cubes were also cast for compressive strength for 3 days. 28 days and 7 days As a result, it was determined that the workability of cement mortar improves as the M-sand content increases to a certain degree, but the strength increases as the manufactured sand content increases. Because the workability of 100% M sand is low, admixture can be utilized.

Nethravathi & Gagan Krishna, 2016 [2], conducted experiments to see if the fine aggregate alternatives to natural sand could be utilized to make cement mortar, which is used in the construction industry. There is a need to develop a sustainable replacement for natural sand because it is a limited resource and the expanding building industry needs more concrete. Blast furnace slag, manufactured sand, quarry dust, foundry sand, and demolition waste are a few possible substitutes for natural sand. Mortar cubes of 7.07 cm were made and evaluated for compressive strength with 100 percent replacement of natural sand on the 3rd and 7th days. The results show that artificial sand is superior to all other possible alternatives. When manufactured sand is used in mortar and tested for compressive strength, it gives a 30% better compressive strength than natural sand mortar. Thus, the study shows that manufactured sand is a feasible and cost-effective substitute for natural sand and can be used.

Mathur and Mathur (2018) [3], carried out many tests on beams, cubes, and cylinders to examine the strength of M. Sand concrete and compare the results to those of natural sand concrete. Manufactured sand concrete has been shown in experiments to have roughly equivalent compressive, flexural, and tensile strengths as conventional concrete. The hardened characteristics of the mixture showed that for all examined concrete ages, the concrete mix with a proportion of manufactured and natural sand achieved a nearly identical compressive strength. Manufactured sands are made by crushing materials to sizes adequate for utilization as fine aggregate. The effect of manufactured sand on the cost of concrete was studied, and it was discovered that there is no significant cost difference for mixes in which manufactured sand is completely replaced with natural sand. The use of artificial sand in the construction industry helps to minimize environmental damage and maximize resource utilization. If concerns about the workability of the concrete mix can be resolved by using a superplasticizer, manufactured sand may be a viable alternative to natural sand. The addition of a super plasticizer to a concrete mix containing manufactured sand improves the mixture's workability. To achieve appropriate quality crushed sand with a combination of fines and a proportion of 2 mm to 4 mm coarse particles for producing an efficient concrete mix, the manufacturer must employ clean washed coarse aggregates ranging in size from 6 mm to 10 mm. The cement required has been determined to be fairly reasonable for all of the combinations. The same amount of cement was sufficient for the same grade of mix with different admixtures. The raw material source influences the mechanical properties of M. Sand. As a result, quarry selection is crucial to achieving high-quality fine aggregates. According to the results of this study, M. Sand has a smaller void content than natural sand, which results in less drying shrinkage and cavitation in the structure, as well as greater durability in all types of concrete construction.

Sachin Kumar et.al (2018) [4], conducted a study in which the strength of cement mortar, concrete cube, beam, and cylinder were compared with M sand and River Sand. A mortar cube of grade 1:4 was made, as well as a concrete cube, beam, and cylinder of grade M20. On the sample, physical and chemical tests were performed. Specific gravity, sieve analysis, compressive strength, split tensile strength, and flexural strength tests were performed. River sand particles were spherical, whereas M-sand particles were cubical. River sand was used in zones II and III, and M sand was used in zone III. The specimens were cast for 7day and 28day strength. As a result, it was determined that M sand has the same qualities as River Sand. Specific gravity, compression strength, flexure, and split tensile strength tests will produce the same or greater value than River sand. Mortar Cube has similar properties and provides similar strength and workability.

Radhakrishna and Kumar (2018) [5], investigated the flow and strength characteristics of cement mortar using varying amounts of alternative fine aggregate, Msand. In plastering mortars, natural sand was utilized as the fine aggregate (1:3 and 1:4). A flow test was used to study the flow properties of the mortar, which yielded a flow rate of 110 % for plastering mortar. M-sand was used to replace natural sand to varying degrees (20%, 40%, 60%, 80%, and 100%). Flow experiments were done on all mortars, and effect of M-sand replacement on its flow characteristics was investigated. Cubes were casted, cured and tested after 7, 14, 28, and 56 days to determine the effect of M-sand replacement on mortar compressive strength. To estimate the modulus of elasticity, mortar prisms were created and tested. According to the data, the water-cement ratio required to achieve a flow of 110 percent in plastering mortar decreases as the amount of M-sand increases. The flow increases as the fraction of M-sand increases at a constant water cement ratio. In comparison to river sand, M-sand mortar takes less water to achieve the same flow. This could be because fines have a larger role in the formation of a larger amount of paste. As expected, the compressive strength of mortar decreases as the water-cement ratio increases. When the fraction of M-sand was increased, compressive strength climbed as well. The modulus of elasticity was found to be higher when M-sand mortar was replaced 40-60% with natural sand mortar. As a result, if the water-cement ratio is adjusted appropriately, M-sand can be used as a substitute for river sand in the formation of high mortars.

