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EFFECT OF MICA CONTENT ON STRESS - DEFORMATION BEHAVIOUR OF MICACEOUS SAND

M. Bokhtair[1], A. Muqtadir[2] and M. H. Ali[2]

ABSTRACT : A series of conventional drained triaxial compression tests on sands at various mica content are performed in the laboratory at different confining pressure. The effects of mica content on the physical properties of sands are studied. It is observed that the maximum and minimum densities of the sample decreases with increasing mica content. Conversely maximum and minimum void ratios increase with mica content. Increasing mica content results in reduction of the value of the angle of internal friction. The initial tangent modulus in found to increase with decreasing mica content. It is also observed that mica has virtually no influence on both axial and volumetric strains.

INTRODUCTION

In most areas of Bangladesh, the soil below ground surface consists of sand in which mica particles are present in addition to quartz. This stratum is used for placement of foundation. Quartz is a stable mineral having massive crystalline structure. However, mica is a weak mineral and mica crystals can be easily separated along cleavage planes with application of stress. Moreover, sand consisting of quartz and mica has larger void ratio than that of sand consisting of quartz only. Mica originates in igneous and metamorphic rocks, and is often present in the residual soils formed by weathering of gneiss's and schist. in addition, the material is found mixed with river sands. As the mica is plate shaped in all sizes, it often represents a textural anomaly. This is particularly true when it is included in river sands, which consist of relatively spherical or bulky particle.

Investigation regarding the frictional characteristics of the mica and quartz carried out by Horn and Deere (1962) reveals that they are of opposing in nature. Gilboy (1928) reported that the compressibility increases with increasing percentages of scale-shaped particles. It was also demonstrated that the porosity of a sand mica mixture poured

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1 Department of Civil Engineering, BIT, Chittagong, Bangladesh
2 Department of Civil Engineering, BUET, Dhaka-1000, Bangladesh

under similar condition increases with increasing mica. Moore (1971) performed a series of tests on micaceous sands under condition of infinitesimal lateral yielding. As mica content is increased, the axial strain for a given principal stress increases markedly. The compressibility also increases with increasing initial void ratio. For all void ratios, a small amount of mica results in relatively large increase in axial strain. It is found that, for entire range of mica contents, the stress deformation relationships are nearly identical.

The stress- deformation behavior of any sand depends one number of factors including its mineralogical compostion. In order to determine the actual stress- deformation behavior of sands, it is desirable that the composition of the specimens tested during laboratory test is identical to those occurring in situ. A large portion of research on engineering behavior of sand has been concentrated on sand containing quartz only and little attention has been paid to the behavior of micaceous sand. However in many projects, it becomes necessary to predict stress–deformation behavior of micaceous sands.

Presence of significant amount of mica in sands of different regions of Bangladesh (UNDP-FAO, 1971) suggest that it is not possible to avoid micaceous sands as foundation materials. On the other hand, there is no study on micaceous sands of Bangladesh. In the above context, the present investigation has been undertaken.

PERCENTAGES OF MICA USED IN THE STUDY

Available test results (BRTC, 1990-91) of mica content from different location of greater Sylhat district shows that the maximum mica content of the sands from this region is about 5%. Similar results have also been reported. in soil survey report by UNDP-FAO (1971). The natural sand used in this investigation was collected from this region. The mica content of the natural sand is found to be about 2.5%. In order to cover the behavior of sands of this region, the maximum mica content of prepared micaceous sand is kept limited to 6%. The muscovite mica used in this study was collected from local market.

PHYSICAL PROPERTIES OF MICACEOUS SAND

Mica content of natural sand was determined by using the method specified in ASTM C-295 (1973). The natural sand has mica content of 2.5%. This sand is designated as SI type. Two other types of sample designated as S2 and S3 type with 4.0% and 6.0% mica content were prepared in the laboratory. The physical properties of these sand samples determined in the laboratory are given in the Table 1.

Table : 1 Physical properties of micaceous sands.

