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.:	**183-8197**
SRP Section:	**03.07.02 – Seismic System Analysis**
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Question No. 03.07.02-3

10 CFR 50 Appendix S requires that safety-related structures, systems, and components (SSCs) remain functional and within applicable stress, strain, and deformation limits for safe shutdown earthquake (SSE) ground motions. Staff review of Section 3 in APR1400-E-S-NR-14003-P finds that additional information is needed to confirm that safety-related SSCs will remain functional and within applicable stress, strain, and deformation limits. Specifically, Section 3 of APR1400-E-S-NR-14003-P states that the reactor containment building (RCB) and the auxiliary building (AB) are separate from each other above the basemat and have a minimum 2 inch seismic gap between them. Additionally, Section 3.1 in the same report states that the containment structure (CS) and internal structure (IS) are also separated by a 2 inch gap. However the staff review of the relative displacement results in DCD Tables 3.7-15 and 3.7-21 and Appendix E in APR1400-E-S-NR-14003-P finds instances of combined RCB and AB relative displacements exceeding 2 inches which would result in interaction between these structures. Therefore, in light of the aforementioned relative displacement results, the staff requests the applicant to describe the approach used for determining the adequacy of the seismic gaps between the aforementioned structures and to justify the appropriateness and sufficiency of the minimum 2 inch gap to preclude adverse interaction between these structures during an SSE event. This justification should address the maximum relative displacements between the AB and the RCB and between the CS and IS throughout coincident elevations and explain whether these relative displacements pertain to a worst case condition such as out-of-phase displacements or justify an alternate condition as necessary. Also, address how construction tolerances have been considered in determining the minimum required gap between these structures.

The staff also request the applicant to clarify the relative displacement discussion in Section 6.3 of APR1400-E-S-NR-14003-P. Specifically, in Section 6.3 of APR1400-E-S-NR-14003-P, the applicant states that displacements relative to the basemat for the RCB are obtained by removing the rigid basemat rotations computed for the region of the basemat under the RCB footprint. In Appendix E of APR1400-E-S-NR-14003-P, for the RCB, the applicant provided relative displacements to the basemat with and without basemat rotations included. The staff review identified that the relative displacements provided in the DCD are those corresponding to those reported in Appendix E of APR1400-E-S-NR-14003-P that include the basemat rotation. The staff requests the applicant to clarify the intent and use of removing basemat rotations as stated in Section 6.3 of APR1400-E-S-NR-14003-P.

Response

The maximum, out-of-phase CSDRS relative displacement demands between the AB and the RCB, and between the CS and the CIS, at coincident elevations are presented below.

Elevation (ft)	Maximum Relative Displacement between AB and RCB (in)		
	X-direction	Y-direction	Z-direction
120	1.484	1.714	1.116
137	1.727	2.100	1.242
156	2.267	2.776	1.398
174	3.227	3.225	1.508
195	3.404	3.455	1.506
216	3.947	4.170	1.609
Elevation (ft)	Maximum Relative Displacement between CS and IS (in)		
	X-direction	Y-direction	Z-direction
100	0.513	0.508	0.605
114	0.727	0.709	0.645
137	0.976	0.963	0.684
156	1.377	1.338	0.747

The seismic gap of no less than two inches is to exist between the containment structure (CS) and the internal structure (IS). The value is determined by performing the square root of the sum of the squares (SRSS) method on the maximum relative displacements presented above and then selecting a reasonable bounding value. The provided margin is determined to be sufficient via engineering judgment which considers previous construction experience obtained through the construction of the reference plants (Shin Kori units 3 & 4). Construction tolerances applied to the CS and the IS are to ensure the minimum seismic gap of two inches.

The intent of the statements made regarding the seismic gap between the reactor containment building (RCB) and the auxiliary building (AB) is to communicate that an additional two inches of clearance is provided beyond the calculated relative displacements in the orthogonal directions at coincident elevations. To simplify the approach, a constant seismic gap of no less than six inches will be provided between the RCB and the AB. The magnitude of six inches has been determined using the same method as that used to determine the seismic gap between the CS and the IS. Construction tolerances applied to the RCB and the AB are to ensure the minimum seismic gap of six inches. DCD Tier 2, Sections 3.8.1.1.1 and 3.8.4.1.1, Table 3.7-8, and technical reports APR1400-E-S-NR-14002, APR1400-E-S-NR-14003, and APR1400-E-S-NR-14006 will be revised to specify the six inch seismic gap and the construction tolerances which are to ensure the minimum gap size, as indicated in the attachments associated with this response.

