EFFECT OF FINE CONTENT ON SHEAR STRENGTH OF SAND

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ABSTRACT
The cumulative damage caused by landslides is far more widespread and poses greater total financial loss than any other geological calamity. Intrinsic soil properties such as apparent cohesion, pore - pressure and soil friction angle all of which are known to be highly influential on slope stability. The main objective of this study is to investigate the effect of fine content on shear strength of sand mainly on angle of internal friction. In order to achieve this objective, a number of experimental tests were performed and variation of angle of internal friction was observed with percent fine content and density. The sand samples were collected from different location of Bangladesh namely, Gabtoli (Gojaria sand), Sylhet (Sylhet sand) and Turag (Turag sand) which were used for the test purpose. Fines was derived by sieving non-plastic soil through No. 200 sieve. Tests were done by varying the percentage of fines in soil sample. The experimental result reveals that in general angle of internal friction decrease with the increase of fine content. Density also changes significantly with the change of % fine content.

Keywords: friction angle; shear strength; fine content; density; non-plastic soil

INTRODUCTION
Angle of internal friction, φ is one of the important parameters considered for reconnaissance of granular soils. Soil friction angle, unlike pore pressure and apparent cohesion, is not temporally variable and is a derivative of the measurement of soil shear strength. Again the fines contents in coarse soils are carefully considered because they determine the composition and type of soil and affect certain soil properties such as permeability, particle friction and cohesion. Fines have also been found to affect the liquefaction potential, compressional characteristics and stress-strain behavior of soil (Georgiannou, et al., 1990).
According to Wang et al. (2009), fines content could affect the dynamic response of soils significantly. The fines content in soil also plays an important role in phase problems including minimum and maximum void ratios and porosity (Lade et al. 1998). Ayodele (Ayodele, 2008) studied the effect of fines content on the performance of soil as sub-base material for road construction and found out that the engineering properties of the studied soil samples generally reduced with increase in fines content. Bayolu et al. (1995), made an experimental study. In this study, effects of the fine particles (diameter <0.074 mm.) on the shear strength and compressibility properties of the soil mixtures were investigated. Soil mixtures having wide range of grain size from sand to silt-clay mixtures were studied. Drained shear box and consolidated undrained triaxial tests were performed on normally consolidated clay-sand mixtures to obtain strength and compressibility parameters. According to the results of drained direct shear tests containing 5 %, 15 %, 35 %, 50 %, 75 %, and 100 % fines, the internal friction angles varied between 30-38 degrees until 50 % fines and a slight decrease existed in the friction angle with increasing fine content. At fine contents higher than 50%, the reduction in the friction angle was significant and decreased to about 10 degrees. Pitman et al. (1994) have carried out a study to investigate the influence of fines and gradation on the behaviour of loosely prepared sand samples. Vu To-Anh Phan et al. (2016), found the effect of fine content on engineering properties of sand-fines mixtures. From his experiments he found that as fines content increased, the internal friction angle decreased.
The specific relationship between fines content and angle of internal friction of soil is not clear. So, there is a need to advance the effect of fines on angle of internal friction of soil (φ). The present research

aims to investigate the variation of angle of internal friction of Gojaria, Sylhet, Turag sand-collected from three selected location of Bangladesh- with the fines content and density.

METHODOLOGY

A detailed laboratory experiment was carried out to determine the physical and index properties of soil samples collected from Gabtoli, Sylhet and Turag riverside. Standard physical characteristics (Specific gravity of soils ASTM D 854) and classification (Grain size analysis of soil ASTM D 422) tests were performed as per ASTM standard procedure. Fines was obtained by sieving non-plastic soil (Gojaria sand) through #200 sieve. Obtained fines was added in varying amount (usually 0, 5, 10, 15%) with the soil samples. The experimental programs were performed to estimate the shear strength and angle of internal friction of the proposed sample. For this purpose, a shear devise was used in Consolidated Drained (CD) condition and the test was performed in the BUET lab as per ASTM D 3080 standard test procedures. Normally tests were conducted under one normal pressure (50kPa). To ensure the linearity some extra tests were done under two normal pressures. For both case zero normal stress and shear stress was used (as sand has no cohesion).

