

BRACING FOR NONBUILDINGS SIMILAR TO BUILDINGS

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What are the options when selecting a bracing system for a nonbuilding structure similar to a building?

WHEN IS A NONBUILDING STRUCTURE similar to a building? The definition, per Chapter 11 of ASCE 7-10 *Minimum Design Loads for Building and Other Structures*, is as follows:

“A nonbuilding structure that is designed and constructed in a manner similar to buildings will respond to strong ground motions in a fashion similar to buildings, and has a basic lateral and vertical seismic force-resisting system conforming to one of the types indicated in Tables 12.2-1 or 15.4-1.”

Thus, a nonbuilding structure similar to a building may be designed using the lateral force resisting systems of a building (Table 12.2-1) or the additional options for nonbuilding structures similar to buildings (Table 15.4-1). Because of the geometry or functional requirements of the nonbuilding structure, some of the available lateral force resisting system options may not be practical or possible.

To illustrate the selection process of a steel vertical bracing system, let's consider the eight available bracing systems, using Seismic Design Category D, for a sample four-level industrial structure that supports process equipment and associated piping on levels 2 and 4. Each bracing system will be reviewed to determine if both ASCE 7-10 and AISC 341-10 requirements can be met.

Table 1 lists the eight possible steel bracing systems from ASCE 7 Tables 12.2-1 and 15.4-1. The table includes the response modification coefficient (R), height limitation and detailing requirements.

North-South Bracing System

From Figures 1 and 2 we see that column line 3 has bracing connections with no out-of-plane support at the third level. Therefore, the north-south bracing in column line 3 is considered as K-brace framing per the AISC 341 Glossary.

- Option 1: Since additional members would cause piping interferences, the link beam bracing requirements of Section F3.4b cannot be met at level 3.
- Options 2 and 5: K-braced framing, as defined in the Glossary, is not permitted for SCBF systems per Section F2.4c. Therefore, the bracing in the north-south direction cannot be classified as a SCBF system because column line 3 contains K-Bracing.

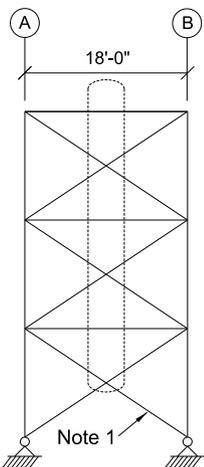
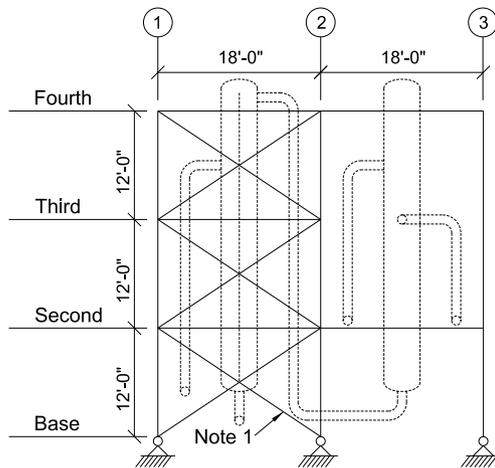
▼ Table 1: Available bracing configurations per ASCE 7 Tables 12.2-1 and 15.4-1

OPTION	ASCE 7 TABLE	BRACING SYSTEM	R	HEIGHT LIMIT	DETAILING REQUIREMENTS
1	12.2-1	Steel eccentrically braced frame	8	160'	AISC 341
2	12.2-1	Steel special concentrically braced frame (SCBF)	6	160'	AISC 341
3	12.2-1	Steel ordinary concentrically braced frame (OCBF)	3¼	35'	AISC 341
4	12.2-1	Steel buckling-restrained braced frame (BRBF)	8	160'	AISC 341
5	15.4-1	Steel special concentrically braced frame (SCBF)	6	160'	AISC 341
6	15.4-1	Steel ordinary concentrically braced frame (OCBF)	3¼	35'	AISC 341
7	15.4-1	Steel ordinary concentrically braced frame with permitted height increase	2½	160'	AISC 341
8	15.4-1	Steel ordinary concentrically braced frame with unlimited height increase	1½	No Limit	AISC 360

