RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

07/08/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1024-7053 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:	**04/26/2013**

QUESTION NO. 03.08.03-113:

The staff reviewed the applicant's response to RAI 931-6467, Question 03.08.03-84, regarding the MHI terminology used for connection regions, connections and connected parts, and questions on how MUAP 11020 (R0) Section 3.1 ensures that the connection design will follow the MHI full strength connection design philosophy.

Regarding MUAP 11020 Section 3.1 Item (ii), the RAI response to RAI Item 3 stated that the required in-plane shear strength of the connection will be calculated as 1.1Asfy. The staff's understanding of the applicant's design approach is that this equation was derived based on the in-plane shear strength contribution from both the steel faceplates and the concrete infill. However, MUAP-11019 indicates that the in-plane shear strength of the SC walls is based on the applicable ACI 349-06 code equations, and as an added conservatism, the contribution of the concrete infill to the in-plane shear strength is ignored. In addition, the recent markups provided to the staff for DCD Section 3.8.3.4.5.2, also indicate that the ACI 349-06 code design strength for in-plane shear is conservatively modified by neglecting the concrete contribution to in-plane shear strength. Since the description of the design information in MUAP-11019 and the markups to the DCD are not consistent with the applicant's design approach for in-plane shear strength calculation of the SC walls and the connections to the walls, the applicant is requested to (1) clearly document in the response to this RAI the the approach used in the calculation of the in-plane shear strength used in the design of the SC walls and the SC connections, and (2) revise MUAP-11019 (and other reports if applicable) and the DCD to reflect the approach used for design of the SC walls and connections.

The staff also reviewed the revised response to RAI 931-6467, Question 03.08.03-84, submitted March 29, 2013, and MUAP-11020, Revision 1, submitted February 27, 2013, and determined the issue still applies.

ANSWER:

The staff is correct in understanding that the design equation was derived based on the in-plane shear strength contribution from both the steel faceplates and the concrete infill. The original American Concrete Institute (ACI) 349-06 Equation 21-7 is modified by neglecting initial concrete contribution before cracking. The concrete contribution to in-plane shear strength after cracking is included directly in the $A_s f_y$ term. The Design Control Document (DCD) and Technical Report will be revised for clarity as indicated in the attached markup.

Impact on DCD

DCD Subsection 3.8.3.4.5.2 will be revised as indicated on the attached markup.

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

Technical Report MUAP-11019, Rev. 1, Sections 7.3 will be revised as indicated on the attached markup.

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

7.3 Conservative Equation for In-plane Shear Strength

Based on the test results obtained from Ozaki et al. (Reference 11) and Sasaki et al. (Reference 15) the nominal in-plane shear strength of SC walls is calculated using the following equation:

by neglecting initial concrete contribution before cracking. The concrete contribution to in-plane shear strength after cracking is included directly in the $A_s f_y$ term.

Equation 7.3-1 $$V_n = A_s f_y$$

where the original ACI 349-06 Equation 21-7 is modified ~~by conservatively neglecting the concrete contribution (A_{cv} α_c $f'_c{}^{0.5}$)~~.

In the above equation, A_s is the area of the steel plates (A_s=A_{cv} ρ_t) in the composite section and f_y is the specified yield strength for the steel plates. The in-plane shear strengths calculated using the above equation and the experimental results reported by both Ozaki et al. (Reference 11) and Sasaki et al. (Reference 15) are compared in Figure 7.2-1 and Figure 7.2-2. These figures indicate acceptable comparison between the experimental results and the in-plane shear strength calculated using Equation 7.3-1.

The strength reduction factor (ϕ) of 0.85 further improves the comparison and ensures the conservatism of the in-plane shear strength calculated using Equation 7.3-1. The SC wall design strength equation for in-plane shear is given as follows:

Equation 7.3-2 $$\phi V_n = \phi A_s f_y$$

The upper bound for the in-plane shear strength of SC walls is limited to

Equation 7.3-3 $$V_n = 10 A_{cv} \sqrt{f'_c}$$

This is a conservative limitation for SC design since the failure modes that are the basis for this requirement, including excessive crack widths and localized concrete crushing, are more critical to RC walls.

Appendices B and D, respectively (Reference 3.8-63). The manner in which the SC walls are detailed to prevent SC-specific limit states is presented in Technical Report MUAP-11019, Chapter 2 (Reference 3.8-71). MIC-03-03-00057

3.8.3.4.5.2 Design for In-Plane Shear

~~Design for in-plane shear is in accordance with the requirements of ACI 349, Chapters 11 and 14 (Reference 3.8-8). The steel faceplates are treated as reinforcement for the concrete, and satisfy the requirements of Section 11.10 of ACI 349 (Reference 3.8-8).~~ Design for in-plane shear is in accordance with the methodology of ACI 349-06 (Reference 3.8-8) Chapters 11 and 21, as supplemented by Section 7 of Technical Report MUAP-11019 (Reference 3.8-71). The steel faceplates are treated as reinforcement for the concrete which satisfy the provisions of Section ~~11.10~~21.7 of ACI 349-06 (Reference 3.8-8). DCD_03.07.02-35 MIC-03-03-00066 MIC-03-03-00057

~~ThisThe design approach is based on behavior of the SC module that is similar to reinforced concrete, which is supported by the test results of References listed in Subsection 3.8.3.4.~~ The design approach is based on SC module experimental research in which the in-plane shear behavior of the infill concrete and longitudinal (faceplate) reinforcement was observed to be similar to that of reinforced concrete shear walls. The observations and results of experimental research on SC wall in-plane shear behavior are summarized in Technical Report MUAP-11005, Appendix C (Reference 3.8-63). The steel plate acts as shear reinforcement in each of ~~2~~two ~~designing~~ orthogonal directions, similar to ~~that of standard concrete reinforcement~~the grids of longitudinal reinforcement provided in standard reinforced concrete shear walls. However, as discussed in Technical Report MUAP-11019, Section 7 (Reference 3.8-71), the ACI 349-06 (Reference 3.8-8) code design strength for in-plane shear is conservatively modified ~~by neglecting the concrete contribution to in-plane shear strength~~. MIC-03-03-00066 MIC-03-03-00057 MIC-03-03-00066 MIC-03-03-00057

[by neglecting initial concrete contribution before cracking. The concrete contribution to in-plane shear strength after cracking is included directly in the $A_s f_y$ term.]

3.8.3.4.5.3 Design for Out-of-Plane Shear

~~Design for out-of-plane shear is in accordance with the requirements of ACI 349, Chapter 11 (Reference 3.8-8).~~ Design for out-of-plane shear is in accordance with the methodology of ACI 349-06 (Reference 3.8-8) Chapter 11, as supplemented by Section 6 of Technical Report MUAP-11019 (Reference 3.8-71). 02-35 MIC-03-03-00066

~~The design approach is based on the premise that the behavior against out-of-plane shear and the effect of shear reinforcement of the SC module are similar to those of reinforced concrete. This methodology is supported by the test results of References listed in Subsection 3.8.3.4.~~ The design approach is based on SC module experimental research in which the out-of-plane shear behavior of the infill concrete and transverse (tie bar) reinforcement was observed to be similar to that of reinforced concrete members. The observations and results of experimental research on SC wall out-of-plane shear behavior are summarized in Technical Report MUAP-11005, Appendix B (Reference 3.8-63). As discussed in Section 6 of Technical Report MUAP-11019, (Reference 3.8-71) the concrete contribution to out-of-plane shear strength is reduced to account for size effects. In addition, the concrete contribution to out-of-plane shear strength is ignored for load cases involving seismic loading. MIC-03-03-00057