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SASCO STRUT – SEISMIC RESTRAINT DESIGN MANUAL

Table of Contents

Structural Engineering Disclaimer

Read Jones Christoffersen Ltd. (RJC) has collaborated 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.

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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 non-structural elements as 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 7 to 10) 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.

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 44)

- 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 = $0.3 \cdot F_a \cdot S_a(0.2) \cdot I_E \cdot S_p$

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 = $C_p \cdot A_r \cdot A_x / R_p$ (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

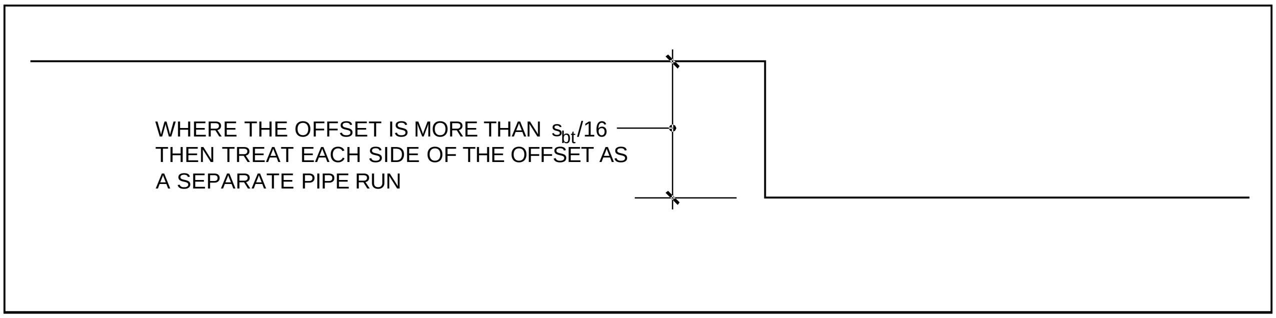
Anchorage to Base Structure

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 26) for common concrete and steel connections

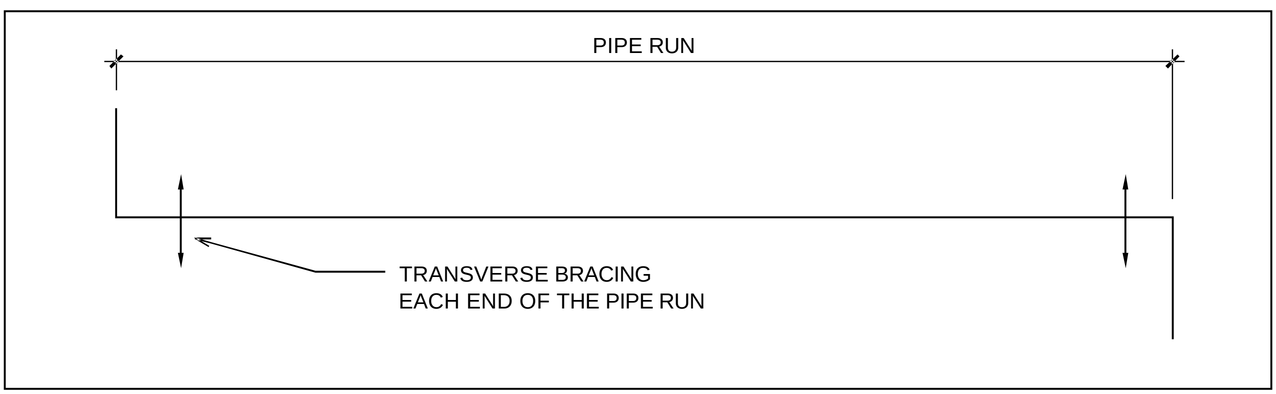
SMACNA – Section 4.2

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.

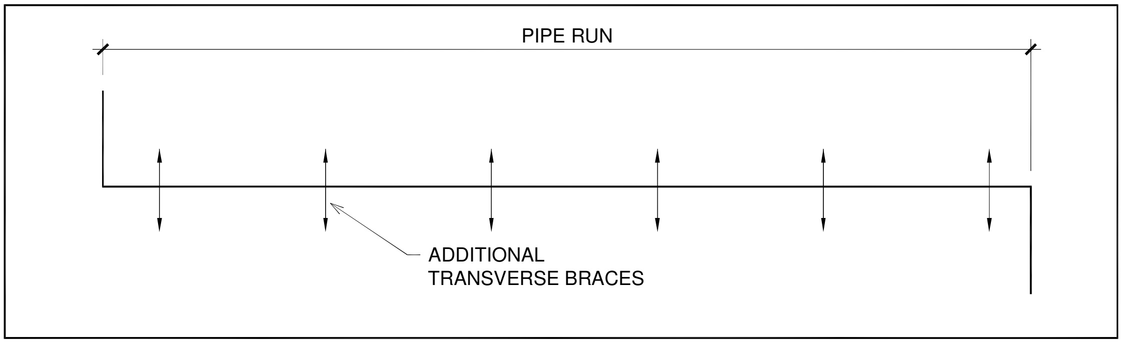
1. Separate the length of the pipe into separate runs. A run is considered to be a single straight section between any bends in the pipe except where the bend is at an offset of less than the allowable transverse brace spacing (s_{bt}) divided by 16. *Note: The maximum transverse brace spacing is shown in Table 3 (Pg 29).*



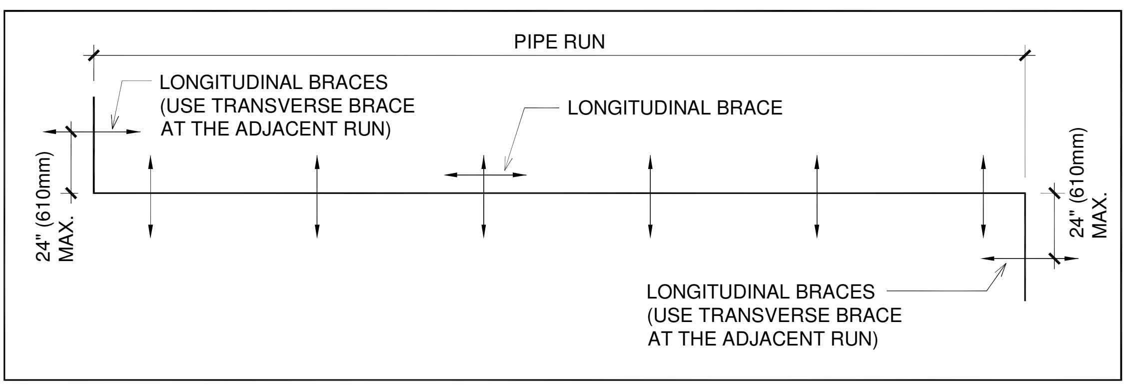
2. Each straight run must be braced in the transverse direction at each end. Where several short runs occur, see item 5 below.



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 29), add transverse braces until the spacing does not exceed the allowable distance.



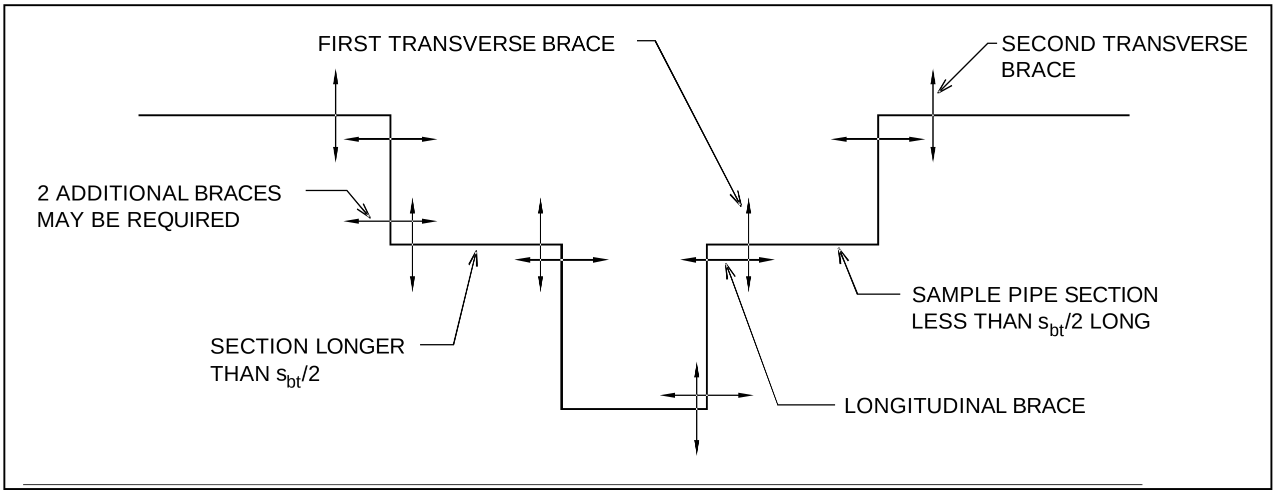
4. Each pipe run must have at least one longitudinal brace. Add longitudinal braces so the spacing does not exceed the maximum spacing in Table 3 (Pg 29).

