DIRECT SHEAR TEST AND TRIAXIAL TEST ON RANDOMLY REINFORCED FINE SAND AND APPLICATION OF ITS PROPERTIES IN FIELD

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Abstract

Nonlinear finite element analysis has been performed. for strip footing using the properties obtained from direct shear test and triaxial test on flex fibres. The soil and strip footing have been discretized as four noded isoparametric finite elements. The soil has been idealized as extended Drucker-Prager yield criterion and the strip footing has been idealized as elastic material. The settlement is more for soil having angle of internal friction equal to 18 degree than the settlement of soil with angle of internal friction equal to 27 degrees. At loading intensity of 60 kN/m^2, the margin of settlement between the two curves is more than the margin of settlement at loading intensity of 10 kN/m^2. For same contact stress, the settlement of the footing is less on reinforced soil than the soil without reinforcement.

Keywords: Direct shear test, triaxial test, fine sand, randomly, yield criterion, settlement, contact stress.

Introduction

Scarcity of suitable land and unavailability of good quality construction soil lead to the implementation of various ground reinforcement techniques. Among the various reinforcement techniques , fibre reinforcement is achieving more attention in geotechnical engineering. Soil reinforcement using discrete randomly distributed fibers has been widely investigated over the last 30 years Soil improved by randomly distributed fibers is approximately a homogeneous media in contrary to the other methods of mechanically stabilizing systems that is the main advantage of using this method. Since the orientation and location of fibers between soil particles are completely random parameters therefore extensive laboratory tests are required to estimate the mechanical behavior of these soils.

Literature Review

Lovisa et.al. (2010) conducted direct shear test to investigate the effects of water content on the shear strength behaviour of sand reinforced with 0.25% randomly distributed glass fibres. The results of the tests suggest that the peak friction angle of the fibre-reinforced sand in moist condition is approximately 3° less than that in dry condition for a relative density greater than 50%..

Sadek et.al. (2010 performed an extensive direct shear testing program which was implemented using coarse and fine sands tested with three types of fibers. A comparison between measured and predicted shear strengths indicates that the energy dissipation model is effective in predicting the shear strength of fiber-reinforced specimens in reference to the tests conducted in this study.

Shiva Nand Mali et al. (2013) have carried out a series of direct shear tests to investigate the shear strength behaviour of a fine sand reinforced with glass fibres. The influence of various parameters such as fibre content and relative density on the strength behaviour of the sand –fibre mixes has been studied

Malil and Singh (2014) reviewed the strength behavior of cohesive soils reinforced with coir fibers, polypropylene fibers and scrap tire rubber fibers as reported from experimental investigation, that includes triaxial, direct shear and unconfined compression tests.

Nguyen. et.al (2015) dealt with soil improvement using polyester fibres of length 70 mm mixed in soil as random reinforcement in amount of 0.5%, 1.0% and 1.5%. Improvement of soil was measured by direct shear tests, using shear box of size 0.3m x 0.3m x 0.15m. It has been shown that for tested soil, optimal amount of fibres is 1.0%, when increase of angle of internal friction was up to 6.0^{o} (from 45.3^{o} to 51.3^{o}).

Noorzad and Ghoreyshi Zarinkolae (2015) investigated the behavior of sand reinforced with polypropylene fiber. To do this, direct shear tests and triaxial tests were performed on the coastal beaches of Babolsar, a city in the North of Iran. In this study, four various fiber contents (0, 0.25, 0.5 and 1 percent), three different lengths of fiber (6, 12 and 18 mm) and four normal or confining pressures (50, 100, 200 and 400 kPa) have been employed. In both direct shear and tri-axial tests, the addition of fibers improved shear strength parameters (C,φ),

Ouria (2016) investigated the shear strength of a silty sand reinforced by glass fibers in the laboratory. The effect of fiber content and fiber length on the cohesion and friction angle of the improved soil was investigated using large scale direct shear test on soil specimens prepared with 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6% fiber contents with different lengths of 5, 10, 20 and 30 mm with optimal water content and 85% of maximum dry density. The results of the laboratory tests indicate that the addition of glass fibers increases the shear strength of the soil increasing both cohesion and internal friction angle. The optimal fiber content and fiber length in these experiments were about 0.4% and 10mm respectively.

