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.:	**255-8285**
SRP Section:	**03.08.05 – Foundations**
Application Section:	**03.08.05**
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Question No. 03.08.05-7

10 CFR 50.55a and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4 and 5 provide the regulatory requirements for the design of the seismic Category I structures. Standard Review Plan (SRP) Section 3.8.5.I.3, “Load and Load Combinations,” states, “These should also include the loads that are induced by the construction sequence and by the differential settlements of the soil under and to the sides of the structures.” Furthermore, SRP Section 3.8.5.I.4, “Design and Analysis Procedures,”, states, “Where a single mat foundation is used for multiple plant structures, attention is given to bending, shear, and similar factors in the basemat that are attributable to uneven settlement, construction sequence, and mat flexibility.”

In DCD Tier 2, Section 3.8.6.4, “Design and Analysis Procedures,” the applicant stated “The maximum differential settlement of foundation is 12.7 mm per 15.24 m (0.5 in per 50 ft) within NI common basemat. The maximum differential settlement between buildings is 12.7 mm (0.5 in) based on enveloping properties of subsurface materials. ” However, it is not clear to the staff how the construction sequence and differential settlement of foundations were considered in the load and load combinations. Therefore, the applicant is requested to describe how the construction sequence and differential settlement of foundations were considered in the load and load combinations. Also, DCD Section 3.8.5 should be updated accordingly.

Response – (Rev. 4)

To judge whether the soft soil case is governed for construction sequence analysis, the moment diagram for each section on profiles (S1, S8) is compared under abnormal/extreme environment load combination (LC08). Figure 1 shows the detailed sections in the basemat.

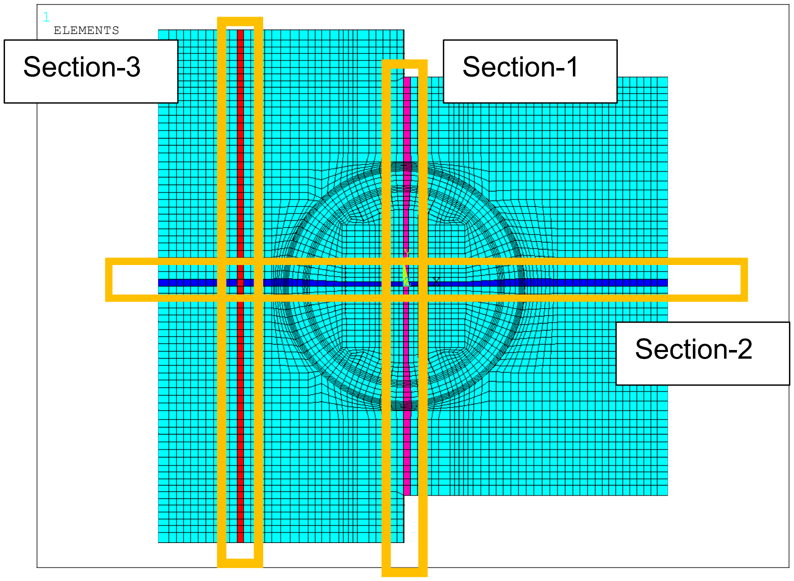
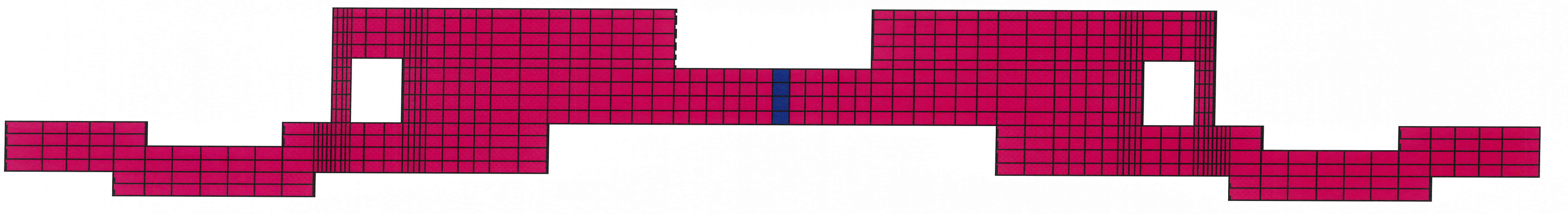


Figure 1. Detailed Section in the NI basemat



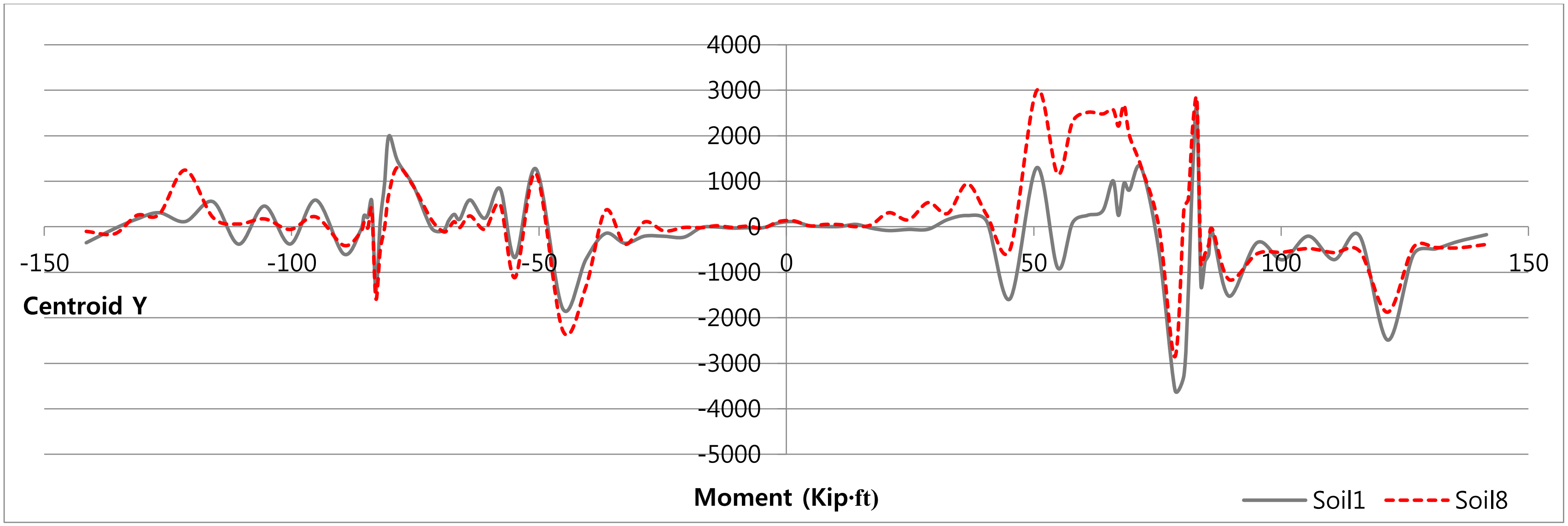


Figure 2. Detailed Section-01 and Moment Diagram under Abnormal/Extreme Case

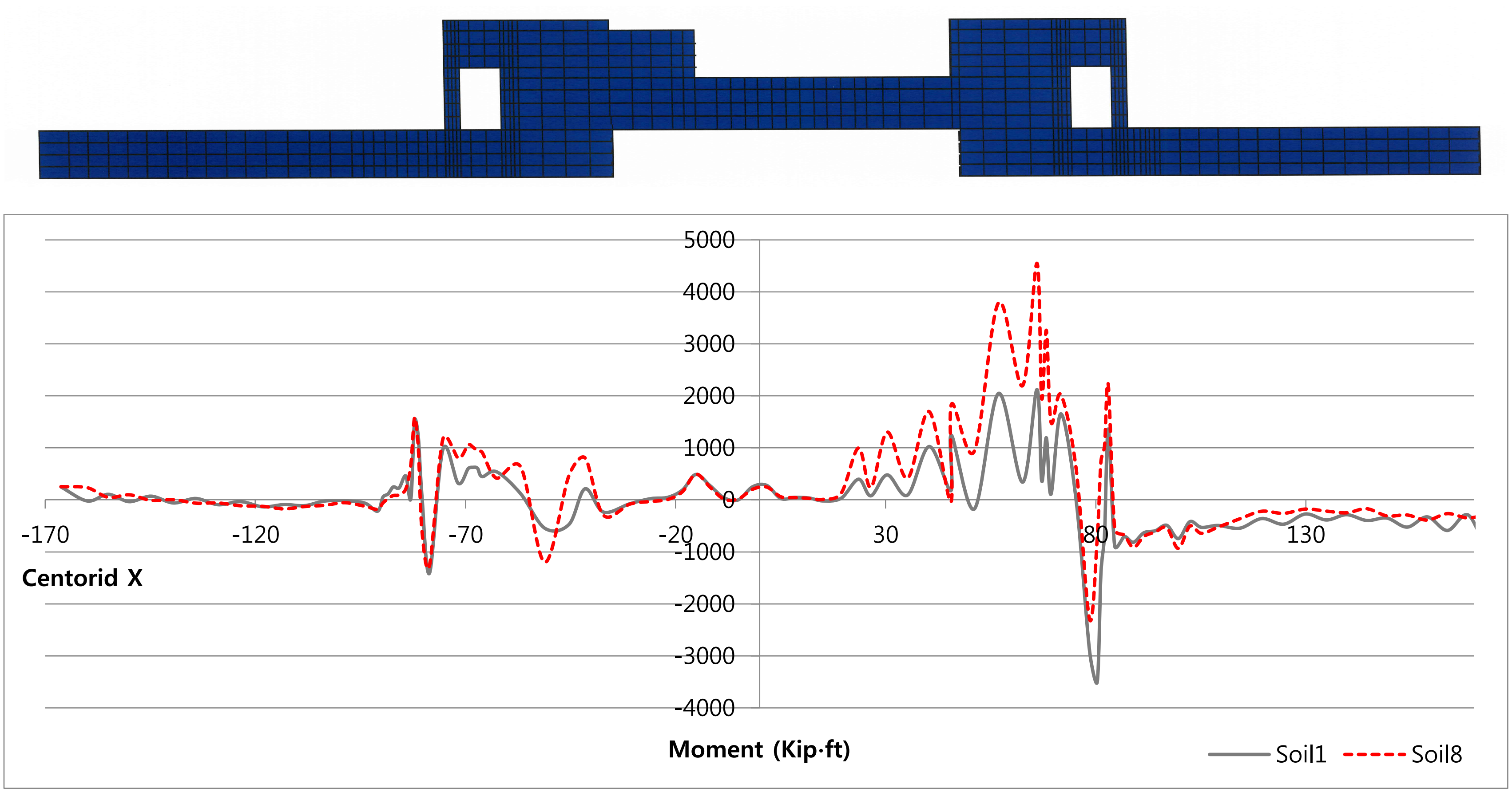


Figure 3. Detailed Section-02 and Moment Diagram under Abnormal/Extreme Case

Figure 4. Detailed Section-03 and Moment Diagram under Abnormal/Extreme Case

Based on three figures above (Figures 2 thru 4), it is not clear which soil case condition is governed for the basemat design. Therefore, both soil profiles S1 and S8 are considered for construction sequence analysis.

The construction sequence analysis model consists of foundation media model considered 11 layer (soil layer model), NI common basemat, and superstructures (Auxiliary building, internal structures, and Shell & Dome). For construction sequence within Ni common basemat, 19 basemat concrete segments were determined based on concrete placement and hardening stages. For construction sequence within superstructures, five segments were determined to consider direction of construction sequence. For construction sequence analysis, the concrete used in analysis is normal weight concrete with the compressive strength of 5,000 psi at 91 days and 6,000 psi at 91 days for NI common basemat and superstructures, respectively. The concrete strength is assumed at the four hardening conditions to consider change of strength due to concrete pouring sequence.

For construction, the properties of foundation media model is applied in table 2-3 of Technical report (TeR) APR1400-E-S-NR-14006-P/NP, Rev, 3. For post-construction, the following equation based on several experimental results, suggested Schmertmann (1970), is considered in soil profile S01 because of sand profile. For post construction in soil profile S08 corresponding to rock profile, it is not necessary to consider the creep effect of soil.

$$C_2 = 1 + 0.2\log_{10}\left(\frac{t}{0.1}\right) \quad \text{where, t is time, in years}$$

In the equation, c2 means that correction factor to account from creep in soil. Considering 60 years, at the end life of plant, C2 is almost 1.55. For foundation media model in post-construction condition, the existing modulus of foundation media model is divided by correction factor based on assuming elastic deformation of soil.

Based on explanation, two construction sequences for check possibility of different cases are performed corresponding to case 1 (Counterclockwise) and case 2 (Clockwise) against each soil profiles S01 and S08. As a result, for various settlements (maximum vertical settlement, maximum tilting settlement, maximum differential settlement, and angular distortion) under construction and post-construction condition, it was calculated based on analysis results.

Maximum vertical settlement

Maximum vertical settlement is the maximum calculated vertical deformation for the construction and post-construction phases under sequence No.58 and 59, respectively. Table 1 shows the maximum settlement for construction and post-construction phases. EDGB and DFOT, the maximum vertical settlement is determined.

Table 1. Maximum Vertical Settlement for Construction and Post-Construction for NI, EDGB, and DFOT building

[Unit: ft]

Structures	Category	Max. settlement			
		Soil profile S1		Soil profile S8	
		#1	#2	#1	#2
NI building	Construction (Sequence No. 58)	0.286	0.282	0.012	0.0120
	Post-construction (Sequence No. 59)	0.386	0.380	Not considered 1)	
EDGB building	Construction	0.142		0.005	
	Post-construction	0.218		Not considered 1)	
DFOT building	Construction	0.172		0.005	
	Post-construction	0.266		Not considered 1)	

1) Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

Maximum Tilting settlement

Tilting settlement is calculated as the ratio of the differential vertical settlement for at the opposite edges of the buildings to the length between two edges. To check tilting settlement, the check points are determined as shown figure 5. Of the construction sequence, the maximum tilting settlement for the construction and post-construction phase is checked by following equations under sequence No.58, end of construction, and No. 59, post-construction. Table 2 shows the maximum tilting settlement for NI common basemat. For EDGB and DFOT buildings, construction sequence and tilting settlement are not needed because these buildings are relatively small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings.

$$\text{Maximum tilting settlement} = \arctan(\Delta Uz/L)$$

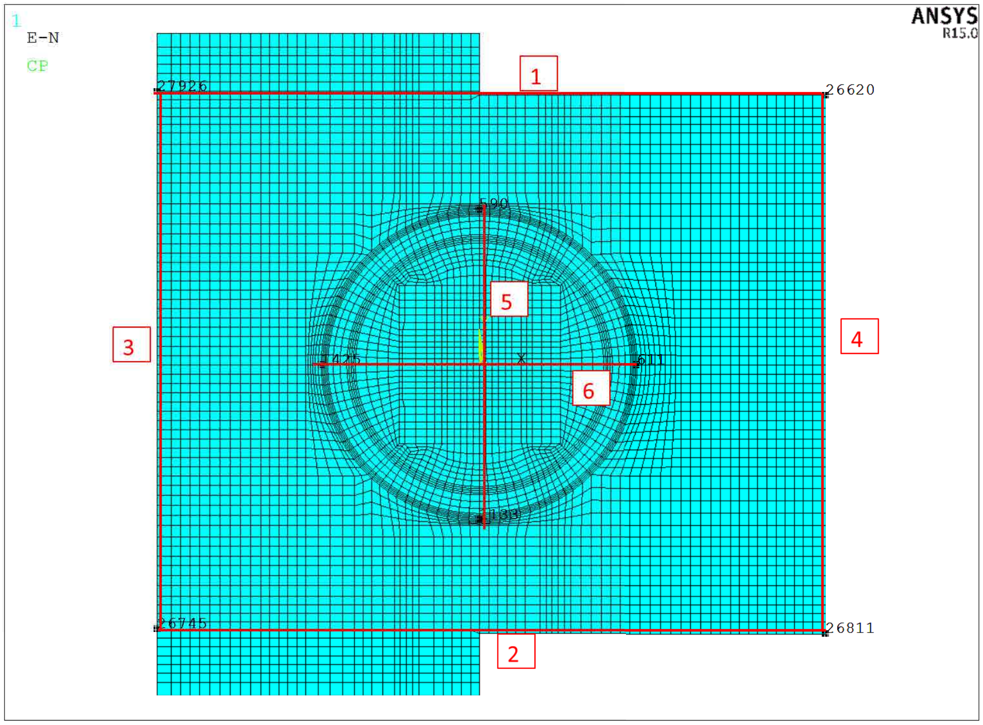


Figure 5 Check Group for Tilting Settlement

Table 2. Tilting Settlement for Construction and Post-Construction for NI building

[Unit: degree]

Category	Max. Tilt settlement		Soil profile S1		Soil profile S8	
	Sequence	Direction	#1	#2	#1	#2
Construction	Sequence No.58	E-W	0.00725	0.00507	0.00015	0.00006
		N-S	0.01253	0.00993	0.00032	0.00030
Post-Construction	Sequence No.59	E-W	0.00989	0.00606	Not considered [1)]	
		N-S	0.0136	0.00961		

[1)] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

Maximum differential settlement between structures

For maximum differential settlement between structures under construction and post-construction, vertical settlement of NI basemat is obtained from sequence No.58 and No.59. However, vertical settlement of EDGB/DFOT is obtained from analysis which does not consider construction sequence analysis since the other structures (i.e., EDGB/ DFOT) are not required. The construction sequence analysis is not needed because these buildings are small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings. For differential settlement between adjacent structures, it is determined based on following six cases. Table 3 shows the summary of differential settlement between NI common basemat and EDGB/ DFOT basemat. Figure 6 shows the locations for differential settlement between structures.

1) Difference between maximum vertical settlement regarding adjacent nodes of EDGB and minimum vertical settlement regarding adjacent nodes of NI common basemat.

2) Difference between minimum vertical settlement regarding adjacent nodes of EDGB and maximum vertical settlement regarding adjacent nodes of NI common basemat.

3) Difference between maximum vertical settlement regarding adjacent nodes of DFOT and minimum vertical settlement regarding nodes of NI common basemat.

4) Difference between minimum vertical settlement regarding adjacent nodes of DFOT and maximum vertical settlement regarding nodes of NI common basemat.

5) Difference between maximum vertical settlement regarding adjacent nodes of DFOT and minimum vertical settlement regarding nodes of EDGB basemat.

6) Difference between minimum vertical settlement regarding adjacent nodes of DFOT and maximum vertical settlement regarding nodes of EDGB basemat.

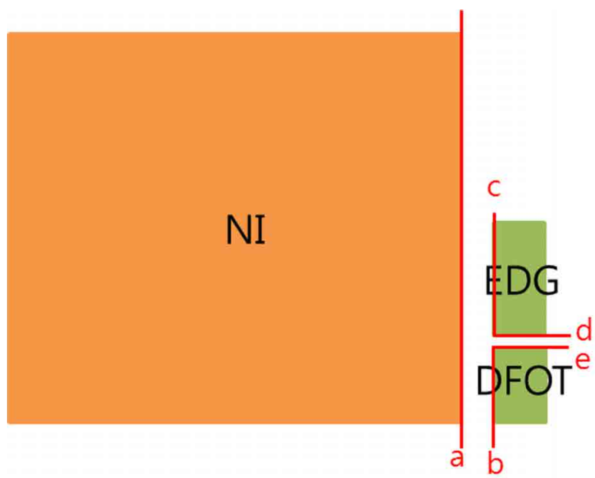


Figure 6 The Locations for Differential Settlement between Structures

Table 3. Differential Settlement between Structures for All buildings under Construction and Post-Construction

Line (Figure 6)			Max. differential settlement between structures [Unit: inch]							
			Construction				Post-construction			
			S01		S08		S01		S08	
			Max	Min	Max	Min	Max	Min	Max	Min
a	NI common basemat	Case1	2.171	1.566	0.078	0.051	3.358	2.671	Not considered 1)	
a	NI common basemat	Case2	2.020	1.527	0.074	0.052	3.132	2.620		
c	EDGB Basemat		1.701	1.670	0.061	0.046	2.615	2.582		
b	DFOT Basemat		2.066	0.986	0.054	0.027	3.193	1.521		
	Differential Settlement (NI and EDGB basemat)		0.501		0.009		0.776			
	Differential Settlement (NI and DFOT basemat)		1.185		0.002		1.837			
d	EDGB Basemat		1.701	1.474	0.061	0.047	2.615	0.189		
e	DFOT Basemat		2.066	1.787	0.053	0.034	3.193	2.773		
	Differential Settlement (DFOT and EDGB basemat)		0.592		0.027		0.925			

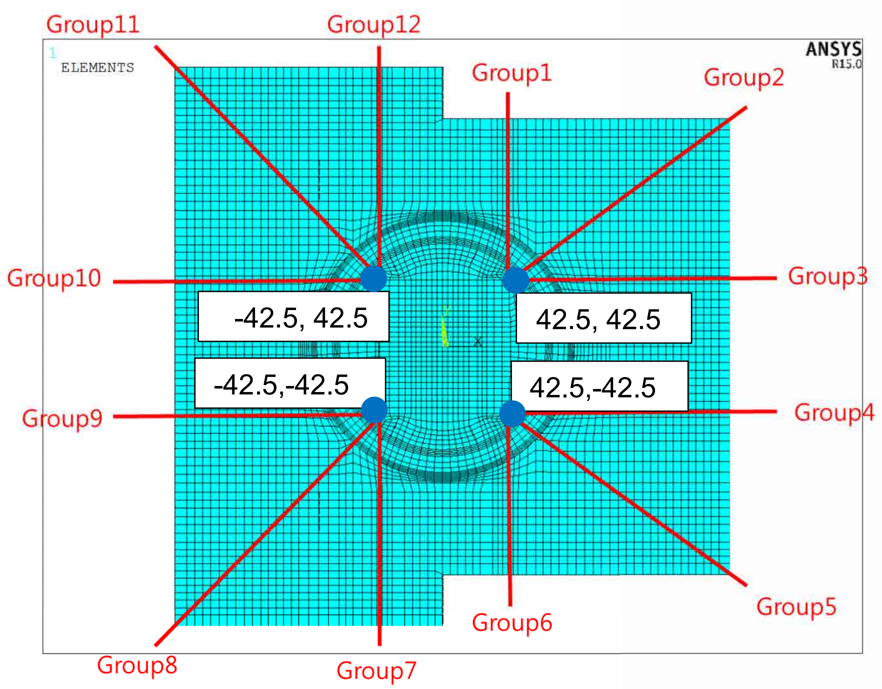
1) Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

Maximum Angular distortion

Maximum angular distortion is $\beta = \delta/L$ is a measure of differential vertical displacement between two adjacent points separated by the distance, L. To determine the angular distortion, three sequences (sequence No. 22 , No.58, and No.59) of all sequences are selected for soil profile S01 and two sequences (sequence No.22 and No.58) for soil profile S08. Based on deformation result from each sequence (No.22, 58, and No.59), the 12 groups are determined to check points for angular distortion as shown Figure 7. These groups are selected along vertical, horizontal and diagonal direction based on starting points. The coordinates in the four boxes indicate the starting points of the red lines for each group.

For checking angular distortion per each group corresponding to soil profiles (S1, S8), it is plotted by vertical displacement along the distance between adjacent nodes within each group as indicated attachment 1. These vertical displacement graphs are used as the acceptance criteria for the COL applicant, not maximum angular distortion value since these figures show the curvature of the entire basemat.

As shown in graphs on pages 46 thru 57 of attachment 1 regarding to angular distortion plotted from adjacent nodes within nodes, the red line indicated the boundary of each segment of basemat. The change of sharp slope indicated in red line is caused by the difference of construction time. In order words, the reason why the shift is occurred is to consider different construction steps at the same nodes in the analysis. Therefore, slope due to step change is not considered for angular distortion. For EDGB and DFOT buildings, construction sequence and maximum angular distortion are not needed because these buildings are relatively small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings.



● Starting points of each group for displacement graph for angular distortion

Figure 7 Check Group for Angular Distortion (Unit: feet)

Based on explanation above, the description and results of construction sequence will be included in DCD Tier 2 section 3.8.5.4.2.1 and Tables 3.8-12 thru 3.8-14 as shown pages 7 thru 11 of attachment 1. In addition, section 5 of Technical report, APR1400-E-S-NR-14006-P/NP, Rev.3 will be revised as shown pages 5 thru 56 of attachment 1. Based on the analysis results of construction sequence for NI building and structural analysis under static loads for EDG and DFOT, four settlement criterion will be included in DCD Tier2 Table 3.8-12 through 3.8-14, and Section 3.8.5.4.2.2.d as shown attachment 1.

For structures, systems and components (SSCs) design for relative displacement of adjacent structures under static and seismic loadings, the description will be included in DCD Tier 2 section 3.8.5.8, 3.9.2.2.8, 3.9A.1.1, and 3.9A2.1, as shown attachment 2.

According to SRP 3.8.1, 3.8.3, 3.8.4 and 3.8.5, the Seismic Category I Structures including foundation and superstructures should be designed to take into account the additional member forces and moments induced by the effects of the construction sequence and the instantaneous and long term settlement of the soil under the foundation. Any difference in forces and moments between sequential analysis and reference analysis is added to dead load in all load combinations.

Although the construction sequence analysis is fulfilled in the DC stage, the construction sequence analysis will be re-evaluated in the COL stage based on the actual site condition and construction sequence established by COL applicant. COL information items (COL 3.8(18), COL 3.8(19)) will be added to the DCD, as indicated in the attachment 1 associated with this response.

Impact on DCD

DCD Tier 2, Table 1.8-2 and Subsection 3.8.6 will be revised as indicated in the attachment 1 associated with this response. DCD Tier 2, Tables 3.8-12 thru 3.8-14 and Subsection 3.8.5.4.2.1, 3.8.5.4.2.2 will be added as indicated in the attachment 1 associated with this response.

DCD Tier 2, Subsection 3.8.5.8 and 3.9.2.2.8, 3.9A.1.1, and 3.9A2.1 will be added as indicated in the attachment 2 associated with this response.

DCD Tier 1, Table 2.1-1 and Tier 2 Tables 1.8-2, 2.0-1 and Subsections 2.5.4.10.1, 2.5.2.6, 2.5.6, 2.5.4.10.2, and 3.8A.3.4.1 will be revised as indicated in the attachment 3 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

Section 5 of Technical report, APR1400-E-S-NR-14006-P/NP, Rev.3 will be revised as indicated in the attachment 1 associated with this response.

maximum vertical settlement,

Table 1.8-2 (8 of 38)

to ensure they are less than the criteria in Table 2.0-1

, Table 3.8.5-12 thru Table 3.8.5-14, and section 3.8.5.4.2.2.d

Item No.	Description
COL 3.8(15)	The COL applicant is to provide a site-specific monitoring program and to monitor differential settlement, tilt, and angular distortion ~~are bounded by following values~~ during construction and plant operation. ~~Allowable differential settlement associated with tilt: 1/1200~~ ~~Allowable differential settlement associated with angular distortion: 1/750~~ Deleted
COL 3.8(16)	The COL applicant is to provide testing and inservice inspection programs to examine inaccessible areas of concrete structures for degradation and to monitor groundwater chemistry.
COL 3.8(17)	The COL applicant is to provide the following soil information for APR1400 site: 1) Elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) Consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) Moisture content, Atterberg limits, grain size analyses, and soil classification, 4) Construction sequence and loading history, and 5) Excavation and dewatering programs.
COL 3.8(18)	The detailed construction sequence analysis for the basemat and superstructure shall be performed according to the construction plan. The construction shall use foundation media model, material properties, and superstructure model that was used for DC application. And the differential settlement of the basemat and concrete stress in the structure shall be checked to demonstrate acceptability. If the results exceed limits of Table 2.0-1, a detailed evaluation and revised construction plan will be described by the Combined License applicant.
COL 3.8(19)	The following items need to be considered by the COL applicant. 1) The surveyed soil profiles will be developed. 2) Based on the surveyed soil characteristics, if stiff/soft spot exist, different soil types (cohesive), potential for loss of cement in the mudmat, and non-uniformity of soil layers, are identified. Then, a site-specific evaluation will be performed. 3) The time (short term vs long term), instantaneous settlement and time-consolidation effect, shall be considered in accordance with surveyed soil profiles. And the differential settlement of the basemat and bearing stress shall be checked to demonstrate acceptability. 4) COL applicant will build the seismic Category I structure according to the construction sequence used in construction sequence analysis. 5) If site-specific evaluation is required, the COL applicant performs construction sequence analysis based on the site-specific parameters. And if the settlement including results of construction sequence analysis exceeds the acceptance criteria in the Table 2.0-1, the construction sequence will be modified to meet the acceptance criteria in the Table 2.0-1 by COL applicant. The effect of the design for seismic Category I structures due to construction sequence analysis shall be accounted by COL applicant.

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maximum vertical settlement,

to ensure they are less than the criteria in Table 2.0-1

The COL applicant is to provide a site-specific monitoring program and to monitor differential settlement, tilt, and angular distortion ~~are bounded by following values~~ during construction and plant operation. (COL 3.8(15))

, Table 3.8.5-12 thru Table 3.8.5-14, and section 3.8.5.4.2.2.d

~~Allowable differential settlement associated with tilt: 1/1200~~

Deleted

~~Allowable differential settlement associated with angular distortion: 1/750 (COL 3.8(15))~~

The COL applicant is to provide testing and inservice inspection programs to examine inaccessible areas of concrete structures for degradation and to monitor groundwater chemistry (COL 3.8(16)).

The long-term settlement is the site-specific characteristics. The COL applicant is to provide the soil parameters for APR1400 site (COL. 3.8(17)).

3.8.6 Combined License Information

COL 3.8(1) The COL applicant is to perform concrete long-term material testing in a way which verifies physical properties of materials used during the design stage and the characteristics of long term deformation of concrete.

COL 3.8(2) The COL applicant is to provide the detailed design results and evaluation of the ultimate pressure capacity of penetrations, including the equipment hatch, personnel airlocks, electrical and piping penetrations in accordance with RG 1.216.

COL 3.8(3) The COL applicant is to provide detailed analysis and design procedure for the equipment hatch, personnel airlocks, and electrical penetrations.

COL 3.8(4) The COL applicant is to provide a detailed analysis and design procedure for the transfer tube penetration assembly.

COL 3.8(5) The COL applicant is to provide the design of site-specific seismic Category I structures such as the essential service water building and the component cooling water heat exchanger building, essential service water conduits, component cooling water piping tunnel, and class 1E electrical duct runs.

to ensure they are less than the criteria in Table 2.0-1

maximum vertical settlement,

COL 3.8(15) The COL applicant is to provide a site-specific monitoring program and to monitor differential settlement, tilt, and angular distortion ~~are bounded by following values~~ during construction and plant operation.

