



IMPERIAL
EARTHQUAKE PROTECTION MADE EASY

**SMART LIVING.
SMART CITIES.
SMART STRUCTURES.**



**20
25**

**2G - 2nd generation
SEISMIC RESILIENT
STRUCTURES**

www.imperialeps.com

Exclusive channel partner of Quaketek Inc. Canada



IMPERIAL

EARTHQUAKE PROTECTION MADE EASY

IMPERIAL EARTHQUAKE PROTECTION SYSTEMS LLP



**BIGGEST SIZE EVER MANUFACTURED SEISMIC FRICTION
BRAKE/DAMPER INSTALLED AT TORRE CUARZO - 8000 KN**

ABOUT IMPERIAL EARTHQUAKE PROTECTION

Imperial Earthquake Protection Systems LLP is a part of KLA Group that is established over 30 years back.

Imperial is a leap towards providing cost effective building upgraded solutions to Indian construction industry with top-of-the-line innovations, worldwide.

Imperial is an exclusive channel partner to Quaketek Inc. (Canada) for India and neighbouring countries including large region of Middle East. Quaketek is one of the world's largest manufacturer and supplier of passive energy dissipation devices commonly known as Seismic Friction Brakes/Dampers (SFB's) from its state of art manufacturing & testing facility in Montreal, Canada.

At Imperial we aim to be one stop facility for our clients where we not only interact and educate them with our vast experience earned from installation of SFB's in over 10 million sqft. of buildings in India but also assist them in planning and design. Imperial team proactively engages with its clients during the installation of SFB's to ensure end to end solution and complete peace of mind.

FROM THE DESK OF FOUNDER & PARTNER



GO GREEN



SUSTAINABILITY



Mr. Anurag Bindal

"As a part of civil engineering fraternity from past 2.5 decades, I often thought to upscale the level of structures that we build in India. Being involved in introducing many new products and technologies like large width expansion joint cover membranes, EPDM, TPO, fireproof mortar etc. to our market, passive energy dissipation devices are the latest and by far most liked system that I am proud to offer."

"I feel excited & motivated with the way our academicians, eminent civil/earthquake engineering institutes have accepted the technology that we offer. Wide range of testing is now being conducted in India on Quaketek Seismic Friction Brakes/Dampers to capture its unmatched advantages."

KEY MEMBERS



Mr. SK Pandey
DGM Projects
B.E.(CIVIL)



Mr. Vineet Gaur
JWP Projects
DCE, AMIE, FTY



Mr. Nitin Raj
JWP Projects
B.E.(CIVIL), DCM



Mr. CM Mehra
VP Group
B.Se(Civil Engg), M.Tech(Structures)



Ms. Shubhi Bindal
Partner
B.Com, MBA, PDI



Ms. Rashmi Bindal
Partner
B.Tech, MBA



IMPERIAL

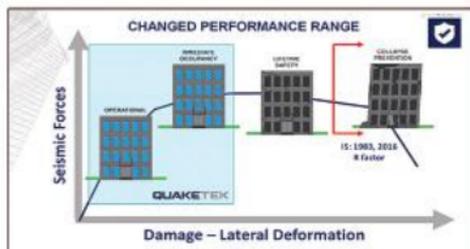
EARTHQUAKE PROTECTION MADE EASY

IMPERIAL EARTHQUAKE PROTECTION SYSTEMS LLP

Modern structural engineering has made significant advancements, evolving from simple masonry structures to framed reinforced concrete (RC) buildings and even more robust designs incorporating shear walls. However, even with these advancements, traditional structural systems often depend on the concept of 'controlled damage' to resist earthquake forces. While this approach can prevent catastrophic collapse, it can result in significant loss of lives, often expensive repairs, and high downtime following seismic events leading to "Death, Dollar and Downtime" case.

To address these limitations, passive energy dissipation devices have emerged as a revolutionary solution. These devices are specifically designed to absorb and dissipate the kinetic energy imparted to a structure during events like earthquakes, windstorms, or other dynamic forces. The fundamental principle behind these systems is their ability to function without external energy input, relying purely on the internal deformation or relative motion within the structure.

