DYNAMIC ANALYSIS OF UNDERGROUND CYLINDERS SUBJECTED TO EARTHQUAKE EXCITATIONS

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SYNOPSIS

A numerical linearly elastic model was developed for the plane strain formulation of the dynamic response of a buried cylinder subjected to earthquake motions transferred from the bedrock. The model consists of: (a) The free field soil - a series of lumped masses, springs and dashpots extending from the bedrock to the top surface represents a typical column of soil at a large distance away from the cylinder. (b) The cylinder-soil composite - a rectangular region of two-dimensional finite elements represents the soil surrounding a circular region of radial springs (packing soil), which circumscribes the cylinder. Two models were used for the cylinder: one with lumped mass and continuous flexibility and the other lumped mass but with infinite rigidity. The motion excites the free field soil column, whose resultant motions are used as inputs to the boundary of the cylinder-soil composite. The feedback between the two parts is assumed to be negligible.

The numerical results are summarized as follows: Based on a study of eigenvalues it was found appropriate to use 12 nodes for the flexible cylinder and a length of six times the cylinder radius for the distance between the soil boundary and the cylinder. The explicit dependence of the response of the cylinder on the bedrock motion is less than that on the free field soil motion. Higher modes were found important. Hence, the method of modal superposition is less efficient than usual. Bending moment in the cylinder increased with its wall stiffness and appeared to converge to the case for the rigid cylinder. The latter case, of course, required much less computation time.

Typical numerical values of the parameters used are: for the cylinder: radius (R) 2 ft., thickness of wall (T) 3/8 in., Young's modulus (E_r) 4.6×10^9 psf, mass 15.16 lb-sec^2/ft^4; for the soil: constrained modulus 1.85×10^5 psf, Poisson ratio (v_s) 0.4, mass 3.7 lb-sec^2/ft^4, distance from the cylinder edge to the top surface (H) 4 ft. and to the bottom and side boundaries of the soil (B) 12 ft. The approximation of the flexible cylinder by a rigid one depends on the ratio H/R and the relative cylinder-soil stiffness $a = (E_r T^3)/(12 E_s(1-v_s^2) R^3 H)$. Results indicated that for the first five modes to converge to within 5% of those for a system with a rigid cylinder ~~the~~ value of a must be no less than 0.15 if H/R = 2, but if H/R = 6, the value of a need only be larger than 0.004.

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