Deleted

~~Allowable differential settlement associated with tilt: 1/1200~~

~~Allowable differential settlement associated with angular distortion: 1/750~~

COL 3.8(16) The COL applicant is to provide testing and inservice inspection programs to examine inaccessible areas of concrete structures for degradation and to monitor groundwater chemistry.

, Table 3.8.5-12 thru Table 3.8.5-14, and section 3.8.5.4.2.2.d

COL 3.8(17) The COL applicant is to provide the following soil information for the APR1400 site: 1) elastic shear modulus and Poisson's ratio of the subsurface soil layers, 2) consolidation properties including data from one-dimensional consolidation tests (initial void ratio, Cc, Ccr, OCR, and complete e-log p curves) and time-versus-consolidation plots, 3) moisture content, Atterberg limits, grain size analyses, and soil classification, 4) construction sequence and loading history, and 5) excavation and dewatering programs.

~~COL 3.8(18) The detailed construction sequence analysis for the basemat and superstructure shall be performed according to the construction plan. The construction shall use foundation media model, material properties, and superstructure model that was used for DC application. And the differential settlement of the basemat and concrete stress in the structure shall be checked to demonstrate acceptability. If the results exceed limits of Table 2.0-1, a detailed evaluation and revised construction plan will be described by the Combined License applicant.~~

~~COL 3.8(19) The following items need to be considered by the COL applicant.~~

~~1) The surveyed soil profiles will be developed.~~

~~2) Based on the surveyed soil characteristics, if stiff/soft spot exist, different soil types (cohesive), potential for loss of cement in the~~

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~~mudmat, and non-uniformity of soil layers, are identified. Then, a site-specific evaluation will be performed.~~

~~3) The time (short term vs long term), instantaneous settlement and time-consolidation effect, shall be considered in accordance with surveyed soil profiles. And the differential settlement of the basemat and bearing stress shall be checked to demonstrate acceptability.~~

~~4) COL applicant will build the seismic Category I structure according to the construction sequence used in construction sequence analysis.~~

~~5) If site-specific evaluation is required, the COL applicant performs construction sequence analysis based on the site-specific parameters. And if the settlement including results of construction sequence analysis exceeds the acceptance criteria in the DCD Table 2.0-1, the construction sequence will be modified to meet the acceptance criteria in the DCD Table 2.0-1 by COL applicant~~

~~6) The effect of the design for seismic Category I structures due to construction sequence analysis shall be accounted by COL applicant.~~

COL 3.8(20) The COL applicant shall perform site-specific evaluations if the shear wave velocity is less than 1,000 ft/s. The site-specific evaluations (differential settlement, soil bearing pressure, and sliding evaluation [if needed]) and 3D FEM global analysis for basemat design of seismic Category I structures shall be performed using the site-specific measured Estatic and the methodology described in DCD Tier 2, Subsection 3.8.5 and Technical report APR1400-E-S-NR-14006-P, Subsection 4.

3.8.7 References

1. 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” U.S. Nuclear Regulatory Commission.

2. ASME Section III, Subsection NE, “Class MC Components,” The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

3. ASME Section III, Division 2, “Code for Concrete Containments,” Subsection CC, American Society of Mechanical Engineers, 2001 Edition with 2003 Addenda.

COL 3.8 (18) A detailed construction sequence analysis to determine the resulting construction settlements, including the various standard soils profiles (S01-S04, S06-S09) and sequencing of concrete pours for the NI common basemat (RCB and Auxiliary Building), and superstructure model (Auxiliary Building, internal structures, and Shell & Dome), is presented in Section 3.8.5.4.2. A comparison of the four types of construction settlements (i.e. maximum vertical settlement, tilting settlement, maximum differential settlement between structures, and angular distortion) to the maximum criteria listed in Table 2.0-1 is summarized in Tables 3.8-12 through 3.8-14. , and section 3.8.5.4.2.2.d.

The COL applicant should use the construction sequence settlement analysis given in Section 3.8.5.4.2, substituting site-specific soil layer conditions, to ensure that the four types of settlement criteria ~~listed in Table 2.0-1~~ are satisfied. An alternative construction sequence and settlement analysis may be performed by the COL applicant in response to 1) the inability to meet the settlement criteria ~~listed in Table 2.0-1~~ using the DCD approach discussed in Section 3.8.5.4.2 or 2) Other site specific factors that may require a different construction plan and foundation sequence. However, in either case the COL applicant shall satisfy four types of settlement criteria ~~listed in Table 2.0-1~~.

described in Table 3.8-12 thru Table 3.8-14, and section 3.8.5.4.2.2.d.

COL 3.8 (19) The following items should be considered by the COL applicant:

1) The surveyed soil profiles will be developed.
2) Based on the surveyed soil characteristics, differences from the DCD soil profiles may exist. These differences may include:
   a. Stiff or soft soil areas;
   b. Different soil types (e.g, cohesive);
   c. Potential for loss of cement in the mudmat;
   d. Non-uniformity of soil layers, or
   e. Other differences in the soil profile from the properties assumed in design certification.
   If any of these items and/or conditions are identified, then a site-specific evaluation[1] shall be performed and checked for adequacy.
3) The time (i.e, short term and long term) instantaneous settlement and time-consolidation effects shall be evaluated in accordance with surveyed soil profiles regardless if a site-specific evaluation is needed under Item 2) above. ~~The settlement of the basemat and bearing pressure shall be checked to demonstrate acceptability with the acceptance criteria in DCD Table 2.0-1.~~
4) The COL applicant will build the seismic Category I structure according to the construction sequence used in the site-specific construction sequence analysis.
5) If a site-specific evaluation[1] is required, the COL applicant should perform a construction sequence analysis based on the site-specific parameters. If the settlement including results of construction sequence analysis exceeds the acceptance criteria ~~in the DCD Table 2.0-1~~, the construction sequence will be modified to meet the acceptance criteria ~~in the DCD Table 2.0-1~~ by COL applicant.
6) The effect on the design of seismic Category I structures due to construction sequence analysis shall be accounted for by the COL applicant.

The bearing pressure shall be checked to demonstrate acceptability with the acceptance criteria in DCD Table 2.0-1. Settlements shall be checked in Table 3.8-12 thru Table 3.8-14, and section 3.8.5.4.2.2.d.

1) evaluation includes basemat and superstructure design (forces/stresses), settlement evaluations, soil bearing pressure evaluation, and stability evaluation.

gradient is approximately 50 °F and a uniform temperature change is less than 10 °C (50 °F). The analysis of the foundation mat is performed by a three-dimensional finite element structure model, and the forces and moments determined in the analysis are input to the structural design.

The analysis and design of the foundations consider the effects of potential mat uplift, with particular emphasis on differential settlements of the basemat.

The foundation of the seismic Category I structure analysis is performed considering a soil/rock properties beneath the foundation as a nonlinear spring elements. The model is capable of determining the possibility of uplift of the basemat from the subgrade during postulated SSE events. The vertical spring at each node in the analytical model acts in compression only. The horizontal springs are active when the vertical spring is in compression and inactive when the vertical spring lifts off.

3.8.5.4.2 Analyses of Settlement during Construction

The basemat is analyzed and designed to consider settlements in various phases of construction.

The basemat is sufficiently reinforced to control stresses until the concrete placement of basemat walls and containment internal structure is completed.

Additional description for construction sequence will be included as shown in pages 7 and 8.

3.8.5.4.3 Design Summary Report

A design summary report for the basemats is presented in Appendix 3.8A, where the design of representative critical sections of the structures is described.

The evaluation considering the deviations of as-procured or as-built construction to the design will be performed with the acceptance criteria, as described in Technical Report, APR1400-E-S-NR-14006-P (Reference 40).

3.8.5.5 Structural Acceptance Criteria

The structural acceptance criteria for the containment and other seismic Category I structures excluding the reactor containment building are described in Subsections 3.8.1.5 and 3.8.4.5, respectively. In particular, the acceptance criteria for the stability of seismic Category I structures are checked together with the structural acceptance criteria against the

3.8.5.4.2.1 Construction Sequence

The construction sequence analysis model consists of foundation media considered 11 layer (soil layer model), NI common basemat (up to El. 78 ft for RCB and 55 ft for Auxiliary Building), and superstructure model (Auxiliary building, Internal structure, and Shell & Dome). The concrete used in analysis is normal weight concrete with the compressive strength of 5,000 psi at 91 days and 6,000 psi at 91 days for NI common basemat and superstructures. The concrete strength is assumed at the four hardening conditions to consider change of strength due to concrete pouring sequence.

For the construction sequence within NI common basemat, 19 basemat concrete segments are determined based on the concrete placement and hardening stages. For the construction sequence within superstructure (Auxiliary Building, Containment Shell & Dome, Containment internal structure), the five segment of superstructure are determined to consider direction of construction sequence.

The construction sequence analysis including NI building structure and superstructure is performed under total 58 construction sequences. In addition, construction sequence of superstructure considers two cases to check possibility of different cases (Case 1: Counterclockwise, Case 2: Clockwise). To consider the equipment load, the RCS weight is applied to each node when the slab located at 156ft is hardening.

For post construction, the settlement due to creep in soil profile S01 is considered. In the soil profile S08, it is not necessary to consider the creep effect of soil because of entire profile is rock. To consider the effect of creep in soil, the equation based on several experimental results suggested Schmertmann (1970) is applied. The equation is following.

$$C_2 = 1+0.2\log_{10}(t/0.1) \quad \text{where, t is time, in years}$$

To consider the effects from construction sequence, the differences in member forces between the construction sequence analysis and the reference analysis are considered in the design.

Detailed description and results for construction sequence are described in Technical Report, APR1400-E-S-NR-14006-P (Referenece 40).

3.8.5.4.2.2 Various Settlement

For various types of settlement for the NI, the maximum vertical settlement, titling settlement, differential settlement between structures, and angular distortion are determined under construction and post-construction phases. Following three sequences are considered for key sequence for checking four types settlements. For the EDGB and DFOT, the maximum vertical settlement and differential settlement between structures are determined. These settlements are used to define settlement criteria to be checked by the COL applicant to ensure that the design is adequate at the site.

Sequence No. 22: Completion of construction of NI common basemat.
Sequence No. 58 (Construction phase): Completion of construction of all superstructures.
Sequence No. 59 (Post-construction phase): End of plant life time, considering creep effect of soil.

a. Maximum vertical settlement

Maximum vertical displacement is the maximum calculated vertical deformation for the construction and post-construction phases under sequence No.58 and 59, respectively. Table 3.8-12 is summarized for maximum vertical settlement under construction and post-construction. For maximum vertical settlement of EDGB and DFOT buildings, it is determined from analysis that construction sequence is not considered. In order to consider characteristic of post-construction, soil spring reflected in the equation described in section 3.8.5.4.2.1 is considered. Table 3.8-12 is summarized as maximum vertical settlement under construction and post-construction.

b. Maximum Tilting settlement

Tilting settlement is calculated as the ratio of the differential vertical settlement for at the opposite edges of the buildings to the length between two edges. In the construction sequence, the maximum tilting settlement for the construction and post-construction phases are determined by the following equation under sequence No.58, end of construction, and No. 59, post-construction. Table 3.8-13 is summarized for maximum tilting settlement under construction and post-construction. For EDGB and DFOT buildings, construction sequence and tilting settlement are not needed because these buildings are relatively small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings.

Maximum tilting settlement = arctan ($\Delta Uz/L$)

c. Maximum differential settlement between structures

For maximum differential settlement between adjacent structures, it is determined based on vertical displacement obtained from adjacent nodes of each structure. For maximum differential settlement between structures under construction and post-construction, vertical settlement of NI basemat is obtained from sequence No.58 and No.59. However, vertical settlement of EDGB/DFOT is obtained from analysis which does not consider construction sequence analysis since the other structures (i.e., EDGB/ DFOT) are not required. The construction sequence analysis is not needed because these buildings are small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings. Table 3.8-14 is summarized for maximum differential settlement between structures under construction and post-construction.

d. Maximum Angular distortion

Maximum angular distortion is $\beta = \delta/L$ is a measure of differential vertical displacement between two adjacent points separated by the distance, L. To determine the angular distortion, three sequences (sequence No.22 , No.58, and No.59) are selected for soil profile S01 and two sequences (sequence No.22 and No.58) for soil profile S08. Based on the deformation results from each sequence (Nos.22, 58, and 59), 12 groups are determined as check points for angular distortion. For checking angular distortion of each group corresponding to soil profiles (S1, S8), angular distortion is plotted by vertical displacement along the distance between adjacent nodes within each group.

Detailed description and displacement graphs for angular distortion are provided in Technical Report, APR1400-E-S-NR-14006-P (Reference 40). These vertical displacement graphs are used as the acceptance criteria for the COL applicant, not maximum angular distortion value since these figures show the curvature of the entire basemat.

For EDGB and DFOT buildings, construction sequence and maximum angular distortion are not needed because these buildings are relatively small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings.

Table 3.8-12 thru 3.8-14 are added in DCD

Table 3.8-12 Maximum vertical displacement for construction and post-construction for NI, EDGB, and DFOT building

a) Results of construction sequence analysis

[Unit: ft]

Structures	Category	Max. settlement			
		Soil profile S1		Soil profile S8	
		#1	#2	#1	#2
NI building	Construction (Sequence No. 58)	0.286	0.282	0.012	0.0120
	Post-construction (Sequence No. 59)	0.386	0.380	Not considered [1)]	
EDGB building	Construction	0.142		0.005	
	Post-construction	0.218		Not considered [1)]	
DFOT building	Construction	0.172		0.005	
	Post-construction	0.266		Not considered [1)]	

[1)] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

b) Summary of maximum vertical settlement criteria

Structures	Category	Criteria
NI building	Construction	87.12mm (0.286ft)
	Post-Construction	117.86mm (0.386ft)
EDG building	Construction	43.28mm (0.142ft)
	Post-Construction	66.45mm (0.218ft)
DFOT building	Construction	52.43mm (0.172ft)
	Post-Construction	81.08mm (0.266ft)

Table 3.8-12 thru 3.8-14 are added in DCD

Table 3.8-13 Maximum tilting settlement for construction and post-construction for NI building

a) Results of construction sequence analysis

[Unit: degree]

Category	Max. Tilt settlement		Soil profile S1		Soil profile S8	
	Sequence	Direction	#1	#2	#1	#2
Construction	Sequence No.58	E-W	0.00725	0.00507	0.00015	0.00006
		N-S	0.01253	0.00993	0.00032	0.00030
Post-Construction	Sequence No.59	E-W	0.00989	0.00606	Not considered [1)]	
		N-S	0.0136	0.00961		

1) Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

b) Summary of maximum tilting settlement criteria

[Unit: degree]

Structures	Category	Direction	Criteria
NI building	Construction	E-W	0.00725
		N-S	0.01253
	Post-Construction	E-W	0.00989
		N-S	0.0136

Table 3.8-12 thru 3.8-14 are added in DCD

Table 3.8-14 Differential settlement between structures for all buildings under construction and post-construction

[Unit: inch]

		Max. differential settlement between structures ~~[Unit: inch]~~[2]							
		Construction				Post-construction			
		S01		S08		S01		S08	
		Max	Min	Max	Min	Max	Min	Max	Min
NI common basemat	Case1	2.171	1.566	0.078	0.051	3.358	2.671	Not considered [1]	
	Case2	2.020	1.527	0.074	0.052	3.132	2.620		
EDGB Basemat		1.701	1.670	0.061	0.046	2.615	2.582		
DFOT Basemat		2.066	0.986	0.054	0.027	3.193	1.521		
Differential Settlement (NI and EDG basemat)		0.501		0.009		0.776			
Differential Settlement (NI and DFOT basemat)		1.185		0.002		1.837			
EDGB Basemat		1.701	1.474	0.061	0.047	2.615	0.189		
DFOT Basemat		2.066	1.787	0.053	0.034	3.193	2.773		
Differential Settlement (DFOT and EDGB basemat)		0.592		0.027		0.925			

[1] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

[2] Maximum allowable differential settlement between buildings is 3inch described in Table 2.0-1.

5 CONSTRUCTION SEQUENCE ANALYSIS

This section presents the construction sequence analysis of the APR1400 NI common basemat for the evaluation of the settlement of the NI common basemat during construction.

5.1 General

The construction sequence analysis accounts for the construction sequence and the associated varying loads and stiffnesses of the NI common basemat. The construction sequence analysis focuses on the response of the basemat in the early stages of construction when it could be susceptible to different loading and deformations. For the construction sequence analysis, 19 basemat concrete segments are constructed during the concrete placement and hardening stages. The construction sequence scenarios are based on construction techniques and experience from the Shin-Kori Nuclear Power Unit 4 (SKN 4). In addition, it is assumed that there are no unscheduled delays and that the site is dewatered and excavated. Figure 5-1 shows the location of each basemat segment, and Table 5-1 represents the sequence of the construction stage. As shown in Figure 5-1 and Table 5-1, segments of concrete blocks are added to the construction site according to the prescribed concrete placement order.

5.2 Development of Finite Element Models for the Construction Sequence Analysis

5.2.1 Material Properties

The concrete used in the construction sequence analysis is normal weight concrete with the compressive strength of 5,000 psi at 91 days. However, the concrete strength is assumed for three hardening conditions to consider strength changes due to the concrete pouring sequence. The purpose of this assumption is to check the stress changes for the concrete according to the hardening (curing) time. If the hardening time has a significant effect on the concrete stresses, an analysis considering the hardening condition of the concrete due to the actual construction schedules is also performed.

In this report, the relationship between the age and strength of the concrete complies with the relationship for moist-cured concrete made with normal Portland cement. The modulus of elasticity for concrete is calculated using the equation, $57{,}000\sqrt{f'_c}$ as given in ACI-349. In addition, the compressive strength based on the hardening time is divided as follows:

Compressive strength according to the hardening time:

- Hardening Step 1 (H1): $0.67 \cdot f'_c$ = 3,350 psi
- Hardening Step 2 (H2): $0.86 \cdot f'_c$ = 4,300 psi
- Hardening Step 3 (H3): $1.00 \cdot f'_c$ = 5,000 psi

The corresponding elastic moduli are:

- Hardening Step 1 (H1): E = 3.30×10^6 psi
- Hardening Step 2 (H2): E = 3.74×10^6 psi
- Hardening Step 3 (H3): E = 4.03×10^6 psi

Replaced by pages 14 thru 17

For the construction sequence analysis, the site cases with the strongest (S8) and weakest (S1) properties are considered to represent the limiting site conditions. Table 5-2 shows the material properties for construction sequence analysis.

5.2.2 Finite Element Model

The FE model for the construction sequence analysis consists of the following:

- Ground (El. -900 ft 0 in. to El. 100 ft 0 in.)
- Basemat concrete segment for concrete pouring

The SOLID185 elements in the ANSYS program are used for the ground and basemat model. In addition, the fixed boundary condition is applied to the bottom and the roller boundary condition is applied to the sides of the ground model. Figure 5-2 shows the FE model for construction sequence analysis.

5.3 Construction Sequence Analysis Results

For S1 and S8, the results of settlement during the construction sequence are presented in Table 5-3. Settlement distribution contours for each site profile and construction stage are provided in Figures 5-3 and 5-4, respectively.

The maximum differential settlement is calculated as 0.39 and 0.029 in. at S1 and S8, respectively.

Replaced by pages 14 thru 17

5 CONSTRUCTION SEQUENCE ANALYSIS

This section presents the construction sequence analysis of the APR1400 NI building for the evaluation of the settlement of the NI common basemat including superstructures (Auxiliary Building, Containment Internal structure, and Containment Shell & Dome) during construction and post-construction phases.

5.1 General

The construction sequence analysis accounts for the construction sequence and the associated varying loads and stiffness of the NI common basemat including superstructures. The construction sequence analysis focuses on the response of the basemat in the early stages of construction when it could be susceptible to loading and deformations which are changed due to construction stages. 52 segments are constructed to simulate the concrete placement and hardening stages for the construction sequence analyses of basemat and superstructures (Auxiliary Building, Containment Shell & Dome, Containment internal structure).

The construction sequence scenarios are based on construction experience from the Shin-Kori Nuclear Power Plant Unit 4 (SKN 4). Figure 5-1 shows the 3D FE model used for construction sequence analysis, and Tables 5-1 thru 5-3 represent the sequence of the construction stage. In accordance with Figures 5-2 and 5-3 and Tables 5-1 thru 5-3, construction sequence analyses are performed.

5.2 Development of Finite Element Models for the Construction Sequence Analysis

5.2.1 Material Properties

The concrete used in the construction sequence analysis is normal weight concrete with the compressive strength of 5,000 psi at 91 days for NI common basemat and 6,000 psi at 91 days for superstructures.
However, the concrete strength is assumed for four hardening conditions to consider strength changes due to the concrete pouring sequence. The purpose of this assumption is to check the stress changes of the concrete according to the hardening (curing) time.
In this report, the relationship between the age and strength of the concrete complies with the relationship of moist-cured concrete made with normal Portland cement. The elasticity modulus of concrete is calculated using the equation, $57{,}000\sqrt{f_c'}$ as given in ACI-349. In addition, the compressive strength based on the hardening time is classified as follows:

Compressive strength according to the hardening time for 5,000 psi:
- Hardening Step 1 (H1): 0.57 = 2,850 psi
- Hardening Step 2 (H2): 0.74 = 3,700 psi
- Hardening Step 3 (H3): 0.85 = 4,250 psi
- Hardening Step 4 (H4): 1.00 = 5,000 psi

The corresponding elastic moduli are:
- Hardening Step 1 (H1): E = 4.3819×10^5 ksf
- Hardening Step 2 (H2): E = 4.9927×10^5 ksf
- Hardening Step 3 (H3): E = 5.3510×10^5 ksf
- Hardening Step 4 (H4): E = 5.8039×10^5 ksf

Compressive strength according to the hardening time for 6,000 psi:
- Hardening Step 1 (H1): 0.57 = 3,420 psi
- Hardening Step 2 (H2): 0.74 = 4,440 psi
- Hardening Step 3 (H3): 0.85 = 5,100 psi

- Hardening Step 4 (H4): 1.00 = 6,000 psi

The corresponding elastic moduli are:

- Hardening Step 1 (H1): E = 4.8001 × 10^5 ksf
- Hardening Step 2 (H2): E = 5.4693 × 10^5 ksf
- Hardening Step 3 (H3): E = 5.8617 × 10^5 ksf
- Hardening Step 4 (H4): E = 6.3579 × 10^5 ksf

For the construction sequence analysis, the S08 and S01 soil profiles are considered.

5.2.2 Finite Element Model

The FE models for the construction sequence analysis consist of the following:

- Ground (El. -900 ft 0 in. to El. 100 ft 0 in.)
- Basemat concrete segment for concrete pouring
- Three superstructures (Auxiliary Building, Containment Internal structure, and Containment Shell & Dome)

The SOLID185 elements in the ANSYS program are used for the ground and basemat model. In addition, the fixed boundary condition is applied to the bottom, and the roller boundary condition is applied to the sides of the foundation media model. Figure 5-2 shows the FE models for construction sequence analysis.

Specially, the 'Birth' and 'Death' options in the ANSYS are applied for analyzing excavation, staged construction, sequential assembly. To achieve the effect of 'element death', the program deactivates them by multiplying deactivation factor to their stiffness. In like manner, when elements are 'born', they are simply reactivated. To consider the role of concrete form, some nodes which experience initial hardening stage are restrained in the horizontal direction and then the form is removed when the concrete strength is over 70% of design compressive strength.

5.3 Construction Sequence Analysis Results

For the review of the effect on construction sequence analysis, sequence No.22, No.58, and No.59 are chosen as key sequence step.

Sequence Number	Description	Application
No.22	Completion of construction of NI common basemat	Settlement Evaluation
No.58	Completion of construction of all superstructures (AB, CIS, Containment Shell & Dome)	Settlement Evaluation, Member force Evaluation
No.59	End of plant lifetime to consider creep effect of soil	Settlement Evaluation Member force Evaluation

5.3.1.1 Comparison between reference analysis and sequential analysis

The purpose of this subsection is to check influence of construction sequence on settlement. For simplified explanation, 'Sequence analysis' is to consider construction sequences. On the contrary, 'Reference analysis' does not consider construction sequences.

Figure 5-4 shows the comparison of displacement contour between sequence analysis (sequence No. 58 of case #1) and reference analysis in soil profile S01. Figure 5-5 shows the comparison of stress contours (SX, SY, SZ) between sequence analysis (sequence No. 58 of case #1) and reference analysis in soil profile S01, respectively. Case #1 represents count clock-wise directional construction sequence of superstructures.

Figure 5-6 shows the comparison of displacement contour between sequence analysis (sequence No. 58 of case #2) and reference analysis in soil profile S01. Figure 5-7 shows the comparison of stress contours (SX, SY, SZ) between sequence analysis (sequence No. 58 of case #2) and reference analysis in soil profile S01, respectively. Case #2 represents clock-wise directional construction sequence of superstructures.

Figure 5-8 shows the comparison of displacement contour between sequence analysis (sequence No. 58 of case #1) and reference analysis in soil profile S08. Figure 5-9 shows the comparison of stress contours (SX, SY, SZ) between sequence analysis (sequence No. 58 of case #1) and reference analysis in soil profile S08, respectively.

Figure 5-10 shows the comparison of displacement contour between sequence analysis (sequence No. 58 of case #2) and reference analysis in soil profile S08. Figure 5-11 shows the comparison of stress contours (SX, SY, SZ) between sequence analysis (sequence No. 58 of case #2) and reference analysis in soil profile S08, respectively.

5.3.2 Four types of settlement

5.3.2.1 Maximum vertical settlement

Maximum vertical displacement is the maximum calculated vertical deformation for the construction and post-construction phases under sequence No.58 and 59, respectively. Table 5-4 shows the maximum settlement for construction and post-construction phases. For the EDG and DFOT, the maximum vertical settlement and differential settlement between structures are determined.

5.3.2.2 Maximum tilting settlement

Tilting settlement is calculated as the ratio of the differential vertical settlement for at the opposite edges of the buildings to the length between two edges. To check tilting settlement, the check points are determined as shown figure 5-12. Of the construction sequence, the maximum tilting settlement for the construction and post-construction phase is checked by following equations under sequence No.58, end of construction, and No. 59, end of post-construction as shown in Table 5-5. For EDGB and DFOT buildings, construction sequence and tilting settlement are not needed because these buildings are relatively small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings.

$$\text{Maximum tilting settlement} = \arctan (\Delta U_z/L)$$

5.3.2.3 Maximum differential settlement between structures

For maximum differential settlement between structures under construction and post-construction, vertical settlement of NI basemat is obtained from sequence No.58 and No.59. Vertical settlement of EDGB/DFOT is obtained from analysis not considered construction sequence analysis since the other structures (i. e., EDGB/ DFOT) are not required. The construction sequence analysis is not needed because these buildings are small and simple structures, and these are sufficient gaps between the EDGB/DFOT buildings and NI buildings. For differential settlement between adjacent structures, it is determined based on following six cases. Table 5-6 shows the summary of differential settlement between NI common basemat and EDGB/ DFOT basemat. Figure 5-13 shows the locations for differential settlement between structures.

1) Difference between maximum vertical settlement regarding adjacent nodes of EDGB and minimum vertical settlement regarding adjacent nodes of NI common basemat.

2) Difference between minimum vertical settlement regarding adjacent nodes of EDGB and maximum vertical settlement regarding adjacent nodes of NI common basemat.

3) Difference between maximum vertical settlement regarding adjacent nodes of DFOT and minimum vertical settlement regarding nodes of NI common basemat.

4) Difference between minimum vertical settlement regarding adjacent nodes of DFOT and maximum vertical settlement regarding nodes of NI common basemat.

5) Difference between maximum vertical settlement regarding adjacent nodes of DFOT and minimum vertical settlement regarding nodes of EDGB basemat.

6) Difference between minimum vertical settlement regarding adjacent nodes of DFOT and maximum vertical settlement regarding nodes of EDGB basemat.

5.3.2.4 Angular distortion

Maximum Angular distortion is $\beta = \delta/L$ is a measure of differential vertical displacement between two adjacent points separated by the distance, L. To determine the angular distortion, three sequences (sequence No. 22 , No.58, and No.59) of all sequences are selected for soil profile S01 and two sequences (sequence No.22 and No.58) for soil profile S08. Based on deformation result from each sequence (No.22, 58, and No.59), the 12 groups are determined to check points for angular distortion as shown Figure 5-14. These groups are selected along vertical, horizontal and diagonal direction based on starting points. The coordinates in the four boxes indicate the starting points of the red lines for each group

For checking angular distortion per each group corresponding to soil profiles (S1, S8), it is plotted by vertical displacement along the distance between adjacent nodes within each group as indicated in Figures 5-15 and 5-16. As shown figures 5-15 and 5-16 regarding to angular distortion plotted from adjacent nodes within nodes, the red line indicated the boundary of each segment of basemat. The change of sharp slope indicated in red line is caused by the difference of construction time. In order words, the reason why the shift is occurred is to consider different construction steps at the same nodes in the analysis.
Therefore, slope due to step change is not considered for angular distortion. For EDGB and DFOT buildings, construction sequence and maximum angular distortion are not needed because these buildings are relatively small and simple structures, and there are sufficient gaps between the EDGB/DFOT buildings and NI buildings.

Table 5-1

Sequence of Basemat Segments due to Concrete Pouring

Stage	A-S001	C-S001	C-S002	A-S004	C-S003	A-S005	C-S004	A-S006	A-S002	A-S003	A-S007	A-S008	C-W007	A-S010	C-S005	A-S009	C-S006	C-S008	C-S009
1	P																		
2	H1	P																	
3	H2	H1	P																
4	H3	H2	H1	P															
5	H3	H3	H2	H1	P														
6	H3	H3	H3	H2	H1	P													
7	H3	H3	H3	H3	H2	H1	P												
8	H3	H3	H3	H3	H3	H2	H1	P											
9	H3	H3	H3	H3	H3	H3	H2	H1	P										
10	H3	H3	H3	H3	H3	H3	H3	H2	H1	P									
11	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P								
12	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P							
13	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P						
14	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P					
15	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P				
16	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P			
17	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1	P		
18	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1		
19	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2		
20	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	P	
21	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H1	P
22	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2	H1
23	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H2
24	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3

Notes:

(1) P indicates the segment where concrete is being poured in the stage

(2) H1 indicates the segment where concrete has hardened to Hardening Step1 which has a compressive strength of 3,350 psi, in the previous stage.

(3) H2 indicates the segment where concrete has hardened to Hardening Step2 which has a compressive strength of 4,300psi, in the previous stage.

