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Experimental evaluation of back-to-back anchored walls by plate anchors

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ABSTRACT: The implementation of -anchored by anchor plates- retaining walls, is one of the most commonly used methods of stabilizing the embankments. Also, Back-to-Back Mechanically Stabilized earth walls (BBMSEW) is one of the types of so-called "mechanically stabilized earth walls with complex geometry", whereas their usages, has been less the subject of researches. So far, no special research has been done to investigate and analyze the behavior of anchored back-to-back retaining walls with anchor plates under the load of shallow foundations and the behavior and interaction of two walls with each other and the interaction of sliding surfaces of two walls and sliding surfaces of shear failure of subsurface soil. Since the effect of the interaction of two back-to-back walls with each other and the loading plate(shallow foundation model) with two walls due to the interference of their failure surfaces, strongly affects the foundation bearing capacity and stability of walls, so in this article by physical modeling, The effect of horizontal distance between two walls, dimensions of loading plate (shallow foundation model) on stability, foundation bearing capacity, yield stress, soil failure model under foundations and behind the walls have been investigated and analyzed. In order to survey the shape, form and how the slip failure curves of the embankment behind the walls intersect, the Particles Image Velocimetry (PIV) technique has been used. The results show that the effective distance between the two back-to-back retaining walls anchored by anchor plates is about 2.5 times of their height. Also, the dimensions of the loading plate will affect the bearing capacity and the interference of the shear failure surfaces of the soil under the foundation and the slip failure surfaces of the walls. The results showed the effective breadth of the loading-plate is about equal to walls height. Finally, back-to-back anchored by anchor plates retaining walls in widths longer than 2.5 times of their height or shallow foundation greater wider than their height can be designed and analyzed individually.

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1- Introduction

The FHWA-NHI-10-024 Code devotes its sixth chapter to the design and construction of mechanically stabilized earth walls and reinforced soil slopes to this kind of wall. According to this Code, if the distance between two walls is more than the value of (H.tan(45-φ/2)) (H is the height of each wall and φ the angle of soil internal friction), the back-to-back walls are far enough far from each other and can be analyzed and designed without interfering the active and reinforcement zones. This distance was introduced as the Effective Distance [1].

In this study, the effect of horizontal distance between two walls, dimensions of loading plate (shallow foundation model) on stability, foundation bearing capacity, yield stress, soil failure model under foundations and behind the walls have been investigated and analyzed.

2- Methodology

In order to make laboratory samples and based on the explanations provided in the dimensional analysis section, a chamber 170 cm long, 50 cm wide and 80 cm deep was built. The larger amount of chamber length and depth was due to prevent the occurrence of boundary effects on the test results and the width of the chamber was selected 50 cm, equal to the length of the wall, to ensure the complete establishment of plane strain conditions [2, 3].

Using a Galaxy S8 camera with a charge-coupled device (CCD) sensor and 10-megapixel shooting power, the walls were photographed at the end of each loading step, and then the displacement of soil particles was determined using PIV (Particle Image Velocimetry) analysis method between consecutive images. Figure 1 shows the test chamber, loading system and performed instrumentation along with the dimensions and location of plate anchors.

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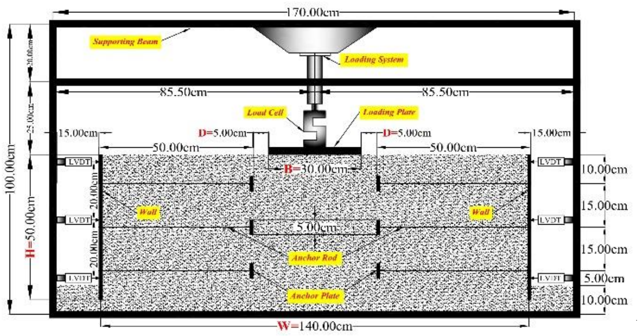

