DEPARTMENT OF HEALTH CARE ACCESS AND INFORMATION
OFFICE OF STATEWIDE HOSPITAL PLANNING AND DEVELOPMENT

APPLICATION FOR HCAI PREAPPROVAL OF MANUFACTURER'S CERTIFICATION (OPM)	OFFICE USE ONLY
	APPLICATION #: OPM-0601

HCAI Preapproval of Manufacturer's Certification (OPM)

Type: [X] New [ ] Renewal/Update

Manufacturer Information

Manufacturer: ISOTECH Industries USA Inc.

Manufacturer's Technical Representative: Matthew Hooti

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Product Information

Product Name: IRR-1000

Product Type: Seismic Bracing system for suspended equipment and distribution systems

Product Model Number: IRR-1000

General Description: Seismic Restraints for Suspended Distribution Systems and Equipment

Applicant Information

Applicant Company Name: ISOTECH Industries USA Inc.

Contact Person: Matthew Hooti

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STATE OF CALIFORNIA – HEALTH AND HUMAN SERVICES AGENCY

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Registered Design Professonal Preparing Engineering Recommendations

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HCAI Special Seismic Certification Preapproval (OSP)

☐ Special Seismic Certification is preapproved under OSP   OSP Number: ______

Certification Method

Testing in accordance with: ☐ ICC-ES AC156 ☒ FM 1950-16

☐ Other(s) (Please Specify): ______

*Use of criteria other than those adopted by the California Building Standards Code, 2019 (CBSC 2019) for component supports and attachments are not permitted. For distribution system, interior partition wall, and suspended ceiling seismic bracings, test criteria other than those adopted in the CBSC 2019 may be used when approved by HCAI prior to testing.

☒ Analysis

☐ Experience Data

☐ Combination of Testing, Analysis, and/or Experience Data (Please Specify): ______

HCAI Approval

Date: 4/10/2024

Name: William Staehlin   Title: Senior Structural Engineer

Condition of Approval (if applicable): ______

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SEISMIC RESTRAINT GUIDELINES FOR SUSPENDED DISTRIBUTION SYSTEMS & EQUIPMENT

3rd EDITION, 2024

OPM-0601

Revision 1: 12/04/2023, Addressed HCAI Comments

Revision 2: 02/13/2024, Addressed HCAI Comments

Revision 3: 04/04/2024, Addressed HCAI Comments

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SECTION 1.0 GENERAL NOTES

1.1 Preface

This HCAI Pre-approval of Manufacturer's Certification (OPM) is based on the 2022 CBC.
The demand/design forces for use with the OPM shall be based on the 2022 CBC, and Section 2.4, ASCE 7-16 for Allowable Stress Design only.
Maximum allowable S_{DS} for this OPM is ≤ 2.8g.

I. Scope & Limitations:

This pre-approval is for the seismic rigid bracing of interior suspended equipment, mechanical pipe & duct systems, as well as electrical conduit & cable trays/raceways. It does not address other loads such as, but not limited to, those generated by thermal growth, pressure or pressure thrust, & fluid dynamics. It does not address components that cross seismic separations of buildings or components attached to portions of the structure or equipment that will experience relative seismic drifts other than pipe & duct risers.

II. The ranges of component sizes and material included in the pre-approval are listed as follows:

1) Mechanical Pipe: Schedule 40 Steel Pipe – Sizes 1” to 8” (Nominal)
2) Mechanical Duct (Round & Rectangular)
3) Electrical Distribution Systems – Conduit & Cable Trays/Raceways
4) Suspended Equipment – Mechanical & Electrical Equipment

III. The anchorage/attachment structures included in this pre-approval are as follows:

1) Composite Deck (concrete cast over Metal Deck)
2) Concrete
3) Unfilled Metal Deck
4) Steel Beams
5) Wood

IV. Construction Tolerances:

1) Construction tolerances shall be as noted on the drawing details from Sections 2.0 to 5.0.
2) Construction tolerances for angles of all braces shall be limited to ±5° out of plane & elevation as shown in the details of Section 2.0.
3) The recommended brace angle is 45° for the diagonal brace, or 1:1 brace ratio. The Rigid Brace shall be installed between 30°- 60° from the horizontal, as detailed in Section 2.0.

1.2 Introduction

I. This Manual is a guideline for seismic bracing design for interior equipment, mechanical piping & duct systems, and electrical conduit & cable trays/raceways. The following is an outline of the manual:

Section 1.0 – General Information: Presents general notes and requirements for bracing of mechanical, electrical, and plumbing systems. A general step by step procedure for seismic rigid bracing design has also been included in this manual.

Section 2.0 – Rigid Bracing & Configuration Details: Provides detailed illustrations of seismic rigid bracing for individually hung and trapeze supported pipe/conduit, cable trays/raceways, & ducts.

Section 3.0 – Rigid Brace Structural Attachments: Details structural attachment design and strengths for attaching the seismic rigid brace to the supporting structure. Attachments to Composite Concrete with Metal Deck, Concrete Slab/Beam/Wall, Unfilled Metal Deck, Steel I-Beam, & Wood Beam are included.

Section 4.0 – Hanger Rod Structural Attachments: Details structural attachment design and strengths for attaching the threaded hanger rod (with stiffener if Req'd) to the supporting structure. Attachments to Composite Concrete with Metal Deck, Concrete Slab/Beam, Unfilled Metal Deck, Steel I-Beam are included.

Section 5.0 – Rigid Brace Components: Includes details and design strengths for bracket, and strut used in the seismic bracing design and brace attachment fittings.

Section 6.0 – Rigid Restraint Spacing Charts: Includes the installation spacing requirements for suspended systems using the rigid restraint bracing. These values are based on brace capacity, not pipe capacity.

Section 7.0 – Referencing Information: Includes weight information of suspended systems (Pipes & Ducts) and brace spacing designed in compliance with ASME guidelines/rules. The brace spacings in this section may govern over the spacings from Section 6.0. Use the lesser of the spacings from both sections.

II. Registered Design Professional Responsibility:

The Registered Design Professional (RDP) is the engineer executing the design of the seismic bracing system, as well as the Mechanical/Electrical Engineer of Record responsible for sizing pipe/duct/conduit. The RDP delivers the complete seismic bracing design to the Structural Engineer of Record (SEOR) for the HCAI project. It is the responsibility of the Registered Design Professional in responsible charge to:

1) Verify that the non-structural components or system is seismically qualified in accordance with the 2022 CBC.

2) Verify that the proper ISOTECH Ind. Brace system is selected to meet the seismic requirements of this OPM.

3) Verify that the structure to which the ISOTECH Ind. seismic brace is anchored meets the requirements of the applicable anchorage ICC ESR Report.

4) Verify that the installation is in conformance with the 2022 CBC and with details shown in this OPM. Testing of post installed anchors shall also be performed in accordance with 2022 CBC Section 1910 A.5. The testing requirements are summarized in Section 1.8 of this manual.

III. Layout Drawings:

1) Layout drawings of the supports, attachments and the bracing systems in accordance with the preapproval shall be submitted to the design team for review in accordance with the 2022 California Administrative Code, Sections 7-115 and 7-126. The layout drawings shall at least satisfy the requirements of ASCE 7 Section 13.6 as modified by 2022 CBC 1617A.1.18.

   a) The Structural Engineer of Record (SEOR) shall verify that the supporting structure is adequate for the forces imposed on it by the supports, attachments, and braces installed in accordance with the preapproval in addition to all other loads.
   b) The SEOR shall forward the supports, attachments, and bracing drawings (including construction documents for supplementary framing where required) to the RDP in responsible charge with a notation indicating that the drawings have been reviewed and are in general conformance with the preapproval and the design of the project.
   c) A review stamp shall be permitted to be used, by the SEOR, to indicate compliance with this requirement.
   d) The RDP, other than SEOR, may provide the review stamp for small projects at the discretion of the HCAI.

2) The Structural Engineer of Record shall design any supplementary framing that is needed to resist the loads, maintain stability, and/or is required for installation of preapproved system. The supplementary framing shall be submitted to HCAI as part of original Construction Documents (CDs) or as a Deferred Submittal Item (DSI) which shall be listed on the cover page of the original Construction Documents.

3) The layout drawings (with the review stamp) shall be submitted to HCAI, as part of original CDs or as DSIs in accordance with 2022 CAC Section 7-126 and 2022 CBC Section 107.3.4.1 for verification that:

   a) Structure supporting the distribution system has adequate capacity.
   b) Seismic design forces (F_P) are in accordance with the 2022 CBC; and

c) Submittal is within the scope of the HCAI Preapproval of Manufacturer's Certification (OPM):
   i. Size of distribution system components
   ii. Spacing of bracing and flexible joints
   iii. Substrate for attachments.

4) The layout drawings, with the review stamp, shall be kept on the jobsite to be used for installation of the support and bracing.

   a) The approved agency/inspector of record shall provide inspection in accordance with CBC Sections 1704A/CAC Section 7-145.
   b) HCAI field staff will review/inspect the installation in accordance with CAC Section 7-147.

5) A copy of the chosen bracing system(s) installation guide/OPM manual shall be on the jobsite prior to starting the installation of hangers and/or braces. The approved agency/inspector shall maintain an approved copy of the OPM (available on HCAI website) in accordance with CAC Section 7-145 Item # 4.

6) Components of two or more preapproved bracing systems shall not be mixed. Only one preapproved bracing system may be used for a run of pipe, duct or raceway and any substitution of component of an OPM system shall require HCAI review and approval.

IV. Anchors:

1) All post installed concrete anchors shall be installed per their ICC ESR report. Detailed ICC ESR listing for each anchor is in Section 1.3.

2) The special inspector shall be on the jobsite continuously during anchor installation, unless otherwise noted in the ICC ESR.

3) Post installed anchors to be tested per the requirements specified in 2022 CBC Section 1910 A.5. The testing requirements are summarized in Section 1.8 of this manual.

4) When anchoring into prestressed/post-tensioned concrete, locate tendons prior to drilling to avoid damaging tendons.

1.3 Building Codes, Standards, & Guidelines

The ISOTECH Industries Seismic Restraint Guidelines are designed to meet or exceed the requirements of the following:

2022 California Building Code (CBC 2022)
ANSI / AWC NDS-2018
American Concrete Institute (ACI 318-19)
American Welding Society (AWS D1.1-20)
American Society of Civil Engineers (ASCE 7-16) including Supplement No. 1, 2 and 3
American Society of Mechanical Engineers (ASME B31.9-2020)
American Institute of Steel Construction (ANSI/AISC 360-16)
ESR-4266 (Hilti KB-TZ2, Latest Edition)
ESR-2196 (Hilti Self-drilling Screws, Latest Edition)
ESR-4145 (Hilti KCM-MD Cast-In Anchors, Latest Edition)

NOTES:

ESR evaluation reports for post-installed anchor bolts into concrete and self-tapping screws to steel are following 2022 California Building Codes.

These guidelines are intended to describe seismic rigid restraints for the ducts, pipes, cable tray/raceways/conduit, and equipment typically used in health care settings. (See Preface, page 8 Section 1.1 for details.)

For piping with additional weights such as flanges, and other mechanical/plumbing/electrical systems, bracing is designed based on maximum weight per foot equivalent to the total weight including additional weights.

1.4 Seismic Bracing General Requirements

I. See CBC 2022, Section 1617A for where transverse and longitudinal seismic bracing is required. Below is a summary of circumstances where it is required per that chapter:

1) Trapeze supported pipe system which meets any of the following conditions:
   a) Trapeze assembly hung with anything other than rod hangers 3/8" or 1/2" in diameter
   b) Trapeze assembly hung more than 12" below the connection to the structure (hanger longer than 12")
   c) Any single nominal pipe diameter exceeds 1"
   d) Trapeze assembly supports more than 100 lbs

2) Single hung pipe which meets any of the following conditions:
   a) Rp in Table 13.6-1 (ASCE 7-16) is less than 4.5
   b) Without seismic bracing pipe would impact other structural or non-structural components
   c) Pipe hung with anything other than individual rod hangers 3/8" or 1/2" in diameter
   d) Pipe hung more than 12" below the connection to the structure (hanger longer than 12")
   e) Pipe hanger supports more than 50 lbs
   f) Nominal pipe diameter exceeds 3"
   g) Ip > 1.0 (See CBC 2022 Section 1617A.1.17) and nominal pipe diameter exceeds 1"

3) Conduits, Cable Trays, and Raceways which meets any of the following conditions:
   a) Conduit, Cable Tray, Raceway, or trapeze supporting cable trays or raceways hung with anything other than rod hangers 3/8" or 1/2" in diameter
   b) Cable Tray, Raceway, or trapeze supporting cable trays or raceways hung more than 12" below the connection to the structure (hanger longer than 12")
   c) Trapeze assembly supports more than 100 lbs of conduit, cable trays, raceways
   d) Individual rod hanger supports more than 50 lbs of conduit, cable trays, raceways
   e) Conduit is greater than or equal to 2.5" trade size
   f) Ip > 1.0 (See CBC 2022 Section 1617A.1.17)

4) Duct systems which meet any of the following conditions:
   a) Duct or trapeze supporting ducts hung with anything other than rod hangers 3/8" or 1/2" in diameter
   b) Duct or trapeze supporting ducts hung more than 12" below the connection to the structure (hanger longer than 12")
   c) Duct trapeze supports more than 100 lbs of duct
   d) Duct trapeze supports combined duct weight of 10 lbs/ft or more
   e) Individual rod hanger supports more than 50 lbs of duct
   f) Duct has cross-sectional area of 6sf or more
   g) Duct weighs more than 20 lbs/ft

II. <u>**Piping or ductwork designed to carry toxic, highly toxic or flammable gases, or used for smoke control shall be designed and braced without consideration of any exceptions.**</u>

III. **A pipe system shall not be braced to different parts of the building that may respond differently during seismic activity unless specifically detailed on documents and approved by HCAI.**

IV. **Refer to the appropriate codes and standards for additional information and requirements.**

1.5 Seismic Bracing Layout – General requirements

1.5.1 Piping/Conduit, Duct, and/or Trapeze Supported Members

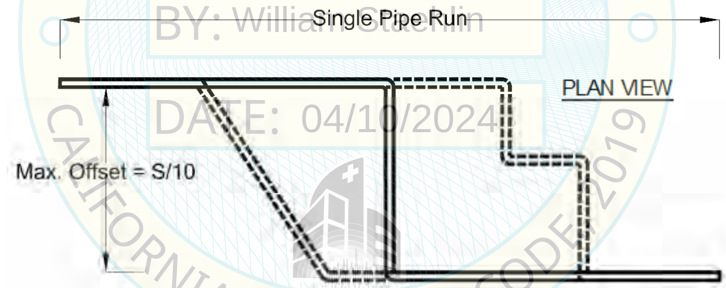
I. The ISOTECH Seismic Rigid Restraint Guidelines provide for the protection of suspended pipe, duct, conduit, cable trays/raceways & equipment against excessive movement due to seismic forces.

II. The seismic restraint assemblies in this guideline are designed to simultaneously resist vertical loads due to the weight of the component and its contents and both horizontal and vertical seismic loads.

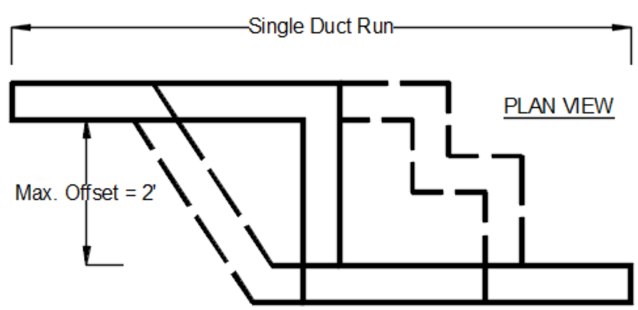
III. Horizontal loads are braced with transverse and/or longitudinal bracing to provide resistance against movement perpendicular or parallel to the run, respectively. Spacing must not exceed the values provided in Section 6 or 7 (whichever governs) of this Manual.

IV. A run of pipe, duct, or electrical system is defined as a straight length. Offset(s) occurring between changes of direction may be neglected if the distance perpendicular to the run is less than the maximum offset length. The maximum offset length for pipes and ducts are shown in the figures below.

Maximum offset length for Pipes $= \frac{S}{10}$, where S is the maximum transverse brace spacing.

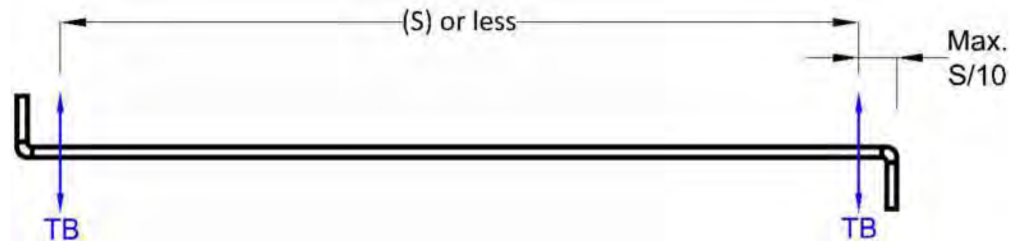


Max. offset length for Ducts = 2' (inside-to-inside)

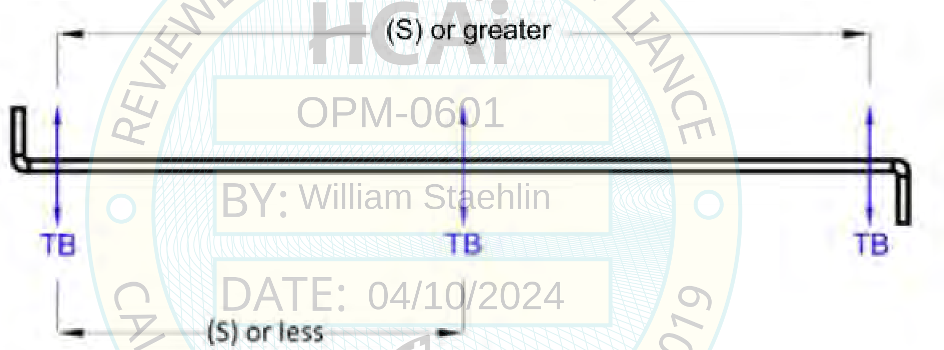


Note: When a run of a pipe, duct, or electrical system that requires bracing transitions down to a size that does not, the point of transition is considered the end of the run and will require a transverse brace

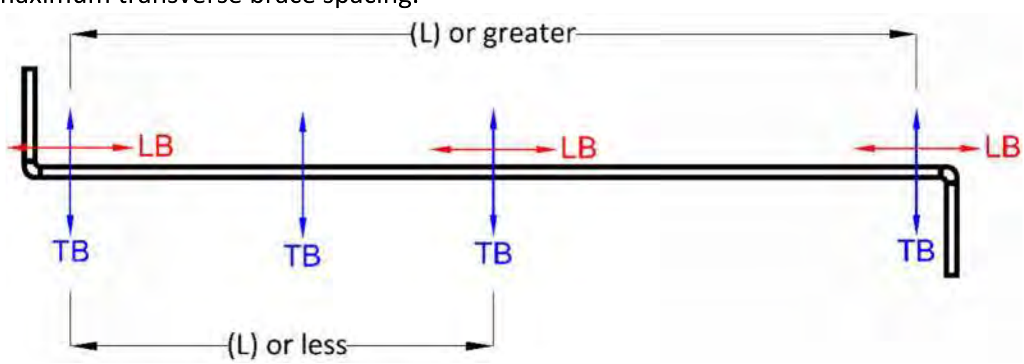
V. Each run of pipe, duct, electrical conduit, cable tray and others require a minimum of two transverse braces (TB), one at each end of the run.



VI. If the distance between two transverse bracing kits exceeds the maximum allowable spacing, add transverse bracing kits as needed.



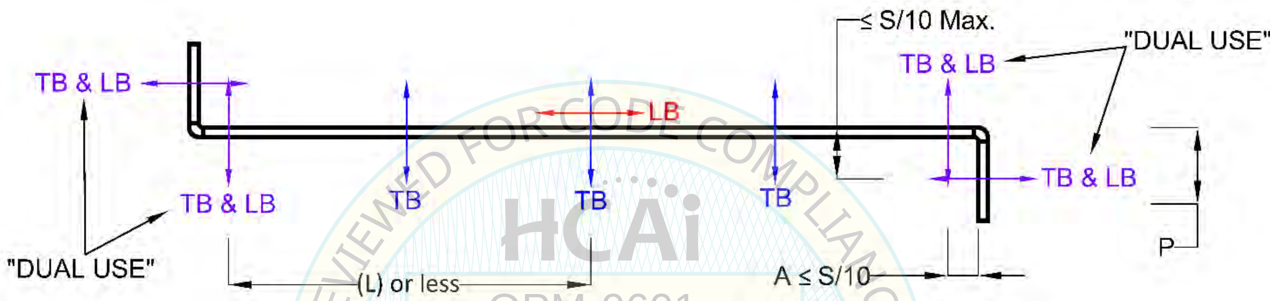
VII. Each run of pipe, duct, electrical system, cable tray and others must have at least one longitudinal brace (LB). If the maximum allowable longitudinal spacing (L), is exceeded then add longitudinal braces to meet the spacing requirement. The longitudinal spacing shall not exceed twice the length of the maximum transverse brace spacing.



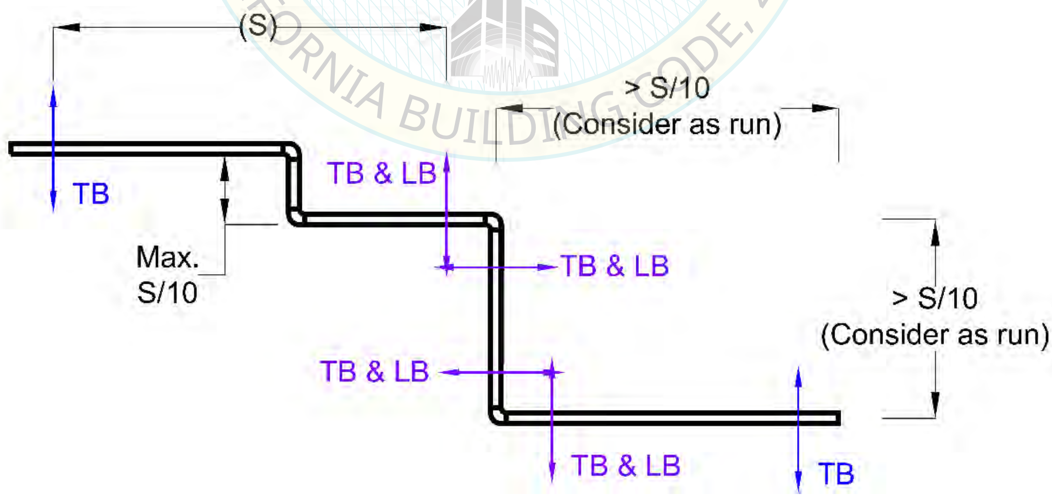
VIII. Each run of pipe, duct, electrical system, cable tray and others require a minimum of one longitudinal brace. However, a transverse brace placed on the run section at the opposite side of an elbow or tee within $\frac{S}{10}$ max. may act as a longitudinal brace and can be referred to as a “DUAL USE” brace. Dual Use Braces are to be designed for worst case of longitudinal or transverse loading. Distance to the first longitudinal brace around corner (P) shall not exceed maximum longitudinal spacing (L), minus $\frac{S}{2}$, minus A, where A is the distance between the corner and the Dual Use bracing nearest the corner.

a) Longitudinal and Longitudinal “DUAL USE” braces on a single supported pipe or conduit shall be attached directly to the pipe or conduit.

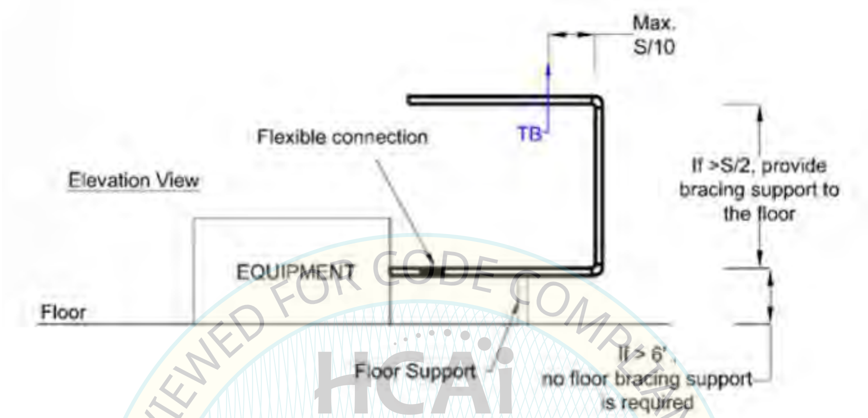
b) Bracing installed to smaller piping shall not be used to brace larger piping.



IX. In some cases, several short runs may occur in close proximity. By following the preceding guidelines each run shall have longitudinal and transverse bracing. Transverse bracing may be used as longitudinal bracing and vice versa on runs adjacent to each other if the total length of pipe tributary to the brace does not exceed the maximum allowable spacing (S). in cases where it does, additional braces are required.



X. A vertical pipe or conduit drop to equipment, where pipe or conduit is connected to the equipment using a flexible connection, provide transverse bracing before the vertical drop. The total length from the transverse brace to the vertical drop shall not be more than the allowable offset previously determined $(\frac{S}{10})$. Provide transverse bracing at the floor after the vertical drop of the total length of the pipe from the transverse brace before the vertical drop to the flexible connection is greater than $\frac{1}{2}$ of the maximum transverse brace spacing $(\frac{S}{10})$.



XI. When systems cross a building seismic separation or seismic joint, they must be capable of accommodating the joint displacements as specified by the engineer of record.

XII. A system shall not be braced to dissimilar parts of a building structure or two dissimilar building systems that may respond differently during a seismic event. Bracing shall be attached to the part of the building structure that is supporting the pipe, duct, or electrical system.

XIII. Transverse and longitudinal braces shall be installed as shown in this guideline between 30° - 60° from horizontal. However, the recommended brace ratio is 45° from horizontal, providing a brace ratio of 1 (vert.):1 (horiz.).

XIV. The seismic brace assemblies in this guideline consist of three important components: (a) supports and attachments to building structure; (b) brace member such as strut (c) seismic brace attachments.

XV. Transverse and Longitudinal bracing kit locations are required to be within 6” of a vertical seismic brace assembly to protect against vertical movement (typically a stiffened hanger rod).

XVI. Steel bolt connections to steel structure or components shall not have a diameter <1/16” less than the mounting hole. Steel bolt connections to concrete structure shall not have a diameter <1/8” less than the mounting hole.

XVII. At a brace location, threaded rod and their building attachment components used in a vertical hanger assembly shall be increased in size when capacity is inadequate for loads due to the additional seismic tension or compression loads placed upon them. The vertical hanger assembly is adequate if the maximum allowable load of its components is greater than or equal to the system gravity load plus any additional seismic loads.

XVIII. Bracing may be omitted for short runs (20") of cable tray if its tributary seismic load can be transferred to an adjacent run of cable tray that is braced and can properly restrain the additional seismic loads.

1.6 General Design Procedure

This HCAI Preapproval of Manufacturer's Certification is in accordance with the 2022 California Building Code. The horizontal seismic force (F_P) and vertical seismic force (F_{PV}) can be calculated as follows based on ASCE 7-16, 13.3:

$$F_P = (\alpha_D)\frac{0.4a_p S_{DS} I_P W_P}{R_P}\left(1 + 2\frac{z}{h}\right); \qquad Use\ if\ (F_{min} \leq F_P \leq F_{max})$$

$$F_{max} = (\alpha_D)1.6S_{DS}I_P W_P; \qquad Use\ if\ (F_P > F_{max}), then\ F_P = F_{max}$$

$$F_{min} = (\alpha_D)0.3S_{DS}I_P W_P; \qquad Use\ if\ (F_P < F_{min}), then\ F_P = F_{min}$$

$$F_{PV} = (\alpha_D)0.2S_{DS}W_P$$

Where:

S_{DS} = short period spectral acceleration. Values of SDS indicated in the general notes of the structural drawing take precedence over those calculated per ASCE 7-16, 11.4.4.

W_P = component operating weight (lbs).

I_P = component importance factor. Use 1.5 unless a lower value is permitted per CBC 2022 Section 1617A.1.17.

a_P = component amplification factor (Ref. ASCE 7-16, Table 13.6-1). A lowered value for a_P is permitted where justified by detailed dynamic analysis. The values for a_P shall not be < 1.0.
= 2.5 for all piping, ductwork, conduit, cable trays

R_P = component response modification factor (Ref. ASCE 7-16, Table 13.6-1). Per ASCE 7-16, Section 13.4.1, do not use a R_P factor greater than 6.0 when calculating F_P and F_{PV} for design of the attachment.

z = height in structure of point of component connection with respect to base (ft).

h = average roof height of structure with respect to base (ft).
α_D = 1.0 for LRFD/Strength Design, 0.7 for ASD/Service Design.
(See Seismic Load Factors from ASCE 7-16 Sections 2.3.6 and 2.4.5)

NOTES:

1) The tables in this manual have been developed using the ASD method, with the exception of the concrete anchors which are required by code to be designed using the Strength method. When anchoring to concrete it is therefore necessary to be calculate both ASD and Strength values.

2) Components mounted on vibration isolators shall have a bumper restraint or snubber in each horizontal direction. The design force shall be taken as $2F_P$ if the nominal clearance (air gap) between the equipment support frame and restraint is > 0.25 in. (6 mm), if ≤ 0.25 in. the design force is permitted to be taken as F_P.

Seismic restraint system design including but not limited to bracing type and strength, spacing determination and connection methods is based on the following design procedures:

Step 1. Determine G-Factor

Calculate the G-Factor as follows:

$$G\ Factor = \frac{F_p}{W_P}$$

Where:

$F_p =$ Seismic Force as calculate per previous page of this document

$W_p =$ Component Operating Weight

Step 2. Seismic Bracing Detail

Select ISOTECH IRRA-3000R seismic bracing for both transverse and longitudinal bracing. Detailed installation and configurations see Section 2 "RIGID BRACE DETAILS" and Section 5 "SEISMIC BRACE AND HANGER COMPONENT". Verifications and integrations would be made in the following steps before finalizing the bracing selection.

Step 3. Brace Spacing

Determine the maximum transverse and maximum longitudinal brace spacings from Sections 6 and 7 (whichever governs) based on the calculated G-factors and maximum operating weight/foot or diameter (pipes only).

Step 4. Determine Horizontal Seismic Forces

Seismic forces (F_{PH}) can be calculated based on:

$$F_{PH} = w_P \times Brace\ Spacing \times G = W_P \times G$$

Where

- W_P component operating weight (lbs).
- w_P is distributed operation weight of the system (lbs/ft), can be read from Tables in Section 7 of this manual.
- G-factor and Brace Spacing are obtained from step 1 and step 3.

Weight of the Pipe indicated in the spacing chart tables represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.

Step 5. Determine Vertical Load on Hanger Rod

When a single rigid bracing is used, a vertical seismic load will be applied to the hanger rod at the seismic brace location. This brace-induced seismic load is a compression load when the sway brace is in tension and is a tension load when the sway brace is in compression. Because there is a tension load on the hanger rod due to the system weight, the vertical seismic load should be added to or subtracted from the existing gravity load.

The maximum vertical load applied to the hanger rod (F_{Rod}) is summation of operating loads (W_P) , vertical seismic load (F_{PV}) and the brace-induced vertical seismic load ($F_{Brace-induced}$, calculated based on the installation angle θ by $F_{Brace-induced} = F_{PH\ Longitudinal} \times tan\theta$).
The longitudinal brace spacing is typically larger, which results in the highest value of F_{PH}, which is why it is used here as opposed to transverse.

F_{Rod}=β_D × W_P+F_{PV}+ $F_{Brace-induced}$
where both vertical seismic load and brace-induced vertical load are in the same direction of the gravity.
β_D = 1.2 for LRFD/Strength design, 1.0 for ASD/Service Design(See Dead Load Factors from ASCE 7-16 Sections 2.3.6 and 2.4.5)
Rod compression is always less than or equal to rod tension. Conservatively assume that rod compression equals F_{Rod} and choose a rod diameter and stiffener from the table in Section 2.14.

Step 6. Brace Detail

Go to Section 2.0 of this manual and find a brace detail that will work for the (ASD Level) transverse and longitudinal forces calculated in Step5.

Step 7. Structural Attachment Detail

- Brace Structural Attachment:

Brace structural attachment details are specified and illustrated in Section 3 “RIGID RESTRAINT STRUCTURAL ATTACHMENTS”. Horizontal Seismic load capacities of each fastener (anchor/screw/bolt) for connecting brace to various types of structures (Concrete, Unfilled Metal Deck, Steel and Wood) are listed in the tables. Types and sizes of fasteners can be selected based on the seismic load calculated in step 4. Follow detailed installation requirements in corresponding sections after selection.

- Hanger Rod Structural Attachment:

Hanger rod structural attachment details are specified and illustrated in Section 4 “HANGER ROD STRUCTURAL ATTACHMENTS”. Vertical load capacities of each fastener (anchor/screw/bolt) for connecting hanger rod to various types of structures (Concrete, Unfilled Metal Deck, Steel) listed in the tables. Types and sizes of fasteners can be selected based on the vertical load calculated in step 5. Follow detailed installation requirements in corresponding sections after selection.

- Anchoring to Concrete:

When anchoring to concrete, F_p must be calculated at Strength level ($\alpha_D = 1.0$), and the G factor must be amplified by the overstrength factor (Ω_0).

Calculate the G Factor for concrete anchors as follows:

$$G\ Factor = \Omega_0 \times \frac{F_p}{W_P}$$

Where:

F_p = Seismic Force as calculated per previous page of this document using α_D=1.0

W_p = Component Operation Weight

Ω_0 = Overstrength factor (Ref.ASCE 7-16, Table 13.6-1)

= 2 for all piping, ductwork, conduit, cable trays

Calculate F_{PH} using the overstrength G factor as shown above.

Calculate $F_{Brace-induced}$ using the F_{PH} value that incorporates the overstrength G factor.

Calculate F_{Rod} using $\beta_D = 1.2$

Step 8. Seismic Bracing Layout

Layout the designed bracing system follow the requirements listed in Section 1.5 "Seismic Bracing Layout" on Page 14-18.

1.6.1 Suspended Piping Design Example

In this example we design seismic bracing for a hypothetical suspended 5'' diameter water pipe made of schedule 40 steel (not in accordance with ASME B31, with threading joints) in a 4-story poured-in-place concrete building where each floor is 10' elevation. The pipe is supported with hangers at every 12'. Short period spectral acceleration S_{DS} and component importance factor I_P are 2.0 and 1.5 indicated by the contract drawings. The pipe is "critical" according to ASME B31.9. HCAI considers all piping in facilities under their regulation to be critical.

Step 1. Determine G-Factor

As read from ASCE 7-16 Table 13.6-1, component amplification a_p and component response modification factors R_P for piping not in accordance with ASME B31, including in-line components, constructed of high- or limited-deformability materials, with joints made by threading are 2.5 and 4.5 correspondingly.

$$F_P = (\alpha_D)\frac{0.4 a_p S_{DS} I_P W_P}{R_P}\left(1 + 2\frac{z}{h}\right)$$

Where:
$\alpha_D = $ 0.7 for ASD Method
$S_{DS} = 2.0$ (contract drawings)
$I_P = 1.5$ (contract drawings)
$a_P = 2.5$ (ASCE 7-16 Table 13.6-1)
$R_P = 4.5$ (ASCE 7-16 Table 13.6-1)
(Note: your value of Rp may be different depending on distribution system. For this example we are using 4.5)

$$F_P = (\alpha_D)\frac{0.4\ (2.5)\ (2.0)\ (1.5) W_P}{(4.5)}\left(1 + 2\frac{z}{h}\right) = 0.47\left(1 + 2\frac{z}{h}\right) W_P$$

$$F_{max} = (\alpha_D) 1.6 S_{DS} I_P W_P = (0.7)\ 1.6\ (2.0)\ (1.5) W_P = 3.36 W_P$$

$$F_{min} = (\alpha_D) 0.3 S_{DS} I_P W_P = (0.7)\ 0.3\ (2.0)\ (1.5) W_P = 0.63 W_P$$

$$F_{PV} = (\alpha_D) 0.2 S_{DS} W_P = (0.7) 0.2\ (2.0) W_P = 0.28\ W_P$$

z = X-th story x 10'/story = 10X', where X stands for floor level point of component connection with
h = 4 story x 10'/story = 40'
(Note: your z and h values may be different. Verify actual z and h values from project drawings. For this example all stories are 10 feet high)

ASD LEVEL G-FACTORS FOR PIPING LOCATED ON DIFFERENT FLOORS				
Floor Level X	Floor Height (ft)	z/h	F_P	G
1	10	0.25	0.7 W_P	0.7
2	20	0.5	0.933 W_P	0.933
3	30	0.75	1.167 W_P	1.167
4	40	1	1.4 W_P	1.4

Step 2. Seismic Bracing Detail

Select the rigid seismic bracing ISOTECH IRRA-3000R and check Section 5 "IRRA-3000R Bracket" for brace details.

Step 3. Brace Spacing

Let's Take the 2nd floor as an example, select maximum brace spacings with G-factor being 0.933 and diameter being 5 inches, assume 45° installation angle.

- From Table 6.1 "SCHEDULE 40 (STD) STEEL PIPE-INSULATED AND FILLED WITH WATER", maximum Longitudinal Brace Spacing @1.0G, 5'' diameter and 45° installation angle = 26 ft (single restraint based on Brace Capacity)
- Maximum Transverse Brace Spacing @1.0G for 5" diameter pipe= 26/2=13 ft based on Brace Capacity
- For installation convenience, 24ft and 12ft. can also be used as the longitudinal and transverse brace spacing correspondingly, so that the braces align with the hangers at 12ft spacing.
- Check the Grade A Steel Water Pipe Table in Section 7.3, the maximum transverse spacing for 5'' schedule 40 steel pipe @1.0G is 19 ft, larger than the selected spacing 12 ft.

Step 4. Determine Horizontal Seismic Forces at Floor Level 1

For 5" diameter, schedule 40 steel pipe, operating weight (with insulation layer and filled with water) is 26.6 lbs/ft (read from Table "SCHEDULE 40 (STD) STEEL PIPE-INSULATED AND FILLED WITH WATER" in Section 6.1).

With maximum operating weight being 26.6 lbs/ft,

- Transverse Direction (bracing space 12 ft):

$$F_{PH\ Transverse} = 0.933\left(26.6\frac{lbs}{ft}\right)(12ft) = 298\ lbs$$

- Longitudinal Direction (bracing space 24 ft):

$$F_{PH\ \ Longitudinal} = 0.933\left(26.6\frac{lbs}{ft}\right)(24ft) = 596\ lbs$$

Step 5. Determine Vertical Loads

β_D= 1.0 FOR ASD/Service Design

- Operating Loads (gravity supports space 12ft):

$$W_P = \left(26.6\frac{lbs}{ft}\right)(12ft) = 319\ lbs$$

- Vertical Seismic Force (gravity supports space 12ft):

$$F_{PV} = 0.28\left(26.6\frac{lbs}{ft}\right)(12ft) = 89\ lbs$$

- Assume the brace installation angle is 45°:

$$F_{Brace-induced} = F_{PH\ Longitudinal} \times tan\theta = F_{PH\ Longitudinal} \times tan45° = 596\ lbs$$

$$F_{Rod} = \beta_D \times W_P + F_{PV} + F_{Brace-induced} = 1004\ lbs$$

Step 6. Brace Detail

- A Transverse Brace can be quickly selected from Section 2.2. For 298 lbs (Transverse seismic load), single transverse bracing is good for (0.6)*(724 lbs) = 434 lbs for insulated pipe (incorporating the 40% reduction for insulation per the table notes).

- A Longitudinal Brace can be quickly selected from Section 2.3. For 596 lbs (Longitudinal seismic load), single longitudinal bracing is good for 680 lbs.

- Conservatively assume that rod compression is 1004 lbs. See the table in Section 2.14 and select a rod size. A 3/8" rod with stiffener is adequate for up to 1246 lbs.

Step 7. Structural Attachment Detail

In this example, the ceiling is made of poured-in-place concrete, so the structure is concrete beam/slab.

When anchoring to concrete, forces must be calculated at Strength Level with overstrength:

STRENGTH LEVEL G-FACTORS FOR PIPING LOCAITON ON DIFFERENT FLOORS

Floor Level X	Floor Height (ft)	z/h	F_P	G	$\Omega_0 \times G$
1	10	0.25	1.0 W_P	1.0	2.0
2	20	0.5	1.333 W_P	1.333	2.667
3	30	0.75	1.667 W_P	1.167	3.333
4	40	1	2.0 W_P	2.0	4.0

F_{PV} = (0.2) *2*W_P=0.4*W_P

$F_{PH\ Transverse}$ = (2.667) *(26.6 lbs/ft) * (12ft) = 851lbs

$F_{PH\ Longitudinal}$ = (2.667) *(26.6 lbs/ft) * (24ft) = 1703lbs

$F_{Brace-induced}$ = (1703 lbs) * tan 45 deg = 1703 lbs

β_D = 1.2 for LFRD/Strength Design

F_{Rod} = (1.2) *(26.6 lbs/ft) * (12ft) + (0.4) *(26.6 lbs/ft) * (12ft) + 1703 lbs = 2214 lbs

- Brace Structural Attachment:

  Brace structural attachment can be quickly selected from Table 3.2.1.1. For 1703 lbs (longitudinal attachment design force) a 1/2 '' diameter Hilti Kwik Bolt TZ2 with 3 1/4 '' minimum embedment is sufficient.

- Hanger Rod Structural Attachment:

  Brace structural attachment can be quickly selected from Table 4.2.1.1. For 2214 lbs a 1/2’’ diameter Hilti Kwik Bolt TZ2 with 3 1/4’’ minimum embedment is sufficient.

Step 8. Seismic Bracing Layout

Layout the designed bracing system follow the requirements listed in Section 1.5 “Seismic Bracing Layout”.

1.6.2 Suspended Ductwork Design Example

In this example we design seismic bracing for a hypothetical suspended 38" x 50" rectangular duct made of 20-gauge sheet metal (constructed under SMACNA standards) in a 4-story concrete w/ metal deck building where each floor is 10' elevation. The ductwork is supported at every 10'. Short period spectral acceleration S_{DS} and component importance factor I_P are 2.0 and 1.5 indicated by the contract drawings.

Step 1. Determine G-factor

As read from ASCE 7-16 Table 13.6-1, component amplification a_p and component response modification factors R_P for ductwork, constructed of high- or limited-deformability materials with joints made by means other than welding or brazing are 2.5 and 6.0 correspondingly.

$$F_P = (\alpha_D)\frac{0.4a_pS_{DS}I_PW_P}{R_P}\left(1+2\frac{z}{h}\right)$$

Where:
$\alpha_D = 0.7$ for ASD Method
$S_{DS} = 2.0$ (contract drawings)
$I_P = 1.5$ (contract drawings)
$a_P = 2.5$ (ASCE 7-16 Table 13.6-1)
$R_P = 6.0$ (ASCE 7-16 Table 13.6-1)
(Note: your value of Rp may be different depending on distribution system. For this example, we are using 6.0)

$$F_P = (\alpha_D)\frac{0.4\,(2.5)\,(2.0)\,(1.5)W_P}{(6.0)}\left(1+2\frac{z}{h}\right) = 0.35\left(1+2\frac{z}{h}\right)W_P$$

$$F_{max} = (\alpha_D)1.6S_{DS}I_PW_P = (0.7)\,1.6\,(2.0)\,(1.5)W_P = 3.36W_P$$

$$F_{min} = (\alpha_D)0.3S_{DS}I_PW_P = (0.7)\,0.3\,(2.0)\,(1.5)W_P = 0.63W_P$$

$$F_{PV} = (\alpha_D)0.2S_{DS}W_P = (0.7)0.2\,(2.0)W_P = 0.28\,W_P$$

z = X-th story x 10'/story = 10X', where X stands for floor level point of component connection with
h = 4 story x 10'/story = 40'
(Note: your z and h values maybe different. Verify actual z and h values from project drawings. For this example

G-FACTORS FOR DUCTWORK LOCATED ON DIFFERENT FLOORS				
Floor Level X	Floor Height (ft)	z/h	F_P	G
1	10	0.25	$0.525W_P < F_{min} \rightarrow F_P = 0.63\ W_P$	0.63
2	20	0.5	$0.7\ W_P$	0.7
3	30	0.75	$0.875\ W_P$	0.875
4	40	1	$1.05\ W_P$	1.05

Step 2. Seismic Bracing Detail

Select the rigid seismic bracing ISOTECH IRRA-3000R and check Section 5 “IRRA-3000R Bracket” for brace details.

Step 3. Brace Spacing

For 38" x 50" 20-gauge galvanized sheet metal, operating weight is 24.8 lbs/ft (can be read from RECTANGULAR DUCT WEIGHT table in Section 7.2 with gauge number 20 and cross-sectional perimeter being 180).

Perimeter= [(38+50) x 2] inches = 176 inches

Let’s take the 1st floor as an example, maximum brace spacings with G-factor being 0.63 and maximum operating weight being 24.8 lbs/ft.

- From Section 6.3 (spacing charts in accordance with max weight and G-factor), maximum Longitudinal Brace Spacing @0.75 G and 25 lb./ft = 37 ft (single restraint based on Brace Capacity) assuming 45° installation angle.
- Maximum Transverse Brace Spacing @0.75 G and 25 lb./ft= 37/2=18.5 ft based on Brace Capacity
- For installation convenience, 20 ft. and 10 ft. can also be used as the longitudinal and transverse brace spacing correspondingly.

Step 4. Determine Horizontal Seismic Forces at Floor Level 1

With maximum operating weight being 24.8 lbs/ft,

General Installation Notes

- Transverse Direction (bracing space 10 ft):

$$F_{PH\ Transverse} = 0.63\left(24.8\ \frac{lbs}{ft}\right)(10\ ft) = 156.24\ lbs$$

- Longitudinal Direction (bracing space 20 ft):

$$F_{PH\ \ Longitudinal} = 0.63\left(24.8\ \frac{lbs}{ft}\right)(20ft) = 312.48\ lbs$$

Step 5. Determine Vertical Loads

β_D = 1.0 for ASD/Service Design

- Operating Loads (gravity supports spaced at 10 ft):

$$W_P = \left(24.8\frac{lbs}{ft}\right)(10ft) = 248\ lbs$$

- Vertical Seismic Force (gravity supports spaced at 10 ft):

$$F_{PV} = 0.28\left(24.8\frac{lbs}{ft}\right)(10ft) = 69.44\ lbs$$

- Assume the brace installation angle is 45°:

$$F_{Brace-induced} = F_{PH\ Longitudinal} \times tan\theta = 312.48\ \ lbs$$

$$F_{Rod} = \beta_D\ \times\ W_P + F_{PV} + F_{Brace-induced} = 629.92\ lbs$$

Step 6. Brace Detail

- A Transverse Brace can be quickly selected from Section 2.6. For 156.24 lbs (Transverse seismic load), single longitudinal bracing with 3/8'' threaded rod is sufficient.
- A Longitudinal Brace can be quickly selected from Section 2.7. For 312.48 lbs (Longitudinal seismic load), dual longitudinal bracing with 3/8'' threaded rod is sufficient.
- Conservatively assume that rod compression is 629.92 lbs. See the table in Section 2.14 and select a rod size. A 3/8" rod with stiffener is adequate for up to 1246 lbs.

Step7. Structural Attachment Detail

In this example, the ceiling is made of corrugated concrete w/ metal deck, so the structure is concrete w/ metal deck.

When anchoring to concrete, forces must be calculated at Strength Level with overstrength:

STRENGTH LEVEL G-FACTORS FOR DUCTWORK LOCAITON ON DIFFERENT FLOORS

Floor Level X	Floor Height (ft)	z/h	F_P	G	$\Omega_0 \times G$
1	10	0.25	1.0 W_P	0.75	1.5
2	20	0.5	1.333 W_P	1	2.0
3	30	0.75	1.667 W_P	1.25	2.5
4	40	1	2.0 W_P	1.5	3.0

F_{PV} = (0.2) *2*W_P=0.4*W_P

$F_{PH\ Transverse}$ = (1.5) *(24.8 lbs/ft) * (15ft) = 558 lbs

$F_{PH\ Longitudinal}$ = (1.5) *(24.8 lbs/ft) * (30ft) = 1116 lbs

$F_{Brace-induced}$ = (1116 lbs) * tan 45 deg = 1116 lbs

β_D = 1.2 for LFRD/Strength Design

F_{Rod} = (1.2) *(24.8 lbs/ft) * (10ft) + (0.4) *(24.8 lbs/ft) * (10ft) + 1116 lbs = 1512.8 lbs

- Brace Structural Attachment:

  Brace structural attachment can be quickly selected from Table 3.2.1.1. For 1116 lbs (longitudinal attachment design force) a 1/2 ʺ diameter Hilti Kwik Bolt TZ2 with 3 1/4 ʺ minimum embedment is sufficient.

- Hanger Rod Structural Attachment:

  Brace structural attachment can be quickly selected from Table 4.2.1.1. For 1512.8 lbs a 1/2ʹʹ diameter Hilti Kwik Bolt TZ2 with 2ʹʹ minimum embedment is sufficient.

Step 8. Seismic Bracing Layout

Layout the designed bracing system follow the requirements listed in Section 1.5 "Seismic Bracing Layout".

1.6.3 Trapeze Design Example

In this example, we design seismic bracing for a hypothetical suspended trapeze which supports two 2'' diameter and one 2.5'' diameter water pipes made of schedule 40 steel (not in accordance with ASME B31, with threading joints) in a 4-story poured-in place concrete building where each floor is 15' elevation. The pipe is supported at every 10'. Short period spectral acceleration S_{DS} and component importance factor I_P are 2.0 and 1.5 indicated by the contract drawings. Use ASD Method. These pipes are "critical" according to ASME B31.9. HCAI considers all piping in facilities under their regulation to be critical.

Step 1. Determine G-Factor

As read from ASCE 7-16 Table 13.6-1, component amplification a_p and component response modification factors R_P for piping not in accordance with ASME B31, including in-line components, constructed of high- or limited-deformability materials, with joints made by threading are 2.5 and 4.5 correspondingly.

$$F_P = (\alpha_D)\frac{0.4a_p S_{DS} I_P W_P}{R_P}\left(1+2\frac{z}{h}\right)$$

Where:
$\alpha_D = 0.7$ for ASD Method
$S_{DS} = 2.0$ (contract drawings)
$I_P = 1.5$ (contract drawings)
$a_P = 2.5$ (ASCE 7-16 Table 13.6-1)
$R_P = 4.5$ (ASCE 7-16 Table 13.6-1)

Note: your value of R_P may be different depending on distribution system. For this example, we are using 4.5

$$F_P = (\alpha_D)\frac{0.4\,(2.5)\,(2.0)\,(1.5)W_P}{(4.5)}\left(1+2\frac{z}{h}\right) = 0.47\left(1+2\frac{z}{h}\right)W_P$$

$$F_{max} = (\alpha_D)1.6S_{DS}I_P W_P = (0.7)\,1.6\,(2.0)\,(1.5)W_P = 3.36W_P$$

$$F_{min} = (\alpha_D)0.3S_{DS}I_P W_P = (0.7)\,0.3\,(2.0)\,(1.5)W_P = 0.63W_P$$

$$F_{PV} = (\alpha_D)0.2S_{DS}W_P = (0.7)0.2\,(2.0)W_P = 0.28\,W_P$$

z = X-th story x 15'/story = 15X', where X stands for floor level point of component connection with

h = 4 story x 15'/story = 60'
Note: your value of z and h may be different. Verify z and h values from project drawings. For this example, all stories are 15 feet high

ASD LEVEL G-FACTORS FOR TRAPEZE LOCATED ON DIFFERENT FLOORS				
Floor Level X	**Floor Height (ft)**	**z/h**	F_P	**G**
1	15	0.25	0.7 W_P	0.7
2	30	0.5	0.933 W_P	0.933
3	45	0.75	1.167 W_P	1.167
4	60	1	1.4 W_P	1.4

Step 2. Seismic Bracing Detail

Select the rigid seismic bracing ISOTECH IRRA-3000R and check Section 5 "IRRA-3000R Bracket" for brace details.

Step 3. Brace Spacing

Take the 3rd floor as an example, select maximum brace spacings with G-factor being 1.167, assume 45° installation angle.

There are 2 pipes (diameter 2 inches and 2.5 inches) in the trapeze supported system.

- From Table "SCHEDULE 40 (STD) STEEL PIPE-INSULATED AND FILLED WITH WATER" in Section 6.1, weights of 2-inch and 2.5-inch piping systems are 6.2 lb./ft and 9.1 lb./ft.

$$w_P = 2 * 6.2 + 1 * 9.1 = 21.5 \frac{lbs}{ft}$$

- From Section 6.5, Maximum Longitudinal Brace Spacing @ 1.25 G for 25 $\frac{lbs}{ft}$ trapeze supported systems = 22ft

- Maximum Transverse Brace Spacing = 22/2 = 11 ft

- For installation convenience, 20 ft. and 10 ft. can also be used as the longitudinal and transverse brace spacing correspondingly, so that the braces align with the hangers at 10 ft spacing.

- Because the pipes were designated as Critical, use the Grade A Steel Water Pipe Table in Section 7.3 to determine maximum brace spacing based on Pipe Capacity. For grade A steel as an example, maximum transverse spacing at 1.25g, 2" diameter = 12ft which is greater than 10 ft spacing based on brace capacity. Therefore, brace capacity spacing limits govern.

General Installation Notes

- For a total pipe weight of 21.5 lbs and a 10 ft trapeze spacing each trapeze supports 215 lbs. See the table in Section 2.13 which indicates that the maximum trapeze span can be 120" with a single strut, which is adequate for 255 lbs.

Step 4. Determine Horizontal Seismic Forces at Floor Level 3

With maximum operating weight being 21.5 lbs/ft,

- Transverse Direction (bracing space 10ft):

$$F_{PH\ Transverse} = 1.167\left(21.5\frac{lbs}{ft}\right)(10ft) = 251\ lbs$$

- Longitudinal Direction (bracing space 20ft):

$$F_{PH\ Longitudinal} = 1.167\left(21.5\frac{lbs}{ft}\right)(20ft) = 502\ lbs$$

Step 5. Determine Vertical Load

β_D: 1.0 for ASD/Service Design

- Operating Loads (gravity supports space 10ft):

$$W_P = \left(21.5\frac{lbs}{ft}\right)(10ft) = 215\ lbs$$

- Vertical Seismic Force (gravity supports space 10ft):

$$F_{PV} = 0.28\left(21.5\frac{lbs}{ft}\right)(10ft) = 60\ lbs$$

- Assume the brace installation angle is 60°:

$$F_{Brace-induced} = F_{PH\ Longitudinal} \times tan60° = 869\ lbs$$

$$F_{Rod} = \beta_D W_P + F_{PV} + F_{Brace-induced} = 1144\ lbs$$

Step 6. Brace Detail

- A Transverse Brace can be quickly selected from Section 2.11. For 251 lbs (Transverse seismic load), single transverse bracing with 1/2" threaded rod is sufficient for 507 lbs.

- A Longitudinal Brace can be quickly selected from Section 2.12. For 502 lbs (longitudinal seismic load), dual longitudinal bracing with ½" threaded rod is sufficient for (2)*(440 lbs) = 880 lbs.

- Conservatively assume that rod compression is 1144 lbs. See the table in Section 2.14 and select a rod size. A 3/8" rod with stiffener is adequate for up to 1246 lbs.

Step 7. Structural Attachment Detail

In this example, the ceiling is made of pour-in-place concrete, so the structure is concrete beam/slab.

When anchoring to concrete forces must be calculated at Strength level for overstrength:

ASD LEVEL G-FACTORS FOR TRAPEZE LOCATED ON DIFFERENT FLOORS

Floor Level X	Floor Height (ft)	z/h	F_P	G	$\Omega_o \times G$
1	15	0.25	1.0 W_P	1.0	2.0
2	30	0.5	1.333 W_P	1.333	2.667
3	45	0.75	1.667 W_P	1.667	3.333
4	60	1	2.0 W_P	2.0	4.0

$$F_{PV} = (0.2)(2)W_P = (0.4)W_P$$

$$F_{PH\ Transverse} = (3.333)\left(21.5\frac{lbs}{ft}\right)(10\ ft) = 717\ lbs$$

$$F_{PH\ Longitudinal} = (3.333)\left(21.5\frac{lbs}{ft}\right)(20\ ft) = 1433\ lbs$$

$$F_{Brace-induced} = 1433\ lbs \times tan60° = 2482\ lbs$$

β_D= 1.2 for LRFD/Strength Design

$$F_{Rod}=(1.2)(21.5)(10)+(0.4)(21.5)(10)+ 2482 = 2826\ lbs$$

- Brace Structural Attachment:

Brace structural attachment can be quickly selected from Table 3.2.1.1. For 1433 lbs (longitudinal attachment design force) a 5/8” diameter Hilti Kwik Bolt TZ2 with 3 1/4” minimum embedment is sufficient for 1750 lbs.

- Hanger Rod Structural Attachment:

Brace structural attachment can be quickly selected from Table 4.2.1.1. For 2482 lbs a 1/2" diameter Hilti Kwik Bolt TZ2 with 3 1/4" minimum embedment is sufficient for 2630 lbs.

Step 8. Seismic Bracing Layout

Layout the designed bracing system follow the requirements listed in Section 1.5 “Seismic Bracing Layout”.

1.7 General Installation Notes

I. Rigid Restraint

ISOTECH Industries IRRA-3000R Rigid Restraint system is not meant to support dead load and should not be used as vertical hangers. IRRA-3000R Rigid Restraint system can be used to secure non-structural component to building structure and provide resisting force against seismic loads. It must be installed at 45°±15° (angle from horizontal) to secure Pipe, Duct, Conduit, Cabe Tray/Raceway to the building structure.

The bracket should be securely attached to pipe or duct with bolts, nuts, and washers. Check available configurations in Section 2.0 and follow the instructions shown in drawings during installation. Check Section 5.0 for Bracket & Rigid Brace Details.

To securely the bracket of rigid restraint to the building structure, requirements listed below must be followed:

- Check structural attachments Section 3.0 for connection details, comply with the corresponding attachment type, size, embedment, and other requirements indicated by notes.
- Follow manufacturer installation instruction for torque value and proper anchor installation.

II. Rod Stiffeners

Rod stiffeners and clamps are required to be attached to the hanger rod for protection if the overall compression load caused by seismic load and brace-induced load (See details in Step 5 on page 21) exceeds allowable compression strength of the rod.

