CURVED SURFACE SLIDERS

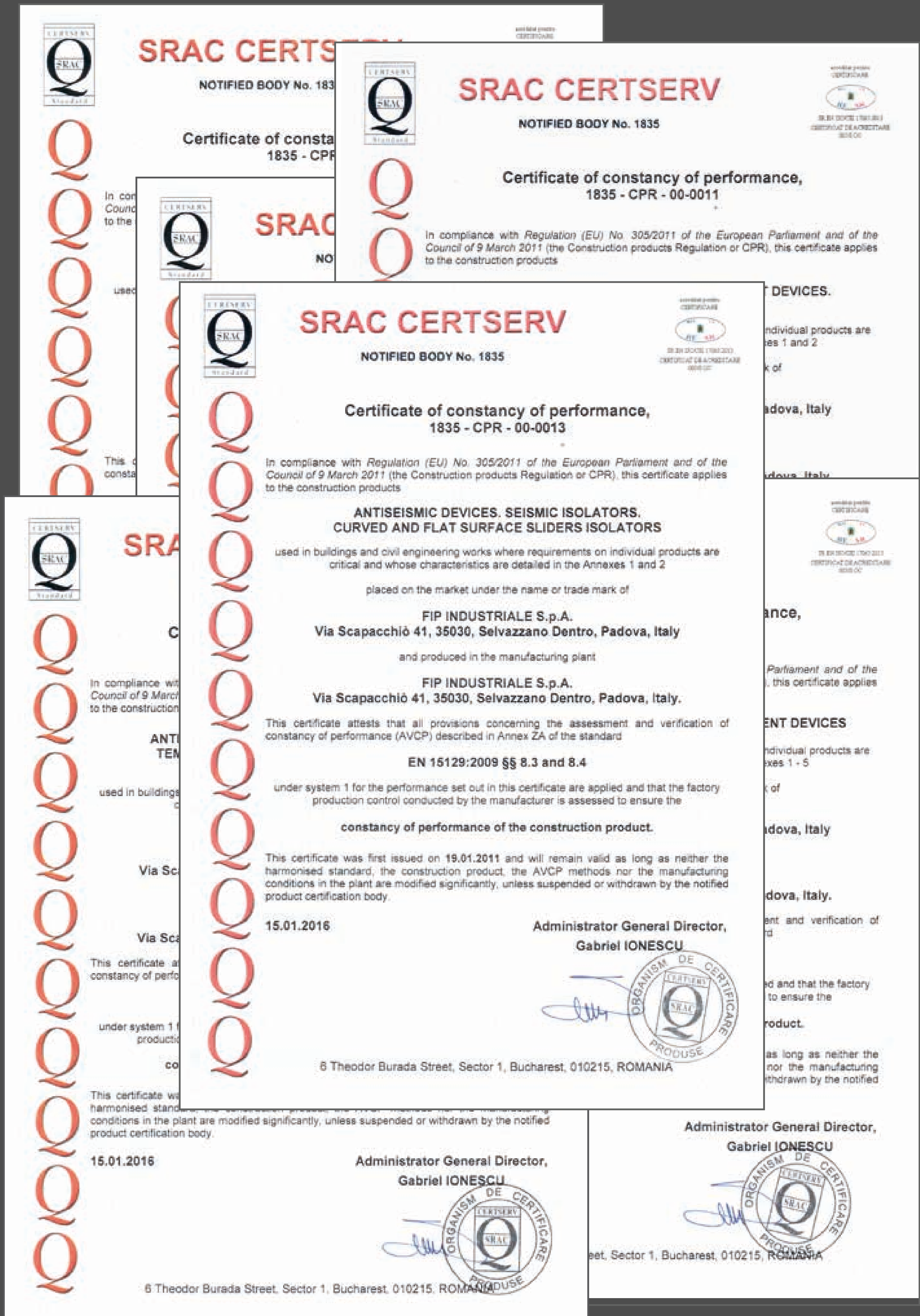
S04

DEVICES WITH CE MARKING

CURVED SURFACE SLIDERS

FIP INDUSTRIALE

leading technologies



SRAC CERTSERV

NOTIFIED BODY No. 1835

Certificate of constancy of performance,
1835 - CPR - 00-0013

In compliance with *Regulation (EU) No. 305/2011 of the European Parliament and of the Council of 9 March 2011* (the Construction products Regulation or CPR), this certificate applies to the construction products

ANTISEISMIC DEVICES. SEISMIC ISOLATORS. CURVED AND FLAT SURFACE SLIDERS ISOLATORS

used in buildings and civil engineering works where requirements on individual products are critical and whose characteristics are detailed in the Annexes 1 and 2

placed on the market under the name or trade mark of

FIP INDUSTRIALE S.p.A.
Via Scapacchiò 41, 35030, Selvazzano Dentro, Padova, Italy

and produced in the manufacturing plant

FIP INDUSTRIALE S.p.A.
Via Scapacchiò 41, 35030, Selvazzano Dentro, Padova, Italy.

This certificate attests that all provisions concerning the assessment and verification of constancy of performance (AVCP) described in Annex ZA of the standard

EN 15129:2009 §§ 8.3 and 8.4

under system 1 for the performance set out in this certificate are applied and that the factory production control conducted by the manufacturer is assessed to ensure the

constancy of performance of the construction product.

This certificate was first issued on **19.01.2011** and will remain valid as long as neither the harmonised standard, the construction product, the AVCP methods nor the manufacturing conditions in the plant are modified significantly, unless suspended or withdrawn by the notified product certification body.

15.01.2016

Administrator General Director,
Gabriel IONESCU

6 Theodor Burada Street, Sector 1, Bucharest, 010215, ROMANIA

INTRODUCTION

CERTIFICATIONS

In 1992, **FIP Industriale** secured CISQ-ICIM certification for its Quality Assurance System in conformance with EN 29001 European Standard (ISO 9001), while the Certificate OHS 618800 today guarantees that **FIP Industriale** operates an Occupational Health and Safety Management System wich complies the requirements of BS OHSAS 18001:2007. **FIP Industriale** quality system is also certified to perform welding activities in accordance with EN ISO 3834-2 and DIN 18800-7.

FIP Industriale is proud to be the first Italian manufacturer of structural bearings, anti-seismic devices and expan-sion joints boasting a Quality Assurance System certified at the highest level – from design to customer service assistance. Certification has been achieved via rigorous evaluation by an internationally recognized Third Party Organisation, thus internationally validating the quality assurance system.

In the framework of the enforcement of the European Construction Products Directive, **FIP Industriale** has gained the CE marking of different types of anti-seismic devices, including curved surface sliders, in accordance with the harmonised European Standard EN 15129:2009 *Anti-seismic devices*.

OHS 618800

BIM READY

The use of shared digital representations to facilitate the design, construction and operation of a structure is the starting point for a reliable and interactive decision-making process which allows municipalities, private clients, contractors and designers to rule all their choices.

FIP Industriale is able to provide BIM models – according to IFC standard – to its Clients in such a way to support the communication, cooperation, simulation and improvement of a project through the whole design life of the built or building structure.

DESCRIPTION

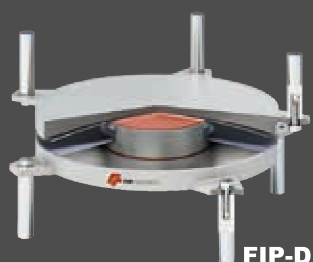
The curved surface sliders or **F**riction **I**solation **P**endula (**FIP**) are sliding isolators based on the working principle of the simple pendulum. In a structure that is isolated by means of curved surface sliders, the period of oscillation mainly depends on the radius of curvature of the curved sliding surface, i.e. it is almost independent from the mass of the structure. The energy dissipation is provided by the friction encountered during the movement of the sliding surfaces, and the re-centring capability is provided by the curvature of the sliding surface.

The **F**riction **I**solation **P**endulum can be designed and manufactured in two main types, with one or two primary spherical sliding surfaces that accomodate the horizontal displacement, respectively classified as **FIP** or +**FIP-D** series as follows.

The **FIP** series devices are characterised by: **i)** a concave slider (top element in the picture) whose radius of curvature imposes the period of oscillation and that accomodates for the horizontal displacement; **ii)** a base element with a secondary concave sliding surface that permits the rotation; **iii)** a steel intermediate element with two convex surfaces suitably shaped to be coupled with the other two elements. The device can also be installed upside-down, i.e. with the main concave slider at the bottom.

FIP series

The **FIP-D** series or double concave curved surface sliders are characterised by two primary concave sliding surfaces with the same radius of curvature; both surfaces accomodate for horizontal displacement and rotation. In this case each single sliding surface is designed to accomodate only half of the total horizontal displacement, so that the dimensions in plan of the devices may be significantly smaller in comparison with **FIP** series. Another advantage of **FIP-D** series versus **FIP** series is that the eccentricity of the vertical load (P-Δ effect) is halved, i.e. is equal to half the displacement, while in **FIP** series devices it is equal to the displacement (on one side).



FIP-D series

A special thermoplastic material (red in the pictures), coupled with stainless steel, is used on both primary and secondary sliding surfaces to govern the friction.

CHARACTERISTICS

MATERIALS

The selection of the sliding material is essential to give the curved surface sliders an optimal behaviour in terms of: i) load bearing capacity; ii) friction coefficient and consequently energy dissipation; iii) stability of the hysteretic force vs. displacement curve both with cycling and with temperature; iv) durability; v) wear resistance.

The sliding material utilized in the primary sliding surfaces is the **FFM** (**F**IP **F**riction **M**aterial), an Ultra-High Molecular Weight Poly-Ethylene (UHMW-PE) characterised by exceptional properties in terms of load bearing capacity, wear resistance, as well as stability and durability. Other important characteristics of **FFM** are the absence of stick-slip and the low value of the ratio between the break-away and the dynamic friction coefficients.

The above properties have been verified through extensive testing campaigns, including among others all the tests required by the European Standard EN 15129, carried out both in **FIP Industriale** laboratory and in independent laboratories.

FFM is used without lubrication. The material used in the secondary sliding surface of **FIP** series devices is **SMF** (**S**liding **M**aterial **F**IP), that is a dimpled and lubricated UHMW-PE.

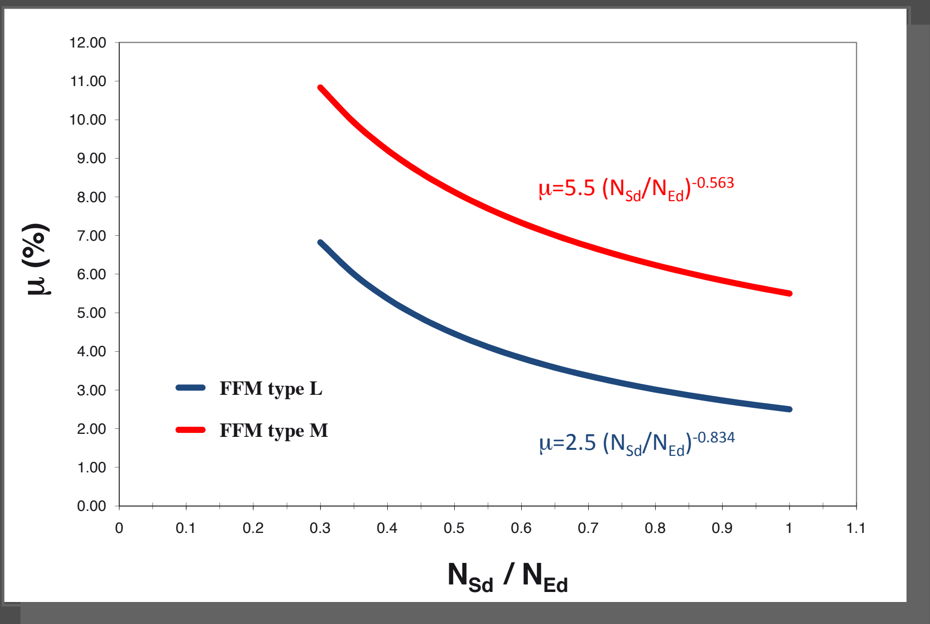
The dynamic friction coefficient is the most important parameter that the Structural Engineer needs to know when modelling a structure with curved surface sliders. For any sliding material the friction coefficient is dependent on both velocity and pressure. However, the dependence on velocity is not significant in the range of velocity associated with earthquake excitation of an isolated structure. Conversely, it is well known from literature, and confirmed by test results, that the dependence on pressure (vertical load) is not negligible; in particular, the friction coefficient decreases at the increasing of the vertical load.

Typical values of dynamic friction coefficient of **FFM** are reported in the table, respectively for **FFM** type L (Low friction) and **FFM** type M (Medium friction).

FFM type	L (low friction)	M (medium friction)
Minimum friction coefficient (%)	2.5	5.5

The above values of the friction coefficient are minimum values and correspond to the maximum design vertical load N_{Ed} of the curved surface slider, i.e. the maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement. For the standard **FIP-D** isolators, the values of the maximum design vertical load N_{Ed} are reported in the tables at the end of this catalogue.

The graphics show how the dynamic friction coefficient varies with the vertical load; in particular, with the ratio of the vertical load N_{Sd} acting on the isolator (usually assumed constant and equal to the quasi-permanent load, see below) to the maximum vertical load N_{Ed} as defined above.



On request, different values of friction coefficient can be provided. Austenitic steel in accordance with the European Standard EN 10088-2 is commonly used as mating surface.

MODELLING

The mathematical model that best resembles the functioning of the curved surface sliders (both **FIP** and **FIP-D** series) consists of a bilinear force-displacement curve as shown in the figure, where:

$F_0 = \mu \cdot N_{Sd}$ ➡ friction force developed by the isolator

$F_{max} = F_0 + K_r \cdot d = \mu \cdot N_{Sd} + \frac{N_{Sd}}{R} \cdot d$ ➡ maximum horizontal force

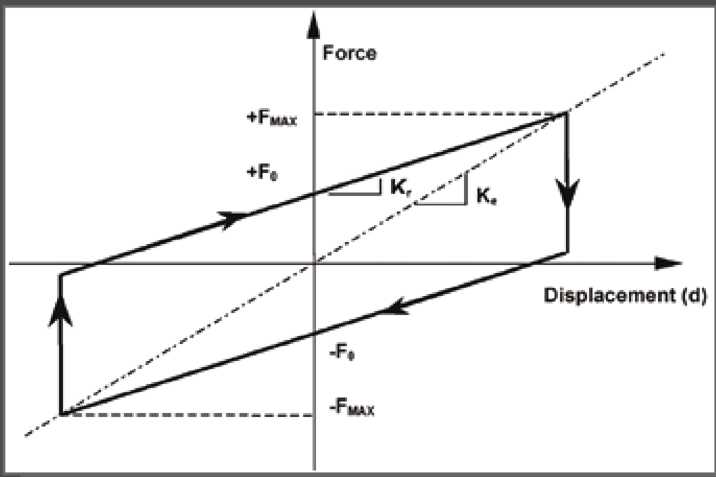
$K_r = \frac{N_{Sd}}{R}$ ➡ restoring stiffness

μ ➡ friction coefficient

N_{Sd} ➡ vertical load acting on the isolator

R ➡ equivalent radius of curvature

d ➡ displacement



The vertical load N_{Sd} used to model the behaviour of the curved surface sliders under earthquake excitation is usually the quasi-permanent vertical load, i.e. the mass multiplied by the gravity acceleration, that is the average load acting on the isolator during the earthquake. Non-linear dynamic models that take into account the variation of vertical load during the earthquake are sometimes used.

The friction coefficient μ is a function of vertical load, as shown before. Usually it is calculated at the value of quasi-permanent load, according to the law $\mu(N_{Sd}/N_{Ed})$ given above.

In **FIP** series, the equivalent radius of curvature R coincides with the geometric radius of curvature of the primary sliding surface, while in **FIP-D** series R is approximately two times the geometric radius of curvature of each sliding surface.

When the Standard used for design of structures allows to model said non linear behaviour as a linear equivalent behaviour, the effective stiffness and the effective viscous damping can be calculated with the following formulae:

$$K_e = N_{Sd} \cdot \left(\frac{1}{R} + \frac{\mu}{d} \right) \qquad \xi_e = \frac{2}{\pi} \cdot \frac{1}{\frac{d}{\mu \cdot R} + 1}$$

It is worth noting that both the effective stiffness and the effective viscous damping depend on displacement; consequently, even when it is allowed to model the isolation system as linear equivalent, an iterative procedure should be applied, until the difference between the assumed and the calculated values of displacement becomes negligible.

Thanks to the dependence of the effective stiffness on vertical load, the center of mass and the center of stiffness of the isolation system coincide in plan.

The effective fundamental period, i.e. the period associated to the effective stiffness, of a structure isolated with curved surface sliders can be estimated as:

$$T_e = 2\pi \sqrt{\frac{1}{g \cdot \left(\frac{1}{R} + \frac{\mu}{d} \right)}}$$

The period associated to the restoring stiffness K_r is instead equivalent to that of a simple pendulum of length R:

$$T = 2\pi \sqrt{\frac{R}{g}}$$

DESIGN AND PRODUCTION CRITERIA

STANDARDS

The curved surface sliders (both series **FIP** and **FIP-D**) are usually designed according to the European Standard EN 15129:2009 *Anti-seismic devices*. On request, they can be designed to satisfy other standards or technical specifications.

DESIGN FEATURES

The standard **FIP-D** isolators whose geometrical and mechanical characteristics are listed in the enclosed tables, are designed for seven different values of maximum displacement, from 100 to 400 mm.

Such entity of displacement is understood to be the maximum displacement d_{Ed} according to EN 15129:2009.

For buildings and other structures other than bridges, d_{Ed} is given by the design displacement under seismic action d_{bd}, factored by the magnification factor γ_x as per Eurocode 8 (EN 1998-1:2005, § 10.3 (2)P).

For bridges, d_{Ed} coincides with d_{max} as defined in EN 1998-2:2009, § 7.6.2, i.e. is obtained by adding to the amplified design seismic displacement $\gamma_x d_{bd}$, the potential offset displacement due to the permanent actions, the long-term deformations of the superstructure, and the 50 % of the thermal action.

The vertical load N_{Ed} indicated in the tables is the maximum vertical load at ULS load combinations including the seismic action, or at any other load combination including horizontal displacement. The vertical load at zero horizontal displacement can be higher than N_{Ed}, and usually in r.c. structures depends on concrete strength.

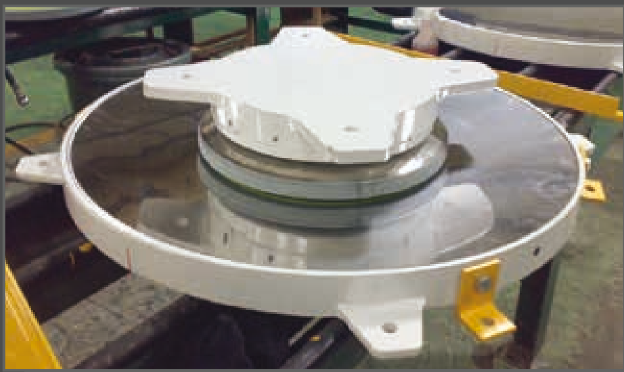
The equivalent radius of curvature is fixed for each value of displacement; three different values have been used, 2.5 m for displacement 100 and 150 mm, 3.1 m for displacement 200 and 250 mm, and 3.7 m for displacement 300, 350 and 400 mm. It is recommended to use in a structure isolators with the same equivalent radius of curvature, in order to avoid differential vertical displacements associated to horizontal displacement.

A rotation value of 0.01 rad is assumed in the design, combined with maximum horizontal displacement d_{Ed}. At lower values of displacement, higher values of rotation are allowed.

FIP Industriale's Technical Department may also design ad hoc curved surface sliders different from the standard ones to satisfy the Engineer's requirement, e.g. with different values of radius of curvature, displacement, vertical load, rotation, friction coefficient, or of the **FIP** series.

QUALITY CONTROL

FIP Industriale's internal quality control system ensures the conformity of the product to the various requirements thus guaranteeing the quality both of materials and manufacturing processes.



Curved surface slider series **FIP** manufactured for Mary Bridge, Turkmenistan

TURKMENISTAN - Mary Bridge

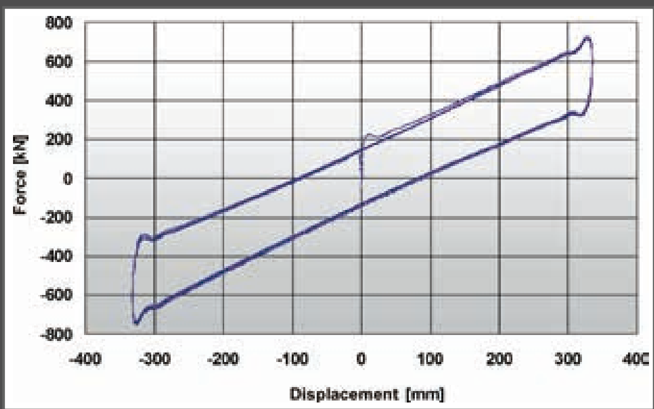
TYPE AND FACTORY PRODUCTION CONTROL TESTS

Both series **FIP** and **FIP-D** isolators have been tested at independent laboratories. In particular, full scale isolators of different sizes have been subjected to type tests according to the European Standard EN 15129, to the Italian Standard NTC 2008, and to other national Standards as well.

Furthermore, two **FIP-D** isolators were tested at the Seismic Response Modification Device Test Facility at the University of California at San Diego, USA, in order to verify their behaviour when submitted to a simultaneous bi-directional dynamic horizontal movement under vertical load. The isolators were subjected both to simultaneous sinusoidal movements along two primary axes (the so called “clover leaf” path as per EN 15129) and to a bi-directional time-history of horizontal displacement which reproduces the effect of an actual earthquake.

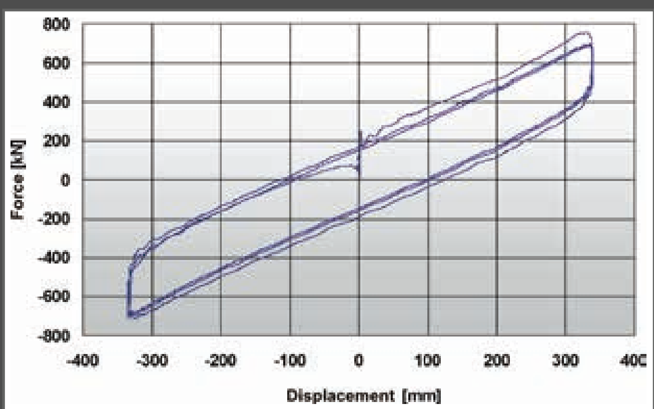
The reliability of **FIP Industriale**’s technology has been confirmed by the above mentioned type tests, as well as by many factory production control tests performed both at independent laboratories and at **FIP Industriale**’s Test Laboratory according to EN 15129 and the Italian Standard NTC 2008. Furthermore, dynamic tests on entire buildings of the C.A.S.E. project in L’Aquila, isolated with **FIP-D** isolators, were carried out by the Italian Civil Defence.

Type tests on a double concave curved surface slider at Eucentre Trees Laboratory in Pavia.



Experimental hysteretic cycles of a double concave curved surface slider obtained in a test at constant velocity.

Bi-directional type tests on a **FIP-D** isolator at the SRMD Test Facility at the University of California at San Diego, USA.



Experimental hysteretic cycles of a double concave curved surface slider obtained in a sinusoidal test.

Dynamic tests on a building of the C.A.S.E. project in l’Aquila (Italy) isolated with **FIP-D** devices.

DESIGN AND PRODUCTION CRITERIA

ANCHORING SYSTEMS

The curved surface sliders are fixed on to the structure by means of mechanical anchoring systems providing 100 % of the horizontal load transfer (despite the European Standard EN 15219:2009 allows that only 75 % of the horizontal load is supported by mechanical anchorages when the minimum vertical load on the isolators during the seismic action has been determined by non-linear dynamic analysis).

INSTALLATION

The typical installation procedure of an isolator anchored on its upper and lower side to reinforced cast-in-situ concrete structures, comprises the following phases:

- casting of the substructure up to a level lower than the isolator itself by a few centimeters, leaving holes for the anchor dowels with a diameter at least twice that of the same;
- positioning the isolator at the design level and leveling its base horizontally;
- construction of a formwork slightly larger than the isolator and approximately 1 cm higher than its lower edge;
- grouting (epoxy mortar or shrink free cementitious mortar) to a suggested thickness between 2 and 5 cm;
- screwing of the upper dowels to the isolator (if not already affixed);
- setting the upper formwork adapting it tightly against the isolator upper plate;
- positioning the superstructure reinforcement followed by concrete casting;
- following the hardening of the concrete, and in any case before the structure starts to be utilized, remove the transportation brackets (usually yellow) unscrewing the screws; re-tight all screw in their respective threaded holes in order to ensure the maximum anti-corrosion protection of the holes.

It is recommended to pay attention to protect the sliding surfaces of the isolators during the pouring of concrete. Should the sliding surfaces get accidentally dirty during installation, they shall be cleaned as soon as possible.

FIRE RESISTANCE

Curved surface sliders are characterised by intrinsic fire resistance, usually higher than 240 minutes, when installed in reinforced concrete structures, i.e. when the exposure to fire is only through lateral surface. However, replacement of the entire isolator that has been subjected to fire or at least of some parts of it (e.g. the sliding material and the stainless steel) could be necessary.

For curved surface sliders installed in steel structures, a passive fire protection system is recommended for the isolators as well as for the structural elements.

COMBINATION OF DEVICES

• **FIP-D** isolator combined with shock transmission units.

Curved surface sliders can be combined with other anti-seismic devices, to obtain special performance, useful in particular in bridge applications.

For example, they can be combined with shock transmission units for application on mobile piers of a bridge; the shock transmission units allow the slow movements due to the variations of temperature without transmitting a significant horizontal force to the pier, while under an earthquake the shock transmission units become stiff and the curved surface slider is activated, thus dissipating energy and ensuring the re-centring according to its force vs. displacement curve. This behaviour can be important in order to reduce the horizontal force transmitted to the pier under service conditions.

MARKS

The curved surface sliders or double concave curved surface sliders are classified by the mark **FIP** or **FIP-D**, respectively, followed by a letter and 3 numbers. The letter identify the friction coefficient (L: low friction – M: medium friction), the first number is a conventional number, the second number represents the total displacement in millimeters and the third number (in brackets) stands for the equivalent curvature radius in millimeters.

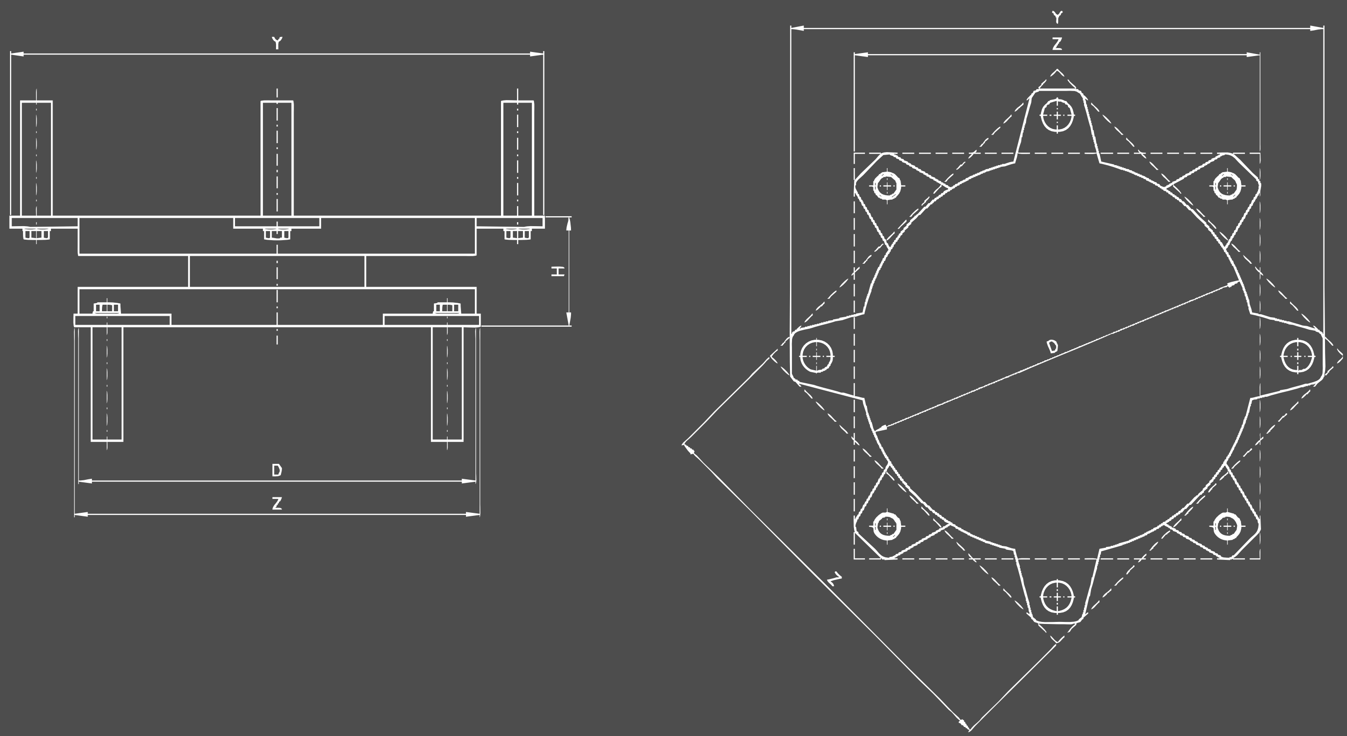
Example:

FIP-D L 1200/600 (3700)	double concave curved surface slider that permits ± 300 mm horizontal displacement in all directions, with an equivalent curvature radius of 3700 mm and using low friction sliding material.

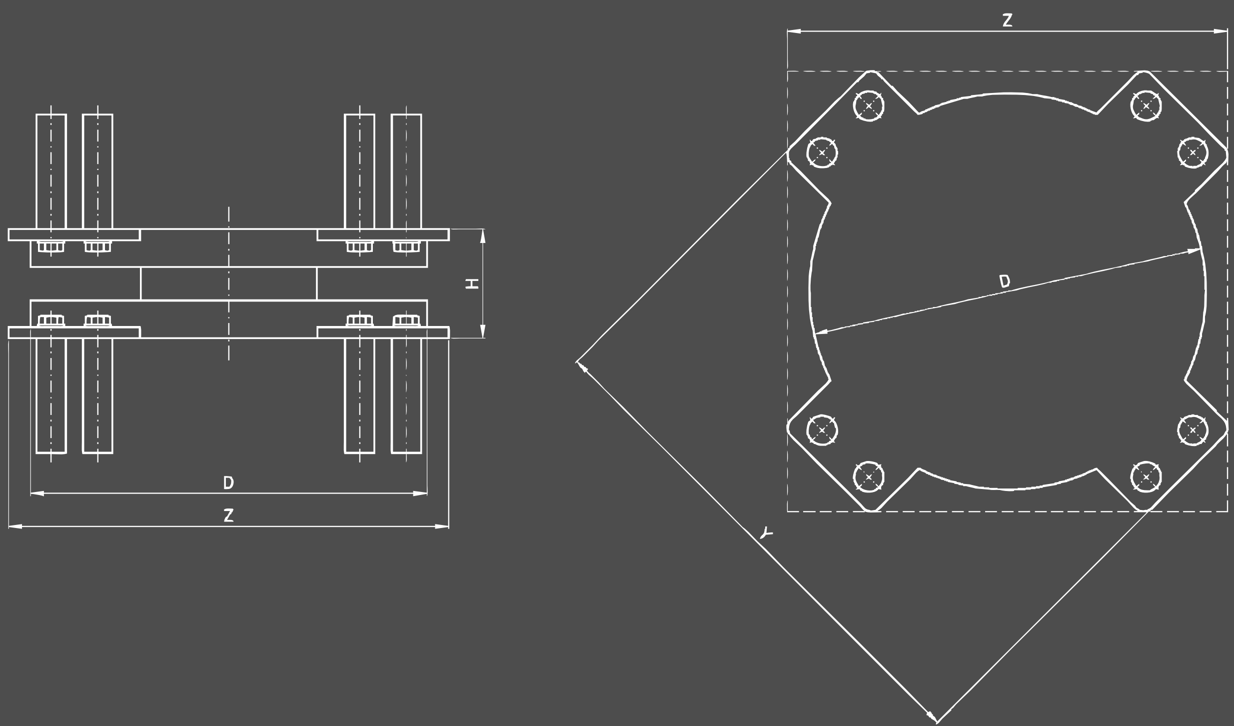
• TURKMENISTAN - Avaza Bridge

• CASTEL DI SANGRO, ITALY - private building

SCHEME FIP-D



Schematic drawing for FIP-D isolator with four upper/lower dowels



Schematic drawing for FIP-D isolator with eight or more upper/lower dowels

TABLES FIP-D STANDARD

Displacement ±100 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} *kN*	Isolator Mark	N_{Ed} *kN*	D *mm*	Y *mm*	Z *mm*	H *mm*	n	W *kg*
FIP-D L 250/200 (2500)	1000	FIP-D M 250/200 (2500)	220	350	460	350	98	4	50
FIP-D L 340/200 (2500)	1500	FIP-D M 340/200 (2500)	560	380	490	380	104	4	65
FIP-D L 440/200 (2500)	2000	FIP-D M 440/200 (2500)	990	410	520	410	99	4	75
FIP-D L 510/200 (2500)	2500	FIP-D M 510/200 (2500)	1330	430	600	470	96	4	85
FIP-D L 590/200 (2500)	3000	FIP-D M 590/200 (2500)	1690	450	620	480	117	4	110
FIP-D L 670/200 (2500)	3500	FIP-D M 670/200 (2500)	2100	470	640	490	113	4	120
FIP-D L 760/200 (2500)	4000	FIP-D M 760/200 (2500)	2540	490	660	510	110	4	130
FIP-D L 910/200 (2500)	5000	FIP-D M 910/200 (2500)	3270	520	690	530	136	4	180
FIP-D L 1100/200 (2500)	6000	FIP-D M 1100/200 (2500)	4380	560	810	630	138	4	230
FIP-D L 1200/200 (2500)	7000	FIP-D M 1200/200 (2500)	4980	580	830	650	144	4	260
FIP-D L 1400/200 (2500)	8000	FIP-D M 1400/200 (2500)	5960	610	860	670	156	4	300
FIP-D L 1600/200 (2500)	9000	FIP-D M 1600/200 (2500)	7030	640	890	690	158	4	340
FIP-D L 1750/200 (2500)	10000	FIP-D M 1750/200 (2500)	7780	660	910	700	164	4	380
FIP-D L 2100/200 (2500)	12500	FIP-D M 2100/200 (2500)	9830	710	1040	810	202	4	560
FIP-D L 2500/200 (2500)	15000	FIP-D M 2500/200 (2500)	12120	760	1090	850	208	4	680
FIP-D L 2950/200 (2500)	17500	FIP-D M 2950/200 (2500)	14630	810	1050	970	213	8	800
FIP-D L 3450/200 (2500)	20000	FIP-D M 3450/200 (2500)	17360	860	1100	1000	259	8	1100
FIP-D L 4150/200 (2500)	25000	FIP-D M 4150/200 (2500)	21600	930	1210	1120	253	8	1300
FIP-D L 4950/200 (2500)	30000	FIP-D M 4950/200 (2500)	26250	1000	1280	1340	332	12	2000
FIP-D L 6500/200 (2500)	40000	FIP-D M 6500/200 (2500)	35300	1120	1400	1430	344	12	2650
FIP-D L 8050/200 (2500)	50000	FIP-D M 8050/200 (2500)	44700	1230	1510	1670	433	16	4000
FIP-D L 9650/200 (2500)	60000	FIP-D M 9650/200 (2500)	54250	1330	1610	1910	424	20	4800

Displacement ±150 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} *kN*	Isolator Mark	N_{Ed} *kN*	D *mm*	Y *mm*	Z *mm*	H *mm*	n	W *kg*
FIP-D L 250/300 (2500)	1000	FIP-D M 250/300 (2500)	220	400	510	400	101	4	65
FIP-D L 340/300 (2500)	1500	FIP-D M 340/300 (2500)	560	430	540	430	96	4	75
FIP-D L 440/300 (2500)	2000	FIP-D M 440/300 (2500)	990	460	630	490	101	4	100
FIP-D L 510/300 (2500)	2500	FIP-D M 510/300 (2500)	1330	480	650	500	97	4	110
FIP-D L 590/300 (2500)	3000	FIP-D M 590/300 (2500)	1690	500	670	520	118	4	140
FIP-D L 670/300 (2500)	3500	FIP-D M 670/300 (2500)	2100	520	690	530	114	4	150
FIP-D L 760/300 (2500)	4000	FIP-D M 760/300 (2500)	2540	540	710	540	110	4	160
FIP-D L 910/300 (2500)	5000	FIP-D M 910/300 (2500)	3270	570	820	640	136	4	220
FIP-D L 1100/300 (2500)	6000	FIP-D M 1100/300 (2500)	4380	610	860	670	135	4	260
FIP-D L 1200/300 (2500)	7000	FIP-D M 1200/300 (2500)	4980	630	880	680	140	4	290
FIP-D L 1400/300 (2500)	8000	FIP-D M 1400/300 (2500)	5960	660	910	700	164	4	360
FIP-D L 1600/300 (2500)	9000	FIP-D M 1600/300 (2500)	7030	690	940	720	156	4	380
FIP-D L 1750/300 (2500)	10000	FIP-D M 1750/300 (2500)	7780	710	1040	810	160	4	460
FIP-D L 2100/300 (2500)	12500	FIP-D M 2100/300 (2500)	9830	760	1090	850	208	4	650
FIP-D L 2500/300 (2500)	15000	FIP-D M 2500/300 (2500)	12120	810	1050	970	213	8	770
FIP-D L 2950/300 (2500)	17500	FIP-D M 2950/300 (2500)	14630	860	1100	1000	217	8	910
FIP-D L 3450/300 (2500)	20000	FIP-D M 3450/300 (2500)	17360	910	1190	1110	260	8	1250
FIP-D L 4150/300 (2500)	25000	FIP-D M 4150/300 (2500)	21600	980	1260	1330	254	12	1550
FIP-D L 4950/300 (2500)	30000	FIP-D M 4950/300 (2500)	26250	1050	1330	1380	333	12	2150
FIP-D L 6500/300 (2500)	40000	FIP-D M 6500/300 (2500)	35300	1170	1450	1630	342	16	2950
FIP-D L 8050/300 (2500)	50000	FIP-D M 8050/300 (2500)	44700	1280	1560	1880	429	20	4400
FIP-D L 9650/300 (2500)	60000	FIP-D M 9650/300 (2500)	54250	1380	1660	2120	438	24	5500

Equivalent radius of curvature R = 2500 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

Displacement ±200 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 280/400 (3100)	1000			460	570	460	108	4	85
FIP-D L 370/400 (3100)	1500	FIP-D M 370/400 (3100)	270	490	600	490	114	4	110
FIP-D L 470/400 (3100)	2000	FIP-D M 470/400 (3100)	670	520	690	530	109	4	130
FIP-D L 550/400 (3100)	2500	FIP-D M 550/400 (3100)	980	540	710	540	106	4	140
FIP-D L 630/400 (3100)	3000	FIP-D M 630/400 (3100)	1340	560	730	560	125	4	170
FIP-D L 720/400 (3100)	3500	FIP-D M 720/400 (3100)	1730	580	750	580	121	4	180
FIP-D L 810/400 (3100)	4000	FIP-D M 810/400 (3100)	2150	600	770	600	128	4	210
FIP-D L 1000/400 (3100)	5000	FIP-D M 1000/400 (3100)	3100	640	890	690	152	4	290
FIP-D L 1150/400 (3100)	6000	FIP-D M 1150/400 (3100)	3950	670	920	710	146	4	310
FIP-D L 1350/400 (3100)	7000	FIP-D M 1350/400 (3100)	4850	700	950	730	150	4	360
FIP-D L 1450/400 (3100)	8000	FIP-D M 1450/400 (3100)	5500	720	970	740	176	4	430
FIP-D L 1650/400 (3100)	9000	FIP-D M 1650/400 (3100)	6500	750	1000	770	169	4	460
FIP-D L 1800/400 (3100)	10000	FIP-D M 1800/400 (3100)	7250	770	1100	850	175	4	550
FIP-D L 2200/400 (3100)	12500	FIP-D M 2200/400 (3100)	9350	820	1150	890	214	4	710
FIP-D L 2600/400 (3100)	15000	FIP-D M 2600/400 (3100)	11500	870	1110	1010	220	8	860
FIP-D L 3050/400 (3100)	17500	FIP-D M 3050/400 (3100)	14000	920	1160	1040	235	8	1100
FIP-D L 3450/400 (3100)	20000	FIP-D M 3450/400 (3100)	16250	960	1240	1140	265	8	1300
FIP-D L 4300/400 (3100)	25000	FIP-D M 4300/400 (3100)	21000	1040	1320	1370	280	12	1800
FIP-D L 5100/400 (3100)	30000	FIP-D M 5100/400 (3100)	25500	1110	1390	1420	361	12	2450
FIP-D L 6650/400 (3100)	40000	FIP-D M 6650/400 (3100)	34500	1230	1510	1670	357	16	3200
FIP-D L 8200/400 (3100)	50000	FIP-D M 8200/400 (3100)	44000	1340	1620	1920	429	20	4600
FIP-D L 9800/400 (3100)	60000	FIP-D M 9800/400 (3100)	53500	1440	1720	2160	426	24	5600

Displacement ±250 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 280/500 (3100)	1000			510	620	510	111	4	110
FIP-D L 370/500 (3100)	1500	FIP-D M 370/500 (3100)	270	540	650	540	106	4	120
FIP-D L 470/500 (3100)	2000	FIP-D M 470/500 (3100)	670	570	740	570	111	4	160
FIP-D L 550/500 (3100)	2500	FIP-D M 550/500 (3100)	980	590	760	590	117	4	190
FIP-D L 630/500 (3100)	3000	FIP-D M 630/500 (3100)	1340	610	780	610	124	4	200
FIP-D L 720/500 (3100)	3500	FIP-D M 720/500 (3100)	1730	630	880	680	130	4	250
FIP-D L 810/500 (3100)	4000	FIP-D M 810/500 (3100)	2150	650	900	700	126	4	260
FIP-D L 1000/500 (3100)	5000	FIP-D M 1000/500 (3100)	3100	690	940	720	152	4	330
FIP-D L 1150/500 (3100)	6000	FIP-D M 1150/500 (3100)	3950	720	970	740	156	4	390
FIP-D L 1350/500 (3100)	7000	FIP-D M 1350/500 (3100)	4850	750	1000	770	159	4	440
FIP-D L 1450/500 (3100)	8000	FIP-D M 1450/500 (3100)	5500	770	1020	780	175	4	490
FIP-D L 1650/500 (3100)	9000	FIP-D M 1650/500 (3100)	6500	800	1130	870	177	4	590
FIP-D L 1800/500 (3100)	10000	FIP-D M 1800/500 (3100)	7250	820	1150	890	182	4	650
FIP-D L 2200/500 (3100)	12500	FIP-D M 2200/500 (3100)	9300	870	1110	1010	220	8	820
FIP-D L 2600/500 (3100)	15000	FIP-D M 2600/500 (3100)	11500	920	1160	1040	235	8	1050
FIP-D L 3050/500 (3100)	17500	FIP-D M 3050/500 (3100)	14000	970	1250	1150	220	8	1150
FIP-D L 3450/500 (3100)	20000	FIP-D M 3450/500 (3100)	16250	1010	1290	1180	269	8	1450
FIP-D L 4300/500 (3100)	25000	FIP-D M 4300/500 (3100)	21000	1090	1370	1410	263	12	1850
FIP-D L 5100/500 (3100)	30000	FIP-D M 5100/500 (3100)	25500	1160	1440	1450	343	12	2500
FIP-D L 6650/500 (3100)	40000	FIP-D M 6650/500 (3100)	34500	1320	1600	1740	342	16	3500
FIP-D L 8200/500 (3100)	50000	FIP-D M 8200/500 (3100)	44000	1390	1670	2130	428	24	5100
FIP-D L 9800/500 (3100)	60000	FIP-D M 9800/500 (3100)	53500	1490	1820	2250	423	20	5950

Equivalent radius of curvature R = 3100 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

Displacement ±300 mm

Low friction Isolator Mark	N_{Ed} kN	Medium friction Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 310/600 (3700)	1000			570	680	570	139	4	160
FIP-D L 400/600 (3700)	1500			600	710	600	134	4	180
FIP-D L 510/600 (3700)	2000	FIP-D M 510/600 (3700)	310	630	800	630	138	4	220
FIP-D L 590/600 (3700)	2500	FIP-D M 590/600 (3700)	600	650	820	650	134	4	230
FIP-D L 670/600 (3700)	3000	FIP-D M 670/600 (3700)	930	670	840	670	143	4	250
FIP-D L 760/600 (3700)	3500	FIP-D M 760/600 (3700)	1300	690	940	720	150	4	300
FIP-D L 860/600 (3700)	4000	FIP-D M 860/600 (3700)	1700	710	960	740	146	4	320
FIP-D L 1050/600 (3700)	5000	FIP-D M 1050/600 (3700)	2650	750	1000	770	171	4	400
FIP-D L 1200/600 (3700)	6000	FIP-D M 1200/600 (3700)	3450	780	1030	790	175	4	460
FIP-D L 1400/600 (3700)	7000	FIP-D M 1400/600 (3700)	4300	810	1060	810	179	4	530
FIP-D L 1600/600 (3700)	8000	FIP-D M 1600/600 (3700)	5250	840	1090	840	195	4	590
FIP-D L 1750/600 (3700)	9000	FIP-D M 1750/600 (3700)	6000	860	1190	920	200	4	690
FIP-D L 1900/600 (3700)	10000	FIP-D M 1900/600 (3700)	6700	880	1210	930	196	4	720
FIP-D L 2250/600 (3700)	12500	FIP-D M 2250/600 (3700)	8650	930	1170	1050	243	8	950
FIP-D L 2700/600 (3700)	15000	FIP-D M 2700/600 (3700)	10900	980	1220	1090	241	8	1100
FIP-D L 3150/600 (3700)	17500	FIP-D M 3150/600 (3700)	13300	1030	1310	1190	247	8	1350
FIP-D L 3550/600 (3700)	20000	FIP-D M 3550/600 (3700)	15500	1070	1350	1220	290	8	1700
FIP-D L 4400/600 (3700)	25000	FIP-D M 4400/600 (3700)	20000	1150	1430	1450	287	12	2100
FIP-D L 5200/600 (3700)	30000	FIP-D M 5200/600 (3700)	24500	1220	1500	1500	356	12	2750
FIP-D L 6750/600 (3700)	40000	FIP-D M 6750/600 (3700)	33500	1340	1620	1750	356	16	3600
FIP-D L 8350/600 (3700)	50000	FIP-D M 8350/600 (3700)	43000	1450	1730	2170	433	24	5300
FIP-D L 9800/600 (3700)	60000	FIP-D M 9800/600 (3700)	51000	1540	1870	2280	418	20	6000

