RAIO-1217-57507

December 06, 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 Supplemental 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)," dated September 27, 2017

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

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

- 03.07.02-2
- 03.07.02-3

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
Samuel Lee, NRC, OWFN-8G9A
Marieliz Vera, NRC, OWFN-8G9A

Enclosure 1: NuScale Supplemental Response to NRC Request for Additional Information eRAI No. 8932

Enclosure 1:

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

NuScale Power

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

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

NRC Question No.: 03.07.02-2

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.

On Page 3.7-20 of the FSAR, in the third paragraph, the applicant states, "The building models have element sizes that are similar to the 6.25 feet layers that were used to determine the wave passage frequency of the soil. There are instances where development of the model required individual elements to have a dimension as large as 12 feet in the RXB and as large as 20 feet in the CRB. However, the typical element size is approximately 6 feet. Therefore the wave passage frequencies of both buildings is above the cut-off frequencies used for the analysis." For elements that have a dimension of 12 ft or 20 ft, the applicant is requested to provide the elements locations in the building, and explain how the presence of these coarse elements do not affect the results of seismic demand analyses for the RXB and CRB.

NuScale Response:

As discussed, during a public meeting with the staff on November 7, 2017, the description of coarse elements provided in NuScale's original response to RAI 8932 03.07.02-2 is added to FSAR Tier 2, Section 3.7.2.1.1.3.

Impact on DCA:

FSAR Tier 2, Section 3.7.2.1.1.3 has been revised as described in the response above and as shown in the markup provided in this response.

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

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

NRC Question No.: 03.07.02-3

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.

a. On Page 3.7-20 of the FSAR, in the first paragraph, the applicant states, "For the analysis of Soil Types 7, 8 and 11 with the CSDRS the cut-off frequency was established at 52 Hz. This is higher than the wave passing frequency of the soft soil profile (Soil Type 11) but less than the passing frequency of the other two soils (see Table 3.7.1-20)." Table 3.7.1-20 shows 12 Hz as the passing frequency of Soil Type 11. Tables 3.7.2-18 and 19 indicate the transfer functions (TFs) are calculated for frequencies up to 52 Hz (cut-off frequency) for Soil Type 11. The applicant is requested to justify the validity of the TF calculations for frequencies beyond the passing frequency for Soil Type 11.

b. On Page 3.7-20 of the FSAR, in the first paragraph, the applicant states, "For the analysis of Soil Types 7, 8 and 11 with the CSDRS, the cut-off frequency was established at 52 Hz." However, in Table 3.7.2- 19, for Soil Type 7 with the CSDRS, a cut-off frequency of 72 Hz is used. The applicant is requested to clarify the inconsistency.

c. On Page 3.7-20 of the FSAR, in the second paragraph, the applicant states, "For the analysis with the rock profiles (Soil Type 7 and 9) and the CSDRS-HF, the cut-off frequency was established at 72 Hz." However, in Table 3.7.2-21, for Soil Type 9 with the CSDRS-HF, a cut-off frequency of 52 Hz is used. The applicant is requested to clarify the inconsistency. Also, Table 3.7.2-21 does not provide analysis frequencies for Soil Types 8 and 11 with CSDRS and for Soil Type 7 with CSDRS-HF. Please explain why these frequencies are not provided.

d. In Figure 3.7.2-20 in the FSAR, The applicant is requested to clarify if the bottom two layers represent the basemat which is to be considered as part of the RXB and color-coded accordingly (in blue). The figure also appears to show mixed coloring for certain elements in the bottom two layers. Please explain what the mixed colors represent for these elements.

NuScale Response:

As discussed, during a public meeting with the NRC staff on November 7, 2017, the following information is provided to supplement NuScale's original response to RAI 8932 03.07.02-3.

A note has been added to FSAR Tier 2, Table 3.7.2-19 to explain the cutoff frequencies used. A note has also been added to Table 3.7.2-21 to explain that Soil Types 8 and 11 with the certified seismic design response spectra (CSDRS) and Soil Type 7 with the high frequency certified seismic design spectra (CSDRS-HF) are not considered and that frequencies used to study the structural response of the control building (CRB) have been limited to 52 Hz.

A legend has been added to Figure 3.7.2-67. Similarly, a legend has been added to other SASSI2010 model figures, for clarity.

Impact on DCA:

FSAR Tier 2 Tables 3.7.2-19 and 3.7.2-21 and FSAR Tier 2, Figure 3.7.2-67 have been revised as described in the response above and as shown in the markup provided in this response.

backfill soil. Beyond the 25 foot backfill soil region, SASSI2010 extends the parameters of the in-situ or free-field soil (i.e., Soil Type 7, 8, 9 or 11) as a semi-infinite elastic half space.

Free-field soil is included in the triple building model. This model has an overall length of 2005.5 feet, a width of 768.5 feet and a depth of 360 feet. For dynamic analysis of the triple building model using SASSI2010, the free field boundaries extends to elastic halfspace implicitly. This is accomplished by SASSI2010 itself. For static analyses, the SAP2000 models explicitly adds the free field soil beyond the backfill soil boundaries. The triple building model is used to determine the static response of the three buildings including the effects of differential displacements. The vertical depth is deeper than the SSI model. At this depth, the vertical displacement become insignificant due to soil stiffness. The horizontal boundaries are also extended a sufficient distance to have insignificant change in the static response of the buildings.

Cut-off Frequency

For the analysis of Soil Types 7, 8 and 11 with the CSDRS the cut-off frequency was established at 52 Hz. This is higher than the wave passing frequency of the soft soil profile (Soil Type 11) but less than the passing frequency of the other two soils (see Table 3.7.1-20). The low wave passing frequency of the soft soil is not a concern. Although high frequency content is not transmitted into or through the building for Soil Type 11, it is transmitted by the Soil Type 7 and Soil Type 8 profiles and by the Soil Type 7 and Soil Type 9 profiles evaluated with the CSDRS-HF. The buildings and associated SSC are designed to remain operable following any of these earthquake/soil combinations, therefore high frequency content is addressed in the design of the site independent Seismic Category I structures by the use of soil profiles that are stiffer than Soil Type 11.

For the analysis with the rock profiles (Soil Type 7 and 9) and the CSDRS-HF, the cut-off frequency was established at 72 Hz. ~~The CSDRS-HF cut-off frequency is less than the peak ground acceleration, which occurs at 100 Hz.~~The CSDRS-HF at a cut-off frequency of 72 Hz is less than the peak ground acceleration frequency, which occurs at 100 Hz. Using a 72 Hz cut off frequency is acceptable because it is above the frequency where maximum acceleration occurs (25 Hz horizontal and 50 Hz vertical).

RAI 03.07.02-2S1, RAI 03.07.02-3S1

The building models have element sizes that are similar to the 6.25 feet layers that were used to determine the wave passage frequency of the soil. There are instances where development of the ~~mol~~model required individual elements to have a dimension as large as 12 feet in the RXB and as large as 20 feet in the CRB. However, the typical element size is approximately 6 feet. Therefore the wave passage frequencies of both buildings is above the cut-off frequencies used for the analysis.

RAI 03.07.02-2S1, RAI 03.07.02-3S1

In the CRB model, the elements with large dimensions or aspect ratios are nonstructural areas or membrane elements used for the purpose of applying wind loads to the steel beams and columns of the steel frame structure above elevation 120 ft. The 20 ft elements are located on the north and south walls whereas the 12 ft elements are located on the east and west walls above elevation 120 ft. Similar surface area loads are applied to the CRB roof to evenly distribute applied loads. The loads are applied as surface pressure on these areas and then transferred to the structural elements through the shared nodes. These coarse elements are not present in the seismic analyses and will therefore not affect the seismic demand results. In the RXB model, there are 24 elements with approximate dimensions of 12 ft x 6 ft at the pool floor. These are transition solid elements beginning in the top layer of solid elements used to model the basemat. The mesh transitions into the uniform soil mesh, matching the soil interaction nodes at the base elevation of the basemat, with an average element size of approximately 6.25 ft. The single layer of coarse basemat transition elements have minimal or no effect on the seismic analysis results.

Modeling Approach

Analysis Methods

There are several modeling approaches that can be used for modeling the excavated soil in the SSI analysis: the direct method (DM), the subtraction method (SM), the modified subtraction method (MSM), and the extended subtraction method (ESM). Each method has different computational demands. A brief discussion of the different methods follows:

The direct method partitions the soil structure system between the building and the excavated soils. It requires only the free-field motions and the free-field soil impedances to compute the seismic excitations on the foundation of structure. The soils to be excavated are retained with the foundation. Therefore, interaction between the structure and the foundation is calculated at all excavated soil nodes. In the analysis, the DM treats all translational degrees of freedoms of the excavated soil as SSI interaction nodes. This corresponds to a theoretical exact SSI model for the excavated soil dynamics. DM analysis is computationally intensive and cannot be used with the large detailed models created for the NuScale buildings.