Because of the massive concrete pedestal in the lower portion of the internal structure, the basemat under the RCB footprint almost responds as a rigid basemat. Thus, the relative displacements are determined after removing rigid basemat rotations. The displacements obtained after removing rigid basemat rotations are used for reactor internal system design, especially for the piping stress analysis. Section 6.3 of APR1400-E-S-NR-14003-P will be modified to state that the displacements obtained by removing the rigid basemat rotations are used in the design of piping and pipe supports in the reactor internal system.

The relative displacements obtained without removing rigid basemat rotations are too large to apply to anchor points in the piping system design; doing so would result in over-conservative design of piping and pipe supports.

Impact on DCD

DCD Table 3.7-8, and Sections 3.8.1.1.1 and 3.8.4.1.1 will be revised, as indicated in the attachment 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

Technical reports APR1400-E-S-NR-14002-P/NP (ABSTRACT, Section 1, and Section 4.2.3), APR1400-E-S-NR-14003-P/NP (Section 1, Section 3, and Section 6.3), and APR1400-E-S-NR-14006-P/NP (Section 1) will be revised.

Table 3.7-8

Foundation Embedment Depth, Foundation Size, and Total Height of Seismic Category I Structures

Structures	Foundation Embedment Depth, m (ft)	Foundation Size, m (ft)	Maximum Height, m (ft)
Nuclear Island – Reactor Containment Building – Auxiliary Building	See note 1. 16.4 (53′-8″)	Radius 25.6 (84′-0″) 107.3 × 88.1 (352′-0″ × 289′-0″)	87.9 (288′-6″) 56.4 (185′-0″)
Emergency Diesel Generator (EDG) Building	2.6 (8′-6″)	39.9 × 18.3 (131′-0” × 60′-0″)	17.8 (58′-6″)
Diesel Fuel Oil Tank (DFOT) Room	1.2 (4′-0″)	20.3 × 18.3 (66′-6″ × 60′-0″)	18.7 (61′-6″)

(1) The auxiliary building wraps around the reactor containment building with a minimum of ~~2~~ 6 inches seismic gap.

3.8 Design of Category I Structures

3.8.1 Concrete Containment

3.8.1.1 Description of the Containment

3.8.1.1.1 Basic Configuration

The containment encloses the reactor vessel, steam generators, reactor coolant loops, and portions of the auxiliary and engineered safety features systems. The containment provides reasonable assurance that leakage of radioactive material to the environment does not exceed the acceptable dose limit as defined in 10 CFR 50.34 (Reference 1) even if a loss-of-coolant accident (LOCA) occurred.

The internal structures are physically independent of the containment, except at the supporting foundation basemat. The connections of operating and intermediate floors to the containment wall are described in Subsection 3.8.3.1.10.

The containment shares a common basemat with the auxiliary building. The auxiliary building wraps around the containment with a seismic isolation gap of ~~50~~ 150 mm (~~2~~ 6 in).

The reactor containment building basemat has a continuous tendon gallery that provides access to the vertical tendons below the wall-basemat junction.

The containment is a prestressed concrete structure composed of a right circular cylinder with a hemispherical dome and is founded on safety-related common basemat. The structures are lined on the inside with steel plate that acts as a leak-tight membrane. The cylindrical portion of the containment is prestressed by a post-tensioning system consisting of horizontal and inverted “U” vertical tendons. There are three buttresses equally spaced around the containment wall, and each horizontal tendon is anchored at buttresses 240 degrees apart, bypassing the intermediate buttress. The dome portion is prestressed by a post-tensioning system consisting of horizontal tendons up to a 45-degree vertical angle and of two groups of inverted “U” vertical tendons oriented 90 degrees to each other. The inverted “U” tendons are carried through the cylindrical wall and anchored at the tendon gallery.

of radioactive spent fuel assemblies. The pool is approximately 10.8 m × 12.8 m (35 ft 6 in × 42 ft) with a depth of 12.8 m (42 ft). The walls and floor of the spent fuel pool are a minimum of 1.7 m (5 ft 6 in) thick.

