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Comparative Studies on Physical Properties of the Soil, Artificial and Natural Sand in Forensic Application

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ABSTRACT

Background: Sand plays a very important role in the construction of industry and many buildings, which require massive amounts of natural sand for their projects. Sand is the compound material having components of both organic and inorganic with different proportions. In most of the states of India, the natural sand mining was prohibited due to the dredging of rivers beyond a safe capacity. Due to the shortage of natural sand, most of the industries are utilising artificial sand for the construction purpose. Many of the mining companies transport natural sand for completion of their project illegally, which is prohibited for transportation and construction. This study was taken up to identify whether the transport vehicle is carrying soil, artificial sand, or natural sand.

Aim: The forensic comparison of the soil, natural sand, and artificial sand plays a very important role in confirming whether the transporting sandy soil was natural or artificial.

Objectives: The physical properties play a very important role in the identification and comparison of the soil, natural and artificial sand in forensic applications.

Materials: The present article reports the physical properties such as bulk density, particle density, specific gravity, porosity, and particle size distribution of soil, artificial sand, and natural sand. Particle size distribution of the sample was performed using 355 micron, 250 micron, and 180 micron sieve mesh respectively.

Results: The specific gravity, bulk and particle densities of the artificial sand were found to be high compared to soil and natural sand. The percentage of porosity of the natural sand was found to be high compared to soil and artificial sand.

KEYWORDS

• Sand • Soil • Density • Specific gravity • Porosity

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INTRODUCTION

The development of many structures and enterprises that require vast amounts of natural sand for their projects depends heavily on sand. Both organic and inorganic components are present in different proportions in sand, making it a complex substance[1]. Since natural sand mining dredged rivers beyond their safe limits, it was prohibited in most Indian states. Due to the scarcity of natural sand, most businesses are constructing their facilities using artificial soil. Many mining firms transport both natural and synthetic sand to complete their tasks.

A forensic comparison of natural and artificial sand is essential to ascertain if the sandy soil being carried was natural or manufactured. Soil evidence is important in crime scenes. Any contact between two surfaces causes the mutual transfer of surface content, according to the Locard exchange principle[2–3]. The drug appears to be used for a number of offences. To stop trafficking, law enforcement uses the movement of unlawful sand as evidence. Specifically, the current study compares natural and manufactured dirt based on morphological data, density, and substance found during illegal transfer for industry expansion.

To compare natural and artificial soil, it is essential to understand and be cognisant of the unique features of each type of soil, such as its composition and creation process[2]. Forensic examiners are able to compare the soils since each one has a unique character, kind, and variation across very short horizontal and vertical distances[3]. Finely crushed pebbles and a variety of mineral particles make up sandy soil, which is granular in nature. Silicate minerals and granular silicate rock particles, which vary in size from 0.06 to 2 mm, make up the majority of it. One of the most prevalent minerals in the sandy soil was quartz. Other common minerals include micas and amphiboles.

The soil also contains some heavy minerals, like zircon and tourmaline. It is distinguished by size; it is coarser than silt and finer than gravel. A textural class or type of soil, such as one that has more than 85% of its bulk in sand-sized particles, can also be referred to as soil [4–9].

Previously we reported that the morphology information of the samples reveals that the particles are found to be single-grained, aggregated, granular, non-porous, massive in nature, and having particles with different colors. In particular, the NS samples having white, red, brown, and black colour stones and plenty of colourless (quartz) stones are observed over the area. The AS samples having fewer colour stones include black and plenty of colourless (quartz) stones. Major six trace elements have been found and reported[10].

