RAIO-1217-57892

December 21, 2017

Docket No. 52-048

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Response to NRC Request for Additional Information No. 110 (eRAI No. 8932) on the NuScale Design Certification Application

REFERENCES:
1. U.S. Nuclear Regulatory Commission, "Request for Additional Information No. 110 (eRAI No. 8932)," dated July 30, 2017
2. NuScale Power, LLC Response to NRC Request for Additional Information No. 110 (eRAI No. 8932) on the NuScale Design Certfication Application, dated September 27, 2017 (ML17271A239)

The purpose of this letter is to provide the NuScale Power, LLC (NuScale) response to the referenced NRC Request for Additional Information (RAI).

The Enclosure to this letter contains NuScale's response to the following RAI Question from NRC eRAI No. 8932:

- 03.07.02-1

The response to RAI Questions 03.07.02-2 and 03.07.02-3 were previously provided in Reference 2. The response schedule for the remaining questions of RAI No. 110, eRAI 8932 were provided in an email to the NRC (Greg Cranston and Marieliz Vera) dated August 30, 2017.

This letter and the enclosed response make no new regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions on this response, please contact Marty Bryan at 541-452-7172 or at mbryan@nuscalepower.com.

Sincerely,

Zackary W. Rad
Director, Regulatory Affairs
NuScale Power, LLC

Distribution: Gregory Cranston, NRC, OWFN-8G9A
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Enclosure 1: NuScale Response to NRC Request for Additional Information eRAI No. 8932

Enclosure 1:

NuScale Response to NRC Request for Additional Information eRAI No. 8932

Response to Request for Additional Information
Docket No. 52-048

eRAI No.: 8932
Date of RAI Issue: 07/30/2017

NRC Question No.: 03.07.02-1

10 CFR 50 Appendix S requires that the safety functions of structures, systems, and components (SSCs) must be assured during and after the vibratory ground motion associated with the Safe Shutdown Earthquake (SSE) through design, testing, or qualification methods.

In modeling structures using finite elements for dynamic analysis, the discretization should be adequately refined to sufficiently capture the frequency contents of the ground motion in the structural response. DSRS Section 3.7.2 provides a guideline that the element mesh size should be selected on the basis that further refinement has only a negligible effect on the solution results. For the RXB and CRB standalone models as well as the triple building model, the applicant is requested to provide a detailed explanation for why the finite elements employed in the models are adequate. Include discussion of applicant's consideration of the effects of element size, shape, and aspect ratio of each structural system and their impact on solution accuracy.

NuScale Response:

The following response provides a detailed explanation for why the finite elements employed in the reactor building (RXB) and control building (CRB) standalone models, and the triple building model are adequate. These details include consideration of the effects of element size, shape and aspect ratio of each structural system and their impact on solution accuracy. A summary of these conclusions has been added to FSAR Tier 2, Section 3.7.2.1.2.

Meshing of the area elements was done automatically using SAP2000 by defining a maximum element size in each direction. The aspect ratios were also kept as low as possible (closer to square shape), and internal sharp angles were avoided.

Meshing for both the RXB and CRB building models were refined further, and it is shown that further refinement does not affect the structural response. The mesh refinement was done by dividing each side of the area elements into two, breaking each element to four elements. The structural responses compared include both local and global responses of the structure. The

comparison shows that effects of further mesh refinement on the structural response is negligible. The tables and figures below show comparisons of the different structural responses.

Soil solid element heights were determined based on 1/5th of the wave length. As shown below, very minor changes in the natural frequencies and their mass participation ratios indicate that other dynamic characteristics of the building models would not change by mesh refinement. Hence, there is no need to study the effects of the mesh refinement on the soil structure interaction (SSI), in-structure response spectra (ISRS), or structure-soil-structure interactions (SSSI). The triple building model has the same mesh as the stand alone model. Also, as it was mentioned the SSSI effects are not expected to change with mesh refinement, therefore no mesh sensitivity analysis was done for the triple building model.

Reactor Building

RXB Roof Vertical Displacement

The middle node of the RXB roof (i.e. Joint Label 30410) is one of the most flexible points in the building. Table 1 shows the comparison of vertical displacement for the joint between the two models for load case 1GZ. As can be seen, the difference in the displacements is negligible. Figure 1 and Figure 2 show the roof vertical displacement contours for the FSAR and refined mesh model, respectively.

Table 1: RXB Roof Vertical Displacements Due to 1 Gz (FSAR and Refined Model)

RXB Model	Joint Label	Center Vertical Displacement Load Case 1GZ Uz (inch)
FSAR Model	30410	1.380
Refined Mesh Model	30410	1.382

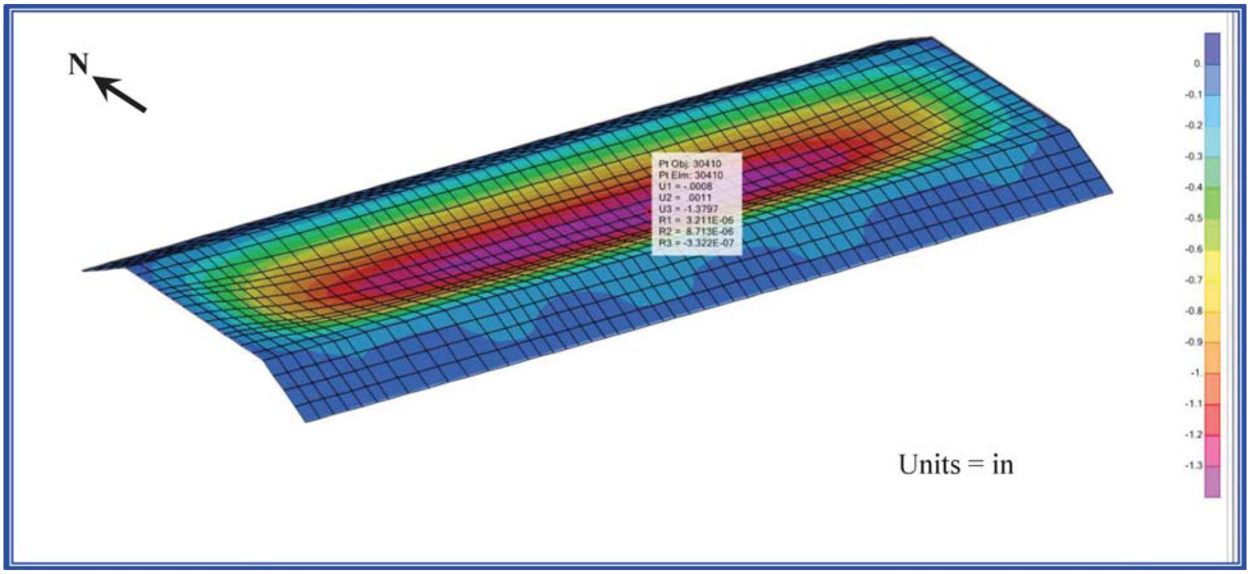

Figure 1: 1 GZ Uz Displacement Contours of Roof for FSAR Model

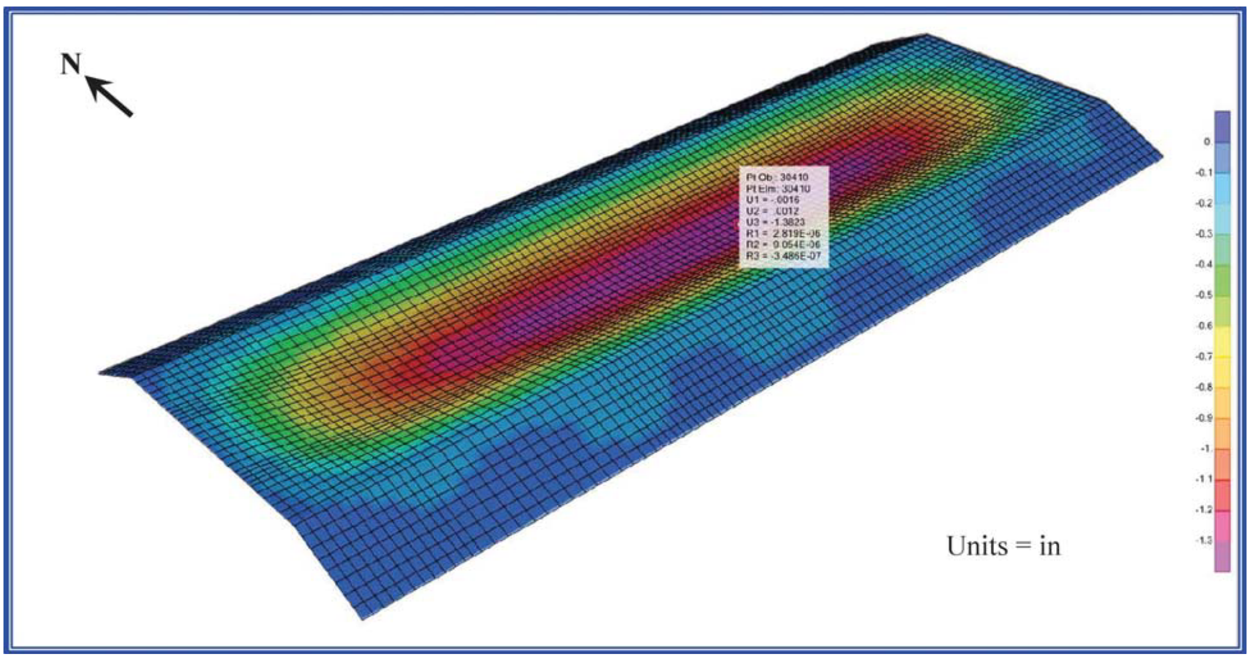

Figure 2: 1GZ Uz Displacement Contours of Roof for Refined Mesh Model

Reactor Building Horizontal Displacements of Building Corner Joints

The four corner joints at Z = 1824" are the most flexible points for lateral loads. Table 2 and Table 3 show the X and Y displacement comparison for these corner nodes for 1GX and 1GY load cases respectively. The difference is negligible.

Table 2: RXB Ux Displacements Due to 1GX (FSAR and Refined Model)

Joint	Load Case	Ux Displacement (in)	
		FSAR Model	Refined Model
29076	1GX	-0.382	-0.392
29098	1GX	-0.381	-0.391
29343	1GX	-0.387	-0.397
29365	1GX	-0.390	-0.400

Table 3: RXB Uy Displacements Due to 1GY (FSAR and Refined Model)

Joint	Load Case	Uy Displacement (in)	
		FSAR Model	Refined Model
29076	1GY	-1.202	-1.246
29098	1GY	-1.200	-1.244
29343	1GY	-1.069	-1.096
29365	1GY	-1.069	-1.096

Reactor Building Modal Analysis Results

Table 4 shows a close comparison of the dominant frequencies obtained using modal analysis with the FSAR and refined mesh RXB models.