The integration of passive dampers & dissipative devices not only reduces the reliance on structural damage for energy absorption but also ensures enhanced safety and resilience. By mitigating excessive vibrations and minimizing structural deformations, these systems provide an efficient and cost-effective means of saving both life and property during and after extreme events.



ABOUT PASSIVE ENERGY DISSIPATION SYSTEMS

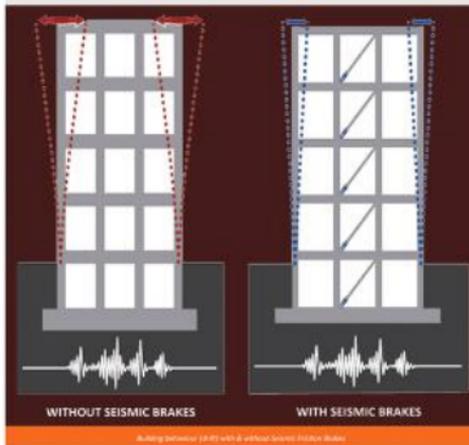


Typical frame with Seismic Friction Brake at end of bracing



Flexibility in installation and re-testing

Passive energy dissipation devices represent the future of structural design, enabling engineers to create buildings that are not just stronger but also smarter, adapting to and withstanding the challenges of an unpredictable environment.



SEISMIC FRICTION BRAKE/DAMPER FROM QUAKETEK INC., CANADA



IMPERIAL
EARTHQUAKE PROTECTION MADE EASY

Quaketek's Seismic Friction Brakes (QSB) are 100% tested high precision damping devices manufactured in Montreal, Canada. The Dampers allow the building to move elastically and dissipate the energy of the earthquake. This, in turn, produces substantial savings as structural elements can be optimized for **cost savings**.

Designed to activate before structural members yield, Seismic Friction Brakes/Dampers act as a reusable fuse (no need for replacement after an earthquake) which simultaneously dissipate energy.

Quaketek manufactures highest quality Seismic Friction Brakes from its state of art manufacturing facility at Montreal, Canada, with most modern and updated R&D setup.

We protect more than 400 buildings around the world

Advantages of using Seismic Friction Brakes in structural systems:

- Limited or no damage to the structure during an earthquake leading to building that can be immediately occupied or operational after an earthquake.
- Cost savings through reduced material usage.
- Lower dead load and optimized foundation.
- Prefabricated assemblies replace conventional system leading to faster and quality construction.
- Sustainability through material reduction.





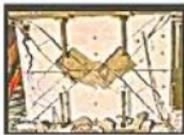
CURRENT APPROACH- RCC SHEAR WALL STRUCTURES

Shear walls are structural members typically used to provide required strength & stiffness to resist lateral loads caused by earthquake, wind & other dynamic forces. They transfer lateral loads from roof, floors etc. to foundations, ensuring building stability and structural integrity.

It is very important to have a good position of the shear walls especially to take care of torsion in the building during ground movements caused by an earthquake. It is important that the center of lateral mass matches the center of stiffness. Largely placing shear walls at the perimeter of the building on both axis is preferable but most architects would like to keep them in the center core wherein the lifts are installed.

Do shear walls completely avoid damage of the building if designed as per code during a major earthquake??

Answer is NO.

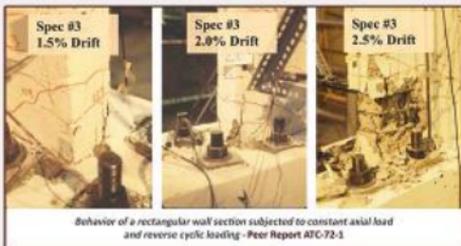


Diagonal damage at 1500 permissible lateral deformation

RCC shear walls design are meant to provide possible safe escape in an event of major earthquake. Shear walls act as a sacrificial structural member which cracks and deform and provide sufficient time to evacuate.



