International Journal of Structural and Civil Engineering Research

ISSN 2319 – 6009 www.ijscer.com
Vol. 2, No. 2, May 2013

Research Paper

EFFECT OF FINES ON THE MECHANICAL BEHAVIOR OF SAND

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The properties of clean sands pertaining to shear strength and stiffness have been studied extensively. However, natural sands generally contain significant amounts of silt and/or clay. The mechanical response of such soils is different from that of clean sands. The study addresses the effects of fines on the small-strain stiffness, void ratio, optimum moisture content, maximum dry density, specific gravity and shear strength of sands. The behavior of sand is affected by the content of fine particles. How and to what degree the fines content affects the small-strain stiffness, void ratio, the optimum moisture content, maximum dry density, specific gravity and shear strength of sands was experimentally studied in detail.

Keywords: Sand, fines, Shear Strength, Void ratio, OMC and MDD

INTRODUCTION

Along the Indo-Gangetic planes, the Indian subcontinent has vast deposits of silty sands along the bank of perennial Himalayan Rivers, where the river sands as are obtained with varied proportions of non-plastic silts. It has diverse experiences with the soil exploration of these deposits for structural foundations. As per soil classification systems, the sand and silt are coarse and fine grained granular materials. Soils can behave quite differently depending on their geotechnical characteristics. In coarse grained soils, where the grains are larger than 0.075 mm (or 75 μm), the engineering behavior is influenced mainly by the relative proportions of the different sizes present, the shapes of the soil grains, and the density of packing. These soils are also called granular soils. In fine grained soils, where the grains are smaller than 0.075 mm, the mineralogy of the soil grains, water content, etc. have greater influence than the grain sizes, on the engineering behavior. The borderline between coarse and fine grained soils is 0.075 mm, which is the smallest grain size one can distinguish with naked eye.

It is obtained in abundance as geological deposits in the earth crust. They occur with

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varied surface textures and shapes ranging from angular to spherical with moisture in void space. In modern times, some of the granular industrial byproducts deposited as structural fill with common range of specific gravity, unit weight and grain characteristics are often classified for sizes as sand and silts. Most of the investigations concerning the stress-strain and shear strength behavior of granular soils basically inspected the response of clean sands.

However, field observations show that granular soils may contain finer geomaterials having different shape and size properties. Therefore, the fines should be expected to affect the engineering behavior of sandy soils. Over past 50 years there were intensive attempts to characterize sandy soil without fines. However there were efforts to map the engineering behavior of silty sands. It is observed that silty sands are deposited largely in a low to medium density states with mixed proportions of moisture. This material supports structural rafts and deep foundations for multistoried buildings, underground excavations, tunnels and pipelines. There is a need to characterize this granular media as an engineering material. The role of non-plastic silt on the behavior of loose sand is a matter of interest for the engineers. Natural sands contain a significant and varying amount of fines, whereas the current knowledge is primarily based on clean sands. Silty sands are one of the most common soils which are encountered during construction of footings. This study was undertaken to investigate the influence of fines content on the minimum and maximum void ratios, shear strength and maximum dry density of clean sand.

This paper presents the results of the study on the effects of fines on small-strain stiffness, void ratio, optimum moisture content, maximum dry density, specific gravity and shear strength of sands.

The behavior of sand is affected by the content of fine particles. How and to what degree the fines content affects the small-strain stiffness, void ratio, the optimum moisture content, maximum -dry density, specific gravity and shear strength of sands was experimentally studied in detail. For this purpose 10 to 40% of fines were used. The main objective of the study was:

(i) To find the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of sand mixed with different percentage of fines.

(ii) To find the optimum percentage of fines mixed with sand to achieve maximum strength.

(iii) To calculate the specific gravity (G) of sand fine mix at different percentages of fines.

(iv) To calculate the void ratio (e) of sand fine mix at different percentages of fines indirectly.

(v) To calculate shear strength parameter (c, φ) of sand fine mix at different percentages of fines.

(vi) And to find out the optimum percentage of fines for strength parameter of sand.

