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BRACING INFORMATION

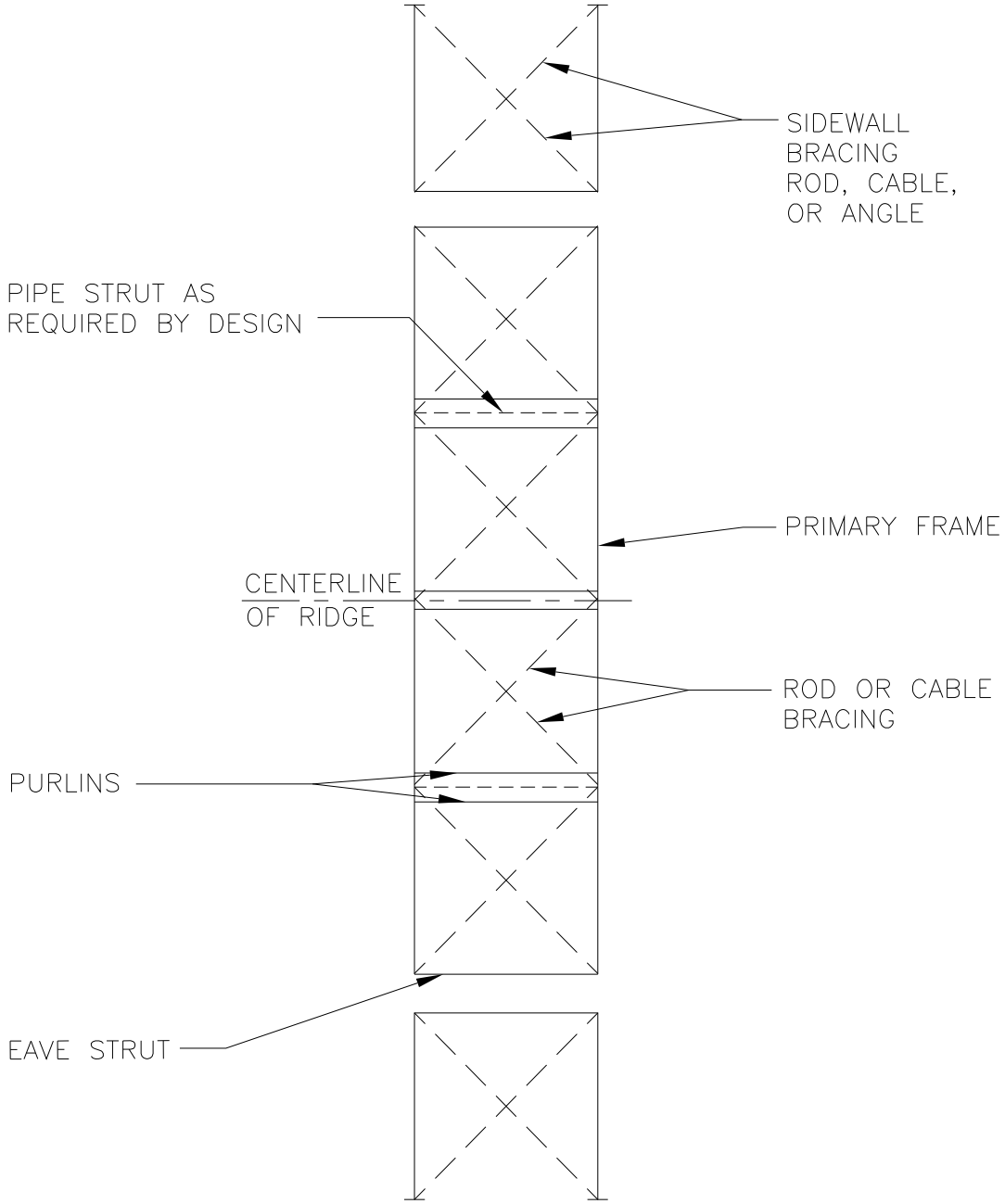
STANDARD BRACING SPECIFICATIONS

1. Longitudinal bracing is a required part of the building system, resisting forces due to wind, earthquakes, cranes, and other stability considerations.
2. The standard product consists of threaded rod or high strength cable used alone or in conjunction with **Girts, Purlins, Purlin Struts** or **Pipe Struts**, to create a truss system. Typically, the compressive forces are resisted by purlins, eave struts or girts until the load is too great. Either a Purlin Strut or a Pipe Strut is used for large compressive forces. The truss chords typically consist of the primary rigid frame rafters and columns.

   NOTE: For certain load situations, structural angle may be used in wall bracing applications.
3. The standard location for longitudinal bracing is in the first interior bay on buildings three bays or longer. Two bay buildings can have bracing in either end bay.
4. Standard bracing is not recommended in adjacent bays, as this causes detailing and erection difficulty.
5. Portal frames or torsional X-bracing options are normally **NOT** available in end bays with post and beam end frames. Single leg portal frames and cantilever portal columns are acceptable alternatives and can be priced by our Estimating Department.
6. To account for building stability, relatively long buildings require additional bays of bracing beyond the requirements listed in **Table 1** (see pg. 4.4.4). The requirements are as follows:
   a. A building with more than 9 bays requires at least two bays of bracing.
   b. Bracing must occur at least once every 6 bays.
7. If a roof transverse expansion joint is specified, at least one braced bay must occur on each side of the expansion joint location.
8. It is very important that bracing locations and type are given at the time of the quote and order entry to avoid additional costs and schedule delays. Accurate reactions cannot be calculated without this very important information.
9. Field slotting of girts is required for the bracing to pass through on inset and flush girt conditions.
10. Two-bay and one-bay buildings with Post & Beam endwalls are required to have bracing in both endwalls and at least one sidewall. If bracing is not allowed in the endwalls of this type project, the endwall frames must be changed to rigid frames.
11. See page 4.4.19 for bracing requirements at buildings employing roof joist components.

STANDARD BRACING SPECIFICATIONS

Pipe Strut Information



STANDARD BRACING REQUIREMENTS

The Table below defines the most economical quantity of braced bays for various combinations of height, width and wind load. This information should be considered when laying out the building parameters and wall openings:

TABLE 1:	MINIMUM NUMBER OF BRACED BAYS (1)															
(2) (3) WIND SPEED	BUILDING WIDTH	≤ 80'				> 80' ≤ 160'				> 160' ≤ 200'				> 200' ≤ 240'			
	EAVE HT	≤ 16'	20'	24'	30'	≤ 16'	20'	24'	30'	≤ 16'	20'	24'	30'	≤ 16'	20'	24'	30'
70 MPH,B or C 80 MPH, B 90 MPH, B		1	1	1	2	2	2	2	3	1	1	3	3	2	3	3	4
80 MPH, C 100 MPH, B		1	1	2	2	2	2	3	3	2	3	3	4	3	4	4	5
90 MPH, C		1	1	2	2	2	3	3	3	3	3	4	5	CONSULT NUCOR			
100 MPH, C		2	2	2	3	3	3	4	4	3	4	5	6	CONSULT NUCOR			