The values of cohesion and friction angles were increased by approximately 40% and 30% respectively in optimal conditions.

Laboratory Test

In laboratory tests specific gravity, sieve analysis and direct shear tests have been conducted. The specific gravity of fine sand obtained from laboratory test is 2.6. Sieve analysis has been performed and the uniformity coefficient, C_u is found to be equal to 2.1 and coefficient of curvature C_c is found equal to 0.75. As C_u is less than 4 and the value of C_c is not between 1 and 3, the soil is classified as poorly graded fine sand.

The direct shear test has been performed for fine sand alone and then with randomly reinforced fibers. Flex fibers having diameter 2 mm and length 25mm have been taken to reinforce soil randomly. The fiber content varied are 0.1%, 0.15%, 0.2%, 0.25% and 0.3%. The optimum fibre content is 0.2 %. The plot was drawn between shear stress and normal stress. The angle of line with horizontal gives the angle of internal friction of soil. For fine sand alone the angle of internal friction obtained was 18 degree and for randomly reinforced fibre sand was 27 degree at optimum fiber content. The modulus of elasticity have been obtained from triaxial test for sand alone and fiber reinforced sand by making a plot between deviatoric stress vs axial strains. The modulus of elasticity for sand obtained is 5000 kN/m^2 and the modulus of elasticity for randomly reinforced fine sand is 7500 kN/m^2.

Finite Element Analysis

A nonlinear finite element analysis has been done for a strip footing on elasto-plastic soil under plane strain condition. The soil as well as strip footing has been discretized into four noded isoparametric elements. The number of nodes considered are 441 and the number of elements are 400. The soil has been idealized as extended Druck-Prager yield criterion and the strip footing has been idealized as linear elastic material. All the bottom nodes are having zero degrees of freedom. On the axis of symmetry there is only vertical degrees of freedom. The outer most boundary has also only vertical degrees of freedom.

Results and Discussions

Fig. 1 shows the loading intensity versus settlement curve for strip footing for angle of internal friction 18 degree and 27 degree. It is found that settlement of strip footing on fine sand with 18 degree of freedom is more than the fine sand with internal angle 27 degree. Thus the effect of reinforcement is to reduce settlement. The nature of the curves is nonlinear.

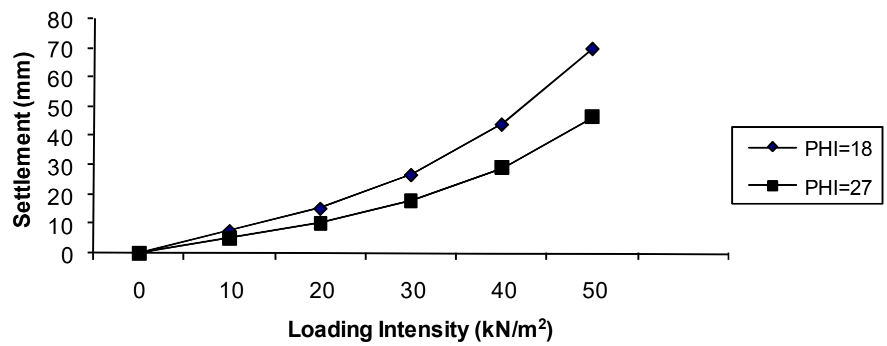

Fig.1 Loading Intensity vs Settlement Curve

Fig.2 shows the settlement plot with distance for loading intensity 10 kN/m^2. The settlement increases from one end to left end of footing, then settlement is uniform i.e horizontal. The settlement is more for soil having angle of internal friction equal to 18 degree than the settlement of soil with angle of internal friction equal to 27 degrees. Hence the effect of adding reinforcement is to decrease the settlement.

