EN
11|2014

Save your constructions!

Earthquake protection by RINGFEDER®

Partner for Performance
www.ringfeder.com

RINGFEDER

Christchurch is at the focal point

The February 2011 Christchurch earthquake was a powerful natural event that severely damaged New Zealand's second-largest city. The earthquake caused widespread damage across Christchurch, especially in the central city and eastern suburbs, with damage exacerbated by buildings and infrastructure already being weakened by 4 September 2010 earthquake and its aftershocks.

- **More than 70% of CBD buildings severely damaged**
- **124 kms of water mains and 300 km of sewer pipes damaged**
- **500,000 tonnes of liquefaction silt removed**
- **600 km of roads seriously damaged**
- **50,000 road surface defects**
- **55% of secondary students sharing with other schools**
- **13 out of 36 hotels operating**
- **NZ$ 40 billion estimated cost**
- **185 lives tragically lost**
- **459,000 EQC claims**

Christchurch in the center of the devastating earthquake 2011

The total cost of the rebuild, based on current estimates is around NZ$ 40 billion, portioned in the following areas:

Residential	**50%**
Commercial	**25%**
Government & Community assets	**15%**
Infrastructure	**10%**

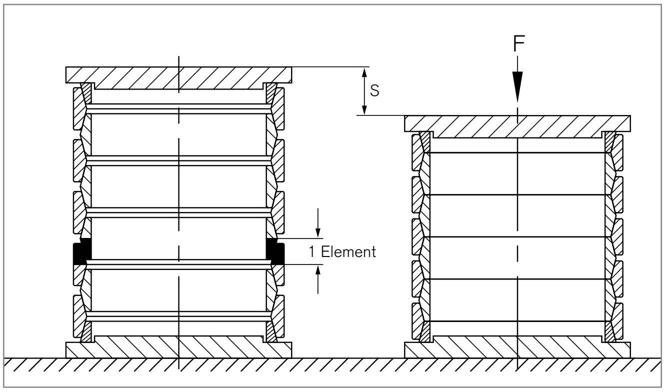
In reality tested: Earthquake protection by RINGFEDER®

Surely not all of the damage could have been avoided, but with RINGFEDER® Friction Springs you have a great possibility that your building survives an earthquake like the ones in 2010/11 and is still habitable. There already are buildings in New Zealand which are equipped with RINGFEDER® Friction Springs, for example Te Puni Village Student Accommodation, 24 Taranaki Street, One Market Lane (all Wellington) and Tait Communication Campus (Christchurch). Te Puni Village was already completed when the earthquake on July 21st 2013 occurred, measuring 6.5 on the Moment Magnitude Scale and the following aftershock measuring 5.8 on the MMS. The building withstood the earthquake without nameable damage.

Te Puni Village Student Accommodation

Description of a RINGFEDER® Friction Spring

A RINGFEDER® Friction Spring consists of outer and inner rings with conical contact surfaces. The figure below shows a cross section through a spring. When the spring column is axially loaded the tapered surfaces overlap causing the outer rings to expand and the inner rings get smaller in diameter. 2/3 of the introduced energy will be absorbed due to friction between the tapered surfaces of the mating rings.



How a RINGFEDER® Friction Spring works

Valid for vertical application

Diagrams 1 to 3 explain how a RINGFEDER® Friction Spring absorbs up to 66% of the introduced energy, depending on the type of grease used.

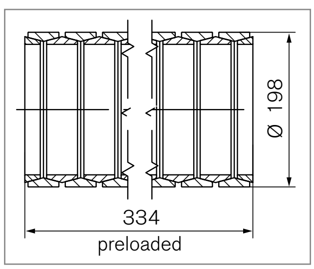


Diagram 1 represents the shown friction spring type 20000, which consists of 8 outer rings, 7 inner rings and 2 half inner rings. It is preloaded with 200 kN to a length of 334 mm. With these values it has a maximum stroke of 38 mm and a capacity of 13400 Joule. The requirement is to absorb a maximum energy of 6000 Joule.