NOTES:

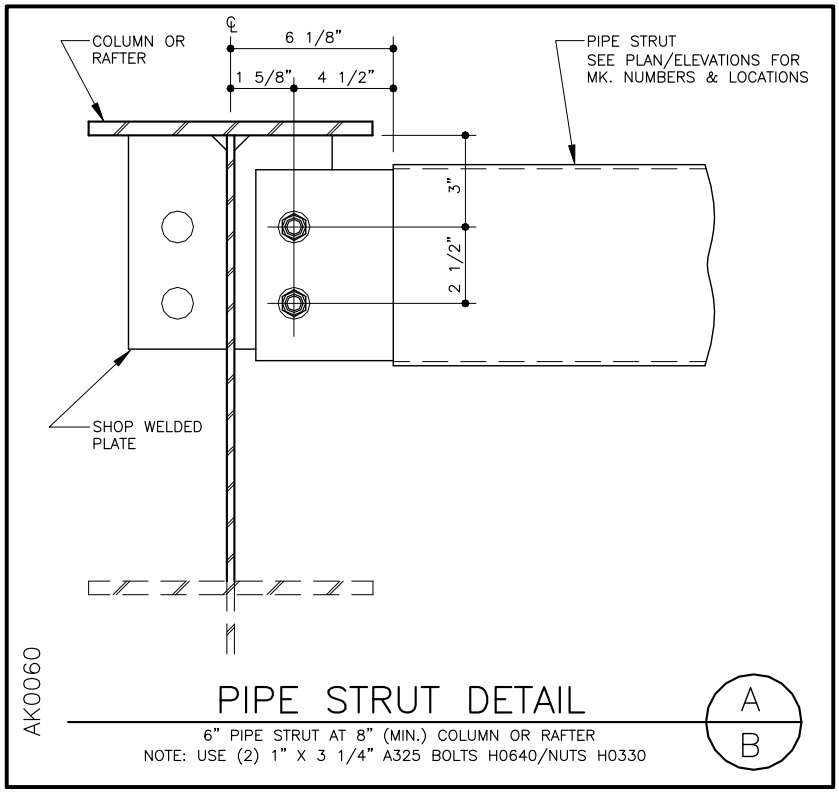
1. A building should have the following minimum quantity of total bays based on the required number of braced bays from Table 1:

Braced bays	Total bays
1	2
2	5
3	7
4	9
5	11

2. This chart is based upon an MBMA Occupancy Class "II" structure (defined by MBMA).
3. The letter "B" or "C" denotes the wind site exposure condition as defined by the appropriate building code. **This table does not consider the structure to be within a hurricane coastline** as defined by the appropriate building code.
4. Consult Nucor Sales Engineering for any specific request other than what is indicated by the chart. This would include using and understanding the chart where a local code does not describe wind velocity as listed above.
5. See Section 9.0 for bracing load reactions.

PIPE STRUT INFORMATION – PRODUCT DESCRIPTION

1. Pipe struts are utilized in roof or wall planes at bracing panel point locations where the axial capacity of the purlin, girt, or purlin strut is exceeded.
2. A pipe strut consists of either a 6 5/8” or 8 5/8” outside diameter pipe located at panel bracing points. Pipe struts are typically called out on the Roof Framing Plan and the Wall Elevations as required by design.
3. The standard pipe strut connection is made using a welded stiffener adjacent the rafter or column flange and 1” dia. A325 high-strength bolts.
4. The alternate pipe strut connection is made using 1” dia, A325 high-strength bolts and attaches the pipe to the rafter or column flange.
5. The end connection of the pipe strut to the frame rafter or column will always be determined by Nucor Building Systems, based upon detailing issues and customer requirements.
6. The minimum rafter depth for a 6 5/8” dia. pipe strut is 8”.
7. The minimum rafter depth for a 8 5/8” dia. pipe strut is 10”.
8. When pipe struts are used with the alternate connection special care must be given to purlin bracing as not to cause an interference problem.



ALTERNATIVE SIDEWALL BRACING OPTIONS:

There are times when standard wall X-bracing is not feasible, due typically to interference with doors or windows.

While standard bracing is always preferred and most economical, the situation sometimes dictates other alternatives.

To determine if standard bracing is **not** acceptable:

1. Lay out the building bracing per information on pages 4.4.2, 4.4.3 and 4.4.4.
2. Review for any conflicts associated with this configuration. It is more economical to relocate a wall opening, if possible.
3. If wall conflicts are unavoidable, select one of the four options shown on pages 4.4.8 through 4.4.18.
4. Note that multiple bracing types are not allowed on the same wall. For example, if you have a building that requires two braced bays and one of the bays has a portal frame, then the other bay must have a portal frame. However, the opposite sidewall can have “X” bracing. See below for example. (“X” bracing will be either rod, cable, or angles depending on the load.

Please note that for any building system layout, the options are presented in order of material cost impact. For the most economical selection, always start with Option 1, and continue through Option 4 based on the limits compared with the actual building parameters.

ALTERNATIVE SIDEWALL BRACING INFORMATION

OPTION #1: TORSIONAL BRACED BAY

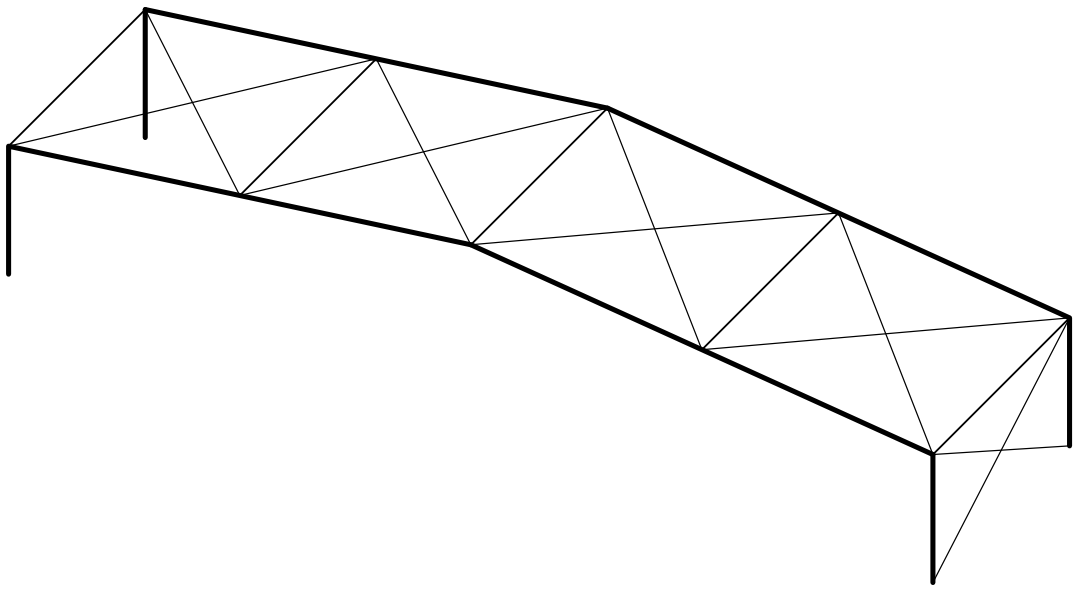
This alternate bracing option braces one sidewall only. The effect is additional lateral forces in the primary frames to offset the torsional impact of taking all longitudinal forces to one sidewall. The following option limits cannot be exceeded unless approved by Nucor Sales Engineering.