RCC framed structures in India are designed with Response reduction factor of 4.0. This means that while designing the building, earthquake forces are reduced by 4.0 times than the design basis earthquake else the quantum of shear walls will be exponentially high and their cost will be unviable.





UPGRADED 2^g RCC STRUCTURES APPROACH

For developers, contractors & engineers, one of the most challenging job in an RCC shear wall construction is to handle quality of concrete in shear walls especially owing to dense reinforcement steel. Segregation, cold joints, honeycombing, line & levels are most common issues that though noticed but yet ignored.



To handle these issues, we bring to you 2^g Seismic Resilient Structure having time tested & proven passive energy dissipation system as a main LFRS.

The RCC shear wall system can be easily replaced with Seismic Friction Brakes to get all the advantages of the 2nd generation structures.

The use of Seismic Friction Brakes allows for the complete elimination or significant reduction of shear walls from the building.

Yield-restrained braces can be easily installed using insert plates and gusset plates. These braces effectively restrict the deformation of the RCC system, resulting in a faster, cost-effective & seismically safe structure.





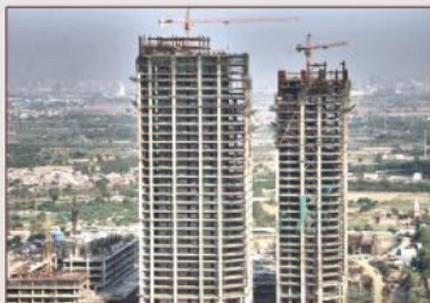
IMPERIAL

EARTHQUAKE PROTECTION MADE EASY

IMPERIAL EARTHQUAKE PROTECTION SYSTEMS LLP

CURRENT APPROACH- STEEL COMPOSITE STRUCTURES

Steel composite structures in India have been one of the preferable building system especially in case of high rise commercial spaces and even for projects that need to be delivered in short span of time owing to early usage of building (like hospitals, datacenters etc.) or dense neighbourhood which may not permit sufficient time/space for conventional RCC building construction.



The reason why composite construction is often so efficient can be expressed in one simple way - concrete is good in compression and steel is good in tension. Structurally, when these two materials work together then their strengths can be exploited to result in a highly efficient and lightweight design.

Steel composite structures conventionally have heavy shearwalls to resist earthquake, wind and other dynamic forces acting on the building. These shearwalls are either in RCC or steel infill concrete. Steel columns are generally jacketed with reinforcement steel and RCC to take care of axial load. Such heavy shearwalls not only increase the time of construction but also increase the overall weight of structure thereby making the building bit expensive.



UPGRADED STEEL COMPOSITE STRUCTURES WITH 2^G APPROACH

As we know that concrete is brittle in nature and perform poor in tension therefore in case of a major event, shear walls are expected to have major damages which may be far from repairs. The steel composite structure with bracings also have brittle failure as the bracings finally fail in buckling. Buckling of structural steel is a sudden brittle phenomenon as well.

2^G approach is the new defined approach of having passive energy dissipation system in place of shear walls (RCC or Concrete Infill Steel shear walls) or regular steel braces that can be easily designed and implemented in the project while honouring relevant IS codes and international codes.

The bracings are upgraded with Seismic Friction Brakes and thereby working as yield restrained bracings. Further, these devices can be easily welded or bolted with the steel beam and columns.

Buildings having Seismic Friction Brakes/Dampers (SFB's) are fast in construction and more robust than the conventional ones.

To add, the owner has peace of mind since all the SFB's are with 30-50 years international warranty and the overall budget of the building remains same or even lower than the conventional way of construction.

Steel composite buildings with Seismic Friction Brakes are the future of construction.

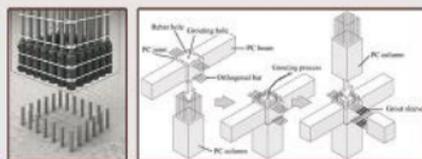
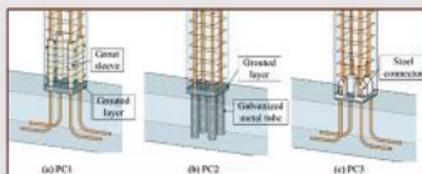
Developing new horizon for steel composite structures with 2nd generation approach.