To reduce computational time, a simplified method, called the subtraction method was developed. The SM assumes only the nodes at interface of the excavated soil volume and surrounding free field soils as interaction nodes. In mathematical implementation, only those specified interaction nodes are described by correct equations of motion. The seismic load component and free field soil impedance are neglected for the non-interaction nodes within the excavated soil volume. Therefore the excavated soil motion can produce spurious vibration modes. This simplification results in anomalies in the transfer functions, usually seen as spurious spikes for soft free field soils at relative high frequency ranges. The SM approach for the excavated soil can be

RAI 03.07.02-2S1, RAI 03.07.02-3S1

Table 3.7.2-19: Frequencies Used in Transfer Function Calculation for RXB from Triple Building Model

No.	For CSDRS Inputs						For CSDRS-HF Inputs			
	Soil Type 11		Soil Type 8		Soil Type 7		Soil Type 7		Soil Type 9	
	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)
1	1	0.01221	1	0.01221	1	0.01221	1	0.01221	1	0.01221
2	41	0.5005	41	0.5005	41	0.5005	41	0.5005	41	0.5005
3	82	1.001	82	1.001	82	1.001	82	1.001	82	1.001
4	123	1.501	123	1.501	123	1.501	123	1.501	125	1.526
5	164	2.002	164	2.002	164	2.002	164	2.002	164	2.002
6	186	2.271	205	2.502	205	2.502	205	2.502	205	2.502
7	205	2.502	246	3.003	246	3.003	246	3.003	246	3.003
8	246	3.003	258	3.149	258	3.149	258	3.149	258	3.149
9	258	3.149	281	3.43	281	3.43	281	3.43	281	3.43
10	281	3.43	287	3.503	287	3.503	287	3.503	287	3.503
11	287	3.503	328	4.004	328	4.004	328	4.004	328	4.004
12	328	4.004	369	4.504	369	4.504	369	4.504	369	4.504
13	369	4.504	410	5.005	410	5.005	410	5.005	410	5.005
14	410	5.005	451	5.505	451	5.505	451	5.505	451	5.505
15	451	5.505	493	6.018	493	6.018	493	6.018	493	6.018
16	493	6.018	533	6.506	533	6.506	533	6.506	533	6.506
17	533	6.506	574	7.007	574	7.007	574	7.007	574	7.007
18	574	7.007	615	7.507	615	7.507	615	7.507	615	7.507
19	615	7.507	656	8.008	656	8.008	656	8.008	656	8.008
20	656	8.008	697	8.508	697	8.508	697	8.508	697	8.508
21	697	8.508	738	9.009	738	9.009	738	9.009	738	9.009
22	738	9.009	779	9.509	779	9.509	779	9.509	779	9.509
23	779	9.509	820	10.01	820	10.01	820	10.01	820	10.01
24	820	10.01	861	10.51	861	10.51	861	10.51	861	10.51
25	861	10.51	902	11.01	902	11.01	902	11.01	902	11.01
26	902	11.01	943	11.51	943	11.51	943	11.51	943	11.51
27	943	11.51	984	12.01	984	12.01	984	12.01	984	12.01
28	984	12.01	1024	12.5	1024	12.5	1024	12.5	1024	12.5
29	1024	12.5	1065	13	1065	13	1065	13	1065	13

Table 3.7.2-19: Frequencies Used in Transfer Function Calculation for RXB from Triple Building Model (Continued)

No.	For CSDRS Inputs						For CSDRS-HF Inputs			
	Soil Type 11		Soil Type 8		Soil Type 7		Soil Type 7		Soil Type 9	
	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)
60	3441	42	3605	44.01	3605	44.01	3605	44.01	3605	44.01
61	3605	44.01	3769	46.01	3769	46.01	3769	46.01	3769	46.01
62	3769	46.01	3933	48.01	3933	48.01	3933	48.01	3933	48.01
63	3851	47.01	4096	50	4096	50	4096	50	4096	50
64	3933	48.01	4260	52	4260	52	4260	52	4260	52
65	4014	49	-	-	4424	54	4424	54	4424	54
66	4096	50	-	-	4588	56.01	4588	56.01	4588	56.01
67	4178	51	-	-	4752	58.01	4752	58.01	4752	58.01
68	4260	52	-	-	4916	60.01	4916	60.01	4916	60.01
69	-	-	-	-	5080	62.01	5080	62.01	5080	62.01
70	-	-	-	-	5243	64	5243	64	5243	64
71	-	-	-	-	5407	66	5407	66	5407	66
72	-	-	-	-	5571	68.01	5571	68.01	5571	68.01
73	-	-	-	-	5735	70.01	5735	70.01	5735	70.01
74	-	-	-	-	5899	72.01	5899	72.01	5899	72.01

Note: The cutoff frequency for Soil Type 7 with the certified seismic design response spectra (CSDRS) is established at 52 Hz. For the reactor building (RXB) from the Triple Building Model, additional frequencies were added to ensure all of the seismic input motion was captured and to ensure there were no peaks in the transfer functions.

RAI 03.07.02-2S1, RAI 03.07.02-3S1

Table 3.7.2-21: Frequencies Used in Transfer Function Calculation for CRB with Triple Building CRB Model

No.	For CSDRS Inputs						For CSDRS-HF Inputs			
	Soil Type 11		Soil Type 8		Soil Type 7		Soil Type 7		Soil Type 9	
	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)
1	-	-	-	-	1	0.01221	-	-	1	0.01221
2	-	-	-	-	41	0.5005	-	-	41	0.5005
3	-	-	-	-	82	1.001	-	-	82	1.001
4	-	-	-	-	123	1.501	-	-	123	1.501
5	-	-	-	-	164	2.002	-	-	164	2.002
6	-	-	-	-	205	2.502	-	-	205	2.502
7	-	-	-	-	246	3.003	-	-	246	3.003
8	-	-	-	-	258	3.149	-	-	258	3.149
9	-	-	-	-	281	3.43	-	-	281	3.43
10	-	-	-	-	287	3.503	-	-	287	3.503
11	-	-	-	-	328	4.004	-	-	328	4.004
12	-	-	-	-	369	4.504	-	-	369	4.504
13	-	-	-	-	410	5.005	-	-	410	5.005
14	-	-	-	-	451	5.505	-	-	451	5.505
15	-	-	-	-	493	6.018	-	-	493	6.018
16	-	-	-	-	533	6.506	-	-	533	6.506
17	-	-	-	-	574	7.007	-	-	574	7.007
18	-	-	-	-	615	7.507	-	-	615	7.507
19	-	-	-	-	656	8.008	-	-	656	8.008
20	-	-	-	-	697	8.508	-	-	697	8.508
21	-	-	-	-	738	9.009	-	-	738	9.009
22	-	-	-	-	779	9.509	-	-	779	9.509
23	-	-	-	-	820	10.01	-	-	820	10.01
24	-	-	-	-	861	10.51	-	-	861	10.51
25	-	-	-	-	902	11.01	-	-	902	11.01
26	-	-	-	-	943	11.51	-	-	943	11.51
27	-	-	-	-	984	12.01	-	-	984	12.01
28	-	-	-	-	1024	12.5	-	-	1024	12.5
29	-	-	-	-	1065	13	-	-	1065	13

