RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/29/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 960-6709 REVISION 0**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**09/24/2012**

QUESTION NO. 03.07.02-217:

Section 4.2.1 of MHI's TR MUAP-12002 (R0), "Sliding Evaluation and Results," describes the selection of the static and kinetic (sliding) coefficients of friction. To assist the staff in evaluating whether appropriate static and kinetic coefficient of friction values are utilized in accordance with the guidance in SRP Section 3.8.5, the staff requests the applicant to provide the following additional information:

a) Section 4.2.1 of the TR states, "The governing friction occurs between the mud mat and the underlying granular soil where a thin soil layer exists that is interlocked with the bottom of the mud mat." The applicant is requested to provide the technical basis and justification for the conclusion that the sliding interface would not be at the concrete to soil interface.

b) The TR indicates that any fine grain materials within a few feet below the basemat will be replaced by engineered fill. Engineered fill will be specified in the DCD as a well drained granular backfill with a minimum friction angle of $\Phi = 35°$. The applicant states that the minimum angle of internal friction will be specified in DCD Table 2.0-1 as a site requirement.

   The staff notes that, regardless whether materials below the basemat are replaced by engineered fill, the DCD needs to specify the minimum angle of internal friction. Therefore, the applicant is requested to confirm that the minimum angle of internal friction for the in-situ soil, and any engineered fill, will be specified in DCD Tier 2, Section 2; and that in-situ soil will also be specified in DCD Tier 1.

c) Another potential sliding interface is at the location of any waterproofing material (e.g., waterproofing material between the mud mat and soil or between the basemat and mud mat).

   Therefore, the applicant is requested to explain where waterproofing material is used; the type of waterproofing material; the coefficient of friction of the waterproofing material with respect to the adjacent material; and the basis for the coefficient of friction.

d) The TR indicates that the cold joint at the mud mat to bottom of foundation contact will be "raked" with a very rough surface (minimum amplitude greater than ¼ inch - as recommended in the Commentary to ACI 349-06 to maintain a minimum friction coefficient of 0.7. The applicant is requested to include this commitment in the DCD.

e) The kinetic coefficient of friction used for the sliding stability analysis is given as 0.5 for all subgrades. The value of the kinetic coefficient of friction is based on laboratory soil tests with samples from seven different types of sands. The applicant is requested to confirm that the kinetic coefficient of friction used for the design basis sliding stability analysis bounds the types of soils and soil properties/conditions considered for the US-APWR standard design.

f) Reference 13 in the TR could not be located. To complete its review, the staff requests the applicant to submit a copy of Reference 13: "Constant Volume Cyclic Simple Shear Testing," Proceedings of the 2nd International Conference on Microzonation, San Francisco, CA, Finn, W.D.L., Laid, Y.P. and Bhatia, S.K., pg. 839-851, 1978

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by Letter UAP-HF-12292 (ML12356A069).

a) The concrete-soil interface discussed in Section 4.4 of the Technical Report MUAP-12002, Rev. 1, is the interface between the mud mat and granular soil. As explained in the Technical Report, for concrete that is placed directly on the granular soil and penetrates between the soil grains, the actual concrete soil interface is not smooth and the friction failure is forced to take place in the soil immediately below the concrete. This is reflected by the fact that the recommended friction angle at contact between mass concrete and granular soil is the internal friction angle of the soil, ϕ (see Reference 17 of the Technical Report).

b) The following requirements are specified in the Design Control Document (DCD):

- In-situ *granular soil* and engineered fill will have a minimum angle of internal friction of 35°.

- Any in-situ *fine grained* soil immediately below the basemat will be replaced by engineered fill. The engineered fill will be specified to be approximately 4 to 6 in. thick.

c) No waterproofing membrane will be used below the basemats of US-APWR structures. Required concrete waterproofing will be ensured by using appropriate concrete admixtures.

d) DCD Subsection 3.8.5.5.2 is revised to include the commitment to rake the concrete to a full amplitude of 0.25 in. to achieve a coefficient of friction of 1.0, per American Concrete Institute (ACI) 349-06, Section 11.7.9, between the fill concrete and the basemat.

e) The kinetic friction coefficient for concrete-to-concrete and concrete-to-rock interfaces are discussed in Section 4.4 of Technical Report MUAP-12002, Rev. 1, based on test results reported in the literature. For interfaces involving soil, granular soils are discussed only in relation to friction coefficients used for sliding analysis (according to the

Answer to Question 217b). Moreover, any friction failure for this type of interface occurs within the soil mass, as explained in the Answer to Question 217a. Therefore, the laboratory test results discussed in this answer refer only to granular soil.

The internal friction angle is the parameter of interest for assessing the shear strength properties of granular soil. The soils and soil property conditions considered for assessing friction coefficients include granular soils with shear wave velocities equal to, or larger than, 270 m/sec., i.e., dense granular soils, either natural soils or engineered fills. As discussed in Section 4.4 of Technical Report MUAP-12002, Rev. 1, the soil samples used in the laboratory soil tests described in Reference 20 of the Technical Report include various types of granular soils with friction angles between 28° and 48°, which envelope the range of friction angles for dense granular soils (either natural or engineered fill) considered for the US-APWR standard design.

f) See the requested reference attached to this response.

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.