SEISMIC BRACING SYSTEMS

Atkore™
Sasco Strut

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The information in this manual is subject to Read Jones Chrisoffersen Ltd.'s Structural Engineering Disclaimer found on Page 3 of this Manual

Structural Engineering Disclaimer

Read Jones Christoffersen Ltd. (RJC) has corroborated on and reviewed this manual for the design procedures for seismically bracing non-structural building components and has provided supplementary design tables derived from the National Building Code of Canada (2010 Edition).

This manual is intended for use by a qualified person who takes full responsibility for the project design. Anyone using the information in this publication assumes any and all liability resulting from such use. Sasco and RJC disclaim any and all express or implied warranties of fitness for any general or particular application.

Final responsibility for the structural adequacy of the support of non-structural elements on any given project rests with the professional engineer for that project who shall also determine compliance with all applicable federal, provincial and municipal codes.

PROVINCE OF
BRITISH COLUMBIA
G. RAYNARD
PROFESSIONAL ENGINEER
12460
DESIGNATED
STRUCTURAL ENGINEER

Gilbert Raynard, P.Eng., Struct Eng.
Principal
Read Jones Christoffersen Ltd.

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Read Jones Christoffersen
Consulting Engineers

Suite 300
1285 West Broadway
Vancouver, BC V6H 3X8
Canada

604 738-0048
Fax 604 738-1107
www.rjc.ca

1. General Information

In response to requests for a Seismic Restraint Design Manual based on the Canadian method of limit states design which compares factored resistance to factored load, Sasco Tubes and Roll Forming Inc. (Sasco) engaged Read Jones Christoffersen Ltd. (RJC), a large Canadian consulting structural engineering company, to create this publication for use in Canada.

Sasco, a Canadian owned and operated company, is recognized as Canada's industry leader with over 40 years of experience in manufacturing a complete line of strut channel and fittings for electrical, mechanical, industrial and seismic applications.

The material provided in this publication is for general information only and is to be used as a reference tool.

Seismic bracing systems designed and detailed in this publication do not guarantee the adequacy of existing structures to withstand the loads transmitted by the seismic bracing system.

Final responsibility for the structural adequacy of the support of nonstructural elementsas well as the adequacy of the existing structures rests with the designer and/or project engineer who must also determine compliance with all applicable codes.

Anyone using the information in this publication assumes any and all liability resulting from such use. Sasco and RJC disclaim any and all express or implied warranties of fitness for any general or particular application.

The information provided in this publication is specifically intended for use in the seismic bracing of non-structural building components in Canada and derived from the 2010 edition of the **National Building Code of Canada (NBCC).** Provincial and municipal codes may also apply and the designer of record shall confirm that all applicable code requirements are satisfied. The design of the structural braces and their attachments are based on the limits states design procedure as required by the NBCC and the tables in this document provide design information in both metric and imperial units. Where applicable, the design recommendations presented within represent "best practices" in Canada.

Notes

- *Design recommendations provided are shown for standard weight steel pipes filled with water. Contents other than water shall be evaluated by the project engineer and pipes of other materials shall be supported in accordance with their approved installation standards*
- *This publication does not address the seismic design of the pipes themselves.*
- *Refer to the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) "Seismic Restraint Manual: Guidelines for Mechanical Systems" (ANSI /SMACNA 001-2000) for additional guidelines on seismic bracing. Section 4.2 of the SMACNA document is provided herein (on pages 8 to 11) for assistance with laying out transverse and longitudinal braces.*
- *See the National Plumbing Code of Canada for more information on pipe supports*
- *See clause 4.1.8.18 of the NBCC for additional information regarding seismic design requirements for non-structural components and equipment. within represent "best practices" in Canada.*

Seismic Bracing Systems

Requirements

- Seismic bracing shall not limit the expansion and contraction of the piping system; the engineer of record shall ascertain that consideration is given to the individual dynamic and thermal properties of these systems and the building structure.
- Where possible, pipes and conduit and their connections shall be constructed of ductile materials such as copper, ductile iron, steel or aluminum.
- Transverse and longitudinal braces shall be placed no more than 45° from the horizontal (see Figures 2 (Pg 20) and 4 (Pg 21))
- Where rod stiffeners are required, a minimum of two Sasco rod stiffener clamps shall be installed (see Figure 6 (Pg 22))
- Braces for trapeze hangers shall be connected directly to the trapeze hanger and all pipes shall be secured to the trapeze with approved Sasco pipe clamps (See Pg 46)
- Longitudinal bracing of trapezes shall have a brace on both ends of the trapeze
- All bolts and Sasco clamping nuts shall be ½" (12.7 mm) diameter

Material Specifications

Item	Standard
Channel Sections	ASTM A653 / 653M SS Grade 33, Galvanized
Bolts	ASTM A307
Clamping Nuts	ASTM A108 Grades 1015 and 1020
Threaded Rod	ASTM A36, A575 or A576

Bolt Torque

½" (12.7 mm) bolts must be tightened to a minimum torque of 68 N.m (50 ft.lbs) when used with Sasco clamping nuts.

Seismic Design Information

The following defines the design lateral seismic force, V_p, for elements and components of buildings as described in the 2010 National Building Code of Canada (NBCC 2005) sentence 4.1.8.18.

V_p = Seismic Load Coefficient x W_p

Seismic Load Coefficient = 0.3 x F_a x $S_a(0.2)$ x I_E x S_p

where

F_a = as defined in NBCC Table 4.1.8.4.B.,

$S_a(0.2)$ = spectral response acceleration value at 0.2 s, as defined in NBCC sentence 4.1.8.4.(1),

I_E = importance factor for the building, as defined in NBCC Article 4.1.8.5

$S_p = C_p \times A_r \times A_x / R_p$ (the maximum value of S_p shall be taken as 4.0 and the minimum value of S_p shall be taken as 0.7)

C_p = element or component factor from NBCC Table 4.1.8.18

A_r = element or component force amplification factor from NBCC Table 4.1.8.18

A_x = height factor $(1 + 2\, h_x/h_n)$, where

h_x = height of component under design consideration
h_n = height of uppermost level in main portion of structure (see Figure 9)

R_p = Element or component response modification factor from NBCC Table 4.1.8.18

W_p = weight of component or element

Note: the following typical seismic loading criteria:

1) Assume importance factor of 1.5 unless noted otherwise

2) If Site Class information is unknown, the NBCC requires that the highest value of F_a for a given $S_a(0.2)$ found in the table for F_a shall be used.

3) The lateral seismic force in the transverse direction may be considered to act independently of forces in the longitudinal direction and vice versa.

See Figure 10 (Pg 24) for values of A_r, R_p, and C_p for mechanical and electrical components in a typical building in Vancouver.

Load Combinations

As required in the NBCC, the effect of factored loads for a building or structural component shall be determined in accordance with the Code and the Load Combination cases outlined therein. From the NBCC, the following loads and Load Combination applies:

Load Combination: 1.0**D** + 1.0**E**

Where: **D** is the Dead load of the system including the weight of the pipes and their contents
and **E** is the load due to Earthquake

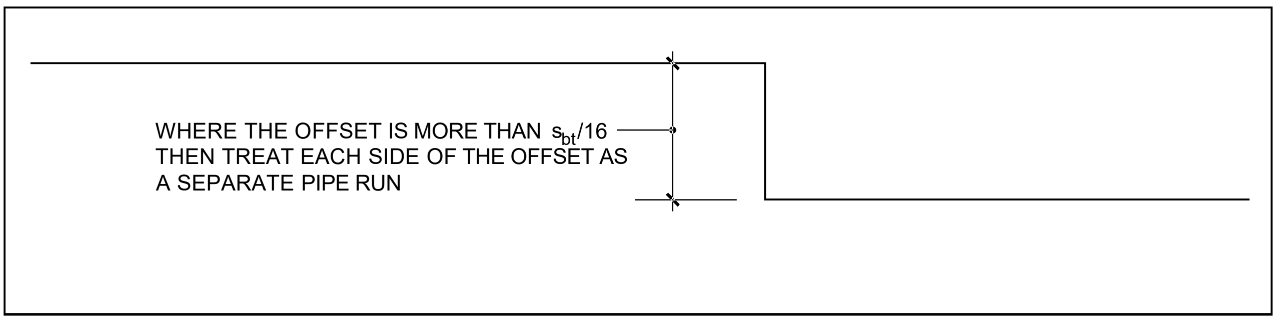
Anchorage to Base Structure

It is the responsibility of the project engineer to confirm that the primary structure can withstand the connection loads of the hanger rods and brace attachments. The design of these connections is the responsibility of the project engineer and should be reviewed by the engineer of record for the base building. See NBCC clause 4.1.8.18 (8) for additional connection information. See Figures 11 (Pg 25) and 12 (Pg 25) for common concrete and steel connections

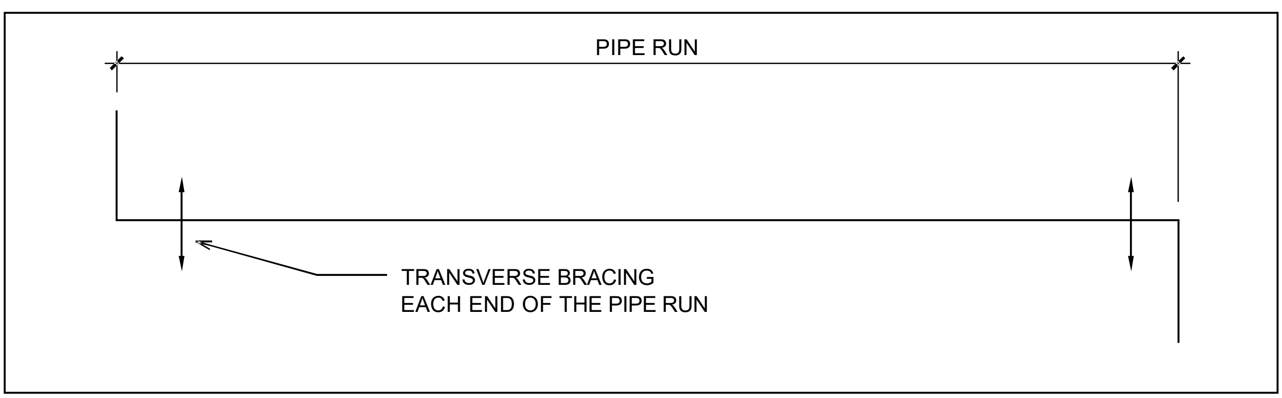
SMACNA – Section 4.2

The following is taken from section 4.2 of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) "Seismic Restraint Manual: Guidelines for Mechanical Systems" (ANSI /SMACNA 001-2000). It is provided for additional guidelines on seismic bracing of non-structural components within a building. Note: the project engineer must ensure that the most current version of SMACNA document is referred to which may supersede the information below.

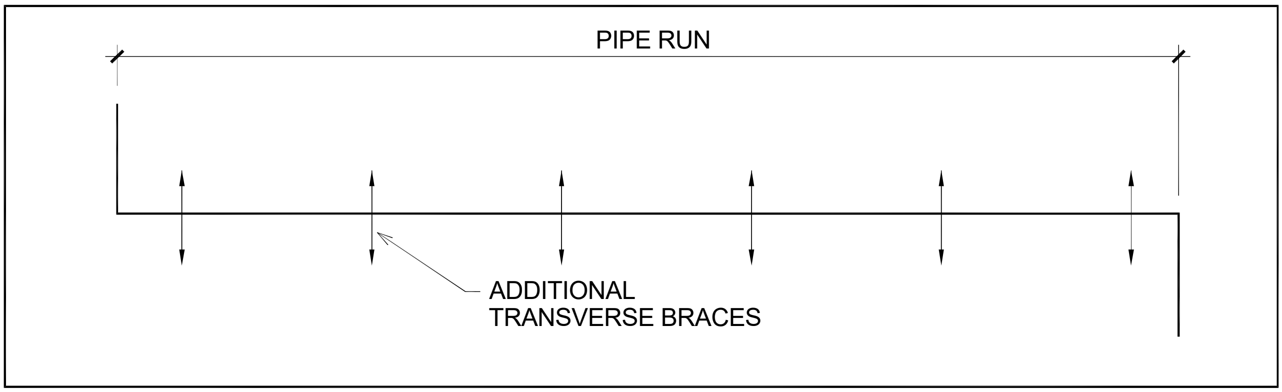
1. Separate the length of the pipe into separate runs. A run is considered to be a single straight section between any bends in the pipe except where the bend is at an offset of less than the allowable transverse brace spacing (s_{bt}) divided by 16. ***Note: The maximum transverse brace spacing is shown in Table 3 (Pg 28).***



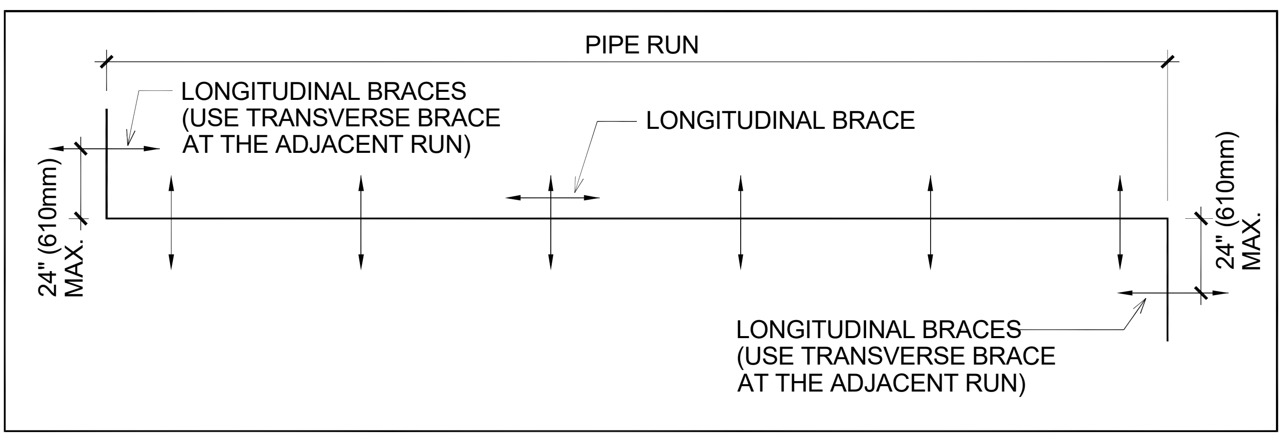
2. Each straight run must be braced in the transverse direction at each end. Where several short runs occur, see item 5 below.



3. Check the spacing of the transverse bracing with the braces at each end of the pipe run. If this distance is greater than the allowable distance in Table 3 (Pg 28), add transverse braces until the spacing does not exceed the allowable distance.