CURRENT APPROACH- PRE CAST BUILDINGS

Precast building structures are constructed using prefabricated components such as beams, columns, walls, and slabs, which are manufactured off-site in controlled environment and then transported to the construction site for assembly. This method is widely used in many countries in residential, commercial, and industrial buildings due to its efficiency, quality, & sustainability.

The advantages are speed of construction, quality control, sustainability, cost-effectiveness and better member strengths.



When it comes to the challenges, other than transportation and handling, initial costs, skilled workforce, specialised vendors etc., **the connection design is the biggest issue specially in high seismic zones.**

Connections should have:

- Adequate ductility and energy dissipation.
- Robustness to transfer forces between elements.

Due to challenge in performance of the connections in high seismic zones, the precast construction for buildings still remains a relatively lesser preferred choice.



IMPERIAL
EARTHQUAKE PROTECTION MADE EASY

UPGRADED 2G PRE CAST BUILDINGS

2g approach addresses the challenge of performance of precast structures in high seismic zones not only in a very scientific way but also in a cost effective manner.

Seismic Friction Brakes come for rescue again. Careful deployment of Quaketek SFB's absorbs the major part of seismic energy leaving the demand on other components/connections to be far less than it would have been in a conventionally designed precast structure.



2g approach enhances the performance of a precast structures to much higher level than well designed conventional cast-in-place construction, defying precast of **being a taboo** for high seismic zones.

Application of Quaketek Seismic Friction Brakes also reduce the amount of concrete in precast elements making them **lighter and more efficient** from crane capacity and construction time point of view.





CURRENT APPROACH - RETROFITTING OF BUILDINGS

Various scenarios may entail the need for the retrofit of an existing structure, which is exposed to a variety of loading conditions and degrading environmental actions during its lifetime. In most cases, the objective of structural repair & strengthening is to reduce the risk of loss of life, whilst recognizing the importance of buildings.

Seismic retrofitting basically means modification of existing structure to make them more resistant to seismic activity, ground motion, or foundation failure due to earthquake. This is largely needed under two situations:

1. Earthquake damaged buildings which could have reduced capacity.
2. Earthquake vulnerable buildings which may have capacity less than the code requirements.

Selecting the appropriate treatment method is a great challenge involved in the retrofit process and must be determined individually for each project. We have grouped various retrofitting schemes under three subgroups which are commonly practiced in India:

Steel/Concrete Jacketing: Increasing structural elements/sections by adding concrete with introduction of new rebar layers or installing steel plate to jacket the columns and members have been proven techniques to achieve the desired capacity and/or performance of buildings.

Braces/BRB's: Increasing stiffness and lateral strength by introducing stiffening elements in the building such as shear wall elements, additional frames or additional bracing systems like Buckling restrained braces (BRB's) or conventional braces.

Fiber Composite Wrap/Laminate: Increasing strength or stiffness or both by use of fibre reinforced polymers (FRP), with the most common being reinforcement with carbon fibre (CFRP) and glass fibre (GFRP). Depending upon the material used, they can add stiffness to the structure with values close to or higher than desired.



UPGRADED 2g APPROACH FOR RETROFITTING

The 2g approach is to retrofit the existing structures with Seismic Friction Brakes. Friction brakes can be easily installed in an existing building by means of chemical anchors. This quick approach ensures minimal disruption to an already functional building. The complete assembly can be fabricated and installed in a fraction of time as compared to traditional strengthening methods.

The Seismic Friction Brakes can be readily used for three cases:

1. Upgrading seismic zone/code of existing building

A building that was constructed for a previous code or a lower seismic zone can be easily upgraded with friction brakes where these brakes absorb the additional forces while improving the performance of the existing structure.

