1. INTRODUCTION

A soil mass is stable when the slope of the surface of soil mass is flatter than the safe slope which is known as angle of repose. When the space is limited, it is not possible to provide a flat slope and therefore, one has to provide a lateral support to that soil mass, which is known as “Retaining Wall”. In the seismic zones, the retaining walls are subjected to dynamic earth pressure, the magnitude of which is more than the static earth pressure due to ground motion. A very first attempt of the determination of seismic active earth pressure was made by Mononobe and Matsuo (1926) and Okabe (1924) which is commonly known as Mononobe-Okabe (1929) approach. In this well-recognized methodology, seismic forces are introduced as static inertia forces acting at the c.g. of the backfill system. Therefore, this method is known as pseudo-static method. The same concept has been extended by Prakash and Saran (1966) and Saran and Prakash (1968) for the determination of total (static plus dynamic) earth pressure for a c-Φ backfill considering horizontal backfill surface and horizontal seismic coefficient only. The same concept has again been extended
by Saran and Gupta (2003), Ghosh and Saran (2007) and Ghosh et al. (2008) to obtain the dynamic active earth pressure for a $c$-$\Phi$ soil considering inclined backfill surface and both horizontal and vertical seismic coefficients into account. Shukla et al. (2009), Ghosh (2010a) and Sharma and Ghosh (2010) have simplified the solution for seismic active earth pressure with some modification in the earlier assumptions. Steedman and Zeng (1990) was first to introduce pseudo-dynamic method. This pseudo-dynamic method has been extended by Choudhury and Nimbalkar (2005, 2006), Ghosh (2007, 2008), and Ghosh (2010b) to consider the different parameters of retaining wall for $\Phi$ backfill under seismic loading condition. This concept has further been extended by Ghosh and Sharma (2010) to get the seismic active earth pressure supporting $c$-$\Phi$ backfill.

The methods as mentioned above are analytical methods. Culmann (1866) was first to introduce concept of force polygon to evaluate active and passive earth pressure on the back of a retaining wall under static loading condition. Culmann (1866) was extended by Kapila (1962) for the evaluation of seismic active and passive earth pressure on the back of a retaining wall supporting $\Phi$ backfill. Till date this force polygon concept to be introduced for the evaluation of seismic earth pressures on the back of a retaining wall supporting $c$-$\Phi$ backfill. Therefore, here an attempt is made to extend the force polygon concept to determine the seismic active earth pressure on the back of a retaining wall supporting $c$-$\Phi$ backfill.

2. GRAPHICAL REPRESENTATION OF ACTIVE EARTH PRESSURE FOR C-$\Phi$ SOIL

The graphical representation of the seismic active earth pressure is done under following sections:

2.1. Retaining Wall-Backfill System Under Seismic Loading Condition

Let us consider a rigid retaining wall of height $H$ the backfill face of which is inclined at an angle $\alpha$ with the vertical supporting $c$-$\Phi$ homogeneous backfill the top surface of which is inclined at an angle $i$ with the horizontal. Under the seismic loading condition of seismic acceleration $\alpha_h$ and $\alpha_v$, during active state if the wedge surface makes an angle $\theta$ with the vertical then the various forces acting on wedge system to keep it in equilibrium are shown in Figure 1.

In this case, it is also considered that in case of cohesive soils, tension cracks may develop in the soil near the top of the wall. The resistance of this soil whose outer side is vertical against movement is neglected and its weight is considered to act at the centre of gravity of the wedge, combined to the weight of the wedge considering that the bottom level of the cracked surface is parallel to the backfill surface.

2.2. Calculation of Weight of Wedge, Weight of Cracked Zone, Surcharge Load, Cohesion and Adhesion

From the geometry of Figure 1, the calculation of weight of wedge, weight of cracked zone, surcharge load, cohesion and adhesion are as follows:

Weight of wedge ($W_1$) =
$$\frac{\gamma H_i^2 \sec^2 \alpha \sin(\alpha + \theta) \cos(\alpha - i) \cos(\theta + i)}{2 \cos(\theta + i) \cos(\alpha + \theta)}$$

(1)

Weight of cracked zone ($W_2$) =
$$\frac{\gamma n H_i^2 \sin(\alpha + \theta) + \gamma n^2 H_i^2 \sin \alpha \cos(\alpha - i)}{\cos^2 \alpha \cos(\theta + i)} + \frac{\gamma n^2 \sin \alpha \cos(\alpha - i)}{2 \cos^2 \alpha \cos i}$$

(2)

Surcharge load ($Q$) =
$$qH_i \sec \alpha \left[ n \sin \alpha \sec i + \frac{\sin(\alpha + \theta)}{\cos(\theta + i)} \right]$$

(3)
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