Table 4: RXB Frequencies and Participating Mass Ratios (FSARand Refined Model)

FSAR Model				Refined Mesh Model			
Frequency	Modal Participation Mass Ratios			Frequency	Modal Participation Mass Ratios		
Hz	UX	UY	UZ	Hz	UX	UY	UZ
1.93	0.000	**0.010**	0.000	1.89	0.000	**0.010**	0.000
2.87	0.000	**0.520**	0.000	2.83	0.000	**0.530**	0.000
3.23	0.000	0.000	**0.021**	3.23	0.000	0.000	**0.021**
4.50	0.000	**0.013**	0.000	4.49	0.000	**0.012**	0.000
4.66	**0.130**	0.000	0.000	4.65	**0.140**	0.000	0.000
4.78	**0.028**	0.000	0.000	4.77	**0.043**	0.000	0.000
4.90	**0.008**	0.000	0.000	5.10	**0.007**	0.000	0.000
5.17	0.000	**0.046**	0.000	5.10	0.000	**0.044**	0.000
5.25	**0.180**	0.000	0.000	5.23	**0.210**	0.000	0.000
5.44	**0.140**	0.000	0.000	5.42	**0.110**	0.000	0.000
5.70	0.000	**0.005**	0.000	5.69	0.000	**0.006**	0.000
5.70	0.000	0.000	**0.014**	5.69	0.000	0.000	**0.012**
5.74	0.000	0.000	**0.013**	5.74	0.000	0.000	**0.015**
5.88	**0.060**	0.000	0.000	5.86	**0.038**	0.000	0.000
5.99	**0.010**	0.000	0.000	5.95	**0.033**	0.000	0.000
6.03	**0.033**	0.000	0.000	6.01	**0.012**	0.000	0.000
6.28	0.000	**0.017**	0.000	6.11	**0.007**	0.000	0.000
6.42	0.000	**0.009**	0.000	6.27	0.000	**0.019**	0.000
6.49	0.000	**0.004**	0.000	6.59	0.000	**0.011**	0.000
6.59	0.000	**0.006**	0.000	6.62	0.000	**0.007**	0.000
7.04	0.000	0.000	**0.040**	6.99	0.000	0.000	**0.024**
7.16	0.000	0.000	**0.021**	7.04	0.000	0.000	**0.014**
7.17	0.000	0.000	**0.031**	7.13	0.000	0.000	**0.065**
7.37	0.000	**0.005**	0.000	7.36	0.000	**0.006**	0.000
9.33	**0.011**	0.000	0.000	9.33	**0.011**	0.000	0.000
10.46	0.000	0.000	**0.023**	10.40	0.000	0.000	**0.017**
12.93	0.000	0.000	**0.013**	12.83	0.000	0.000	**0.023**
13.14	0.000	0.000	**0.014**	13.01	0.000	0.000	**0.013**
13.45	0.000	0.000	**0.024**	13.44	0.000	0.000	**0.026**
96.45	**0.010**	0.000	0.000	96.44	**0.007**	0.000	0.000
96.91	0.000	**0.006**	0.000	96.96	0.000	**0.007**	0.000
107.52	0.000	**0.006**	0.000	107.41	0.000	**0.006**	0.000

Note: Only the dominant frequencies are shown.

RXB Averaged Absolute Maximum Roof End Moments

Table 5 shows the comparison of averaged absolute maximum RXB roof end moments at location "A" as shown in Figure 3. The load case considered is 1GZ. Figure 3 and Figure 4 show the contours for the moment about global X and Y axes for the two models respectively.

Table 5: RXB Averaged Absolute Maximum Roof End Moments at Location A Due to 1GZ (FSAR and Refined Model)

RXB Model	Moment About Global X Axis (M11) Lb-in/in	Moment About Global Y Axis (M22) Lb-in/in
FSAR Model	262,704 (Elem. 18084)	39,563 (Elem. 18084)
Refined Mesh Model	255,686 (Elem. 34779, 34780, 34781,34782)	40,756 (Elem. 34779, 34780, 34781,34782)

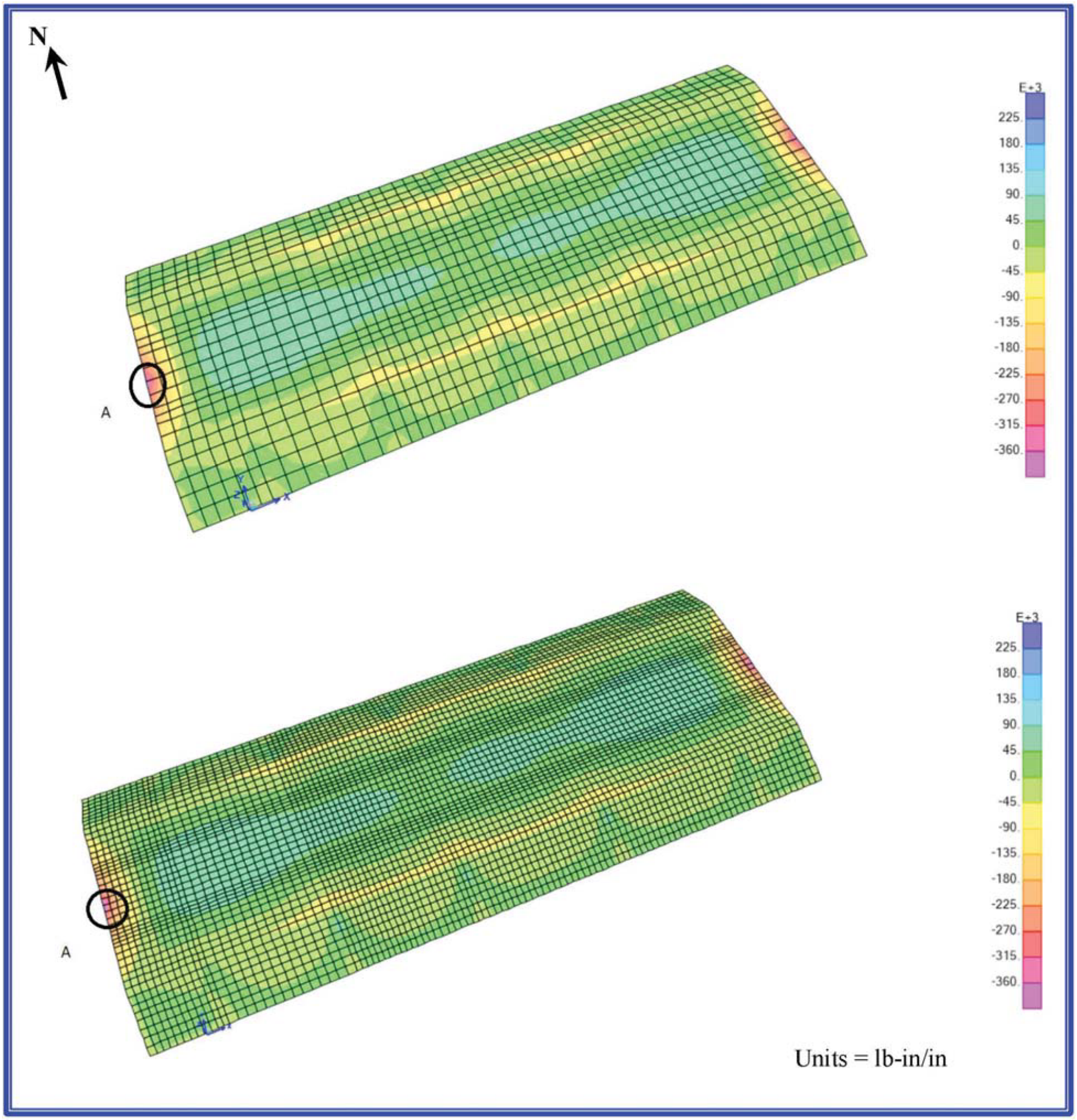

Figure 3: 1GZ M11 Contours at Roof for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

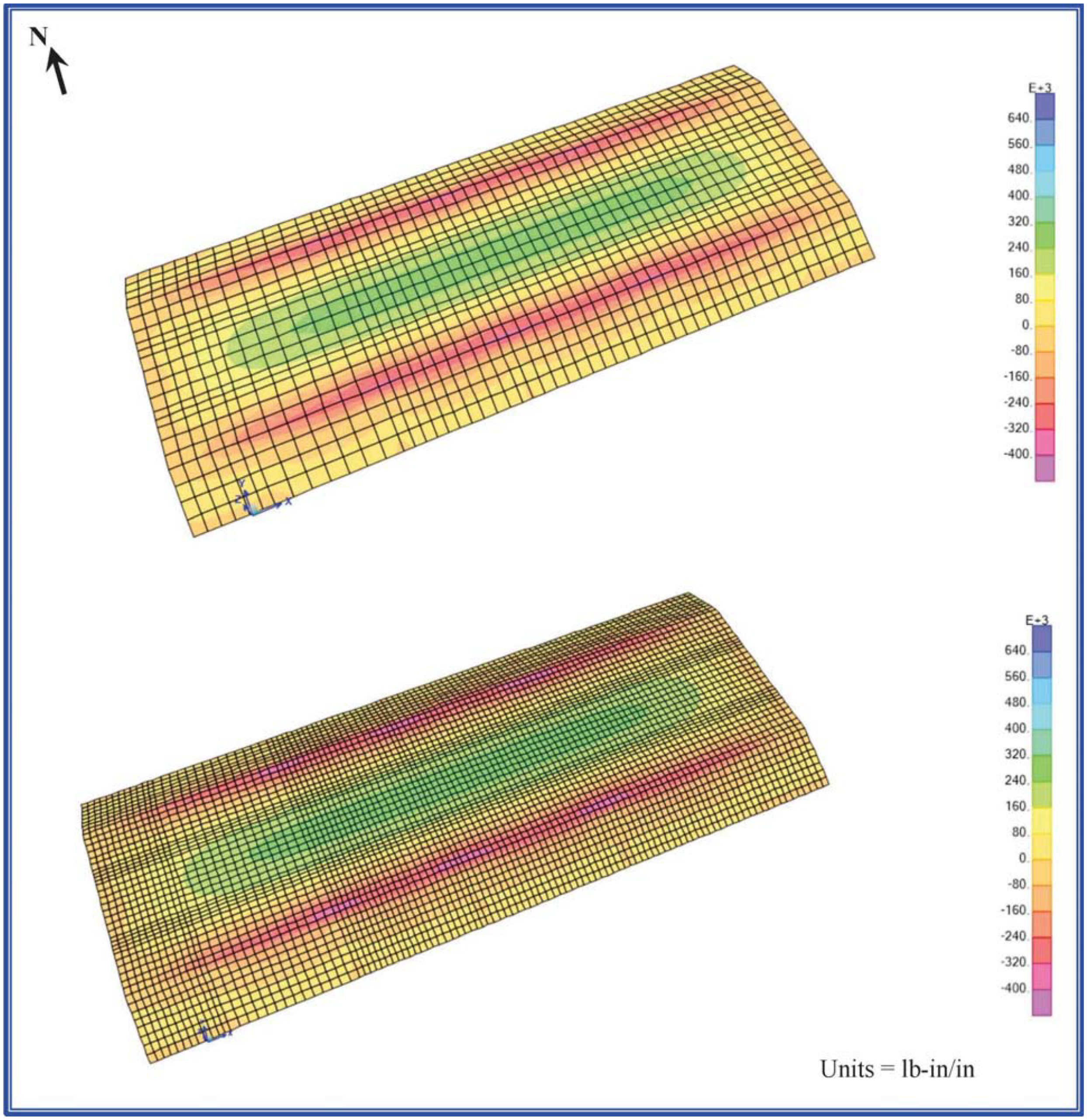

Figure 4: 1GZ M22 Contours at Roof for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum In-Plane Shear in Roof

Table 6 shows the comparison of averaged absolute maximum RXB roof in-plane shears in the RXB roof. Figure 5 and Figure 6 show the contours for the in-plane shear in the roof for 1GX and 1GY respectively. Areas marked “A” and “B” in the figures represent the locations for maximum in-plane shear for 1GX and 1GY respectively.

