ABSTRACT

Vertical plate anchors are being widely used in the construction of geotechnical structures such as sheet pile walls, bulkheads, bridge abutments and retaining walls etc. Holding capacity of the anchor plates is a major concern in the design and analysis of the supported structures and if not evaluated properly may lead to failure. In view of this the load carrying mechanism of the vertical plate anchors needs to be understood properly.

At times the retained structures undergo failure due to rupture of anchor plate owing to excessive loading or inadequate resistance from the soil around. In order to enhance the pullout capacity and prevent sudden failure it is necessary that the soil in which these anchors are embedded be improved. Amongst the various ground improvement techniques used, soil reinforcement is probably the most popular one. Geocell reinforcement is the latest development in this field. It is a three dimensional, polymeric, honeycomb like structure of cells interconnected at joints. The reinforcement mechanism in the geocells is by all-round confinement of soil within its pockets. Therefore, it is expected that the soil supporting the anchor if reinforced with geocells can inhibit the slip planes effectively leading to enhanced pullout capacity. The work reported herein has investigated these issues through physical model tests.

A series of model tests were carried out in a test bed-cum-loading frame assembly in the laboratory. In the first phase, pullout behavior of anchor was studied through full model tests conducted in a flexible laminar box. In the second phase, to delineate the rupture surfaces in the anchor bed, half model tests were conducted in a steel tank with transparent face. The anchor used was made of steel and measured 100 mm in width, 100 mm in height and 10 mm in thickness. The test beds were formed using sand raining technique. The geocell reinforcements were made out of geogrid strips and bodkin joints. The anchor plate was connected to the tie rod passing through the geocells, following which sand raining was continued until the target depth was reached. The load was applied in stress controlled manner by adding weight increments. Each load increment was maintained constant until the anchor displacement stabilized. Loading was continued till failure. The measurements carried out are; anchor load and displacement, deformations on fill surface, strain in reinforcement, and pattern of movement of soil in the anchor bed.

It was observed that the load carrying capacity of the anchor increases with increase in density of the fill soil and embedment depth. In case of shallow anchor the rupture surface reached out to the ground surface leading to a general shear mode of failure whereas in case of deeper embedment the rupture surface was localised around the anchor plate. The size of rupture surface increases with increase in density of fill soil that mobilises higher resistance leading to enhanced anchor capacity. There exists a critical embedment depth beyond which further increase in anchor capacity is practically negligible. It is observed that the critical embedment depth is higher in case of dense soil.

The geocell reinforcement can significantly enhance the anchor load carrying capacity and induce a stable behaviour until very large displacements. This is because the interconnected cells form a panel like structure that redistributes the anchor load over a wider area leading to reduced stress on the supporting soil mass that the system could sustain increased loading without failure. With geocell reinforcement the extent of surface heaving was much larger in size. It indicates that with geocell reinforcement a larger mass of soil has participated in sharing the anchor load. As a result of which higher resistance is mobilised giving rise to enhanced anchorage capacity. Post test measurements indicate that under horizontal pull the anchor has moved in the upward direction as well. This is because during failure the supporting soil mass sheared up and moved upward pulling the anchor along with it. But with geocell reinforcement, the anchor upward displacement was found to have reduced substantially which establishes that the geocell reinforcement can significantly enhance the stability of the system. The critical height, width and length of geocell mattress giving maximum performance improvement are found to be $2.8h_a$, $3h_a$ and $5h_a$ respectively, where h_a is the height of the anchor. Similarly, the critical embedment depth giving maximum performance improvement is found to $7h_a$.

In an attempt to transfer the results of the model tests to the field conditions dimensional analysis is carried out. It is observed that for the present test data to be valid in prototype case the strength of geocells should be N^2 times the strength of geocells used in the present tests, where N is the model scale. For predicting the load carrying capacity of the geocell reinforced anchors, simple analytical and empirical models are developed.

Keywords: Vertical plate anchor, load carrying capacity, reinforced sand, geocell reinforcement, model tests.