*Abstract of the thesis*

# DYNAMIC RESPONSE OF BLOCK FOUNDATIONS SUBJECTED TO VIBRATIONS INDUCED BY SINGLE AND TWO ROTATING MACHINES

*by*


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# ABSTRACT

The dynamic response of the block foundation soil-oscillator system largely depends on the geotechnical characteristics of the surrounding soil, half-space parameters, and foundation geometry (shape, size, and depth of embedment). These parameters influence the stiffness of the soil-foundation system and damping characteristics. The analysis of machine foundations is carried out assuming that the foundation rests on the surface of the ground. However, in reality, foundations are usually embedded. The soil resistance is mobilized below the base and on the sides for an embedded foundation and significantly influences the dynamic response. Calculating the dynamic response of an embedded foundation supporting a machine is of great importance and has been the subject of several theoretical and experimental studies over the past eight decades or so. However, there are only guidelines available in the literature to analyze and design block foundations subjected to a single dynamic load. Experimental investigations are still carried out to date for evaluating/refining/modifying the existing theoretical solutions and improve design practices. The literature also observed relatively little field confirmation of the accuracy of commonly used design methods for the combined block foundation subjected to two dynamic loads. Thus, there is a great need to monitor the performance of prototype machine foundations.

The present study determines dynamic responses of block foundation soil-oscillator systems subjected to single and two dynamic loads. The behavior of block foundations subjected to a single dynamic load is identified under machine-induced vertical and coupled sliding and rocking vibrations in the field. Another aspect of the present study is analyzing the measured responses under different vibration modes for the combined block foundations subjected to two dynamic

loads under different machine orientations. To fulfill these objectives, dynamic vibration tests were carried out in the field on three different surface and embedded block foundations of various aspect ratios ($L/B$ = 1.0, 1.25, and 1.5) under vertical and coupled vibrations to determine the frequency-amplitude responses for various excitation forces and two static loads ($W_s$ = 6.6 kN and 8.6 kN). Another combined block foundation of aspect ratio $L/B$ = 2.5 was constructed to determine the influence of machine orientations on the overall dynamic response of the block foundation subjected to two unbalanced forces and resultant moments. The six possible machine orientations for combined block foundations in the present study are $V_Z$-$V_Z$, $V_Z$-$H_X$, $V_Z$-$H_Y$, $H_X$-$H_X$, $H_X$-$H_Y$, $H_Y$-$H_Y$. The effect of dynamic force ratio, static weight ratio, and embedment depth on the frequency amplitude response is also determined for the combined block foundations.

The numerical analyses are performed by the theories proposed by various researchers and approximate methods to determine the dynamic response of block foundations under vertical and coupled modes of vibration. The geotechnical properties obtained from the in-situ and laboratory tests are used as input parameters to determine the dynamic stiffness and damping parameters and the frequency amplitude responses for vertical and coupled vibration modes. The experimental response curves of the block foundations subjected to a single dynamic load for the vertical and coupled vibration modes are nonlinear. The response also indicates nonlinear behavior with the increasing embedment depth, resulting in increased resonant frequency and a decrease in the resonant amplitude of the block foundation system. Comparing the theoretical and experimental response curves, a variation of about 5 to 10 % in the resonant frequency is observed, whereas an overestimation of damping value is observed from the different theories for vertical and coupled modes of vibration.

The influence of machine orientation on the dynamic response curves is attributed to the vibration amplitudes obtained in the various vibration modes for a specific machine orientation. Due to the nature of the applied dynamic forces, the maximum resonant amplitudes along the translational *X*-axis, *Y*-axis, and *Z*-axis are obtained for the machine orientations $H_X$-$H_X$, $H_Y$-$H_Y$, and $V_Z$-$V_Z$. The applied dynamic forces in these orientations are additive, and due to the beating effect, the responses are canceled after some time, whereas the applied dynamic forces for the machine orientations $V_Z$-$H_X$, $V_Z$-$H_Y$, $H_X$-$H_Y$ are always out of phase and are independent of each other. The dynamic responses for the different orientations are studied and compared with the theoretical results obtained using the theories incorporated in DYNA 6 (El. Naggar et al., 2011). Finally, a comparative study is presented for the effect of machine orientation and other parameters on the dynamic response of the combined block foundation resting on the surface and embedded in the ground.

**Keywords:** Block foundation, Vertical vibration, Coupled vibration, Combined block foundation, Dynamic force ratio, Embedment depth, Excitation force, Static loads