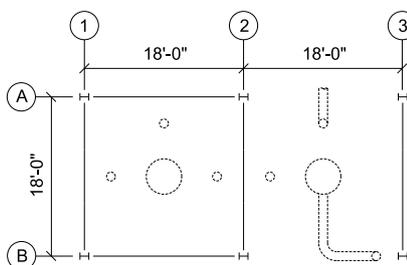
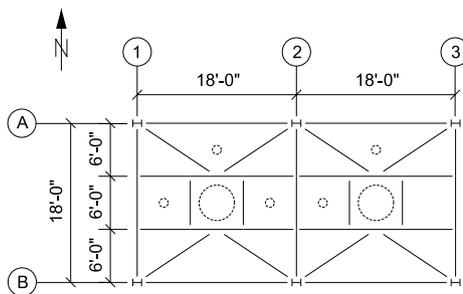
Figures 1 and 2 show the elevation of the structure, Figure 3 shows the plan view of levels 2 and 4 and Figure 4 shows the plan view of level 3 (all figures are on page 18). The X-bracing shown in Figures 1 and 2 represents locations where any bracing configuration (X-brace, inverted V or eccentric) may be used. To avoid interferences with piping and process equipment, beams cannot be placed on level 3 between column lines 2 and 3. Also, bracing cannot be placed between column lines 2 and 3 on both the north and south faces of the structure. In addition, supplementary beams and horizontal bracing cannot be added to provide lateral bracing.

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- ▲ Figure 1: Braced frame elevation column lines 1, 2 and 3
- ◀ Figure 2: Braced frame elevation column lines A and B
- ▼ Figure 3: Plan view levels 2 and 4



◀ Figure 4: Plan view level 3

- ▶ Options 3, 6 and 7: K-braced framing, as defined in the Glossary, is not permitted for OCBF systems per Section F1.4b. Therefore, the bracing in the north-south direction cannot be classified as an OCBF system because column line 3 contains K-bracing. Also, Options 3 and 6 are not permitted because the height of the structure exceeds the height limit of 35 ft.
- ▶ Option 4: K-braced framing, as defined in the Glossary, is not permitted for BRBF systems per Section F4.4b. Therefore, the bracing in the north-south direction cannot be classified as a BRBF system because column line 3 contains K-bracing.
- ▶ Option 8: As indicated in ASCE 7 Table 15.4-1, this option does not need to meet the AISC 341 *Seismic Provisions* and can meet the other code requirements of ASCE 7 and AISC 360.

Thus, none of the bracing systems options meet the AISC 341 requirements for the north-south bracing. However, since Option 8 doesn't need to meet AISC 341 requirements, it becomes the only acceptable option.

East-West Bracing System

- ▶ Option 1: Since additional members would cause piping interferences (OCBF), the link beam bracing requirements of Section F3.4b cannot be met at level 3.
- ▶ Options 2 and 5: It is possible to meet the SCBF requirements.
- ▶ Options 3 and 6: These options for OCBF cannot be used since the structure height exceeds the ASCE 7 height limitations.
- ▶ Option 4: It is possible to meet the BRBF requirements.
- ▶ Option 7: It is possible to meet the OCBF requirements.
- ▶ Option 8: As indicated in ASCE 7 Table 15.4-1, this option does not need to meet the AISC 341 *Seismic Provisions* and can meet the other code requirements of ASCE 7 and AISC 360.

Thus, Options 2, 4, 5, 7 and 8 may be used for the east-west bracing to meet code requirements.

Know your Options

In the north-south direction, only Option 8—an OCBF with unlimited height increase—can be used to meet all code requirements. For the east-west direction, there are several options. Keep in mind that the use of systems with higher R values in only the east-west direction would not likely provide a more economical design. Furthermore, systems with higher R values would not likely reduce the foundation size since the north-south direction has more impact on the design of the foundation. Therefore, the most practical way to design this nonbuilding structure is by using ordinary concentric X-bracing or inverted V-bracing in both directions detailed per AISC 360 in accordance with ASCE 7 Chapter 15 (Option 8). As illustrated here, ASCE 7 Chapter 15 can be very important, since it may provide the only options to meet code requirements for certain nonbuilding structures. **MSC**