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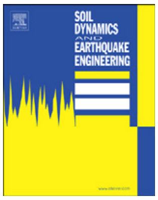

Interpretation of dynamic retaining wall model tests in light of elastic and plastic solutions

Christos Giarlelis*, George Mylonakis

Department of Civil Engineering, University of Patras, 26500 Rio, Greece

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ABSTRACT

The dynamic response of rigid and flexible walls retaining dry cohesionless soil is examined in light of experimental results and analytical elastodynamic and limit analysis solutions. Following a brief review of the problem, experimental findings from three different testing programs on retaining walls are presented, and compared with theoretical predictions based on the above-mentioned approaches. Reasonable agreement is found depending on the assumptions. It is shown that wall flexibility – which is not taken into account in classical design approaches – should be considered to establish the point of application of seismic thrust on the wall. Detailed calculations and set of graphs and charts are presented, which highlight salient aspects of the problem.

1. Background

Despite extensive research carried out over the years, the dynamic behavior of retaining structures is far from being well understood. Significant unresolved issues, both of practical and theoretical nature persist, which appear to have impeded advances in design methods and seismic regulations. These include: (1) dependence of soil thrust on magnitude of earthquake acceleration; (2) importance of wall kinematics on the distribution of earth pressures; (3) importance of the dynamics of the backfill; (4) description of boundary condition pertaining to wave radiation away from the wall; (5) role of pore water pressure and associated loss of strength behind and under the wall; (6) importance of pre-existing and stress-induced inhomogeneities in the soil; (7) influence of construction processes on the above. Evidence of a lack of understanding comes from post-earthquake investigations (notably in Kobe [1] and Chi-Chi [2]) which have reported extensive damage on a number of retaining structures, which were thought to have been properly designed against seismic action.

Past analyses of dynamic response of earth-retaining systems can be roughly classified into two main groups: (a) limit-state analyses, in which the wall is considered to displace and/or rotate sufficiently at the base to fully mobilize the shearing strength of the backfill and (b) elastic analyses, in which the wall is considered to be fixed at the base, while the backfill is presumed to respond in a linearly elastic or viscoelastic manner. Representatives of the first group is the classical Mononobe–Okabe (M–O) approach [3,4] and its variants (Seed and Whitman [5], Richards and Elms [6], Nadim and Whitman [7], Dubrova [8]), which have found widespread acceptance in practice (e.g., ATC [9], EC-8 [10]). Representatives of the second group are the contributions of Matsuo and Ohara [11], Wood [12,13], Arias et al. [14] and Veletsos and Younan [15–19].

In a large number of reports (a list of references is available in Giarlelis [20]), results from experimental studies are presented in an effort to evaluate the predictions of theoretical analyses—mainly the ones in the first group. However, little effort has been put in interpreting experimental results in light of elastic solutions. This is potentially important as elastic solutions incorporate the effect of wall kinematics, which is missing from the limit analysis solutions. This need provided the initial motivation for the herein-reported work.

Following a review of limit-state analyses, a brief presentation is made of the available elastic solutions, especially the ones developed by Arias et al. [14] and later extended by Veletsos and Younan [15–19]. The article then focuses in comparing experimental results against the predictions of these solutions. The comparisons are carried out by means of two key parameters: (1) the magnitude of the force exerted on the wall by the soil ("base shear"); (2) the point of application of this force ("overturning moment"). It is shown that, while the estimation of these parameters under limit-state analyses is problematic – particularly regarding the point of application of the force – this is not the case with the elastic solutions. More importantly, theoretical predictions based on elastic solutions appear to compare better to experimental results than those based on limit-state analyses, as demonstrated in the ensuing.

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* Correspondence address: 9 Kariotaki, Athens 11141, Greece.
E-mail address: giarlelis@alumni.rice.edu (C. Giarlelis).

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