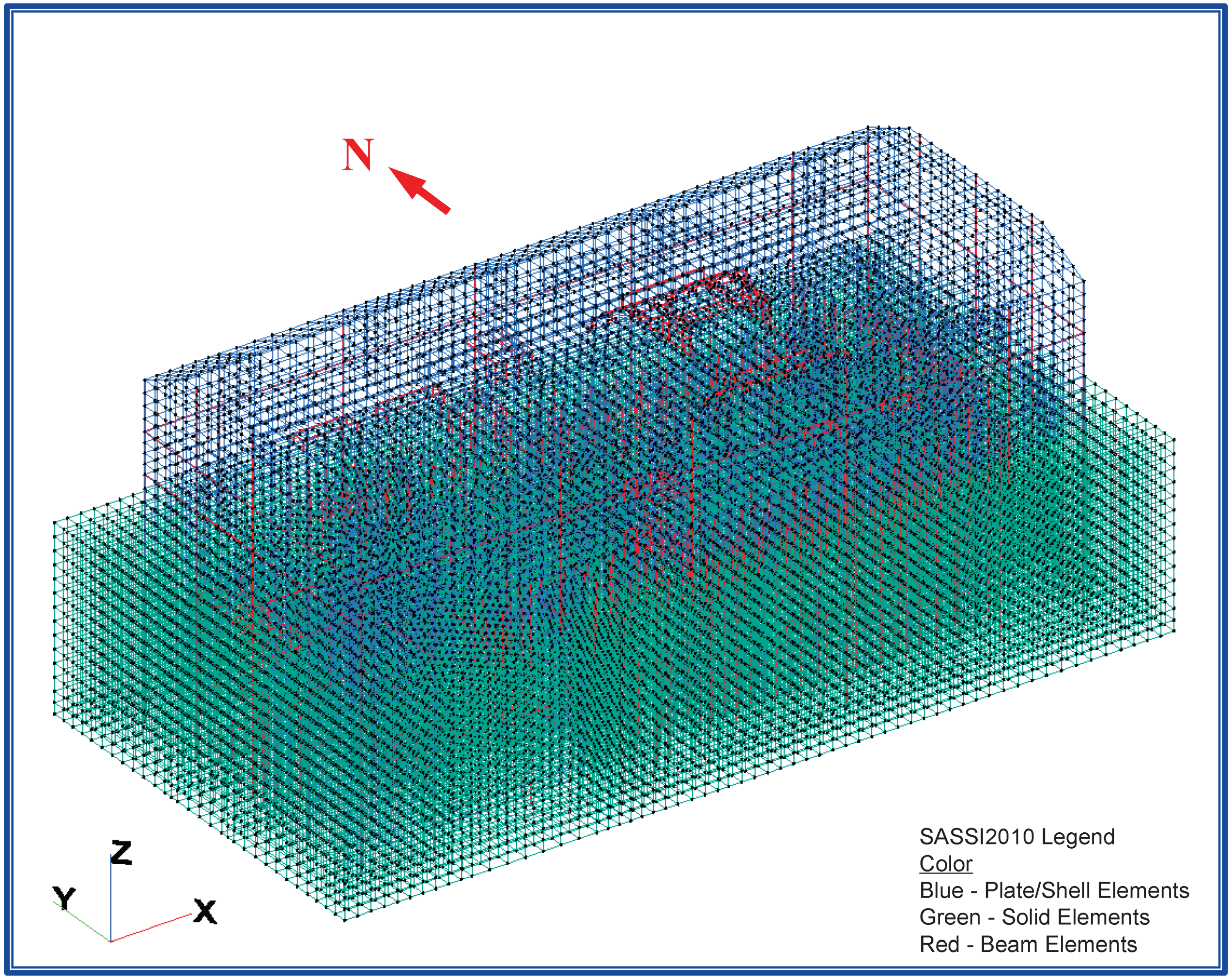
Table 3.7.2-21: Frequencies Used in Transfer Function Calculation for CRB with Triple Building CRB Model (Continued)

No.	For CSDRS Inputs						For CSDRS-HF Inputs			
	Soil Type 11		Soil Type 8		Soil Type 7		Soil Type 7		Soil Type 9	
	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)	No. of Frequency Steps	Frequency (Hz)
90	-	-	-	-	-	-	-	-	-	-
91	-	-	-	-	-	-	-	-	-	-
92	-	-	-	-	-	-	-	-	-	-
93	-	-	-	-	-	-	-	-	-	-

Note: Soil Types 8 and 11 with the CSDRS and Soil Type 7 with the CSDRS-HF are not considered for the design because, in general, the controlling case for the CRB is the Soil Type 7 with CSDRS. The frequencies in this table are used to study the structural response of the CRB where high frequencies are expected to be non-damaging and have been limited to 52 Hz.

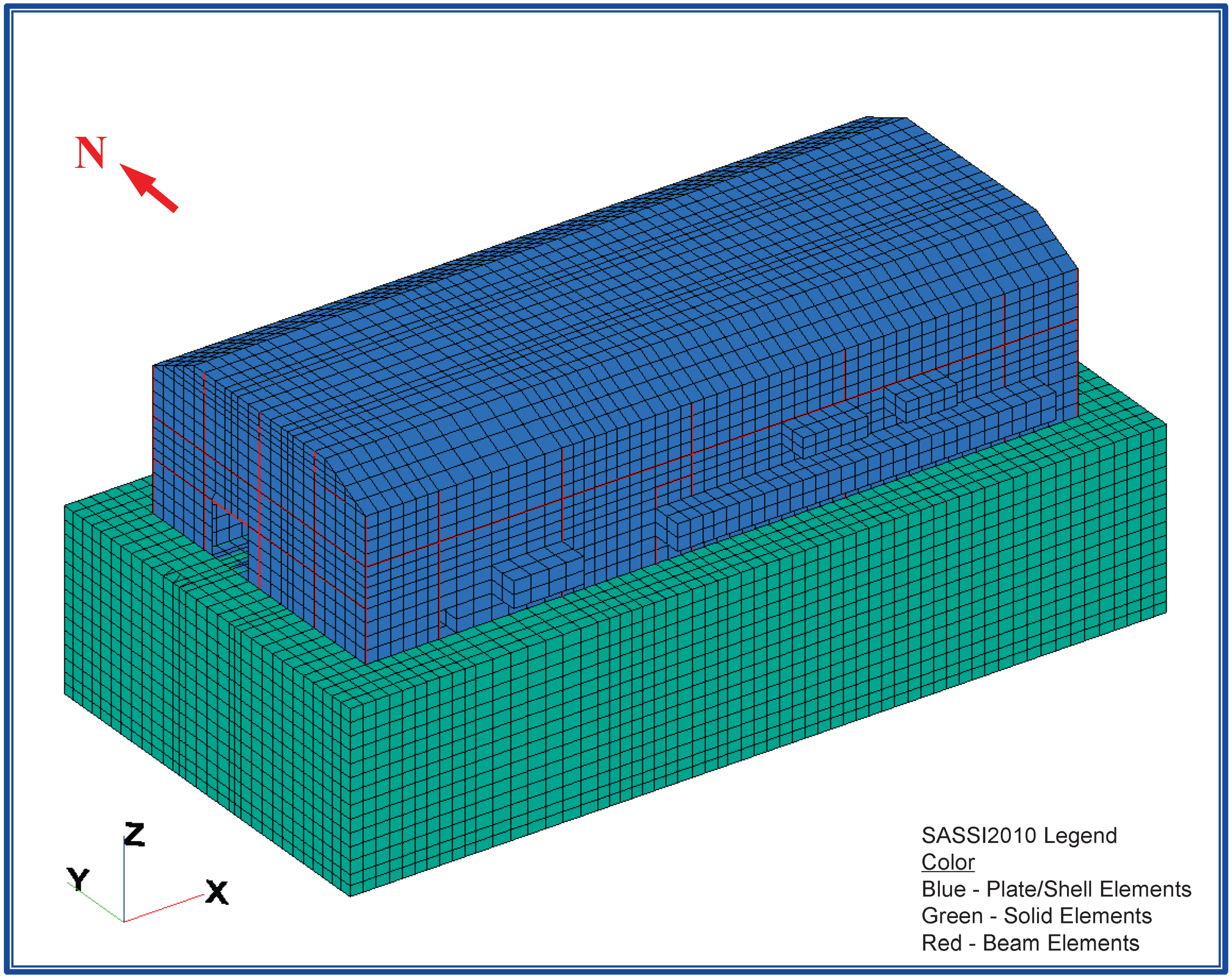
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-15: Reactor Building SASSI2010 Model



