Performance of Fine Aggregates: A Comparative Study on Sands of Goa

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ABSTRACT

Natural sand is commonly utilized in the manufacture of cement concrete and mortar. Due to a scarcity of good quality natural sand and the negative environmental effects of extracting natural sand from river beds, various research institutes are researching to identify and characterize alternative materials that can replace natural sand. However, it received attention as a result of the building industry's hue and cry on the resource crunch. Even literature history confirms this fact. The present work brings an insight into the physical properties of sands available in and around Goa. The rheological and mechanical properties of mortar and concrete have a large impact on their durability. The properties of the fine aggregates get influenced significantly by their particle size distribution, specific gravity, and surface roughness to name a few. The chemical characteristics of fine aggregates are frequently impacted by the elastic modulus, mineralogical composition, toughness, and degree of change of the aggregates. Research was done on 5 different type of sands, and their compatibility was evaluated using physical and chemical parameters. The study materials include standard (as per IS650) sand , river sand, manufactured sand, fine silica sand, and coarse silica sand. The properties of all sands are compared with that of Standard sand. The data is more important to the construction industry. The building sector necessitates such a thorough investigation.

Keyword: ***Fine aggregates, Rheology, Mineralogy, Standard sand***

1. INTRODUCTION

Aggregates have a considerable impact on the rheological and mechanical qualities of mortars and concrete. Their specific gravity, particle size distribution, shape, and surface roughness all have a significant effect on the qualities of fresh mortars and concrete.

The mineralogical composition, toughness, elastic modulus, and degree of change of aggregates, on other hand, are often found to affect the properties of mortars and concrete in the hardened stage [1]. The most common are stone and sand, both in coarse and fine grades. Fine aggregates are defined as any naturally occurring sand particles extracted from the ground. These are made of natural sand or crushed stone. Consideration is given to any component of concrete that falls within the range of 4.75 mm to 20 mm as coarse aggregate. Grit is any aggregate that passes through a 6 mm filter and is retained in a 4.75 mm sieve. It is a well-known fact that an aggregate that passes through a 4.75mm IS sieve and retains on a 150 micron IS sieve is considered a fine aggregate.

Natural sand is the recommended fine aggregate for use in the production of concrete. The environment has been harmed by the indiscriminate mining of sand, which is primarily extracted from riverbeds. Availability of natural sand is now extremely rare in most areas. Poor grade natural sands have been used in construction as a result of the scarcity of good natural sand and the strong reliance on it for the production of the concrete posed the problems of durability. Finding alternatives to natural sand and evaluating them for use in the making of concrete has thus become necessary [6].

Akshay C. Sankh et al. (2014) [2], researched the most important resource used in the construction i.e., river sand. This study discusses the strength of mortar and concrete as well as their physical and mechanical characteristics. Concrete's compressive strength, split tensile strength, and flexural strength have all been proven to be enhanced by copper slag. Quarry dust's compressive strength is increased when sand is used in place of some of it. Concrete loses workability as quarry dust content rises as a result of the quarry dust absorbing water. Additionally, it has been demonstrated that waste sheet glass powder is easily accessible. The tensile strength of concrete improves for all mixtures as compared to regular concrete of the same curing age and falls as the SGP % increases.

Kockal (2016) [3], performed an investigative experiment to determine the mechanical, physical, thermal properties of cement mortars with various tiny particles present in them. The results showed that compared to basic pumice aggregate mortar, acidic pumice aggregate mortar had increased capillary absorption and lower heat conductivity. Also, the experiment indicated that the mortar with porous slag had the highest permeability and the lowest strength. They did, however, perform better in terms of thermal properties than conventional mortars. When lightweight aggregates were utilized as fines in mortars, weight and strength were reduced. Despite the fact that the use of lightweight aggregates lowered indirect tensile and compressive strength, the strength values of the various aggregate mortars were adequate for structural and non-structural applications. The thermal properties of mortars were impacted by aggregate type, sorption behavior, component mineralogy, porosity, and particle characteristics. As a result, future research should include all of these above-mentioned factors to construct equations that can better predict thermal behavior.