1.8 Post- Installed Anchor Test Values

	Anchor Size	Concrete Slab Test Values (lbs)	Torque Test Values (ft-lbs)
HILTI KB-TZ2 (3000 psi Slab or Wall)	Ø3/8” x 2” Min.EFF.EMBED	1970	30
	Ø1/2” x 2” Min.EFF.EMBED	1970	50
	Ø1/2” x 3 1/4” Min.EFF.EMBED	3300	50
	Ø5/8” x 3 1/4” Min.EFF.EMBED	4100	40
	Ø5/8” x 4” Min.EFF.EMBED	4510	40
	Ø3/4” x 3 3/4” Min.EFF.EMBED	5050	110
	Ø3/4” x 4 3/4” Min.EFF.EMBED	5550	110
HILTI KB-TZ2 (Soffit of Slab on Composite Metal Deck)	Ø3/8” x 2” Min.EFF.EMBED	1390	30
	Ø1/2” x 2” Min.EFF.EMBED	1300	50
	Ø1/2” x 3 1/4” Min.EFF.EMBED	2020	50
	Ø5/8” x 4” Min.EFF.EMBED	2660	40

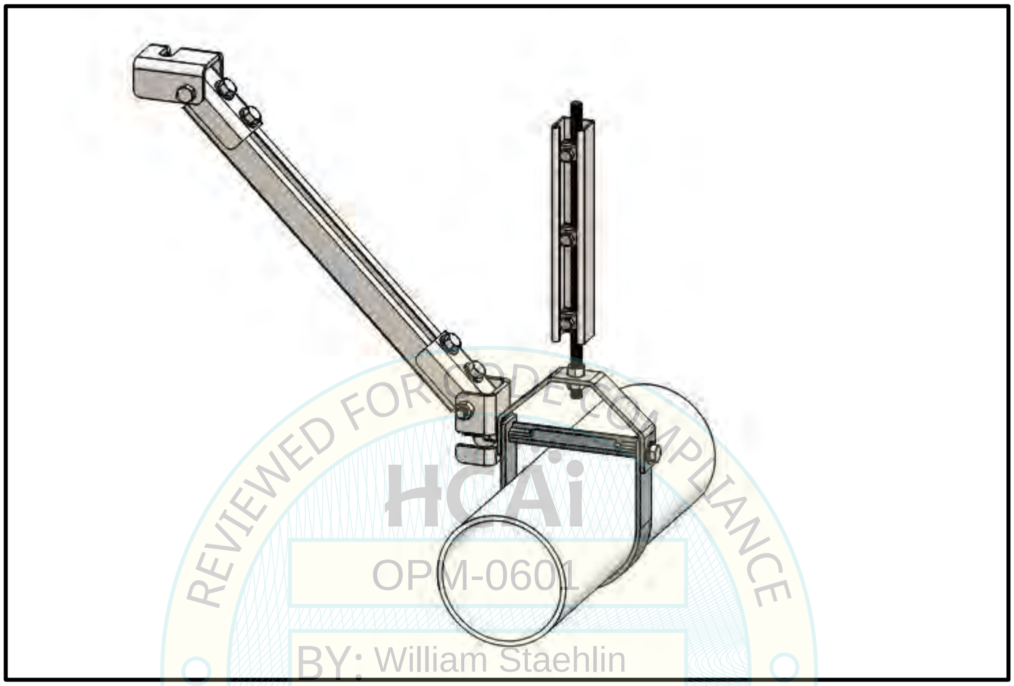
Notes:

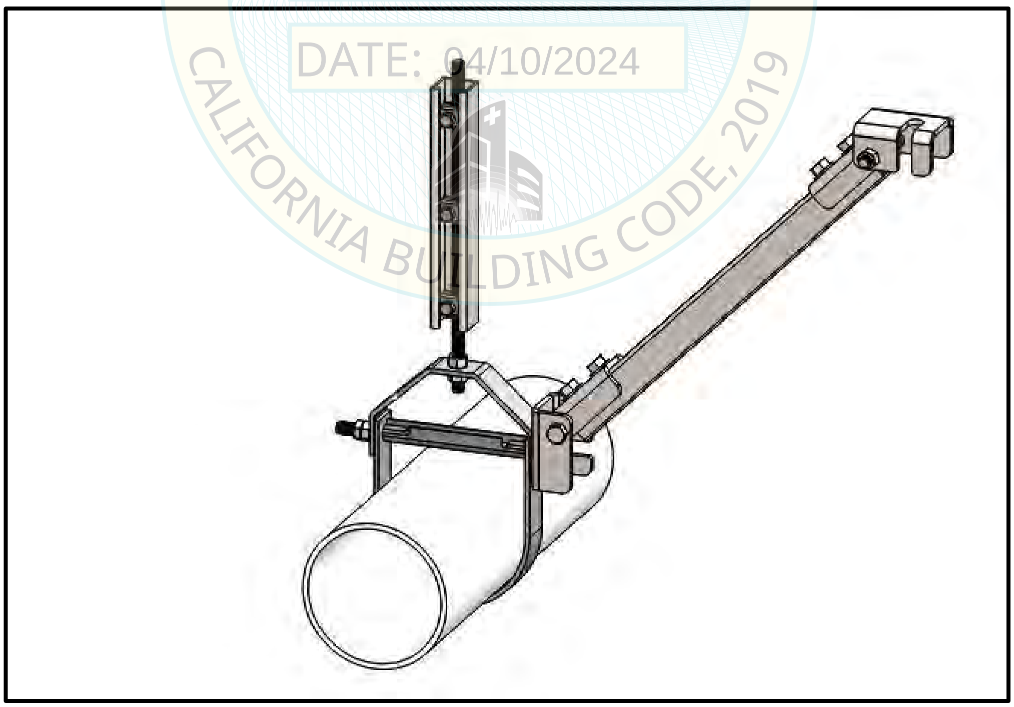
1. Anchor diameter refers to the thread size.
2. Apply proof test loads to anchors without removing the nut if possible. If not remove nut and install a threaded coupler to the same tightness of the original nut using a torque wrench and apply load.
3. Reaction loads form test fixtures may be applied close to the anchor being tested, provided the anchor is not restrained from withdrawing by the fixture(s).
4. Test equipment is to be calibrated by an approved testing laboratory in accordance with standard recognized procedures.
5. Testing shall be done in the presence of the special inspector and a report of the test results shall be submitted to the enforcement agency.
6. The following criteria apply for the acceptance of installed anchors:
   HYDRAULIC RAM METHOD: The anchor should have no observable movement at the applicable test load. A practical way to determine observable movement is that the washer under the nut becomes loose.
   TORQUE WRENCH METHOD: The applicable test torque must be reached within ½ turn of the nut.
7. Testing shall occur 24 hours minimum after installation of the subject anchors.

SECTION 2.0 RIGID BRACING & CONFIGURATION DETAILS

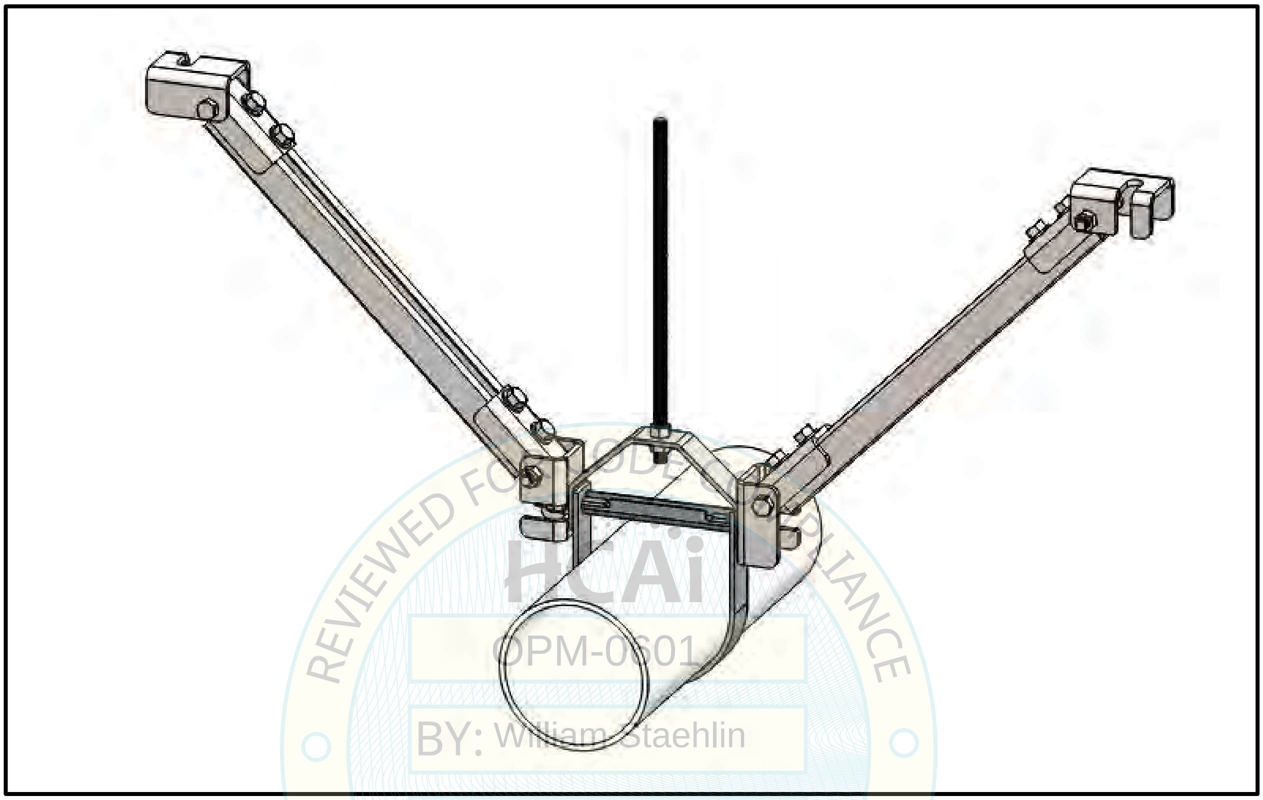
2.1 Single & Dual Transverse Bracing on Clevis Hanger for Pipe/Conduit

Single Transverse Bracing

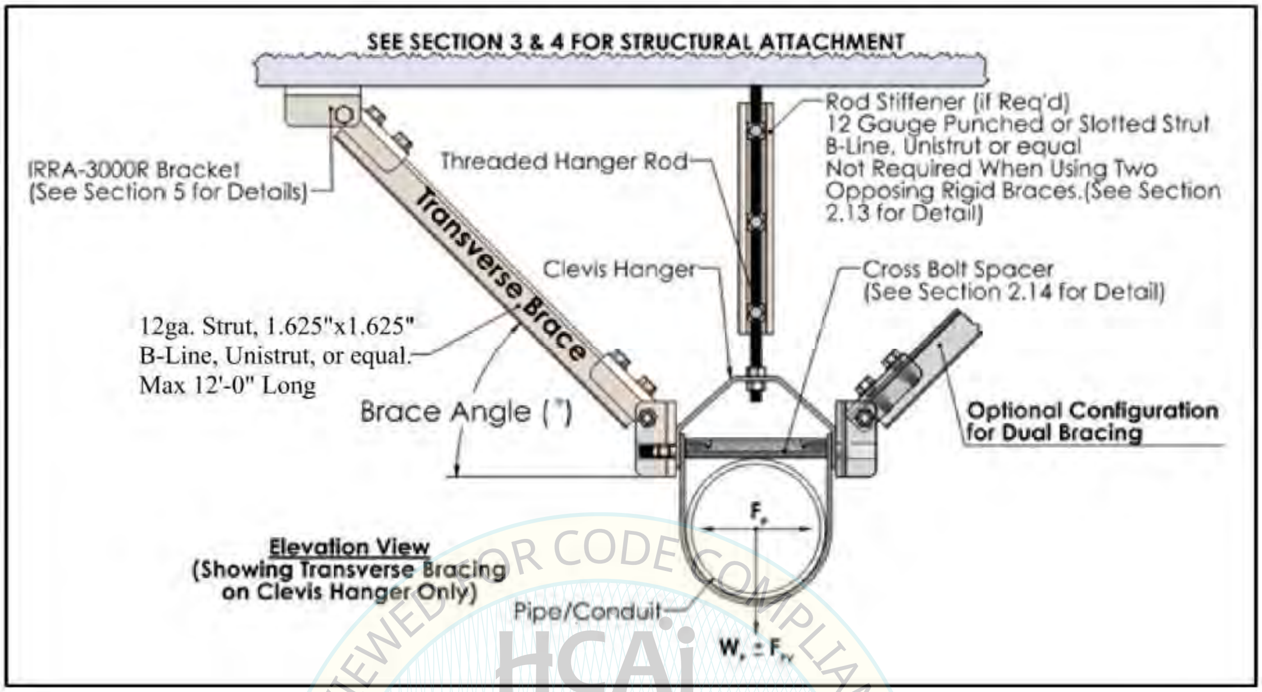


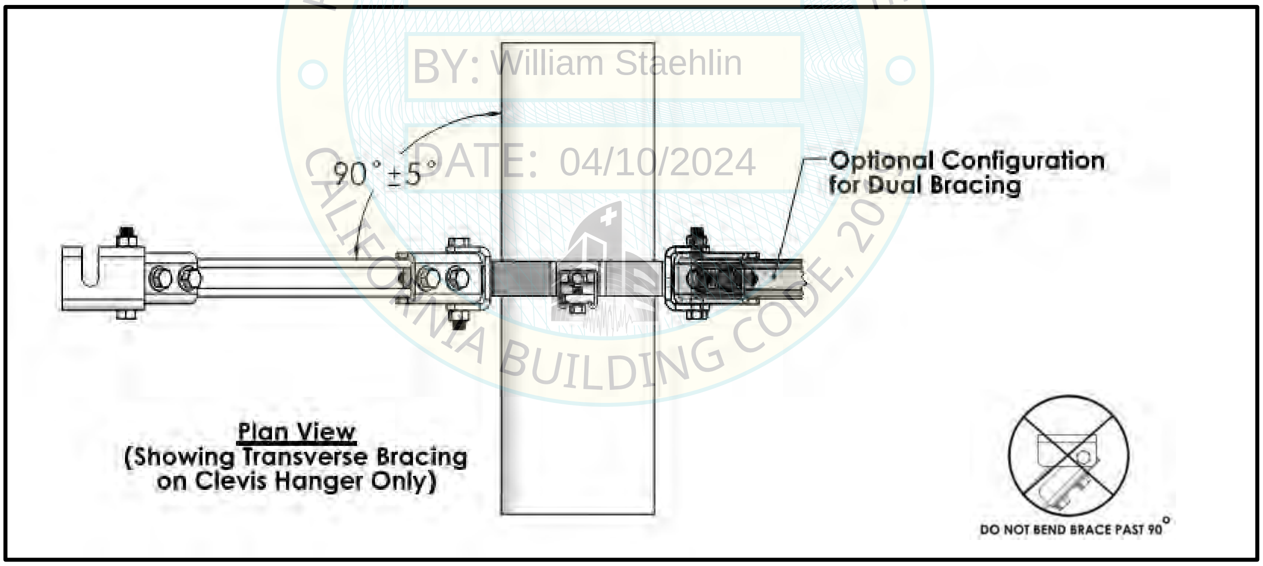


Dual Transverse Bracing



Single & Dual Transverse Bracing on Clevis Hanger for Pipe/Conduit





Single & Dual Transverse Bracing on Clevis Hanger for Pipe/Conduit

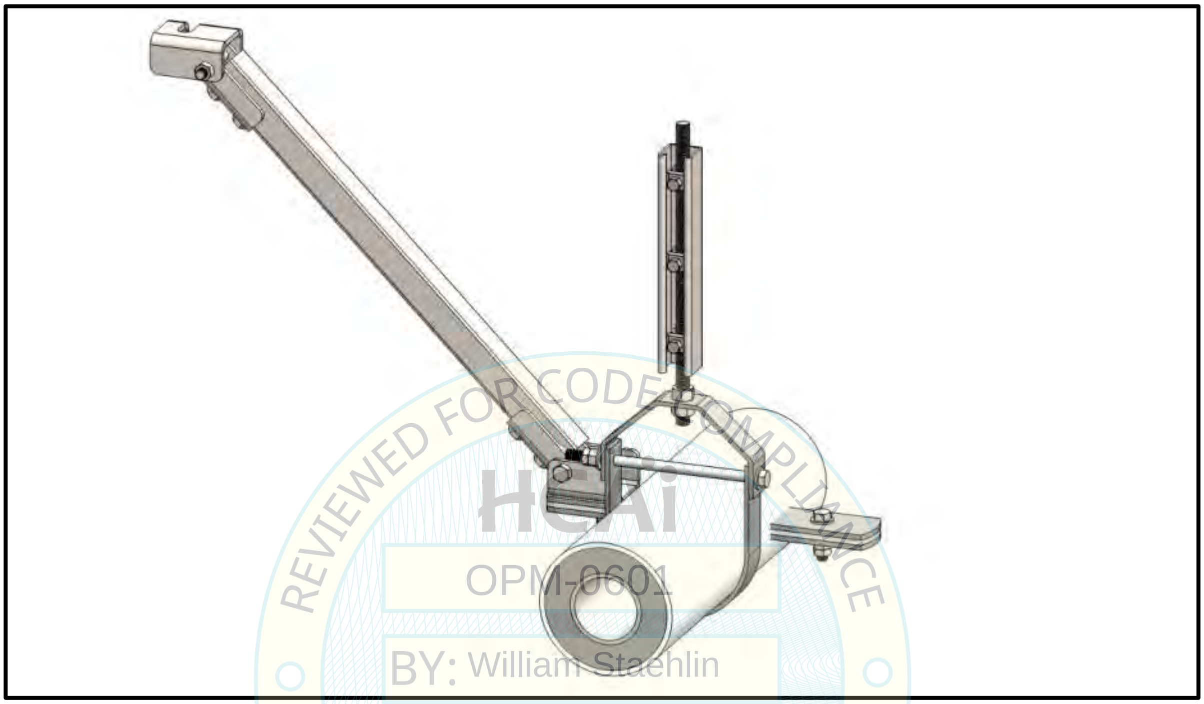
Pipe Diameter	Transverse Assembly Allowable Load (ASD) Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
2 1/2" - 3 1/2"	129	213	110
4" - 5"	236	448	292
6"	556	593	454
8"	556	593	454

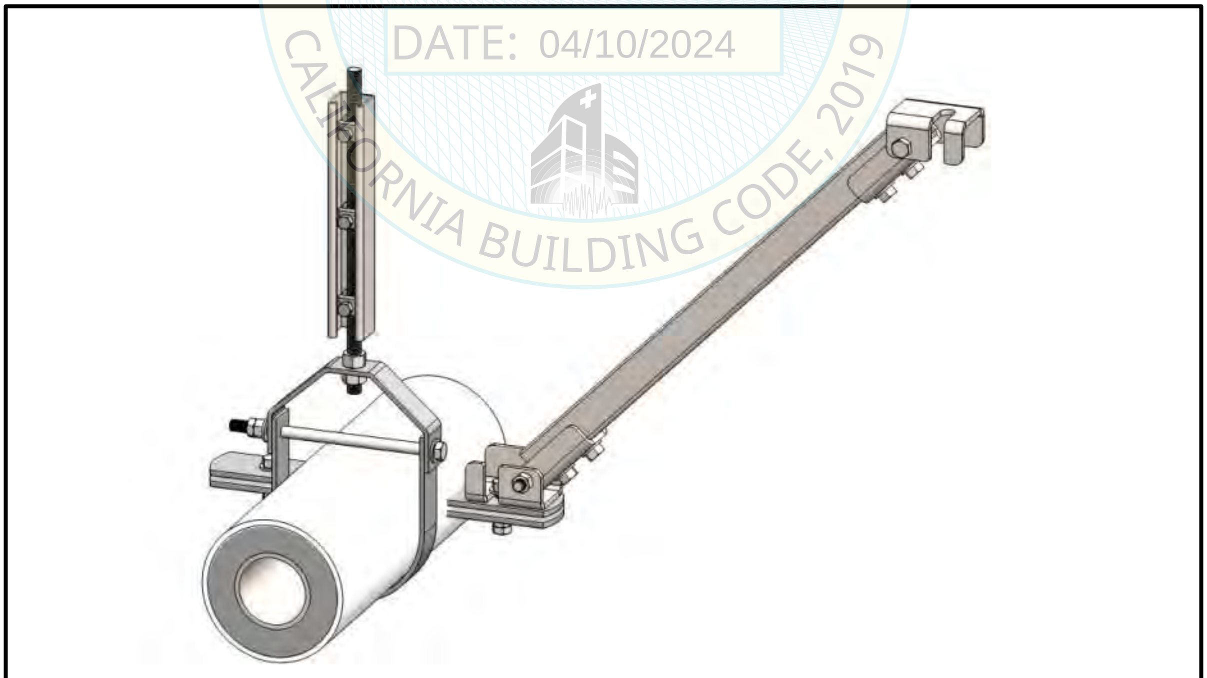
NOTES:

1. PIPES WITH INSULATION SHALL NOT BE USED
2. FOR BRACES LONGER THAN 12 FT, A SPECIFIC DESIGN OF THE BRACE FOR COMPRESSION MUST BE PERFORMED.

2.2 Single & Dual Transverse Bracing on Riser Clamp for Pipe/Conduit

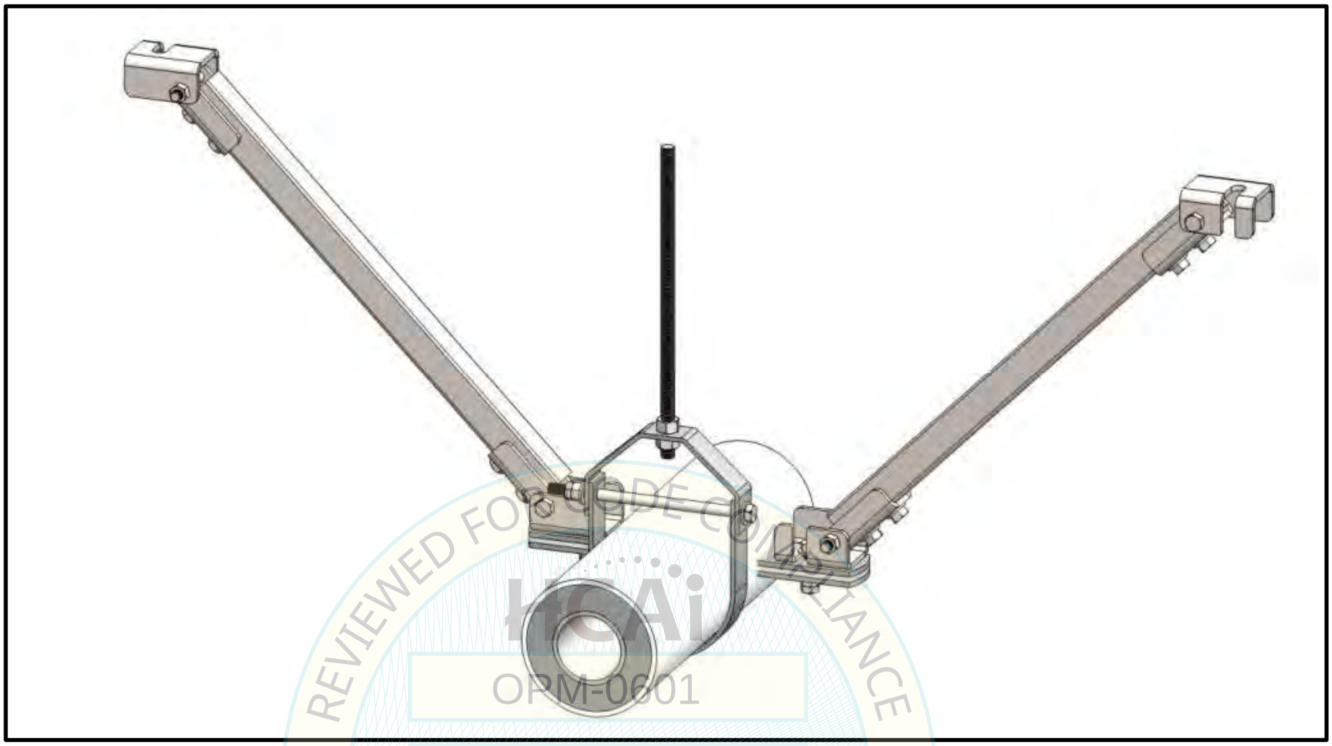
Single Transverse Bracing



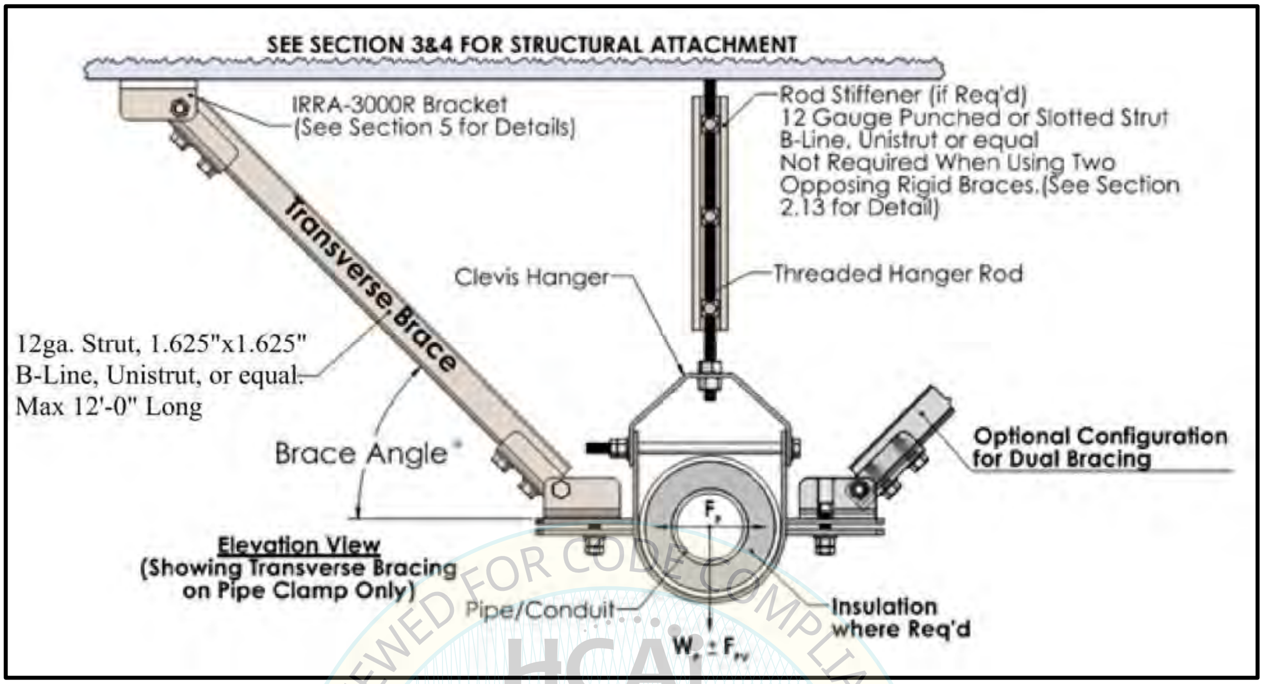


Single & Dual Transverse Bracing on Riser Clamp for Pipe/Conduit

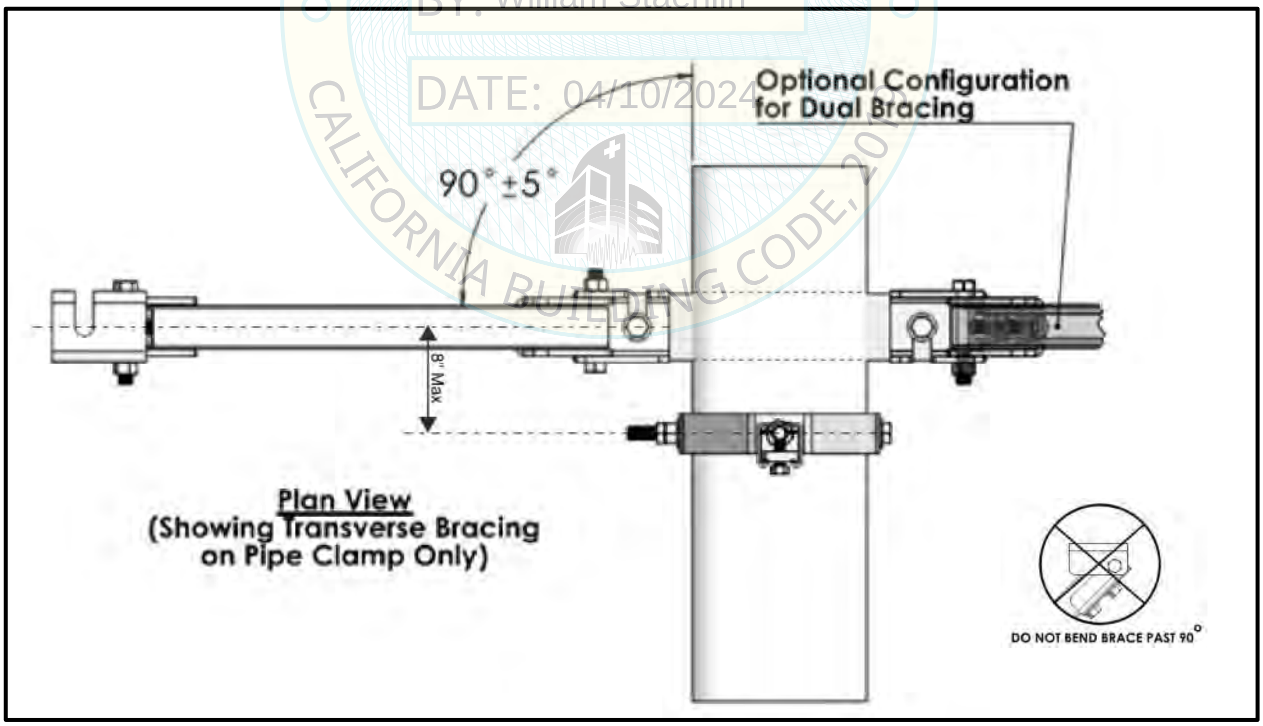
Dual Transverse Bracing



Single & Dual Transverse Bracing on Riser Clamp for Pipe/Conduit



Note: Rigid Insulation or rigid blocks to be used at pipe hanger and brace locations to prevent insulation crushing



Single & Dual Transverse Bracing on Riser Clamp for Pipe/Conduit

Pipe Diameter	Transverse Assembly Allowable Load (ASD) Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
1 1/4" - 2"	272	317	310
2 1/2" - 3 1/2"	272	317	310
4" - 5"	582	724	517
6"	920	746	636
8"	920	746	636

NOTES:

1. LOADS LISTED ABOVE ARE FOR SCHEDULE 10 AND BETTER PIPING. THE FOLLOWING REDUCTIONS SHALL APPLY FOR OTHER PIPING AND SYSTEMS:
   a.) PIPING WITH INSULATION – REDUCE LOADS BY 40% FOR 1 ¼''-5'' PIPES AND 25% FOR 6''-8'' PIPES.
   b.) THIN WALL PIPING – REDUCE LOADS BY 0%
   c.) CONDUITS EXCLUDING EMT – REDUCE LOADS BY 0%

2. FOR TOLCO FIG.4B SPECIAL PIPE CLAMP, TIGHTEN BOLTS TO FOLLOWING TORQUE VALUES:

   5/16'' – 11 ft·lbs

   3/8'' – 19 ft·lbs

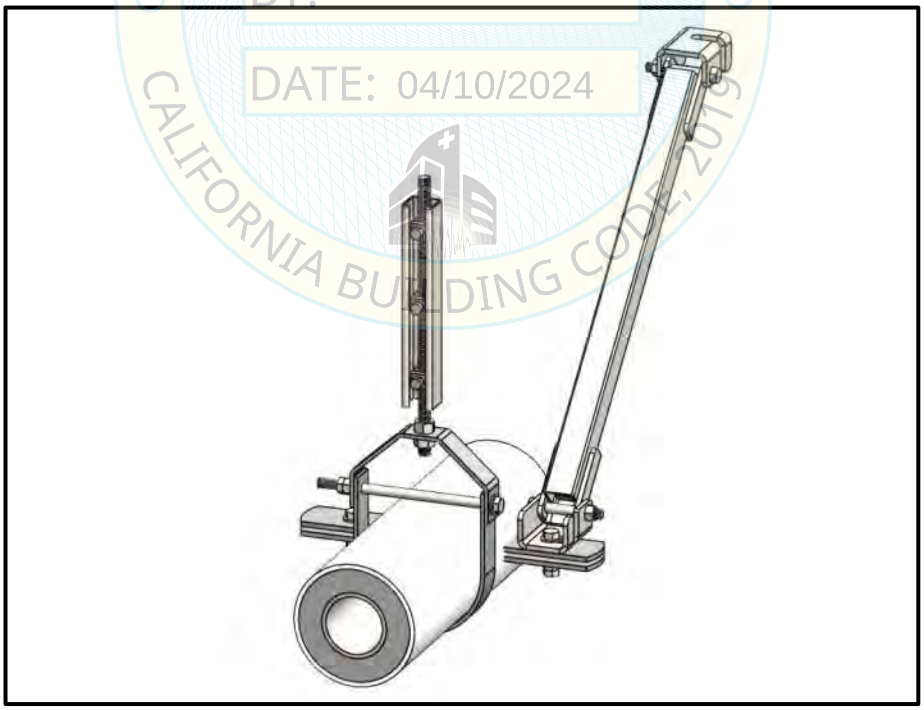
   1/2'' – 50 ft·lbs

   5/8'' – 65 ft·lbs

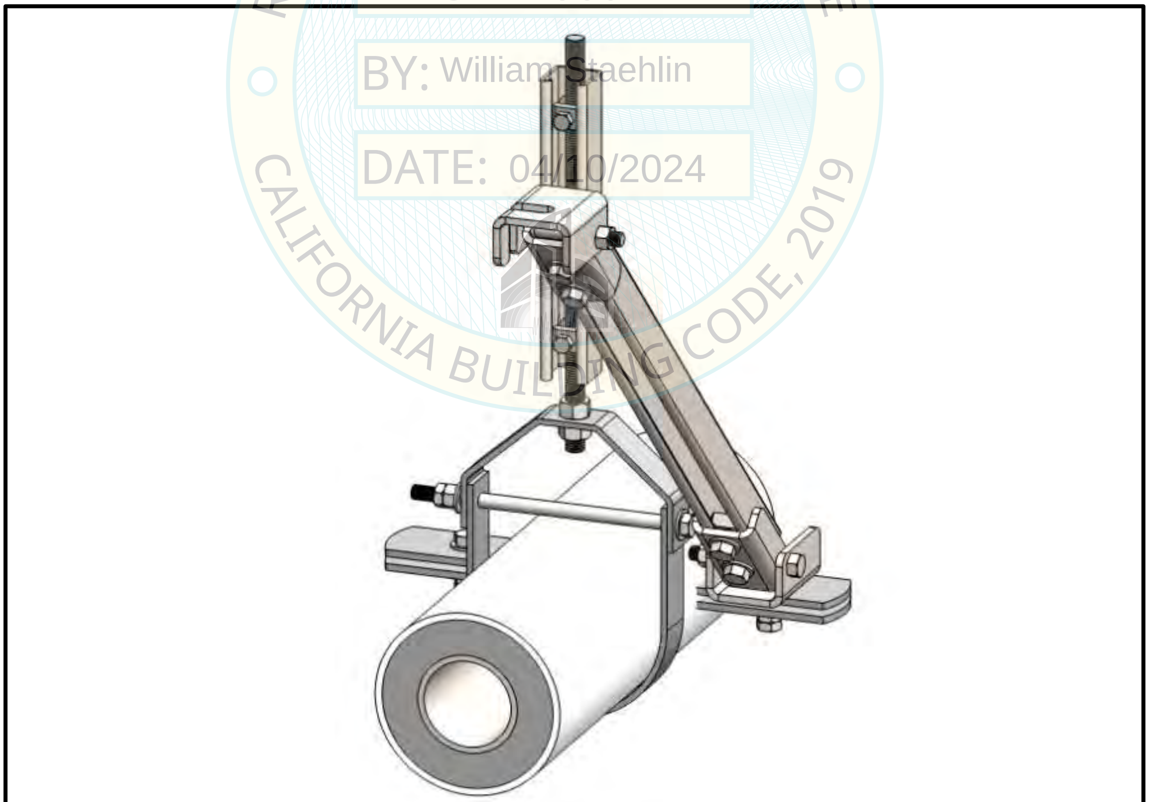
3. FOR BRACES LONGER THAN 12 FT, A SPECIFIC DESIGN OF THE BRACE FOR COMPRESSION MUST BE PERFORMED.

2.3 Single & Dual Longitudinal Bracing on Riser Clamp for Pipe/Conduit

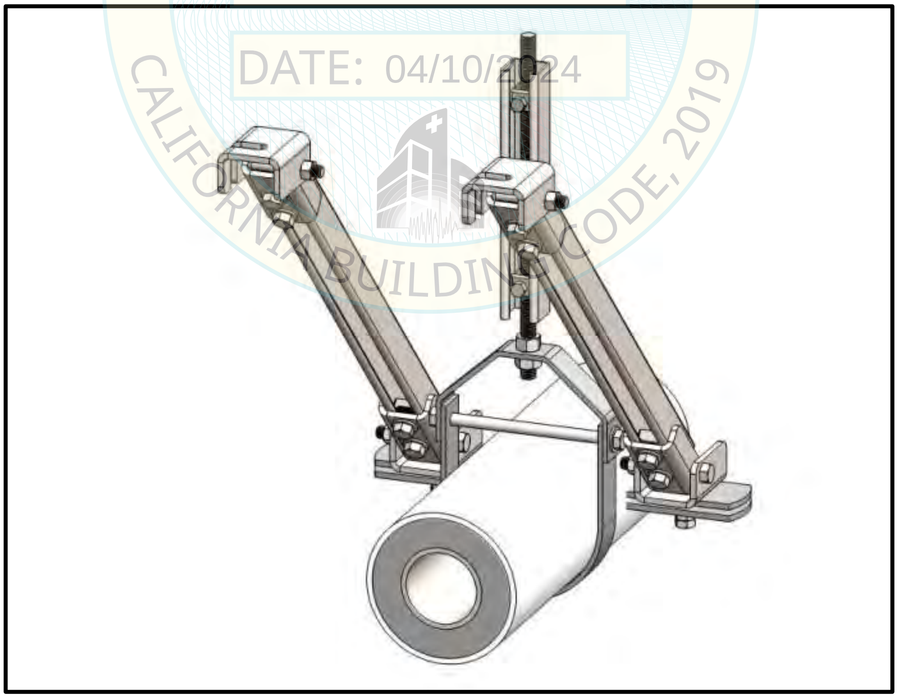
Single Longitudinal Bracing



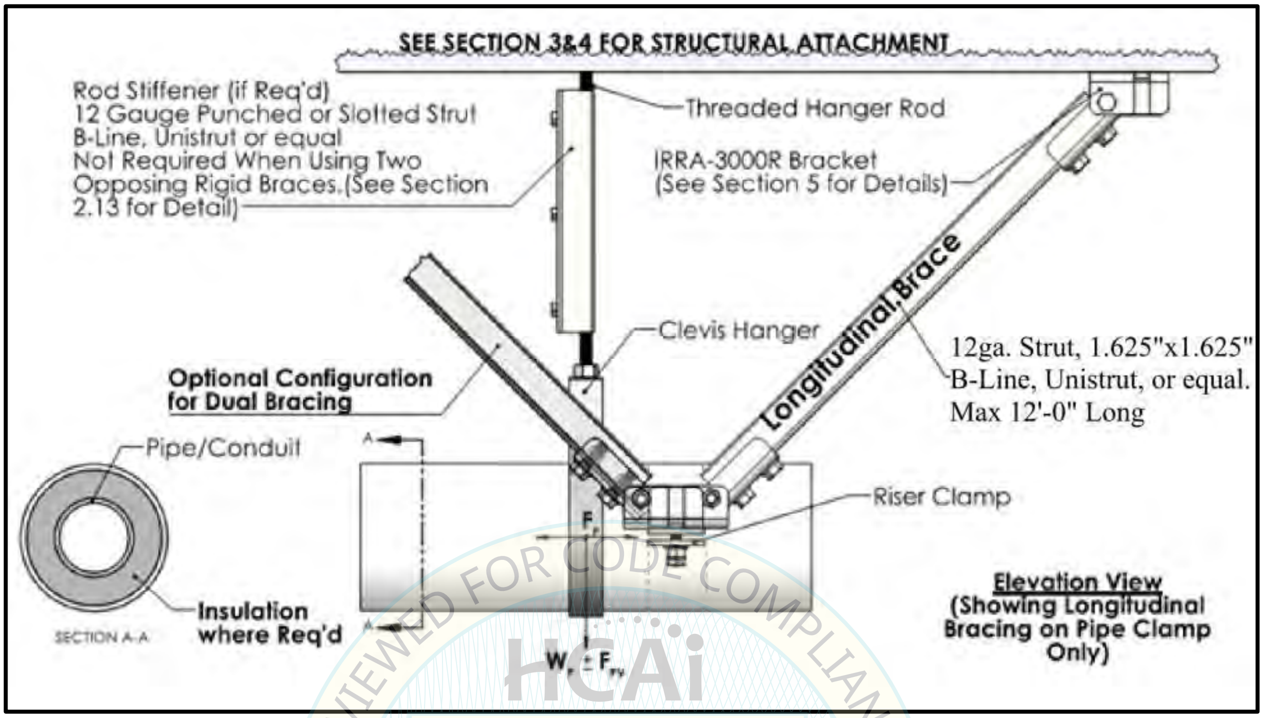
Transverse & Longitudinal Bracing for Pipe/Conduit



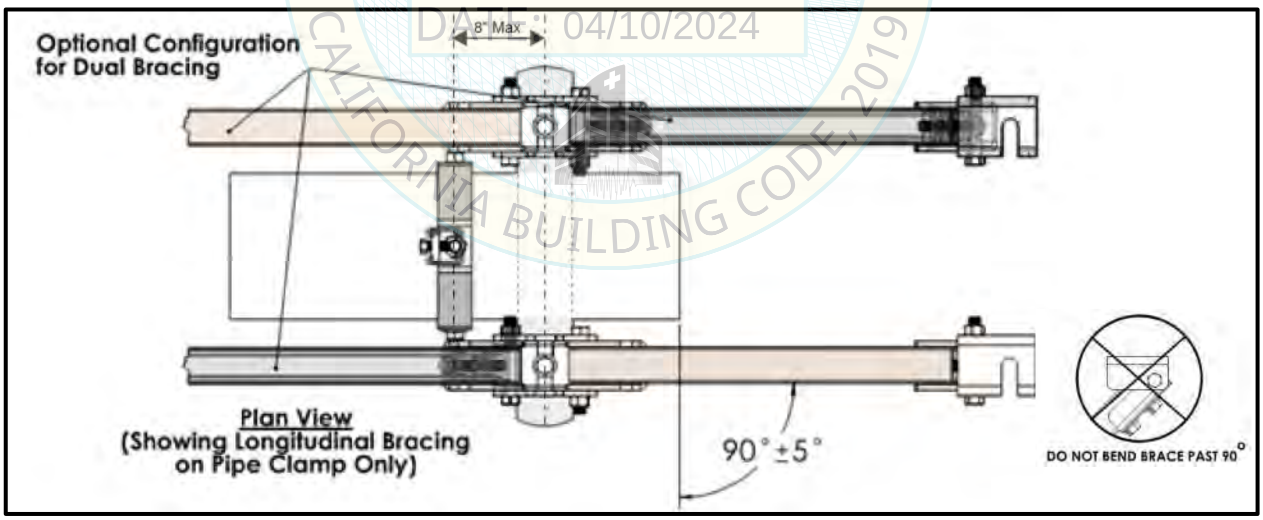
Dual Longitudinal Bracing



Transverse & Longitudinal Bracing for Pipe/Conduit



Note: Rigid Insulation or rigid blocks to be used at pipe hanger and brace locations to prevent insulation crushing



Transverse & Longitudinal Bracing for Pipe/Conduit

Pipe Diameter	Longitudinal Assembly Allowable Load (ASD) Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
2 1/2"	1420	1180	1030
3" - 4"	890	730	530
5" - 8"	830	680	490

NOTES:

1. FOR TOLCO FIG.4L LONGITUDINAL CLAMP, TIGHTEN BOLTS TO FOLLOWING TORQUE VALUES:

   1/4'' – 6 ft·lbs

   5/16'' – 11 ft·lbs

   3/8'' – 20 ft·lbs

   1/2'' – 49 ft·lbs

   5/8'' – 97 ft·lbs

2. FOR TOLCO FIG.4B SPECIAL PIPE CLAMP, TIGHTEN BOLTS TO FOLLOWING TORQUE VALUES:

   5/16'' – 11 ft·lbs

   3/8'' – 19 ft·lbs

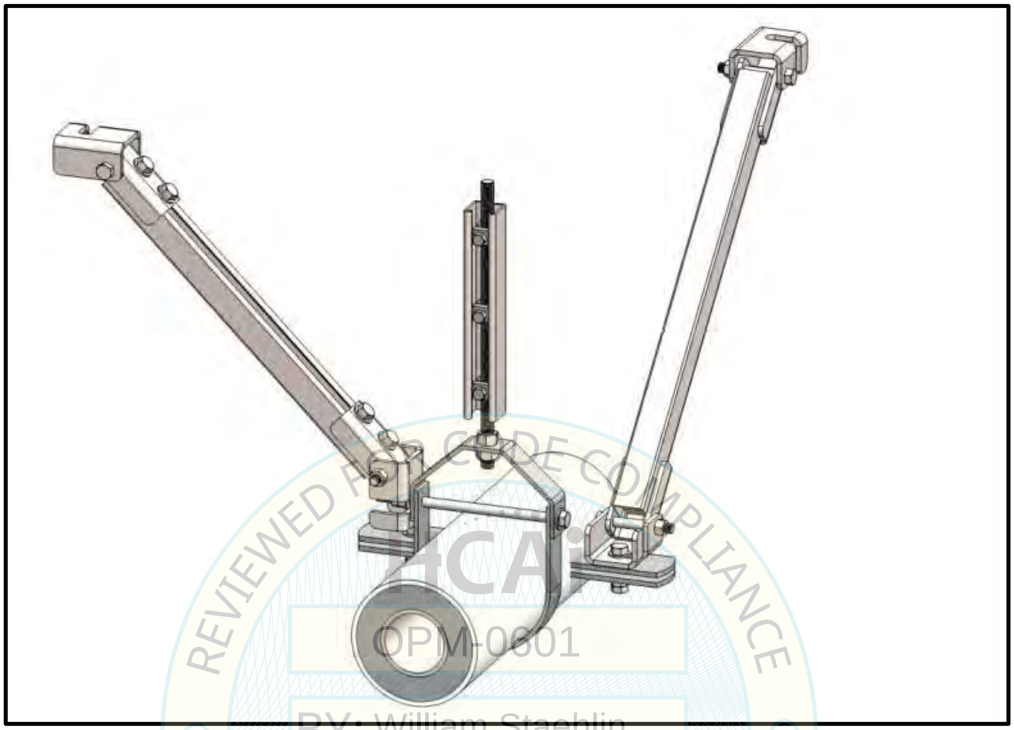
   1/2'' – 50 ft·lbs

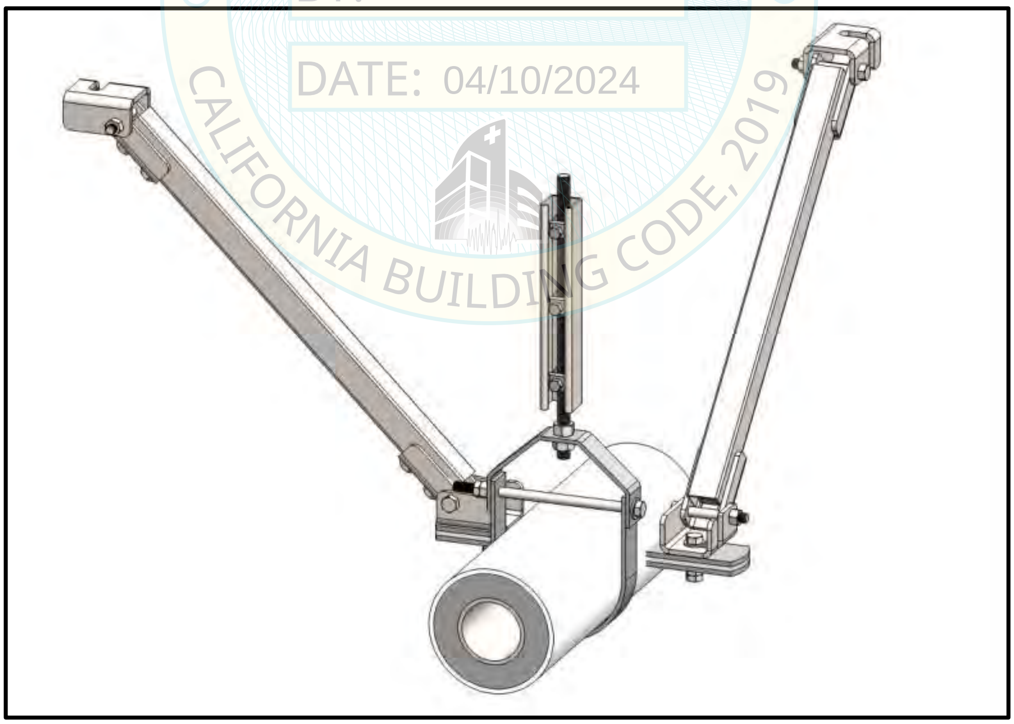
   5/8'' – 65 ft·lbs

3. NO SUBSTITUTIONS ALLOWED FOR TOLCO CLAMPS LISTED HERE.

4. FOR BRACES LONGER THAN 12 FT, A SPECIFIC DESIGN OF THE BRACE FOR COMPRESSION MUST BE PERFORMED.

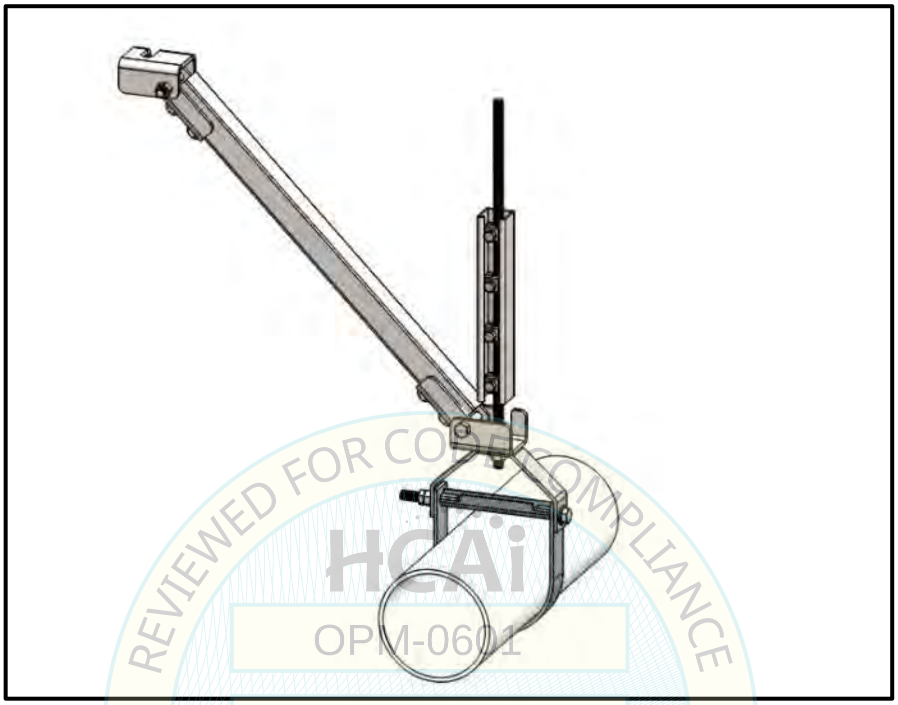
2.4 Transverse & Longitudinal Bracing for Pipe/Conduit

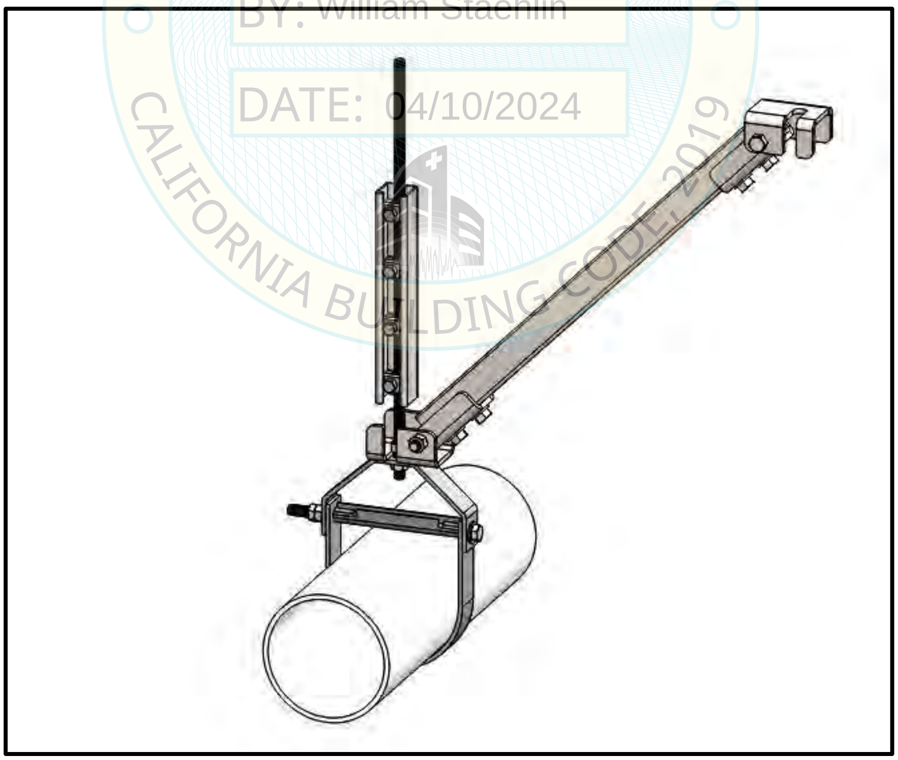




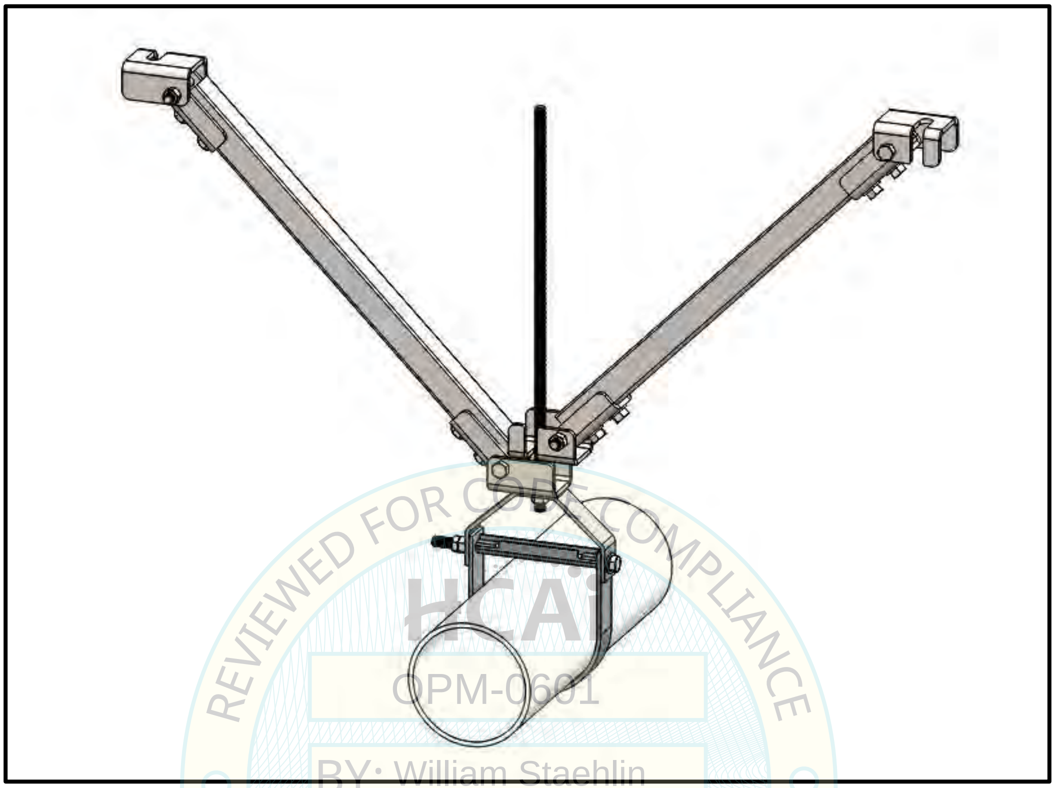
2.5 Single & Dual Transverse Bracing for Pipe/Conduit on Threaded Rod