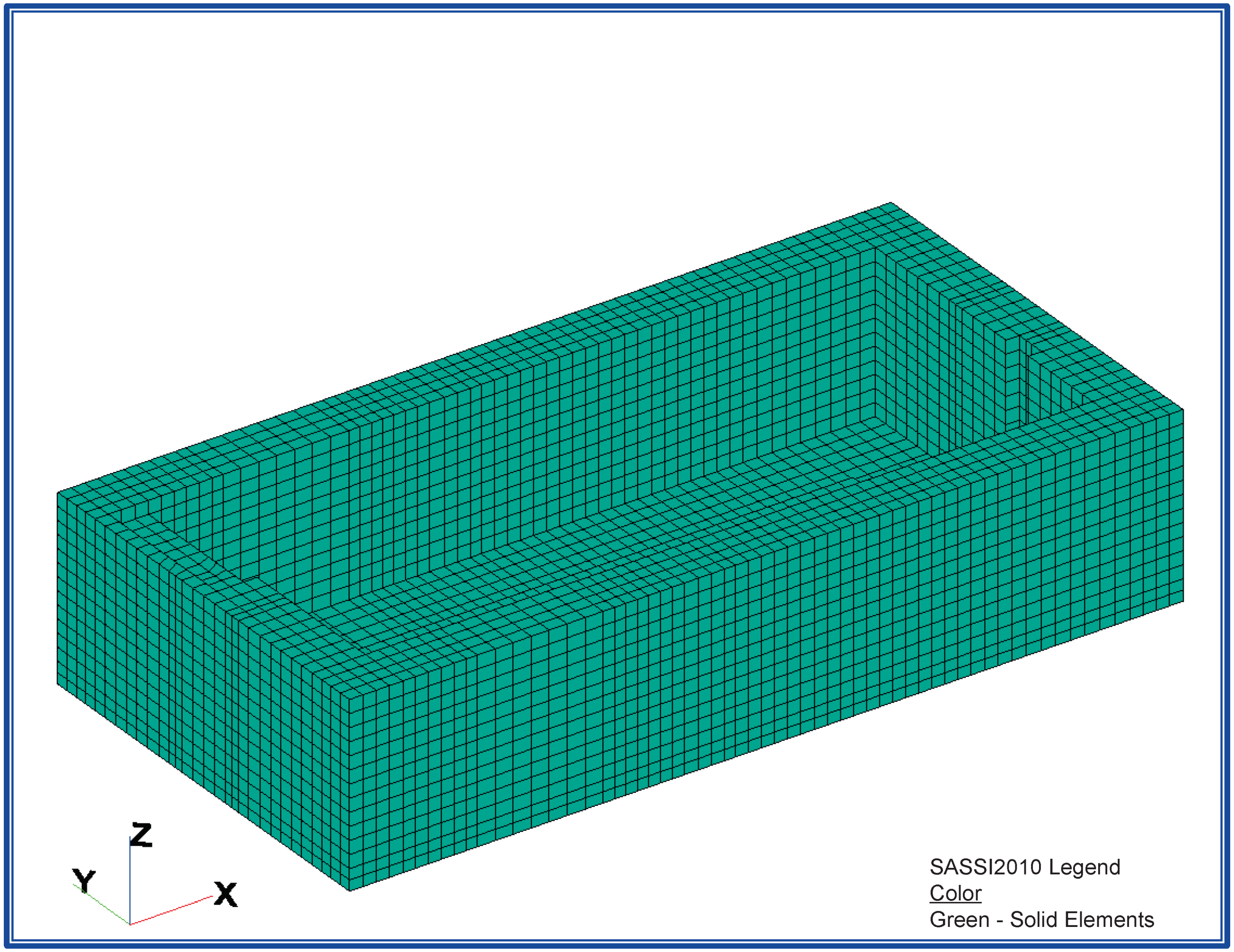
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-16: Reactor Building SASSI2010 Model without Hidden Lines



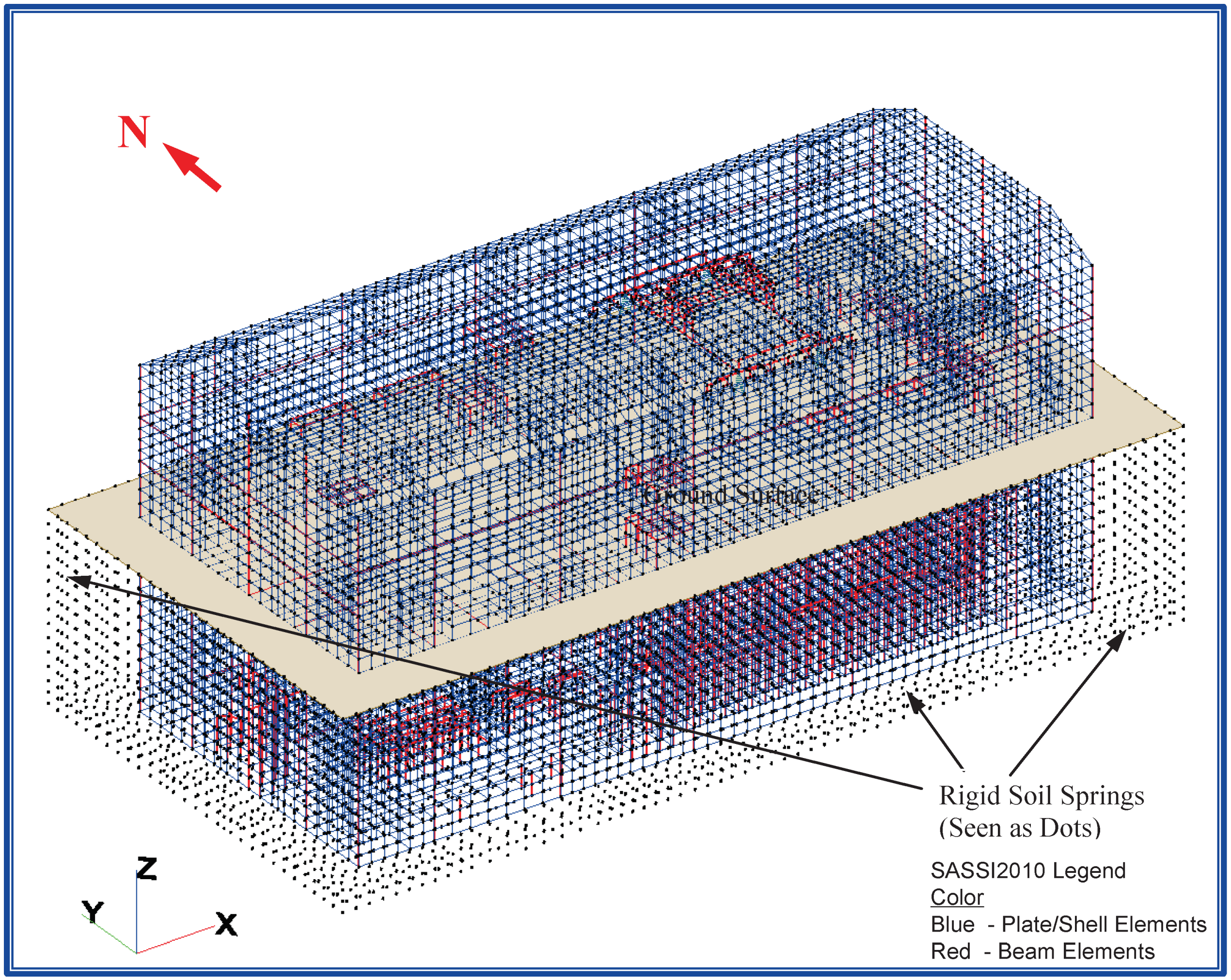
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-17: Reactor Building SASSI2010 Backfill Soil Model



