RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/29/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 858-6126 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:	**10/25/2011**

QUESTION NO. 03.08.03-45:

Section 1.3 of MHI TR MUAP-11013-P (R1) discusses the component tests of SC walls. The TR states that "There are some differences in the section details and fabrication details of the US-APWR SC walls with respect to those in the experimental database. The comprehensive plan presented in this report evaluates these differences...." Also, Section 2.1 of MHI TR 11013-P (R1) indicates that most of the SC-type walls in the CIS have material and geometric parameters that are within the range evaluated in various SC tests. Because of the numerous tests, the differences in some of the section details referred to in Section 1.3 of the TR, and to aide in the evaluation of the many tests that are relied on for the US-APWR design, provide a table for the three SC type walls (Category 1, 2, and 3) which compares the material and geometric parameters used in the US-APWR CIS to the parameters of the test specimens. The parameters to be compared should include overall wall thicknesses, steel faceplate thicknesses, plate to concrete thickness ratios, shear stud sizes and spacings, tie bar sizes and spacings, material properties, anchorage configuration, welds, connections of SC wall sections to other SC wall sections if multiple SC sections are used in the tests, type of loading, purpose of the test and results/conclusions. For the type of loading, the information should identify whether it was pseudo-static pushover, pseudo-static cyclic, dynamic motion, single or multiple directional. For the multidirectional loading explain whether it included only individual loads (membrane, bending, or shear) or also multiple/combined loading (i.e., in-plane combined with out-of-plane forces). It would be helpful if these test data entries in the table are grouped based on the analysis or design aspect of interest (e.g., SC single panel tests for performance under membrane loadings, shear loadings, flexure loadings, combined loadings, multiple panel tests (e.g., 1/10th, 1/6, etc.), connection tests, etc.).

From the comparisons made in the table described above, if any of the differences are significant or fall outside the range of the test parameters, then the test data should not be relied on for demonstrating the adequacy of the US-APWR SC structures.

The tables should demonstrate that the US-APWR SC type members have been tested for all member forces (membrane, bending, and shear) and their combinations. The staff notes, for example, that the current SC wall component tests described in Section 5.3 do not include some combined loading tests such as flexural loading combined with membrane

loading. Also, provide the test summary reports available for the various component tests if they are not included in MHI TR MUAP-11005-P (R0).

ANSWER:

This answer supplements the previous MHI answer that was transmitted by letter UAP-HF-12051 (ML12075A108). For clarity, the original response is repeated below and the supplemental information follows.

A table summarizing the design parameters of the various tests referenced in Technical Reports MUAP-11005, Rev. 1, MUAP-11013, Rev. 2, MUAP-11018, Rev. 1, MUAP-11019, Rev. 1, and MUAP-11020, Rev. 1 is included as Attachment 5 of this transmittal. As discussed in the "Design Philosophy and Executive Summary" section of Technical Report MUAP-11019, Rev. 1, the steel concrete (SC) walls in the US-APWR CIS fall within the wide range of design parameters considered in the experimental investigations. The key parameters considered include steel reinforcement ratio (taken as total plate thickness divided by wall thickness, or $2t_p/T$), plate slenderness ratio (stud spacing divided by plate thickness, or s/t_p), concrete compressive strength (f'_c), and steel yield strength (f_y). For the US-APWR CIS, the steel reinforcement ratio varies from 1.5 to 4.2%, plate slenderness ratio varies from 8 to 16, f'_c is equal to 4000 psi (27.6 MPa), and f_y of the plates is equal to 50 ksi (345 MPa).

The experimental data in Attachment 5 has been grouped according to the analysis or design aspect of interest. This grouping resulted in a series of separate tables presenting experimental data for tests on out-of-plane shear strength, in-plane shear strength with and without axial loading and considering either panel sections or flanged sections, axial compression, SC behavior under thermal loading, fire resistance, and full-structure tests subjected to lateral loading. All of the requested geometric and material properties are then identified for each test specimen in each group. The tables also identify the corresponding US-APWR SC wall category (i.e. 1, 2, or 3) for each test specimen, and which of the actual US-APWR SC wall cross sections most closely corresponds based on reinforcement ratio ($2t_p/T$). This parameter is the focus of the comparison because it is the most influential in terms of in-plane shear and out-of-plane flexural performance of SC walls. It is essential that the tests evaluate walls with similar reinforcement ratios to those of the actual CIS walls in order to adequately confirm the conservatism of the American Concrete Institute (ACI) 349-06 design provisions used for design. As shown in Attachment 5, the experimental database achieves this purpose by covering a wide range of reinforcement ratios that is inclusive of the various US-APWR SC wall cross sections.

With regard to stud spacing, which is critical to such design aspects as faceplate buckling, anchorage, and development, all of the US-APWR SC walls utilize stud spacing to plate thickness ratios less than or equal to 16. Likewise, tie bar spacing (which governs out-of-plane shear strength) is less than or equal to wall thickness (T) divided by two in all US-APWR SC walls. Thus the detailing of the US-APWR designs is equal to or better than that used for the various SC specimens in the experimental database. This leaves the steel reinforcement ratio as the key parameter of interest for correlating the test specimens to the US-APWR design.

Please see the first page of Attachment 5 for further description of the contents provided in each of the included tables.

For additional tabular comparisons of the geometric and material properties of the 1/10th scale test and the actual US-APWR CIS, please refer to technical report MUAP-11005, Rev. 0, Sections 3.2.1 through 3.2.3 on pages 15 through 25.

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

An appendix will be added to technical report MUAP-11005, Rev. 1 that includes the experimental database provided in Attachment 5. This appendix will also address the additional requests related to the experimental database provided in RAI 858-6270 and any future requests for additional information that have not yet been transmitted to MHI. The complete appendix will be provided to the NRC upon resolution of all related RAI responses.

SUPPLEMENTAL INFORMATION:

Technical Report MUAP-11005, Rev. 1, has been updated to include summaries of the experimental database. Appendix A provides an overview of the experimental database and summarizes the US-APWR design parameters. Appendices B, C, and D summarizes tests used to confirm design equations for out-of-plane shear, in-plane shear, and axial compression and local buckling, respectively. The full research papers for each test are provided in Appendix E.

Due to practical limits of physical testing, combination of member forces are generally not considered. The design for combined forces is based on a conservative interpretation of the conventional design of reinforced concrete walls for combined forced as detailed in MUAP-11019, Rev. 1, Section 8.0.

Sections 3.2.1 through 3.2.3 of Technical Report MUAP-11005, Rev. 1, are now found on pages 16 through 26 (previously on pages 15 through 25 of Technical Report MUAP-11005, Rev. 0).

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.