Single Transverse Bracing

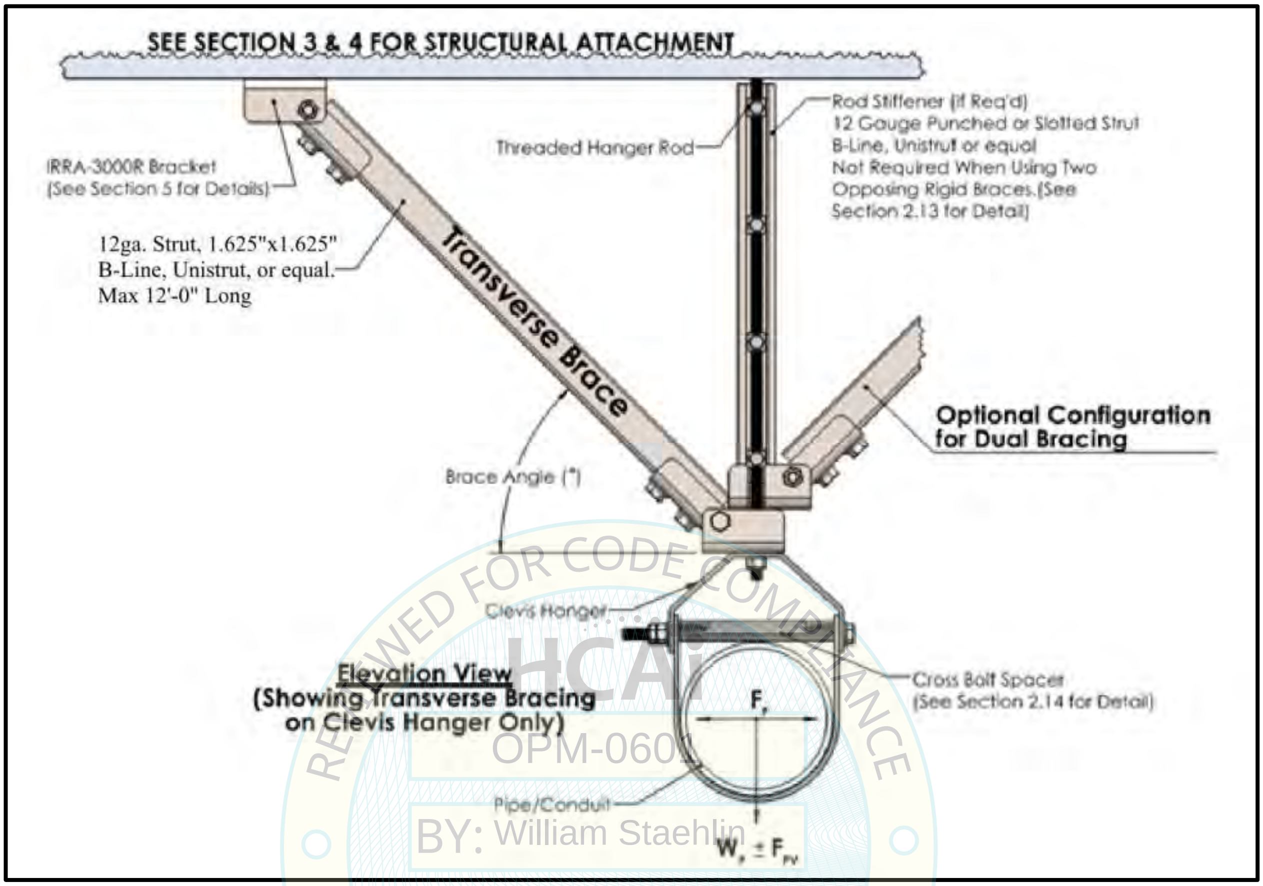


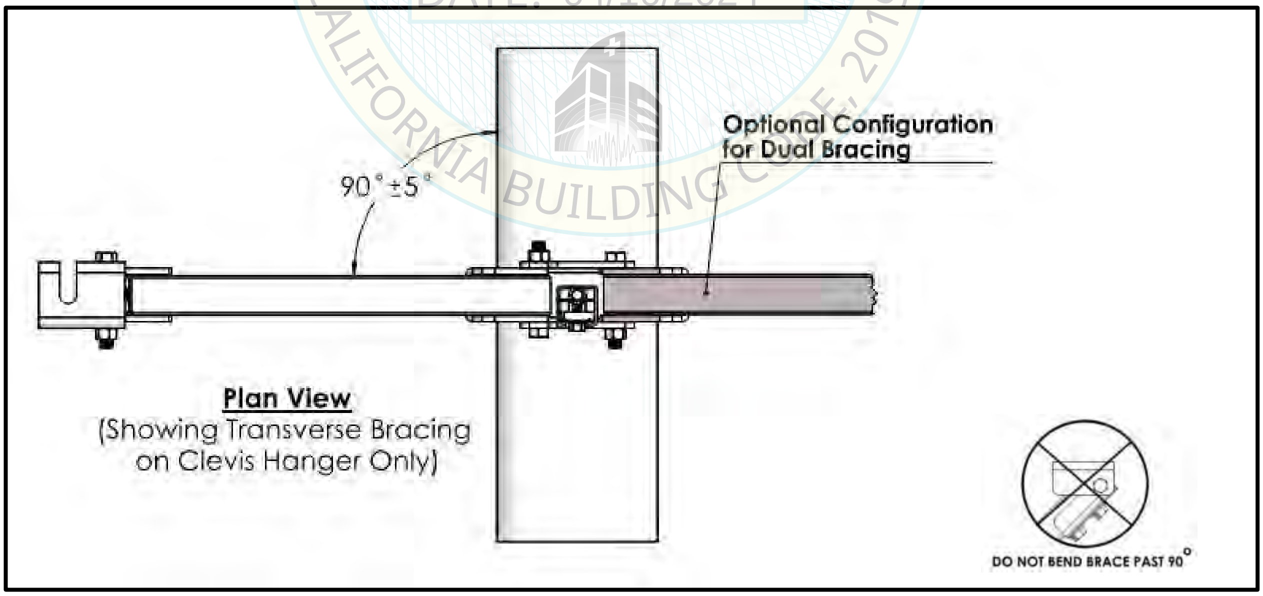


Dual Transverse Bracing



Transverse & Longitudinal Bracing for Pipe/Conduit





Transverse & Longitudinal Bracing for Pipe/Conduit

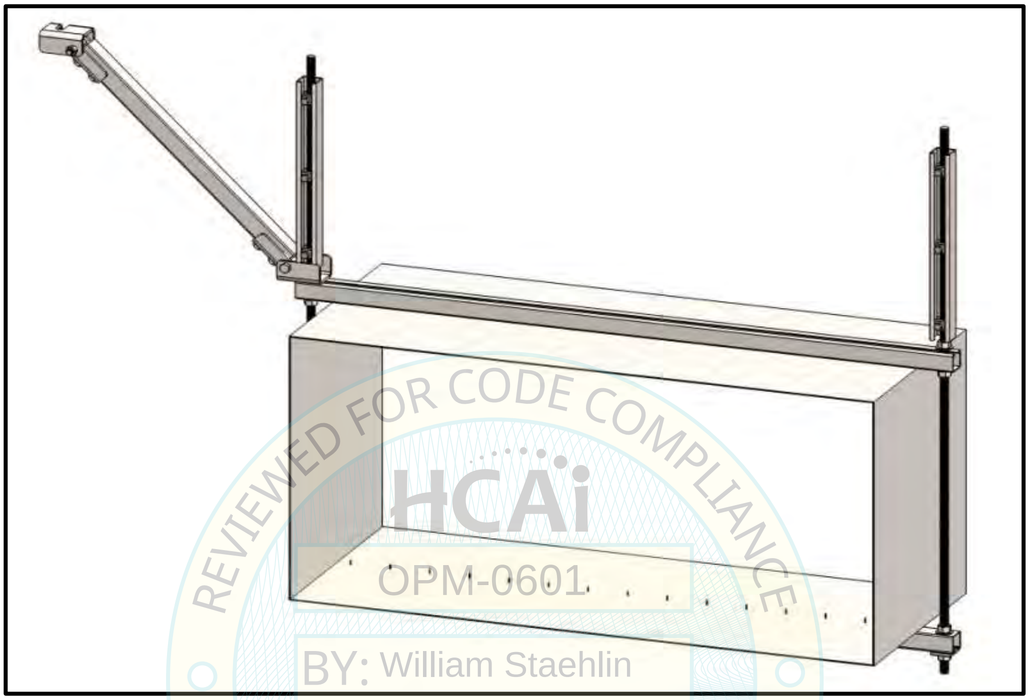
Pipe Diameter	Transverse Assembly Allowable Load (ASD) Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
1 1/4" – 2 1/2"	93	97	96
3"	111	109	107

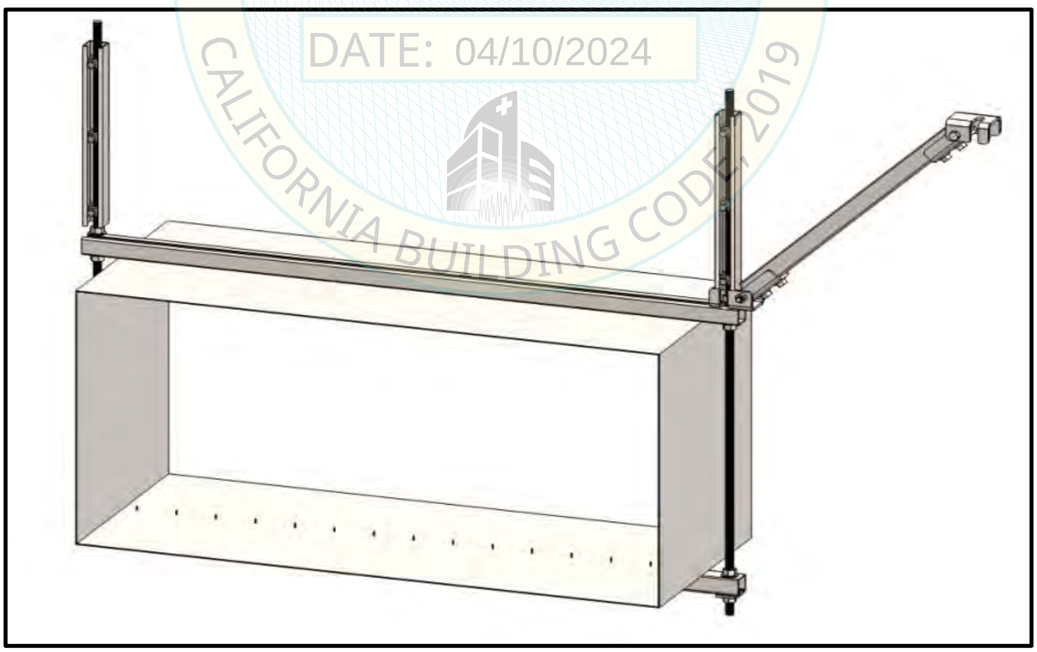
NOTES:

1. PIPES WITH INSULATION SHALL NOT BE USED.
2. FOR BRACES LONGER THAN 12 FT, A SPECIFIC DESIGN OF THE BRACE FOR COMPRESSION MUST BE PERFORMED.

2.6 Single & Dual Transverse Bracing for Trapeze Supported Rectangular Duct

Single Transverse Bracing





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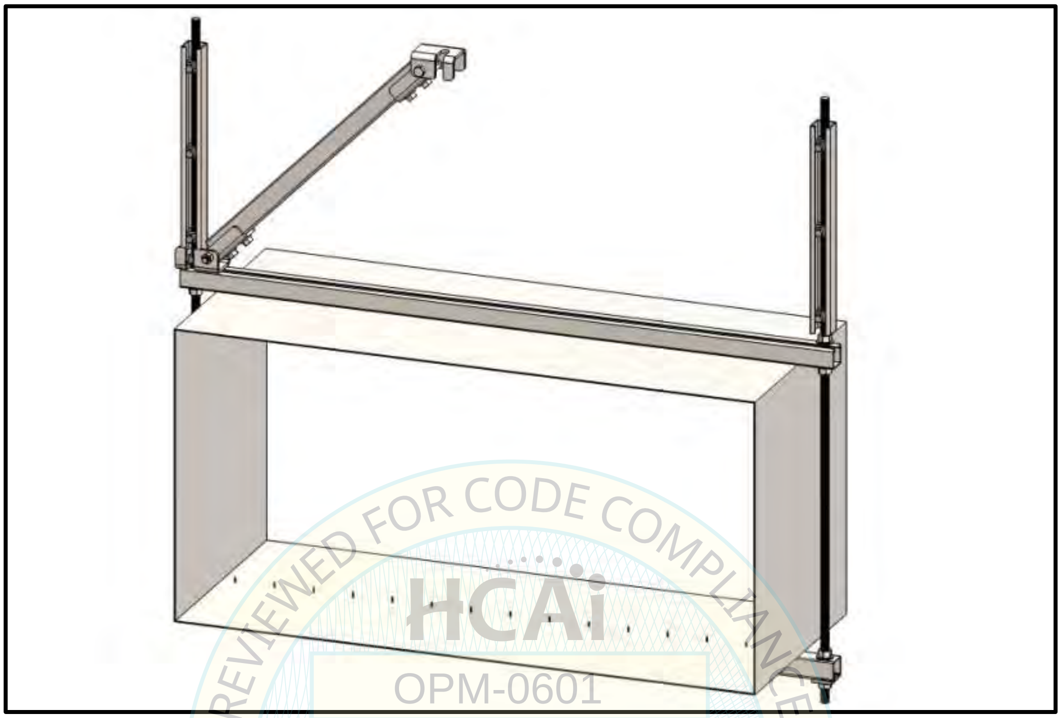
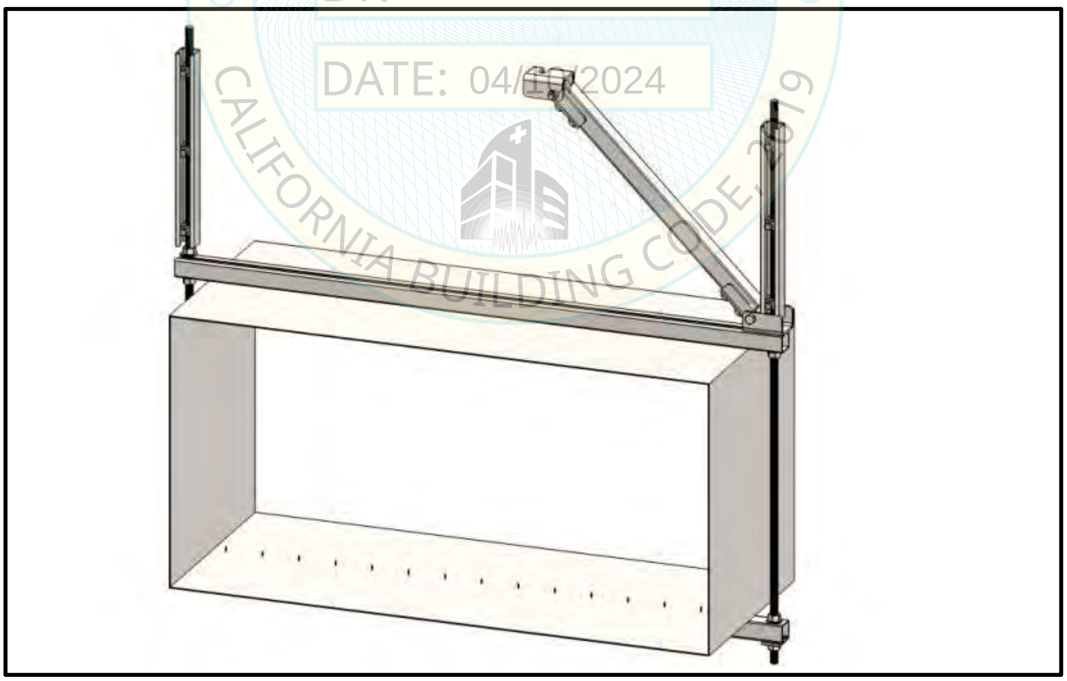
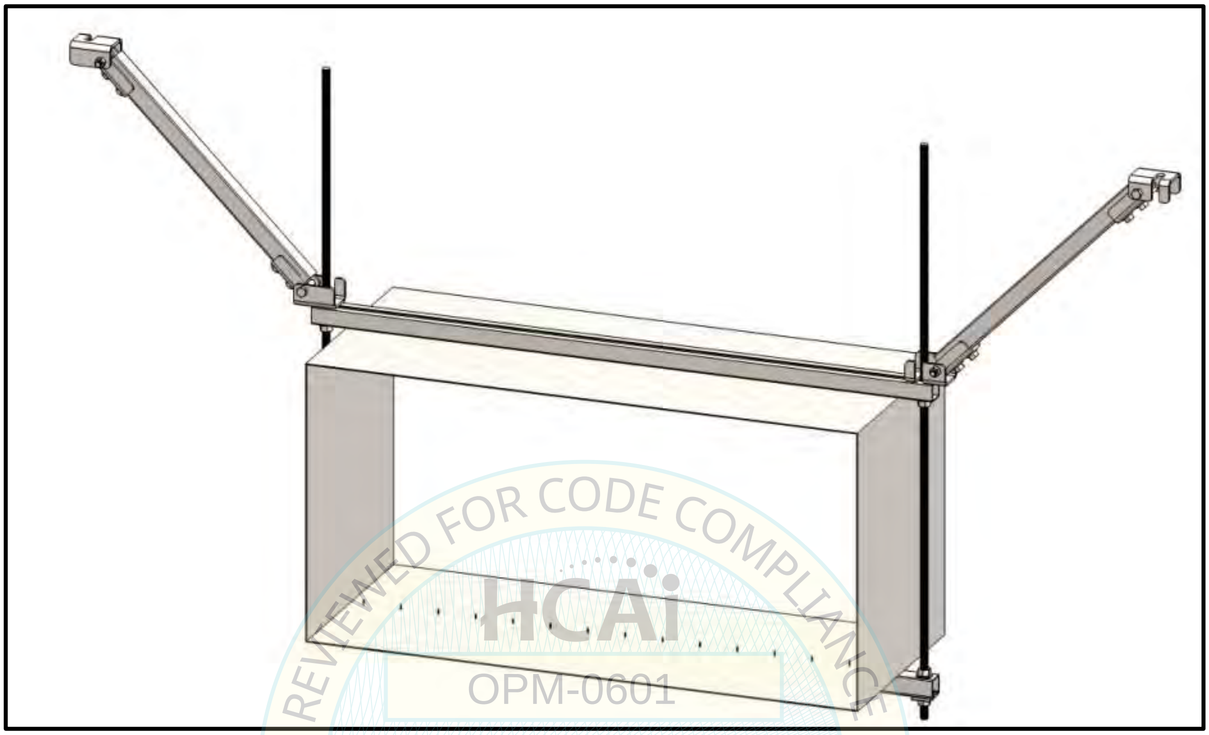
Single & Dual Transverse Bracing for Trapeze Supported Rectangular Duct

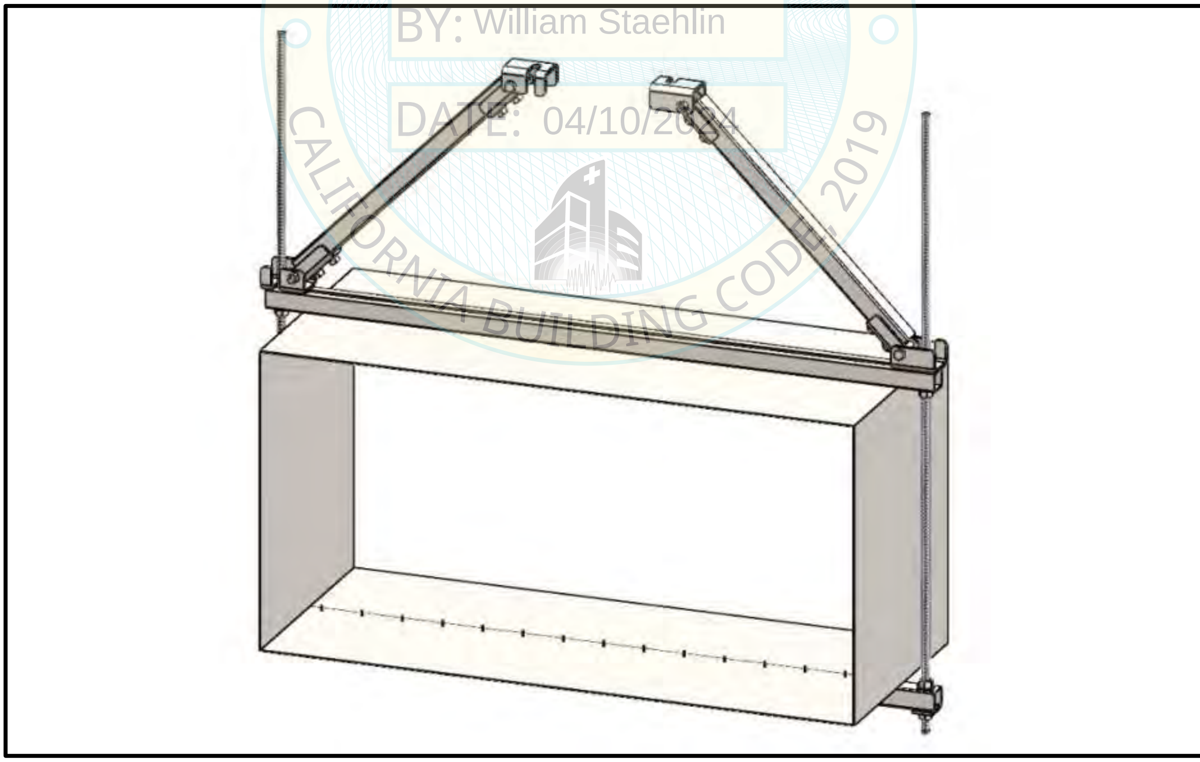




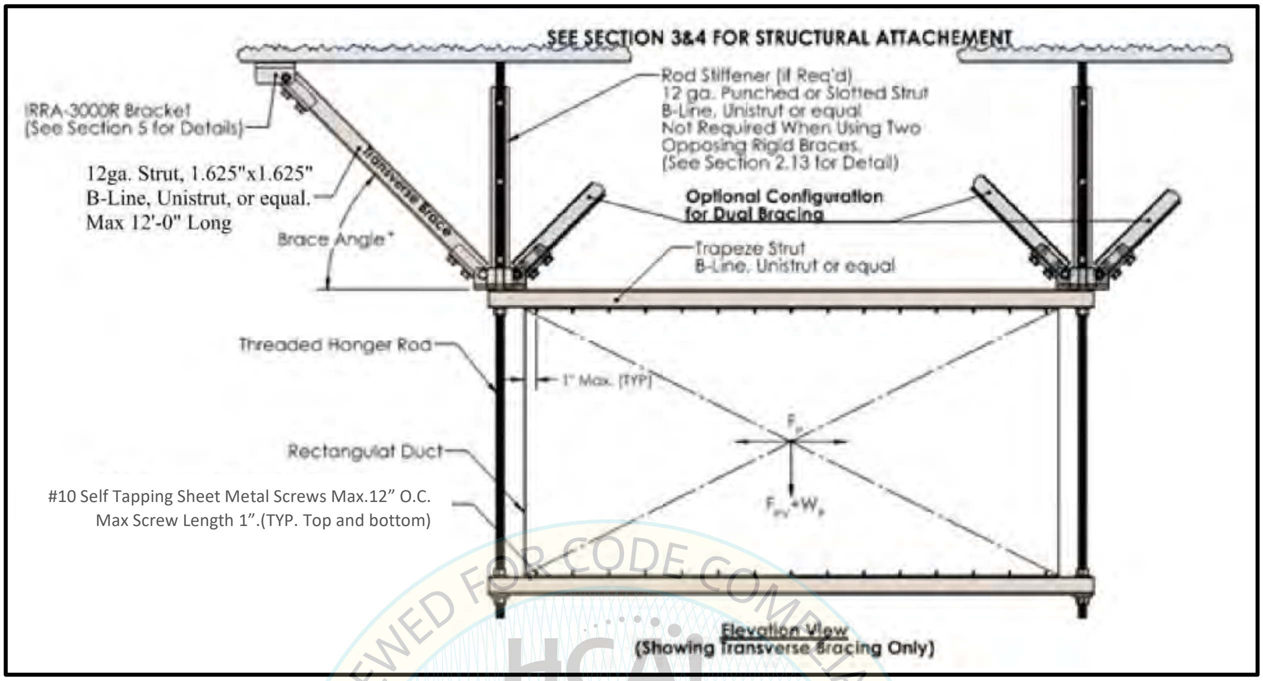
Single & Dual Transverse Bracing for Trapeze Supported Rectangular Duct

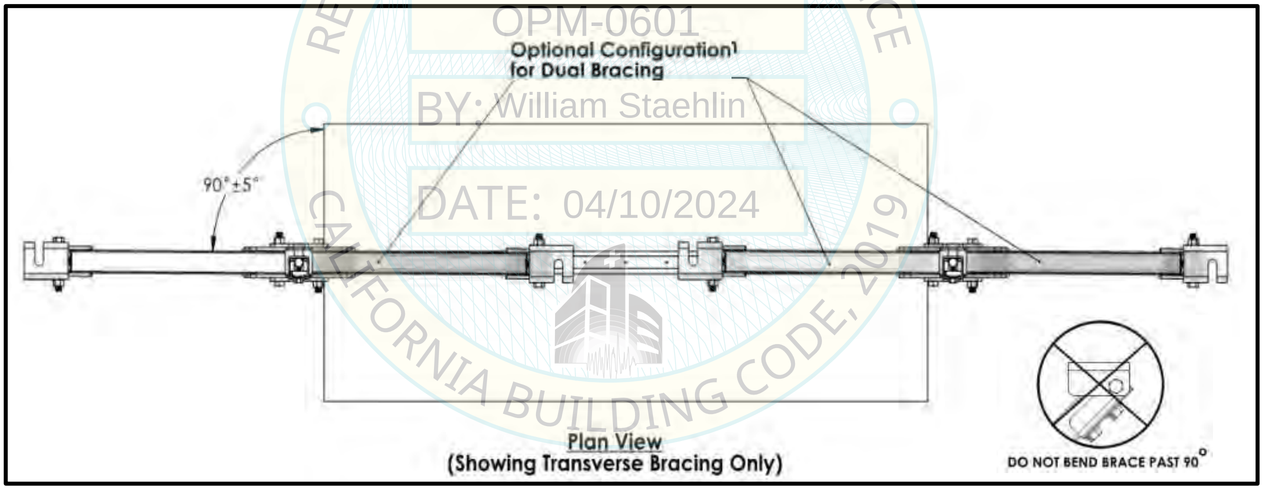
Dual Transverse Bracing





Single & Dual Transverse Bracing for Trapeze Supported Rectangular Duct

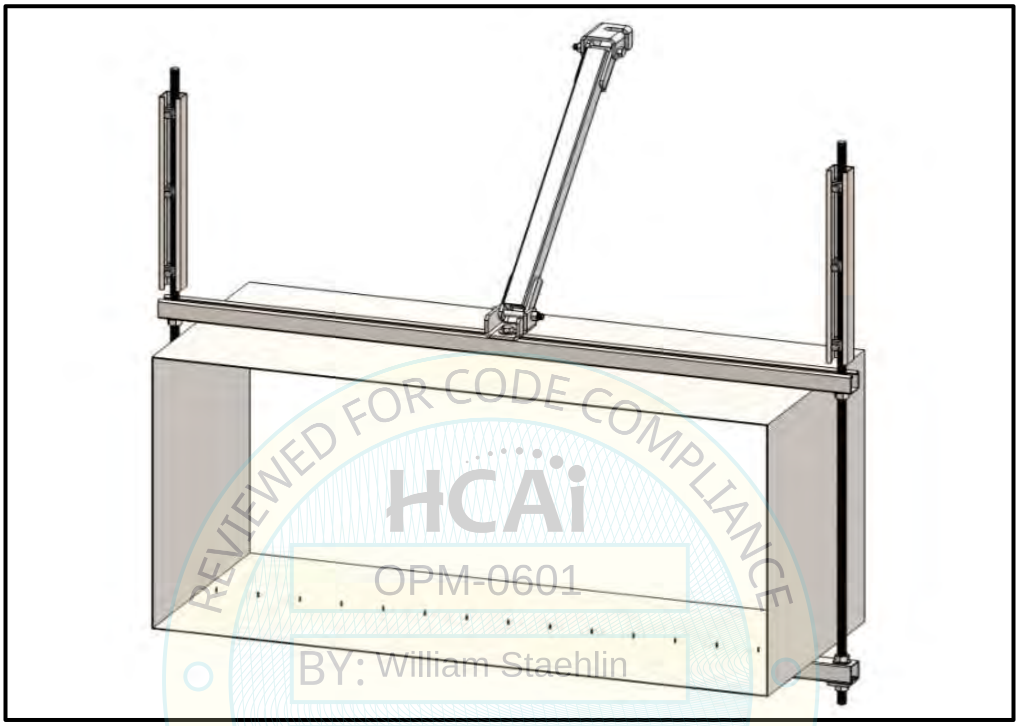


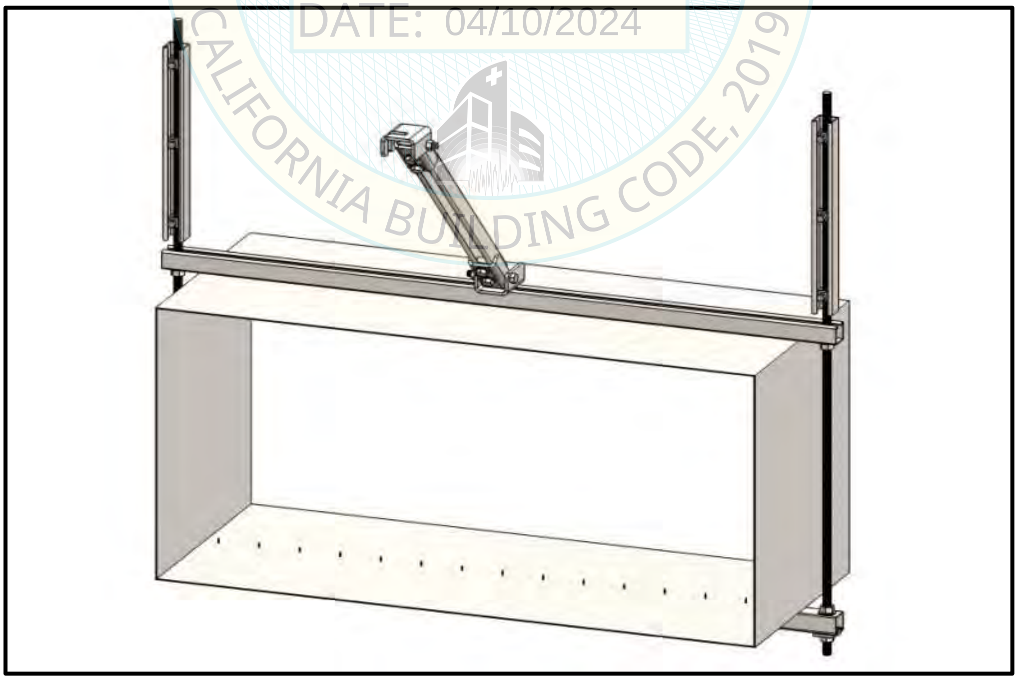


All Thread Rod Size	Transverse Assembly Allowable Load F_P (ASD) Brace Angle Measured From Horiz. [lbs]			Minimum Number of Screws
	30°	31° - 45°	46° - 60°	
3/8"	549	234	507	10
1/2"	549	234	507	10

2.7 Single & Dual Longitudinal Bracing for Trapeze Supported Rectangular Duct

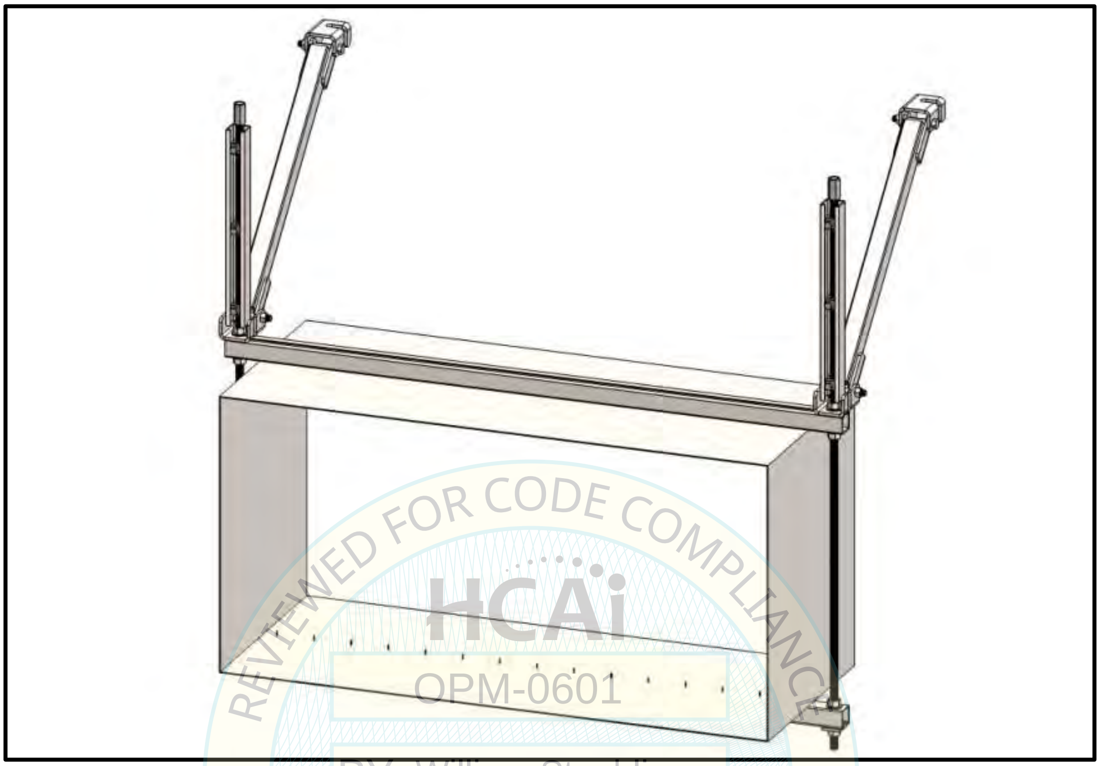
Single Longitudinal Bracing

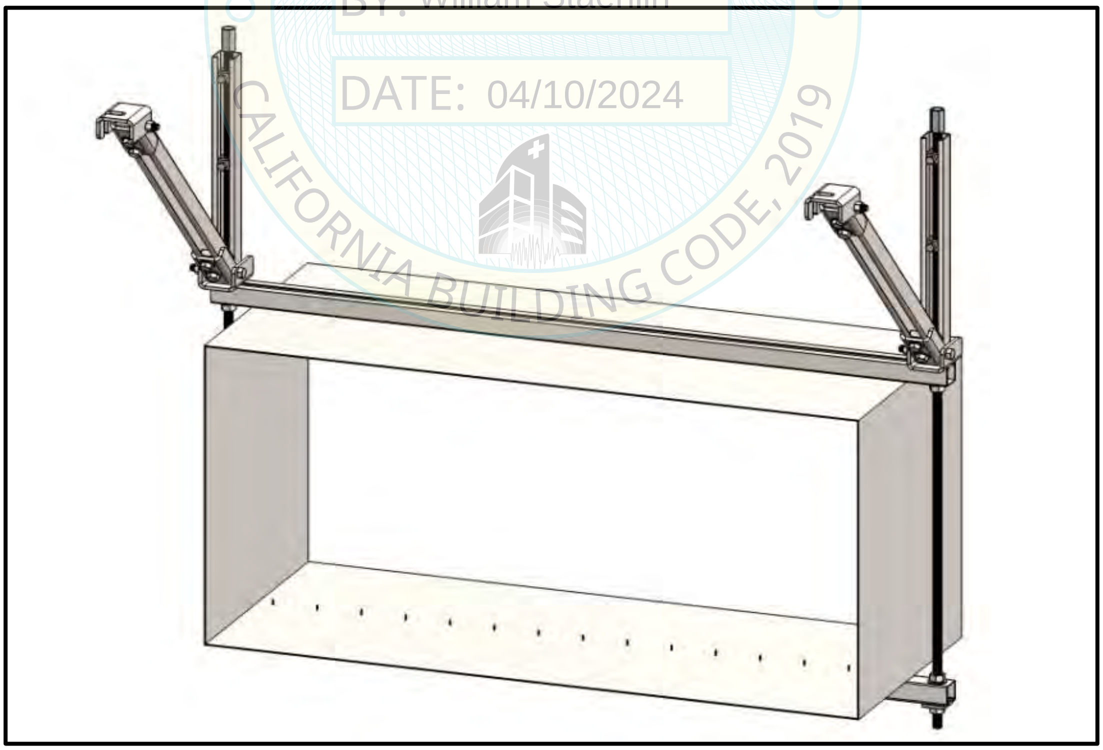


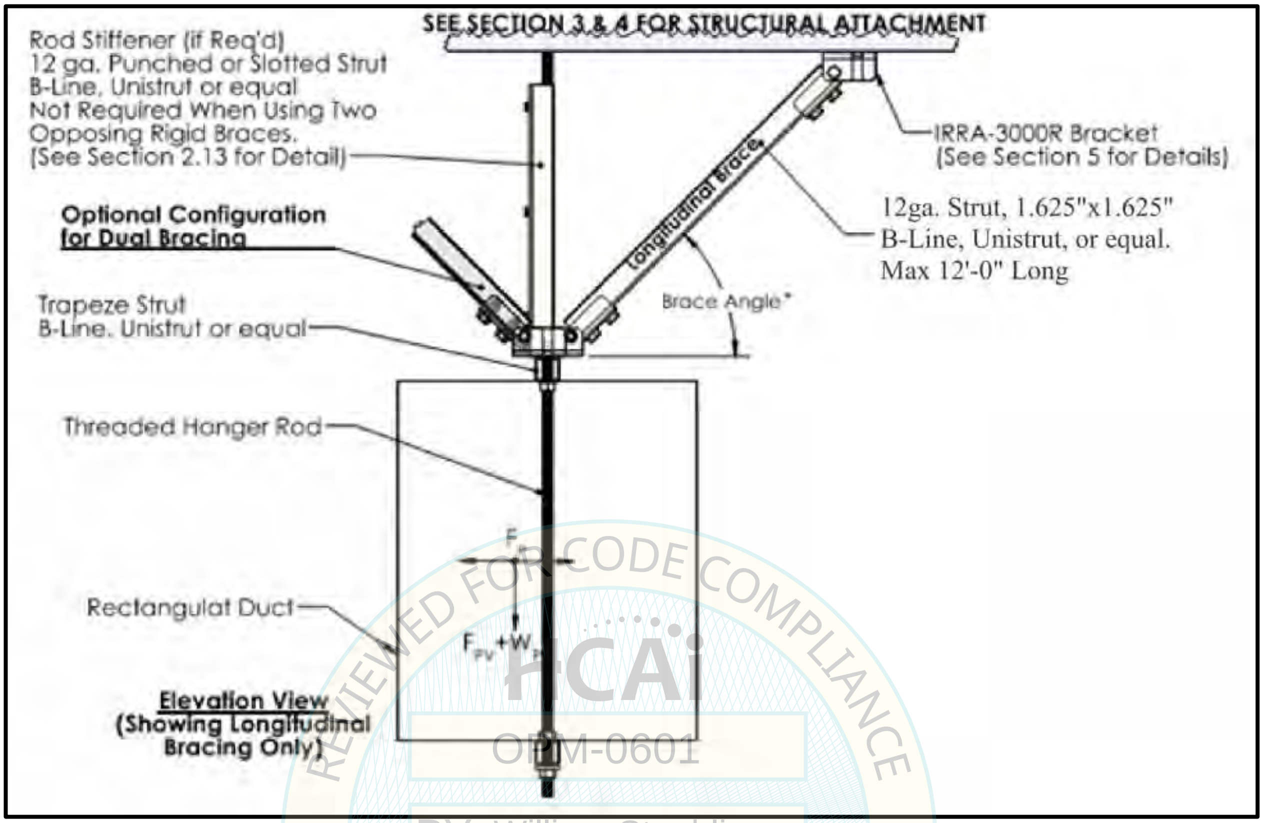


Single & Dual Longitudinal Bracing for Trapeze Supported Rectangular Duct

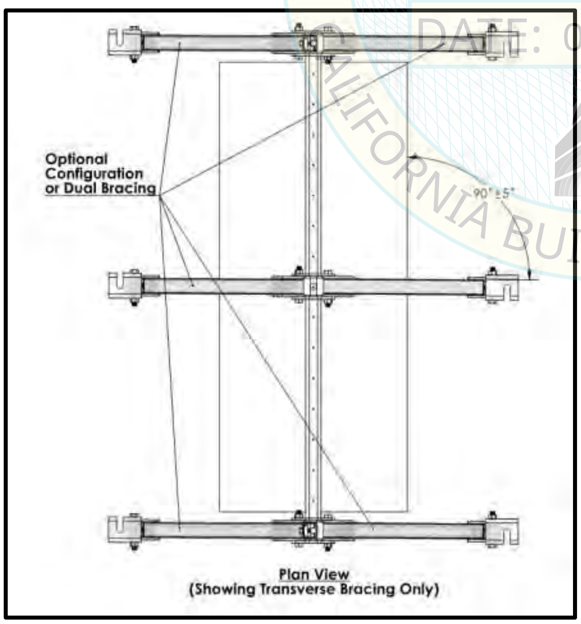
Dual Longitudinal Bracing







Elevation View
(Showing Longitudinal
Bracing Only)



Plan View
(Showing Transverse Bracing Only)

All Thread Rod Size	Dual Longitudinal Assembly Allowable Load F_P (ASD) Brace Angle Measured From Horiz. [lbs]			Single Longitudinal Assembly Allowable Load F_P (ASD)
	30°	31° - 45°	46° - 60°	
3/8"	463	492	440	197
1/2"	463	492	440	197

DO NOT BEND BRACE PAST 90°

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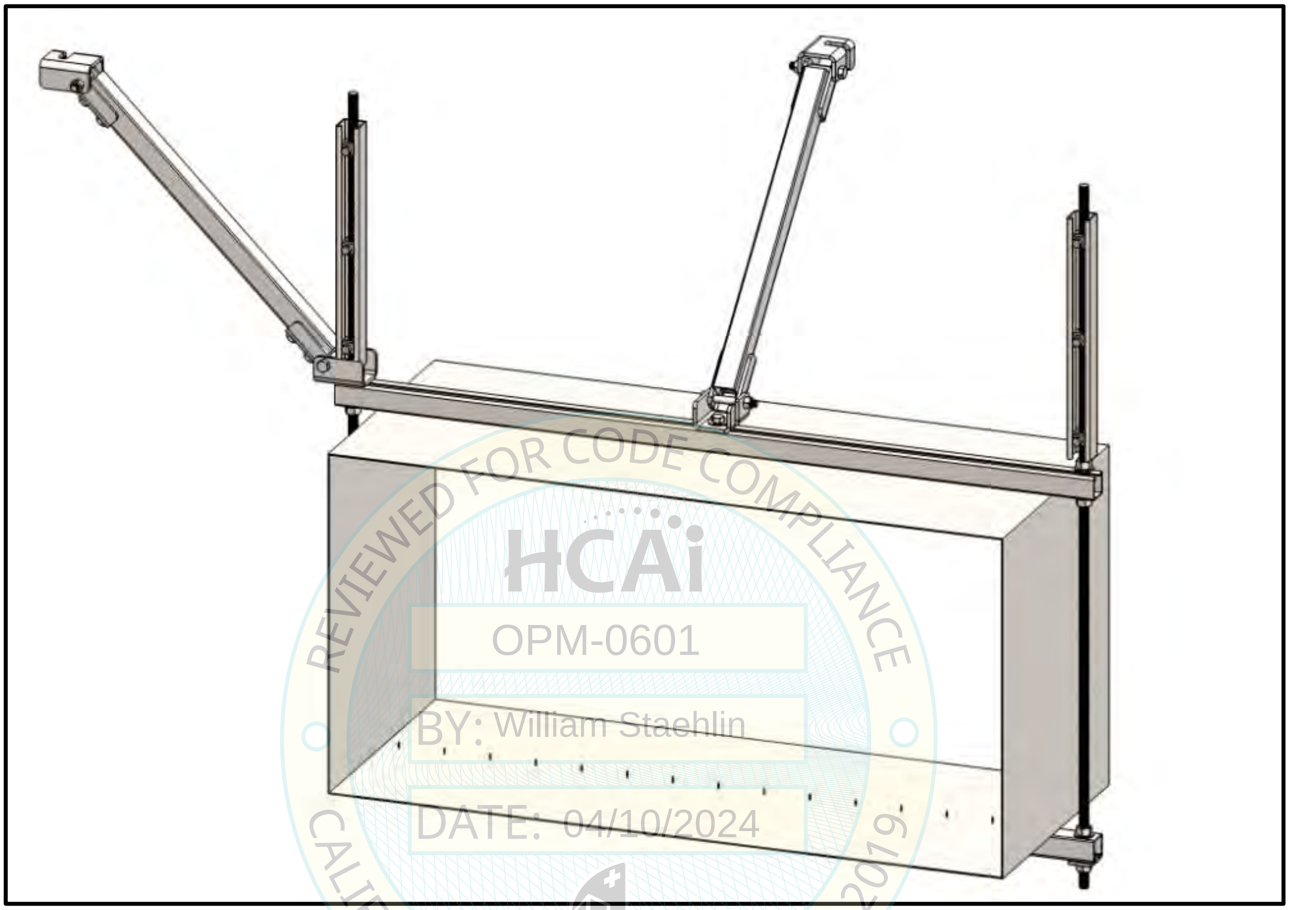
Section

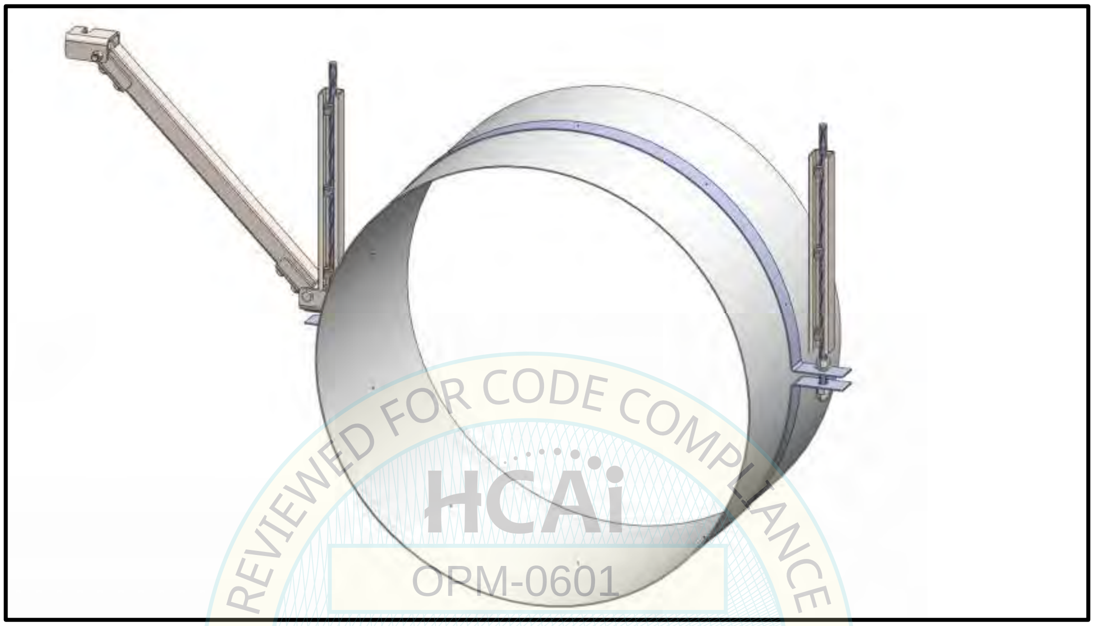
2.7

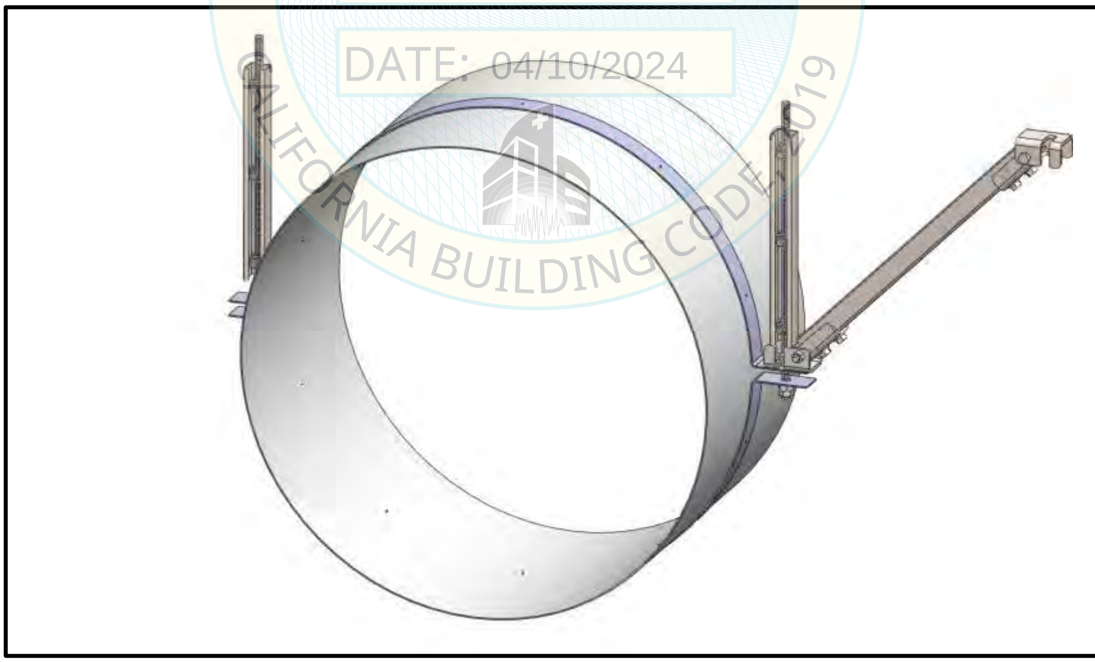
2.8 Transverse & Longitudinal Bracing for Trapeze Supported Rectangular Duct



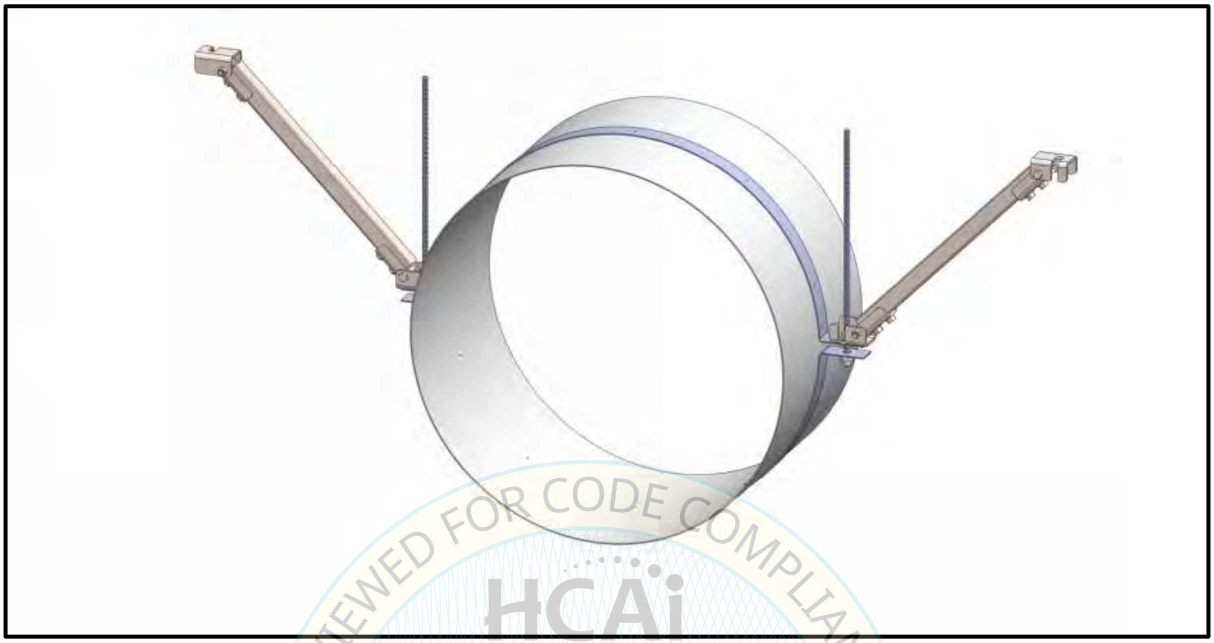
2.9 Single & Dual Transverse Bracing for Metal Strap Supported Round Duct

Single Transverse Bracing

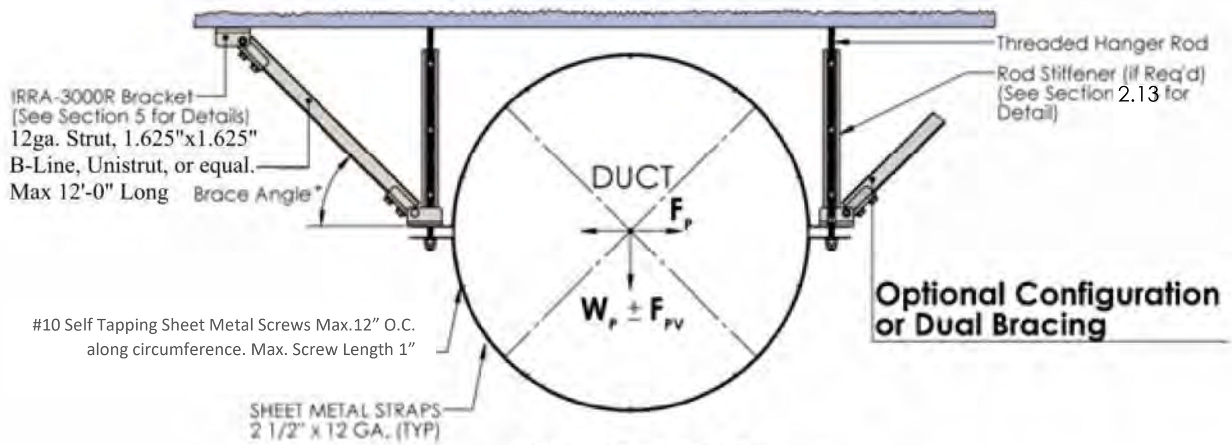




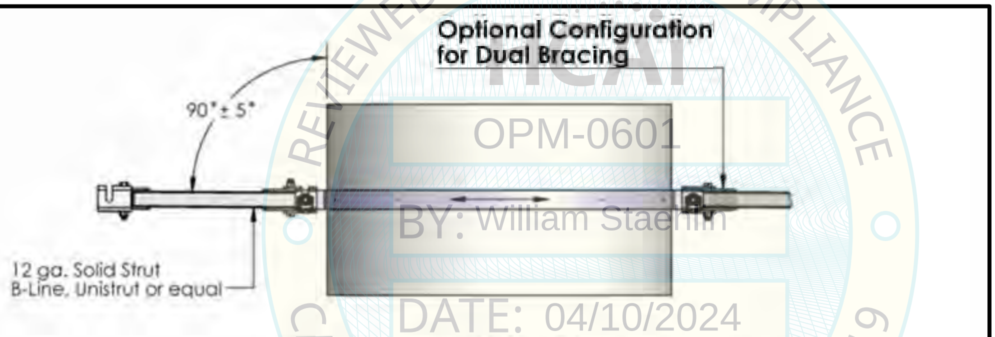
Dual Transverse Bracing



Single & Dual Transverse Bracing for Metal Strap Supported Round Duct



Elevation View
(Showing Transverse Bracing Only)

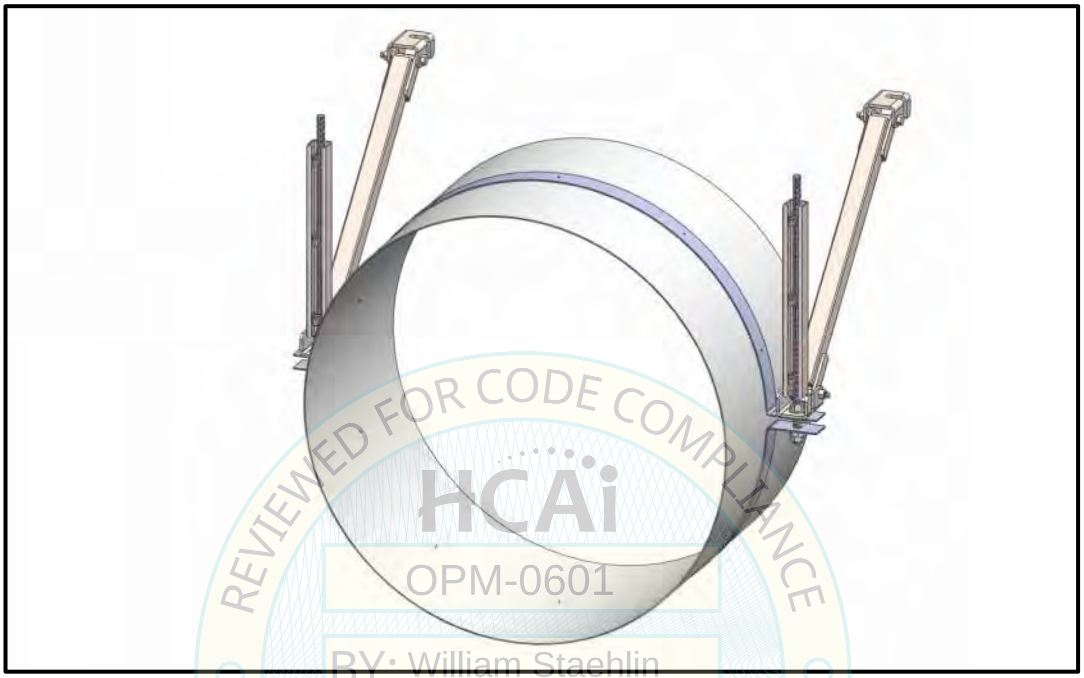


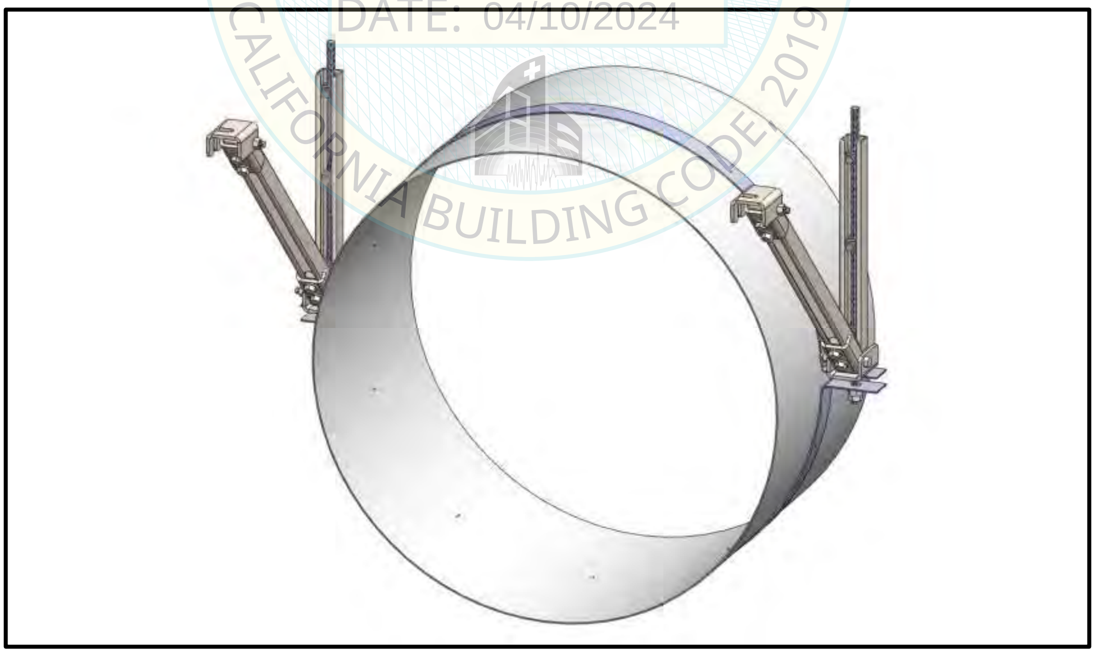
PLAN VIEW
(Showing Transverse Bracing Only)

