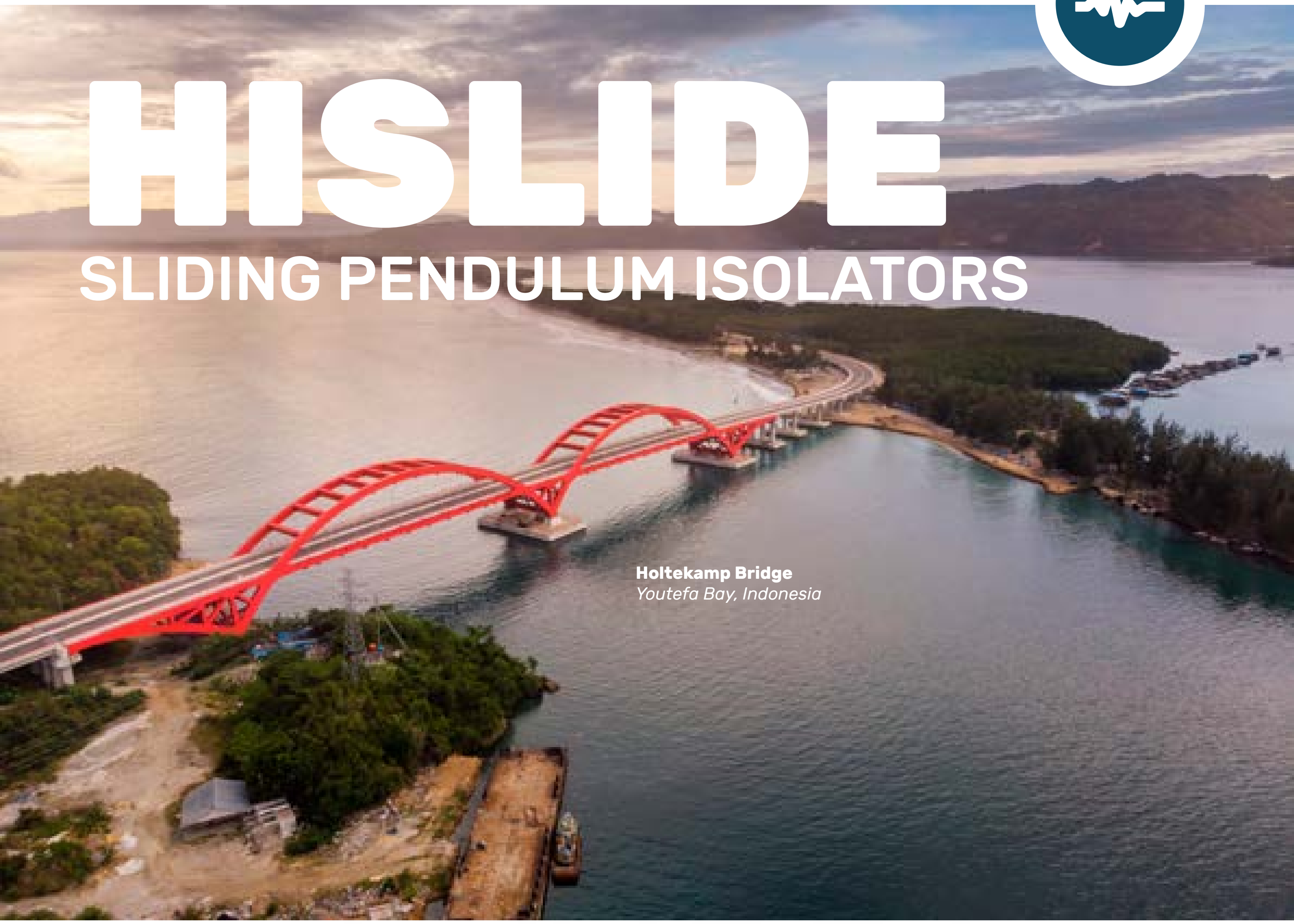
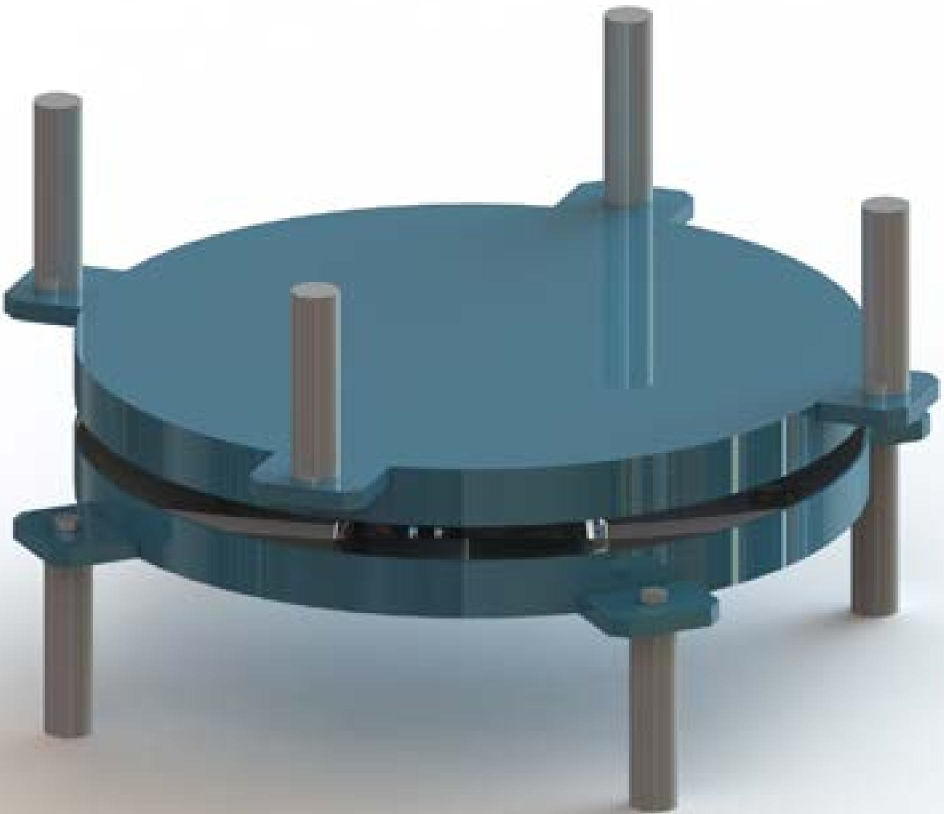
HISLIDE