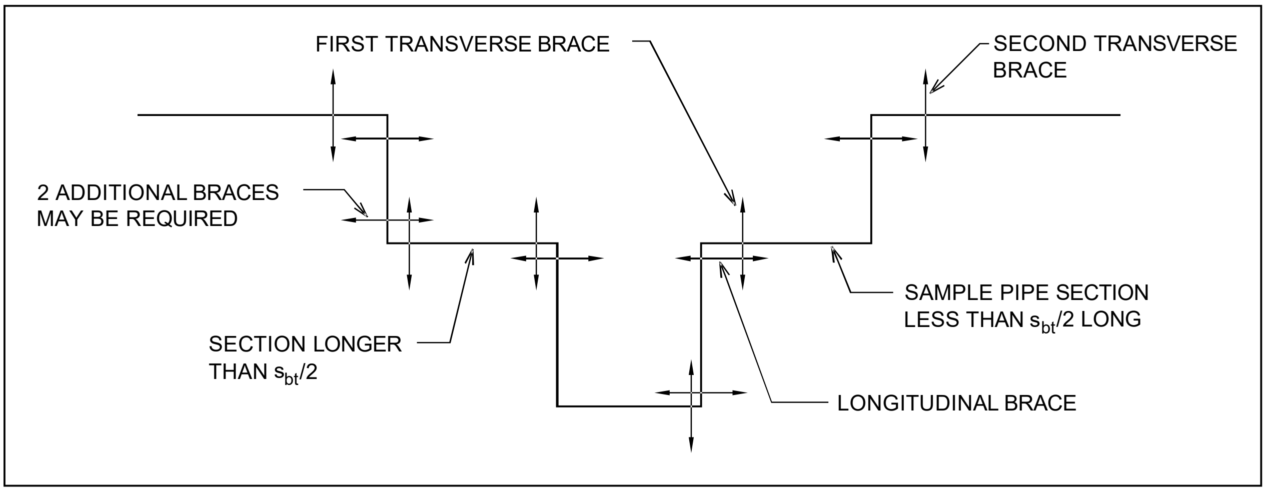
4. Each pipe run must have at least one longitudinal brace. Add longitudinal braces so the spacing does not exceed the maximum spacing in Table 3 (Pg 28).

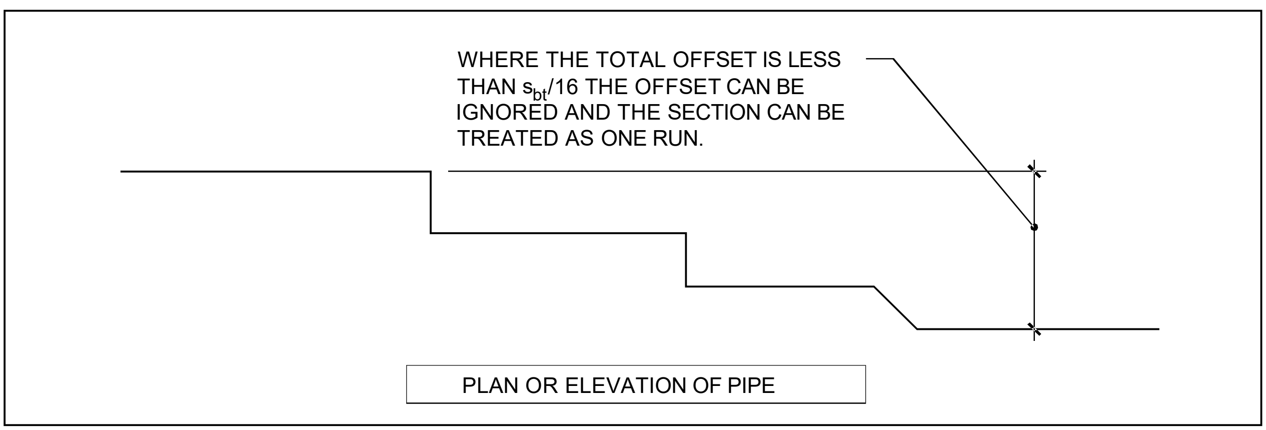


If an adjacent run has a transverse brace within 610 mm (24in) of the 90 degree corner, it can be used a longitudinal brace. Use the larger of the two braces, the longitudinal brace for this run or the transverse brace of the adjacent run.

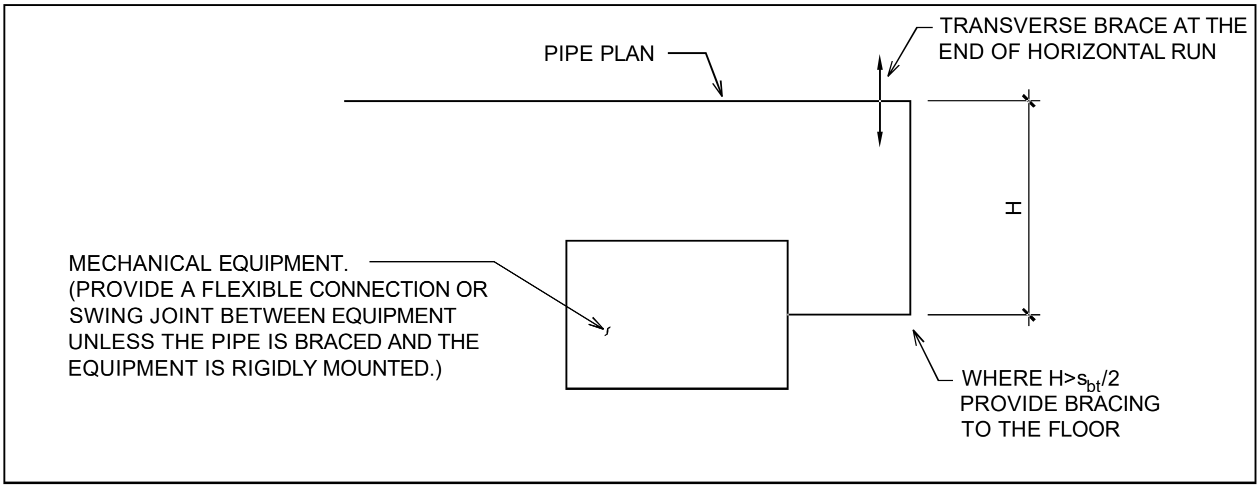
5. In many cases, several short sections of pipe occur one after the other. Based upon the requirements above, each section should be provided with a longitudinal brace if the offset is greater than s_{bt} /16. The longitudinal braces can act as transverse braces as long as the total length of pipe tributary to the brace does not exceed s_{bt}.

With a layout as shown below, in which each section shown is less than s_{bt} /2 long, transverse braces can be used as the longitudinal braces. Where a section is longer than s_{bt} /2, additional braces will be required.





6. The following figure shows a different condition. When a flexible connection or swing joint is used, such as at a pipe drop to mechanical equipment, the pipe may cantilever as much as $s_{bt}/2$ without adding additional bracing.



2. Design Procedures

Trapeze Hangers

Step 1 **Determine maximum spacing of trapeze hangers and seismic braces**

Use Table 3 (Pg 28) to select the maximum support spacing, $s_{trapeze,}$ governed by the requirement of the smallest diameter pipe. Us e Table 3 to select the maximum seismic brace spacing (transverse, $s_{bt,}$ and longitudinal, $s_{b\ell}$) and note that they should be multiples of the trapeze spacing. ***Note: The project engineer must ensure that any other pipe support spacing requirements that may be required for a specific project are also met. See also SMACNA Section 4.2 for guidelines regarding brace layout.***

Step 2 **Determine Dead Load, Wp, supported by trapeze**

Use Table 3 (Pg 28) to determine the dead load of the pipes and their contents per unit length supported by the trapeze.

$W_p = \Sigma (DL_p \times N_p)$
DL_p = pipe diameter unit dead load (kN/m or lb/ft)
N_p = number of pipes of each diameter.

Step 3 **Calculate seismic forces**

Use the Seismic Design Information given on Page 6 to calculate the Seismic Load Coefficient and design lateral seismic force, $V_{p.}$ Recall, from the Load Combination provided earlier on page 7, the load factor for load due to earthquake is 1.0

In the transverse direction:
V_{pt} = 1.0 x Seismic Load Coefficient x W_p x s_{bt}

In the longitudinal direction:
$V_{p\ell}$ = 1.0 x Seismic Load Coefficient x W_p x $s_{b\ell}$

Step 4 **Determine Sasco pipe clamp required**

Use Table 9 (Pg 31) to ensure that each pipe is secured to the trapeze with a clamp that can withstand the applied forces in all three directions: transverse, longitudinal, and vertical (if applicable). See Figure 7 (Pg 22). The resistances (or capacities) for the clamp ($R_{clamp\_t,}$ $R_{clamp\_\ell,}$ R_{clamp_v}) are provided in Table 9 (Page 31) and must exceed the applied factored forces which are calculated according to the following expressions:

Transverse:
$R_{clamp\_t} > F_{clamp\_t}$ = 1.0 x Seismic Load Coefficient x DL_p x s_{bt}

Longitudinal:
$R_{clamp\_\ell} > F_{clamp\_\ell}$ = 1.0 x Seismic Load Coefficient x DL_p x $s_{b\ell}$

Vertical:
$R_{clamp\_v} > F_{clamp\_v} = 1.0 \times DL_p \times s_{trapeze}$

Step 5 Check trapeze for bending about both axes

Use the maximum factored load capacities provided in Tables 4 (Pg 29) and 5 (Pg 29) to check the capacity of the trapeze. The project engineer must determine if the loads are to be considered as distributed or concentrated.

For bending about both axes, the following interaction equation must be satisfied:

$(M_{fX} / Mr_{rX}) + (M_{fY} / M_{rY}) \leq 1.0$

where:

M_{fX} = Factored Bending Load about the X-X axis
$= 1.0 \times W_p \times S_{trapeze}$

M_{fY} = Factored Bending Load about the Y-Y axis
$= V_{p\ell}$

M_{rX} and M_{rY} = Maximum Factored Load about the X-X and Y-Y axes taken from Tables 4 and 5.

Note: Elastic deflections for the channel sections are also provided in Tables 4 and 5. The engineer of record shall ensure that the deflections are within acceptable criteria for the project. If necessary, a larger section or closer trapeze spacing can be employed to reduce the deflections.

Step 6 Check seismic braces

Use Table 6 (Pg 30) to ensure the axial capacity of the seismic brace exceeds the axial force. Table 6 provides the factored axial capacity, P_r, for Sasco SR2 channel. The factored axial force in the seismic brace, Pb, in tension or compression is given by the following: (See Figure 3 (Pg 20))

In the transverse direction:
$P_r > P_{bt} = V_{pt} \times (1 / \cos \theta_t)$

In the longitudinal direction:
$P_r > P_{b\ell} = ½ \times V_{p\ell} \times (1 / \cos \theta_\ell)$

Note: Where possible the braces should be installed at 45°, which is the maximum angle. See Figure 2 (Pg 20)

Step 7 Check hinge and connections

The connection of the Sasco seismic hinge (see Figure 2 (Pg 20)) to the seismic brace will be governed by the capacity of the bolt(s) and clamping nut(s). Use Table 8 (Pg 32) to check that the slip resistance, $V_{slip,}$ of the bolt(s) and clamping nut(s) exceeds the axial force in the seismic brace. The following must be satisfied:

$V_{slip} > Pb$ (where P_b is the larger of P_{bt} and $P_{b\ell}$)

Step 8 Check capacity of hanger rod and requirement for stiffener assembly

Use Table 7 (Pg 30) to ensure that the factored axial forces (tension and compression) in the hanger rod do not exceed the factored axial capacities ($P_{r\_rod,}$ T_{r_rod}) See Figure 6 (Pg 22). Table 7 contains the necessary information to select the required diameter of rod and determine if rod stiffeners are required for the compression condition. ***Note: that forces from the transverse and lateral directions can be considered independently. The following equations must be satisfied:***

In the transverse direction:

Compression:
$P_{r\_rod} > P_{rod\_t} = (P_{bt} \times \sin \theta_t) - (½ \times W_p \times s_{trapeze})$

Tension:
$T_{r\_rod} > T_{rod\_t} = (½ \times W_p \times s_{trapeze}) + (P_{bt} \times \sin \theta_t)$

In the longitudinal direction:

Compression:
$P_{r\_rod} > P_{rod\_\ell} = (P_{bl} \times \sin \theta_l) - (½ \times W_p \times s_{trapeze})$

Tension:
$T_{r\_rod} > T_{rod\_\ell} = (½ \times W_p \times s_{trapeze}) + (P_{b\ell} \times \sin \theta_\ell)$

If P_{rod_t} and/or $P_{rod\_\ell} > 0$, and the length of the rod exceeds the maximum clamp spacing shown in Table 7, then stiffener clamps must be added as shown in Figure 6**.**

Step 9 Check anchorages to base structure

It is the responsibility of the project engineer to confirm that the primary structure can withstand the connection loads of the hanger rods and brace attachments. The design of these connections is the responsibility of the project engineer and should be reviewed by the engineer of record for the base building. See NBCC clause 4.1.8.18 (8) for additional connection information. See Figures 11 (Pg 25) and 12 (Pg 25) for common steel and concrete connections

Single Pipe Hangers

Step 1 Determine maximum spacing of pipe hanger and seismic braces

Use Table 3 (Pg 28) to select the maximum support spacing, s_{hanger}. Use Table 3 to select the maximum seismic brace spacing (transverse, s_{bt}, and longitudinal, $s_{b\ell}$) and note that they should be multiples of the hanger spacing. ***Note: The project engineer must ensure that any other pipe support spacing requirements that may be required for a specific project are also met.***

Step 2 Determine Dead Load, Wp, supported by pipe hanger

Use Table 3 (Pg 28) to determine the dead load of the pipe and its contents per unit length.

