OBSERVATION OF THE DYNAMIC BEHAVIOR OF KINUURA SUBMERGED TUNNEL DURING EARTHQUAKES

by

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In order to understand the earthquake resistant properties and develop a proper design method for submerged tunnels, it is of greatest importance to measure the dynamic behavior of soil and structures during earthquakes.

Therefore, observations have been carried out at Kinuura Submerged Tunnels since August 1973. This submerged tunnel is provided for crossing the port of Kinuura by a roadway. This port is situated in Aichi prefecture, some 300 km South West of Tokyo. This submerged tunnel is composed of six reinforced concrete elements cast in steel segments of 7.13 m high, 15.6 m wide and 80.0 m long and the elements are connected with rigid uniform. It rests in a soft clay layer which has a thickness of approximately 20 m at the land and 6 m at the seabottom. This layer rests on a very dense sand having an N-value over 50.

In order to record the earthquake properly, 20 accelerometers, 8 bar stress transducers, 6 dynamic strainmeters and one displacement meter were installed. The accelerometers were placed on the ground surface, in the ventilation towers and in the submerged tunnel elements. The displacement meter was placed in the middle of the submerged tunnel. The strainmeters and bar stress transducers were installed on both side walls of the submerged tunnel elements. Furthermore, strain records yielded the strains produced by axial deformation and by bending deformation about the vertical axis.

Up to April 1976, eight earthquake records have been gathered and four of these have been analyzed. These observed results were then compared to earthquake response calculation. In this calculation, the ground along the longitudinal axis was divided into a number of segments. Each of these was replaced by a mass-spring system and the submerged tunnel was replaced by beams. These masses and beams were connected with springs and dashpots. The earthquake motions applied to this model were based on the accelerations gathered from actual observations.

From the analyses of the observed earthquake records and the theoretical calculations, the following were found. The dynamic behavior of the submerged tunnel depends largely on the characteristics of earthquakes, such as frequency component. Most of the observed maximum accelerations at the structures were not larger than the maximum accelerations at the ground surface. The strains due to axial deformation almost exceeded the strains due to bending deformation. The observed maximum accelerations, bending moments and axial forces agreed with the calculated values, with acceptable differences.

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