SLIDING PENDULUM ISOLATORS



Holtekamp Bridge
Youtefa Bay, Indonesia



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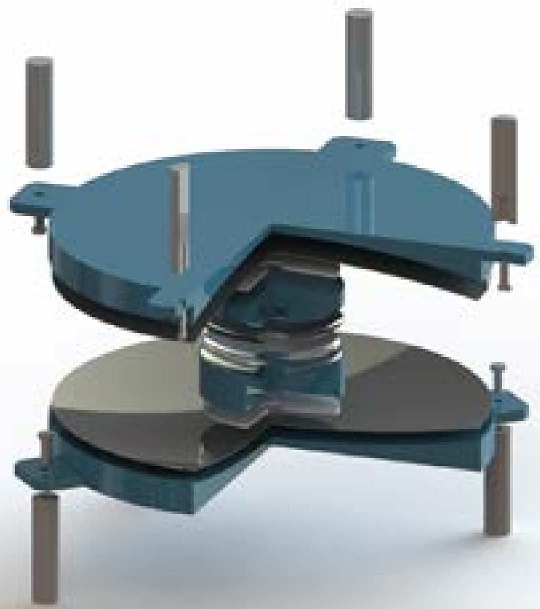
The engineering solution.

The efficient solution in high seismic areas.



These isolators can dissipate very large amounts of energy. The dissipation is given by the friction of the sliding material. The re-centering capacity is given by the pendulum effect. The vertical component of the earthquake greatly amplifys the re-centering capacity.

They are suitable for any kind of structure, up to the most important bridges. They are not sensitive to fire action and can grant a very long service life with negligible maintenance.

Sliding pendulum isolators are very often the most cost/performance effective devices.