2. Change of use of building/increase in number of floors

Change of use of building/increase in number of floors generally lead to higher dead load leading to increase in earthquake forces. The additional seismic forces can be easily tackled with the friction brakes.

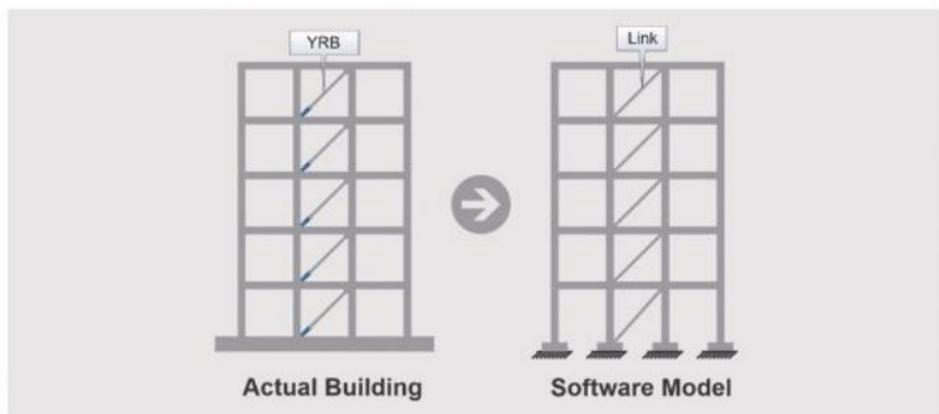
3. Rehabilitation of existing building

After an earthquake event, the existing structure is weakened and can be easily rehabilitated with friction brakes. In some cases, the structures are not appropriately designed for the seismic forces. Such buildings are also a valid case for retrofitting with friction brakes.



The friction damped brace or yielding restrained brace (YRB) is modeled as a link element in most software. In other words, it is modeled as a fictitious yielding brace. Because the Ten-Co Seismic brake can be treated as an ideal elastoplastic element, this allows the application of Wen's model. The assembly behaves as a friction damper. While a simplification of the damper's behavior, the Wen model simplifies the analysis.

A yielding brace or Buckling restrained brace (BRB) would yield and begin to deform allowing the building to absorb and dissipate the earthquake's energy. However, the brace would need to be replaced after the earthquake and the capacity of the fuse element changes as the steel strain hardens.



In contrast a brace equipped with a Ten-Co seismic brake (usually idealized as an inline Seismic friction damper mechanism) is a damage free approach that slips instead of yielding, and, by means of the elasticity of the primary structural elements returns to its original position. This is an important distinction as the technology reduces displacements through energy dissipation allowing the primary elements to remain within their elastic range (e.g. 1% of storey height or less in some structures). Studies have shown that a moment frame capable of even just 25% of the design base shear elastically is sufficient to re-center the damper mechanism. Other studies have shown that the moment resistance in shear tabs can also be sufficient in many cases.

Please contact us for detailed references.

The inline friction damper assembly's ultimate response force remains symmetric in tension and compression (hence the name Ten-Co), and has a high initial stiffness and is independent of displacement. This important characteristic simplifies modeling & maximizes energy dissipation as large displacements are not required in order to dissipate significant amounts of energy.

The Ten-co Seismic brake's hysteretic curve allows the damper assembly (Ten-Co and brace) to be modeled as a link in static, dynamic and non-linear analysis. The only information needed is the properties of the link which in this case is a fictitious yielding brace with its own linear and non-linear properties. This can be modeled in popular software such as **ETABS** or **SAP2000** using the parameters prescribed. The hysteretic loop is characteristically rectangular and based on rapidly converting seismic energy to thermal energy: which maximizes the energy dissipation.

DESIGNING WITH SEISMIC FRICTION BRAKES

Response force should be equal to 75% of the actual brace's yield strength and 130% of the service loads (e.g. wind shear). The mass of the damper assembly will vary depending on the dimensions of the seismic brake and travel required.

This technology allows new ways to answer architectural and customer constraints.

We encourage you to contact us at any time with any questions you may have.