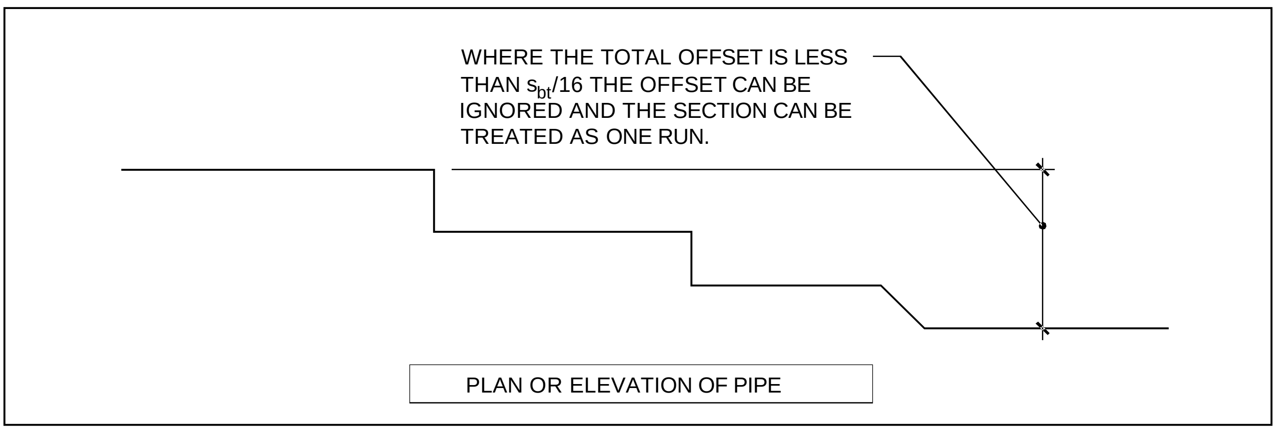


If an adjacent run has a transverse brace within 610 mm (24in) of the 90 degree corner, it can be used a longitudinal brace. Use the larger of the two braces, the longitudinal brace for this run or the transverse brace of the adjacent run.

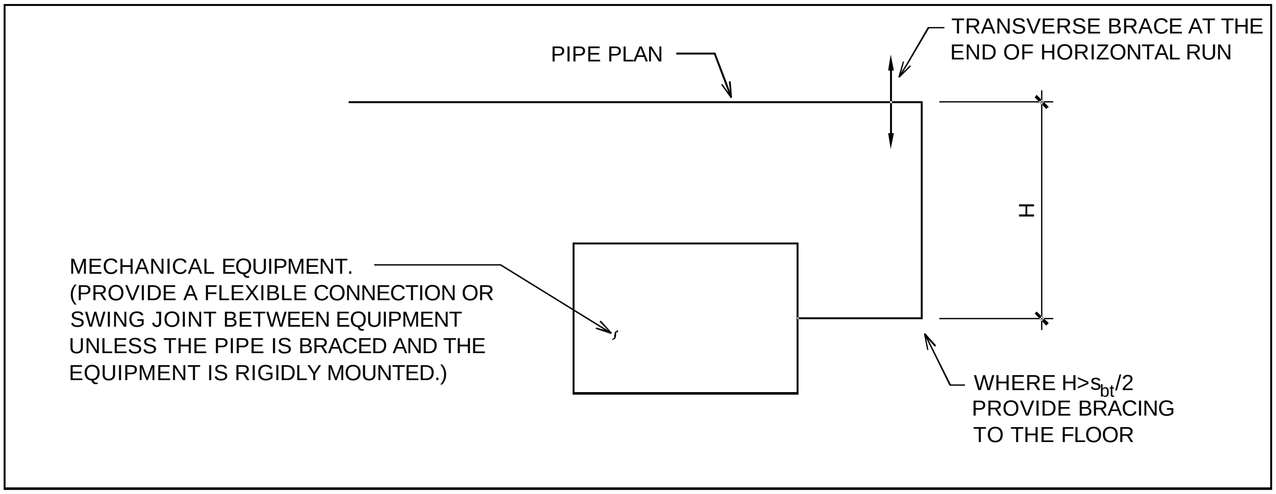
5. In many cases, several short sections of pipe occur one after the other. Based upon the requirements above, each section should be provided with a longitudinal brace if the offset is greater than s_{bt} /16. The longitudinal braces can act as transverse braces as long as the total length of pipe tributary 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 Procedure

Trapeze Hangers

Step 1 Determine maximum spacing of trapeze hangers and seismic braces

Use Table 3 (Pg 29) to select the maximum support spacing, $s_{trapeze}$, governed by the requirement of the smallest diameter pipe. 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 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, W_p, supported by trapeze

Use Table 3 (Pg 29) to determine the dead load of the pipes and their contents per unit length supported by the trapeze.

$W_p = \sum (DL_p \times N_p)$
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 5 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 $s_{b\ell}$

Step 4 Determine Sasco pipe clamp required

Use Table 9 (Pg 33) 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_ℓ}, $R_{clamp\_v,}$) are provided in Table 9 (Page 33) and must exceed the applied factored forces which are calculated according to the following expressions:

Transverse:

$R_{clamp\_t} > F_{clamp\_t} = 1.0 \times \text{Seismic Load Coefficient} \times DL_p \times s_{bt}$

Longitudinal:

$R_{clamp\_\ell} > F_{clamp\_\ell} = 1.0 \times \text{Seismic Load Coefficient} \times DL_p \times s_{b\ell}$

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 30) and 5 (Pg 31) 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:

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

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 32) 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, P_b, 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:

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

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

Use Table 7 (Pg 32) 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 30). 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: $P_{r\_rod} > P_{rod\_\ell} = (P_{b\ell} \times \sin \theta_\ell) - (½ \times W_p \times s_{trapeze})$

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 26) for common steel and concrete connections

Single Pipe Hangers

Step 1 Determine maximum spacing of pipe hanger and seismic braces

Use Table 3 (Pg 29) 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, W_p, supported by pipe hanger

Use Table 3 (Pg 29) 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 5 to calculate the Seismic Load Coefficient and design lateral seismic force, V_p. Recall, from the load combination provided on page 6, the load factor for load due to earthquake is 1.0

In the transverse direction:

$V_{pt} = 1.0 \times \text{Seismic Load Coefficient} \times W_p \times s_{bt}$

In the longitudinal direction:

$V_{p\ell} = 1.0 \times \text{Seismic Load Coefficient} \times W_p \times s_{b\ell}$

Step 4 Determine pipe hanger 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 32) 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 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:

$V_{slip} > P_b$ (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 32) 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: $P_{r\_rod} > P_{rod\_\ell} = (P_{b\ell} \times \sin \theta_\ell) - (W_p \times s_{hanger})$
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 26) for common concrete and steel connections

3. Figures

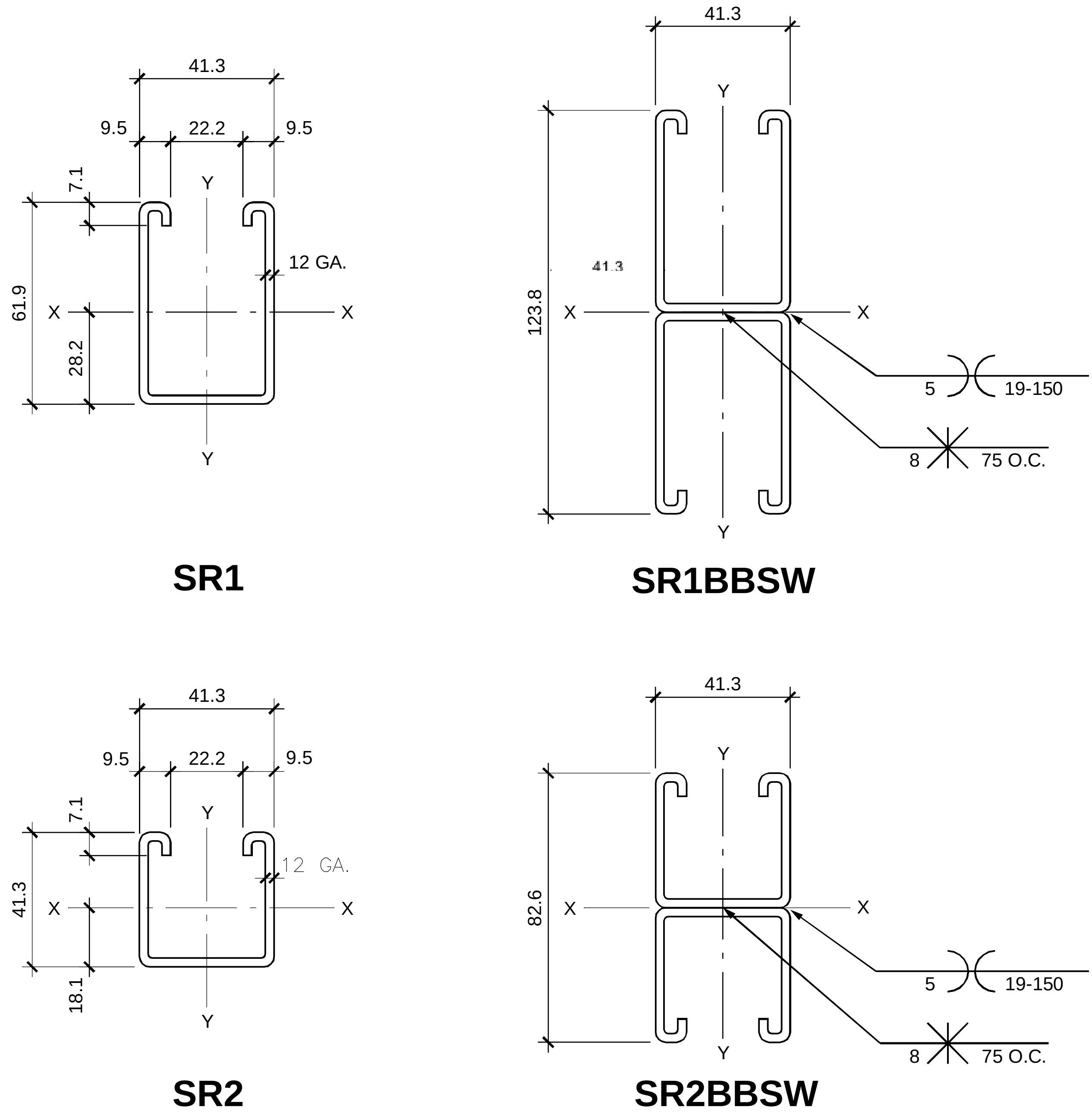


Figure 1A – Sasco Channels (Metric)