The eave height must be $\leq$ 20 ft.

and The width must be $\leq$ 70 ft.

and The roof slope must be $\leq$ 1 to 12.

This alternate is not available for crane building bracing and may not be used in areas where seismic loads control the design.



DETAILS AND LOAD REACTION INFORMATION

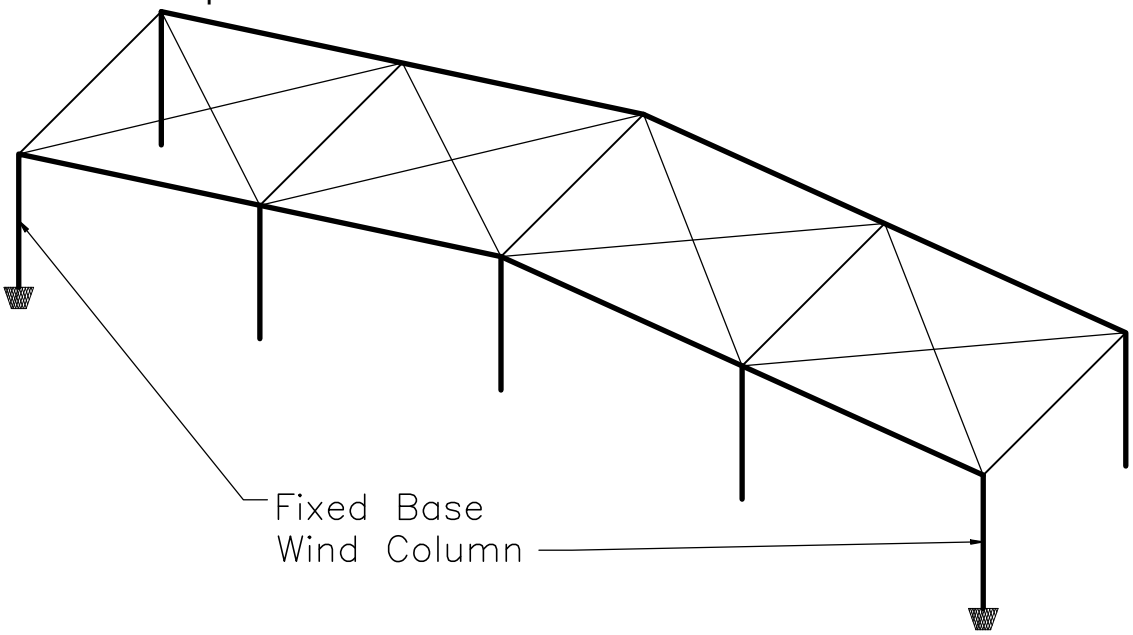
STEP 1: For a given combination of eave height, building width (up to the limit for this option), and wind load, refer to the Frame Reactions section of this manual. Find the bracing reactions and the number of braced bays for this building. **These loads must be doubled to account for the total bracing reaction being resisted along one sidewall.**

OPTION #2: FIXED BASE ENDWALL CORNER COLUMNS

This alternate bracing option uses fixed base corner columns. The result is that all four post and beam frame corner columns are designed fixed base, which has impact on both the material cost and the foundation design. **The following limits for this option cannot be exceeded unless approved by Nucor Sales Engineering:**

Available with post and beam condition at end frames only.

The eave height must be $\leq$ 18 ft.
AND The width must be $\leq$ 100 ft.
AND The roof slope must be $\leq$ 1 to 12.



DETAILS AND LOAD REACTION INFORMATION

STEP 1: For a given combination of eave height, building width (up to the limit for this option), and wind load, refer to the Frame Reactions section of this manual. Find the bracing reactions and number of braced bays for this building.

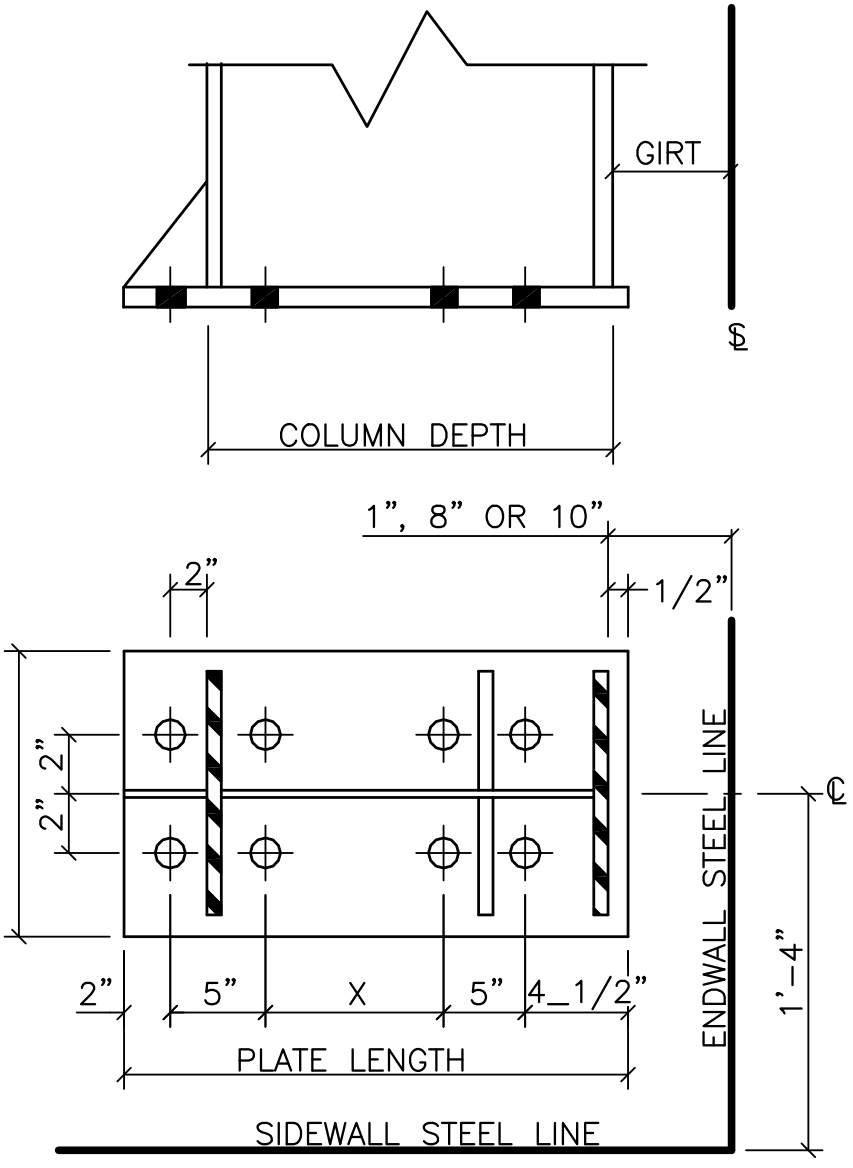
STEP 2: Take the total X (horizontal) bracing load, multiply by the number of braced bays listed then divide by 2. This gives the total horizontal load of each corner column.