Fuel assemblies are transferred from the fuel handling area to the refueling pool via the refueling canal in the auxiliary building and then the fuel transfer tube in the reactor containment building. The refueling canal measures 1.8 m (6 ft) wide by 20.5 m (67 ft 3 in) long. The minimum wall thickness on the fuel pool side is 1.8 m (6 ft). An opening in the fuel pool wall allows for passage of fuel between the fuel pool and the refueling canal. A steel divider is provided for the opening. Seals are incorporated to allow draining of the refueling canal while maintaining the water level in the spent fuel pool. An overhead bridge crane with a capacity of 150 tons is provided over the shipping bay and extending over the fuel pool and refueling canal. Interlocks are provided to prevent the crane from moving over the spent fuel storage area during cask handling operations. A new fuel-handling crane, running on rails mounted over the operating floor, is provided to handle the new fuel assemblies.

The two AFW tanks consist of three stainless steel lined reinforced concrete rooms. Each room has a single tank. The tanks extend from elevation 100 ft 0 in to the underside of the floor slab at elevation 137 ft 6 in.

The auxiliary building is rectangular with maximum dimensions of 106.0 m × 107.6 m (348 ft × 353 ft). It wraps around the reactor containment building with a seismic gap of ~~50~~ 150 mm (~~2~~ 6 in). The auxiliary building shares common basemat structure with the reactor containment building. The auxiliary building is separated from other buildings by the isolation gap of 900 mm (3 ft).

The outlines of the auxiliary building are shown in Figures 1.2-9 through 1.2-19.

3.8.4.1.2 Emergency Diesel Generator Building

The emergency diesel generator (EDG) building block comprises two buildings, one that houses two additional generators and the other for the diesel fuel oil tank (DFOT). The two buildings are independent structures built on separate basemats – one at elevation 100 ft 0 in for the EDG building, and the other at 63 ft 0 in for the DFOT building. The two basemats are horizontally separated by an isolation gap of 900 mm (3 ft).

ABSTRACT

This technical report provides the finite element model used in the soil-structure interaction analysis for the APR1400 nuclear island structures. The nuclear island structures consist of the reactor containment building and auxiliary building, and are founded on the monolithic common basemat. Above the basemat, the reactor containment building and auxiliary building are separate structures with a minimum seismic gap of ~~2~~ 6 in. Therefore, the finite element models for each building are developed separately.

Two finite element models for each building, namely, a fine-mesh finite element model and a coarse-mesh finite element model, are developed using the ANSYS computer program.

The fine-mesh finite element model is developed with a finite element mesh that is sufficiently refined for a detailed structural analysis. The coarse-mesh finite element model is developed with larger finite element size to reduce the model's total number of degrees of freedom to a level that can be accommodated by the presently available SASSI computer program.

Model validation is made in which the dynamic properties of coarse-mesh finite element model are compared against the corresponding dynamic properties of the fine-mesh finite element model. This validation is intended to demonstrate that both models are capable of representing the natural vibration modal properties sufficiently accurately up to a high frequency cut-off of at least 50 Hz.

1 INTRODUCTION

The purpose of this technical report is to present the methodologies used to develop the finite element seismic models for the nuclear island (NI) structures. The NI finite element seismic models are developed for use in three-dimensional (3-D) seismic soil-structure interaction (SSI) analysis of the APR1400.

The NI structures are the reactor containment building (RCB) and auxiliary building (AB), which are founded on a monolithic common basemat. The RCB is structurally separate from the AB with a minimum seismic gap of ~~2~~ 6 in. above the common basemat. The RCB is a seismic category I structure that consists of a pre-stressed concrete cylindrical shell, hemispherical dome, and reinforced concrete internal structure that are supported on a reinforced concrete mat foundation.

The AB wraps around the RCB, leaving a seismic gap space above the common basemat. The AB is a seismic category I structure that consists of reinforced concrete shear walls and floor slabs, which are lateral load-resisting systems, and frames that support the vertical loads.

The RCB and AB finite element models (FEMs) are developed separately and then combined (i.e., the AB structure, RCB structures, and the common basemat are combined in one coupled NI structural FEM). All finite element seismic models are developed and combined using the ANSYS (Reference 1) computer program. The ANSYS FEM of the combined NI is converted to a SASSI (Reference 2) 3-D FEM for seismic SSI analysis.