Nethravathi and Gagan Krishna (2016) [4], carried out a study to see if the natural sand in cement mortar for construction could be replaced with other alternative fine aggregates. Natural sand alternatives include blast furnace slag, demolition waste, quarry dust, foundry sand, and manufactured sand. Mortar cubes of 7.07 cm were created with 100 percent natural sand replacement and evaluated for compressive strength on the third and seventh days to assess their capabilities. The data reveal that produced sand outperforms all other viable solutions. When the compressive strength of manufactured sand mortar is measured, it delivers a 30% greater compressive strength than natural sand mortar. As a consequence of the research, synthetic sand appears to be a feasible and cost-effective replacement for natural sand.

Halesh Kumar B T et. Al (2017) [5], had conducted experimental concrete experiments in which they attempted to replace natural river sand with artificial sand to see how it performed. The study had been done at a time when natural sand is becoming scarce, and prices are rising. The authors advocate producing M20 concrete specimens with manufactured sands partially substituting natural sand in the following proportions: 0%, 5%, 10%, 15%, 20%, and 25%. The concrete mix design is prepared with a W/C ratio of 0.53 and a ratio of 1:1.82:2.96. Slump cone tests are used to measure workability, whereas compressive and split tensile strength tests are used to determine strength and durability. According to the experiment findings, when the replacement ratio is kept at 15%, the ultimate compressive strength and point tensile strength are achieved. It also demonstrates that manufactured sand is a good and efficient alternative to natural sand due to its simple availability, improved performance, better gradation control, reduced impurity concentration, and the flexibility to vary the sand's shape and zoning.

Sachin Kumar et al. (2018) [6], studied that There are a few options that the business can rely on, but manufactured sand, or M-sand as it is known, is thought to be the best option to replace river sand. M-sand has attracted the interest of both environmentalists and the construction sector due to its high quality and minimal harm to the environment. Utilizing M-Sand can significantly lower costs since, like river sand, it is free of contaminants, and because there are no waste products because it is produced using cutting-edge machinery and technology. The demand for river sand and illegal sand mining would decline as M-sand gained popularity in the construction sector. In this study, he compared river sand with M sand, cast mortar, and concrete cube and compared strength for 7 and 28 days and concluded that Manufactures sand shows the same property as river sand and also shows the same compressive strength as river sand.

2. MATERIALS AND METHODOLOGY

2.1 Materials

Based on the physical qualities examined, the suitability of five different sands was examined. The study materials comprise river sand, manufactured sand, standard (as per IS650) sand, and coarse and fine silica sand.

1) **Standard Sand**

The Indian standard sand (IS 650) is made from local natural silica sand with a water content of less than 0.1 percent and a silica concentration of 99 percent. This sand's component grains are spherical and uncrushed. The sand is utilized in hydraulic cement testing. This sand is manufactured by Tamil Nadu Minerals Limited (TAMIN).

2) **Coarse and fine silica sand**

Silica sand is made up of two basic elements: silica and oxygen. Silica Sand is a granular substance. It occasionally contains minerals. It contains quartz as well as trace amounts of coal and clay. Quartz sand is another name for it. The industrial sand's most important component. Because of the effect of wind and water, quartz eventually transforms into silica sand with time. Silica sand, known as industrial sand, is a sort of high purity quality Silica Sand product. However, it is the material's size that is in control. It is not like ordinary concrete or asphalt gravel. Silica's chemical formula is $SiO2$. It is a collection of minerals composed of silicon and oxygen.

It is frequently obtained in crystalline form. Plankton fossilization occurs as a result of weathering, resulting in the crystallization of $SiO2$. These can be found as mines in almost every corner of the planet. It has a high hardness. The , silica ratio, hardness ratio and chemical structure of mines are more important in producing good silica sand crystals. In the industry, silica sand is generally used wet and dry. These are available in yellow, white, and beige.

3) **Manufactured sand**

Manufactured sand is created by crushing hard stones into small, angular particles the size of sand, which are then cleaned and finely graded for use as construction aggregate. It is a better alternative to river sand for construction.

M-Sand offers greater flexural and compressive strength. Natural sand is rounded due to weathering, whereas M Sand is angular and has a rougher surface texture, allowing for better bonding with the mortar in concrete and improving strength qualities.

