

Structural Attachment Details for Suspended Equipment Restraints

When restraining suspended equipment to a structure, there are several different construction options that impact the restraint selection. Primary among these are the interface with masonry- or concrete-, steel-, and wood-framed structures. Within each of these are subgroups that can impact the restraint selection as well.

This chapter is broken down into the three main categories listed above, and offers examples of restraint attachment arrangements suitable for each.

While this section addresses local stresses at attachment points, it is critical in any seismic installation that the design professional responsible for the structure as a whole is made aware of the particular attachment points. Locations and estimated loads must be provided and there must be agreement that the addition of these loads will not overload the structure.

In addition, the attachment of this hardware should be done in such a way as to avoid any significant reduction in capacity of the member to which it is being connected.

The authors of this manual in no way assume any liability relative to any limitations on the capacity of the structure to resist the potential forces carried through the restraints or any reduction in capacity of the structure that might result from improper or inappropriate installation of the hardware.

General Installation Issues

Caution should be exercised when using struts for restraint in lieu of cables. A more detailed summary is available earlier in this chapter. The use of struts will more than likely require an increase in the hanger rod size and a decrease in the restraint spacing as compared to cables, and appropriate factors must be used for component selection and placement.

Code requirements also dictate that systems are supported from and restrained to components that do not move in a significantly different fashion during an earthquake. Because structures tend to flex about 1% with respect to height, this would indicate that a relative motion between the floor and ceiling of a 10 ft tall room would be about $\frac{1}{2}$ ". As a result, attachment of a component to the ceiling and restraint to the floor (or the reverse) is unacceptable. Ideally, the components should be supported from and restrained to the same surface (mount to ceiling/restrain to ceiling). As a worst case, no more than $\frac{1}{4}$ " relative motion should be permitted (which might permit mounting to the ceiling and restraining to a surface near the top of an adjacent structural wall). The stiffer the structure, the more flexibility the installer has in placing restraints.

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS

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When installing restraints there are often opportunities to use the same attachment points used for suspending hanger rods to also connect restraint cables or struts. All hardware size information indicated in this manual is based on independent support and restraint hardware. The use of common connection points is not recommended and, if used, both seismic and support forces along with worst-case safety factors and hardware selection criteria must be included in the evaluation. This is beyond the scope of this document.

Connections to Masonry Structures (Including Concrete)

Masonry structural elements can be either concrete or block. When concrete, they might be poured in place with a removable form, poured over decking, or pre-cast and erected on site. When attaching to masonry, it is important to be aware of the locations of any reinforcing steel that may be embedded in it. It is not permissible to damage the reinforcement.

Damage to the reinforcement will (at best) weaken the structure and can (at worst) result in severe injury or death. Do not under any circumstances drill into a masonry element without first obtaining approval and, second, locating and avoiding any reinforcement components.

All connections that bear the weight (only) of ceiling-mounted components must be rated for a 5:1 safety factor, but may not require seismically approved anchorage hardware. Any connection that must resist only a seismic force must use seismically rated hardware with an inherent 2:1 safety factor. Connections that must withstand both seismic and gravity loads require both seismically rated anchorage and a 5:1 safety factor. Examples of the above are as follows:

	5:1	Seismic Rating
Hanger rod Anchorage for Cable-Restrained System	Yes	No
Restraint Anchor (Strut or Cable System)	No	Yes
Hanger rod Anchorage for Strut-Restrained System	Yes	Yes

Connections into portions of beams or other elements that are loaded in tension will have a reduced capacity as compared to published ratings. These should be avoided, or if unavoidable, should be analyzed independently of the charts and tables published in this document.

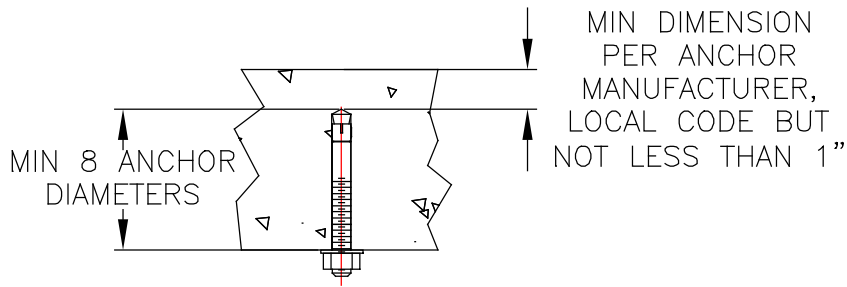
All tables used in this document are based on the use of Kinetics Noise Control-supplied seismically rated anchors. Caution should be used to ensure that adequate embedment depth and cover (per local code or anchor manufacturer with a 1" minimum) is provided.

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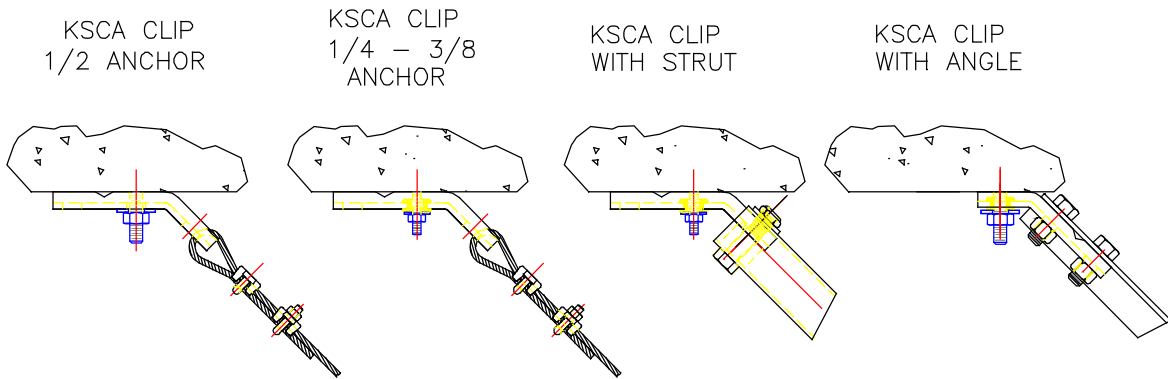


Minimum Anchor Installation Requirements

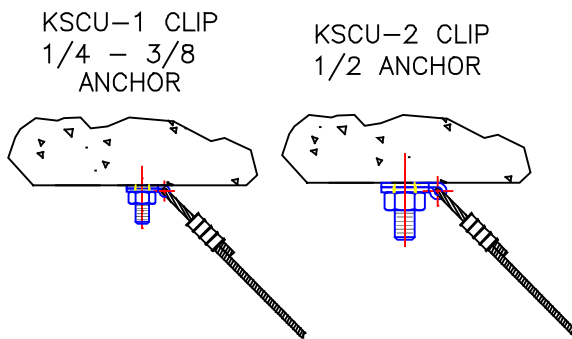
Ceiling Connections

The most efficient connection to the underside of a concrete slab is with a single anchor. Depending on the load requirements and available slab thickness, this may not be practical, and in order to get adequate capacity, multiple anchors may be required.