Sample Designation	Sample. S1	Sample-S2	Sample-S3
Mica content (%)	2.50	4.00	6.00
Specific gravity	2.66	2.67	2.67
D_{10} (mm)	0.31	0.31	0.31
D_{30} (mm)	0.45	0.45	0.45
D_{60} (mm)	0.93	0.91	0.91
Uniformity coefficient	2.93	2.93	2.93
Coefficient of curvature	0.72	0.72	0.72

TRIAXIAL SAMPLE PREPARATION

Conventional drained triaxial compression tests were performed using standard triaxial compression testing equipment, Cylindrical specimens of 38 mm diameter and 75 mm long were used for all tests. The specimen were all formed at the same bulk density. This was achieved by taking a given amount of sand and tamping the specimen uniformly. Water, equal to 3% of the weight of dry sample, was added to produce uniform density of specimen.

ANALYSIS AND INTERPRETATION OF RESULTS

Effect on densities / void ratios

The maximum and minimum densities / void ratios at various mica contents were determined and their values are given in Table 2 along with the relative densities of S1, S2 and S3. The variation of maximum and minimum density / void ratio at different mica contents are also

Table: 2 Densities and Void ratios of the Sands

Sample Designation	Sample.-S1	Sample-S2	Sample-S3
Mica content (%)	2.50	4.00	6.00
Maximum Density (Dcf)	105.10	98.00	94.10
Minimum Density (pcf)	86.30	82.20	79.00
Maximum Void Ratio	0.92	1.03	1.11
Minimum Void Ratio	0.58	0.70	0.77
Void Ratio of the specimen tested	0.82	0.82	0.82
Relative Density of the specimen tested (%)	29.00	63.00	85.00
Density State	Loose	Medium Dense	Dense

plotted in Fig. 1 and Fig. 2. It is seen that the natural sand S1 has the lowest minimum void ratio and the lowest maximum void ratio. From Fig. 2, it is confirmed that the limiting void ratios increase with increasing mica content of the sands i.e. the more the mica content the more void in the sand, if the sands are poured under similar condition. A small amount of mica results in relatively large increase in void ratio. This trend of the results is in agreement with Gilboy (1928) who reported that the porosity of a mass of sand poured under similar condition increases with increasing mica content. The results revealed that the mica content has significant influence on the void ratio of a sand mass and the sand mass containing higher mica content have larger amount of voids although the relative densities of these masses are same. As a consequence sand masses at same relative density with higher mica contents may show higher deformation for the same applied load.

Effect of Confining pressure, σ_3

The stress-strain and volume change diagrams obtained from conventional triaxial tests are shown in Figs. 3, 4 and 5 for various mica contents. During tests, the mean effective stress increases. Deviator stress corresponding to a particular axial strain, increases with confining pressure, The axial strain at failure also increases with increasing confining pressure. At lowest confining pressure,

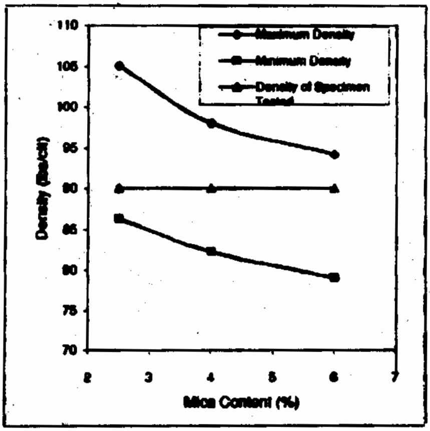

Fig 1. Variation of Densities with Mica Content

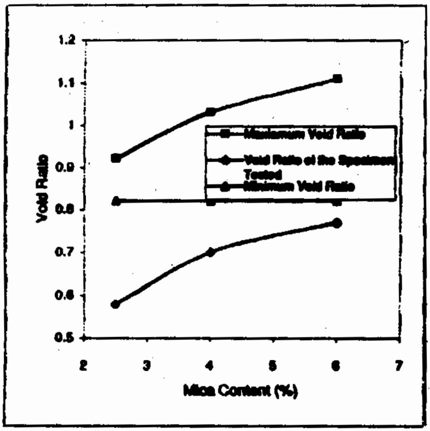

Fig 2. Variation of Void Ratio with Mica Content

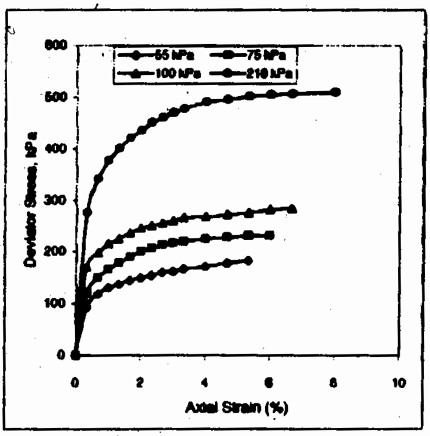

Fig 3a. Stress-Strain relationship of Sample S1 (mica Content·2.5%) for Conventional Triaxial Compression, σ_3 = Constant Tests