Table 6: RXB Averaged Absolute Maximum Roof In-Plane Shear at Location A and B Due to 1GX and 1GY (FSAR and Refined Model)

RXB Model	In-Plane Shear (F12) for 1GX Lb/in	In-Plane Shear (F12) for 1GY Lb/in
FSAR Model	4,131 (Elem. 17323)	26,007 (Elem. 18085)
Refined Mesh Model	4,143 (Elem. 33239, 33240, 33241, 33242)	26,751 (Elem. 34783, 34784, 34785, 34786)

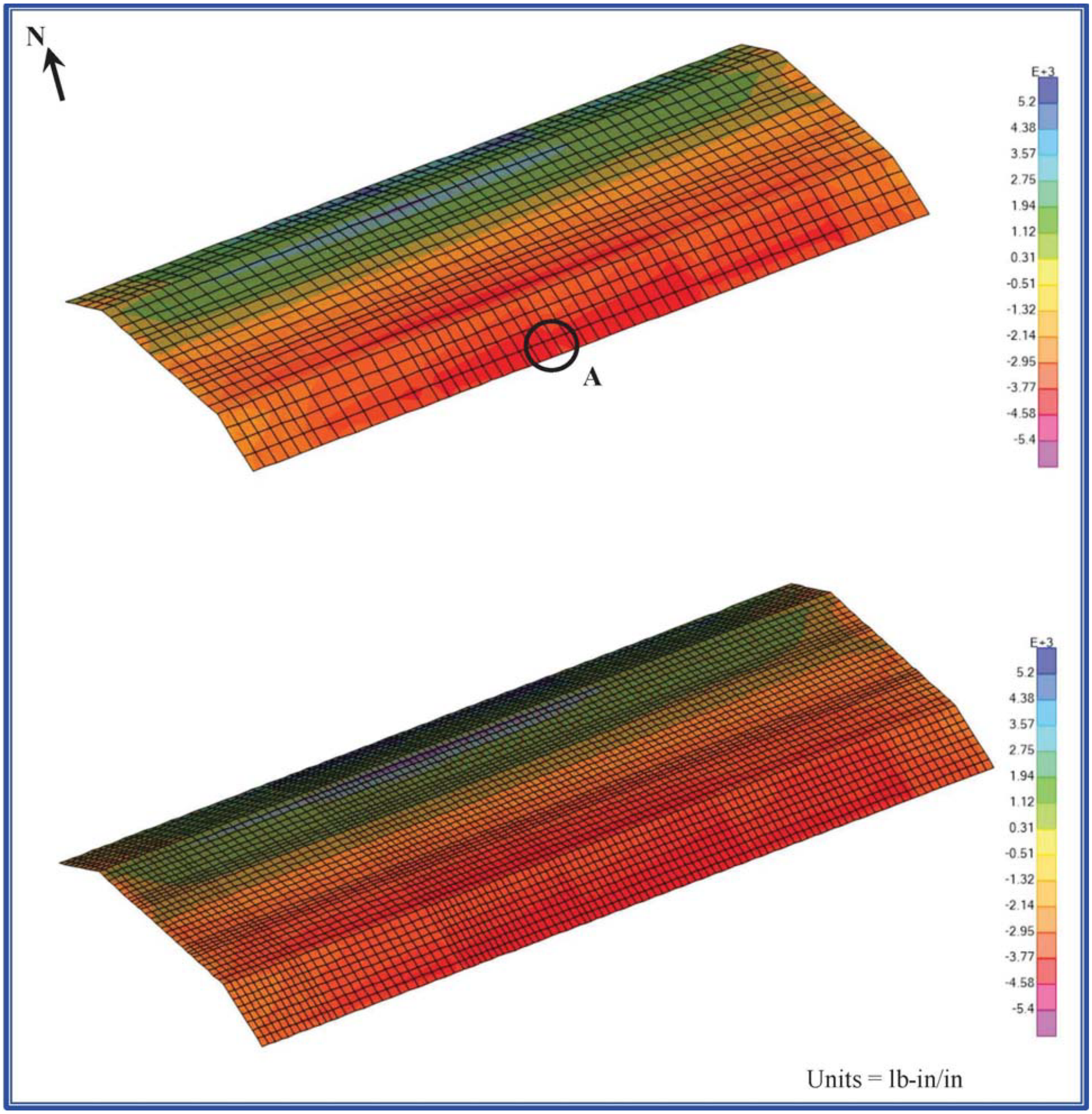

Figure 5: 1GX F12 Contours at Roof for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

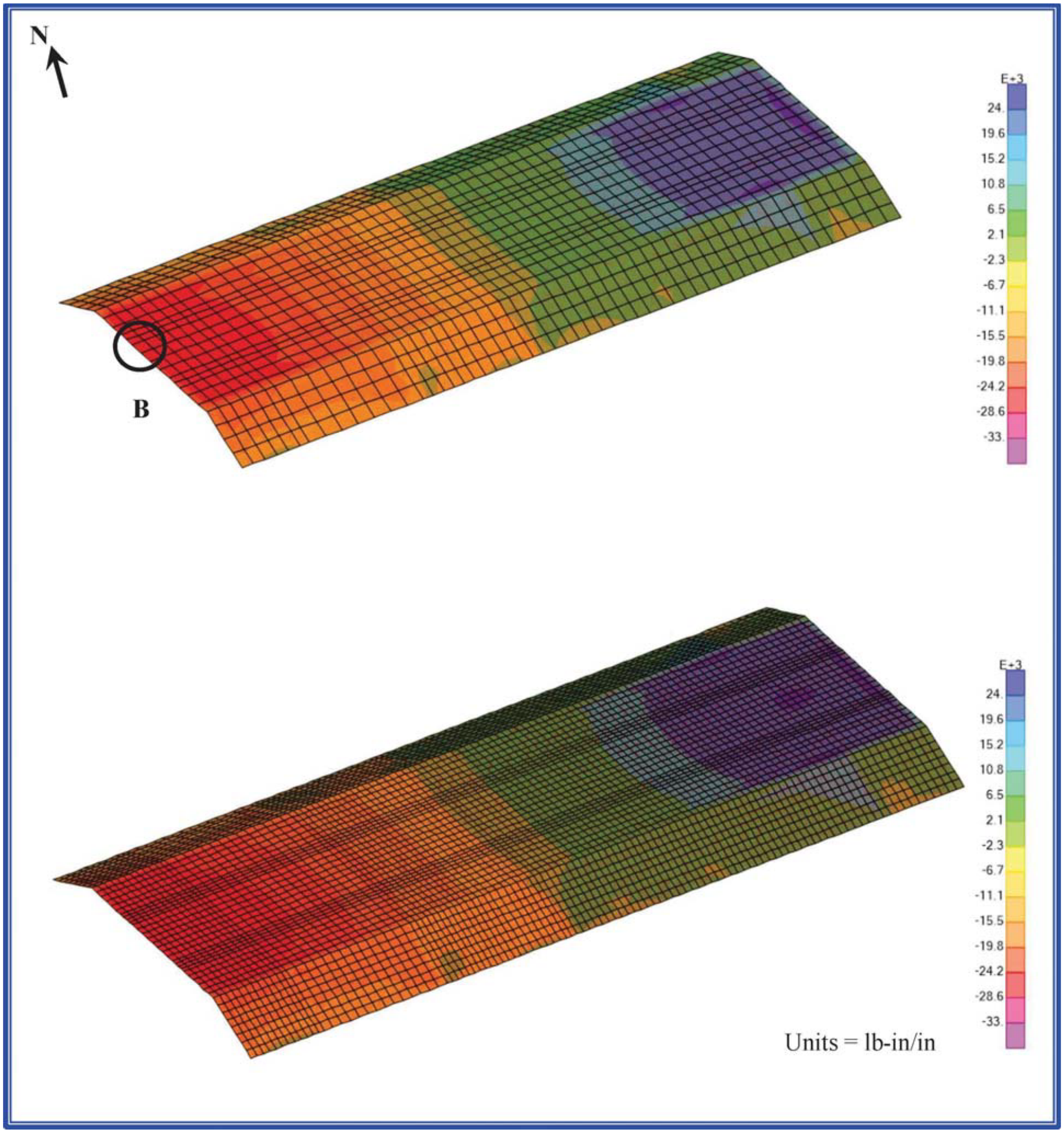

Figure 6: 1GY F12 Contours at Roof for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum Moments in Slab at El 50' -0"

Table 7 shows the comparison of averaged absolute maximum moments in RXB slab at EL 50' at locations A (for M11) and B (for M22) for load case 1GZ. Figure 7 and Figure 8 show contours for M11 and M22 moments respectively for the FSAR model and refined mesh model.

Table 7: RXB Averaged Absolute Maximum Moments in Slab at EL 50'-0" Due to 1GZ (FSAR and Refined Model)

RXB Model	Moment About Global X Axis (M11) Lb-in/in	Moment About Global Y Axis (M22) Lb-in/in
FSAR Model	24,611 (Elem. 5491)	16,776 (Elem. 5193)
Refined Mesh Model	24,206 (Elem. 40952, 40953, 40954, 40955)	15,976 (Elem. 39760, 39761, 39762,39763)

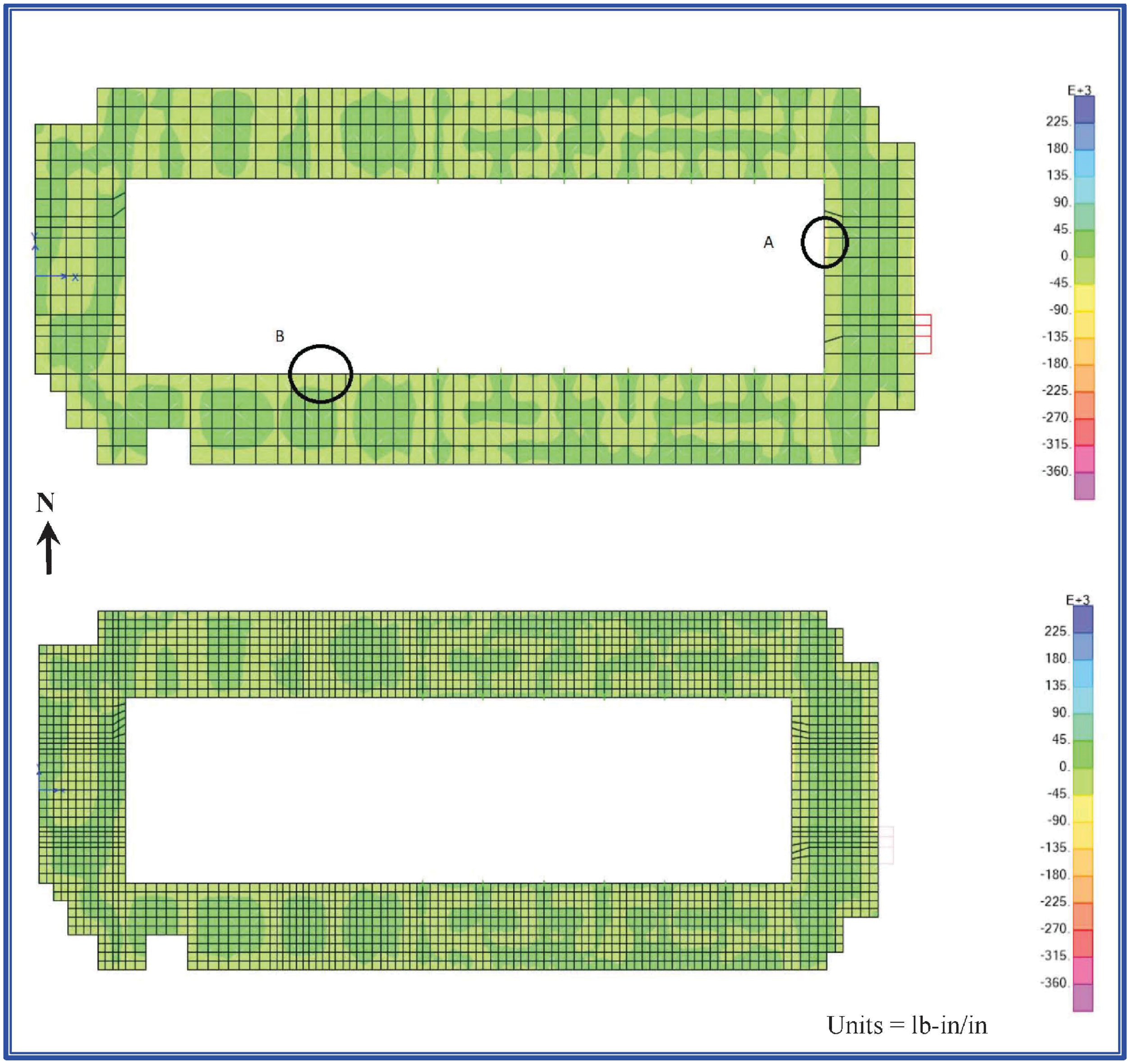

Figure 7: 1GZ M11 Contours for Slab at EL 50'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