Single anchor attachments can be made with anchors from 1/4 up to 1/2 using the Kinetics Noise Control KSCA bracket and the KSUA bracket as shown below.



KSCA Clip with Single 1/4 to 1/2 Anchor



KSCU Clips for 1/4 Through 1/2 Anchors

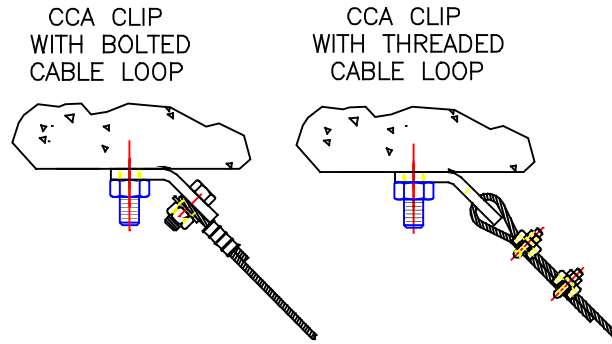
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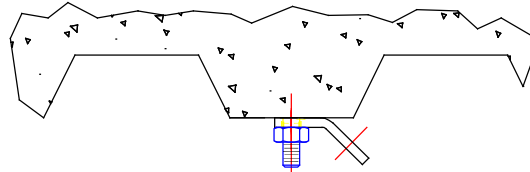
For larger, single-anchor arrangements, the CCA can be used. Depending on the orientation, it can be used with either a 5/8 or 3/4 anchor.



CCA Clips for Single 5/8 and 3/4 Anchors

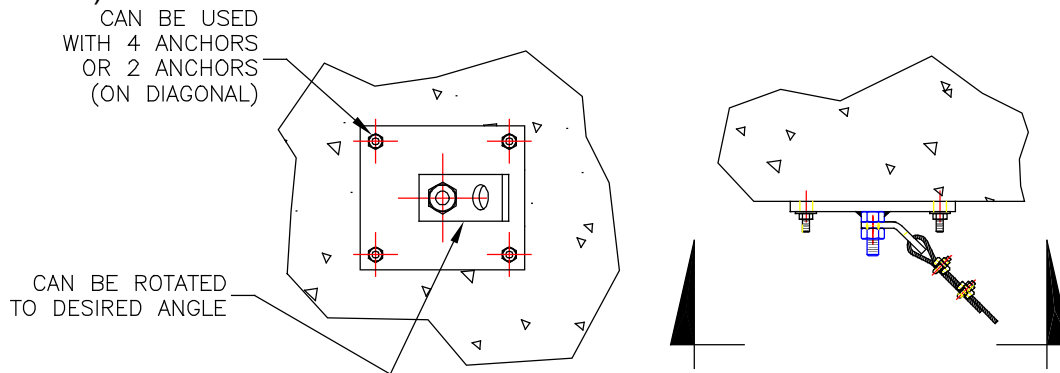
Anchors can be embedded in concrete through the decking as shown below:

WHEN CONNECTING TO CONCRETE THROUGH METAL DECKING, THE RESTRAINT SHOULD BE ANCHORED TO THE DEEPEST SECTION



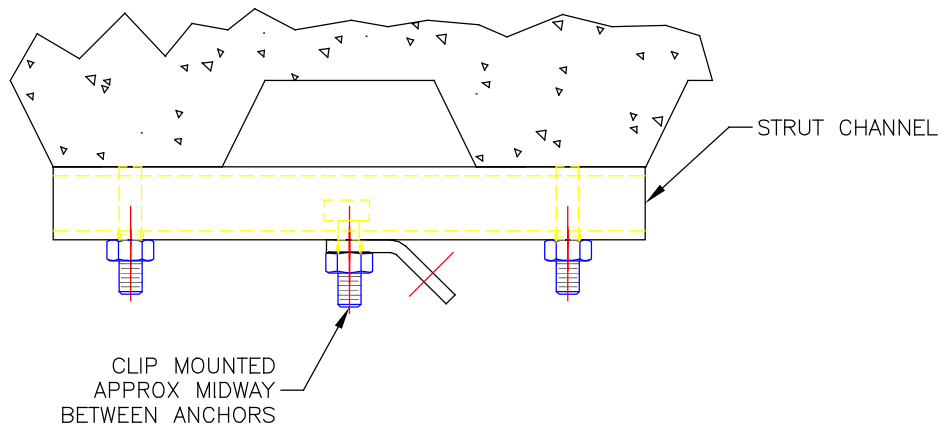
Typical Restraint Clip Anchored to Concrete Through Decking

In cases where multiple anchors are required to meet load and/or maximum allowable embedment requirements, a clip fitted with a multiple-anchor embedment plate or a bridging strut member should be used. If using a strut, spacing between anchors must not be less than the allowed spacing per Kinetics Noise Control anchor data tables (Chapter P10).



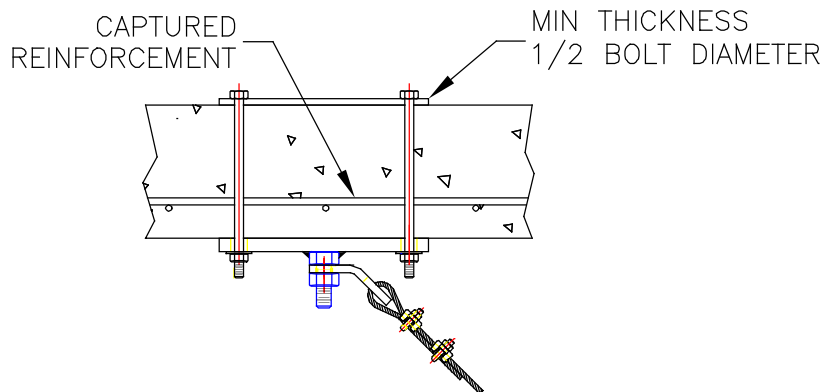
CCA Clip attached using Kinetics Noise Control 2/4 Bolt Mount Plate

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS



Multiple-Anchor Mounting Using Strut Channel

Under extreme conditions, where the slab to which the restraint is being attached is too thin to achieve the needed capacity with conventional concrete anchors, it may be necessary to bolt through the slab. This method eliminates concerns related to failures due to anchor pullout and allows both the use of the higher through-bolt rating as well as eliminates the penalty factors associated with connections using concrete anchors. Connections made in this manner must bridge over reinforcement steel embedded in the concrete slab as shown below.



