A Review on the International Research Status on Seismic Analysis Program of Fuel Assembly

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1. Introduction

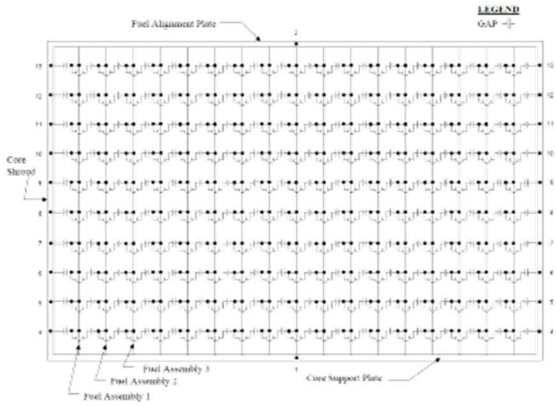
Since the great east Japan earthquake, structural integrity assessment under seismic loading is important in maintenance of nuclear power plant components. The fuel assembly is core component of reactor vessel internal, and it is very important to evaluate the structural integrity of the fuel assembly under seismic loading condition. The fuel assembly in the seismic model of reactor vessel internal is simulated with the beam and mass element due to complex structures and constraints, contact condition. For the specificity of nuclear power plant type, nuclear power plant exporting countries such as the United State, France and Japan have their own fuel assembly seismic analysis codes. OPR1000 and APR1400 are seismic analysis of fuel assembly through the CESHOCK program owed by Westinghouse. CESHOCK program is developed by Combustion Engineering in the 1980s, and it is necessary to develop seismic analysis code as copyright problems may occur when exporting nuclear power plants. In order to develop a new code, an analysis of the existing codes must be performed. In this study, a comparative analysis study was conducted among CESHOCK(Westinghouse), CASAC(AREVA) and FINDS(Mitsubishi) [1-3].

2. Comparison of seismic analysis codes

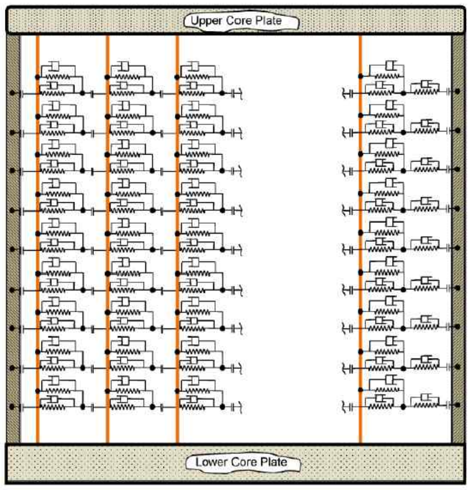
Figure 1 shows the seismic analysis model of CESHOCK, CASAC and FINDS. In this section, the similarities and differences of each code were analyzed

2.1 Similarities between codes

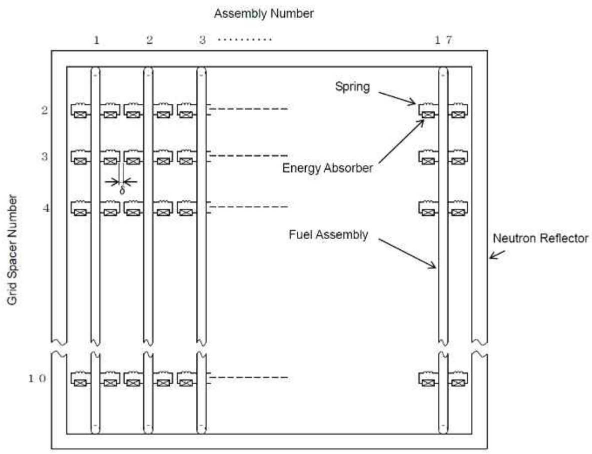
All programs consist of 2-D beam elements to analyze the reactor vessel internal including fuel assembly. Also, the each analysis model composed a horizontal model and a vertical model independently. The analysis model presents a fuel assembly between lower core plate and upper core plate. Fuel assembly is modeled as a single column consisting of nodes grouped by a guide tube and fuel rod. Fuel assembly material properties such as spacer grid stiffness, spacer grid impact strength, natural frequency, etc are used as input data for FE analysis model. All models take into account the damping of FE analysis model using the fuel assembly vibration test results. Each program is performed by simulating the impact between spacer grid to grid with a double load path, as shown in fig. 2.



(a)



(b)



(c)

Fig. 1. Fuel assembly seismic analysis model; (a) CEHSOCK, (b) CASAC, (c) FINDS [1-3]

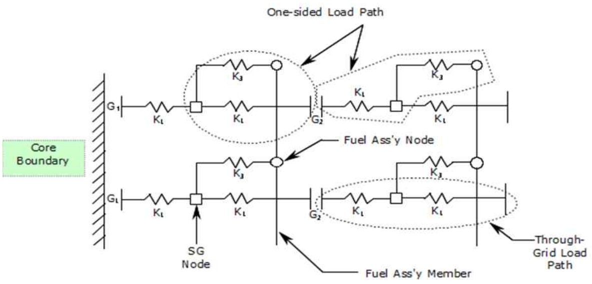


Fig.2. Illustration of the double load path between spacer grid to spacer grid..

2.2 Differences between codes

CESHOCK, CASAC use the direct integration method to calculate the numerical integration solution by the Runge-Kutta method, while FINDS use the time history analysis by the mode superposition method. CESHOCK, FINDS consider the interaction with the fluid by applying a hydrodynamic added mass, whereas CASAC considers the interaction between the fuel assembly and baffle plate. CASAC, FINDS use damping element to simulate energy dissipation during grid impact, while CESHOCK considers energy dissipation by use of the coefficient of restitution. FINDS considers the properties of the spacer grid in the elastic-plastic region, whereas CESHOCK, CASAC only consider the elastic region.

3. Conclusions

This paper analyzed the similarities and differences related to the three programs used in the seismic analysis of fuel assembly. Each code had a similar configuration overall, such as consisting of a 2-D beam element, but there were differences in detail analysis method. The analysis result between codes can be used as reference data for new code development.

REFERENCES

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