Providing Seismic Protection with Wire Rope Isolators

Wire Rope Isolators (WRIs) are used for a wide variety of applications that require vibration control. However, knowledge of their overall advantages compared to elastomer and coil spring products are not as well known. WRI's are the preferred solution in industries such as defense and aerospace due to their all-metal construction, maintenance free installations, long product life and ability to protect vital and sensitive equipment in high shock applications. Their large dynamic deflection capabilities, unique damping characteristics, flexible mounting configurations and customizability, also make them ideal for many other applications.

One area of growing interest is seismic protection.

SEISMIC PROTECTION

Established methods of supporting equipment in seismically active areas already exist. However, they come with compromises. One widely accepted design configuration consists of undamped springs with snubbers. Use of these can result in substantial magnification of the seismic input when the lateral displacements are large enough to engage the snubbers. While not an issue in terms of safety, this limitation may require special reinforcement of the equipment to resist forces due to seismic accelerations. Ruggedizing structures to withstand earthquakes can be impractical and costly.

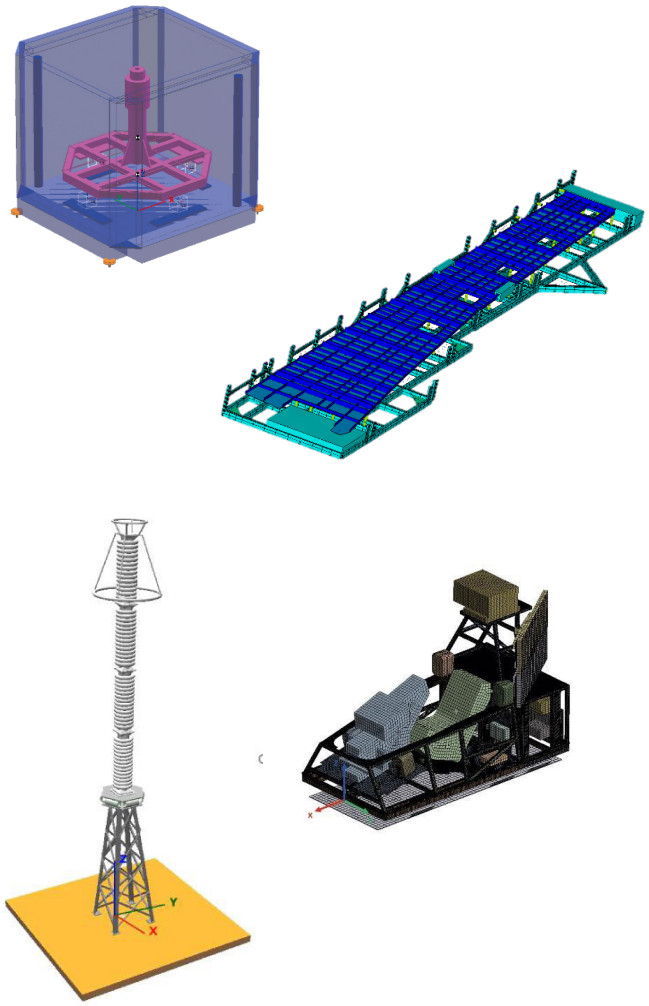
Driven by our goal of providing solutions for shock and vibration challenges, the Socitec Group and Vibro/Dynamics have continued to research, develop and document numerous examples of WRIs as a superior means of seismic protection. Case studies and field results have shown Wire Rope Isolator based systems as an effective base isolation solution with significant advantages. Wire Rope Isolators are completely captured (anchored or bolted), have large dynamic deflection capabilities in all axes, and respond with non-linear damping, enabling them to absorb seismic energy to avoid a bottoming out or snubbing effect. Wire Rope Isolators possess inherent non-linear damping through the friction between the strands of the cable. WRIs can exhibit a high damping ratio equivalent to around 20% or greater, unlike coil springs which possess no effective damping.