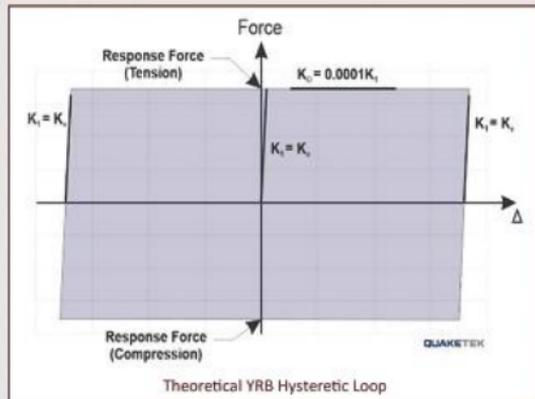
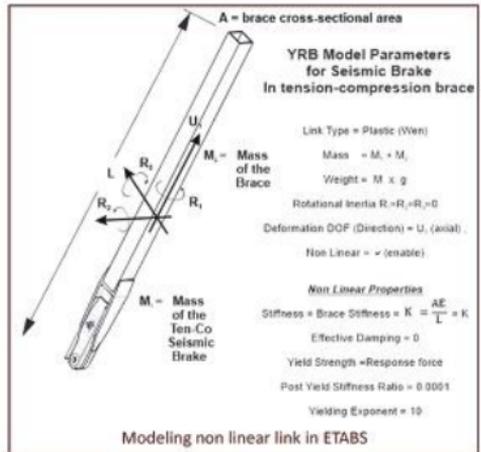
Hysteretic Loop :

Response Force – Displacement

Some software allows for the direct input of the hysteretic loop. In the case that the engineer would like to perform the analysis using these features, the quasi-rectangular hysteretic loop can be used.

Since the damper assembly stiffness is approximately equal to the brace stiffness up until it activates, the effective and brace stiffness are equal.

The damper assembly activates and performs at approximately constant load and therefore the post-yield stiffness ratio can be estimated at near zero, 0.0001.



Finding the Optimal Response Force

The optimum response force maximizes energy absorption for a given frame configuration and a given lateral force. It has been found that this force is below 50% of the story shear but different forces are often selected by the structural designer depending on his/her constraints and objectives.

Once found, small changes to the response force (e.g. +/-20%) have minimal effect on the structure's response.

For quick calculations use $1/3^{\text{rd}}$ of the story shear, ensuring that the ratio of lateral brace stiffness to total lateral story stiffness (frame + braces) is strictly greater than 0.5 and constant throughout the building height.

Please communicate with our engineering department for further advice on how to integrate Seismic Friction Brakes/Damper idealizations and other concepts in your project.

IS: 1893 (2016) forward says...

Structures designed as per this standard are expected to sustain damage during strong earthquake ground shaking. The provisions of this standard are intended for earthquake resistant design of only normal structures (without energy dissipation devices or systems in-built). This standard provides the minimum design force for earthquake resistant design of special structures (such as large and tall buildings, large and high dams, long-span bridges and major industrial projects). Such projects require rigorous, site-specific investigation to arrive at more accurate earthquake hazard assessment.

To control loss of life and property, base isolation or other advanced techniques may be adopted. Currently, the Indian Standard is under formulation for design of such buildings; until the standard becomes available, specialist literature should be consulted for design, detail, installation and maintenance of such buildings.

IS: 13935 draft code writes...

6.1 Strategies of Retrofit

To overcome the deficiencies identified in 5.8, two options shall be explored, namely:

- Reduce the earthquake demand on the building, or/and
- Enhance capacities of the structure and members.

6.1.1 Reduce Earthquake Demand

The following are options for reducing earthquake demand on members:

- Modify the functional use of the buildings, towards reducing the mass of the building
- Introduce new stiff and strong structural elements in the building...
- Introduce new:

- Supplemental Energy Dissipation Devices in the different storeys of existing buildings, towards increasing damping in the building and reducing its overall reduction in lateral displacement. This measure is most effective in buildings that are relatively flexible and are designed to sustain inelastic deformation, and
- Base Isolation Devices at the base of the existing building, towards reducing the earthquake demands...



