SECTION D11.0 – TABLE OF CONTENTS

D11.0 – ARCHITECTURAL ELEMENTS

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FLOATING FLOOR SEISMIC RESTRAINT DESIGN

Floating floors, by nature of their design, can move horizontally when subjected to earthquakes. Large lateral movements could generate instability in the isolation pads or springs and must be prevented. The amount and type of restraint required is a function of the design earthquake and the properties of both the isolation system and the floor design.

Restraint Types

There are two basic types of floating floor seismic restraints – perimeter and interior. A perimeter isolation system consists of shock-absorbing pads spaced around the perimeter of the floor and attached to structural supports. These pads prevent direct contact between the floating floor and the supporting structural elements and their flexibility reduces the impact load on the floor and provides some damping for the horizontal motion. Ideally, the structural support will be integral with the building structural system, consisting of a structural wall or curb around the floor perimeter. Alternatively, the support system can be installed after the structure is complete by anchoring structural angles to the structural system. Both types of restraints are shown in Figures D11.1-1 and D11.1-2.

Interior restraints are embedded within the floating floor. Each restraint restricts seismic motion in all horizontal directions, reducing the number of restraints required. Large floors often require internal restraints to prevent buckling of the floor during an earthquake. Another common application is for a floor without perimeter supports where the use of angles is not desired. Figures D11.1-1 and D11.1-2 show typical installations of internal seismic restraints.

Restraint Selection

The choice of internal versus external seismic restraint most often depends upon the size of the floor to be restrained (preventing buckling in the floor system) and the presence or absence of a perimeter structural support. Kinetics Noise Control or the Structural Engineer or Architect of Record for the project should determine the buckling characteristics of the floor.

If a perimeter system is selected, the ability of any supporting structure (curb or wall) to carry the applied seismic load must be determined by the Structural Engineer of Record. If no adequate support is available, a support can be designed and supplied by Kinetics. The perimeter isolation system usually consists of twelve-inch wide neoprene pads spaced five to six feet on center, with the actual spacing determined by calculation. Kinetics PIB is placed between the pads to eliminate any flanking path for noise.

Internal restraints are used when they are required to prevent buckling of the floor or when no adequate perimeter support is available. The restraints are placed before the floor is formed in either the final position (RIM-type floor) or on the structural slab (lift-slab system). The outer portion of the restraint is attached to the floating floor while the inner portion is attached to the

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structural slab. Neoprene pads integral to the support provide the impact cushioning and damping required for proper restraint.