This technical report consists of seven (7) sections. Section 1 is an introduction that includes background information. Section 2 describes the methodology of the FEM development for the NI structures. Section 3 presents the modeling process for the RCB finite element seismic model. Section 4 describes the modeling process for the AB finite element seismic model. Section 5 describes the validation of the RCB and AB finite element seismic models. Section 6 provides the final combined FEM to be used in SSI analysis. Section 7 contains the cited references.

4 AUXILIARY BUILDING MODEL

This section describes the AB structure and methodology of developing the APR1400 AB FEM.

4.1 Description of AB Structure

The APR1400 AB is a safety-related seismic category I structure with an embedment of approximately 54 ft (Reference 11). It encloses the RCB in the center without structural connection except at the common basemat. The combined RCB and AB with a common basemat are generally referred to as the NI structures. Three adjacent structures, the emergency diesel generator building, turbine generator building, and compound building, are separated from the AB with a typical 3 ft building gap. This building layout with adjacent buildings is shown in Figure 4-1. The primary dimensions of the AB are listed in Table 4-1.

The AB houses important facilities including the fuel handling area, spent fuel pool, cask loading pit, refueling canal, cask decontamination pit, auxiliary feed water (AFW) tanks, main control room, equipment hatch access, and others. The AB structural system consists of shear walls in the east-west (E-W) and north-south (N-S) directions and a total of seven (7) major floor and roof slabs. The walls and slabs are made of normal reinforced concrete. Columns and girders are also used to support floor and roof slabs. The shear walls have various sizes of door openings and corridors partial openings on floor slabs.

4.2 Development of Finite Element Models for AB Structure

This section describes the development of 3-D AB FEM for SSI analysis.

4.2.1 Coordinate System

A rectangular Cartesian coordinate system is used for the ANSYS and SASSI models. The origin in a horizontal plan of this coordinate system is located at the center of the RCB. In this coordinate system, the positive X points to the plant east direction, the positive Y to the plant north direction, and the positive Z to the vertical upward direction, as shown in Figure 4-2.

4.2.2 Material Properties

The major AB structural components are reinforced concrete structures. Material properties of uncracked-concrete for the basemat, slabs, walls, and columns are listed in Table 4-2. Material properties for the horizontal cracked concrete model and vertical cracked concrete model based on the ASCE 43-05 are listed in Tables 4-3 and 4-4, respectively. Material properties of structural steel for columns and for girders are listed in Table 4-5. Critical damping ratios are taken from NRC RG 1.61.

4.2.3 Common Basemat for AB and RCB

The 10 ft thick basemat, as shown in Figure 4-3 serves as a common foundation for the AB and RCB. In the basemat, the central circular area with a radius of 83'-6" serves as the RCB foundation, while the rest of the basemat supports the AB with an embedment of 53'-6". The two buildings are separated with a minimum ~~2~~ 6 in. seismic gap above the top surface of the common basemat at El. 55'-0".

The AB and RCB common basemat is modeled separately in the ANSYS by four (4)-node elastic SHELL63 elements for the AB at the bottom surface of the concrete foundation (El. 45'-0") to account more closely for SSI effects and by eight (8)-node SOLID45 elements for the RCB concrete foundation, as shown in Figure 4-4 for the coarse mesh. To provide continuation of rotational deformation at the

1. INTRODUCTION

This technical report presents the soil-structure interaction (SSI) analysis methodologies and results for the nuclear island (NI) structures of the APR1400 standard plant. The seismic ground motion input, site conditions, dynamic models, and analysis methodology and procedures used in carrying out the seismic analysis are described in this report. The key analysis results are also presented.

The NI structures are the reactor containment building (RCB) and auxiliary building (AB), which are founded on a monolithic common basemat (References 1, 2). The RCB is structurally separated from the AB with a minimum seismic gap of ~~2~~ 6 in above the common basemat. The RCB is a Seismic Category I structure that consists of a pre-stressed concrete cylindrical shell and hemispherical dome, and a reinforced concrete internal structure that are supported by a reinforced concrete mat foundation.

The AB wraps around the RCB leaving a space with a seismic gap above the common basemat. The AB is a Seismic Category I structure that consists of reinforced concrete shear walls and floor slabs which are lateral load-resisting systems and frames that support the vertical loads.

