RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/29/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 977-6899 REVISION 3**
SRP SECTION:	**03.08.03 – Concrete and Steel Internal Structures of Steel or Concrete Containments**
APPLICATION SECTION:	**3.8.3**
DATE OF RAI ISSUE:	**11/20/2012**

QUESTION NO. 03.08.03-100:

The staff reviewed the applicant's response to RAI 894-6270 Question 03.08.03-66, dated April 3, 2012, regarding test information that is used to calibrate the in-plane shear stiffnesses for steel-concrete (SC) Category 1 walls. The staff noted that the uncracked and cracked stiffness equations proposed by the Ozaki paper (2004) for SC members had been calibrated by experimental tests, including the one done in Purdue University and summarized in Appendix 6 of MUAP-11019-P (R0). "Containment Internal Structure Design Criteria for SC Walls." As indicated in Section 4.1.3 of MUAP-11018-P (R0), "Containment Internal Structure: Stiffness and Damping for Analysis," a "fully cracked" secant in-plane shear stiffness equation (Eq. 4-10) is proposed for the analysis and design of US-APWR SC Category 1 structures, in order to obtain a reasonable assessment of the dynamic response for the anticipated level of cracking. This equation is different than the Ozaki's cracked in-plane stiffness equation (Eq.4-4), which had been calibrated by experimental tests. Both Section 4.1.3 of MUAP-11018-P (R0) and the RAI response provide limited information about the calibration of Eq.4-10. Therefore, the staff requests that the applicant provide the test report/information that is used to calibrate the cracked in-plane stiffness equation (Eq.4-10 of MUAP-11018-P (R0)) for the design of the USAPWR Category 1 SC members, and a description of how the test results are used to calibrate the equation. In addition, discuss the difference between the cracked stiffness equations proposed by the Ozaki paper (2004) and the one used for US-APWR SC analysis and design. If significant, discuss how they affect the analysis results.

ANSWER:

The in-plane shear force-shear strain behavior of steel concrete (SC) panels is idealized using a trilinear curve consisting of three linear branches. The first branch corresponds to uncracked elastic behavior of the composite SC section. The second branch corresponds to the cracked behavior of the composite SC section. The third and final branch corresponds to the behavior of the composite SC section after steel faceplate Von Mises yielding. The slope of the first branch is referred as the uncracked shear stiffness (K_{uncr}). The slope of the second branch is referred to as the cracked composite shear stiffness (K_{cr}). The slope of the third branch is equal to zero.

Each of these three slopes represents the tangent stiffness of the SC panel, which is defined as stiffness at the current value of load or displacement on the load-displacement curve. The stiffness equation in Ozaki, et al., (2004) corresponds to the slope or tangent stiffness of the second branch.

Secant stiffness is the slope of the line connecting the origin to the current value of load or displacement on the load-displacement curve. Thus, the secant stiffness at a particular value of load or displacement is not equal to the tangent stiffness at the same value of load or displacement. Figure 03.08.03-100.1 illustrates the difference between the tangent stiffness (K_{cr}) and the secant stiffness (K_{sec}) for the in-plane shear force-shear strain behavior of SC wall panels.

Figure 03.08.03-100.1 Definition and Comparison of Tangent and Secant Stiffness for In-Plane Shear Force-Shear Strain Behavior of SC Wall Panels.

The typical cyclic in-plane shear behavior of SC wall panels is illustrated graphically in Figure 03.08.03-100.2. The monotonic in-plane shear force-shear behavior from Figure 03.08.03-100.1 serves as the envelope of the cyclic response, and the hysteresis rules consist of unloading from and reloading directly to the previous peak in the cyclic load-displacement response. As shown in Figure 03.08.03-100.2, the cyclic (hysteretic) load-displacement behavior follows the secant stiffness corresponding to the peak load or displacement points.

Therefore, a new set of equations was developed to represent the secant (in-plane shear) stiffness of SC wall panels. The development and calibration of the secant stiffness equation for SC wall panels is presented in detail in Technical Report MUAP-11018, Rev. 1, Appendix C.

Figure 03.08.03-100.2 Typical Cyclic In-Plane Shear Force-Strain Behavior of SC Wall Panels

Figure 03.08.03-100.3 Cyclic Lateral Load-Interstory Drift Behavior of SC Wall Specimen in Test Series 6 from Technical Report MUAP-11013, Rev. 2, Appendix B.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on the Technical/Topical Report.

This completes MHI's response to the NRC's question.