MATERIALS AND METHODS

The sand was collected from the local market and the fines were extracted in the laboratory by wet analysis. The soil for extracting fines was taken from the backyard of geotechnical laboratory IIT (BHU) Varanasi, India. This was an experimental work andconventional geotechnical laboratory equipments were used like triaxial machine and proctor apparatus.

RESULTS AND DISCUSSION

Specific Gravity of Sand-Fines Mix at Different Percentage (10, 20, 30 and 40%) and Variation of Void Ratio

The specific gravity of sand-fine mix are found by using pycnometer method by following IS: 2720 (part 3) 1980. The variations of specific gravity of sand-fine mix found for different percentage of fines (10, 20, 30 and 40%) are shown in Figure 1.

Void-ratio (e) of the sand-fine mix is calculated indirectly with help of specific gravity and dry density of the sand-fine mix. The variation of Void-ratio with different percentage of fine content is shown in the Figure 2.

This investigation shows that void ratio of the sand decreases as the fine content are increases till 30% further increase in fine content increases the void ratio. So the optimum value of fine content is 30% for the void ratio.

OMC and MDD of Sand-Fines Mix at Different Percentages

This investigation shows that OMC of the sand decreases as the fine content are increases till 30%, further increase in fine content increases the OMC. And MDD of the sand increases as the fine content are increases till 30%, further increment in fines reduces the MDD of sand. So the optimum value of fine content is 30% for the MDD and OMC. In the above context, Figure 3 shows the graphical representation.