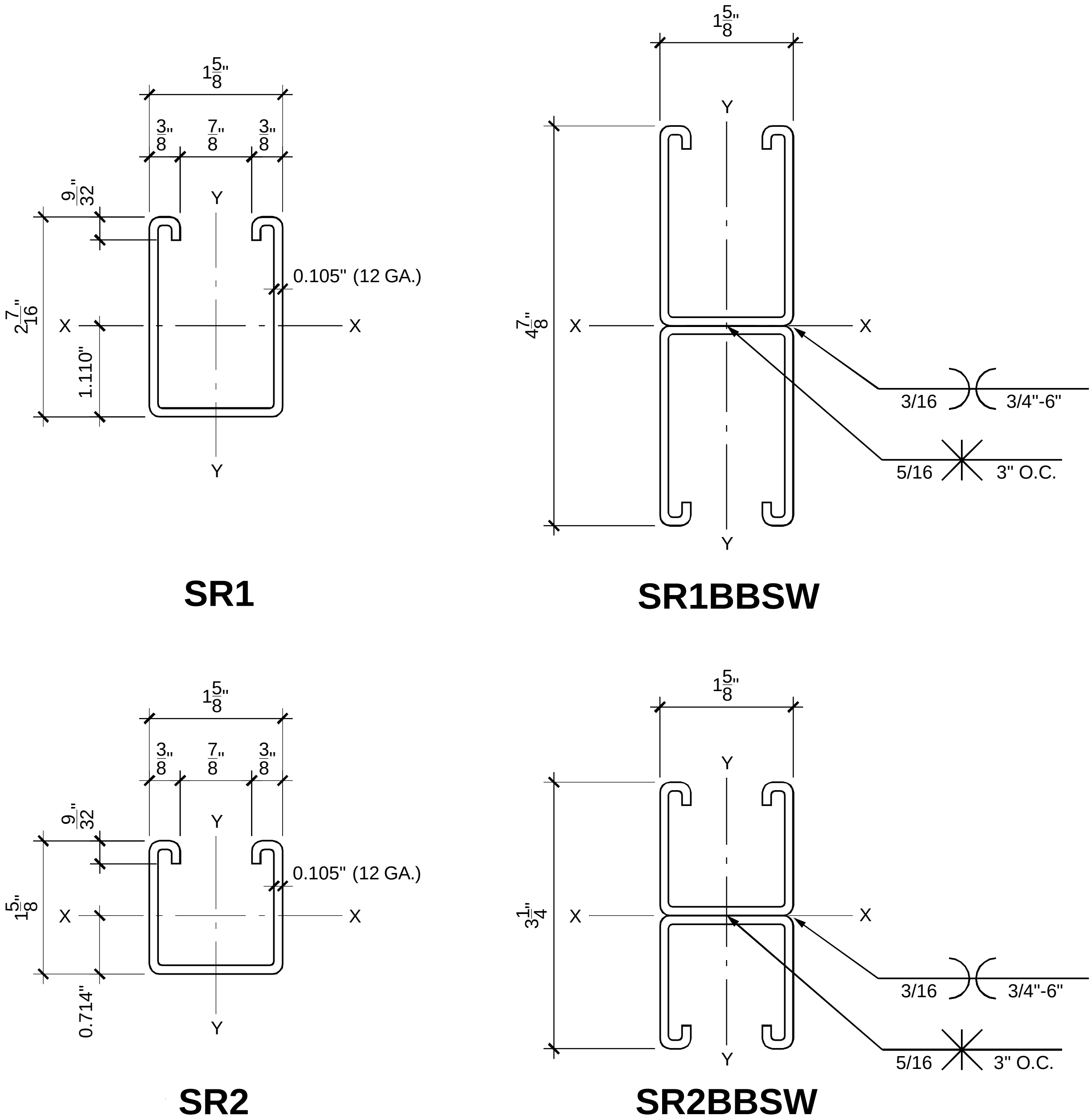


Figure 1B – Sasco Channels (Imperial)

