REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**227-8274**
SRP Section:	**03.08.04 – Other Seismic Category I Structures**
Application Section:	**03.08.04**
Date of RAI Issue:	**09/25/2015**

Question No. 03.08.04-4

10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of seismic Category I structures. Standard Review Plan (SRP) 3.8.4, Section II.3 includes the various loads and load combinations to be considered which include dead load, live load, hydrodynamic loads resulting from LOCA and/or safety relief valve loads, earthquake loads, and floods.

In APR1400 DCD Tier 2, Section 2.4, “Hydrologic Engineering,” the applicant described the types of hydrodynamic loads on the safety-related structures. In subsection 2.4.15, “Combined License Information,” the applicant requires a COL applicant to provide the site-specific hydrological events in COL item 2.4(1). In Section 3.4, “Water Level (Flood) Design,” the applicant described the flood loads due to design basis flood levels from external and internal events on Seismic Category I structures. In subsection 3.4.3, “Combined License Information,” the applicant requires a COL applicant to provide site-specific internal and external flooding sources in COL items 3.4(2) and 3.4(3). In subsection 3.8.4.3, “Loads and Load Combinations,” the applicant requires a COL applicant to identify the site-specific loads such as effects of seiches, surges, waves, and tsunamis in COL item 3.8(2). However, it is not clear whether the applicant considered all the hydrological events described in Section 2.4 and 3.4 as loading and in the load combination(s) for the seismic Category I structures in Section 3.8.4, “Design of Seismic Category I Structures,” and is there enough allowable margin(s) in loading combinations to accommodate the potential flooding loads of site-specific internal and external flooding sources, including the factors of safety given in DCD Section 3.8A (Tables 3.8A-15 & -38), and Technical Report APR1400-E-S-NR-14006-P, Rev. 0, Table 4-5.

Therefore, the applicant is requested to address the following, and include this information in the DCD:

Applicant is requested to describe how the various water/flood related loads are classified (e.g., normal, severe environmental, abnormal, etc.), how they are calculated in terms of the loads used in DCD Section 3.8.4, how are they applied in the design of seismic Category I structures,

and whether there is sufficient design margin(s) in the loading combinations to accommodate the potential flooding loads of site-specific internal and external flooding sources.

Response - Rev. 2

1) The classification of effective loadings complies with code specification (ACI 349 Ch.9) and the classified effective loadings are as follows:

   - Hydrostatic load (L_h): Normal load as described in DCD Section 3.8.4.3.1.b.2)

     Hydrostatic loads due to weight and pressure of fluids with well-defined densities and controllable maximum heights or related internal moment and forces. This load is not related to natural phenomena. It is calculated as a linearly distributed pressure on the internal and external walls.

   - Soil and surcharge load (L_g): Normal load as described in DCD Section 3.8.4.3.1.b.1)

     The soil and surcharge load (L_g) include hydrostatic pressure, surcharge load, and earth pressure. Hydrostatic pressure is applied up to elevation of groundwater specified in DCD Tier 2 Table 2.0-1 (0.61m (2 ft) below plant grade). Earth pressures are applied up to the grade level, as shown in the Figure 1.

   - Flooding load (Y_f): Abnormal load as described in DCD Section 3.8.4.3.2.g

     This load is applied due to internal flooding generated by a postulated pipe break in abnormal extreme environmental loading condition.

   - Design flood/precipitation (H): Severe environmental load as described in DCD Section 3.8.4.3.3.b

     This load is applied up to the maximum site flood elevation which is specified in DCD Tier 2 Table 2.0-1 (0.30m (1 ft) below plant grade).

   - Probable maximum flood/precipitation (PMF/PMP) (H_s): Extreme environmental load as described in DCD Section 3.8.4.3.4.c

     This load is applied based on the maximum flood elevation which is specified in DCD Tier 2 Table 2.0-1 (0.30m (1 ft) below plant grade).

   - Hydrodynamic load in safe shutdown earthquake (SSE) loads (E_s): Extreme environmental load as described in DCD Section 3.8.4.3.4.a.1)

     This load is included as part of the SSE loads (E_s) and is applied based on the maximum elevation of groundwater specified in DCD Tier 2, Table 2.0-1 (0.61m (2 ft) below plant grade).

     The dynamic soil pressure and hydrodynamic load in the SSE loads (E_s) are applied to the seismic category I structures as shown in Figure 2. Design flood/precipitation (H) and PMF/PMP (H_s) are not governing loads in the design of

APR 1400 since the load combinations including those loadings are negligibly small compare to the other load combinations.

2) The water heads are transformed into hydro static or hydrodynamic loadings as shown below.

