

CONNECTION STIFFNESS IMPLEMENTATION PROCEDURE FOR RAM USERS (v14.04 & NEWER)

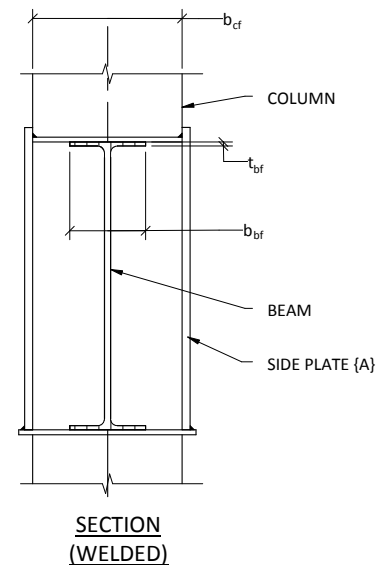
Comprehensive analysis and design of moment frames using SidePlate® connection technology are now available in the RAM Structural System. This document describes the use of this feature.

Column-Beam Relationship:

Create the model as customary for any project using steel moment frames. When selecting preliminary lateral beam and columns sizes in RAM Modeler, it is important to keep in mind the following two rules:

WELDED GEOMETRIC COMPATIBILITY: $b_{bf} + 1.1b_{bf} + 1/2'' \leq b_{cf}$

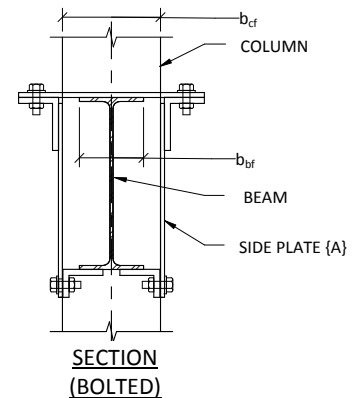
Background: The SidePlate connection typically consists of cover plates at the beam ends to bridge the difference between the beam flange width and the wider column flange width. The cover plates are fillet welded to the beam flange edges of which the top cover plate is detailed to be approximately the same width as the column flange width.



BOLTED GEOMETRIC COMPATIBILITY: $b_{bf} + 1\ 1/2'' \leq b_{cf}$

Background: The SidePlate connection typically consists of a cover plate and angles at the beam ends. The cover plates are fillet welded to the beam flange edges.

Note that RAM Frame will check geometric compatibility each time Analysis is run when moment connections have been assigned as SidePlate.



STRONG COLUMN

WEAK BEAM COMPLIANCE FOR R=8 SMF DESIGNS ONLY:

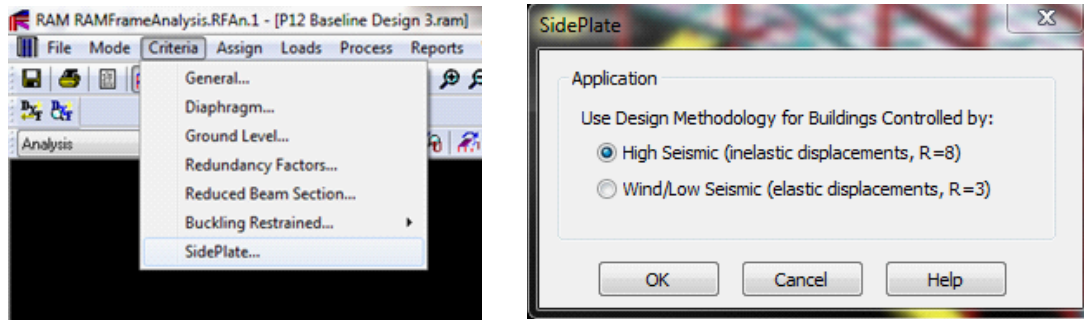
$$\sum (Z_{x,col}) > 1.7 * \sum (Z_{x,bm}) \text{ for 1-12 stories (rule of thumb)}$$

Background: The above equation takes into account the latest Seismic Provisions equation for SCWB compliance of SMF connections, including an approximate allowance for reduction in column capacity due to axial loads as well as the pushing out of the plastic hinge into the beam.

Note that RAM Frame Steel - Seismic Provisions includes the actual SCWB checks for SidePlate moment connections.

Criteria:

In RAM Frame, the Criteria for these moment connections can be specified using the **Criteria – SidePlate** command.