(4) H3 indicates the segment where concrete has hardened to Hardening Step3 which has a compressive strength of 5,000psi, in the previous stage.

Replaced Tables 5-1 ~ 5-6 in pages 21 thru 28

Table 5-2

Material Properties for the Construction Sequence Analysis

Material		Elastic Modulus (ksf)	Poisson's Ratio	Weight Density (pcf)	Remarks
Concrete	H1	4.7506E+05	0.17	150	at 0.67·f_c'
	H2	5.3827E+05	0.17	150	at 0.86·f_c'
	H3	5.8032E+05	0.17	150	at 1.00·f_c'
S1	Layer 1	1.8970E+03	0.4	125	El. 70′-0″ ~ El. 100′-0″
	Layer 2	2.3680E+03	0.4	125	El. 35′-0″ ~ El. 70′-0″
	Layer 3	2.9140E+03	0.4	125	El. 0′-0″ ~ El. 35′-0″
	Layer 4	3.6200E+03	0.4	125	El. -50′-0″ ~ El. 0′-0″
	Layer 5	5.8510E+03	0.4	125	El. -100′-0″ ~ El. -50′-0″
	Layer 6	3.1805E+04	0.38	130	El. -200′-0″ ~ El. -100′-0″
	Layer 7	3.8754E+04	0.38	130	El. -300′-0″ ~ El. -200′-0″
	Layer 8	4.5255E+04	0.38	130	El. -400′-0″ ~ El. -300′-0″
	Layer 9	1.1751E+05	0.35	135	El. -520′-0″ ~ El. -400′-0″
	Layer 10	1.2999E+05	0.33	145	El. -1,000′-0″ ~ El. -520′-0″
S8	Layer 1	1.4741E+05	0.33	145	El. 70′-0″ ~ El. 100′-0″
	Layer 2	1.5413E+05	0.33	145	El. 35′-0″ ~ El. 70′-0″
	Layer 3	1.6128E+05	0.33	145	El. 0′-0″ ~ El. 35′-0″
	Layer 4	1.6979E+05	0.33	145	El. -50′-0″ ~ El. 0′-0″
	Layer 5	1.7956E+05	0.33	145	El. -100′-0″ ~ El. -50′-0″
	Layer 6	3.2513E+05	0.33	155	El. -1,000′-0″ ~ El. -100′-0″

Replaced Tables 5-1 ~ 5-6 in pages 21 thru 28

Table 5-3

Results of Construction Sequence Analysis

Stage	Settlement (in)					
	S1			S8		
	Max	Min	Diff	Max	Min	Diff
1	-	-	-	-	-	-
2	-0.1644	-0.1044	-0.06	-0.0096	-0.0048	-0.0048
3	-0.2124	-0.0756	-0.1368	-0.012	-0.0036	-0.0072
4	-0.2448	-0.0792	-0.1656	-0.012	-0.0036	-0.0084
5	-0.2496	-0.1296	-0.1212	-0.0132	-0.0048	-0.0084
6	-0.2964	-0.0672	-0.2304	-0.0144	-0.0048	-0.0096
7	-0.306	-0.096	-0.21	-0.0144	-0.0048	-0.0096
8	-0.3432	-0.0924	-0.2508	-0.0156	-0.0048	-0.0108
9	-0.3516	-0.1716	-0.18	-0.0168	-0.006	-0.0096
10	-0.3648	-0.1608	-0.204	-0.0168	-0.0072	-0.0096
11	-0.378	-0.162	-0.216	-0.0168	-0.006	-0.0108
12	-0.3804	-0.168	-0.2136	-0.018	-0.006	-0.0108
13	-0.3948	-0.1728	-0.222	-0.018	-0.006	-0.012
14	-0.3972	-0.2016	-0.1956	-0.0192	-0.0072	-0.012
15	-0.4752	-0.2028	-0.2724	-0.024	-0.0072	-0.0168
16	-0.4944	-0.2688	-0.2256	-0.0252	-0.0084	-0.018
17	-0.546	-0.2712	-0.2748	-0.0276	-0.0084	-0.0204
18	-0.546	-0.276	-0.2688	-0.0276	-0.0084	-0.0204
19	-0.5448	-0.2796	-0.2652	-0.0276	-0.0084	-0.0204
20	-0.6228	-0.2844	-0.3384	-0.0348	-0.0084	-0.0264
21	-0.6876	-0.2976	-0.3888	-0.0372	-0.0084	-0.0288
22	-0.6876	-0.2976	-0.39	-0.0372	-0.0084	-0.0288
23	-0.6864	-0.2988	-0.3876	-0.0372	-0.0084	-0.0288
24	-0.6852	-0.2988	-0.3864	-0.0372	-0.0084	-0.0288

Replaced Tables 5-1 ~ 5-6 in pages 21 thru 28

Table 5-1. Sequence of Segments due to Concrete Pouring

TS

Table 5-2 Construction Sequence of Superstructures (Counterclockwise)

TS

TS

Table 5-3 Construction Sequence of Superstructures (Clockwise)

TS

TS

Table 5-4 Maximum Vertical Settlement for Construction and Post-Construction for NI, EDGB, and DFOT building

[Unit: ft]

Structures	Category	Max. settlement			
		Soil profile S1		Soil profile S8	
		#1	#2	#1	#2
NI building	Construction (Sequence No. 58)	0.286	0.282	0.012	0.0120
	Post-construction (Sequence No. 59)	0.386	0.380	Not considered [1)]	
EDGB building	Construction	0.142		0.005	
	Post-construction	0.218		Not considered [1)]	
DFOT building	Construction	0.172		0.005	
	Post-construction	0.266		Not considered [1)]	

[1)] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

Table 5-5 Tilting Settlement for Construction and Post-Construction for NI building

[Unit: degree]

Category	Max. Tilt settlement		Soil profile S1		Soil profile S8	
	Sequence	Direction	#1	#2	#1	#2
Construction	Sequence No.58	E-W	0.00725	0.00507	0.00015	0.00006
		N-S	0.01253	0.00993	0.00032	0.00030
Post-Construction	Sequence No.59	E-W	0.00989	0.00606	Not considered [1)]	
		N-S	0.0136	0.00961		

[1)] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

Table 5-6 Differential Settlement between Structures for All buildings under Construction and Post-Construction

[Unit: inch]

		Max. differential settlement between structures							
		Construction				Post-construction			
		S01		S08		S01		S08	
		Max	Min	Max	Min	Max	Min	Max	Min
NI common basemat	Case1	2.171	1.566	0.078	0.051	3.358	2.671	Not considered [1]	
	Case2	2.020	1.527	0.074	0.052	3.132	2.620		
EDG Basemat		1.701	1.670	0.061	0.046	2.615	2.582		
DFOT Basemat		2.066	0.986	0.054	0.027	3.193	1.521		
Differential Settlement (NI and EDG basemat)		0.501		0.009		0.776			
Differential Settlement (NI and DFOT basemat)		1.185		0.002		1.837			
Differential Settlement (DFOT and EDG basemat)		0.592		0.027		0.925			

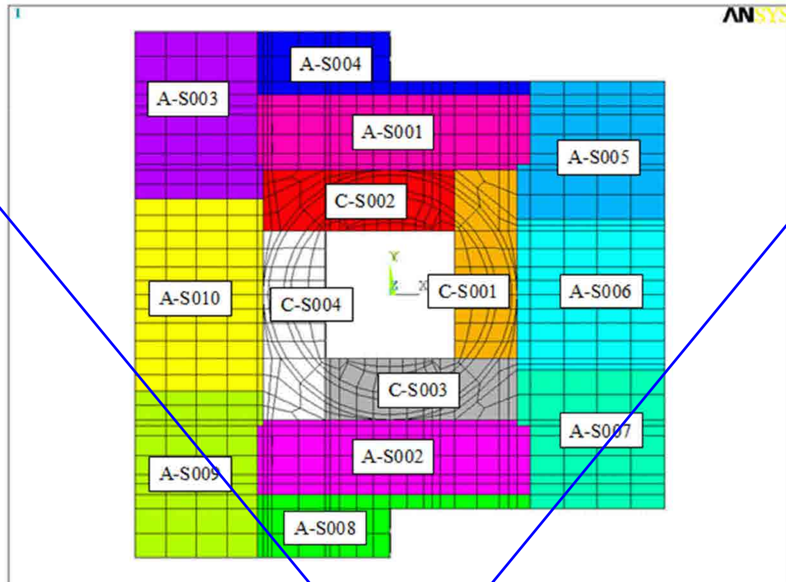
[1] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.

Replaced

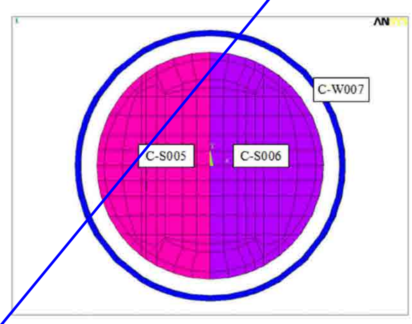
[Unit: inch]

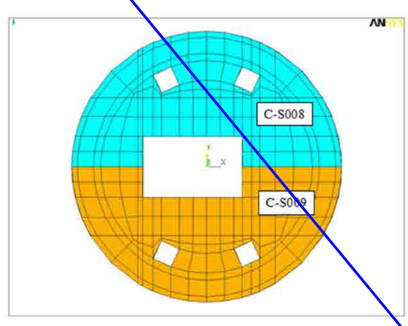
		Max. differential settlement between structures							
		Construction				Post-construction			
		S01		S08		S01		S08	
		Max	Min	Max	Min	Max	Min	Max	Min
NI common basemat	Case1	2.171	1.566	0.078	0.051	3.358	2.671	Not considered [1]	
	Case2	2.020	1.527	0.074	0.052	3.132	2.620		
EDGB Basemat		1.701	1.670	0.061	0.046	2.615	2.582		
DFOT Basemat		2.066	0.986	0.054	0.027	3.193	1.521		
Differential Settlement (NI and EDG basemat)		0.501		0.009		0.776			
Differential Settlement (NI and DFOT basemat)		1.185		0.002		1.837			
EDGB Basemat		1.701	1.474	0.061	0.047	2.615	0.189		
DFOT Basemat		2.066	1.787	0.053	0.034	3.193	2.773		
Differential Settlement (DFOT and EDGB basemat)		0.592		0.027		0.925			

[1] Since soil profile S08 consists of rock profile, the creep effect of soil is not considered.



(a) RCB and AB Areas (El. 35′-0″ ~ El. 55′-0″)



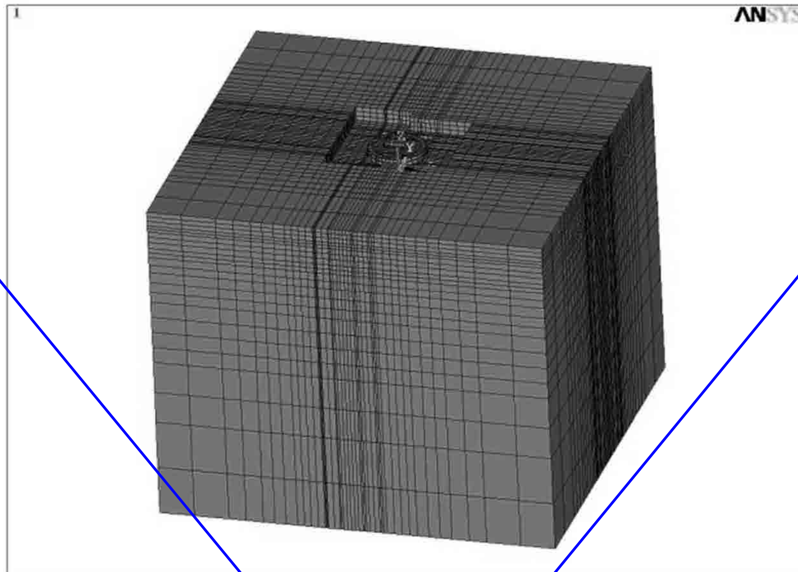


(b) RCB Area (El. 55′-0″ ~ El. 68′-0″)

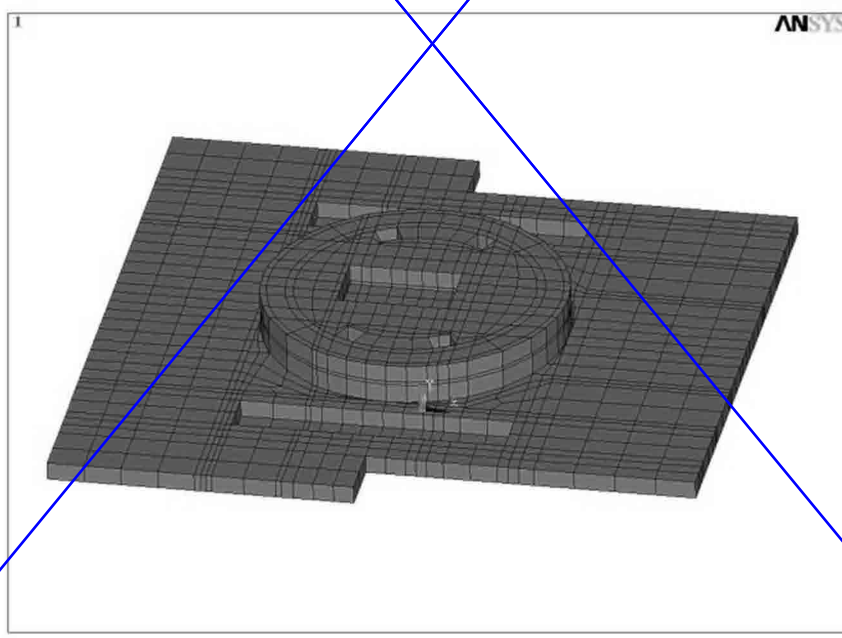
(c) RCB Area (El. 68′-0″ ~ El. 78′-0″)

Figure 5-1 Individual Segments of Basemat Foundation for Concrete Pouring

Replaced Figures 5-1 ~ 5-16 in pages 33 thru 66



(a) Full Model



(b) NI Common Basemat

Figure 5-2 Construction Sequence FE Model

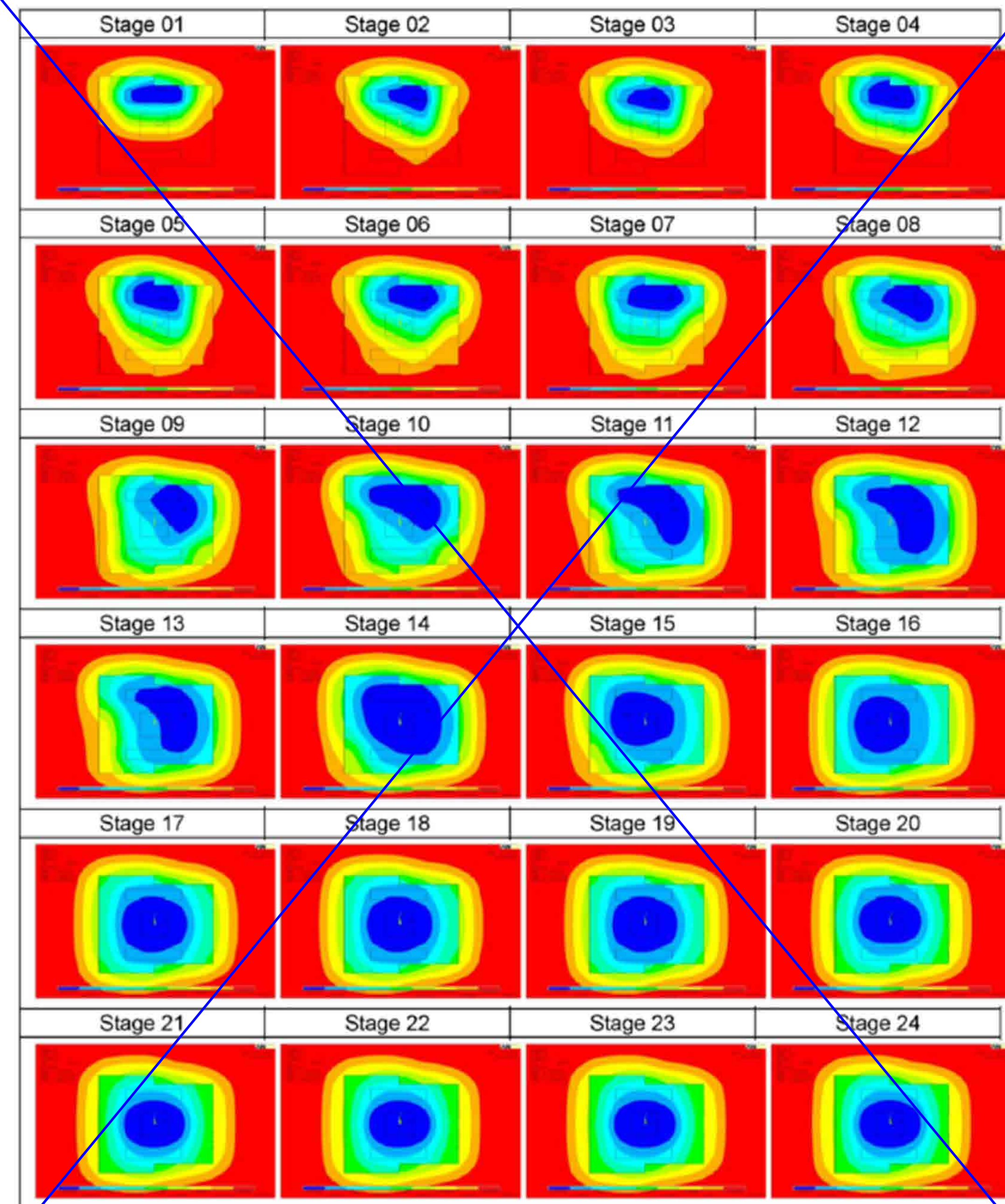


Figure 5-3 Settlement Distribution Contour for Construction Sequence Analysis for S1

Replaced Figures 5-1 ~ 5-16 in pages 33 thru 66

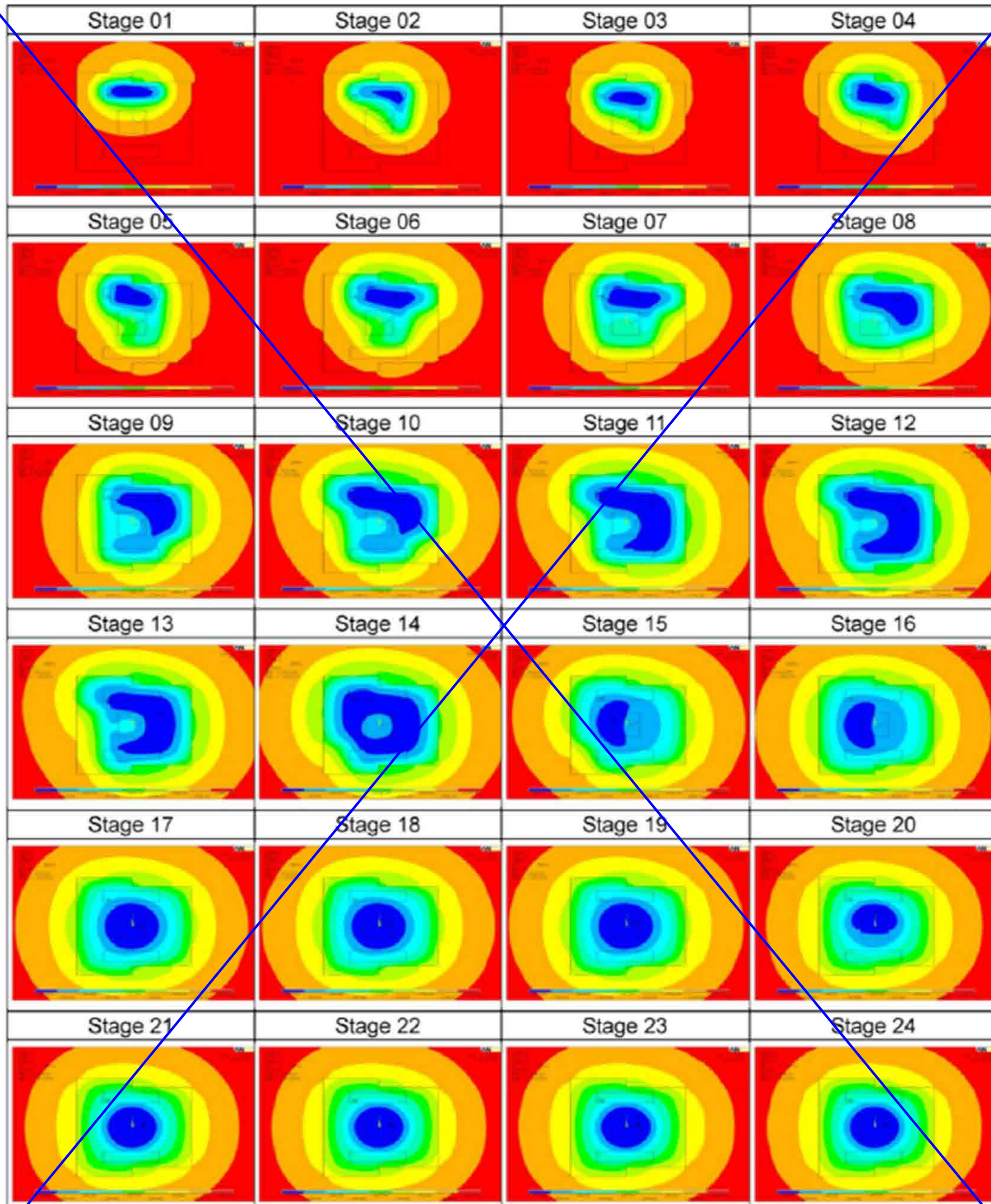


Figure 5-4 Settlement Distribution Contour for Construction Sequence Analysis for S8

 Replaced Figures 5-1 ~ 5-16 in pages 33 thru 66

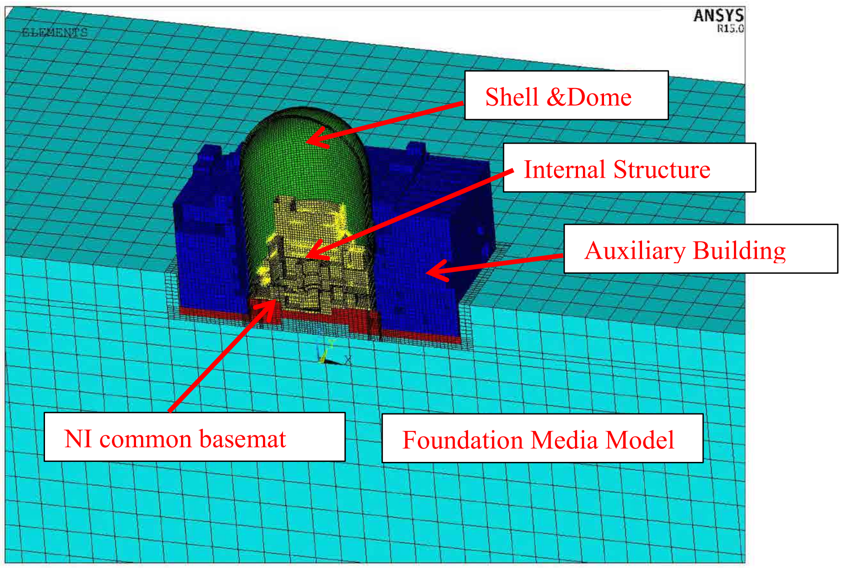
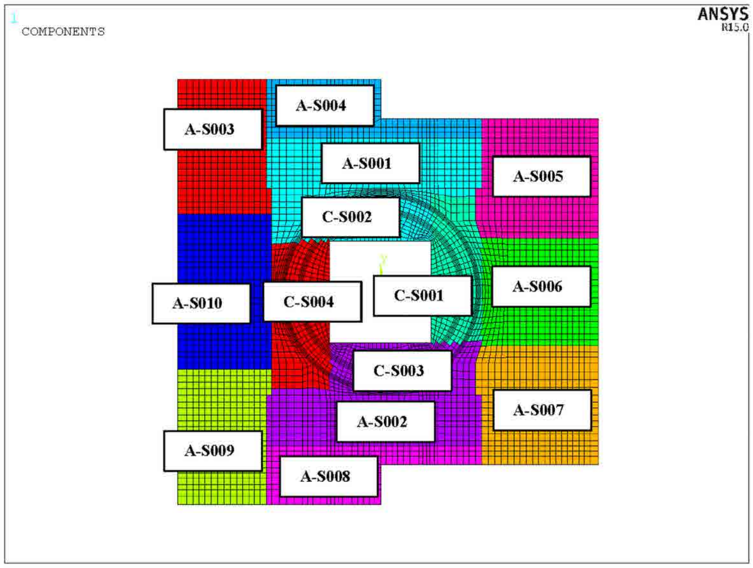
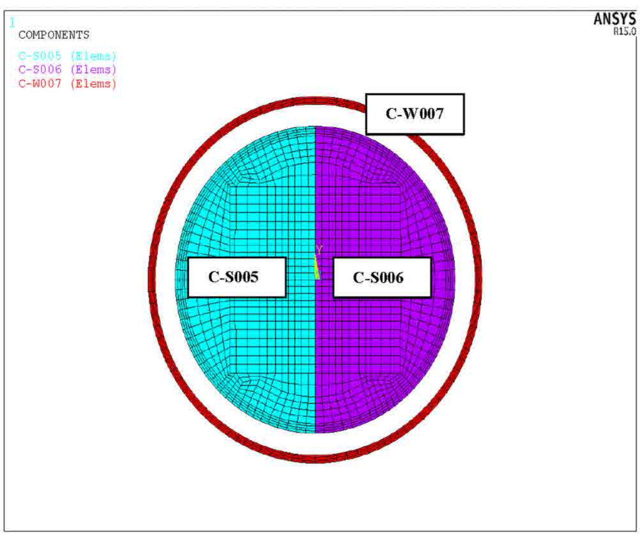


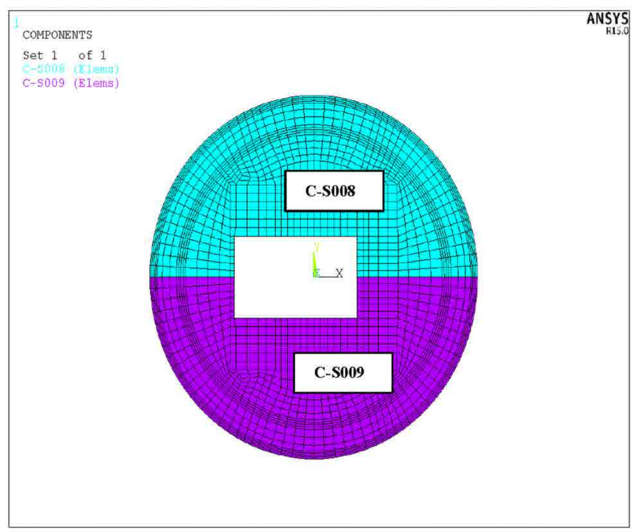
Figure 5-1 3D FE Model for Construction Analysis