The NI seismic analysis described in this technical report provides the maximum seismic response (demand) parameters, which include maximum seismic response absolute accelerations, relative displacements, building structural forces, and moments under the design-basis seismic ground motion input for use in the structural design of NI structures. The analysis is also used to generate the in-structure response spectra (ISRS) for the seismic response motions which are used in seismic analysis or qualification of the equipment, subsystems, and components housed in the NI structures.

The seismic analysis of NI structures described in this report includes seismic soil-structure interaction (SSI) analyses of the RCB and AB supported on nine (9) generic site-profile cases including a fixed-base case analysis.

Since the RCB and AB share a common basemat, the seismic SSI analysis is performed for the combined NI structures (i.e., the combined RCB and AB supported on a common basemat foundation, References 3, 4). The SSI analysis is performed using the SASSI analysis methodology and the associated SASSI computer program (Reference 5). The Direct Method or the Flexible Volume Method of SASSI substructuring is used in the SSI analysis. The maximum seismic response parameters and ISRS generated from the fixed-base seismic response analysis case are enveloped with the corresponding results of the seismic SSI analysis performed for the nine generic site profile cases to produce the final enveloped maximum seismic response parameters and ISRS for the standard design.

This technical report consists of seven (7) sections. Section 1 provides an introductory note and background information. Section 2 describes design ground motion developed for seismic analysis of the APR1400. Section 3 presents a description of the NI structures. Section 4 describes the generic site profiles and site response analysis for the SSI analysis. Section 5 describes the SSI analysis for the NI structures. Section 6 provides the SSI analysis results of the NI structures. References cited in this technical report are listed in Section 7.

General arrangement drawing for NI structures, numerical data, and results are presented in Appendices A through G.

3. DESCRIPTION OF NI STRUCTURES

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This section contains a description of the NI structures. The NI structures are classified as safety-related Seismic Category I structures. The RCB and AB are separate from each other above the basemat and have a minimum 2 in seismic gap between them. In the plant layout, the AB wraps around the RCB. The finished grade of the plant is at El. 98’-8”. The top of the NI common basemat is at El. 55’-0”. Thus, the exterior walls of the AB are embedded to a depth of about 44 ft below the finished grade of the plant. The thickness of the NI reinforced concrete basemat is nominally 10 ft. The methodology and results used to develop the finite element models (FEMs) for the APR1400 NI structures are presented in Technical Report APR1400-E-S-NR-13002-P, “Finite Element Seismic Models for SSI Analyses of the NI Buildings” (Reference 11).

3.1 Description of RCB Structures

The RCB of the APR1400 is a safety-related Seismic Category I structure and comprises the following three concrete sub-structures:

- Containment structure (CS)
- Primary shield wall (PSW)
- Secondary shield wall (SSW)

The CS is also referred to as a pre-stressed concrete containment vessel. The PSW and SSW are combined to form the reinforced concrete internal structure (IS) and are the supporting structures for the reactor coolant system (RCS).

The CS and IS are separated by a 2 in gap and are connected only at their basemat at El. 78’-0”. There is no interaction between the two structures except through the common basemat.

3.1.1 Containment Structure

The CS is a cylindrical post-tensioned shell with 4.5 ft thick walls. The dome is hemispherical with 4 ft thick walls. The intersection of the cylindrical and hemispherical shapes is called the spring-line and is at El. 254’-6”.

The CS has four openings, as follows:

- Each opening has a diameter of 11.16 ft.

Two of the openings are the north side, and two are on the east side.

- The personnel emergency exit airlock opening (one on the north side and one on the east side) is at center El. 103’-9” and azimuth 280°.
- The personnel access airlock opening (one on the north side and one on the east side) is at center El. 159’-9” and azimuth 234°.

The CS also has one equipment hatch opening.

- The opening is on the east side, has a 26 ft circular opening, and is at center El. 167’-6” and at azimuth 280°.

1 INTRODUCTION

The purpose of this technical report is to present the stability check for the nuclear island (NI) common basemat.

The NI common basemat consists of the reactor containment building (RCB) base area and auxiliary building (AB) base area structures. The RCB is structurally separate from the AB with a seismic gap of ~~2~~ in. above the common basemat. The RCB is a seismic Category I structure composed of a pre-stressed concrete cylindrical shell with a hemispherical-type dome and reinforced concrete internal structures. The AB wraps around the RCB, leaving a space for a seismic gap above the common basemat and is a seismic Category I structure. The AB consists of reinforced concrete shear walls and slabs that constitute a lateral load-resisting system.