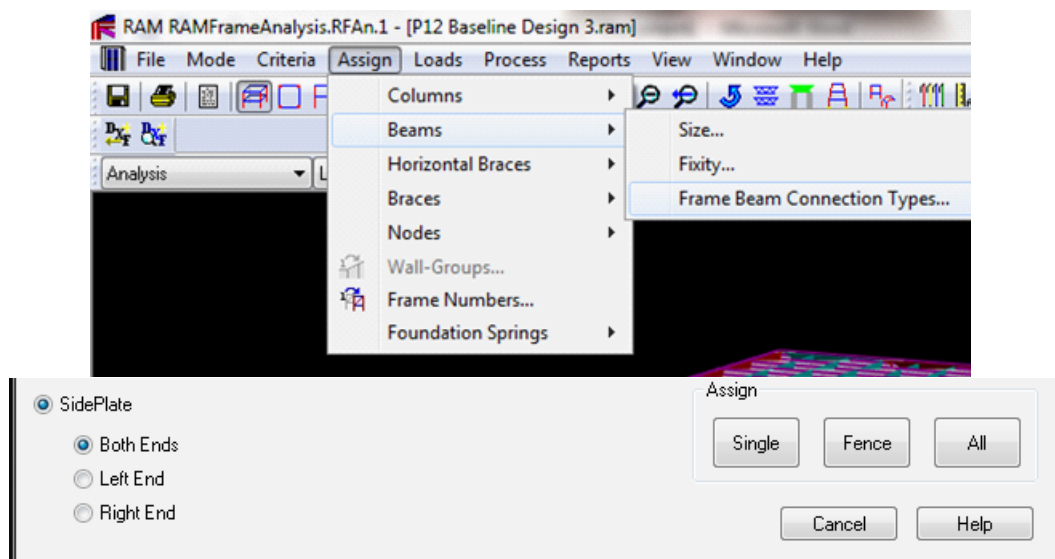
The connection properties are different for high seismic (inelastic) applications versus wind (elastic) and low seismic applications. Select the criteria that will most likely govern the sizing of the moment frames. For R=8 designs, seismic displacement will typically govern. For R=3 designs, wind displacement will typically govern.

Note that SidePlate's 100% rigid end zone (e.g. panel zone) properties are now built-in automatically and accounted for when SidePlate is assigned as a moment connection and will be considered as such regardless of the specific selection in **General Criteria – Rigid End Zones**.

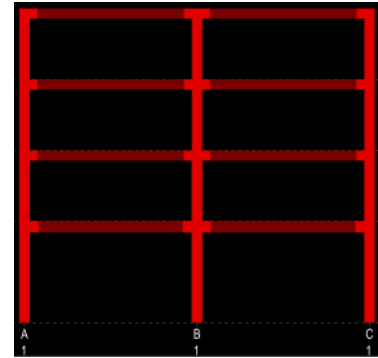
Assign:

In RAM Frame, assign the moment connection type using the **Assign – Beams - Connection** command.

Selecting "Both Ends" and "All" will assign a SidePlate connection at both ends of every lateral frame beam. If there are lateral beams that are fixed at one end and pinned at the other, select the "Left End" or "Right End" and Assign those specific beams using the Single command.



Once the beam ends have been assigned, RAM Frame will display a red rectangle symbolizing a SidePlate moment connection as shown to the right:

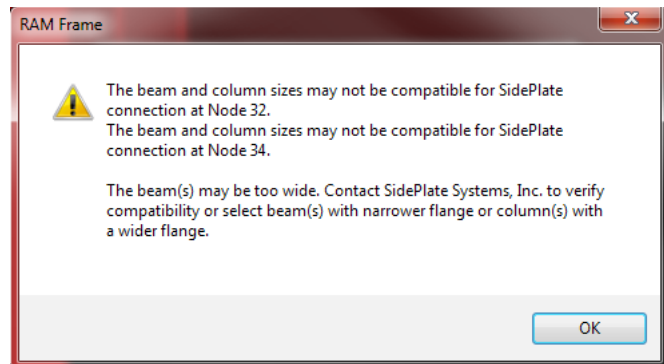


Analysis:

When the Analysis is performed, the appropriate SidePlate connection criteria properties are applied accordingly. A frame beam-to-column geometric compatibility is performed each time an analysis is performed to confirm compliance.