Typical Through-Bolted Restraint Attachment Option

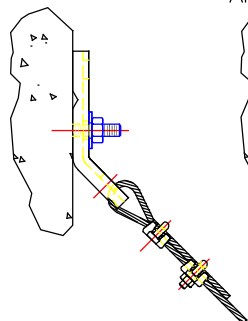
Wall and Column Connections

In general, restraint connections to walls and columns made of concrete are very similar to the connections to the ceiling. Wall connections in this group, however, also encompass connections to masonry walls which require some additional attention.

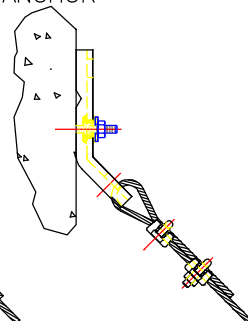
Illustrated below are the wall or column versions of the connections previously shown for the ceiling applications.

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS

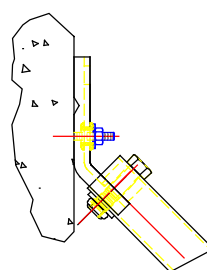
KSCA CLIP
1/2 ANCHOR



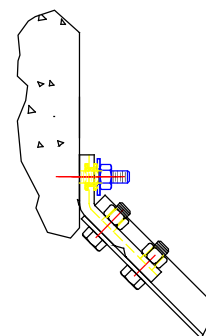
KSCA CLIP
1/4 - 3/8
ANCHOR



KSCA CLIP
WITH STRUT

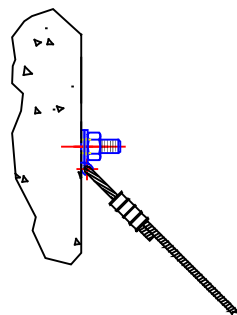


KSCA CLIP
WITH ANGLE

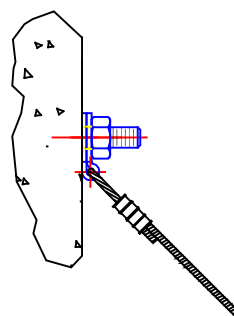


KSCA Clip with Single 1/4 to 1/2 Anchor

KSCU-1 CLIP
1/4 - 3/8
ANCHOR

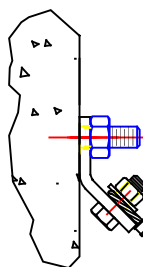


KSCU-2 CLIP
1/2 ANCHOR

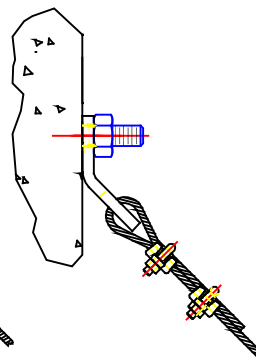


KSCU Clips for 1/4 Through 1/2 Anchors

CCA CLIP
WITH BOLTED
CABLE LOOP



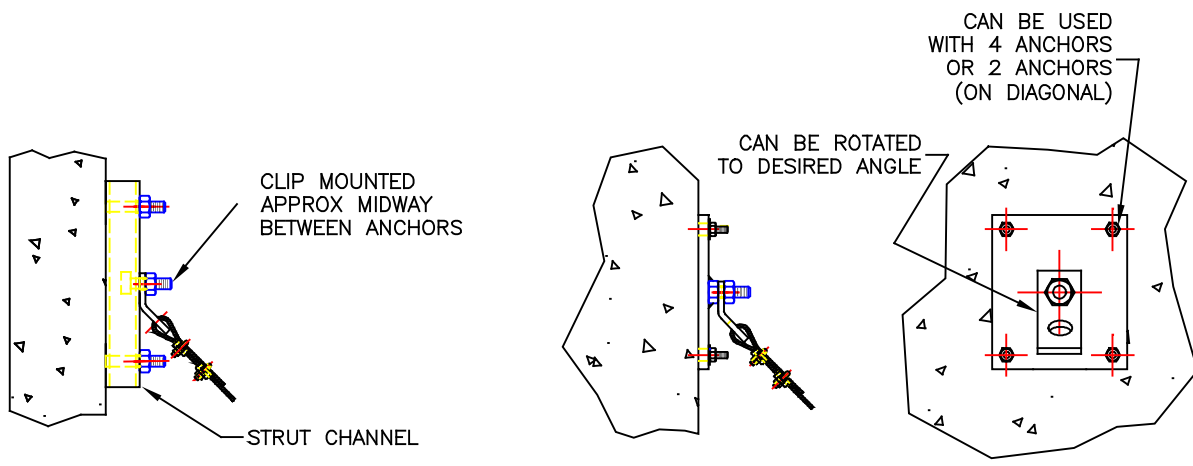
CCA CLIP
WITH THREADED
CABLE LOOP



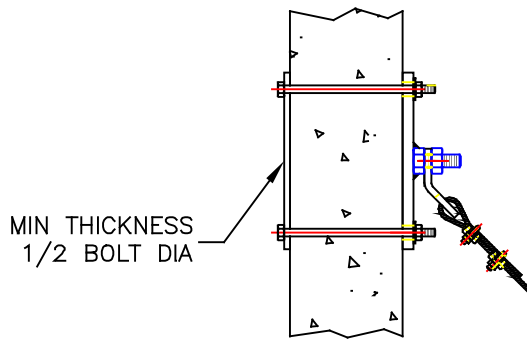
CCA Clips for Single 5/8 and 3/4 Anchors

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS





CCA Clip attached using Multiple Bolt Mount Plate and Strut Channel



Through Bolted Connection

Because of the materials lesser strengths, there are limited methods of attachment to masonry block walls. Caution should be exercised to avoid installing wedge-type anchors directly into the mortar used to cement the blocks together.

When used, anchors must penetrate into the core of the masonry unit and achieve adequate embedment into the concrete or grout that fills the cavity. If the blocks are not filled, the use of seismically rated wedge-type anchors should be avoided.

When working with hollow core block walls, restraint components must bolt through either one or both surfaces of the block units. Penetrations through both sides require backer plates of adequate size to distribute stress, while penetrations through one wall are more limited in capacity and must make use of an umbrella or other positive gripping internal element.

Masonry walls used to anchor restraints, as with other structural elements to which restraints are connected, must be reviewed and approved by the design professional of record on the project.