STEP 3: Multiply the horizontal load from Step 2 by the eave height to determine the column base moment. Refer to Table 3 on page 4.4.9 and determine the column size and base detail required.

NOTE: Using fixed base corner columns does not eliminate the need for endwall "X" bracing, it only accounts for the sidewall bracing. Please show available locations on the order documents.

FOR FIXED BASE ENDWALL COLUMNS OPTIONS #2 AND #3

TABLE 3: COLUMN BASE SIZE:				
TYPE	COLUMN MOMENT CAPACITY	COLUMN DEPTH	PLATE LENGTH	X
1	60 k-ft	1'-4"	1'-10 1/2"	6"
2	100 k-ft	1'-10"	2'-4 1/2"	12"
3	160 k-ft	2'-6"	3'-0 1/2"	20"

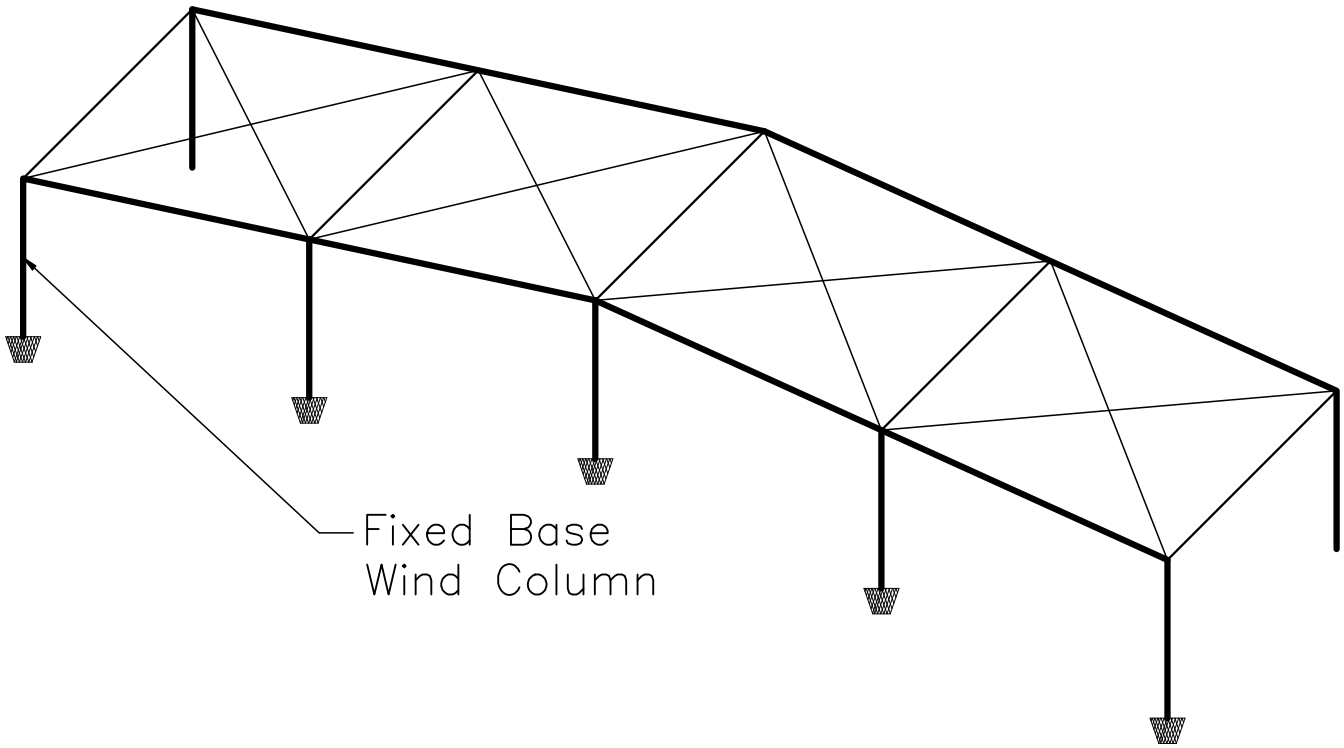


OPTION #3 CON'T: FIXED BASE ENDWALL COLUMNS

This alternate bracing option uses fixed base endwall columns. The result is that ALL post and beam frame columns are designed fixed base, which has impact on both the material cost and the foundation design. **The following limits for this option cannot be exceeded unless approved by Nucor Sales Engineering.**

Available with post and beam condition at end frames only.

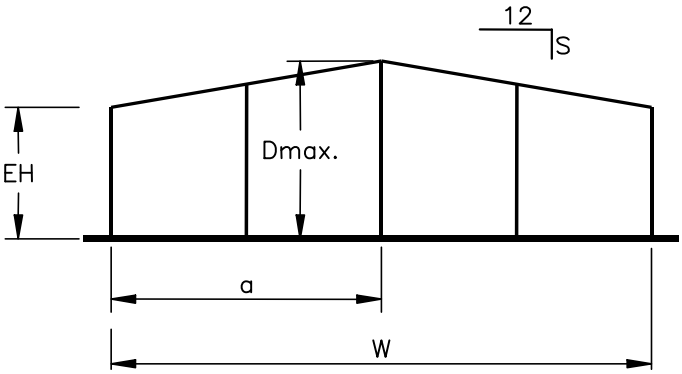
The eave height must be $\leq$ 18 ft.
AND The width must be $\leq$ 160 ft.
AND The roof slope must be $\leq$ 1 to 12.



Refer to page 4.4.9 for base details.

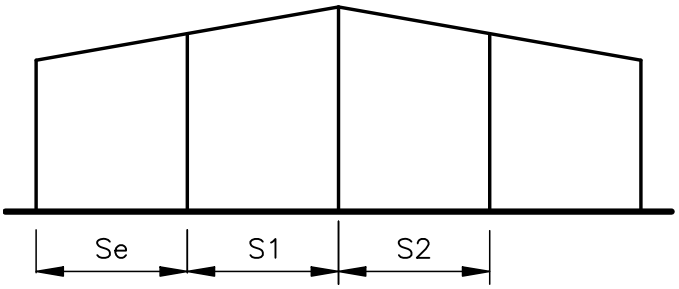
OPTION #3 CON'T: FIXED BASE ENDWALL COLUMNS
DETAIL AND LOAD REACTION INFORMATION

STEP 1:For a given eave height, width and slope, determine the maximum endwall height for a column.



