ABSTRACT

Concrete gravity dam should be designed considering dynamic exciting force so that it can sustain earthquake excitations. Hydrodynamic pressure develops at the face of the gravity dam during the earthquake. Variation of hydrodynamic pressure depends on the geometrical parameters of the adjacent reservoir. Inclination of the reservoir bed, inclined length of the reservoir base and reflection coefficient of the reservoir bottom are examples of such parameters influencing the hydrodynamic pressure of the reservoir and stresses of the gravity dam. In this study, the focus has been given to the variation of hydrodynamic pressure and stresses in the gravity dam for those parameters by applying dynamic excitations.

Fluid is considered compressible and inviscid and its motion is irrotational with small amplitude. Two-dimensional geometry of the dam, reservoir and foundation has been modelled using finite element. Standard eight-node isoparametric element has been used for the discretization of the dam, reservoir and foundation domain. Pressure is considered as nodal variable in the fluid domain following the Eulerian approach and displacement is considered as nodal variable for the gravity dam and foundation following the Lagrangian approach. Both dam and foundation are in plane strain condition. Length of the reservoir has been truncated to a suitable distance for saving computational time. A suitable non-reflecting boundary condition is applied along the truncated face of the reservoir. Similarly, along the truncated face of the foundation viscous boundary condition has been implemented. The effect of the surface wave is neglected. However, reservoir bottom absorption is considered in the study.

In the present study, dam-reservoir and dam-foundation interactions are included for the dynamic analysis of dam-reservoir-foundation systems. Analysis has been carried out by direct coupling approach of dam-reservoir-foundation coupled systems. A MATLAB code has been generated for numerical simulation. Hydrodynamic pressure of the reservoir and major and minor principal stresses of the dam and foundation have been observed by applying harmonic and earthquake excitations.

From the present study, it is clear that when the bed slope of the reservoir is in the anticlockwise direction the hydrodynamic pressure and stresses at the heel of the dam always increased due to an increase in slope angle. The stress of the foundation under the heel decreased with the increase of bed slope when aligned in anticlockwise direction. When the slope of the reservoir bed is in anticlockwise direction, the inclined reservoir bed is towards the concrete gravity dam. Hence, the reservoir bed reflects the wave towards the gravity dam and enhances the hydrodynamic pressure and stresses at the heel of the dam. Again, due to the reduction in stiffness of the soil for the reduction in volume, the stress below the heel of the dam is decreasing for an anticlockwise slope. It is also observed that when the bed slope of the reservoir is in the clockwise direction the hydrodynamic pressure and stresses at the heel of the dam always decreased due to an increase in slope angle. The stress of the foundation under the heel increased with the increase of bed slope for clockwise slope. In the case of clockwise slope, the reflecting wave from the bed of the reservoir is going away from the gravity dam and decreases the pressure and stress at the heel of the dam. The stiffness of soil is increased due to an increase in volume in the case of clockwise slope. Hence, the stress in the foundation below the heel is decreasing.

Keywords: *Dam-reservoir-foundation coupled system; Non-reflecting boundary condition; viscous boundary condition; Inclined reservoir bottom; Hydrodynamic pressure; Earthquake Excitation*

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