Figure 1: Variation of Specific Gravity with Fines

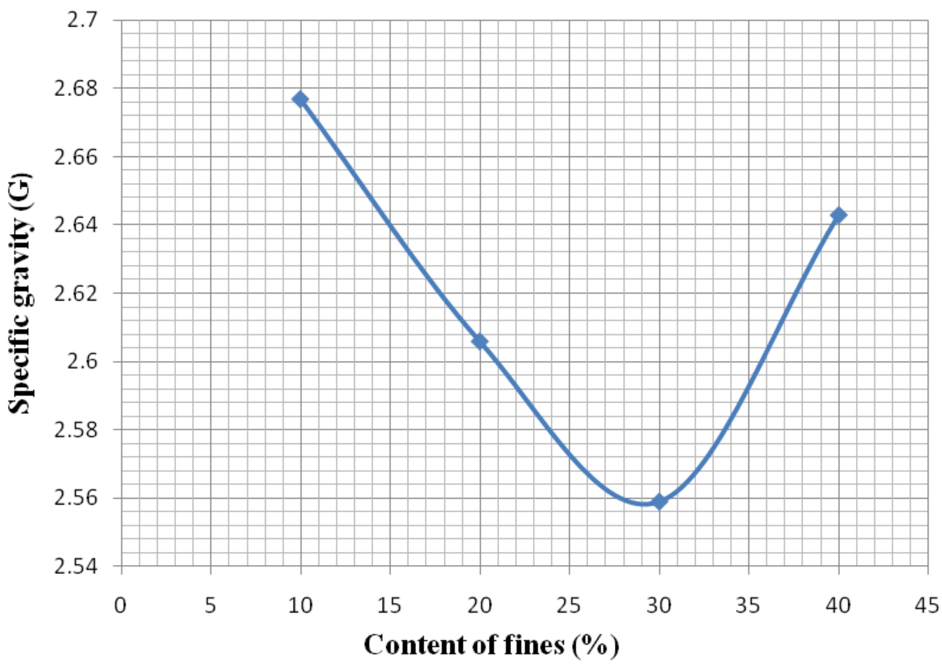


Figure 2: Variation of Void-Ratio with Fines

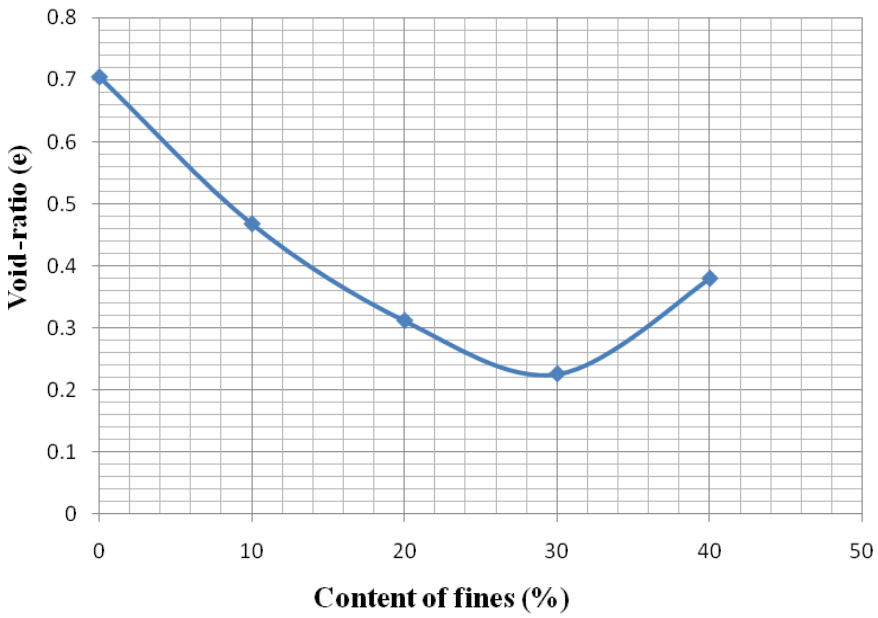
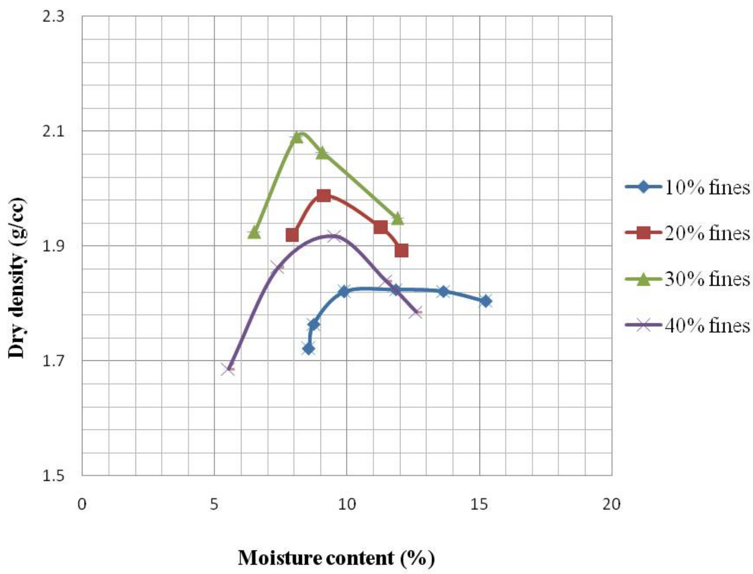


Figure 3: Moisture Density Relationships of Sand with 10, 20, 30 and 40% Fines



Triaxial Test on Sand-Fines Mix at Different Percentages

Figure 4 shows the variation of deviator stress with strain for different percentages of fines (10, 20, 30 and 40%) for 0.5 kg/cm^2 cell pressure.

Figure 4: Stress-Strain Curve of Sand with 10, 20, 30 and 40% Fines (cell pressure = 0.5 kg/cm²)