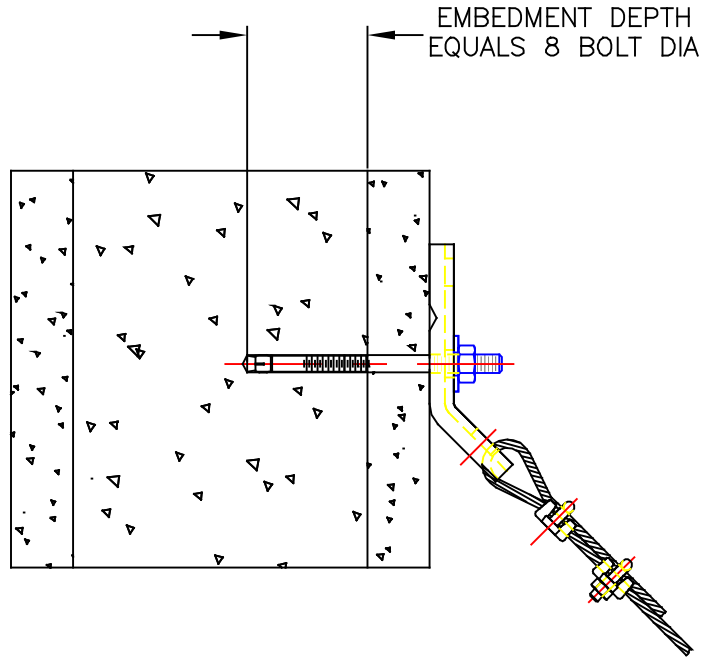
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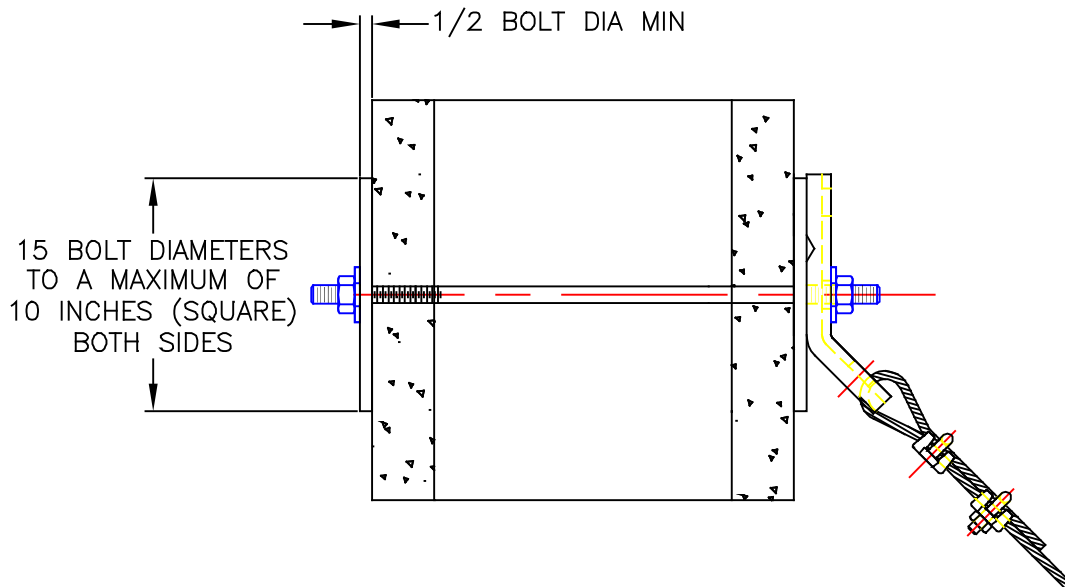
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Shown below is an example of a rated anchor embedded into the filled core of a masonry wall unit.

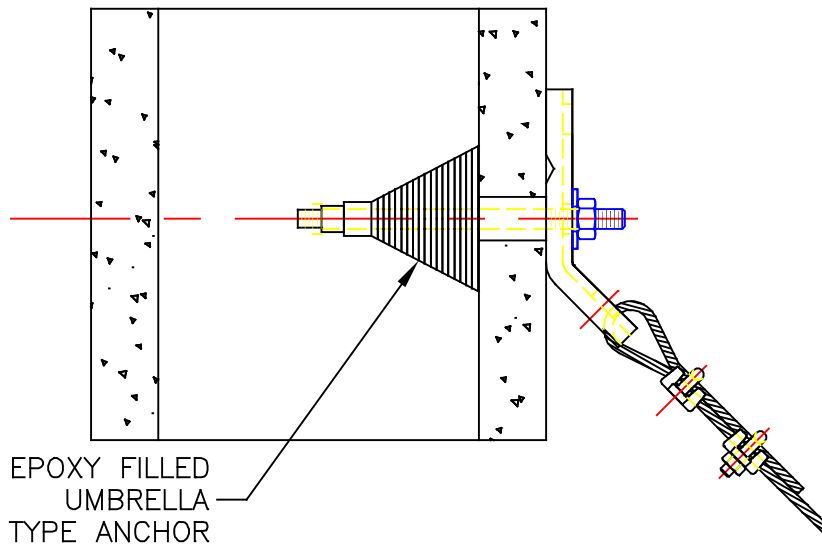


Attachment to filled Masonry Wall with Wedge-Type Anchor



Through-Bolted Connection to a Hollow Block Masonry Wall

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS



Filled Umbrella-Type Anchor for 1/4 and 1/2 Bolt Sizes

Connections to Steel Structures

Connections can be made to steel building elements by drilling and bolting, clamping (in some instances), or by welding. As most connections are made to hanging components, the most common structural members used as restraint supports tend to be beams and trusses.

Some cautions are appropriate when connecting to these elements, as their primary function is normally to support the floor or roof above, and they are already subject to significant stress. In addition, these elements are oriented such that, while they can withstand high vertical loads, they can be quite weak when horizontal loads are applied to them, especially when the loads are applied at 90 degrees to the beam axis (transverse).

While it is generally safe to make seismic restraint connections near the top of these beams, it is often less convenient than making the attachment at the bottom. Extreme caution must be exercised when connecting to the bottom flange of I-beams and, in particular, open web joists, as frequently a small lateral load applied to these areas can result in a catastrophic failure of the beam. No connections should be made without prior review and approval of the design professional of record.

Assuming approval has been granted for the installation of a restraint at a particular location, welding or clamping the restraint in place is typically the fastest, least invasive method of making the connection. Bolting requires that the structural element be drilled and is normally avoided where possible.