MATERIALS AND METHODS

Total one kilograms of soil, natural and artificial sand, were taken separately for the evaluation of physical properties. The particle size obtained by sieving the soil, natural and artificial sand, which includes less than 180 microns, equal to 180 microns, 250 microns, and 355 micron particles were used for evaluation of different physical properties. The bulk and particle density of the soil, natural and artificial sand, was evaluated according to the procedure IS 2386(PART III): 1963. The specific gravity of the soil, natural and artificial sand, was determined using the density bottle method in accordance with the procedure IS: 2720 (Part III/Sec 1)–1980. The Specific gravity of the samples were conducted using using density bottle method

RESULT AND DISCUSSION

Bulk and particle density:

The main aim is to differentiate the soil, natural and artificial sand, on the basis of the bulk and particle density in order to confirm the evidence or sample is soil, natural or artificial sand collected from the place of the offence. The bulk and particle density of the soil, natural and artificial sand, was evaluated according to the procedure IS 2386(PART III): 1963[11]. Determination of bulk density of soil, natural and artificial sand includes different types and sizes of particles, i.e., without sieves of particles. Determination of particle density of soil, natural and artificial sand includes similar types and the same particle size, i.e., with sieve of particles. The particle density evaluation is categorised as per the particle size obtained by sieving the soil, natural and artificial sand, which includes less than 180 microns, equal to 180 microns, 250 microns, and 355 micron particles. A Total of 100 grams of soil, natural and artificial sand, were taken

separately for the evaluation of bulk and particle density. The test results of the bulk and particle density were shown in Table 1 and represented in Figure 1.

Table 1: Bulk and particle density

Sample	Soil Kg/m3	Natural sand Kg/m3	Artificial sand Kg/m3
Bulk density (Without sieve)	1234.56	1497.42	1703.96
Particles density (250 micron)	1026.51	1428.57	1454.54
Particles density (180 micron)	957.85	1300.81	1355.92

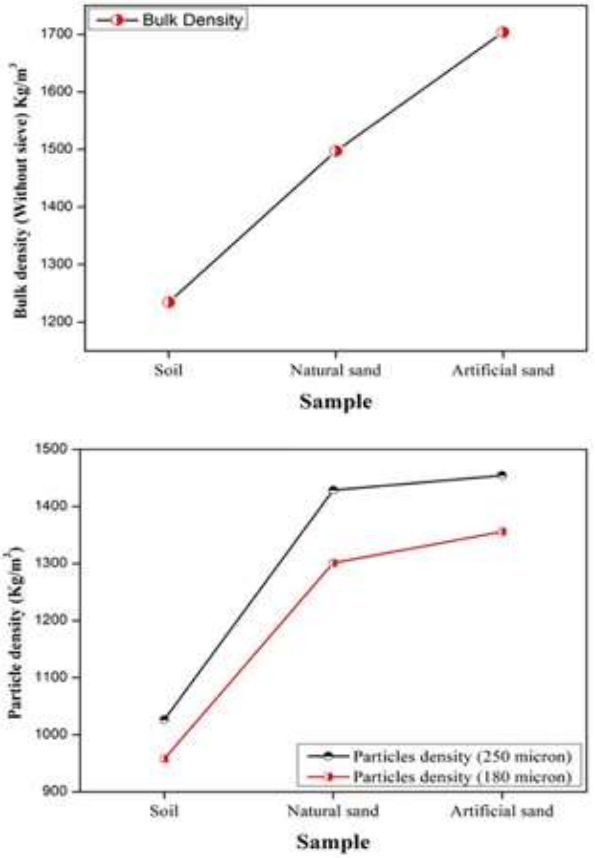


Figure 1: (a) Bulk and (b) particle density of natural sand, artificial sand and soil

Figure 1(a) represents the bulk density of the natural sand, artificial sand and soil. The bulk density of soil found to be 1234.56 Kg/ m^3 and which increases to 1497.42 and 1703.96 Kg/m^3 for natural sand and artificial sand respectively. The bulk density of the soil found to be less compared to the natural sand and artificial sand may due the presence of more clay particles in the soil sample. Highest bulk density found to be for artificial sand. Figure 1 (b) represents the particle density of natural sand, artificial sand and soil. The particle density of soil found to be 1026.51 Kg/m^3 and which increases to 1428.57 and 1454.54 Kg/m^3 for natural sand and artificial sand respectively.