Figure D11.1-1; Floating Floor Perimeter Isolation w/Structural Support

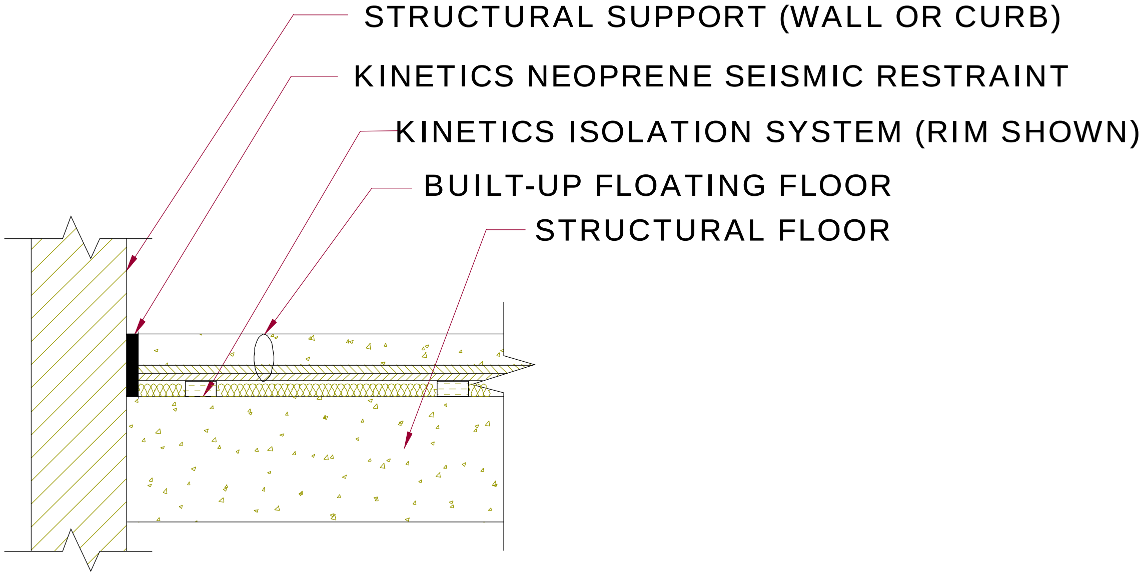

Figure D11.1-2; Floating Floor Perimeter Isolation w/Kinetics Structural Support

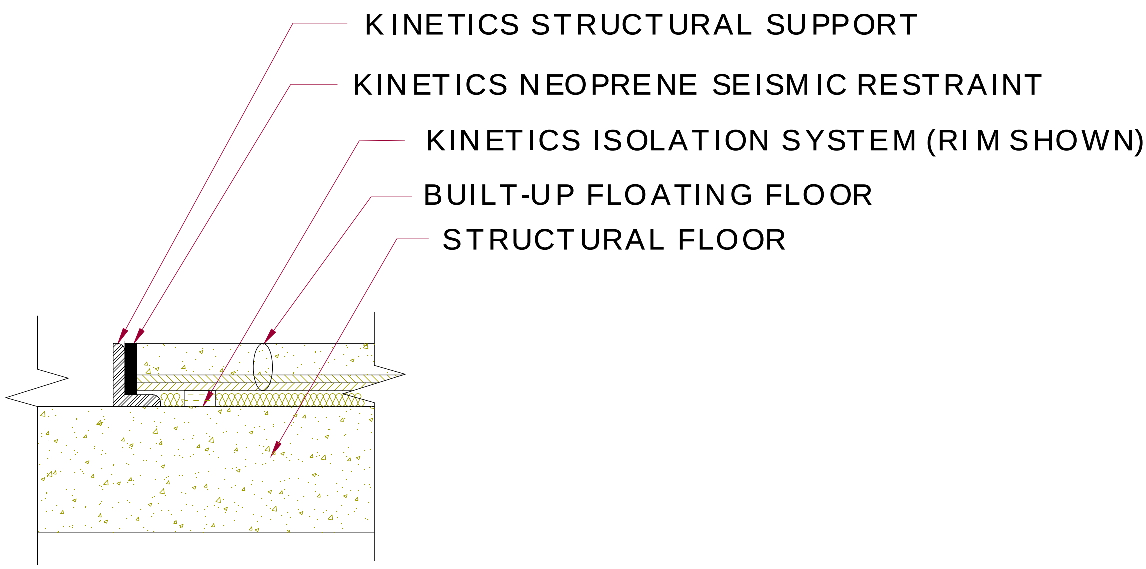

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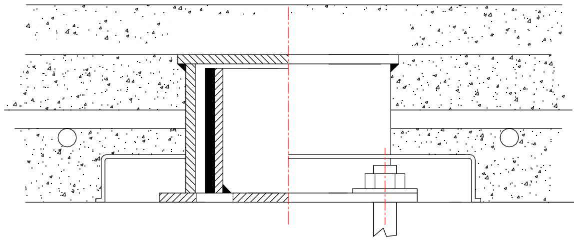
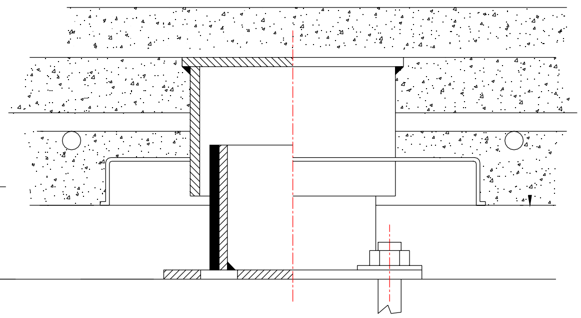
Figure D11.1-3; Internal Restraint for Lift-Slab System

