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EXTENDED ABSTRACT

Introduction and Determination of the New Generation of Mechanical Anchors for Using As a Geotechnical Supporting System

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1. Introduction

So far, various methods have been reported for estimating the tensile bearing capacities using laboratory tests, software modeling, and estimation theory (Das and Shukla, 2013; Moghadam et al, 2018; Randolf , 2011). In the present study, different aspects of the mechanical behavior of EMPLAs are evaluated during the performed pullouts using experimental test and 3d numerical modelling. In addition, the effect of the properties of anchor plates such as their shape and curvature on locking speed of expandable plates in the soil, and activation of anchors, as well as the tensile bearing capacity and degradation intensity of reinforcement traction under a constant pullout speed are investigated.. Additionally, to validate the results of physical modeling, the anchors with the best performance and the maximum tensile bearing capacity were selected as a representative of each group, modeled, and evaluated in PLAXIS 3D V.2018 finite element software program. Based on the results, the circular shaped mechanical anchor showed the maximum bearing capacity among the other anchors.

2. Experimental setup

2.1. Expandable mechanical plate anchors (EMPLAs)

To construct the anchor plates, 3 mm steel sheets were used due to inadequate thickness of the 2 mm plates in the preliminary experimental tests. Depending on the required bearing capacity of the mechanical plate anchor reinforcements, plates with different dimensions were designed and implemented. Since EMPLAs were firstly introduced in this study, the area of anchor plate was selected and proposed 625 cm2 by considering the boundary conditions, i.e. chamber dimensions. Plate curvature was created on 1/3 of length/radius of plates for square, circle, and rectangle geometries in order to evaluate the effectiveness of plate curvature and its angle with respect to the plate on expanding speed of plates in the soil during the pullout test. In other words, since the curvature of the plates directly affects the required displacement rate, a quick expansion of the plates occurs in soil (activation of the anchor) and, subsequently increases the bearing capacity due to an increase in the optimal embedded depth. Fig. 1 shows the schematic of the proposed reinforcements for experimental tests.

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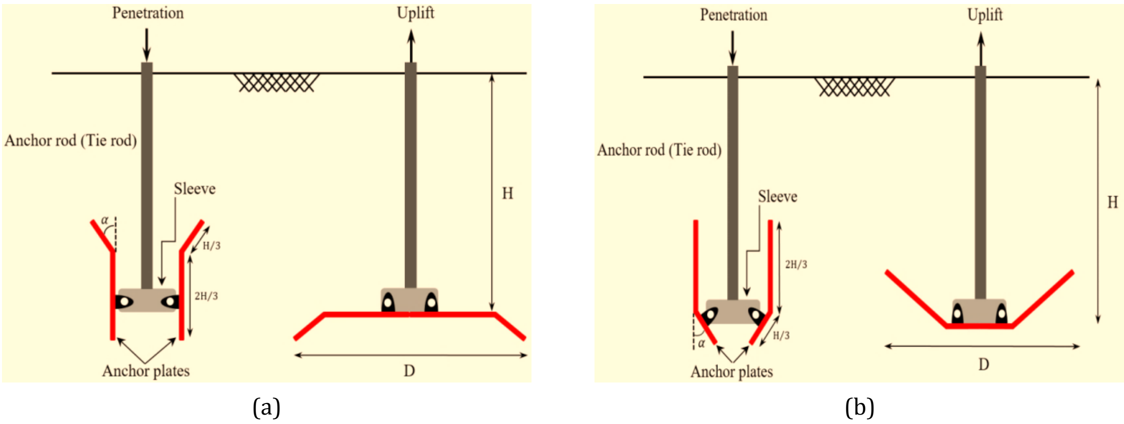

Fig. 1. Schematic cross section of anchor plates with top and down curvatures: a) Expandale plates with top curvature, b) Expandale plates with down curvature

2.2. Test chamber and loading system

A frame was made in four corners of the chamber up to 2100 mm by 100×100 mm profiles to integrate the soil chamber with the loading system.The loading system applied in these experiments was a motor-gearbox type with a 1200 mm height screw. The engine power was 1.5 hp with 1420 rpm and gearbox power was 7.5kg. In order to read the force, the screw was coupled to load cell from the bottom and the load cell also was connected to anchor rod. The vertical displacement of the anchor rod inside the soil was defined as 1 m. The system of data acquisition and recording included a digital ruler with a precision of 0.1 mm and a load cell with a 3-tons bearing capacity.

2.3. Soil

The backfill soil used in all experimental tests was sandy soil collected from Sufian in East Azerbaijan Province, Iran. According to the Unified Soil Classification System (USCS), the soil is poorly graded sand (SP).

3. Test methodology

The same procedure was applied for all anchors, which included installation of the anchor rod to the sleeve, threading the anchor plates to the sleeve, penetration of the reinforcement into the soil up to 700 mm depth by 1mm/sec constant speed, and pullout of the reinforcement by the same size and speed.

4. Results and discussion

4.1. Plates with top curvatures

The results of uplift tests on EMPLAs 1 to 4 are shown in Fig. 2.