(a) RCB & AB building Area, El. 35′-0″ ~ El. 55′-0″

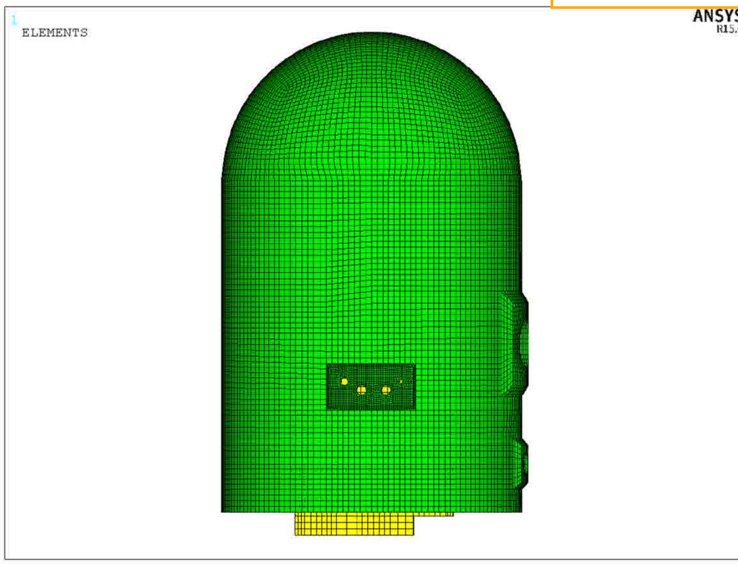


(b) RCB & AB building Area, El. 55′-0″ ~ El. 68′-0″

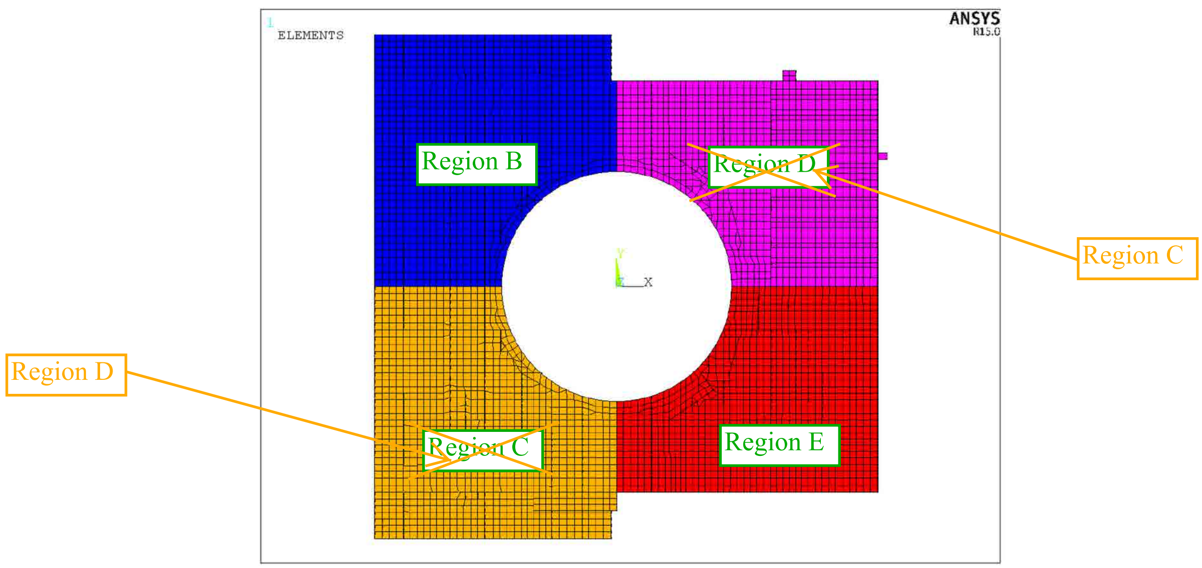


(c) RCB & AB building Area, El. 68′-0″ ~ El. 78′-0″

Figure 5-2 Individual Segment of NI basemat



(a) Region A



(b) Region B, C, D, E

Figure 5-3 Individual Segment of Superstructure

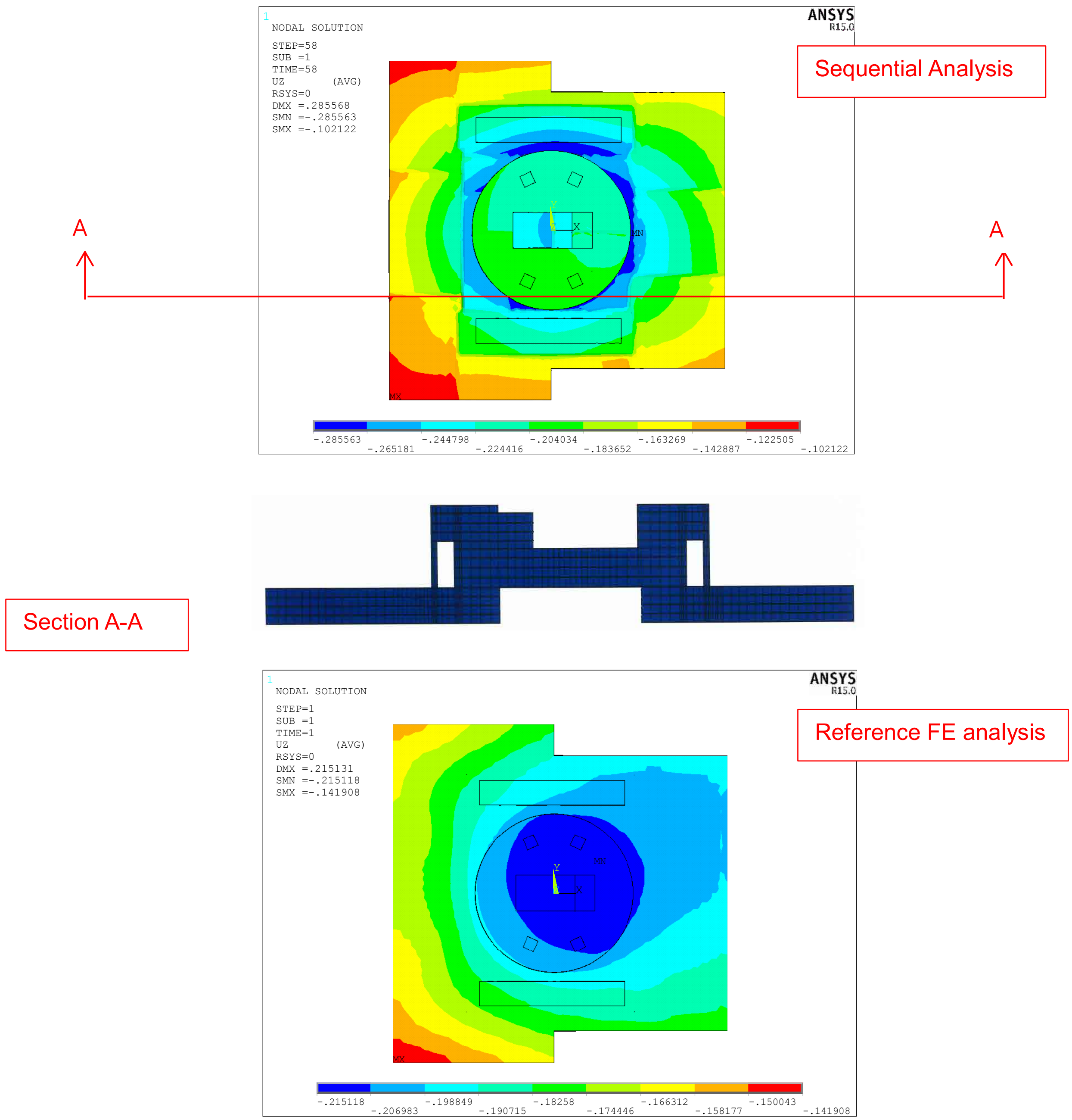
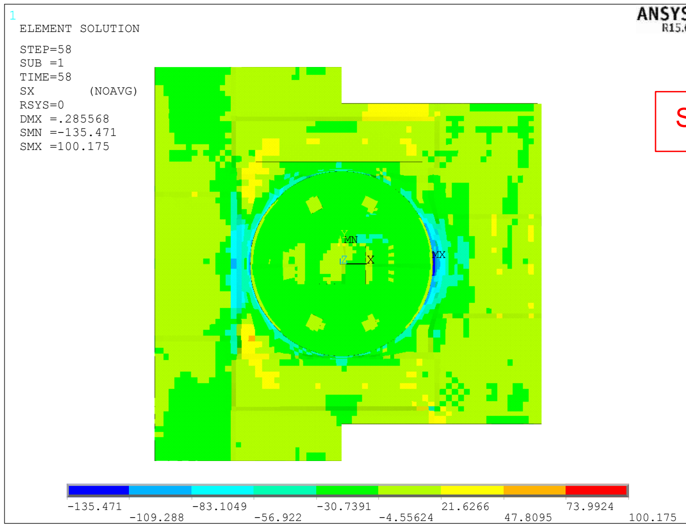
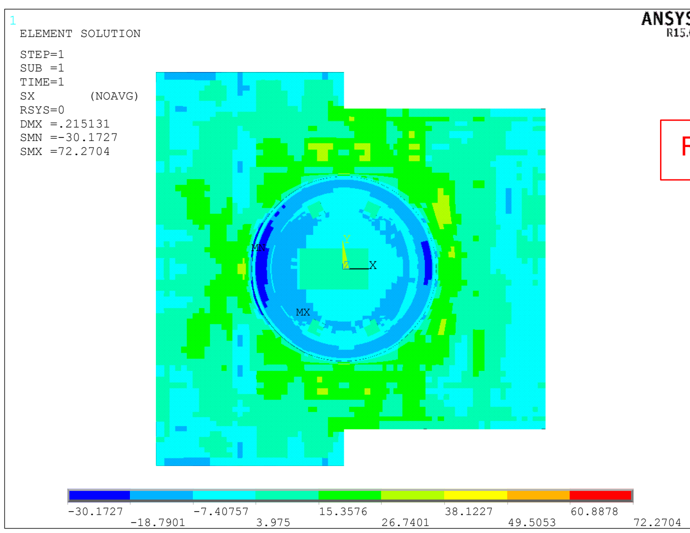


Figure 5-4. Comparison displacement contour between sequential and reference analysis (S01, Case#1)

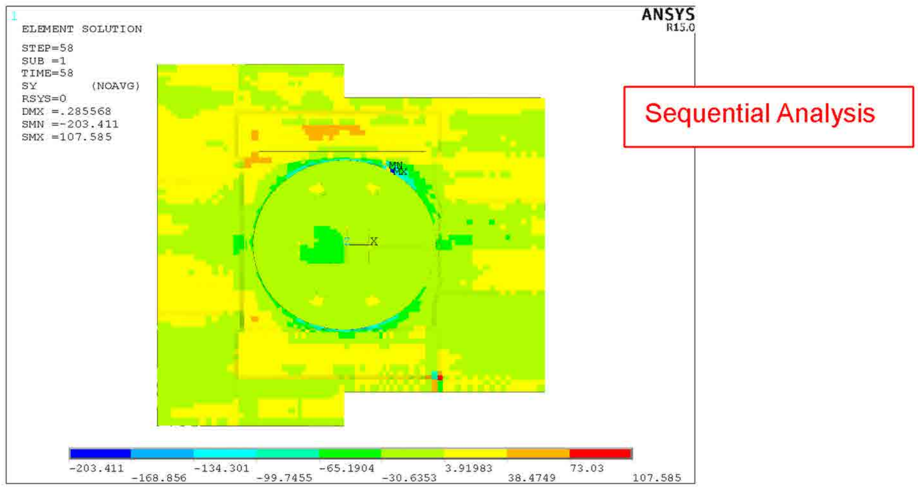


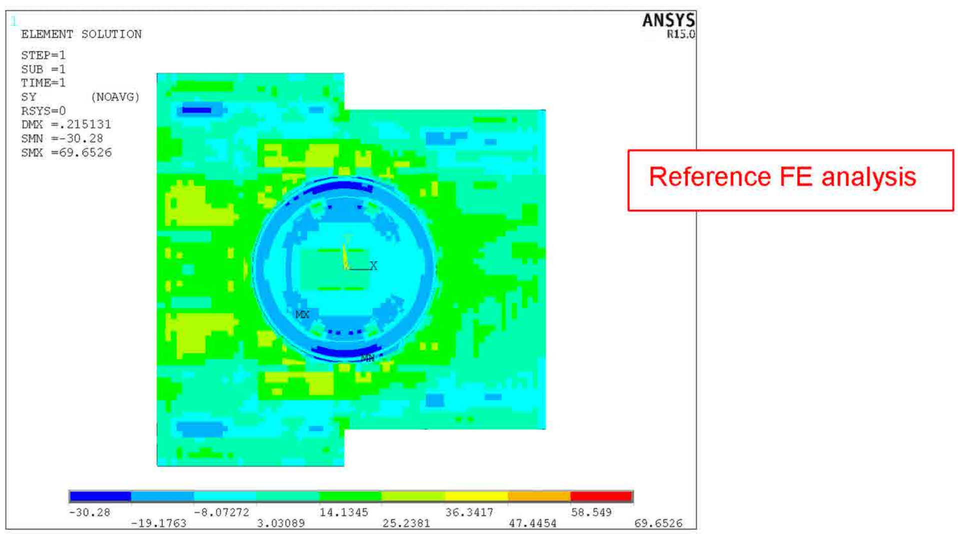
Sequential Analysis



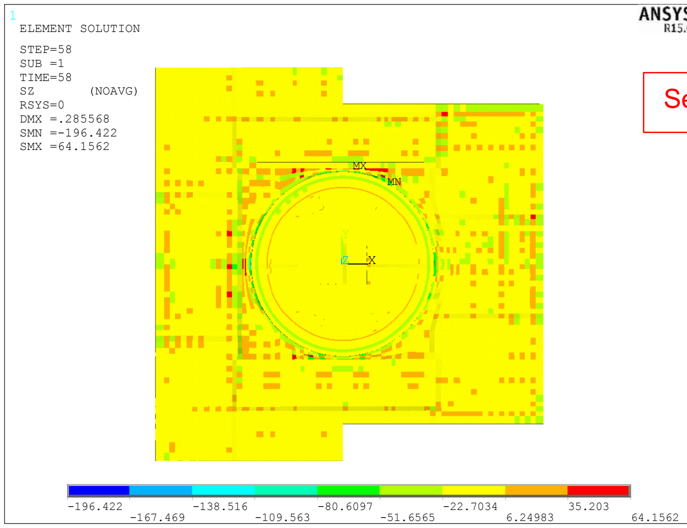
Reference FE analysis

(a) Stress X Contour

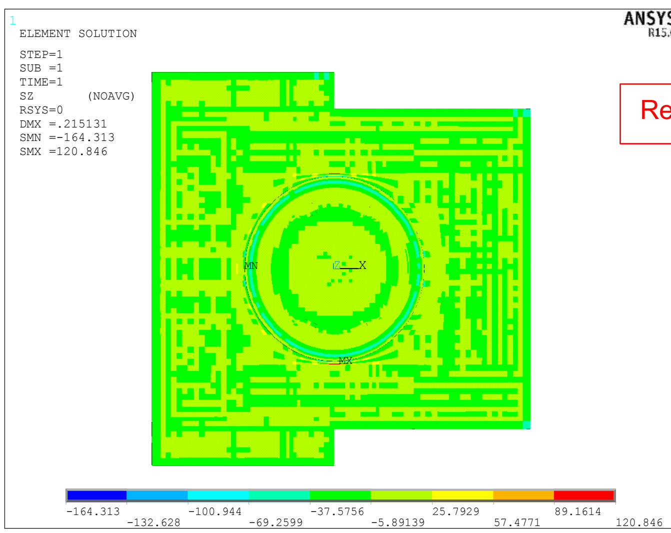




(b) Stress Y Contour



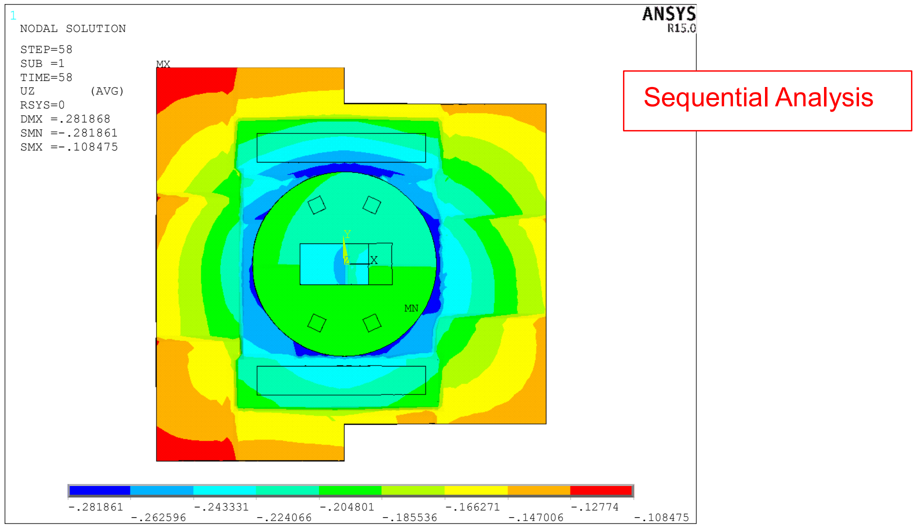
Sequential Analysis



Reference FE analysis

(c) Stress Z Contour

Figure 5-5. Comparison stress contour between sequential and reference analysis (S01, Case#1)



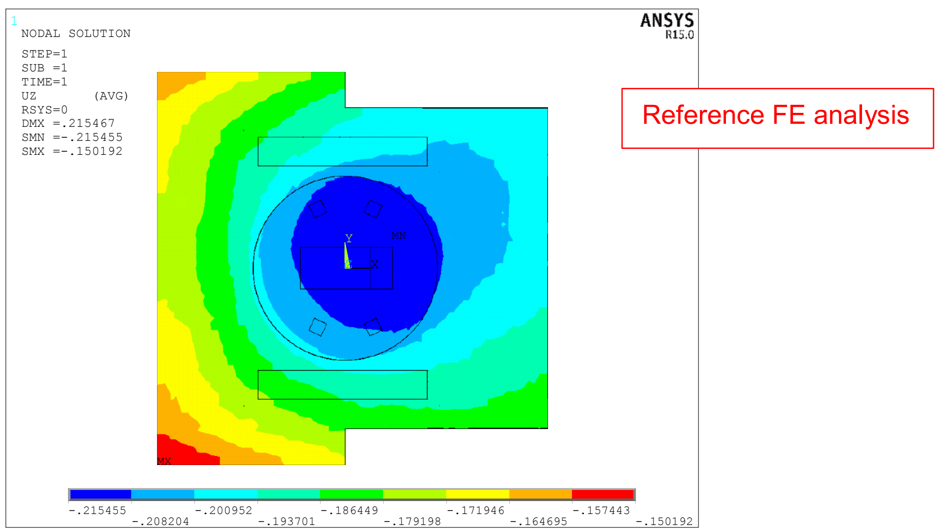
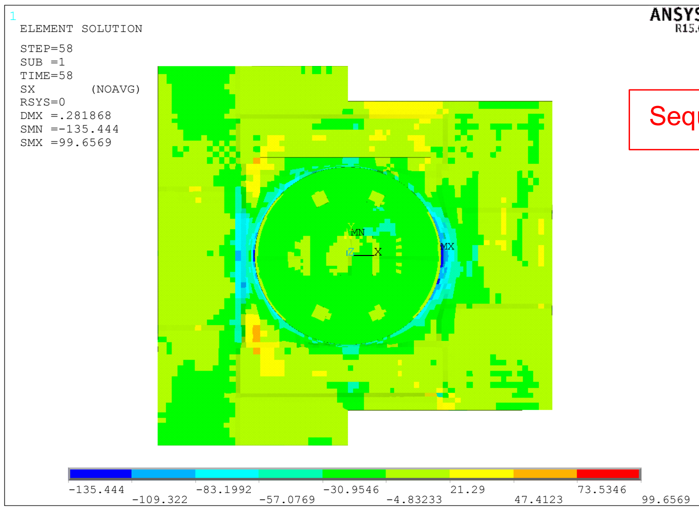
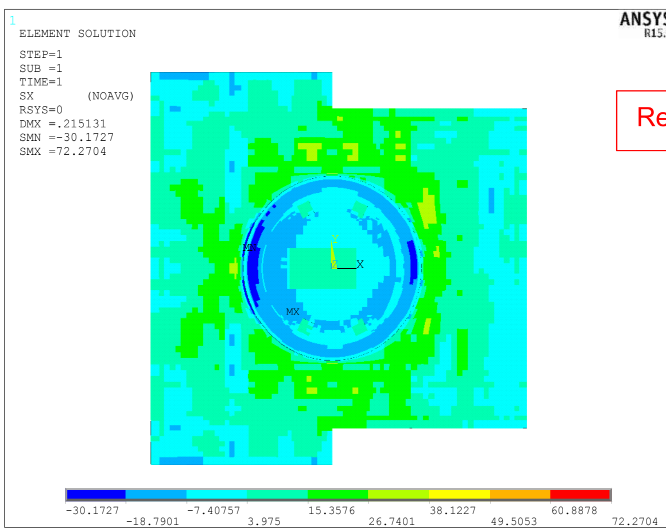


Figure 5-6. Comparison displacement contour between sequential and reference analysis (S01, Case#2)

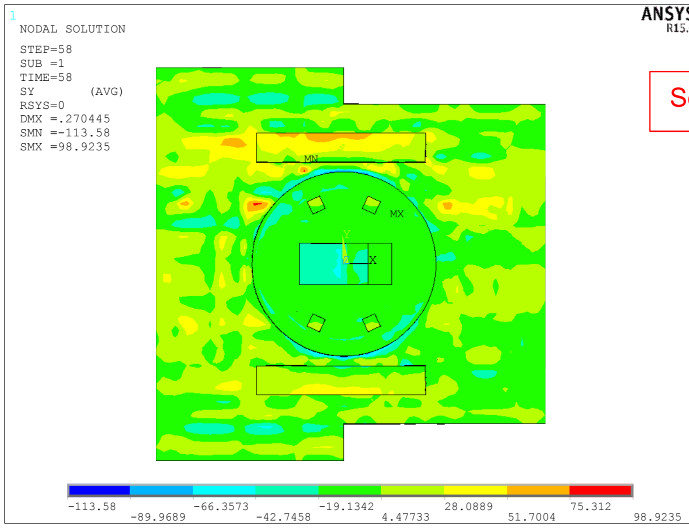


Sequential Analysis

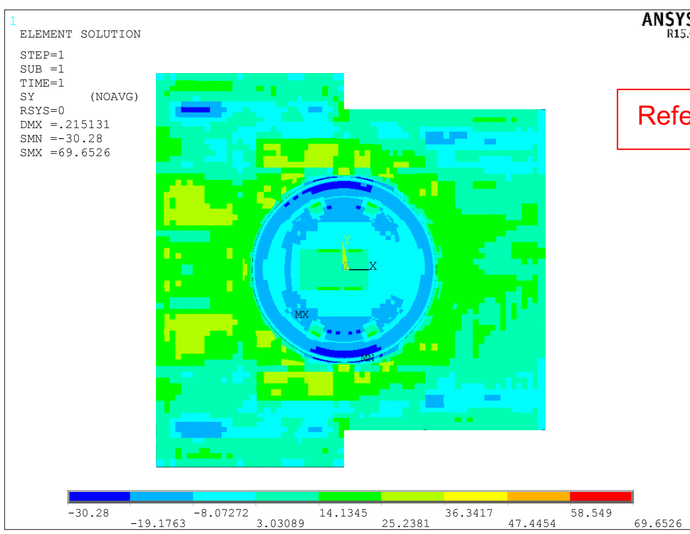


Reference FE analysis

(a) Stress X Contour

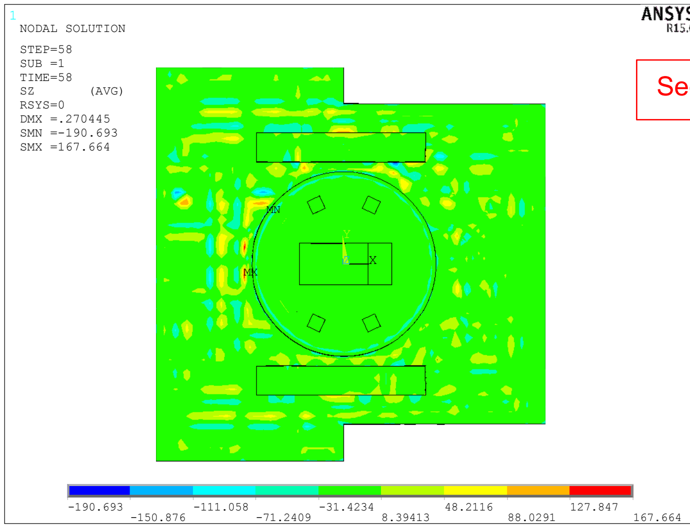


Sequential Analysis

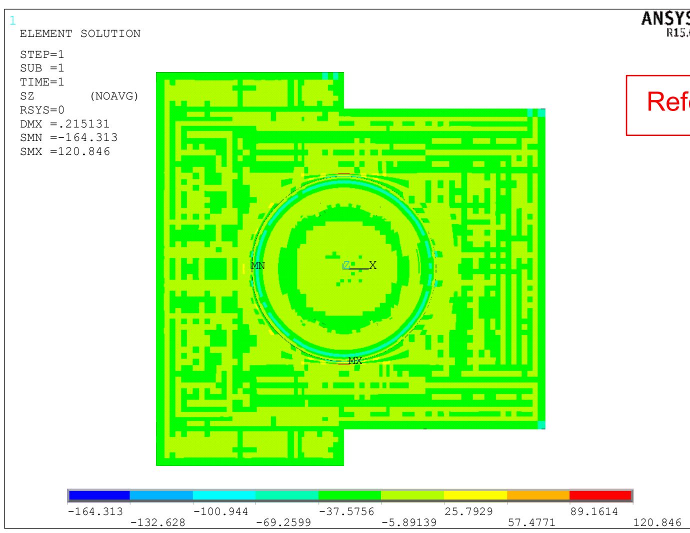


Reference FE analysis

(b) Stress Y Contour



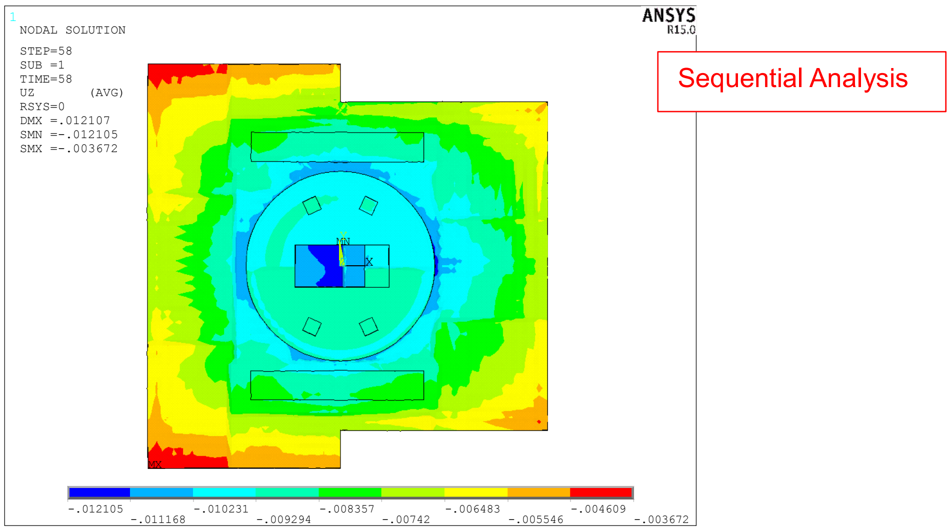
Sequential Analysis



Reference FE analysis

(c) Stress Z Contour

Figure 5-7. Comparison stress contour between sequential and reference analysis (S01, Case#2)



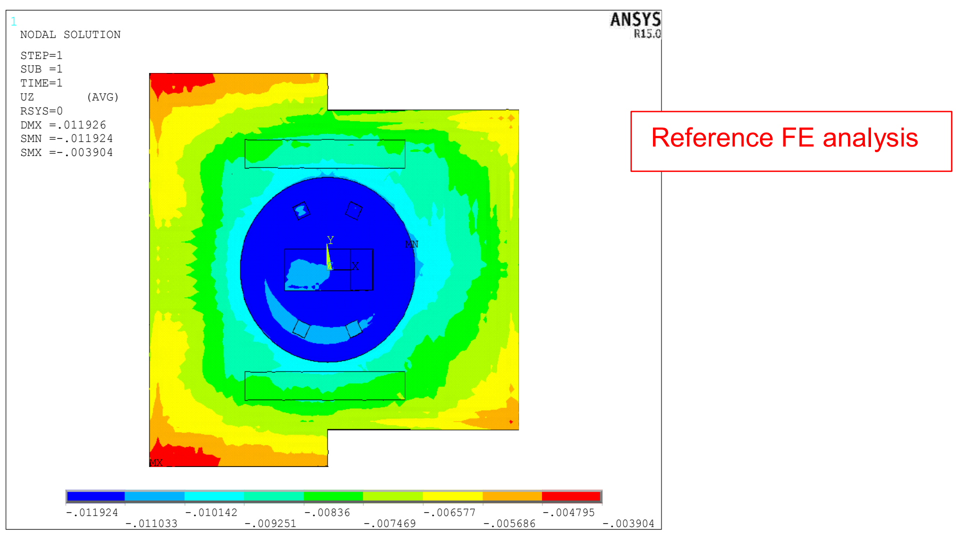
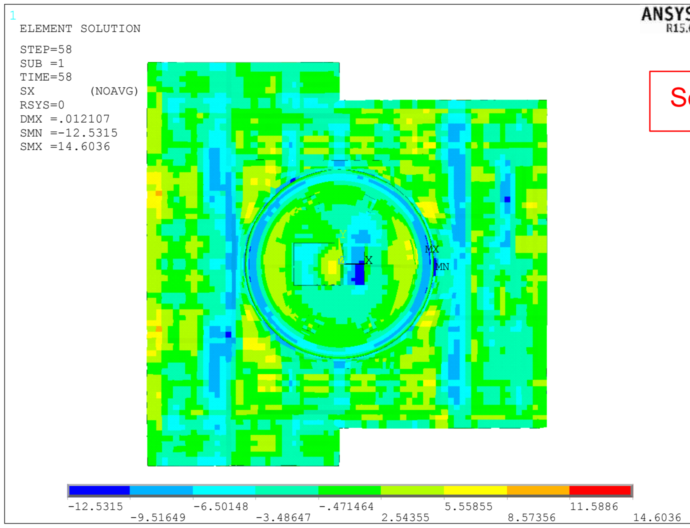
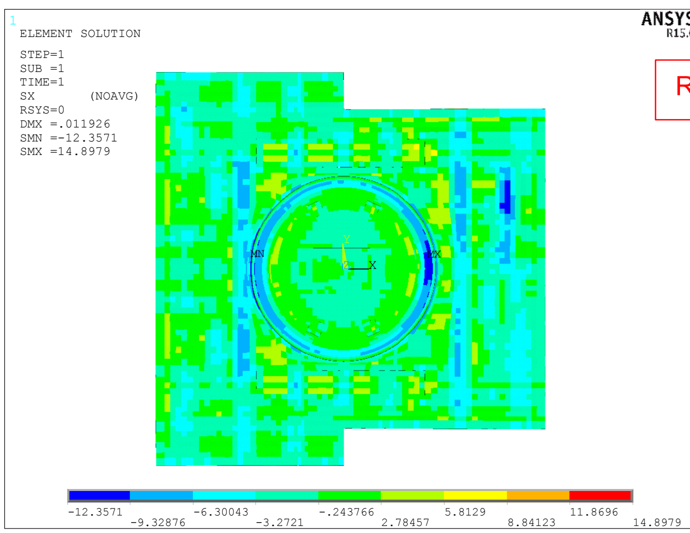


Figure 5-8. Comparison displacement contour between sequential and reference analysis (S08, Case#1)