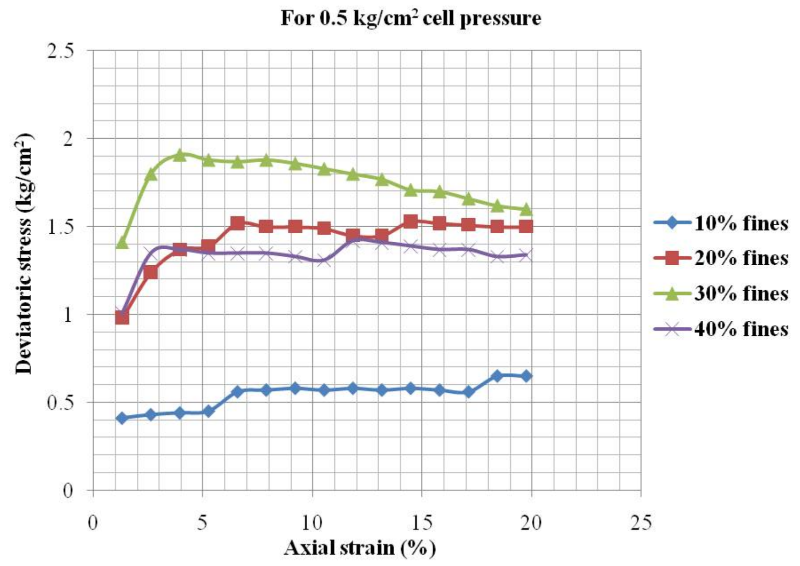


Figure 5 show the variation of deviator stress with strain for different percentages of fines (10, 20, 30 and 40%) for 1.0 kg/cm^2 cell pressure.

Figure 5: Stress-Strain Curve of Sand with 10, 20, 30 and 40% Fines for (cell pressure = 1.0 kg/cm²)

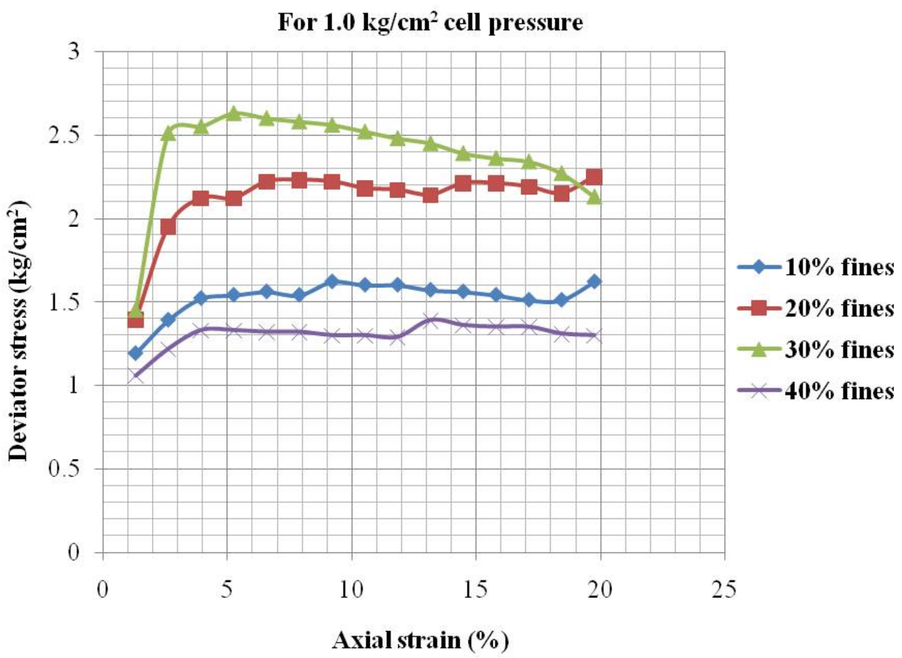
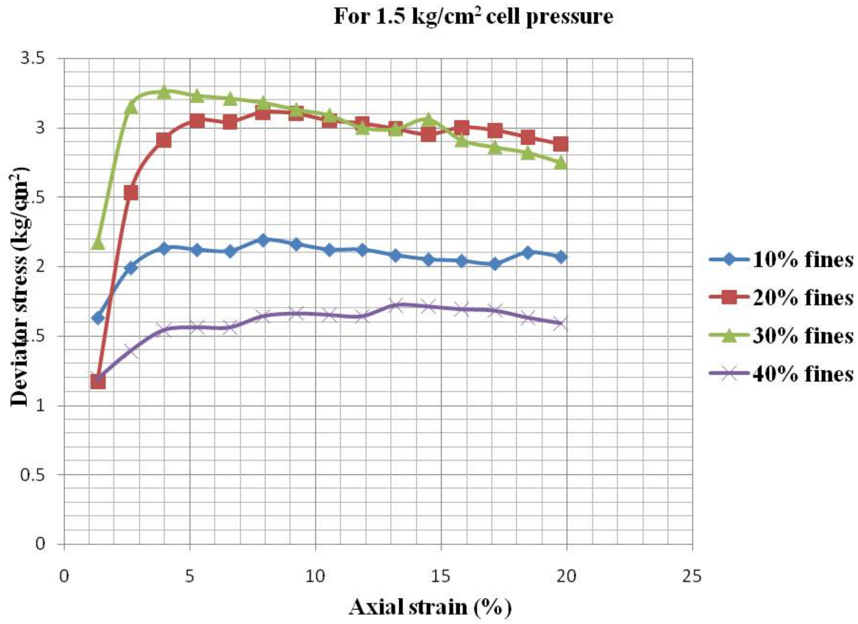