- Hydrostatic load

  Hydrostatic loads are calculated as a linearly distributed pressure on external walls depending on the design water level (EL. 96'-8") according to the basic equation of hydrostatics as shown in Figure 1. The design groundwater elevation for the APR1400 standard plant design is based on the EPRI ALWR URD (Utility Requirement Document) Table 1.2-6 “Envelope of ALWR Plant Site Design Parameter.” Therefore, the maximum design ground water level is determined to be 0.61m (2 feet) below the plant grade in the vicinity of the SSSc important to safety, (see the applicant’s response to RAI 75-8023 Question 03.04.02-1 item a. (ii)).

  $P_W = \gamma_W h$

  Where, γ_W = unit weight of water = 62.4(lbs/ft^3),

  h = depth (ft)

- Surcharge load

  $\mathrm{P_{sur}} = \mathrm{K_o q}$

  Where, $\mathrm{K_o}$ = coefficient of earth pressure at rest condition

  q = static surcharge pressure

- Earth Pressure

  $P_s = K_o \gamma h$

  Where, $\gamma = \gamma_s$ = Soil density in saturated condition

  $\gamma = \gamma_{sub}$ = Soil density in submerged condition

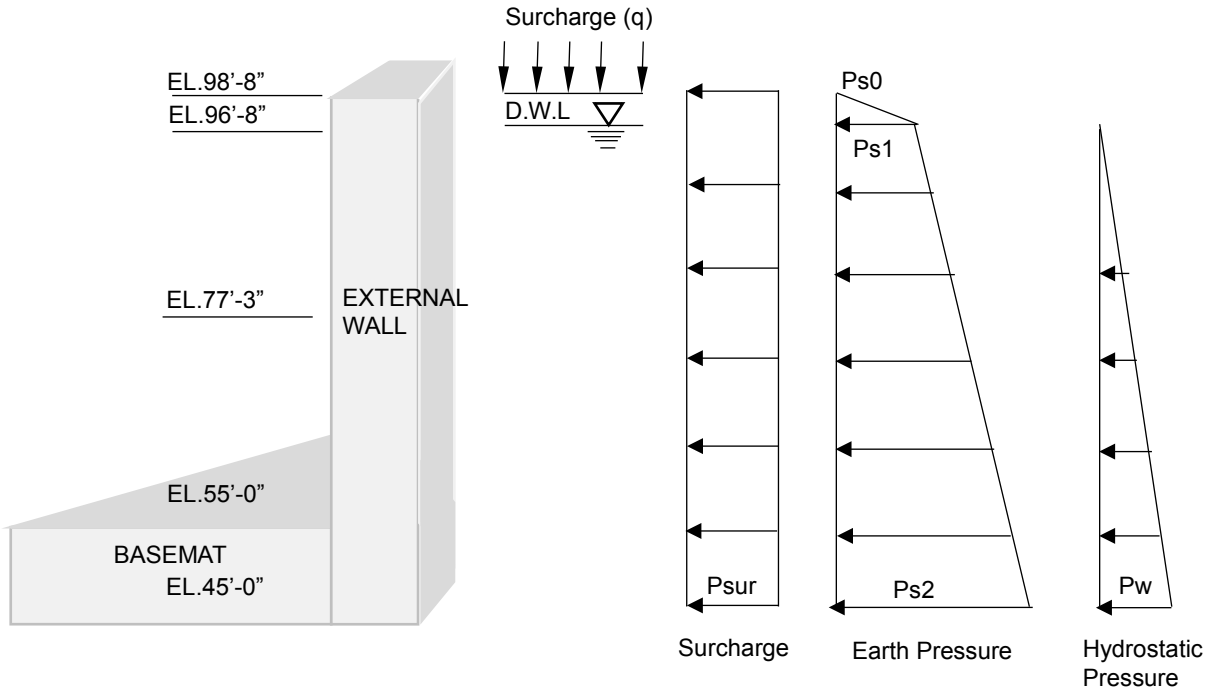

Figure 1 Static Lateral Pressure

- Dynamic groundwater pressure (Hydrodynamic water pressure)

  Dynamic groundwater pressure is calculated based on the hydro-dynamic formula suggested by Matsuo and O'Hara in "Principles of Soil Dynamics," written by Braja M. DAS. Based on the hydro-dynamic formula, the hydrodynamic water pressure due to SSE load is expressed as a parabolic distributed pressure as shown in Figure 2. The design water level (EL. 96'-8") is considered in the calculation of hydrodynamic water pressure.

  For details of dynamic groundwater pressure and dynamic earth pressure, refer to Question No.03.08.04-7 of this RAI response.

