COMPARATIVE STUDY ON THE OBSERVATION OF A WATERPIPE DURING EARTHQUAKE AND THE EQUIVALENT VISCOUS THEORY

by

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This paper describes ① the observation of a steel waterpipe in service during earthquakes, ② a calculation method of stress on underground pipelines during earthquakes, using the results of a laboratory test on underground pipes and ③ a comparative study on the observations and the theory.

A steel waterpipe (ϕ 1219 $\times$ t 16) 200 meters long has been observed in terms of the following items ① accelerations due to earthquakes through rock foundation and surface stratum of the ground as well as pipeline and valve pit ② strain of pipeline ③ elongation of an expansion joint. Four earthquakes have been recorded.

On the other hand three kinds of pipes, plastic coated, asphalt coated and no coating, with 216 mm diameter and 10.7 m length were tested in a laboratory to obtain spring constant K and viscous coefficient C by applying vibrating axial forces at the end of each pipe which was buried in sand. As a result the relationship between the axial forces and the displacements formed a closed curve as a hysteresis. Applying equivalent viscous system to the experimental results it was found that K and C were inversely proportioned to the amplitude of the relative displacement U_O between pipe and soil as follows when the amplitude surpassed a certain value U_A and U_B.

$U_O \leqq U_A$: $K=A/U_A$, $C=BT_O/U_B$ (1)

$U_A < U_O \leqq U_B$: $K=A/U_O$, $C=BT_O/U_B$ (2)

$U_O > U_B$: $K=A/U_O$, $C=BT_O/U_O$ (3)

where A, B: constant (kg/cm^2) T_O: period (sec)

Now take X in the direction of the pipe axis and consider X component alone of the ground displacement during earthquakes then following formula is obtained.

$$U_S = U_{SO} \sin(\omega T - \beta X) \quad (4)$$

U_O is written as follows.

$$U_O = |Q| U_{SO} / \sqrt{(Q+K)^2 + (\omega C)^2} \quad (5)$$

where $Q = Et\beta^2 - m\omega^2$ E: Young's modulus t: pipe thickness

m: mass per surface area of the pipe

If $U_O \leqq U_A$ equation (1) is used. If $U_O > U_B$

$$K = Q / \{\pm\sqrt{(Q\ U_{SO})^2 - (2\pi B)^2} / A - 1\} \quad (6)$$

$$C = BT_O K / A \quad (7)$$

The maximum stress obtained by the observations during earthquakes was nearly equal to the one obtained by the theoretical method mentioned above.

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