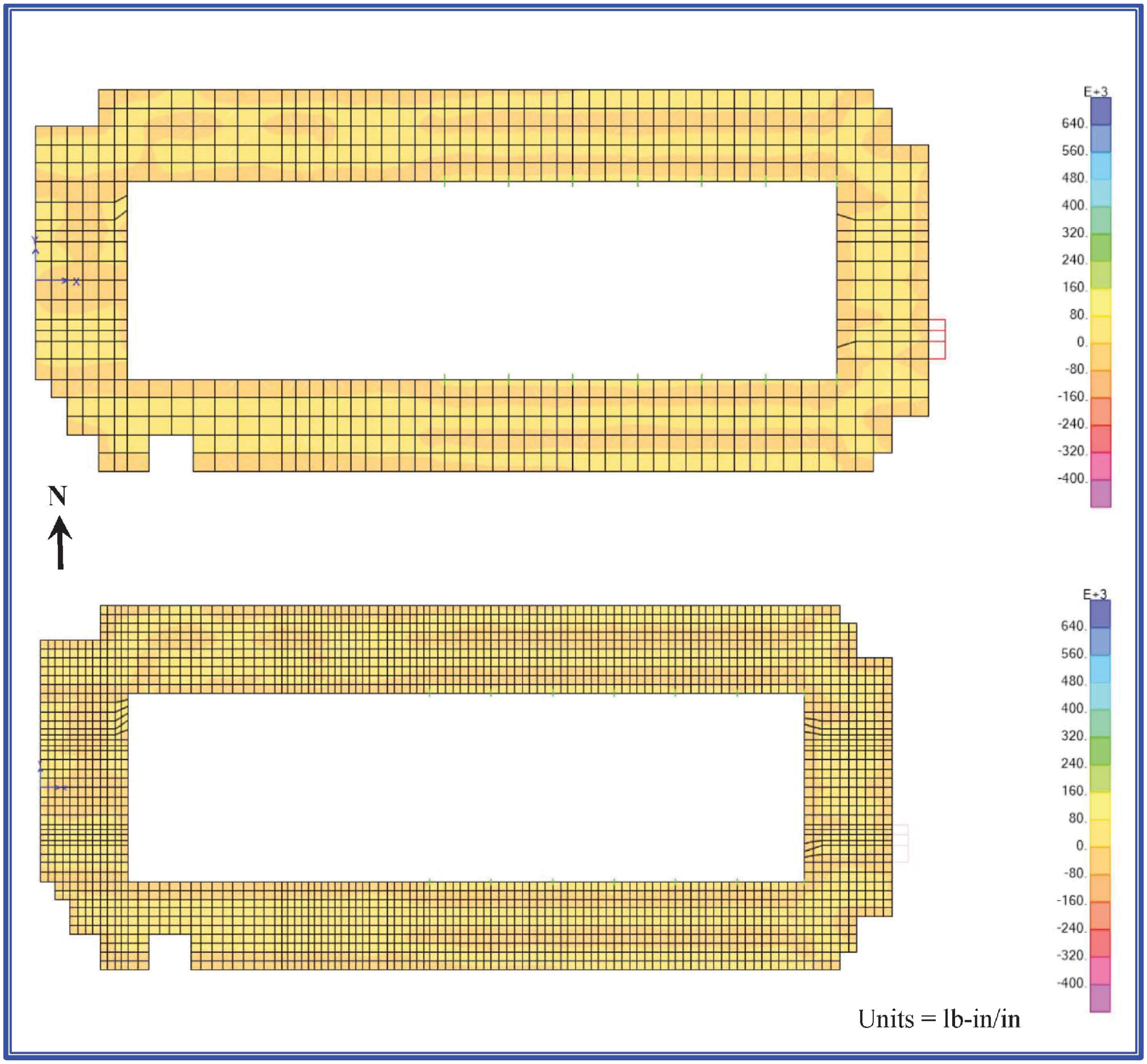

Figure 8: 1GZ M22 Contours for Slab at EL 50'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

<u>RXB Averaged Absolute Maximum In-Plane Shear in Slab at EL 50'-0"</u>

Table 8 shows the comparison of averaged absolute maximum in-plane shears in RXB slab at EL 50'-0". Figure 9 and Figure 10 show the contours for the in-plane shear in the slab for 1GX and 1GY respectively. Areas marked “A” and “B” in figures represent the locations for maximum in-plane shears for 1GX and 1GY respectively.

Table 8: RXB Averaged Absolute Maximum In-Plane Shear in Slab at EL 50'-0" Due to 1GX and 1GY (FSAR and Refined Model)

RXB Model	In-Plane Shear (F12) for 1GX Lb/in	In-Plane Shear (F12) for 1GY Lb/in
FSAR Model	7,923 (Elem. 5046)	31,458 (Elem. 5134)
Refined Mesh Model	8,604 (Elem. 39172, 39173,39174, 39175)	27,762 (Elem. 39524,39525, 39526, 39527)

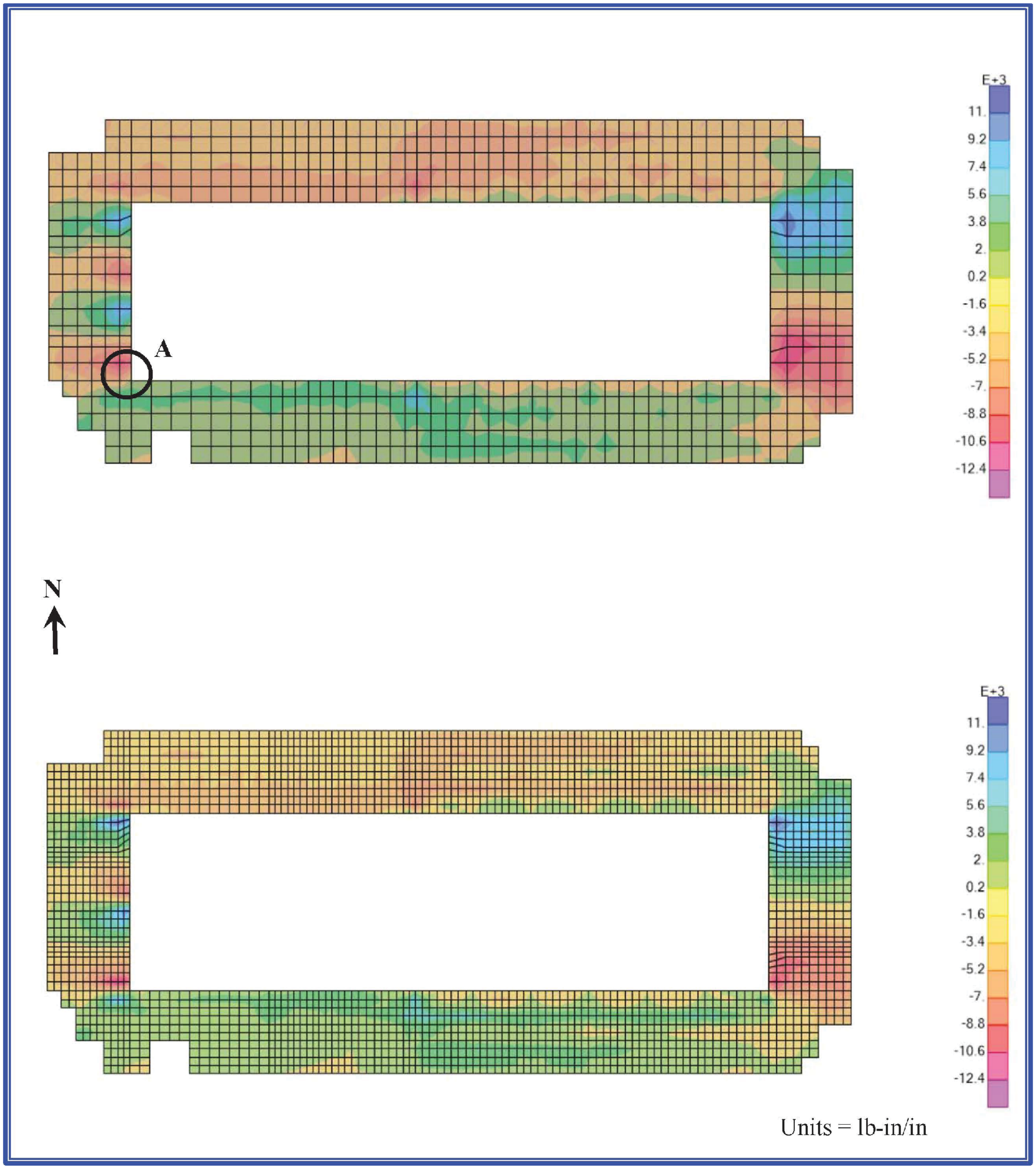

Figure 9: 1GX F12 Contours in Slab at EL 50'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