Specific gravity using density bottle method:

The specific gravity of the soil, natural and artificial sand, was determined using the density bottle method in accordance with the procedure IS: 2720 (Part III/Sec 1)–1980[12]. Determination of specific gravity of soil, natural and artificial sand, includes the same particle size, i.e., with a sieve of 250 micron particles. Total 50 grams of oven dried soil at 105 to 110 oC and sieved soil, natural and artificial sand (250 microns) were taken separately along with the oven dried density bottle for the evaluation of specific gravity. The test results of the specific gravity were shown in Table 2.

Table 2: Specific gravity

Sample	Specific gravity		
	Trial-1	Trial-2	Average
Soil of 250 micron size	2.41	2.42	2.415
Natural sand of 250 micron size	2.60	2.61	2.605
Artificial sand of 250 micron size	2.80	2.82	2.81

Table 2 represents the specific gravity of the natural sand, artificial sand and soil. The specific gravity of soil found to be 2.415 Kg/m^3 and which increases to 2.605 and 2.81Kg/m^3 for natural sand and artificial sand respectively. The specific gravity of the soil found to be less compared to the natural sand and artificial sand may due the presence of organic matter or porous particles in the soil sample. Highest specific gravity found to be for artificial sand.

Porosity or void space

The porosity of the soil, natural and artificial sand, was determined using a graduated measuring cylinder on the basis of the amount of water it takes to fill the existing void space between the particles. Porosity measurement plays a very important role because it varies greatly from one kind of soil to another as the grains of soil are loosely or densely packed. Determination of porosity of soil, natural and artificial sand includes the same particle size, i.e., with a sieve of 250 micron particles[13]. A Total of 100 grams of oven dried at 105 to 110^{o}C and sieved soil and natural and artificial

sand were taken separately for the evaluation of porosity. Initially, the volume of the sample was measured in the graduated cylinder and the volume of water required to fill the void space was noted. The test results of the porosity were shown in Table 3 and represented in Figure 2.

Table 3: Percentage of porosity

Sample	Volume of sample	Amount of water added	Porosity
Natural sand	66 ml	26 ml	28.26%
Artificial sand	58 ml	17 ml	22.66%
Soil	35 ml	8 ml	18.60%

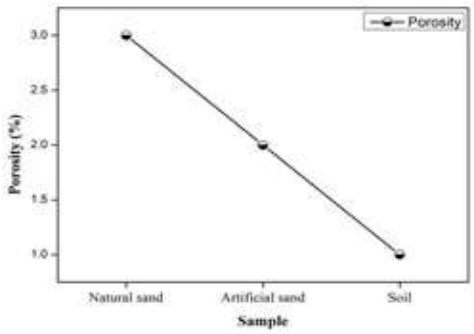


Figure 2: Porosity of natural sand, artificial sand and soil

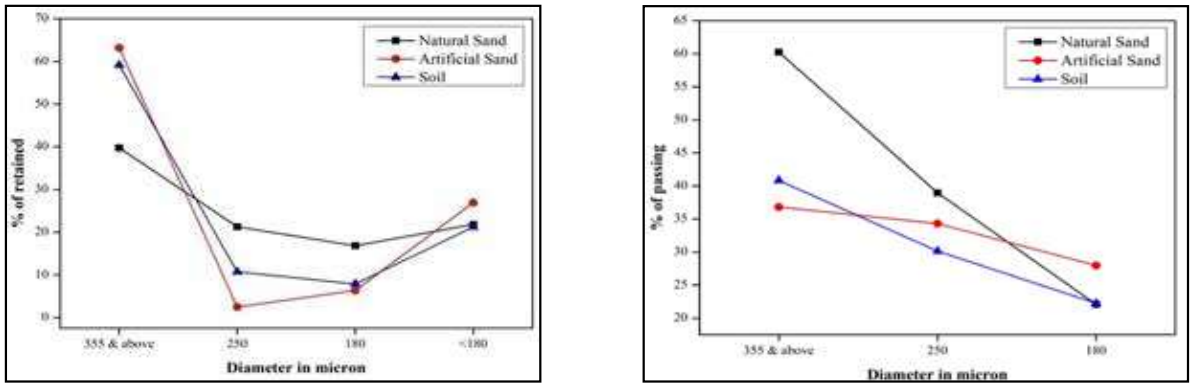
Figure 2 represents the porosity of the natural sand, artificial sand and soil. The porosity of the soil found to be 18.60% and which increases to 22.66% and 28.26% for artificial sand and natural sand respectively. The porosity of the soil found to be less compared to the natural sand and artificial sand may due the presence of more clay particles and high for artificial sand and natural sand may due to the presence of granular stones.