## 3. MATERIALS

Materials used in this work are listed are follows

3.1 Cement

In the preparation of cement mortar, ordinary Portland Cement of 53 grade meeting the requirements of IS 12269-2013 was used [1]. Properties of cement used are shown below in Table 1

Table 1: Physical properties of cement

| Sl no | Properties | Findings | Requirement as per IS 12269-2013 |
|---|---|---|---|
| 1 | Standard consistency | 31% | |
| 2 | Specific Gravity | 3.1 | |
| 3 | Initial setting time | 155 Minutes | Not more than 30min |
| 4 | Final setting Time | 225 Minutes | Not more than 600 min |
| 5 | Fineness | 6% | 10% or less |
| 6 | Soundness | 1 mm | 10mm or less |

Figure 1. Consistency test


Figure 2. Opc 53 grade Cement

3.2 Water

The use of drinkable water, free of dissolved contaminants, is preferred in the manufacture of Mortar mix. Seawater use is strictly prohibited. The water utilized complied with the requirements of IS 456:2000.

3.3 Standard Sand

Indian standard sand IS 650 is made from local natural silica sand with less than 0.1 percent water content and a silica concentration of 99 percent. The grains in this sand are uncrushed and spherical. TAMIN of Tamil Nadu provides it in a 25 kg package. The sand is used in testing of hydraulic cement. This material is compared to every other material considered in this study.

3.4 River Sand

River sand is a naturally occurring loose, fragmentary material made up of tiny fragments of decomposed shells, coral, or boulders. Sand is a significant component of the river and is necessary for the construction sector. In the construction business, it is one of the most often used and utilized materials, and it is widely utilized and utilized in the world to add bulk, strength, and other properties to building materials like concrete and asphalt. River sand is directly retrieved using a dredging boat or a suction pump.

3.5 Manufactured Sand

Manufactured sand is a type of sand that is created by crushing rock and is used in cement and concrete.

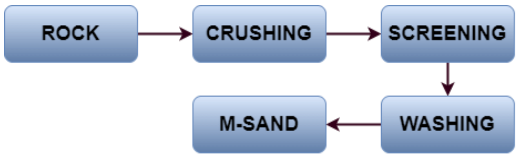


Figure 3. Manufacturing process of M Sand.

It is used in place of river sand. M sand differs from natural river sand in terms of its physical and mineralogical properties.

### 3.6 Coarse and Fine Silica Sand

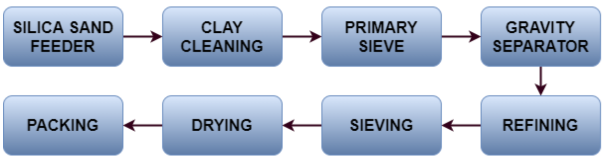


Figure 4. Manufacturing process of Silica Sand

Silica sand is made up of two basic elements: silica and oxygen. It is also known as quartz sand, white sand, and industrial sand. Silicon dioxide is the primary component of silica sand ($SiO_2$).

## 4. METHODOLOGY ADOPTED

In this experiment, we have used five types of sand available in and around Goa. The process involved in determining the workability, strength, and elastic properties of mortar. As per IS4031 the consistency and methodology to work are explained, However when we mix the sand the part doesn't work, so the other alternative proposed by the literature is considered which is flow value.

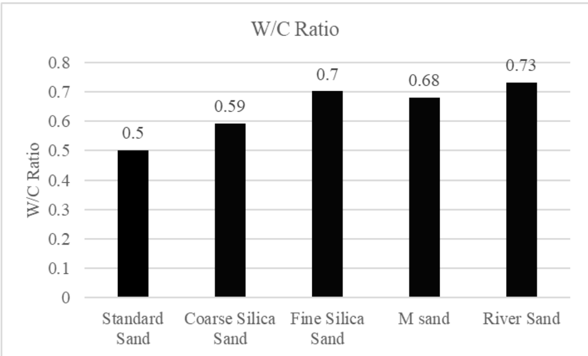


Figure 5. Water-cement ratio

First Standard sand cubes are cast with the ratio of 1:3 and water/cement ratio of 0.5, then the flow value is checked and noted and three cubes were cast for 7 days. Similarly for other sands flow test was conducted by varying the water/cement ratio until the flow value of standard sand is reached, thus the water/cement ratio was decided for the rest four sands (Fine aggregate) are shown in Fig 4.

