Verification Technology of Structural Resistance to Earthquake and Tsunami

1. Analysis Technology of Verification for Earthquake-Resistant of Complicated Structure

No solution is available so far to analyze the verification for resistant of complicated structure in shape, like a long pier, a dolphin and so on. A frame model, that has been applied for structure analysis of steel structure until now, is 2D framework analysis that approximates 1 element by 1 factor and that can not cater for dynamic response analysis in the time of earthquake motion and analysis of elasto-plastic range. FEM models, of which is used most popularly in Japan is FLIP, are widespread as a verification method for port and coastal structures. FILP cannot solve directly 3D deformation with a variation of axial load, although nonlinearity is considered by M - φ model in FILP.

In contrast, using the fiber model unable that the nonlinearity of material is considered by stress-strain(σ-ε) model that can consider axial tension after modeling structure with arbitrary shape by 3D. And also elasto-plastic analysis considering the large deformation can be possible.

The analysis of earthquake response applying the fiber model is carried out in the following steps: 1) modeling considering nonlinearity of material, 2) setting natural period mode of structure, 3) calculating input acceleration and 4) inputting earthquake acceleration at the contact point of embedment section.

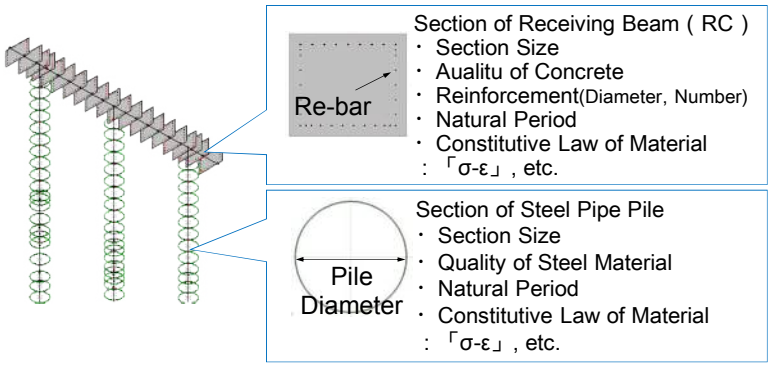

Figure 1 : Modeling of Pier (Factor of Fiber and Section Information)

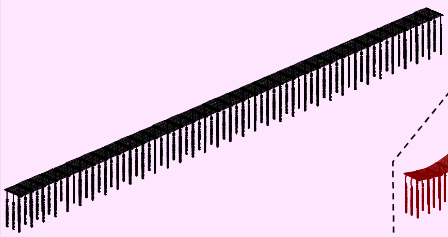

Figure 2 : Modeling of Pier (Overall View)

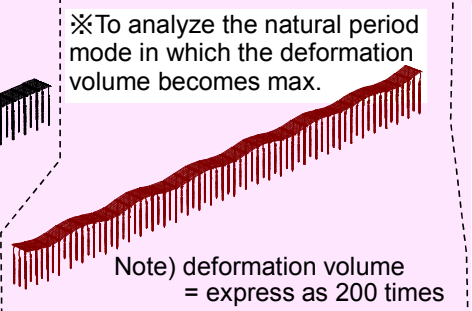

Figure 3: Analysis of Natural Period Mode of Pier

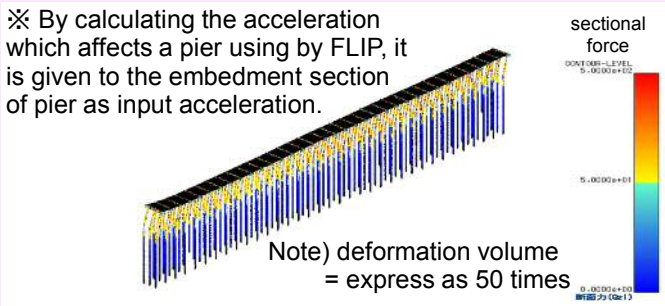

Figure 4 : Analysis of Earthquake Response of Pier (Shear Force of Bridge Axial Direction)

2. Verification Analysis for Tsunami-Resistant of Structure with Complicated Shape

When tsunami propagates on the shallow water and land, tsunami front becomes bending forward and is changed to hydraulic bore. When this tsunami front affects coastal structures, the three dimensional flow is reproduced to estimate tsunami height, current speed and wave force occurred at the front. As an analysis method of 3D current, the direct numerical analysis of 3D Navier-Stokes equations is usually adopted. The 3D fluid analysis code, introducing turbulence model, is applied to this numerical analysis, by using unstructured grid system enabling to express compex shape of structure with higher accuracy.

Figure 5 shows what result of the numerical analysis for tsunami front affecting spherical gas tank. The structural analysis by the fiber model allows us to predict applied stress to each structure component and structural deformation, which are affected by tsunami. In the course of the analysis, tsunami deformation around structure can be available.

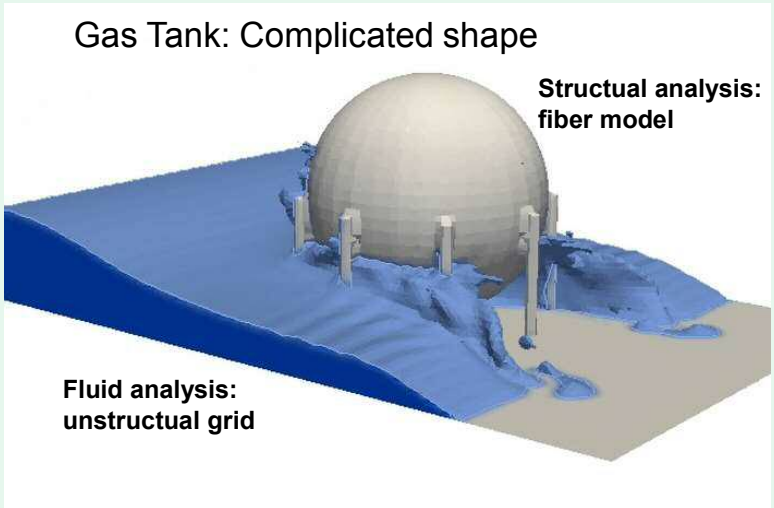

Figure 5 : Example of Numerical Analysis on Gas Tank with Curved Configuration Affected by Tsunami