RESULTS AND DISCUSSIONS

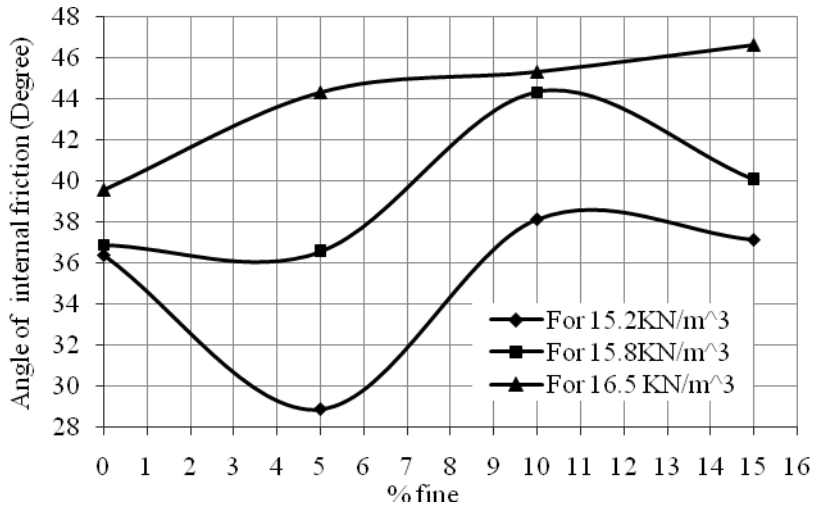
A series of experimental results have been presented herein to evaluate the effect of fines on the angle of internal friction and density. Based on these results detailed analyses and discussions are presented in the following subsections. The properties of Gojaria, Sylhet and Turag sands obtained by laboratory investigation are presented in table 1.

Table 1: Soil's physical properties

Soil Sample	Gojaria	Sylhet	Turag sand
Specific Gravity, G_s	2.69	2.68	2.74
EffectiveSize,D_{10} (mm)	0.025	0.25	0.0784
D_{30} (mm)	0.132	0.53	0.166
D_{60}(mm)	0.219	0.99	0.238
Uniformity Coefficient, C_u	8.75	3.96	3.04
Coefficient of Curvature, C_z	3.18	1.13	1.48
Fineness Modulus, F.M.	0.87	2.87	1

Effect of Percent fine

The variations of angle of internal friction (φ) with % fine are shown in Figure 1. It is seen that, for Gojaria sand, φ decreases with the increase of fine content upto 5%. Then φ increases with the increase of fine content. This occurs for loose and highly dense conditions. For medium dense condition, φ firstly increases then decreases after 10% fine content. For Sylhet sand, initially φ decreases with the increase of fine content upto 5% fine content then increases with the increase of fine content and decreases again after 10% fine content. This occurs for loose and medium dense conditions. For highly dense condition, φ increases with the increase of fine content. For Turag sand, the behavior of φ with fine content is similar to that of Gojaria sand but only for loose and medium dense condition. For highly dense condition, φ increases with the increase of fine content. But for loose condition, all sand follows the same behavior. Initially φ increases with the increase of fine content then decreases.



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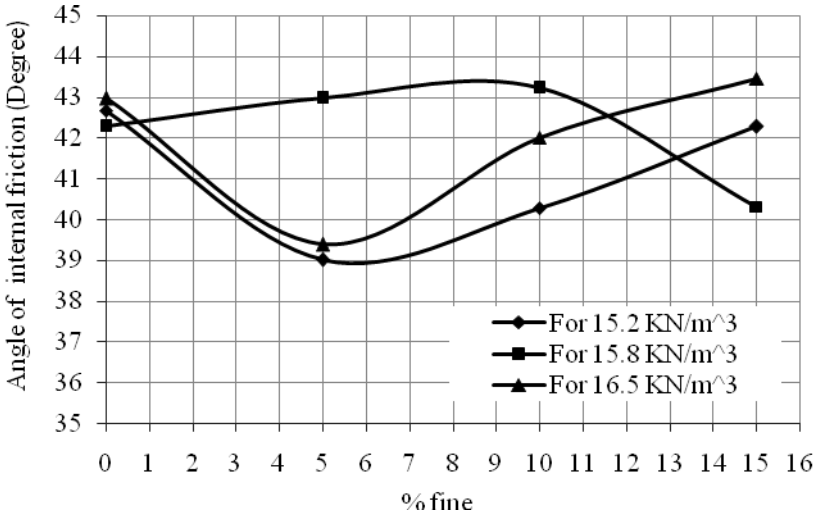

