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. 03.08.03-104:

The staff reviewed the applicant's response to the RAI 905-6311, Question 03.08.03-69 on how the delamination or splitting failure mode of the concrete in the SC sections can be prevented by providing adequate out-of-plane shear strength. Regarding the first example case, where a segment of the steel-concrete (SC) wall is subjected to an axial compression force on the concrete only at one end, a 3T (T =wall section thickness) transfer length is assumed in the calculation for the resisting moment. However, the staff noticed that Section 2.4 of technical report (TR) MUAP-11019 indicates a steel faceplate development length of 2T for a typical 48 inch thick SC wall. Therefore, the staff requests that the applicant reconcile the use of the 3T transfer length versus the 2T value, which was utilized in Section 2.4 of TR MUAP-11019.

Regarding the second example case, in which the splitting moment results from slightly different yield forces in the two steel faceplates, the staff found that insufficient information is provided for the derivation of the splitting moment. Therefore, the staff requests that the applicant provide additional information on how the splitting moment in the second example case is obtained, e.g., include a complete free body diagram showing all forces balancing each other.

In addition, as requested in the original RAI, identify what tests exist which provide additional justification to show that delamination or splitting would not occur anywhere for the configuration that is the same or similar to the US-APWR configuration.

Furthermore, the RAI response stated that the splitting or delamination failure is hypothesized, and its force demand is not real and will not be combined with other load demands. It is unclear to the staff why the failure mode is not a real case; therefore, the applicant is requested to provide additional explanation regarding this issue.

ANSWER:

The transfer length for a steel-concrete (SC) wall section is not the same as the development length for the steel faceplates. Transfer length (L_T) is defined as the length over which the

shear studs develop composite action in terms of strain compatibility in the SC wall, as shown in Technical Report MUAP-11019, Rev. 1 Figure 2.7-1. Development length (L_d) is defined as the length over which the shear studs develop the yield strength of the steel faceplates, as shown in Technical Report MUAP-11019, Rev. 1 Figure 2.4-1.

The development length of the steel faceplates of SC wall is dependent upon the relative strengths of the steel faceplates and the shear studs. It was calculated in Technical Report MUAP-11019, Rev. 1 Section 2.4, and was shown to be less than two times the wall thickness (T) for typical US-APWR SC walls.

The transfer length depends on the relative stiffness of the shear studs and the steel faceplates. It was not calculated explicitly, but is expected to be greater than the development length (two times the wall thickness T). It was assumed to be equal to 3T in the sample calculation presented in Technical Report MUAP-11019, Rev. 1 Section 2.7. Figure 2.7-4 shows the free body diagram for the case with slightly different yield forces in the two steel faceplates, and the resulting splitting moment. This figure will be revised as indicated on the attached markup to provide additional information on how the splitting moment is obtained.

There are no tests that show that delamination or splitting will not occur for the configuration that is the same or similar to the US-APWR configuration. Delamination or splitting failure has been observed only once in the laboratory for tests conducted on SC walls without tie bars. Delamination or splitting failure has not been observed in any tests conducted on SC walls with tie bars exceeding the minimum requirements of American Concrete Institute (ACI) 349-06 Section 11.5.6.3, which are discussed in Section 2.6 of Technical Report MUAP-11019, Rev. 1.

Delamination or splitting failure is not a plausible failure mode for the US-APWR design because:

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

Technical Report MUAP-11019, Rev. 1 Figure 2.7-4 will be revised as indicated on the attached markup.