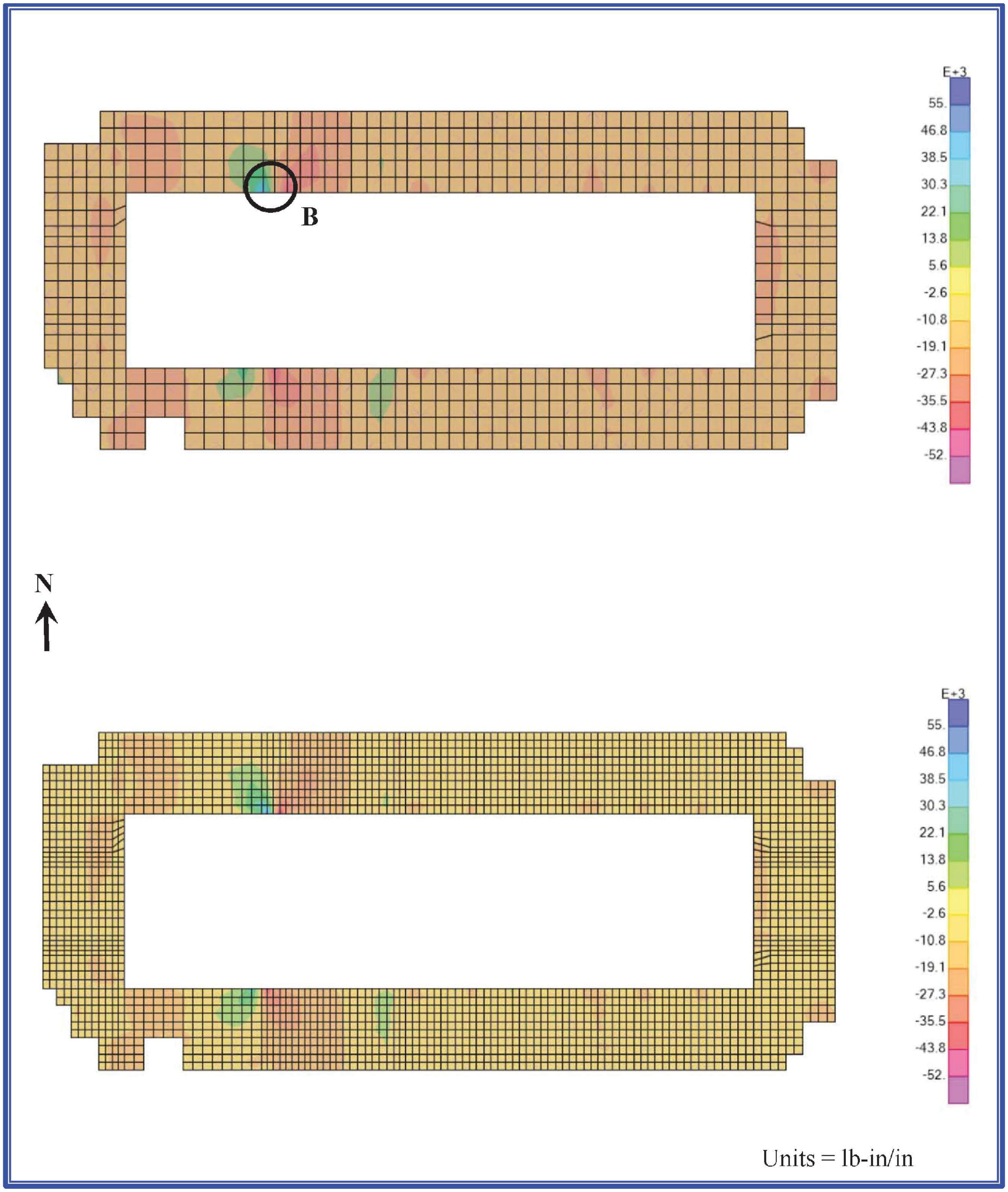

Figure 10: 1GY F12 Contours in Slab at EL 50'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum Moments in Slab at EL 75'-0"

Table 9 shows the comparison of averaged absolute maximum moments in RXB slab at EL 75'-0" at locations A (for M11) and B (for M22) for load case 1GZ. Figure 11 and Figure 12 show contours for M11 and M22 moments respectively for the FSAR model and refined mesh model.

Table 9: RXB Averaged Absolute Maximum Moments in Slab at EL 75'-0" Due to 1GZ (FSAR and Refined Model)

RXB Model	Moment About Global X Axis (M11) Lb-in/in	Moment About Global Y Axis (M22) Lb-in/in
FSAR Model	27,593 (Elem. 8749)	17,062 (Elem. 8374)
Refined Mesh Model	27,363 (Elem. 43428, 43429, 43430, 43431)	16,102 (Elem. 41928, 41929, 41930, 41931)

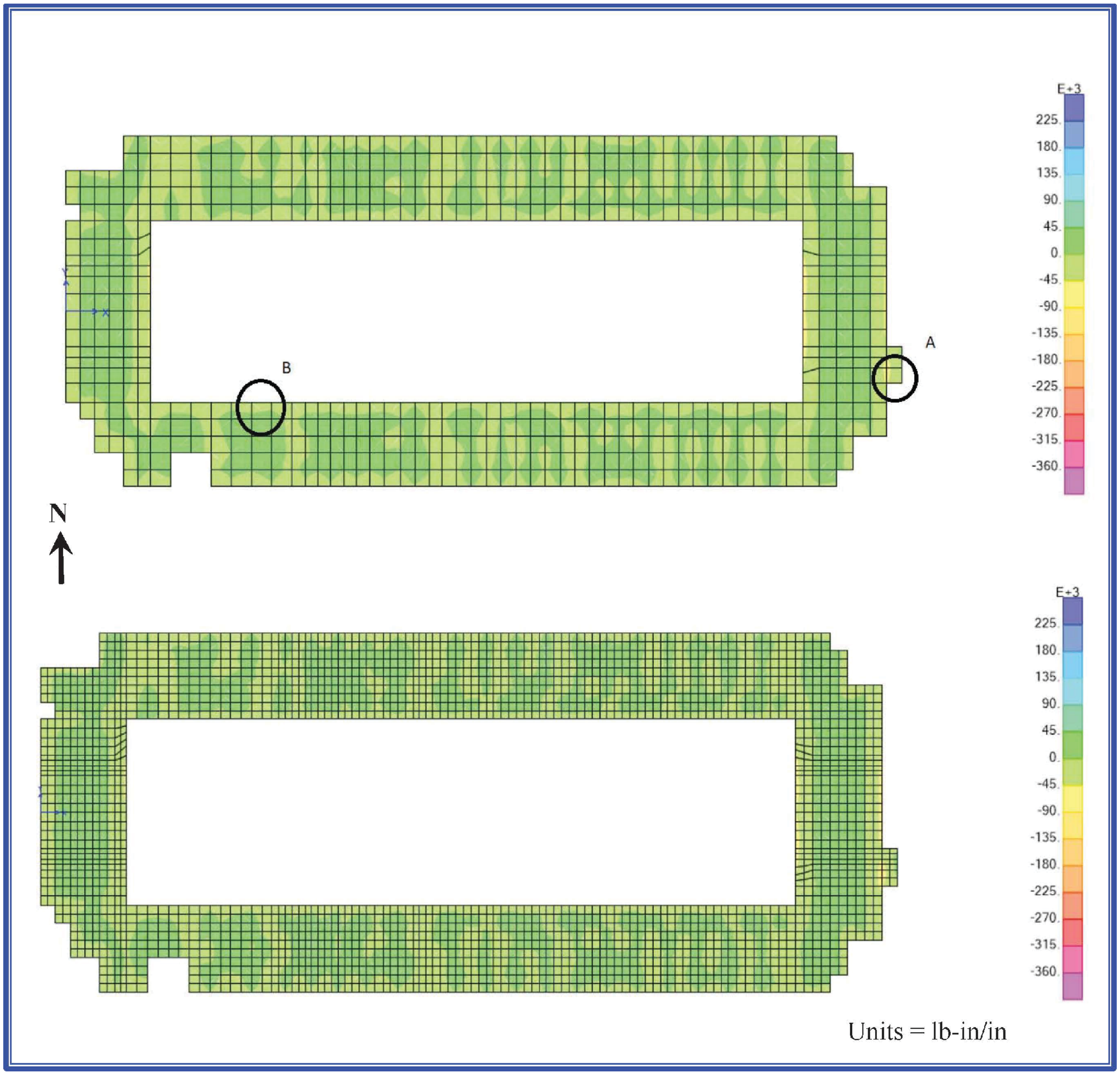

Figure 11: 1GZ M11 Contours for Slab at EL 75'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

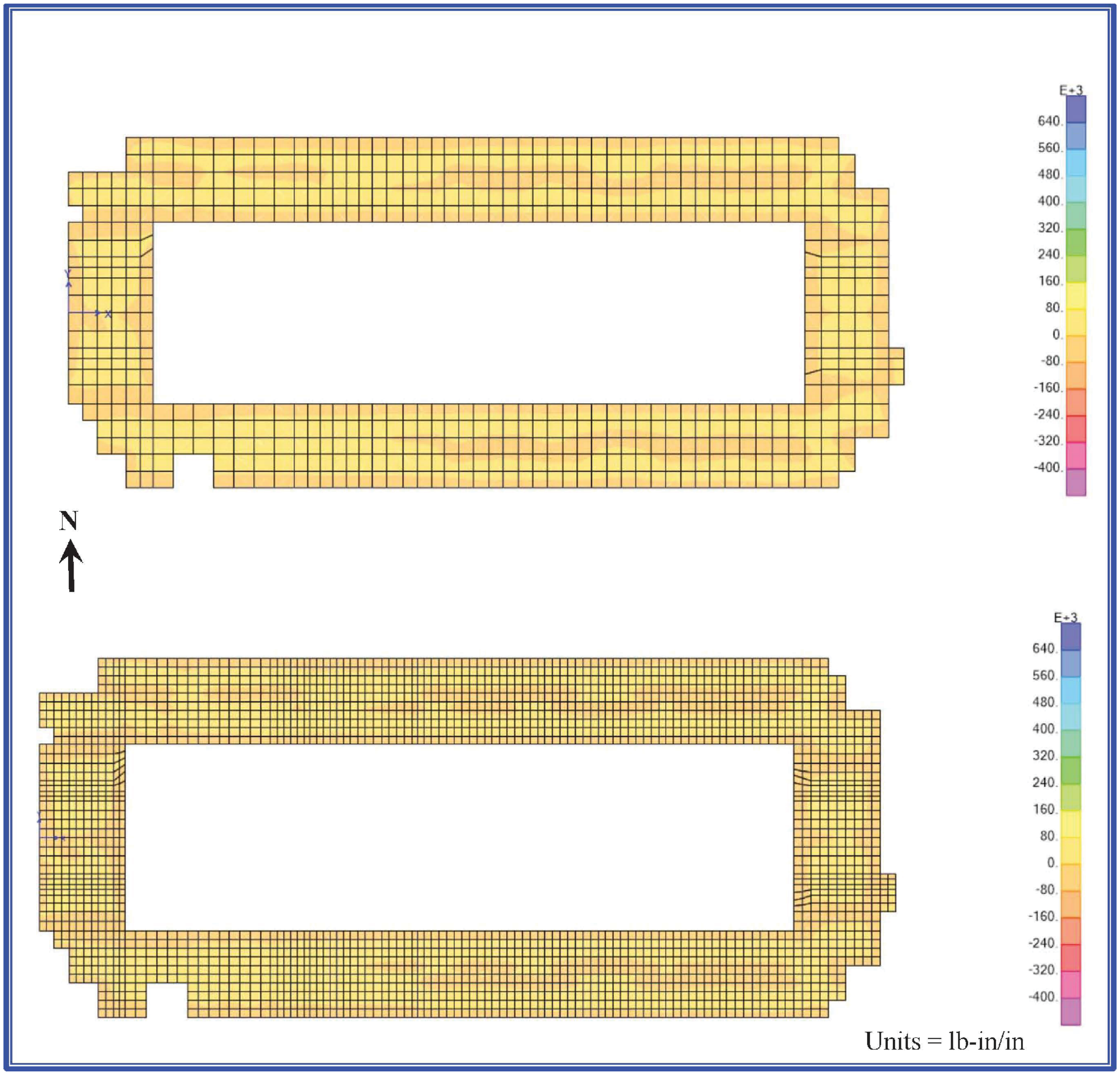

Figure 12: 1GZ M22 Contours for Slab at EL 75'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum In-Plane Shear in Slab at EL 75'-0"

Table 10 shows the comparison of averaged absolute maximum in-plane shears in RXB slab at EL 75'-0". Figure 13 and Figure 14 show the contours for the in-plane shear in the slab for 1GX and 1GY respectively. Areas marked “A” and “B” in figures represent the locations for maximum in-plane shears for 1GX and 1GY respectively.