Figure 6 shows the variation of deviator stress with strain for different percentages of fines (10, 20, 30 and 40%) for 1.5 kg/cm^2 cell pressure.

Figure 6: Stress and Axial Strain Curve of Sand with 10, 20, 30 and 40% Fines (cell pressure = 1.5 kg/cm^2)



The values of angle of internal friction and cohesion of sand with different percentage of fines are shown graphically in bar chart in Figures 7 and 8.

Figure 7: Relationship Between Angle of Friction (ϕ) v/s % of Fines

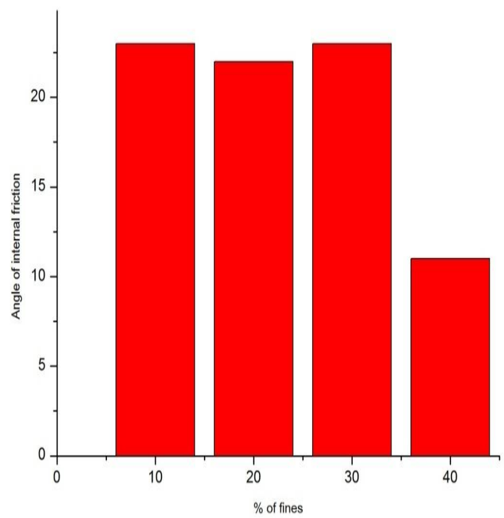
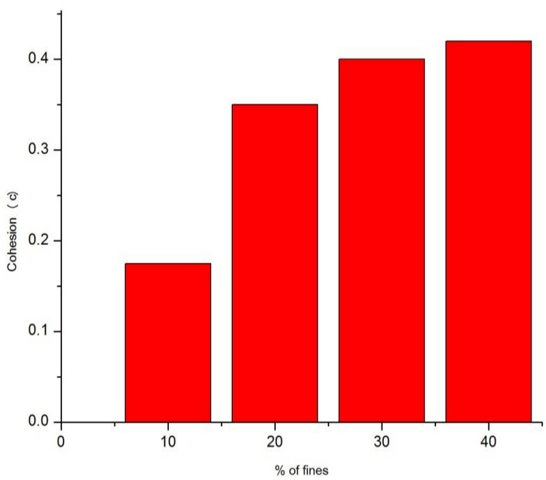


Figure 8: Relationship Between Cohesion (c) v/s % of Fines



CONCLUSION

A study was undertaken to investigate the influence of fines on sand. Tests were performed to evaluate dry densities and OMC relationship, shear strength parameters, specific gravity and void ratio. The results of the test conducted have been presented and discuss-ed above. The following conclusions are drawn based on the test results:

1. Maximum Dry Density (MDD) of sand increases with up to 30% of fines. Further increment of fines leads to a decrease of the MDD.
2. Optimum Moisture Content (OMC) of sand decreases up to 30% of fines. Further increment of fines leads to an increase of OMC.
3. The angle of internal friction (ϕ) increases with up to 30% of fines. Further increment of fines leads to a reduction in ϕ.
4. The cohesion (c) value of sand increases continuously; but after 30% of fines, the rate of increase of c reduces rapidly.
5. Specific gravity (G) of sand decreases with up to 30% of fines. Further increment of fines leads to increase G of sand.
6. Void ratio (e) of sand decreases with up to 30% of fines. Further increment of fines leads to increases the e of sand.
7. To set the highest shear strength parameters of sand, the fines was 30% , in our case.

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