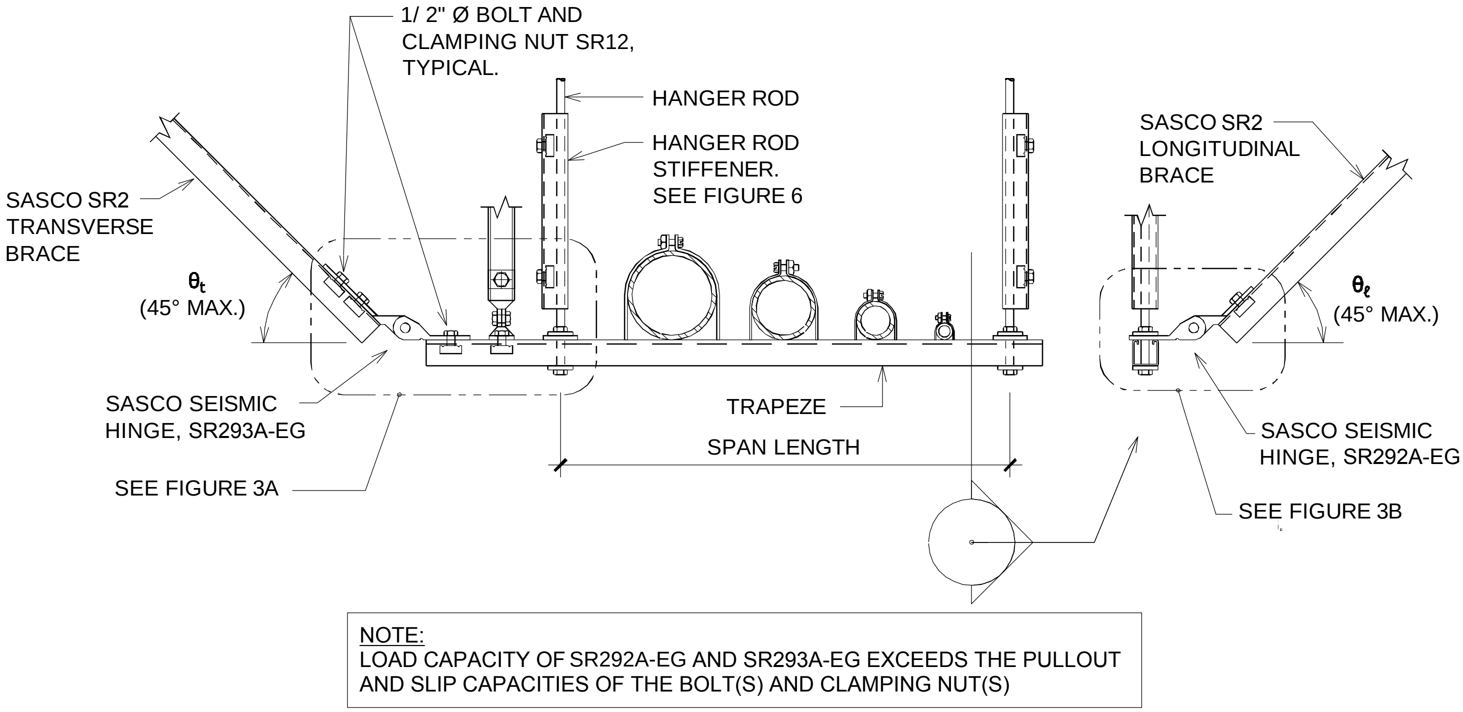


Figure 2 – Typical Trapeze with Transverse and Longitudinal Braces

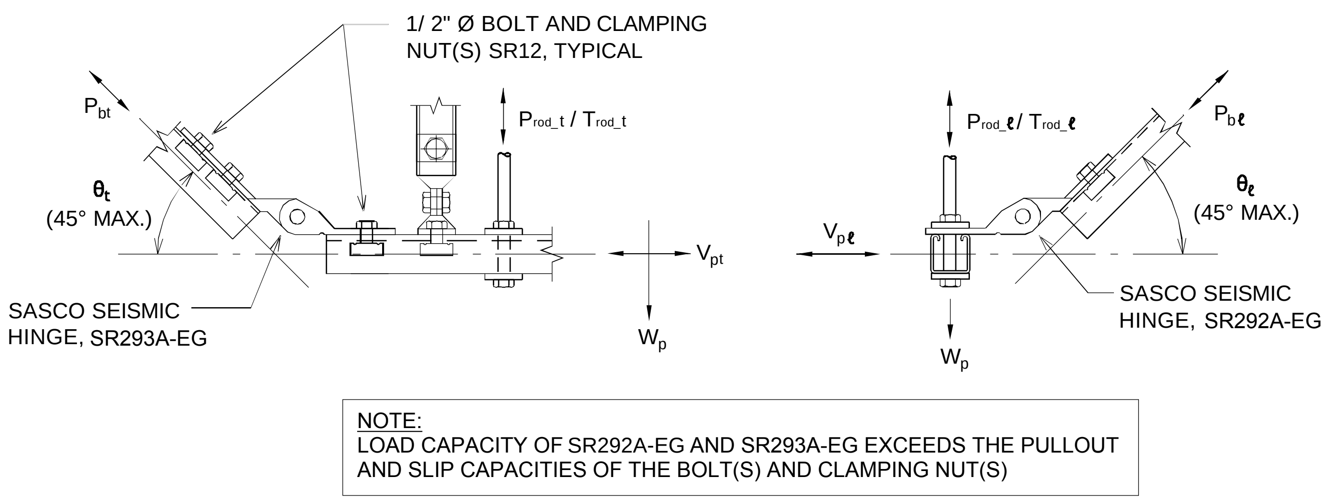


Figure 3 – Typical Trapeze and Brace Details

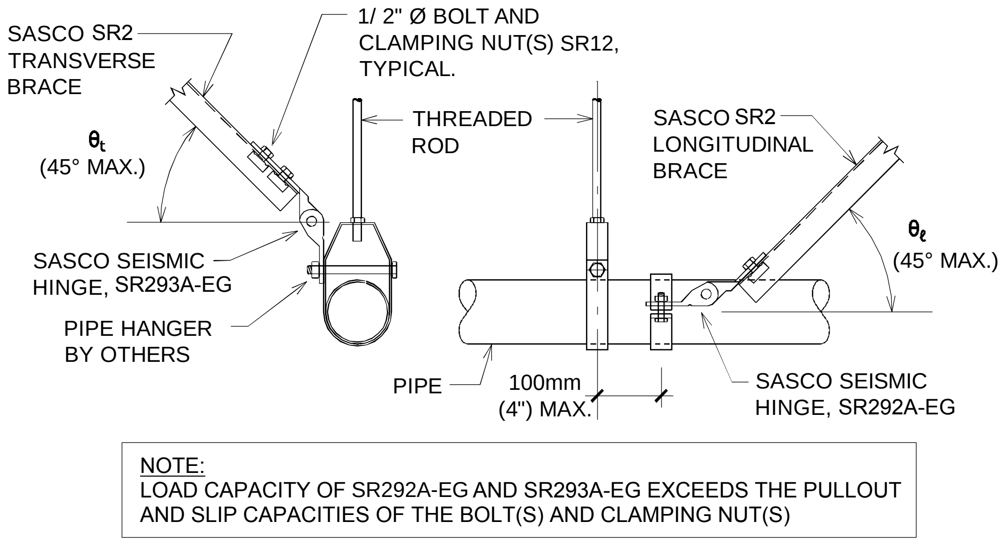


Figure 4 – Typical Single Pipe with Transverse and Longitudinal Braces

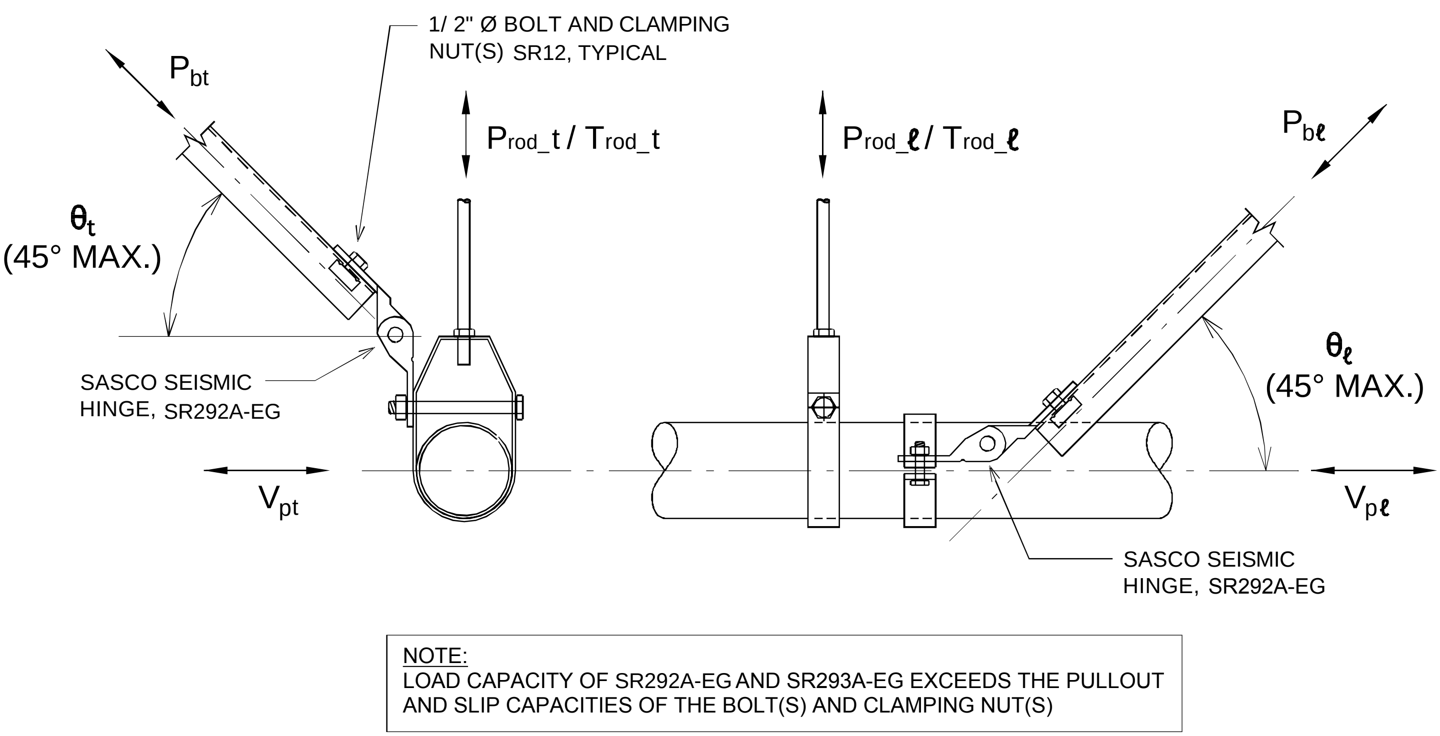
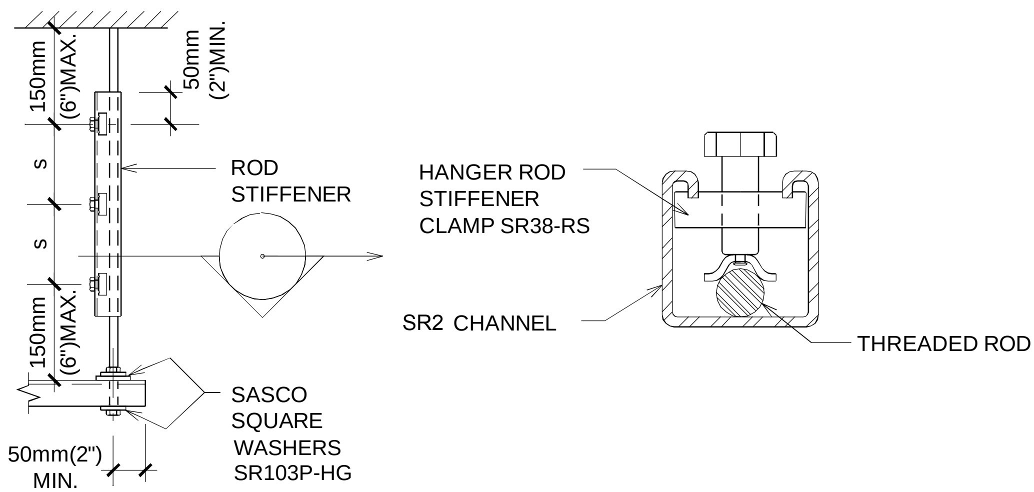


Figure 5 – Typical Single Pipe and Brace Details



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 6 – Hanger Rod with Stiffener Assembly