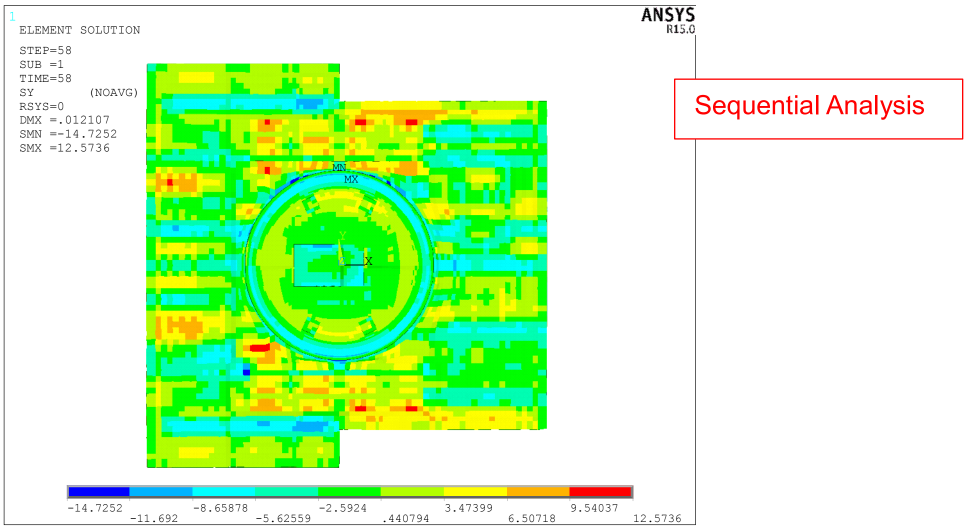


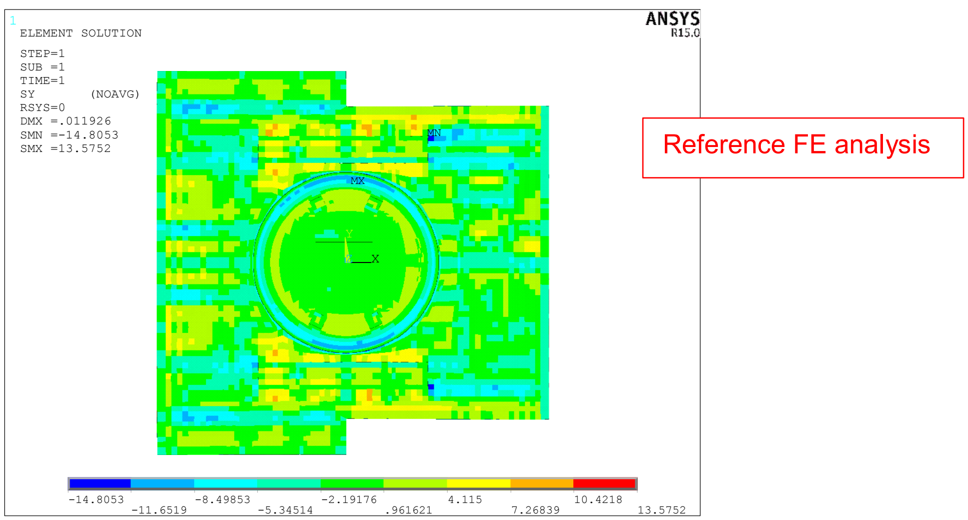
Sequential Analysis



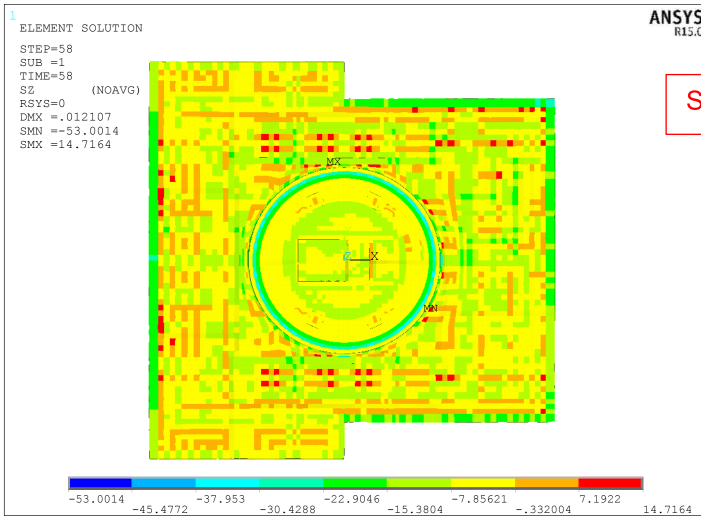
Reference FE analysis

(a) Stress X Contour

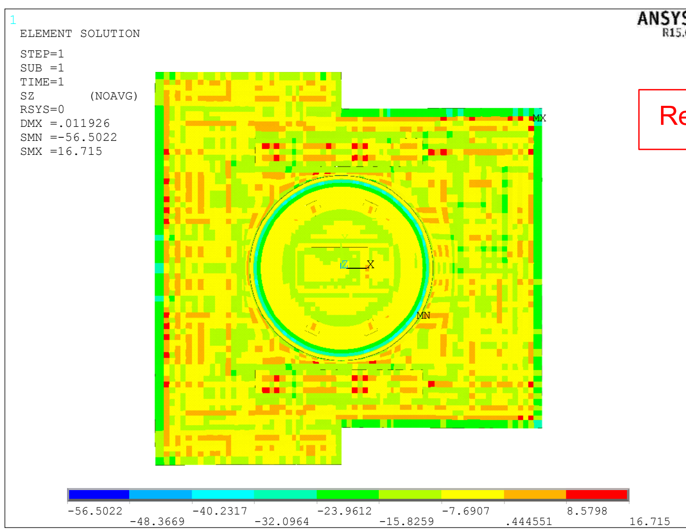




(b) Stress Y Contour



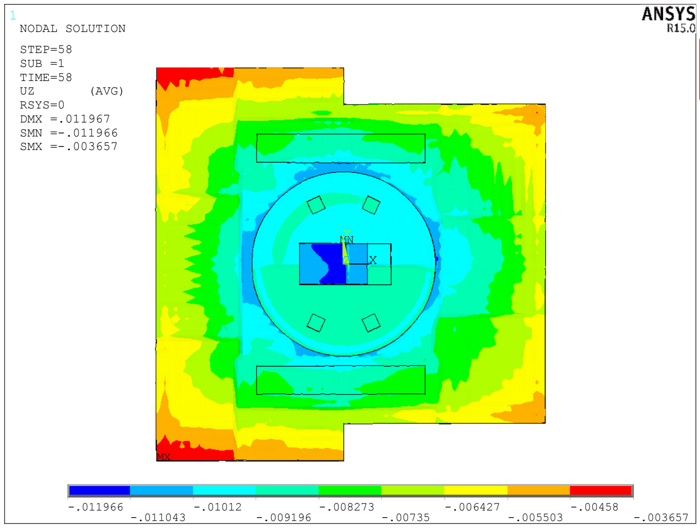
Sequential Analysis



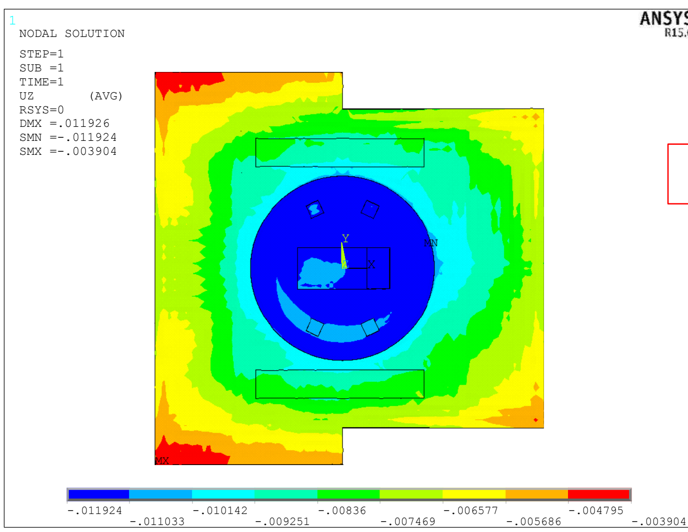
Reference FE analysis

(c) Stress Z Contour

Figure 5-9. Comparison stress contour between sequential and reference analysis (S08, Case#1)

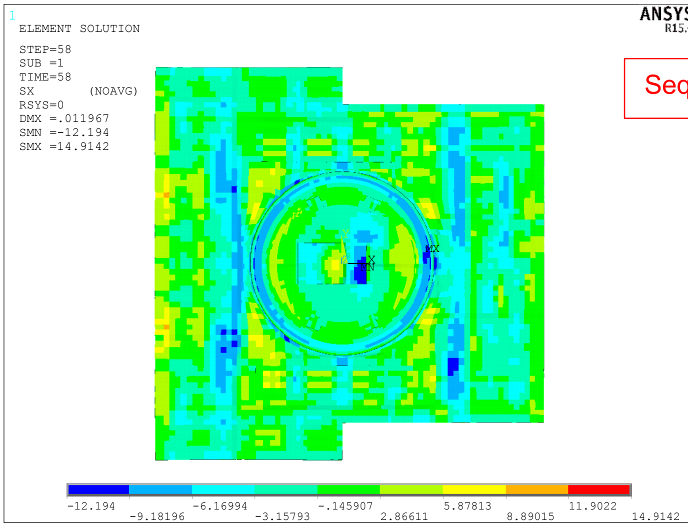


Sequential Analysis

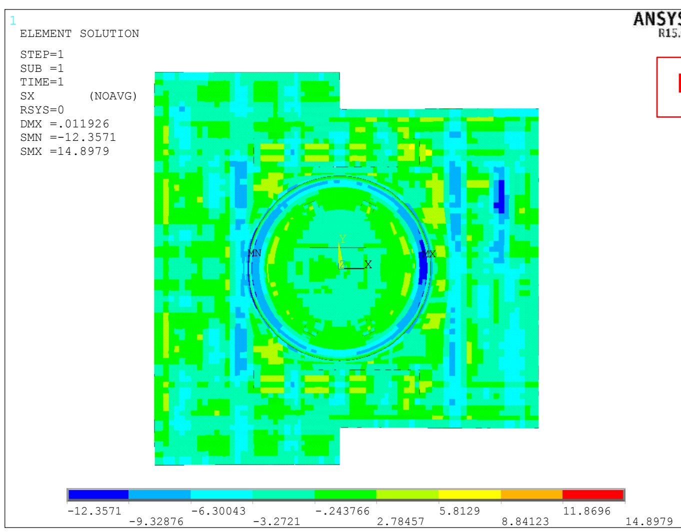


Reference FE analysis

Figure 5-10. Comparison displacement contour between sequential and reference analysis (S08, Case#2)

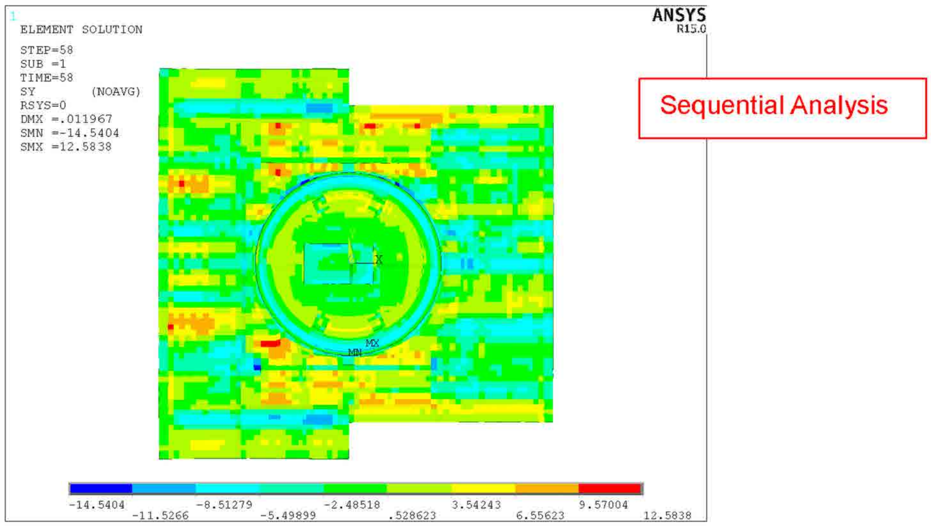


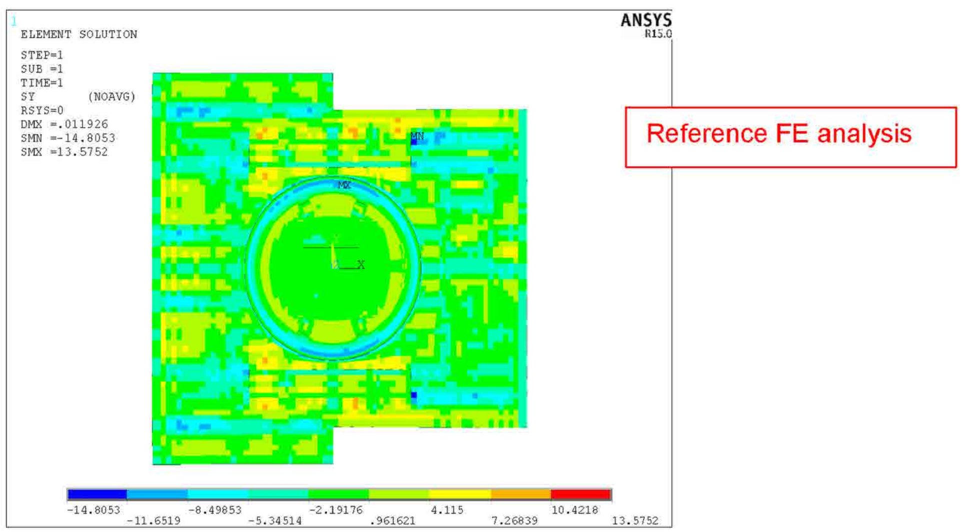
Sequential Analysis



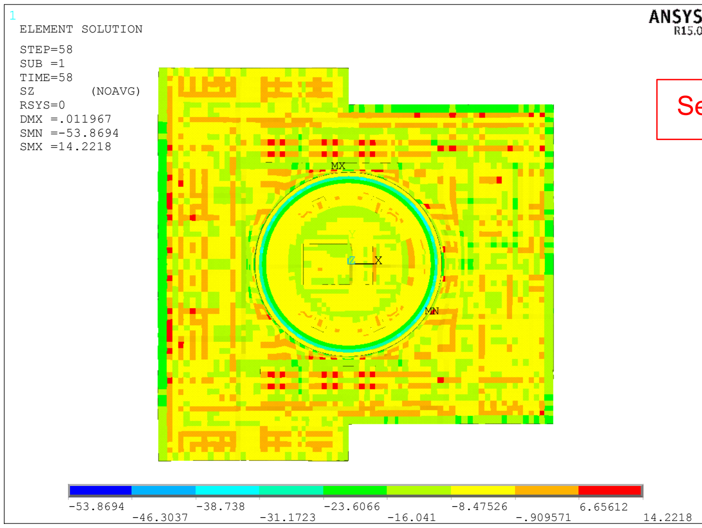
Reference FE analysis

(a) Stress X Contour

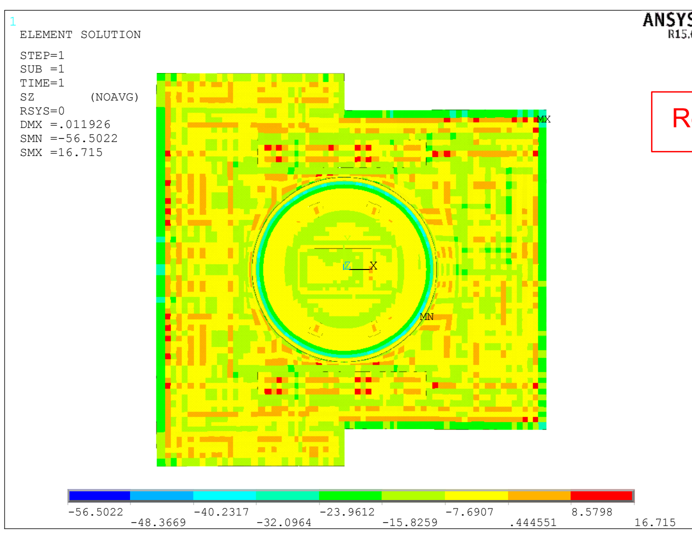




(b) Stress Y Contour



Sequential Analysis



Reference FE analysis

(c) Stress Z Contour

Figure 5-11. Comparison stress contour between sequential and reference analysis (S08, Case#2)

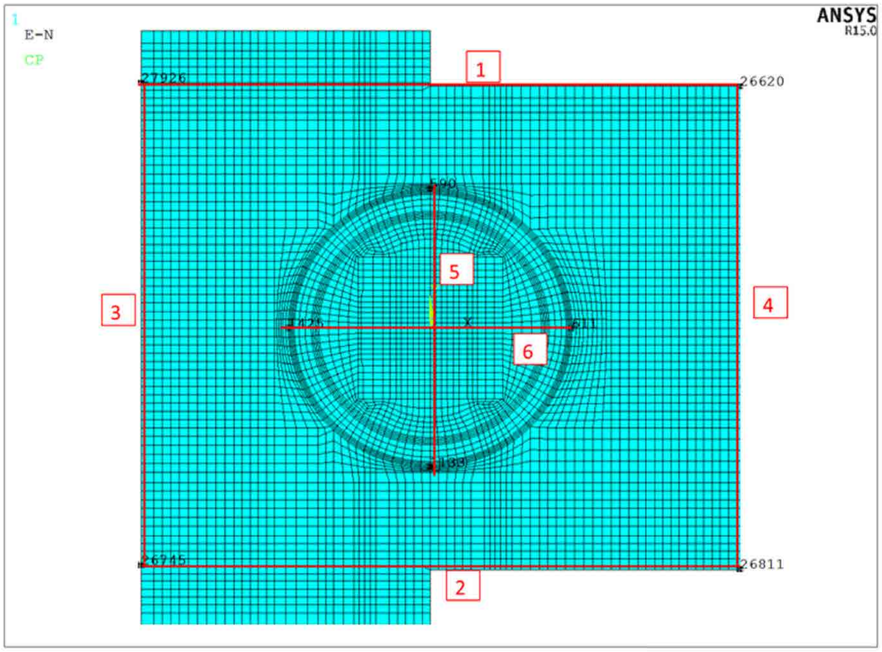


Figure 5-12 Check Group for Tilting Settlement

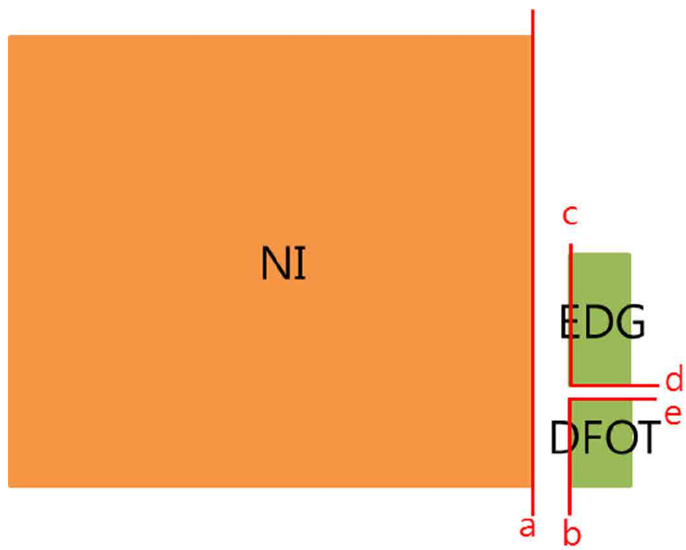


Figure 5-13 The Locations for Differential Settlement between Structures

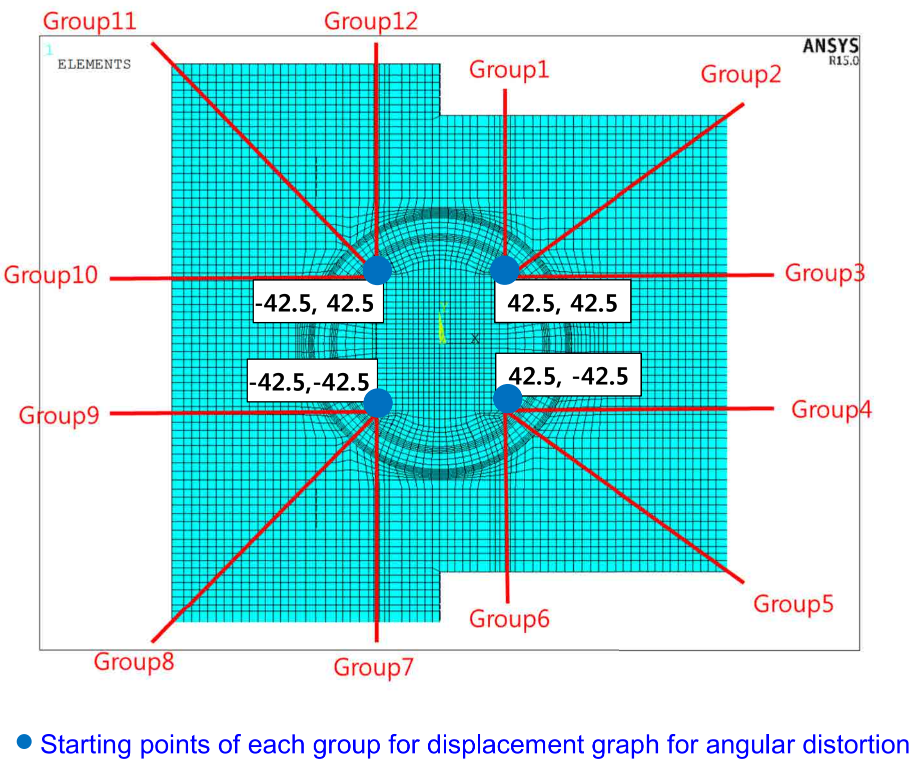
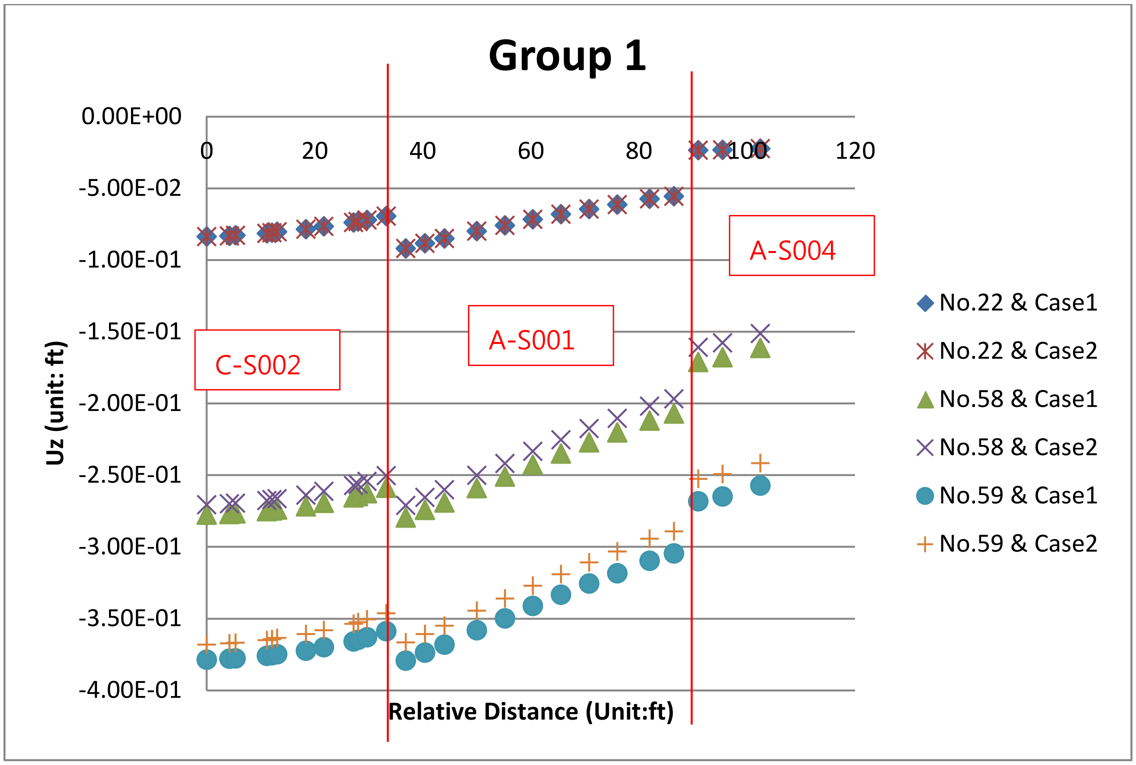
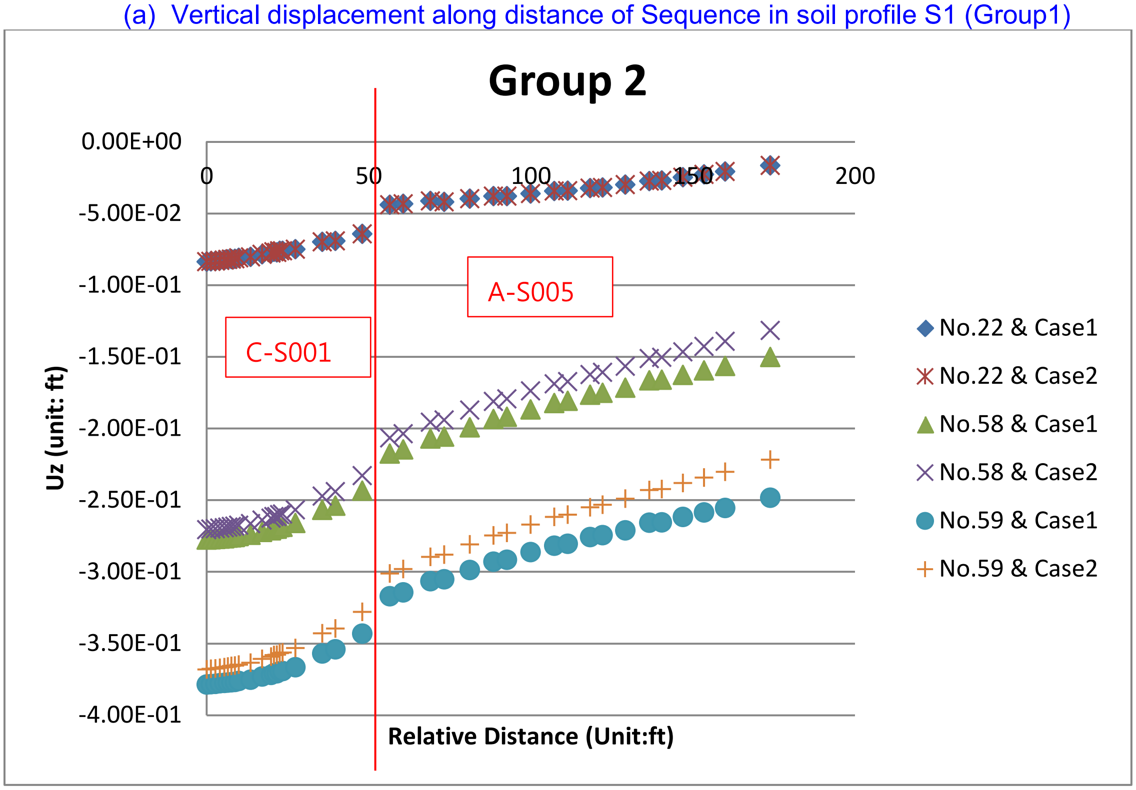


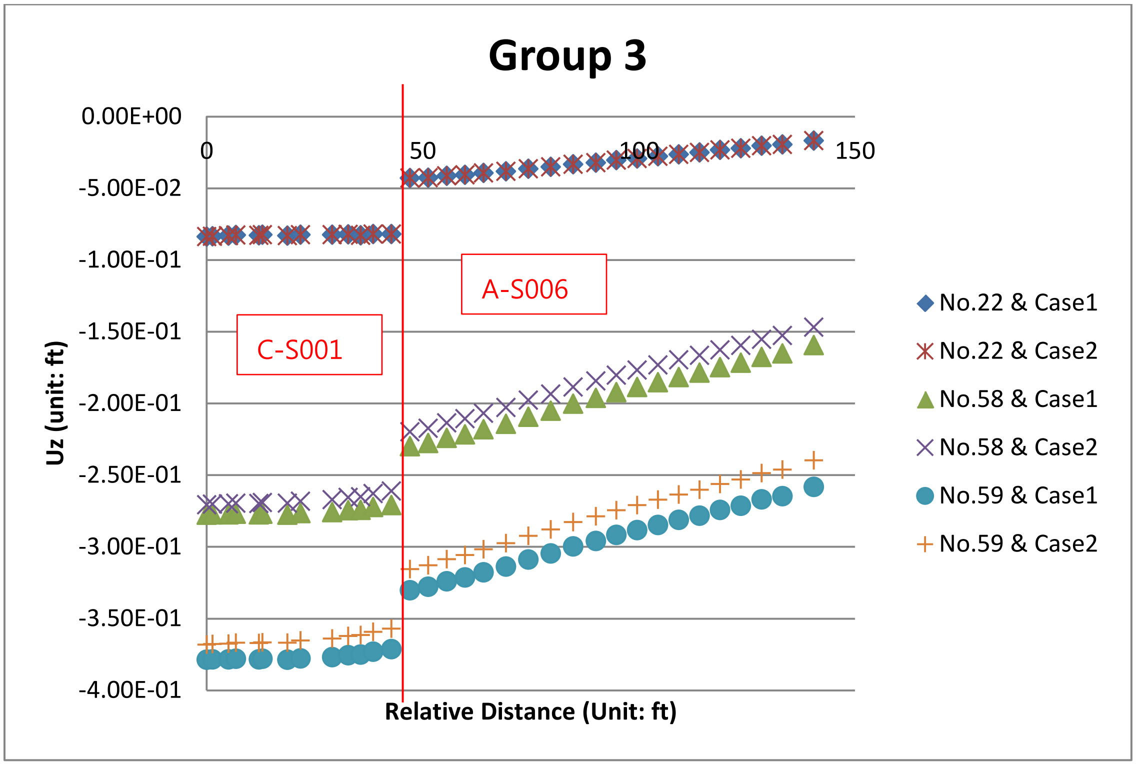
Figure 5-14 Check Group for Angular Distortion (Unit: feet)



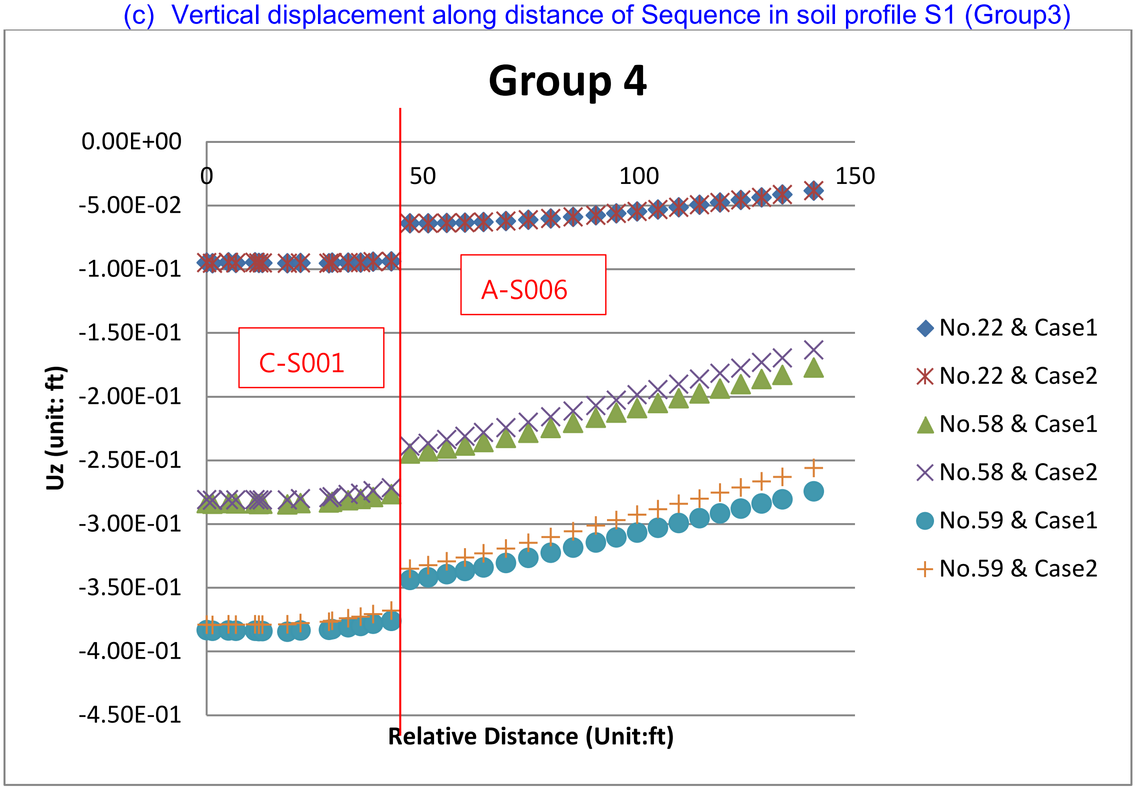
(a) Vertical displacement along distance of Sequence in soil profile S1 (Group1)



