SEISMIC RESPONSE OF BUILDINGS ON SOFT FOUNDATION SOILS

by

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SYNOPSIS

A method of analysis for predicting the earthquake induced rocking motion of a structure on a flexible foundation soil is presented. Both the horizontal and the vertical components of the earthquake are considered. The foundation soil is represented by a bed of elastic-plastic springs allowing both the strength of the soil and its stiffness to be incorporated in the analysis. Application of the method indicates: (1) the vertical component of the earthquake has a negligible effect on the response of the structure (2) the maximum induced overturning moment depends primarily on the strength of the soil and whether the foundation is free to lift from the soil (3) overturning of tall buildings is unlikely to occur unless the foundation soil suffers a strength loss due to the shaking.

INTRODUCTION

The design of buildings to resist earthquake forces is generally based on the assumption that the building rests on a rigid foundation. Analyses have been performed in which the flexibility of the foundation soil has been included (Parmelee et al. (7)) and these analyses show that the horizontal dynamic forces applied to the structure are not greatly altered as a result of the flexibility of the foundation soil. However, these analyses have treated the foundation soil as a linear elastic material. In fact, due to rocking motion, the pressure at one edge of the building foundation may well reach the ultimate bearing pressure of the soil while at the other edge, the foundation may lose contact with the soil. These conditions lead to plastic deformations which significantly alter the response of the building. This type of behaviour has been considered by Byrne (1, 2, 3). Meek (5) and Huckelbridge and Clough (4) have considered the effect of foundation separation or uplifting and shown that it has a major effect on the response of the building.

Byrne (2) considered the rocking of a building on an elastic plastic foundation soil when subjected to horizontal base excitation only. Herein, the analysis is extended to consider combined horizontal and vertical earthquake excitation. The method is applied to a number of structures using two earthquake histories and a variety of soil conditions. The results are evaluated in terms of both the maximum rotation and the maximum overturning and stabilizing moments induced by the earthquake.

METHOD OF ANALYSIS

If the structure is quite rigid compared to the soil, then, for planar motion it can be modelled by the rigid three degrees of freedom

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TABLE 1

Properties for Rigid Structures

Constant Aspect Ratio

Base Width B Ft.	Height H Ft.	Aspect Ratio H/B	Weight W Kip	Moment of Inertia, K/Ft/Sec^2	k_v K/Ft/Ft^2	k_h K/Ft/Ft	Rocking Period Seconds (Elastic)
10	50	5.0	9.0	58.2	50.0	300.0	1.48
					150.0	900.0	0.85
					500.0	3000.0	0.47
30	150	5.0	81.0	4,716.	50.0	300.0	2.57
					150.0	900.0	1.48
					500.0	3000.0	0.81
60	500	5.0	324.0	75,466.	50.0	300.0	3.64
					150.0	900.0	2.10
					500.0	3000.0	1.15

NOTE: Weight and Moment of Inertia values are for a one foot thickness.

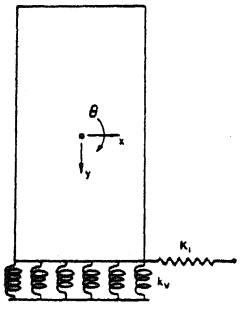

FIG.1 BUILDING ON A FLEXIBLE FOUNDATION.

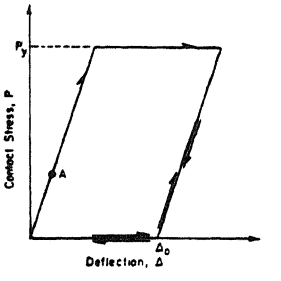

FIG.2 STRESS-DEFLECTION BEHAVIOUR OF FOUNDATION SOIL.

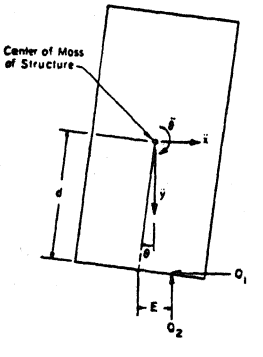

FIG.3 FREE BODY DIAGRAM OF RIGID BUILDING.

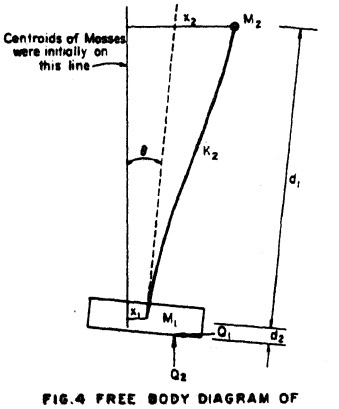

FIG.4 FREE BODY DIAGRAM OF FLEXIBLE BUILDING.