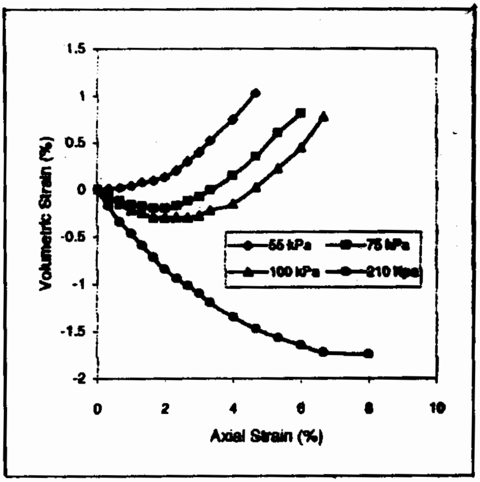

Fig 3b. Volume change- Strain relationship of Sample S1 (Mica Content 2.5 %) for Conventional Triaxial Compression, σ_3= Constant Tests

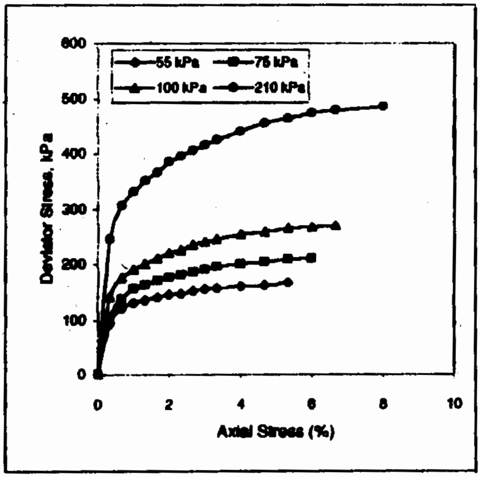

Fig 4a. Stress-Strain relationship of Sample S2 (Mica Content 4.%) for Conventional Triaxial Compression, σ_3= Constant Tests

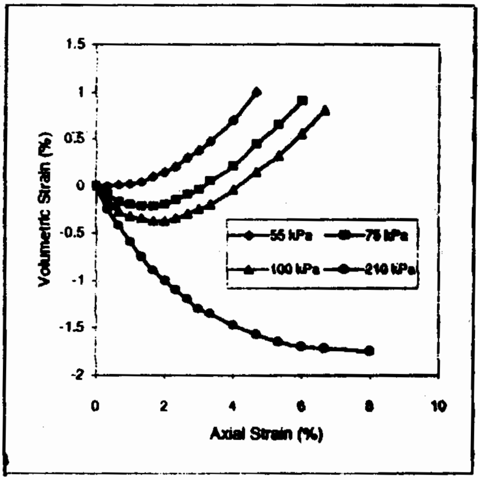

Fig 4b. Volume change-Strain relationship of Sample S2 (Mica Content 4.0%) for Conventional Triaxial Compression, σ_3= Constant Tests

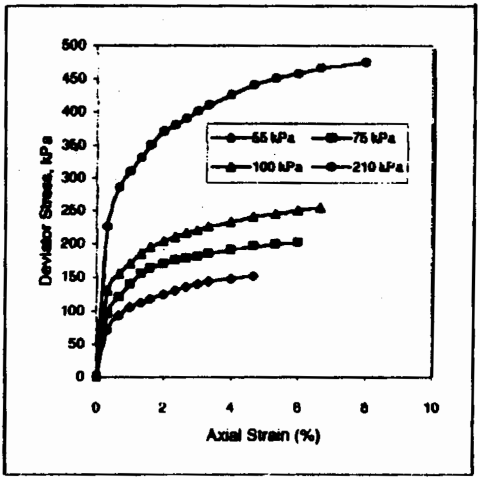

Fig 5a. Stress-Strain relationship of Sample S3 (Mica Content 6.0%) for Conventional Triaxial Compression, σ_3= Constant Tests