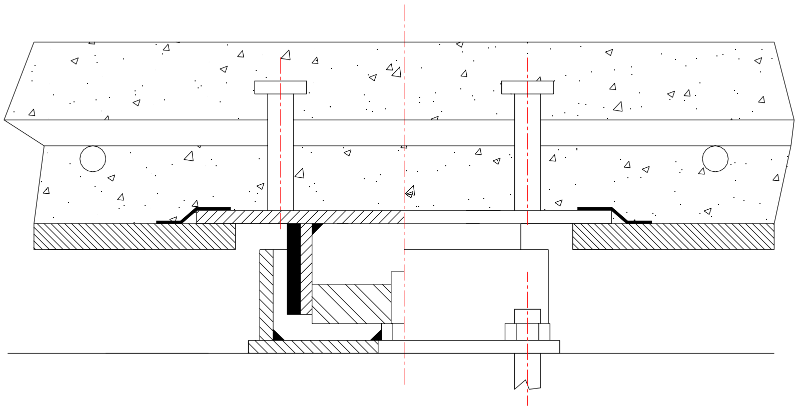


a) Initial Position



b) Raised Position

Figure D11.1-4; Internal Restraint for Roll-Out System



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ISOLATED CEILING SEISMIC RESTRAINT

Isolated ceilings typically weigh between 2 and 7.5 pounds per square ft and are made of 1, 2 or 3 layers of drywall. Over larger areas, the total weight of a ceiling system can become significant and the resulting seismic forces can be significant as well. In addition, it is not uncommon for ceilings to have a stepped or otherwise non-flat profile that can limit the ability to transfer these forces out to the perimeter. Even where this is not the case, significant crushing can occur along the perimeter on even moderately sized ceilings if no centralized restraint system is provided. Because of this, for ceilings either whose length or width exceeds 15 ft, internal seismic restraint elements are recommended.

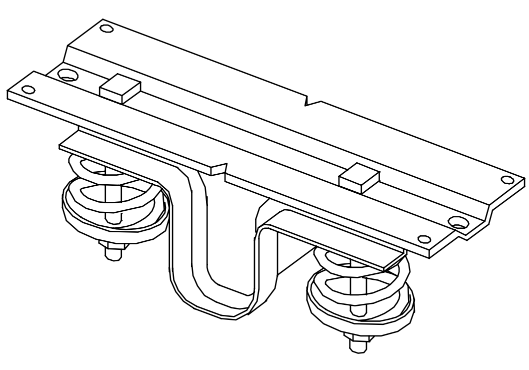
Even on smaller ceilings in some cases, equipment or light fixtures can add to the seismic loading that must be resisted and requires that appropriately sized restraints be fitted.

Restraint Types

Typically cable restraint systems are used to transfer seismic forces from the isolated ceiling to the structure in much the same way as with piping or duct systems. Because the ceilings are isolated, there is a need for cables rather than struts. An added issue when fitting restraint cables is that the cables must typically be installed and adjusted prior to the installation of the ceiling. As the drywall is added, the springs that support it will continue to deflect a noticeable additional amount. Care must be taken to ensure that this added deflection does not take all of the clearance out of the restraint cables and in so doing, generate a mechanical “short” for vibrations.

In some cases, seismically rated, housed ceiling isolators can be used. These are tolerant of the added deflection which occurs with the addition of the drywall. These however may not be suitable for all applications. More commonly conventional cable restraints are used with special attention given to ensure that no mechanical shorts will occur.

Figure D11.2-1; Seismically Rated KSCH Ceiling Support Isolator



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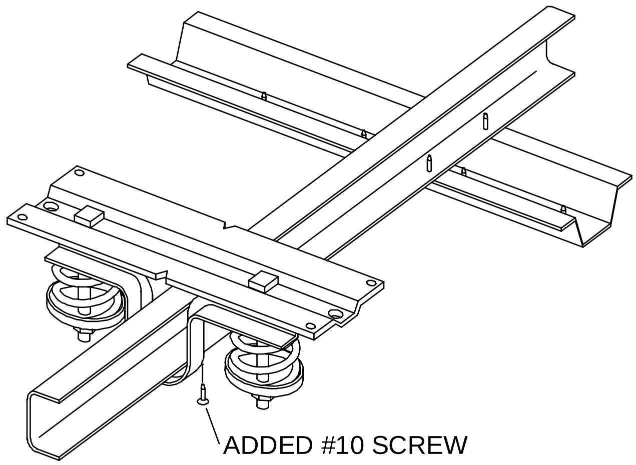
This isolator bolts directly to wood or concrete and offers positive seismic restraint for a broad range of applications. Included is a saddle that fully contains the CR channel commonly used to support isolated drywall ceiling systems. This saddle prevents side to side motion of the channel in its basic configuration. For use in seismic applications, it must be fitted with an additional #10 screw to prevent the channel from sliding through the saddle. See below.