Table 10: RXB Averaged Absolute Maximum In-Plane Shear in Slab at EL 75'-0" Due to 1GX and 1GY (FSAR and Refined Model)

RXB Model	In-Plane Shear (F12) for 1GX Lb/in	In-Plane Shear (F12) for 1GY Lb/in
FSAR Model	11,982 (Elem. 8312)	27,693 (Elem. 8336)
Refined Mesh Model	10,977 (Elem. 41680, 41681, 41682, 41683)	28,621 (Elem. 41776, 41777, 41778, 41779)

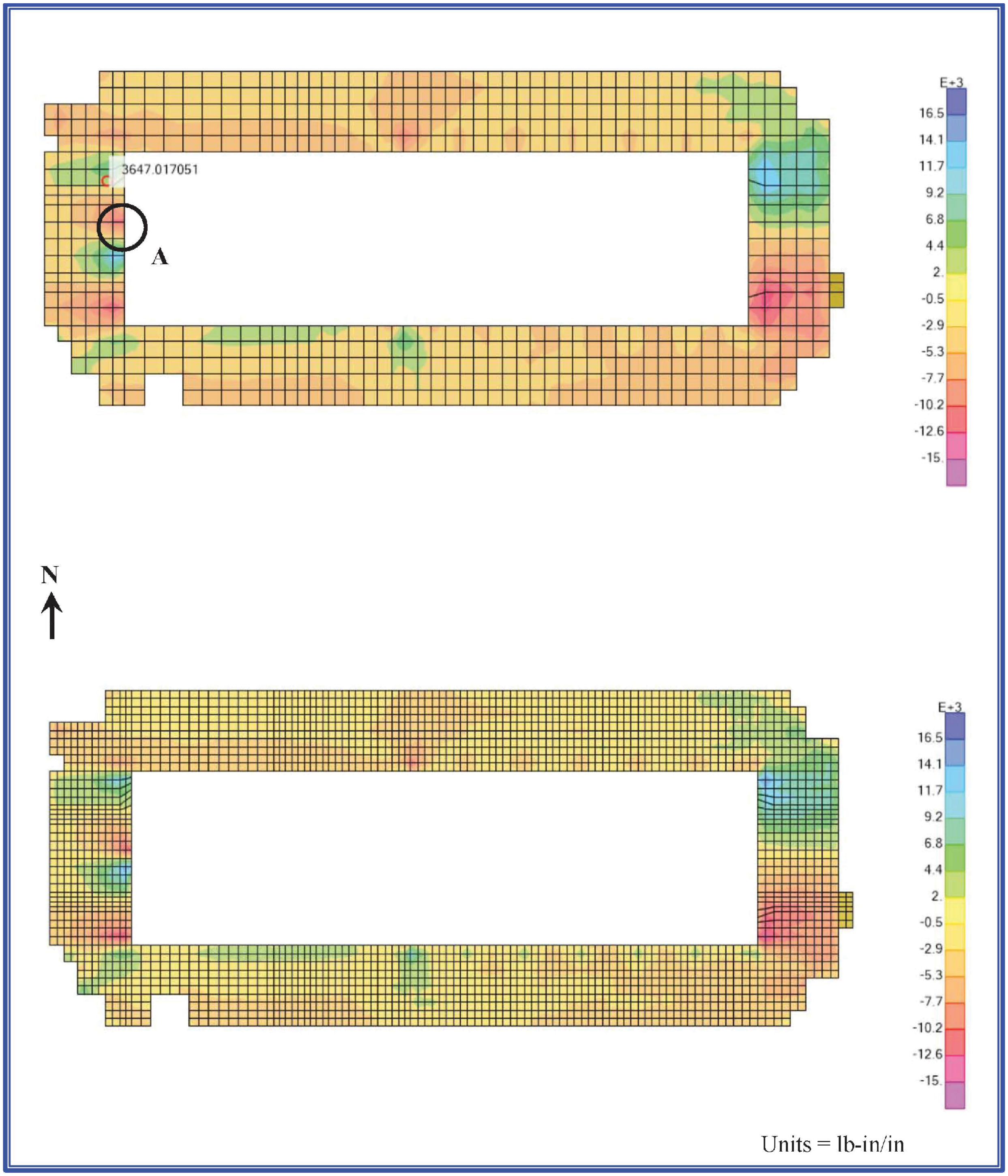

Figure 13: 1GX F12 Contours in Slab at EL 75'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

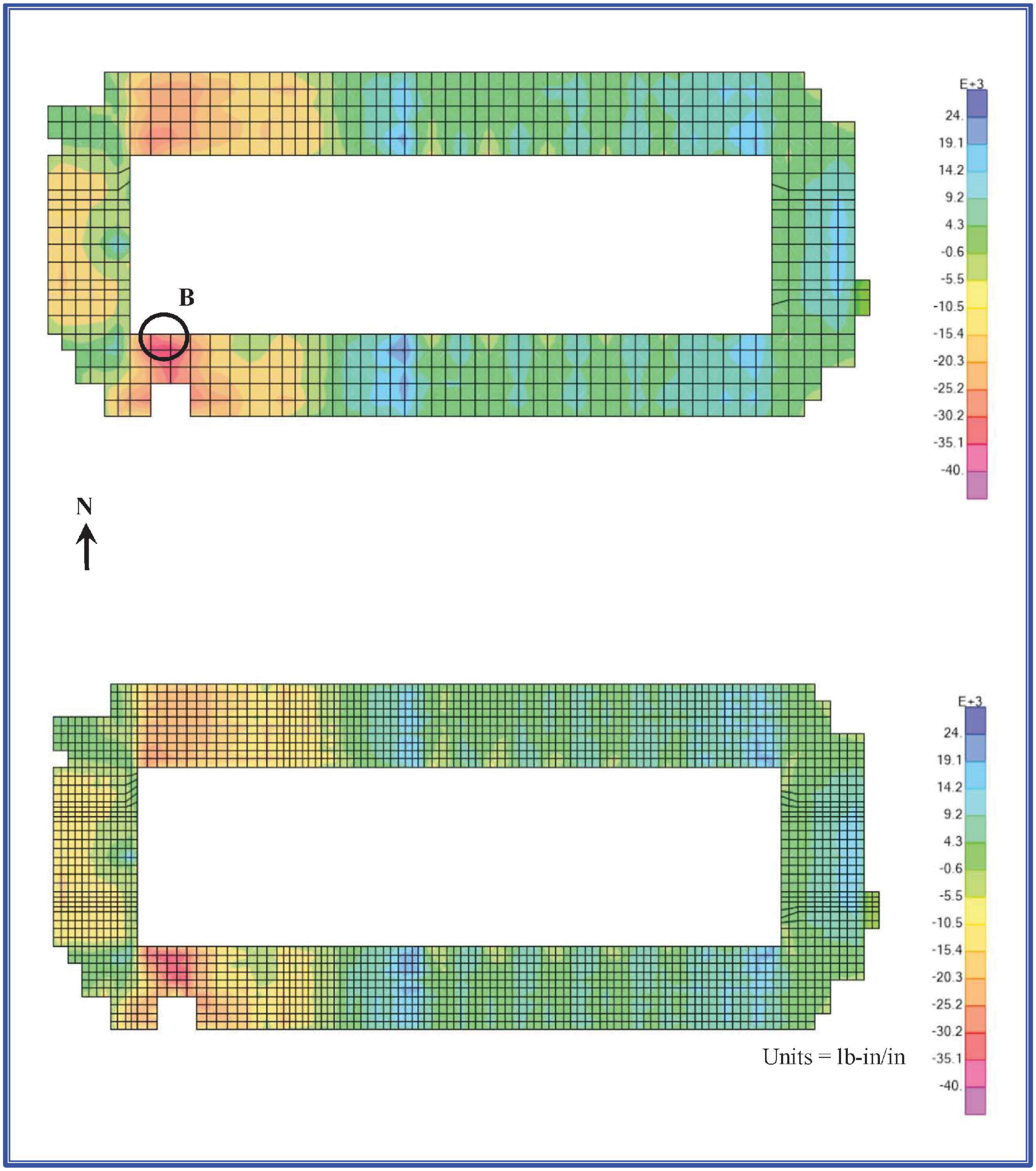

Figure 14: 1GY F12 Contours in Slab at EL 75'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum Moments in Slab at EL 100'-0"

Table 11 shows the comparison of averaged absolute maximum moments in RXB slab at EL 100'-0" at locations A (for M11) and B (for M22) for load case 1GZ. Figure 15 and Figure 16 show contours for M11 and M22 moments respectively for the FSAR model and refined mesh model.

Table 11: RXB Averaged Absolute Maximum Moments in Slab at EL 100'-0"Due to 1GZ (FSAR and Refined Model)

RXB Model	Moment About Global X Axis (M11) Lb-in/in	Moment About Global Y Axis (M22) Lb-in/in
FSAR Model	29,859 (Elem. 11787)	15,174 (Elem. 11850)
Refined Mesh Model	30,329 (Elem. 44164, 44165, 44166, 44167)	15,472 (Elem. 44416, 44417, 44418, 44419)

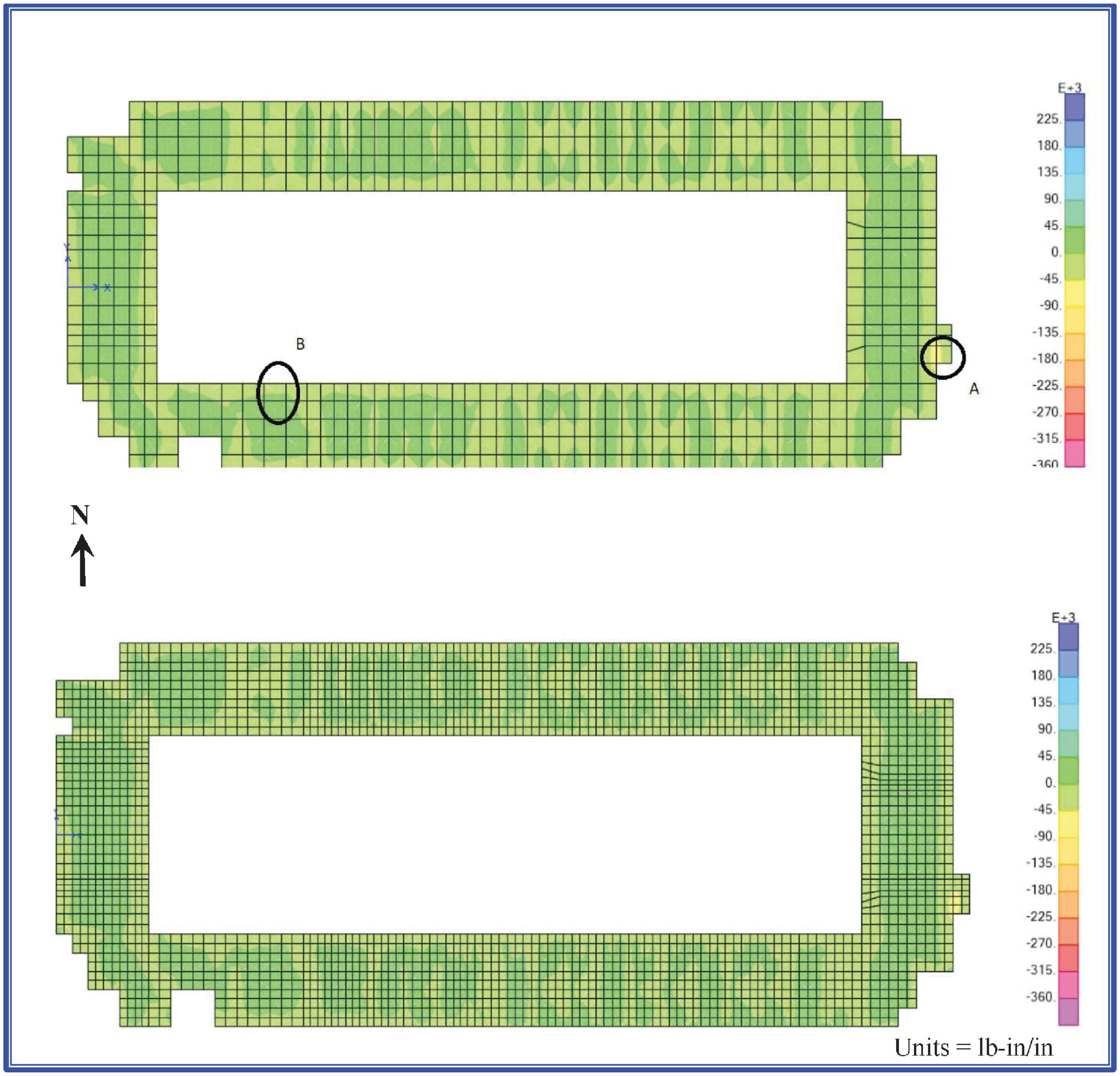

Figure 15: 1GZ M11 Contours for Slab at EL 100'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

