EARTHQUAKE RESISTANCE OF SUBSURFACE TUBULAR STRUCTURES

by

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Construction of subsurface tubular structures, such as submerged tunnels and pipelines is now popular in Japan, and is expected to become more frequent in the near future. Since these structures are usually embedded into soft soil deposits in bay areas and river mouths, their stability against earthquakes is very important. In order to establish rational design methodology in providing adequate resistanse to seismic disturbances, extensive studies including soils investigations, measurements and analyses of seismic behavior of soil deposits, experiments and analyses of their dynamic responses, have been cerried out in recent years. This paper presents the results of a dynamic response analysis, together with an aseismic design method by means of a simplified procedure considering ground displacements.

In the simplified aseismic design method, the structure is assumed to deform as a beam supported by an elastic media, and displacements and forces of the structure are evaluated by giving appropriate ground displacements and wave lengths.

For the dynamic analysis of a submerged tunnel which is proposed as a part of a six-lane highway across the central part of Tokyo Bay, the following assumptions were made:
1) The average water depth is 28m. The bedrock at the depth of 65m below the water surface(or 37m below the sea bottom).
2) Shear moduli of soils are determined by referring to the results of the field seismic survey(shear wave velocity) and by considering the reduction of the rigidity which depends upon strain amplitudes expected during strong earthquakes.
3) The damping ratio of the soil-structure system is taken as 20 percent of critical.
4) As for seismic inputs, average response spectra and seismic records obtained underground were employed. The maximum acceleration of the input is regarded as 150 gals horizontally and 75 gals vertically, at the level of bedrock.

By comparing the design with the results of the dynamic analysis it is seen that the simplified design method, in which ground displacements are regarded as the input to the tunnel, provides sufficiently reasonable response values for both displacements and forces generated in the tunnel during earthquakes considered.

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