Displacement ±350 mm

Low friction Isolator Mark	N_{Ed} kN	Medium friction Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 310/700 (3700)	1000			620	730	620	129	4	170
FIP-D L 400/700 (3700)	1500			650	820	650	134	4	210
FIP-D L 510/700 (3700)	2000	FIP-D M 510/700 (3700)	310	680	850	680	129	4	230
FIP-D L 590/700 (3700)	2500	FIP-D M 590/700 (3700)	600	700	870	700	136	4	270
FIP-D L 670/700 (3700)	3000	FIP-D M 670/700 (3700)	930	720	890	720	154	4	320
FIP-D L 760/700 (3700)	3500	FIP-D M 760/700 (3700)	1300	740	990	760	150	4	350
FIP-D L 860/700 (3700)	4000	FIP-D M 860/700 (3700)	1700	760	1010	770	146	4	370
FIP-D L 1050/700 (3700)	5000	FIP-D M 1050/700 (3700)	2650	800	1050	800	171	4	460
FIP-D L 1200/700 (3700)	6000	FIP-D M 1200/700 (3700)	3450	830	1080	830	174	4	520
FIP-D L 1400/700 (3700)	7000	FIP-D M 1400/700 (3700)	4300	860	1110	860	178	4	600
FIP-D L 1600/700 (3700)	8000	FIP-D M 1600/700 (3700)	5250	890	1220	940	193	4	700
FIP-D L 1750/700 (3700)	9000	FIP-D M 1750/700 (3700)	6000	910	1240	950	207	4	810
FIP-D L 1900/700 (3700)	10000	FIP-D M 1900/700 (3700)	6700	930	1260	970	202	4	830
FIP-D L 2250/700 (3700)	12500	FIP-D M 2250/700 (3700)	8650	980	1220	1090	241	8	1050
FIP-D L 2700/700 (3700)	15000	FIP-D M 2700/700 (3700)	10900	1030	1310	1190	247	8	1300
FIP-D L 3150/700 (3700)	17500	FIP-D M 3150/700 (3700)	13300	1080	1360	1230	254	8	1550
FIP-D L 3550/700 (3700)	20000	FIP-D M 3550/700 (3700)	15500	1120	1360	1330	275	12	1700
FIP-D L 4400/700 (3700)	25000	FIP-D M 4400/700 (3700)	20000	1200	1480	1480	291	12	2300
FIP-D L 5200/700 (3700)	30000	FIP-D M 5200/700 (3700)	24500	1270	1550	1700	360	16	3100
FIP-D L 6750/700 (3700)	40000	FIP-D M 6750/700 (3700)	33500	1390	1670	1960	358	20	4050
FIP-D L 8350/700 (3700)	50000	FIP-D M 8350/700 (3700)	43000	1500	1780	2200	414	24	5350
FIP-D L 9800/700 (3700)	60000	FIP-D M 9800/700 (3700)	51000	1590	1920	2320	417	20	6300

Equivalent radius of curvature R = 3700 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

Displacement ±400 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 310/800 (3700)	1000			670	780	670	131	4	210
FIP-D L 400/800 (3700)	1500			700	870	700	136	4	260
FIP-D L 510/800 (3700)	2000	FIP-D M 510/800 (3700)	310	730	900	730	140	4	310
FIP-D L 590/800 (3700)	2500	FIP-D M 590/800 (3700)	600	750	920	750	136	4	320
FIP-D L 670/800 (3700)	3000	FIP-D M 670/800 (3700)	930	770	1020	780	154	4	390
FIP-D L 760/800 (3700)	3500	FIP-D M 760/800 (3700)	1300	790	1040	790	150	4	410
FIP-D L 860/800 (3700)	4000	FIP-D M 860/800 (3700)	1700	810	1060	810	156	4	460
FIP-D L 1050/800 (3700)	5000	FIP-D M 1050/800 (3700)	2650	850	1100	850	180	4	560
FIP-D L 1200/800 (3700)	6000	FIP-D M 1200/800 (3700)	3450	880	1130	880	173	4	590
FIP-D L 1400/800 (3700)	7000	FIP-D M 1400/800 (3700)	4300	910	1240	950	184	4	750
FIP-D L 1600/800 (3700)	8000	FIP-D M 1600/800 (3700)	5250	940	1270	970	199	4	810
FIP-D L 1750/800 (3700)	9000	FIP-D M 1750/800 (3700)	6000	960	1290	990	204	4	900
FIP-D L 1900/800 (3700)	10000	FIP-D M 1900/800 (3700)	6700	980	1220	1090	199	8	910
FIP-D L 2250/800 (3700)	12500	FIP-D M 2250/800 (3700)	8650	1030	1270	1120	247	8	1200
FIP-D L 2700/800 (3700)	15000	FIP-D M 2700/800 (3700)	10900	1080	1360	1230	254	8	1500
FIP-D L 3150/800 (3700)	17500	FIP-D M 3150/800 (3700)	13300	1130	1410	1260	259	8	1750
FIP-D L 3550/800 (3700)	20000	FIP-D M 3550/800 (3700)	15500	1170	1450	1460	280	12	2000
FIP-D L 4400/800 (3700)	25000	FIP-D M 4400/800 (3700)	20000	1250	1530	1520	275	12	2350
FIP-D L 5200/800 (3700)	30000	FIP-D M 5200/800 (3700)	24500	1320	1600	1740	343	16	3150
FIP-D L 6750/800 (3700)	40000	FIP-D M 6750/800 (3700)	33500	1440	1720	1990	360	20	4350
FIP-D L 8350/800 (3700)	50000	FIP-D M 8350/800 (3700)	43000	1550	1830	2240	414	24	5650
FIP-D L 9800/800 (3700)	60000	FIP-D M 9800/800 (3700)	51000	1640	1970	2560	416	24	6750

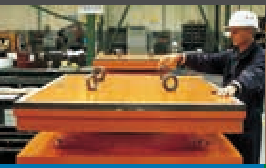
Equivalent radius of curvature R = 3700 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

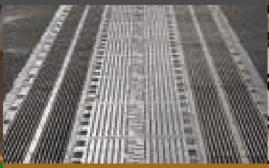
• L'AQUILA, ITALY - C.A.S.E. Project, installation of **FIP-D**

DEC 2016



BRIDGE BEARINGS

ANTI-SEISMIC DEVICES



EXPANSION JOINTS

FITTINGS FOR TUNNEL

NOISE BARRIERS

DAMPING SYSTEMS

FIP INDUSTRIALE
leading technologies

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