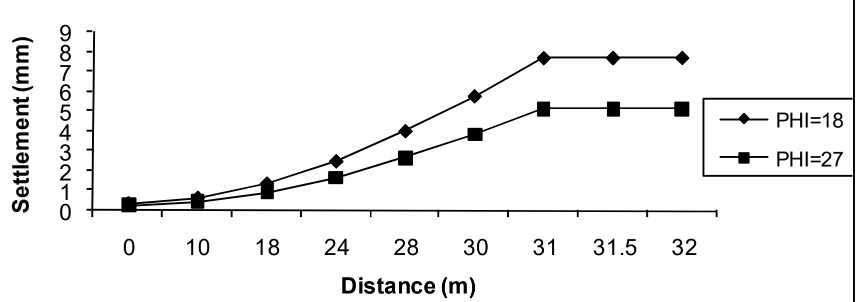

Fig.2 Comparision of Settlement (Loading Intensity=10 kN/m^2)

Fig.3 shows the comparison of settlement for loading intensity 10 and 60 kN/m^2 . In this case the settlement between two soils (fine sand and randomly reinforced sand) is more than in Fig.2. The margin of settlement between two soils is more at intensity of loading 60 kN /m^2 (Fig.3) than at loading intensity of 10 kN/m^2 (Fig.2). The settlement of footing is uniform for both soils and for both loading intensities.

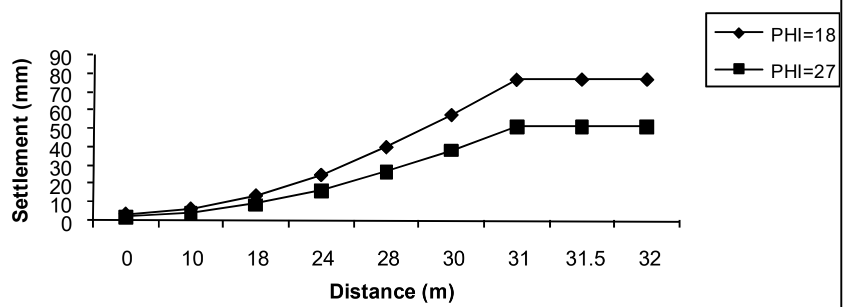

Fig.3 Comparision of Settlement (Loading Intensity=60 kN/m^2)

Fig.4 indicates that for the same contact stress to develop, the settlement of fine sand without reinforcement is more than the reinforced fine sand. Thus reinforced fine sand reduces settlement. For the same settlement the contact stress is more for soil with angle of internal friction 27 degrees than the soil with angle of internal friction 18 degrees.

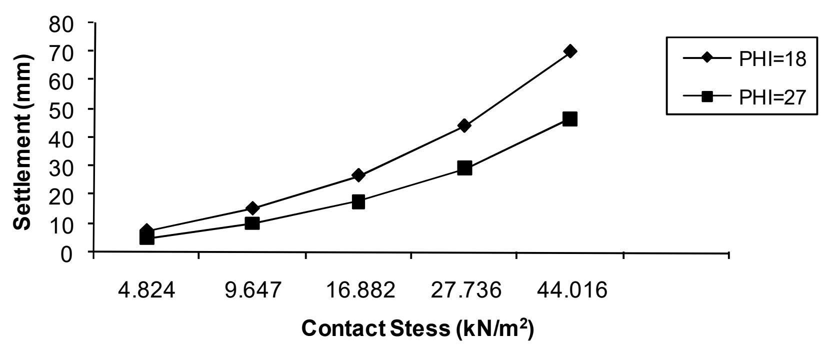

Fig.4 Contact Stress vs Settlement

Conclusions

From sieve analysis results it has been found that the sand taken is fine sand. Due to addition of randomly reinforced fibers in fine sand the angle of internal friction has increased from 18 to 27 degrees and the modulus of elasticity has increased from 5000 kN/m^2 (for fine sand) to 7500 kN/m^2 (for randomly reinforced sand). The effect of adding reinforcement is to reduce settlement for the same loading intensity. The settlement increases from one end to left end of footing, then settlement is uniform i.e horizontal. The settlement is more for soil having angle of internal friction equal to 18 degree than the settlement of soil with angle of internal friction equal to 27 degrees. Hence the effect of adding reinforcement is to decrease the settlement. At loading intensity of 60 kN/m^2, the margin of settlement between the two curves is more than the margin of settlement at loading intensity of 10 kN/m^2. For same contact stress, the settlement of the footing is less on reinforced soil than the soil without reinforcement. For the same settlement the contact stress is more for soil with angle of internal friction 27 degrees than the soil with internal friction 18 degrees.

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