RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/29/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**894-6270 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:	**01/25/2012**

QUESTION NO. 03.08.03-56:

The Executive Summary of MHI Technical Report MUAP-11018-P (R0), page vii, states "However, some aspects of SC specific behavior can cause slight deviations from RC behavior. For example: … (iii) The steel reinforcement ratios for SC walls are much higher (about 2-4%)." Since this range of steel ratios for SC members is very high, the staff requests that the applicant explain what is the technical basis for accepting these higher values. In addition, the staff requests that the applicant provide sufficient test data to show that the steel-concrete (SC) composite member performance is equal to or better than reinforced concrete (RC) members. This should be demonstrated by comparison of performance parameters that include stiffness, ultimate strength, cyclic behavior, and ductility in all member directional loadings (i.e., membrane, bending, shear in and out of plane, and combination of these loadings).

ANSWER:

This answer supplements the previous MHI answer that was transmitted by letter UAP-HF-12083 (ML12096A040). For clarity, the original response is repeated below and the supplemental information follows.

The technical basis for accepting the higher reinforcement ratio (2-4%) is that these ratios are representative of typical steel concrete (SC) designs and specimens that have been tested and included in the experimental database for developing the design criteria. SC walls cannot be made with lower reinforcement ratios because of the minimum plate thickness requirements associated with local bending due to concrete hydrostatic pressure during casting. Finally, the steel faceplate thickness is also governed by local buckling requirements, which have been described in Technical Report MUAP-11019, Rev. 1, Chapter 2.2. As shown there, the steel plate thickness has been designed to achieve yielding before local buckling under applied compressive loads. This results in larger steel plate thickness, and consequently higher reinforcement ratios.

ACI 349-06 limits steel reinforcement ratio for flexural and compression members in Sections 10.3.5 and 10.9.1. For compression members, area of longitudinal reinforcement is limited

to a maximum of $0.08*A_g$, which exceeds the maximum reinforcement ratio used in the US-APWR SC walls. In terms of the flexural member limitation inherent in Section 10.3.5, Technical Report MUAP-11019, Rev. 1, Section 5.2.2 explains that this limit does not apply to SC walls because they are doubly reinforced with equal steel plate area and strength on both the compression and tension faces. Because of the balance of tension and compression reinforcement in the SC walls, the limiting concrete compressive strain (0.003) cannot be reached before the tension reinforcement has yielded except under very large axial compression values.

The SC walls in the US-APWR CIS have reinforcement ratios between 1.5% and 4.2%. The reinforcement ratios used in the tests range from 1.3% to 4.5%, which covers the range of values used in the US-APWR. This is illustrated in the experimental database table submitted in response to Question 03.08.03-45 in RAI 858-6126. Thus, the technical basis for accepting these higher reinforcement ratios are: (i) practical considerations of steel plate stiffness for resisting concrete casting hydrostatic pressure, (ii) prevention of yielding before local buckling, and (iii) range of reinforcement ratios used in the experimental database.

In response to the second request in this RAI question for test data demonstrating equal or better performance of SC walls vs. RC walls, the experimental database prepared for RAI 858-6126 has been augmented to include a detailed discussion of the experimental findings pertaining to SC performance relative to RC performance. This discussion will be provided along with the experimental database tables in an appendix to MUAP-11005, Rev. 1.

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 Report:

There is no impact on the Technical Report.

SUPPLEMENTAL INFORMATION:

Technical Report MUAP-11005, Rev. 1, Appendices A through D, now provides a detailed discussion of the experimental findings pertaining to steel concrete (SC) performance relative to reinforced concrete performance. The experimental database has been provided in Appendix E of Technical Report MUAP-11005, Rev. 1.

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.