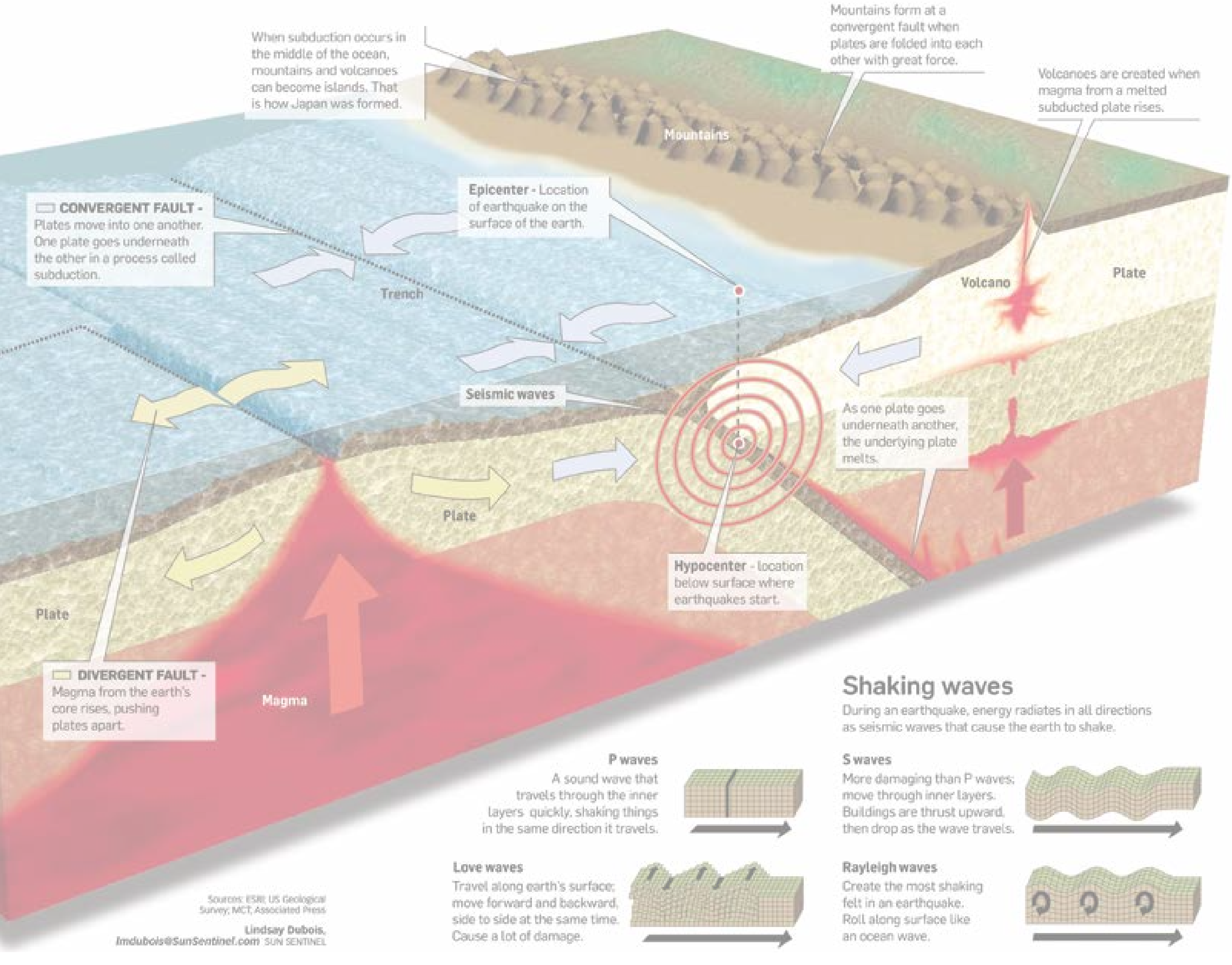
TECHNICAL INFORMATION

SEISMIC ISOLATORS

TECHNICAL INFORMATION

TABLE OF CONTENTS



When subduction occurs in the middle of the ocean, mountains and volcanoes can become islands. That is how Japan was formed.
Mountains form at a convergent fault when plates are folded into each other with great force.
Volcanoes are created when magma from a melted subducted plate rises.
Mountains
CONVERGENT FAULT - Plates move into one another. One plate goes underneath the other in a process called subduction.
Epicenter - Location of earthquake on the surface of the earth.
Trench
Volcano
Plate
Seismic waves
As one plate goes underneath another, the underlying plate melts.
Plate
Hypocenter - location below surface where earthquakes start.
Plate
DIVERGENT FAULT - Magma from the earth's core rises, pushing plates apart.
Magma
Shaking waves
During an earthquake, energy radiates in all directions as seismic waves that cause the earth to shake.
P waves
A sound wave that travels through the inner layers quickly, shaking things in the same direction it travels.
S waves
More damaging than P waves; move through inner layers. Buildings are thrust upward, then drop as the wave travels.
Love waves
Travel along earth's surface; move forward and backward, side to side at the same time. Cause a lot of damage.
Rayleigh waves
Create the most shaking felt in an earthquake. Roll along surface like an ocean wave.
Sources: ESRI; US Geological Survey; MCT; Associated Press
Lindsay Dubois, lmdubois@SunSentinel.com SUN SENTINEL

Base isolation

The principles of base isolation Why?

Base isolation offers important advantages over conventional protection methods because it reduces the earthquake forces transmitted into a structure. Thus it protects not only the structure itself but also the contents and secondary structural features. Such a capability is particularly important for buildings such as hospitals and emergency facilities that need to maintain full serviceability after an earthquake.
Base isolation has now become an established and accepted technology all over the world. The technique is applicable to bridges and industrial structures, such as LNG tanks, in addition to buildings. It is suitable for upgrading existing buildings.
The capability to protect the contents is a major advantage for buildings such as hospitals and emergency centres where maintenance of functions during and after an earthquake is necessary, and in cases such as museums and advanced technology factories where the value of the contents is high.

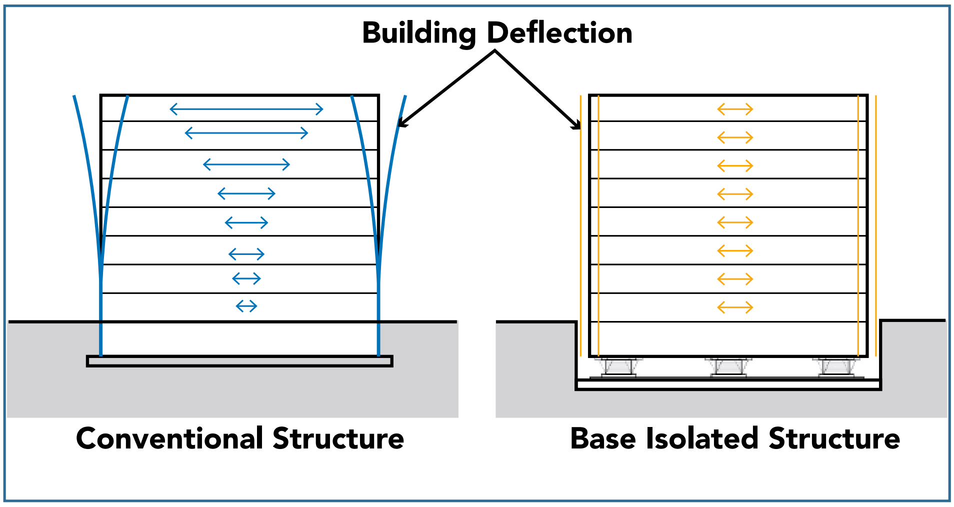
In seismic isolation part or all of the superstructure is separated from the lower part of the structure by an interface that is soft and flexible in the horizontal direction. Generally, the interface is placed between the foundation or basement and the ground floor and so the term base isolation can be accurately applied.

In a base isolated building, the structure is isolated from its foundations so as to minimize the effect of ground motion on the superstructure and, thereby, reduce its force and deflection response. The difference in how conventional structures and base isolated structures respond to earthquakes is illustrated in the figure below.

Typical damage in conventional structures

Savings in the superstructure can be expected through a reduction of forces afforded by the isolation. The reduction in forces also allows for greater flexibility in space planning and reduced footprint of structural elements. Additionally, foundations under lateral load resisting elements may be reduced with base isolation.