(Note: If the built-in formula indicates that a particular combination is not compatible, but is close, please call SidePlate Systems as a quick project specific connection design may be needed)

If any particular combination is not satisfied, the following WARNING will be displayed:



RAM Frame - Frame Takeoff

1:1

in 0 1 2 3 4 5 6 7

2

3

4

5

6

7

8

9

TOTAL STRUCTURE FRAME TAKEOFF

Floor Area (ft**2): 124892.5

Columns:

Wide Flange:
Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W24X131	48	672.0	88035	
W24X162	56	880.0	142833	
W24X192	16	272.0	52108	
	120		282976	2.27

Beams:

Wide Flange:
Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W24X76	32	1024.0	78050	
W27X94	48	1536.0	144776	
	80		222826	1.78

SidePlate Connections:
Number of Joints with Connection: 120
Weight of Side Plates (lbs): 90763.53 UnitWt (psf): 0.727

Note: Length and Weight based on Centerline dimensions.

The Member Forces report has been enhanced to include pertinent SidePlate information such as beams being identified as having SidePlate connections with forces reported at key points along the beam. Such added locations are used for stress checks in the beam as well as information for connection designs used by SidePlate. Column rigid end zones reflect the geometry of SidePlate connections, including appropriate depths of side plates.

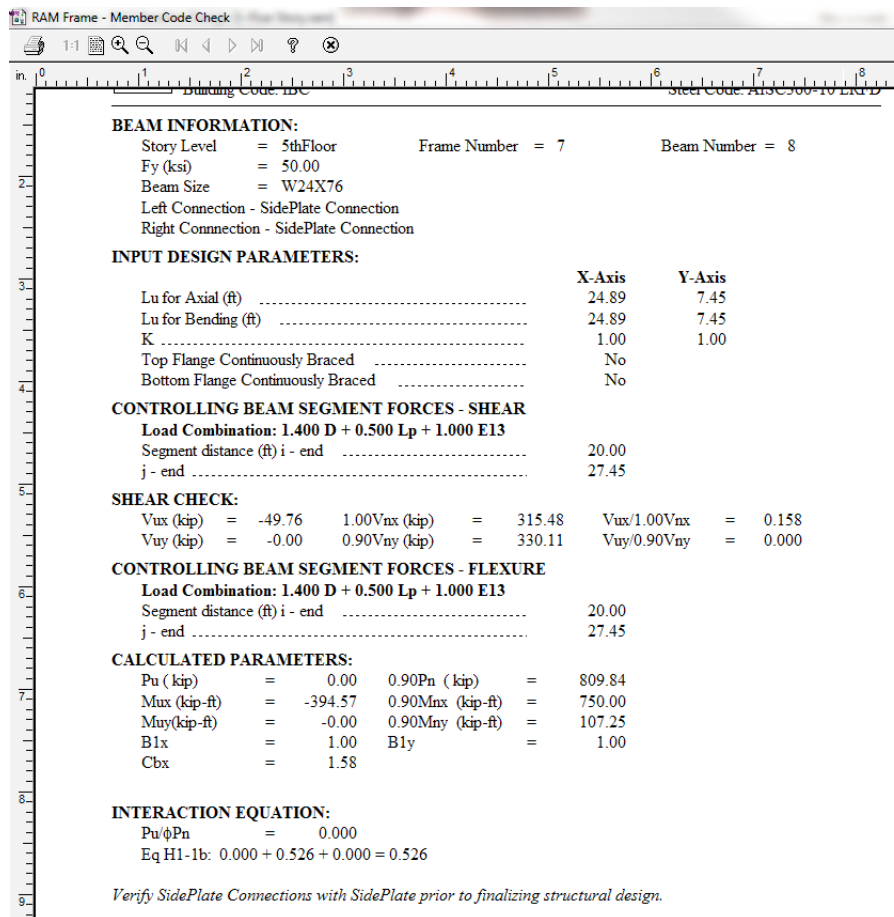
A new section has been added to the Frame Takeoff report to include the plate weight of the SidePlate connection.

Steel – Standard Provisions:

The Design moment and shear for the beams is taken at the face (end) of the SidePlate connection. The unbraced length of the beam is measured from end of side plate to end of side plate. No design is performed for the beam within the connection, nor for the connection itself. Connection designs are provided by SidePlate Systems, Inc. (www.sideplate.com).

The Design moment and shear for the columns is taken at the face (top and bottom edges) of the side plates. The unbraced length (both x and y) is taken as the clear height between the side plates.

