ANALYSIS OF ABSORPTION EFFECT DUE TO SEDIMENT LAYERS ON DYNAMIC RESPONSE OF DAM-RESERVOIR SYSTEM

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A concrete gravity dam impounds water and entails high risk, as failure of a dam particularly during an earthquake may be disastrous for human life and property at the downstream. Hence, design and analysis of such a structure should be carried out with high level of accuracy. Seismic analysis for each dam is unique depending on site geology and seismicity, foundation materials, dam and foundation geometry. Specially, a main concern regarding the instability of dams in seismic regions is the incidence of a strong ground motion. The developed hydrodynamic force on the dam is highly dependent on the physical characteristics of the boundaries surrounding the reservoir including the reservoir bottom and sides. The predetermination of magnitude of hydrodynamic pressure is important as in the event of severe earthquake; it may lead to crack initiation and propagation. The response of dam to an earthquake considerably depends on (i) the effect of dam reservoir interaction (ii) the compressibility of water in the reservoir and (iii) the absorption of pressure at the bottom of reservoir. As a result, an accurate evaluation of hydrodynamic pressure on dam must consider these effects with more realistic boundary conditions.

Commonly used analysis techniques in the time domain do not take into account the absorption and/or transmission of hydrodynamic pressure waves by/through the sediments and the foundation rock that form the reservoir boundary. Assuming a non-absorbing, rigid bottom at reservoir boundary may lead to an unrealistically large estimation of the hydrodynamic pressure on the upstream face of the dam because no attempt is made to model the escaping energy of the pressure waves reflected at the bottom surface in the real situation. The damping due to radiation of waves in the unbounded upstream direction and due to absorption of incidental waves at the reservoir bottom may result in a significant reduction of dynamic response of a concrete dam subject to ground motion. During the last few years studies pertaining to development of hydrodynamic pressure indicate that the presence of sediment at the reservoir bottom have significant effect on the response of dam as they absorb part of energy of hydrodynamic waves.

In the present work, the complex hydrodynamic response is evaluated for a rigid concrete gravity dam due to horizontal harmonic ground motion. The reservoir water is assumed to be inviscid, irrotational and linearly compressible. The effect of sediment layer at the bottom of the reservoir is considered in the closed-form solution. The boundary condition at the horizontal bottom of the reservoir is formulated considering the characteristics of sediment layer above the reservoir bottom. A closed form solution (Bouaanani et al. 2003) is adopted which incorporates the compressibility effect of water and more realistic conditions at the surface of the reservoir due to gravity waves; and at the reservoir bottom due to sediment effect. The damping due to the presence of sediment at the reservoir bottom is incorporated by using reflection coefficient that is dependent on the impedance of sediment layers at the reservoir bottom. The hydrodynamic response obtained by the closed form solution is complex valued. The absolute hydrodynamic pressure coefficient thus evaluated show that a decrease in the reflection coefficient of the reservoir bottom absorption is to reduce the hydrodynamic pressure coefficient along its vertical height.

The present study brings out the contribution of considering the imaginary terms in a dynamic analysis. The effect of sediment layers on the reflection coefficient is presented which reveals that the presence of sediment having less elastic modulus than the overlying sediment would be more absorptive than a rigid underlying medium. Considering the presence of sediment at the reservoir bottom leads to a solution that yields complex values of hydrodynamic pressure. The results presented show that for excitation frequencies higher than the fundamental frequency of the reservoir and for highly absorptive reservoir bottom the imaginary terms exists and cannot be neglected.

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