Figure D11.2-2; KSCH Ceiling Support Isolator Installation



These Isolators are capable of supporting loads up to 140 lb per isolator while at the same time offer a horizontal restraint capacity of 100 lb each.

Figure D11.2-3; KSCH Typical Arrangement

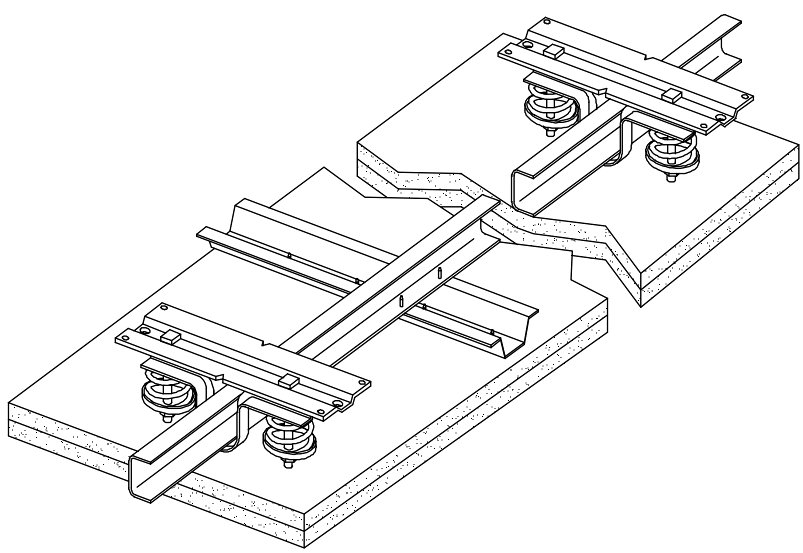


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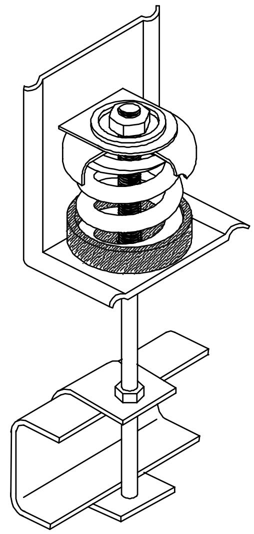
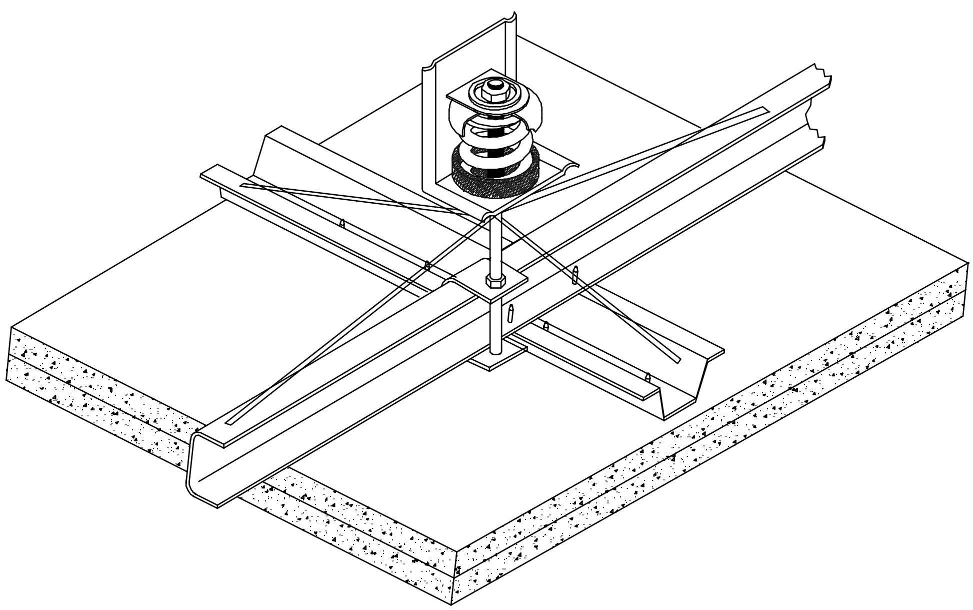
Figure D11.2-3; Seismically Rated ICW Ceiling Support Hanger



