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Investigation of Maximum Active Pressure and Accelerated of Retaining Wall under Dynamic Load

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ABSTRACT: The design of the retaining wall requires a complete examination of the wall in static and dynamic conditions. The movement of the wall can be very effective in the analysis and design of the wall. In this paper, numerically and using the ABAQUS/CAE finite element software, seismic performance of the suspended wall under harmonic loading, and under resonant frequency conditions for various factors has been investigated. In this research, various variables, including substrate profile, type of backfill, geometry and wall dimensions, and acceleration and vibration frequency have been investigated. The results of this study indicate that with increasing wall height and denting density, vertical stress and mean of maximum absorbed acceleration decrease, which can be considered in the economic design of the wall.

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1. INTRODUCTION

A retaining wall is a structure that holds or retains soil behind it. There are many types of materials that can be used to create retaining walls like concrete blocks, poured concrete, treated timbers, rocks or boulders. Some are easy to use, others have a shorter life span, but all can retain soil [1]. Seismic designs of geotechnical earth structures, such as slopes, retaining walls, embankments, and dams, are conducted routinely using a pseudo-static approach [2, 3]. The Mononobe (1924) and Okabe (1924) approach for retaining wall design, is the most well-known pseudo-static procedures. It is considered an earth pressure approach where the solution is obtained by extending Coulomb's analysis [4, 5]. Bonaparte et al. (1986) proposed a pseudo-static limit equilibrium approach for designing reinforced slopes. The geosynthetics length and strength required to resist these failure modes were presented in several design chart. This approach does not consider permanent displacement [6, 7]. Ling et al. (1997) conducted a seismic design for designing geosynthetics-reinforced slopes base on a pseudo-static limit equilibrium analysis, which considers horizontal acceleration and incorporates a permanent displacement limit. Internal and external stability analysis conducted to determine the required strength and length of geosynthetics, considering different modes of failure [8, 9]. In this research, using numerical methods using ABAQUS finite element software, the response of concrete rigid walls under harmonic load is investigated. The relationship between the maximum vertical stress and the mean of the average maximum absorbed acceleration of the backfill (part of the backfill located in contact with the back of the wall) due to dynamic loading is investigated. The effects of different factors, including loading frequency, wall geometry, physical and mechanical characteristics of the embankment, and the bottom soil have been evaluated.

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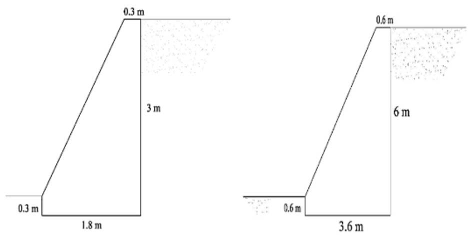

Fig. 1. Geometry and wall dimensions

2. METHODOLOGY

The height of the wall of 3 and 6 meters and their geometry details are shown in Figure 1. In this research, the backfill is considered as sandy granular and unsaturated (with natural or dry moisture content) Table 1.

For land types 1 to 4 in accordance with the 2800 regulations (fourth edition). The site classification criterion in the 2800 regulations is the soil profile, layering, and shear wave velocity up to a depth of 30 meters. The underground

Table 1. Characteristic of the backfill

Dense Sand B3	Medium Sand B2	Loose Sand B1	unit	Characteristic
1900	1800	1700	kg/m^3	Special Weight
35	30	25	degree	friction angle
0	0	0	kPa	cohesion
50	30	10	Mpa	Modulus of elasticity
0.35	0.3	0.25	-	Poisson ratio
10	5	2	degree	Angle of expansion
400	250	125	m/s	Shear wave speed

Table 2. Characteristic of the foundation

F4	F3	F2	F1	unit	Characteristic
1700	1800	2000	2200	kg/m^3	Special Weight
25	30	35	45	degree	friction angle
0	0	0	0	kPa	cohesion
20	30	40	80	Mpa	Modulus of elasticity
0.45	0.4	0.35	0.3	-	Poisson ratio
2	5	7	10	degree	Angle of expansion
125	275	565	850	m/s	Shear wave speed

