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Bending Test for the Lateral Stiffness of a 16 by 16 type PWR Fuel Assembly using FAMeCT

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1. Introduction

This paper deals with the lateral stiffness test of a PWR fuel assembly (FA). The purpose of the fuel assembly lateral bending test is to obtain the lateral load vs. FA deflection characteristics of an axially preloaded fuel assembly. The test results will be used to verify the static lateral characteristics of a fuel assembly finite element model for the safety analyses.

The test specimen for this test was used the previous skeleton with lead pellet rods. It was set the grid cell size for other test. It might be caused a little difference characteristic from normal fuel assembly.

2. Test Apparatus and Method

2.1 Facility Description

The fuel assembly was positioned vertically in the test stand and restrained at the top and bottom nozzles with core plate simulators, which provide an actual support condition in a reactor. Preload of 1678 lbs was exerted on the hold-down plate by a motorized screw jack, which simulated the beginning of life (BOL) hot condition in the reactor core. The schematic configuration is shown in Figure 1.

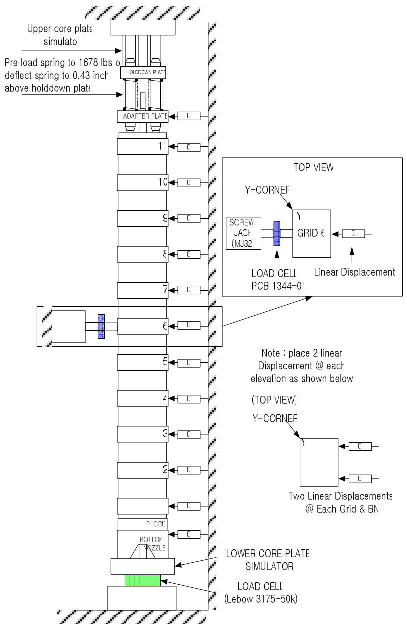

Fig. 1 Schematic diagram of the lateral stiffness test arrangement.

2.2 Fuel Assembly Specimen

The fuel assembly consists of 236 lead filled fuel rods. The test fuel assembly weight was obtained using the calibrated scale. The total weight of it was 628.6 kg, which was slightly smaller than that of the uranium filled fuel rods. The other geometric dimensions and the material data except this were exactly same with conventional fuel assembly.

2.3 Test Method

The bending test was executed using the above test facility. The lateral load applied at the sixth grid position by screw jack. The deflections were obtained at those positions from linear transducers. These were located two sensors at the same grid elevation, top and bottom end piece positions. And the forces at the mid and lowest position were measured with strain type load cell. The increment deflections were 2 mm until 20 mm.

3. Test Result

3.1 Forces vs. Deflections

The lateral stiffness test was executed using the FAMeCT. This test was accomplished using the PLUS7 fuel assembly (a fuel for the Korea Standard Nuclear Power Plants: design-improved by the KNFC) for verifying the performance of it. Figure 2 shows the lateral load vs. deflection at each spacer grid position. The force was measured at the sixth grid position by a load cell (PCB 1344-01). The load vs. deflection characteristics was found to be non-linear mainly due to a fuel rod slippage at the grid-to-rod contacts. The fuel assembly did not return to its original position although it was fully unloaded due to the frictional forces of the fuel rods against the grids (i.e., springs/dimples). Also, Figure 3 shows the FA deflection shape and magnitude along the FA height measured at the center grid (presently grid 6). In the present test, the fuel assembly was deflected up to 20 mm at the grid 6. In an actual test for the verification and license of new fuel design, the deflection range was usually larger than that. The intrinsic purpose of the present test is to verify the FAMeCT performance rather than the fuel assembly. It was decided that the deflection range was 0~20 mm to prevent a considerable deformation that certainly affect other tests (e.g., vibration). The normalized characteristic curves (Fig. 2) showed that the deflection of the upper part (higher than grid 6 location) was a little higher than that of the lower part (lower than grid 6 location). It may be caused by the upper end fitting assembly that is more flexible than the lower end fitting structure. The largest lateral stiffness was evaluated as about 37 N/mm, which was much lower than that of the previous test result [3]. It might be caused by the loose grid cells presently existed in the test assembly. It will be further clarified when the same test is conducted with the new fuel assembly without loose cells. Nevertheless, these characteristic behaviors (load vs. grid deflection, fuel assembly deflection shape) showed typical phenomena of a commercial fuel assembly.

