Formulation of Seismic Passive Resistance of Retaining Wall Backfilled with c-Φ Soil

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ABSTRACT

Knowledge of passive resistance is extremely important and it is the basic data required for the design of geotechnical structures like the retaining wall moving towards the backfill, the foundations, the anchors etc. An attempt is made to develop a formulation for the evolution of seismic passive resistance of a retaining wall supporting c-Φ backfill using pseudo-static method. Considering a planar rupture surface, the formulation is developed in such a way so that a single critical wedge surface is generated. The variation of seismic passive earth pressure coefficient are studied for wide range of variation of parameters like angle of internal friction, angle of wall friction, cohesion, adhesion, surcharge, unit weight of the backfill material, height and seismic coefficients.

Keywords: c-Φ Backfill, Pseudo-Static, Rigid Retaining Wall, Seismic Passive Resistance, Single Wedge

1. INTRODUCTION

Computation of passive resistance is extremely important and the level of importance of the passive earth pressure increases many fold under earthquake conditions due to the devastating effects of earthquake. Hence to analyze the retaining wall under passive condition for both under the static and seismic conditions, the basic theory is very complex and the several researchers have discussed on this topic. Initially Okabe (1926) and Mononobe and Matsuo (1929) had proposed the theory to compute the pseudo-static lateral earth pressure on the wall, which is commonly known as the Mononobe-Okabe method (Kramer, 1996). Based on the classical limit equilibrium theory, this method is a direct modification of the Coulomb wedge method where the earthquake effects are replaced by a quasi-static inertia forces, whose magnitude is computed with seismic coefficient concept. Again, by using the approximate method based on modified shear beam model Wu and Finn (1999) developed charts for seismic thrusts against rigid walls. Psarropoulos et al. (2005) have developed a general finite element solution for analyzing the distribution of dynamic earth pressures on rigid and flexible walls. Davies et al. (1986), Morrison and Ebeling (1995), Soubra (2000), and Kumar (2001) to name a few had analyzed the seismic passive earth pressure problems. All the analyses as mentioned are for
Φ backfill. Subba Rao and Choudhury (2005) had given a solution for seismic passive earth pressure supporting c-Φ backfill in such a way that they are getting separate critical wedge surfaces and separate coefficients for unit weight, surcharge and cohesion. But from practical point of view, this fact is not true, as for the simultaneous action of unit weight, surcharge and cohesion, we will get single failure surface. Keeping this fact in mind, here an attempt is made to develop a formulation for the seismic passive resistance on the back of a retaining wall supporting c-Φ backfill in such a way that a single failure wedge is developed. A planar rupture surface is considered in that analysis to extend the Mononobe-Okabe concept for c-Φ backfill.

2. METHOD OF ANALYSIS FOR SEISMIC PASSIVE RESISTANCE

Consider a rigid retaining wall of height H supporting c-Φ backfill of unit weight γ, the planar triangular wedge surface ABD of which is inclined at an angle θ with the vertical. If c_a is the unit adhesion, c is the unit cohesion, δ is the angle of wall friction, k_h and k_v are the seismic acceleration coefficients then the forces acting on the wedge surface during passive state of equilibrium are shown in Figure 1. P_p and R are the passive resistance and reactive force due to retained backfill respectively.

Applying the force equilibrium conditions, \( \sum H = 0 \) and \( \sum V = 0 \),

\[
P_p \cos \delta + (W + Q)k_h - C \sin \theta - R \cos (\theta - \phi) = 0
\]

(1)

\[
P_p \sin \delta + (W + Q)(1 \pm k_v) + C_a + C \cos \theta - R \sin (\theta - \phi) = 0
\]

(2)

Solving Equation 1 and 2 and putting \( W = (\gamma H \tan \theta)/2, Q = qH \tan \theta, C = cH \sec \theta, C_a = c_a H, \psi = \tan^{-1}(k_h/(1 \pm k_v)) \) we get Equation 3, shown in Box 1.

Substituting,

\[
\frac{2c}{(\gamma H + 2q)(1 \pm k_v)} = n_c
\]

and

\[
\frac{2c_a}{(\gamma H + 2q)(1 \pm k_v)} = m_c,
\]

the above equation reduces to equations 4-6, shown in Box 2.
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