$W_p = DL_p$

Step 3 Calculate seismic forces

Use the Seismic Design Information given on Page 6 to calculate the Seismic Load Coefficient and design lateral seismic force, V_p. Recall, from the Load Combination provided earlier on page 6, the load factor for load due to earthquake is 1.0

In the transverse direction:
V_{pt} = 1.0 x Seismic Load Coefficient x W_p x s_{bt}

In the longitudinal direction:
$V_{p\ell}$ = 1.0 x Seismic Load Coefficient x W_p x $s_{b\ell}$

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Step 4 Determine Sasco pipe clamp required

The project engineer must ensure that the pipe hanger can withstand the following factored forces: (see Figure 8 (Pg 23))

Transverse:

$F_{hang\_t} = V_{pt}$

Longitudinal:

$F_{hang\_\ell} = V_{p\ell}$

Vertical:

$F_{hang\_v} = 1.0 \times W_p \times s_{hanger}$

Where s_{hanger} is the spacing of pipe hangers

Step 5 Check seismic braces

Use Table 6 (Pg 30) to ensure the axial capacity of the seismic brace exceeds the axial force. Table 6 provides the factored axial capacity, P_r, for the Sasco SR2 channel. The factored axial force in the seismic brace, P_b, in tension or compression is given by the following: (See Figure 5 (Pg 21))

In the transverse direction:

$P_r > P_{bt} = V_{pt} \times (1 / \cos \theta_t)$

In the longitudinal direction:

$P_r > P_{b\ell} = V_{p\ell} \times (1 / \cos \theta_\ell)$

Note: Where possible the braces should be installed at 45°, this is the maximum angle. See Figure 4 (Pg 21)

Step 6 Check hinge and connections

The connection of the Sasco seismic hinge (see Figure 4 (Pg 21)) to the seismic brace will be governed by the capacity of the bolt(s) and clamping nut(s). Use Table 8 (Pg 30) to check that the slip resistance, V_{slip}, of the bolt(s) and clamping nut(s) exceeds the axial force in the seismic brace. The following must be satisfied:

$V_{slip} > P_b$ (where P_b is the larger of P_{bt} and $P_{b\ell}$)

Step 7 Check capacity of hanger rod and requirement for stiffener assembly

Use Table 7 (Pg 30) to ensure that the factored axial forces (tension and compression) in the hanger rod do not exceed the factored axial capacities ($P_{r\_rod,}$ T_{r_rod}) See Figure 6 (Pg 22). Table 7 contains the necessary information to select the required diameter of rod and determine the rod stiffeners required for the compression condition.

Note: that forces from the transverse and lateral directions can be considered independently. The following equations must be satisfied:

In the transverse direction:

Compression:

$$P_{r\_rod} > P_{rod\_t} = (P_{bt} \times \sin \theta_t) - (W_p \times s_{hanger})$$

Tension:

$$T_{r\_rod} > T_{rod\_t} = (W_p \times s_{hanger}) + (P_{bt} \times \sin \theta_t)$$

In the longitudinal direction:

Compression:

$$P_{r\_rod} > P_{rod\_\ell} = (P_{bl} \times \sin \theta_\ell) - (W_p \times s_{hanger})$$

Tension:

$$T_{r\_rod} > T_{rod\_\ell} = (W_p \times s_{hanger}) + (P_{b\ell} \times \sin \theta_\ell)$$

If P_{rod_t} and/or $P_{rod\_\ell} > 0$, and the length of the rod exceeds the maximum clamp spacing shown in Table 7, then stiffener clamps must be added as shown in Figure 6.

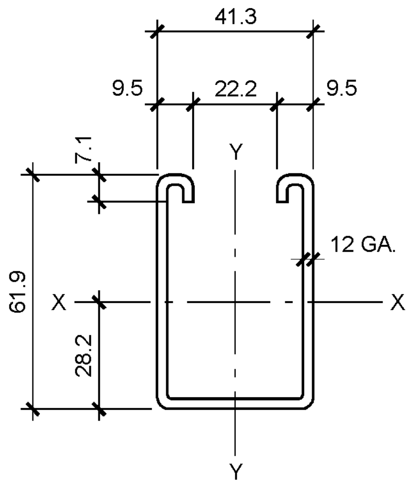
Step 8 Check anchorages to base structure

It is the responsibility of the project engineer to confirm that the primary structure can withstand the connection loads of the hanger rods and brace attachments. The design of these connections is the responsibility of the project engineer and should be reviewed by the engineer of record for the base building. See NBCC clause 4.1.8.18 (8) for additional connection information.

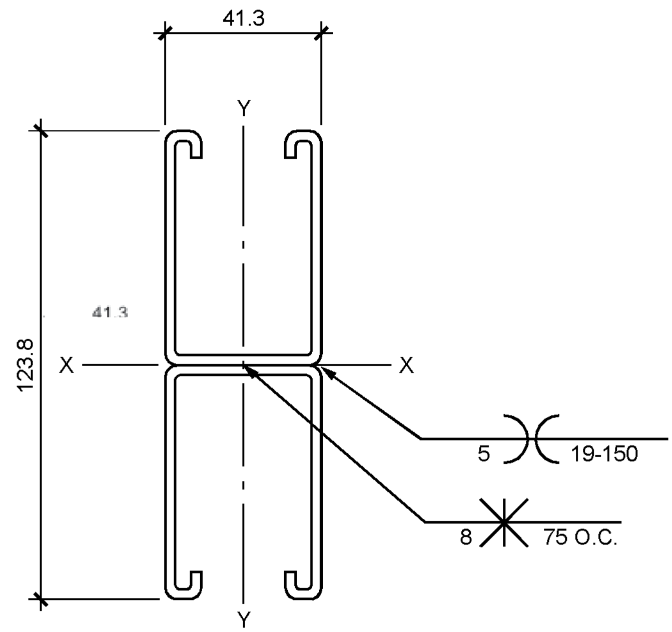
See Figures 11 (Pg 25) and 12 (Pg 25) for common concrete and steel connections.

3. Figures

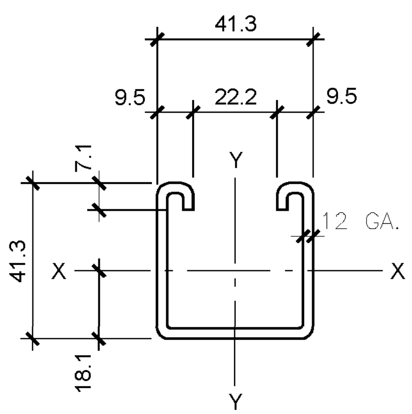
Figure 1A - Sasco Channels (Metric)



SR1



SR1BBSW



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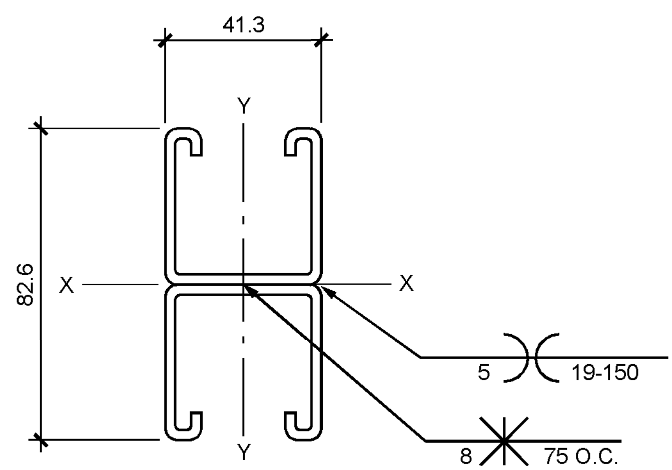
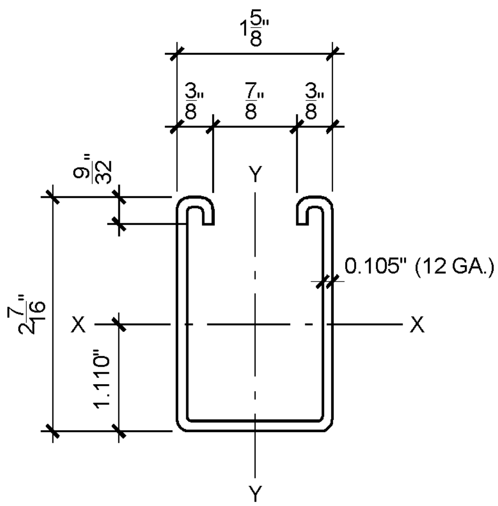
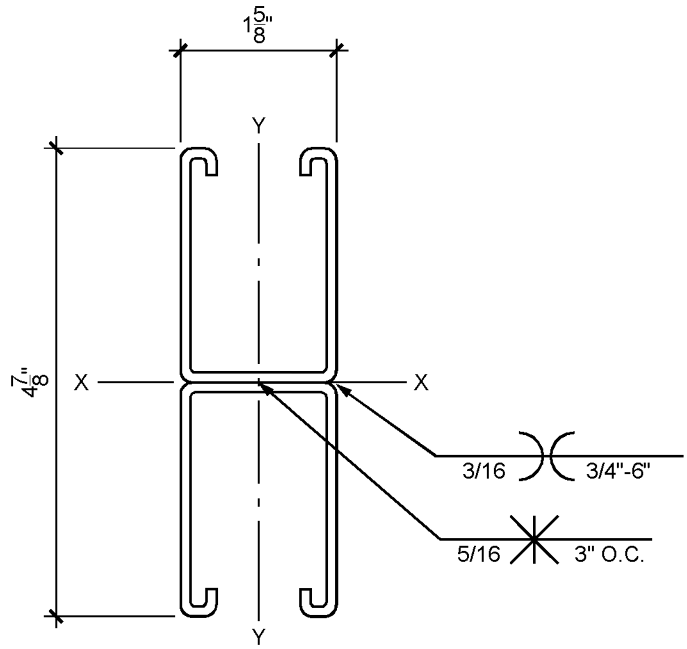


SR2BBSW

Figure 1B - Sasco Channels (Imperial)



SR1



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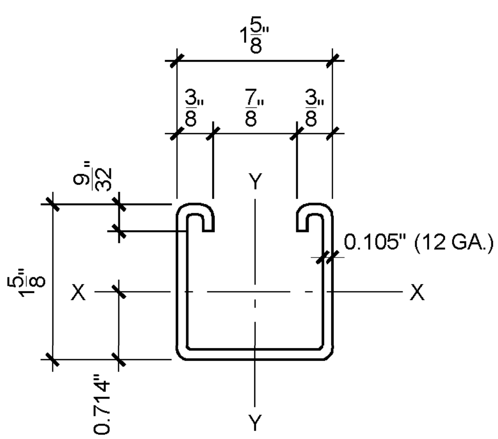

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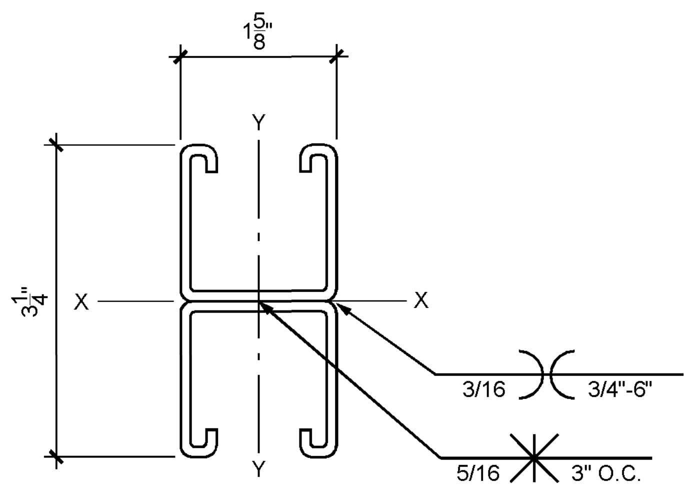

SR2BBSW

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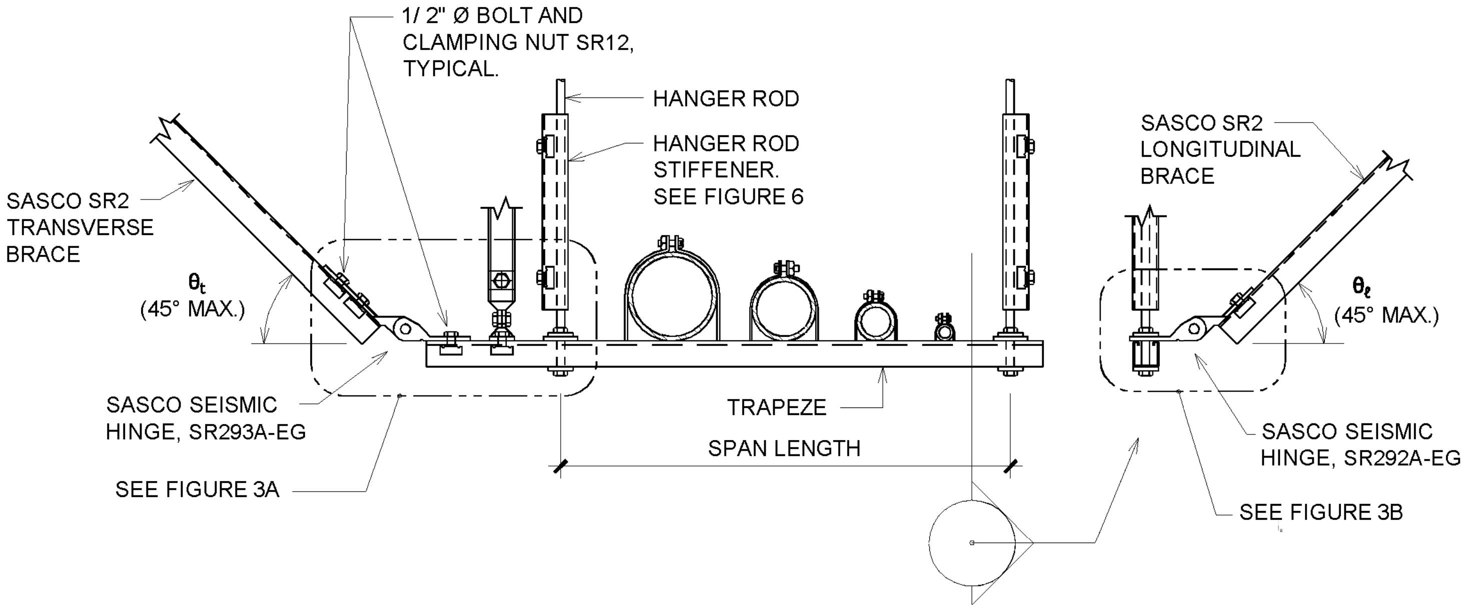
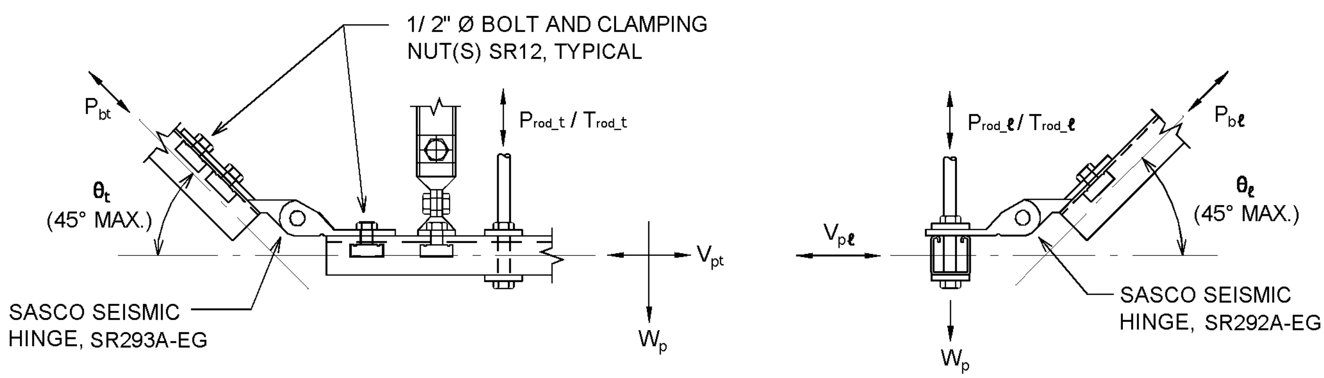
Figure 2 - Typical Trapeze with Transverse and Longitudinal Braces