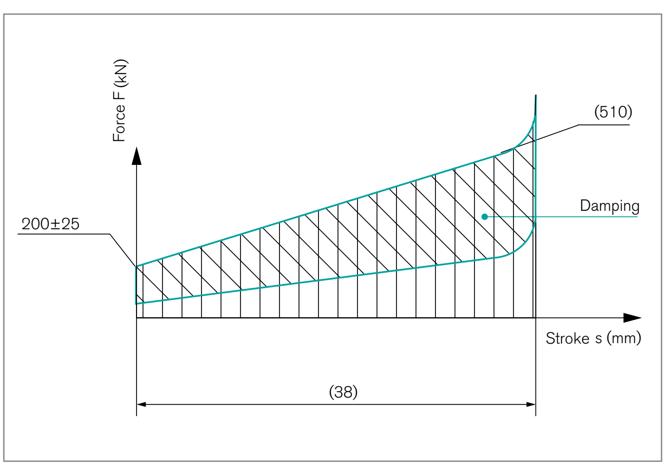


Diagram 1

Diagram 2: When the Friction Spring receives the impact force, it compresses 21 mm and absorbs 6000 Joule (=66%) from which 4000 Joule are converted to heat. After the compression, the friction spring discharges back by the same 21 mm due to a reaction force and there are 2000 Joule which has to be absorbed.

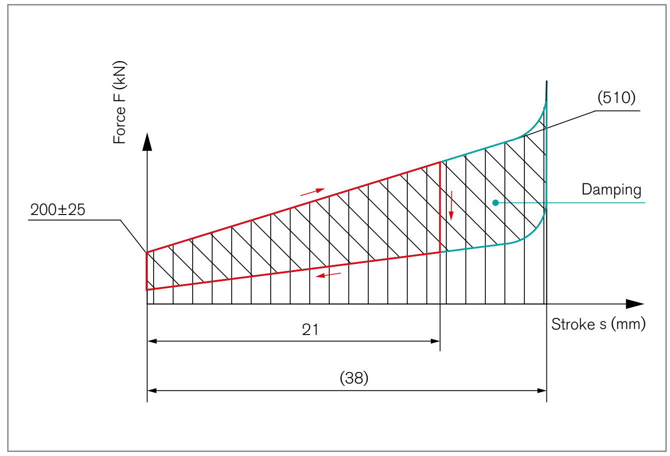


Diagram 2

Diagram 3: The impacting body strikes again on the friction spring with the remaining 2000 Joule and compress it by 8,5 mm. After the compression, the buffer springs back by the same 8,5 mm due to the reaction force. Based on the fact that the friction not only occurs between the rings of the friction spring but in the whole system, the complete 6000 Joule are now absorbed and the system comes to rest.

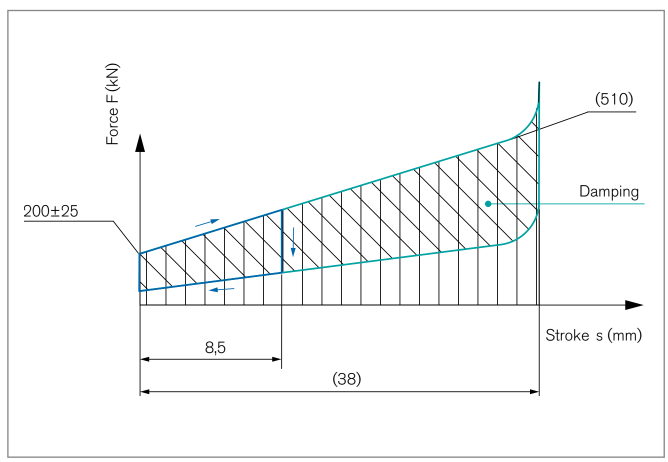


Diagram 3

Advantages of a RINGFEDER® Friction Spring

1. **Long life** – RINGFEDER® Friction Springs are designed to last through many cycles and are reusable. If one of the rings in a RINGFEDER® Friction Spring assembly breaks, the spring will still work but lose a little travel and become slightly stiffer. The end force and the dampening remain unaffected. As a comparison, if a coil spring or a Belleville spring breaks, there will be a total failure and you have no protection any more.