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

Replace figure with 'Revised Figure 2.7-4' attached

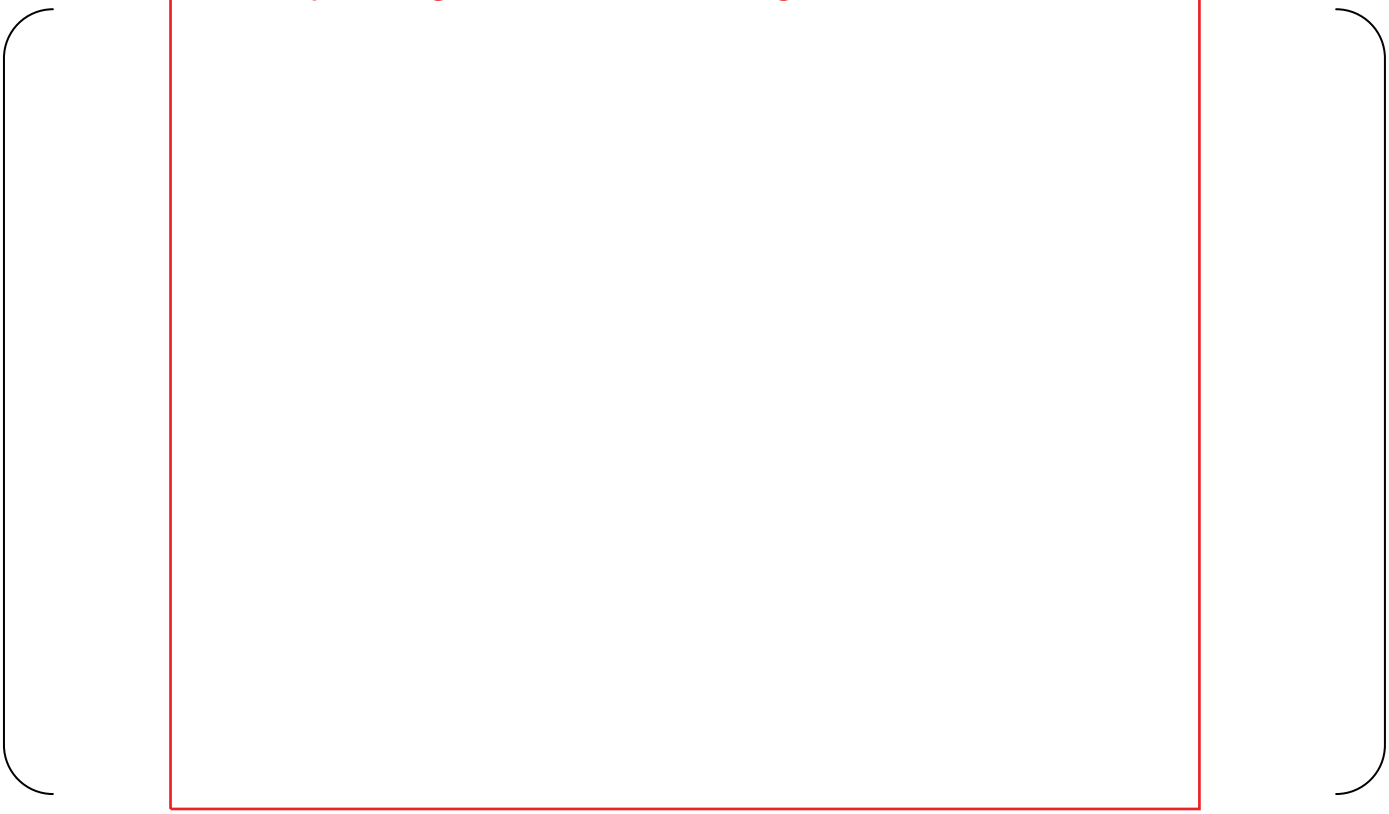


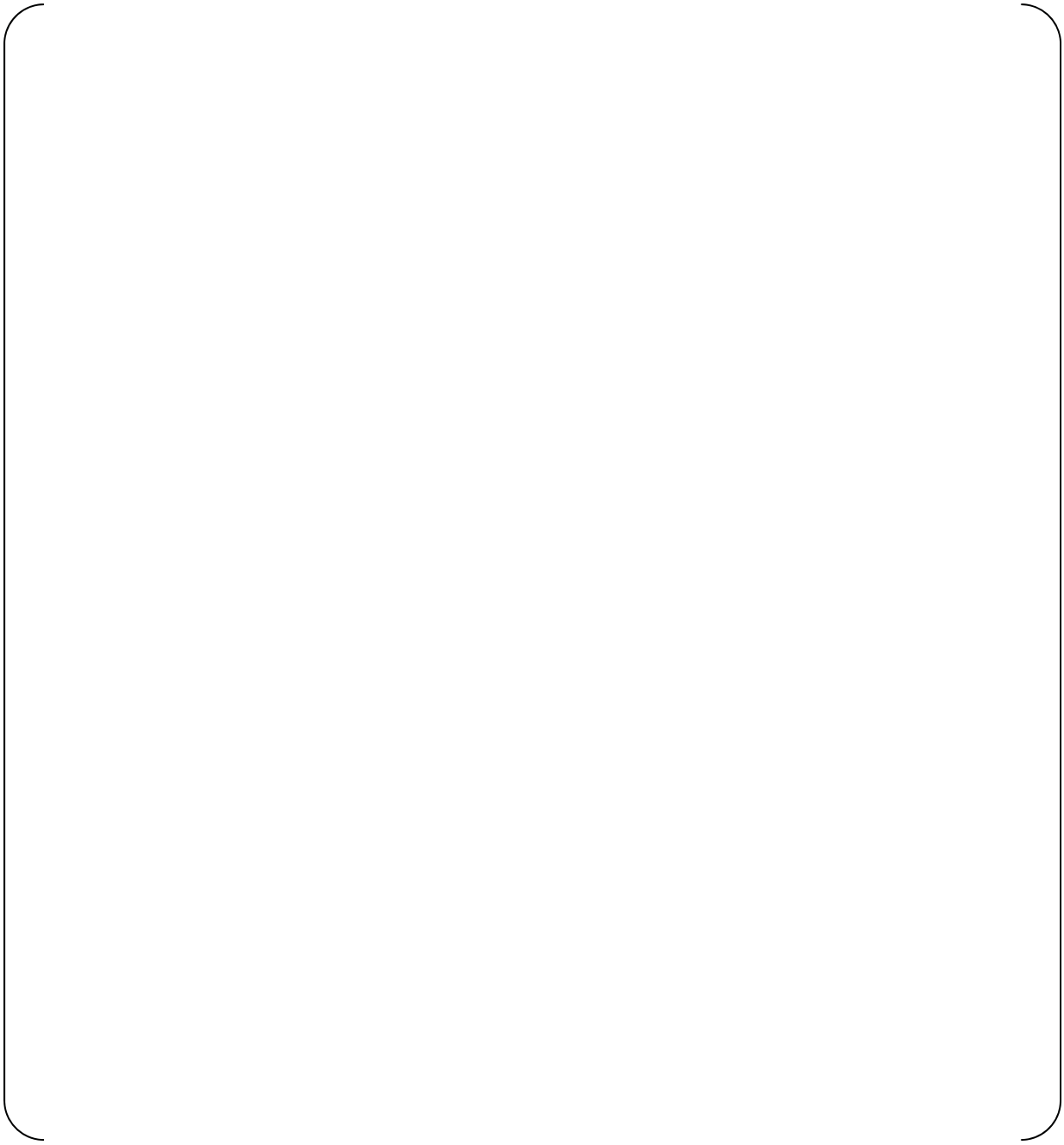
Figure 2.7-4 Eccentric Moment (M_O) Due to Imbalance in Yield Forces of Steel Faceplates

The US-APWR SC walls typically have the same specified thickness and yield stress for opposing steel faceplates. Any force imbalance will primarily occur as a result of differences in actual thickness and yield stress behavior of opposing steel faceplates. As described above, the tie bars have more than sufficient capacity to prevent a splitting failure resulting from this imbalance.

2.7.1 Summary

Loss of structural integrity due to delamination or splitting failure is plausible for SC walls because of the imbalance of stresses resisted by the steel faceplates and the concrete infill, and because of the significant eccentricities associated with the large wall thicknesses used. ACI 349-06 does not provide design requirements to prevent splitting failure of large-thickness RC walls. Nevertheless, each US-APWR SC wall cross section is to be evaluated for two conditions resulting in eccentric moments that must be resisted by the tie bars to prevent delamination or splitting, including 1) eccentricity between applied and resisting forces in the composite section, and 2) eccentricity resulting from differences in opposing faceplate resisting forces due to small differences in actual plate thickness or yield stress. **[**

] it has been shown that the tie bars have more than sufficient capacity to prevent splitting or delamination failure modes.



Revised Figure 2.7-4