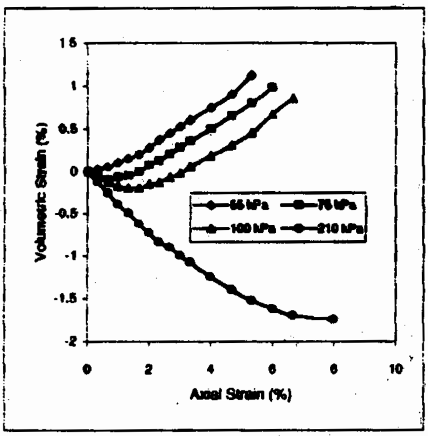

Fig 5b. Volume change-Strain relationship of Sample S23(Mica Content 6.0%) for Conventional Triaxial Compression, σ_3= Constant Tests

applied in this study, the volumetric expansion occurred from the beginning of the test. But with increasing confining pressure the specimen undergoes volumetric compression at the early stage of the tests after which it begins to expand.

The relative density of the specimen prepared from Sample S1, Sample-S2 and Sample-S3 are 29%, 63% and 85% respectively. But these specimen give similar stress-strain curves with no peak. This may be due to same initial void ratio of the specimen and higher compressibility of mica particles.

Effect of mica content

The variation of angle of internal friction with mica content is plotted in Fig. 6 and it appears that, for all confining pressures, the angle of internal friction decreases with increasing mica content. Horn and Deere (1962) investigated frictional resistance at contacts between the same mineral. They observed that quartz offer higher frictional resistance than that of mica. At contact between quartz and mica, the frictional resistance may be lower than that of quartzes and higher than that of micas. In sand mass, there are hundreds of contacts. Most of them are quart to quartz, some of them are quart to mica and a few of them are mica to mica. Hence sand mass comprising quartz and mica should offer less frictional resistance than the sand mass of quartz only which is reflected in Fig. 6. Audibert et al. (1976) reported that the mica content has no influence on the friction angle of sands with same relative density and variation of friction angle with confining pressure appears to be the same regardless of mica content. The disagreement of the findings of this study with that of Audibert et al. (1976) may be due to the differences in particle size distribution of mica mixed with the sand and the same bulk density rather than same relative, of the specimen tested in this investigation.

The relationship between initial tangent modulus and mica content is illustrated in Fig. 7. There is a decrease in initial tangent modulus with increase in mica content. For higher confining pressure, the variation in tangent modulus with mica content becomes larger. Similar finding was also reported by Audibert et al. (1976).

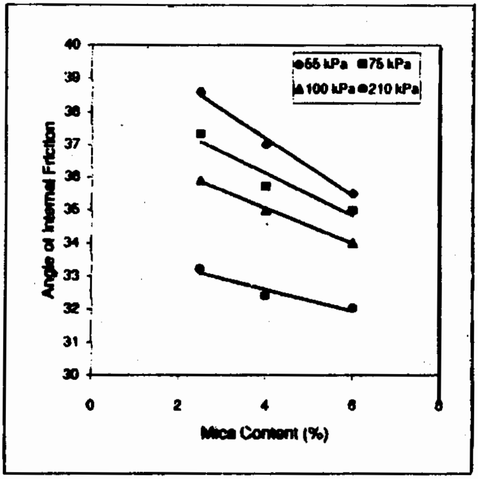

Fig 6a. Variation of Angle of Internal Friction with Mica Content for Different Confining Pressure

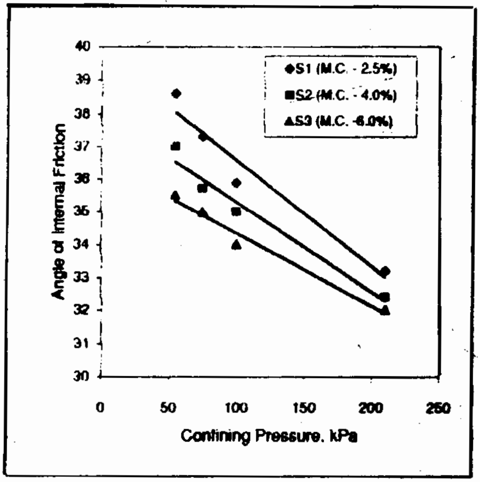

Fig 6b. Variation of Angle of Internal Friction with Confining Pressure for Various Mica Content.