IS: 13920 draft code mentions...

6 EARTHQUAKE RESISTANT DESIGN

Structures can be designed to resist effects of earthquake shaking with:

- Low damage in structural elements, or
- Damage in structural elements.

6.1 Low Damage in Structural Elements

No member of the lateral load resisting system shall sustain damage under the effects of design earthquake shaking. Only, specially designed devices placed at select locations shall dissipate the earthquakes shaking energy input to the structure.

6.1.1 Energy Dissipation in Devices

The following devices shall be permitted, namely:

- Base Isolators, and
- Supplemental Damping Devices.

IS: 1893 (1) draft code mentions...

7.2.5 Energy Dissipation and Desirable Collapse Mechanism

A structure shall possess large inelastic energy absorption capacity associated with a predetermined desirable lateral collapse mechanism. When structural elements are not permitted to sustain any inelastic action, then the energy absorption shall be ensured to occur in the special devices meant to absorb the same (for example, base isolators and energy dissipation devices).

ASCE 7-16 extracts...

18.1.1 Scope. Every structure with a damping system & every portion thereof shall be designed & constructed in accordance with the requirements of this standard as modified by this chapter. Where damping devices are used across the isolation interface of a seismically isolated structure, displacements, velocities, & accelerations shall be determined in accordance with Chapter 17. The seismic base shear used for design of the seismic force-resisting system shall not be less than V_{min} where V_{min} is determined as the greater of the values computed using Eqs. (18.2-1) & (18.2-2):

$$V_{min} = \frac{V}{B_{1.2}}$$

Table 18.17-1 Design Earthquake Spectra, S_a , S_v , S_d , S_w , $S_{\ddot{w}}$, and $S_{\ddot{w}}$ (Other Periods of the Spectrum) $S_{\ddot{w}}$	S_a	S_v	S_d	S_w	$S_{\ddot{w}}$
(Percentage of Critical Damping)	(%)	(%)	(%)	(%)	(%)
5	1.0	0.1	0.1	0.1	0.1
10	1.0	0.1	0.1	0.1	0.1
15	1.0	0.1	0.1	0.1	0.1
20	1.0	0.1	0.1	0.1	0.1
25	1.0	0.1	0.1	0.1	0.1
30	1.0	0.1	0.1	0.1	0.1
35	1.0	0.1	0.1	0.1	0.1
40	1.0	0.1	0.1	0.1	0.1
45	1.0	0.1	0.1	0.1	0.1
50	1.0	0.1	0.1	0.1	0.1
55	1.0	0.1	0.1	0.1	0.1
60	1.0	0.1	0.1	0.1	0.1
65	1.0	0.1	0.1	0.1	0.1
70	1.0	0.1	0.1	0.1	0.1
75	1.0	0.1	0.1	0.1	0.1
80	1.0	0.1	0.1	0.1	0.1
85	1.0	0.1	0.1	0.1	0.1
90	1.0	0.1	0.1	0.1	0.1
95	1.0	0.1	0.1	0.1	0.1
100	1.0	0.1	0.1	0.1	0.1

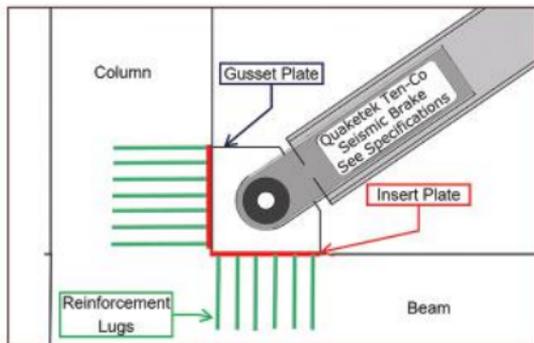
INSTALLATIONS AND CONNECTIONS



CONNECTIONS & DETAILING

The gusset plate is welded with the insert plate at site. The insert plate is connected to the column and beam by means of either:

