TRANSIENT DYNAMIC RESPONSE ANALYSIS OF EMBEDDED RIGID FOUNDATIONS
(ケーソン基礎の時刻歴応答解析)

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Introduction

This paper presents the transient dynamic response analysis of embedded rigid foundations using time domain model developed by the authors(1,2). It is assumed that a number of identical rigid foundations are embedded in an elastic soil and are circular cylindrical bodies. A model with a certain mechanism similar to the Winkler model is considered for each cylindrical body in reproducing the soil-cylinder interaction as shown in Fig. 1. According to this mechanism, the soil reaction force acting at the side of the cylinder is related to the soil displacements along the horizontal plane in the medium located only at the same depth where the soil reaction is considered. The motion transmitted from the medium to the cylinder generates the support motions to account for the cylinder-medium-cylinder interaction. The motions of the rigid foundations are assumed to be either in vertical or horizontal direction, and thus the rocking motion coupled with the horizontal motion is restrained.

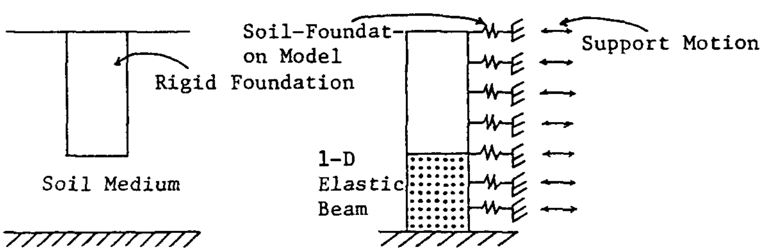

Fig.1 Idealized soil-foundation system for analysis

Dynamic Response of Rigid Foundations

Identical multiple foundation bodies and soil medium are divided into a number of horizontal slices as shown in Fig. 2 to account for inhomogenety of the soil medium and nonlinearity due to slippage at the soil-foundation interface. The time histories of external loads are digitized as shown in Fig. 3 so that the traveling time of the disturbances through the soil from one foundation body to another is longer than Δt. This results a support motion in a known quantity when the foundation responses are computed at every Δt. Thus, each of the foundation bodies can be handled as a body uncoupled from the others in the response analysis.

Under the restrainment of the rotational response, the equation of motion of each foundation body can be described for both vertical and horizontal directions as

$$M\ddot{u}(t) = -P^s(t) - P^b(t) + F(t) \qquad (1)$$

where M = mass of a rigid foundation body; P^s and P^b = soil-foundation interaction at the side and base of the foundation body, respectively; and F = external load. Digitizing the time history, P^s and P^b can be rewritten as

$$P^s = \sum_{n=1}^{N} h_n p^s_{i,n} \qquad (2)$$

and

$$P^b = K^b u_i + D^b_{i-1} \qquad (3)$$

where h_n = thickness of the nth layer; N = total number of layers in contact with the side of the foundation body; $p^s_{i,n}$ is the interaction force for both vertical and horizontal loads, and also K^b and D_{i-1} are known values at t = ti by computing from solution. Thus, after substituting Eq.2 and Eq.3 into Eq.1, Eq.1 contains only one unknown u_i to be solved.

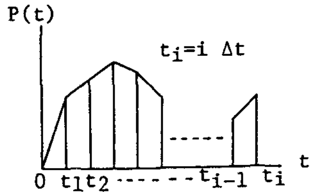

Fig.2 Piecewise linear variation of force with time。

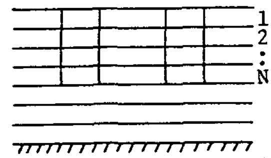

Fig.3 Multiple foundation in soil divided by horizontal slices。

Numerical Examples

In order to demonstrate the present approach, the response of the three embedded rigid foundations are computed for identical impulse load simultaneously applied to the foundations. The conditions considered for the foundation and an impulse loads time history are shown in Fig.4. The computed results are presented in Fig.5, in which dots correspond to the displacements computed for a single foundation or computed for a foundation group neglecting the excitation coming through the soil. As is seen, the responses of the foundation bodies start to diverge from that of the single foundation as soon as the waves generated by the foundation responses without properly considering the exitations coming through the soil from neighboring foundations.

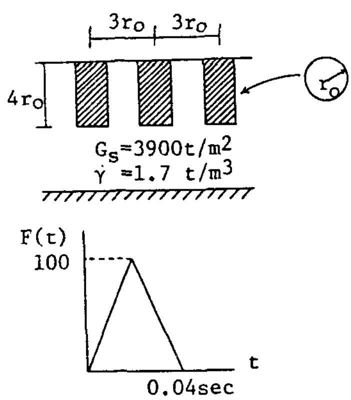

Fig.4 Conditions considered for the first numerical example.

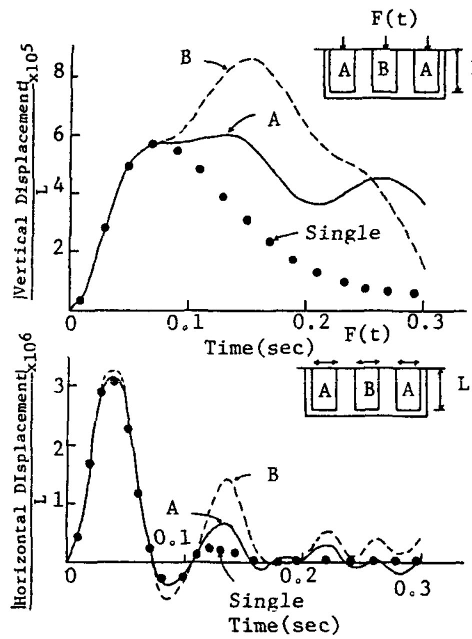

Fig.5 Response of foundation simultaneous-subjected to identical impulse load。

Conclusion

An analytical method for the dynamic transient responses of embedded rigid foundation group is introduced utilizing the Winkler's hypothesis. The method is based on the time-domain approach which results in each foundation body decoupled from others in the analysis. The motions coming through the soil from the neighboring foundation bodies are treated as motions provided at the support of the soil-foundation interaction model. Those motions are known quantities when the digitized time interval is smaller than the time required for the waves to travel from one foundation body to others. It is comfirmed that the method presented herein is efficient and can accomodate the nonlinear mechanism in a logical manner.

References (1) Nogami,T. et al 'Time-Domain Dynamic Response of Nonlinear Pile Foundations' IMR Report No.87-4 IMR, University of California,1987.(2) Otani,J. et al 'Nonlinear Analytical Model for Pile Group under Dynamic Transient Forces',Proc. of 23th Annual Meeting of JSSMFE, 1988.