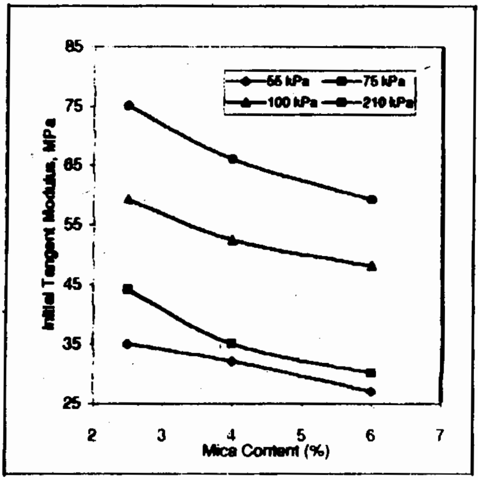

Fig 7. Effect of Mica Content on Initial Tangent Modulus at Different Confining Pressure

Figure 8 illustrates the relationship between axial strain at failure and mica content. The axial strain at failure is found to be equal for all mica contents except at lowest confining pressure used in this investigation.

Influence of mica content on volumetric strain is shown in Fig. 9. where it can be seen that the mica content has virtually no effect.

The strength of a granular mass is represented as sum of the three components: strength mobilized by frictional resistance at contacts, strength developed by energy required to rearrange and re-orient soil particles, and strength developed by energy required to cause expansion or dilation. For a particular confining pressure, practically equal axial strain and volumetric strain at failure indicate that the specimen have same volume at failure irrespective of their mica content. This implies that, for sands with same initial void ratio and similar particle size distribution, the energy required for the re-orientation and rearrangement for sand particle, and energy required to cause expansion are equal. This suggests that the variation in angle of internal friction with mica content may be due to difference in frictional resistance at contacts.

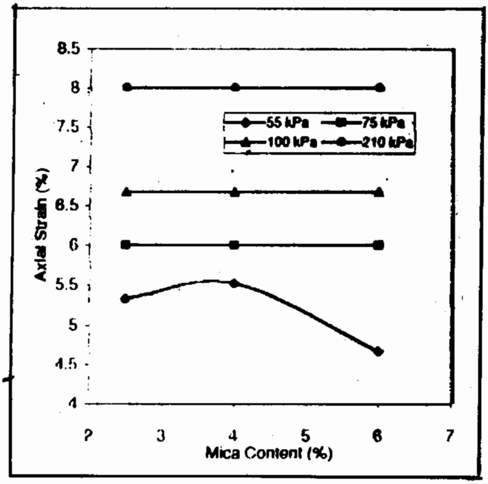

Fig 8. Effect of Mica Content on Axial Strain at Different Confining Pressure

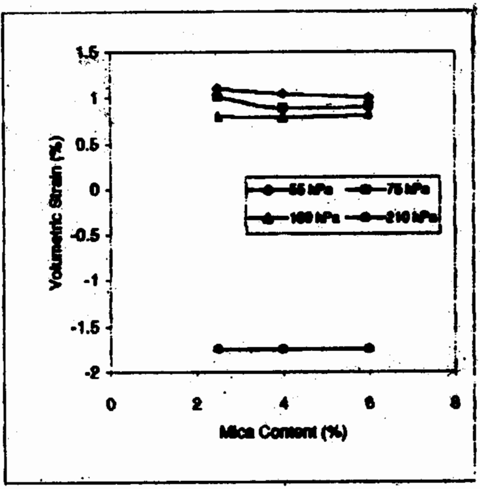

Fig 9. *Effect of Mica Content on Volumetric Strain at Different confining Pressure*

SUMMARY AND CONCLUSION

Triaxial tests are performed on Sylhet sands containing 2.5%, 4.0% and 6.0% of mica. The effects of mica on density void ratio are examined. Stress-deformation behaviour of micaecous sands are also studied. It is observed that the maximum and minimum densities of sample decreases with increasing mica content. Increase in mica content results in 3.1° reduction in the value of angle of internal friction. It is also observed that the angle of internal friction increases with decreasing confining pressure. The initial tangent modulus is also found to increase with decrease in mica content. On the other hand, mica content has no effect on the axial and volumetric strain at failure.

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