The Member Code Check report for the beams indicates that the beam has SidePlate connection(s):



The screenshot shows a software window titled "RAM Frame - Member Code Check". The report content is as follows:

BEAM INFORMATION:
Story Level = 5thFloor Frame Number = 7 Beam Number = 8
Fy (ksi) = 50.00
Beam Size = W24X76
Left Connection - SidePlate Connection
Right Connection - SidePlate Connection

INPUT DESIGN PARAMETERS:

	X-Axis	Y-Axis
Lu for Axial (ft)	24.89	7.45
Lu for Bending (ft)	24.89	7.45
K	1.00	1.00
Top Flange Continuously Braced	No	
Bottom Flange Continuously Braced	No	

CONTROLLING BEAM SEGMENT FORCES - SHEAR
Load Combination: 1.400 D + 0.500 Lp + 1.000 E13
Segment distance (ft) i - end 20.00 | || j - end | 27.45 | |

SHEAR CHECK:
Vux (kip) = -49.76 1.00Vnx (kip) = 315.48 Vux/1.00Vnx = 0.158
Vuy (kip) = -0.00 0.90Vny (kip) = 330.11 Vuy/0.90Vny = 0.000

CONTROLLING BEAM SEGMENT FORCES - FLEXURE
Load Combination: 1.400 D + 0.500 Lp + 1.000 E13
Segment distance (ft) i - end 20.00 | || j - end | 27.45 | |

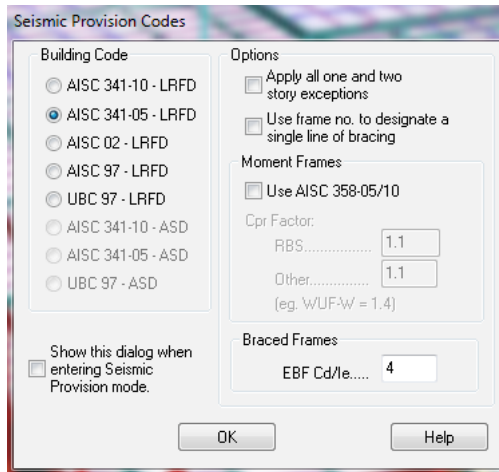
CALCULATED PARAMETERS:
Pu (kip) = 0.00 0.90Pn (kip) = 809.84
Mux (kip-ft) = -394.57 0.90Mnx (kip-ft) = 750.00
Muy(kip-ft) = -0.00 0.90Mny (kip-ft) = 107.25
B1x = 1.00 B1y = 1.00
Cbx = 1.58

INTERACTION EQUATION:
Pu/φPn = 0.000
Eq H1-1b: 0.000 + 0.526 + 0.000 = 0.526

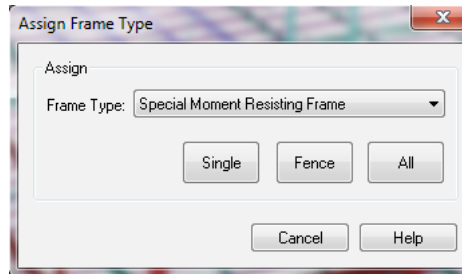
Verify SidePlate Connections with SidePlate prior to finalizing structural design.

Steel – Seismic Provisions:

In the Steel – Seismic Provisions mode the seismic provision requirements for AISC 341 ASD and LRFD have been implemented for SidePlate connections. Select one of the codes in the **Criteria – Codes** command.



It is necessary to assign a frame type to each member, used by the program to determine which seismic provisions are pertinent. This is done using the **Assign – Frame Type** command. Select either *Special Moment Resisting Frame*, *Intermediate Moment Resisting Frame* or *Ordinary Moment Resisting Frame* as appropriate.



The Frame Type assignment on each member can be displayed using the View – Members command by selecting the Frame Type labels option on the Frame Beam and Frame Column tabs.

The text should show either SMRF, IMRF or OMRF.



Select the **Process – Member Code Check** to have the code check performed on all of the members and select the **Process – Member View/Update** command to select and view the results for an individual member.



Seismic Provisions Member Code Check

RAM Frame v14.05.03.00

DataBase: 20120518_FLS Office 2 revised atrium floor plan-SP4a

Building Code: IBC

07/03/13 11:07:40

Steel Code: AISC341-05 - LRFD

Beam Parameters

Story: 1st Floor Frame No: 7 Member No: 2
Fy (ksi): 50.00 Size: W24X76
Frame Type: Special Moment Resisting Frame
Left Connection - SidePlate Connection
Right Connection - SidePlate Connection

9.2 Beam-to-Column Joints and Connections

*SidePlate beam-to-column connection must be capable of sustaining a 0.04 radian interstory drift ratio. **OK***

Required flexural strength of connection (kip-ft) = 666.67 at story drift angle in (1)

*All SidePlate beam-to-column joints to demonstrate conformance with 9.2a as indicated in 9.2b per ICC-ES ESR-1275. **OK***