Figure 6. Flow table testing Figure 7. Mortar mixer

Thus, keeping the flow value constant all other properties were worked out. Fifteen cubes of size 70.6 x70.6 x70.6mm were cast for each set of mortar. Cubes were cured at 27$^{o}$C and tested for 7 days.

Figure 8. Compression testing

Figure 9. Cast Mortar Cubes

## 5. RESULTS

The physical and chemical properties of fine aggregate are shown in Table 1 below

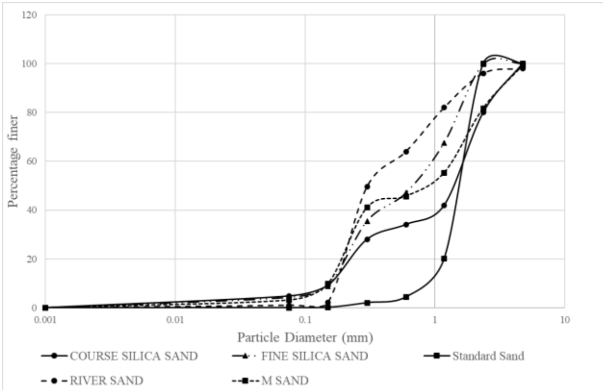


Figure 10. Particle size distribution Curve

Among all the tests, sieve analysis is considered to be the important test. The test results of various sands to standard sand are listed in Fig 3. In this case, they vary once they cross 0.1mm in their size. Standard sand has got a typical S- type curve accommodating 1 mm to 2 mm particles constituting almost 80-90 % whereas all others are not similar to the S-type of Standard sand except for river sand, however coarse content is more in river sand.

Analysis of physical and chemical properties shows, that Standard sand, Coarse Silica sand, and Fine Silica sand show similar specific gravity compared to river sand and manufactured sand. River sand shows high chloride content compared to standard sand but within limits of codal provisions, Coarse silica sand, fine silica sand, and manufactured sand. Manufactured sand and fine silica sand show high density due to the higher volume of fines. Coarse and fine silica sand shows high DLBD (Dry loose bulk density) whereas manufactured sand has the lowest DLBD among five of them.

Table 2. Properties of Fine Aggregate

| Sr no | Material used | DLBD Kg/m$^3$ | Bulk Density Kg/m$^3$ | Specific Gravity | Chloride Content (mg/l) | Silt Content (%) | `Moisture Absorption (%) | Bulking (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | Coarse Silica Sand | 1472.46 | 1698.69 | 2.77 | 32.0 4 | No Silt | 0.203 | 4 |
| 2 | Fine Silica Sand | 1475.40 | 1730.49 | 2.779 | 50.06 | 2.50 | 0.303 | 4 |
| 3 | Standard Sand | 1439.67 | 1656.39 | 2.775 | 64.07 | No Silt | 0.098 | 6 |
| 4 | River sand | 1385.57 | 1553.77 | 2.614 | 48.05 | 2.50 | 0.356 | 0 |
| 5 | M sand | 1333.77 | 1766.22 | 2.645 | 198.22 | 2.50 | 0.178 | 4 |

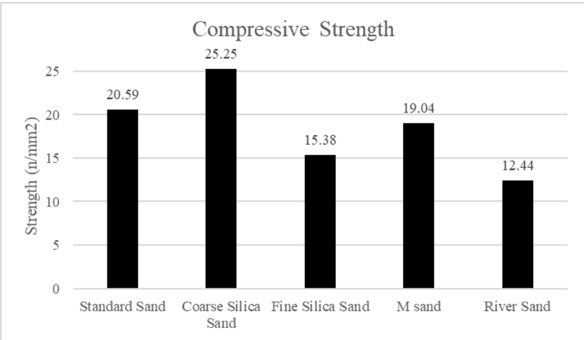


Figure 11. Seven days Compressive strength

There is no silt content in Standard sand and coarse silica sand, whereas fine silica sand, river sand, and M sand show similar silt content. Fine silica sand bulks more compared to Coarse silica, River sand, and manufactured sand, whereas no bulking was observed on standard sand. Manufactured sand has a lower volume of voids as the percentage of the fine is more.

## 7. CONCLUSION

Based on the content of the particle this conclusion has been derived.

1. For better Compressive strength Minimum Coarse content (2.36- 1.18) shall at least be 20-35% which acts as a load-bearing material and supports better bonding.
2. Fines content (300 microns to 600 microns) above 30-35 % seriously affects compressive strength, Volume stability, and Bulk density of the mixes
3. Flow value (water demand) increases with an increase in finer content
4. Void volume increases with fine content and decreases the density of concrete during initial stabilization (First 24 hrs.)
5. Increased flow values result in shrinkage of concretes/ mortars leading to the durability of concrete

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