Seismic Analysis of Retaining Wall – A review

Swapnil Navgrahe[1], Prof. Deepak Sukheja[2]
[1, 2] Department Of Civil Engineering
[1, 2] Oriental University, Indore, Madhya Pradesh, India

Abstract- *Structures which are used to hold back a soil mass are called retaining structures. This project is concern with seismic analysis and design retaining wall. Retaining walls are the structures designed to restrain soil to unnatural slopes. They are used to bound soils between two different elevations in areas of terrain possessing undesirable slopes. They are also used in areas where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway overpasses. They are also used in bridge abutments and wing walls. The design of structures like retaining wall requires the knowledge of the earth pressure acting on the back of the wall because of the soil backfill in contact with it. Hence relation between the earth pressure on the retaining wall and strains within a backfill is a prerequisite.*

Keywords- seismic, analysis retaining, wall

I. INTRODUCTION

A soil mass is stable when the slope of the surface of the soil mass is flatter than the safe slope. At some locations where the space is limited, it is not possible to provide flat slope and the soil is to be retained at a slope steeper than the surface one. In such cases, a retaining structure is required to provide lateral support to the soil mass. Retaining walls are relatively rigid walls used for supporting the soil mass laterally so that the soil can be retained at different levels on the two sides.

The available literature data consistently shows that for the height of structures considered herein, i.e. in the range of 20-30 ft, the maximum dynamic earth pressure increases with depth and can be reasonably approximated by a triangular distribution This suggests that the point of application of the resultant force of the dynamic earth pressure increment is approximately 1/3H above the base of the wall as opposed to 0.5-0.6 H recommended by most current design procedures. In general, the magnitude of the observed seismic earth pressures depends on the magnitude and intensity of shaking, the density of the backfill soil, and the type of the retaining structures. The computed values of seismic earth pressure coefficient (ΔKae) back calculated from the centrifuge data at the time of maximum dynamic wall moment suggest that for free standing cantilever retaining structures seismic earth pressures can be neglected at accelerations below 0.4 g. While similar conclusions and recommendations were made by Seed and Whitman (1970), their approach assumed that a wall designed to a reasonable static factor of safety should be able to resist seismic loads up 0.3 g. In the past study, experimental data suggest that seismic loads up to 0.4 g could be resisted by cantilever walls designed to an adequate factor of safety. This observation is consistent with the observations and analyses performed by Clough and Fragaszy (1977) and Fragaszy and Clough (1980) and Al-Atik and Sitar (2010) who concluded that conventionally designed cantilever walls with granular backfill could be reasonably expected to resist seismic loads at accelerations up to 0.4 g.

Since the pioneering work of Mononobe and Matsuo (1929) and analytical work of Okabe (1926), there have been numerous experimental, analytical and numerical studies of the dynamic behavior of retaining walls in order to provide a methodology for rational design. The different approaches used to study dynamic earth pressures can be divided into analytical, numerical, and experimental methods. While a vast amount of literature exists on the topic of seismically induced lateral earth pressures, this chapter summarizes previous research performed highlighting only selected works of relevance to this study.

II. ANALYTICAL METHODS

Following the great Kanto Earthquake of 1923 in Japan, Mononobe and Matsuo (1929) performed a series of highly original experiments using a shaking table. Their original shaking table design consisted of a rigid base box mounted on rails and driven with an ingenious conical drum winch connected through a crankshaft to the base of the This arrangement allowed for simple application of sinusoidal excitation with linearly varying frequency, i.e. a frequency sweep. The ends of the box were trap doors, spring mounted at the base, with pressure gauges mounted at the top to measure the load as the “wall” tilted outward. As shown in the figure, the box dimensions were 9 ft long, 4 ft wide and 4 ft deep, with one door, door A, spanning the whole width of the box and the other door, door B, spanning only one half of the width of the box. Although, the box was quite substantial in size, the depth of the medium dense sand fill was only 4 ft and the sides of the box were rigid.

The results of these experiments and Okabe's (1926) and analytical work then led to the development of what is now often referred to as the Mononobe-Okabe (M-O) method. This methodology was originally developed for gravity walls retaining cohesionless backfill materials, however, since then it has been extended to a full range of different soil properties. The method is an extension of Coulomb's sliding wedge theory and for active conditions the M-O analysis incorporates the following assumptions:

1. The backfill soil is dry, cohesion less, isotropic, homogenous and elastically undeformable material with a constant internal friction angle.
2. The wall is long enough to make the end effect negligible.
3. The wall yields sufficiently to mobilize the full shear strength of the backfill along potential sliding surface and produce minimum active pressures.
4. The potential failure surface in the backfill is a plane that goes through the heel of the wall.

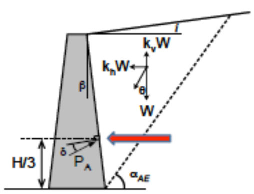

Figure 1. Coulomb's sliding wedge theory

A recent alternative to the M-O method for plastic soils was developed by Mylonakis et al. (2007). They proposed a closed-form stress plasticity solution for gravitational and earthquake-induced earth pressures on retaining walls. The presented solution is essentially an approximate yield-line approach, based on the theory of discontinuous stress fields, and takes into account the following parameters: (1) weight and friction angle of the soil material, (2) wall inclination, (3) backfill inclination, (4) wall roughness, (5) surcharge at soil surface, and (6) horizontal and vertical seismic acceleration. Both active and passive conditions are considered by means of different inclinations of the stress characteristics in the backfill.

Wood (1973) used elastic and elastic wave propagation theories to develop solutions for an elastic soil stratum on a rigid base with a rigid wall under various forcing conditions. For a perfectly rigid wall, supporting a relatively long layer of soil, he determined that the earthquake force component computed was likely to be greater than twice that estimated by M-O method. Identical horizontal earthquake coefficients kh were used in the computation. It was thus recommended that for rigid wall embedded in rock or very firm soil, restrained by piles or deeply buried, an elastic analysis should be used instead of the M-O method (Building Seismic Safety Council, 2010). Wood established that the dynamic amplification was insignificant for relatively low-frequency ground motions (i.e., motions at less than half of the natural frequency of the unconstrained backfill), which would include many earthquake problems. The point of application of the dynamic thrust is taken typically at a height of 0.6H above the base of the wall. It should be noted that the model used by Wood (1973) does not incorporate any effect of the inertial response of a superstructure connected to the top of the wall (Building Seismic Safety Council, 2010). This effect may modify the interaction between the soil and the wall and thus modify the pressures from those calculated assuming a rigid wall on a rigid base Although the study performed by Wood included dynamic analysis of a rigid wall with fixed base condition, the solution commonly used and presented in Equations 2.7 and 2.8 is based on static "1g" loading of the soil and wall and does not include the effects of the wave propagation in the soil.

REFERENCES

[1] Aitken, G.H. (1982). Seismic Response of Retaining Walls, MS Thesis, University of Canterbury, Christchurch, New Zealand.

[2] Al-Atik, L. and Sitar, N. (2010), "Seismic Earth Pressures on Cantilever Retaining Structures," Journal of Geotechnical and Geoenvironmental Engineering, October, (136) 10, pp. 1324-1333.

[3] Clough, G.W. and Fragaszy, R.F. (1977). "A Study of Earth Loadings on Floodway Retaining Structures in the 1971 San Fernando Valley Earthquake," Proceedings of the Sixth World Conference on Earthquake Engineering, Vol. 3.

[4] Coulomb, CA. "Foundation Analysis and Design, Fifth Edition, McGraw-Hill, New York," Memoires de I'Academie Royale pres Divers Savants, Vol. 7, 1776