RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

05/31/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 985-6948 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:	**01/08/2013**

QUESTION NO. 03.08.03-105:

The staff reviewed the applicant's response to RAI 905-6311, Question 03.08.03-70 on how to prevent interfacial shear failure as an steel-concrete (SC) specific limit state. The applicant is requested to provide the following additional information to resolve this RAI:

In the response to Item 1 of the original RAI, an interfacial shear design equation (Eq. 03.08.03-70-4) is derived. The staff determined that the interfacial shear design equation, which is based on the calculated out-of plane shear strength, may not ensure that the out-of-plane shear failure occurs before the interfacial shear failure as stated in the RAI response. This is because the calculated out-of plane shear strength is a lower bound strength used in design, and in reality, the actual out-of-plane shear strength of an SC section is most likely higher than the corresponding calculated strength. In a similar case discussed in technical report (TR) MUAP-11020-P (R0) (see pages 3-1 and 7-2 of the TR), to ensure that flexural yielding will occur before out-of-plane shear failure in the SC wall connection region, the calculated flexural strength is increased by 25% to determine the required out-of-plane shear strength. Considering the above discussion, the staff requests that the applicant appropriately increase the calculated out-of-plane shear strength for the interfacial shear strength design, to prevent the interfacial shear strength from being the governing failure mode. This would ensure that the SC section fails in out-of- plane shear before interfacial shear failure could occur. Otherwise, provide an alternative approach which demonstrates the SC design philosophy that the out-of-plane shear limit state controls the design. Regarding the response to Item 3 of the original RAI, the staff noticed that strength reduction factors are not considered in the interfacial shear strength calculations presented, and this is inconsistent with the similar calculations presented in TR MUAP-11019-P (R0) Section 2.3. Therefore, the staff requests that the applicant resolve the inconsistency and indicate which strength reduction factors will be used in the interfacial shear strength design of US-APWR SC walls. If not used, explain why not. The staff also notes that the RAI response indicated that the information provided does not have any impact on the DCD nor the technical report. Since this response provided important analysis and design information, and the corresponding information in the technical report is outdated, revise the technical report to incorporate, and revise the DCD to summarize, the important information provided in the RAI response which has not yet been included. It should be noted that the request to update the technical report and DCD also applies to other aspects of the design of SC walls which

should incorporate any changes made in design and to capture the important analysis and design methodology.

ANSWER:

Out-of-plane Behavior

The US-APWR steel-concrete (SC) walls are detailed such that failure mode of flexural yielding of the steel faceplates governs the out-of-plane behavior. This is accomplished by designing the SC modules such that the flexural strength is the lowest calculated capacity of the out-of-plane failure modes (e.g., flexural, shear, and interfacial).

As discussed in Technical Report MUAP-11020, Rev. 1 Section 3.2, for the purposes of detailing the SC wall cross-section, the required out-of-plane shear strength (V_{no}^{reqd}) is calculated using: **[**

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Therefore, the governing out-of-plane failure mode will be flexural yielding of the steel faceplates, which is the objective of the US-APWR SC wall detailing. This is confirmed by the full-scale test results presented in Technical Report MUAP-11013, Rev. 2, Appendix B, Section 9, for Specimens 2.2.1 and 2.2.2.

Strength Reduction Factors

The strength reduction factor is not included in the calculation of the stud shear strength (Q_n) in Technical Report MUAP-11019, Rev. 1 Section 2.5 for three reasons:

The large scale test results presented in Technical Report MUAP-11013, Rev. 2, Appendix B, Section 8, for Specimens 2.1.1 - 2.1.4 confirm that if the flexural yielding limit state is eliminated as a possible limit state, then the governing failure mode is out-of-plane shear (not interfacial shear failure). Specimens 2.1.1 and 2.1.2 had shear span ratios of 2.0, and they both failed in out-of-plane shear (diagonal shear failure mode).

Thus, the hierarchy of failure modes for out-of-plane behavior of US-APWC SC walls is: (1) flexural yielding of the steel faceplates governs first, followed by (2) out-of-plane shear failure, and then (3) interfacial shear failure. The design approach presented in Technical Report MUAP-11019, Rev. 1 Section 2.5 for interfacial shear strength of SC walls is adequate.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-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.