Particle size distribution:

Particle-size distribution is a fundamental physical property of soils and sand. Particle size distribution of the soil, natural and artificial sand, was performed for the dry sample using 355 micron, 250 micron, and 180 micron sieve mesh. Further, the percentage of retained and the percentage of passing were determined. A Total of 100 grams of dried soil, natural and artificial sand, were taken separately for the evaluation of particle size distribution. Initially, a total of 100 grams of sample were placed on top of the sieve mesh, and the whole sieve assembly was shaken. Further, the retention and passing of samples in each sieve were noted. The test results of the particle size distribution were shown in Table 4 and represented in Figure 3.

Table 4: Particle size distribution

Diameter in micron	Natural Sand		Artificial Sand		Soil	
	% of retained	% of passing	% of retained	% of passing	% of retained	% of passing
355 & above	39.77%	60.23%	63.20%	36.80%	59.16%	40.84%
250	21.29%	38.96%	2.49%	34.31%	10.69%	30.15%
180	16.85%	22.11%	6.32%	27.99%	7.88%	22.27%
<180	21.82%	–	26.92%	–	21.25%	–



(a) **(b)**

Figure 3: Particle size distribution of natural sand, artificial sand and soil **(a)** % of retained **(b)** % of passing

Figure 3 (a) & (b) represents the percentage of retained and percentage of passing of natural sand, artificial sand and soil. The higher percentage of retained was found 355 micron and above particles and for 250 micron particles with less percentage of retained. Among all the samples, the artificial sand with 250 micron particle was shown lowest percentage of retained.

CONCLUSION

The physical properties such as bulk density, particle density, specific gravity, porosity, and particle size distribution were successfully conducted. The bulk and particle densities of the samples show that, in comparison to soil and natural sand, manufactured sand has higher bulk and particle densities. The bulk density of the artificial sand was found to be 1703.96 Kg/m^3. The samples specific gravities show that artificial sand has a greater specific gravity than both soil and natural sand. The specific gravity of the artificial sand was found to be 2.81. When compared to both natural and artificial sand, the proportion of porosity or voids in the soil sample is lowered. The highest percentage of porosity or void space is found at 28.26% for natural sand compared to artificial sand. Particle-size distribution reveals that the percentage of passing is high for soil samples compared to sand samples. Hence, it is concluded that manufactured sand, artificial sand, and soil samples can be differentiated on the basis of physical properties.

CASE STUDY

Type of case: Illegal transport of natural sand.

CASE HISTORY

On suspicious movement of the truck, the police personnel seized the truck and found it transporting sand. The police suspected that the truck was transporting natural sand, which is prohibited due to the dredging of rivers beyond a safe capacity. The accused states that the truck is transporting artificial sand for the construction, which is not prohibited. The crime scene team visited and suspected that the transporting truck appears to be carrying natural sand and suggested for forensic examination. Two specimens of sand from various locations inside the truck were received from the investigating officer for examination. The investigating officer's query is to examine and determine if the seized exhibits are natural or artificial sand.

For analysis, the two control samples of natural and artificial sands were collected from different locations for comparison. The physical properties, microscopic, elemental profiling, and density distribution of the two control samples of natural and artificial sands, along with questioned sand samples sized from a truck, were examined and recorded.

On comparing the physical properties, microscopic, elemental profiling, and density distribution of the control and questioned sand samples, it is found that the questioned sand seized from the truck is natural sand.

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