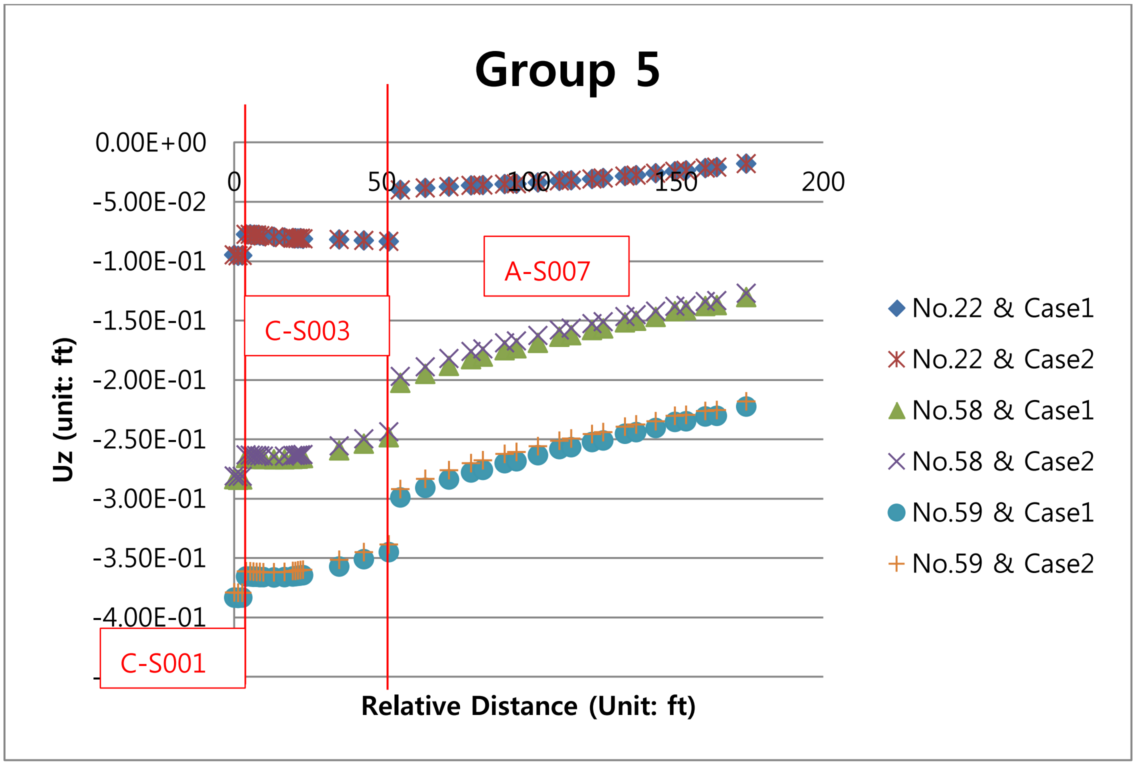
(b) Vertical displacement along distance of Sequence in soil profile S1 (Group2)



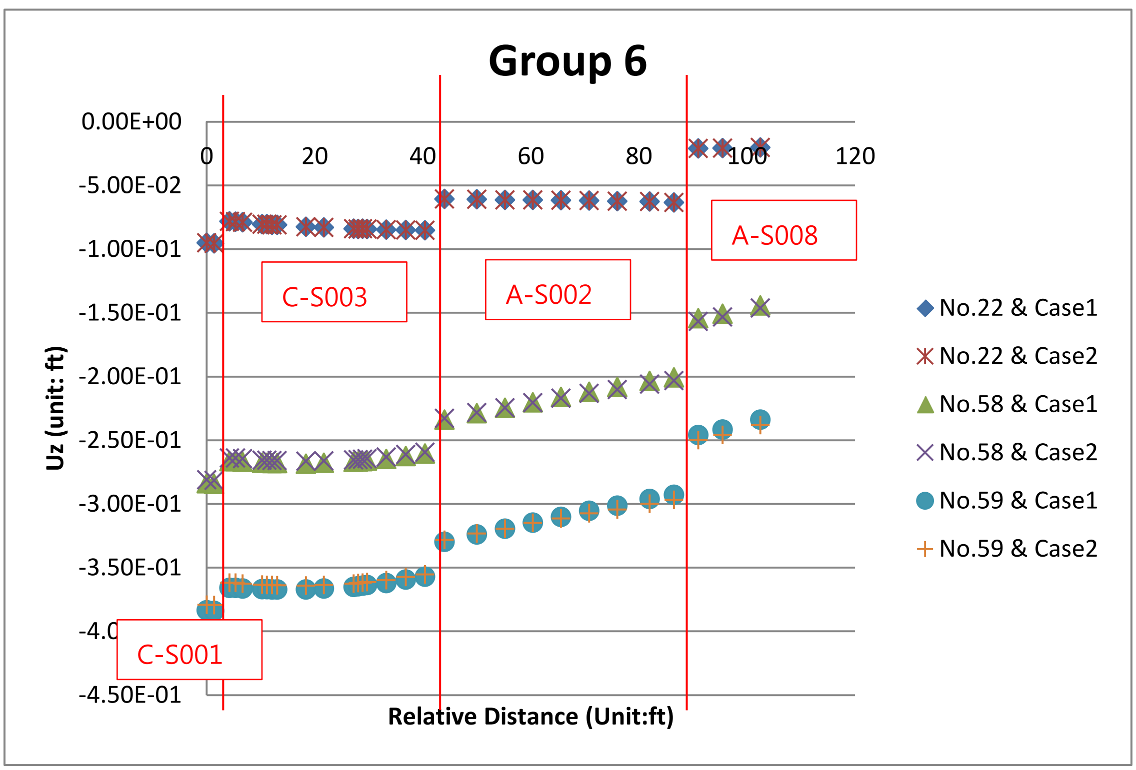
(c) Vertical displacement along distance of Sequence in soil profile S1 (Group3)



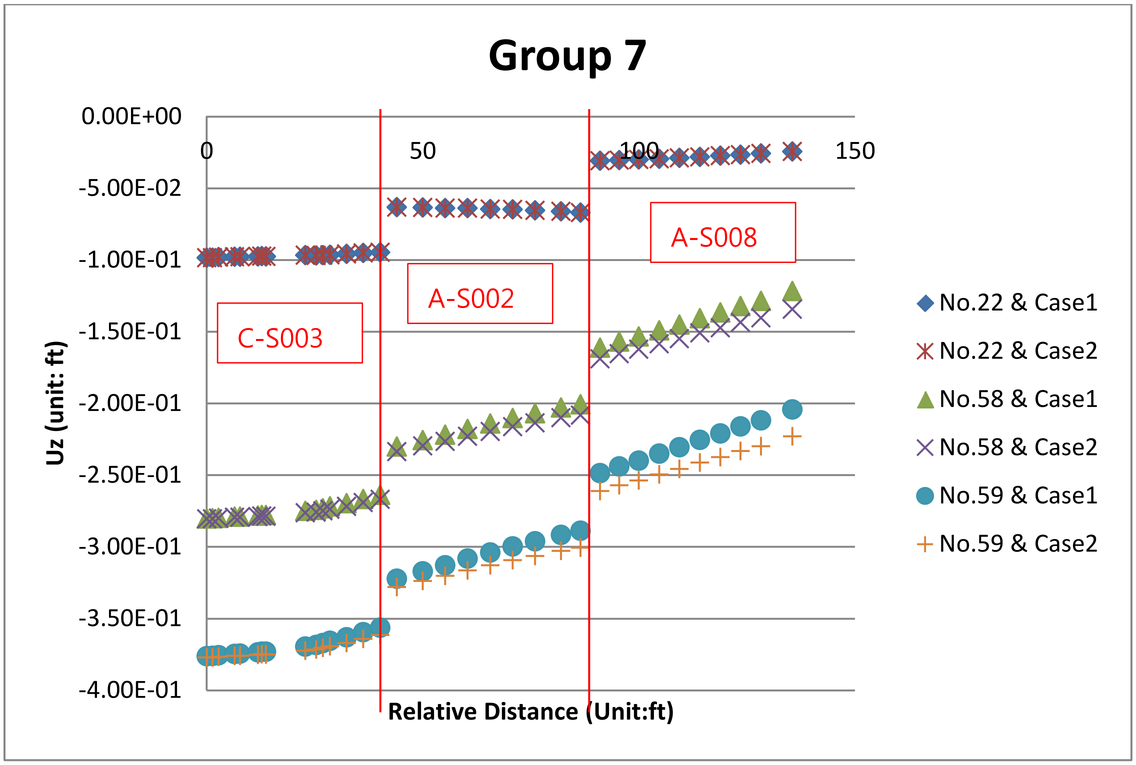
(d) Vertical displacement along distance of Sequence in soil profile S1 (Group4)



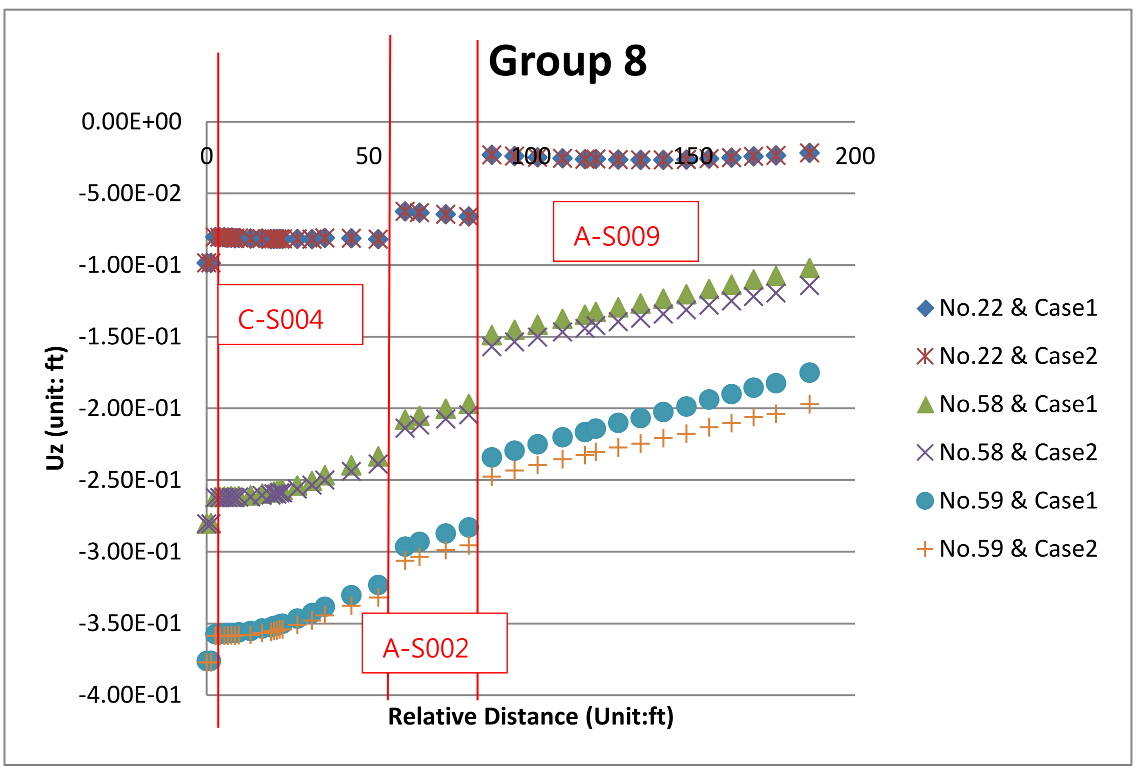
(e) Vertical displacement along distance of Sequence in soil profile S1 (Group5)



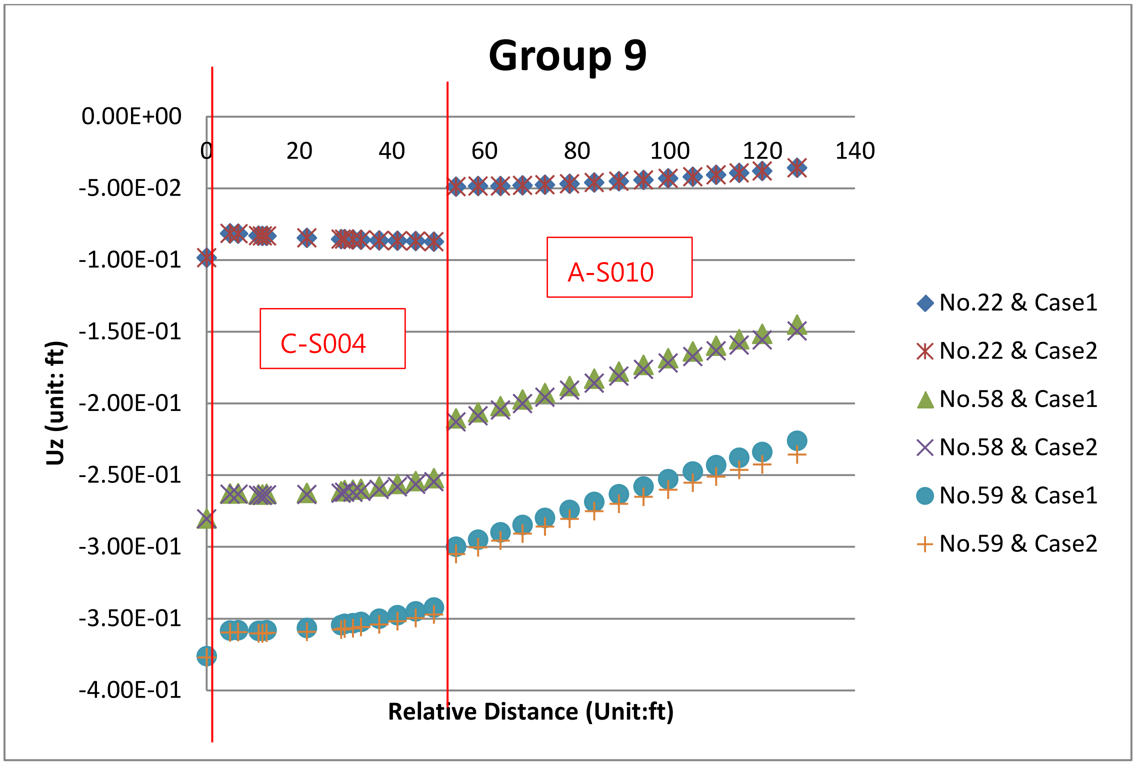
(f) Vertical displacement along distance of Sequence in soil profile S1 (Group6)



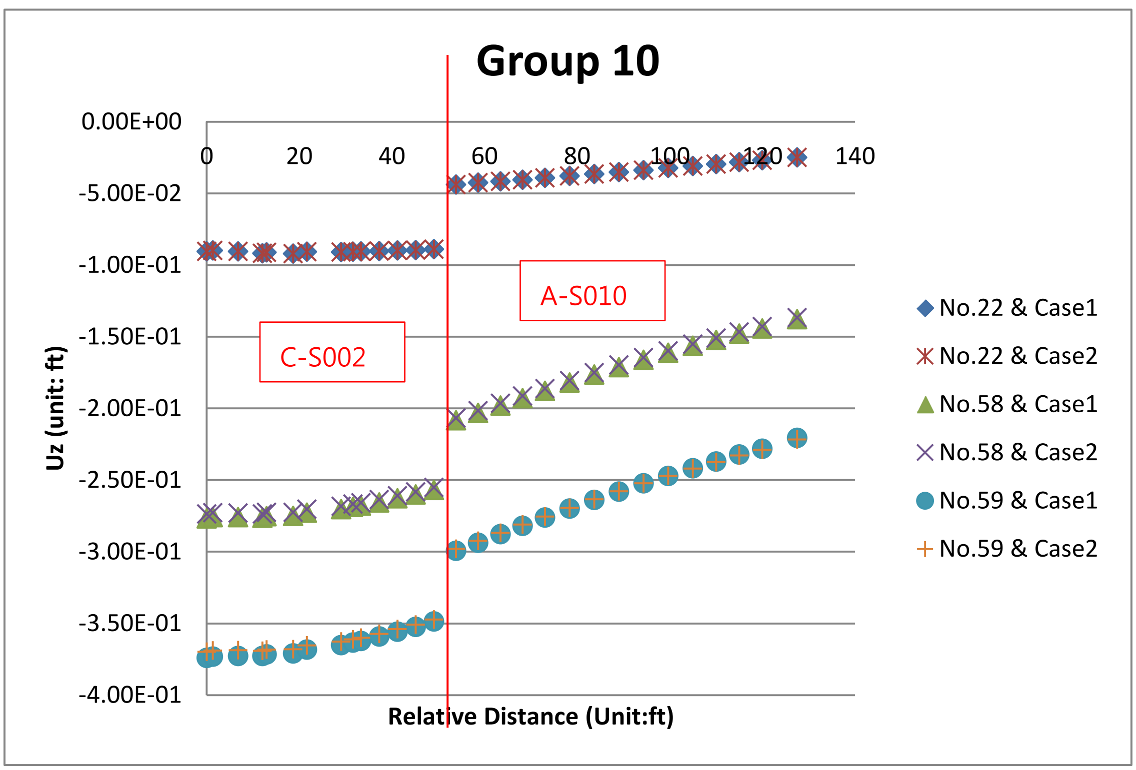
(g) Vertical displacement along distance of Sequence in soil profile S1 (Group7)



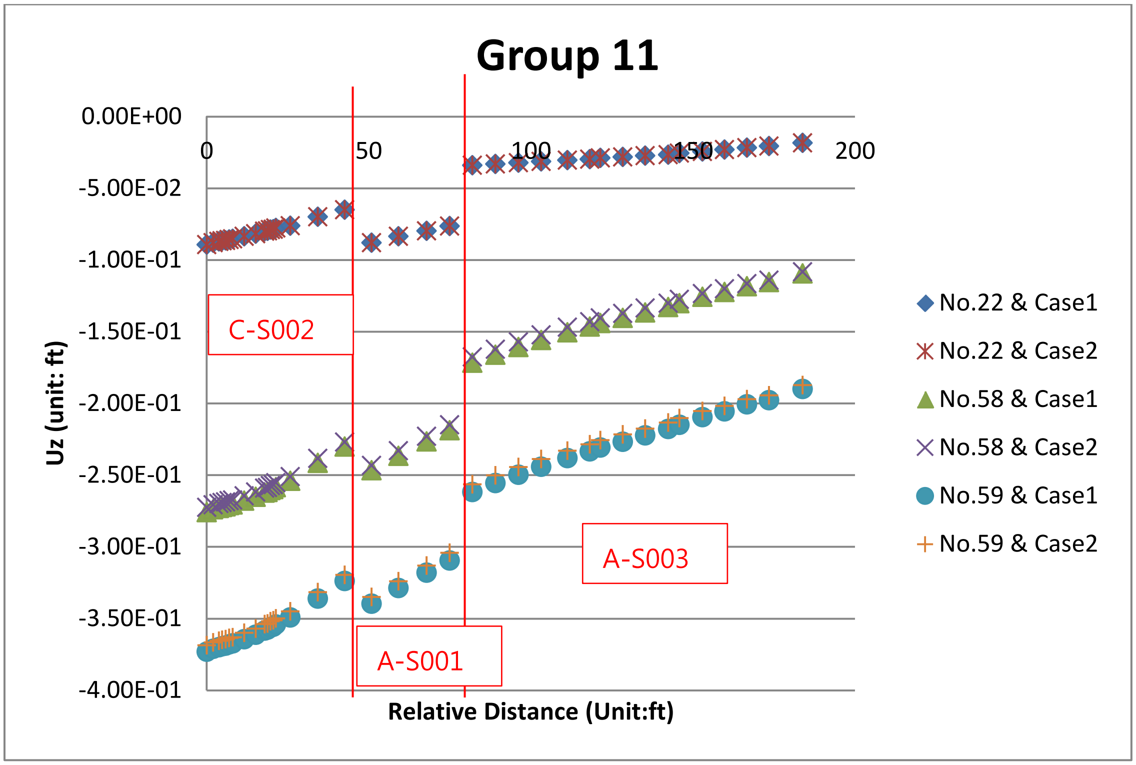
(h) Vertical displacement along distance of Sequence in soil profile S1 (Group8)



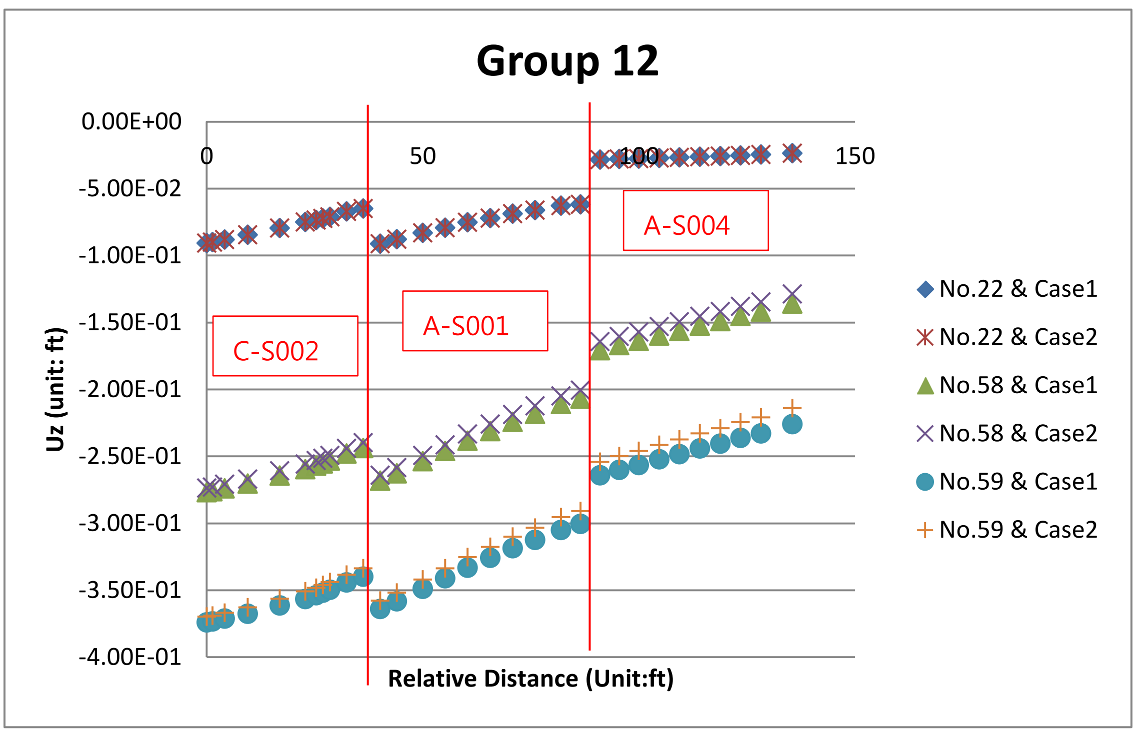
(i) Vertical displacement along distance of Sequence in soil profile S1 (Group9)



(j) Vertical displacement along distance of Sequence in soil profile S1 (Group10)

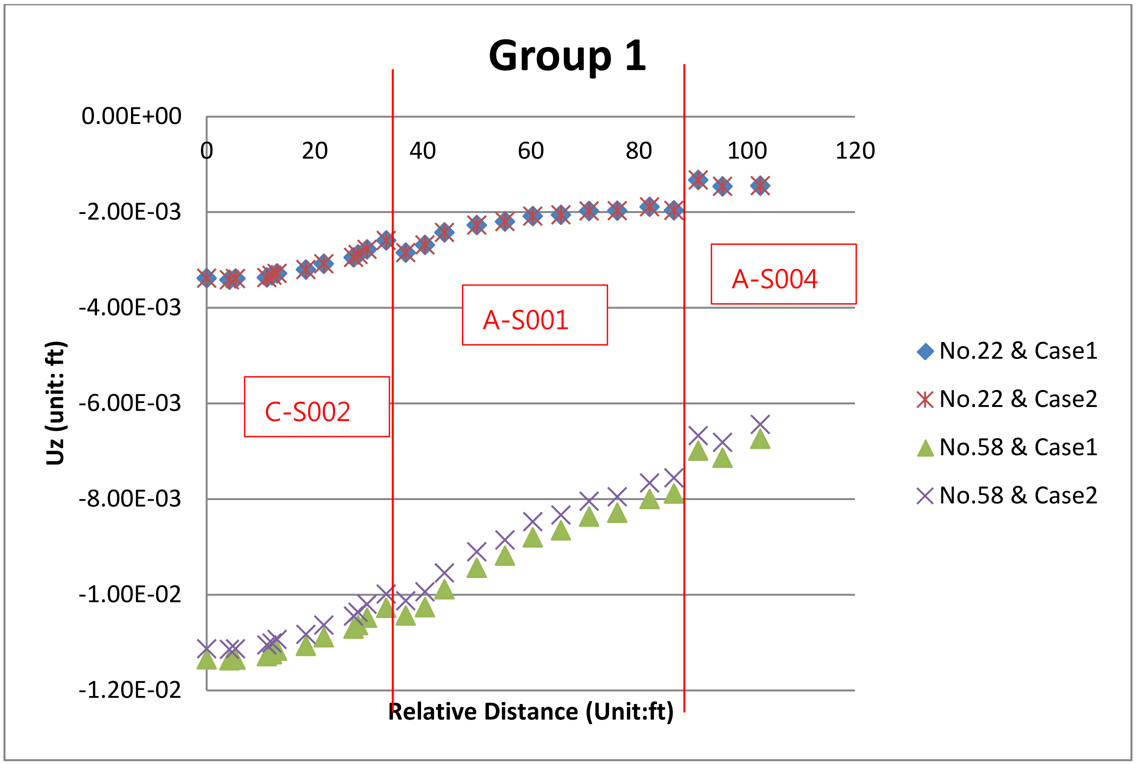


(k) Vertical displacement along distance of Sequence in soil profile S1 (Group11)

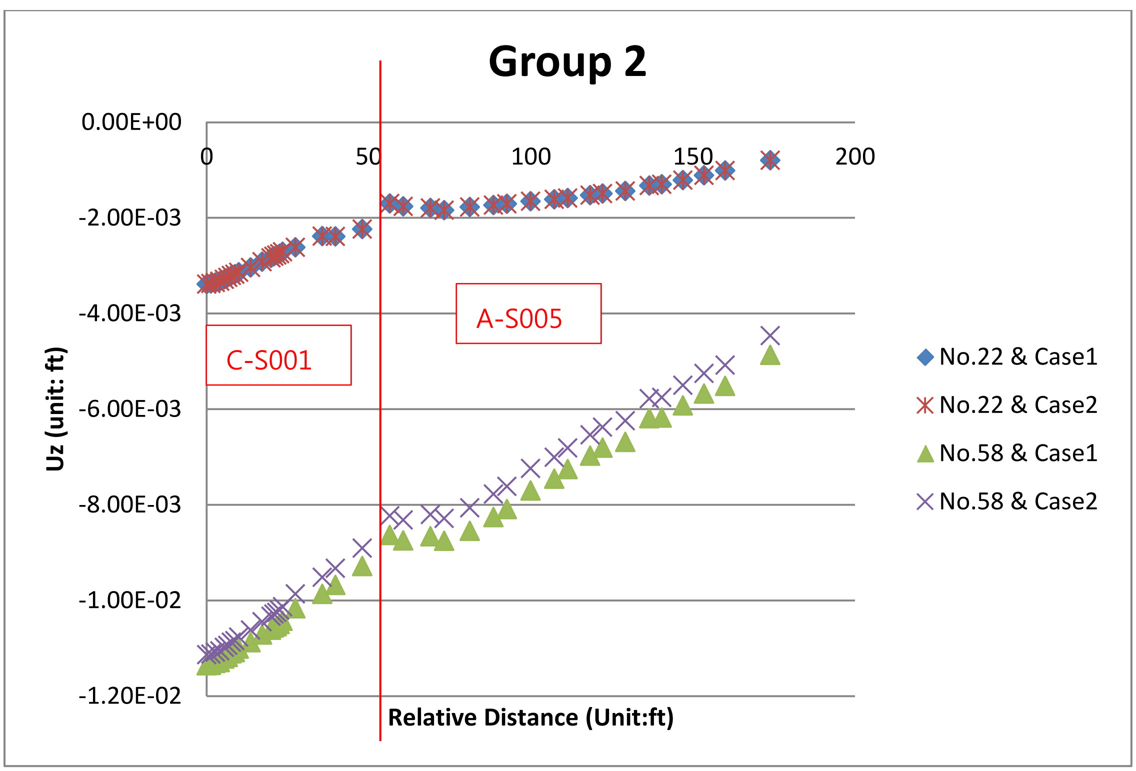


(l) Vertical displacement along distance of Sequence in soil profile S1 (Group12)