NOTE:
LOAD CAPACITY OF SR292A-EG AND SR293A-EG EXCEEDS THE PULLOUT AND SLIP CAPACITIES OF THE BOLT(S) AND CLAMPING NUT(S)

Figure 3 - Typical Trapeze and Brace Details



NOTE:
LOAD CAPACITY OF SR292A-EG AND SR293A-EG EXCEEDS THE PULLOUT AND SLIP CAPACITIES OF THE BOLT(S) AND CLAMPING NUT(S)

Figure 4 – Typical Single Pipe with Transverse and Longitudinal Braces

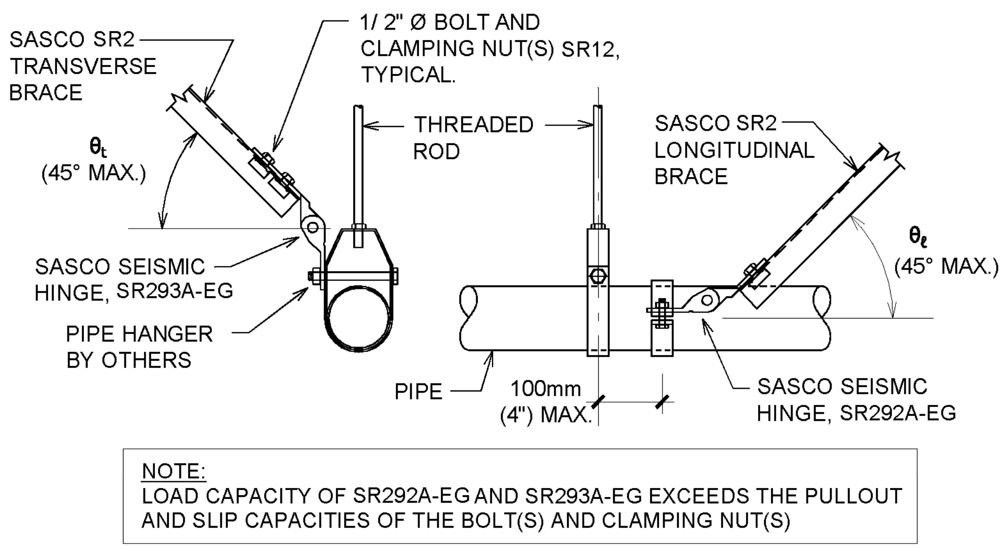
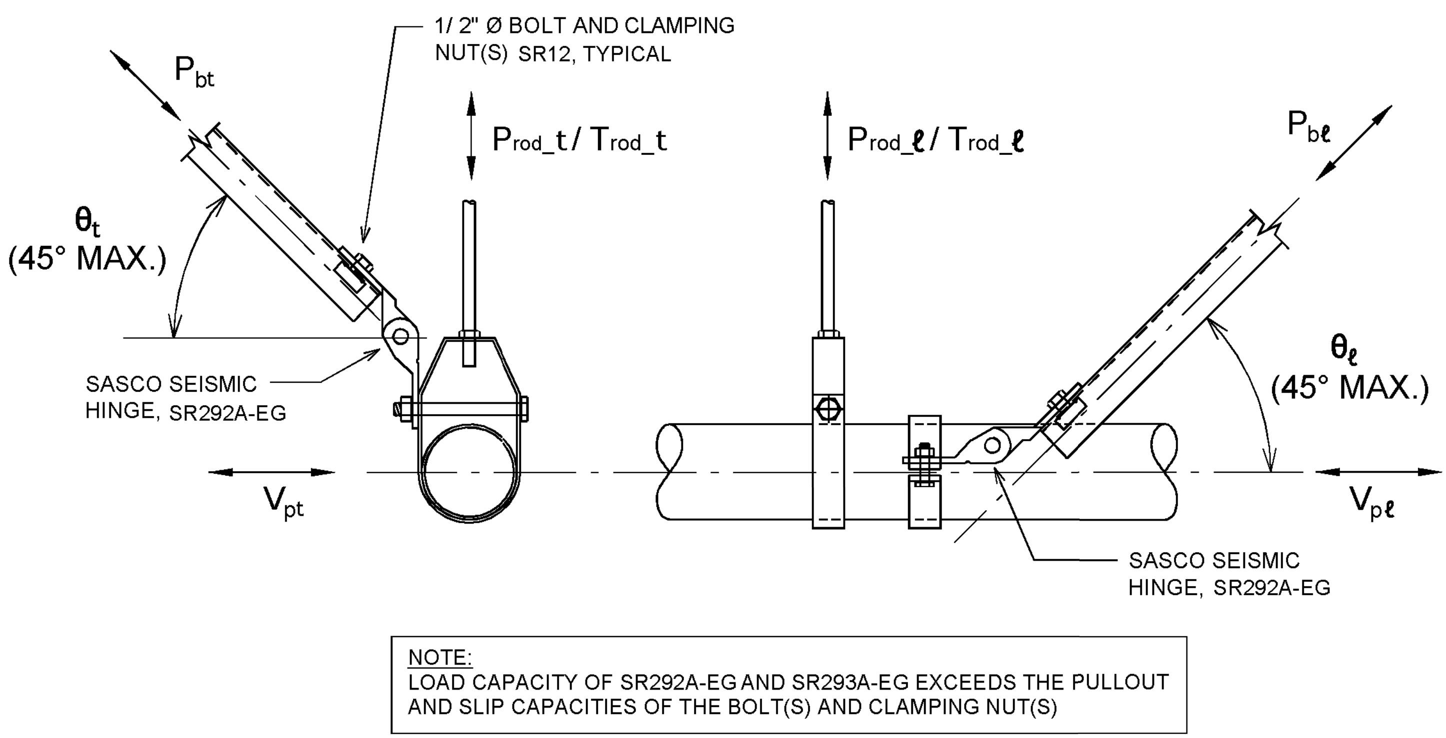
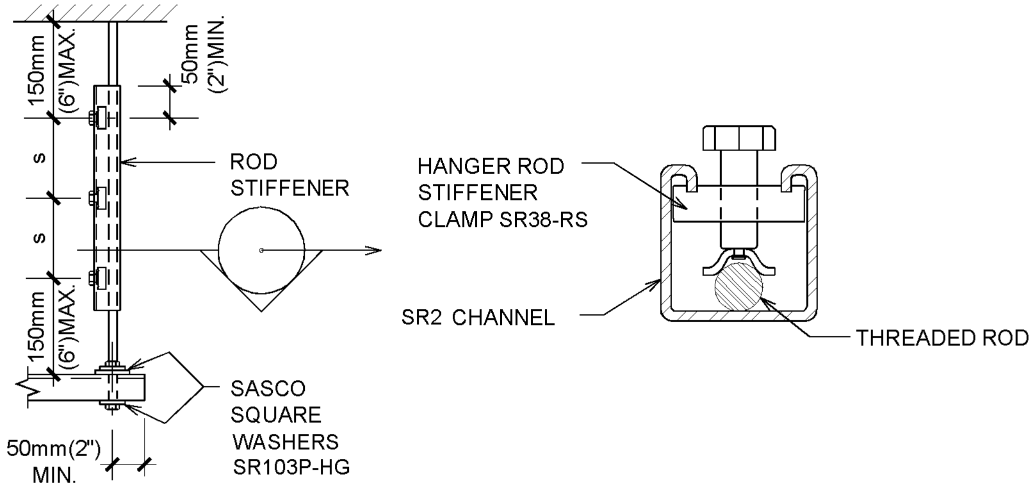


Figure 5 – Typical Single Pipe and Brace Details



Seismic Bracing Systems

Figure 6 – Hanger Rod with Stiffener Assembly



NOTES:
1. SEE TABLE 7 (PAGE 32) FOR MAXIMUM CLAMP SPACINGS 's'.
2. ROD STIFFENERS REQUIRED ONLY FOR HANGER RODS WITH SEISMIC BRACING ATTACHED TO PIPE HANGER OR TRAPEZE.
3. ROD STIFFENERS ARE REQUIRED WHEN ROD IS IN COMPRESSION AND LENGTH OF ROD EXCEEDS 's'.
4. WHEN ROD STIFFENERS ARE REQUIRED, ASSEMBLY SHALL HAVE MINIMUM OF 2 CLAMPS.

Figure 7 – Pipe Clamp Forces

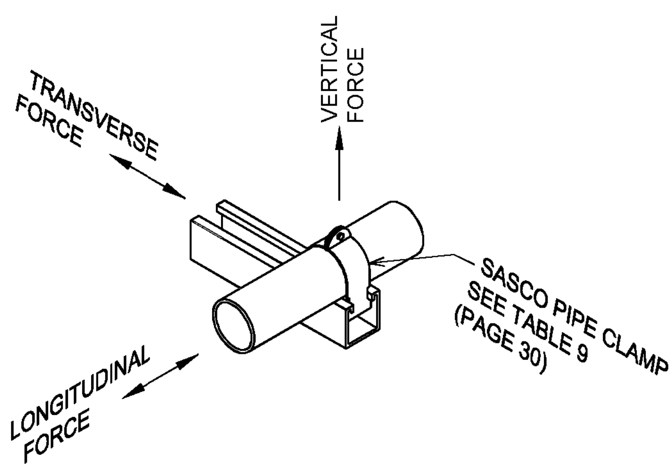


Figure 8 – Pipe Hanger Forces

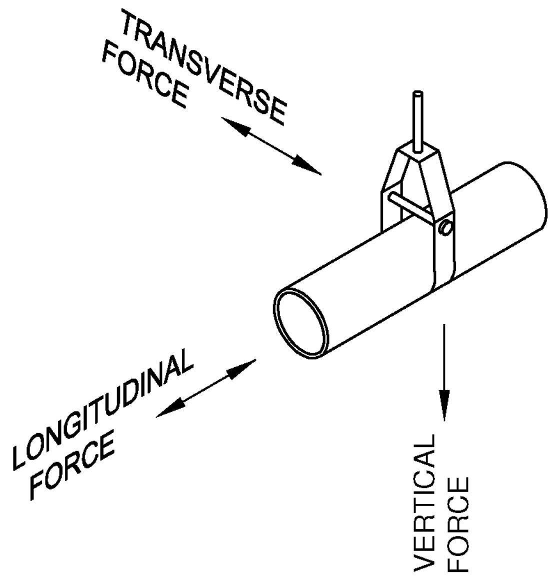


Figure 9 – Seismic Force Height Factor

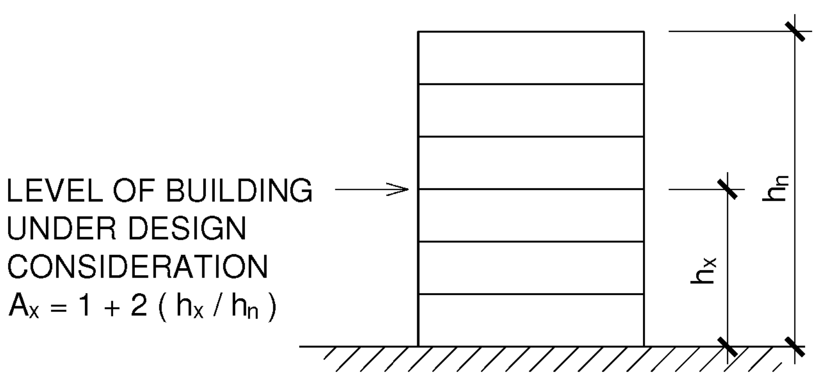
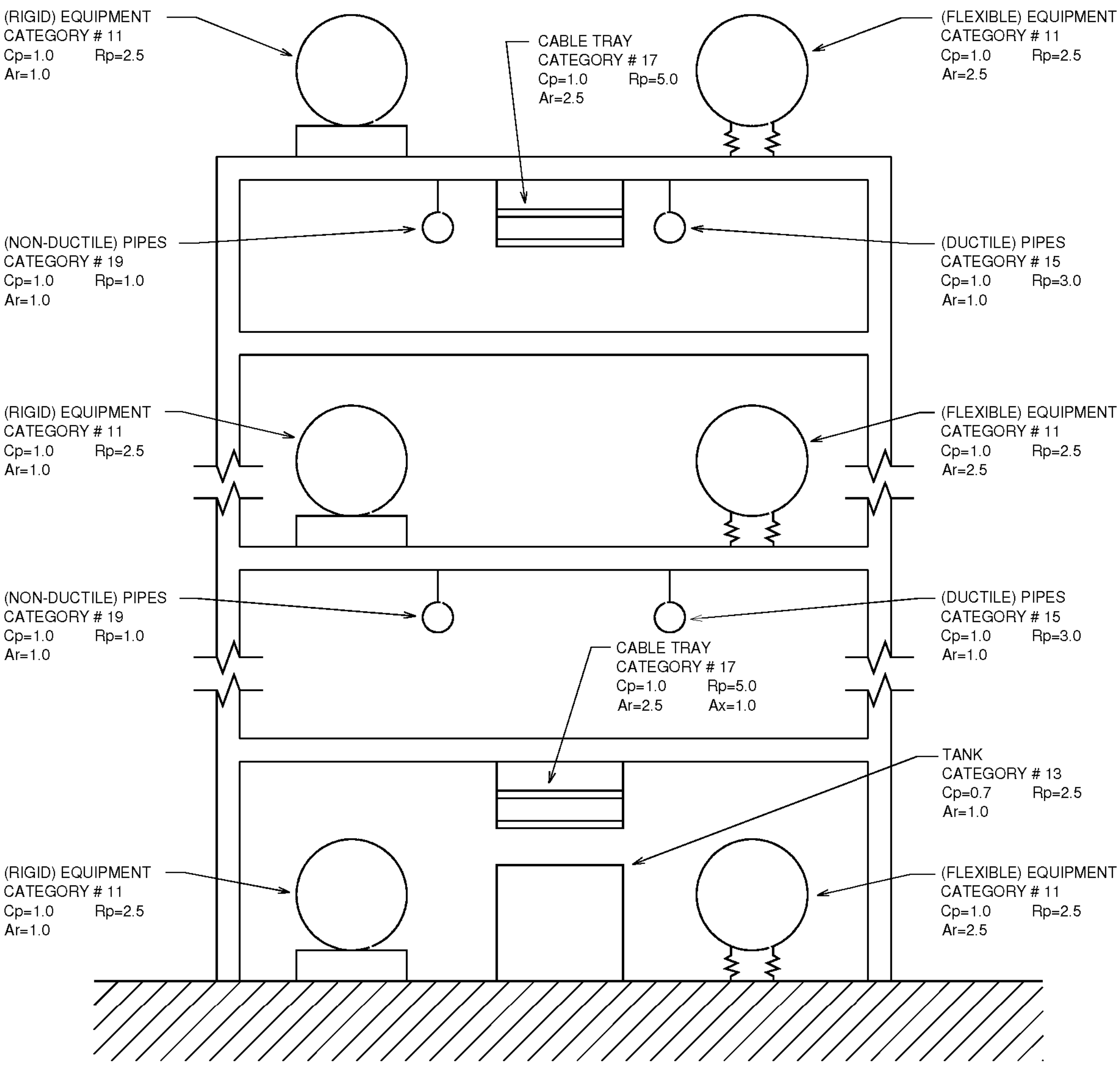