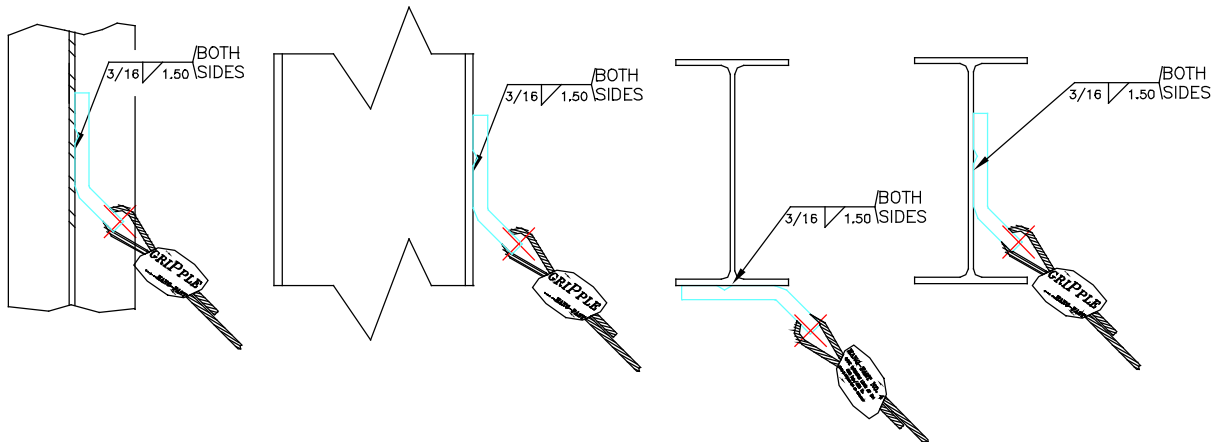
STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS



Welded Connections to Beams and Columns

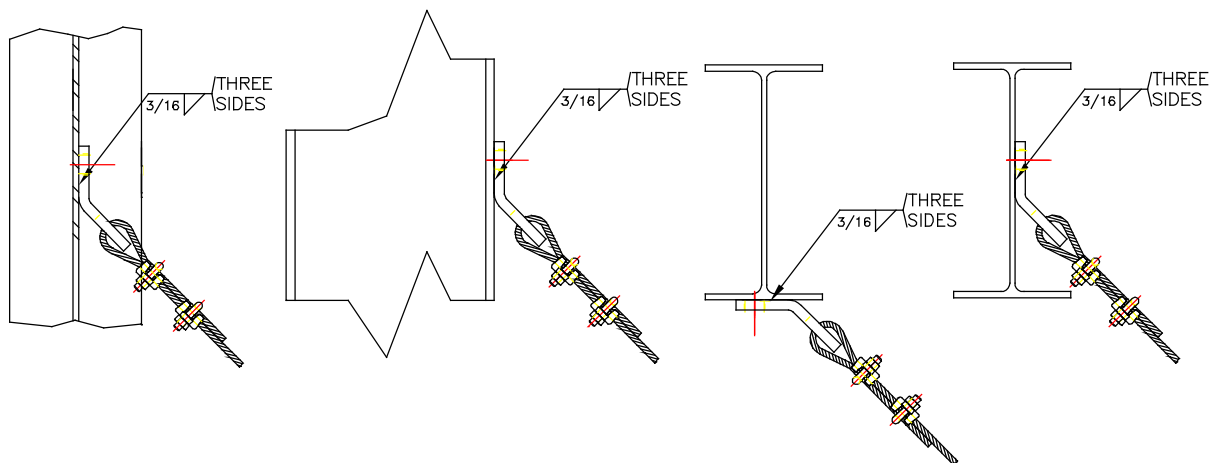
There are two basic methods for making weld attachments. The first is to directly weld a bracket to the structure and the second is to weld a threaded piece of hardware (typically a nut or bolt) to the structure and then attach the bracket to it. Looking first at the direct bracket welding options, the most suitable clips are the KSCA and the CCA.

Below are shown optional weld locations for the KSCA clip mounted to both beams and columns. These same arrangements are appropriate for floor- or roof-mounted connections with the exception that they are inverted.



Weld Data and Orientation for the attachment of the KSCA Clip

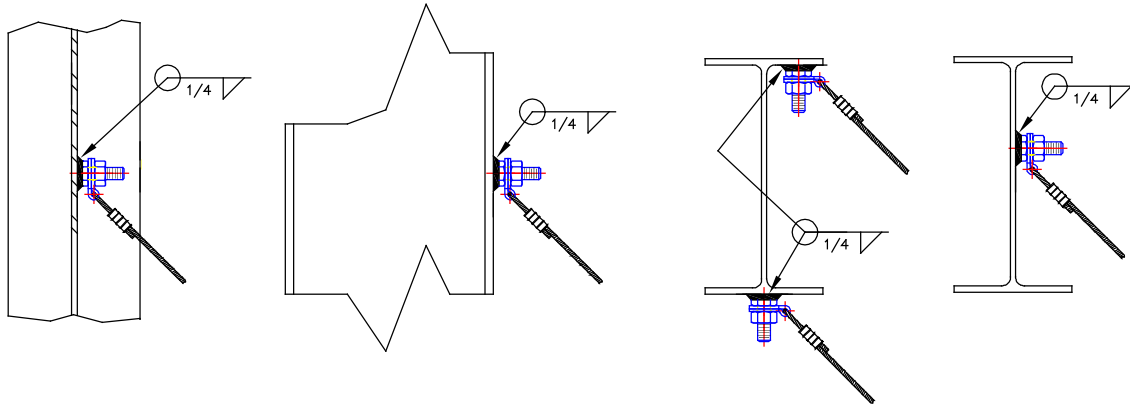
The CCA clip can be mounted in a similar fashion.



Weld Data and Orientation for the attachment of the CCA Clip

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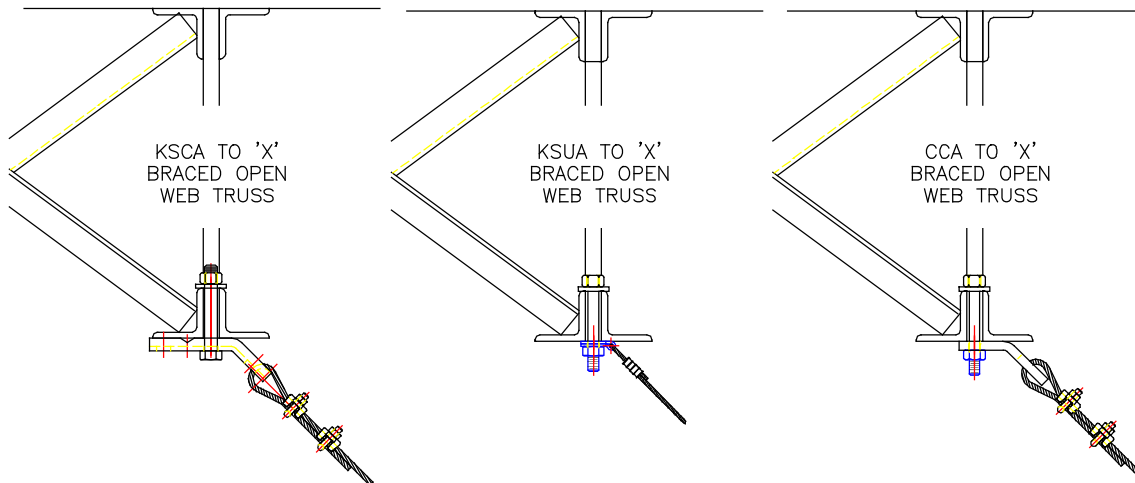
The second type of weld attachment is to weld hardware to the structure and use that to attach the restraint bracket. The KSCU is well adapted to that type of connection.