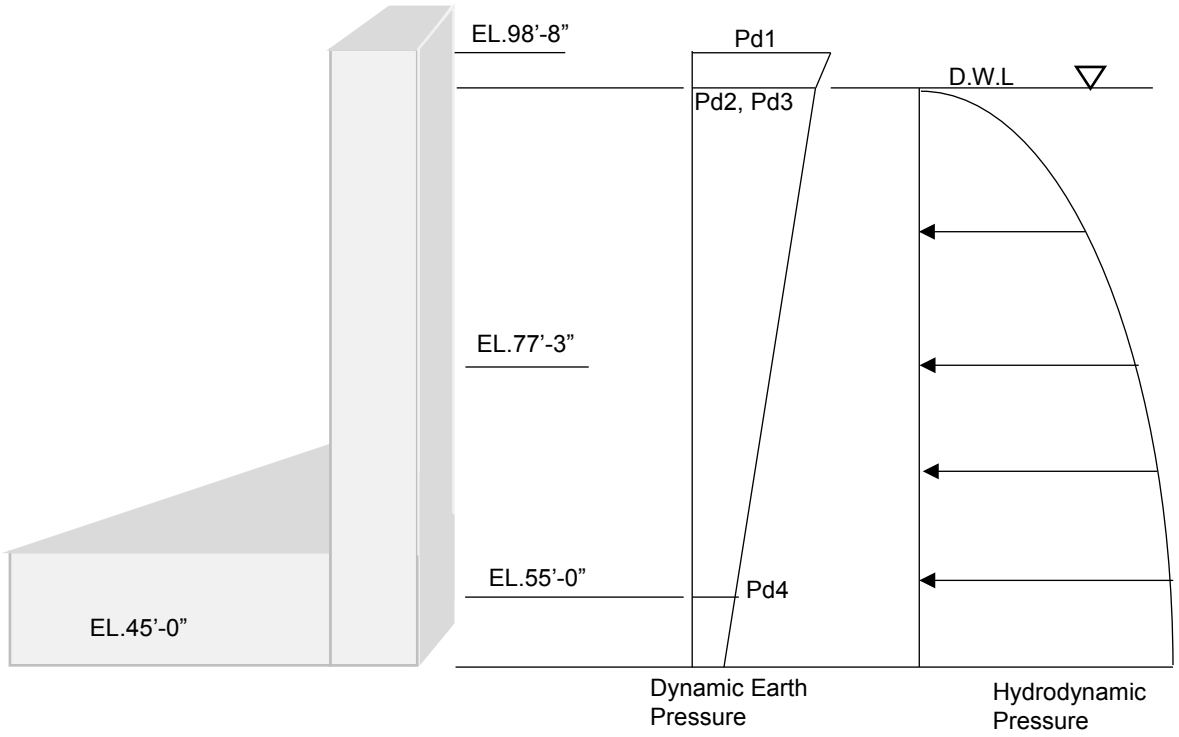

Figure 2 Dynamic Earth Pressure & Hydrodynamic Pressure

These explanations will be added to DCD subsection 3.8.4.3.7 as shown attachment 1 this response.

3) The surcharge, earth pressure, and groundwater pressure loads were applied to the exterior walls of all seismic Category I structures and in the direction of the loads were toward inside of the buildings below grade, as shown in Figure 3. Therefore, Subsection 3.8.4.3.1 will be revised as shown in the attachment 2 of this response.

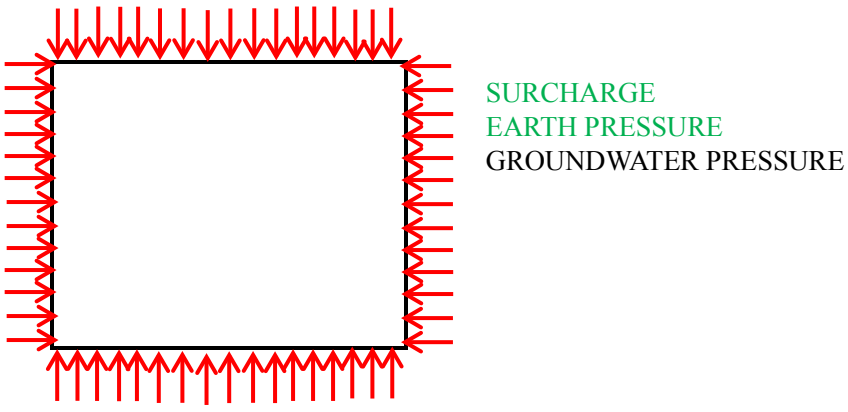

Figure 3 Schematic for Applied Lateral Earth Pressure

4) Seismic Category I structures are designed to have sufficient margins for the maximum flood load based on the maximum flood elevation specified in DCD Tier 2, Table 2.0-1. The site-specific flood level varies depending on the site location and site characteristics, the COL applicant shall determine the proper site grade elevation to maintain sufficient margin and minimize the influence of the potential higher flood loads.