Where the isolated ceiling is suspended tight below the structure such that the CR channel is not more than 1/2" below the bottom of the bracket, the ICW Seismic Isolator can often be used.

If however, the ceiling grid is not tight up against the underside of the Isolator, it is necessary to incorporate additional cable restraint assemblies to protect the hanger rod as shown below.

Figure D11.2-4; Seismically Rated ICW Ceiling Support Hanger with Cables Added



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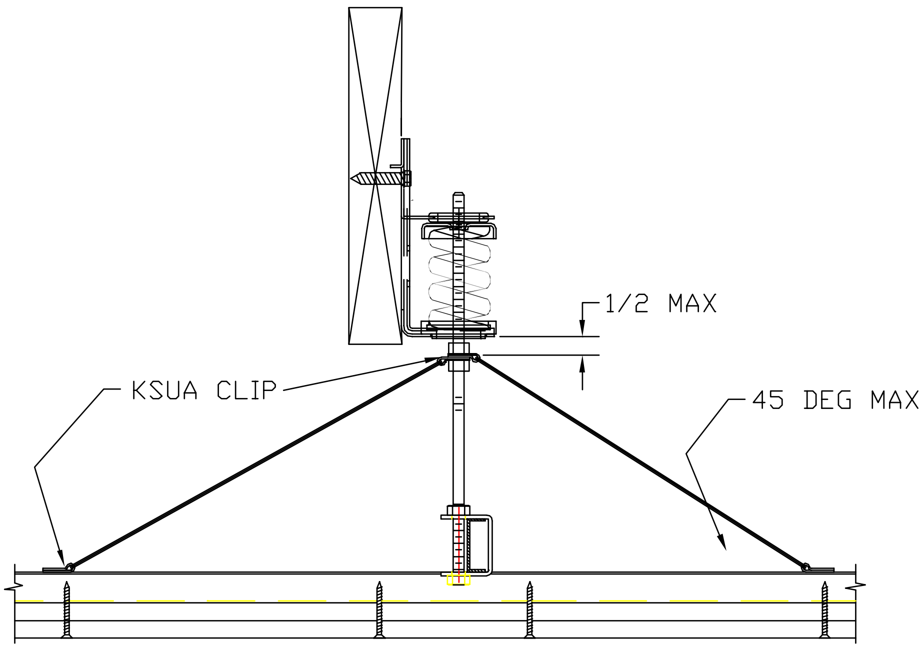
The cable restraint assemblies must connect to the hanger rod within ½" of the underside of the ICW restraint bracket as shown, but the actual exposed length of the hanger rod can be as much as 12". Connections to the ceiling grid must be with a ¼" bolt (min).

Figure D11.2-5; Seismically Rated ICW Ceiling Support Hanger Section



This restraint device is rated for 60 lb in any direction.

Restraining Ceiling Systems with Cables

Ceiling systems can be restrained using cable restraints in fashion similar to that shown above, but with the restraints connected directly to structure. When this is done, the graphs in section D4.4 of this manual can be used to aid in the selection process.

When installed, it should be assumed that the ceiling will drop ½" - 1" for most systems and provisions must be made in the cable tightness to accommodate this. It is generally recommended that the cable be put in on a shallow slope not to exceed 15 degrees from the horizontal. In addition the grid should be deflected downward manually when installing the cables to approximately the expected deflection amount. In that condition, the cable should be slightly loose (1/16" to 3/16" lateral motion allowed).