All Thread Rod Size	Transverse Assembly Allowable Load F_P (ASD)		
	Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
3/8"	549	234	507
1/2"	549	234	507

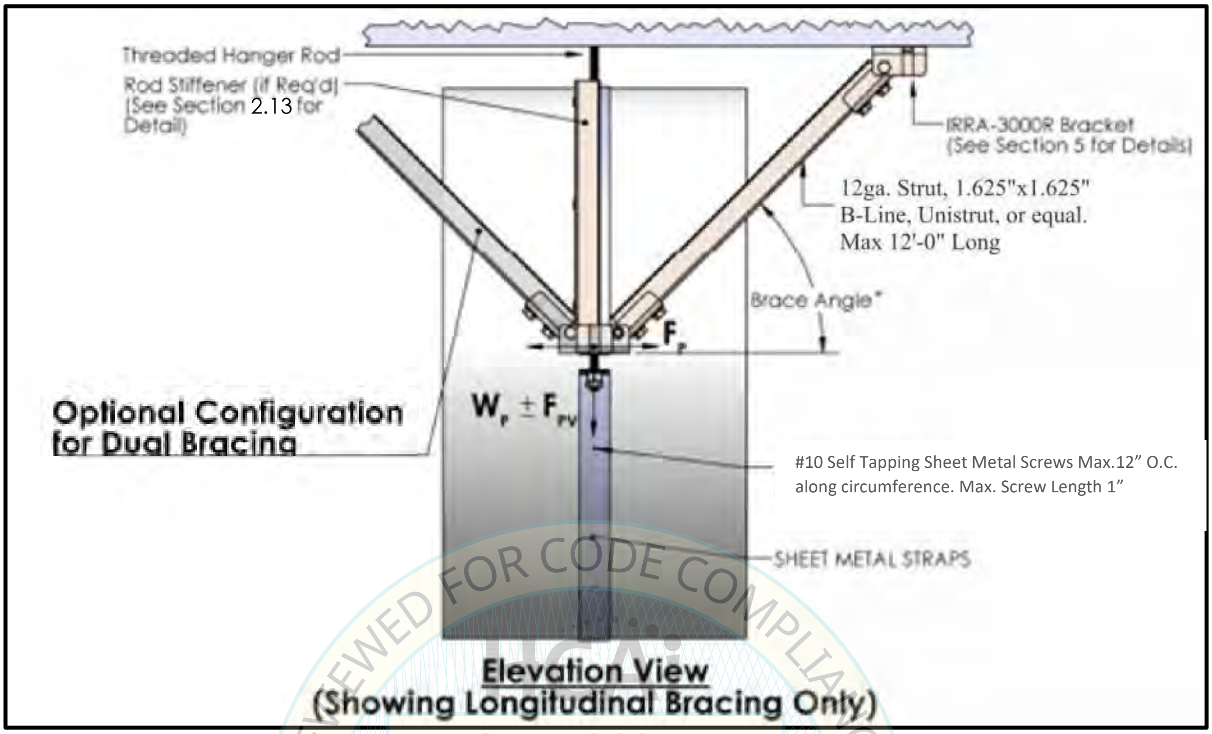
2.10 Dual Longitudinal Bracing for Metal Strap Supported Round Duct

Dual Longitudinal Bracing

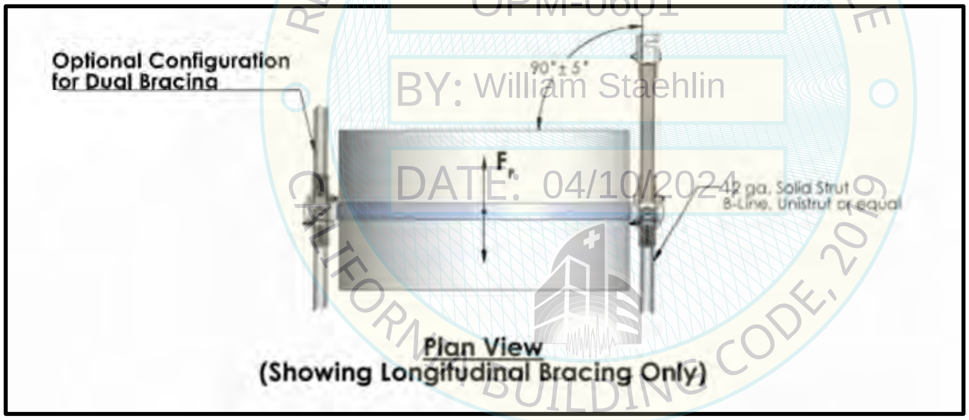




Single & Dual Longitudinal Bracing for Metal Strap Supported Round Duct



Elevation View
(Showing Longitudinal Bracing Only)

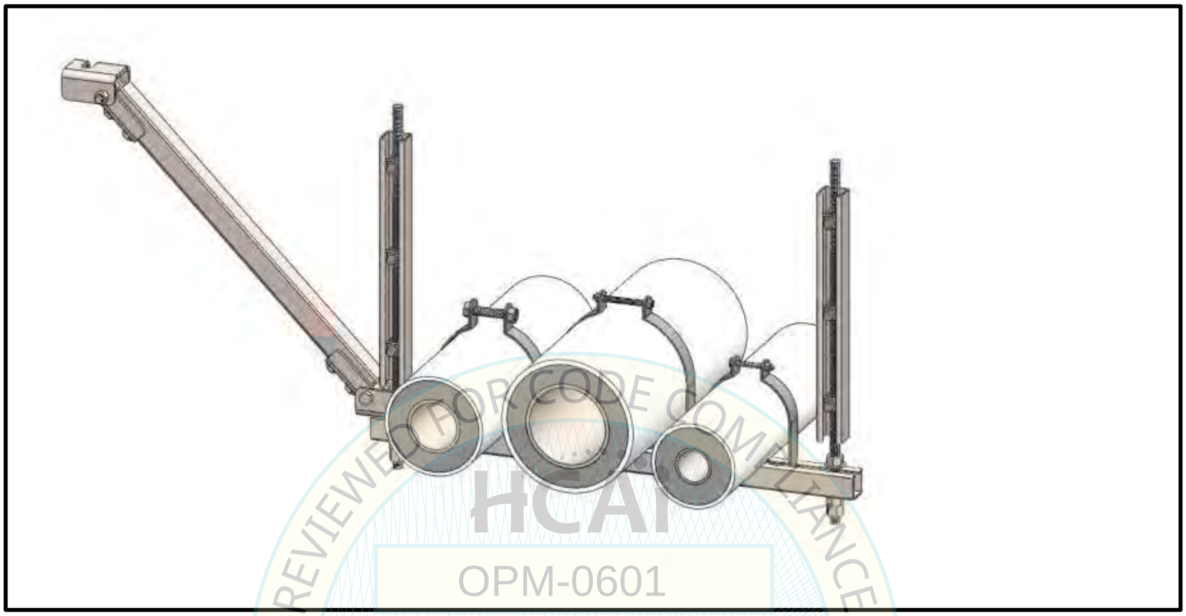


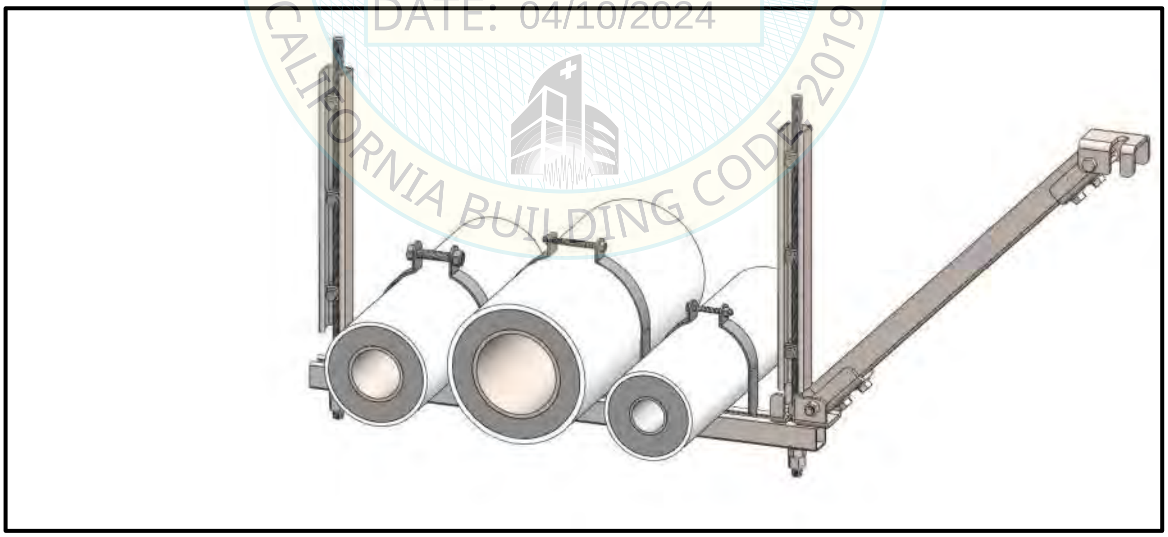
Plan View
(Showing Longitudinal Bracing Only)

All Thread Rod Size	Longitudinal Assembly Allowable Load F_P (ASD)		
	Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
3/8"	463	492	440
1/2"	463	492	440

2.11 Single & Dual Transverse Bracing for Trapeze Supported Pipe/Conduit

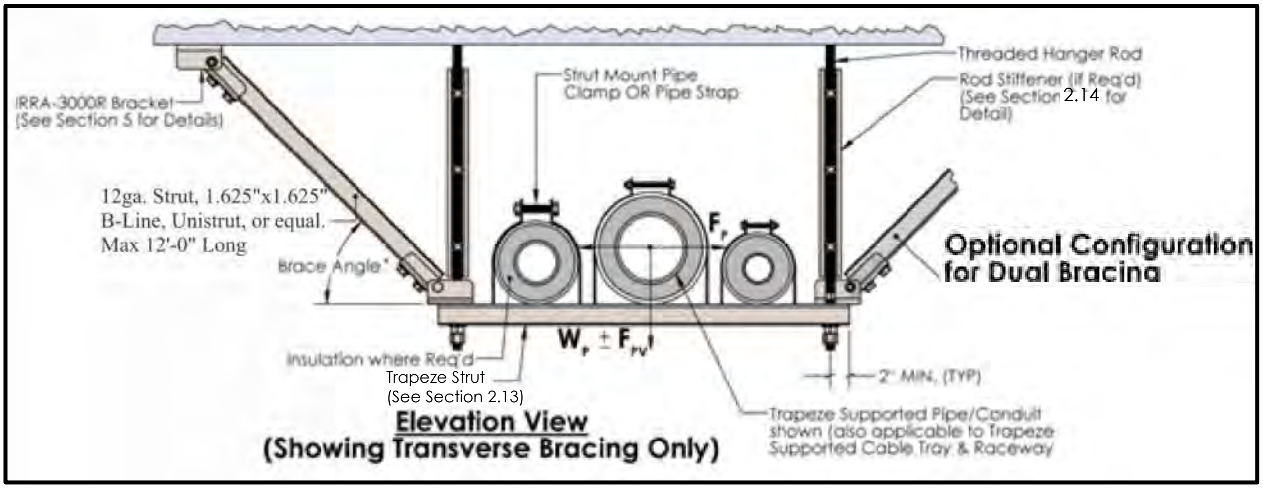
Single Transverse Bracing



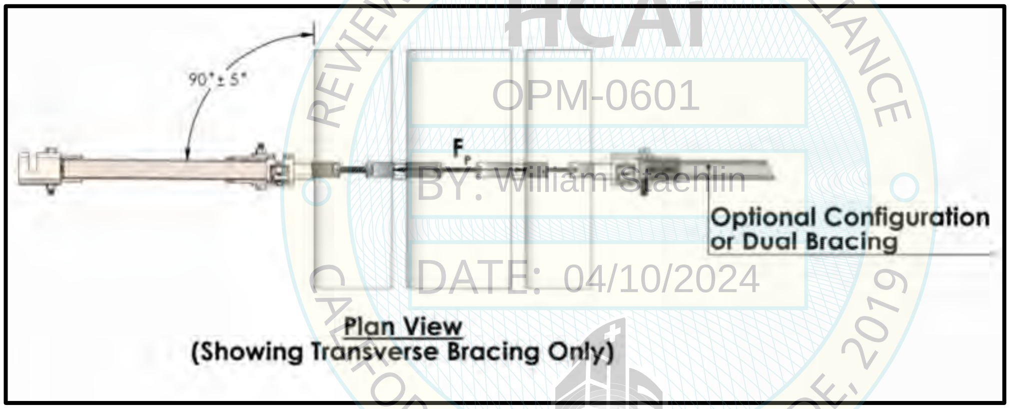


Dual Transverse Bracing

Single & Dual Transverse Bracing for Trapeze Supported Pipe/Conduit



Note: Rigid Insulation or rigid blocks to be used at pipe hanger and brace locations to prevent insulation crushing



Single & Dual Transverse Bracing for Trapeze Supported Pipe/Conduit

All Thread Rod Size	Transverse Assembly Allowable Load F_P (ASD)		
	Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
3/8"	549	234	507
1/2"	549	234	507

NOTES:

1. LOADS LISTED ABOVE ARE FOR SCHEDULE 10 AND BETTER PIPING. THE FOLLOWING REDUCTIONS SHALL APPLY FOR OTHER PIPING AND SYSTEMS:
   a. PIPING WITH INSULATION – REDUCE LOADS BY 25% FOR 1''-2'' PIPES, 32% FOR 2.5''-3.5'' PIPES AND 43% FOR 4''-8'' PIPES.
   b. THIN WALL PIPING – REDUCE LOADS BY 0%
   c. CONDUITS INCLUDING EMT – REDUCE LOADS BY 15%

2. MOUNTING HARDWARE FOR PIPE CLAMP OR PIPE STRAP SEE BELOW:

   USE ¼'' x 1 ¼'' HARDWARE ON 1 1/2" PIPE AND SMALLER (TORQUE TO 6 ft·lbs).

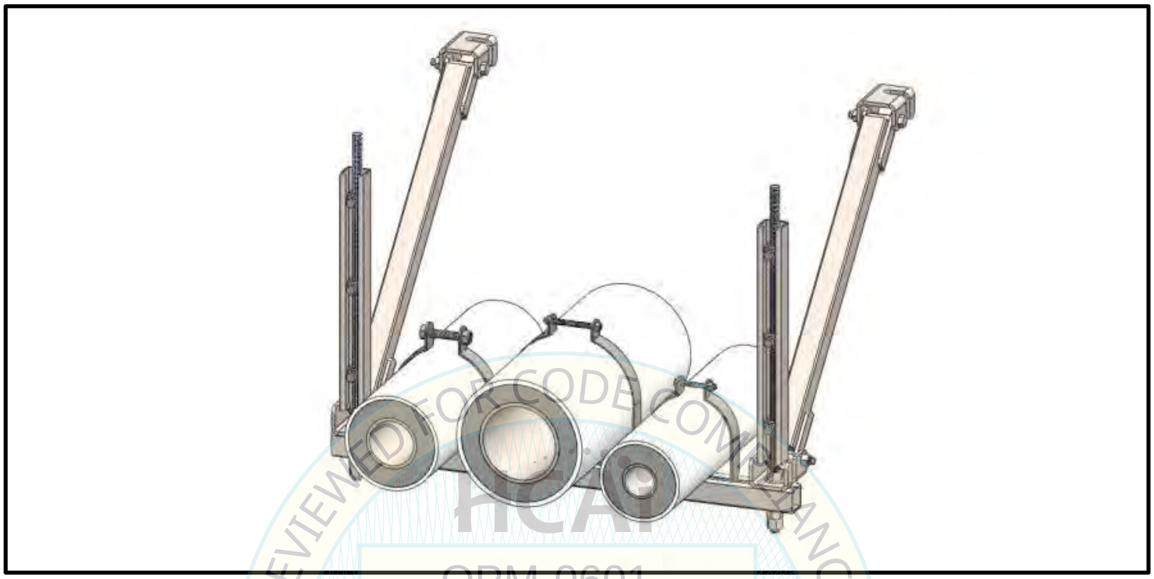
   USE 3/8'' x 1 ¼'' HARDWARE ON 2'' – 3 1/2'' PIPE (TORQUE TO 19 ft·lbs).

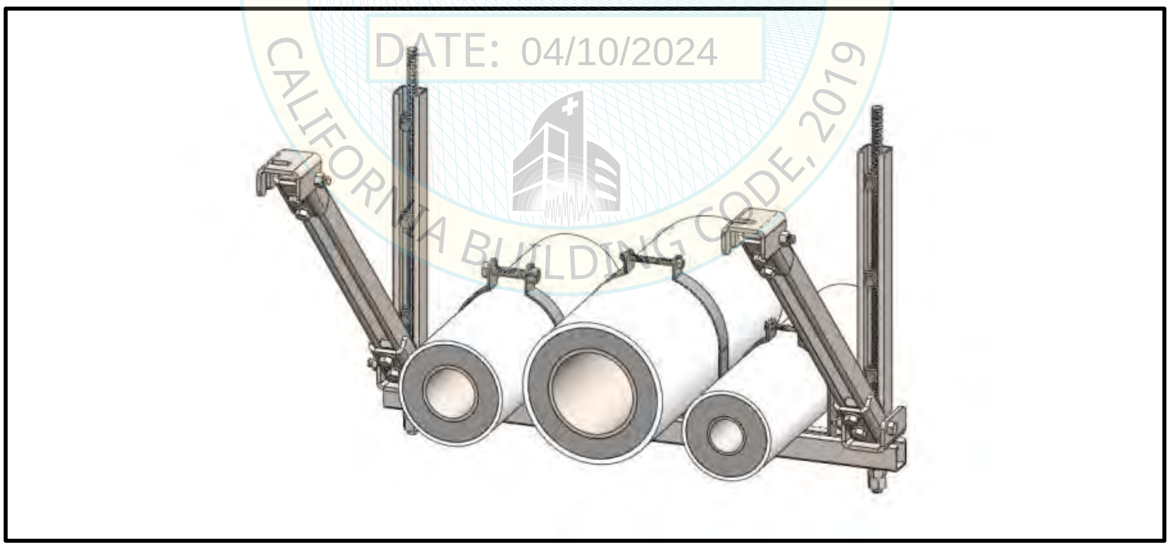
   USE ½'' x 1 ¼'' HARDWARE ON 4'' PIPES AND LARGER (TORQUE TO 50 ft·lbs).

3. FOR BRACES LONGER THAN 12 FT, A SPECIFIC DESIGN OF THE BRACE FOR COMPRESSION MUST BE PERFORMED.

2.12 Dual Longitudinal Bracing for Trapeze Supported Pipe/Conduit

Dual Longitudinal Bracing





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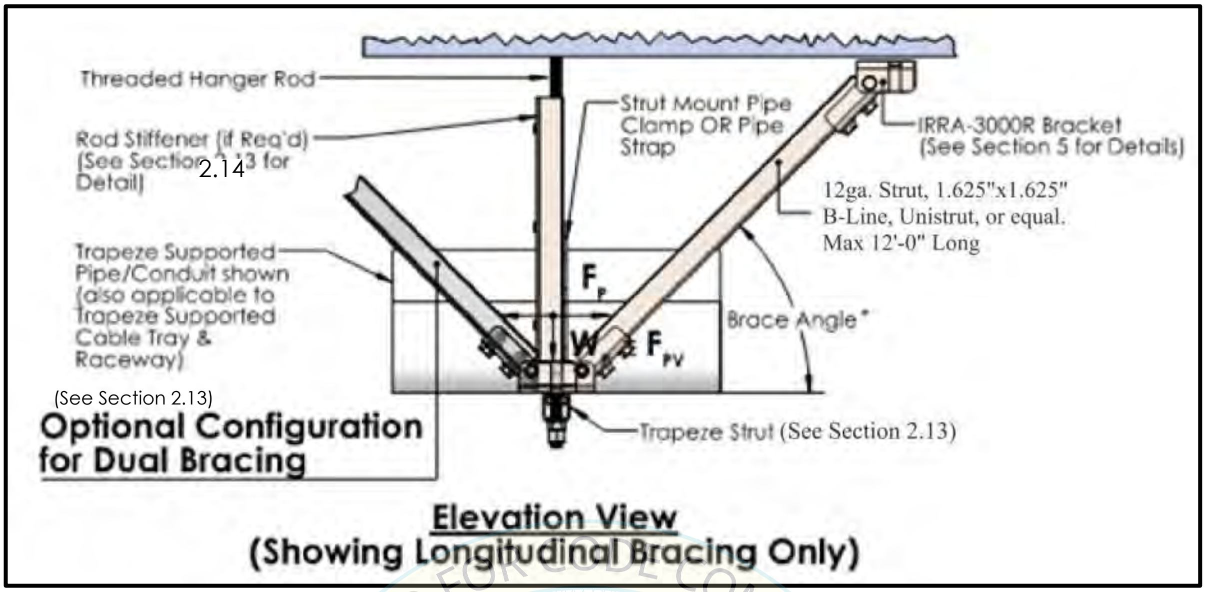
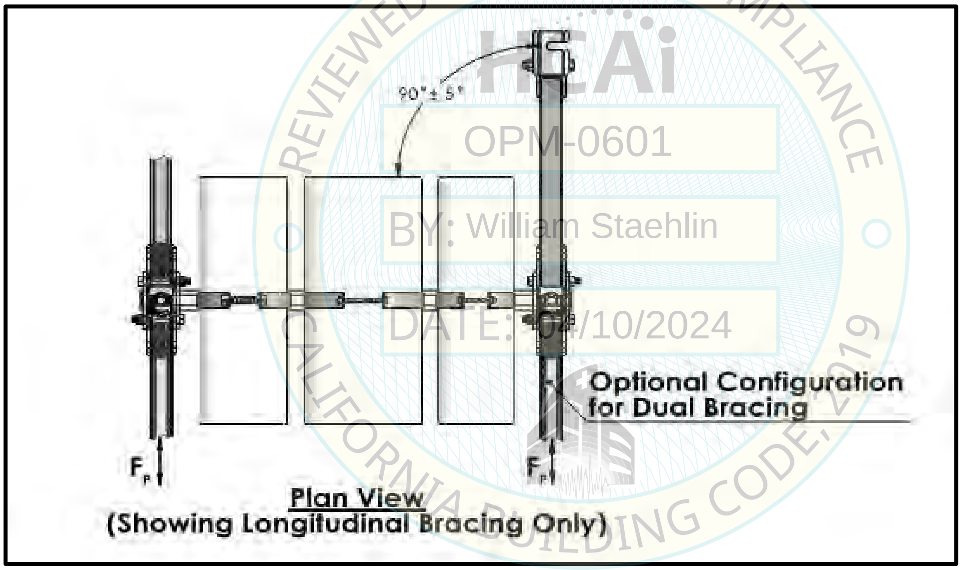
S.E. #S5877 (CA)





All Thread Rod Size	Longitudinal Assembly Allowable Load F_P (ASD)		
	Brace Angle Measured From Horiz. [lbs]		
	30°	31° - 45°	46° - 60°
3/8"	463	492	440
1/2"	463	492	440

NOTE: FOR BRACES LONGER THAN 12 FT, A SPECIFIC DESIGN OF THE BRACE FOR COMPRESSION MUST BE PERFORMED.

2.13 Maximum Supporting Weight for Strut

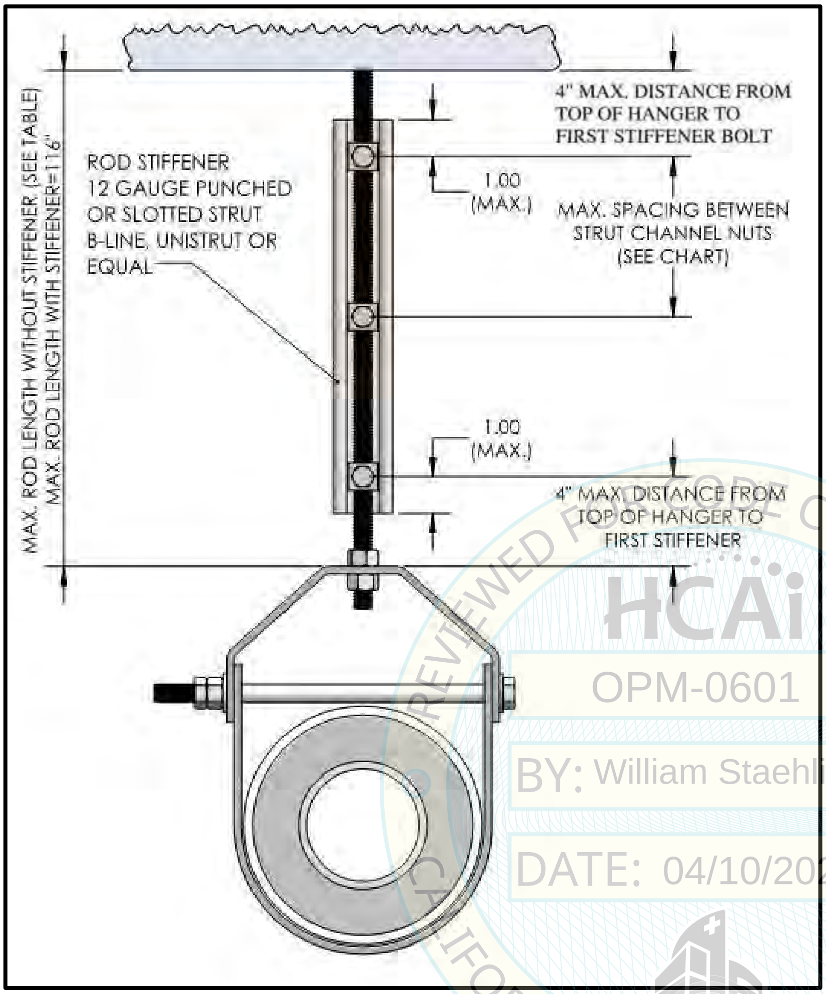
Trapeze Span (in)	Allowable Load Per Trapeze (lbs)	
	Single Strut	*Double Strut*
24	*1349*	*3823*
36	*897*	*2544*
48	*670*	*1902*
60	*533*	*1517*
72	*442*	*1258*
84	*376*	*1073*
96	*326*	*933*
108	*287*	*824*
120	*255*	*736*
144	*207*	*602*
168	*172*	*505*
192	*145*	*430*
216	*123*	*371*
240	*105*	*322*

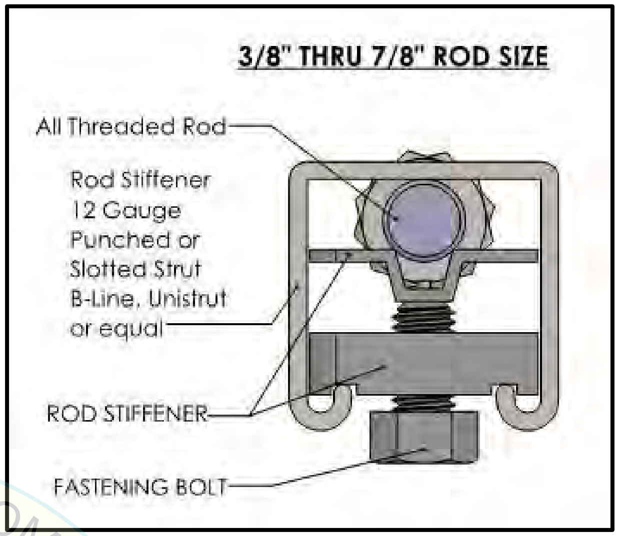
NOTES:

1. STRUTS ARE ASSUMED TO BE 1.625" x1.625" x12ga. SINGLE STRUT REFERS TO UNISTRUT P1000 OR EQUIVALENT. DOUBLE STRUT REFERS TO UNISTRUT P1001 OR EQUIVALENT.

2. CAPACITIES ARE BASED ON A UNIFORM LOAD OVER THE MIDDLE 75% OF THE TRAPEZE.

2.14 Rod Stiffener





Rod Size	Max. Rod Length Without Rod Stiffener	Max. Compression Force without Stiffener	Max. Spacing Between Strut Channel Nuts	Max. Compression Force with Stiffener
3/8"	18"	410	13"	1246
1/2"	25"	730	18"	2105
5/8"	31"	1160	23"	3187
3/4"	37"	1690	28"	4493
7/8"	43"	2320	33"	6021

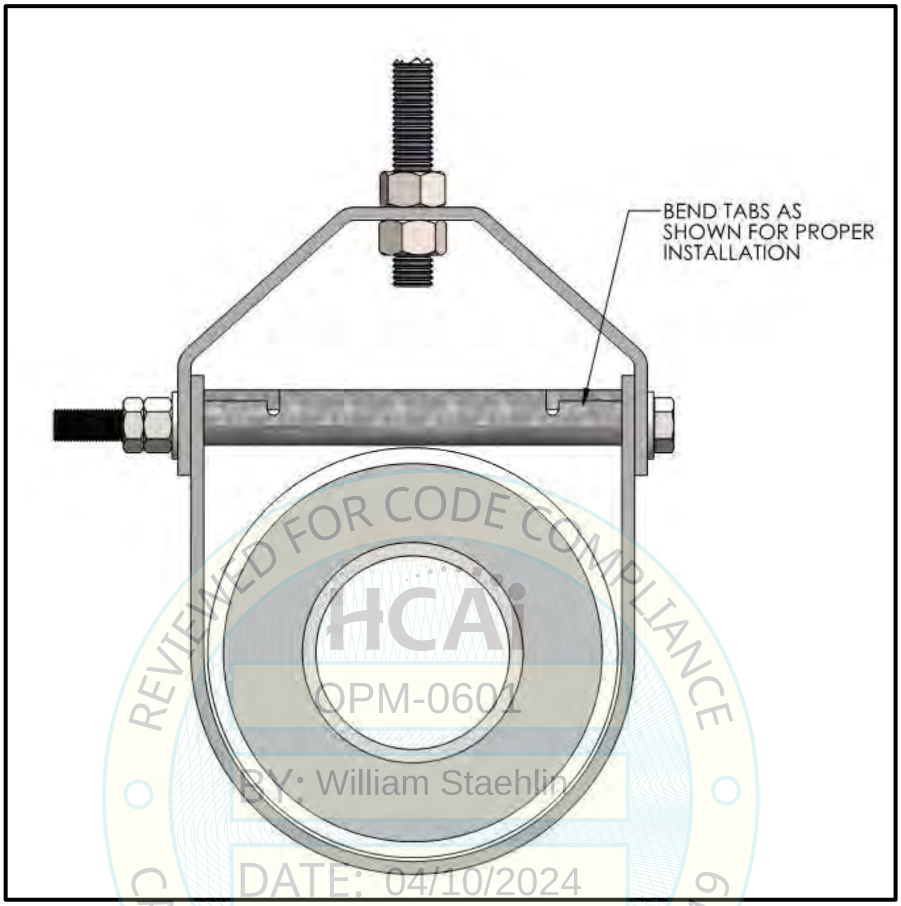
Notes:

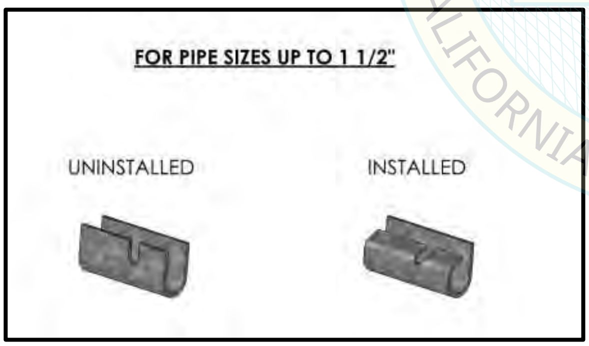
1) ROD STIFFENERS ARE REQUIRED ONLY ON VERTICAL STRUT COMPONENT OF THE SEISMIC BRACE SYSTEM ON HANGER AND TRAPEZE ASSEMBLIES THAT HAVE SEISMIC BRACING ATTACHED AT OR WITHIN 4" OF THE ROD. A MINIMUM OF TWO ROD STIFFENERS MUST BE INSTALLED.

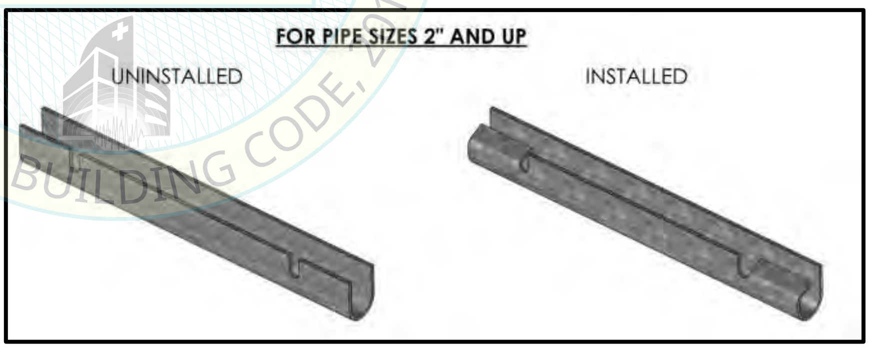
2) DETAIL APPLIES TO ALL HUNG UTILITIES INCLUDING SINGLE HUNG UTILITIES, TRAPEZE HUNG UTILITIES, AND HUNG EQUIPMENT.

3) AN EXCEPTION IS THE USE OF TWO OPPOSING RIGID BRACES AT THE SAME LOCATION. FOR INDIVIDUALLY HUNG PIPE THE TWO OPPOSING RIGID BRACES MUST BE AT THE SAME HANGER ROD; TOTAL OF TWO (2) FOR TRANSVERSE, OR TWO (2) FOR LONGITUDINAL. FOR A TRAPEZE HANGER THE TWO OPPOSING RIGID BRACES MUST BE AT THE SAME HANGER ROD; TOTAL OF TWO (2) FOR TRANSVERSE, OR FOUR (4) FOR LONGITUDINAL. THE TWO OPPOSING BRACES MUST BE AT THE SAME ANGLE FROM HORIZONTAL AND WITHIN 5-DEGREES OF 180 DEGREES FROM EACH OTHER. IN THIS CASE NO STIFFENING OF VERTICAL ROD IS NECES

2.15 Cross Bolt Spacer







Notes:

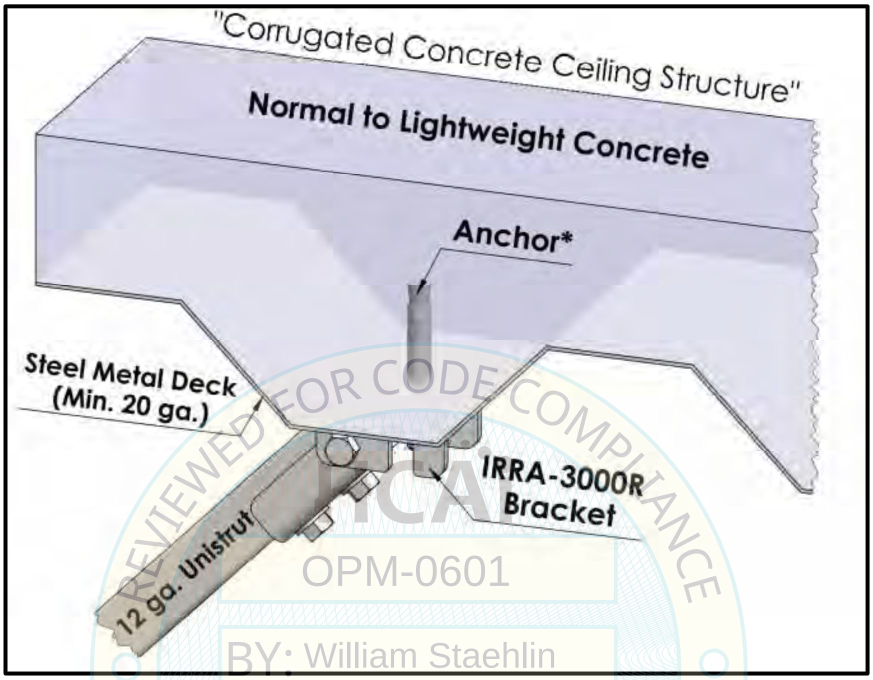
1) CROSS BOLT SPACER ONLY REQUIRED AT SEISMIC BRACING LOCATIONS
2) RIGID INSULATION OR RIGID BLOCKS TO BE USED AT PIPE HANGER AND BRACE LOCATIONS TO PREVENT INSULATION CRUSHING.

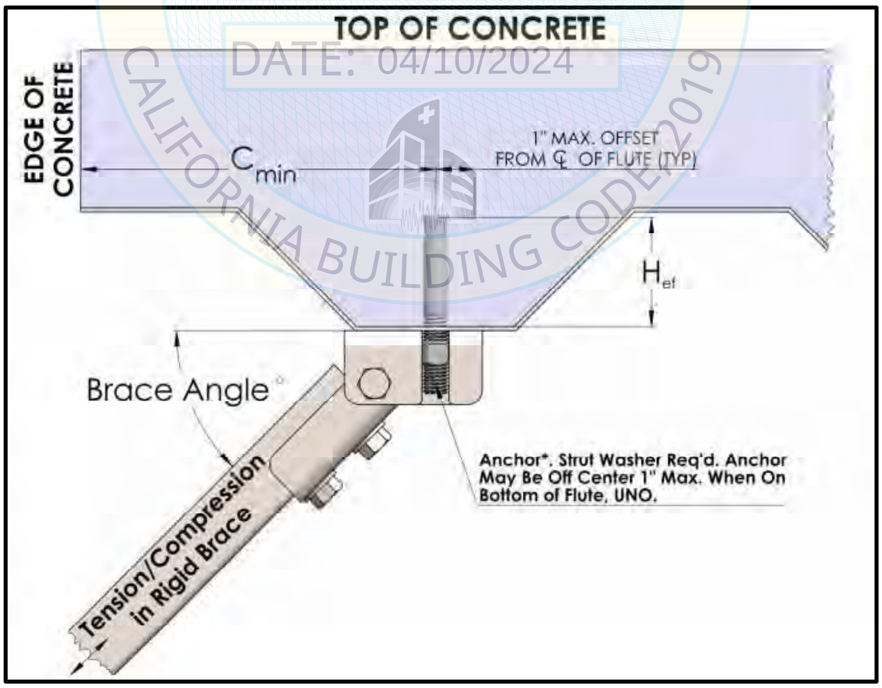
SECTION 3.0 RIGID RESTRAINT STRUCTURAL ATTACHMENT

3.1 Concrete over Metal Deck

3.1.1 Post-installed Wedge Anchor

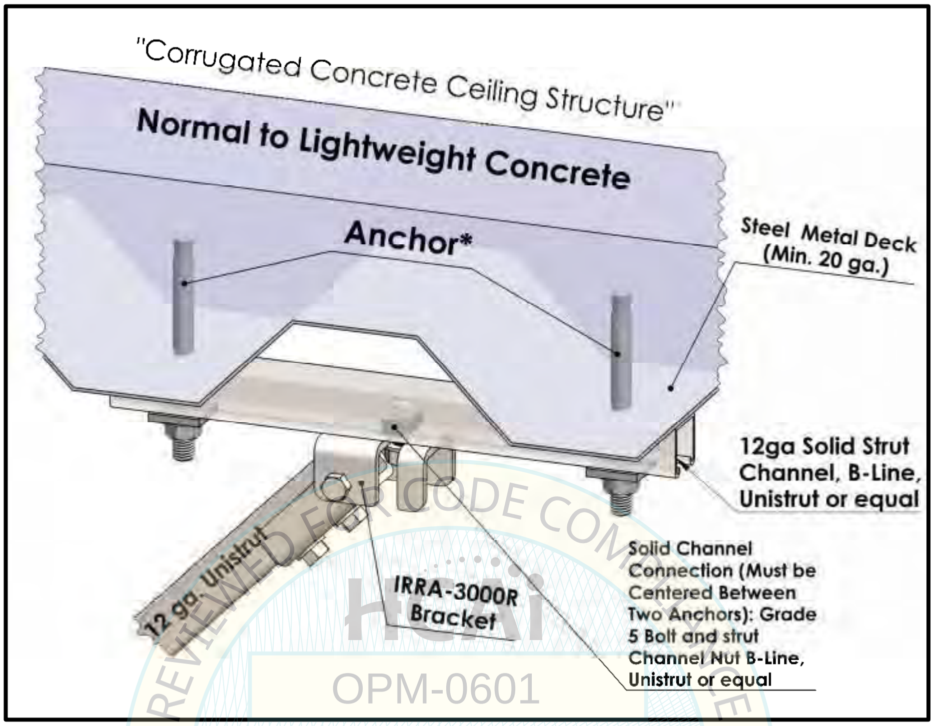
Single Anchor

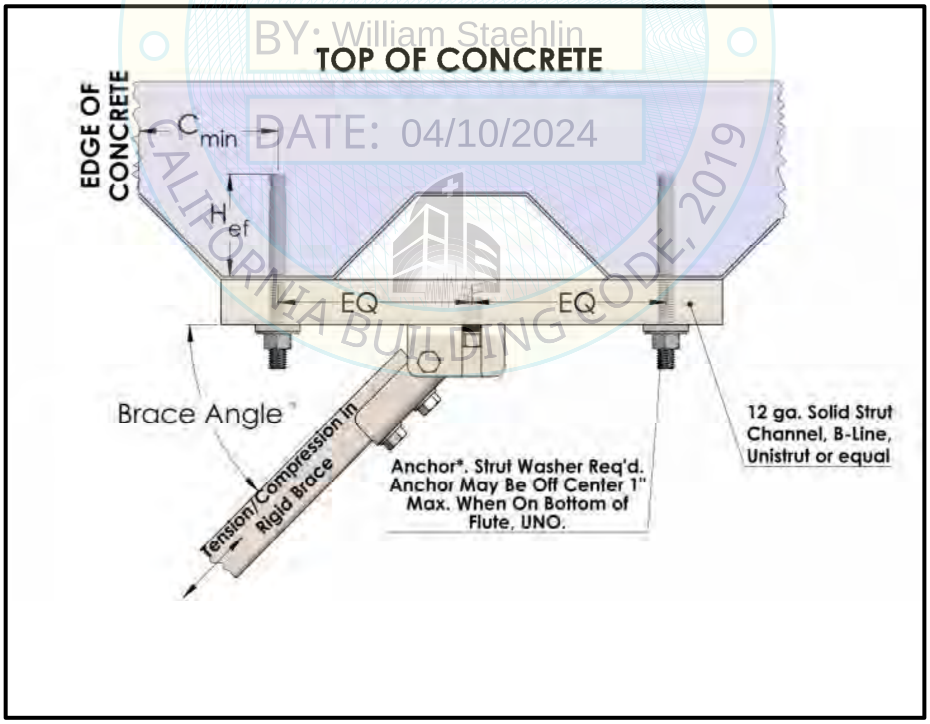




Metal Deck – Rigid Restraint Attachment

Double Anchor w/ Solid Channel





*Type/Brand of Anchor Specified in Section 3.1.1.1

Metal Deck – Rigid Restraint Attachment

3.1.1.1 Hilti KB-TZ2 Anchor

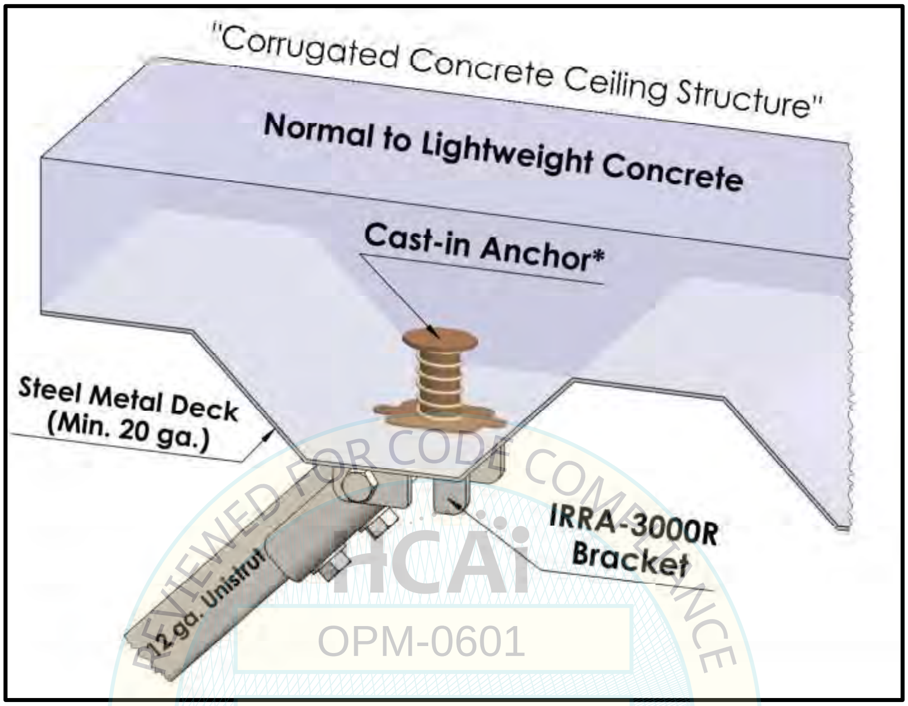
Anchor Dia.	Min. Effective embed. Depth hef	Cmin' Min. Edge Distance	Min. Spacing Between Anchors on Same Flute	Strength Design Seismic Capacity					
				Max. Horizontal Load Brace Angle Measured From Horizontal					
				Single (LB)			Double (LB)		
				0°-30°	31°-45°	46°-60°	0°-30°	31°-45°	46°-60°
3/8"	2"	6 3/4"	12"	1050	800	550	2100	1600	1100
1/2"	2"	6 3/4"	12"	1060	790	530	2120	1580	1060
1/2"	3 1/4"	9 3/4"	12"	1820	1300	850	3640	2600	1700
5/8"	4"	12"	12"	2500	1780	1120	5000	3560	2240

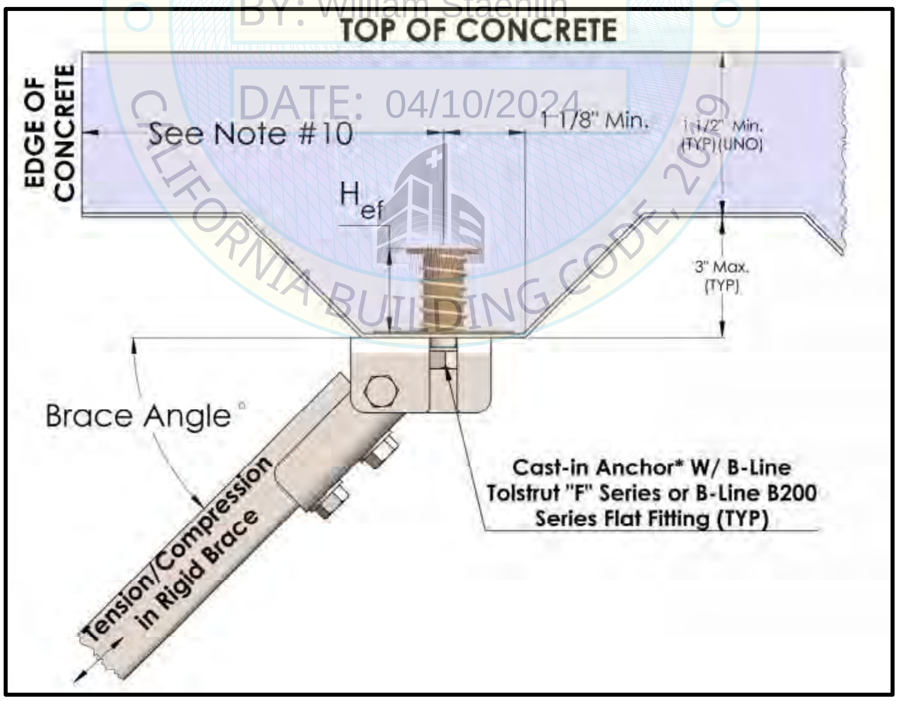
NOTES:

1. CAPACITIES ARE FOR ANCHORS INSTALLED IN STONE AGGREGATE CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS.
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266.
4. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
5. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
6. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
7. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
8. IRRA-3000R ATTACHMENT DIAMETER SHALL BE EQUAL TO THE ANCHOR DIAMETER.
9. STRUT HOLE SIZE SHALL BE NO LARGER THAN BOLT DIAMETER PLUS 1/16" PER AISI.
10. HOLE DIAMETER THROUGH METAL DECK MAY NOT EXCEED ANCHOR HOLE DIAMETER BY MORE THAN 1/8" PER ICC-ESR.
11. S-MAX (MAX SPACING BETWEEN ANCHORS ON SAME FLUTE) NOT TO EXCEED 21 INCHES

3.1.2 Cast-In Anchor

Single Anchor

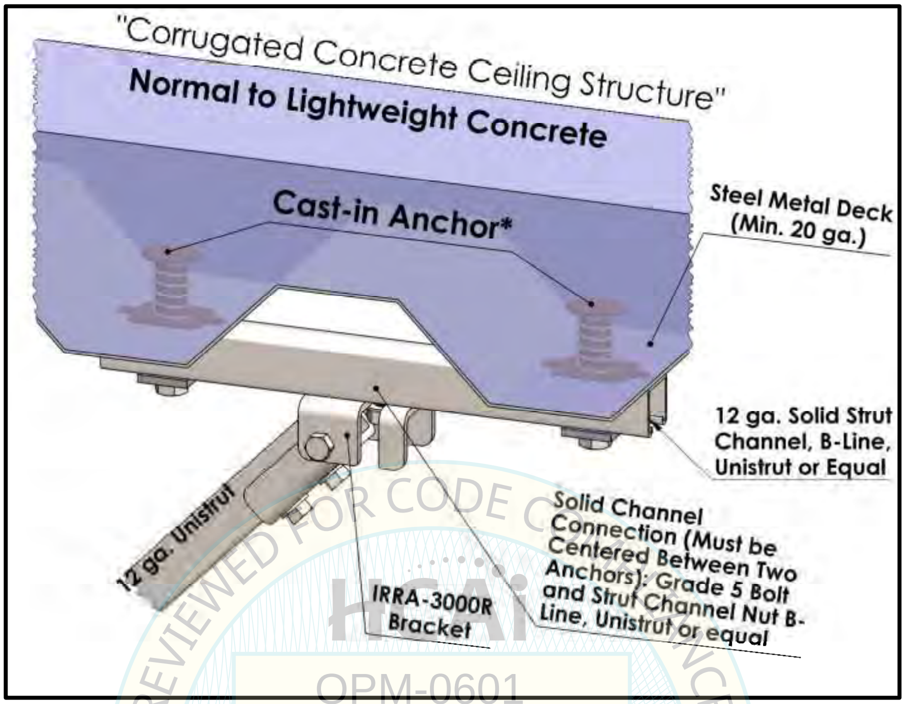


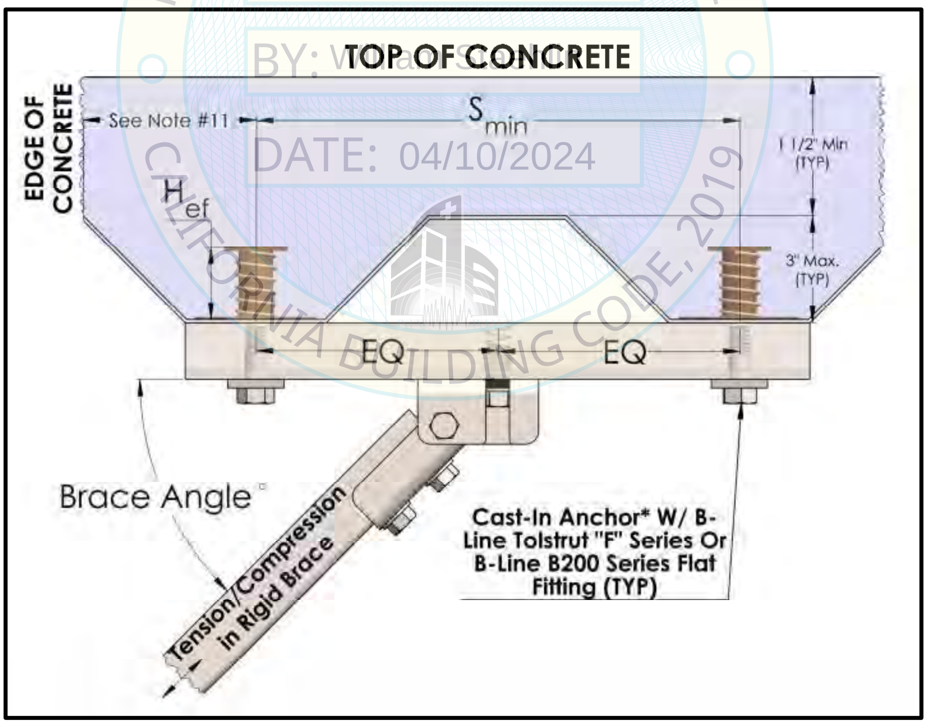


*Type/Brand of Cast-In Anchor Specified in Section 3.1.2.1

Metal Deck – Rigid Restraint Attachment

Double Anchor w/ Solid Channel





*Type/Brand of Cast-In Anchor Specified in Section 3.2.2.1

Metal Deck – Rigid Restraint Attachment

3.1.2.1 Hilti KCM-MD Headed Stud Cast-In Anchor

Anchor Dia.	Min. Anchor Effective Depth	Strength Design Seismic Capacity					
		Upper Flute Max. Horizontal Load Brace Angle Measured From Horiz. (LB)			Lower Flute Max. Horizontal Load Brace Angle Measured From Horiz. (LB)		
		0° - 30°	31° - 45°	46° - 60°	0° - 30°	31° - 45°	46° - 60°
3/8"	1 3/4"	1900	1380	900	1100	740	470
1/2"	2"	2850	1900	1200	1400	950	600
5/8"	2 1/2"	3700	2400	1500	1700	1120	700
3/4"	2 1/2"	3850	2500	1550	1700	1130	700

NOTES:

1. CAPACITIES ARE FOR ANCHORS INSTALLED IN 3,000 PSI SAND LIGHTWEIGHT CONCRETE.
4. HOLE MUST BE MADE IN THE STEEL DECK USING A STEP-DRILL, HOLE SAW, DECK PUNCH OR EQUIVALENT IN ACCORDANCE WITH THE ANCHOR DIAMETER.
5. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
6. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS AND ANCHOR EMBEDMENT. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
7. MINIMUM SPACING BETWEEN INSERTS SHALL BE 3 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER (WHICH EVER IS GREATER), UNLESS NOTED OTHERWISE.
8. IRRA-3000R ATTACHMENT DIAMETER SHALL BE EQUAL TO THE ANCHOR DIAMETER.
9. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER WHICHEVER IS GREATER, UNLESS NOTED OTHERWISE.
10. FOLLOW ALL Hilti KCM-MD INSTALLATION REQUIREMENTS PER ICC-ESR 4145.
11. S-MAX (MAX SPACING BETWEEN ANCHORS) NOT TO EXCEED 17 INCHES

3.1.2.2 Hilti KCM-MD Headed Stud Cast In Anchor – Double Anchors

Anchor Dia.	Min. Anchor Effective Depth	Strength Design Seismic Capacity Lower Flute Double Anchors Max. Horizontal Load Brace Angle Measured From Horiz. (LB)		
		0° - 30°	31° - 45°	46° - 60°
3/8"	1 3/4"	2200	1480	940
1/2"	2"	2800	1900	1200
5/8"	2 1/2"	3400	2240	1400
3/4"	2 1/2"	3400	2260	1400

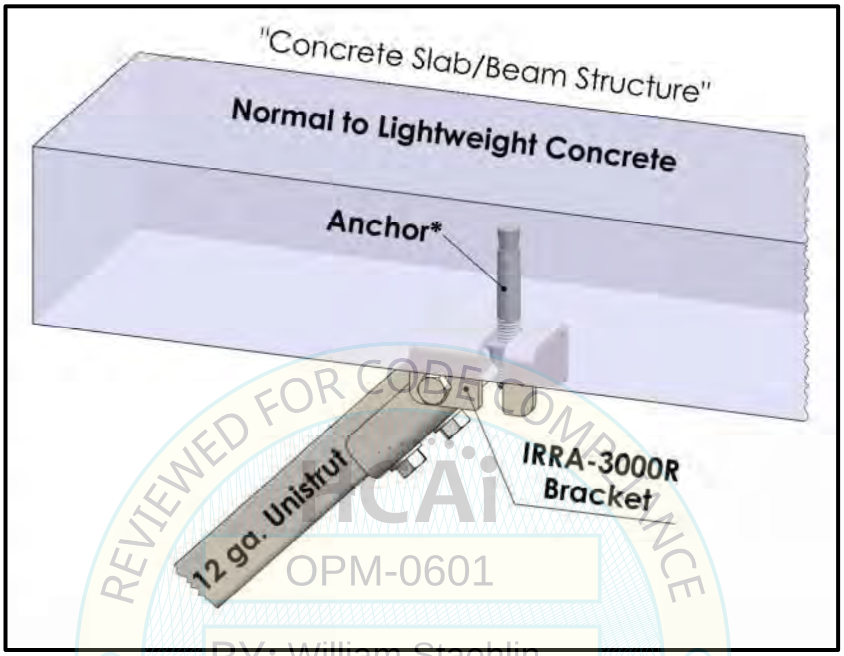
NOTES:

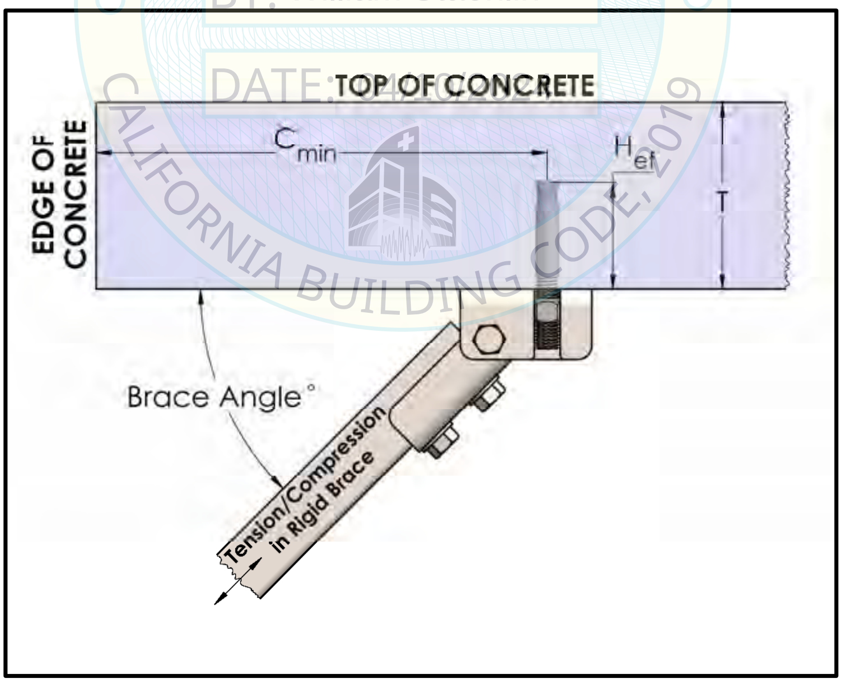
1. CAPACITIES ARE FOR ANCHORS INSTALLED IN 3,000 PSI SAND LIGHTWEIGHT CONCRETE.
2. HOLE MUST BE MADE IN THE STEEL DECK USING A STEP-DRILL, HOLE SAW, DECK PUNCH OR EQUIVALENT IN ACCORDANCE WITH THE ANCHOR DIAMETER.
3. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
4. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS AND ANCHOR EMBEDMENT. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
5. MINIMUM SPACING BETWEEN INSERTS SHALL BE 3 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER (WHICH EVER IS GREATER), UNLESS NOTED OTHERWISE.
6. IRRA-3000R ATTACHMENT DIAMETER SHALL BE EQUAL TO THE ANCHOR DIAMETER.
7. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER WHICHEVER IS GREATER, UNLESS NOTED OTHERWISE.
8. FOLLOW ALL Hilti KCM-MD INSTALLATION REQUIREMENTS PER ICC-ESR 4145.
9. S-MAX (MAX SPACING BETWEEN ANCHORS) NOT TO EXCEED 17 INCHES

3.2 Concrete Slab/Beam

3.2.1 Post-installed Wedge Anchor

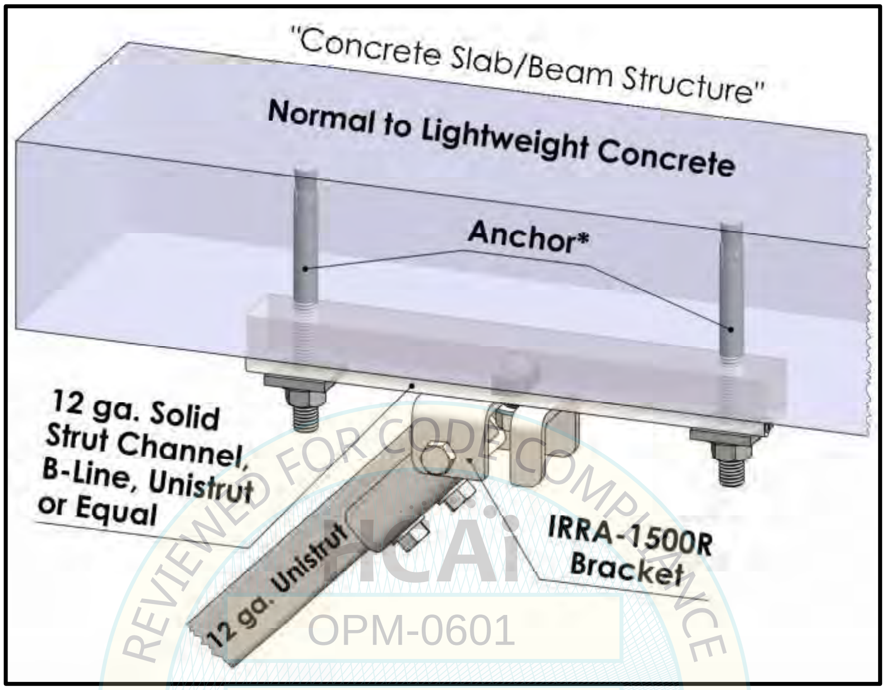
Single Anchor

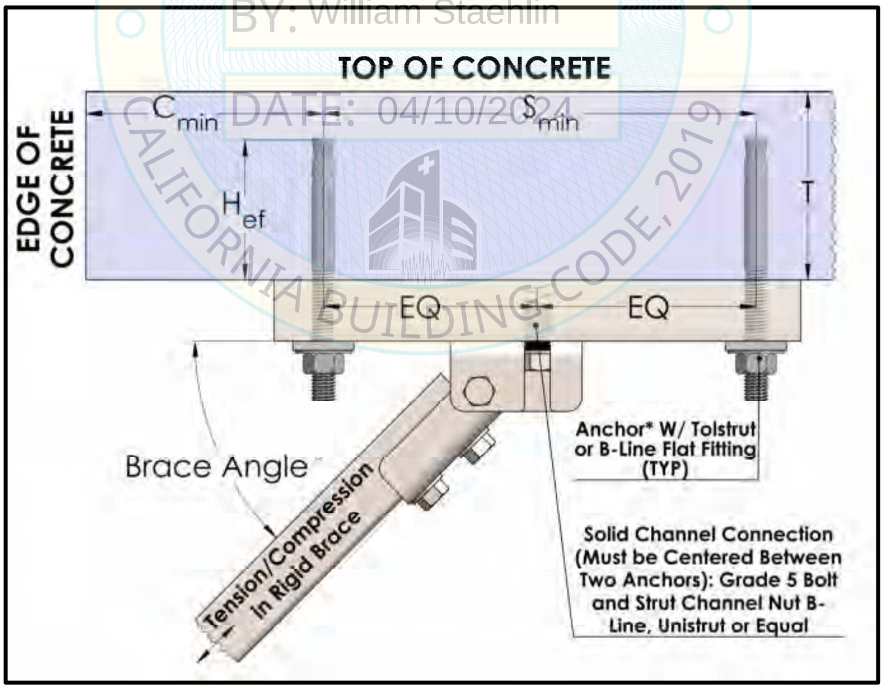




*Type/Brand of Anchor Specified in Section 3.2.1.1

Double Anchor w/ Solid Channel





*Type/Brand of Anchor Specified in Section 3.2.1.1

Concrete Slab/Beam – Rigid Restraint Attachment

3.2.1.1 Hilti KB-TZ2 Anchor

Anchor Dia.	Min. Effective embed. Depth hef	Cmin' Min. Edge Distance	Smin' Min. Spacing Between Anchors	T' Min. Base Material Thickness	Strength Design Seismic Capacity — Max. Horizontal Load Brace Angle Measured From Horizontal					
					Single (LB)			Double (LB)		
					0°-30°	31°-45°	46°-60°	0°-30°	31°-45°	46°-60°
3/8"	2"	6 3/4"	12"	4"	1600	1200	800	3200	2400	1600
1/2"	2"	6 3/4"	12"	4"	1600	1200	800	3200	2400	1600
1/2"	3 1/4"	9 3/4"	12"	6"	2900	2100	1400	5800	4200	2800
5/8"	3 1/4"	9 3/8"	12"	5"	4000	2700	1750	8000	5400	3500
5/8"	4"	12"	12"	6"	4200	2950	1900	8400	5900	3800
3/4"	3 3/4"	11 1/4"	12"	6"	5100	3500	2200	10200	7000	4400

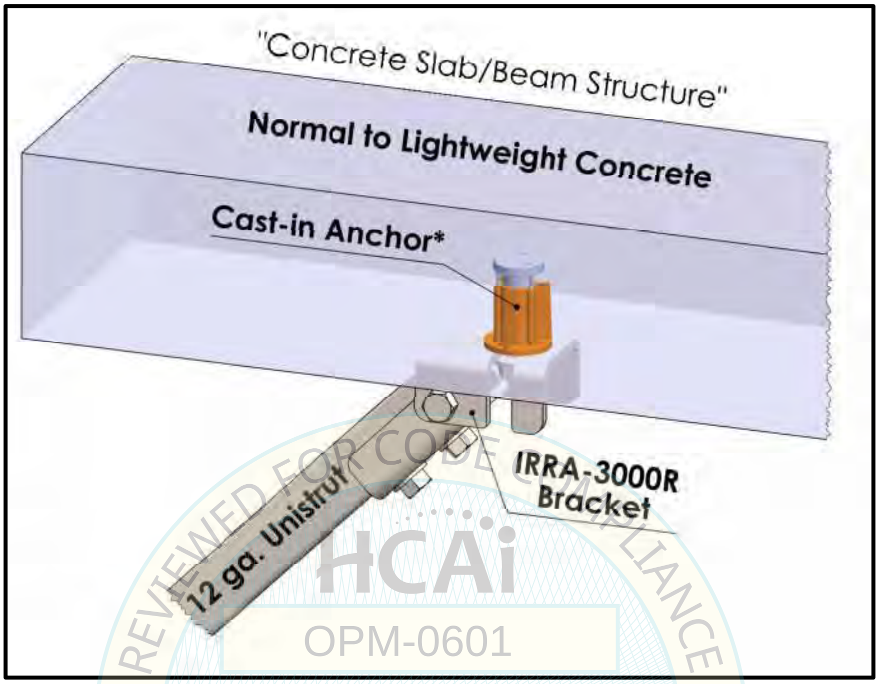
NOTES:

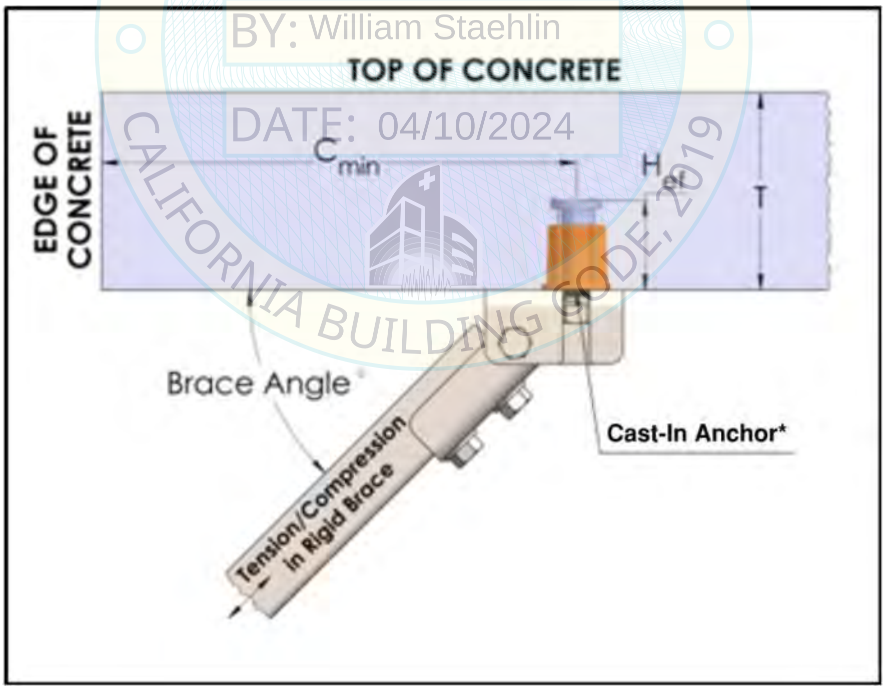
1. CAPACITIES ARE FOR ANCHORS INSTALLED IN STONE AGGREGATE CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS.
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266
4. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
5. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
6. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
7. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
8. IRRA-3000R ATTACHMENT DIAMETER SHALL BE EQUAL TO THE ANCHOR DIAMETER.
9. STRUT HOLE SIZE SHALL NOT BE LARGER THAN BOLT DIAMETER PLUS 1/16" PER AISI.
10. S-MAX (MAX SPACING BETWEEN ANCHORS) NOT TO EXCEED 17 INCHES

Concrete Slab/Beam – Rigid Restraint Attachment

3.2.2 Cast-In Anchor

Single Anchor

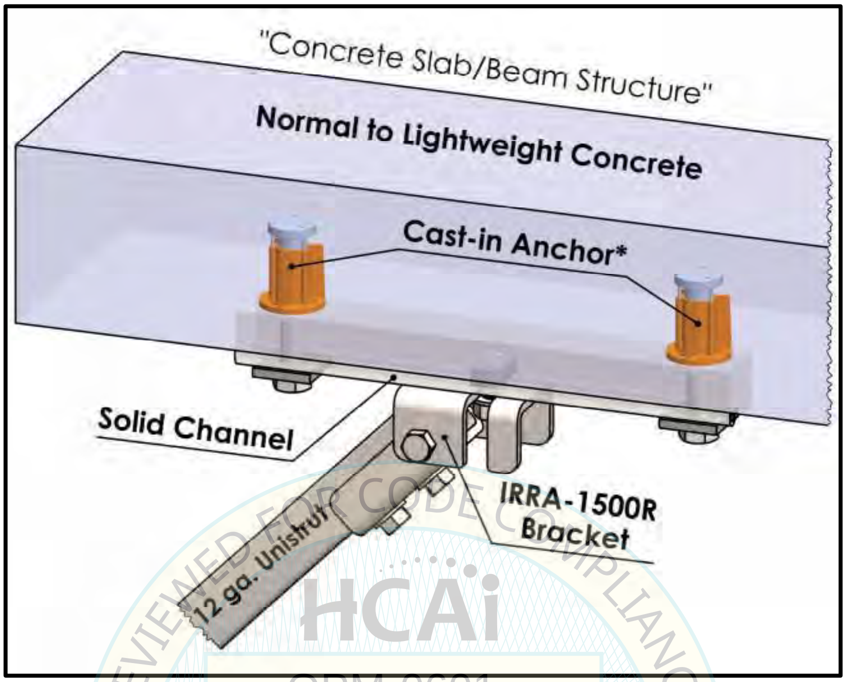


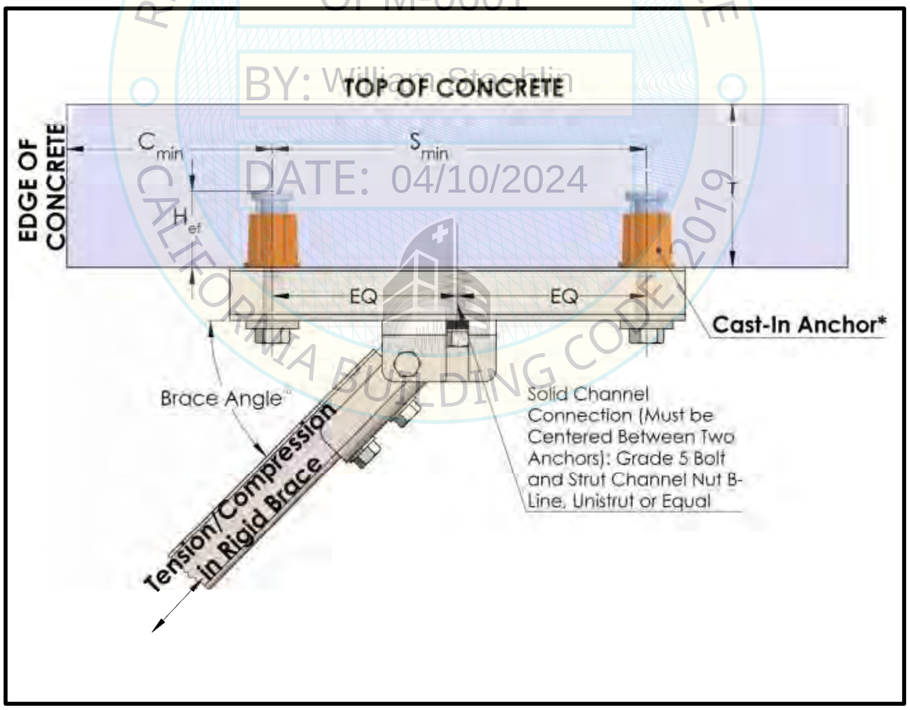


*Type/Brand of Cast-In Anchor Specified in Section 3.2.2.1

Concrete Slab/Beam – Rigid Restraint Attachment

Double Anchor w/ Solid Channel





*Type/Brand of Cast-In Anchor Specified in Section 3.3.3.1

3.2.2.1 Hilti KCM-WF Headed Stud Cast-In Anchor

Anchor Dia.	Min. Effective embed. Depth hef	T' Min. Base Material Thickness	Strength Design Seismic Capacity					
			Max. Horizontal Load Brace Angle Measured From Horiz (LB)					
			Single			Double		
			0° - 30°	31° - 45°	46° - 60°	0° - 30°	31° - 45°	46° - 60°
3/8"	1 3/4"	3 1/2"	1050	900	700	2100	1800	1400
1/2"	2"	4"	1700	1400	1050	3400	2800	2100
5/8"	2 1/2"	5"	2600	2100	1500	5200	4200	3000
3/4"	2 1/2"	5"	2600	2100	1500	5200	4200	3000

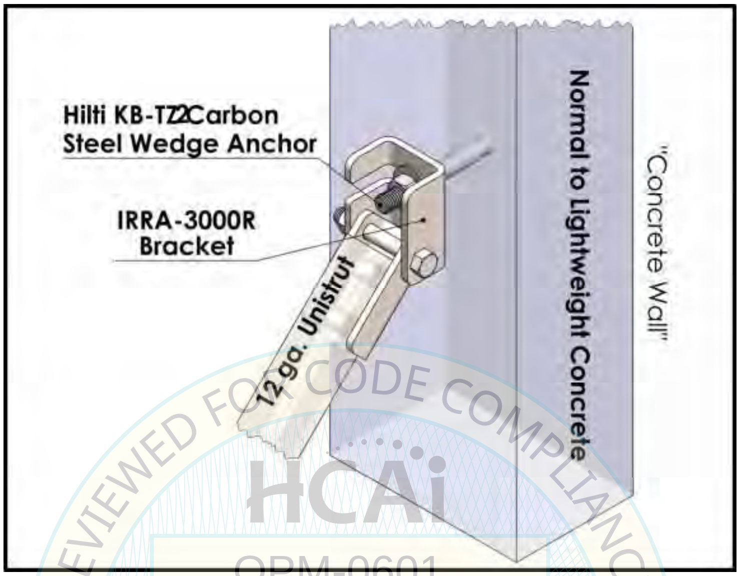
NOTES:

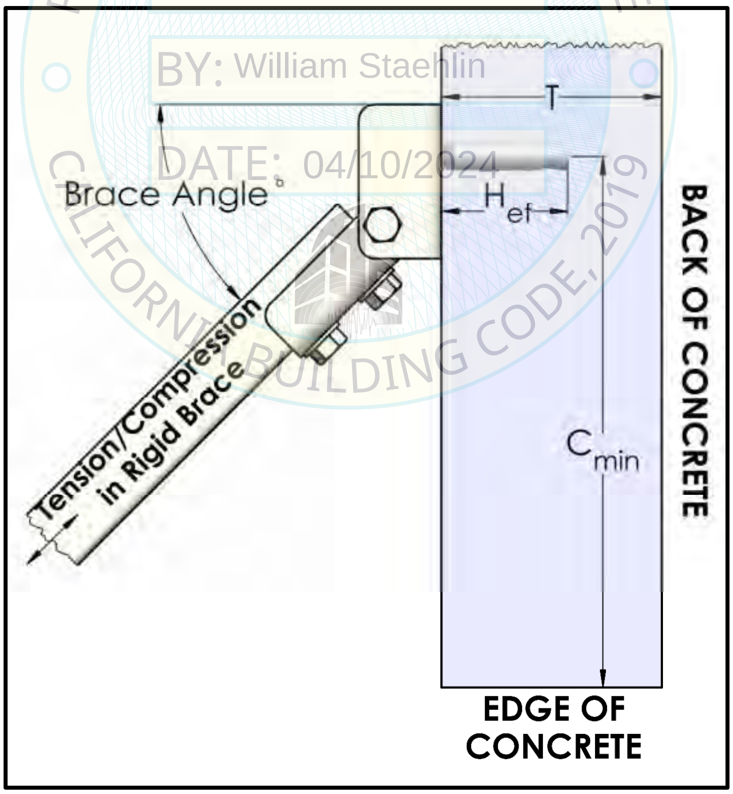
1. Hilti KCM-WF INSERTS MUST BE POSITIONED ON WOOD OR SIMILAR FORMWORK WITH ALL THREE NAILS IN CONTACT WITH THE FORM. THE HEAD OF THE Hilti KCM-WF MUST BE IMPACTED WITH SUFFICIENT FORCE TO DRIVE NAILS ALL THE WAY INTO THE FORMWORK UNTIL THE PLASTIC BASE SITS FLUSH AND TIGHT AGAINST THE FORM.
2. CAPACITIES ARE FOR 4,000 PSI NORMAL WEIGHT CONCRETE.
3. MINIMUM CONCRETE THICKNESS OF 2 TIMES THE EFFECTIVE EMBEDMENT DEPTH, OR THE EMBEDMENT DEPTH PLUS THREE TIMES THE DIAMETER, WHICHEVER IS GREATER, SHALL BE PROVIDED, UNLESS NOTED OTHERWISE.
4. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
5. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS AND ANCHOR EMBEDMENT. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
6. MINIMUM SPACING BETWEEN THE INSERTS SHALL BE 3 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER (WHICH EVER IS GREATER), UNLESS NOTED OTHERWISE.
7. Hilti KCM-WF IS A CAST-IN-PLACE ANCHOR BOLT AND COMPLIES WITH ACI 318 CHAPTER 17 AND DOES NOT REQUIRE ADDITIONAL TESTING CERTIFICATION.
8. IRRA-3000R ATTACHMENT DIAMETER SHALL BE EQUAL TO THE ANCHOR DIAMETER.
9. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER WHICHEVER IS GREATER, UNLESS NOTED OTHERWISE.
10. FOLLOW ALL Hilti KCM-WF INSTALLATION REQUIREMENTS PER ICC-ESR 4145.
11. S-MAX (MAX SPACING BETWEEN ANCHORS) NOT TO EXCEED 33 INCHES

3.3 Concrete Wall

3.3.1 Post-installed Wedge Anchor

Single Anchor





Concrete Wall – Rigid Restraint Attachment

3.3.1.1 Hiliti KB-TZ2 Anchor

Anchor Dia.	Min. Effective embed. Depth hef	Cmin' Min. Edge Distance	T' Min. Base Material Thickness	Strength Design Seismic Capacity Max. Horizontal Load Brace Angle Measured From Horizontal (LB)		
				0° - 30°	31° - 45°	46° - 60°
3/8"	2"	12"	4"	1600	1200	800
1/2"	2"	12"	4"	1600	1200	800
1/2"	3 1/4"	12"	6"	2900	2100	1400
5/8"	3 1/4"	12"	5"	4000	2700	1750
5/8"	4"	12"	6"	4200	3500	2200

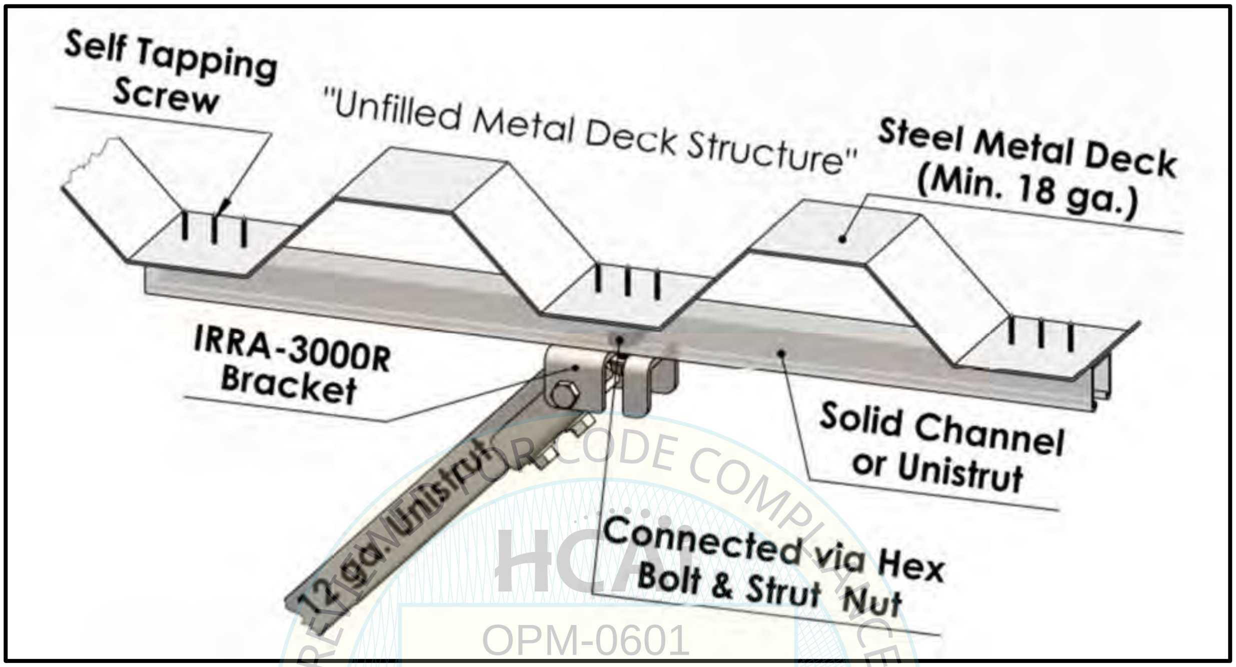
NOTES:

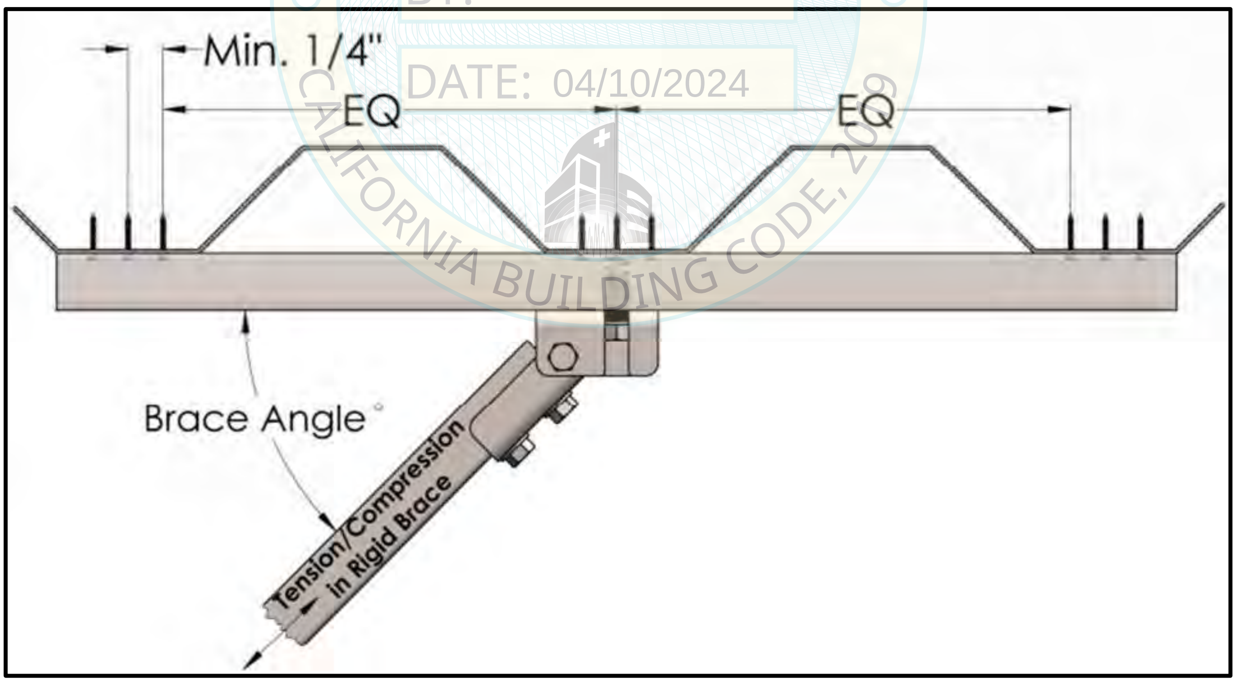
1. CAPACITIES FOR ANCHORS INSTALLED IN STONE AGGREGATE CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 EXPANSION ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS.
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266
4. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
5. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
6. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
7. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
8. IRRA-3000R ATTACHMENT DIAMETER SHALL BE EQUAL TO THE ANCHOR DIAMETER.

Unfilled Metal Deck – Rigid Restraint Attachment

3.4 Unfilled Metal Deck

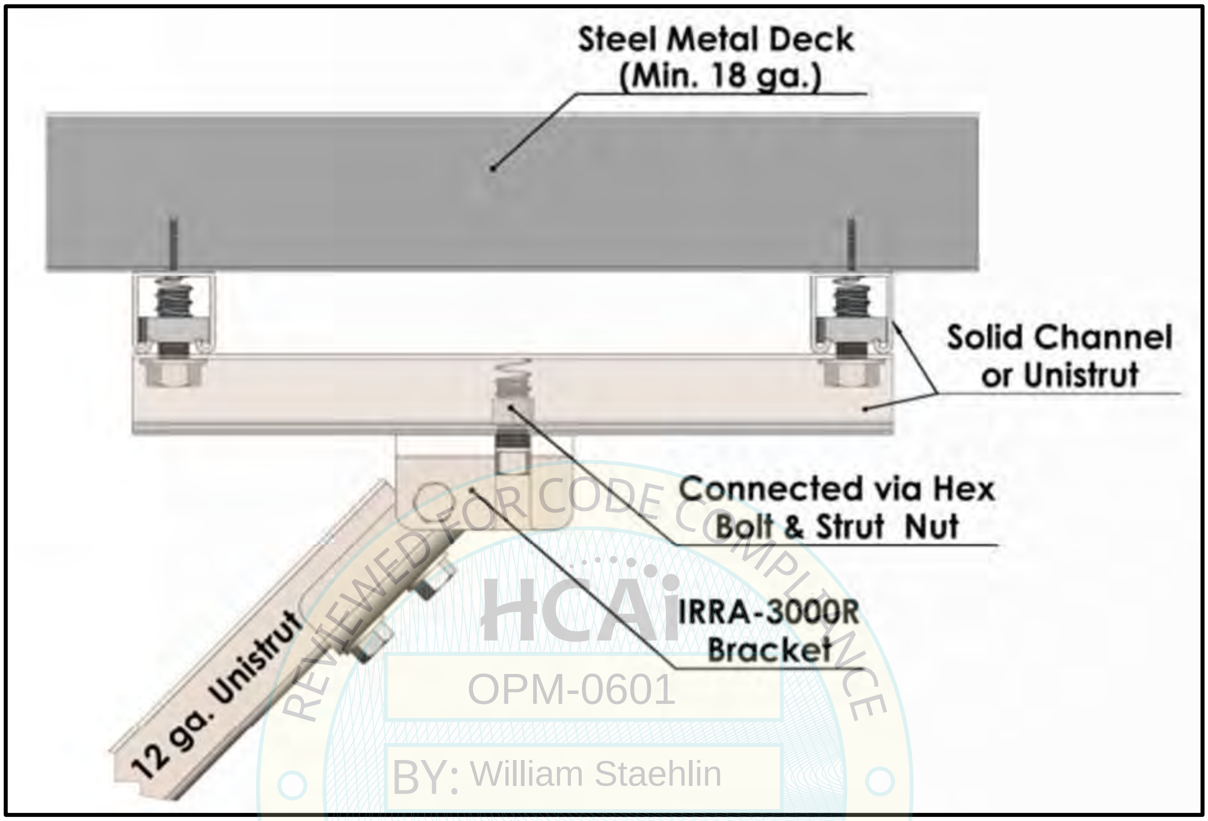
Perpendicular To Flutes





Unfilled Metal Deck – Rigid Restraint Attachment

Parallel To Flutes



Unfilled Metal Deck – Rigid Restraint Attachment

3.4.1 Hilti PPH Self-Drilling Screw

ALLOWABLE STRENGTH DESIGN (ASD)					
MAX. HORIZONTAL LOAD BRACE ANGLE MEASURED FROM HORIZONTAL (LB)					
PERPENDICULAR			PARALLEL		
0° - 30°	31° - 45°	46° - 60°	0° - 30°	31° - 45°	46° - 60°
100	100	100	100	100	100

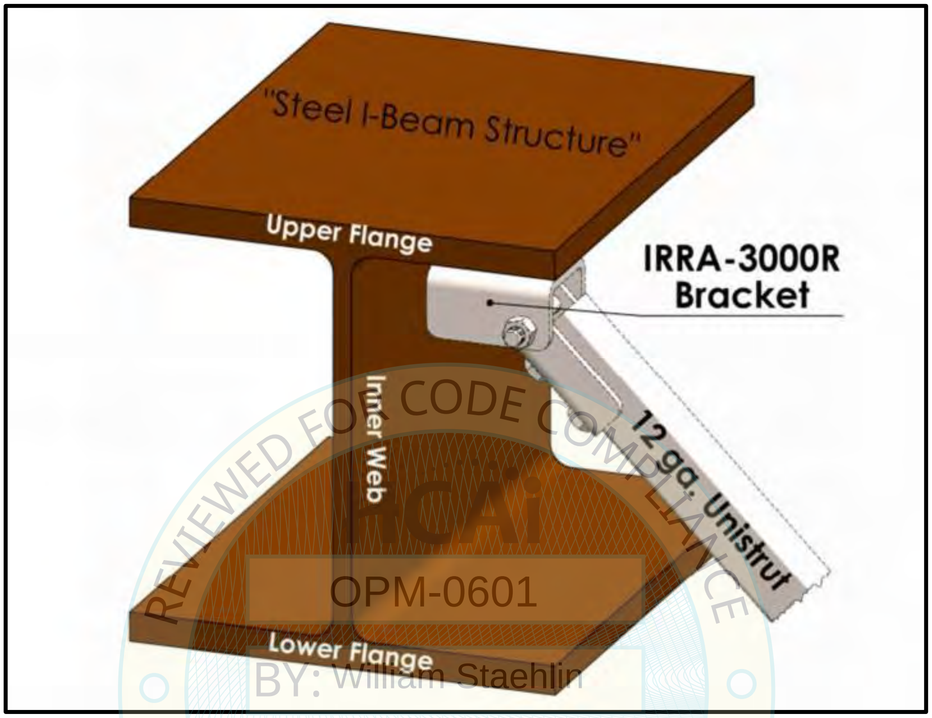
NOTES:

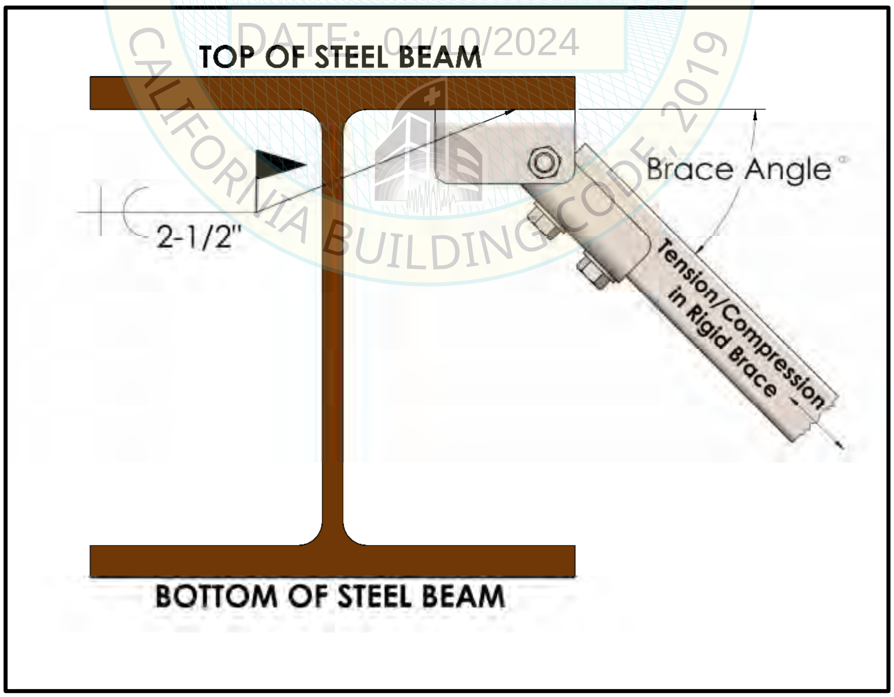
1. ALLOWABLE LOADS ARE CALCULATED BASED ON CAPACITY OF HILTI SELF-DRILLING SCREW S-MD 8-18 PPH #2 WITH NOMINAL SCREW LENGTH ¾ INCH WHICH IS USED FOR CONNECTION BETWEEN METAL DECK (MIN. GAUGE # 18) AND A STEEL CHANNEL (GAUGE # 12).
2. TO UTILIZE FULL CAPACITY OF THE SCREW, PROTRUSION LENGTH OF THE SCREW SHALL NOT BE LESS THAN 0.375 INCH. ALSO FOLLOW OTHER INSTALLATION AND INSPECTION REQUIREMENTS PER ICC ESR 2196 (2022).
3. FOR SHEET METALS WITH $F_u \geq 65$ KSI, THE MAXIMUM ALLOWABLE STRENGTH VALUE SHALL BE MULTIPLIED BY 1.44 IN ACCORDANCE WITH ICC ESR 2196.
4. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE FOR THE TABULATED ANCHOR LOAD CAPACITY.
5. MINIMUM 2 SCREWS PER FLUTE
6. MINIMUM 2 SCREWS AT EACH UNISTRUT-TO-FLUTE CONNECTION

3.5 Steel Beam

3.5.1 Welded

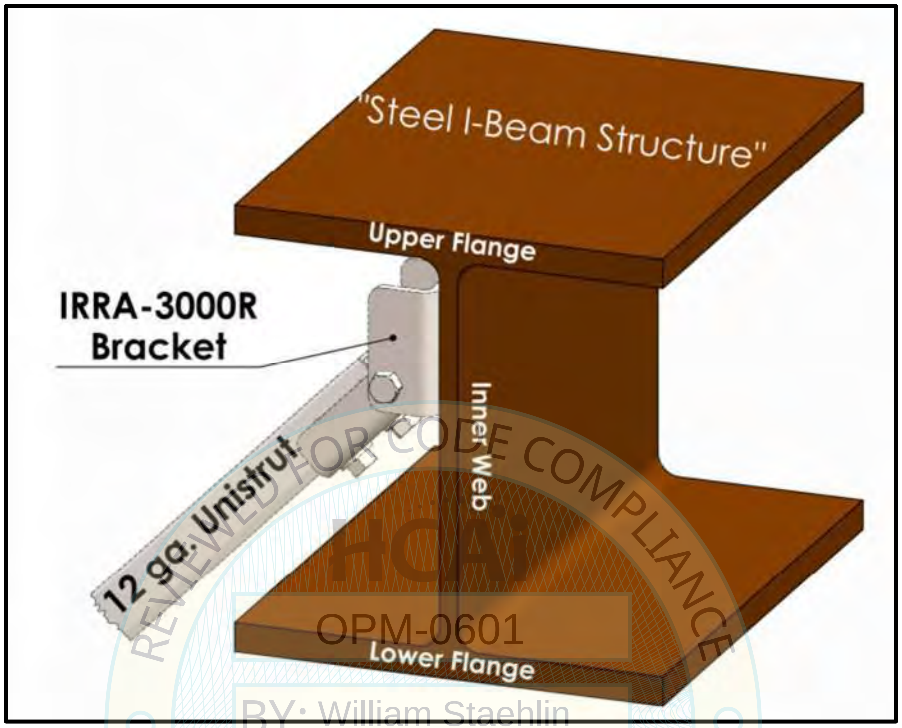
Welding to Upper Flange

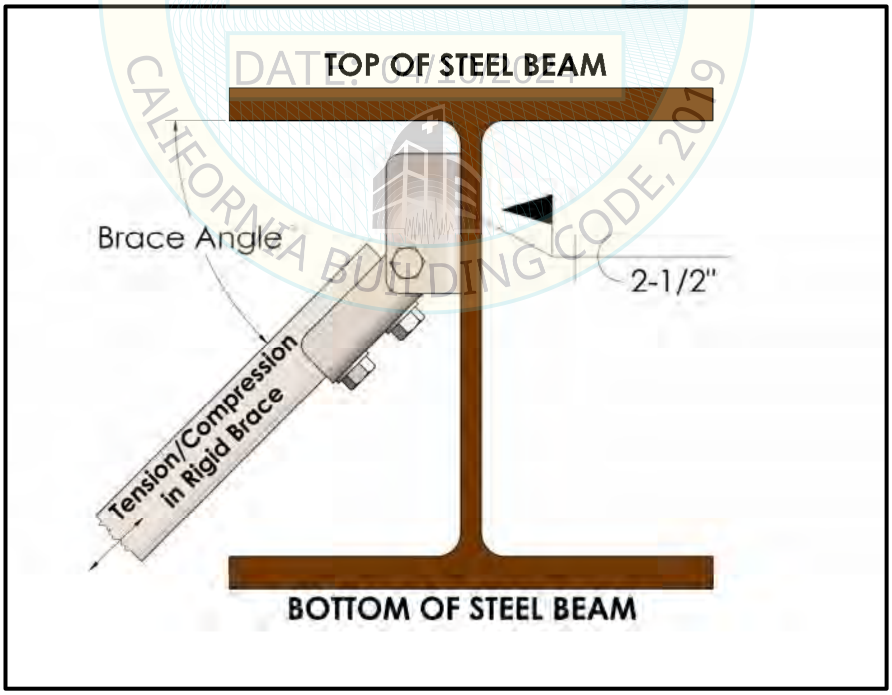




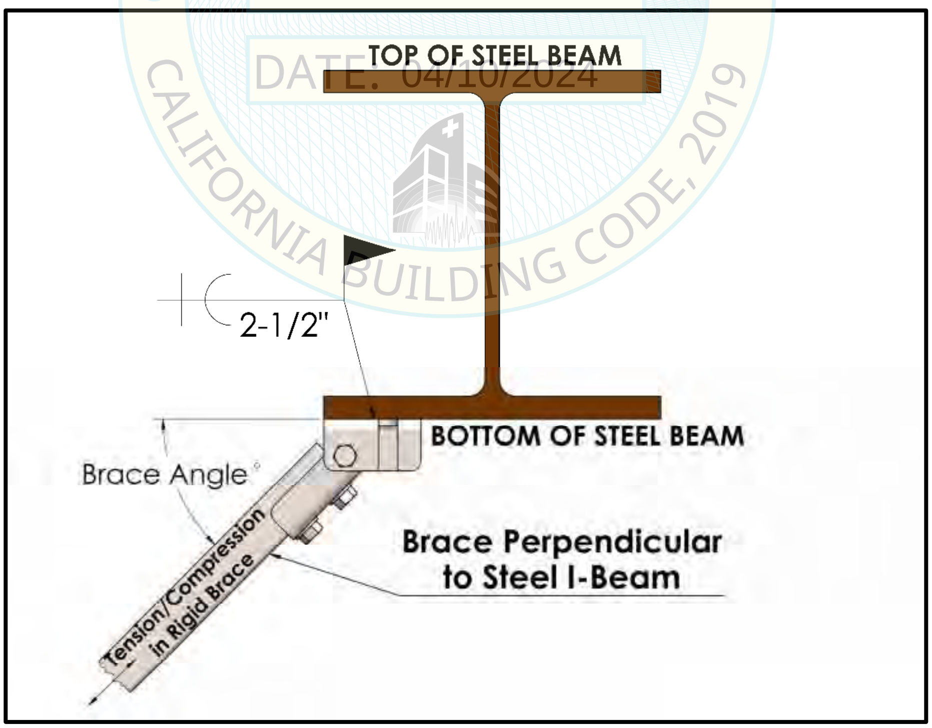
Steel Beam – Rigid Restraint Attachment

Welding to Inner Web



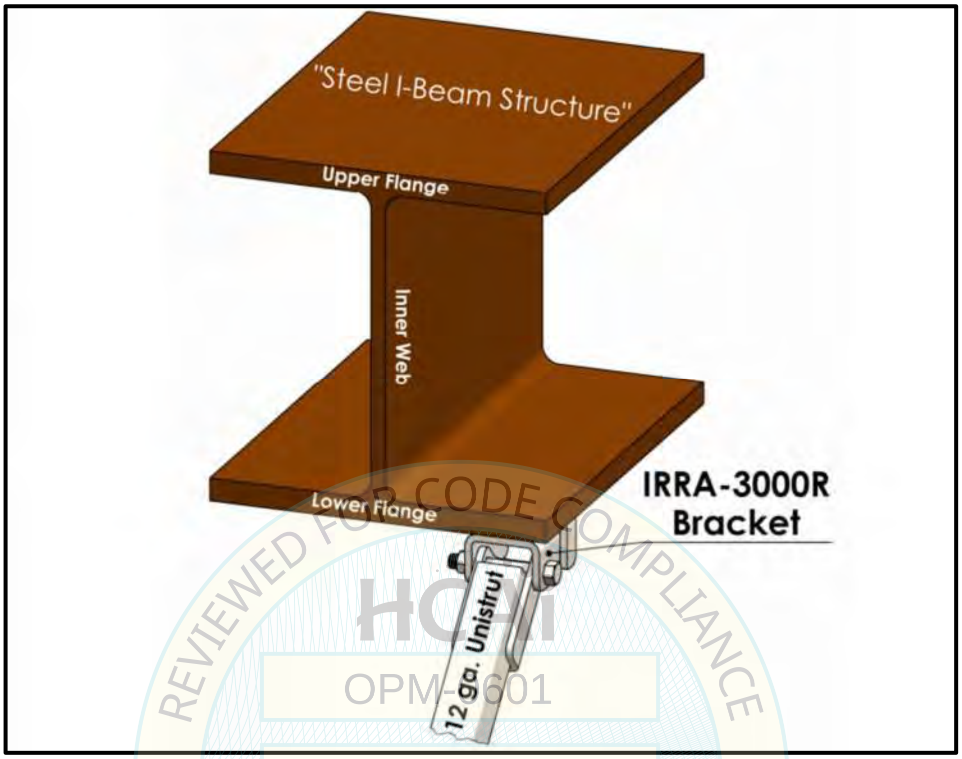


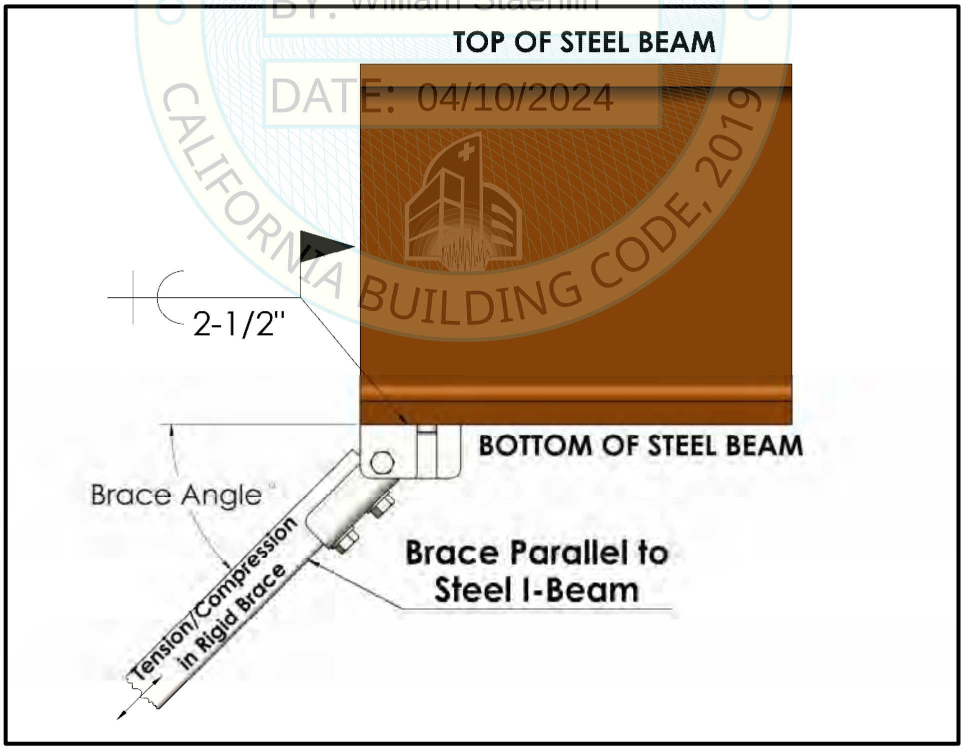
Welding to Lower Flange Perpendicular to Beam



Steel Beam – Rigid Restraint Attachment

Welding to Lower Flange Parallel to Beam





Steel Beam – Rigid Restraint Attachment

ALLOWABLE STRENGTH DESIGN (ASD)		
MAX. HORIZONTAL LOAD BRACE ANGLE MEASURED FROM HORIZONTAL (LB)		
0° - 30°	31° - 45°	46° - 60°
1155	1220	1250

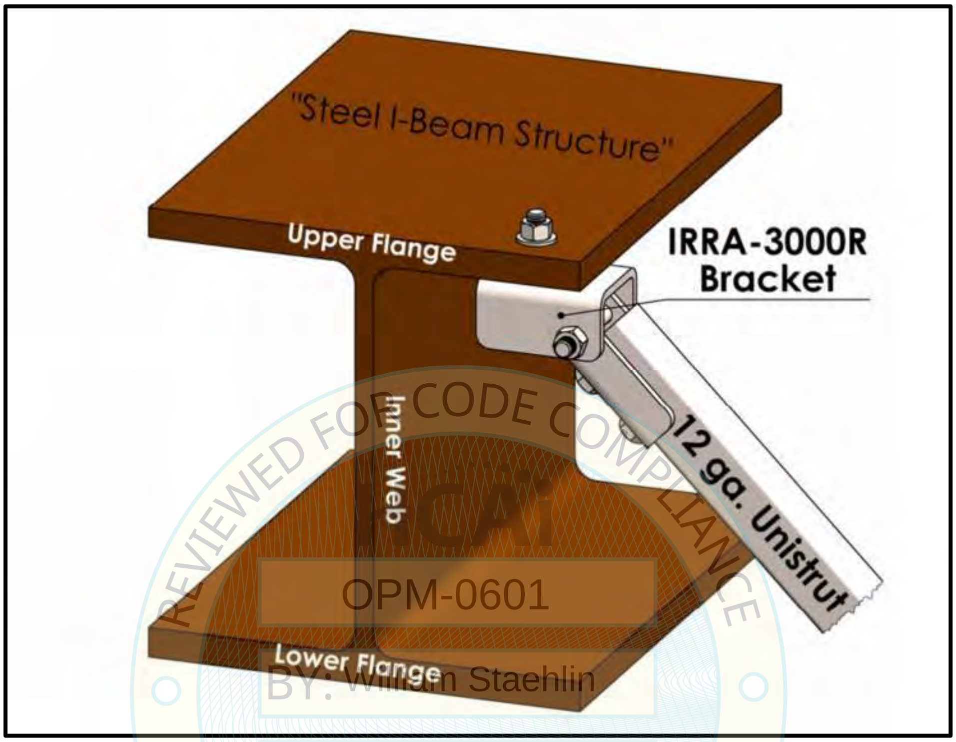
NOTES:

* Due to high strength of welding connection, the tabulated capacity values of the attachment are limited by capacity of IRRA-3000R rigid brace system, i.e., the brace would fail before the attachment failure.

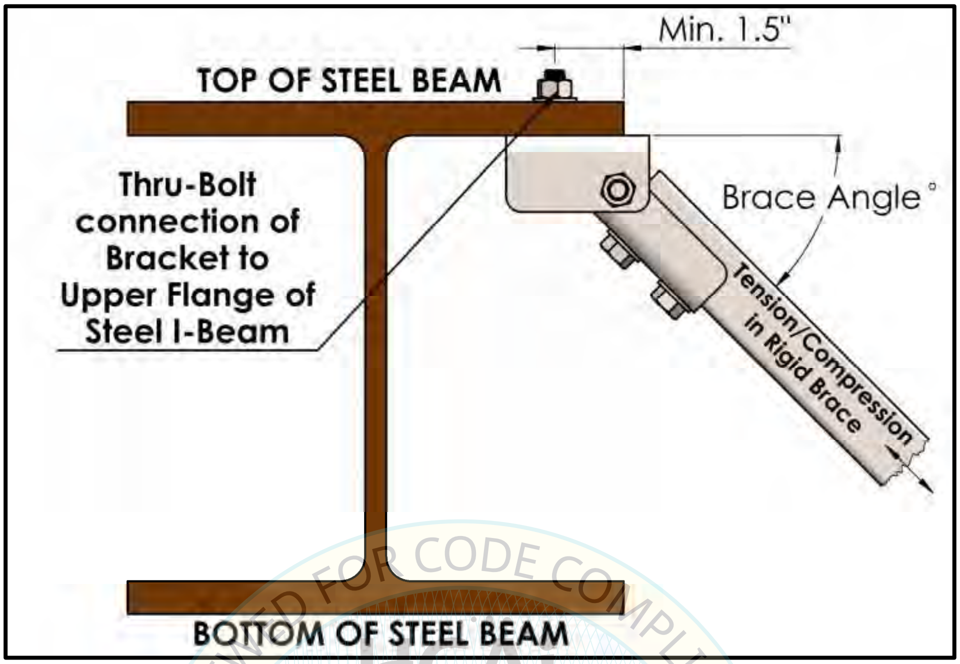
1. ALL STRUCTURAL STEEL SHALL BE MINIMUM ASTM A36. BOLT SHALL BE A307 BOLT OR BETTER, IT SHALL MEET ASME STANDARD B18.2.1, WITH A MINIMUM MATERIAL SPECIFICATION, YIELD STRENGTH F_y OF 45 KSI.
2. WELDING SHALL BE DONE BY ELECTRIC SHIELDED ARC PROCESS USING E-70XX ELECTRODE.
3. ALL WELDING SHALL BE PERFORMED BY CERTIFIED WELDER AND IN CONFORMED WITH AWS STANDARDS AND 2022 CBC. CONTINUOUS INSPECTIONS ARE REQUIRED FOR ALL WELDING CONNECTIONS.
4. DO NOT WELD IN ANY PORTION OF A BEAM THAT IS DESIGNATED AS A "PROTECTED ZONE" PER AISC 358 OR AISC 341. SEE STRUCTURAL DRAWINGS FOR LOCATIONS OF PROTECTED ZONES.
5. THE BUILDING STRUCTURAL ENGINEER OF RECORD MUST BE NOTIFIED OF REACTION FORCES ON THE STEEL BEAM TO VERIFY THEIR ADEQUACY, INCLUDING BEAM TORSION EFFECTS ON BOTTOM FLANGE CONNECTIONS.