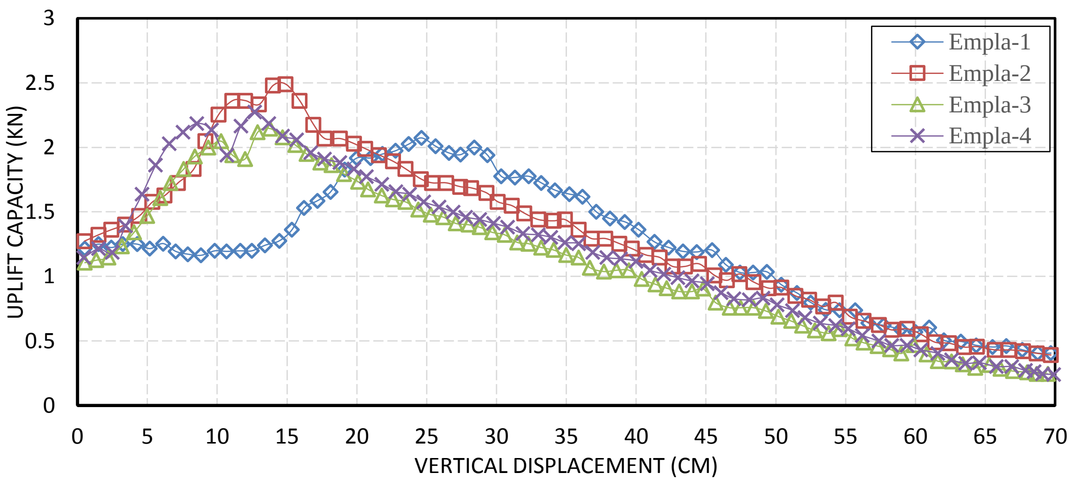

Fig. 2. Uplift results of EMPLAs 1 to 4

4.2. Plates with down curvatures

The results of uplift tests performed on EMPLAs 5 to 7 (plates with down curvature) are shown in Fig. 3.

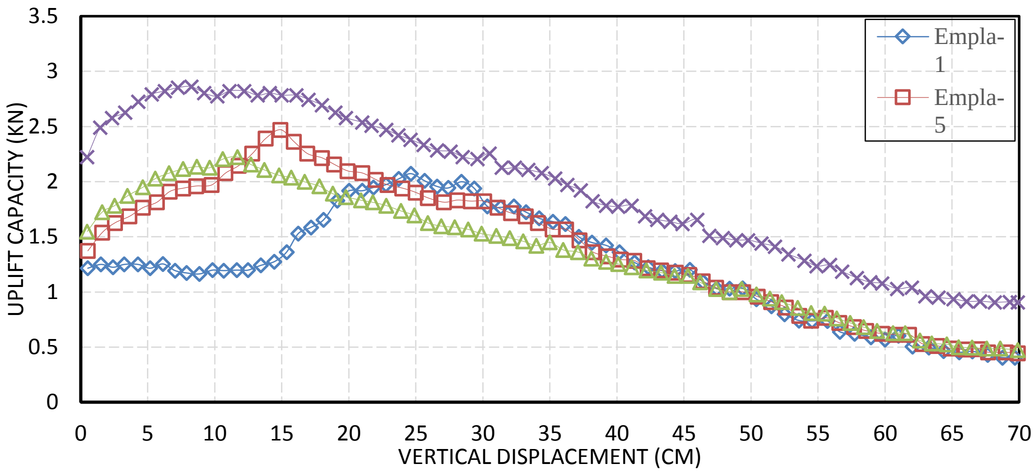

Fig. 3. Uplift results of EMPLAs 1 and 5 to 7

5. Conclusion

The main results of this study can be outlined as follows:

- The curvature of the plates has a great influence on the locking speed and activation of the reinforcements. In the plates with top curvature, an increase in the curvature of the plates has a positive effect on final bearing capacity due to an increase in the speed of plate expansion and embedded depth of reinforcement. In comparison, it has a negative and destructive effect on final bearing capacity due to an increase in the escape of effective soil mass over the plates. So, based on the experimental test results, the most optimal angle of curvature is 15°.
- In the plates with down curvature, an increase in curvature of the plate directly affects the increase in bearing capacity due to an increase in the expansion speed of plates, activation speed of reinforcement and its embedded depth, and a decrease in the escape of soil particles over the plates. The most optimal angle of curvature in laboratory tests for these anchors is 45°, which results in a decrease in the escape of the soil over the plates.
- Circular, square, and rectangular anchors presented the maximum to minimum bearing capacity, in the order of their appearance. The rectangular shaped anchors showed the worst performance in bearing capacity, expansion and locking speed, and degradation potential in comparison to other two shapes; therefore, they are not suggested to use.

6. References

DAS BM, Shukla SK, “Earth anchors”, Journal of Ross Publishing, 2013.

Moghadam MJ, Zad A, Mehrannia N, Dastaran N, “Experimental evaluation of mechanically stabilized earth walls with recycled crumb rubbers”, Journal of Rock Mechanics and Geotechnical Engineering, 2018a, 10, 947-957.

Randolph M, Gourvenec S, White D, Cassidy M, “Offshore geotechnical engineering”, Spon Press New York, 2011.