Dmax. = **EH** + **a** x (**S** / 12); ft.
EH = EAVE HEIGHT;ft.
a = distance to maximum height endwall column from sidewall; ft.
S = roof slope per foot (1, 0.5, etc.)

b. Determine the endwall column spacing adjacent to $\mathbf{D_{max.}}$ location:



Se = distance from sidewall steel line to centerline of the first endwall column
S1 or **S2** = endwall column spacing either side adjacent to column in question

c. Maximum moment is determined by;

i. For endwall columns: $\text{MAXIMUM MOMENT} = \left(\frac{WL}{1000} X \frac{Dmax}{2} X \frac{(S1+S2)}{2}\right) X\ Dmax$; k-ft.

WIND VELOCITY	W L (1) (2)
70 mph, EXPOSURE B OR C 80 mph, EXPOSURE B 90 mph, EXPOSURE B	9.8 psf
80 mph, EXPOSURE C 100 mph, EXPOSURE B	13.0 psf
90 mph, EXPOSURE C	16.3 psf
100 mph, EXPOSURE C	20.2 psf

1) WL is determined from values in the **BOCA** code. **UBC** and **SBC** values are similar, but not greater than the **BOCA** load values.

2) WL is based upon a use occupancy class II-96 structure (defined by **MBMA**). **WL** is based upon a structure **NOT** being within 100 miles of a hurricane coastline.

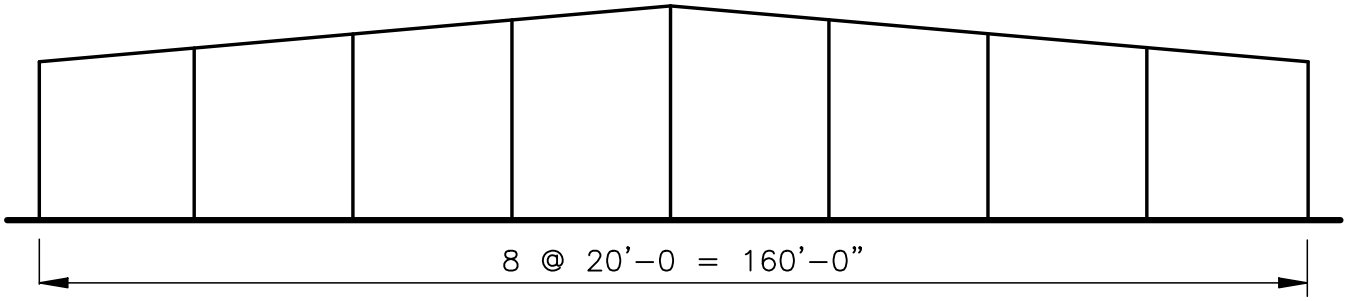
ii. For corner column use 1/2 of the endwall column values.

STEP 2: Compare the base moment with **TABLE 3** on page 4.4.9 to determine the column size and column base detail. **NOTE:** EACH ENDWALL COLUMN WILL HAVE THE SAME SIZE COLUMN AND COLUMN BASE CONDITION FOR THIS OPTION. CORNER COLUMNS WILL TYPICALLY BE A SMALLER SIZE.

OPTION #3 CON'T: FIXED BASE ENDWALL COLUMNS

FOR EXAMPLE:

BUILDING: 18'--0" High, 160'-0" Wide
1/2 : 12 Slope
100 MPH, Exposure B Wind



STEP 1:

a. **Dmax.** = 18 + 80 x (0.5 / 12) = 21.33'

b. $S_1 = S_2 = 20'$

c. $\text{MAXIMUM MOMENT} = \left(\frac{13.0}{1000} X \frac{21.33}{2} X20\right) X21.33$ = 59.1k-ft [Interior Endwall Column]

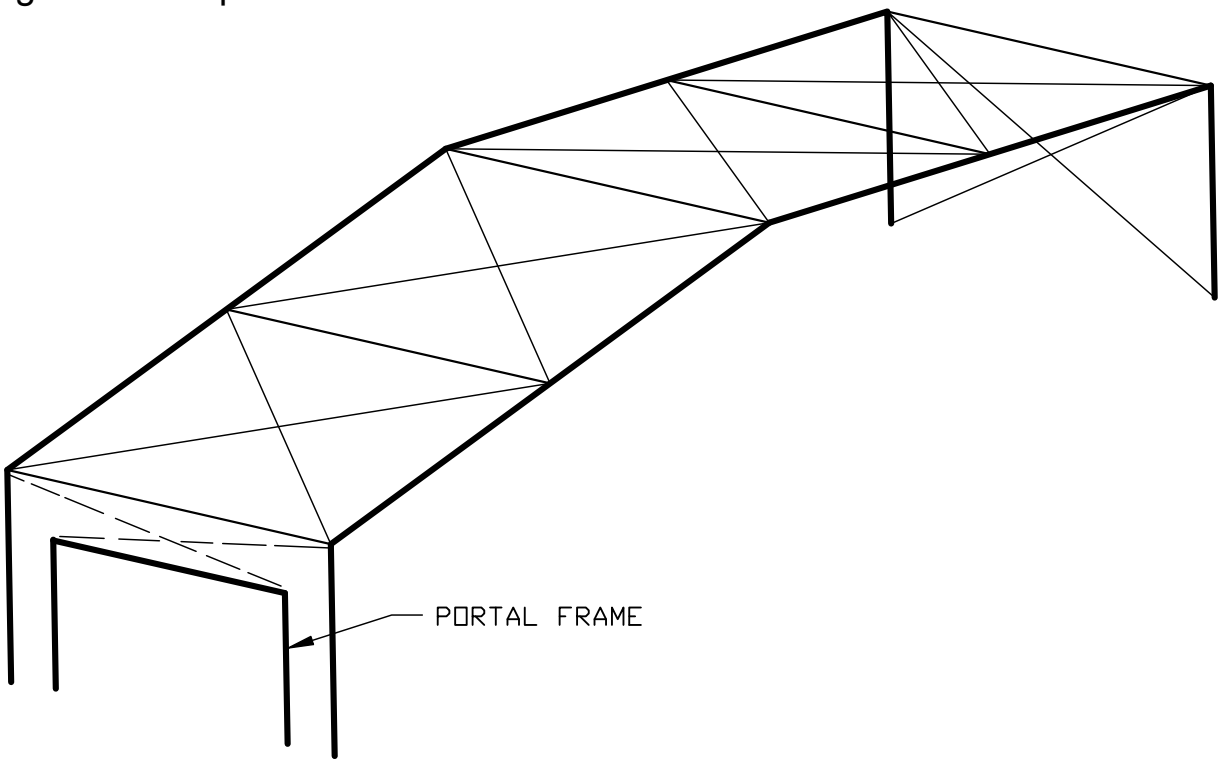
$\text{MAXIMUM MOMENT CORNER} = \frac{59.1}{2} = 29.6$ k-ft [Corner Endwall Column]

STEP 2: From **TABLE 3** on page 4.4.9, determine a type 1 base will be adequate for **ALL** endwall and corner columns.

OPTION #4: SIDEWALL PORTAL FRAMES

This alternate bracing option is to use portal frames. The result of this is a rigid frame designed perpendicular to the primary frames located wherever a braced bay can not accommodate a full height "X". There will be an impact on material cost and potentially some impact on foundation cost. The following option limits must not be exceeded unless approved by Nucor Sales Engineering.