3.5.2 Bolted

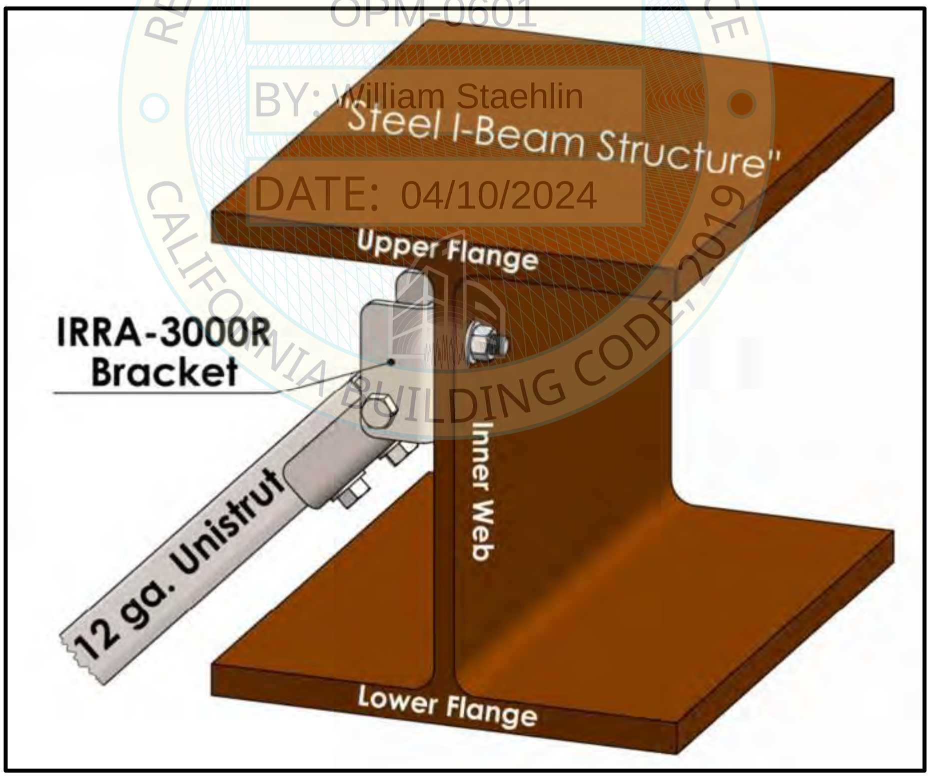
Bolting to Upper Flange



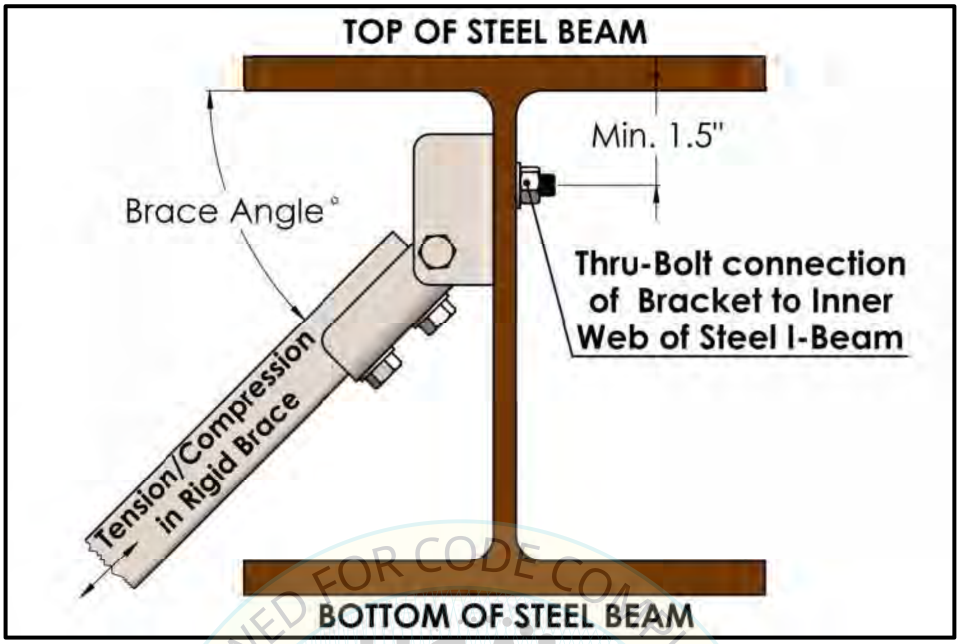
Steel Beam – Rigid Restraint Attachment



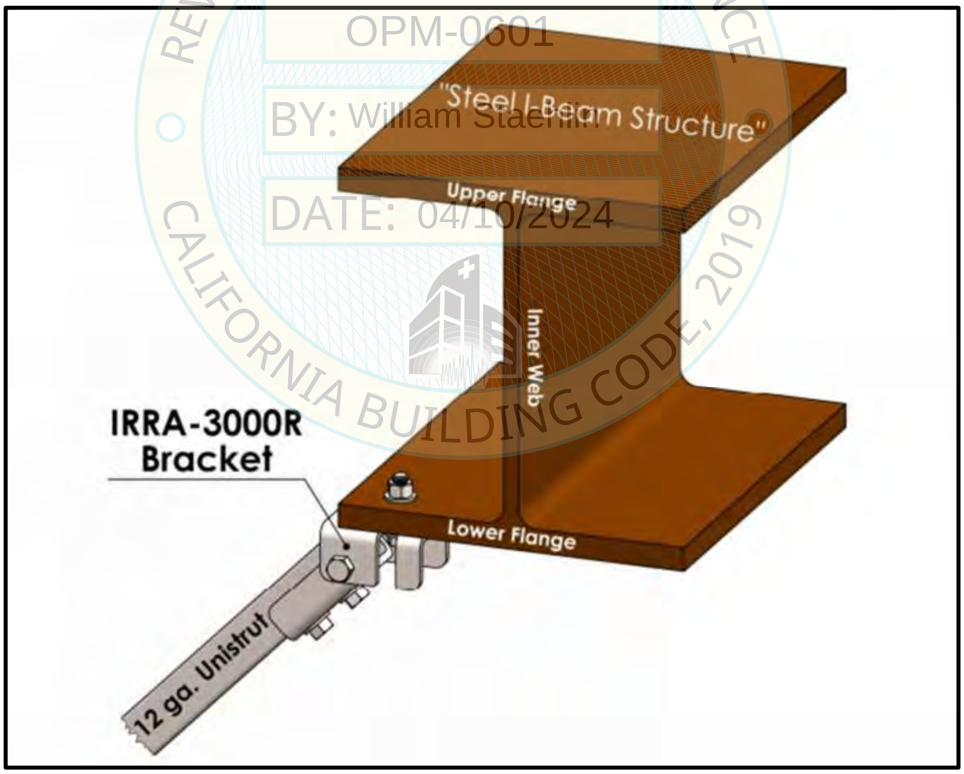
Bolting to Inner Web



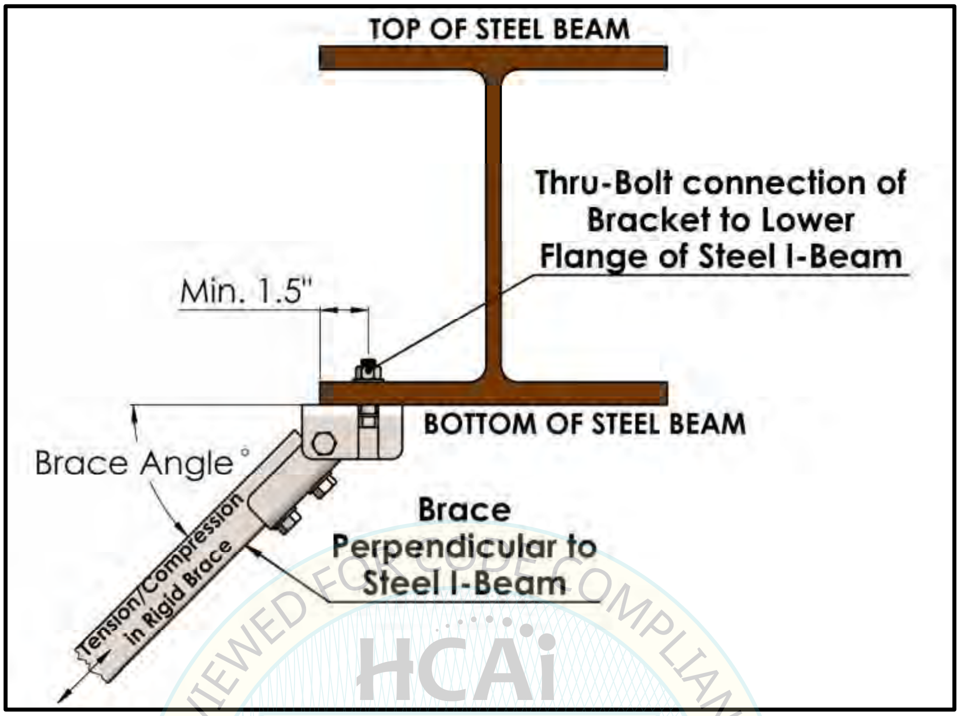
Steel Beam – Rigid Restraint Attachment



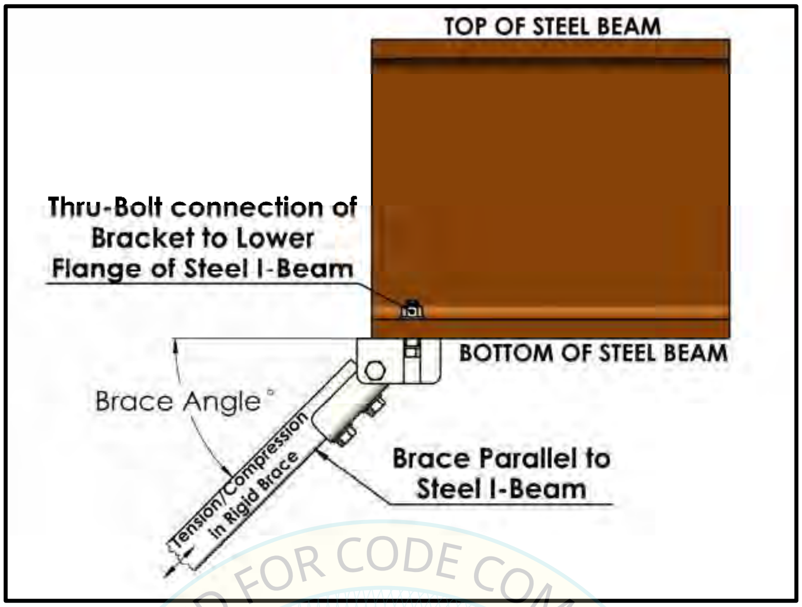
<u>**Bolting to Lower Flange Perpendicular to Beam**</u>



Steel Beam – Rigid Restraint Attachment



Bolting to Lower Flange Parallel to Beam



BOLT DIA.	ALLOWABLE STRENGTH DESIGN (ASD) MAX. HORIZONTAL LOAD BRACE ANGLE MEASURED FROM HORIZONTAL (LB)			MIN. EDGE DISTANCE
	0° - 30°	31° - 45°	46° - 60°	
3/8''	500	500	500	1''
1/2''	800	800	800	1''
5/8''	1200	1200	1200	1 1/2''

NOTES:

1. ALL STRUCTURAL STEEL SHALL BE ASTM A36 OR BETTER WITH A MINIMUM FLANGE THICKNESS OF 0.25 INCH. BOLT SHALL BE A307 BOLT OR BETTER, IT SHALL MEET ASME STANDARD B18.2.1, WITH A MINIMUM MATERIAL SPECIFICATION, YIELD STRENGTH F_y OF 45 KSI.

2. INSTALLATION OF BOLTS (DRILLED HOLES REQUIRED) INTO STEEL STRUCTURE SHALL BE APPROVED BY STRUCTURAL ENGINEER OF RECORD IN ADVANCE.

3. ATTACHMENTS ARE PROHIBITED IN PROTECTED ZONES. (EXEMPTIONS SEE AISC 341, CHAPTER D). SEE STRUCTURAL DRAWINGS FOR LOCATIONS OF PROTECTED ZONES.

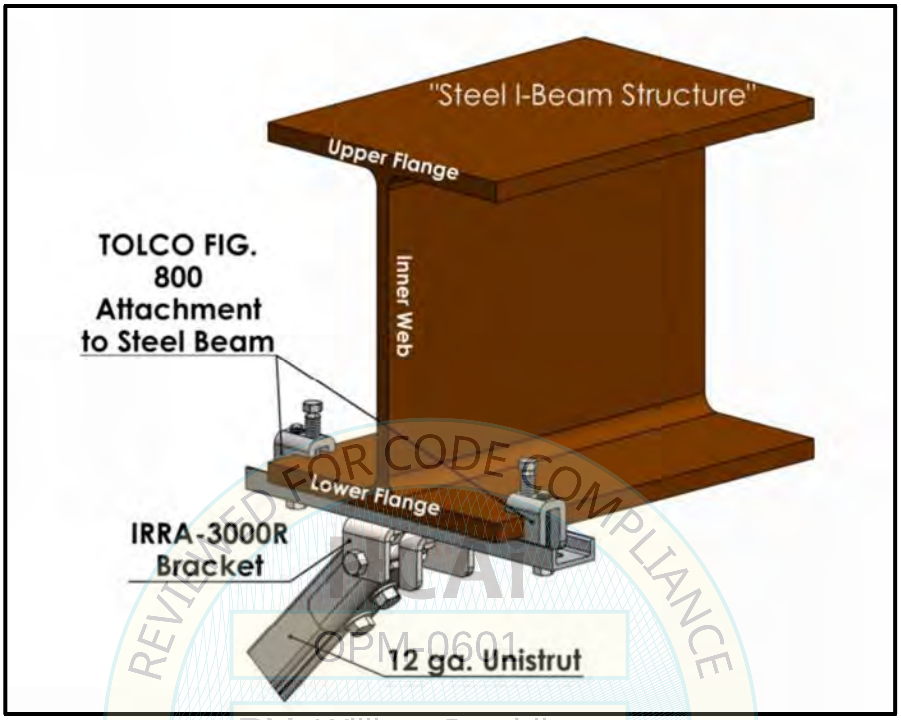
4. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE FOR THE TABULATED BOLT LOAD CAPACITY.

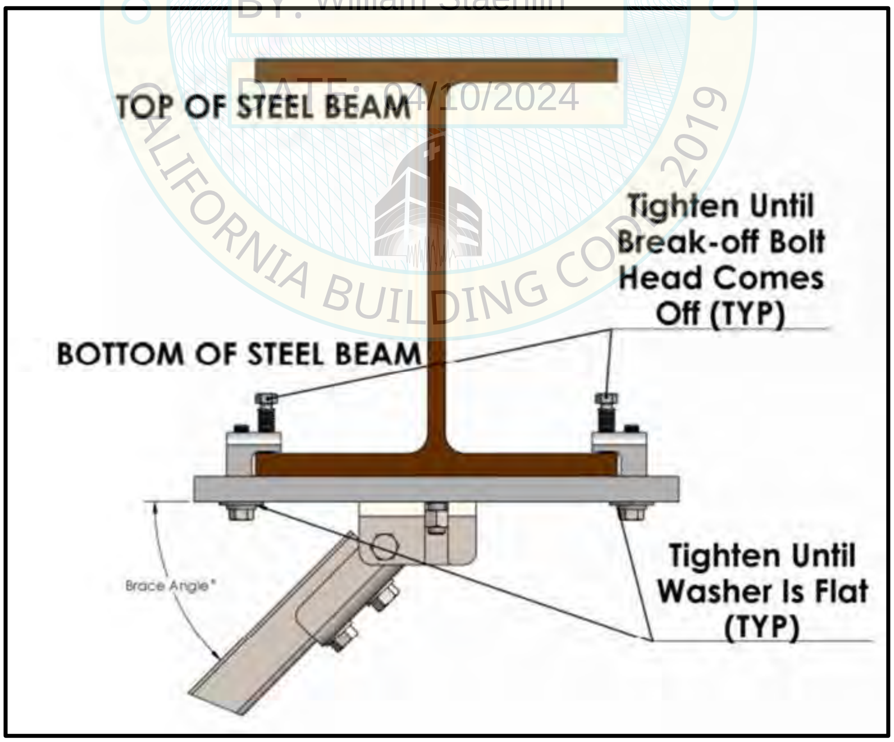
THE BUILDING STRUCTURAL ENGINEER OF RECORD MUST BE NOTIFIED OF REACTION FORCES ON THE STEEL BEAM TO VERIFY THEIR ADEQUACY, INCLUDING BEAM TORSION EFFECTS ON BOTTOM FLANGE CONNECTIONS.

Steel Beam – Rigid Restraint Attachment

3.5.3 Beam Clamp

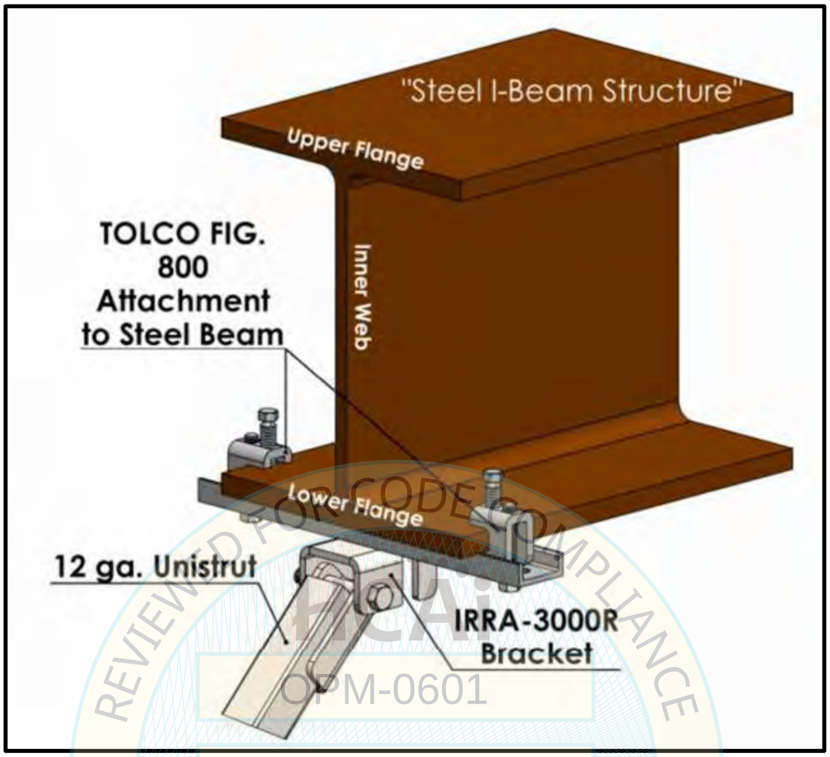
Clamp to Flange Parallel to Beam

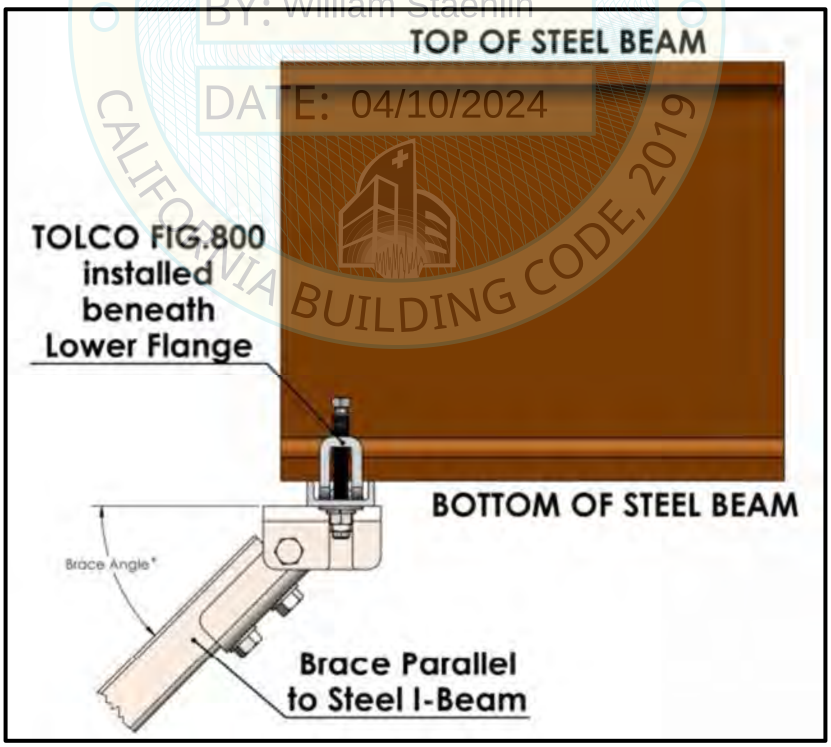




Steel Beam – Rigid Restraint Attachment

Clamp to Flange Perpendicular to Beam





Steel Beam – Rigid Restraint Attachment

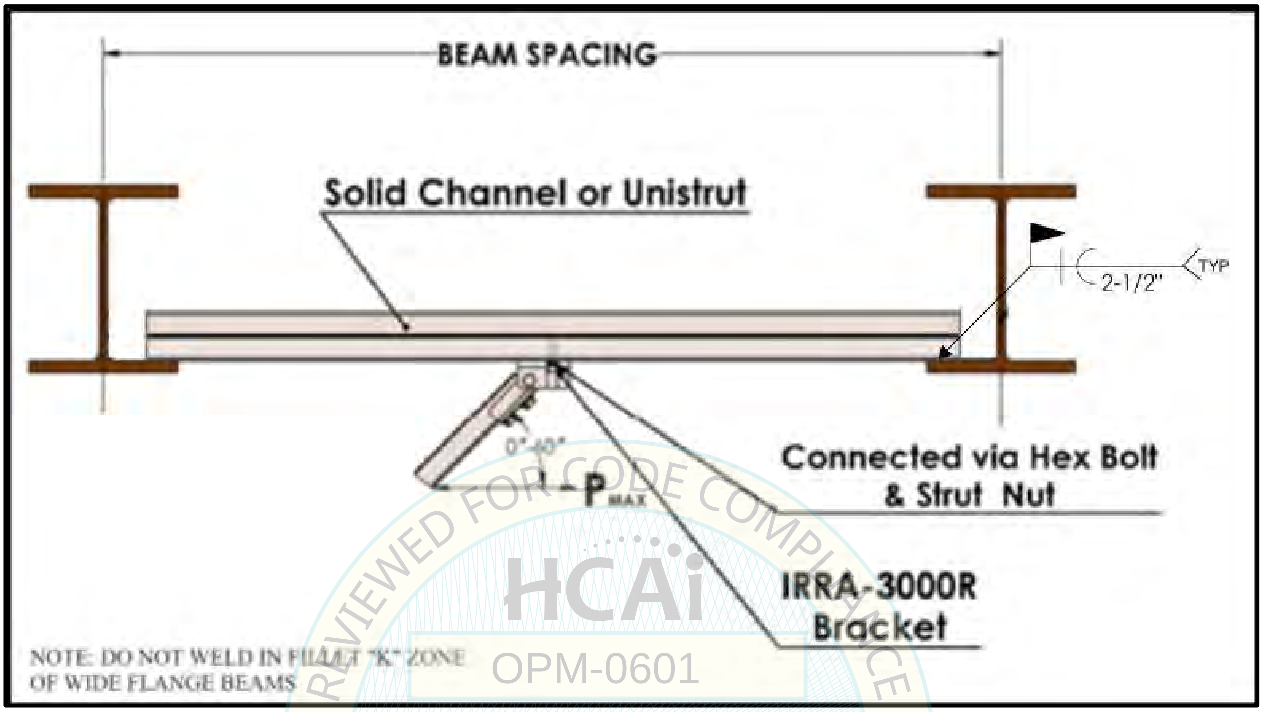
ORIENTATION	ALLOWABLE STRENGTH DESIGN (ASD)		
	MAX. HORIZONTAL LOAD BRACE ANGLE MEASURED FROM HORIZONTAL (LB)		
	15° - 30°	31° - 45°	46° - 60°
PERPENDICULAR TO BEAM	1390	920	465
PARALLEL TO BEAM	1610	1310	715

NOTES:

1. BEAM FLANGE THICKNESS TO BE NO MORE THAN ¾ INCH
2. THE BEAM CLAMP STEEL SHALL BE MINIMUM ASTM A36
3. INSTALLATION OF BOLTS (DRILLED HOLES REQUIRED) INTO STEEL STRUCTURE SHALL BE APPROVED BY STRUCTURAL ENGINEER OF RECORD IN ADVANCE.
4. ATTACHMENTS ARE PROHIBITED IN PROTECTED ZONES. (EXEMPTIONS SEE AISC 341, CHAPTER D). SEE STRUCTURAL DRAWING FOR LOCATIONS OF PROTECTED ZONES
5. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE FOR THE TABULATED CLAMP FORCE CAPACITY.

Steel Beam – Rigid Restraint Attachment

3.5.4 Supplemental Strut



Steel Beam – Rigid Restraint Attachment

MAXIMUM BEAM SPAN	PMAX MAXIMUM HORIZONTAL ALLOWABLE LOAD (LB)(ASD)	
	BRACE ANGLE MEASURED FROM HORIZONTAL	
	0° - 45°	46° - 60°
6'-0''	350	300
10'-0''	225	180

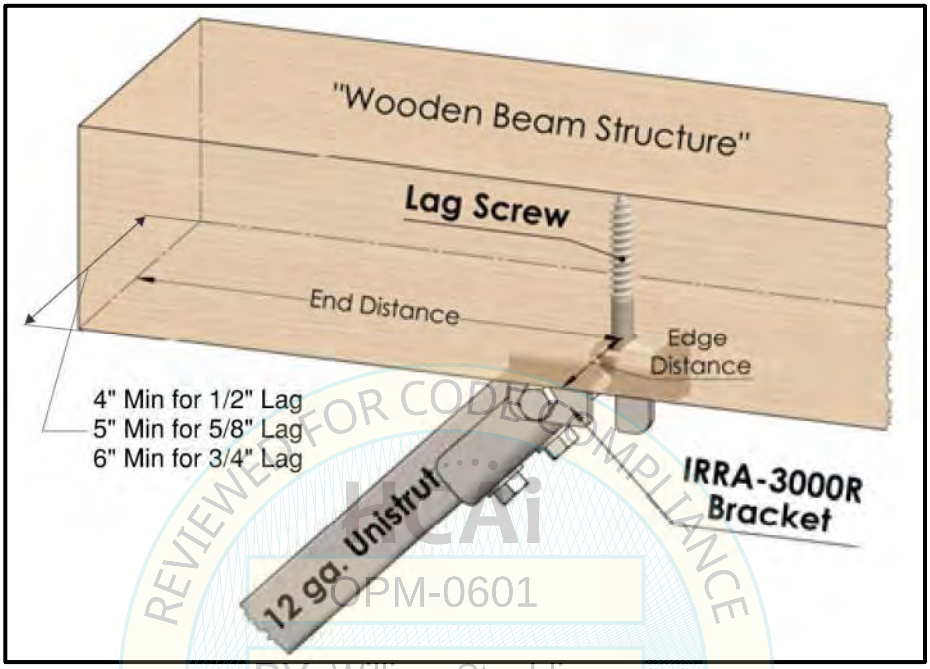
NOTES:

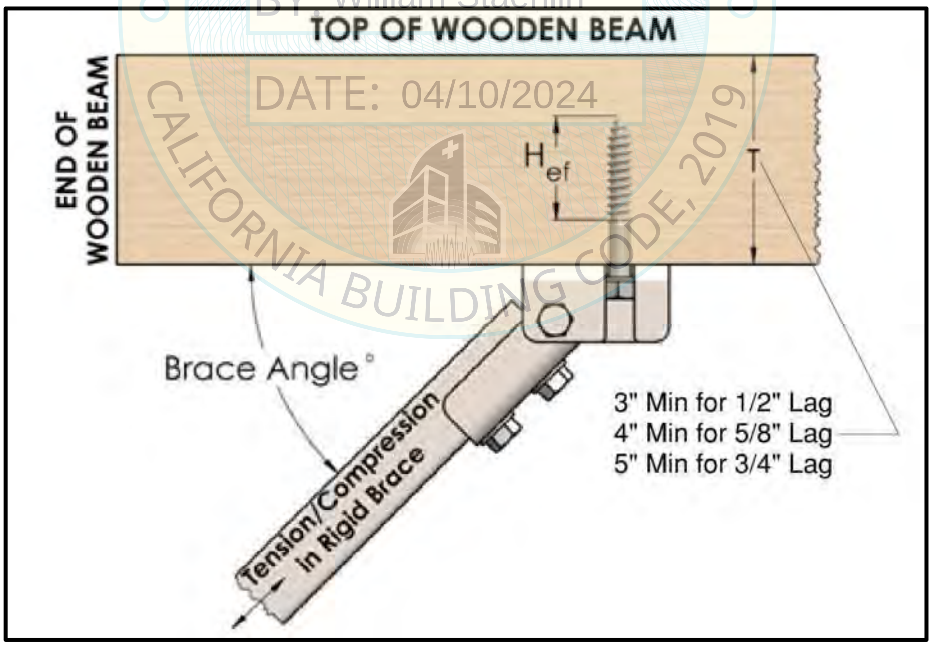
1. FOR 6'-0" BEAM SPACING, TOTAL PMAX = 350# AT ANY LOCATION WITH BRACE ANGLE MEASURED FROM HORIZONTAL OF 0°-45°, PMAX = 300# AT ANY LOCATION WITH BRACE ANGLE MEASURED FROM HORIZONTAL OF 46°-60°.
2. FOR 10'-0" BEAM SPACING, TOTAL PMAX = 225# AT ANY LOCATION WITH BRACE ANGLE MEASURED FROM HORIZONTAL OF 0°-45°, PMAX = 180# AT ANY LOCATION WITH BRACE ANGLE MEASURED FROM HORIZONTAL OF 46°-60°.
3. STRUCTURAL ENGINEER OF RECORD TO VERIFY ADEQUACY OF THE STRUCTURE FOR THE APPLIED LOADS.
4. NO ATTACHMENTS SHALL BE IN PROTECTED ZONES. (SEE AISC 341, CHAPTER 7.3). SEE STRUCTURAL DRAWINGS FOR LOCATIONS OF PROTECTED ZONES.
5. WELDING SHALL BE DONE BY ELECTRIC SHIELDED ARC PROCESS USING E-70XX ELECTRODES.
6. ALL WELDING SHALL BE PERFORMED BY CERTIFIED WELDER AND IN CONFORMED WITH AWS STANDARDS AND 2022 CBC. CONTINUOUS INSPECTIONS ARE REQUIRED FOR ALL WELDING CONNECTIONS.
7. ALL WELDS SHALL BE IN CONFORMANCE WITH 2022 CALIFORNIA BUILDING CODE. (CBC)
8. CONTINUOUS INSPECTION IS REQUIRED FOR ALL WELDING.
9. LOADS ARE BASED ON ALLOWABLE STRENGTH DESIGN.
10. BRACE MUST BE RUNNING IN SAME DIRECTION AS SOLID CHANNEL/UNISTRUT.

3.6 Wood Beam

3.6.1 Lag Screw

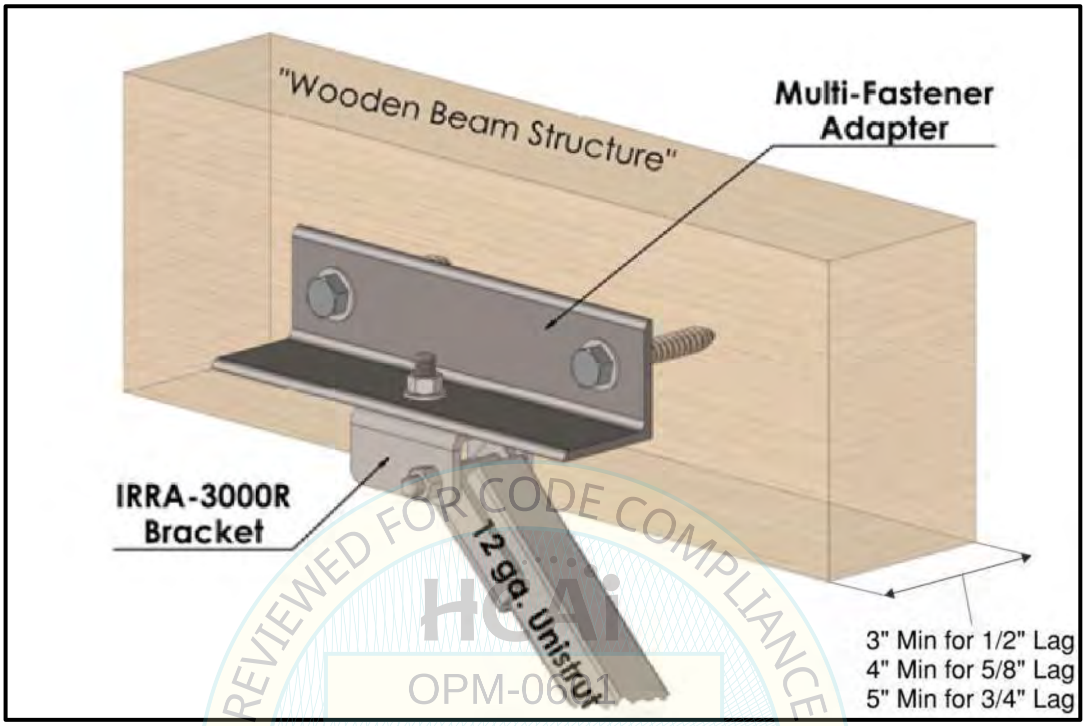
Single Screw

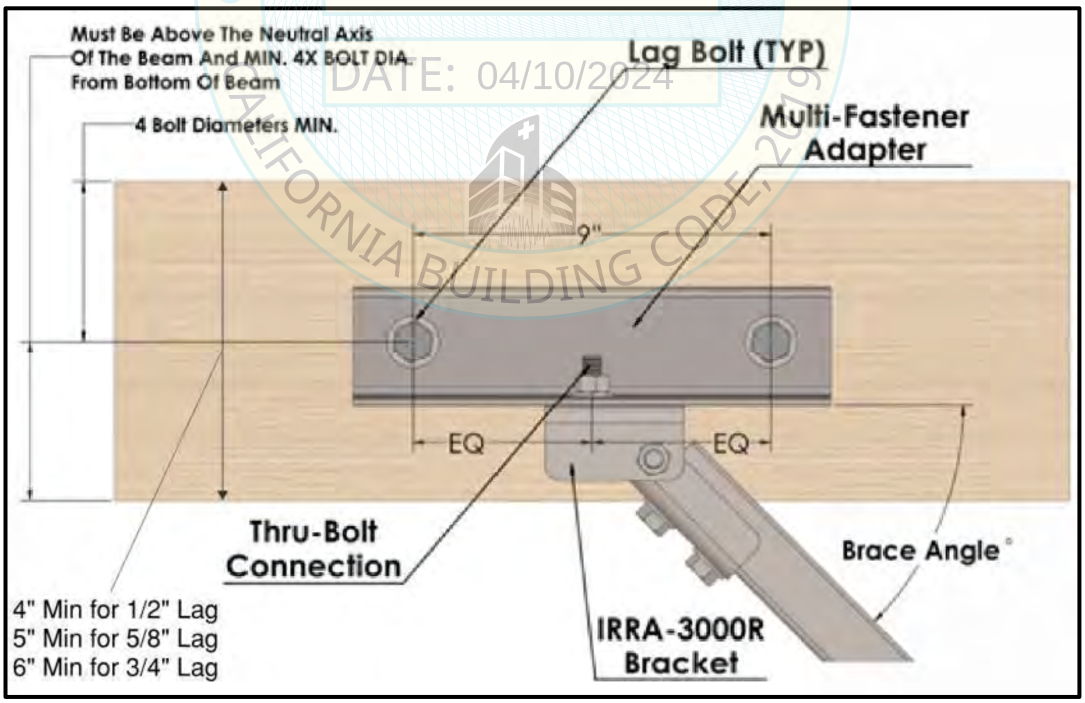




Wood Beam – Rigid Restraint Attachment

Double Screw w/ Mounting Plate





Wood Beam – Rigid Restraint Attachment

LAG BOLT SIZE DIA. X LENGTH	ALLOWABLE STRENGTH DESIGN (ASD) MAX. HORIZONTAL LOAD BRACE ANGLE MEASURED FROM HORIZONTAL (LB)					
	1 BOLT			2 BOLT		
	0° - 30°	31° - 45°	46° - 60°	0° - 30°	31° - 45°	46° - 60°
1/2'' X 3''	122	87	55	150	100	58
5/8'' X 4''	190	134	84	237	154	89
3/4'' X 5''	279	194	119	347	222	127

NOTES:

1. ALLOWABLE LOADS ARE CALCULATED BASED ON CAPACITY OF LAG-SCREW INSTALLED IN STANDARD CONSTRUCTION WOOD (SPECIFIC GRAVITY 0.35 OR HIGHER) WITH MIN. THICKNESS OF ¼ INCH SIDE PLATE (IRRA-3000R BRACKET OR MULTI-FASTENER ADAPTER).

2. MAXIMUM ALLOWABLE SCREW DIAMETER FOR ISOTECH RIGID BRACE IRRA-3000R IS 5/8''.

3. TO UTILIZE FULL CAPACITY OF THE LAG-SCREW, A MINIMUM EDGE DISTANCE 4D, END DISTANCE 7D AND SCREW SPACING S_{min} 5D MUST BE FOLLOWED DURING INSTALLATION. ALSO FOLLOW OTHER INSTALLATION AND INSPECTION REQUIREMENTS PER ASME STANDARD B18.2.

4. FASTENERS SHALL BE A307 SCREWS OR BETTER. LAG-SCREW SHALL MEET ASME STANDARD B18.2, WITH A MINIMUM MATERIAL YIELD STRENGTH F_y OF 45 KSI.

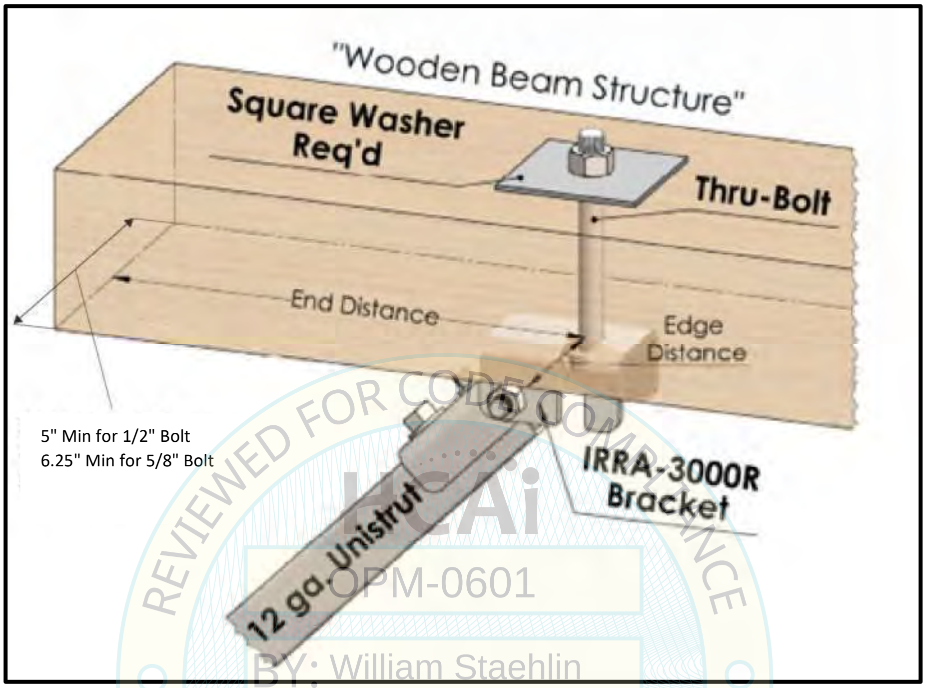
5. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE FOR THE TABULATED SCREW LOAD CAPACITY.

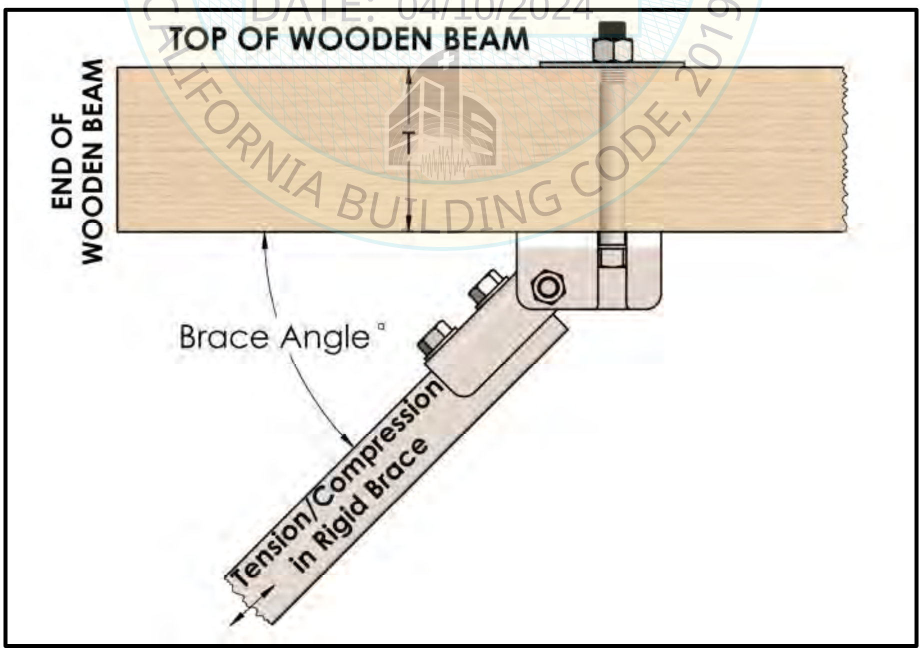
6. VERIFY THAT WOOD MEMBER THICKNESS IS GREATER THAN LAG SCREW LENGTH.

Wood Beam – Rigid Restraint Attachment

3.6.2 Thru-Bolt

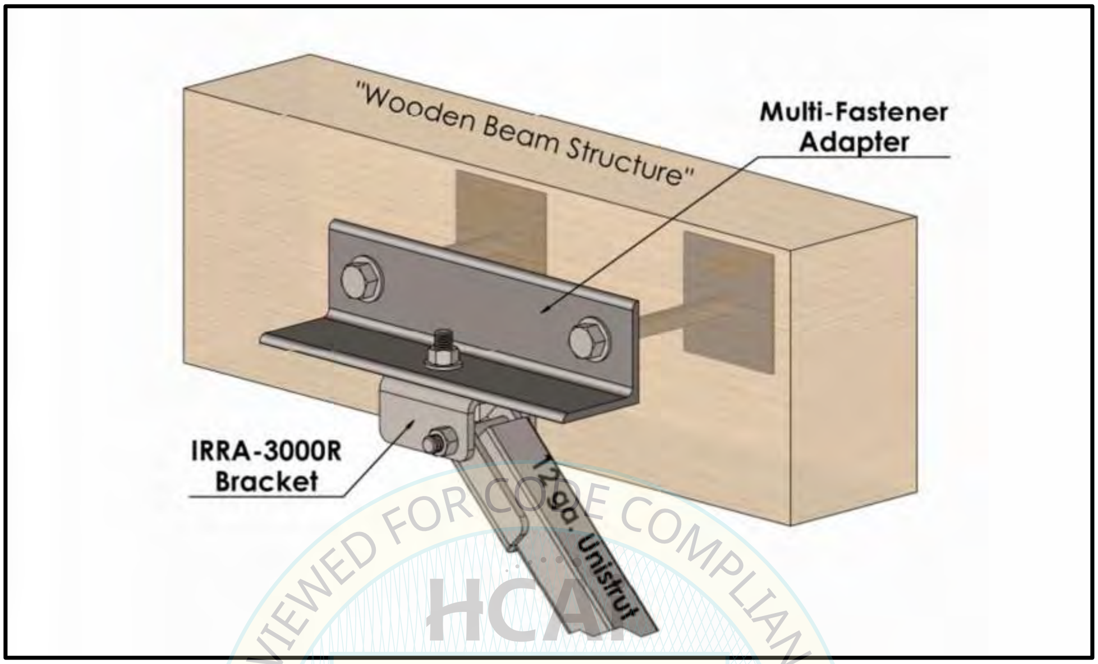
Single Bolt

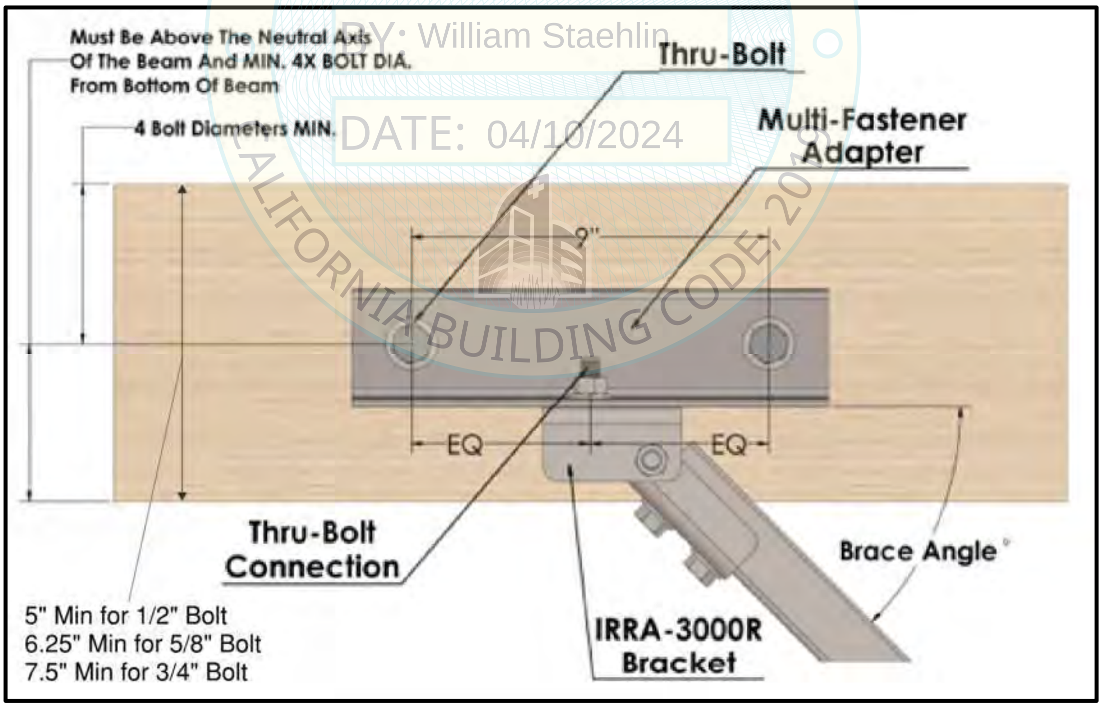




Wood Beam – Rigid Restraint Attachment

Double Bolt w/ Mounting Plate





Wood Beam – Rigid Restraint Attachment

BOLT DIAMETER	ALLOWABLE STRENGTH DESIGN (ASD)					
	MAX. HORIZONTAL LOAD BRACE ANGLE MEASURED FROM HORIZONTAL (LB)					
	1 BOLT			2 BOLTS		
	0° - 30°	31° - 45°	46° - 60°	0° - 30°	31° - 45°	46° - 60°
1/2''	260	260	260	440	440	440
5/8''	320	320	320	540	540	460
3/4''	-	-	-	600	600	460

NOTES:

1. LOADS FOR THRU-BOLT ATTACHMENTS WERE DERIVED FROM AWC NDS 2018 FOR DOUGLAS FIR-LARCH [S.G.=0.50], CALIFORNIA REDWOOD (CLOSE GRAIN) [S.G.=0.44] AND SOUTHERN PINE [S.G.=0.55].
2. TO UTILIZE FULL CAPACITY OF THE THRU-BOLT, A MINIMUM EDGE DISTANCE 5D, END DISTANCE 7D AND BOLT SPACING S_{min} 5D MUST BE FOLLOWED DURING INSTALLATION WHERE D BEING THE UNTHREADED SHANK DIAMETER. ALSO FOLLOW OTHER INSTALLATION AND INSPECTION REQUIREMENTS PER ASME STANDARD B18.2.1.
3. BOLT HOLES SHALL BE BORED MIN. 1/32'' AND MAX. 1/16'' LARGER THAN THE NOMINAL BOLT DIAMETER, A STANDARD CUT WASHER SHALL BE PROVIDED BETWEEN THE WOOD AND THE BOLT HEAD OR NUT IN ACCORDANCE WITH NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION (NDS 2018) 12.1.3.
4. MAXIMUM ALLOWABLE BOLT DIAMETER FOR ISOTECH RIGID BRACE IRRA-3000R IS 5/8''.
5. FASTENERS SHALL BE A307 BOLTS OR BETTER. THRU-BOLT SHALL MEET ASME STANDARD B18.2.1, WITH A MINIMUM MATERIAL SPECIFICATION, BENDING YIELD STRENGTH F_{by} OF 45 KSI AND DOWEL BEARING STRENGTH F_e OF 87 KSI.
6. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE FOR THE TABULATED BOLT LOAD CAPACITY.

3.7 Channel Nuts Selection Table (Atkore Unistrut)

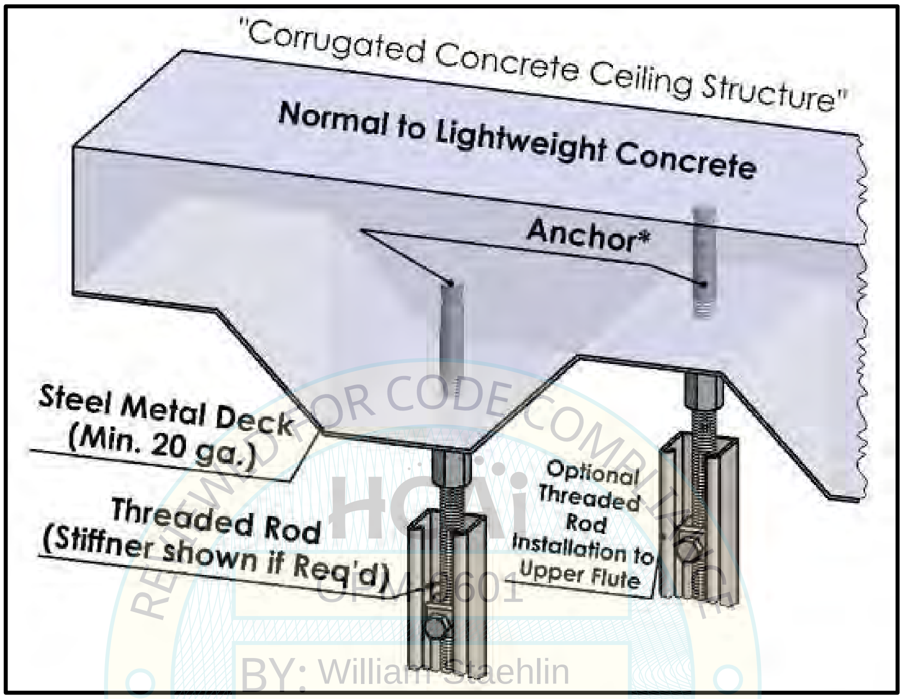
Channel	Channel Nut Size-Thread	Gauge	Allowable Pull-Out Strength Lbs	Resistance to Slip Lbs	Torque Ft-Lbs
P1000 P3000 P4400 P4526 P5000 P5500	7/8''-9	12	2500	1700	125
	3/4''-10	12	2500	1700	125
	5/8''-11	12	2500	1500	100
	1/2''-13	12	2000	1500	50
	7/16''-14	12	1400	1000	35
	3/8''-16	12	1000	800	19
	5/16''-18	12	800	500	11
	1/4''-20	12	600	300	6
P3300	1/2''-13	12	1500	1500	50
	3/8''-16	12	1000	800	19
	5/16''-18	12	800	500	11
	1/4''-20	12	600	300	6
P1100 P4100	1/2''-13	14	1400	1000	50
	3/8''-16	14	1000	750	19
	5/16''-18	14	800	400	11
	1/4''-20	14	600	300	6
P2000 P4000	1/2''-13	16	1000	1000	50
	3/8''-16	16	1000	750	19
	5/16''-18	16	800	400	11
	1/4''-20	16	600	300	6

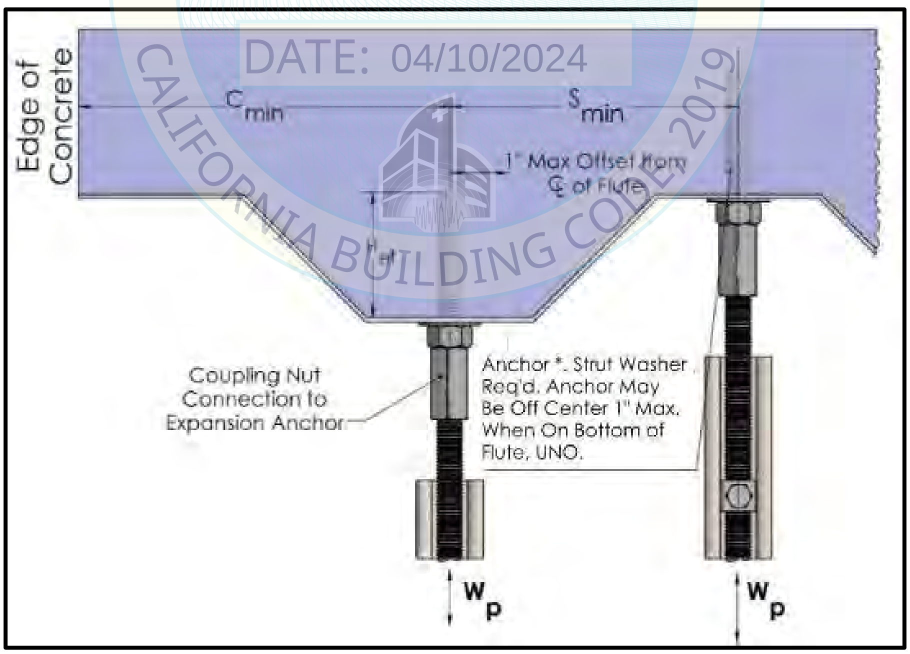
SECTION 4.0 HANGER ROD STRUCTURAL ATTACHMENTS

4.1 Concrete over Metal Deck

4.1.1 Post-installed Wedge Anchor

Single Anchor

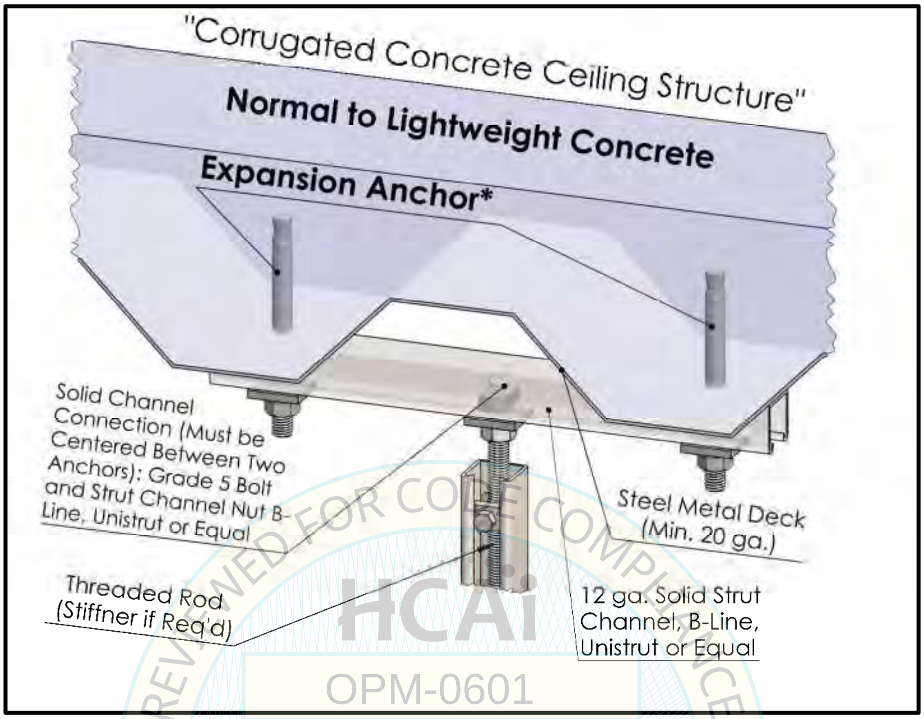


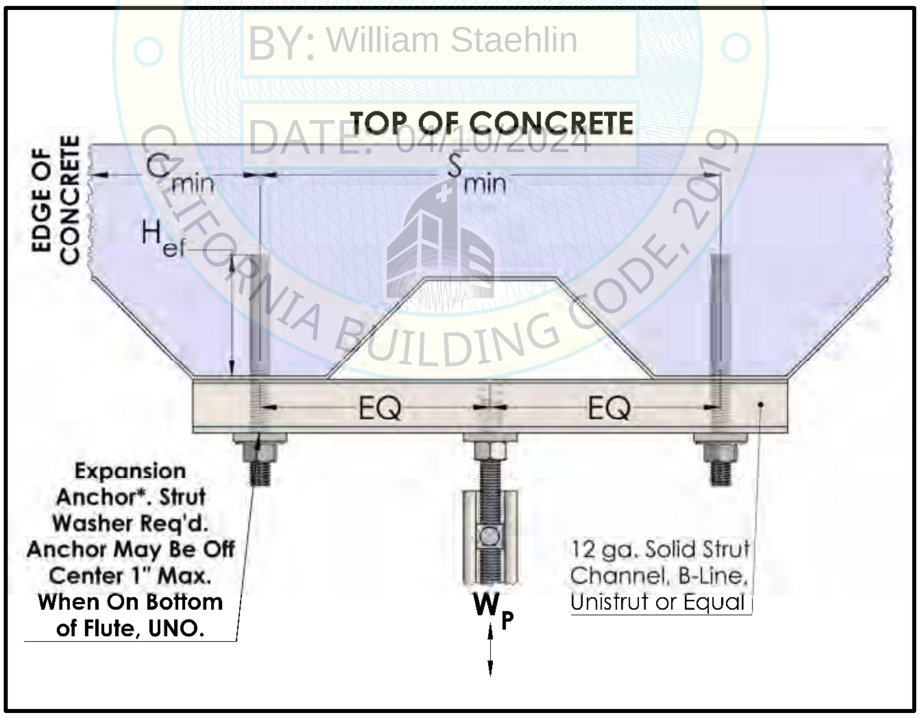


*Type/Brand of Expansion Anchor Specified in Section 4.1.1.1

Concrete over Metal Deck – Hanger Rod Attachment

Double Anchor w/ Solid Channel





*Type/Brand of Expansion Anchor Specified in Section 4.1.1.1

Concrete over Metal Deck – Hanger Rod Attachment

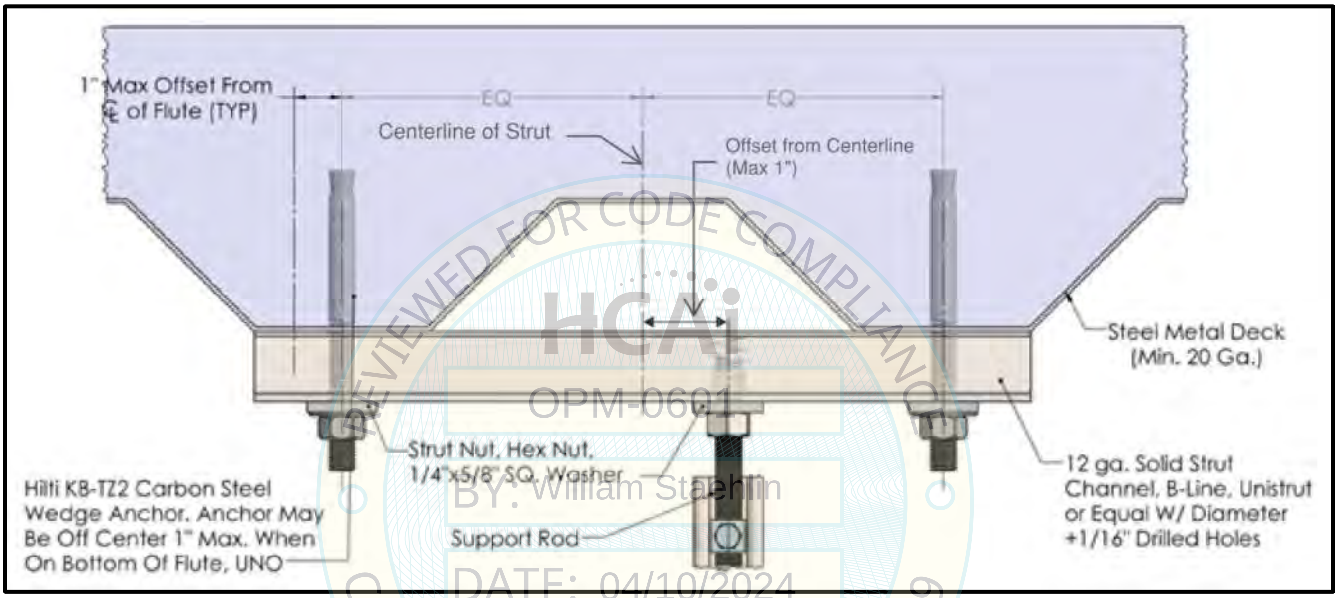
4.1.1.1 Hilti KB-TZ2 Anchor

Anchor Dia.	Min. Effective embed. Depth hef	Cmin' Min. Edge Distance	'Smin' Min. Spacing Between Anchors on Same Flute	Strength Design Seismic Capacity	
				Max. Vertical Load	
				Single (LB)	Double (LB)
3/8"	2"	6 3/4"	12"	1110	2220
1/2"	2"	6 3/4"	12"	1030	2060
1/2"	3 1/4"	9 3/4"	12"	1600	3200
5/8"	4"	12"	12"	2130	4260

NOTES:

1. CAPACITIES ARE FOR ANCHORS INSTALLED IN SAND LIGHTWEIGHT CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 EXPANSION ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266 (2021)
4. MINIMUM CONCRETE THICKNESS SHALL COMPLY WITH ICC ESR-4266 (2021). REFER TO METAL DECK DIMENSIONS SHOWN ABOVE.
5. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
6. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
7. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
8. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
9. HANGER ROD DIAMETER SHALL BE EQUAL TO OR GREATER THAN THE ANCHOR DIAMETER.
10. IF ALLOWABLE LOAD FOR ONE ANCHOR IS USED, HANGER ROD MAY BE OFF CENTER WHEN USING TWO ANCHORS WITH STRUT.
11. APPLIED LOADS INCLUDE VERTICAL GRAVITY LOADS PLUS VERTICAL SEISMIC LOADS.
12. NOT USED
13. STRUT HOLE SIZE SHALL BE NO LARGER THAN BOLT DIAMETER PLUS 1/16" PER AISI.
14. HOLE DIAMETER THROUGH METAL DECK MAY NOT EXCEED ANCHOR HOLE DIAMETER BY MORE THAN 1/8" PER ICC-ESR.
15. S-MAX (MAX SPACING BETWEEN ANCHORS ON SAME FLUTE) NOT TO EXCEED 15 INCHES

