Experimental Evaluation of Performance of Mechanical Retaining Walls Reinforced with Plate Anchors

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Received: 11 Nov. 2017 Accepted: 11 April 2018

Extended Abstract

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Introduction

Retaining walls are geotechnical structures built to resist the driving and resistant lateral pressure. In terms of serviceability life, these walls are divided into two groups including short-term structures (temporary), such as urban excavation project, and long-term (permanent) structures, such as Mechanically Stabilized Earth Walls (MSE Walls). Retaining walls are implemented by two main methods including Top-down and Bottom-up. Among the reinforcements applied in the Bottom-up walls, one can name geocells, geogrids, metal strips, and plate anchors. On the other hand, the common reinforcements applied in the Top-down walls are grouted soil nails and anchors and helical (screw) soil nails and anchors.

Plate anchors are burial mechanical reinforcements that have one or multiple bearing plates with a bar or cable to transfer the load to an area with stable soil. Among different types of plate anchor applied in onshore and offshore projects, one can name simple horizontal, inclined, and vertical plate anchors, deadman anchors, multi-plate anchors, cross-plate anchors, expanding pole key anchors, helical anchors, drag embedment anchors, vertically loaded anchors (VLAs), suction-embedded plate anchors (SEPLAs), dynamically-embedded plate anchors (DEPLAs) like Omni-max and torpedo anchors, and duckbill, manta ray and stingray anchors.

The present research reports the results from physical modeling of plate anchor retaining walls under static loading. The evaluation parameters in this work include the geometry, dimension, and reinforcement configuration of plate anchors on wall stability. PIV technique was employed to observe critical slip surface. It is worth mentioning that PIV is an image processing technique firstly used in the field of fluid mechanics to observe the flow path of gas and fluid particles. This method was used in geotechnical modeling by White et al. (2003) and few reports are already available about its application to observe wedge failure of mechanically stabilized retaining walls.

Material and methods

To carry out tests at a laboratory scale, a dimensionality reduction ratio of 1/10 was applied. Thus, all dimensions of the designed retaining wall were divided by 10. As a result, a retaining wall with a height and length of 3000 mm was reduced to a wall with 300×300 mm^2 dimensions. To build a retaining wall, a chamber was designed with a length, width, and depth of 1000 mm, 300 mm, and 600 mm, respectively.

The soil used in all tests was the sandy soil supplied from Sufian (in Eastern Azerbaijan, Iran). According to the Unified Soil Classification System (USCS), the soil is classified as poorly graded sand with letter symbol ‘SP’.

To create a perfect planar strain condition and prevent any friction between the footing and the lateral sides of the test box, the footing length was selected 1 mm smaller than the 300 mm width of the test chamber. Therefore, the length, width, and thickness of footing were selected as 299, 70, and 30 mm, respectively.

The length and diameter of applied tie rods were respectively 300 mm and 4 mm, which are the smaller scales of 3000 mm length and 40 mm diameter tie rod. The two sides of the tie rods were threaded to plate anchors and wall facing. Four polished square and circular anchor plates with two different areas were used. The area of small and medium circulars are respectively equivalent to the area of small and medium square plates.

Because no post-tensioning occurs in these plate anchors, the horizontal and vertical distances were both selected as 1500 mm. By applying a dimensionality reduction coefficient of 1/10, a 150 mm center-to-center distance was obtained for reinforcements in the wall. Accordingly, three applied reinforcement configurations including 5-anchor, diamond, and square configurations were used.

To construct permanent retaining wall facing, prefabricated or precast concrete blocks with a thickness of 300 mm were used. Wood (2003) conducted a dimensional analysis and introduced four types of material with different thicknesses for a 300 mm concrete facing in laboratory modeling. Accordingly, a 0.9 mm thick aluminum plate was used in the experiments performed in the present work.

Results and discussion

With an increase in dimensions of anchor plates, an increase in bearing capacity of footing and a decrease in horizontal displacement of the wall are noticed. By comparing the 24 mm footing settlement in three configurations, with changing dimension of the plates from C1 to C2 and S1 to S2 respectively, 63% increases are observed in bearing capacity of the wall.

An increase in anchor plate dimensions results in a significant decrease in wall displacement. Therefore, changing the plates from C1 to C2, S1 to S2 leads to 24% and 28% declination in wall displacement.

By changing reinforcement configuration from square to diamond, diamond to 5-anchore, and square to 5-anchor, respectively, 27%, 31%, and 67.5% increases in bearing capacity for small plates, 9.2%, 27%, and 38% for medium plates are achieved using a comparison of the final loading steps in experiments. An analogy of percentages shows that a decrease in the effect of changing the reinforcement configurations on the bearing capacity of the wall with an increase in plate anchors dimensions is reached.

Conclusion

In the present research, a set of laboratory experiments were carried out to evaluate the stability of mechanical retaining walls reinforced with plate

anchors with different geometries (square and circular), sizes (small and medium), and configurations (diamond, square, and 5-anchor). The main results of the present work can be outlined as follows:

- The maximum bearing capacity is for the 5-anchor configuration since it has one more reinforcement. After 5-anchor configuration, the diamond configuration results in a higher bearing capacity compared to the square configuration.
- Circular anchor plates compared to square anchor plates provide a higher wall stability and in the most of the experiments lead to higher bearing and lower displacement in the wall.
- Wall displacement in a diamond configuration with one less reinforcement shows a little difference with 5-anchor configuration. The maximum wall displacement occurs in a square configuration and more wall swelling is observed in the wall middle height due to inefficient anchors configuration in the wall.

Keywords: mechanical retaining walls, plate anchors, bearing capacity, wall displacement

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