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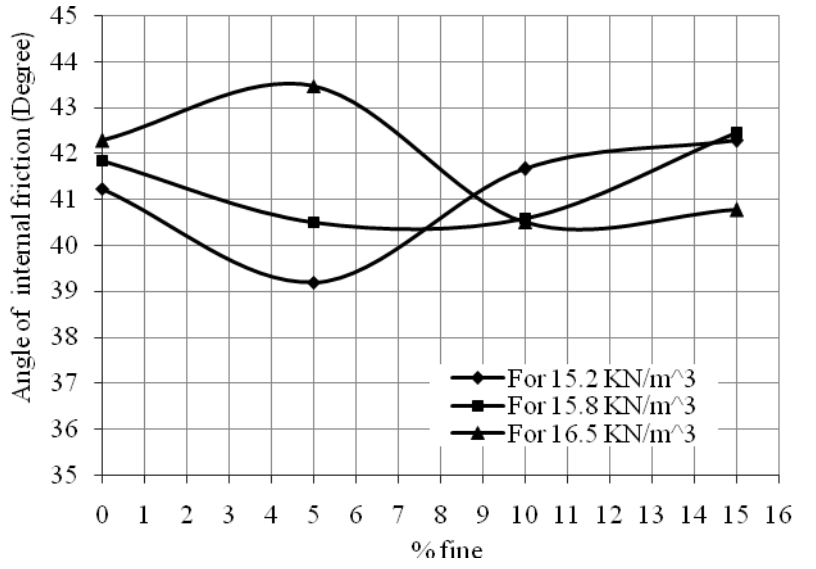

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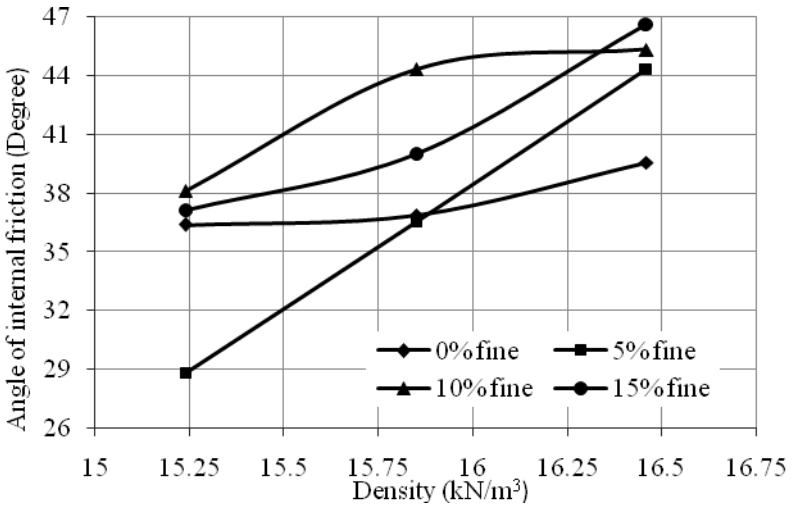
Fig. 1: Angle of internal friction (degree) vs % fine content (a) Sylhet (b) Gojaria (c) Turag sand