Concrete over Metal Deck – Hanger Rod Attachment



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Section
4.1

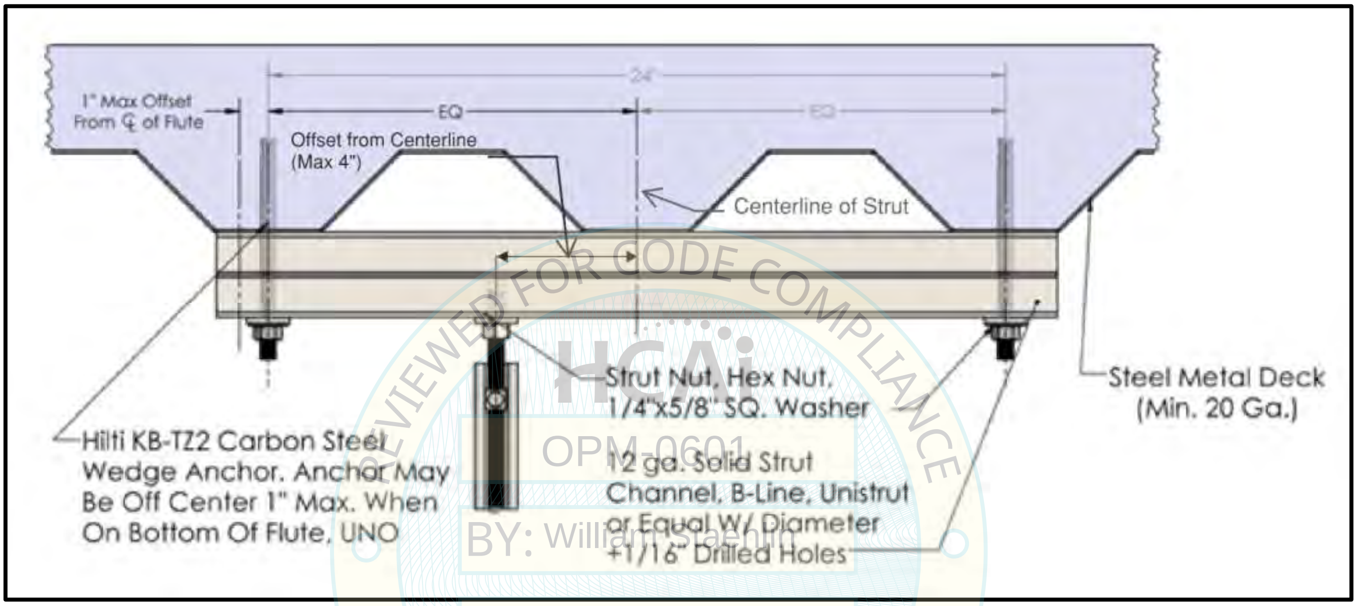
Concrete over Metal Deck – Hanger Rod Attachment

Anchor Dia.	Min. Effective embed. Depth hef	'Smin' Min. Spacing Between Anchors on Same Flute	Min. Edge Distance	Two Anchor Connection (Strength Design Seismic Capacity) Combined Total Allowable Rod Tension Design Value (Lbs.) Vertical Support Rod Max. Offset From C.L (LB)		Max. Allowable Load on Single Anchor (LB)(Strength Design Seismic Capacity)
				CL ± 0"	CL ± 1"	
3/8"	2"	12"	6 3/4"	2220	1903	1110
1/2"	2"	12"	6 3/4"	2060	1766	1030
1/2"	3 1/4"	12"	9 3/4"	3200	2743	1600
5/8"	4"	12"	12"	4260	3651	2000

NOTES:

1. CAPACITIES ARE FOR ANCHORS INSTALLED IN SAND LIGHTWEIGHT CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 EXPANSION ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS.
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266 (2021)
4. MINIMUM CONCRETE THICKNESS SHALL COMPLY WITH ICC ESR-4266 (2021). REFER TO METAL DECK DIMENSIONS ABOVE.
5. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
6. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
7. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
8. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
9. HANGER ROD DIAMETER SHALL BE EQUAL TO OR GREATER THAN THE ANCHOR DIAMETER.
10. IF ALLOWABLE LOAD FOR ONE ANCHOR IS USED, HANGER ROD MAY BE OFFSET ANYWHERE BETWEEN THE TWO ANCHORS.
11. APPLIED LOADS INCLUDE VERTICAL GRAVITY LOADS PLUS VERTICAL SEISMIC LOADS.
12. NOT USED.
13. STRUT HOLE SIZE SHALL BE NO LARGER THAN BOLT DIAMETER PLUS 1/16" PER AISI.
14. HOLE DIAMETER THROUGH METAL DECK MAY NOT EXCEED ANCHOR HOLE DIAMETER BY MORE THAN 1/8" PER ICC-ESR.
15. S-MAX (MAX SPACING BETWEEN ANCHORS ON SAME FLUTE) NOT TO EXCEED 15 INCHES

Concrete over Metal Deck – Hanger Rod Attachment



Concrete over Metal Deck – Hanger Rod Attachment

Anchor Dia.	Min. Effective embed. Depth h_{ef}	'S_{min}' Min. Spacing Between Anchors on Same Flute	Min. Edge Distance	Two Anchor Connection (Strength Design Seismic Capacity) Combined Total Allowable Rod Tension Design Value (Lbs.) Vertical Support Rod Max. Offset From C.L (LB)					Max. Allowable Load on Single Anchor (LB) (Strength Design Seismic Capacity)
				CL ± 0"	CL ± 1"	CL ± 2"	CL ± 3"	CL ± 4"	
3/8"	2"	12"	6 3/4"	2220	2049	1903	1776	1665	1110
1/2"	2"	12"	6 3/4"	2060	1902	1766	1648	1545	1030
1/2"	3 1/4"	12"	9 3/4"	3200	2954	2743	2560	2400	1600
5/8"	4"	12"	12"	4260	3932	3651	3408	3195	2130

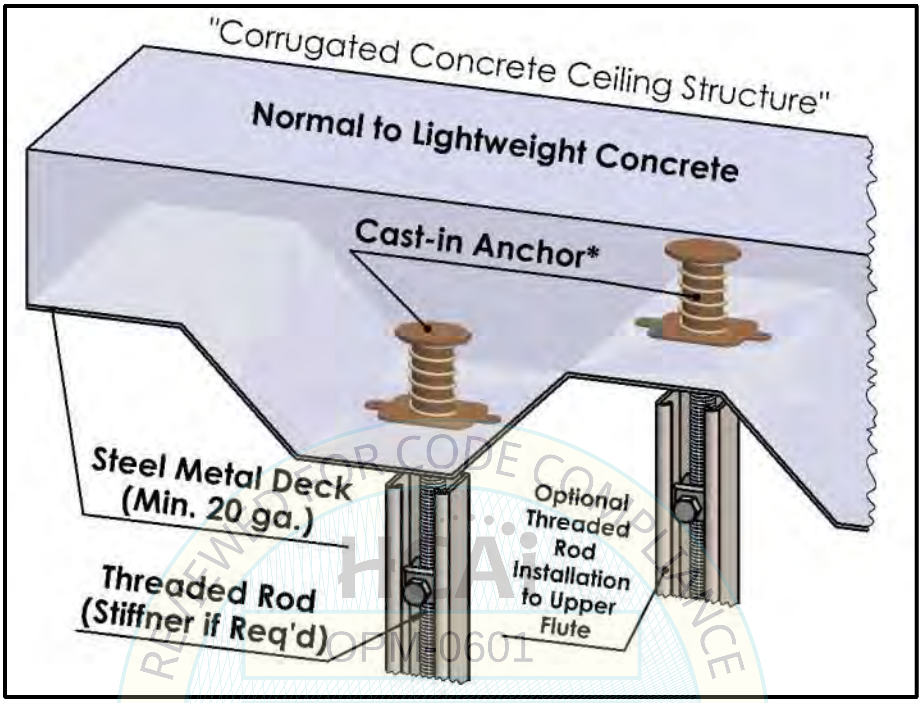
NOTES:

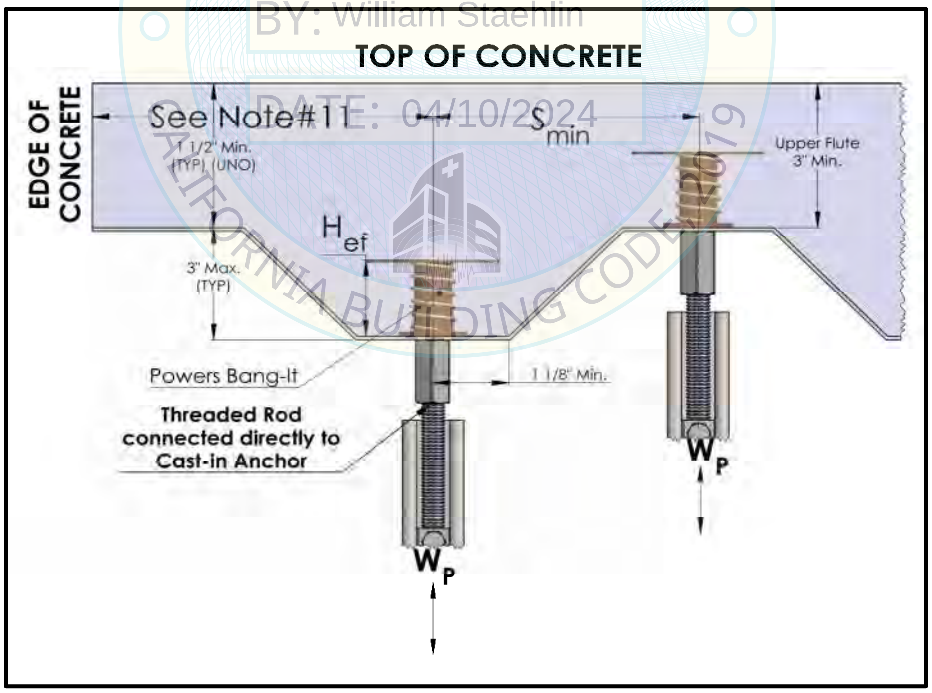
1. CAPACITIES ARE FOR ANCHORS INSTALLED IN SAND LIGHTWEIGHT CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 EXPANSION ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS.
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266 (2021)
4. MINIMUM CONCRETE THICKNESS SHALL COMPLY WITH ICC ESR-4266 (2021). REFER TO METAL DECK DIMENSIONS ABOVE.
5. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
6. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
7. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
8. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
9. HANGER ROD DIAMETER SHALL BE EQUAL TO OR GREATER THAN THE ANCHOR DIAMETER.
10. IF ALLOWABLE LOAD FOR ONE ANCHOR IS USED, HANGER ROD MAY BE OFFSET ANYWHERE BETWEEN THE TWO ANCHORS.
11. APPLIED LOADS INCLUDE VERTICAL GRAVITY LOADS PLUS VERTICAL SEISMIC LOADS.
12. NOT USED.
13. STRUT HOLE SIZE SHALL BE NO LARGER THAN BOLT DIAMETER PLUS 1/16" PER AISI.
14. HOLE DIAMETER THROUGH METAL DECK MAY NOT EXCEED ANCHOR HOLE DIAMETER BY MORE THAN 1/8" PER ICC-ESR.

Concrete over Metal Deck – Hanger Rod Attachment

4.1.2 Cast-In Anchor

Single Anchor





*Type/Brand of Cast-In Anchor Specified in Sections 4.1.2.1

Concrete over Metal Deck – Hanger Rod Attachment

4.1.2.1 Hilti KCM-MD Cast-In Anchor

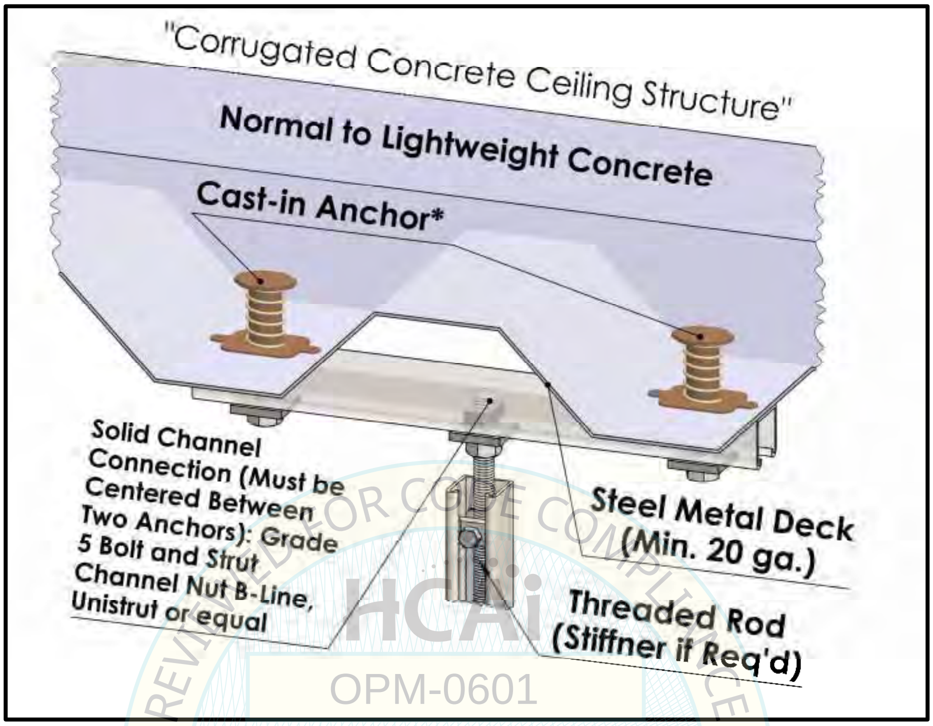
Anchor Dia.	Min. Anchor Effective Depth	Strength Design Seismic Capacity	
		Upper Flute Max. Vertical Load (LB)	Lower Flute Max. Vertical Load (LB)
3/8"	1 3/4"	1740	840
1/2"	2"	2150	1100
5/8"	2 1/2"	2720	1260
3/4"	2 1/2"	2720	1260

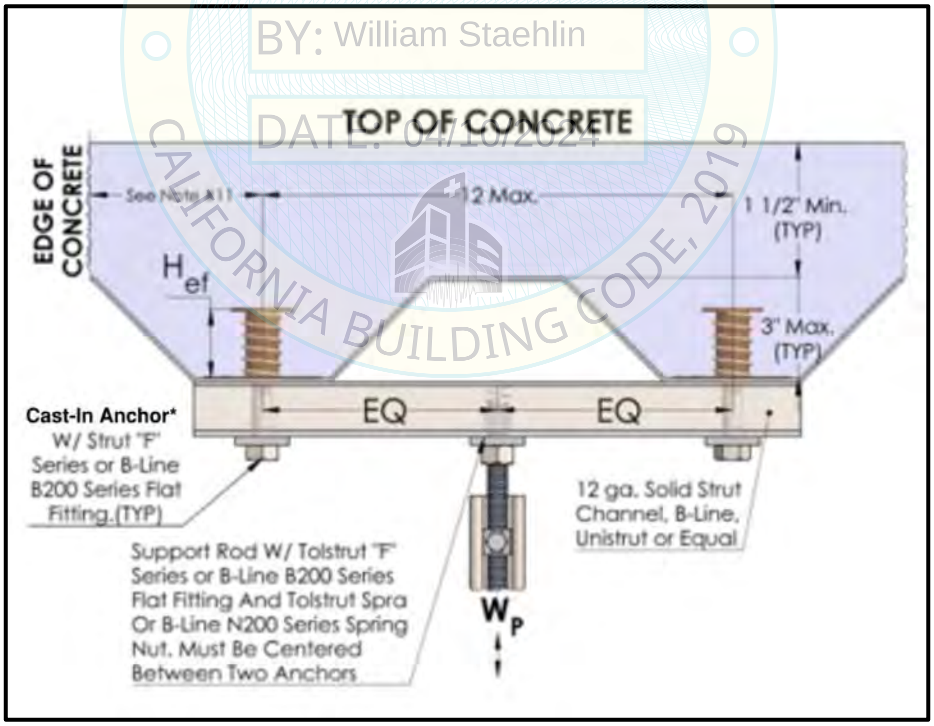
NOTES:

1. CAPACITIES ARE FOR ANCHORS INSTALLED IN 3,000 PSI SAND LIGHTWEIGHT CONCRETE.
2. CALIFORNIA BUILDING CODE STATES: "ALL BOLTS SHALL BE ACCURATELY AND SECURELY SET PRIOR TO PLACEMENT OF CONCRETE..." NAILS OR STRUT MAY BE USED. TYPICAL FOR ALL APPLICATIONS.
3. A HOLE MUST BE MADE IN THE STEEL DECK USING A STEP-DRILL, HOLE SAW, DECK PUNCH OR EQUIVALENT IN ACCORDANCE WITH THE ANCHOR DIAMETER.
4. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
5. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS AND ANCHOR EMBEDMENT. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
6. MINIMUM SPACING BETWEEN INSERTS SHALL BE 3 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER (WHICH EVER IS GREATER), UNLESS NOTED OTHERWISE.
7. ROD COUPLING DOES NOT NEED TO BE TIGHT UP AGAINST THE UNDERSIDE OF THE DECK.
8. HANGER ROD DIAMETER SHALL BE EQUAL TO OR MORE THAN THE ANCHOR DIAMETER.
9. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER WHICHEVER IS GREATER, UNLESS NOTED OTHERWISE.
10. FOLLOW ALL Hilti KCM-MD INSTALLATION REQUIREMENTS PER ICC-ESR 4145.

Concrete over Metal Deck – Hanger Rod Attachment

Double Anchor w/ Solid Channel





*Type/Brand of Cast-In Anchor Specified in Sections 4.1.2.1

Concrete over Metal Deck – Hanger Rod Attachment

Anchor Dia.	Min. Anchor Effective Depth	Strength Design Seismic Capacity
		Lower Flute Double Anchors Max. Vertical Load (LB)
3/8"	1 3/4"	1680
1/2"	2"	2200
5/8"	2 1/2"	2520
3/4"	2 1/2"	2520

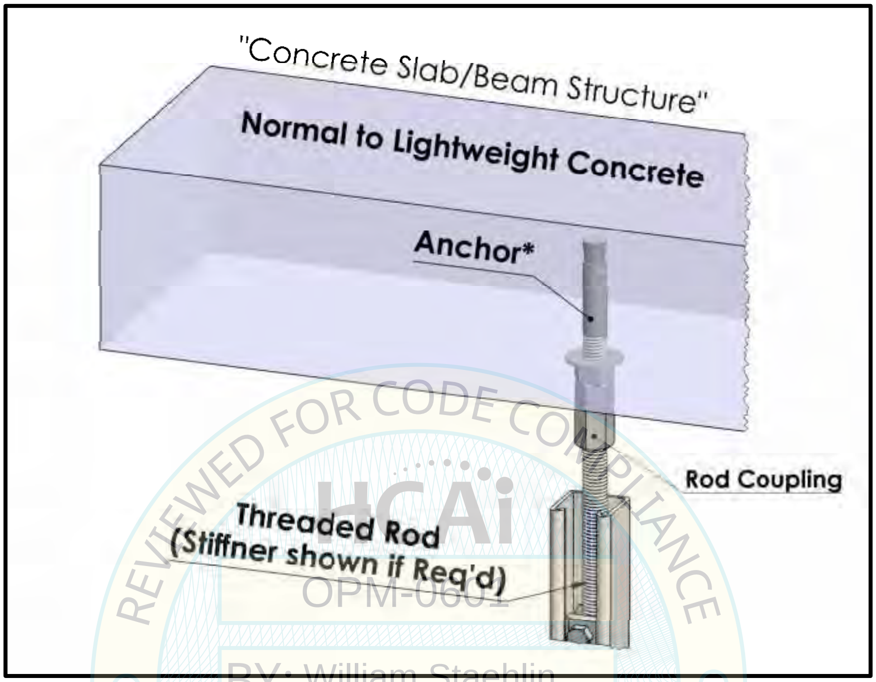
NOTES:

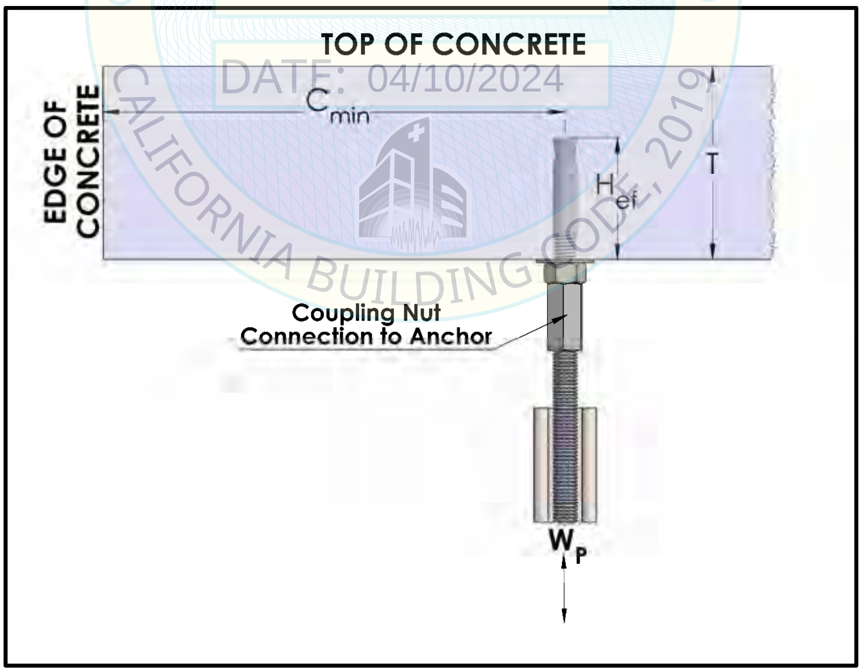
1. CAPACITIES ARE FOR ANCHORS INSTALLED IN 3,000 PSI SAND LIGHTWEIGHT CONCRETE.
2. CALIFORNIA BUILDING CODE STATES: "ALL BOLTS SHALL BE ACCURATELY AND SECURELY SET PRIOR TO PLACEMENT OF CONCRETE..." NAILS OR STRUT MAY BE USED. TYPICAL FOR ALL APPLICATIONS.
3. A HOLE MUST BE MADE IN THE STEEL DECK USING A STEP-DRILL, HOLE SAW, DECK PUNCH OR EQUIVALENT IN ACCORDANCE WITH THE ANCHOR DIAMETER.
4. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
5. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS AND ANCHOR EMBEDMENT. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
6. MINIMUM SPACING BETWEEN INSERTS SHALL BE 3 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER (WHICH EVER IS GREATER), UNLESS NOTED OTHERWISE.
7. ROD COUPLING DOES NOT NEED TO BE TIGHT UP AGAINST THE UNDERSIDE OF THE DECK.
8. HANGER ROD DIAMETER SHALL BE EQUAL TO OR MORE THAN THE ANCHOR DIAMETER.
9. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER WHICHEVER IS GREATER, UNLESS NOTED OTHERWISE.
10. FOLLOW ALL Hilti KCM-MD INSTALLATION REQUIREMENTS PER ICC-ESR 4145.

4.2 Concrete Slab/Beam

4.2.1 Post-installed Wedge Anchor

Single Anchor

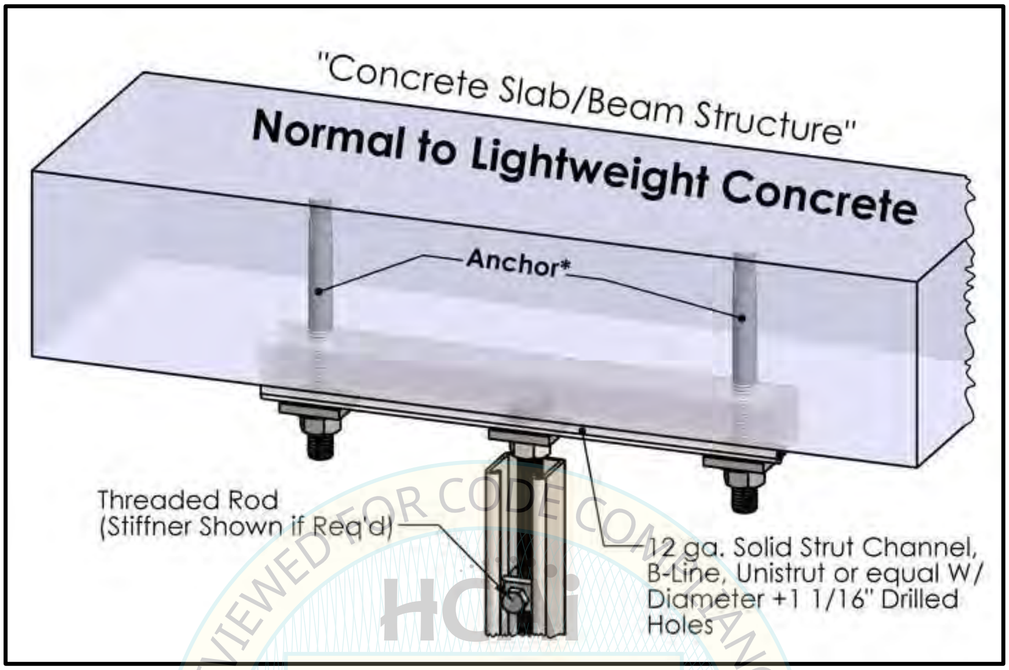


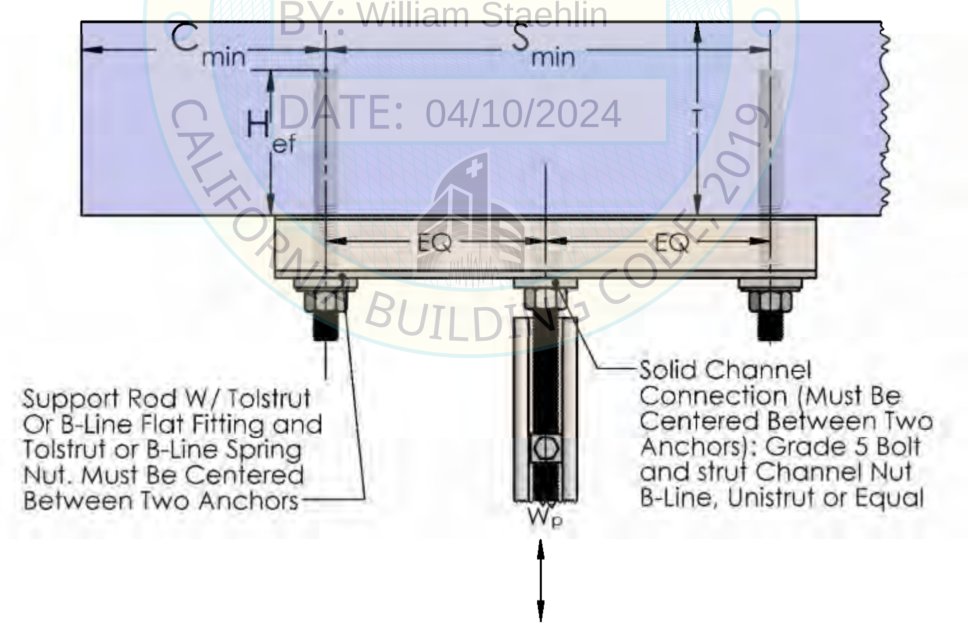


*Type/Brand of Anchor Specified in Section 4.2.1.1

Concrete Slab/Beam – Hanger Rod Attachment

Double Anchor w/ Solid Channel





*Type/Brand of Expansion Anchor Specified in Section 4.2.1.1

Concrete Slab/Beam – Hanger Rod Attachment

4.2.1.1 Hilti KB-TZ2 Anchor

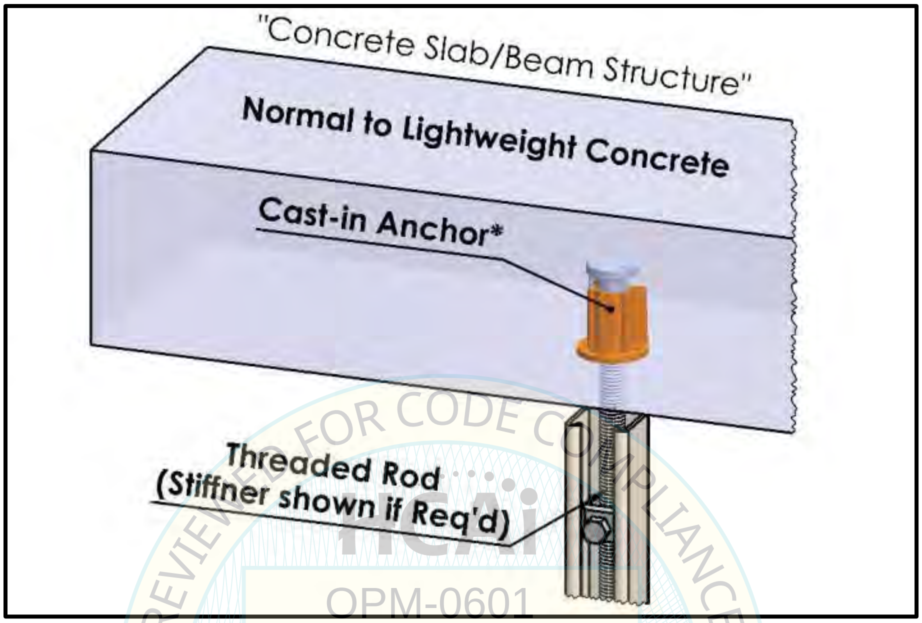
Anchor Dia.	Min. Effective embed. Depth h_{ef}	C_{min}' Min. Edge Distance	Max Spacing Between Anchors	T' Min. Base Material Thickness	Strength Design Seismic Capacity	
					Max. Vertical Load	
					Single (LB)	Double (LB)
3/8"	2"	6"	24"	4"	1580	3160
1/2"	2"	6"	23"	4"	1580	3160
1/2"	3 1/4"	9 3/4"	11"	6"	2630	5260
5/8"	3 1/8"	9 1/2"	11"	5"	3260	6520
5/8"	4"	12"	10"	6"	3620	7240
3/4"	3 3/4"	11 1/4"	10"	6"	4060	8120

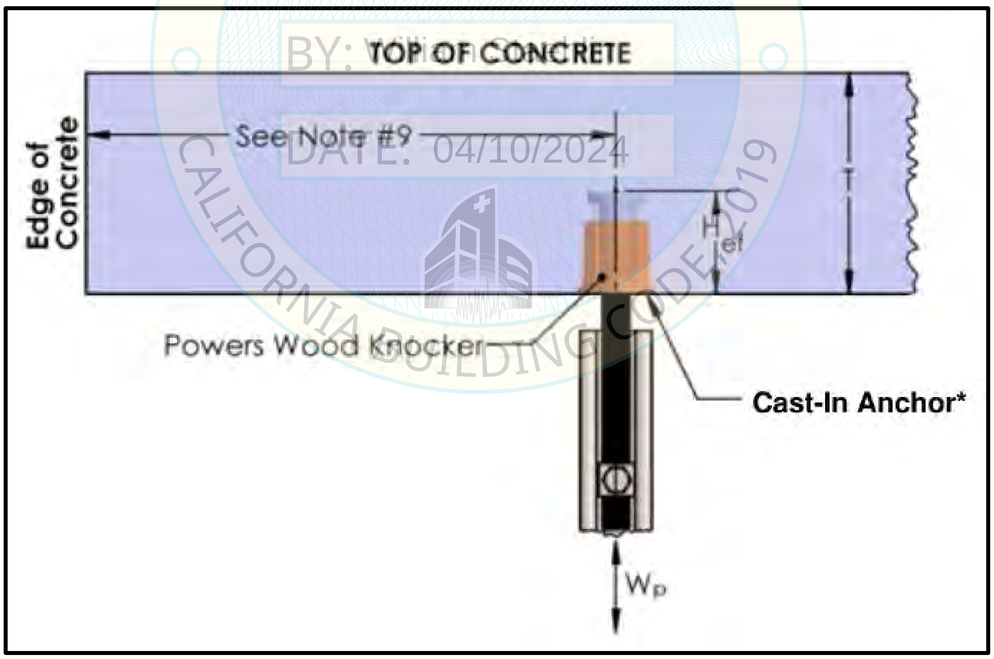
NOTES:

1. CAPACITIES ARE FOR ANCHORS INSTALLED IN STONE AGGREGATE CONCRETE HAVING A MIN. COMPRESSIVE STRENGTH OF 3,000 PSI AT THE TIME OF INSTALLATION AND DETERMINED PER ICC ESR-4266 (HILTI KB-TZ2 ANCHOR) FOR ANCHORS IN CRACKED CONCRETE. ALLOWABLE LOADS HAVE BEEN MULTIPLIED BY THE SEISMIC REDUCTION FACTOR PER ACI 318-19 Table 17.5.3(a).
2. SEE SECTION 1.8 FOR TESTING REQUIREMENTS
3. FOLLOW ALL WEDGE ANCHOR INSTALLATION REQUIREMENTS PER ICC ESR-4266
4. WHEN INSTALLING ANCHORS IN REINFORCED CONCRETE, AVOID DAMAGING REINFORCING STEEL.
5. WHEN INSTALLING ANCHORS IN PRESTRESSED CONCRETE. LOCATE PRESTRESSING STEEL AND AVOID DAMAGING PRESTRESSING STEEL.
6. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
7. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS, ANCHOR EMBEDMENT AND TIGHTENING TORQUE. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
8. HANGER ROD DIAMETER SHALL BE EQUAL TO OR GREATER THAN THE ANCHOR DIAMETER.
9. IF CAPACITY FOR ONE ANCHOR IS USED, HANGER ROD MAY BE OFF CENTER WHEN USING TWO ANCHORS WITH STRUT.
10. APPLIED LOADS INCLUDE VERTICAL GRAVITY LOADS PLUS VERTICAL SEISMIC LOADS.
11. STRUT HOLE SIZE SHALL NOT BE LARGER THAN BOLT DIAMETER PLUS 1/16" PER AISI.

4.2.2 Cast-In Anchor

Single Anchor





*Type/Brand of Cast-In Anchor Specified in Section 4.2.2.1

Concrete Slab/Beam – Hanger Rod Attachment

4.2.2.1 Hilti KCM-WF Cast-In Anchor

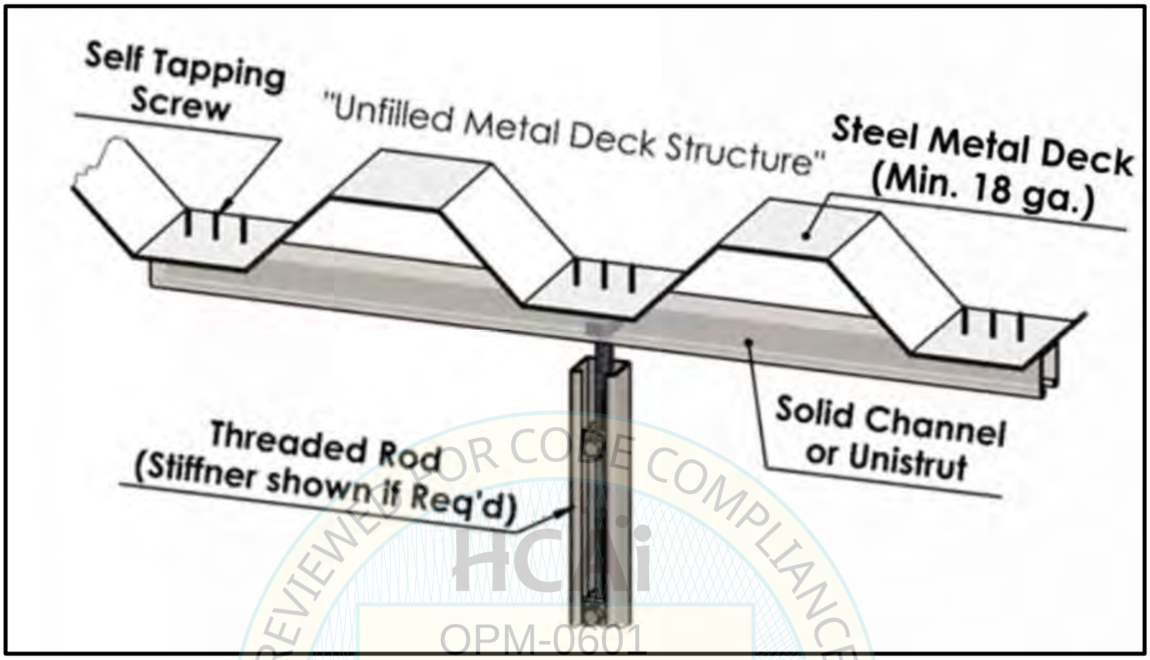
Anchor Dia.	Min. Effective embed. Depth	T' Min. Base Material Thickness	Strength Design Seismic Capacity
			Max. Vertical Load (LB)
3/8"	1 3/4"	3 1/2"	1640
1/2"	2"	4"	2300
5/8"	2 1/2"	5"	3120
3/4"	2 1/2"	5"	3120

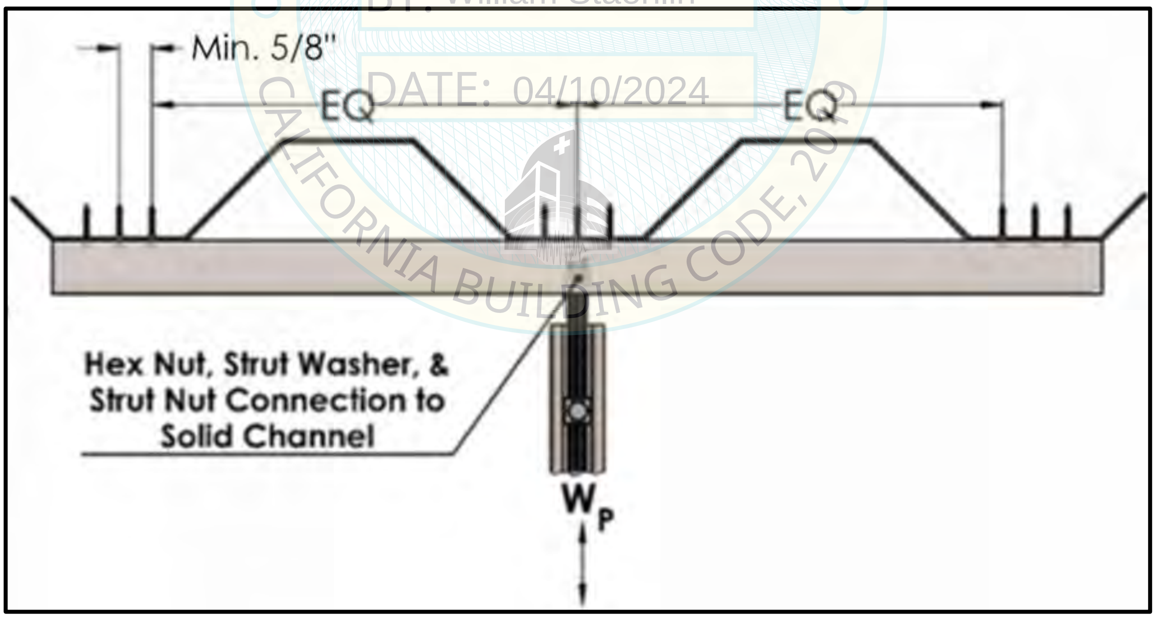
NOTES:

1. Hilti KCM-WF INSERTS MUST BE POSITIONED ON WOOD OR SIMILAR FORMWORK WITH ALL THREE NAILS IN CONTACT WITH THE FORM. THE HEAD OF THE HILTI KCM-WF MUST BE IMPACTED WITH SUFFICIENT FORCE TO DRIVE NAILS ALL THE WAY INTO THE FORMWORK UNTIL THE PLASTIC BASE SITS FLUSH AND TIGHT AGAINST THE FORM.
2. CAPACITIES ARE FOR 4,000 PSI NORMAL WEIGHT CONCRETE.
3. MINIMUM CONCRETE THICKNESS OF 3 TIMES THE EFFECTIVE EMBEDMENT DEPTH, OR THE EMBEDMENT DEPTH PLUS THREE TIMES THE DIAMETER, WHICHEVER IS GREATER, SHALL BE PROVIDED.
4. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED CAPACITIES.
5. SPECIAL INSPECTION SHALL BE PROVIDED PER CBC. THE SPECIAL INSPECTOR MUST BE ON THE JOBSITE CONTINUOUSLY DURING ANCHOR INSTALLATION TO VERIFY ANCHOR TYPE, ANCHOR DIMENSIONS, HOLE DIMENSIONS, ANCHOR SPACING, EDGE DISTANCES, SLAB THICKNESS AND ANCHOR EMBEDMENT. TEST REPORT OF THE RESULTS SHALL BE SUBMITTED TO HCAI.
6. MINIMUM SPACING BETWEEN THE INSERTS SHALL BE 3 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER (WHICH EVER IS GREATER), UNLESS NOTED OTHERWISE.
7. Hilti KCM-WF IS A CAST-IN-PLACE ANCHOR BOLT AND COMPLIES WITH ACI 318 CHAPTER 17 AND DOES NOT REQUIRE ADDITIONAL TESTING CERTIFICATION.
8. HANGER ROD DIAMETER SHALL BE EQUAL TO OR MORE THAN THE ANCHOR DIAMETER.
9. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE EMBEDMENT DEPTH OR 6 TIMES THE ANCHOR DIAMETER WHICHEVER IS GREATER, UNLESS NOTED OTHERWISE.
10. FOLLOW ALL Hilti KCM-WF INSTALLATION REQUIREMENTS PER ICC-ESR 4145.
11. MINIMUM 2 SCREWS PER FLUTE

4.3 Unfilled Metal Deck

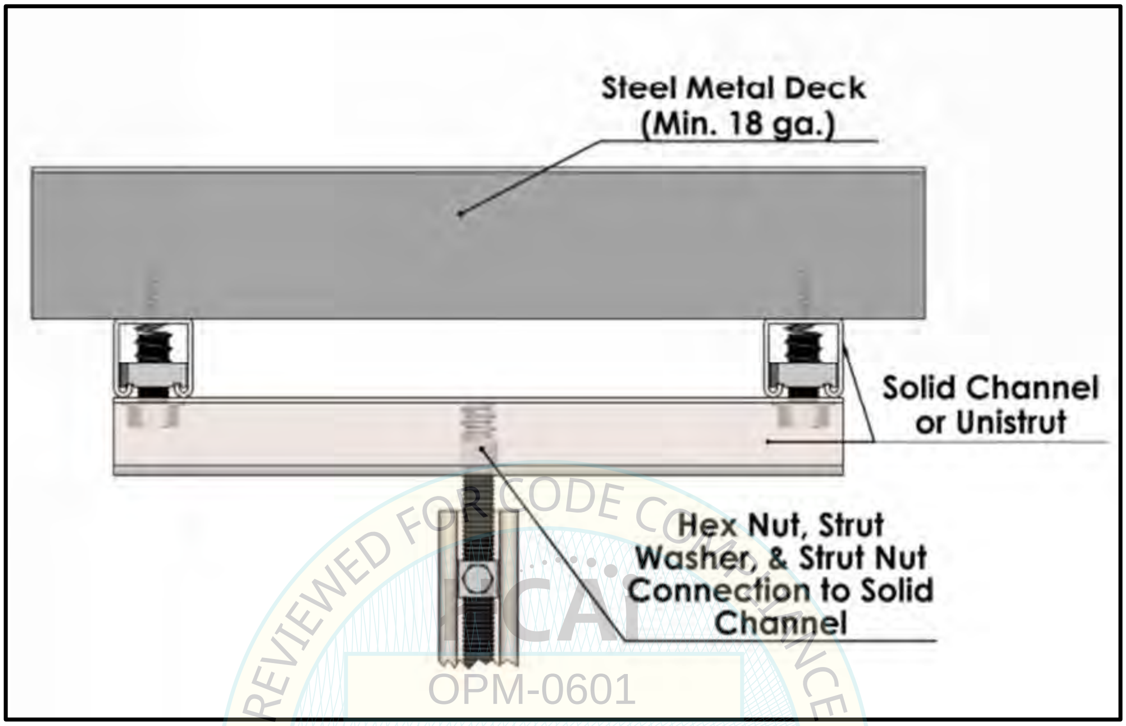
Perpendicular To Flutes





Unfilled Metal Deck – Hanger Rod Attachment

Parallel To Flutes



4.3.1 Hilti PPH Self-Drilling Screw

ALLOWABLE STRENGTH DESIGN (ASD)	
MAX. VERTICAL LOAD (LB)	
PERPENDICULAR	PARALLEL
100	100

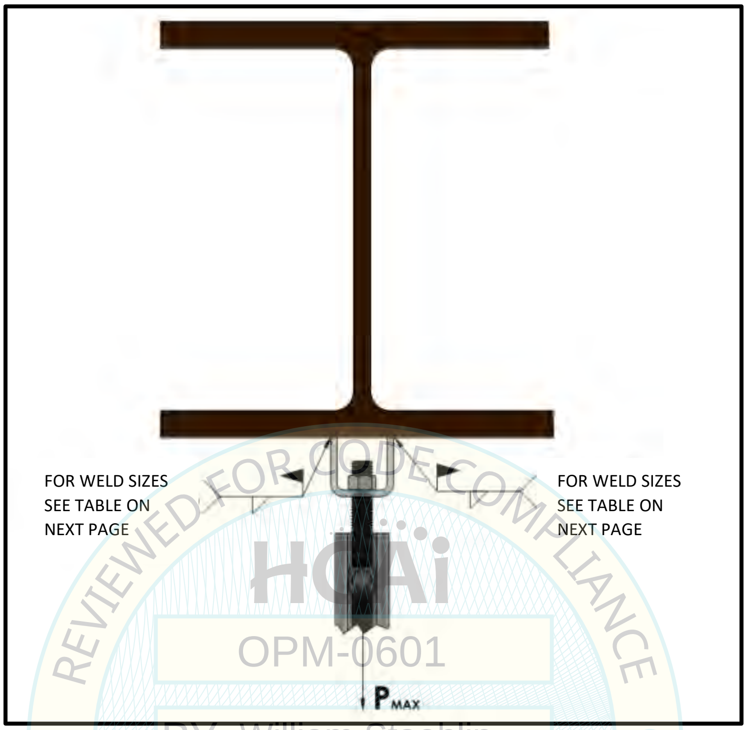
NOTES:

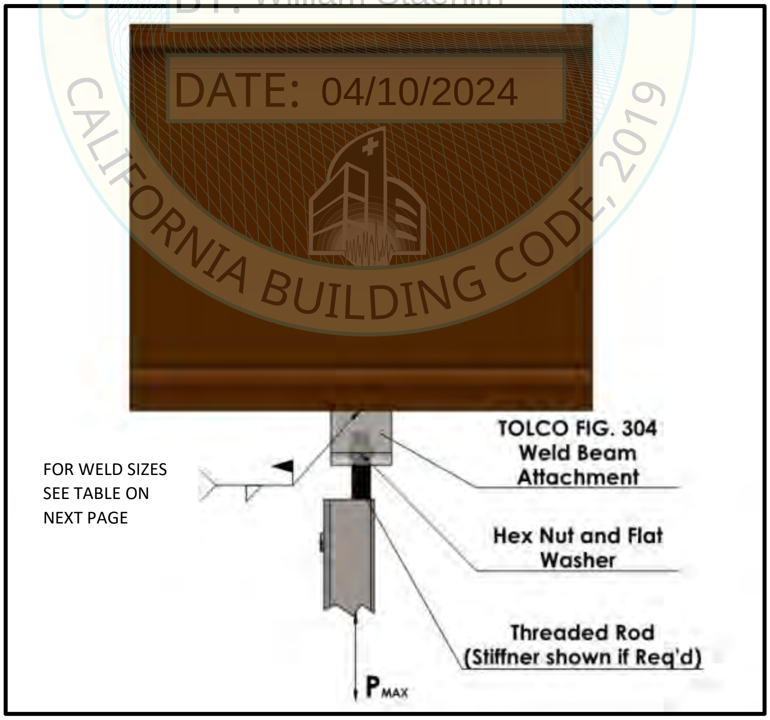
1. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY ADEQUACY OF THE STRUCTURE FOR THE TABULATED ALLOWABLE LOADS.
2. STRUT NUTS MAY BE USED INSTEAD OF SPRING NUTS AS SHOWN.
3. SCREWS SHALL BE 1'' MIN. LONG.
4. SCREWS SHALL BE SPACED AT 5/8'' MINIMUM SPACING WITH 3/8'' MIN. EDGE DISTANCE.
5. APPLIED LOADS INCLUDE VERTICAL GRAVITY LOADS PLUS VERTICAL SEISMIC LOADS.
6. STRUT HOLE SIZE SHALL BE NO LARGER THAN BOLT DIAMETER PLUS 1/16'' PER AISI.
7. MINIMUM 2 SCREWS AT EACH UNISTRUT-TO-FLUTE CONNECTION, MINIMUM SCREW SPACING IS ½''

Steel Beam – Hanger Rod Attachment

4.4 Steel Beam

4.4.1 Welded Lug Attachment To Steel Beam





Steel Beam – Hanger Rod Attachment

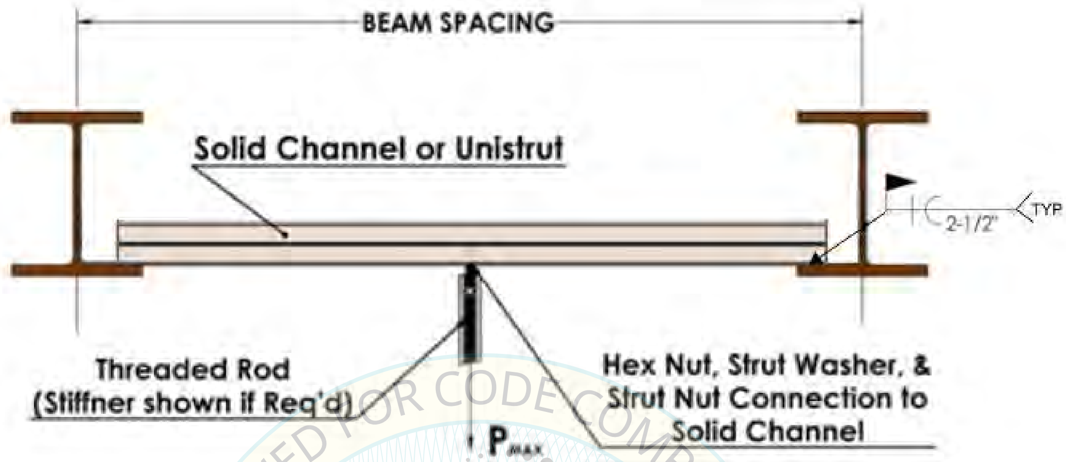
HANGER ROD DIAMETER	MIN. WELD SIZE EACH SIDE OF BRACKET	ALLOWABLE STRENGTH DESIGN (ASD) MAX. VERTICAL LOAD PMAX (LB)
3/8''	3/16''	730
1/2''	3/16''	1350
5/8''	3/16''	2160
3/4''	1/4''	3230
7/8''	1/4''	4480
1''	1/4''	4480

NOTES:

1. CONNECTION TO STRUCTURE BEAM SUBJECT TO PRIOR APPROVAL FROM STRUCTURAL ENGINEER OR RECORD.
2. ATTACHMENTS ARE PROHIBITED IN PROTECTED ZONES. SEE STRUCTURAL DRAWINGS FOR LOCATIONS OF PROTECTED ZONES.

Steel Beam – Hanger Rod Attachment

4.4.2 Supplemental Steel



Steel Beam – Hanger Rod Attachment

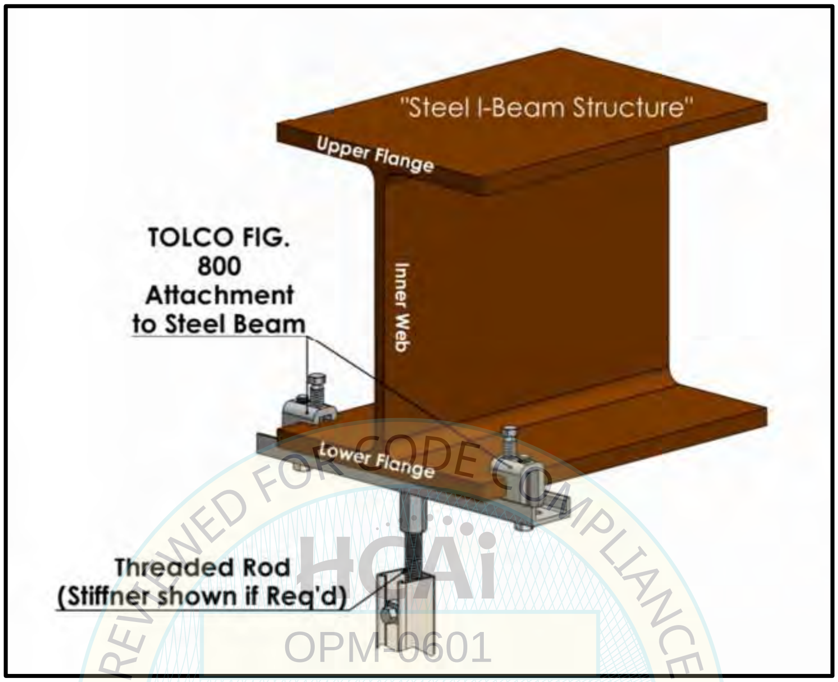
MAXIMUM BEAM SPAN	PMAX MAXIMUM VERTICAL ALLOWABLE LOAD (LB)(ASD) (TOTAL OF ALL APPLIED INDIVIDUAL LOADS SHALL NOT EXCEED PMAX)
6'-0''	500
8'-0''	475

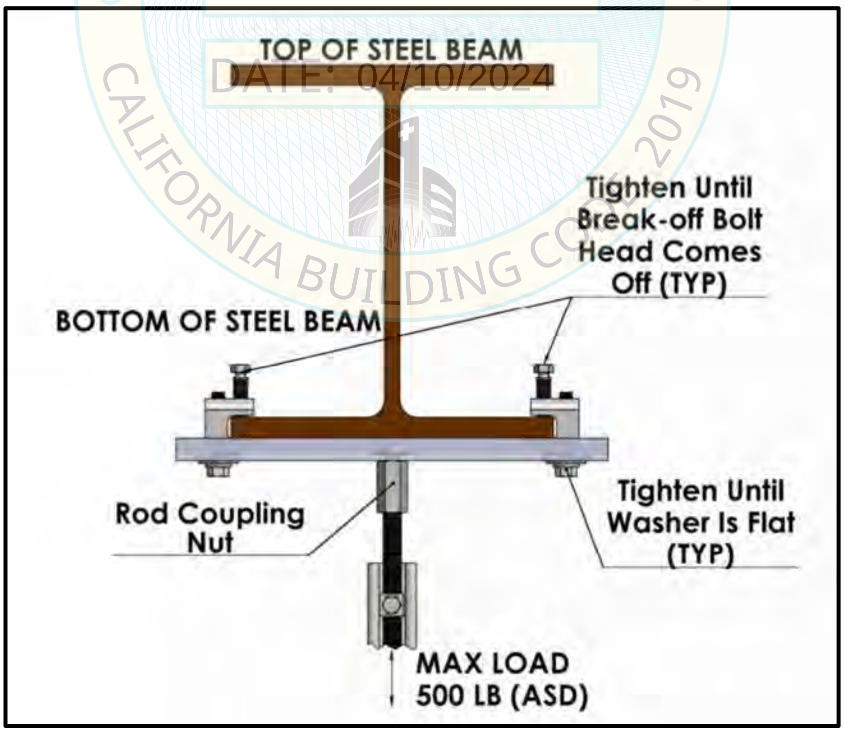
NOTES:

1. CONNECTION TO STRUCTURAL STEEL BEAMS SUBJECT TO APPROVAL FROM STRUCTURAL ENGINEER OF RECORD.
2. NO ATTACHMENTS SHALL BE IN PROTECTED ZONES. (SEE AISC 341, CHAPTER D). SEE STRUCTURAL DRAWINGS FOR LOCATIONS OF PROTECTED ZONES.
3. WELDING SHALL BE DONE BY ELECTRIC SHIELDED ARC PROCESS USING E-70XX ELECTRODES.
4. ALL WELDING SHALL BE PERFORMED BY CERTIFIED WELDER AND IN CONFORMED WITH AWS STANDARDS AND 2022 CBC. CONTINUOUS INSPECTIONS ARE REQUIRED FOR ALL WELDING CONNECTIONS.
5. ALL WELDS SHALL BE IN CONFORMANCE WITH 2022 CALIFORNIA BUILDING CODE. (CBC)
6. CONTINUOUS INSPECTION IS REQUIRED FOR ALL WELDING
7. LOADS ARE BASED ON ALLOWABLE STRENGTH DESIGN.
8. ECCENTRIC LOADING IS NOT ALLOW

Steel Beam – Hanger Rod Attachment

4.4.3 Beam Clamp





Steel Beam – Hanger Rod Attachment

NOTES:

1. THREADED ROD SHALL BE DIRECTLY MOUNTED THROUGH THE I-BEAM FLANGE AND FASTENED BY WASHERS AND NUTS ON BOTH SIDES (ACTING LIKE A THRU-BOLT). IN CASE DRILLING HOLES ON THE BEAM ARE NOT PERMITTED, THREADED ROD CAN BE MOUNTED THROUGH BEAM CLAMP BY NUTS AND WASHERS.