Weld Data and Orientations for attachment of the KSCU Clip

Bolted Connections to Steel Members

When used, bolted connections to steel structural members are normally made to open web joists or trusses. These are amenable to bolted connections as they have an integral slot, although caution is required to ensure that the addition of the restraint loads will not result in a buckling failure. It is also important to ensure that the load is oriented in such a way as to not cause the attachment bolt to slip in the slot to which it is attached.

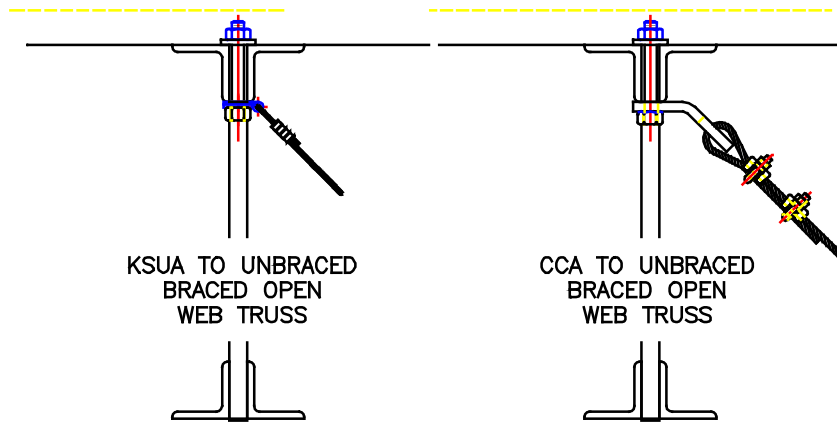


Transverse load Connections to "X" Braced Open Web Trusses

It is not recommended that restraints be connected to the bottom flange of an open web truss without substantial "X" bracing in the immediate area of the restraint attachment point. The bracing must be sufficient in nature and adequately connected to the truss to

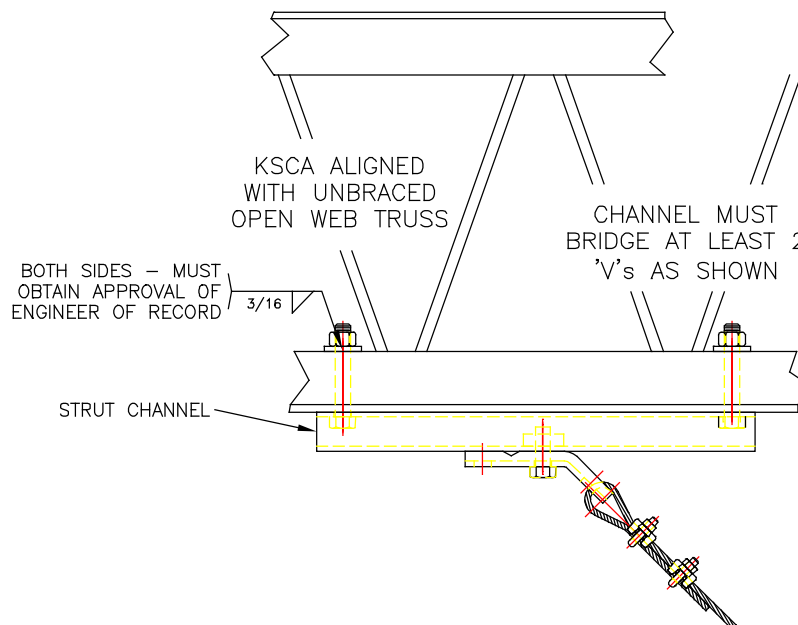
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carry all restraint loads to the deck above.



Connections to the Top Chord of an Open Web Truss

“X” bracing is normally not required when restraints are connected to the top chord of an open web truss as long as the truss is adequately tied into the decking and/or floor structure above. This, along with the case below showing loads that are carried parallel to the truss, transfer only minimal stress to the truss itself. Even so, as with the other arrangements, permission should be obtained before making either of these connections.



Bolted Connection to an Open Web Truss for loads parallel to the Truss

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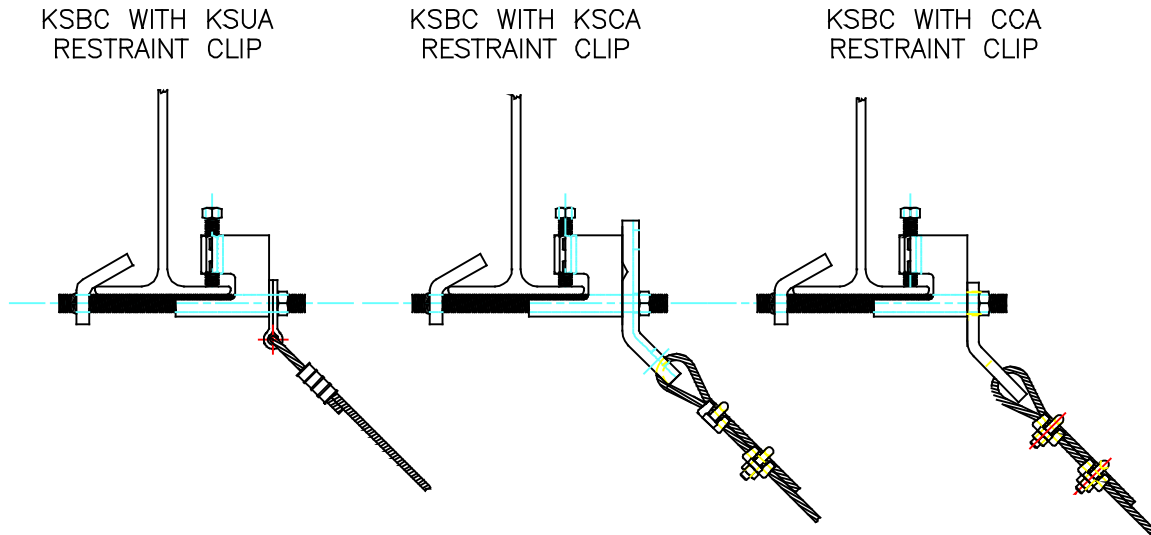
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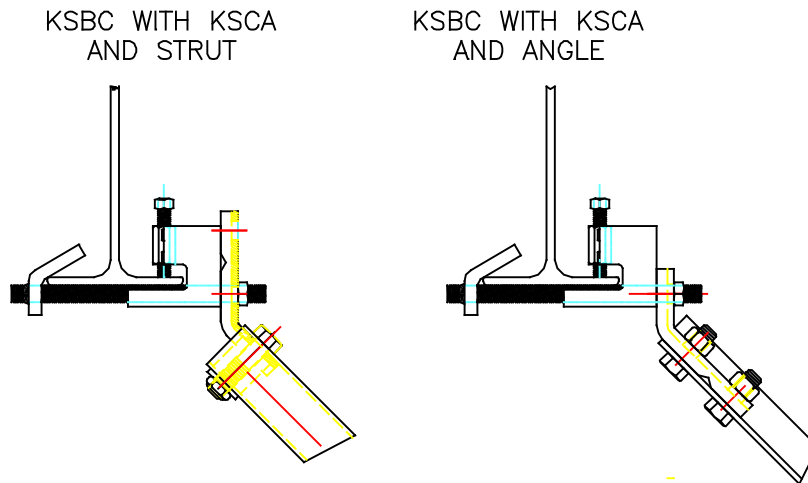
Clamped Connections to Steel Members

Another frequent restraint connection arrangement is to clamp the cable to a beam with a beam clamp. Again it is critical to ensure that the addition of these loads will not result in damage to the beam. The beam clamp selected must have a significant lateral force transferring capacity. Most readily available clamps are intended as supports for vertical loads and have only minimal lateral capacity. As such they are not suitable.