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The NI common basemat is a reinforced concrete mat foundation with an area of approximately 99,180 ft^2 (348 ft × 285 ft). The thickness of the AB basemat is 10 ft. The thickness of the RCB basemat varies from 10 ft at the center to 33 ft at the side, except for transient areas such as the tendon gallery and reactor cavity. The NI common basemat is embedded to a depth of 55 ft below the nominal plant grade of El. 100 ft 0 in.. The bottom of the foundation is at El. 45 ft 0 in.. Figure 1-1 is a plan view of the APR1400 basemat. Figures 1-2 and 1-3 show cross-sectional views at the containment centerline.

This technical report contains five sections. Section 1 is an introduction with background information. Section 2 describes the site profiles for the APR1400 NI common basemat. Section 3 presents the modeling process of the finite element (FE) model for the NI common basemat analysis. Section 4 describes the stability evaluation of the NI common basemat. Section 5 presents the construction sequence analysis of the NI common basemat.

Thus, the second set of displacements relative to the basemat is obtained from the first set of relative displacements with respect to the free-field ground surface by removing the rigid basemat rotations computed for the region of basemat under the RCB footprint. For the AB, the second set of displacements relative to the basemat is obtained from the first set of relative displacements with respect to the free-field ground surface by subtracting the basemat displacements at the containment centerline relative to the free-field ground surface from the first set of relative displacements.

The displacements obtained by removing the rigid basemat rotations are used in the design of piping and pipe supports in the reactor internal system.

For the first set of relative displacements, which are displacements relative to the free-field ground surface, the post-processing procedure used to generate these displacements for the selected nodal points on the designated structure elevations are as follows:

(1) For each selected nodal point *"i"* on each designated structure elevation *"l,"* the acceleration response transfer function computed at a calculated frequency f_j in the *"q"* direction due to the seismic input in the *"p"* direction, designated by the symbol $\left(H^a\left(f_j\right)\right)_p^q$, is used to compute the transfer function of displacement relative to the free-field ground surface, designated by the symbol $\left(H^d\left(f_j\right)\right)_p^q$, using the following equation:

$$\left(H^d\left(f_j\right)\right)_p^q = -\left(\left(H^a\left(f_j\right)\right)_p^q - 1\right) \,/\, \left(2\pi f_j\right)^2 \tag{6-8}$$

The computed relative displacement transfer function $\left(H^d\left(f_j\right)\right)_p^q$ at the calculated frequencies is then interpolated and convolved with the seismic input acceleration time history to obtain the time history of displacement relative to the free-field ground surface in the *"q"* direction due to the seismic input in the *"p"* direction, designated by $d_p^q(t)$.

(2) The maximum displacement in the "q" direction relative to the free-field ground surface due to the seismic input in the "p" direction, designated as $d_{p\,\max}^q$, is obtained as the maximum absolute value of the time history $d_p^q(t)$. The maximum relative displacement in the "q" direction due to the seismic input in all three directions, i.e., p = X, Y, Z, designated by the symbol $d_{\max}^q$, is obtained by combining the maximum relative displacements due to the inputs in all three directions using the SRSS combination rule, i.e.,

$$d_{\max}^q = \sqrt{\left(d_{X\max}^q\right)^2 + \left(d_{Y\max}^q\right)^2 + \left(d_{Z\max}^q\right)^2} \tag{6-9}$$

(3) The maximum relative displacement $d_{\max}^q$ obtained from Eq. (6-9) for all selected nodes *"i"* on a designated elevation *"l"* in the structure *"k"* are enveloped to generate the enveloped maximum relative displacement in the direction *"q."*

The enveloped maximum relative displacements generated from Step (3) above for all designated elevations in the RCB and AB for each of the twenty SASSI analysis cases are tabulated in Appendix E.

To remove the rigid RCB basemat rotation from the displacements relative to the free-field ground surface, the basemat rotation about a global coordinate axis *"p," p* = X or Y, located at the center of the containment on top of the basemat, designated as point *"o,"* is computed first. The basemat rotation is calculated using the following steps: