SINCE 1945
a reference in civil engineering works

FIP MEC S.r.l. is an Italian company founded in 1945. It is currently a leading company in the design and production of structural devices. Its long and wide experience in earthquake engineering started in the 1970s with the first European seismically isolated bridge, the Somplago Bridge. Since then, a complete range of anti-seismic devices has been developed. Now hundreds of structures throughout the world are protected from earthquake and other dynamic actions with FIP MEC's isolators, energy dissipation devices, and connection devices. Amongst these, world's record structures such as the Taipei 101 skyscraper or the recently completed 1915 Çanakkale Bridge.

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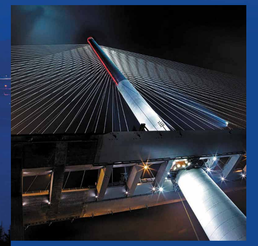
FIPMEC

1915 Çanakkale Bridge - Turkey

ANTI-SEISMIC DEVICES

70 YEARS
of history and innovation
for civil engineering works

REFERENCES
our works



Stonecutters Bridge
Hong Kong

Linares Hospital
Chile

Rion Antirion Bridge
Greece

Taipei 101
Taiwan

SEISMIC ISOLATORS

ELASTOMERIC

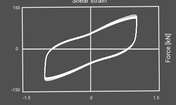
Elastomeric isolators

Elastomeric isolators (Els) are made up of rubber layers alternating with steel laminates joined together through vulcanization.
Their behaviour can be modelled as linear, by means of effective stiffness and equivalent viscous damping. Usually they are manufactured with High Damping Rubber compound, i.e. with equivalent viscous damping 10÷15% at 100% shear strain (HDRB).

Experimental hysteresis loops of an EI at frequency 0.5 Hz, shear strain ± 100%.

Lead rubber bearings

Lead Rubber Bearings (LRBs) are elastomeric isolators with a cylindrical lead plug inserted in their centre, with the aim to increase the damping by hysteretic shear deformations of the lead. The equivalent viscous damping can be up to 30%. Their constitutive behaviour, typically bilinear, can be modelled as linear or non-linear, according to the used code.

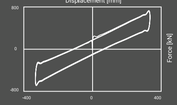


Experimental hysteresis loops of a LRB at frequency 0.5 Hz, shear strain ± 100 %.

SLIDERS

Curved surface sliders

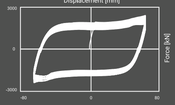
The Curved Surface Sliders or Pendulum isolators use gravity as the restoring force. Energy dissipation is provided by friction. The parameters of the bilinear constitutive law depend on the radius of curvature and friction coefficient. They can be designed and manufactured in two main types, with one (FIP series) or two (FIP-D series) primary spherical sliding surfaces that accommodate the horizontal displacement. Usually FIP-D series is preferred because of the smaller plan dimension.



Experimental hysteresis loops of a CSS (Friction Isolation Pendulum - FIP).

Flat surface sliders with dampers

These isolators combine in a single device a slider and dampers, that typically are steel hysteretic and/or fluid viscous dampers.
Thus, the resulting behaviour is characterised by a very high energy dissipation capacity. The slider can be free-sliding or guided, as required.
The isolator can also combine STUs or mechanical fuse restraints.

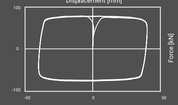


Experimental hysteresis loops of a flat surface slider with steel hysteretic dampers.

VELOCITY DEPENDENT DEVICES

Fluid viscous dampers

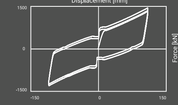
Fluid Viscous Dampers (FVDs) are cylinder/piston devices that exploit the reaction force of silicon fluid forced to flow through an orifice and/or valve system.
The typical force-velocity law of FIP's FVDs is non-linear, i.e. $F=Cv^{\alpha}$, where α=0.15, F is the force, C is the damping constant and v is the velocity.
Different values of the exponent α can be provided on request.



Experimental hysteresis loops of a FVD under sinusoidal input.

Fluid spring dampers

The reaction force F of Fluid Spring Dampers (FSDs) depends on both imposed velocity v and displacement x according to the law $F=F_0+Kx+Cv^{\alpha}$, where F_0 is the preload force, K is the stiffness, C is the damping constant and α=0.15. The pre-load force can be useful to avoid displacements under service horizontal loads (e.g. braking forces in a bridge).



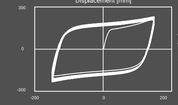
Experimental hysteresis loops of a FSD without pre-load force.

DISPLACEMENT DEPENDENT DEVICES

NON-LINEAR

Steel hysteretic dampers

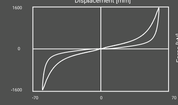
Steel Hysteretic Dampers (SHDs) use as a source of energy dissipation the hysteretic yielding of steel elements of various shapes, developed to guarantee many stable hysteresis loops.
The crescent moon and tapered pin elements are the most used in bridges, while the Buckling Restrained Axial Dampers (BRAD®) are the most used as dissipative braces in framed buildings.



Experimental hysteresis loops of a SHD with crescent moon elements.

Buffers

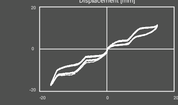
Buffers are double-acting axial devices comprising a certain number of elastomeric discs, each of them vulcanized to two steel plates. A particular arrangement of steel rods allows the discs to always be compressed, regardless of the direction of the movement. Buffers are used in bridges at abutments and/or between adjacent decks where expansion joints are located.



Experimental force vs displacement curve of a buffer.

Shape memory alloy devices

Shape Memory Alloy Devices (SMADs) are axial restraint devices exploiting the superelastic properties of shape memory alloys in the austenitic state.
Their force displacement curve exhibiting one or more "plateaux" enables SMADs to limit the maximum load transmitted to the structure to which they are connected. They have a strong recentring capability.

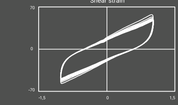


Experimental force vs displacement curve of a SMAD.

LINEAR

Elastomeric viscoelastic dampers

Elastomeric Viscoelastic Dampers (EVEDs) are made of one or several layers of elastomer which are strained in shear, connecting the relatively moving parts of a structure. Usually they are installed in bracings in framed buildings. The elastomer compound used is high damping, with equivalent viscous damping 15÷20% at 100% shear strain.

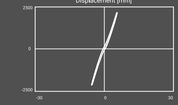


Experimental hysteresis loops of an EVED at frequency 0.5 Hz, shear strain ± 100 %.

TEMPORARY

Shock transmission units

Shock Transmission Units (STUs) provide a very stiff dynamic connection, whilst their reaction to low velocity applied displacements, e.g. due to thermal changes, is negligible. STUs find valid application whenever the structure is requested to change its behaviour in the event of earthquakes or other dynamic actions. Sometimes STUs are also referred to as lock-up devices.

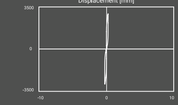


Experimental force vs displacement curve of a STU.

PERMANENT

Guide bearings and restraint bearings

Guide bearings and restraint bearings are devices which provide steady restraint in one or two horizontal directions, respectively, accommodate rotations and vertical displacements, i.e. do not transmit bending moments and vertical loads. Guide bearings are also referred to as Moveable Connection Devices, and restrained bearings as Fixed Connection Devices.

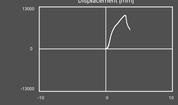


Experimental force vs displacement curve of a guide bearing.

RIGID CONNECTION DEVICES

Mechanical fuse restraints

Mechanical Fuse Restraints (MFRs) below a pre-established force threshold prevent relative movement between connected parts, whilst they permit movements after the aforesaid threshold has been exceeded, provoking the breakaway of sacrificial components. Movements can be in one or any direction; i.e. a MFR can be designed to become a guide bearing after breakaway.



Experimental force vs displacement curve of a MFR.

1) Setting up for testing of two 1150 mm diameter EIs at FIP laboratory.
2) EI as installed in a residential building in Siracusa, Italy.

1) LRB under test at FIP MEC's laboratory.
2) LRB as installed in a school in Bojano, Italy.

1) Test at FIP MEC's laboratory on a CSS
2) A FIP-D series isolator as installed in a school in Rome, Italy.

1) A flat surface slider with steel hysteretic dampers for the Crescenza Viaduct, Italy.
2) A flat surface slider with steel hysteretic dampers as installed in the Marquam Bridge, Oregon, USA.

1) FVDs for the Rion-Antirion Bridge (Greece) under testing at FIP laboratory.
2) FVDs as installed in the Tuned Mass Damper in CCNC building in Santiago, Chile

1) Fluid spring dampers for installation in transverse direction of bridges.
2) A FSD as installed in the Rio Higuamo Bridge, Dominican Republic.

1) Type test on a BRAD® at FIP MEC's laboratory.
2) BRAD® as installed for seismic retrofit of a school in Italy.

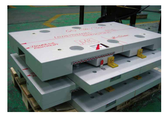
1) Buffers for viaducts on the TAG Motorway, Turkey.
2) Buffers as installed in the Somplago Bridge, Italy, the first seismically isolated bridge in Europe (1974-1976).

1) Shaking table tests on masonry walls connected with SMADs.
2) SMADs as installed in the Basilica of San Francesco in Assisi, Italy.

1) Shaking table tests on a reinforced concrete frame with EVED atop chevron bracings.
2) An EVED as installed in the Gentile-Fermi School, Fabriano, Italy.

1) Setting up for testing at FIP laboratory of a STU for the Storebælt Bridge, Denmark.
2) STUs under installation in the Stonecutters Bridge, Hong Kong, China.

1) A guide bearing for the Panagia Grevena Section Bridges, Greece.
2) A restraint bearing for the Viaduct 1.1, Caracas-Tuy Medio Railway, Venezuela



1) MFRs coupled with a bearing (Krka Bridge, Croatia).
2) A MFR as installed together with FVDs in the Rion Antirion Bridge, Greece.