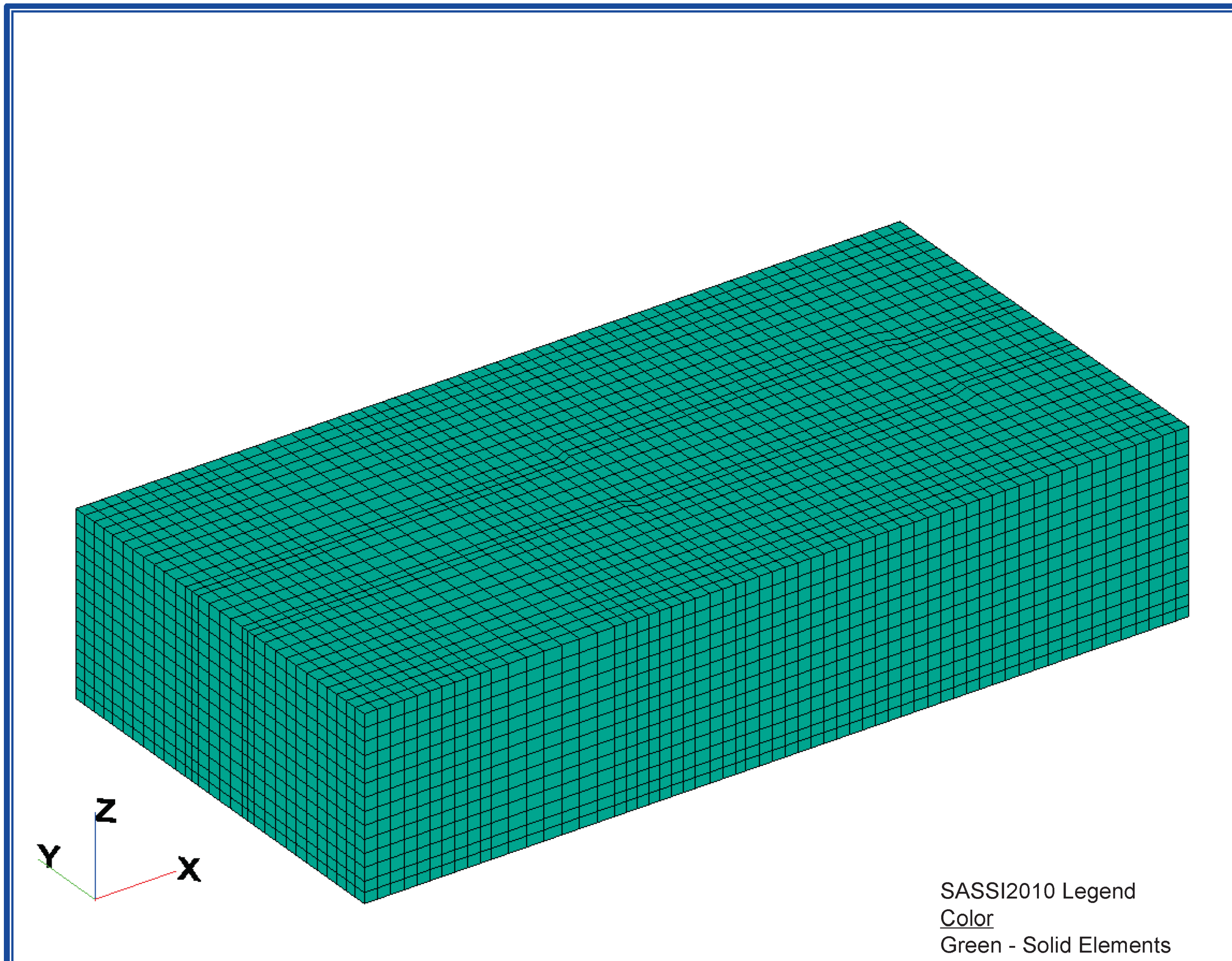
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-18: Reactor Building SASSI2010 Model without Backfill



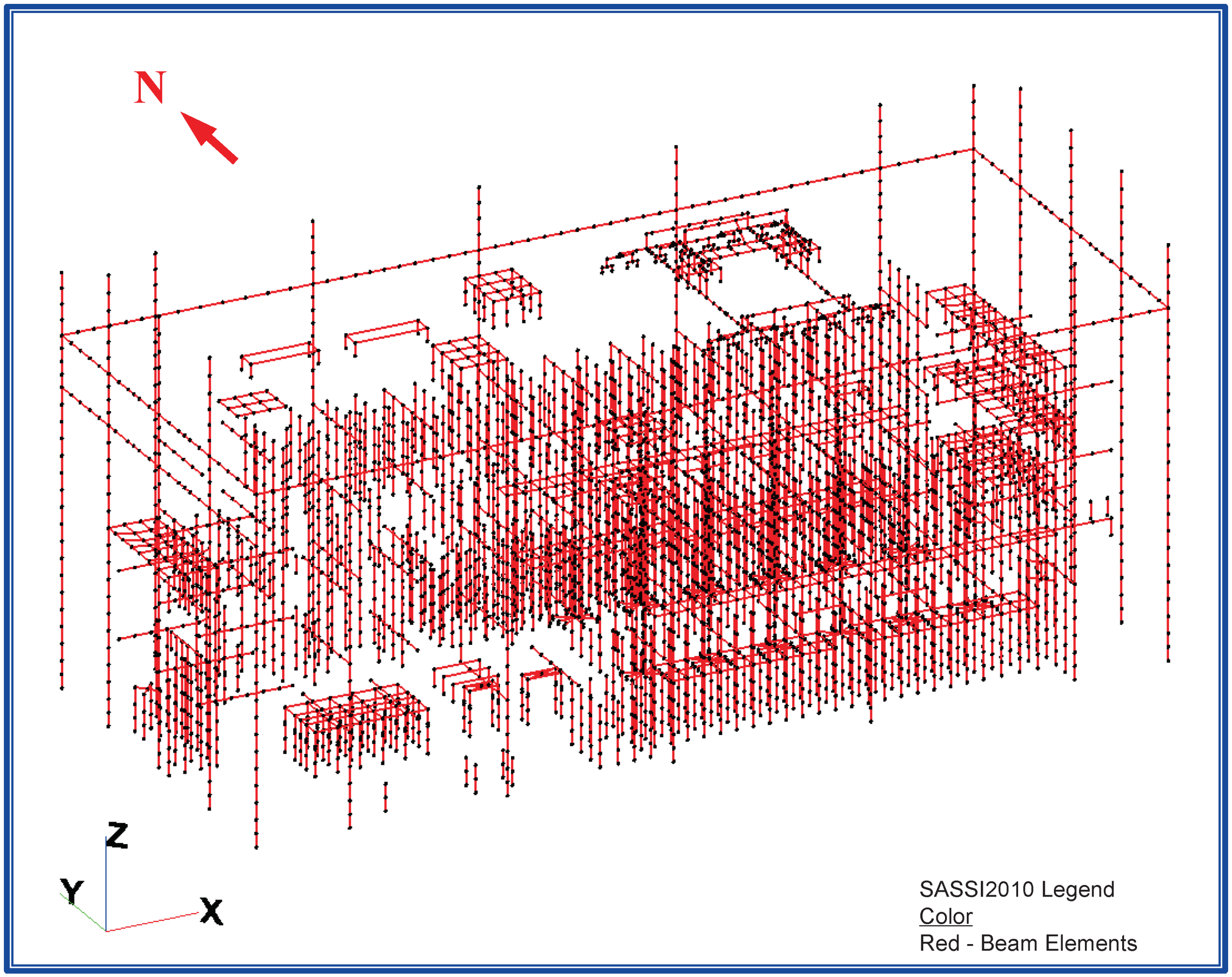
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-19: Reactor Building SASSI2010 Excavated Soil Model without Hidden Lines



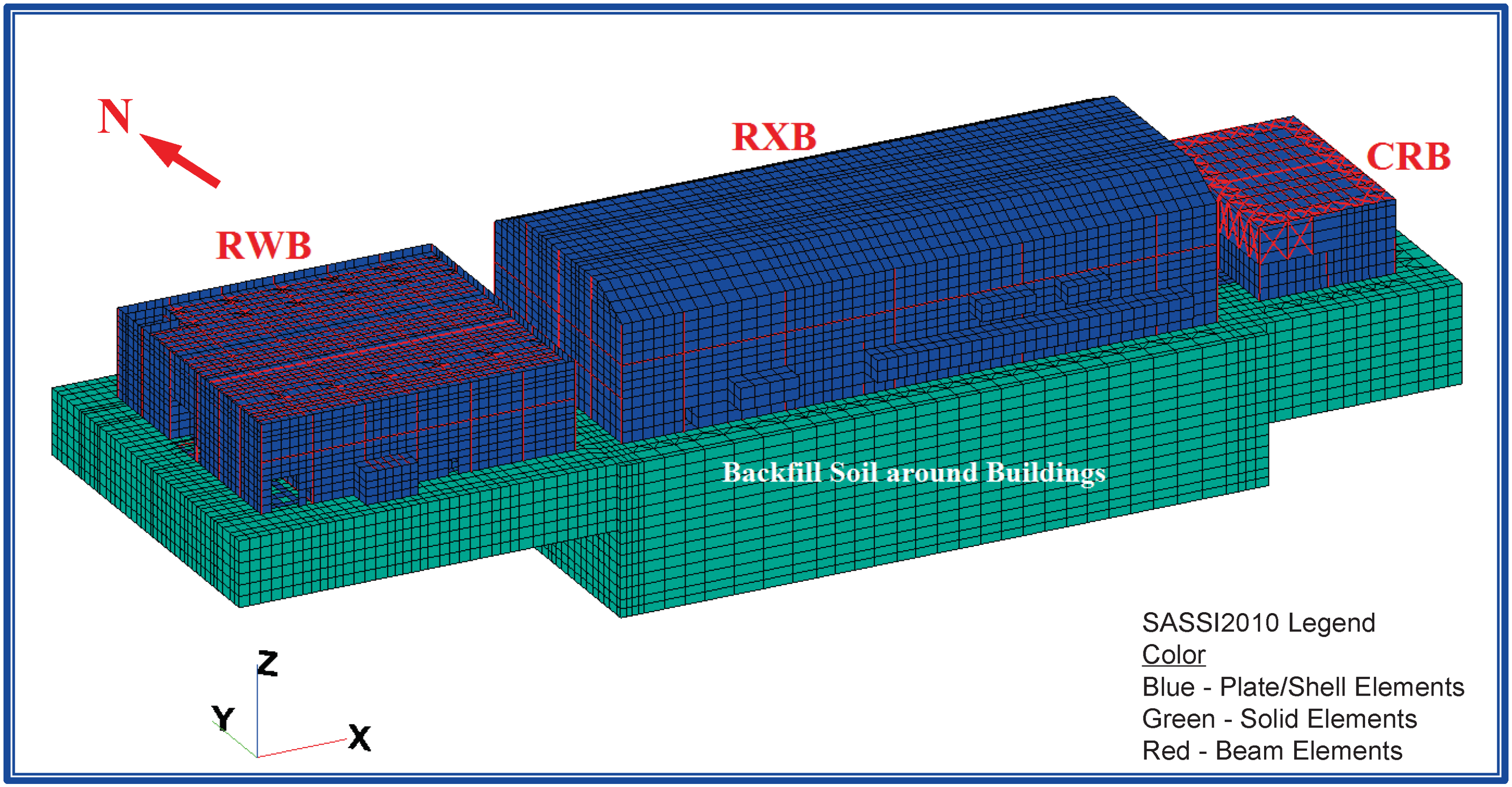
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-21: Reactor Building Beam Elements of SASSI2010 Model