The eave height must be $\leq$ 30 ft.
The width must be $\leq$ 240 ft.
The length has no special considerations.

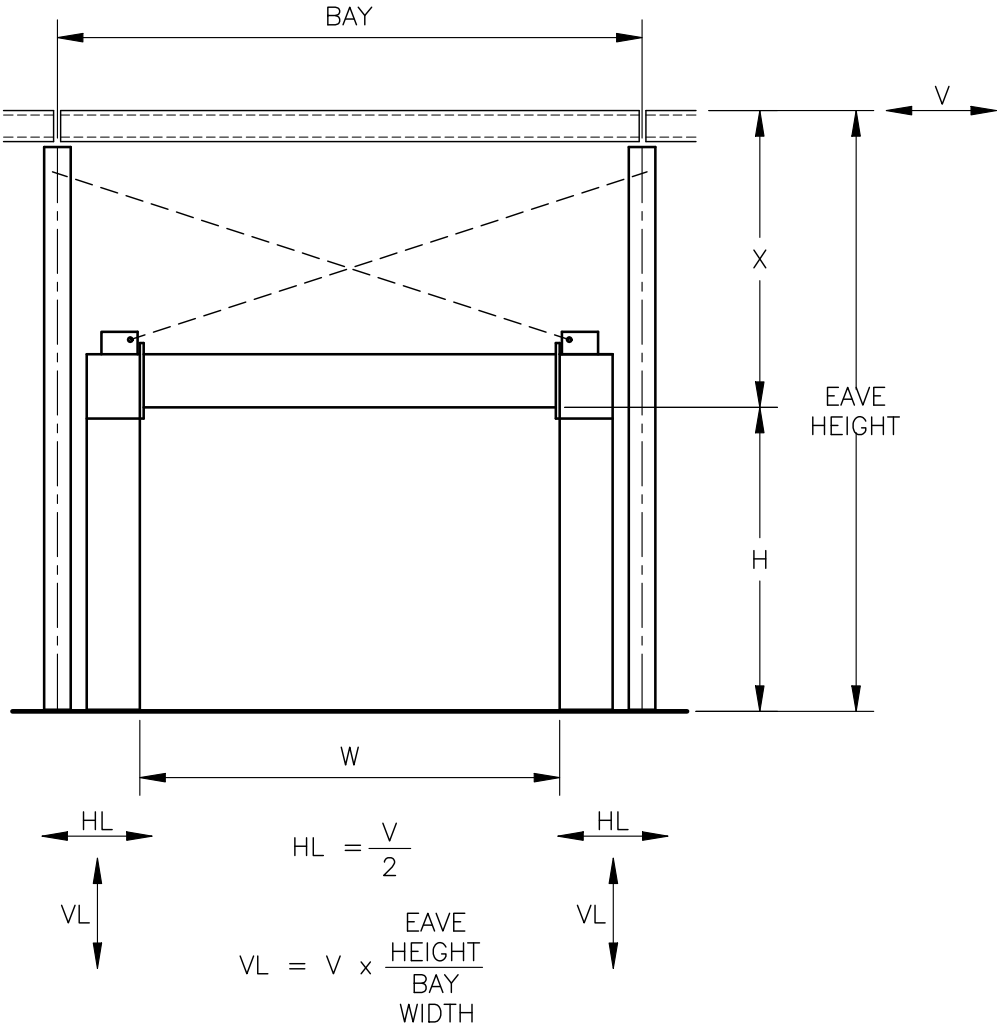


If the specified clear height is within 6 ft. of the building eave height, the portal frame will be provided as full height. The clear height and width for a portal frame is a function of the amount of load per braced bay and the clear height requirements. Consult Nucor's sales engineer to determine the load requirements.

Refer to page 4.4.15 for a list of steps to follow to determine base reactions.

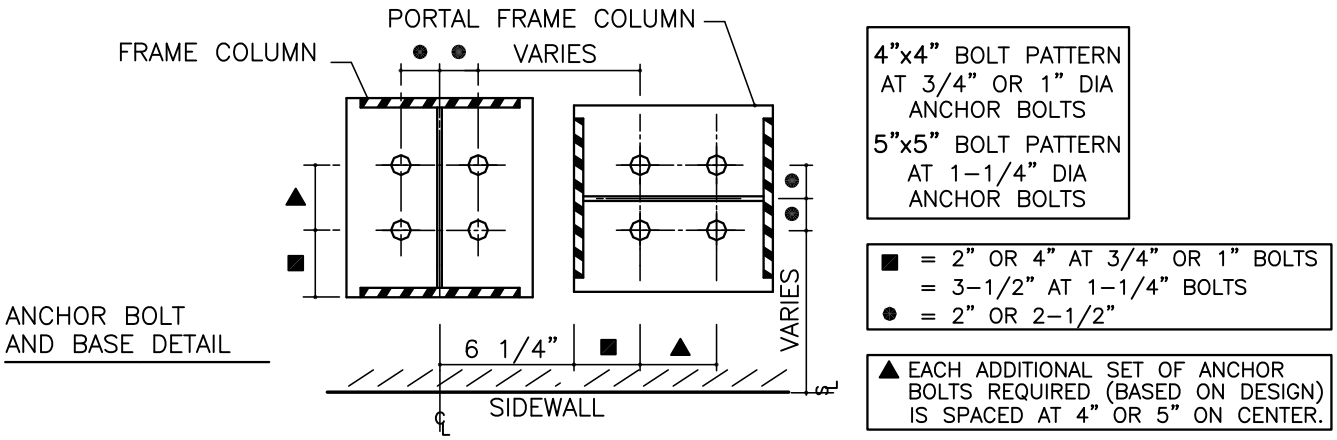
OPTION #4 CON'T: SIDEWALL PORTAL FRAMES

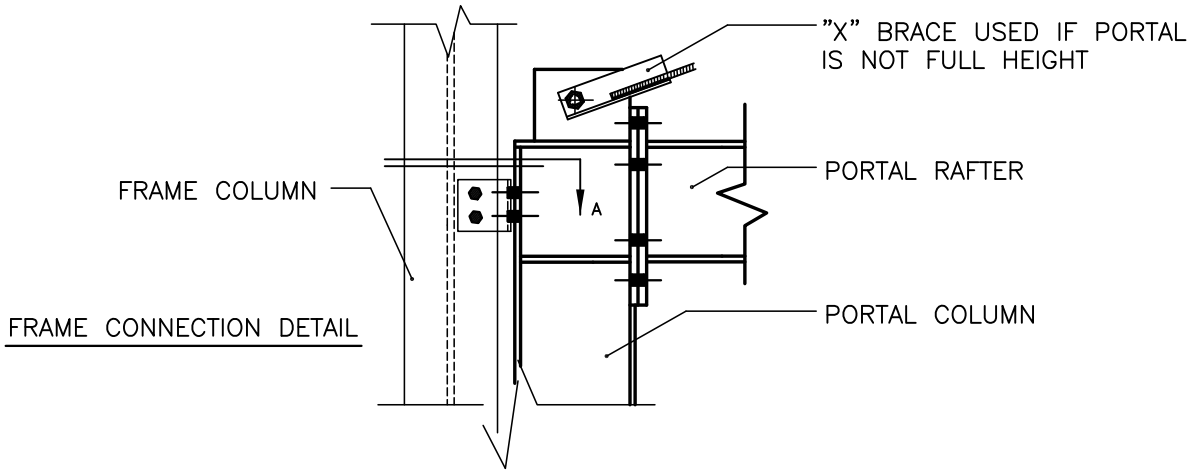
STEP 1: For a given combination of eave height, building width (up to the limits for this option), and wind load, refer to the Frame Reactions section of this manual. Find the bracing reactions based on the number of braced bays for this building. The horizontal base reaction from that table corresponds to "V" in the figure below. The base reactions, "HL" and "VL" can now be determined using "V" as shown.