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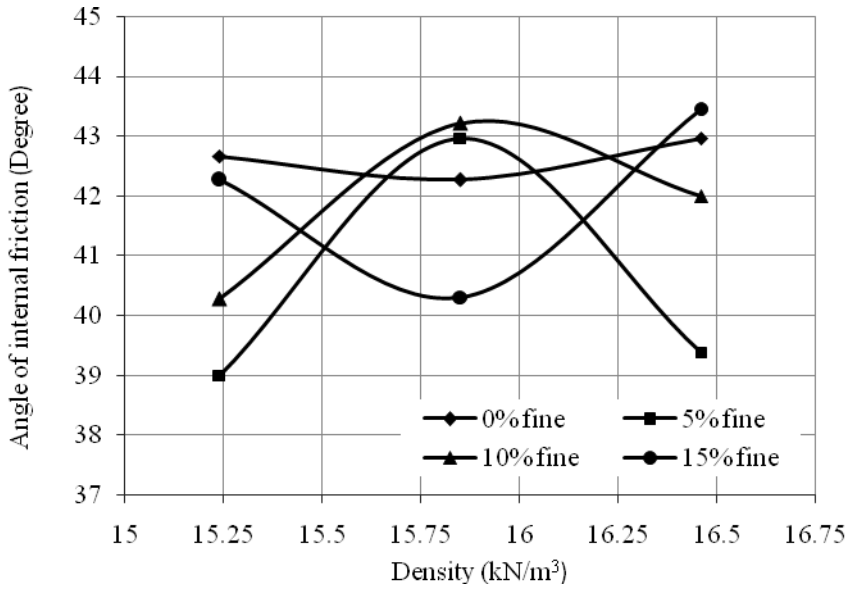

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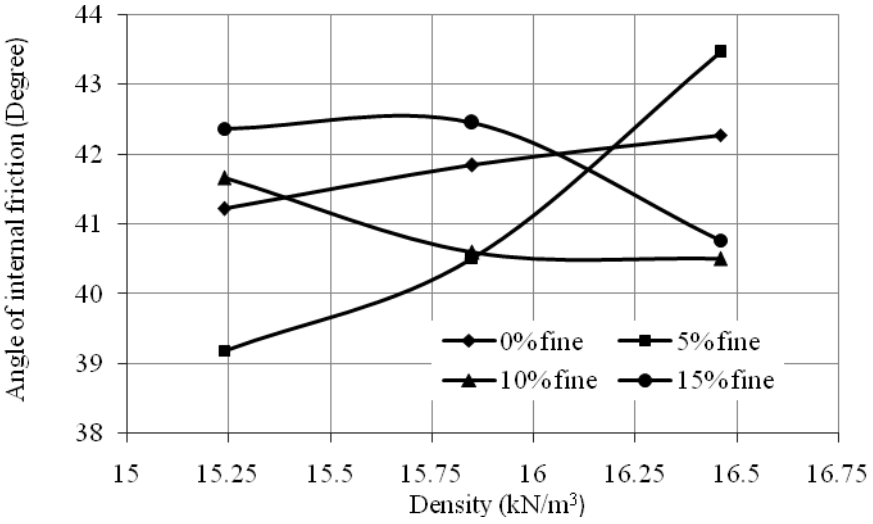

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Fig. 2: Angle of internal friction (degree) vs density (kN/m^3) (a) Sylhet (b) Gojaria (c) Turag sand

Effect of Density

The behavior of the angle of internal friction (φ) with density is represented graphically in figure 2. For Gojaria sand the relationship is ambiguous. With the increase of density, φ initially increases then decreases and this occurs upto 10% fine content. At 15% fine content, φ increases with the increase of density. But for Sylhet sand, the relationship is almost linear. With the increase of density and fine content, φ also increases. For Turag sand, at small percentage of fines the relationship is almost linear. With the increase of percentage of fines the linear relation tends to deviate from the linearity.

CONCLUSIONS

It is found that fine content and density significantly affect the shear strength parameters of sand but it is ambiguous to make a specific conclusion from the test result. Therefore an attempt has been made characterizing some correlation among the friction angle, density and percent fine content. The main findings are:

(1) The angle of internal friction decreases with the increase of percent fines upto 5% fine content at loose and highly dense conditions for Gojaria sand and at loose and medium dense conditions for Turag and Sylhet sand.

(2) With the increase of density angle of internal friction increase upto 10% fine content for Gojaria sand. For Sylhet sand, this relationship almost linear. For Turag sand, upto 5% fine content this relationship all most linear and with the increase of fine this linear relation tends to deviate.

ACKNOWLEDGMENTS

The author would like to express sincere gratitude to Bangladesh University of Engineering and Technology for providing laboratory facilities for conducting this study.

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