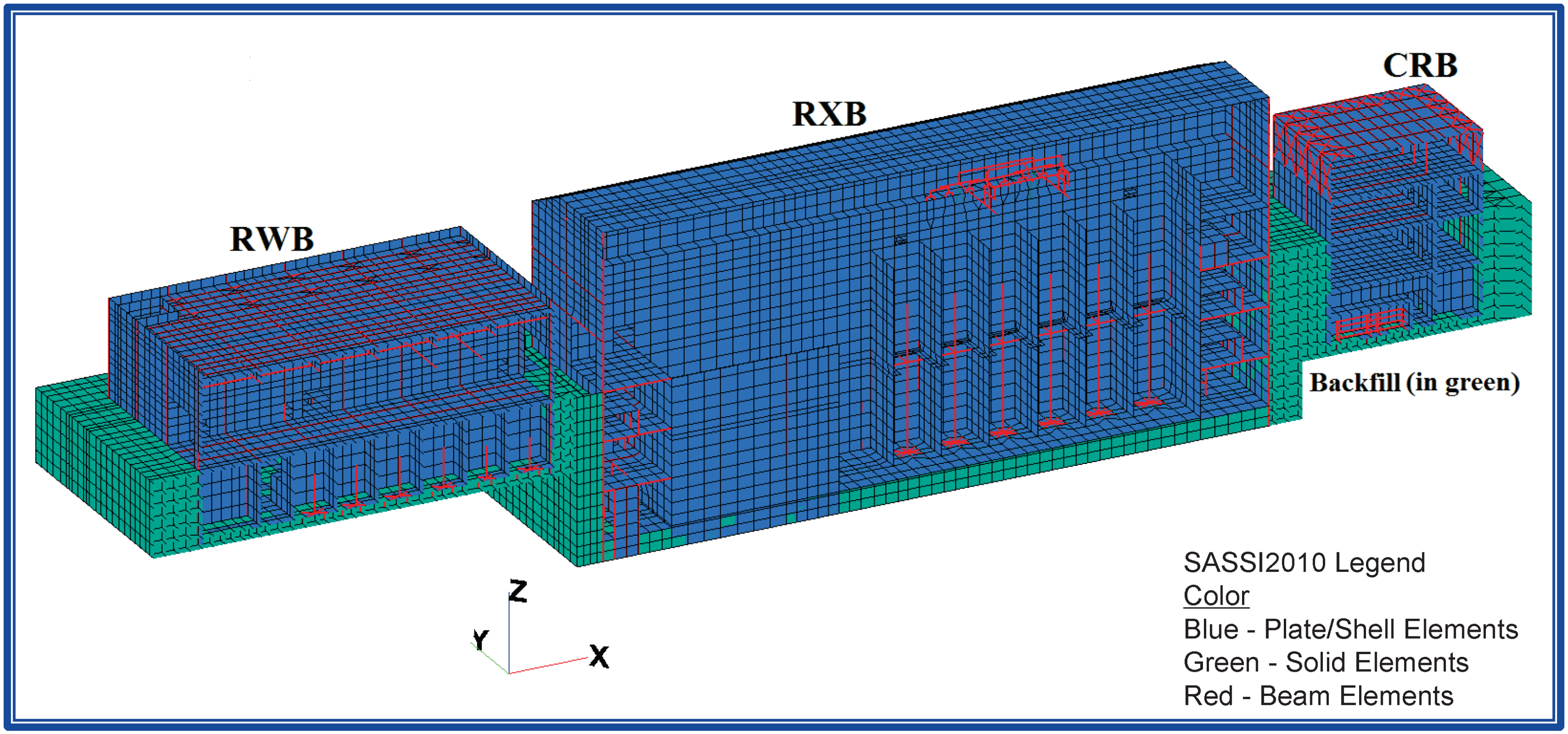
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-67: Isometric View of SASSI2010 Triple Building



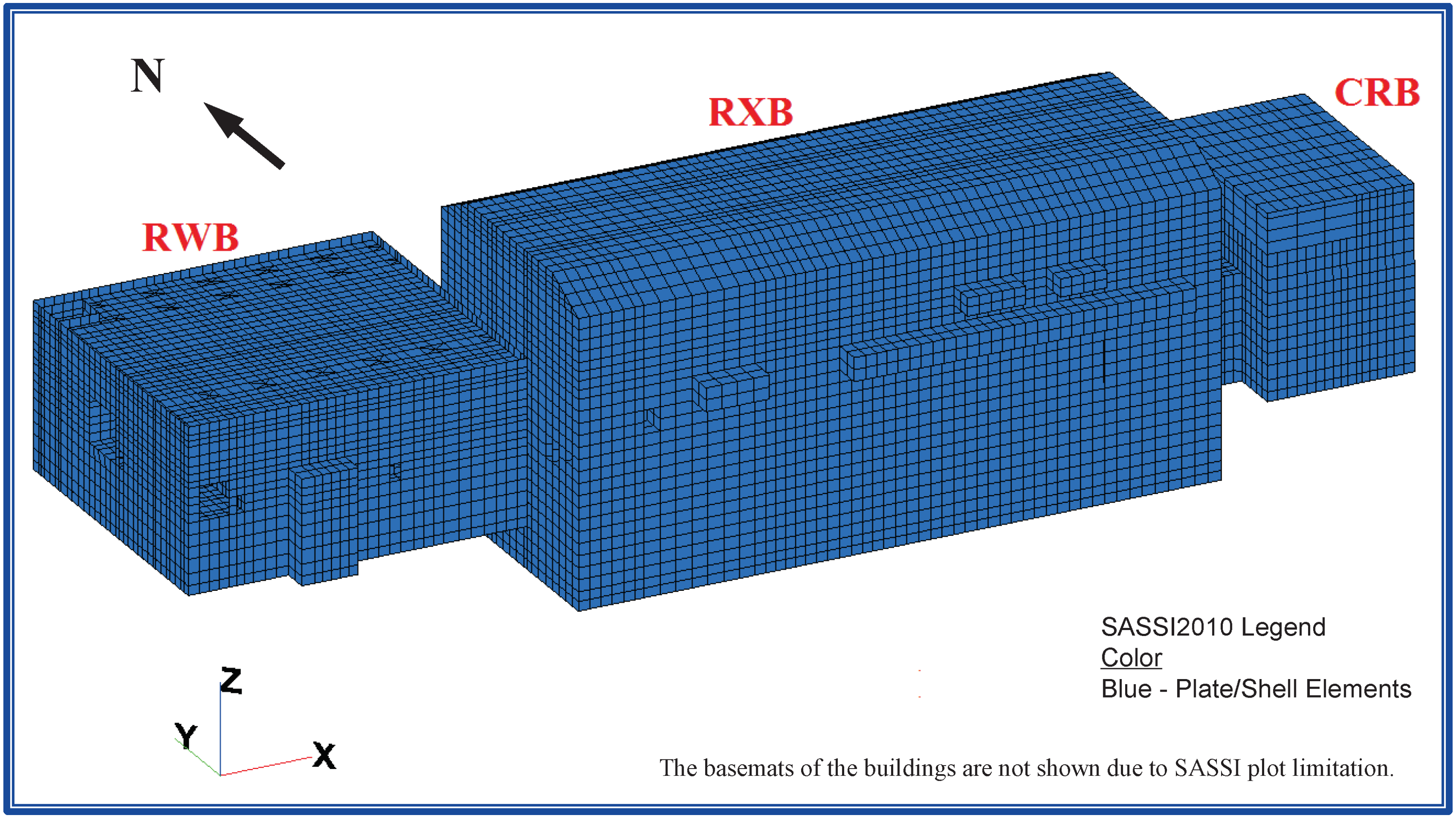
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-68: North Half View of SASSI2010 Triple Building Model