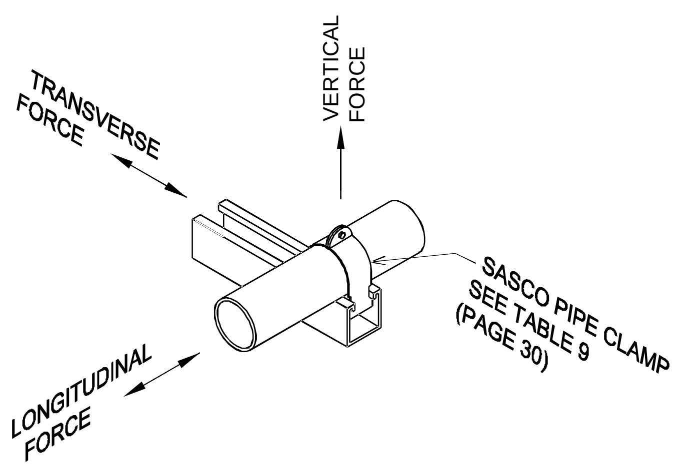


Figure 7 – Pipe Clamp Forces

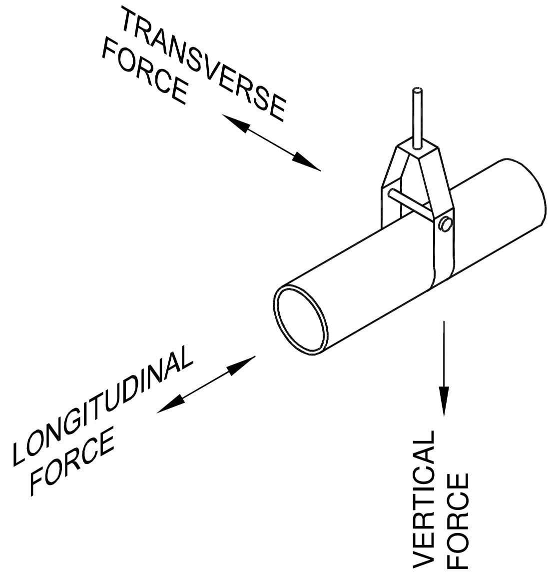


Figure 8 – Pipe Hanger Forces

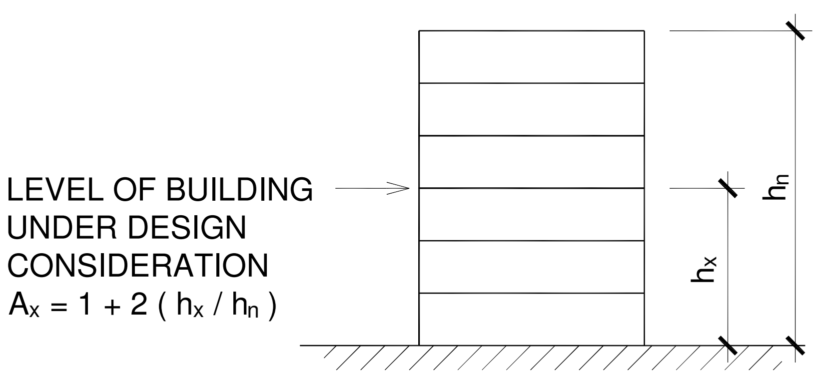
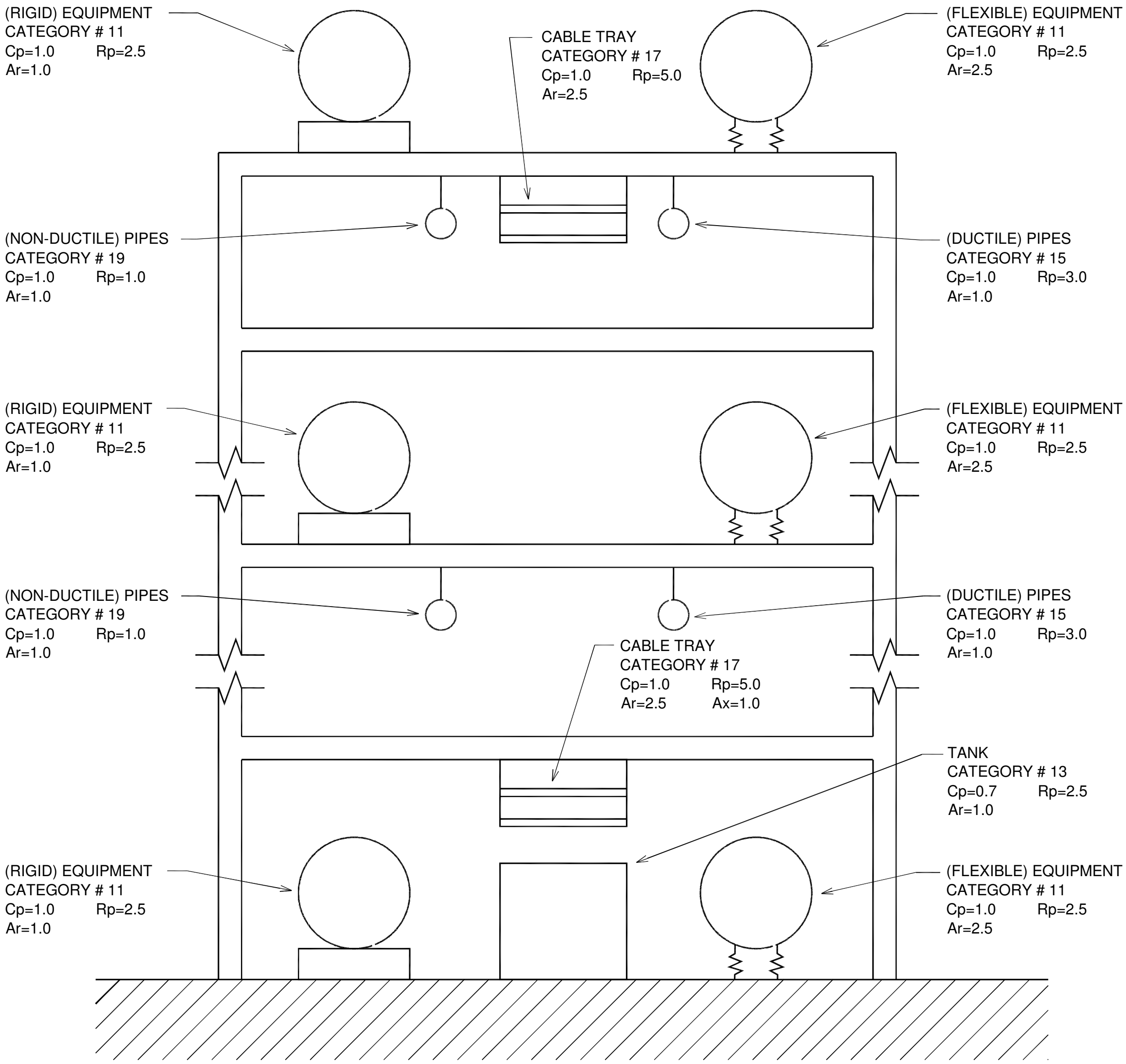


Figure 9 – Seismic Force Height Factor



- Values Must be verified by Project Engineer

Figure 10 – Typical A_r, R_p, C_p for mechanical and electrical components for a building in Vancouver.

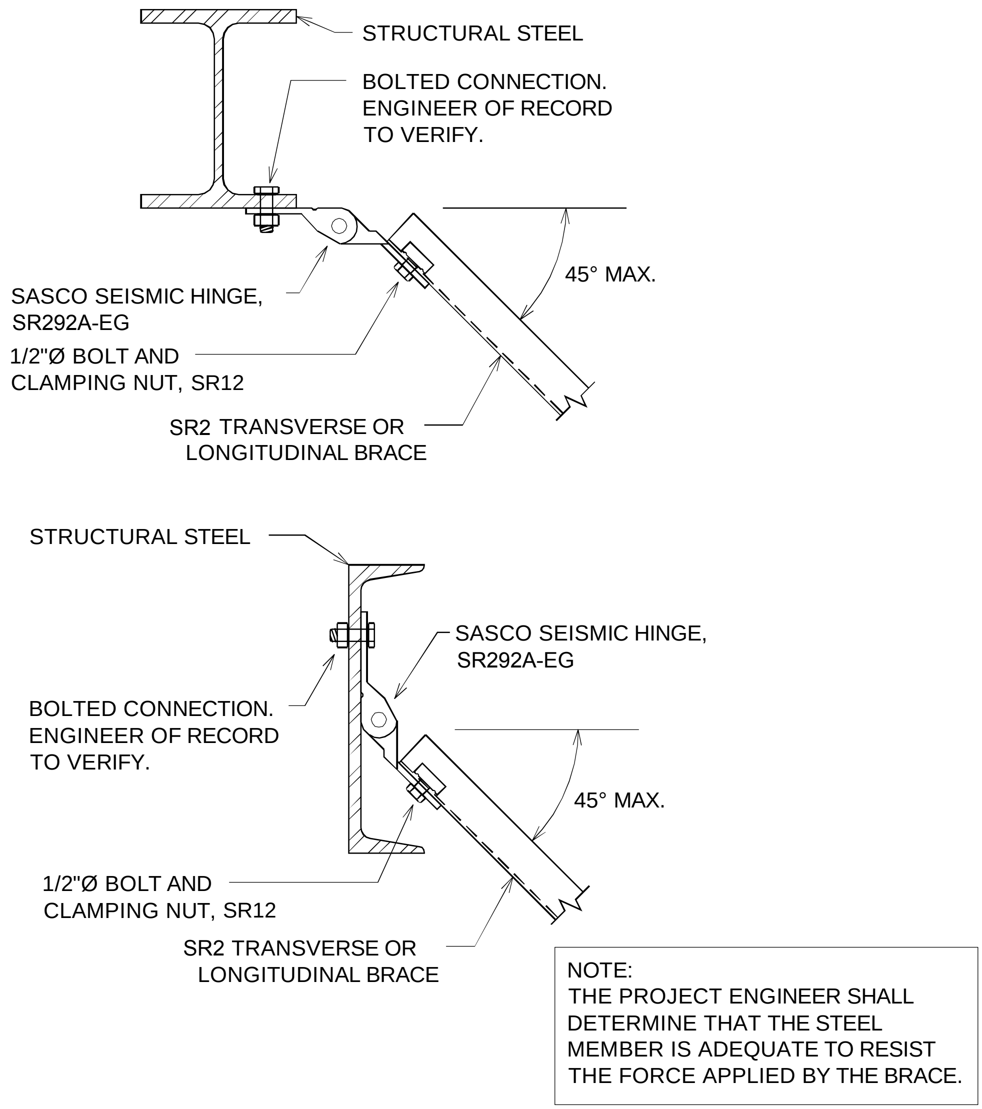


Figure 11 – Typical Steel Connection Details

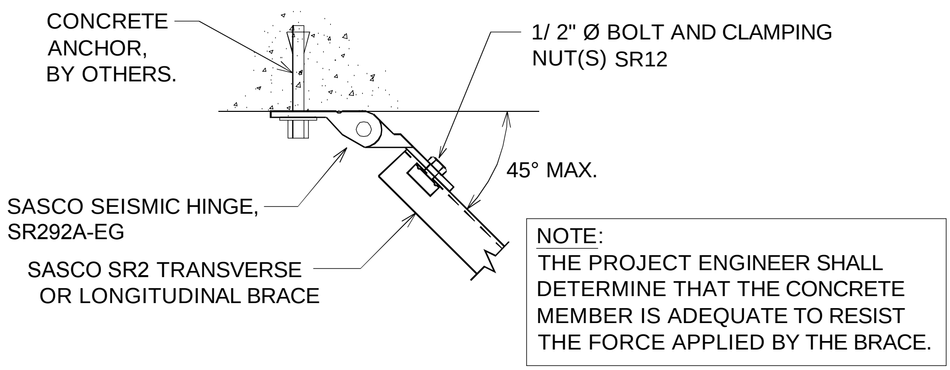


Figure 12 - Typical Concrete Connection Detail

4. Design Tables

<u>Conversion Table</u>

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

Table 1 - Elements of Sasco Channels - Metric Units

Channel Catalogue Number	GA.	WT. Kg/m	A cm^2	x-x I cm^4	x-x S cm^3	x-x r cm	B cm	y-y I cm^4	y-y S cm^3	y-y r cm
SR1	12	3.68	4.70	21.30	6.37	2.16	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

1. See Figure 1A

Table 2 - Elements of Sasco Channels - Imperial Units

Channel Catalogue Number	GA.	WT. lb/ft	A in^2	x-x I in^4	x-x S in^3	x-x r in	B in	y-y I in^4	y-y S in^3	y-y r 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	.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	.954	0.587	0.921	1.625	0.475	0.583	0.655