Main Field

Any kind of bridges and building

INSTALLATION — Requires trained team

DURABILITY — > 100 years

MAINTENANCE — Corrosion protection after 15 years

COST — Best cost/performance ratio

VERTICAL LOAD
Unlimited

HORIZONTAL DISPLACEMENT
High

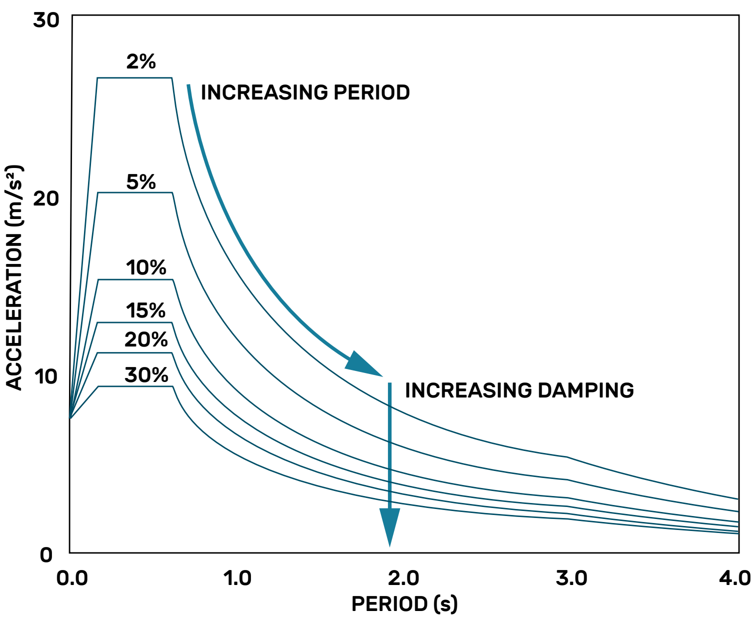
RE-CENTERING CAPACITY
Very High

DAMPING
High

FIRE RESISTANCE
High

Basic principles and requirements of the base isolation.

A response spectrum is a diagram giving the response of a structure forced into motion in function of its natural frequency. The response can be given in terms of displacement, velocity or acceleration,
The acceleration response spectrum is a very useful tool for the seismic design of structures.
Normally the acceleration response spectrum is given by the relevant seismic codes and provides to the designer all the useful information allowing designing the structure.
In the response spectrum in particular are given the information about the intensity of the earthquake and the effect of the soil properties
In the following figures are shown as an example the response spectra given by the European standard in function of the damping.



The strategies for the reduction of the seismic action in a structure shown on a typical response spectrum

Looking at the typical feature of a response spectrum it appears quite evident which strategy shall be used to reduce the seismic action in a structure:

- Increase the natural period
- Increase the damping, or the energy dissipation

Sliding pendulum isolators apply a combination of the 2 strategies

Sliding Pendulum Isolators

Base isolators, as defined in the EN 15129 are the devices or the combination of devices providing the following four functions:
1. Support the weight of the structures.
2. Provide lateral displacement capability.
3. Provide re-centring capability
4. Dissipate energy

Sliding Pendulum Isolators indeed are one of the most efficient systems of base isolators. They are based on the principle of the physical pendulum and therefore they force the structure to oscillate in accordance to their own period.

Their period is determined by the length l or the radius R of the pendulum and the gravity g only. The period of the pendulum is not influenced by the mass. In the reality the sliding pendulum isolators are based on sliding materials mated with spherical sliding surfaces as shown in the picture. The friction of the sliding material can provide the energy dissipation
So the Sliding Pendulum Isolators will shift the period of the structures forcing them to swing according to their own period.

The cinematic behavior of the elementary pendulum is perfectly reproduced both by the pendulum with one main sliding surface and 2 sliding surfaces as shown in side figures: they reproduce the behavior of an elementary pendulum with length R where R corresponds to the equivalent radius of the sliding pendulum isolators.
The equivalent radius is not coincident with the radius of the spherical calottes of the sliding pendulum isolators but is a function of the 2 radii of them and their distance.
In this device the surface with the bigger radius is mainly devoted to allow displacement and dissipate energy. The surface with the smaller radius is mainly devoted to allow for rotation. However both surfaces contribute, with different amounts, to the rotation, displacement and energy dissipation.

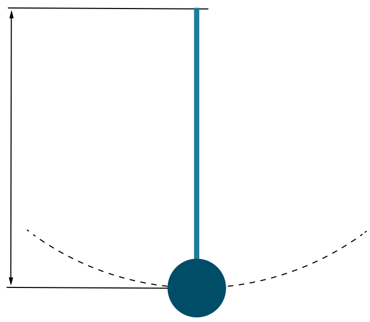
The mathematical model can be represented by the following equations that are defined by two parameters only:
- R the equivalent radius
- μ the dynamic friction

and by the design displacement D and the weight of the supported structure W

The equations representing the behavior of the sliding pendulum are the following:

- Stiffness $K = W\left(\frac{1}{R} + \frac{\mu}{D}\right)$
- Period $T = 2\pi\sqrt{\frac{RD}{(D+\mu R)g}}$
- Equivalent viscous damping $\xi = \frac{2\mu}{\pi\left(\mu + \frac{D}{R}\right)}$

The principle of the Sliding Pendulum Isolator



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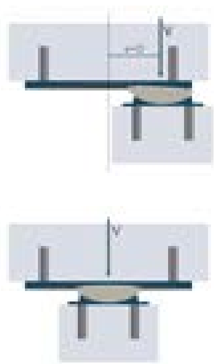
How to choose the right one.

Sliding pendulum isolators are perfectly defined by 2 parameters only:
- The equivalent radius R
- The dynamic friction μ

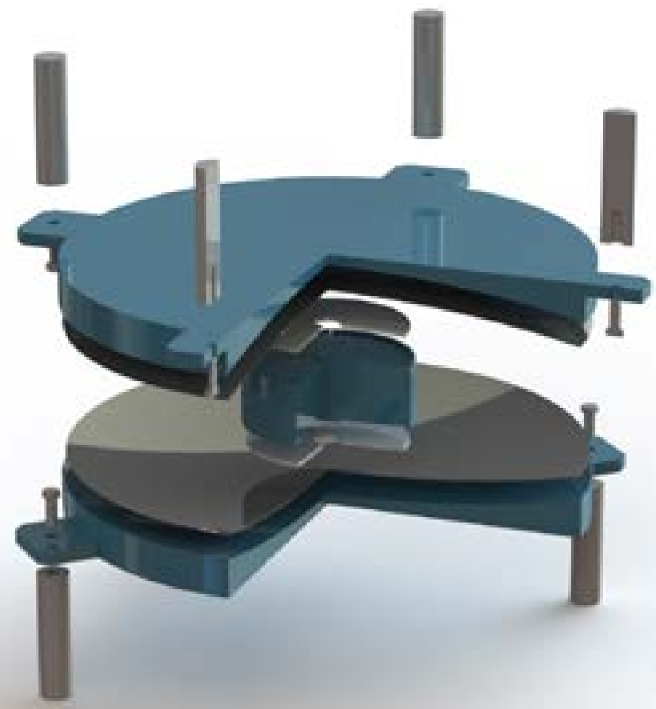
To choose the right one you also need to know the following values
- Vertical load in all loading combinations
- Horizontal displacement for all kind of actions
- Rotation

Sliding pendulum isolators types **HP1** and **HP2** are perfectly equivalent from the cinematic point of view, bearing, displacement and rotation capability.
The only difference are the dimensions in plan and the displacement of the vertical resultant when a horizontal displacement is applied:
- **HP1** shifts the resultant at the top only (or at the bottom only if upside down installed)
- **HP2** shift the resultant at top and bottom for half the total value.
HP1 and HP2 (with or without center articulation) can accommodate big rotations (common value of the rotation is 0.01 rad but rotations up to 0.05 rad can be accommodated if required to compensate prefabrication tolerances)

HP1 typical function



HP2 typical function



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Standard

Normally HISLIDE Sliding Pendulum Isolators are designed, manufactured and tested in accordance with EN 15129 and CE marked with supervision of the Notified Body ICECON that executes the regular audit visits as foreseen by the EN standard.

Quality Assurance

The whole production of HIRUN INTERNATIONAL is subjected to a quality assurance program in accordance with ISO 9000 certified by CQC, member of the International Mutual Acknowledgment Body IQNET.
In addition the production of the Sliding Pendulum Isolators is subjected to a specific quality assurance program in accordance with EN 15129 Annex ZA for the CE marking with the supervision of the Notified Body ICECON. (The relevant certificates are shown on the side)

Sliding Materials

HIRUN developed outstanding sliding materials:
- HI-3 mainly for use in spherical bearings
- HI-M and HI-H for use in sliding pendulum isolators.
- Here below a comparison table of the most commonly used sliding materials

For the sliding pendulum isolators a dynamic friction from 3 to 9%, according to the Engineers's requirements, can be granted

SLIDING MATERIAL PROPERTY	PTFE	HI-3	HI-M	HI-H
Compressive strength	90 MPa	180 MPa	270 MPa	180 MPa
Heat resistance (long term)	48°C	90°C	120°C	90°C
Heat resistance (short term)	80°C	120°C	180°C	180°C
Wear resistance	10,000 m	50,000 m	50,000 m	10,000 m
Static friction	<3%	<3%	<6%	<10%
Dynamic friction	<3%	<3%	2,5%	6 10%

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Corrosion protection

The corrosion protection of structural steel is normally performed in accordance with EN ISO 12944.
The working life of the protective coating system on the bearing can be assumed to be fulfilled with a protective system designed for the durability "high" of more than 15 years in accordance with EN ISO 12944-5:2007, 5.5 for corrosivity category C5-I (I=industrial) for inland locations and C5-M (M=marine) for sea side locations.
Surfaces in contact with concrete need no corrosion protection, however a layer of 50 μm of the first pack is applied in order to prevent oxidation during the storage before the installation. A return of at least 50 mm is applied.
In alternative paint will conform to the Project specifications, as specified by the purchaser

Fire resistance

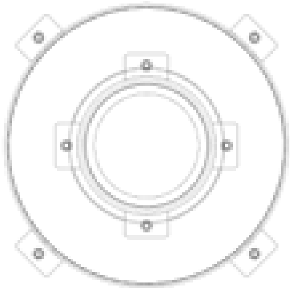
HISLIDE Isolators are fire resistant and don't require special precautions to protect them from the fire. After a fire event an inspection is recommended and, depending on the fire intensity, the sliding material may need to be replaced

Fixings

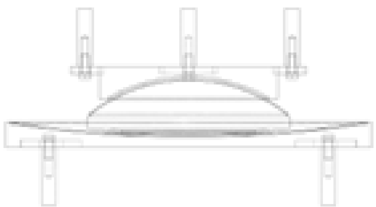
The HISLIDESliding Pendulum isolators are provided with fixings made with bolts or dowels according to the type of structure. The fixing are connected to the Isolator in such a way to allow the easy replacement if necessary.

Fuses

In case of use of the HISLIDE Isolators in railway bridges it is recommended the use of mechanical fuses in order to grant the fixity of the bridge under service condition. In case of a strong earthquake the fuses will be sheared of and the isolators can start their antiseismic function



Plan



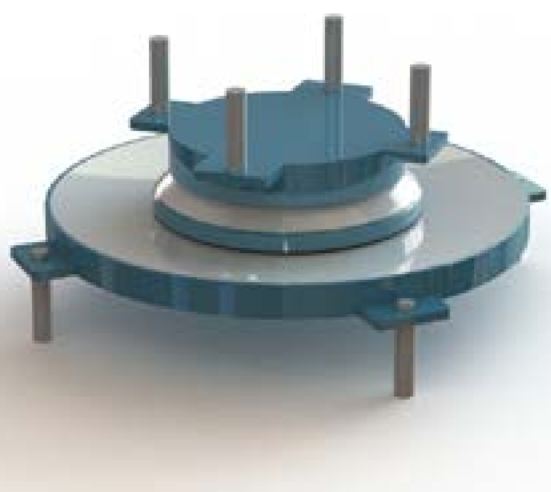
Section

Dimensions Table

HISLIDE HP1

They are identified by the following Mark: **HP1 N_{Sd}(kN)/d_{Ed}(mm)**
EXAMPLE: **HP1 4000/500**: Friction Pendulum with single sliding surface with 4000 kN characteristic vertical load and 500 mm horizontal displacement (±250)

N_{sd}	N_{max}	d_{Ed}	A	B	HT
kN	*kN*	*±mm*	*mm*	*mm*	*mm*
1000	1400	250	190	690	88
2000	2800	250	270	770	102
3000	4200	250	330	830	112
4000	5600	250	380	880	119
5000	7000	250	430	930	127
6000	8400	250	470	970	134
7000	9800	250	500	1000	140
8000	11299	250	540	1040	147
9000	12600	250	570	1070	150
10000	14000	250	600	1100	169
11000	15400	250	630	1130	174
12000	16800	250	660	1160	179
13000	18200	250	680	1180	183
15000	21000	250	730	1230	192
17500	24500	250	790	1290	200
20000	28000	250	850	1350	210
25000	35000	250	950	1450	227
30000	42000	250	1040	1540	243
40000	56000	250	1190	1690	269
50000	70000	250	1340	1840	292
60000	84000	250	1460	1960	314