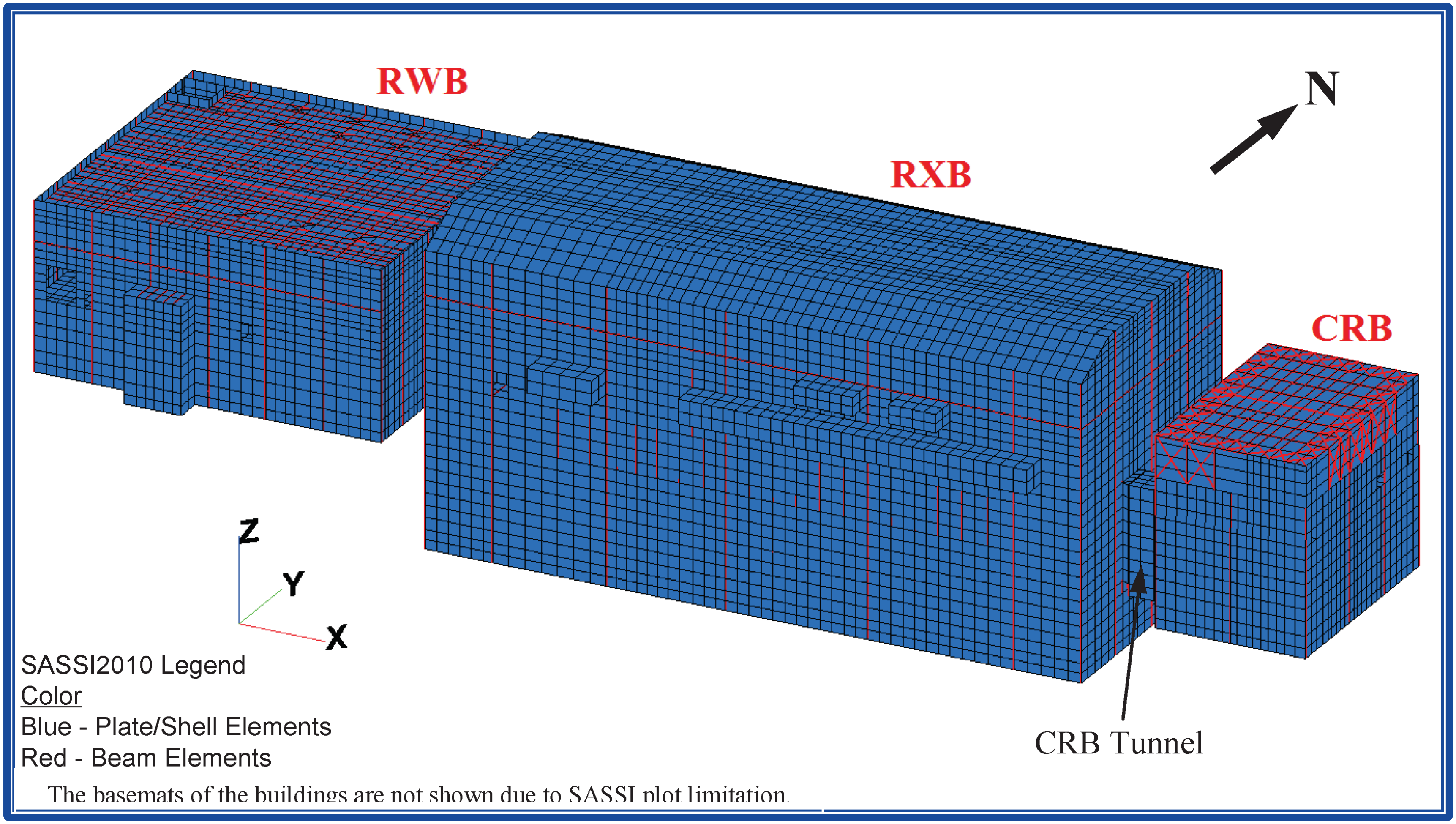
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-69: SASSI2010 Triple Building Model Shown without Backfill



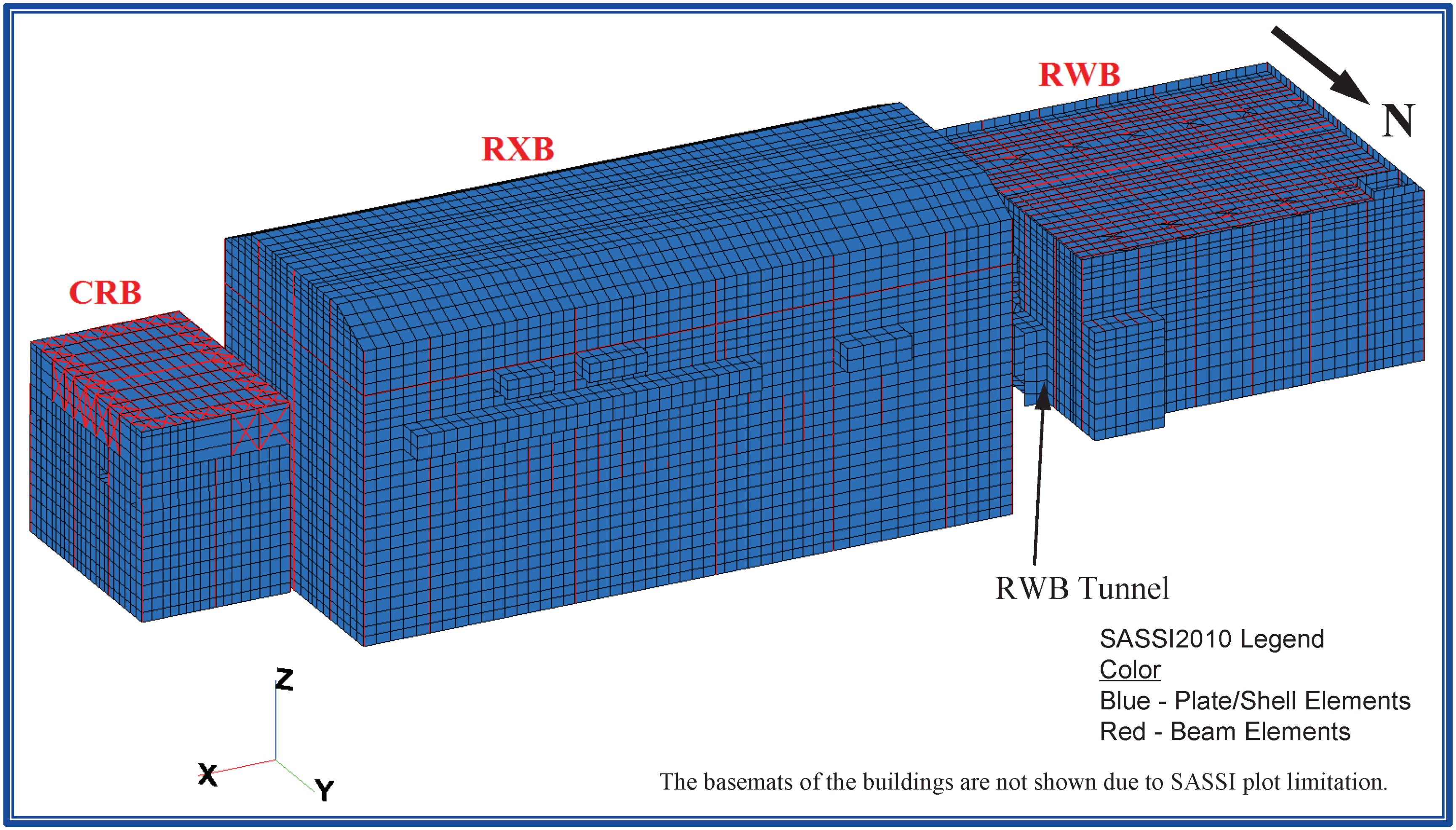
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-70: SASSI2010 Triple Building Model Showing South Side of Three Buildings (Looking Northwest)