2. **Damping** – Using our standard RINGFEDER® F-S1 grease, our friction springs will damp 2/3 of the introduced energy. If you need less damping, we can easily design a customized solution that is tailored to your needs to achieve a reduced damping of about 1/3 of the introduced energy. This is a simple solution that can change the properties of the friction spring. In certain seismic designs you may require the friction spring to have a higher force when the spring is unloaded to help to push the building structure back to its vertical position.

3. **Fire and high temperatures** – Friction springs are made of special spring-steel. They are coated with grease. In case of a fire, rubber products will be destroyed but our friction springs will endure the fire. It is only needed to regrease the springs.

One Market Lane

4. **Return force** – You can discuss your application with us to determine the best return force of the spring for your specific design. This is not possible with other, e.g. conventional spring types. We can change the grease, increase the outside diameter or change the taper angle to achieve the results you need.

5. **Re-Usability** – Friction springs can be re-used after a seismic event. They are designed to withstand many cycles and remain stable. Friction springs are maintenance-free.

6. **Speed** – Friction springs react faster to applied forces than any other spring type.

7 **Space** – Friction springs give you the highest forces at a given diameter.

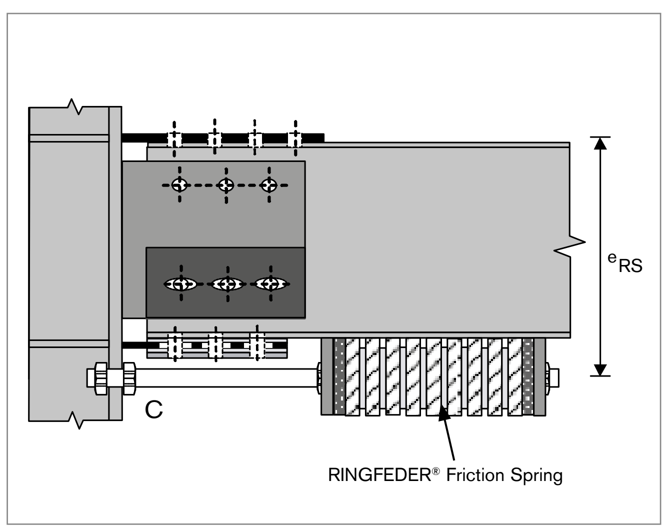
So the essence from all these advantages is:

If you buy a RINGFEDER® Friction Spring, you assemble it and never have to think about it again. And you can rest assured to have chosen a long-time proven, solid and reliable protection system from the global experts in damping technology.

Tait Communication Campus

The Sliding Hinge Joint

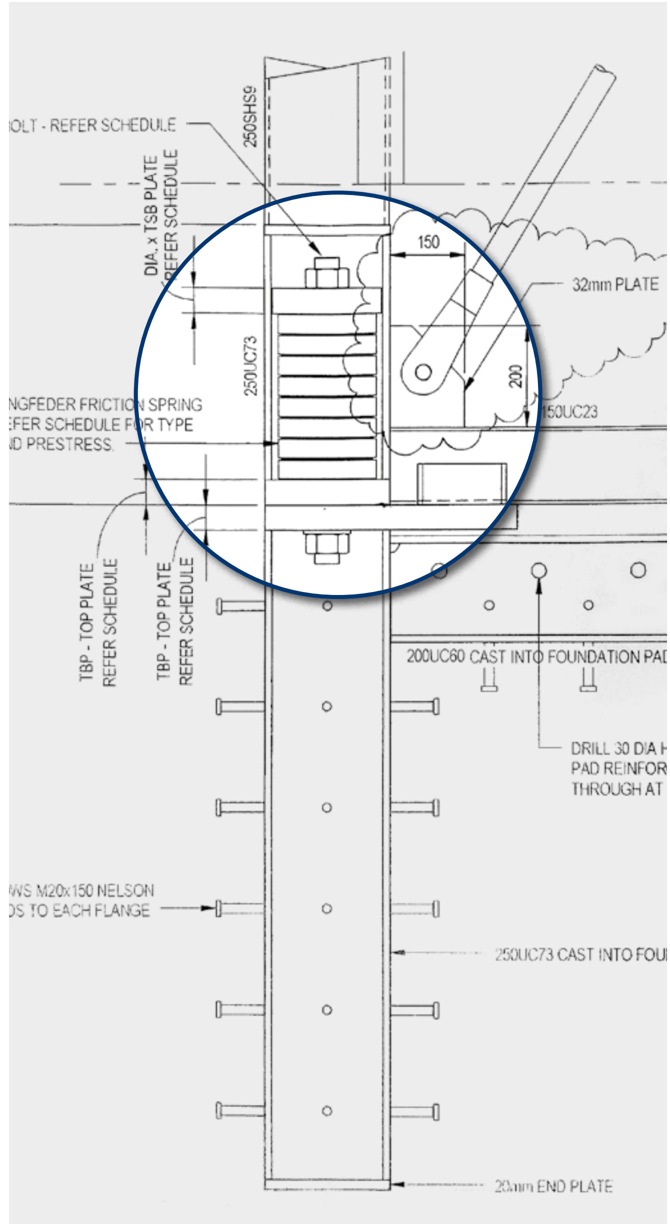
The Sliding Hinge Joint (SHJ) is a beam-column connection that is able to undergo large inelastic rotations with minimal damage. This is achieved through sliding in asymmetric friction connections (AFCs) to allow joint rotation The SHJ has been used in practice, with many benefits over welded connections which include decoupling of joint strength and stiffness, confining inelastic demand to the bolts which are easily replaced following an earthquake, improving dynamic re-centering ability and re-ducing construction costs. The SHJ however undergoes a loss of elastic strength and stiffness once forced into the sliding state. As the next stage of the SHJ development, the self-centering version of the SHJ (SCSHJ) was proposed, which incorporates RINGFEDER® Friction Springs to reduce joint elastic strength and stiffness losses, and reduce frame residual drifts to within construction tolerances following an earthquake.