1. See Figure 1B

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

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] Transverse s_{bt}		Longitudinal $s_{b\ell}$		Min. Rod Dia.[1]	
Designation	(nominal size)	O.D (in)	kN/m	(lb/ft)	m	(ft)	m	(ft)	m	(ft)	mm	(in)
DN15	(1/2)	0.84	0.014	(0.98)	2.5	(8)	12	(40)	24	(80)	6	(1/4)
DN20	(3/4)	1.05	0.020	(1.36)	2.5	(8)	12	(40)	24	(80)	6	(1/4)
DN25	(1)	1.315	0.030	(2.05)	2.5	(8)	12	(40)	24	(80)	6	(1/4)
DN32	(1 1/4)	1.66	0.043	(2.93)	2.5	(8)	12	(40)	24	(80)	6	(1/4)
DN40	(1 1/2)	1.9	0.053	(3.60)	2.5	(8)	12	(40)	24	(80)	6	(1/4)
DN50	(2)	2.375	0.075	(5.11)	2.5	(8)	12	(40)	24	(80)	6	(1/4)
DN 65	(2 1/2)	2.875	0.115	(7.87)	2.5	(8)	12	(40)	24	(80)	8	(5/16)
DN80	(3)	3.5	0.157	(10.78)	2.5	(8)	12	(40)	24	(80)	8	(5/16)
DN100	(4)	4.5	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	(1/2)
DN150	(6)	6.625	0.460	(31.51)	2.5	(8)	12	(40)	12	(40)	13	(1/2)
DN200	(8)	8.625	0.734	(50.29)	3.75	(12)[5]	12	(40)	12	(40)	13	(1/2)

1. Per the National Plumbing Code of Canada 2010 Part 2. See also any appropriate provincial or territorial regulations or municipal by-laws 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]

	SR1			SR2		
Span Length	Maximum Factored Load[2] x-x axis, M_{rX}	Deflection[3]	Maximum Factored Load[2] y-y axis, M_{rY}	Maximum Factored Load[2] x-x axis, M_{rX}	Deflection[3]	Maximum Factored Load[2] y-y axis, M_{rY}
m (in)	kN (lb)	mm (in)	kN (lb)	kN (lb)	mm (in)	kN (lb)
.6 (24)	17.1 (3851)	1.27 (0.05)	18.2 (4099)	9.0 (2039)	1.8 (0.07)	12.8 (2871)
.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 (816)	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)

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 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] y-y axis, M_{rY}		Maximum Factored Load[2] x-x axis, M_{rX}		Deflection[4]		Maximum Factored Load[2] y-y axis, M_{rY}	
m	(in)	kN	(lb)	mm	(in)	kN	(lb)	kN	(lb)	mm	(in)	kN	(lb)
.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)
.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	(0.4)	9.1	(2042)	6.5	(1453)	17.5	(0.69)	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 previously published Allowable Stress Design Values
2. Load must be uniformly distributed over span length of the trapeze
3. Capacity limited by weld shear
4. Elastic deflections in the X direction under maximum load
5. For Concentrated Loads at centre of span – Multiply Load by 0.5 and deflection by 0.8
6. See Figures 1A and 1B

Table 6 - Brace Factored Axial Capacity (SR2 Channel)

Length in.	Maximum Factored Compression Load[1], P_r
m (in)	kN (lb)
.6 (24)	17.7 (3980)
.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 mm (in)	Max. Factored Compression Load, P_{r_rod}	Max. Factored Tension Load, T_{r_rod}	Max Clamp Spacing[1] "s"
	kN (lb)	kN (lb)	mm (in)
10 (3/8)	1.9 (438)	7.7 (1741)	350 (14)
13 (1/2)	3.3 (741)	14.3 (3226)	500 (20)
16 (5/8)	5.0 (1128)	23.0 (5171)	650 (26)
19 (3/4)	7.3 (1650)	34.4 (7731)	800 (32)
22 (7/8)	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 1/2" Clamping Nuts

Mechanism	Resistance (per nut) kN (lb)[1]
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

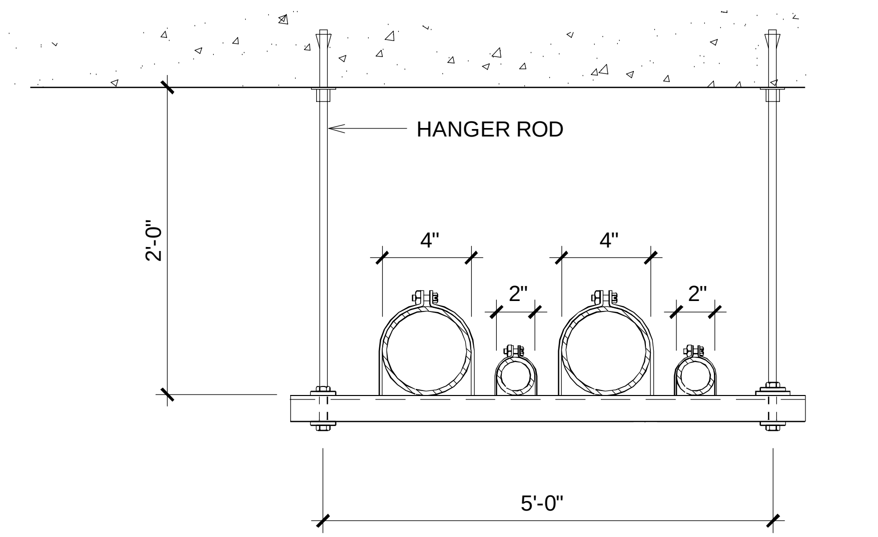
Table 9 – Factored Resistance of Sasco Pipe Clamps

				Clamp Factored Resistances		
Designation	Pipe Size (nominal size)	O.D (in)	Part No.	Transverse R_{clamp_t} [1] kN (lb)	Longitudinal R_{clamp_ℓ} [1] kN (lb)	Vertical R_{clamp_v} [1] kN (lb)
DN15	(1/2)	0.84	SR12R	0.46 (105)	0.31 (70)	2.49 (560)
DN20	(3/4)	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)
DN32	(1 1/4)	1.66	SR114R	0.94 (210)	0.94 (210)	3.74 (840)
DN40	(1 1/2)	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)
DN 65	(2 1/2)	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)
			SR4RHD	2.0 (460)	1.24 (280)	6.23 (1400)
DN125	(5)	5.563	SR5R	1.55 (350)	1.24 (280)	4.98 (1120)
			SR5RHD	2.0 (460)	1.24 (280)	6.23 (1400)
DN150	(6)	6.625	SR6R	1.55 (350)	1.24 (280)	4.98 (1120)
			SR6RHD	2.0 (460)	1.24 (280)	6.23 (1400)
DN200	(8)	8.625	SR8R	1.55 (350)	1.24 (280)	4.98 (1120)
			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

$W_p = \sum(DL_p \times N_p)$ therefore, using Table 3:

W_p = (5.11 lb/ft x 2) + (16.31 lb/ft x 2) = 42.84 lb/ft

Step 3 Calculate seismic forces

Using information from Section 1 and NBCC 2010

$F_a = 1.0$
$S_a(0.2)=0.94$
$I_E = 1.0$
$C_p = 1.0$
$A_r = 1.0$
$h_x = 20$ ft
$h_n = 30$ ft
$\therefore A_x = 1 + 2 \times (20 / 30) = 2.33$
$R_p = 3.0$

$$S_p = C_p \cdot A_r \cdot A_x / R_p = \frac{1.0*1.0*2.33}{3.0} = 0.78$$

Therefore the Seismic Load Coefficient is:

$= 0.3 \cdot F_a \cdot S_a(0.2) \cdot I_E \cdot S_p$

= 0.3 x 1.0 x 0.94 x 1.0 x 0.78 = 0.22

and the Seismic Forces are:

Transverse direction:
V_{pt} = 1.0 x Seismic Load Coefficient x W_p x s_{bt}
V_{pt} = 1.0 x 0.22 x 42.84 lb/ft x 40 ft = 377 lb

Longitudinal direction:
$V_{p\ell}$ = 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 80 ft = 754 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 x W_p x $S_{trapeze}$
= 1.0 x 42.84 lb/ft x 8 ft = 343 lb

Factored Bending Load about y-y axis due to seismic

M_{fY} = $V_{p\ell}$
= 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 ∴ 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: $P_{bt} = V_{pt} \times (1 / \cos \theta_t)$
=377 lb x 1 / cos 45° = 533 lb
Longitudinal direction: $P_{b\ell} = \frac{1}{2} \times V_{p\ell} \times (1 / \cos \theta_\ell)$
= ½ 377 lb x 1 / cos 45° = 267 lb

P_b = larger of of P_{bt} and P_{bl} = 533 lb

Check brace factored capacity, P_r from Table 6 (Page 22)
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 ∴ the brace is adequate.

Step 7 Check hinge and connections

From Table 8 (Page 32):
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

∴ $V_{slip} > P_b$ ∴ 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} x sin θ_t) – (½ x W_p x $s_{trapeze}$)
= (533 lb x sin 45°) – (½ x 42.84 lb/ft x 8 ft) = 206 lb

T_{rod_t} = (½ x W_p x $s_{trapeze}$) + (P_{bt} x sin θ_t)
= (½ x 42.84 lb/ft x 8 ft) + (533 lb x sin 45°) = 548 lb

P_{rod_ℓ} = ($P_{b\ell}$ x sin θ_ℓ) – (½ x W_p x $s_{trapeze}$)
= (267 lb x sin 45°) – (½ x42.84 lb/ft x 8 ft) = 17 lb

T_{rod_ℓ} = (½ x W_p x $s_{trapeze}$) + ($P_{b\ell}$ x sin θ_ℓ)
= (½ x42.84 lb/ft x 8 ft) + (267 lb x sin 45°) = 360 lb