In addition, the isolation hangers should be mounted close to, but not in contact with the underside of the ceiling structure. Maximum clearance under load should not exceed 1/8".

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ISOLATED WALL SEISMIC RESTRAINT

Proper installation of isolated walls requires that the wall not only be resiliently supported, but that they are also resiliently stabilized. Because the walls are not part of the building structure, they do not have a membrane to support the upper edges. This makes them inherently unstable. They are also subject to lateral loads from contact with other objects or due to the attachment of wall mounted components to them. The requirement for stabilization is compounded in seismic areas where the walls can be exposed to significant lateral acceleration forces.

Because masonry walls require high compressive loads to prevent internal buckling and because they possess a high level of mass, the requirement for restraint becomes more critical. The stabilizing compressive load present in a load bearing wall is not present in a free standing wall rendering them easily susceptible to seismic damage.

To determine the amount of support required by the wall several factors must be taken into account. These are: 1) the amount of natural support dictated by the room geometry (corners and intersections), 2) the stability provided by the type of construction, 3) the unit mass of the isolated wall and 4) the anticipated lateral loading to which the wall may be subjected.

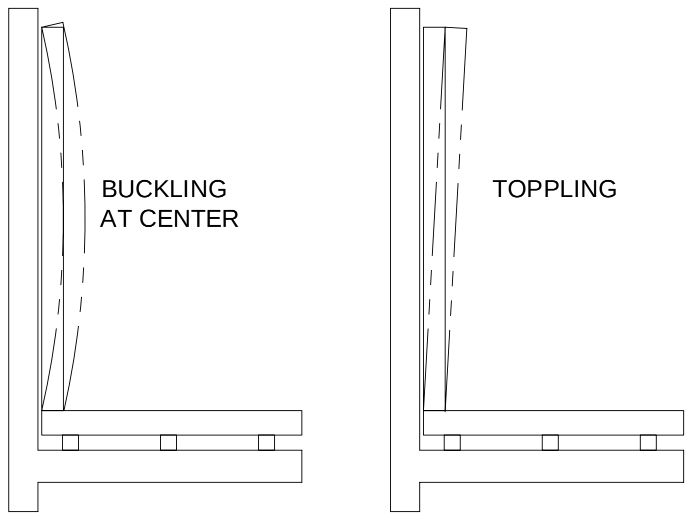
Beginning with the rooms "natural support", it is safe to assume that any corner or intersection point that occurs in the isolated wall system where at least 2 of the intersecting walls extend a distance equal to 50% of the walls height can be considered to form a natural restraint. For example, a 10 ft x 10 ft room with 8 ft tall isolated walls can be considered to have 4 naturally supported corners. However, if we consider a wall with a 6 in long jog in its center, the jog (since it's length is less than 50% of the wall height) cannot be considered to be a natural support.

The various methods used to construct isolated walls have different levels of resistance against buckling. For example, a masonry wall that is not subjected to weight bearing loads is quite weak in buckling, where a masonry wall that is bearing weight can be quite resistant to it. In non-weight bearing applications, frame construction is generally more resistant to vertical buckling loads than masonry. On the other hand, frame construction is also generally weaker than masonry walls when evaluating the transfer of loads along the length of the wall. This is because, apart from the top and bottom, the framing members do not normally run in the horizontal axis.

The surface mass of a wall works in conjunction with seismic accelerations to generate buckling and toppling forces. Lower surface mass framed walls are much less subject to damage from seismic loads than are heavy masonry ones.

Floating walls subjected to horizontal loads can buckle or topple in the vertical plane or can buckle along their length. Illustrations of the vertical failure modes are shown below. The first case (buckling) is the result of the wall being restrained top and bottom but with too great a vertical center distance between restraints. The second (toppling) is the result of inadequate restraint at the top.

Figure 11.3-1; Wall Failure Modes



The buckling mode along the walls length is similar to the buckling case above except that it occurs in the horizontal plane. It most commonly occurs along the top edge of a wall where there is no positive continuous restraint fitted and where the horizontal distance between localized restraints is excessive.

