# Abstract

Fluid retaining structures such as tanks should be designed considering dynamic loading such that it can effectively sustain ground excitations. These structures are the source of the basic needs of common people. Hence malfunction of such structures has direct adverse effect on society. Large liquid retaining structures are the source of huge mass and failure of the same under earthquake can be catastrophic. Side walls of such structures are generally made of concrete or steel which is another source of huge mass and which leads to worsen the situation. Composite materials having high strength with low seismic weight contributes less in seismic excitations. Stiffness of such materials can also be modified with simple modification of fiber orientation. Hence the designer has the freedom to use the material as per requirement. Hence in the present study composite material is used for the construction of side walls of the tank. This will effectively reduce the overall response of the tank under dynamic loading. The side walls are modeled as two dimensional isoparamentric plate elements with eight nodes per element. First order shear deformation theory is considered for the formation of strain terms of the thin plate. Displacement is considered as the nodal variable following Lagrangian approach.

Fluid is considered to be compressible and inviscid. It is modelled as twenty node three dimensional brick elements. The effect of sloshing is considered in the present study. One opposite sides of tank are considered to have composite plates as side walls where the rest two sides are considered to be rigid. The tank is always considered to be filled with liquid.

In case of a fluid retaining structure, the structure or the fluid does not behave as a separate entity at the interface. Rather they behave in a coupled way. Hence, in the present study direct coupling method is employed to couple the composite plate and adjacent fluid within the tanks. A MATLAB code has been generated for the numerical simulation of this composite-fluid coupled systems.

The present study starts with the free and forced vibration of uncoupled side walls with parametric variations. The fundamental frequency increases with increment of ply angle up to 45°. Central displacement of the side walls is higher for symmetric laminations. Effect of various boundary conditions are studied and simply supported edge shows highest displacement values. Stress contour for two, four and six layered plate is also presented. The response of the same is studied under Koyna ground motion also.

The coupled structure is then studied for free and forced vibration. Displacement time history at the middle of the side walls is studied considering variations in ply orientations, boundary conditions and tank geometry. It is clear from the present study that coupled frequency of the system increases up to wall height to length ratio 0.5, then it becomes constant. Central displacement of the side walls is higher for anti-symmetric lamination for the coupled system which is in contrast with the uncoupled one. Comparative study of central displacement of left and right tank (both cross and angle ply laminations) wall is presented. It is found that initially both the wall responded in the same manner but as time progresses there is a phase difference between the two plates. Time history response of normal stress, inplane shear stress and transverse shear stress at side walls are also obtained and presented. Contour plot at different layers under various loading conditions are plotted using Origin software and presented. The response of the same is studied under El-Centro ground motion also.

**Keywords:** *Composite plates; 3-D finite element method; Transient response; Stress contour plot; Koyna earthquake; El-Centro earthquake; Fluid-structure interaction; Direct coupling*.