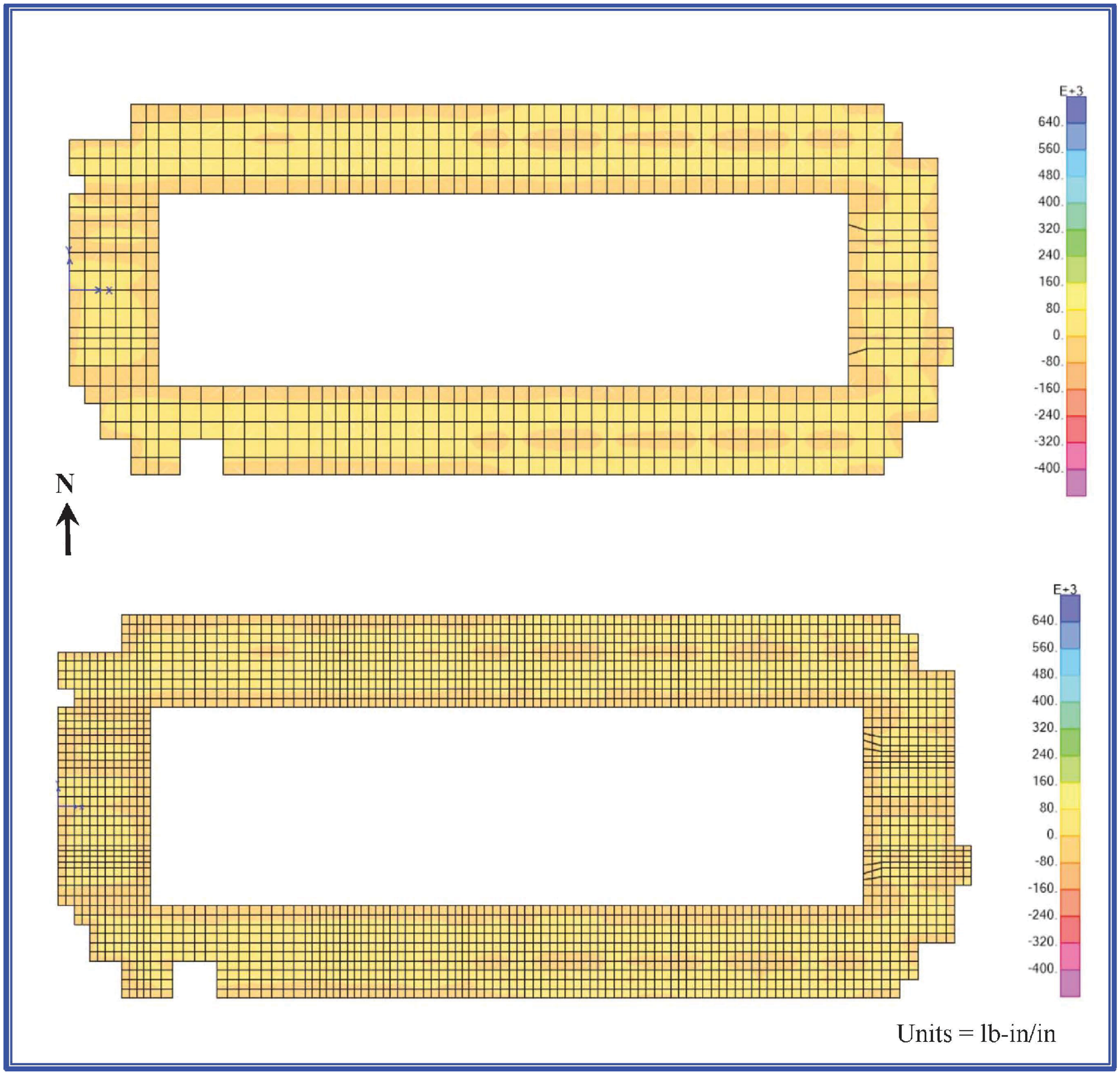

Figure 16: 1GZ M22 Contours for Slab at EL 100'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum In-Plane Shear in Slab at EL 100'-0"

Table 12 shows the comparison of averaged absolute maximum in-plane shears in RXB slab at EL 100'-0". Figure 17 and Figure 18 show the contours for the in-plane shear in the slab for 1GX and 1GY respectively. Areas marked “A” and “B” in figures represent the locations for maximum in-plane shears for 1GX and 1GY respectively.

Table 12: RXB Averaged Absolute Maximum In-Plane Shear in Slab at EL 100'-0" Due to 1GX and 1GY (FSAR and Refined Model)

RXB Model	In-Plane Shear (F12) for 1GX Lb/in	In-Plane Shear (F12) for 1GY Lb/in
FSAR Model	9,188 (Elem. 11788)	32,937 (Elem. 11804)
Refined Mesh Model	8,094 (Elem. 44168, 44169, 44170, 44171)	31,748 (Elem. 44232, 44233, 44234, 44235)

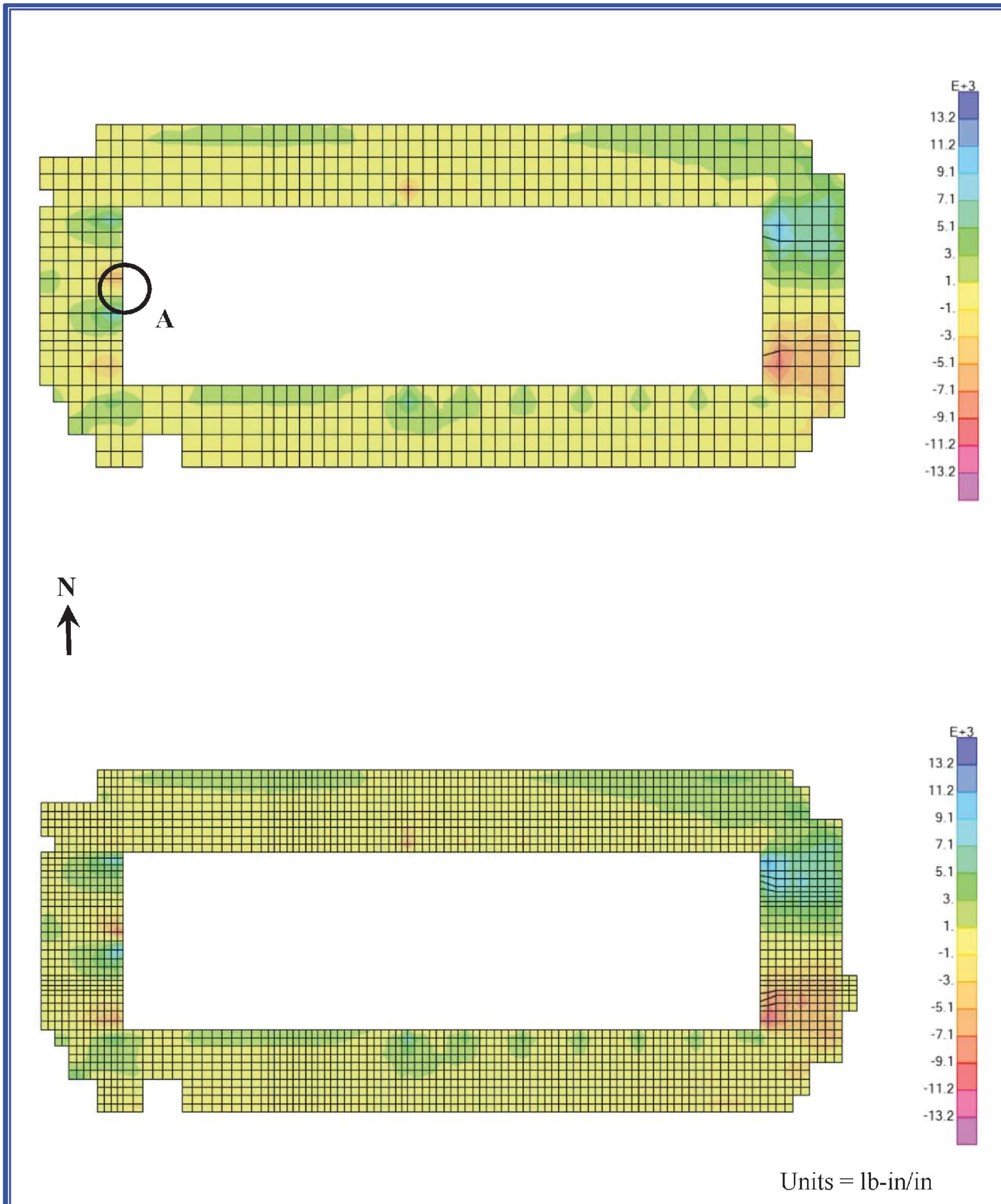

Figure 17: 1GX F12 Contours in Slab at EL 100'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