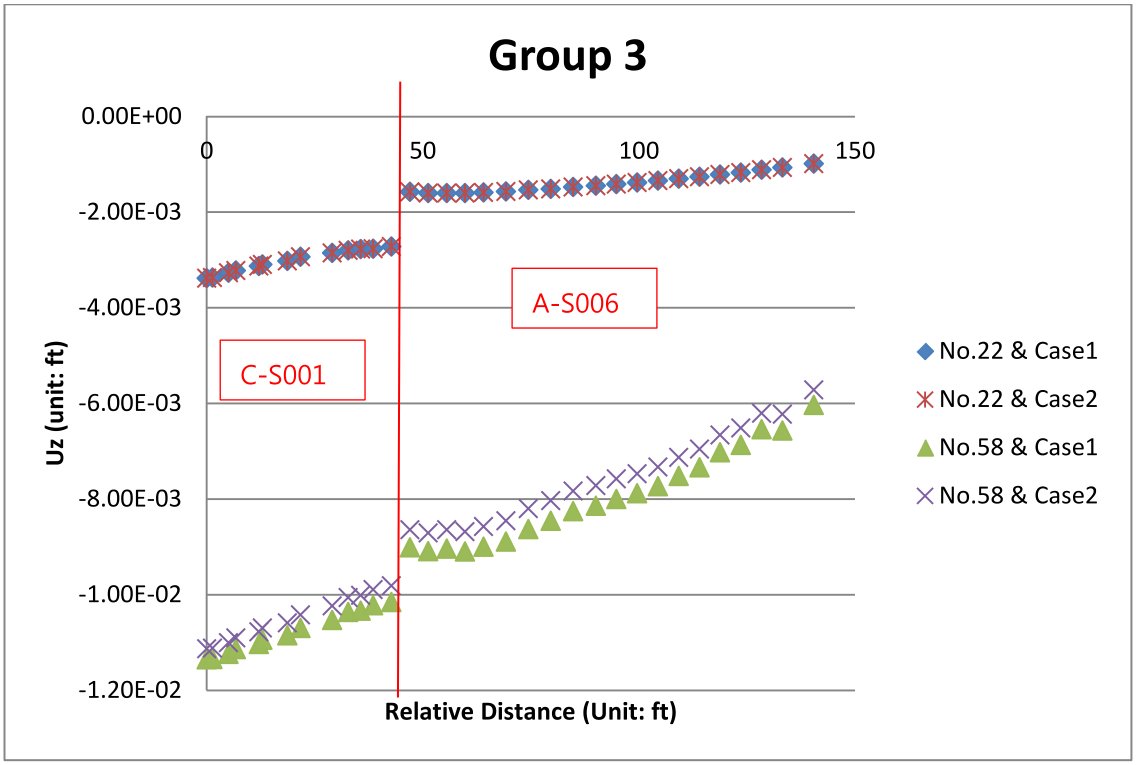
Figure 5-15 Vertical Displacement Graph for Angular Distortion each group of NI building (S01)



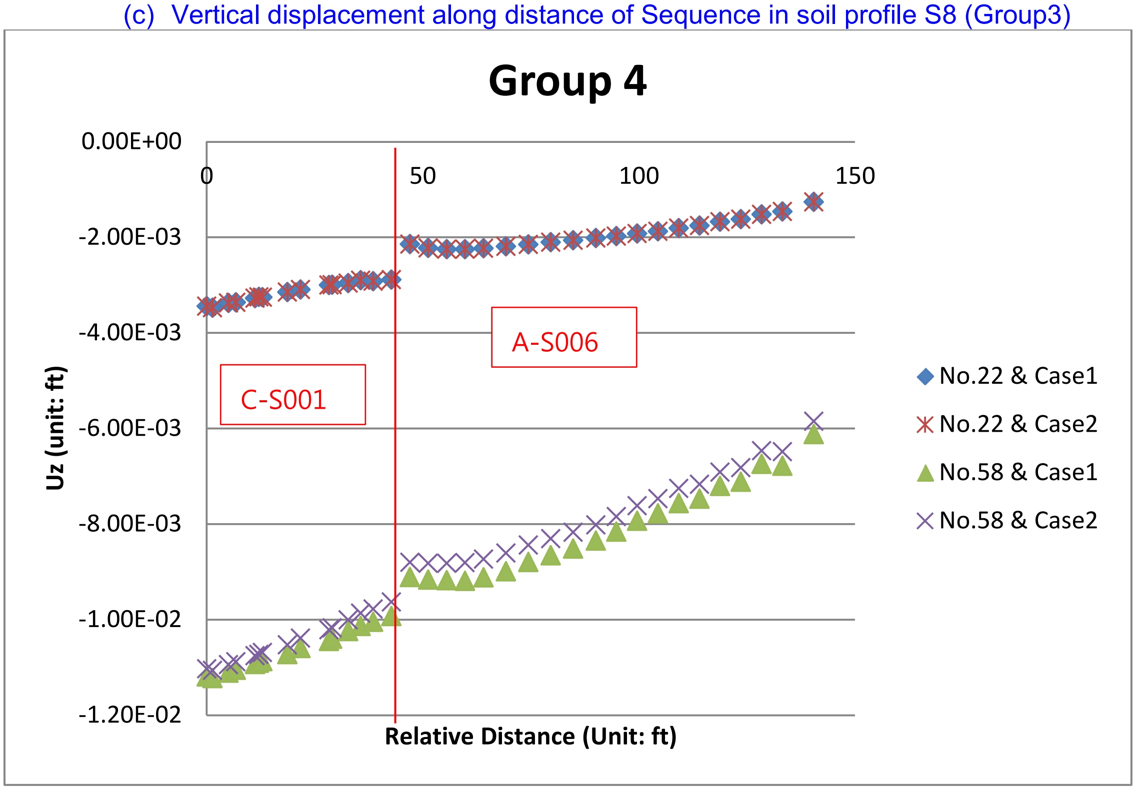
(a) Vertical displacement along distance of Sequence in soil profile S8 (Group1)



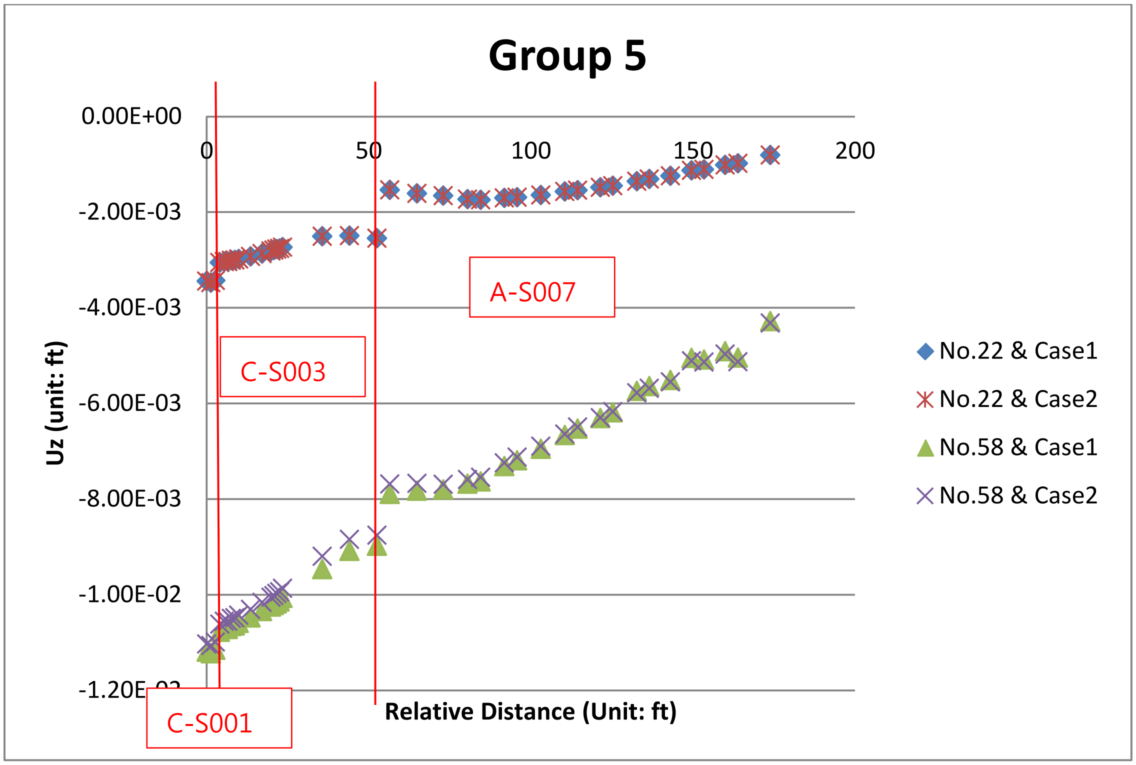
(b) Vertical displacement along distance of Sequence in soil profile S8 (Group2)



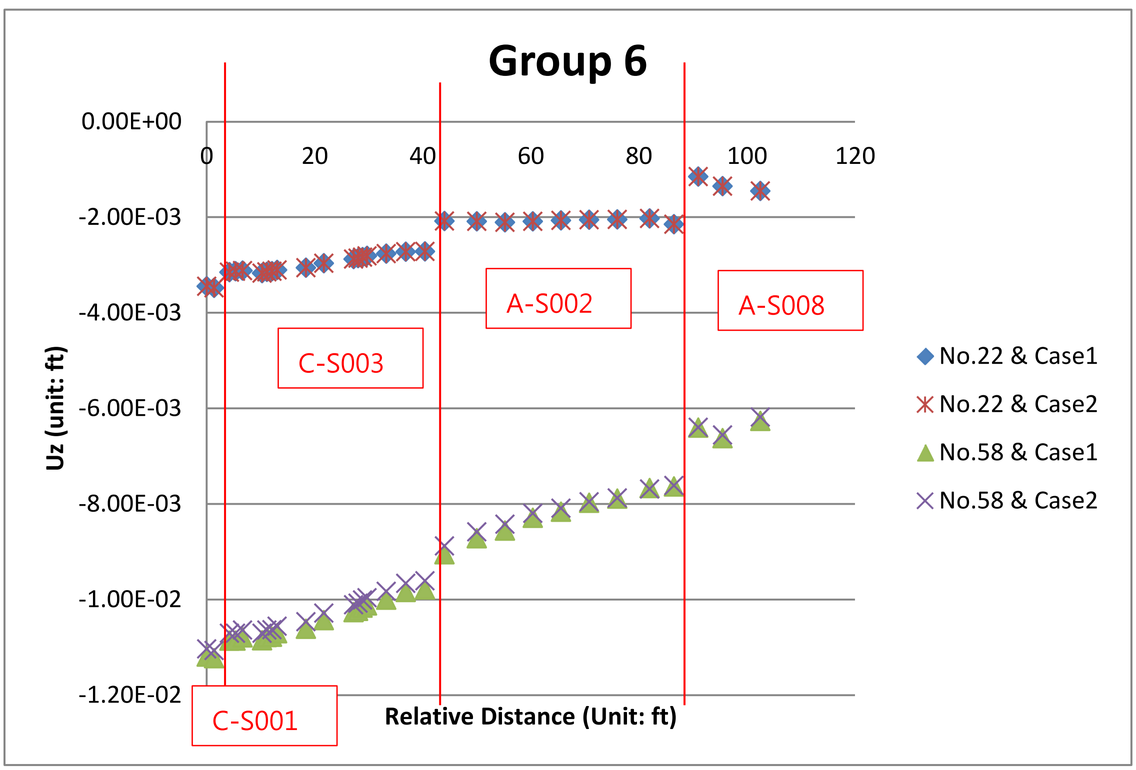
(c) Vertical displacement along distance of Sequence in soil profile S8 (Group3)



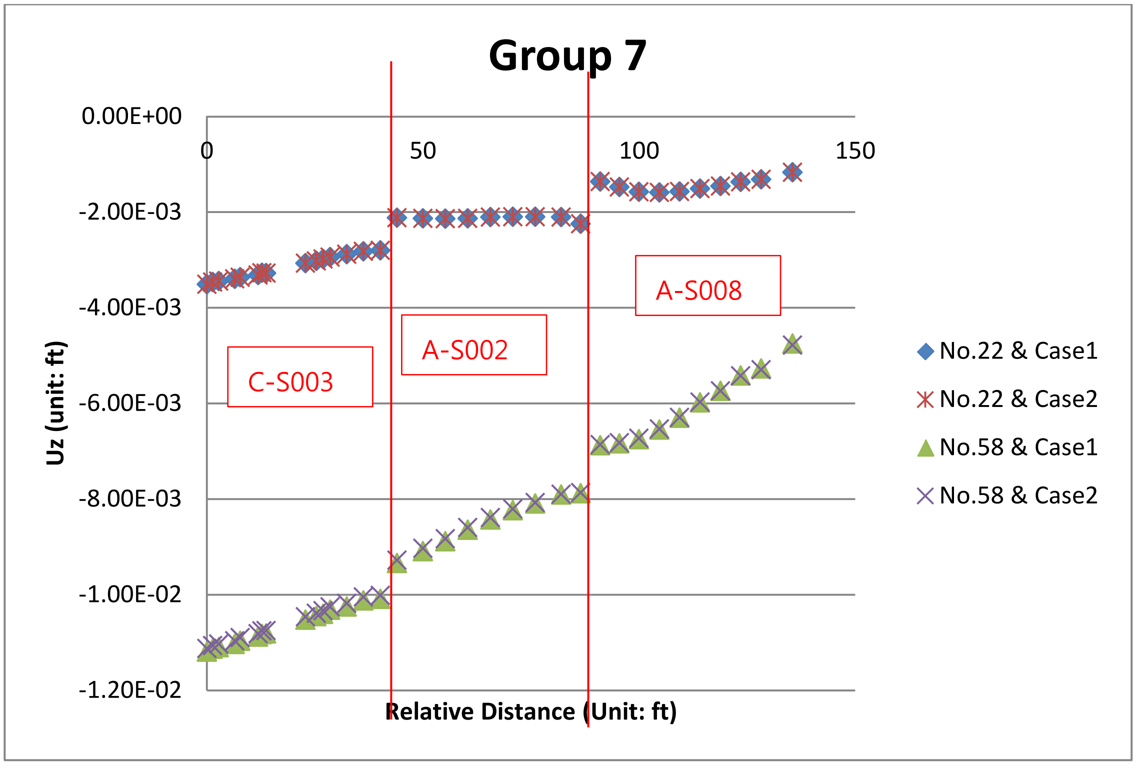
(d) Vertical displacement along distance of Sequence in soil profile S8 (Group4)



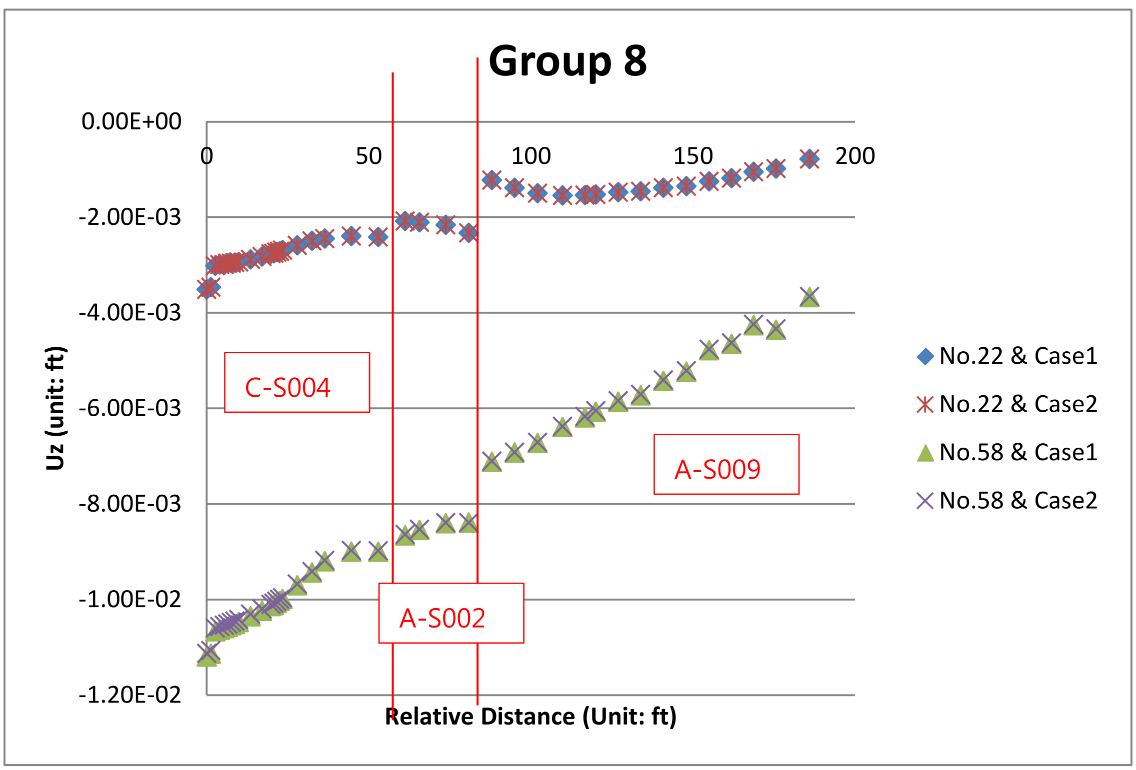
(e) Vertical displacement along distance of Sequence in soil profile S8 (Group5)



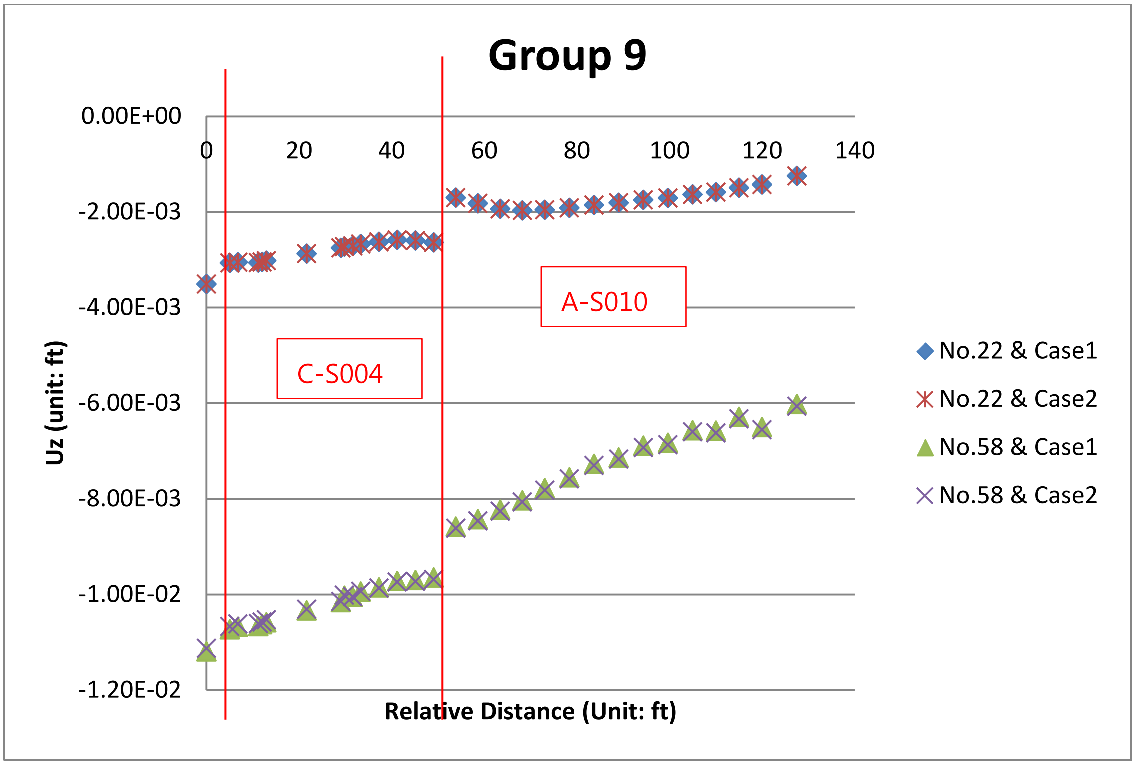
(f) Vertical displacement along distance of Sequence in soil profile S8 (Group6)



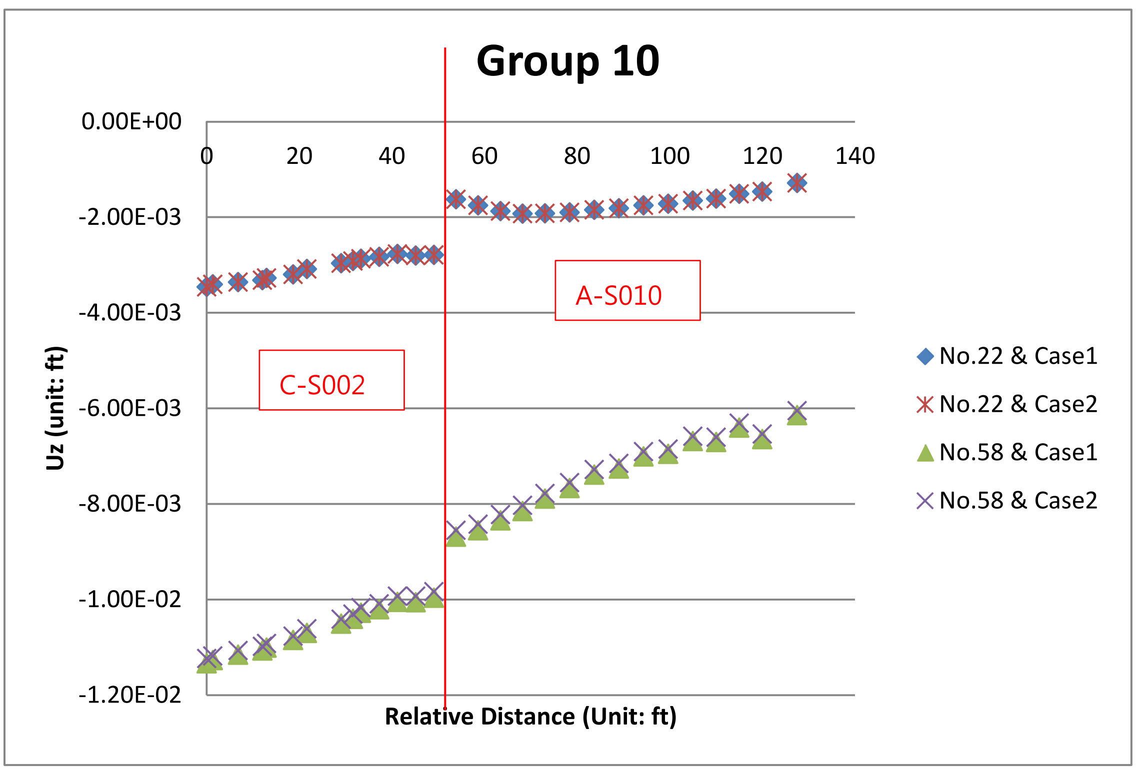
(g) Vertical displacement along distance of Sequence in soil profile S8 (Group7)



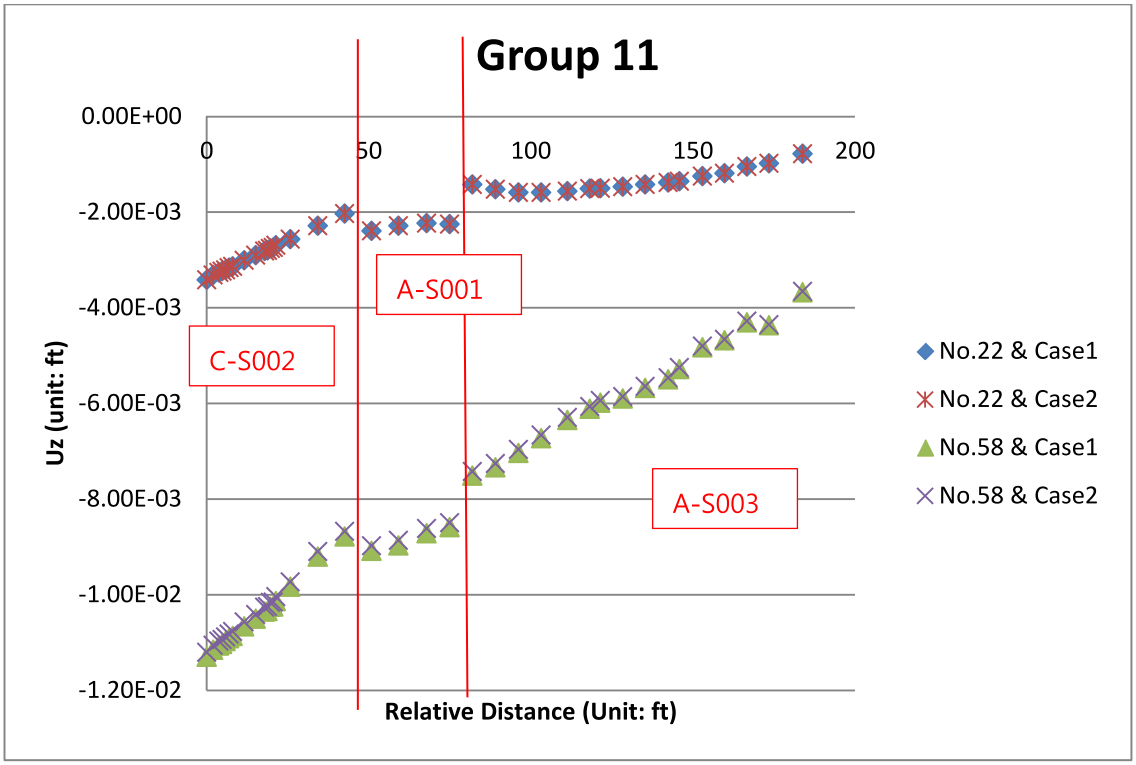
(h) Vertical displacement along distance of Sequence in soil profile S8 (Group8)



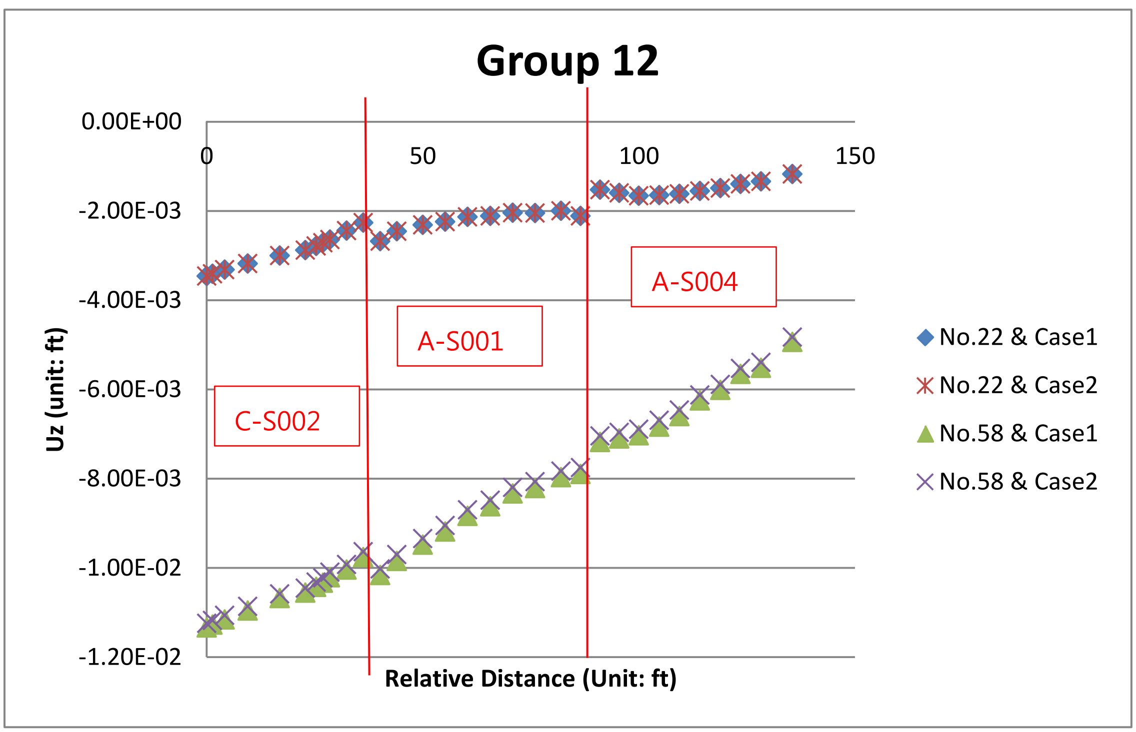
(i) Vertical displacement along distance of Sequence in soil profile S8 (Group9)



(j) Vertical displacement along distance of Sequence in soil profile S8 (Group10)



(k) Vertical displacement along distance of Sequence in soil profile S8 (Group11)



(l) Vertical displacement along distance of Sequence in soil profile S8 (Group12)

Figure 5-16 Vertical Displacement Graph for Angular Distortion each group of NI building (S08)

The COL applicant is to provide a site-specific monitoring program and to monitor differential settlement, tilt, and angular distortion are bounded by following values during construction and plant operation.

Allowable differential settlement associated with tilt: 1/1200

Allowable differential settlement associated with angular distortion: 1/750 (COL 3.8(15))

The COL applicant is to provide testing and inservice inspection programs to examine inaccessible areas of concrete structures for degradation and to monitor groundwater chemistry (COL 3.8(16)).

The long-term settlement is the site-specific characteristics. The COL applicant is to provide the soil parameters for APR1400 site (COL. 3.8(17)).

Add Section 3.8.5.8 described in next page

3.8.6 Combined License Information

COL 3.8(1) The COL applicant is to perform concrete long-term material testing in a way which verifies physical properties of materials used during the design stage and the characteristics of long term deformation of concrete.

COL 3.8(2) The COL applicant is to provide the detailed design results and evaluation of the ultimate pressure capacity of penetrations, including the equipment hatch, personnel airlocks, electrical and piping penetrations in accordance with RG 1.216.

COL 3.8(3) The COL applicant is to provide detailed analysis and design procedure for the equipment hatch, personnel airlocks, and electrical penetrations.

COL 3.8(4) The COL applicant is to provide a detailed analysis and design procedure for the transfer tube penetration assembly.

COL 3.8(5) The COL applicant is to provide the design of site-specific seismic Category I structures such as the essential service water building and the component cooling water heat exchanger building, essential service water conduits, component cooling water piping tunnel, and class 1E electrical duct runs.

3.8.5.8 SSCs between structures

Differential settlements (76.2 mm (3.0 in) shown in DCD Table 2.0-1) between structures (NI and EDG, NI and DFOT, EDG and DFOT) are used for design of SSCs under static loads.

The SSCs between buildings or structures are designed to allow the relative displacement or resist the forces due to relative movements of buildings. For this purpose, the floor response spectra and seismic anchor motions are used in the following procedure.

1) Seismic analyses of building structures are performed to compute floor response spectra and seismic anchor motions for the SSCs design.

2) SSCs shall have the support details to allow relative movements of between buildings or structures.

3) The seismic anchor motions between buildings or structures are considered in the SSCs design.

For piping analysis, the guidance on combining the individual modal results in NRC RG 1.92 is used as described in Subsection 3.12.3.2.

3.9.2.2.7 Analytical Procedures for Piping

All seismic Category I and II piping is analyzed for seismic effects as described in Subsection 3.12.3.

3.9.2.2.8 Multiple-Supported Equipment Components with Distinct Inputs

When the equipment or component is supported at points with different elevations within a building and between buildings, either the envelope of these elevation response spectra or multiple supports excitation is used for the seismic qualification of the equipment.