∴ Maximum P_{rod} = 206 lb and maximum T_{rod} = 548 lb

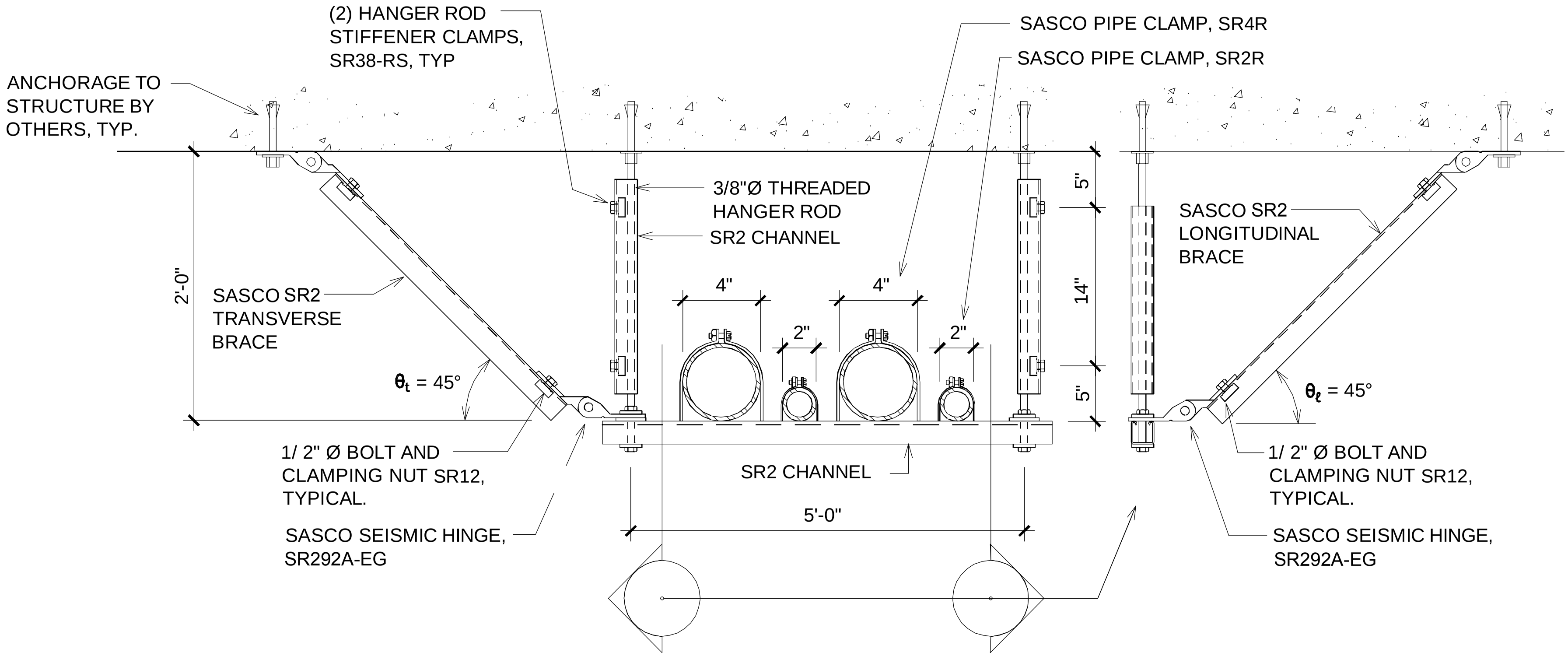
Using Table 7, start with smallest diameter rod:
⅜"ø rod: P_{r_rod} = 438 lb > 206 lb
T_{r_rod} = 1741 lb > 548 lb

∴ 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 32), 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

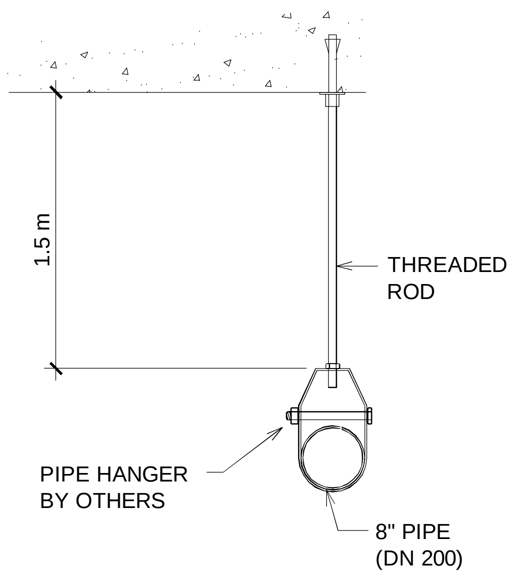
It is the responsibility of the project engineer to confirm that the primary structure can withstand the connection loads of the hanger rods and brace attachments. The design of these connections is the responsibility of the project engineer and should be reviewed by the engineer of record for the base 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 hanger and seismic braces

Pipe support spacing is determined based on the diameter of the pipe
$S_{hangers}$ = 3.75 m (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 11.25 m (Table 3)
$S_{b\ell}$ = 12 m use 11.25 (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

$F_a = 1.0$
$S_a(0.2)=1.2$
$I_E = 1.0$
$C_p = 1.0$
$A_r = 1.0$
$h_x = 4.5$ m
$h_n = 7.5$ m
$\therefore A_x = 1 + 2 \times (4.5 / 7.5) = 2.2$
$R_p = 3.0$

$$S_p = C_p \cdot A_r \cdot A_x / R_p = \frac{1.0*1.0*2.2}{3.0} = 0.73$$

Therefore the Seismic Load Coefficient is

$= 0.3 \cdot F_a \cdot S_a(0.2) \cdot I_E \cdot S_p$

$= 0.3 \times 1.0 \times 1.2 \times 1.0 \times 0.73 = 0.26$

and the Seismic Forces are:

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

Longitudinal direction
$V_{p\ell} = 1.0 \times$ Seismic Load Coefficient $\times W_p \times s_{b\ell}$
$V_{p\ell} = 1.0 \times 0.26 \times .734$ kN/m $\times 11.25$ m $= 2.1$ 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: $F_{hang\_\ell} = V_{p\ell} = 2.1$ kN
Gravity: F_{hang_v} $1.0 \times W_p \times s_{hang} = 1.0 \times 0.734$ kN/m x 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 x (1 / cos 30) = 2.4 kN

Longitudinal direction:

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

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

Check brace factored capacity, P_r from Table 6:

The transverse brace length is 3 m (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 $P_{b\ell} = 3.0$ 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:

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

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

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

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

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

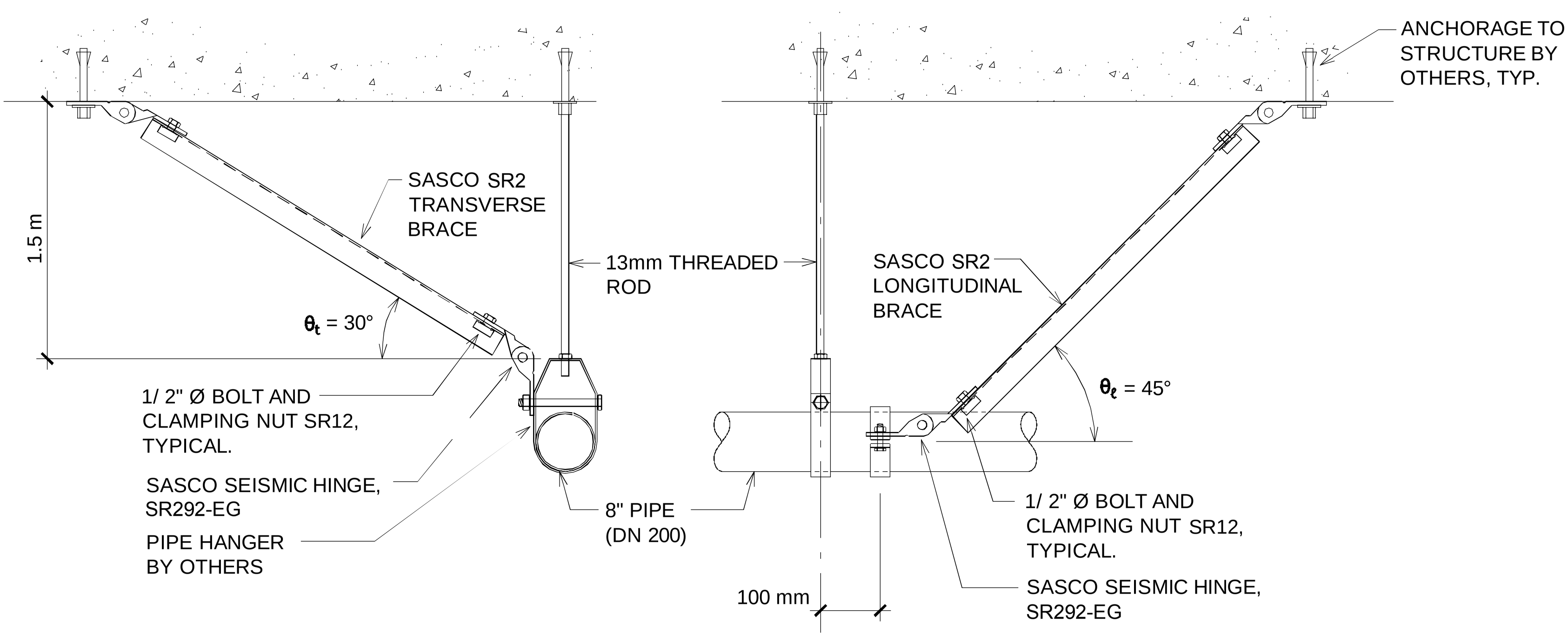
From Table 3, the minimum diameter rod for an 8" ø pipe is 13mm.
Using Table 7:
13mm ø rod $T_{r\_rod} = 14.3\ kN > 4.9\ kN$

∴ use 13 mm 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

Notation

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	$C_p \cdot A_r \cdot A_x / R_p$
$s_{trapeze}$	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

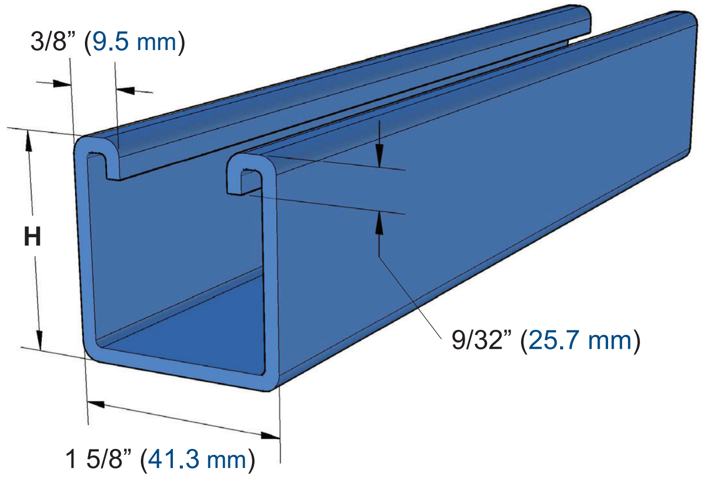
STRUT CHANNEL

SINGLE CHANNEL

STEEL

Channel Prefix	H (Inches)	H (mm)	Thickness (Ga.)
SR1	2 7/16	61.91	12
SR2	1 5/8	41.28	12

Steel Strut Channels are roll formed from 33000 psi steel.