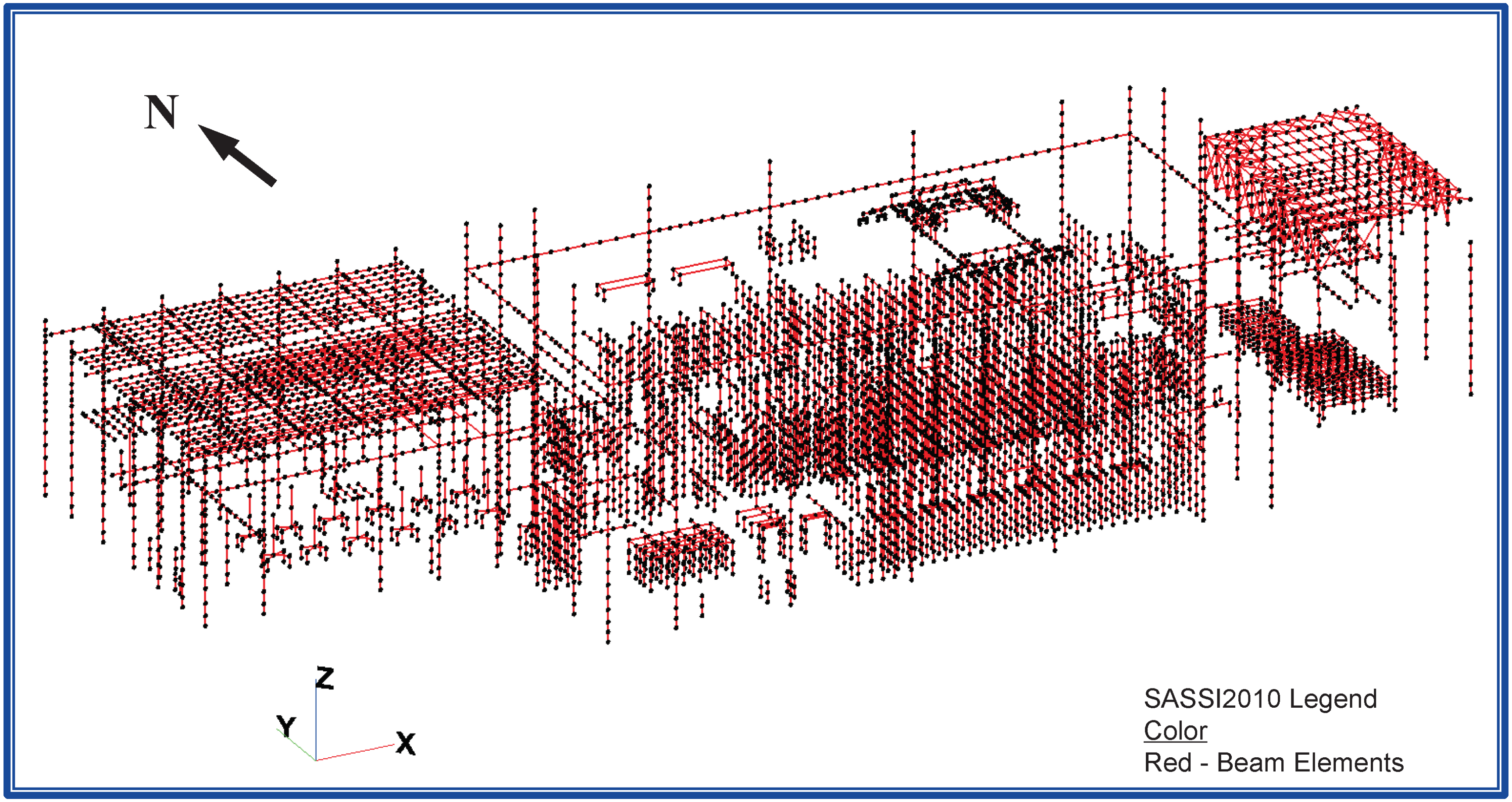
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-71: SASSI2010 Triple Building Model Showing North Side of Three Buildings (Looking Southwest)



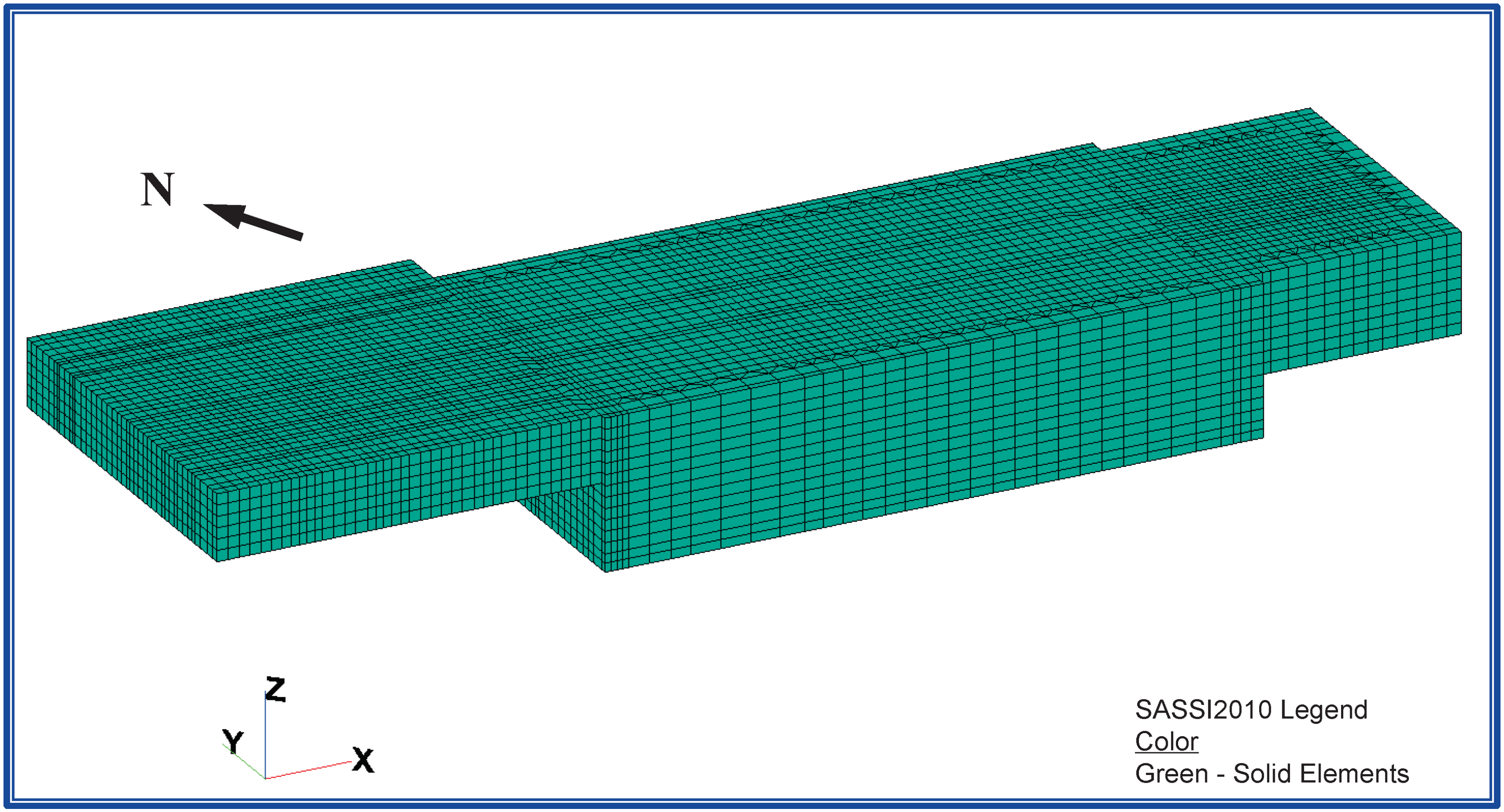
RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-72: Beam Elements of SASSI2010 Triple Building Model



RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-73: Excavated Soil Solid Elements of the SASSI2010 Triple Building Model



RAI 03.07.02-2S1, RAI 03.07.02-3S1

Figure 3.7.2-74: Backfill Soil Solid Elements of the SASSI2010 Triple Building Model