ABSTRACT

The concept of reinforcing soil beds for improving the load carrying capacity of soil and reducing settlement is an age old art. However the technique is not fully exploited, as there are very few studies available pertaining to methods of design and analysis. Thus there is a need to understand soil-reinforcement interaction. The applicability of a method for predicting ‘bearing capacity increase’ in reinforced sandy ground is examined by the author using tests performed under various test conditions.

In the present investigation, total four different types of reinforcing materials have been used. Four model circular footings of various internal diameters are been used for investigating the effect of annular ratio on bearing capacity of the sand bed with different reinforcing conditions. Model plate-load test have been performed under monotonic and cyclic loading in three series which are mentioned as follows:

SERIES 1:
1. Monotonic plate-load tests on a ring footing resting on sand beds reinforced with Geogrid, Netlon-CE121 as reinforcing material- Fifteen numbers.
2. Cyclic plate-load tests with Geogrid, Netlon-CE121 as reinforcing material – Fifteen numbers.
3. Monotonic plate-load tests with Geo-jute as reinforcing material – Nine numbers.
4. Cyclic plate-load tests with Geo-jute as reinforcing material – Nine numbers.

SERIES 2:
Total twenty four monotonic plate-load tests were performed on four different model circular footings having various annular ratios resting on sand beds.
reinforced with two different types of geogrids, Netlon-CE121 and Netlon-CE131.

SERIES 3:

1. Monotonic plate-load tests on a ring footing resting on sand beds reinforced with Geocells made up of geogrid, Netlon-CE121—eighty numbers.

2. Cyclic plate-load tests on a ring footing resting on sand beds reinforced with Geocells made up of geogrid, Netlon-CE121—ninety numbers.

An ultimate bearing capacity equation of ring footing on reinforced sand bed has been developed based on the analytical study of test series-1 data, is as under:

\[ q_{ur} = S_f q_o + q_D + q_B \]

where,

\[ S_f = 12.516(h/d) + 2.28 \quad \text{for} \quad 0.0 < h/d < 0.5 \]

\[ q_o = 0.5 \gamma B N_f \]

\[ q_D = \gamma^* D_R^* N_q \]

\[ q_B = -12.688[(b*D_R)/d^2]^2 + 53.717[(b*D_R)/d^2] - 21.229 \]

which has been validated using the experimental data of test series-2.

From the study of the damping capacities of the sand beds at selected load levels, it may be stated that all the reinforced sand beds reinforced with different sizes of geo-grid and geo-jute have a higher percentage damping capacities than un-reinforced sand bed at a particular load level. Therefore the reinforced sand beds will have a higher capacity for supporting machine foundations and foundations subjected to cyclic loading. It can also be observed from Fig. 5.1.7 and Fig. 5.1.8 that as load intensity increases on the footing the damping characteristic decreases. For sand bed reinforced with geo-grid CE121(N=3, b=3d,) the percentage damping capacity has been observed about 2.6 times higher than that of un-reinforced bed at a particular load level.
From cyclic plate load test results, the load-settlement curves were plotted and from the cyclic loops, it was conveniently possible to separate out the two components of settlement namely, elastic rebound or elastic settlement \((S_e)\) and the plastic settlement \((S_p)\) at a particular pressure intensity \((p)\). The constitutive equations have been developed for maximum size of reinforcement used in sand bed with Netlon Geogrid CE121, and reported in chapter-5.

From the analysis of test series-2, various parameters like Initial tangent modulus \((E_i)\), Modulus of subgrade reaction \((K_s)\), and Modular ratio \((m=E_i/E_{io})\) for different annular ratio of the ring footing have been calculated. For \(h/d = 0.0\), the values of above parameters are found to be optimum for sand bed reinforced with Netlon geogrid-CE121, \(N=3, b=3d\), the modular ratio \((m)\) is found to be 4.0. For \(h/d = 0.31\), the above parameters are found to be optimum for the same condition as in case of \(h/d = 0.0\) and the modular ratio \((m)\) is found to be equal to 3.8. For ring footing having \(h/d = 0.38\), optimum reinforcing condition is Netlon geogrid-CE131, \(b=3d, N=3\) and the modular ratio \(m=3.49\). For \(h/d = 0.46\) again the optimum reinforcing condition is same as for \(h/d = 0.38\). The modular ratio is 3.33 for this condition of reinforcement. The reduction in settlement is found to be maximum 90.7 percentage for ring footing with \(h/d=0.31\) reinforced with three number of geogrid CE121.

From the cyclic loading analysis the dynamic soil parameters, the coefficient of elastic uniform compression \(C_u\), the coefficient of elastic shear \(C_r\), the coefficient of elastic non-uniform shear \(C_\psi\) and the coefficient of elastic non uniform compression \(C_\phi\) have been obtained. The natural frequency of foundation-soil system for different reinforcing conditions of sand beds can be determined and designed for earthquake resisting foundation system. These parameters can also be used for design.
of machine foundation on reinforced sand bed for various reinforcing conditions.

From the test series-3, it has been observed that as number of Geocells increases, the ultimate load carrying capacity increases. This is due to the confinement of sand into the reinforcing Geocell layers and hence load carrying capacity increases at lesser settlement. It is observed that with increase in depth of placement of Geocell layer from $Z=0.25d$ to $Z=0.75d$ the load carrying capacity is decreased. So, the results are optimum for $Z=0.25d$. From the experimental investigation it has been observed that with increase in diameter of Geocell from $D_g=0.27d$ to $0.46d$ the load carrying capacity is increasing. Beyond $D_g=0.46d$ the improvement in bearing capacity is marginal. From the experimental investigation it is concluded that with increase in height of Geocell from $H_g=0.61d$ to $1.38d$ the load carrying capacity is increasing.

The tensile force in the geogrid has been validated using Binquet and Lee [18] analysis which was found less than the tensile strength of the geogrid used in the investigation. Four tests were performed on sand beds under submerged condition; two under monotonic loading and two under cyclic loading. The BCR at $S=7.5\%$ was found to be 1.6 for geogrid (Netlon CE121) reinforced sand bed. The indicative of percentage damping capacities of reinforced sand bed for all the load levels are also found to be greater than that of unreinforced sand bed under submerged condition.

Finally the reinforced sand bed with geogrid reinforcement has been analyzed using a finite element analysis software – PLAXIS.