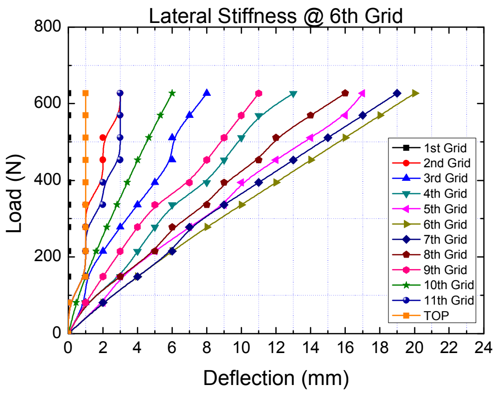

Fig. 2 Lateral load vs. deflection curves from the lateral bending test.

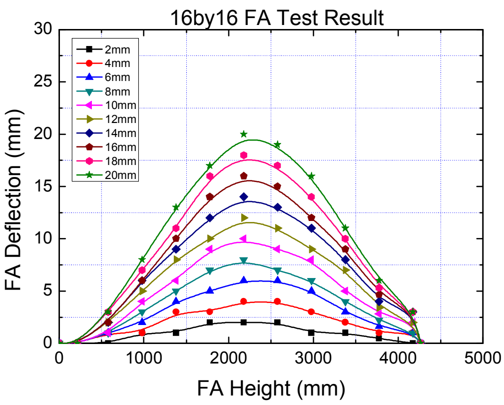

Fig. 3 Fuel assembly deflection shape obtained from the lateral bending test.

3.2 *Bending and Membrane Strain*

The strains of the guide tubes, instrumentation tube and the structural parts were monitored during the loading events. Some representative strain values are shown in Table 1. The typical membrane and bending stresses at the predefined gage positions were calculated using these two strain values. Of course, there were very small stress values at the flange of guide thimble position. In addition to this, the bending strain and stress increased linearly with respect to the deflection. Therefore, these bending and membrane stresses were within the elastic range of each material. For more detail characteristic behavior, it is necessary to test a normal fuel assembly without cell size setting.

Table 1 Representative strain values on the guide/instrumentation tubes at the 6 grid position.

Grid 6 δ (mm)	Gage Identification Number (Unit : micro strain)					
	68	69	70	71	72	73
2	-5	-13	10	1	29	-38
4	75	-88	8	-45	43	-12
6	-12	-39	37	12	99	-116
8	-22	-50	48	23	135	-166

4. Concluding Remarks

The lateral bending test for obtaining the FA characteristics was executed using the established test facility (FAMeCT). The test results revealed a similar behavior when compared with the previously conducted ones by a foreign vendor. Therefore, it was successfully verified that the present tester and methods could provide reliable data of the fuel assembly behavior during lateral bending load. It is regarded that the lower stiffness in the present test is due to the loose cells. It will be clarified as the same test is conducted with a fuel assembly with normal cells.

Acknowledgement

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References

[1] K. H. Yoon et al., Functional Test for the Lateral Stiffness of a PWR Fuel Assembly using FAMeCT, KNS P04B28, (2005).
[2] K. H. Yoon, Test Procedure of the Fuel Assembly Lateral Stiffness, FAMeCT-TP-01, (2006).
[3] Y. K. Jang, KAFD Fuel Assembly Mechanical Test Report – Final Verification Test, KAFD-02D-19, (2002).