Fig. 1. The schematic shape of the modeling apparatus

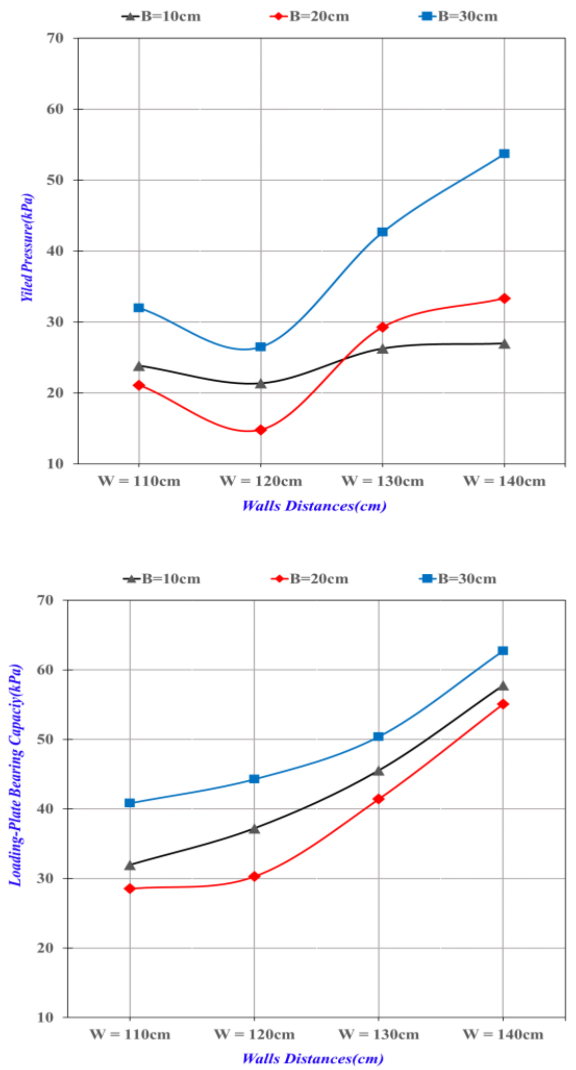

Fig. 2. Loading plates yield pressure and bearing capacity with different walls displacement

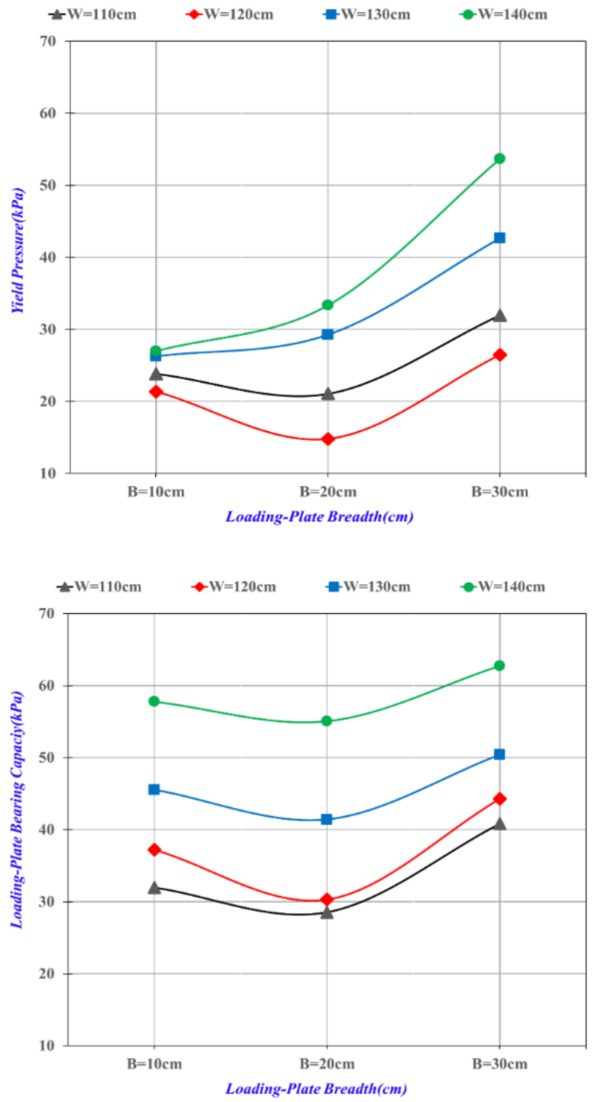

Fig. 3. Loading plates yield pressure & bearing capacity with different width

3- Results and Discussion

3- 1- Influence of walls distances

Increasing the distance of BBMSE anchored walls (W) -loaded by the limited-breadth shallow foundation- leads to an increase in shallow foundation yield stress and bearing capacity and walls horizontal displacements (Figure 2)