Figure 10 – Typical Ar, Rp, Cp for mechanical and electrical components for a building in Vancouver



- Values Must be verified by Project Engineer

Figure 11 – Typical Steel Connection Details

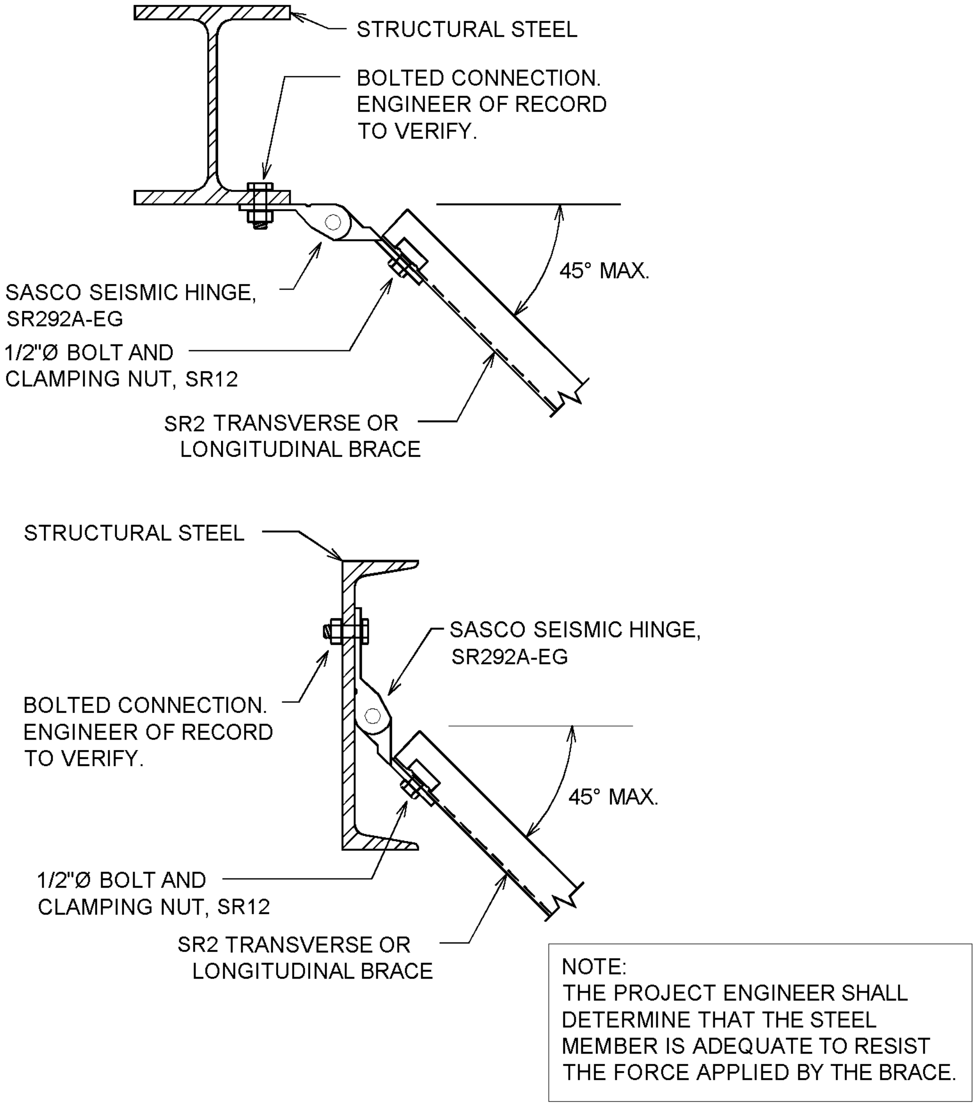
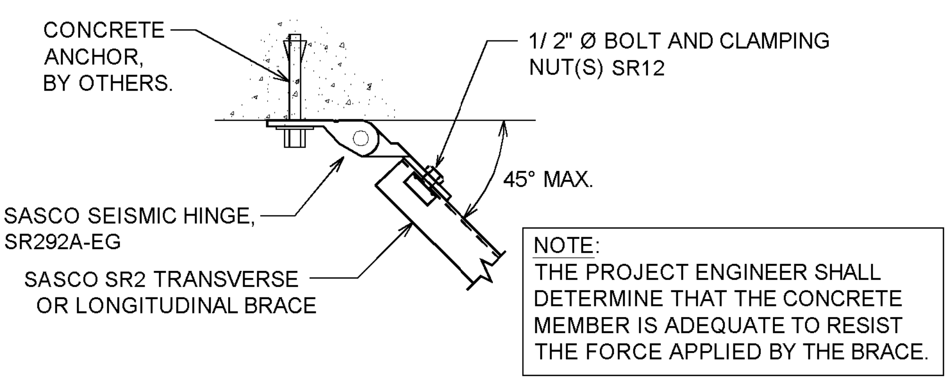


Figure 12 – Typical Concrete Connection Detail



4. Design Tables

Conversion Table

Length	
1 ft = 0.3048m	1 in = 25.4mm
1m = 3.281 ft	1mm = 0.0394 in
Area	
1 ft^2 = 0.0929m^2	1 in^2 = 645.2mm^2
1m^2 = 10.764 ft^2	1mm^2 = 0.0016 in^2
Volume	
1 ft^3 = 0.0283m^3	1 in^3 = 16387mm^3
1m^3 = 35.31 ft^3	1mm^3 = 0.00006 in^3
Force	
1 lb = 0.0044kN	1 kN = 224.8 lbs

Table 1 - Elements of Sasco Channels - Metric Units

Channel Catalogue Number	GA	WT.	A	x-x			B	y-y		
				I	S	r		I	S	r
		Kg/m	cm^2	cm^4	cm^3	cm	cm	cm^4	cm^3	cm
SR1	12	3.68	4.70	21.30	6.37	22.16	2.82	13.80	6.78	1.74
SR2	12	2.81	3.60	7.74	3.38	1.47	1.81	9.66	4.75	1.66
SR1BBSW	12	7.36	9.39	119.00	19.20	3.54	6.19	27.70	13.50	1.73
SR2BBSW	12	5.62	7.20	39.70	9.62	2.34	4.13	19.80	9.55	1.66

A = Area of Section
I = Moment of Inertia
S = Section Modulus
r = Radius of Gyration

See Figure 1A (page 18)

Table 2 - Elements of Sasco Channels - Imperial Units

Channel Catalogue Number	GA	WT.	A	x-x			B	y-y		
				I	S	r		I	S	r
		lb/ft	in^2	in^4	in^3	in	in	in^4	in^3	in
SR1	12	2.47	0.728	0.512	0.389	0.849	1.110	0.332	0.414	0.684
SR2	12	1.89	0.558	0.186	0.206	0.580	0.714	0.232	0.290	0.652
SR1BBSW	12	4.94	1.456	2.806	1.170	1.394	2.438	0.665	0.825	0.680
SR2BBSW	12	3.78	1.116	0.954	0.587	0.921	1.625	0.475	0.583	0.655

A = Area of Section
I = Moment of Inertia
S = Section Modulus
r = Radius of Gyration

See Figure 1B (page 19)

Table 3 – Schedule 40 Pipe Data

Pipe Size			Dead load[3], DL_P		Maximum support spacing[1] ($S_{trapeze}$ / S_{hanger} as applicable)		Maximum Brace Spacing[2]				Min. Rod Dia.[1]	
Designation	Nominal Size	O.D					Transverse (S_{bt})		Longitudinal (S_{bl})			
		in	kN/m	lb/ft	m	ft	m	ft	m	ft	mm	in
DN15	½	0.84	0.014	0.98	2.5	8	12	40	24	80	6	¼
DN20	¾	1.05	0.020	1.36	2.5	8	12	40	24	80	6	¼
DN25	1	1.315	0.030	2.05	2.5	8	12	40	24	80	6	¼
DN32	1¼	1.66	0.043	2.93	2.5	8	12	40	24	80	6	¼
DN40	1½	1.90	0.053	3.60	2.5	8	12	40	24	80	6	¼
DN50	2	2.375	0.075	5.11	2.5	8	12	40	24	80	6	¼
DN65	2½	2.875	0.115	7.87	2.5	8	12	40	24	80	8	5/16
DN80	3	3.50	0.157	10.78	2.5	8	12	40	24	80	8	5/16
DN100	4	4.50	0.238	16.31	2.5	8	12	40	24	80	8	5/16
DN125	5	5.563	0.340	23.29	2.5	8	12	40	24	80	13	½
DN150	6	6.625	0.460	31.51	2.5	8	12	40	12	40	13	½
DN200	8	8.625	0.734	50.29	3.75	12[5]	12	40	12	40	13	½

1. Per the National Plumbing Code of Canada 2010 Part 2. See also any appropriate provincial or territorial regulations or municipal bylaws or Mechanical / Electrical / Plumbing drawings or specifications for project specific requirements.
2. Per SMACNA "Seismic Restraint Manual: Guidelines for Mechanical Systems". Project engineer must ensure any other applicable requirements are met.
3. Includes self weight of pipe plus water
4. Design recommendations provided here are shown for standard weight steel pipes filled with water. Contents other than water shall be evaluated by the project engineer and pipes of other materials shall be supported in accordance with their approved installation standards
5. Note this is often limited to 3 m (10 ft) as required by some jurisdictions such as California

Table 4 - Uniformly Distributed Factored Load Capacity (Single Channel)[4]

Span Length		SR1						SR2					
		Maximum Factored Load[2] x-x axis, M_{rX}		Deflection[3]		Maximum Factored Load[2] x-x axis, M_{rY}		Maximum Factored Load[2] x-x axis, M_{rX}		Deflection[3]		Maximum Factored Load[2] x-x axis, M_{rY}	
m	in	kN	lb	mm	in	kN	lb	kn	lb	mm	in	kn	lb
0.6	24	17.1	3851	1.27	0.05	18.2	4099	9.0	2039	1.8	0.07	12.8	2871
0.9	36	11.4	2567	2.8	0.11	12.5	2732	6.0	1360	3.8	0.15	8.5	1914
1.2	48	8.6	1926	4.8	0.19	9.1	2049	4.5	1020	6.9	0.27	6.4	1436
1.5	60	6.8	1540	7.4	0.29	7.9	1639	3.7	216	10.7	0.42	5.1	1148
1.8	72	5.7	1284	10.7	0.42	6.1	1366	3.0	680	15.2	0.60	4.3	957
2.1	84	4.9	1100	14.5	0.57	5.2	1171	2.6	583	20.8	0.82	3.6	820
2.4	96	4.3	963	19.1	0.75	4.6	1025	2.3	510	27.2	1.07	3.2	718
2.7	108	3.8	856	24.1	0.95	4.1	911	2.0	453	34.3	1.35	2.8	638
3.0	120	3.4	770	29.7	1.17	3.6	820	1.8	408	42.4	1.67	2.6	574

Table 5 - Uniformly Distributed Factored Load Capacity (Double Channel)[5]

Span Length		SR1BBSW						SR2BBSW					
		Maximum Factored Load[2] x-x axis, M_{rX}		Deflection[4]		Maximum Factored Load[2] x-x axis, M_{rY}		Maximum Factored Load[2] x-x axis, M_{rX}		Deflection[4]		Maximum Factored Load[2] x-x axis, M_{rY}	
m	in	kN	lb	mm	in	kN	lb	kn	lb	mm	in	kn	lb
0.6	24	24.1 [3]	5426 [3]	0.3	0.01	36.3	8168	16.3 [3]	3671 [3]	0.5	0.02	25.7	5772
0.9	36	24.1 [3]	5426 [3]	1.0	0.04	24.2	5445	16.3 [3]	3671 [3]	2.0	0.08	17.1	3848
1.2	48	24.1 [3]	5426 [3]	2.3	0.09	18.2	4084	12.9	2906	3.8	0.15	12.8	2886
1.5	60	20.6	4633	4.1	0.16	14.5	3267	10.3	2325	6.1	0.24	10.3	2309
1.8	72	17.2	3861	5.8	0.23	12.1	2723	8.6	1937	10.4	0.41	8.6	1924
2.1	84	14.7	3309	7.9	0.31	10.4	2334	7.4	1660	13.7	0.54	7.3	1649
2.4	96	12.9	2896	10.2	0.40	9.1	2042	6.5	1453	17.5	0.59	6.4	1443
2.7	108	11.4	2574	13.0	0.51	8.1	1815	5.7	1291	21.8	0.86	5.7	1283
3.0	120	10.3	2317	16.0	0.63	7.3	1634	5.2	1162	26.7	1.05	5.1	1154

1. Values shown are Limit States Design Values. These numbers differ from Allowable Stress Design Values
2. Load must be uniformly distributed over span length of the trapeze
3. Elastic deflections in the X direction under maximum load
4. For Concentrated Loads at centre of span – Multiply Load by 0.5 and deflection by 0.8
5. See Figures 1A and 1B

Table 6 - Brace Factored Axial Capacity (SR2 Channel)