9.4 Beam and Column Limitations --- **OK**

Flange b/tf = 6.61 Limit = 7.22 **OK**
Web h/tw = 48.95 Limit = 59.00 **OK**

9.8 Lateral Bracing of Beams --- **OK**

Max Lu (in) = 64.67 Lu Limit = 95.73 **OK**

Lateral Bracing Requirements along Beam

Required strength of lateral brace along beam = 9.47 kip

Required stiffness of bracing (A-6-8) = 6316.39 kip / Lb

Lateral Bracing Requirements at Plastic Hinge

Not Required per ICC-ES ESR-1275

Cd = 1.0 assumed for eqns (A-6-7/8)

Lb = distance between braces (in)

Hinge-to-Hinge / Beam Depth Ratio

Hinge-to-Hinge Length L' (ft) = 25.87

Minimum L' / Depth = 4.5

L' / Depth = 12.99 **OK**

Protected Zone

Protected Zone i (ft): 2.44 to 4.10

Protected Zone j (ft): 27.98 to 29.64

No members frame into Protected Zone **OK**

Verify SidePlate Connections with SidePlate prior to finalizing structural design.

Select the **Process – Joint Code Check** to have the code check performed on all of the joints and select the **Process – Joint View/Update** command to select and view the results for an individual member.



Seismic Provisions Joint Code Check

RAM Frame v14.05.03.00
 DataBase: 20120518_FLS Office 2 revised atrium floor plan-SP4a
 Building Code: IBC
 07/03/13 11:09:34
 Steel Code: AISC341-05 - LRFD

Joint Parameters

Story: 2nd Floor Frame No: 7 Joint No: 39
 Fy (ksi): 50.00 Column Size: W21X132
 Joint Frame Type: Special Moment Resisting Frame
 Strain Hardening Factor Cpr = 1.20

9.2a Connection Required Shear Strength --- OK

All SidePlate beam-to-column joints demonstrate conformance with 9.2a as indicated in 9.2b per ICC-ES ESR-1275.

9.3 Panel Zone of Beam-to-Column Connections --- OK

The column panel zone shear strengths need not be calculated for the SidePlate moment connection system, since SidePlate connection technology design inherently provides at least three panel zones (i.e., two side plates plus the column web(s)).
 Therefore, the configuration of the SidePlate connection system satisfies the requirements for checking panel zone strength.

9.5 Continuity Plates

Continuity plates shall be provided to match tested connection.

9.6 Column-Beam Moment Ratio --- OK

Col.	Size	M*pc (kip-ft)	Zc (in ³)	Pu (kip)	Combo#
Top	W21X101	1146.52	253.00	118.07	151
Bot	W21X132	1485.97	333.00	181.05	151
Bm.	Size	M*pb (kip-ft)	Mpr (kip-ft)	Muv (kip-ft)	Sh+dc/2 (in)
40	W24X76	1240.87	1240.87	372.14	37.27
9	W24X76	1240.09	1240.09	378.63	37.27

$$\Sigma M^*_{pc} = \Sigma Z_c(F_y - P_u/A_g) \times [h/(h-d_p)] \text{ (kip-ft)} = 2632.49$$

$$\Sigma M^*_{pb} = \Sigma Z_b(1.2 \times F_y \times L/L') \text{ (kip-ft)} = 2480.96$$

$$\Sigma M^*_{pc} / \Sigma M^*_{pb} \text{ (Eqn 9-3)} = 1.06 > 1.0 \text{ OK}$$

9.7a Restrained Beam-to-Column Connection --- OK

Joint is restrained in the minor axis at both the top and bottom flange of the moment-frame beams.

Note: The lateral bracing at the column, working with the side plates, provides indirect support that satisfies the required bracing of column flanges at both the top and bottom beam flanges whether or not the column remains elastic, as defined by Section 9.7a of AISC 341.

The full-depth side plates have been shown, in full-scale tests, to provide the required indirect lateral bracing of the column flanges through the side plate-to-column flange welds and the connection elements that connect the column web to the side plates.

Verify SidePlate Connections with SidePlate prior to finalizing structural design.

The Seismic Provisions Member Code Check and Joint Code Check reports shows the results of all the checks, including compliance that structural framing does not exist within the beam's protected zone as defined for SidePlate connections.

Upon completion of preliminary and/or final lateral designs using SidePlate connection technology, users should send their RAM model (e.g. "xxx.rss" file), including any customized beam, column or deck tables, to SidePlate Systems, Inc. (1-949-238-8900) at solutions@sideplate.com for verification and validation of computer model. Upon completion of model review, SidePlate Systems will provide structural drawings (notes and details), including stamped/signed calculations for each SidePlate moment connection for the specific project.