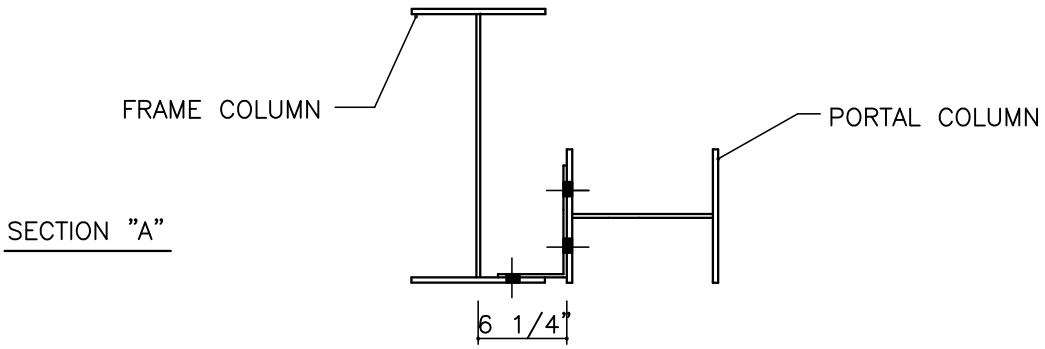


STEP 2: Using the tables provided on page 4.4.18, determine clearances provided by standard portal frames and base details. If clearance provided by the standard portal frames does not meet the requirements of the job, contact Sales Service at Nucor Building Systems for assistance.

OPTION #4 CON'T: SIDEWALL PORTAL FRAMES







1. Select desired CLEAR HEIGHT (H) and determine the minimum clear width available from TABLE 6 on page 4.4.18.
2. If distance X [EAVE HEIGHT - CLEAR HEIGHT (H)], is less than the value shown in the chart below, Nucor will provide the portal frame full height, without any x bracing above.
3. The maximum vertical clear height for a given eave height is as listed in TABLE 7 on page 4.4.18:

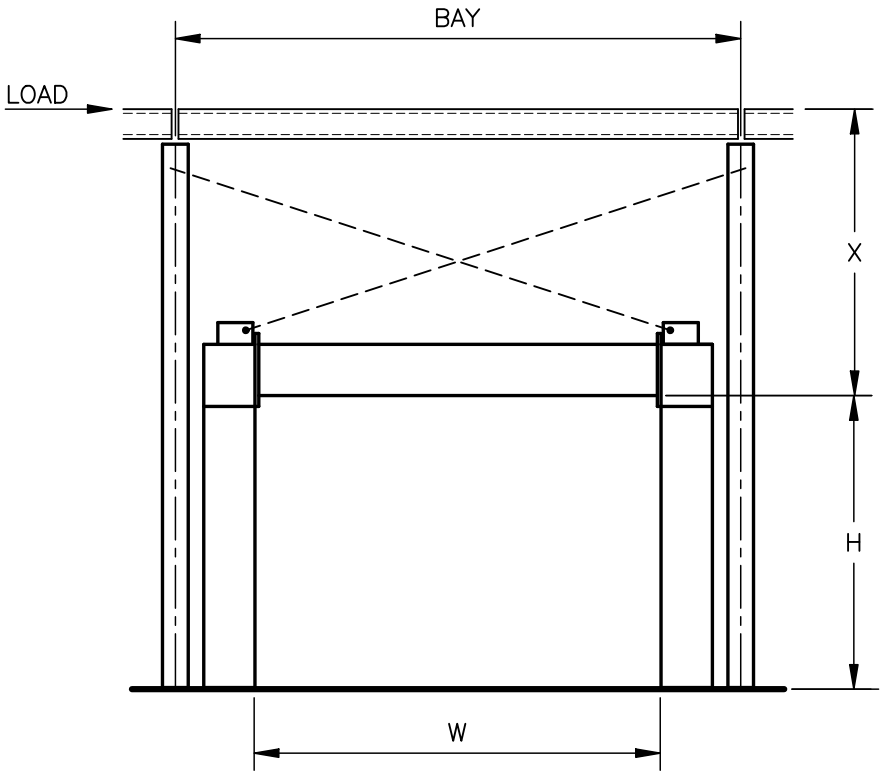


TABLE # 5 CLEARANCES

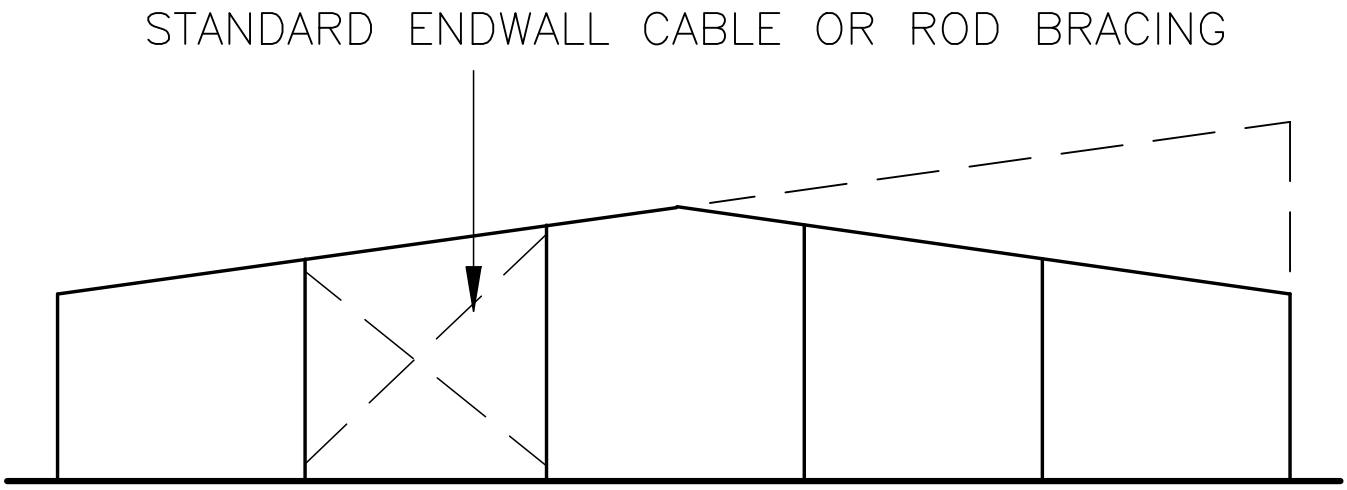
BAY	LOAD	X minimum
20'-0"	5^k	6'-6"
	10^k	6'-6"
	15^k	7'-0"
25'-0"	5^k	6'-6"
	10^k	6'-6"
	15^k	7'-0"
30'-0"	5^k	6'-6"
	10^k	7'-3"
	15^k	7'-3"