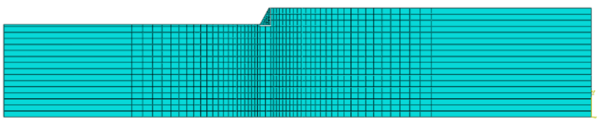

Fig. 2. Meshed model

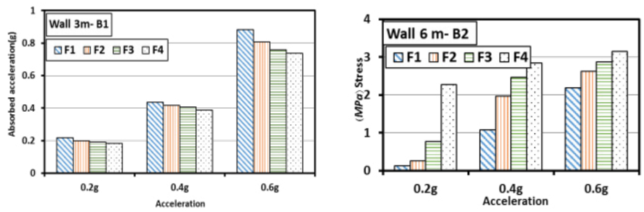

Fig. 3. The effect of foundation on the average absorbed acceleration and maximum vertical stress

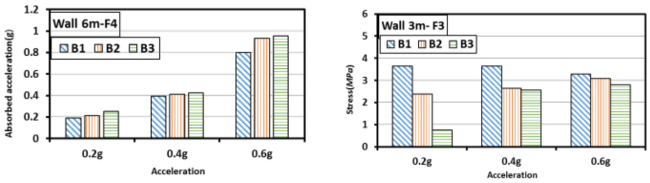

Fig. 4. The effect of backfill on the average absorbed acceleration and maximum vertical stress

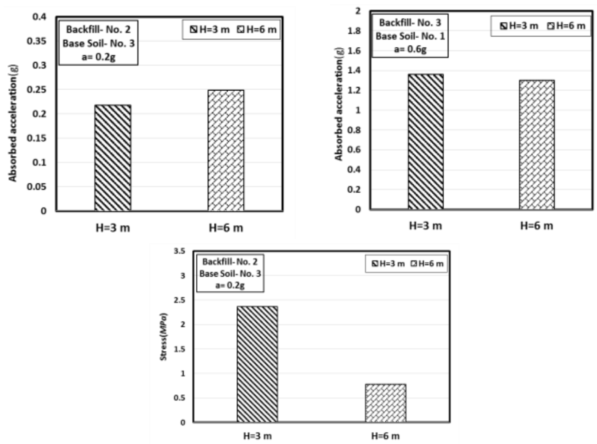

Fig. 5. The effect of height on the average absorbed acceleration and maximum vertical stress

water table is assumed to be deep down, and the soil layer is considered to be an unsaturated wall surface Table 2. In this study, the critical average damping of the soil is considered to be 5%.

Soil environment is considered homogeneous, half infinite, and matched. Also, the elastoplastic model was used to simulate the soil environment based on Mohr-Coulomb rupture criterion. Contact interfaces have been used for interaction between the soil and the wall. In this research, a dynamic absorbing boundary has been used to prevent the propagation of waves. The load is applied as a sinusoidal harmonic with 12 cycles, and at the fundamental frequency of the soil and wall system (the first natural frequency) with accelerations of 0.2g, 0.4g and 0.6g applied to the bottom model. In Figure 2, the meshed model is shown.

In the following, the effect of different parameters on the maximum vertical stress and average maximum absorbed acceleration of backfill are presented.

3. RESULTS AND DISCUSSION

The higher the density of the soil in the site, the lower the maximum vertical stress on the wall. By changing the soil profile and increasing soil bed density, the mean value of the average maximum absorbed acceleration increases Figure 3.

By changing the mechanical properties of the embankment, including increased density, internal friction, and hardness, the average maximum acceleration is increased and the maximum vertical stress decreases Figure 4.

As you can see, with increasing loading acceleration, the average maximum acceleration is increased. Under the basic vibration of the system, the height and dimensions of the wall do not have a clear trend in the mean of maximum absorbed acceleration. As the wall height increases, the maximum vertical wall stress decreases Figure 5.

4. CONCLUSION

In this study, the effect of type and physical characteristics and soil mechanics on the substrate and embankment as well as the geometry of the retaining wall on the mean absorbed maximum acceleration and the maximum vertical wall stress in different conditions of seismic acceleration by numerical method were investigated. The numerical models were analyzed for sinusoidal harmonic loading at the fundamental frequency of the model (natural frequency of the first mode). The results of this research are summarized as follows.

• Increasing the density of soil around the wall (backfill and foundation), followed by increasing density and hardness, the average maximum acceleration absorbed by the part of the backfill that is in contact with the back of the wall increases.

• With increasing soil density around the wall (backfill and foundation) due to the increased hardness of the soil, the wall shows a good resistance to the forces involved and creates a lower stress in the wall.

• By increasing the wall height, the vertical stresses generated in the model are reduced. The increase in wall height does not have a significant effect on the average maximum absorbed acceleration.

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