Impact on DCD

DCD Subsection 3.8.4.3.1 will be revised and Subsection 3.8.4.3.7 will be added as indicated in the attachments associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Stresses due to seismic loads from different directions are combined by the SRSS method using the following expression:

3) Additional seismic loads due to accidental torsion

Additional seismic loads due to accidental torsion are accounted for as required by SRP Subsection 3.7.2.II.11. An additional eccentricity of the mass at each floor equivalent to 5 percent of the maximum building dimension is included. The accidental torsion load is represented by an additional shear force at each floor elevation determined from the analysis for the product of resultant story shear and accidental eccentricity at each elevation.

b. Tornado or hurricane load – (W_t)

The tornado or hurricane loads are described in Subsection 3.3.2.

c. Probable maximum flood/precipitation – (H_s)

H_s is the forces, due to the probable maximum precipitation as well as the maximum flood level, which includes the effects of seiches, surges, waves, and tsunamis.

3.8.4.3.5 Other Loads

Other loads are loads resulting from aircraft hazard and explosion pressure wave that are not included in the design basis. These loads are evaluated to prevent damage to safety-related structures, systems, and components beyond the design basis condition.

3.8.4.3.6 Load Combinations

The load combinations to be used in the design of the structure are in accordance with Tables 3.8-9A and 3.8-9B, and in conjunction with the definitions of load conditions and design loads as provided in Subsections 3.8.4.3.1 through 3.8.4.3.5.

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3.8.4.3.7 Below Grade Exterior Walls

The design and analysis procedures for seismic Category I exterior walls below grade are described below.

Hydrostatic (groundwater)

The hydrostatic unit water pressure (P_w) at a depth h below ground level is calculated as a linearly distributed pressure depending on the design water level (0.61m (2 ft) below plant grade).

$$P_W = \gamma_W h$$

Where, γ_W = unit weight of water = 62.4pcf

Static Earth Pressure

Static earth pressure is based on "at-rest" conditions and the coefficient of earth pressure is calculated as the following relationship. In addition, the soil parameters are described in DCD Table 2.0-1.

$$P_s = K_o \gamma h$$

Where, $K_o = 1 - \mathrm{Sin}(\varphi)$ = Coefficient of earth pressure at rest condition

$\gamma = \gamma_s$ = Soil density in saturated condition

$\gamma = \gamma_{sub}$ = Soil density in submerged condition

Surcharge Pressures

The surcharge pressure is defined for all soil cases as the at-rest pressure as follows:

$$P_{sur} = K_o q$$

Where, q = static surcharge pressure

The dynamic lateral surcharge pressure is the same as the static surcharge pressure, for conservatism.

Dynamic Earth Pressures

The dynamic earth pressure is calculated in accordance with ASCE 4 (Reference 41), Section 3.5.3, Figure 3.5-1, "Variation of Normal Dynamic Soil Pressures for the Elastic Solution."

Dynamic Groundwater Pressures

Dynamic groundwater pressure is calculated based on the hydro-dynamic formula suggested by Matsuo and O'Hara in "Principles of Soil Dynamics," written by Braja M. DAS

(Reference 42). The design water level (0.61m (2 ft) below plant grade) is considered in the calculation of hydrodynamic water pressure.

Passive Earth Pressure

The passive earth pressure is not included in the resistance force for sliding and overturning in the basemat stability check. Therefore, passive earth pressure on exterior walls does not need to be considered.

Evaluation of the capability of a structure for a given load combination is based on providing a factor of safety appropriate to the probability of occurrence. The appropriate factor of safety is reflected in the load factors and allowable stresses for the various load combinations.

The COL applicant is to identify any applicable site-specific loads such as site proximity explosions and missiles, potential aircraft crashes, and the effects of seiches, surges, waves, and tsunamis (COL 3.8(2)).

3.8.4.3.1 Normal Loads

a. Dead loads – (D)

Dead load refers to loads that are constant in magnitude and point of application. The types and definitions of dead loads and their combination requirements are given in Table 3.8-8.

b. Live loads – (L)

Live load refers to any normal loads that may vary with intensity and location of occurrence. The types and definitions of live loads and their combination requirements are given in Table 3.8-8. The specified design values for live loads are summarized in Table 3.8-7.

1) Soil and surcharge load (L_g)

These loads are applied on seismic Category I structures below grade, with the force directed toward the inside of the structures.

Soil and surcharge load refers to load due to weight and pressure of soil, water in soil, or other material such as soil surcharge. Maximum flood level is specified to be 0.30 m (1 ft) below plant grade for safety-related structures. For the construction loading condition, the minimum surcharge load is 48.0 kN/m^2 (1,000 psf) over any unoccupied area plus the actual construction loading surcharge from any known structures or load sources. For the normal loading condition, the minimum surcharge load is 24.0 kN/m^2 (500 psf). For the design of underground utilities, the minimum surcharge load for the construction loading condition is 24.0 kN/m^2 (500 psf) and for the