	TABLE 6: CLEAR DIMENSIONS			
BAY	CLEAR HEIGHT (H)	5^K LOAD CLEAR WIDTH (W) (minimum)	10^K LOAD CLEAR WIDTH (W) (minimum)	15^K LOAD CLEAR WIDTH (W) (minimum)
	12'-0"	16'-10"	16'-10"	16'-10"
	14'-0"	16'-6"	16'-6"	16'-6"
20'	**16'-0"**	16'-2"	16'-2"	16'-2"
	18'-0"	16'-2"	16'-2"	16'-2"
	20'-0"	15'-11"	15'-11"	15'-11"
	12'-0"	21'-10"	21'-10"	21'-10"
	14'-0"	21'-6"	21'-6"	21'-6"
25'	**16'-0"**	21'-2"	21'-2"	21'-2"
	18'-0"	21'-2"	21'-2"	21'-2"
	20'-0"	20'-11"	20'-11"	20'-11"
	12'-0"	26'-10"	26'-10"	26'-10"
	14'-0"	26'-6"	26'-6"	26'-6"
30'	**16'-0"**	26'-2"	26'-2"	26'-2"
	18'-0"	26'-2"	26'-2"	26'-2"
	20'-0"	25-11"	25-11"	25-11"

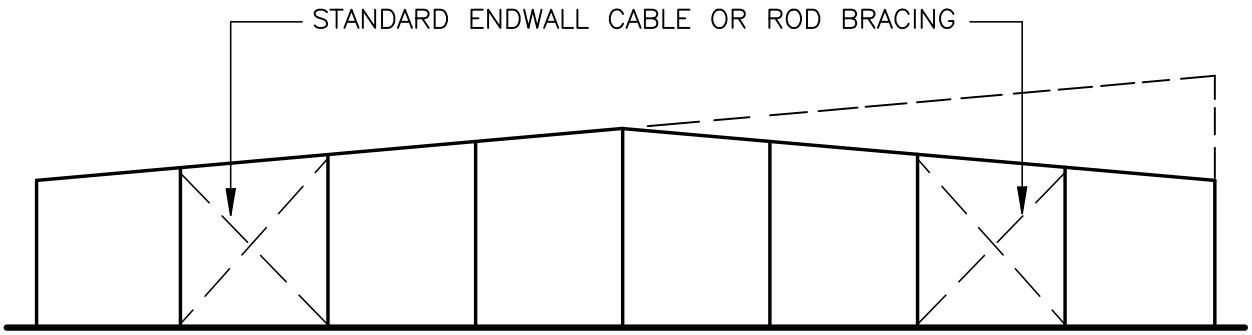
TABLE 7: CLEAR DIMENSIONS				
LOAD (Kips)	EAVE HEIGHT	20' BAY CLEAR HEIGHT (H) (maximum)	25' BAY CLEAR HEIGHT (H) (maximum)	30' BAY CLEAR HEIGHT (H) (maximum)
5	12'	9'-10"	9'-6"	9'-2"
	16'	13'-8"	13'-6"	13'-2"
	20'	17'-6"	17'-6"	17'-2"
	24'	21'-6"	20'-6"	21'-2"
	30'	27'-4"	27'-4"	27'-2"
10	12'	9'-6"	9'-4"	9'-2"
	16'	13'-6"	13'-2"	12'-8"
	20'	17'-4"	17'-2"	17'-0"
	24'	21'-4"	20'-8"	20'-6"
	30'	27'-2"	26'-8"	27'-2"
15	12'	9'-2"	8'-8"	8'-8"
	16'	13'-0"	12'-8"	12'-8"
	20'	17'-0"	16'-8"	17'-0"
	24'	21'-10"	20'-8"	20'-6"
	30'	26'-8"	27'-9"	27'-2"

ENDWALL BRACING REQUIREMENTS

Post and beam frames require endwall bracing as a standard. One or two sets of bracing is required as defined below:



If the width is $\leq$ 100'-0" then one "X" is required.

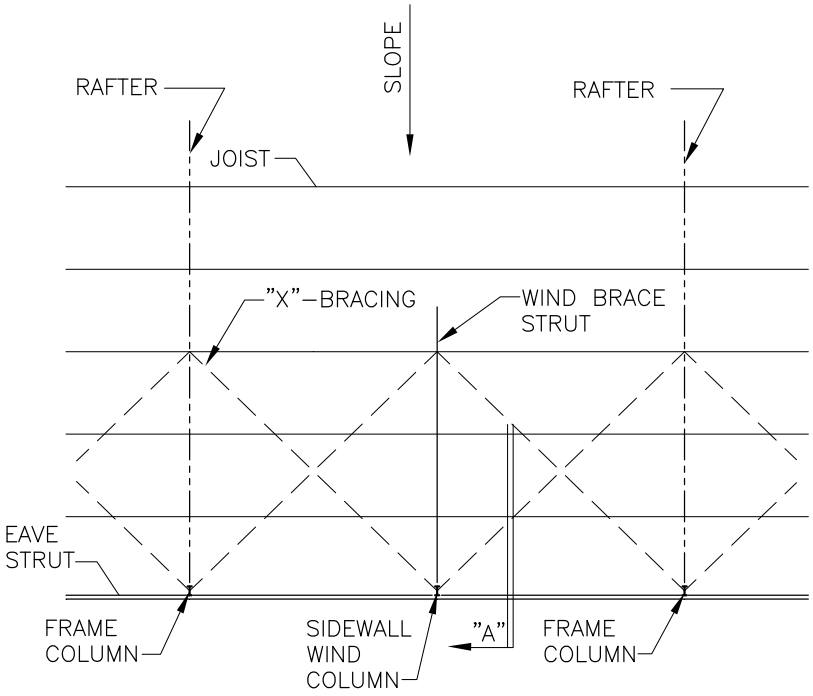


If the width is >100' $\leq$ 240' then two "X" locations are required.

Endwall X-bracing should be located between the first and second interior columns as a standard, although it could be located anywhere along the endwall as allowed by the customer.

BRACE DETAIL FOR SIDEWALL WIND COLUMNS

Long bay buildings (bays greater than or equal to 35 feet) should normally employ mid-bay wind columns in order to reduce the span of sidewall girts, thus reducing costs. NBS uses the following detail in order to transfer the wind or stability forces from the wall to the adjacent main frames.



*NOTE: "X"–BRACING IS REQUIRED IN EACH BAY