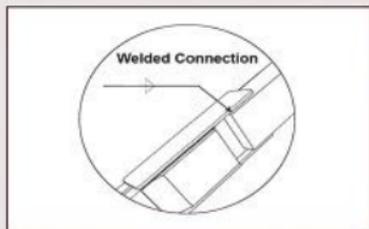
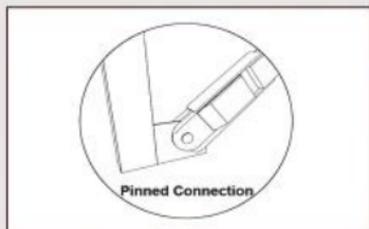
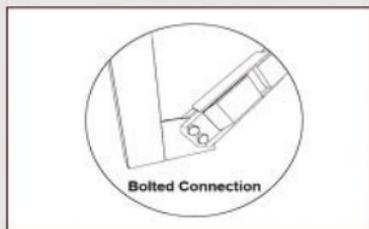
1. Reinforcement Lugs for in-situ casting of concrete column and beams.
2. Chemical anchors for already casted concrete columns and beams.
3. Welding with steel columns and beams.



Seismic Friction Brakes are attached at the end of bracings. These bracings become yield restrained braces (YRB's) due to which they can be designed with multiple orientations:

- Single height diagonal bracing
- Double height diagonal bracing
- Chevron bracing
- Knee bracing
- Toggle bracing
- Cross bracing

The Seismic Friction Brake is attached at the end of the bracing with the means of welding and/or bolting to the gusset plate which in turn is welded to pre-installed insert plate.



ADVANTAGES OF USING SEISMIC FRICTION BRAKES ON YOUR PROJECT

-  **Code Compliant:** Buildings constructed with Quaketek Seismic Friction Brakes are in compliance with IS code & International code.
-  **Warranty:** 30 year standard international warranty is provided by the manufacturer which if required can be extended to 50 years.
-  **Time Tested:** For over 30 years, buildings having Quaketek's Seismic Friction Brakes have stand as a testimony in events of major earthquakes.
-  **Maintenance:** No maintenance required.
-  **Easy Installation:** A normal fabricator under supervision can install the Seismic Friction Brakes comfortably.
-  **Cost Saving:** There are most likely chances of saving in the cost of construction when compared to traditional approaches.
-  **Time Saving:** Project timelines are definite to reduce owing to lesser amount of RCC/Steel/ Shuttering usage in the building.
-  **Accessibility:** YRB's are accessible and can be inspected any time during the life of the building.
-  **Building Upgrade:** With Seismic Friction Brakes/Dampers, design and construction of building to next seismic zone is easily possible. In most cases the cost of construction will remain almost the same as that of building design in lower seismic zone with traditional approach of construction.
-  **Can Be Hidden:** If required, braces having Seismic Friction Brakes can be hidden between walls with nominal edge spacings.
-  **Easy Retrofit:** Seismic Friction Brakes provides most rational and logical option as a global retrofit solution which is least destructive and most practical.
-  **100% Tested:** Each and every device is tested at 100% force and displacement before supplied to the project site.
-  **Fire Proof:** Quaketek Seismic Friction Brakes can be supplied with 2 hours of fire rating having Intumescent paint top coat.
-  **Re-testing:** Quaketek offers re-testing of randomly picked device installed on the project for it's performance confirmity, if requested by the client.

PROJECTS



Sanj Nirankari Hospital



HQ 27 - Bharati Realty



One FKG - Group 108



Regency Hospital



One Oaks - Oaks Realty



NTT Data Center



Stellar 1423 - Stellar Group



Republic Media House



Alphatum - Bhufani Group



IOCL R&D Megacentre - Shapoorji & Pallonji



Hotel Le Meridien



Mantaki - Patel Engineering

59, Okhla Industrial Estate, Phase 3,
New Delhi, Delhi 110020

+91 9990009050/55/60

www.imperialeps.com