All walls must be designed to resist the anticipated seismic forces (as a minimum) and if there are known or anticipated forces that may result from other factors which exceed the seismic loads, they must be identified and used for sizing the appropriate restraint devices. This document will identify the restraints necessary based on seismic requirements only.

In the case of seismic events, the driving force is created by horizontal accelerations acting on the mass of the wall. Resisting this loading are the restraints and the buckling strength of the wall itself. The wall's buckling strength and mass can be determined for commonly used building cross sections and using this, the wall's natural ability to withstand horizontal accelerations can be determined. This resistance/force relationship can then be used to determine the maximum allowable span length between restraints.

Once the spacing is determined, the actual load that the restraint must be capable of handling can be quickly determined by dividing the supported wall mass among the supporting restraints and applying the appropriate acceleration factor to it.

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As wall restraints/isolators include no running clearance, these devices must be capable of developing this force while still maintaining a low enough natural frequency to ensure the isolation characteristics of the wall.

As the natural frequency of a system is a function of its supported mass and spring rate (measured as deflection if the spring is oriented vertically). A restraint should be selected based on its having the desired spring rate in the unloaded condition. It is also desirable to have a relatively short working range to minimize wall motion during a seismic event. Restraints with a graduated spring rate such as occur in neoprene pads with simple shapes tend to be ideal for this.

It is always worthy of note to indicate that when isolators are oriented horizontally and are not affected by gravity, the installed deflection is not part of the design requirement. This is because natural frequency is a function of mass and spring rate and not of deflection.

Based on the trade-off between the inherent or natural strength of isolated walls of various constructions and their mass, the following table has been generated. It provides a recommended maximum spacing for restraints on both the vertical and horizontal axis based on seismic accelerations and is broken down by wall type. It also lists the approximate maximum load that the restraint is likely to see.

Seismic Acceleration in G's

Acceleration Factor	2		1		0.75		0.4		0.2		0.1		Maximum Restraint Force
Type Wall	Horiz	Vert	Horiz	Vert	Horiz	Vert	Horiz	Vert	Horiz	Vert	Horiz	Vert	
Masonry	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	CD (in)	lbs
6" Block/Hollow	22	22	31	31	36	36	49	49	70	70	99	99	509
6" Block/Sand Filled	26	26	36	36	42	42	57	57	81	81	114	114	509
8" Block/Hollow	23	23	33	33	38	38	52	52	73	73	104	104	749
8" Block/Sand Filled	27	27	38	38	44	44	60	60	85	85	120	120	749
12" Block/Hollow	24	24	34	34	40	40	54	54	77	77	109	109	1232
12" Block/Sand Filled	28	28	40	40	46	46	63	63	89	89	120	120	1232
Frame/Drywall													
16" Centers / 1/2" Drywall	22	78	32	111	37	120	50	120	71	120	71	120	61
16" Centers / 1" Drywall	17	60	24	85	28	98	38	120	54	120	77	120	61
16" Centers / 1-1/2" Drywall	14	51	20	72	24	83	32	113	46	120	65	120	61
16" Centers / 5/8" Drywall	21	72	29	102	34	118	46	120	65	120	93	120	61
16" Centers / 1-1/4" Drywall	16	55	22	77	26	89	35	120	50	120	70	120	61
16" Centers / 1-7/8" Drywall	13	46	19	65	21	75	29	102	41	120	59	120	61
24" Centers / 1/2" Drywall	24	67	33	95	39	110	53	120	75	120	75	120	50
24" Centers / 1" Drywall	18	51	25	72	29	83	40	113	56	120	79	120	50
24" Centers / 1-1/2" Drywall	15	42	21	60	24	69	33	94	47	120	66	120	50
24" Centers / 5/8" Drywall	22	62	31	87	35	101	48	120	68	120	97	120	50
24" Centers / 1-1/4" Drywall	16	46	23	65	26	75	36	102	51	120	72	120	50
24" Centers / 1-7/8" Drywall	13	38	19	54	22	62	30	85	42	120	60	120	50

To ensure that the wall is not damaged when subjected to the max loading condition, total design deflection in the restraint device should be limited to 1/4" (max).