Shown below is Kinetics Noise Control's KSBC beam clamp.



The KSBC Beam Clamp can be mated with a wide range of I-Beams as well as KSUA, KSCA, and CCA Restraint Clips



KSBC Beam Clamps are also compatible with Strut and Angle Bracing

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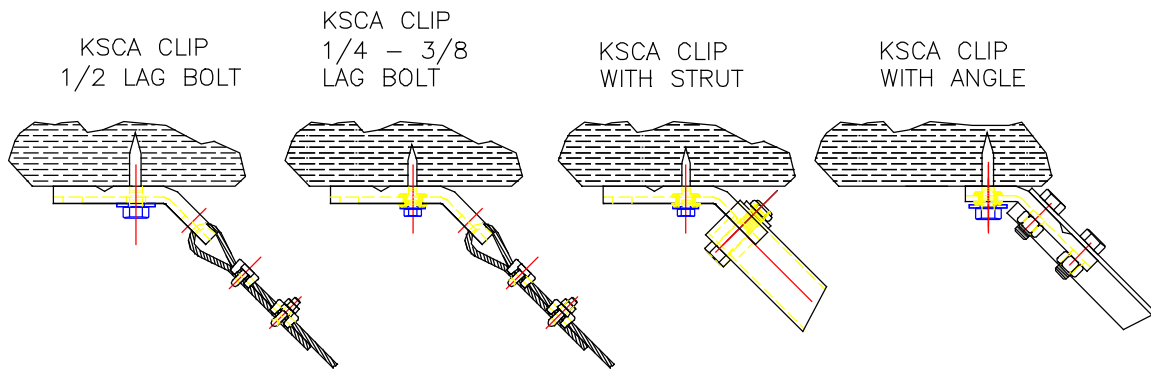
Connections to Wood

Connections to Ceilings and other Horizontal Surfaces

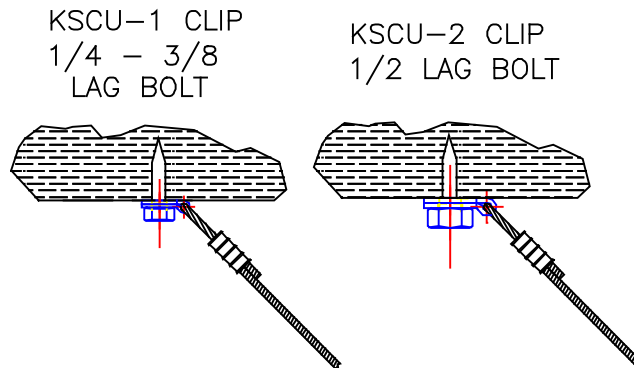
Wood structural members can often create issues when it comes to connecting seismic restraint hardware. Although lag screws are easy to install, adequate depth, end and edge distance issues frequently make them impractical. The option to bolt through a wood member and include a backer plate eliminates the depth issue, but the end and edge distance requirements still must be met. The minimum edge distance is 1.5 bolt diameters and the minimum end distance is seven times the bolt diameter.

The capacity of connections to wood using through bolts and a backer plate is limited only by bolt capacity and the structural capacity of the frame member. Capacities using lag bolts are severely limited, as the pull-out capacity of the lag bolt is much less than that of a through bolt.

Shown below are typical connections to the underside of horizontal surfaces (floor-mounted systems would be the same, but inverted).



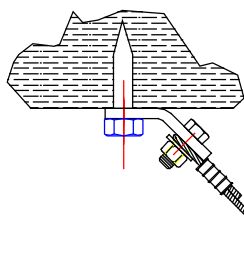
KSCA Clip with Single 1/4 to 1/2 Lag Bolt



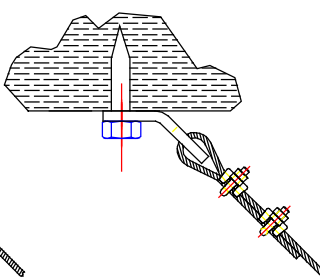
KSCU Clips for 1/4 Through 1/2 Lag Bolts

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CCA CLIP WITH BOLTED CABLE LOOP



CCA CLIP WITH THREADED CABLE LOOP

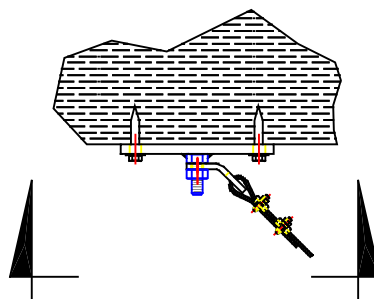
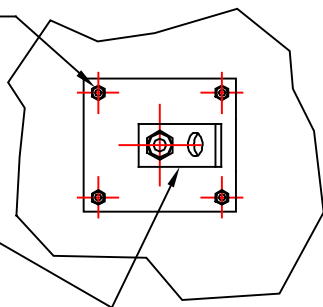


CCA Clip with Lag Bolts 5/8 and 3/4 Diameter

Where loads are such that a single anchor is inadequate, multiple anchors can be used as shown below.