4) **River Sand**

River sand is a loose, fragmentary material that occurs naturally and is composed of microscopic bits of decomposing shells, coral, or boulders. The river has a large amount of sand, which is essential for the building industry. It is one of the most often used and used materials in the construction industry, and it is widely utilized and used around the world to provide bulk, strength, and other attributes to building materials like concrete and asphalt. With the use of a suction pump or a dredging boat, river sand is immediately recovered.

2.2 Methodology

In this study, the various parameter of Standard sand is compared with coarse (Coarse silica sand and river sand) and Fine sand (Fine silica sand and Manufactured Sand). Standard methods following relevant IS Codes have been used to establish the data of the materials referred to above.

Table- 1 Physical and Chemical properties of Fine Aggregates

Sr no	Material used	Specific Gravity	% of bulking	DLBD Kg/m^3	Bulk Density Kg/m^3	Silt Content (%)	Moisture Absorption (%)	Chloride Content (mg/l)	Bulking (%)
1	Standard Sand	2.77	6	1440	1656	No Silt	0.10	32	0
2	Coarse Silica Sand	2.78	4	1472	1699	No Silt	0.20	50	4
3	Fine Silica Sand	2.78	4	1475	1730	2.50	0.30	64	6
4	M sand	2.64	4	1334	1766	2.50	0.18	48	4
5	River sand	2.61	0	1386	1554	2.50	0.36	198	4

(a) (b) (c) (d)

Fig 1, Laboratory Test Performed

3. RESULTS

3.1 Sieve Analysis

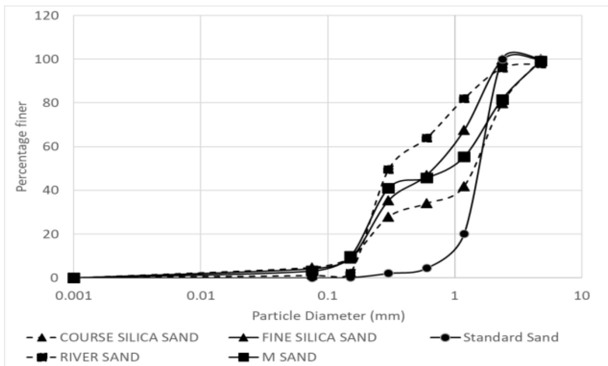


Chart -1: Particle size distribution curve

The particle size distribution curve implies that standard sand shows an S-shaped curve which implies well-graded sand. M-sand behaves differently, indicating a higher percentage of fines. Whereas other sand types follow almost similar patterns indicating uneven particle distribution.

3.2 Specific Gravity

A material's strength or quality is believed to be measured by the specific gravity of the aggregate. Chart 2 shows the specific gravity of the fine aggregate. As compared to standard sand, coarse and fine silica sand shows almost the same specific gravity, but river sand and manufactured sand show lower specific gravity. This is because river sand and M sand contain finer particles as compared to other sand types.

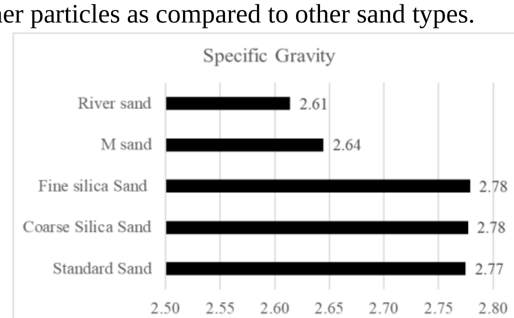
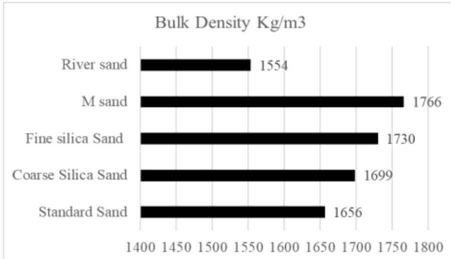


Chart -2, Specific Gravity comparison

Low specific gravity aggregates are typically weaker than high specific gravity aggregates. The generic identification of aggregates is facilitated by this property. Higher specific gravity aggregates imply more strength. Denser concrete leads to stronger concrete and mortar.