If ISM (Independent Support Motion) method is utilized for alternate method of multiple supports excitation, the criteria for the use of ISM method will be followed in accordance with NUREG -1061, Volume 2, Section 4.

For analyzing the piping systems supported at multiple locations within a single structure or multiple structures, the method used is described in Subsection 3.12.3.2.

The SSCs design procedure for differential settlement and relative displacement is described in section 3.8.5.8.

3.9.2.2.9 Use of Constant Vertical Static Factors

A constant static factor is not used for the seismic design of seismic Category I structures, systems, and components specified in Subsections 3.7.2.10 and 3.7.3.6.

3.9.2.2.10 Torsional Effects of Eccentric Masses

All concentrated loads in a piping subsystem, such as valves and valve operators, are modeled as massless members with the mass of each component lumped at its center of gravity. Massless members are modeled by connecting the center of gravity of components to the centerline of piping so that the torsional effects of the eccentric masses are considered.

Torsional effects of eccentric masses are also considered in the analysis of seismic Category I subsystems other than piping.

APPENDIX 3.9A – SUPPLEMENTAL INFORMATION ON CRITERIA OF THE APR1400 DISTRIBUTION SYSTEMS

3.9A.1 HVAC Ductwork and Supports

3.9A.1.1 General

Heating, ventilation, and air conditioning (HVAC) ductwork is designed and supported to withstand the loading combinations presented in this section, as applicable. The design and analysis guidelines herein apply to seismic Category I and II HVAC ductwork and supports. Seismic Category II HVAC ductwork and supports, as defined in Subsection 3.2.1, are analyzed to provide reasonable assurance that their failure would not adversely impact safety-related equipment or components.

The SSCs design procedure for differential settlement and relative displacement is described in section 3.8.5.8.

3.9A.1.2 Design Considerations

3.9A.1.2.1 Internal Pressure Load (P_O, P_A)

Internal pressure loads (P_o, P_A) do not affect the design of HVAC duct supports but should be considered in the design of ductwork. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) guidelines (References 1 and 2) are used in determining duct thickness, stiffener, and companion angle requirements.

3.9A.1.2.2 Dead Load (D)

Dead load (D) includes the weight of the ductwork itself, in-line components (e.g., dampers, humidifiers, in-duct electric heaters), externally mounted components, and insulation. Self-weight of structural members and dead load of ductwork are considered in the design of HVAC duct supports. An additional 23 kg (50 lb) concentrated load is considered in the design of HVAC duct supports for attachments such as conduits and lighting fixtures.

3.9A.1.2.3 Thermal Load (T_O, T_A)

Stresses resulting from the movement of supports or expansion of ductwork under temperature changes are avoided by using expansion joints in the system design. For ducts with gasket companion angles, thermal loads are negligible.

3.9A.2 Cable Tray/Conduit Supports

3.9A.2.1 General

Cable tray and conduit are designed and supported to withstand the loading combinations presented in this section, as applicable. The design and analysis guidelines herein apply to seismic Category I and II cable tray/conduit supports as defined in Subsection 3.2.1.

The SSCs design procedure for differential settlement and relative displacement is described in section 3.8.5.8.

3.9A.2.2 Design Considerations

3.9A.2.2.1 Dead Load (D)

Dead loads (D) include the weight of the cable tray or conduit, fittings, covers, and any other dead loads applied to the system. An additional 23 kg (50 lb) concentrated load is considered in the design of the cable tray supports for attachments such as conduits and lighting fixtures.

3.9A.2.2.2 Live Load (L)

Cable tray supports are designed to withstand expected live load. The live load considered is a construction/maintenance man load of 90 kg (200 lb). Live load is not considered in the design of conduit supports. However, where live loads such as wind and snow are applicable, they are considered in the design.

3.9A.2.2.3 Seismic Load (SSE)

Cable tray/conduit supports are designed to withstand seismic load. Stresses are determined for the seismic excitation in each of the three orthogonal directions by the SRSS method. Seismic load is determined using the equivalent static analysis method or the dynamic analysis method.

3.9A.2.2.3.1 Equivalent Static Analysis Method

The equivalent static analysis method is used for cable tray/conduit supports. The system response is assumed to be the peak of the required response spectra. This response is then multiplied by a static coefficient of 1.5. The seismic load in the design of the cable tray/conduit supports is obtained by multiplying the peak acceleration by a static coefficient of 1.5 and the participating mass.

Table 2.1-1 (3 of 4)

Soil Properties (cont.)	
Maximum Dip Angle for Soil Uniformity	20 degrees
Liquefaction Potential	See Tier 2 Subsection 2.5.4.8
Maximum Allowable Differential Settlement inside Building	12.7 mm (0.5 in.) per 15.24 m (50 ft) in any direction for [all] seismic Category I structures under static ~~and seismic~~ load.
Maximum Allowable Differential Settlement between Buildings	76.2 mm (3.0 in.) ~~between NI Common Basemat and EDG Building & DFOT Building 12.7 mm (0.5 in.) under static and seismic load.~~ [between NI and EDGB, NI and DFOT, EDGB and DFOT under static load.]
Minimum Soil Angle of Internal Friction	Greater than or equal to 35 degrees below the footprint of the seismic Category I structures at their excavation depth
Slope Failure Potential (yes/no)	No
Tectonic and Non-tectonic Surface Deformation Potential	See Tier 2 Subsection 2.5.3
Backfill Material Density	137 pcf
Backfill Material Dynamic Poisson's Ratio	0.33
Backfill Material Dynamic Properties (Normalized Minimum Shear Moduli & Maximum Damping) (6)	Shear Strain (%) / G/G_{max} / Damping (%): 1.0 / 0.05 / 24.0 0.1 / 0.22 / 16.0 0.01 / 0.54 / 6.0 0.001 / 0.85 / 2.0 0.0001 / 1.00 / 1.0
Strain-compatible Minimum Shear-wave velocity of Backfill	510 fps
Seismology	
Safe Shutdown Earthquake (SSE)	0.3g peak ground acceleration
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.1-1 and 2.1-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.1-3 and 2.1-4

~~Insert table in page 2 of attachment 3~~ Deleted

Maximum Vertical settlement	87.12mm (3.43 in) under construction phase for NI building 117.86mm (4.64in) under post-construction phase for NI building 43.28mm (1.70 in) under construction phase for EDGB 66.45mm (2.62in) under post-construction phase for EDGB 54.43mm (2.06 in) under construction phase for DFOT 81.08mm (3.19in) under post-construction phase for DFOT
Maximum Tilting Settlement	0.00725° for E-W direction 0.01253° for N-S direction under construction phase for NI building 0.00989° for E-W direction 0.0136° for N-S direction under post-construction phase for NI building Not applicable for EDGB and DFOT

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Table 2.0-1 (3 of 4)

Parameter Description	Parameter Value
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.0-1 and 2.0-2
Hard Rock High Frequency (HRHF) Response Spectra(4)	0.46g peak ground acceleration See Figures 2.0-3 and 2.0-4
Tectonic and Non-tectonic Surface Deformation Potential	See Subsection 2.5.3
Allowable Static Bearing Capacity for Seismic Category I Structures (Dead and Live Load)	The allowable static bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum static bearing demand of ~~718.2 kPa (15 ksf)~~ 957.6 kPa (20 ksf). The allowable static bearing capacity is the value of ultimate bearing capacity divided by 3.0.
Allowable Dynamic Bearing Capacity for Seismic Category I Structures (Design Load Combination including SSE Load)	The allowable dynamic bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60 ksf). The allowable dynamic bearing capacity is the value of ultimate bearing capacity divided by 2.0.
Minimum Factor of Safety for Slope on Static condition	1.5
Minimum Factor of Safety for Slope on Dynamic condition (SSE)	1.2
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Maximum Dip Angle for Soil Uniformity	20 degrees
Liquefaction Potential	See Subsection 2.5.4.8
Maximum Allowable Differential Settlement inside Building	12.7 mm (0.5 in.) per 15.24 m (50 ft) in any direction ~~for~~ all seismic Category I structures under static and seismic load
Maximum Allowable Differential Settlement between Buildings	76.2 mm (3.0 in.) ~~between NI Common Basemat and EDG Building & DFOT Building 12.7 mm (0.5 in.) under static and seismic load~~ between NI and EDGB, NI and DFOT, EDGB and DFOT under static load.
Minimum Soil Angle of Internal Friction	Greater than or equal to 35 degrees below the footprint of the seismic Category I structures at their excavation depth
Slope Failure Potential (yes/no)	No
Backfill Material Density	2.2 g/cm^3 (137 pcf)

~~Three settlement criterion described on page 4 will be added.~~ Deleted

Maximum Vertical settlement	87.12mm (3.43 in) under construction phase for NI building 117.86mm (4.64in) under post-construction phase for NI building 43.28mm (1.70 in) under construction phase for EDGB 66.45mm (2.62in) under post-construction phase for EDGB 54.43mm (2.06 in) under construction phase for DFOT 81.08mm (3.19in) under post-construction phase for DFOT
Maximum Tilting Settlement	0.00725° for E-W direction 0.01253° for N-S direction under construction phase for NI building 0.00989° for E-W direction 0.0136° for N-S direction under post-construction phase for NI building Not applicable for EDGB and DFOT (Refer to Section 3.8.5.4.2.2.b)
Maximum Angular Distortion	Refer to Section 3.8.5.4.2.2.d Not applicable for EDGB and DFOT

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Settlement Check

Differential settlements are divided by the differential settlement within the EDG building basemat and the differential settlement within DFOT building. For the differential settlements within the each basemat, the static (dead and live loads) loading case is calculated.

The distance of approximately 15.24 m (50 ft) is selected to check the differential settlement. Table 3.8A-39 shows the differential settlements of each soil profile. The maximum differential settlement for EDG building per 15.24 m (50 ft) is 4.52 mm (0.18 in.). The maximum differential settlement for DFOT building per 15.24 m (50 ft) is 7.21 mm (0.28 in.).

The differential settlement of each soil profiles between the NI common basemat and EDG building is checked. The maximum differential settlement between the NI common basemat and EDG building is ~~58.14 mm (2.29 in.)~~. 19.58 mm (0.77 in.)

The differential settlement of each soil profiles between the NI common basemat and DFOT building is checked. The maximum differential settlement between the NI common basemat and DFOT building is ~~53.32 mm (2.10 in.)~~. 46.66 mm (1.84 in.)

The differential settlement of each soil profiles between the EDG building and DFOT building is checked. The maximum differential settlement between the EDG building and DFOT building is ~~4.83 mm (0.19 in.)~~. 23.50 mm (0.93 in.)

Figure 3.8A-58 and Figure 3.8A-59 show the node locations at the bottom of the EDG & DFOT basemat for checking the settlements. The analysis of multiple of settlements (long and short term) will use these nodes.

3.8A.3.4.2 Shear Walls

Description

The shear walls and slabs of the EDG building representing the primary lateral load-resisting system are designed against seismic or extreme wind-related loads. The concrete slab distributes lateral forces through diaphragm action to the shear walls as in-plane loads in proportion to the relative stiffness of the shear walls. These in-plane shear forces are

Table 2.1-1 (2 of 4)

Extreme Wind	
50-Year 3-Second Wind Gust Speed	64.8 m/s (145 mph)
Importance Factors	1.15 (2)
Tornado	
Maximum Tornado Wind Speed	102.8 m/s (230 mph)
Translational Speed	20.6 m/s (46 mph)
Maximum Rotational Speed	82.2 m/s (184 mph)
Radius of Maximum Rotational Speed	45.7 m (150 feet)
Pressure Drop	8.274 kPa (1.2 psi)
Rate of Pressure Drop	3.447 kPa/s (0.5 psi/s)
Missile Spectra	Table 2 (Region I) of NRC RG 1.76 (2007)
Hurricane	
Maximum 3-Second Wind Gust Speed	116 m/s (260 mph)
Missile Spectra	Table 1 of NRC RG 1.221 (2011)
Soil Properties	
Allowable Static Bearing Capacity	The allowable static bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum static bearing demand of ~~718.2 kPa (15 ksf)~~ 957.6 kPa (20 ksf). The allowable static bearing capacity is the value of ultimate bearing capacity divided by 3.0.
Allowable Dynamic Bearing Capacity	The allowable dynamic bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60 ksf). The allowable dynamic bearing capacity is the value of ultimate bearing capacity divided by 2.0.
Minimum Factor of Safety for Slope on Static Condition	1.5
Minimum Factor of Safety for Slope on Dynamic Condition (SSE)	1.2
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/sec)

Table 1.8-2 (2 of 38)

Item No.	Description
COL 2.5(1)	The COL applicant is to provide the site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206. The COL applicant is to conduct the probabilistic seismic hazard analysis (PSHA) and develop the site-specific GMRS using the PSHA results as required in NRC RG 1.208.
COL 2.5(2)	The COL applicant is to confirm that the foundation input response spectra (FIRS) of each seismic Category I structure are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of each seismic Category I structure for a site with the low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation. Alternately, the COL applicant is to confirm that the FIRS of each seismic Category I structure are completely enveloped by the CSDRS for a hard rock site with a low-strain shear wave velocity of supporting medium for each seismic Category I structure greater than 2,804 m/s (9,200 ft/s).
COL 2.5(3)	The COL applicant is to confirm that (i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2,002.3 kg/m^3 (125 lb/ft^3); (ii) the profiles of site-specific soil properties are generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11; (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it; and (iv) the site-specific best estimate (BE), lower bound (LB), and upper bound (UB) strain-compatible soil shear wave velocity profiles, including backfill, are consistent with one of the APR1400 generic site conditions ~~S1 through S9~~ S1 through S4 and S6 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11. The lower bound and upper bound shear wave velocity profiles are obtained, as defined in SRP Section 3.7.2, from the mean properties plus or minus one standard deviation, maintaining the minimum variation of 1.5G_{BE} for the upper bound range and G_{BE}/1.5 for the lower bound range, where G_{BE} denotes the best estimate low-strain shear modulus. The lower bound low-strain shear wave velocity for the site-specific soil profile is not to be less than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation.
COL 2.5(4)	The COL applicant is to confirm that the site-specific profile for a HRHF site is consistent with the soil profile provided in Table 3.7B-3 and the site-specific GMRS determined at the finished grade are completely enveloped by the APR1400 HRHF response spectra. In addition, the COL applicant is to confirm that the FIRS of the seismic Category I structures are completely enveloped by the HRHF-compatible free-field response motions at the bottom elevation of each seismic Category I structure.
COL 2.5(5)	The COL applicant is to perform a site-specific seismic analysis to develop in-structure response spectra at key locations using the procedure described in Appendix 3.7A if COL 2.5(2) and COL 2.5(3) above are not met. The COL applicant's site-specific strain-compatible properties are to be consistent with the assumptions used in the SSI analyses including embedment and extent of backfill, as described in Appendix 3.7A. The COL applicant is to confirm that the site-specific 5% damped in-structure response spectra so generated are enveloped by the corresponding 5% damped in-structure response spectra provided in Appendix 3.7A. If this requirement is not satisfied, the COL applicant is to calculate the site-specific member forces and compare them with CSDRS member forces at key locations to determine whether further site-specific seismic design is required.

Table 1.8-2 (3 of 38)

Item No.	Description
COL 2.5(6)	The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions," if COL 2.5(4) is not met. The COL applicant is to develop the site specific in-structure response spectra and compare them with the corresponding HRHF-based in-structure response spectra to determine whether further structural integrity (including member forces) and functionality evaluations are required.
COL 2.5(7)	The COL applicant is to perform an evaluation of the subsurface conditions within the standard plant structure footprint based on the geologic investigation in accordance with NRC RG 1.132.
COL 2.5(8)	The COL applicant is to evaluate the potential future surface deformation of tectonic and non-tectonic origin.
COL 2.5(9)	If the potential for future surface deformation exists, the COL applicant needs to demonstrate the potential effects of surface deformation are within the design basis of the facility.
COL 2.5(10)	The COL applicant is to confirm that the soil angle of internal friction below the footprint of the seismic Category I structures at their excavation depth is a minimum of 35 degrees.
COL 2.5(11)	The COL applicant is to confirm that the dynamic properties of structural fill granular and the compressive strength of lean concrete to be used in construction of the APR1400 seismic Category I structures satisfy the requirements of structural fill granular provided in Table 2.0-1 and the minimum compressive strength of 140 kg/cm^2 (2,000 psi) for the lean concrete.
COL 2.5(12)	The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198. In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level.
COL 2.5(13)	The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5.
COL 2.5(14)	The COL applicant will verify whether the predicted settlements within each building ~~and between buildings~~ exceed the maximum ~~differential settlement~~ [settlements as] [differential settlement] specified in Table 2.0-1 ~~or not.~~ [for site suitability determination.] If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by COL applicant ~~using the APR1400 basemat model and methodology described in subsection 3.8.5~~ to demonstrate ~~acceptable.~~ [acceptability. The COL applicant will also meet settlement criteria specified in COL 3.8(18) for construction sequence and post construction settlement limits.]
COL 2.5(15)	The COL applicant is to provide site-specific information about the static and dynamic stability of all natural and man-made soil and rock slopes including embankments and dams.
COL 3.2(1)	The COL applicant is to identify the seismic classification of site-specific SSCs that should be designed to withstand the effects of the SSE.

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Item No.	Description
COL 3.8(20)	The COL applicant shall perform site-specific evaluations if the shear wave velocity is less than 1,000 ft/s. The site-specific evaluations (~~differential settlement~~ settlements, soil bearing pressure, and sliding evaluation [if needed]) and 3D FEM global analysis for basemat design of seismic Category I structures shall be performed using the site-specific measured Estatic and the methodology described in Subsection 3.8.5 and Technical report APR1400-E-S-NR-14006-P, Subsection 4.
COL 3.9(1)	The COL applicant is to provide the inspection results for the APR1400 reactor internals classified as non-prototype Category I in accordance with RG 1.20.
COL 3.9(2)	The COL applicant is to identify the site-specific active pumps.
COL 3.9(3)	The COL applicant is to provide a full description of the IST program (including PST and MOV testing) for pumps, valves and dynamic restraints that will be administratively controlled such that the applicable requirements of the ASME OM Code edition and addenda are incorporated in the IST program.
COL 3.9(4)	The COL applicant is to provide an IST program including the type of testing and frequency of site-specific pumps subject to IST in accordance with the ASME OM Code and Table 3.9-13
COL 3.9(5)	The COL applicant is to provide an IST program including the type of testing and frequency of any site-specific valves subject to IST in accordance with the ASME OM Code and Table 3.9-13
COL 3.9(6)	The COL applicant is to provide a table listing all safety-related components that use snubbers in their support systems.
COL 3.10(1)	The COL applicant is to provide documentation that the designs of seismic Category I SSCs are analyzed for OBE, if OBE is higher than 1/3 SSE.
COL 3.10(2)	The COL applicant is to investigate if site-specific spectra generated for the COLA exceed the APR1400 design spectra in the high-frequency range. Accordingly, the COL applicant is to provide reasonable assurance of the functional performance of vibration-sensitive components in the high-frequency range.
COL 3.10(3)	The COL applicant is to develop the equipment seismic qualification files that summarize the component's qualification, including a list of equipment classified as seismic Category I in Table 3.2-1 and seismic qualification summary data sheets (SQSDS) for each piece of seismic Category I equipment.
COL 3.10(4)	The COL applicant is to perform equipment seismic qualification for seismic Category I equipment and provide milestones and completion dates of equipment seismic qualification program.
COL 3.11(1)	The COL applicant is to identify and qualify the site-specific mechanical, electrical, I&C, and accident monitoring equipment specified in RG 1.97.
COL 3.11(2)	The COL applicant is to identify the nonmetallic parts of mechanical equipment in procurement process.
COL 3.11(3)	The COL applicant is to operational address aspects for maintaining the environmental qualification status of components after initial qualification.
COL 3.11(4)	The COL applicant is to provide a full description of the environmental qualification of mechanical and electrical equipment program.

less than 304.8 m/s (1,000 ft/s), the submaterials are completely excavated to expose competent material with a low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s), and the GMRS are defined as a free-field motion on the hypothetical outcrop after the excavation. For a site where the seismic Category I structures are located on hard rock with a shear wave velocity greater than 2,804 m/s (9,200 ft/s), the site-specific GMRS can be defined at the foundation level. For this case, GMRS could be referred to as foundation input response spectra (FIRS) for the seismic Category I structures. The site-specific GMRS need to be transferred to the foundation elevations of each seismic Category I structure to obtain FIRS of each seismic Category I structure. The COL applicant is to confirm that the site meets the following requirements:

a. For a site with a low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation, the site-specific GMRS at the finished grade are completely enveloped by the APR1400 CSDRS shown in Figures 3.7-1 and 3.7-2. In addition, according to the NRC DC/COL-ISG-017 (Reference 5), the FIRS of each seismic Category I structure are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of each seismic Category I structure shown in Figures 3.7A-12 through 3.7A-14 (COL 2.5(2)).

b. For hard rock sites with a low-strain shear wave velocity of supporting medium for each seismic Category I structure greater than 2,804 m/sec (9,200 ft/s), FIRS of each seismic Category I structure are completely enveloped by the CSDRS (COL 2.5(2)).

c. For soil sites, (i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2,002.3 kg/m^3 (125 lb/ft^3); (ii) the profiles of site-specific soil properties are generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11; (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it; and (iv) the site-specific best estimate (BE), lower bound (LB), and upper bound (UB) strain-compatible soil shear wave velocity profiles, including backfill, are consistent with one of the APR1400 generic site conditions ~~S1 through S9~~ considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11. The lower bound and upper bound shear wave velocity profiles are obtained, as defined in SRP Section 3.7.2 (Reference 10), from the mean properties plus or minus one standard

S1 through S4 and S6 through S9

2.5.4.2 Properties of Subsurface Materials

The static and dynamic engineering properties of the foundation soil and rock in the site area will be provided. Procedures and methods of site investigations follow NRC RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Laboratory testing follows NRC RG 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants."

Subsurface materials are grouped in terms of origin, geologic stratigraphy, and weathering. The representative values for each group will be determined.

The site-specific engineering properties include the following:

a. Physical properties (e.g., density, deformation modulus, Poisson's Ratio)

b. Mechanical properties (e.g., strength, bearing capacity)

c. Dynamic properties (e.g., P-wave velocity, S-wave velocity, dynamic deformation modulus, dynamic shear modulus, dynamic Poisson's Ratio)

The minimum soil angle of internal friction is 35 degrees as indicated in Table 2.0-1. The friction angle of soil is used for estimating the friction resistance of the foundation. The friction coefficient derived from the soil friction angle was used for evaluating the stability of NI common basemat against sliding as described in Subsection 3.8A.1.4.2.3.2. The COL applicant is to confirm that the soil angle of internal friction below the footprint of the seismic Category I structures at their excavation depth is a minimum of 35 degrees (COL 2.5(10)).

2.5.4.3 Foundation Interfaces

NRC RG 1.132, "Site Investigation for Foundation of Nuclear Power Plant," defines procedures for and the extent of field investigations to determine the engineering properties of soil and rock materials.

The spacing and minimum depth of sounding as defined in NRC RG 1.132 will be followed. The results of investigations will be presented as forms of cross sections and profiles with a proper scale. ~~Piezometers and other monitoring instruments for settlement or tilting, if needed, will be installed at a proper location to represent the site conditions.~~

~~Monitoring of settlements is described in subsection 3.8.5.7.~~

Piezometers and other monitoring instruments for settlement or tilting, if needed, will be installed at a proper location to represent the site conditions.

2.5.4.7 Response of Soil and Rock to Dynamic Loading

Site-specific information will be provided on the response of soil and rock to dynamic loading, including investigations to determine the effects of prior earthquakes on the soils and rocks, compressional and shear wave velocity profiles determined from field seismic surveys, and the results of dynamic tests in the laboratory on samples of the soil and rock. The methodology of site response analysis is described in Appendix 3.7A.

2.5.4.8 Liquefaction Potential

No liquefaction potential is allowed for the foundation at the site adjacent to and under seismic Category I structures. The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198 (Reference 9). In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level (COL 2.5(12)).

2.5.4.9 Earthquake Site Characteristics

The earthquake site-specific characteristics are described in Subsection 2.5.2.

2.5.4.10 Static Stability

Bearing capacity analysis and settlement computation using stratigraphic conditions, strength, and elastic parameters of the rock mass, building loads, and structural interfaces are provided.

An evaluation of lateral earth pressures and hydrostatic groundwater loads acting on plant facilities will be provided. Foundation information and factor of safety (FOS) of stability on seismic Category I structures are provided in Subsection 3.8.5.

An analysis will be conducted using a two-dimensional or three-dimensional model.

2.5.4.10.1 Bearing Capacity

The maximum bearing pressure under static loading conditions for the foundation basemat beneath the Seismic Category I structure (reactor containment building, auxiliary building, emergency diesel generator building and diesel fuel oil tank) is ~~641.5 kPa (13,397 lb/ft^2)~~ 937.02 kPa (19,570 lb/ft^2), which includes the dead weight of the structure and components and live load. The maximum bearing pressure under safe shutdown earthquake loads combined with static loads, as described in Subsection 3.8.5, is ~~1415.9 kPa (29,572 lb/ft²)~~ 2586.01 kPa (54,010 lb/ft²) (Reference 8). The maximum bearing pressure is smaller than the allowable bearing capacity specified in Table 2.0-1.

The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5 (COL 2.5(13)).

2.5.4.10.2 Settlement

The safety-related structures of APR1400 are reactor containment building, auxiliary building, emergency diesel generator building, and diesel fuel oil tank. Based on the distributed arrangement of safety-related systems and components, there are some restricted interfaces between systems which communicate between or within buildings. The effect of ~~total settlement and differential~~ Total settlement and differential settlement will be considered where these interfaces occur.

~~Total settlement and differential settlement is~~ ~~Settlements are~~ Total settlement and differential settlement is dependent on site-specific conditions, construction sequence, loading condition, and excavation plans. It is expected that most of this settlement occurs during civil construction prior to final installation of the equipment. Site-specific considerations for the predicted settlement will be taken into account. Site-specific considerations include the effects of excavation, foundation material preparation, sequence of concrete placement of the basemat, and site specific construction sequence of the superstructure.

The COL applicant will verify whether the predicted settlements within each building and between buildings exceed the maximum ~~differential settlement~~ ~~settlements as~~ differential settlement specified in Table 2.0-1 or not. If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5 to demonstrate acceptable (COL 2.5(14)).

304.8 m/s (1,000 ft/s) up to the structural foundation elevation. Alternately, the COL applicant is to confirm that the FIRS of each seismic Category I structure are completely enveloped by the CSDRS for a hard rock site with a low-strain shear wave velocity of supporting medium for each seismic Category I structure greater than 2,804 m/s (9,200 ft/s).

COL 2.5(3) The COL applicant is to confirm that (i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2,002.3 kg/m^3 (125 lb/ft^3); (ii) the profiles of site-specific soil properties are generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11; (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it; and (iv) the site-specific best estimate (BE), lower bound (LB), and upper bound (UB) strain-compatible soil shear wave velocity profiles, including backfill, are consistent with one of the APR1400 generic site conditions ~~S1 through S9~~ S1 through S4 and S6 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-9 and Figures 3.7A-3 through 3.7A-11. The lower bound and upper bound shear wave velocity profiles are obtained, as defined in SRP Section 3.7.2, from the mean properties plus or minus one standard deviation, maintaining the minimum variation of 1.5G_{BE} for the upper bound range and G_{BE}/1.5 for the lower bound range, where G_{BE} denotes the best estimate low-strain shear modulus. The lower bound low-strain shear wave velocity for the site-specific soil profile is not to be less than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation.

COL 2.5(4) The COL applicant is to confirm that the site-specific profile for a HRHF site is consistent with the soil profile provided in Table 3.7B-3 and the site-specific GMRS determined at the finished grade are completely enveloped by the APR1400 HRHF response spectra shown in Figures 3.7-12 and 3.7-13. In addition, the COL applicant is to confirm that the FIRS of the seismic Category I structures are completely enveloped by the HRHF-compatible free-field response motions at the bottom elevation of each seismic Category I structure.

COL 2.5(5) The COL applicant is to perform a site-specific seismic analysis to develop in-structure response spectra at key locations using the procedure described

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APR1400 seismic Category I structures satisfy the SFG requirements provided in Table 2.0-1 and the minimum compressive strength of 140 kg/cm^2 (2,000 psi) for the lean concrete.

COL 2.5(12) The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198. In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level.

COL 2.5(13) The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5.

Differential settlement

~~settlements as~~

COL 2.5(14) The COL applicant will verify whether the predicted settlements within each building and between buildings exceed the maximum ~~differential settlement~~ specified in Table 2.0-1 ~~or not.~~ If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant ~~using the APR1400 basemat model and methodology described in Subsection 3.8.5~~ to demonstrate ~~acceptable.~~

for site suitability determination.

COL 2.5(15) The COL applicant is to provide site-specific information about the static and dynamic stability of all natural and man-made soil and rock slopes including embankments and dams.

2.5.7 References

1. Regulatory Guide 1.206, “Combined License Applications for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, June 2007.

acceptability. The COL applicant will also meet settlement criteria specified in COL 3.8(18) for construction sequence and post construction settlement limits.

which includes the dead weight of the structure and components and live load. The maximum bearing pressure under safe shutdown earthquake loads combined with static loads, as described in Subsection 3.8.5, is 1415.9 kPa (29,572 lb/ft^2) (Reference 8). The maximum bearing pressure is smaller than the allowable bearing capacity specified in Table 2.0-1.

The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5 (COL 2.5(13)).

2.5.4.10.2 Settlement

The safety-related structures of APR1400 are reactor containment building, auxiliary building, emergency diesel generator building, and diesel fuel oil tank. Based on the distributed arrangement of safety-related systems and components, there are some restricted interfaces between systems which communicate between or within buildings. The effect of total settlement and differential settlement will be considered where these interfaces occur.

Total settlement and differential settlement is dependent on site-specific conditions, construction sequence, loading condition, and excavation plans. It is expected that most of this settlement occurs during civil construction prior to final installation of the equipment. Site-specific considerations for the predicted settlement will be taken into account. Site-specific considerations include the effects of excavation, foundation material preparation, sequence of concrete placement of the basemat, and site specific construction sequence of the superstructure.

for site suitability determination.

The COL applicant will verify whether the predicted settlements within each building and between buildings exceed the maximum differential settlement specified in Table 2.0-1 ~~or not.~~ If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant ~~using the APR1400 basemat model and methodology described in Subsection 3.8.5~~ to demonstrate ~~acceptable~~ (COL 2.5(14)).

acceptability. The COL applicant will also meet settlement criteria specified in COL 3.8(18) for construction sequence and post construction settlement limits.