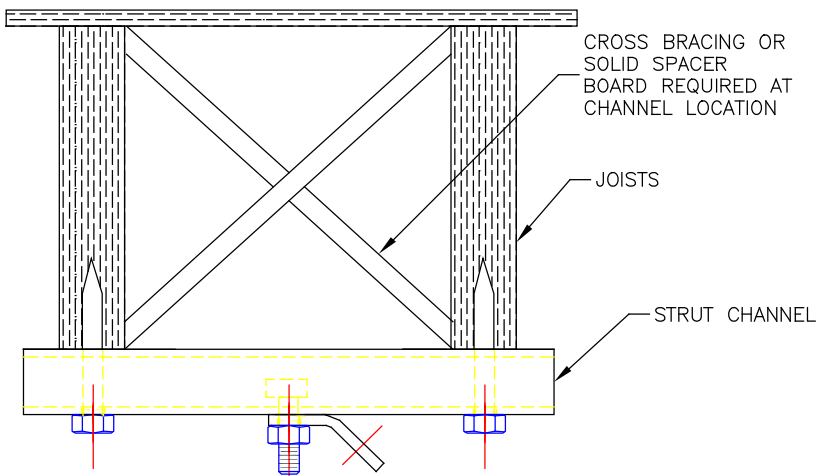
CAN BE USED WITH 4 OR 2 LAG SCREWS (ON DIAGONAL)

CAN BE ROTATED TO DESIRED ANGLE



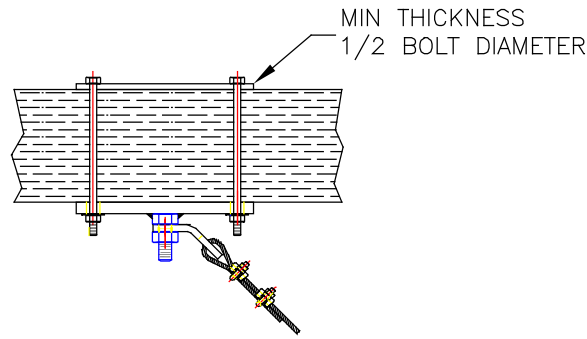
CCA Clip attached using Kinetics Noise Control 2/4 Bolt Mount Plate

As long as adequate resistance to prevent twisting of the joists is provided, it is possible to bridge across multiple joists and install a restraint in between.



Two Anchor Mounting using a Strut Channel

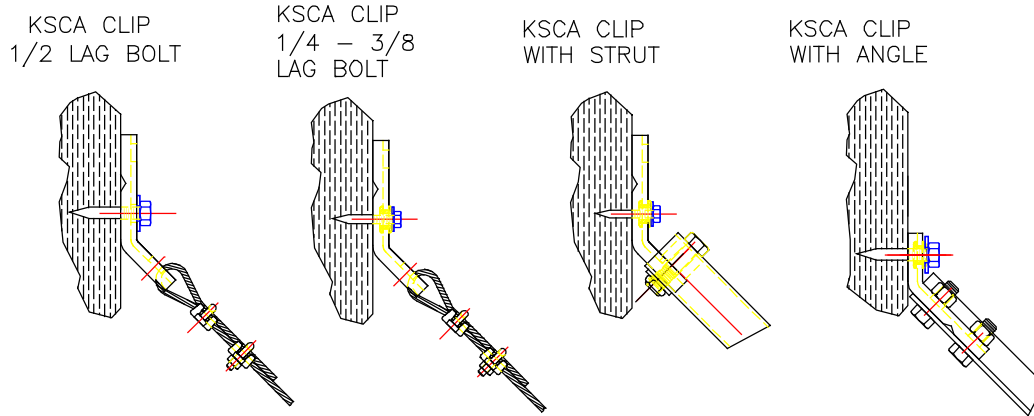
For worst-case conditions, as with concrete anchors, it is possible to bolt through a wood member with a backer plate.



Through-Bolted Application with Backer Plate

Wall and Column Connections

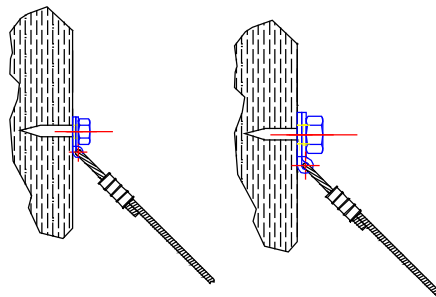
As with concrete anchors, the wall and column connections to wood members are very similar to those for horizontally oriented surfaces. Shown below are typical examples.



KSCA Clips Mounted with Single 1/4 to 1/2 Lag Bolts

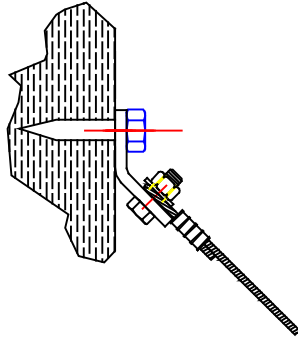
KSCU-1 CLIP
1/4 - 3/8 LAG BOLT

KSCU-2 CLIP
LAG BOLT

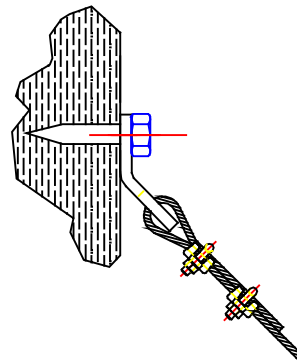


KSCU Clips for 1/4 and 1/2 Diameter Lag Screws

CCA CLIP
WITH BOLTED
CABLE LOOP



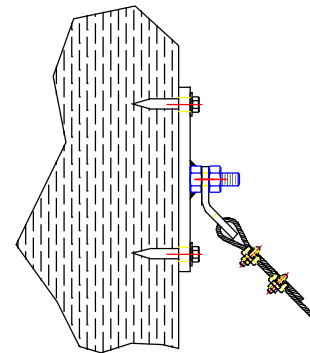
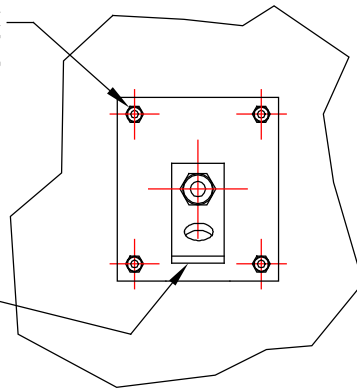
CCA CLIP
WITH THREADED
CABLE LOOP



CCA Clip with Lag Bolts 5/8 and 3/4 Diameter

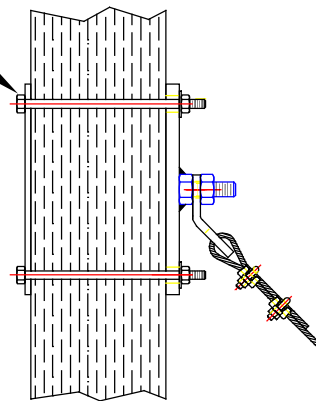
CAN BE USED
WITH 4 OR 2
LAG SCREWS
(ON DIAGONAL)

CAN BE ROTATED
TO DESIRED ANGLE



Multiple Bolt Anchor Plate with CCA Clip

MIN THICKNESS
1/2 BOLT DIAMETER



Through-Bolted Connection

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS

Conclusion

This sections attempts to list the bulk of the structural attachment arrangements that are likely to be found in the field. Not all combinations of struts, angles, cables, etc., have been shown for each option. Except for cases where a connection obviously won't fit, the ability to "mix and match" the various end connection combinations shown can be assumed.

STRUCTURAL ATTACHMENT DETAILS / SUSPENDED EQUIP RESTRAINTS

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RELEASE DATE: 05/05/04



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