3.3 Bulk Density and Dry Loose Bulk Density



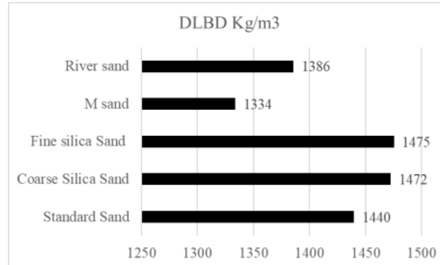


Chart- 3, Bulk density comparison **Chart- 4,** DLBD comparison

M sand in Chart 3 shows higher bulk density after vibration compared to other sand types. While the river shows the least bulk density. This is mainly because of the presence of higher voids in river sand after vibration resulting in lower bulk density. From the Chart 4, it can be observed that Fine silica sand, coarse silica sand, and standard sand show higher dry loose bulk density compared to river sand and M sand. This implies that there is no proper packing of particles between river sand and sand due to their uneven particle distribution. As a result, DLBD is reduced.

3.4 Silt Content

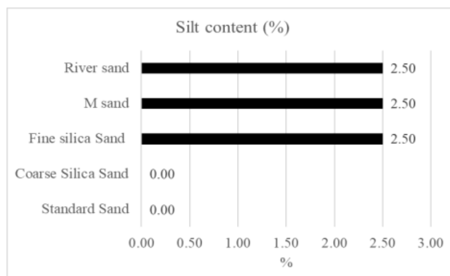


Chart-5, Silt content comparison

Silt content is higher for river sand, M sand, and fine silica sand as shown in chat 5. Whereas it is nil for coarse silica sand and standard sand.

3.5 Moisture Content

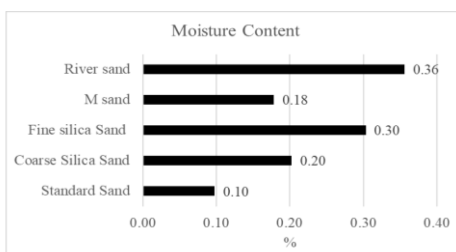


Chart- 6, Moisture content comparison

Moisture content is highest in the case of river sand whereas it is least for standard sand. M-sand also shows comparatively lesser moisture content.

3.6 Chloride Content

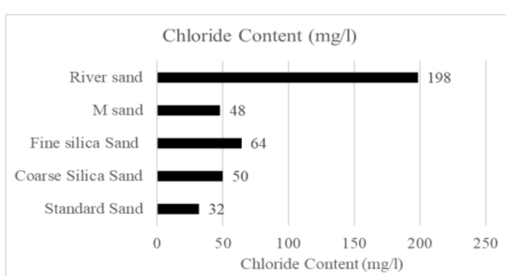


Chart 7, Chloride content comparison

River sand shows the highest amount of chloride content since the soil is directly extracted from the river. Whereas other sand types show lesser chloride content shown in chart 7

3.6 Bulking of Sand

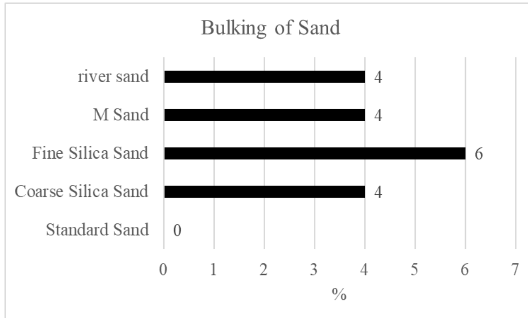


Chart 8, Bulkage of sand comparison

Fine silica sand shows higher bulking as shown in chart 8. This is because of the presence of higher finer particles resulting in the absorption of more water. Standard sand shows zero bulking. Whereas other sand types show moderate bulking.

4. CONCLUSIONS

1. Standard sand shows a typical S-shaped curve which is ideal sand.
2. Higher specific gravity ensures higher strength, but river sand and manufactured sand show lower specific gravity due to the presence of more fines.
3. Lower DLBD values interfere with the interlocking properties of the material
4. Unwashed M-sand shows higher bulk density due to the presence of more fines. The effect of vibration leads to stratification of particles leading to honeycombing and later interferes with durability issues. While the river shows the least bulk density.
5. The lower bulk density of river sands attributes to the presence of a higher volume of voids leading to durability issues.
6. Silt content in other words disturbs the volume stability of the concrete matrix
7. Moisture retention improves with higher silt content
8. Finer contents of sand directly affect bulkage

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