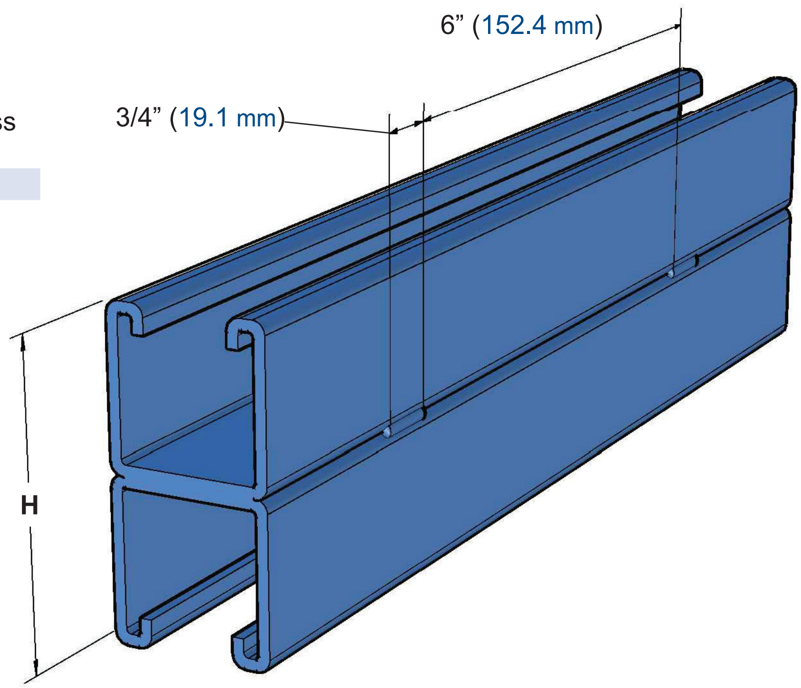
BACK TO BACK

STEEL

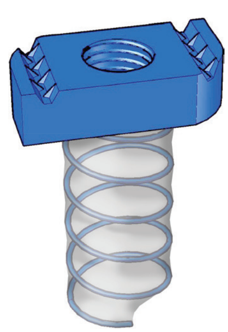
Channel Prefix	H (Inches)	H (mm)	Thickness (Ga.)
SR1BBSW	4 7/8	123.83	12
SR2BBSW	3 1/4	82.55	12

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

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



CLAMPING NUTS

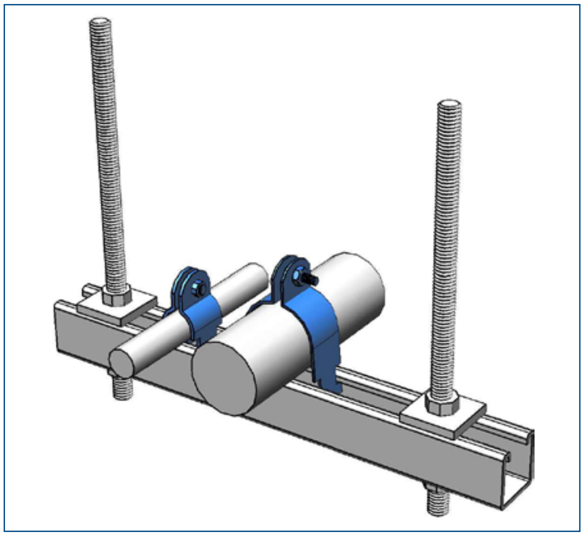


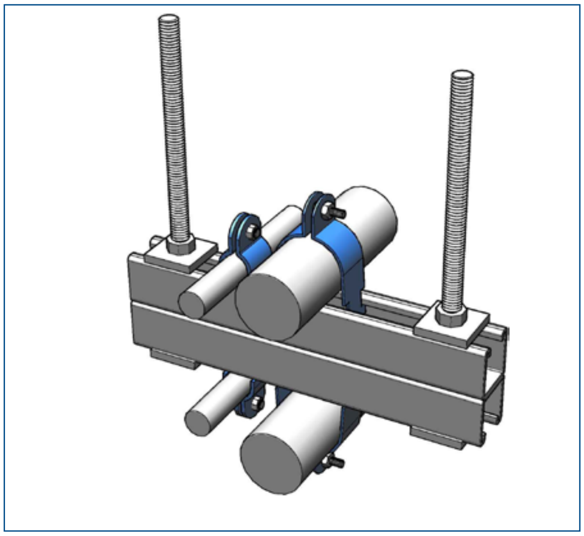
Thread Size	Catalogue Numbers		Spring Length
	Regular Spring	No Spring	Regular
1/2” - 13	**SR12**	**SR12W**	1.5”

PIPE CLAMPS

For Rigid Conduit:

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



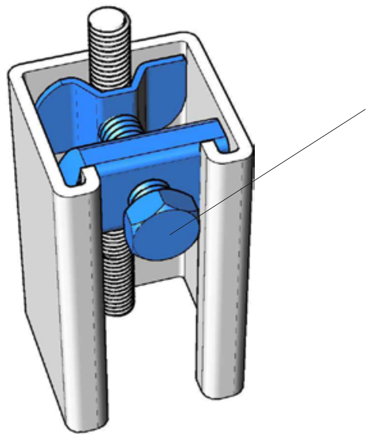


Finish:

Pre-galvanized (standard): -G

Other finishes are available. Please consult the factory.

ROD STIFFENER CLAMP



SR38-RS

Bolt length: 1 3/8”
Thread dia.: 3/8” - 16

Secures 3/8” through 5/8” diameter hanger rod.

Standard finish is electro-galvanized,
Stainless steel available upon request.

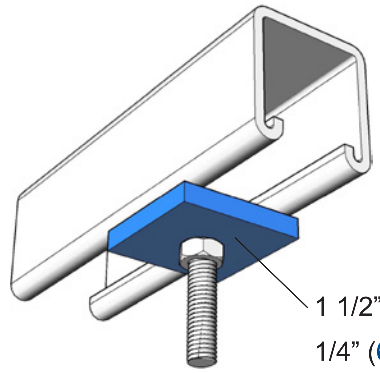
SQUARE WASHERS

Hole Diameter (Inches)	(mm)	Catalogue No.
9/16	14.3	**SR103P-HG**

Finish:

Hot dipped galvanized after fabrication -HG

Other finishes are available. Please consult the factory.

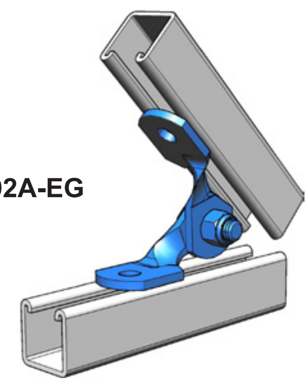


ADJUSTABLE BRACES AND HINGES

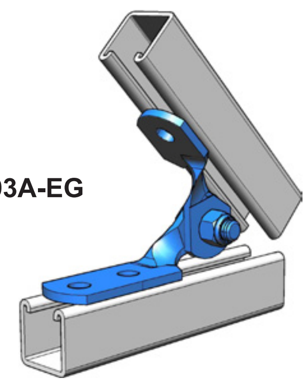
ADJUSTABLE HINGES:

Hinges rotate on 1/2” bolts with nylon insert nuts. Holes 1 5/8” (41.3 mm) cc.

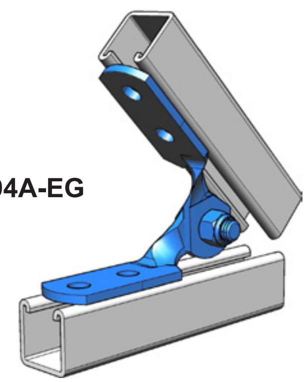
SR292A-EG



SR293A-EG



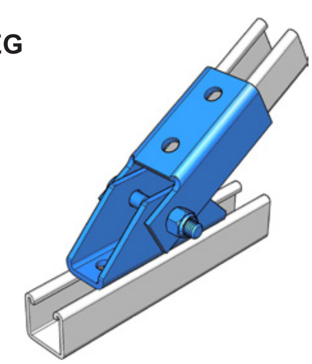
SR294A-EG



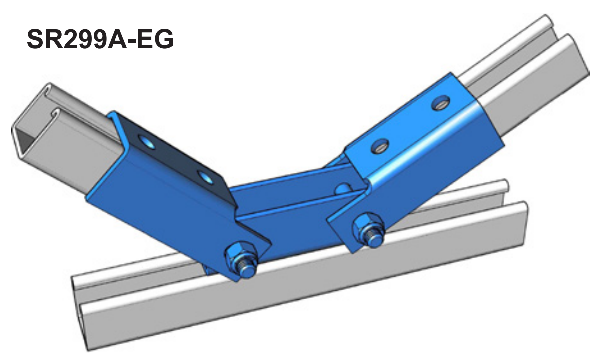
ADJUSTABLE BRACES:

Braces anchor to strut via two 9/16” dia. (14.3 mm) holes, 3 3/4” (95.3 mm) cc. Hinges rotate on 1/2” bolts with nylon insert nuts. Holes in adjustable channel component are 1 7/8” (47.6 mm) cc.

SR298A-EG



SR299A-EG



GENERAL DATA:
Holes 9/16” (14.3 mm) dia. centred 13/16” (20.6 mm) from ends. Steel is 1 5/8” (41.3 mm) wide and 1/4” (6.4 mm) thick. Standard finish is electro-galvanized zinc (-EG).Other finishes available. Please consult factory.

SASCO STRUT

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