Length		Maximum Factored Compression Load[1], P_r	
m	in	kN	lb
0.6	24	17.7	3980
0.9	36	16.1	3610
1.2	48	14.4	3250
1.5	60	12.8	2880
1.8	72	11.1	2500
2.1	84	9..7	2170
2.4	96	8.4	1890
2.7	108	7.4	1660
3.0	120	6.5	1460

1. Braces act in Compression and Tension. The Capacity is governed by the compression condition.

Table 7 - Hanger Rod Factored Capacity

Rod Size		Max. Factored Compression Load, P_{r_rod}		Max. Factored Tension Load, T_{r_rod}		Max Clamp Spacing[1] "s"	
mm	in	kN	lb	kN	lb	mm	in
10	⅜	1.9	438	7.7	1741	350	14
13	½	3.3	741	14.3	3226	500	20
16	⅝	5.0	1128	23.0	5171	650	26
19	¾	7.3	1650	34.4	7731	800	32
22	⅞	10.0	2257	47.7	10726	950	38

1. Rod stiffeners are required when rod is in compression and the rod length exceeds "s"
2. When rod stiffeners are required, assembly shall have minimum of 2 clamps
3. See Figure 6 (page 22)

Table 8 - Factored Resistance of SR12 ½" Clamping Nuts

Length	Resistance (per nut)[1]	
	kN	lb
Slip (V_{slip})	9.4	2100
Pullout ($T_{pullout}$)	12.5	2800

1. For Allowable Resistances divide values in table by 1.4
2. Resistances shown for nut connected to 12 gauge channels only

Table 9 – Factored Resistance of Sasco Pipe Clamps

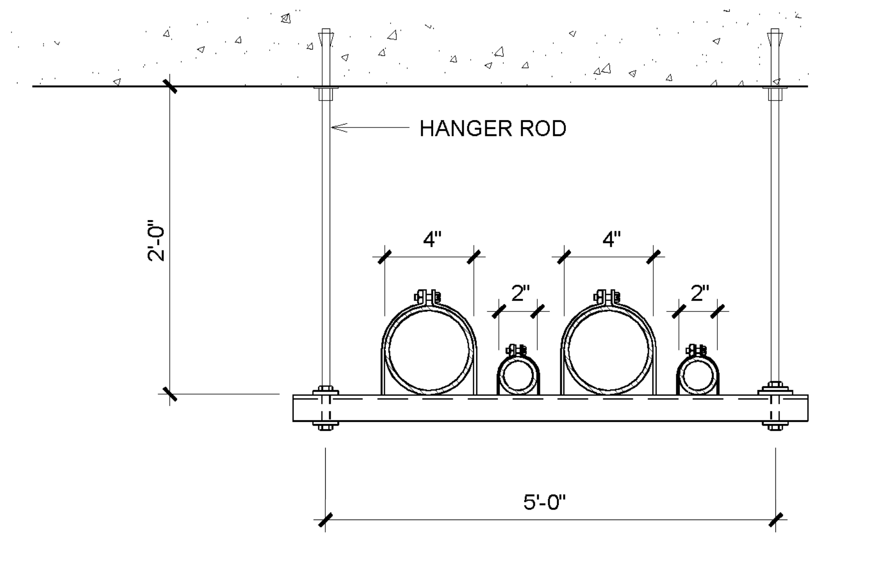
Pipe Size			Part Number	Clamp Factored Resistances					
Designation	Nominal Size	O.D		Transverse R_{clamp_t} [1]		Longitudinal R_{clamp_ℓ} [1]		Vertical R_{clamp_v} [1]	
		in		kN	lb	kN	lb	kN	lb
DN15	½	0.84	SR12R	0.46	105	0.31	70	2.49	560
DN20	¾	1.05	SR34R	0.46	105	0.43	100	2.49	560
DN25	1	1.315	SR1R	0.46	105	0.43	100	2.49	560
DN35	1¼	1.66	SR114R	0.94	210	0.94	210	3.74	840
DN40	1½	1.9	SR112R	0.94	210	0.94	210	3.74	840
DN50	2	2.375	SR2R	0.94	210	1.24	280	3.74	840
DN65	2½	2.875	SR212R	1.55	350	1.24	280	4.98	1120
DN80	3	3.5	SR3R	1.55	350	1.24	280	4.98	1120
DN100	4	4.5	SR4R	1.55	350	1.24	280	4.98	1120
DN100	4	4.5	SR4RHD	2.0	460	1.24	280	6.23	1400
DN125	5	5.563	SR5R	1.55	350	1.24	280	4.98	1120
DN125	5	5.563	SR5RHD	2.0	460	1.24	280	6.23	1400
DN150	6	6.625	SR6R	1.55	350	1.24	280	4.98	1120
DN150	6	6.625	SR6RHD	2.0	460	1.24	280	6.23	1400
DN200	8	8.625	SR8R	1.55	350	1.24	280	4.98	1120
DN200	8	8.625	SR8RHD	2.0	460	1.24	280	6.23	1400

1. For Allowable Resistances divide values in table by 1.4

2. See Figure 7

5. Design Examples

Example #1 – Trapeze Hanger



Problem:

Design the seismic bracing for a trapeze hanger with a span length of 5'-0" and carrying two 2"ø pipes and two 4"ø pipes, each carrying water. The trapeze is hung from the underside of the 2nd floor (h_x= 20 ft) in a 3 storey (normal importance) building (h_n= 30 ft). The transverse and longitudinal bracing are placed at 45° to the horizontal. The building is located in Vancouver, BC on a Site Class C.

Solution:

Step 1 Determine maximum spacing of trapeze hangers and seismic braces

Pipe support spacing is governed by the requirement of the smallest diameter pipe, in this case both pipes require the same spacing.

$S_{trapeze}$ = 8 ft (Table 3)

Begin by selecting the maximum brace spacing suggested by the SMACNA "Seismic Restraint Manual: Guidelines for Mechanical Systems" and note that they should be multiples of the hanger support spacing:

S_{bt} = 40 ft (Table 3)
$S_{b\ell}$ = 80 ft (Table 3)

Note: The project engineer must ensure that any other pipe support spacing requirements that may be required for a specific project are also met. See also SMACNA Section 4.2 for guidelines regarding brace layout.

Step 2 **Determine Dead Load, W_p, supported by trapeze**

$W_p = \Sigma(DL_p \times N_p)$ therefore, using Table 3:
$W_p = (5.11 \text{ lb/ft} \times 2) + (16.31 \text{ lb/ft} \times 2) = 42.84 \text{ lb/ft}$

Step 3 **Calculate seismic forces**

Using information from Section 1 and NBCC 2010

$F_a = 1.0$

$S_a(0.2)=0.94$

$I_E = 1.0$

$C_p = 1.0$

$A_r = 1.0$

$h_x = 20 \text{ ft}$

$h_n = 30 \text{ ft}$

$\therefore A_x = 1 + 2 \times (20 / 30) = 2.33$

$R_p = 3.0$

$S_p = C_p \times A_r \times A_x / R_p = (1.0 \times 1.0 \times 2.33) / 3.0 = 0.78$

Therefore the Seismic Load Coefficient is:

$= 0.3 \times F_a \times S_a(0.2) \times I_E \times S_p$
$= 0.3 \times 1.0 \times 0.94 \times 1.0 \times 0.78 = 0.22$

and the Seismic Forces are:

Transverse direction:

$V_{pt} = 1.0 \times \text{Seismic Load Coefficient} \times W_p \times s_{bt}$
$V_{pt} = 1.0 \times 0.22 \times 42.84 \text{ lb/ft} \times 40 \text{ ft} = 377 \text{ lb}$

Longitudinal direction:

$V_{p\ell} = 1.0 \times \text{Seismic Load Coefficient} \times W_p \times s_{b\ell}$
$V_{p\ell} = 1.0 \times 0.22 \times 42.84 \text{ lb/ft} \times 80 \text{ ft} = 754 \text{ lb}$

Step 4 **Determine pipe clamp required**

Check pipe clamp for each pipe:

1) 2" ø: F_{clamp_t} = 1.0 x Seismic Load Coefficient x DL_p x s_{bt}
F_{clamp_t} = 1.0 x 0.22 x 5.11 x 40 = 45 lb

From Table 9: R_{clamp_t} = 210 lb > 45 lb ∴Okay

F_{clamp_ℓ} = 1.0 x Seismic Load Coefficient x DL_p x $s_{b\ell}$
F_{clamp_ℓ} = 1.0 x 0.22 x 5.11 x 80 = 90 lb

From Table 9: R_{clamp_ℓ} = 280 lb > 90lb ∴Okay

2) 4" ø: F_{clamp_t} = 1.0 x Seismic Load Coefficient x DL_p x s_{bt}
F_{clamp_t} = 1.0 x 0.22 x 16.31 x 40 = 144 lb

From Table 9: R_{clamp_t} = 350 lb > 144 lb ∴Okay

F_{clamp_ℓ} = 1.0 x Seismic Load Coefficient x DL_p x $s_{b\ell}$
F_{clamp_ℓ} = 1.0 x 0.22 x 16.31 x 80 = 287 lb

From Table 9: R_{clamp_ℓ} = 280 lb < 287lb ∴Not Okay

∴ Since using a heavy duty clamp will not increase R_{clamp_ℓ} F_{clamp_ℓ} must be reduced by changing the brace spacing. Try longitudinal brace spacing of 40 ft:

F_{clamp_ℓ} = 1.0 x Seismic Load Coefficient x DL_p x $s_{b\ell}$
F_{clamp_ℓ} = 1.0 x 0.22 x 16.31 x 40 = 144 lb

From Table 9: R_{clamp_ℓ} = 200 lb > 144lb ∴Okay

Note, $V_{p\ell}$ has now also changed:

$V_{p\ell}$ = 1.0 x Seismic Load Coefficient x W_p x $s_{b\ell}$
$V_{p\ell}$ = 1.0 x 0.22 x 42.84 lb/ft x 40 ft = 377 lb

Note, there is no vertical force on the clamps in this example as none of the pipes are hung from below the trapeze ∴ F_{clamp_v} = 0

Step 5 Check trapeze for bending about both axes

The project engineer must determine if the loads are to be considered as distributed or concentrated. In this case, the loads can be assumed to be distributed over the span length.

Factored Bending Load about x-x axis due to gravity

$M_{fX} = 1.0 \times W_p \times S_{trapeze}$
$M_{fX} = 1.0 \times 42.84$ lb/ft x 8 ft = 343 lb

Factored Bending Load about y-y axis due to seismic

$M_{fY} = V_{p\ell}$
$M_{fY} = 377$ lb

Factored Load Capacity of SR2 channel about x-x axis

$M_{rX} = 816$ lb (Table 4)

Factored Load Capacity of SR2 channel about y-y axis

$M_{rY} = 1148$ lb (Table 4)

Therefore, interaction:

$(M_{fX} / M_{rX}) + (M_{fY} / M_{rY})$
$(343 / 816) + (377 / 1148) = 0.75 < 1.0 \therefore$ Okay

Elastic deflections for the channel sections are also provided in tables 4 and 5. The engineer of record shall ensure that the deflections are within acceptable criteria for the project. If necessary, a larger section or closer trapeze spacing can be employed to reduce the deflections.

Step 6 Check seismic braces

Note: Transverse and longitudinal braces shall be placed no more than 45° from the horizontal.

Factored axial force in seismic brace:

Transverse direction:

$P_{bt} = V_{pt} \times (1 / \cos \theta_t)$
$P_{bt} = 377$ lb x 1 / cos 45° = 533 lb

Longitudinal direction:

$P_{bl} = ½ \times V_{p\ell} \times (1 / \cos \theta_\ell)$
$P_{bl} = ½$ 377 lb x 1 / cos 45° = 267 lb

P_b = larger of of P_{bt} and $P_{b\ell}$ = 533 lb

Check brace factored capacity, P_r from Table 6 (page 30) The transverse and longitudinal braces have a length of 34”, therefore use capacity for nearest tabulated length greater than 34” i.e. use capacity for 36” length.

$P_r = 3610$ lb > 533 lb $\therefore$ the brace is adequate.

Step 7 Check hinge and connections

From Table 8 (page 30):
V_{slip} = 2100 lb for a single bolt and clamping nut

Recall, P_b = larger of of P_{bt} and $P_{b\ell}$ = 533 lb

$\therefore V_{slip} > P_b \therefore$ single bolt and clamping nut is adequate

Step 8 Check capacity of hanger rod and requirement for stiffener assembly

Factored Rod Forces:

$$P_{rod\_t} = (P_{bt} \times \sin \theta_t) - (½ \times W_p \times s_{trapeze})$$
$$P_{rod\_t} = (533 \text{ lb} \times \sin 45°) - (½ \times 42.84 \text{ lb/ft} \times 8 \text{ ft}) = 206 \text{ lb}$$

$$T_{rod\_t} = (½ \times W_p \times s_{trapeze}) + (P_{bt} \times \sin \theta_t)$$
$$T_{rod\_t} = (½ \times 42.84 \text{ lb/ft} \times 8 \text{ ft}) + (533 \text{ lb} \times \sin 45°) = 548 \text{ lb}$$

$$P_{rod\_\ell} = (P_{bl} \times \sin \theta_\ell) - (½ \times W_p \times s_{trapeze})$$
$$P_{rod\_\ell} = (267 \text{ lb} \times \sin 45°) - (½ \times 42.84 \text{ lb/ft} \times 8 \text{ ft}) = 17 \text{ lb}$$

$$T_{rod\_\ell} = (½ \times W_p \times s_{trapeze}) + (P_{bl} \times \sin \theta_\ell)$$
$$T_{rod\_\ell} = (½ \times 42.84 \text{ lb/ft} \times 8 \text{ ft}) + (267 \text{ lb} \times \sin 45°) = 360 \text{ lb}$$

$\therefore$ Maximum P_{rod} = 206 lb and maximum Trod = 548 lb

Using Table 7, start with smallest diameter rod:

⅜"ø rod: P_{r_rod} = 438 lb > 206 lb
⅜"ø rod: T_{r_rod} = 1741 lb > 548 lb

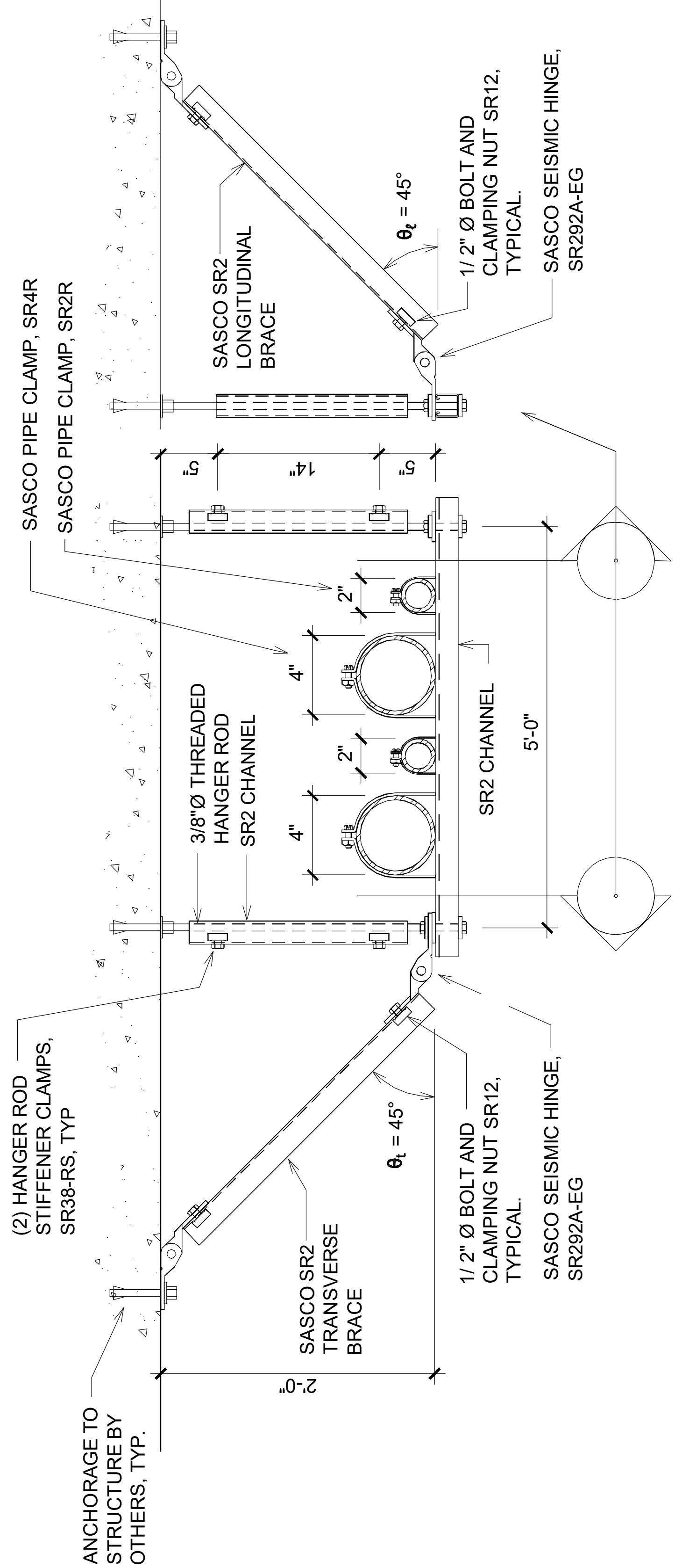
$\therefore$ Use ⅜"ø threaded hanger rod. Since the length of the hanger rod is 24" which is greater than the clamp spacing limit of 14" shown in Table 7 (Page 30), use the stiffener assembly shown in Figure 6 (Page 22) and clamps spaced at 14" max. per Table 7 and Figure 6.

Step 9: Anchorage to structure

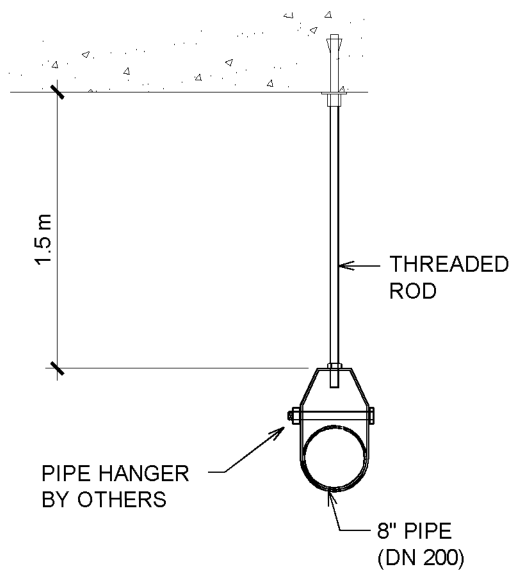
It is the responsibility of the project engineer to confirm that the primary structure can withstand the connection loads of the hanger rods and brace attachments. The design of these connections is the responsibility of the project engineer and should be reviewed by the engineer of record for the base building. See NBCC clause 4.1.8.18 (8) for additional connection information.

See the figure below for the final design diagram

Example #1 – Final Design Diagram



Example #2 – Single Pipe Hanger



Problem:

Design the seismic bracing for a single pipe hanger with an 8” ø pipe carrying water. The pipe is suspended below the underside of the 1st floor (h_x= 4.5 m) in a 2 storey (normal importance) building (h_n= 7.5 m). The transverse braces are placed at 30° and longitudinal braces are placed at 45° to the horizontal. The building is located in downtown Victoria on a Site Class B.

Solution:

Step 1 Determine maximum spacing of pipe hangers and seismic braces

Pipe support spacing is determined based on the diameter of the pipe.

$S_{hangers}$ = 3.75m (Table 3)

Begin by selecting the maximum brace spacing suggested by the SMACNA “Seismic Restraint Manual: Guidelines for Mechanical Systems” and note that they should be multiples of the hanger support spacing:

S_{bt} = 12m use 11.25m (Table 3)
$S_{b\ell}$ = 12m use 11.25m (Table 3)

Note: The project engineer must ensure that any other pipe support spacing requirements that may be required for a specific project are also met.

Step 2 Determine Dead Load, W_p, supported by trapeze

Using Table 3:
$W_p = DL_p = 0.734$ kN/m

Step 3 Calculate seismic forces

Using information from Section 1 and NBCC 2010

$F_a = 1.0$

$S_a(0.2) = 1.2$

$I_E = 1.0$

$C_p = 1.0$

$A_r = 1.0$

$h_x = 4.5\text{m}$

$h_n = 7.5\text{m}$

$\therefore A_x = 1 + 2 \times (4.5 / 7.5) = 2.2$

$R_p = 3.0$

$S_p = C_p \times A_r \times A_x / R_p = (1.0 \times 1.0 \times 2.2) / 3.0 = 0.73$

Therefore the Seismic Load Coefficient is:

$= 0.3 \times F_a \times S_a(0.2) \times I_E \times S_p$
$= 0.3 \times 1.0 \times 1.2 \times 1.0 \times 0.73 = 0.26$

and the Seismic Forces are:

Transverse direction:

$V_{pt} = 1.0 \times \text{Seismic Load Coefficient} \times W_p \times s_{bt}$
$V_{pt} = 1.0 \times 0.26 \times .734 \text{ kN/m} \times 11.25 \text{ m} = 2.1 \text{ kN}$

Longitudinal direction:

$V_{p\ell} = 1.0 \times \text{Seismic Load Coefficient} \times W_p \times s_{b\ell}$
$V_{p\ell} = 1.0 \times 0.734 \text{ kN/m} \times 11.25 \text{ m} = 2.1 \text{ kN}$

Step 4 Determine pipe hanger required

The project engineer must ensure that the pipe hanger can withstand the following factored forces:

Transverse:
$F_{hang\_t} = V_{pt} = 2.1$ kN

Longitudinal:
$F_{hang\_\ell} = V_{pl} = 2.1$ kN

Gravity:
F_{hang_v} $1.0 \times W_p \times s_{hang} = 1.0 \times 0.734$ kN/m $\times 3.75$ m $= 2.75$ kN

Step 5 Check seismic braces

Note: Transverse and longitudinal braces shall be placed no more than 45° from the horizontal. Site conditions require the transverse brace to be placed at 30° rather than 45° and the longitudinal brace to be placed at 45°.

Factored axial force in seismic brace:

Transverse direction:
$P_{bt} = V_{pt} \times (1 / \cos \theta t)$
$P_{bt} = 2.1$ kN $\times (1 / \cos 30) = 2.4$ kN

Longitudinal direction:

$P_{b\ell} = V_{p\ell} \times (1 / \cos \theta l)$

$P_{b\ell} = 2.1$ kN $\times (1 / \cos 45) = 3.0$ kN

Check brace factored capacity, P_r from Table 6:

The transverse brace length is 3m (this is the max. allowable brace length)

$P_r = 6.5$ kN > 2.4 kN ∴ the brace is adequate.

The longitudinal brace length is 2.1 m

$P_r = 9.7$ kN > 3.0 kN ∴ the brace is adequate.

Step 6 Check hinge and connections

From Table 8:

$V_{slip} = 9.4$ kN for a single bolt and clamping nut

Recall, P_b = larger of of P_{bt} and $P_b = 3.0$ kN

∴ $V_{slip} > P_b$ ∴ single bolt and clamping nut is adequate

Step 6 Check hinge and connections

From Table 8:

V_{slip} = 9.4 kN for a single bolt and clamping nut

Recall, P_b = larger of of P_{bt} and P_b = 3.0 kN

∴ $V_{slip} > P_b$ ... single bolt and clamping nut is adequate

Step 7 Check capacity of hanger rod and requirement for stiffener assembly

Factored Rod Forces:

$P_{rod\_t} = (P_{bt} \times \sin \theta_t) - (W_p \times s_{hanger})$
$P_{rod\_t} = (2.4 \text{ kN} \times \sin 30°) - (0.734 \text{ kN/m} \times 3.75 \text{ m}) = -1.5 \text{ kN}$ \ rod is in tension

$T_{rod\_t} = (W_p \times s_{hanger}) + (P_{bt} \times \sin \theta_t)$
$T_{rod\_t} = (0.734 \text{ kN/m} \times 3.75 \text{ m}) + (2.4 \text{ kN} \times \sin 30°) = 4.0 \text{ kN}$

$P_{rod\_\ell} = (P_{bl} \times \sin \theta_l) - (W_p \times s_{hanger})$
$P_{rod\_\ell} = (3.0 \text{ kN} \times \sin 45°) - (0.734 \text{ kN/m} \times 3.75 \text{ m}) = -0.5 \text{ kN}$ \ rod is in tension

$T_{rod\_\ell} = (W_p \times s_{hanger}) + (P_{b\ell} \times \sin \theta_\ell)$
$T_{rod\_\ell} = (0.734 \text{ kN/m} \times 3.75 \text{ m}) + (3.0 \text{ kN} \times \sin 45°) = 4.9 \text{ kN}$

∴ Maximum T_{rod} = 4.9 kN and rod is not in compression

From Table 3, the minimum diameter rod for an 8” ø pipe is 13mm.

Using Table 7:

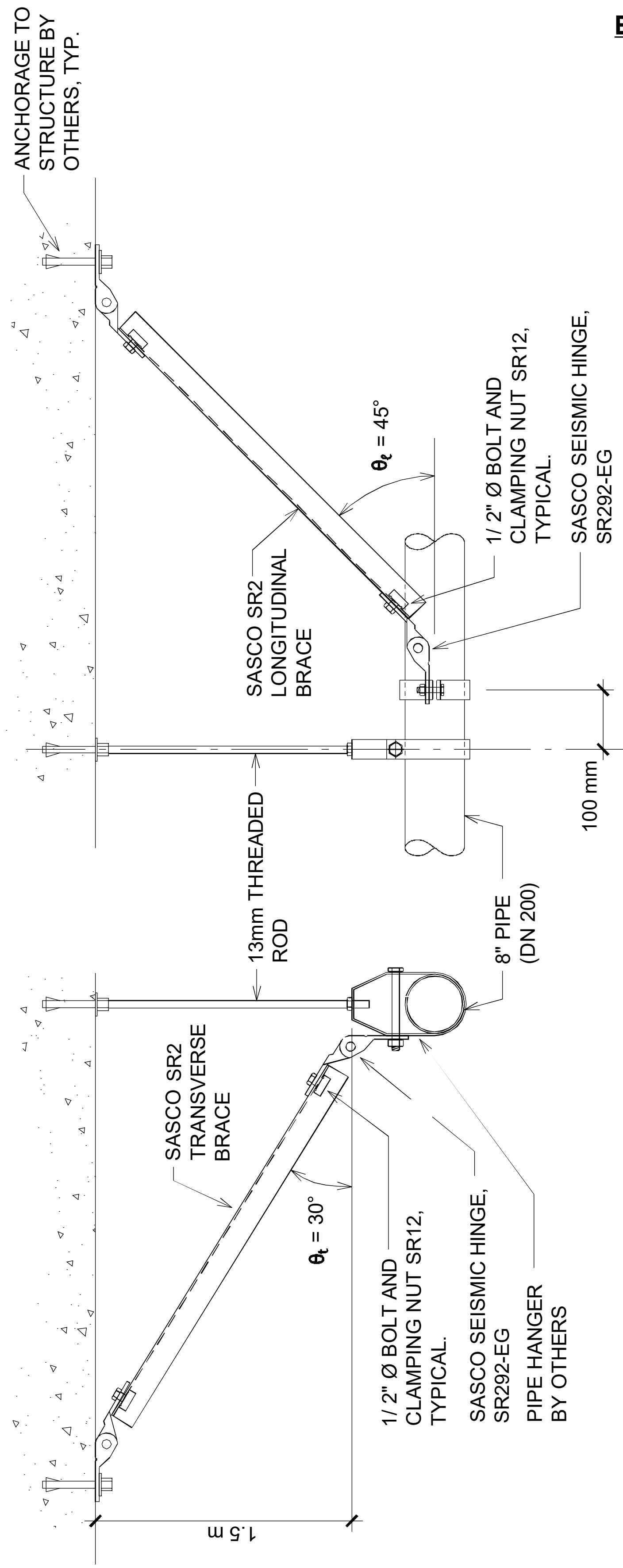
13mm ø rod T_{r_rod} = 14.3 kN > 4.9 kN

∴ Use 13mm ø threaded hanger rod, and since P_{rod_t} and P_{rod_l} are both < 0, stiffener clamp assembly is not required.