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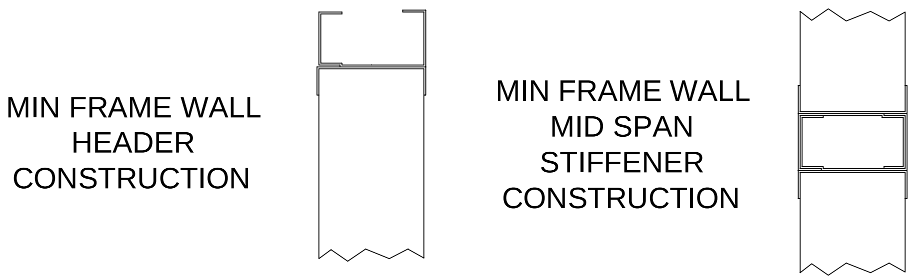
The following assumptions were used in compiling these tables:

The masonry construction assumes a tensile strength of 275 PSI in the mortar.

The frame construction assumes the use of 20 ga metal 2 x 4 studs. It also requires that if the frame wall exceeds 120" in height, 2-20 ga metal 2 x 4 studs are interlocked and sandwiched between 2-20 ga 2 x 4 metal framing channels. These must run horizontally along the walls length and are oriented to align the ends of the upper and lower vertically oriented studs. For all frame walls a single 20 ga metal 2 x 4 stud is welded or screwed to a 20 ga 2 x 4 metal framing channel to form the top plate of the wall.

Figure 11.3-2; Framed Wall Typical Sections



Isolated Masonry walls are normally set into a pocket formed by extending the recess in the structural slab allowed for installation of a floating floor beyond the perimeter of the floating floor itself. When used, this gap is sized to allow an isolated wall to penetrate the floating floor and sit on its own set of support pads. As an option, masonry walls can also be set onto the perimeter of the floating floor and doweled to it in a fashion that can resist seismic shear loads at the wall's base.

Framed walls are frequently supported either on the perimeter of the floating floor as mentioned above or are mounted on their own set of isolation pads that are spaced at regular intervals down the length of the base rail. In either case, the anchors used to connect the wall to the floor must be sized to resist the seismic shear loads that can occur at the base of the wall. Normal spacing as specified by Kinetics Noise Control is adequate for this task in all seismic conditions

As the isolated wall is intended to reduce the flow of noise from one space to another, the tops of these walls will normally about the underside of a floor or ceiling element. These connections should be sealed to resist the flow of sound and frequently this is accomplished via the use of rubber faced angles that hard attach to the structure and cradle the top of the wall. If these are used for restraint purposes, they must be sized based on the expected load. Kinetics Noise Control offers the IPRB, neoprene faced angle brackets that are frequently used for this task.

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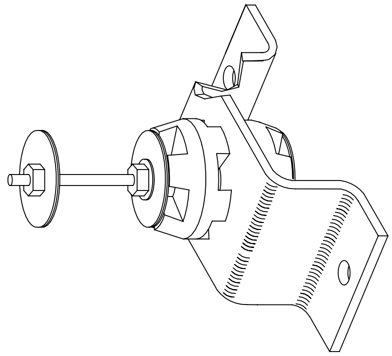
Seismic Sway Braces for Masonry

For the interior expanse of isolated walls or where the IPRB does not possess adequate capacity on its own to restrain the top, there are several products that can be used. The Kinetics PSB sway brace is commonly used for the restraint of isolated walls made of masonry. These are rated with capacities up to 2000 lb.

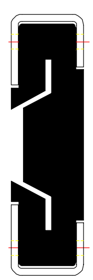
Figure 11.3-3; PSB Sway Brace



An additional option for lighter duty applications is the KWSB. This is lighter duty and is made to connect to the framing members that make up the structure of the isolated wall. Capacities on KWSB go up to 50 lb.

Probably the best solution for gauge material is the Isomax wall clip. This is designed to both support a wall and when spaced in a 24" x 48" array, can provide adequate restraint for walls made up of as much as 3 layers of 5/8" drywall in applications as high as .5 G. The Seismic rating can increase with reduced spacing if need be.

Figure 11.3-4; IsoMax Wall Isolation Clip



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