3- 2- Influence of Loading-Plate breadth

Increasing the breadth of shallow foundation (B) of -loading two BBMSE anchored walls- causes to increase its yield stress, bearing capacity and walls horizontal displacements (Figure 3).

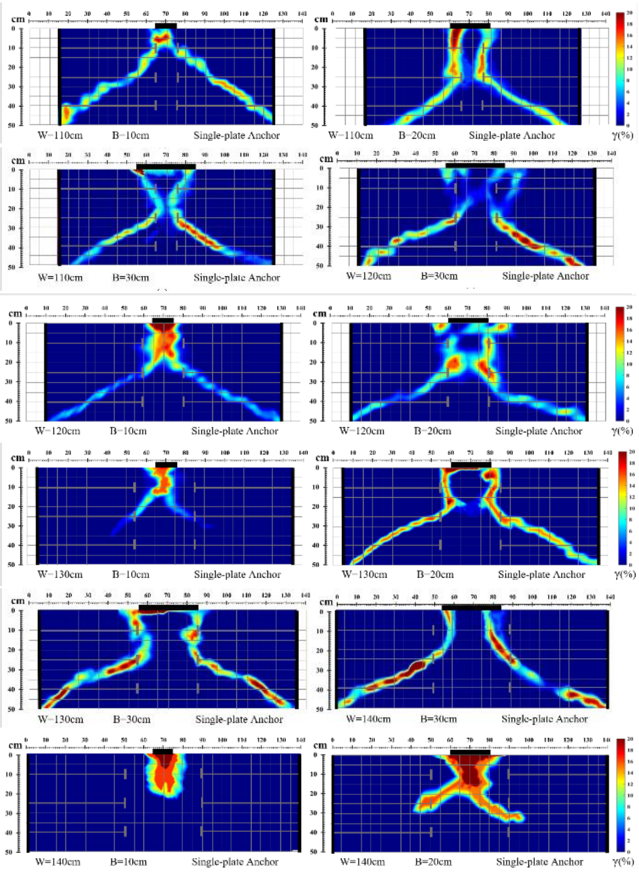

Fig. 4. PIV contours of shear strains in % (compound failure wedges)

3- 3- PIV results

During each test, consecutive photos were taken from the backfill surface during deformation by a digital camera and soil deformations were evaluated between each pair of photos through the PIV analysis (Figure 4) [4].

In this compound system of two BBMSE anchored walls loaded by a shallow foundation, there are two slip failure surfaces of walls and one shear failure surface of shallow foundation will occur. The formation of each of them and its interaction with others can lead to different failure behavior and different form of the composite failure surface. From the theoretical point of view, there are two composite modes of interferences and failure as a result of that;

Mode I; The first mode is the interference of one side of the loading-plate shear surface with that sidewall slip failure surface that cause to form of a new compound and superposed surface that is called "*Composite Failure Surface*" since now.

Mode II; The second mode is interference and superposes of the two composite failure surfaces (mode I.) of walls. It should be noted that Mode II just when happens that Mode I happened before. Otherwise, Mode II. is meaningless.

4- Conclusions

The effective distance is W/H=2.5 (H= height of back-to-back walls) and for longer distances, the walls composite failure surfaces do not interact with each other and can be analyzed and designed individually.

The effective breadth is B=H (H= height of back-to-back walls) and for this breadth and wider foundations, the walls composite failure surfaces do not interfere each other and can be analyzed and design singularly.

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