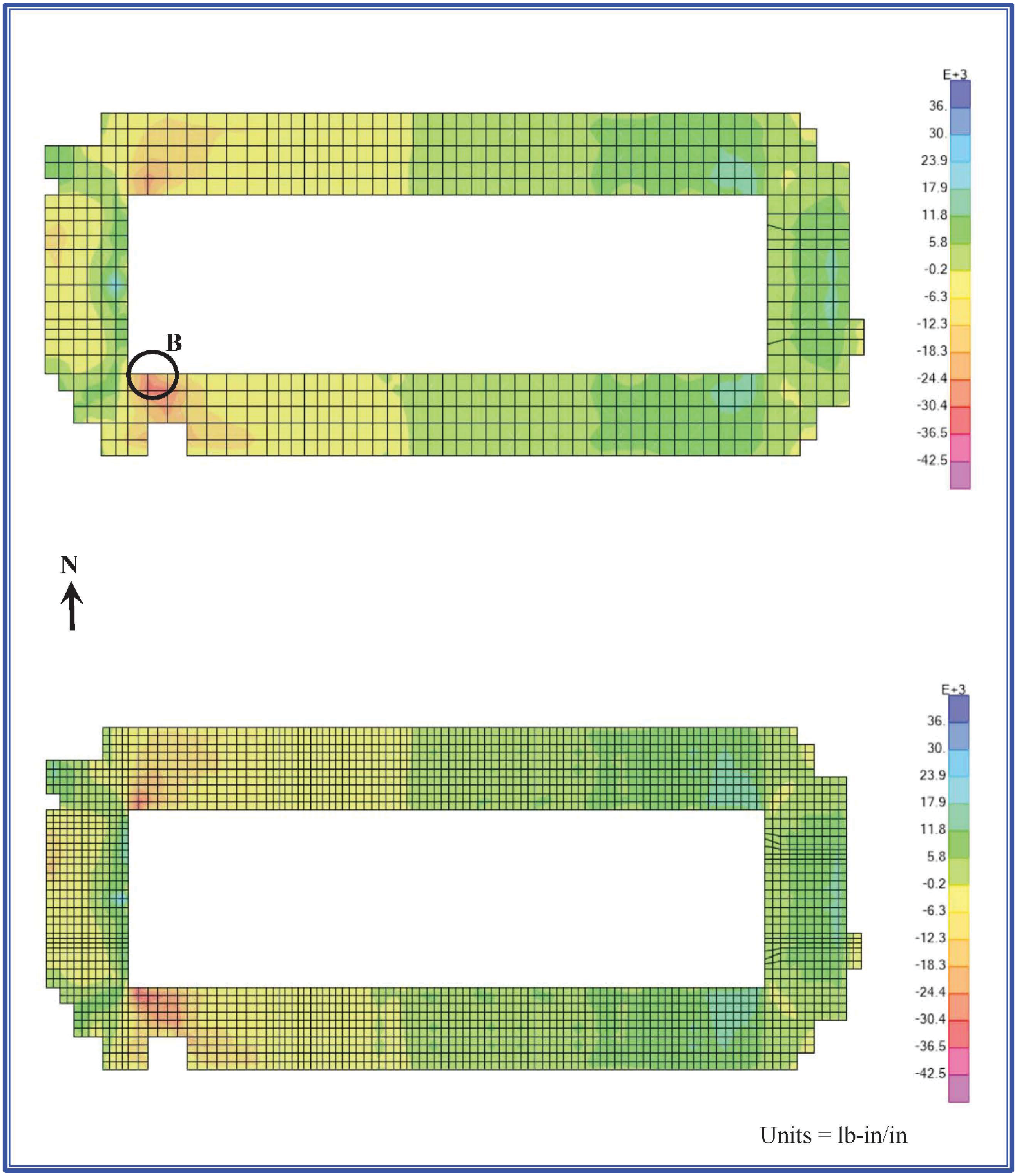

Figure 18: 1GY F12 Contours in Slab at EL 100'-0" for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

RXB Averaged Absolute Maximum Moments in North Outer Wall.

Table 13 shows the comparison of averaged absolute maximum moments in RXB north outer wall for load case 1GY. Figure 19 and Figure 20 show contours for M11 and M22 moments respectively for the FSAR model and refined mesh model.

Table 13: RXB Averaged Absolute Maximum Moments in North Outer Wall Due to 1GY (FSAR and Refined Model)

RXB Model	Moment About Global X Axis (M11) Lb-in/in	Moment About Global Y Axis (M22) Lb-in/in
FSAR Model	135,309 (Elem. 14720)	386,806 (Elem. 2769)
Refined Mesh Model	138,200 (Elem. 28555, 28556, 28557,28558)	399,033 (Elem. 19135,19136, 19137, 19138)

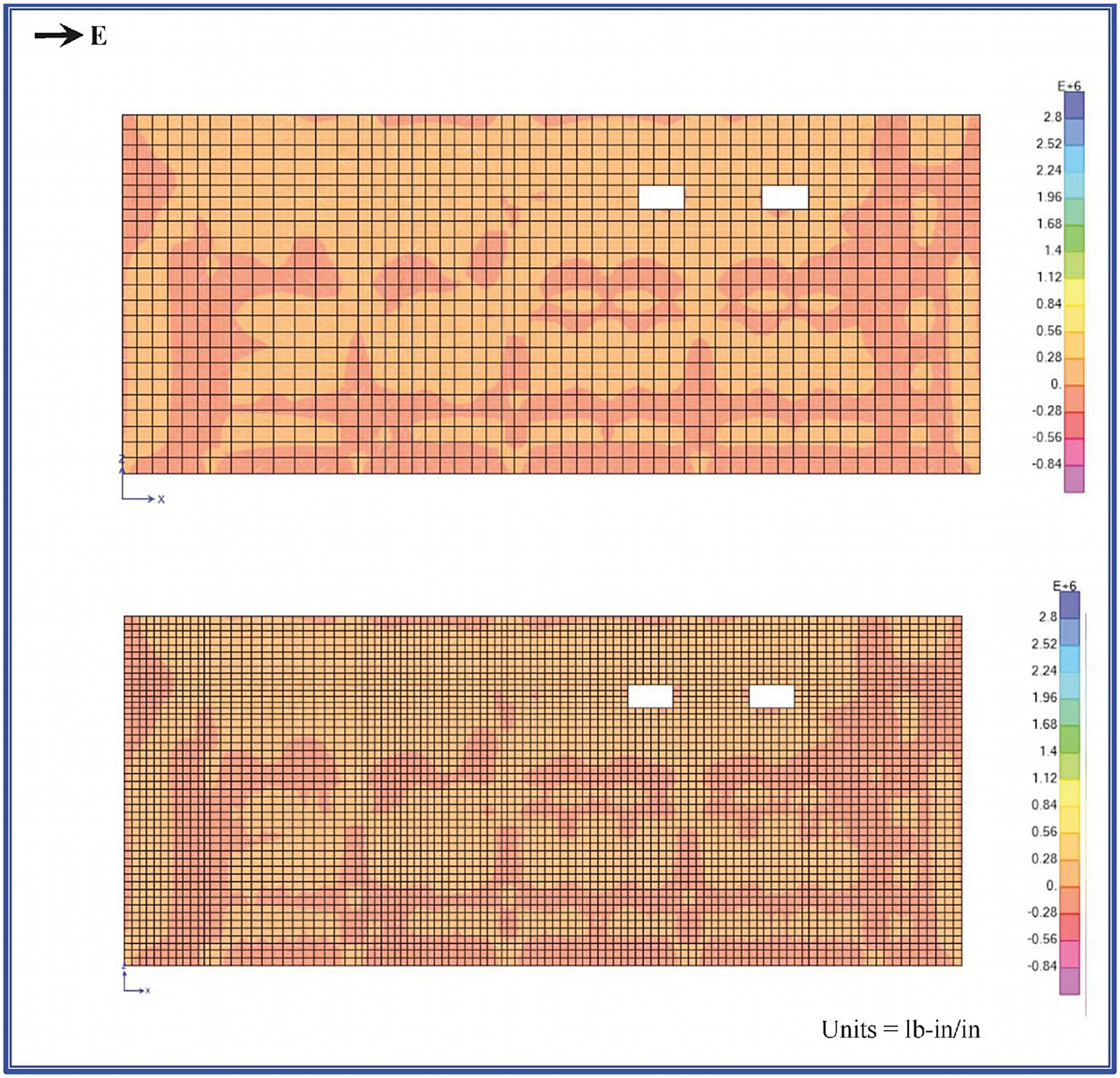

Figure 19: 1GY M11 Contours for North Outer Wall for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)

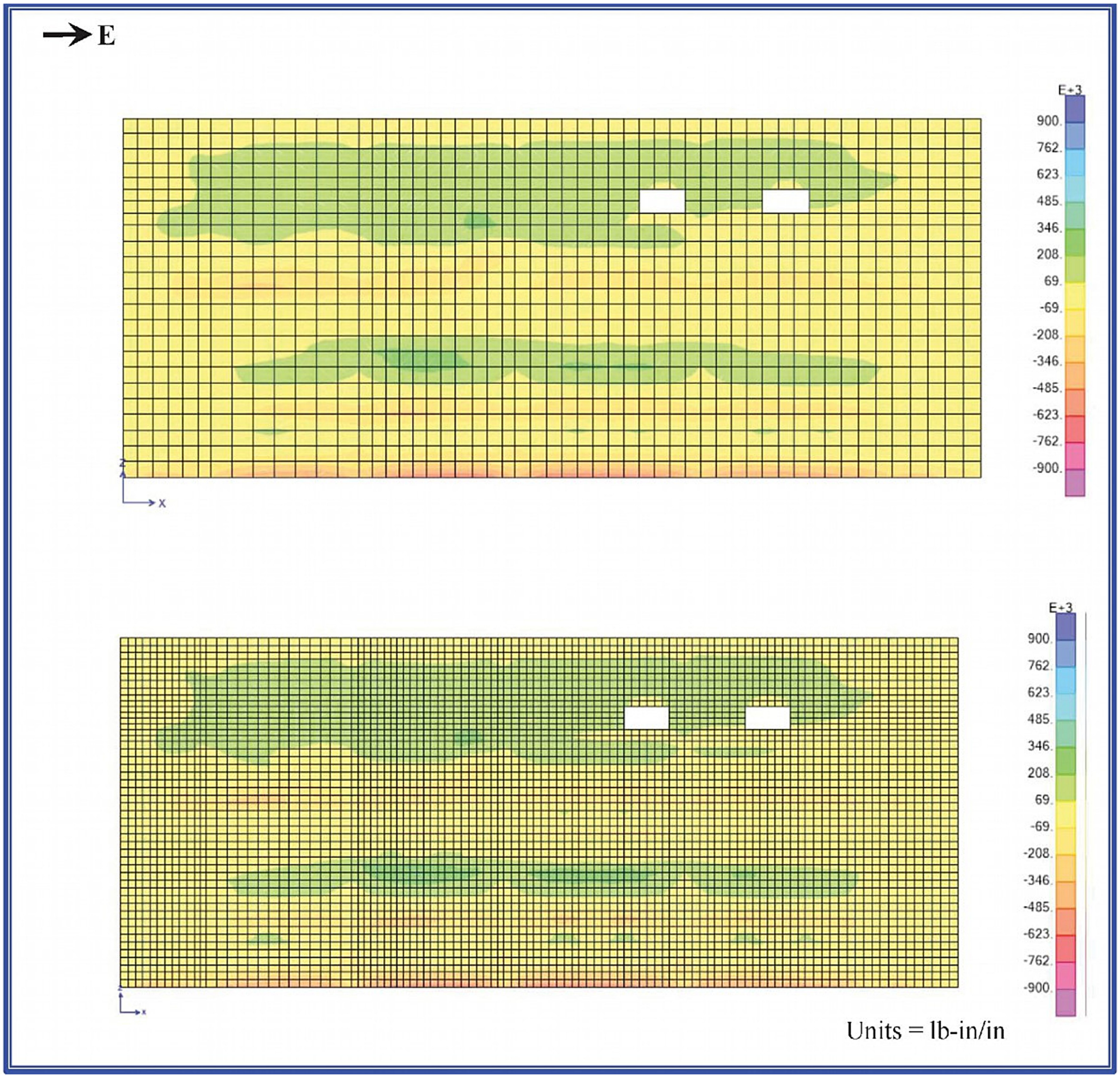

Figure 20: 1GY M22 Contours for North Outer Wall for the FSAR RXB Model (Top) and RXB Refined Mesh Model (Bottom)