SEISMIC MODEL TEST OF GCFR CORE SUPPORT STRUCTURE*

L. E. PENZES, D. R. BUTTEMER

General Atomic Company,
P.O. Box 81608, San Diego, California 92138, U.S.A.

R. L. BEDORE

Engineering Department, San Diego State University,
San Diego, California 92138, U.S.A.

SUMMARY

In the 300 MW(e) GCFR demonstration plant design each of the core assemblies is firmly held at the upper end within a thick grid plate and no other form of core restraint is provided. To assist in understanding the dynamic behaviour of the core and its support structure during a seismic disturbance a vibrational test program of a 15% scale model of the core and grid plate was performed at San Diego State University. The test program was performed in two stages. The first stage involved separate testing of individual fuel and blanket assembly simulators and of free vibration testing of the grid plate model itself. The second stage involved testing of the combined core-grid plate assembly.

The core assembly simulators were individually installed in a rigid steel block simulating the assembly-to-grid plate connection and were "plucked" to determine the lowest natural frequency and damping factor. The natural frequency of the blanket assembly was 38.5 Hz and that of the fuel assembly was 54 Hz. The grid plate was subjected to a free vibration test using an acoustic generator as the excitation source. This test determined that the two lowest frequencies of the perforated plate were 1498 and 4441 Hz.

After completion of the individual component tests, the core assemblies were fixed into the grid plate and horizontal and vertical harmonic excitations were separately applied to the grid plate in order to determine the resonant frequencies and the general mode shapes of the assembly. For horizontal excitations, system resonances were observed at 21, 41 and 48 Hz. At the 21 Hz frequency, the fuel and blanket assemblies moved in-phase in the direction of excitation and considerable grid plate shear type motion was observed. At 41 Hz, the blanket assemblies are predominantly excited and move in-phase in the direction of excitation and at 48 Hz the fuel assemblies vibrate predominantly in-phase in the direction of excitation. The tests show the existence of a system resonant frequency which is approximately half the frequency of the single core assembly due to the rotational effect of the grid plate. The observed resonant frequencies due to vertical excitation were 23, 30, and 34 Hz, the lowest being the classical drum mode.

The test results were compared with both analytical and computer code results. The maximum error between the single fuel and blanket assembly tests results and the analytical simulation was 9%. The effective elastic modulus of the perforated portion of the grid plate was determined using the measured frequency and mode shape from the grid plate free vibration tests. Applying thick plate theory the effective elastic modulus is 27% lower than that given in the ASME code. The resonant frequencies and the mode shapes of the "combined" core and grid plate assembly were also calculated. Applying thick plate theory to the analytical method, the two lowest frequencies were determined and the comparison with the test results shows errors of 3% and 6%. Based on the test and the analysis it is concluded that thick plate theory should be used.

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