SEISMIC MODELING AND ANALYSIS

To model the dynamics of a structure in a seismic application, one of our tools is the Socitec Group's proprietary simulation software SYMOS. It is a nonlinear, multiple degree of freedom software package using lumped element method to calculate the response of a system. In SYMOS each body is assumed rigid, and the interactions between the bodies are incorporated using links that can be nonlinear. SYMOS uses the geometries and density of each body to calculate its dynamic properties (mass, CG location, moments, and products of inertia). Since SYMOS considers the bodies to be non-deforming (i.e., rigid), it uses elastic links to simulate the flexibility and damping of the connections between the bodies as well as the flexibility of the bodies themselves where necessary. The input-data of the Wire Rope Isolator stiffness and damping used to simulate in SYMOS comes from years of rigorous product tests.

Applicable standards or specifications from any specific region can be inputted to the analysis.

2243 Braga. Drive, Broadview, IL 60155
tel.: 800.842.7668 • vibro@vibrodynamics.com
www.vibrodynamics.com



Typically, a very specific seismic design response spectrum for the installation site of the equipment is used. To more accurately account for the non-linear properties of the Wire Rope Isolator, this spectrum must be converted into a time-history that corresponds to the design spectrum. Combining this approach with our extensive isolator performance database in SYMOS, peak acceleration and motion responses can be predicted, allowing for an efficient, optimal selection of a Wire Rope Isolator solution.

SURGE ARRESTERS CASE STUDY

The Socitec Group was contracted by a substation equipment manufacturer to design a base isolation solution for their high voltage surge arrester. The surge arrester's data was given by the customer.

The objective: To provide a solution resulting in a bending moment less than 96 kN-m under a 1g peak ground acceleration input.

High-voltage surge arresters and circuit breakers are especially vulnerable due to their tall, slender structure and fragile (porcelain) insulation materials. In this particular case, the IEEE Std 693-2005 was meticulously followed to design the seismic base isolators, hence it specifies how to design substation equipment to withstand earthquakes specific to that region.

The Socitec Group worked with 2 cases. The 1st in which the arresters were hard mounted (no base isolation) and the 2nd using Wire Rope Isolators as the elastically mounted case.

Given that the ultimate bending strength of the porcelain is 96 kN-m, this means that the arrester will survive the 1g. The results also showed that the deflections of the isolators are well within their capabilities, even under repeated long-term forces, so no fatigue problems are to be expected.

This solution was tested on a shake table and approved per the IEEE Std 693-2005. Test results were very close to the simulation results.

There are several other types of seismic isolators (e.g., Lead Rubber Bearings, Friction Sliding Bearings) (from IEEE std 693, ASCE/SEI 7-16) which also have the following limitations when compared to Wire Rope Isolators:

- Damping or frequency characteristics change over time due to creep or relaxation of the material.
- Degrading effects of chemicals, weather and extreme environments requiring regular inspection, maintenance, and costly replacement.
- Variations in raw materials can result in products with less consistency and reliability.

2243 Braga. Drive, Broadview, IL 60155
tel.: 800.842.7668 • vibro@vibrodynamics.com
www.vibrodynamics.com

Considering and comparing all of these relevant factors Wire Rope Isolators as Seismic isolators stand out as one of the best options for seismic applications.

Other examples of applications where Wire Rope Isolators should be considered for shock and vibration isolation are:

- Critical Power Grid Components (transformers, surge arresters, circuit breakers, etc.)
- Resilient Suspensions Meeting Military Standards
- Sensitive Electronic Equipment
- Generators, Pumps and Compressors
- Cabinets, Containers, Rack, etc.
- Protection of Equipment during Transport
- Extreme Temperature Applications
- Harsh Chemical Environment Applications

The Socitec Group is a globally recognized supplier of shock and vibration isolation products and engineering services. Our more than 50 years of experience means we have the technical expertise to offer solutions our customers can be confident in. Solving a shock or vibration problem requires an analysis of the behavior of the entire dynamic system, and an understanding of all inputs and reactions of the system to reach the optimal solution.

PERSONAL, DIRECT CUSTOMER SUPPORT

With multiple manufacturing, sales and technical support facilities strategically located around the globe we are positioned to serve our customers needs around the world. We offer timely, direct engineering support with our standard lines or development of custom designs for unique applications.

Our highly skilled personnel will help and guide you from the very beginning of under-standing a task at hand, to the design stage, production/testing, and if required, project management to ensure correct and timely implementation onsite. In other words, you can tailor our involvement based on your specific needs and requirements.

2243 Braga. Drive, Broadview, IL 60155
tel.: 800.842.7668 • vibro@vibrodynamics.com
www.vibrodynamics.com