Self-centering Sliding Hinge Joint (SCSHJ)

The beam is connected to the column through the top flange plate which acts as the point of rotation. AFCs are installed in the bottom flange and web bolt groups. The properties of the joint can be altered by varying the percentage of moment capacity contributed by the ring springs. The joints can thus be categorized into the standard SHJ, where moment capacity is developed only by AFCs, the friction spring joint (RSJ) where the moment capacity is developed only by ring springs and the SCSHJ where the moment capacity is a combination of AFC and ring springs. The SCSHJ was studied and analyzed on a 10-storey frame. Frames with a percentage of total joint moment capacity (PRS) of 25% had residual drifts within 0, 2 %, showing its viability in developing frame dynamic re-centering characteristics.

Taranaki Street



Column base detail with RINGFEDER® Friction Springs on a cut out of an engineer drawing

Large springs to prevent damage to building structure

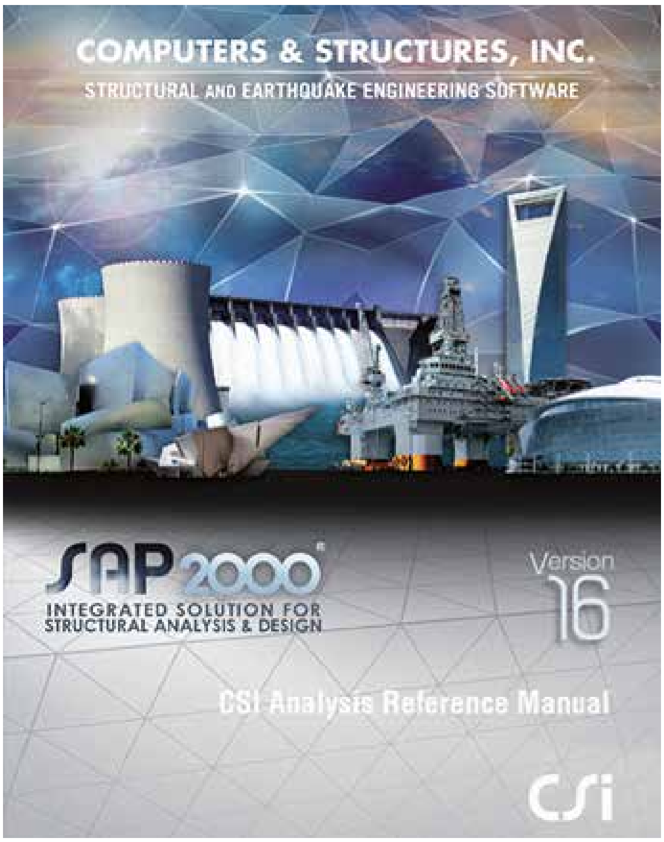
The steel frames, taking the place of traditional shear walls, have vertical columns with diagonal steel bracing (K-frames). At the base of each frame are large friction springs installed – similar to what you may find in a railway station to cushion the impact of a runaway train. These are precision springs made by RINGFEDER POWER TRANSMISSION in Germany.