Step 8: Check anchorage to base structure

It is the responsibility of the project engineer to confirm that the primary structure can withstand the connection loads of the hanger rods and brace attachments. The design of these connections is the responsibility of the project engineer and should be reviewed by the engineer of record for the base building. See NBCC clause 4.1.8.18 (8) for additional connection information. See the figure below for the final design diagram

Example #2 - Final Design Diagram



6. Notations

A	Area of channel section
A_r	Element or component force amplification factor from NBCC Table 4.1.8.18
A_x	Height factor $(1 + 2\ h_x/h_n)$
C_p	Element or component factor from NBCC Table 4.1.8.18
D	Dead load of the system - a permanent load due to the weight of building components
DL_p	Pipe diameter unit dead load
E	Earthquake load
F_a	As defined in NBCC Table 4.1.8.4.B.
F_{clamp_t}	Transverse force imparted on pipe clamp
F_{clamp_v}	Vertical force imparted on pipe clamp
F_{clamp_ℓ}	Longitudinal force imparted on pipe clamp
F_{hang_v}	Vertical force imparted on pipe hanger
F_{hang_t}	Transverse force imparted on pipe hanger
F_{hang_ℓ}	Longitudinal force imparted on pipe hanger
h_{ef}	Effective anchor embedment depth
h_n	Height of uppermost level in main portion of structure
h_x	Height of component under design consideration
I	Moment of Inertia
I_E	Importance factor for the building, as defined in NBCC Article 4.1.8.5
M_{fX}	Factored Bending Load about the X-X axis
M_{fY}	Factored Bending Load about the Y-Y axis
M_{rX}	Factored Bending Capacities about the X-X axis
M_{rY}	Factored Bending Capacities about the Y-Y axis
N_p	Number of pipes of each diameter
P_b	Axial force in the seismic brace
P_{bt}	Axial force in the transverse seismic brace
$P_{b\ell}$	Axial force in the longitudinal seismic brace

P_r Factored axial capacity of the strut

P_{r_rod} Factored axial compression capacity of hanger rod

P_{rod_t} Factored axial compression force on hanger rod (transverse direction)

P_{rod_ℓ} Factored axial compression force on hanger rod (longitudinal direction)

r Radius of Gyration

R_{clamp_t} Transverse force resistance of pipe clamp

R_{clamp_v} Vertical force resistance of pipe clamp

R_{clamp_ℓ} Longitudinal force resistance of pipe clamp

R_p Element or component response modification factor from NBCC Table 4.1.8.17.

s Maximum hanger rod stiffener spacing

S Section Modulus

$S_a(0.2)$ Spectral response acceleration value at 0.2 s, as defined in NBCC sentence 4.1.8.4.(1)

s_{bt} Transverse seismic brace spacing

$s_{b\ell}$ Longitudinal seismic brace spacing

s_{hanger} Maximum spacing of the pipe hangers

S_p Cp·Ar·Ax/Rp

$s_{trapeze}$ Maximum trapeze spacing

$T_{pullout}$ Pullout resistance of bolt and clamping nut(s)

T_{r_rod} Factored axial tension capacity of hanger rod

T_{rod_t} Factored axial tension force on hanger rod (transverse direction)

T_{rod_ℓ} Factored axial tension force on hanger rod (longitudinal direction)

V_{pt} Transverse design lateral seismic force

$V_{p\ell}$ Longitudinal design lateral seismic force

V_{slip} Slip resistance of bolt and clamping nut(s)

W_p Weight of component or element

θ_t Angle of transverse seismic brace to horizontal

θ_ℓ Angle of longitudinal seismic brace to horizontal

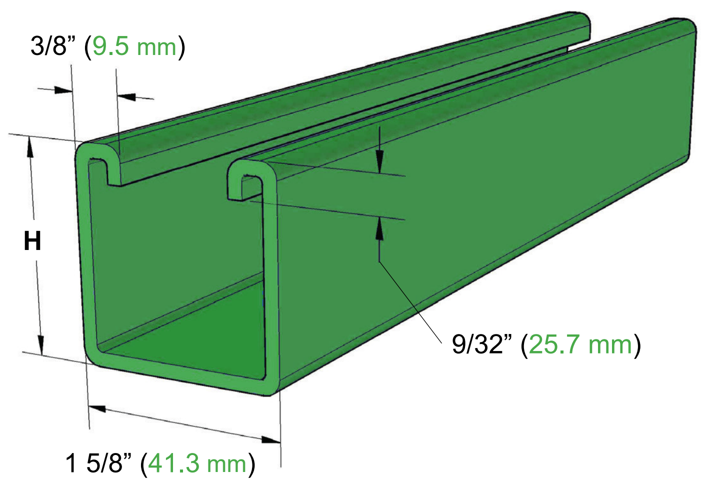
7. Parts

Strut Channel - Single (Steel)

Product Number	Height (h)		Thickness (GA)
	in	mm	
SR1BBSW	4.878	123.83	12
SR2BBSW	3.25	82.55	12

Back to back steel channels are spot welded on approx. 3" centres, and seam welded as shown.

Finishes:
Pre-galvanized (standard): add -G and length in inches to Channel Prefix above for Product Number (SR2-G-120). Other finishes available.

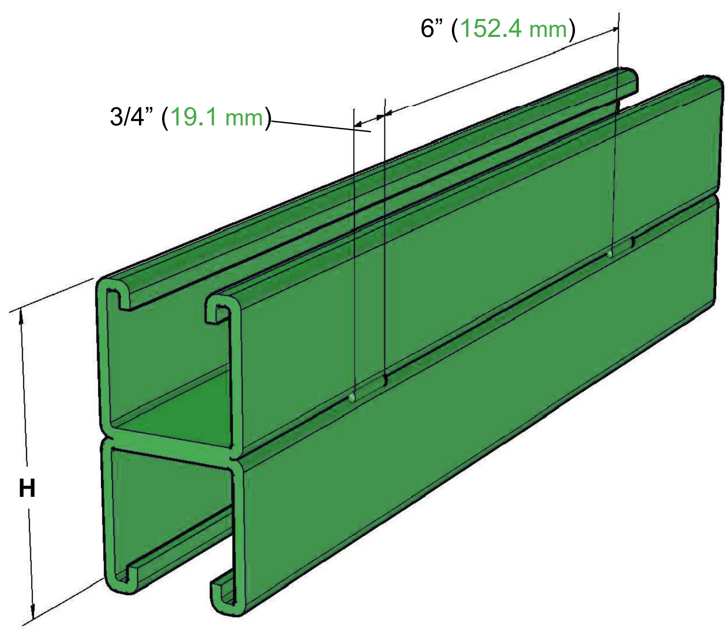


Strut Channel - Back to Back (Steel)

Product Number	Height (h)		Thickness (GA)
	in	mm	
SR1BBSW	4.875	123.83	12
SR2BBSW	3.25	82.55	12

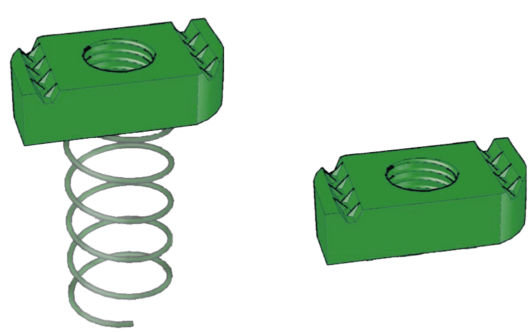
Back to back steel channels are spot welded on approx. 3" centres, and seam welded as shown.

Finishes:
Pre-galvanized (standard): add -G and length in inches to Channel Prefix above for Product Number (SR2-G-120). Other finishes available.



Clamping Nuts

Product Number	Thread Size	Spring Length
	in	in
Regular Spring		
SR12	0.50 - 13	1.5
No Spring		
SR12W	0.50 - 13	--

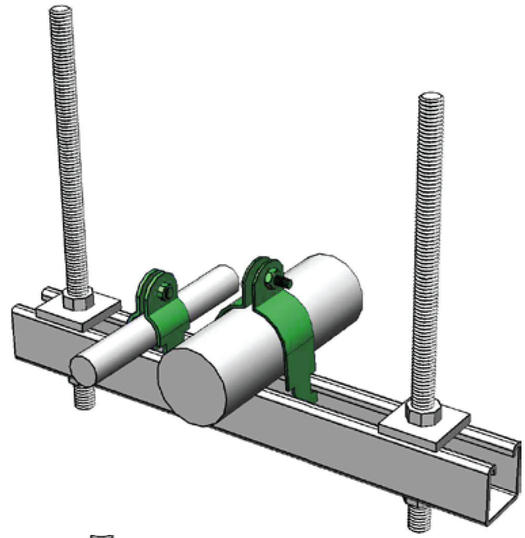


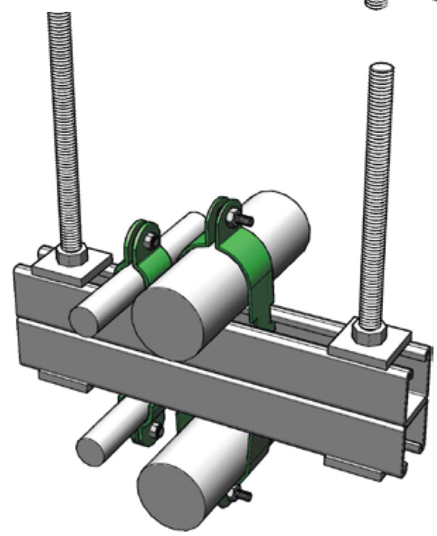
Pipe Clamps - For Rigid Conduit

Channel Prefix	Conduit Size	Outside Diameter	
	in	in	mm
SR12R-G	0.50	0.840	21.34
SR34R-G	0.75	1.050	26.67
SR1R-G	1	1.315	33.40
SR114R-G	1.25	1.660	42.16
SR112R-G	1.50	1.900	48.26
SR2R-G	2	2.375	60.33
SR212R-G	2.50	2.875	73.03
SR3R-G	3	3.500	88.90
SR4R-G	4	4.500	114.30
SR4RHD-G	4	4.500	114.30
SR5R-G	5	5.563	141.29
SR5RHD-G	5	5.563	141.29
SR6R-G	6	6.625	168.28
SR6RHD-G	6	6.625	168.28
SR8R-G	8	8.625	219.08
SR8RHD-G	8	8.625	219.08

Finishes:
Pre-Pre-galvanized (standard): -G

Other finishes are available upon request.





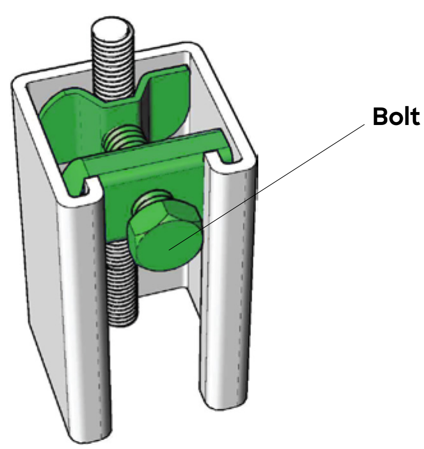
Rod Stiffener Clamp

Product Number	Hanger Rod	Bolt	
	Diameter	Length	Diameter
	in	in	in
SR38-RS	0.625	1.375	0.375 - 16

Bolt secures 0.375" through 0.625" hanger rod.

Finishes:
Electro-Galvanized (standard)

Stainless steel available upon request.



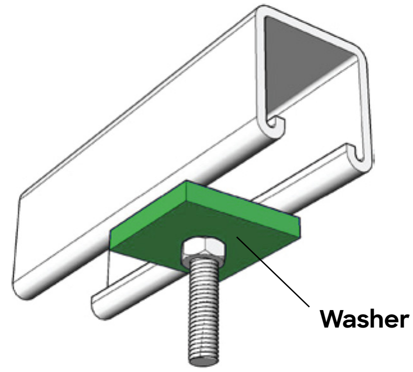
Seismic Bracing Systems

Square Washers

Product Number	Size		Thickness		Hole Diameter	
	sq. in	sq. mm	in	mm	in	mm
SR103P-HG	1.50	38.1	0.25	6.35	0.56	14.3

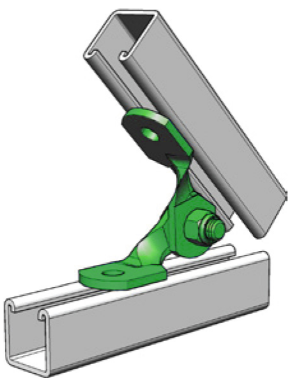
Hex nut not included.

Finishes:
Hot dipped galvanized after fabrication (standard) - HG
Other finishes available.

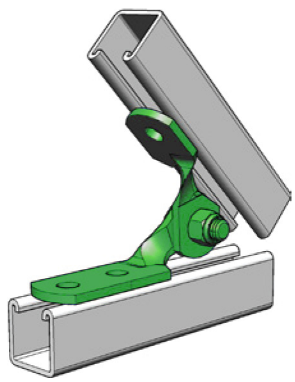


Adjustable Hinges

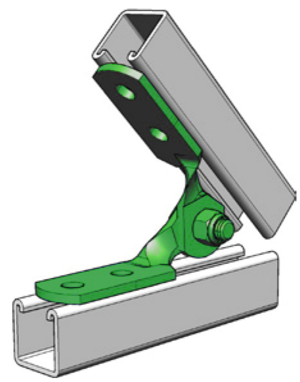
Hinges rotate on 0.05" bolts with nylon insert nuts. Holes in steel measure 0.56" (14.3mm) diameter holes,



SR292A-EG



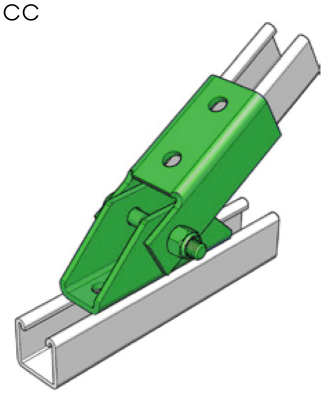
SR293A-EG



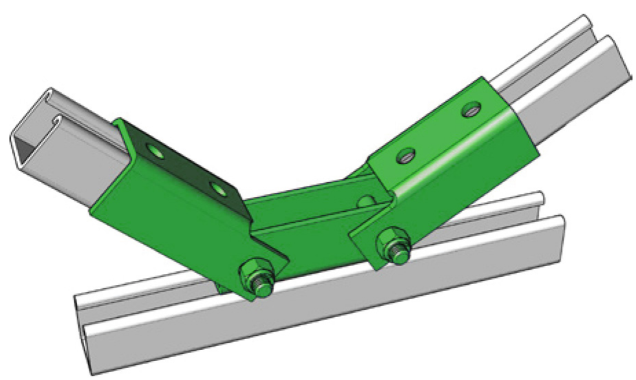
SR294A-EG

Adjustable Braces

Braces anchor to strut via two 0.56" (14.3mm) diameter holes, 3.75" (95.3mm) cc. Hinges rotate on 0.05" bolts with nylon insert nuts. Holes in adjustable channel component are 1.875" (47.6mm) cc



SR298A-EG



SR299A-EG

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777 Fenmar Drive
Toronto, ON M9L1C8

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