2. ATTACHMENTS ARE PROHIBITED IN PROTECTED ZONES. SEE STRUCTURAL DRAWINGS FOR LOCATIONS OF PROTECTED ZONES.

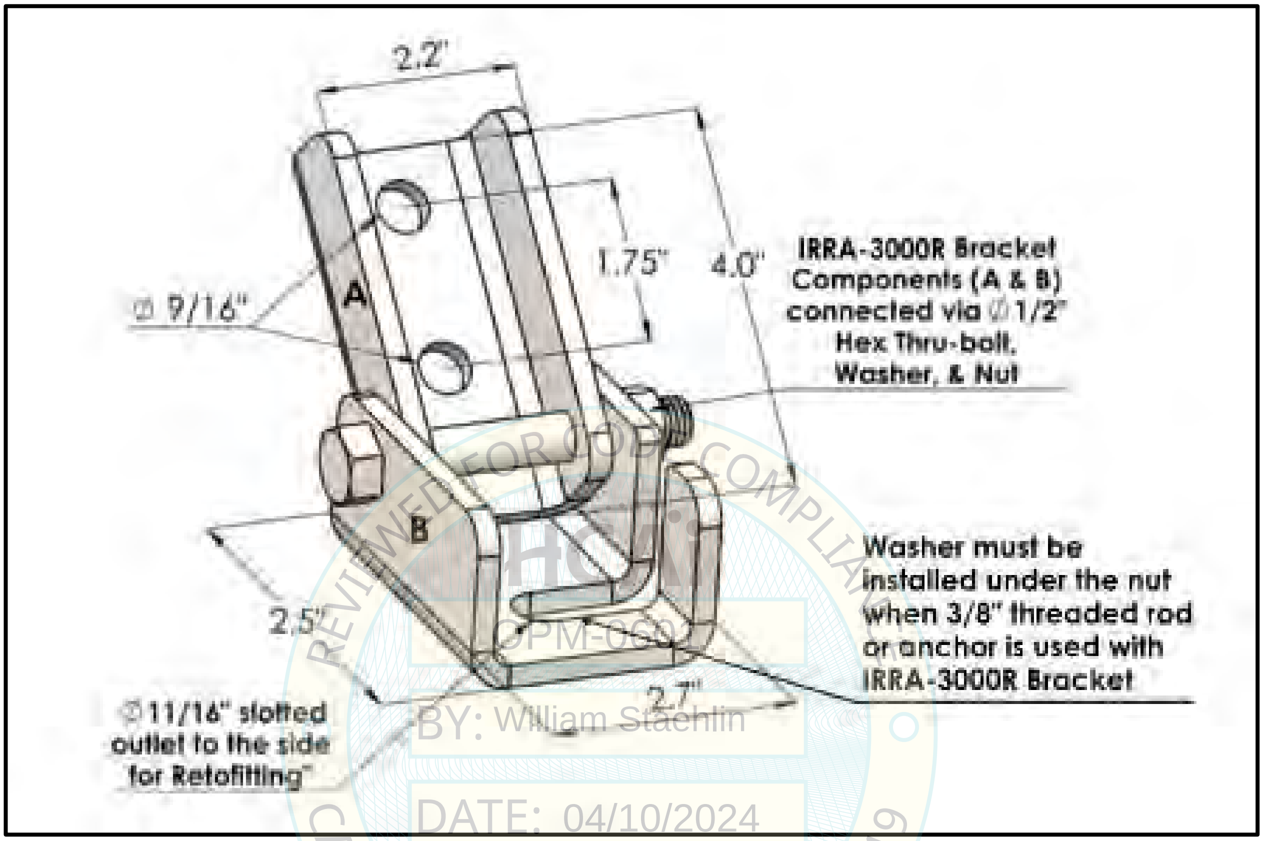
3. STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE FOR THE TABULATED THREADED ROD LOAD CAPACITY.

4. BEAM FLANGE THICKNESS TO BE NO MORE THAN ¾ INCH

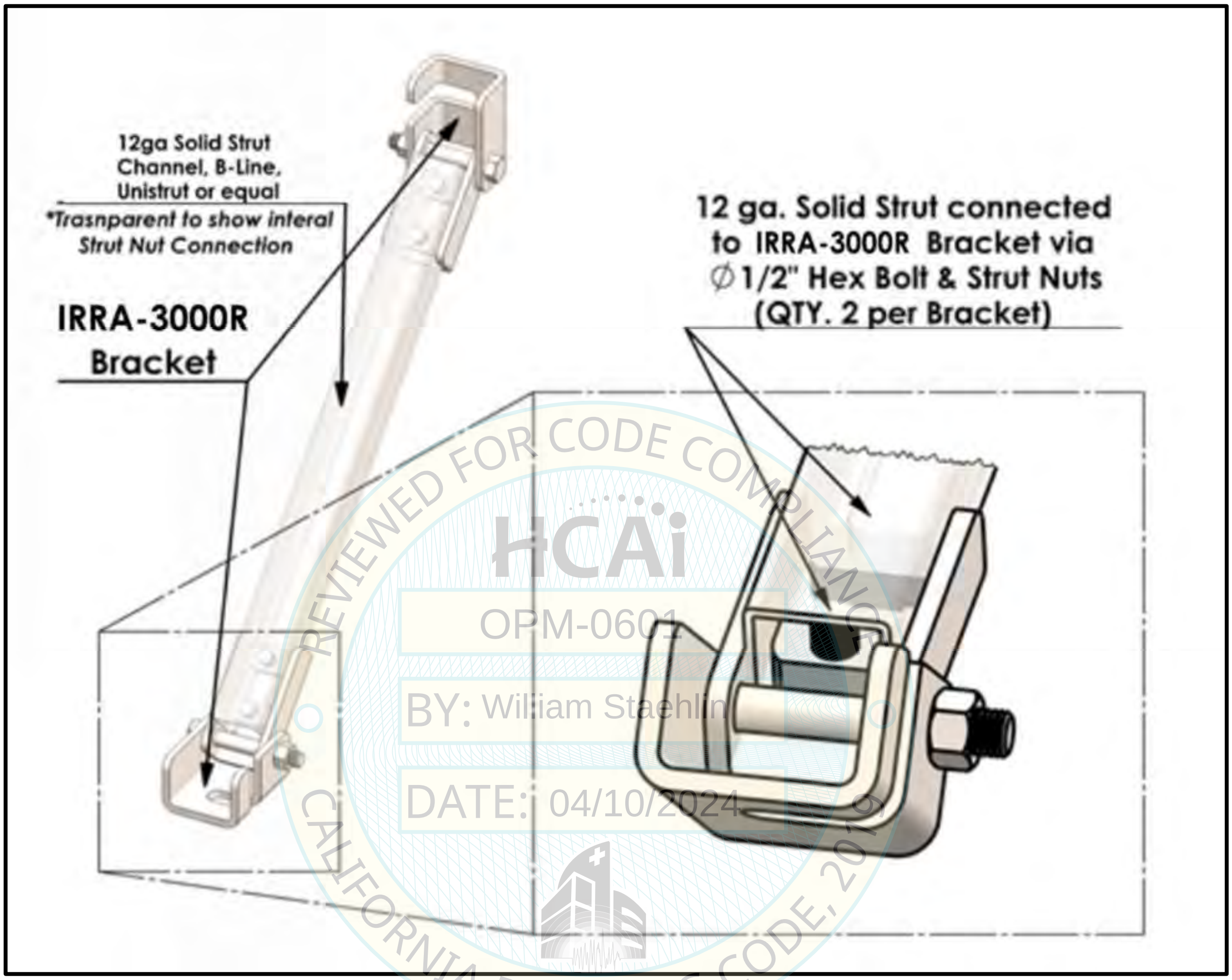
SECTION 5.0 RIGID BRACE COMPONENTS

IRRA – 3000R Bracket

5.1 IRRA-3000R Bracket



5.2 IRRA-3000R Rigid Restraint



IRRA-3000R RIGID RESTRAINT SPECIFICATIONS

Max. Allowable Load (Tension or Compression)	Max. Strut Nut Size (Component A)	Max. Anchor/Bolt Size (Component B)	Approximate Weight
lb.	in.	in.	lb.
1000	1/2	5/8	3.7

SECTION 6.0 RIGID RESTRAINT SPACING CHART BASED ON BRACE CAPACITY

6.1 Pipe Spacing Charts (Single Restraint)

SCHEDULE 40 (STD) STEEL PIPE

FILLED WITH GAS / EMPTY

Pipe Diameter in	Pipe Diameter mm	Weight of the Pipe lb/ft	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle G-Factors						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
1	25	1.7	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	2.3	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	2.7	80	80	80	80	80	80	80	80	80	80	80	80
2	50	3.7	80	80	80	80	80	80	80	80	80	80	80	80
2.5	65	5.8	80	80	80	80	80	80	80	80	80	80	68	57
3	75	7.6	80	80	80	80	74	62	80	80	80	65	52	43
4	100	11	80	80	80	64	51	42	80	80	60	45	36	30
5	125	15	80	80	62	47	37	31	80	66	44	33	26	22
6	150	19	80	74	49	37	29	24	80	52	35	26	21	17*
8	200	29	80	48	32	24	19*	16*	68	34	22	17*	13*	11*

***Double restraint system is recommended, see section 6.2 for detailed double restraint spacing chart.**

SPACE SELECTION & NOTES:

1. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.
2. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.
3. Detailed configurations and installations for single restraint piping system are shown in Section 2.0.
4. Weight of the Pipe represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.
5. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.
6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling. See Section 7.3.

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SCHEDULE 40 (STD) STEEL PIPE

INSULATED AND FILLED WITH WATER

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	0.5	0.75	1.0	1.25	1.5	0.25	0.5	0.75	1.0	1.25	1.5
1	25	2.8	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	3.8	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	4.5	80	80	80	80	80	80	80	80	80	80	80	74
2	50	6.2	80	80	80	80	80	76	80	80	80	80	64	53
2.5	65	9.1	80	80	80	77	62	51	80	80	73	54	43	36
3	75	12.1	80	80	77	58	46	38	80	80	55	41	33	27
4	100	18.3	80	77	51	38	30	25	80	54	36	27	21	18*
5	125	26.6	80	53	35	26	21	17*	75	37	25	18*	15*	12*
6	150	34.8	80	40	27	20	16*	13*	57	28	19*	14*	11*	9*
8	200	55.1	51	25	17*	12*	10*	8*	36	18*	12*	9*	7*	6*

SCHEDULE 40 (STD) STEEL PIPE

FILLED WITH FUEL

Pipe Diameter		Weight of the Pipe	**Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle**						**Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle**					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	0.5	0.75	1.0	1.25	1.5	0.25	0.5	0.75	1.0	1.25	1.5
1	25	2	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	2.9	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	3.5	80	80	80	80	80	80	80	80	80	80	80	80
2	50	5	80	80	80	80	80	80	80	80	80	80	80	66
2.5	65	7.6	80	80	80	80	74	62	80	80	80	65	52	43
3	75	10.3	80	80	80	68	54	45	80	80	64	48	38	32
4	100	15.7	80	80	60	45	36	30	80	63	42	31	25	21
5	125	22.4	80	63	42	31	25	21	80	44	29	22	17*	14*
6	150	29.6	80	47	31	23	19*	15*	67	33	22	16*	13*	11*
8	200	47.7	59	29	19*	14*	11*	9*	41	20	13*	10*	8*	6*

***Double restraint system is recommended, see section 6.2 for detailed double restraint spacing chart.**
See page 154 for Notes.

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Section
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SCHEDULE 10 STAINLESS STEEL PIPE

FILLED WITH GAS / EMPTY

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
1	25	1.4	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	1.8	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	2.1	80	80	80	80	80	80	80	80	80	80	80	80
2	50	2.6	80	80	80	80	80	80	80	80	80	80	80	80
2.5	65	3.5	80	80	80	80	80	80	80	80	80	80	80	80
3	75	4.3	80	80	80	80	80	80	80	80	80	80	80	77
4	100	5.6	80	80	80	80	80	80	80	80	80	80	71	59
5	125	7.8	80	80	80	80	72	60	80	80	80	64	51	42
6	150	9.3	80	80	80	76	60	50	80	80	71	53	43	35
8	200	13.4	80	80	70	52	42	35	80	74	49	37	29	24

SPACE SELECTION & NOTES:

1. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.
2. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.
3. Detailed configurations and installations for single restraint piping system are shown in Section 2.0.
4. Weight of the Pipe represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.
5. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.
6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling. See Section 7.3.

SCHEDULE 10 STAINLESS STEEL PIPE

INSULATED AND FILLED WITH WATER

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	0.5	0.75	1.0	1.25	1.5	0.25	0.5	0.75	1.0	1.25	1.5
1	25	2.5	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	3.3	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	3.9	80	80	80	80	80	80	80	80	80	80	80	80
2	50	5.1	80	80	80	80	80	80	80	80	80	80	78	65
2.5	65	6.8	80	80	80	80	80	69	80	80	80	73	58	49
3	75	8.8	80	80	80	80	64	53	80	80	75	56	45	37
4	100	12.9	80	80	73	54	43	36	80	77	51	38	31	25
5	125	19.4	80	72	48	36	29	24	80	51	34	25	20	17*
6	150	25.1	80	56	37	28	22	18*	79	39	26	19*	15*	13*
8	200	39.5	71	35	23	17*	14*	11*	50	25	16*	12*	10*	8*

SCHEDULE 10 STAINLESS STEEL PIPE

FILLED WITH FUEL

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	0.5	0.75	1.0	1.25	1.5	0.25	0.5	0.75	1.0	1.25	1.5
1	25	1.7	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	2.4	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	2.9	80	80	80	80	80	80	80	80	80	80	80	80
2	50	3.9	80	80	80	80	80	80	80	80	80	80	80	80
2.5	65	5.3	80	80	80	80	80	80	80	80	80	80	75	62
3	75	7	80	80	80	80	80	67	80	80	80	71	57	47
4	100	10.3	80	80	80	68	54	45	80	80	64	48	38	32
5	125	15.2	80	80	62	46	37	31	80	65	43	32	26	21
6	150	19.9	80	71	47	35	28	23	80	50	33	25	20*	16*
8	200	32.1	80	44	29	22	17*	14*	62	31	20	15*	12*	10*

***Double restraint system is recommended, see section 6.2 for detailed double restraint spacing chart.**
See page 155 for Notes.

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COPPER (TYPE L) PIPE

INSULATED AND FILLED WITH WATER*

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
1	25	2.2	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	3	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	3.6	80	80	80	80	80	80	80	80	80	80	80	80
2	50	5	80	80	80	80	80	80	80	80	80	80	80	66
2.5	65	7.6	80	80	80	80	74	62	80	80	80	65	52	43
3	75	10.2	80	80	80	69	55	46	80	80	65	49	39	32
4	100	15	80	80	62	47	37	31	80	66	44	33	26	22

***Copper pipes are commonly used for domestic water pipes and fan coil units, insulation required.**

SPACE SELECTION & NOTES:

1. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.
2. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.
3. Detailed configurations and installations for single restraint piping system are shown in Section 2.0.
4. Weight of the Pipe represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.
5. This table was only generated for G-factors up to 1.5. For larger G-factors, this table is unconservative; use engineering calculations instead.
6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling.

PVC PIPE

FILLED WITH WATER

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	0.5	0.75	1.0	1.25	1.5	0.25	0.5	0.75	1.0	1.25	1.5
1	25	0.7	80	80	80	80	80	80	80	80	80	80	80	80
1.25	30	1.1	80	80	80	80	80	80	80	80	80	80	80	80
1.5	38	1.5	80	80	80	80	80	80	80	80	80	80	80	80
2	50	2.2	80	80	80	80	80	80	80	80	80	80	80	80
2.5	65	3.2	80	80	80	80	80	80	80	80	80	80	80	80
3	75	4.6	80	80	80	80	80	80	80	80	80	80	80	72
4	100	7.5	80	80	80	80	75	62	80	80	80	66	53	44
5	125	11.4	80	80	80	62	49	41	80	80	58	43	35	29
6	150	16	80	80	58	44	35	29	80	62	41	31	25	20
8	200	27.4	80	51	34	25	20	17*	72	36	24	18*	14*	12*

***Double restraint system is recommended, see section 6.2 for detailed double restraint spacing chart.**

SPACE SELECTION & NOTES:

1. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.

2. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.

3. Detailed configurations and installations for single restraint piping system are shown in Section 2.0.

4. Weight of the Pipe represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.

5. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling.

PEX PIPE

FILLED WITH WATER

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
3/8’’	25	0.195	80	80	80	80	80	80	80	80	80	80	80	80
0.5’’	30	0.258	80	80	80	80	80	80	80	80	80	80	80	80
5/8’’	38	0.3338	80	80	80	80	80	80	80	80	80	80	80	80
0.75’’	50	0.41	80	80	80	80	80	80	80	80	80	80	80	80
1’’	65	0.571	80	80	80	80	80	80	80	80	80	80	80	80

SPACE SELECTION & NOTES:

1. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.

2. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.

3. Detailed configurations and installations for single restraint piping system are shown in Section 2.0.

4. Weight of the Pipe represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.

5. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling.

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6.2 Pipe Spacing Chart (Double Restraint)

SCHEDULE 40 (STD) STEEL PIPE – DOUBLE RESTRAINT

FILLED WITH GAS / EMPTY

Pipe Diameter in	Pipe Diameter mm	Weight of the Pipe lb/ft	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle G-Factors 0.25	0.5	0.75	1.0	1.25	1.5	Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle G-Factors 0.25	0.5	0.75	1.0	1.25	1.5
5	125	15.0	80	80	80	80	75	62	80	80	80	66	53	44
6	150	19.0	80	80	80	74	59	49	80	80	70	52	42	35
8	200	29.0	80	80	65	48	39	32	80	68	45	34	27	22

INSULATED AND FILLED WITH WATER

in	mm	Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle 0.25	0.5	0.75	1.0	1.25	1.5	Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle 0.25	0.5	0.75	1.0	1.25	1.5
2.5	65	9.1	80	80	80	80	80	80	80	80	80	80	80	73
3	75	12.1	80	80	80	80	80	77	80	80	80	80	66	55
4	100	18.3	80	80	80	77	61	51	80	80	72	54	43	36
5	125	26.6	80	80	70	53	42	35	80	75	50	37	30	25
6	150	34.8	80	80	54	40	32	27	80	57	38	28	22	19
8	200	55.1	80	51	34	25	20	17	72	36	24	18	14	12

FILLED WITH FUEL

in	mm	Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle 0.25	0.5	0.75	1.0	1.25	1.5	Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle 0.25	0.5	0.75	1.0	1.25	1.5
4	100	15.7	80	80	80	80	72	60	80	80	80	63	50	42
5	125	22.4	80	80	80	63	50	42	80	80	59	44	35	29
6	150	29.6	80	80	63	47	38	31	80	67	45	33	27	22
8	200	47.7	80	59	39	29	23	19	80	41	27	20	16	13

***** These tables were only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

SCHEDULE 10 STAINLESS STEEL PIPE

FILLED WITH GAS / EMPTY

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
8	200	13.4	80	80	80	80	80	70	80	80	80	74	59	49

INSULATED AND FILLED WITH WATER

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
4	100	12.9	80	80	80	80	80	73	80	80	80	77	62	51
5	125	19.4	80	80	80	72	58	48	80	80	68	51	41	34
6	150	25.1	80	80	75	56	45	37	80	79	53	39	31	26
8	200	39.5	80	71	47	35	28	23	80	50	33	25	20	16

FILLED WITH FUEL

Pipe Diameter		Weight of the Pipe	**Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle**						**Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle**					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
5	125	15.2	80	80	80	80	74	62	80	80	80	65	52	43
6	150	19.9	80	80	80	71	56	47	80	80	67	50	40	33
8	200	32.1	80	80	58	44	35	29	80	62	41	31	24	20

PVC PIPE

FILLED WITH WATER

Pipe Diameter		Weight of the Pipe	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
in	mm	lb/ft	G-Factors						G-Factors					
			0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
5	125	11.4	80	80	80	80	80	80	80	80	80	80	70	58
6	150	16	80	80	80	80	70	58	80	80	80	62	50	41
8	200	27.4	80	80	68	51	41	34	80	72	48	36	29	24

SPACE SELECTION & NOTES:

1. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for double rigid seismic bracing is 1000 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for double rigid seismic bracing is 1414 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.
2. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.
3. Detailed configurations and installations for double restraint piping system are shown in Section 2.0.
4. Weight of the Pipe represent the overall system weight including the weight of the empty pipe, contents, and insulation layers.
5. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling.

6.3 Duct Spacing Charts (Single Restraint)

DUCT SPACING CHART (SINGLE RESTRAINT)

Weight of the Duct lb/ft	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle G-Factors						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle G-Factors					
	0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
5.0	80	80	80	80	80	80	80	80	80	80	80	66
6.0	80	80	80	80	80	78	80	80	80	80	66	55
7.0	80	80	80	80	80	67	80	80	80	71	57	47
8.0	80	80	80	80	70	58	80	80	80	62	50	41
9.0	80	80	80	78	62	52	80	80	74	55	44	37
10.0	80	80	80	70	56	47	80	80	66	50	40	33
11.0	80	80	80	64	51	42	80	80	60	45	36	30
12.0	80	80	78	58	47	39	80	80	55	41	33	27
13.0	80	80	72	54	43	36	80	76	51	38	30	25
14.0	80	80	67	50	40	33	80	71	47	35	28	23
15.0	80	80	62	47	37	31	80	66	44	33	26	22
16.0	80	80	58	44	35	29	80	62	41	31	25	20
17.0	80	80	55	41	33	27	80	58	39	29	23	19*
18.0	80	78	52	39	31	26	80	55	37	27	22	18*
19.0	80	74	49	37	29	24	80	52	35	26	21	17*
20.0	80	70	47	35	28	23	80	50	33	25	20	16*
25.0	80	56	37	28	22	18*	80	40	26	20	16*	13*
30.0	80	47	31	23	18*	15*	66	33	22	16*	13*	11*
35.0	80	40	26	20	16*	13*	57	28	19*	14*	11*	9*
40.0	70	35	23	17*	14*	11*	50	25	16*	12*	10*	8*

***Double restraint system is recommended, see section 6.4 for detailed double restraint spacing chart.**

SPACE SELECTION & NOTES:

1. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

2. Brace spacing of a duct is selected bases on distributed weight of the duct (lbs/ft), for intermediate values, interpolations are accepted. If select directly, use the spacing corresponds to higher weight boundary. For distributed weight of commonly used rectangular/round duct, see section 7.2.

SPACE SELECTION & NOTES (Continued):

3. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.

4. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.

5. Detailed configurations and installations for single restraint duct system are shown in Section 2.0.

6. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

7. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by duct bending or buckling.

6.4 Duct Spacing Charts (Double Restraint)

DUCT SPACING CHART (DOUBLE RESTRAINT)

Weight of the Duct lb/ft	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle G-Factors						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle G-Factors					
	0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
12.0	80	80	80	80	80	78	80	80	80	80	66	55
13.0	80	80	80	80	80	72	80	80	80	76	61	51
14.0	80	80	80	80	80	67	80	80	80	71	57	47
15.0	80	80	80	80	75	62	80	80	80	66	53	44
16.0	80	80	80	80	70	58	80	80	80	62	50	41
17.0	80	80	80	80	66	55	80	80	78	58	47	39
18.0	80	80	80	78	62	52	80	80	74	55	44	37
19.0	80	80	80	74	59	49	80	80	70	52	42	35
20.0	80	80	80	70	56	47	80	80	66	50	40	33
25.0	80	80	75	56	45	37	80	80	53	40	32	26
30.0	80	80	62	47	37	31	80	66	44	33	26	22
35.0	80	80	53	40	32	26	80	57	38	28	22	19
40.0	80	70	47	35	28	23	80	50	33	25	20	16

SPACE SELECTION & NOTES:

1. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.
2. Brace spacing of a duct is selected based on distributed weight of the duct (lbs/ft), for intermediate values, interpolations are accepted. If select directly, use the spacing corresponds to higher weight boundary. For distributed weight of commonly used rectangular/round duct, see section 7.2.
3. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the DOUBLED rigid seismic bracing is 1000 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the DOUBLED rigid seismic bracing is 1414 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.
4. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, g-factor, installation angle) is less than 20 ft. **(highlighted in dark grey),** the same spacing can be applied to both longitudinal and transverse directions.
5. Detailed configurations and installations for double restraint duct system are shown in Section 2.0.
6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by duct bending or buckling.

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6.5 Pipe /Conduit, Raceway, & Cable Tray Trapeze Supported System Spacing Charts (Single Restraint)

PIPE/CONDUIT, RACEWAY, & CABLE TRAY TRAPEZE SUPPORTED SYSTEM SPACING CHART

SINGLE RESTRAINT

Weight of the System lb/ft	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle G-Factors						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle G-Factors					
	0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
5	80	80	80	80	80	80	80	80	80	80	80	66
6	80	80	80	80	80	78	80	80	80	80	66	55
7	80	80	80	80	80	67	80	80	80	71	57	47
8	80	80	80	80	70	58	80	80	80	62	50	41
9	80	80	80	78	62	52	80	80	74	55	44	37
10	80	80	80	70	56	47	80	80	66	50	40	33
11	80	80	80	64	51	42	80	80	60	45	36	30
12	80	80	78	58	47	39	80	80	55	41	33	27
13	80	80	72	54	43	36	80	76	51	38	30	25
14	80	80	67	50	40	33	80	71	47	35	28	23
15	80	80	62	47	37	31	80	66	44	33	26	22
16	80	80	58	44	35	29	80	62	41	31	25	20
17	80	80	55	41	33	27	80	58	39	29	23	19*
18	80	78	52	39	31	26	80	55	37	27	22	18*
19	80	74	49	37	29	24	80	52	35	26	21	17*
20	80	70	47	35	28	23	80	50	33	25	20	16*
25	80	56	37	28	22	18*	80	40	26	20	16*	13*
30	80	47	31	23	18*	15*	66	33	22	16*	13*	11*
35	80	40	26	20	16*	13*	57	28	19*	14*	11*	9*
40	70	35	23	17*	14*	11*	50	25	16*	12*	10*	8*
45	62	31	20	15*	12*	10*	44	22	14*	11*	8*	7*
50	56	28	18*	14*	11*	9*	40	20	13*	10*	8*	6*
55	51	25	17*	12*	10*	8*	36	18	12*	9*	7*	6*
60	47	23	15*	11*	9*	7*	33	16*	11*	8*	6*	5*
65	43	21	14*	10*	8*	7*	30	15*	10*	7*	6*	5*
70	40	20	13*	10*	8*	6*	28	14*	9*	7*	5*	4*

See Page 168 for Notes

PIPE/CONDUIT, RACEWAY, & CABLE TRAY TRAPEZE SUPPORTED SYSTEM SPACING CHART

SINGLE RESTRAINT (Continued)

Weight of the System	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle					
lb/ft	G-Factors						G-Factors					
	0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
75	37	18*	12*	9*	7*	6*	26	13*	8*	6*	5*	4*
80	35	17*	11*	8*	7*	5*	25	12*	8*	6*	5*	4*
85	33	16*	11*	8*	6*	5*	23	11*	7*	5*	4*	3*
90	31	15*	10*	7*	6*	5*	22	11*	7*	5*	4*	3*
95	29	14*	9*	7*	5*	4*	21	10*	7*	5*	4*	3*
100	28	14*	9*	7*	5*	4*	20	10*	6*	5*	4*	3*
105	26	13*	8*	6*	5*	4*	19	9*	6*	4*	3*	3*

***Double restraint system is recommended, see section 6.6 for detailed double restraint spacing chart.**

SPACE SELECTION & NOTES:

1. Brace spacing for cable tray, conduit, trapeze supported system are selected base on distributed weight of these units (lbs/ft), for intermediate values, interpolations are accepted. If select directly, use the spacing corresponds to higher weight boundary.

2. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for the rigid seismic bracing is 500 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for the rigid seismic bracing is 707 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.

3. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.

4. Detailed configurations and installations for single restraint system are shown in Section 2.0.

5. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

6. This table is based only on brace capacity. Brace spacings may need to be less than these values if governed by pipe bending or buckling.

6.6 Pipe /Conduit, Raceway, & Cable Tray Trapeze Supported System Spacing Charts (Double Restraint)

PIPE/CONDUIT, RACEWAY, & CABLE TRAY TRAPEZE SUPPORTED SYSTEM SPACING CHART

DOUBLE RESTRAINT

Weight of the System lb/ft	Maximum Longitudinal Spacing (ft) 30°-45° Installation Angle G-Factors						Maximum Longitudinal Spacing (ft) 46°-60° Installation Angle G-Factors					
	0.25	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**	**0.25**	**0.5**	**0.75**	**1.0**	**1.25**	**1.5**
12	80	80	80	80	80	78	80	80	80	80	66	55
13	80	80	80	80	80	72	80	80	80	76	61	51
14	80	80	80	80	80	67	80	80	80	71	57	47
15	80	80	80	80	75	62	80	80	80	66	53	44
16	80	80	80	80	70	58	80	80	80	62	50	41
17	80	80	80	80	66	55	80	80	78	58	47	39
18	80	80	80	78	62	52	80	80	74	55	44	37
19	80	80	80	74	59	49	80	80	70	52	42	35
20	80	80	80	70	56	47	80	80	66	50	40	33
25	80	80	75	56	45	37	80	80	53	40	32	26
30	80	80	62	47	37	31	80	66	44	33	26	22
35	80	80	53	40	32	26	80	57	38	28	22	19
40	80	70	47	35	28	23	80	50	33	25	20	16
45	80	62	41	31	25	20	80	44	29	22	17	14
50	80	56	37	28	22	18	80	40	26	20	16	13
55	80	51	34	25	20	17	72	36	24	18	14	12
60	80	47	31	23	18	15	66	33	22	16	13	11
65	80	43	29	21	17	14	61	30	20	15	12	10
70	80	40	26	20	16	13	57	28	19	14	11	9
75	75	37	25	18	15	12	53	26	17	13	10	8
80	70	35	23	17	14	11	50	25	16	12	10	8
85	66	33	22	16	13	11	47	23	15	11	9	7
90	62	31	20	15	12	10	44	22	14	11	8	7
95	59	29	19	14	11	9	42	21	14	10	8	7
100	56	28	18	14	11	9	40	20	13	10	8	6

See Page 170 for Notes

Pipe/Conduit, Raceway, & Cable Tray Trapeze Supported System Spacing Charts - Double Restraint

SPACE SELECTION & NOTES:

1. For cable tray, conduit, trapeze supported system with weight less than 20 lbs/ft, not carrying toxic, highly toxic, or flammable gasses and not used for smoke control, no restraint system is required.

2. Brace spacing of cable tray, conduit, trapeze supported system is selected base on distributed weight of the system (lbs/ft), for intermediate values, interpolations are accepted. If select directly, use the spacing corresponds to higher weight boundary.

3. For installation angles between 46° and 60°, the minimum allowable horizontal seismic loads (at 60°) for double rigid seismic bracing is 1000 lbs. For installation angle between 30° and 45°, the minimum allowable horizontal seismic loads (at 45°) for double rigid seismic bracing is 1414 lbs. These two capacities are used to calculate maximum allowable longitudinal spacing of rigid brace at corresponding installation angles.

4. In general, transverse spacing selected should be half the longitudinal spacing listed in tables. If suggested spacing for a certain combination (distributed weight, G-factor, installation angle) is less than 20 ft. **(highlighted in dark grey)**, the same spacing can be applied to both longitudinal and transverse directions.

5. Detailed configurations and installations for double restraint system are shown in Section 2.0.

6. This table was only generated for G factors up to 1.5. For larger G-Factors this table is unconservative, use engineering calculations instead.

SECTION 7.0 REFERENCING INFORMATION

7.1 Weight of Pipes and Contents

PIPE/CONTENT WEIGHT

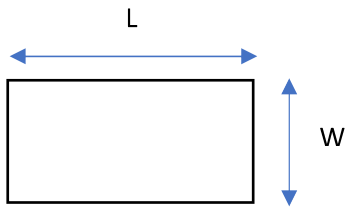
Pipe Diameter (inch)	Empty Pipe Weight (lbs/ft)						Content Weight (lbs)				Insulation (lbs)
	Material						Type of Content				(If Req'd)
	Sch. 40 steel	Sch. 10 s.s.	Copper	PVC	PEX	Cast Iron	Water	Fuel	Gas	Drainage	
3/8					0.05		0.15				
1/2					0.06		0.2				
5/8					0.08		0.25				
3/4					0.11		0.3				
1	1.7	1.4	0.84	0.32	0.17		0.4	0.34	0.0	0.20	0.7
1.25	2.3	1.8	1.04	0.43			0.7	0.60	0.0	0.35	0.8
1.5	2.7	2.1	1.36	0.55			0.9	0.77	0.0	0.45	0.9
2	3.7	2.6	2.06	0.68			1.5	1.28	0.0	0.75	1.0
2.5	5.8	3.5	2.92	1.07			2.1	1.79	0.0	1.05	1.2
3	7.6	4.3	4.00	1.41		5.4	3.2	2.72	0.0	1.60	1.3
4	11.0	5.6	6.51	2.01		7.1	5.5	4.68	0.0	2.75	1.8
5	15.0	7.8	9.67	2.73		9.8	8.7	7.40	0.0	4.35	2.9
6	19.0	9.3	13.87	3.53		11.8	12.5	10.63	0.0	6.25	3.3
8	29.0	13.4		5.39		17.1	22.0	18.7	0.0	11.0	4.1

NOTE:

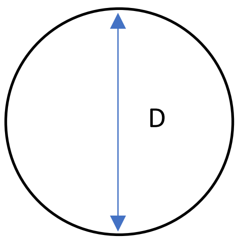
1. The distributed operating weight (w_P) in lbs/ft is calculated as the combined weight of the empty pipe contents, and insulation (if required). Weight details regarding size & material of pipe, type of contents, and insulation are shown in the table above.
2. The 0.85 specific gravity was used for fuel.
3. The 0.5 specific gravity was used for drainage.
4. For 1-4 inches pipes, insulation weight is based on 1-inch-thick calcium silicate insulation. For 5-8 inches pipes, insulation weight is based on 1.5-inch-thick calcium silicate insulation.

7.2 Weight of Ducts (Gauge Numbers)

Distributed weight of duct can be calculated as (perimeter) x (sheet metal weight):



$$w_P = [(L + W) \times 2]\ inch \times \frac{ft}{12\ inch} \times a \frac{lbs}{ft^2}$$



$$w_P = [\pi D]\ inch \times \frac{ft}{12\ inch} \times a \frac{lbs}{ft^2}$$

Where

w_P is distributed weight of the duct in lbs/ft

a is sheet metal weight in lbs/ft^2 , check Sheet Metal Weights Table (below) for different gauge numbers

For rectangular duct, L is length of the cross section, W is width of duct cross section

For round duct, D is diameter of the cross section

Sheet Metal Weights (GA GALV)

GAUGE #	26	24	22	20	18	14	12	11	10
(lbs/ft^2)	0.906	1.156	1.406	1.656	2.156	3.281	4.531	5.000	5.781
$(kg/1000\ mm^2)$	0.0044	0.0056	0.0069	0.0081	0.0105	0.0160	0.0221	0.0244	0.0283

Source: SMACNA Duct Construction Standards

RECTANGULAR DUCT WEIGHT

Rectangular Duct Perimeter (inch)	Distributed Weight (lbs/ft)								
	Gauge Numbers (Unit Weight lbs/sqft.)								
	26	**24**	**22**	**20**	**18**	**14**	**12**	**11**	**10**
	0.906	**1.156**	**1.406**	**1.656**	**2.156**	**3.281**	**4.531**	**5.000**	**5.781**
40	3.0	3.9	4.7	5.5	7.2	10.9	15.1	16.7	19.3
50	3.8	4.8	5.9	6.9	9.0	13.7	18.9	20.8	24.1
60	4.5	5.8	7.0	8.3	10.8	16.4	22.7	25.0	28.9
70	5.3	6.7	8.2	9.7	12.6	19.1	26.4	29.2	33.7
80	6.0	7.7	9.4	11.0	14.4	21.9	30.2	33.3	38.5
90	6.8	8.7	10.5	12.4	16.2	24.6	34.0	37.5	43.4
100	7.6	9.6	11.7	13.8	18.0	27.3	37.8	41.7	48.2
110	8.3	10.6	12.9	15.2	19.8	30.1	41.5	45.8	53.0
120	9.1	11.6	14.1	16.6	21.6	32.8	45.3	50.0	57.8
130	9.8	12.5	15.2	17.9	23.4	35.5	49.1	54.2	62.6
140	10.6	13.5	16.4	19.3	25.2	38.3	52.9	58.3	67.4
150	11.3	14.5	17.6	20.7	27.0	41.0	56.6	62.5	72.3
160	12.1	15.4	18.7	22.1	28.7	43.7	60.4	66.7	77.1
170	12.8	16.4	19.9	23.5	30.5	46.5	64.2	70.8	81.9
180	13.6	17.3	21.1	24.8	32.3	49.2	68.0	75.0	86.7
190	14.3	18.3	22.3	26.2	34.1	51.9	71.7	79.2	91.5
200	15.1	19.3	23.4	27.6	35.9	54.7	75.5	83.3	96.4
210	15.9	20.2	24.6	29.0	37.7	57.4	79.3	87.5	101.2
220	16.6	21.2	25.8	30.4	39.5	60.2	83.1	91.7	106.0
230	17.4	22.2	26.9	31.7	41.3	62.9	86.8	95.8	110.8
240	18.1	23.1	28.1	33.1	43.1	65.6	90.6	100.0	115.6
250	18.9	24.1	29.3	34.5	44.9	68.4	94.4	104.2	120.4

Weight of Ducts (Gauge Numbers)

ROUND DUCT WEIGHT

Round Duct Diameter (inch)	Distributed Weight (lbs/ft)								
	Gauge Numbers (Unit Weight lbs/sqft.)								
	26	**24**	**22**	**20**	**18**	**14**	**12**	**11**	**10**
	0.906	**1.156**	**1.406**	**1.656**	**2.156**	**3.281**	**4.531**	**5.000**	**5.781**
3	0.7	0.9	1.1	1.3	1.7	2.6	3.6	3.9	4.5
4	0.9	1.2	1.5	1.7	2.3	3.4	4.7	5.2	6.1
5	1.2	1.5	1.8	2.2	2.8	4.3	5.9	6.5	7.6
6	1.4	1.8	2.2	2.6	3.4	5.2	7.1	7.9	9.1
7	1.7	2.1	2.6	3.0	4.0	6.0	8.3	9.2	10.6
8	1.9	2.4	2.9	3.5	4.5	6.9	9.5	10.5	12.1
9	2.1	2.7	3.3	3.9	5.1	7.7	10.7	11.8	13.6
10	2.4	3.0	3.7	4.3	5.6	8.6	11.9	13.1	15.1
12	2.8	3.6	4.4	5.2	6.8	10.3	14.2	15.7	18.2
14	3.3	4.2	5.2	6.1	7.9	12.0	16.6	18.3	21.2
16	3.8	4.8	5.9	6.9	9.0	13.7	19.0	20.9	24.2
18	4.3	5.4	6.6	7.8	10.2	15.5	21.4	23.6	27.2
20	4.7	6.1	7.4	8.7	11.3	17.2	23.7	26.2	30.3
22	5.2	6.7	8.1	9.5	12.4	18.9	26.1	28.8	33.3
24	5.7	7.3	8.8	10.4	13.5	20.6	28.5	31.4	36.3
26	6.2	7.9	9.6	11.3	14.7	22.3	30.8	34.0	39.4
28	6.6	8.5	10.3	12.1	15.8	24.1	33.2	36.7	42.4
30	7.1	9.1	11.0	13.0	16.9	25.8	35.6	39.3	45.4
32	7.6	9.7	11.8	13.9	18.1	27.5	38.0	41.9	48.4
34	8.1	10.3	12.5	14.7	19.2	29.2	40.3	44.5	51.5
36	8.5	10.9	13.3	15.6	20.3	30.9	42.7	47.1	54.5
38	9.0	11.5	14.0	16.5	21.4	32.6	45.1	49.7	57.5
40	9.5	12.1	14.7	17.3	22.6	34.4	47.4	52.4	60.5
44	10.4	13.3	16.2	19.1	24.8	37.8	52.2	57.6	66.6
48	11.4	14.5	17.7	20.8	27.1	41.2	56.9	62.8	72.6
52	12.3	15.7	19.1	22.5	29.4	44.7	61.7	68.1	78.7
56	13.3	16.9	20.6	24.3	31.6	48.1	66.4	73.3	84.8
60	14.2	18.2	22.1	26.0	33.9	51.5	71.2	78.5	90.8
64	15.2	19.4	23.6	27.7	36.1	55.0	75.9	83.8	96.9
68	16.1	20.6	25.0	29.5	38.4	58.4	80.7	89.0	102.9

Weight of Ducts (Gauge Numbers)

ROUND DUCT WEIGHT (CONTINUED)

Round Duct Diameter (inch)	Distributed Weight (lbs/ft)								
	Gauge Numbers (Unit Weight lbs/sqft.)								
	26	**24**	**22**	**20**	**18**	**14**	**12**	**11**	**10**
	0.906	**1.156**	**1.406**	**1.656**	**2.156**	**3.281**	**4.531**	**5.000**	**5.781**
72	17.1	21.8	26.5	31.2	40.6	61.8	85.4	94.2	109.0
76	18.0	23.0	28.0	32.9	42.9	65.3	90.2	99.5	115.0
80	19.0	24.2	29.4	34.7	45.2	68.7	94.9	104.7	121.1
84	19.9	25.4	30.9	36.4	47.4	72.2	99.6	110.0	127.1

7.3 Design by Analysis for Critical Pipes ASME

As limited by yield strength of the piping system, maximum brace spacing should satisfy the following equation, as provided by ASME B31.9-2020, Section B-3.4:

$$\frac{P \times D}{4t} + 0.75i\,\frac{M_{sustained} + M_{seismic}}{Z} \leq 1.33\,S$$

Where

P = System Operating Pressure (psi)

D = Pipe Inner Diameter(in)

t = Pipe wall thickness including allowance for corrosion

i = Stress intensification factor from ASME B31.1

$M_{sustained}$ = Pipe moment due to gravity force acting concurrently with seismic load

$M_{seismic}$ = Pipe moment due to seismic force

Z = Pipe section modulus

S = Allowable Stress per ASME B31.1-2022, Appendix A

7.3.1 Pipe Stress Calculation Design Example

Section B-3.4 (Design by Analysis)

$P = 400\ psi$ @650°F (System Operating Pressure)

$D_{nominal} = 4\ in$ (Nominal Pipe Diameter)

$D_{outer} = 4.5\ in$ (Outer Pipe Diameter)

$t_{nominal} = 0.237\ in$ (Nominal Pipe Wall Thickness)

$D = D_{outer} - 2 \cdot t_{nominal} = 4.026\ in$ (Inner Pipe Diameter without Corrosion)

$S = 14.6\ ksi$ (Allowable Stress per ASME B31.1-2022, Appendix A)

$t_{corrosion.allowance} = 0.0625\ in$

$t_{corroded} = t_{nominal} - t_{corrosion.allowance} = 0.175\ in$

$G = 0.5$ (Seismic Design Acceleration @ ASD)

$S_{hanger} = 14\ ft$ (Spacing of Vertical Hangers)

$w_{empty.pipe} = 11\ plf$

$w_{water} = 5.5\ plf$

$w_{insulation} = 1.8\ plf$

$w_{full.pipe} = w_{empty.pipe} + w_{water} + w_{insulation} = 18.3\ plf$

$D_{corroded} = D - (2 \cdot t_{corrosion.allowance}) = 4.151\ in$ (Inner Pipe Diameter with corrosion)

$Z = \frac{\pi \cdot (D_{outer}{}^4 - D_{corroded}{}^4)}{32 \cdot D_{outer}} = 2.469\ in^3$ (Corroded Section Modulus, not to be confused with Plastic Modulus which ASME does not use)

$t = t_{nominal}$ $t_n = t_{nominal}$

$S_{DS.max} = 2.5$ (Largest S_{DS} in California)

$F_{pv} = 0.7 \cdot 0.2 \cdot S_{DS.max} = 0.35$ (Vertical Effect ASD)

ASME B31.1-2022 Appendix D

Unreinforced Fabricated Tee or Extruded Outlet (Worst Cases)

$r = \frac{D_{outer} - 1.0 \cdot t_{nominal}}{2} = 2.132\ in$ (Mean Radius of Pipe)

$h = \frac{t_n}{r} = 0.111$ $i = \frac{0.9}{h^{2/3}} = 3.892$

Note:

Miter Bends, Reinforced Fabricated Tees, Branch Connections, Corrugated not Considered.

Section B-3.4 (Design by Analysis)

$F_{bending} = 1.33 \cdot S - \frac{P \cdot D}{4 \cdot t} = 17.039\ ksi$

$M_{allowable} = \frac{F_{bending} \cdot Z}{0.75 \cdot i} = 14.41\ in \cdot kip$

$\beta_D = 1.0$ (ASD)

$w_{gravity.ASD} = \beta_D \cdot w_{full.pipe} = 18.3\ plf$

$w_{vertical.seismic.ASD} = F_{pv} \cdot w_{full.pipe} = 6.405\ plf$

$w_{horizontal.seismic.ASD} = G \cdot w_{full.pipe} = 9.15\ plf$

$M_{sustained} = \frac{w_{gravity.ASD} \cdot {S_{hanger}}^2}{8} = 5.38\ in \cdot kip$ (Simply supported or middle support on two-span beam)

$M_{seismic.vertical} = \frac{w_{vertical.seismic.ASD} \cdot {S_{hanger}}^2}{8} = 1.883\ in \cdot kip$

Pipe stress is based on resultant moment, not sum of biaxial moments.

$M_{seismic.horizontal.allowable} = \sqrt{{M_{allowable}}^2 - (M_{sustained} + M_{seismic.vertical})^2} = 12.446\ in \cdot kip$

$S_{brace.allowable} = \sqrt{\frac{8 \times M_{seismic.horizontal.allowable}}{w_{horizontal.seismic.ASD}}} = 30.113\ ft$ (Simply supported or middle support on two-span beam)

Note:

It is assumed that equation B-3.4c has been satisfied.

7.3.2 Max Transverse Brace Spacing Based On Pipe Size And G Force

GRADE A STEEL

Water Pipe S_{allow}=11.7 ksi

NPS	PIPE SCHEDULE	MAX WEIGHT PER FOOT (LBS/FT)	MAX GRAVITY SUPPORT SPACING (FT)	MAX TRANSVERSE BRACE SPACING BASED ON PIPE SIZE AND G FORCE (FT)									
				G Force									
				0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
1	40	2.8	7	22	16	13	11	10	9	8	8	7	7
1 1/4	40	3.8	7	24	17	14	12	11	10	9	8	8	7
1 1/2	40	4.5	8	25	17	14	12	11	10	9	8	8	8
2	40	6.2	8	27	19	15	13	12	11	10	9	9	8
2 1/2	40	9.1	10	34	24	20	17	15	14	13	12	11	11
3	40	12.1	11	36	25	20	18	16	14	13	12	12	11
4	40	18.3	11	38	27	22	19	17	15	14	13	12	12
5	40	26.6	12	39	27	22	19	17	16	14	13	13	12
6	40	34.8	13	41	29	23	20	18	16	15	14	13	13
8	40	55.1	14	44	31	25	22	19	18	16	15	14	14

Gas Pipe S_{allow}=11.7 ksi

NPS	PIPE SCHEDULE	MAX WEIGHT PER FOOT (LBS/FT)	MAX GRAVITY SUPPORT SPACING (FT)	MAX TRANSVERSE BRACE SPACING BASED ON PIPE SIZE AND G FORCE (FT)									
				G Force									
				0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
1	40	1.7	9	29	20	17	14	13	12	11	10	9	9
1 1/4	40	2.3	9	31	22	18	15	14	12	12	11	10	10
1 1/2	40	2.7	10	33	23	19	16	14	13	12	11	11	10
2	40	3.7	10	35	24	20	17	15	14	13	12	11	11
2 1/2	40	5.8	13	43	30	25	21	19	17	16	15	14	13
3	40	7.6	14	45	32	26	22	20	18	17	16	15	14
4	40	11	15	49	34	28	24	21	20	18	17	16	15
5	40	15	16	52	37	30	26	23	21	19	18	17	16
6	40	19	17	56	39	32	28	25	23	21	19	18	17

Notes:

1. Assume $P(system\ operating\ pressure) = 400\ psi$
   $t_{corrosion.allowance} = 0.0625\ in$
   $F_{pv} = 0.350$

2. FOR LONGITUDINAL AND ALL-DIRECTIONAL BRACE SPACING, TRIPLE THE VALUES IN THE ABOVE TABLE. BRACE AND/OR CONNECTION CAPACITY MAY GOVERN MAXIMUM SPACING IN SOME CASES.

3. BRACE SPAINGS ARE BASED ON STEEL PIPE CONFORMING TO ASTM SPECIFICATION A53, TYPE E, GRADE A WITH MINIMUM $F_y = 30\ ksi$ AND $S_A = 11.7\ ksi$ AT MAXIMUM OPERATING PRESSURE AND TEMPERATURE OF 400 PSI AND 650° F, RESPECTIVELY.

GRADE B STEEL

Water Pipe S_{allow}=14.6 ksi

NPS	PIPE SCHEDULE	MAX WEIGHT PER FOOT (LBS/FT)	MAX GRAVITY SUPPORT SPACING (FT)	MAX TRANSVERSE BRACE SPACING BASED ON PIPE SIZE AND G FORCE (FT)									
				G Force									
				0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
1	40	2.8	7	26	18	15	13	11	10	10	9	8	8
1 1/4	40	3.8	7	28	20	16	14	12	11	10	10	9	9
1 1/2	40	4.5	9	28	20	16	14	12	11	10	10	9	9
2	40	6.2	9	30	21	17	15	13	12	11	10	10	9
2 1/2	40	9.1	11	39	28	22	19	17	16	15	14	13	12
3	40	12.1	12	41	29	23	20	18	16	15	14	13	13
4	40	18.3	13	43	30	25	21	19	17	16	15	14	13
5	40	26.6	13	45	32	26	22	20	18	17	16	15	14
6	40	34.8	14	47	33	27	23	21	19	18	16	15	15
8	40	55.1	16	50	36	29	25	22	20	19	18	16	16

Gas Pipe S_{allow}=14.6 ksi

NPS	PIPE SCHEDULE	MAX WEIGHT PER FOOT (LBS/FT)	MAX GRAVITY SUPPORT SPACING (FT)	MAX TRANSVERSE BRACE SPACING BASED ON PIPE SIZE AND G FORCE (FT)									
				G Force									
				0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
1	40	1.7	9	34	24	19	17	15	13	12	12	11	10
1 1/4	40	2.3	10	36	25	20	18	16	14	13	12	12	11
1 1/2	40	2.7	11	37	26	21	18	16	15	14	13	12	11
2	40	3.7	12	39	28	22	19	17	16	15	14	13	12
2 1/2	40	5.8	14	49	35	28	24	22	20	18	17	16	15
3	40	7.6	15	52	37	30	26	23	21	19	18	17	16
4	40	11	17	55	39	32	27	25	22	21	19	18	17
5	40	15	18	59	42	34	29	26	24	22	21	19	18
6	40	19	20	64	45	36	32	28	26	24	22	21	20

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Notes:

1. Assume $P(system\ operating\ pressure) = 400\ psi$
   $t_{corrosion.allowance} = 0.0625\ in$
   $F_{pv} = 0.350$

2. FOR LONGITUDINAL AND ALL-DIRECTIONAL BRACE SPACING, TRIPLE THE VALUES IN THE ABOVE TABLE. BRACE AND/OR CONNECTION CAPACITY MAY GOVERN MAXIMUM SPACING IN SOME CASES.

3. BRACE SPAINGS ARE BASED ON STEEL PIPE CONFORMING TO ASTM SPECIFICATION A53, TYPE E, GRADE A WITH MINIMUM $F_y = 30\ ksi$ AND $S_A = 11.7\ ksi$ AT MAXIMUM OPERATING PRESSURE AND TEMPERATURE OF 400 PSI AND 650° F, RESPECTIVELY.

COPPER TYPE L DRAWN TUBE

S_{allow}=10.3 ksi

NPS	MAX WEIGHT PER FOOT (LBS/FT)	MAX GRAVITY SUPPORT SPACING (FT)	MAX TRANSVERSE BRACE SPACING BASED ON PIPE SIZE AND G FORCE (FT)									
			G Force									
			0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
1	1.71	2	9	7	5	4	4	4	3	3	3	3
1 1/4	2.23	3	11	8	6	5	5	4	4	4	3	3
1 1/2	2.81	3	12	9	7	6	5	5	4	4	4	4
2	4.09	4	15	11	8	7	6	6	5	5	5	4
2 1/2	5.74	5	17	12	10	8	7	7	6	6	5	5
3	7.57	6	19	13	11	9	8	7	7	6	6	6
4	11.9	7	22	16	13	11	10	9	8	8	7	7

Notes:

1. Assume $P(system\ operating\ pressure) = 100\ psi$
   $t_{corrosion.allowance} = 0.0315\ in$
   $F_{pv} = 0.350$

2. FOR LONGITUDINAL AND ALL-DIRECTIONAL BRACE SPACING, TRIPLE THE VALUES IN THE ABOVE TABLE. BRACE AND/OR CONNECTION CAPACITY MAY GOVERN MAXIMUM SPACING IN SOME CASES.

3. BRACE SPACINGS ARE BASED ON PIPE CONFORMING ASTM SPECIFICATION B88 TYPE K OR L COPPER PIPE WITH MAXIMUM OPERATING PRESSURE AND TEMPERATURE OF 100 PSI AND 250° F, RESPECTIVELY.

Appendix A. Design by Rule for Noncritical Pipes ASME

As limited by yield strength of the piping system, maximum brace spacing should not exceed the span length given by the following equations, as provided by ASME B31.9-2020, Section B-3.3:

$L_{max} = 1.94 \times \frac{L_T}{a^{0.25}}$ OR $L_{max} = 0.01 \times L_T \times \sqrt{\frac{S_y}{a}}$

Where

a= peak spectral acceleration, largest in any of the three directions, including in-structure amplification

L_{max} = maximum permitted pipe span between lateral seismic restraints, ft

L_T = reference span, the recommended span between weight supports, from ASME B31.1, Table 121.5 (reproduced in Section 7.3 Tables), ft

S_y = material yield strength at operating temperature, psi

Notes:

1. Maximum brace spacing is based on ASME B31.9-2020 Design by Rule equation.
2. In general, maximum longitudinal spacing can be twice as much as the transverse spacing listed in tables.
3. Spacing limits listed in this section shall not be used for critical pipes.
4. Noncritical pipe defined as: piping that may not be operable or leak-tight during or following an earthquake.
5. Critical pipe defined as: piping that must remain leak-tight or operable during or following an earthquake.
6. For critical pipes the pipe brace spacing must be determined "By Analysis" per ASME B31.9-2020, see section 7.3

GRADE A STEEL

WATER PIPE ($S_y = 30\ ksi$)

Pipe Diameter (in)	Maximum Gravity Support Spacing (ft)	Maximum Transverse Spacing (L_T) (ft) Peak Spectral Acceleration					
		0.25 g	0.5 g	0.75 g	1 g	1.25 g	1.5 g
1	7	19	16	14	13	12	12
1.25	7	19	16	14	13	12	12
1.5	9	24	20	18	17	16	15
2	10	27	23	20	19	18	17
2.5	11	30	25	22	21	20	19
3	12	32	27	25	23	22	20
4	14	38	32	29	27	25	24
5	16	43	36	33	31	29	27
6	17	46	39	35	32	31	29
8	19	52	43	39	36	34	33

GAS PIPE ($S_y = 30\ ksi$)

Pipe Diameter (in)	Maximum Gravity Support Spacing (ft)	Maximum Transverse Spacing (L_T) (ft) Peak Spectral Acceleration					
		0.25 g	0.5 g	0.75 g	1 g	1.25 g	1.5 g
1	9	24	20	18	17	16	15
1.25	10	27	23	20	19	18	17
1.5	12	32	27	25	23	22	20
2	13	35	29	27	25	23	22
2.5	14	38	32	29	27	25	24
3	15	41	34	31	29	27	26
4	17	46	39	35	32	31	29
5	19	52	43	39	36	34	33
6	20	54	46	41	38	36	34

NOTES:

Maximum gravity support spacing is based on MSS SP-58 Table 4, limited to 20 feet. Pipe weights used are based on standard schedule including water and insulation (refer to section 7.1). Pipes with thicker walls and / or filled with vapor or gas may use spacings as tabulated. Grade A steel has a yield strength of 207 MPa or 30,000 psi.

GRADE B STEEL

WATER PIPE ($S_y = 35\ ksi$)

Pipe Diameter (in)	Maximum Gravity Support Spacing (ft)	Maximum Transverse Spacing (L_T) (ft) Peak Spectral Acceleration					
		0.25 g	**0.5 g**	**0.75 g**	**1 g**	**1.25 g**	**1.5 g**
1	7	19	16	14	13	12	12
1.25	7	19	16	14	13	12	12
1.5	9	24	20	18	17	16	15
2	10	27	23	20	19	18	17
2.5	11	30	25	22	21	20	19
3	12	32	27	25	23	22	21
4	14	38	32	29	27	25	24
5	16	43	36	33	31	29	28
6	17	46	39	35	32	31	29
8	19	52	43	39	36	34	33

GAS PIPE ($S_y = 35\ ksi$)

Pipe Diameter (in)	Maximum Gravity Support Spacing (ft)	Maximum Transverse Spacing (L_T) (ft) Peak Spectral Acceleration					
		0.25 g	**0.5 g**	**0.75 g**	**1 g**	**1.25 g**	**1.5 g**
1	9	24	20	18	17	16	15
1.25	10	27	23	20	19	18	17
1.5	12	32	27	25	23	22	21
2	13	35	29	27	25	23	22
2.5	14	38	32	29	27	25	24
3	15	41	34	31	29	27	26
4	17	46	39	35	32	31	29
5	19	52	43	39	36	34	33
6	20	54	46	41	38	36	35

NOTES:

Maximum gravity support spacing is based on MSS SP-58 Table 4, limited to 20 feet. Pipe weights used are based on standard schedule including water and insulation (refer to section 7.1). Pipes with thicker walls and / or filled with vapor or gas may use spacings as tabulated. Grade B steel has a yield strength of 241 MPa or 35,000 psi.

COPPER-TYPE L DRAWN TUBE

WATER PIPE ($S_y = 30\ ksi$)

Pipe Diameter	Maximum Gravity Support Spacing	Maximum Transverse Spacing (L_T) (ft)					
(in)	(ft)	Peak Spectral Acceleration					
		0.25 g	**0.5 g**	**0.75 g**	**1 g**	**1.25 g**	**1.5 g**
1	6	16	13	12	11	11	10
1.25	7	19	16	14	13	12	12
1.5	8	21	18	16	15	14	13
2	8	21	18	16	15	14	13
2.5	9	24	20	18	17	16	15
3	10	27	23	20	19	18	17
4	10	27	23	20	19	18	17

NOTES:

Maximum gravity support spacing is based on MSS SP-58 Table 4, limited to 10 feet. Pipe weights used are based on standard schedule including water and insulation (refer to section 7.1). Pipes with thicker walls and / or filled with vapor or gas may use spacings as tabulated.