During an earthquake these friction springs work dynamically to prevent damage from occurring in the building structure. Each column contains either two or four springs at the base. The springs vary in size, with the larger springs being 300 mm in diameter and nearly 1000 mm tall.

It is expected that more buildings of this nature will be constructed in Wellington and other seismic areas around the world in the years to come.

Software integration of RINGFEDER® Friction Springs

The friction spring damper is integrated in the SAP2000® software for the structural analysis and design of buildings, created by "Computers and Structures, Inc. (CSI)". The company which has been founded in 1975 and is based in California, U.S.A. has created, amongst others, the structural analysis and design software ETABS®. It has been used to create the mathematical model of the Burj Khalifa, currently the world tallest building (gravity, wind and seismic response were all characterized using ETABS®)



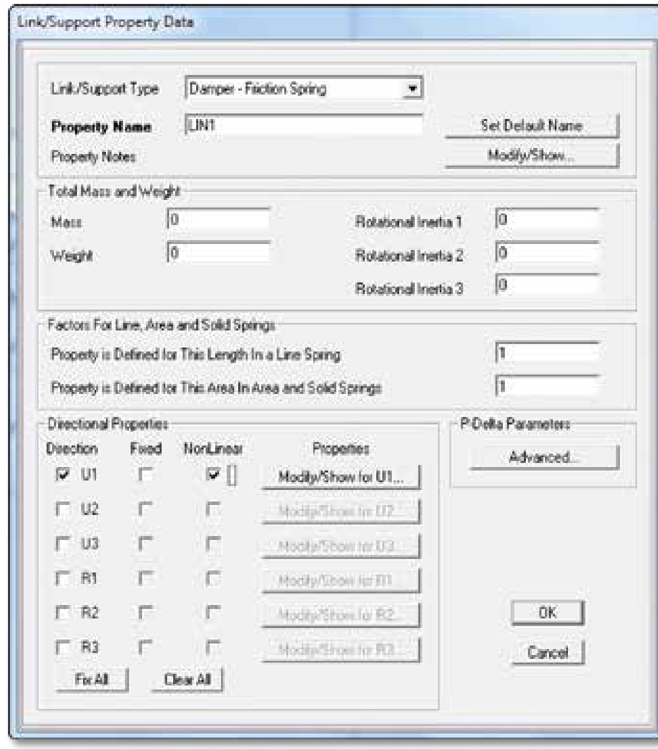
How to use the software

First you have to make the following menu selections in SAP2000® to create an seismic isolator like the friction spring is one.

Define → Section properties → Link/Support Properties → Add New Property.

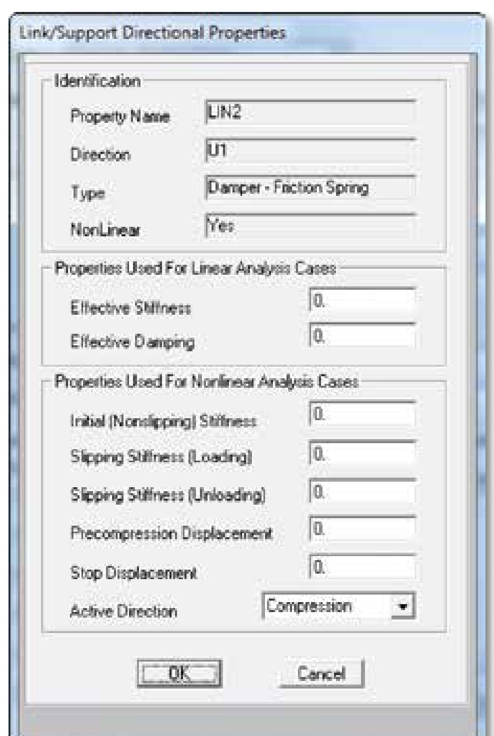
After that you have to fill in as shown:

Select Damper-Friction Spring from the drop down menu. Check the box "U1" and also check the box "Non-Linear". Then click the box "Modify/Show for U1". If you don't check the box "Non-Linear" proceed to screen shot 3 and skip 2.



