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The Inspection of Dimensions and Geometry of Ring Foundations on Their Dynamic Stiffness Using the Cone Model

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Abstract

To anticipate the response of a foundation to seismic excitations including earthquakes and machinery loading it is essential to have at hand the dynamic stiffness of the foundation as a component of the impedance based on the geometry of the foundation and the site soil. Different types of foundations may be investigated among which ring foundations are of observed in this paper. A typical range of ring foundations has been inspected with the Cone Model propagation of seismic waves and dynamic stiffness coefficients under a covering range of frequencies for all degrees of freedom have been calculated and compared. For indicated amounts of increase in dimension ratios results show a tendency to converge and as the frequency goes up dynamic stiffness decreases. A convergence threshold equal to 0.4 to 0.8 for dimension ratio was achieved for constant-width foundations which can serve as the upper limit for them to remain dynamically stiff enough when induced by earthquakes. For constant-outer-radii footings the threshold serves a limit of which if the dimension ratio exceeds the rocking stiffness does not reveal noticeable change although torsional stiffness drops drastically. Diagrams for comparison of the results are presented.

Keywords: seismic excitation, earthquake, impedance, ring foundation, Cone Model

1. INTRODUCTION

The importance of soil-structure interaction (SSI) effects has been growing since the effects of incident motion frequency versus the natural frequency of the structure has come into consideration and resonance possibilities have been inspected. However, in order to account well for the interactional effects and interaction forces, one of the most important factors with which calculations and modeling procedures are followed will be the dynamic stiffness coefficient of the free field and of the site, which is strictly bound to some or all factors including the form of the foundation, geotechnical properties of the site, geometry of the foundation, physical and geometrical specifications of the strata, etc. considering the method and hypotheses taken to calculate the stiffness coefficients. Cone Model is an approximate method which models the medium and wave propagation with simple hypotheses; yet the results obtained from this method are of very good accuracy which reveals the method meets engineering requirements for average projects and verifications with rigorous methods all confirm this acceptable accuracy.

The method assumes a one-dimensional model of propagation for the seismic wave whose traveling path is cone-like; as a conical bar conveying a wave through its cross section [2]. Three basic assumptions are considered to use this model to solve problems of interest: First, the Hook's law using the famous elastic-constitutive model with Young's modulus of elasticity; second, dynamic equilibrium; and third, basic equation of motion. Further derivations and expansions of the model have been carried out based on these three assumptions [2,3]. It should be noted that the Cone Model must be made use of for axisymmetric problems, hence for other types of foundations an equivalent radius must be calculated with an acceptable method to which the results should comply; the verification can then be carried out by a rigorous numerical method to ensure that the equivalent radius has been selected close to reality.

In this study, changes in dynamic stiffness of a range of ring foundations of different geometries and effects of dimension ratios on this coefficient have been studied. Ring foundations have already been studied in other aspects and with other methods too. Velestos and Tang (1986) studied vertical vibration of ring foundations with mass [1]. Egorov (1965) reviewed calculations of bed for foundations with ring footings [8]. Milovic (1973) inspected stresses and displacements produced by a ring foundation [9]. Saha (1978) had a research on ultimate bearing capacity of ring footings on sand [10]. Saran, Bhandari and Al-Samadi (2003) analyzed eccentrically-obliquely loaded ring footings on sand [11]. Boushehrian and Hataf (2003) had numerical and experimental investigations on bearing capacity of circular and ring footings on reinforced sand [12]. Kumar and Ghosh (2005) used the method of characteristics to find the bearing capacity factor $N\gamma$ for ring footings [13]. In this study, dynamic stiffness coefficient of these foundations is observed using the