N_{Sd}: quasi static load (SLS)
N_{max}: max load (ULS)
d_{Ed}: horizontal displacement (±D_{ed})
A: bottom plate dimension
B: Upper plate dimension
HT: Total height
R: equivalent radius (from 1500mm to 6000mm)
μ: dynamic friction coefficient (from 1,5% to 10%)

Note: The dimension B is given in the table
for the standard design displacement D_{Ed} = ±250 mm
For different values of D the dimension B will be increased by 2 Δd_{Ed}
For instance if d_{Ed} = ±500 mm will be B = B_{250} + 500 mm

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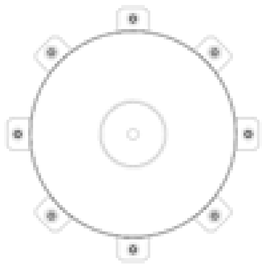

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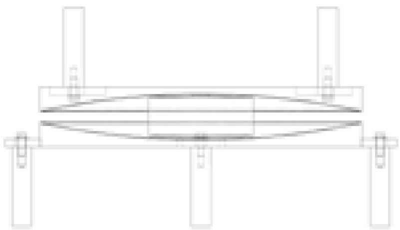


Section

Dimensions Table

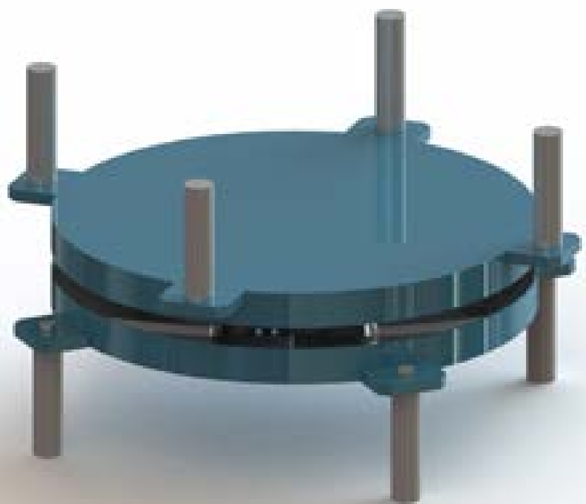
HISLIDE HP2

They are identified by the following Mark: **HP2 N_{Sd}(kN)/d_{Ed}(mm)**
EXAMPLE: **HP2 3000/500**: Friction Pendulum with single sliding surface with 4000 kN characteristic vertical load and 500 mm horizontal displacement (±250)

N_{sd}	N_{max}	d_{Ed}	A	HT
kN	*kN*	*±mm*	*mm*	*mm*
1000	1400	250	440	108
2000	2800	250	520	122
3000	4200	250	580	132
4000	5600	250	630	139
5000	7000	250	680	147
6000	8400	250	720	154
7000	9800	250	750	160
8000	11299	250	790	167
9000	12600	250	820	170
10000	14000	250	850	189
11000	15400	250	880	194
12000	16800	250	910	199
13000	18200	250	930	203
15000	21000	250	980	212
17500	24500	250	1040	220
20000	28000	250	1100	230
25000	35000	250	1200	247
30000	42000	250	1290	263
40000	56000	250	1440	289
50000	70000	250	1590	312
60000	84000	250	1710	334

N_{Sd}: quasi static load (SLS)
N_{max}: max load (ULS)
d_{Ed}: horizontal displacement (±D_{Ed})
A: bottom plate dimension
B: Upper plate dimension
HT: Total height
R: equivalent radius (from 1500mm to 6000mm)
μ: dynamic friction coefficient (from 1,5% to 10%)

Note: The dimension B is given in the table
for the standard design displacement D_{Ed} = ±250 mm
For different values of D the dimension B will be increased by 2 Δd_{Ed}
For instance if d_{Ed} = ±500 mm will be B = B_{250} + 250 mm



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References

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Dintai Building
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Green Museum
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