Window 1

Click on OK and you will reach the next window. Here you fill in the values of the chosen friction spring type from the attached table. Input Damping = 66% for standard F-S1 grease.



Window 2

Attached Diagram with input values:

Effective Stiffness	=	Input Spring Slope during the Loading Cycle (spring rate).
Effective Damping	=	Input Damping = 66 for standard F-S1 grease.
Initial (Nonslipping) Stiffness	=	Input Spring Slope during the Loading Cycle (spring rate).
Slipping Stiffness (Loading)	=	Input Spring Slope During the Unloading Cycle.
Slipping Stiffness (Unloading)	=	Input Spring Slope During the Unloading Cycle.
Precompression Displacement	=	Input Preload Travel.
Stop Displacement	=	Input Total Spring Travel minus Preload Travel.

Window 3

This software is a very beneficial tool for helping you to increase the flexibility of your steel frame in combination with the necessary stiffness.

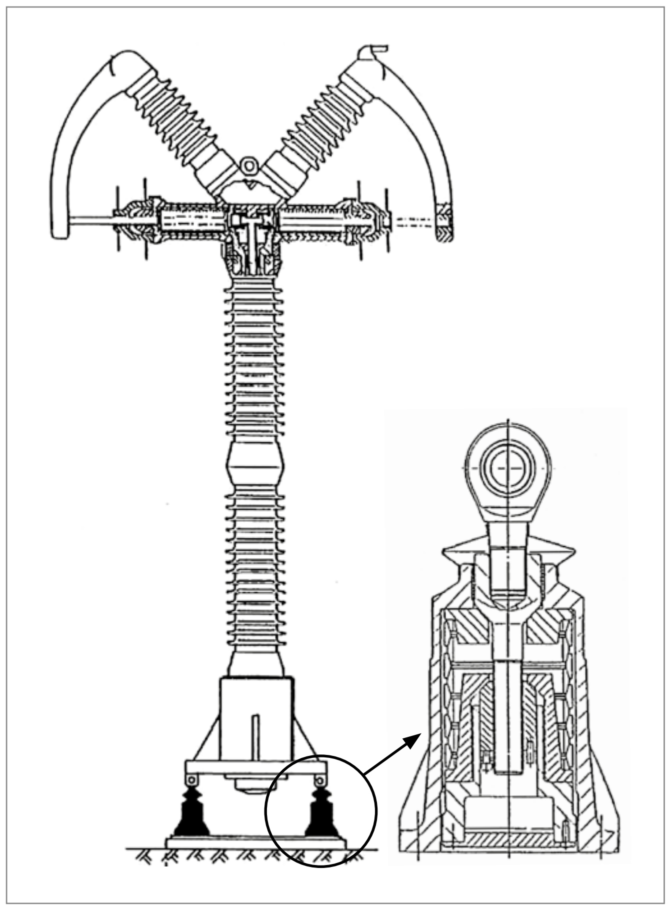
Protection of electrical switchgears

After an earthquake it is not only important that the buildings are still usable. It is also essential that the electric power supply is ensured, so that at least the most important public institutions like the police, the fire department, the hospitals and relief organizations can do their work. Here RINGFEDER® Friction Springs can be involved, too. To prevent earthquake damages from electric power substations or electrical switchgears we have developed special types of dampers. One type is normally used during the installation of new equipment; the other type is for retrofitting old equipment

Retrofitting

For retrofitting, one damper is assembled on top of the base plate to each base anchor of an electrical switchgear.

New equipment



For new equipment one of the dampers on the right side is assembled beneath the base plate to each base anchor of an electrical switchgear.

With both systems you uncouple the switchgears from direct contact to the ground and give them the possibility for a better assimilation of the upcoming seismic shocks.

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