Response of Conventional Structures and Base Isolated Structures to Earthquakes

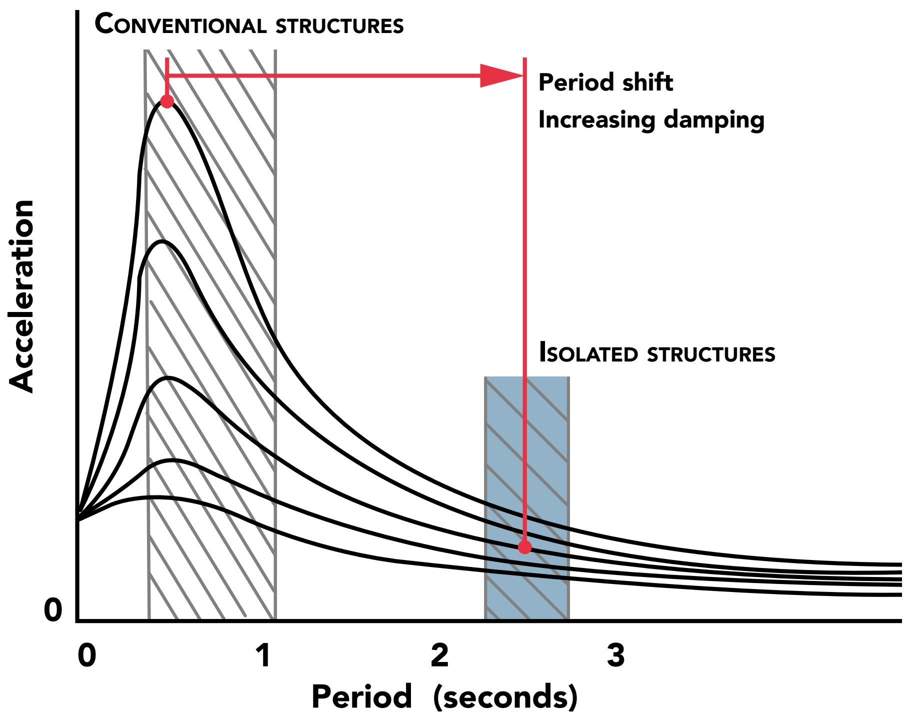


The principles of base isolation How?

Isolation is achieved by mounting the structure on a system of supports giving a low stiffness in the horizontal direction. The natural period of the structure on the isolation system is typically two seconds. This period is chosen to be long compared with both the dominant period of the earthquake ground shaking and the period of the superstructure in the fixed-base conditions.

The figure below shows that the period lengthening achieved greatly reduces the acceleration response compared with that of a typical conventional structure. It also shows that the response to input excitations at the isolation period and the amplitude of the horizontal movement of the structure.

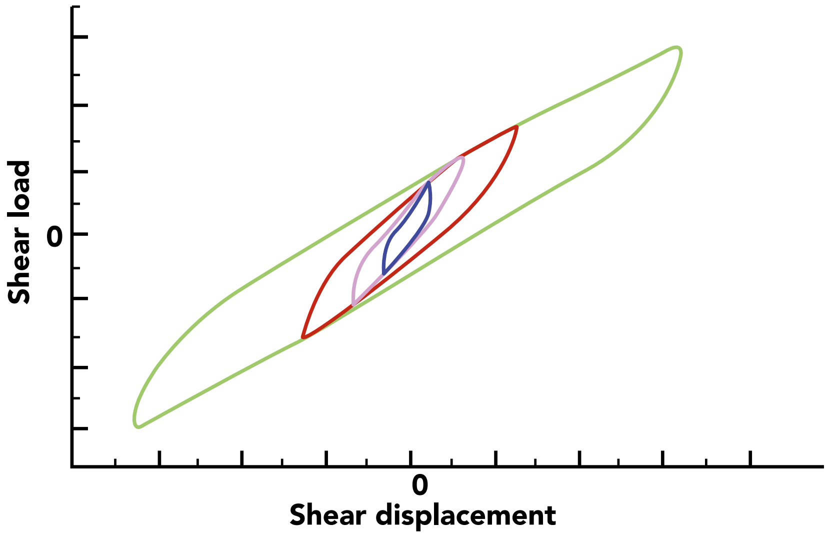
It is important to realise that despite the need for some damping, the isolators are not principally acting to absorb the energy of the earthquake, but are providing an interface that reflects earthquake energy back into the ground so reducing its transmission into the structure.



The effect of the isolation system is that during an earthquake the structure moves virtually as a rigid body on the isolators. The deformation is concentrated at the isolation interface, but unlike the structure, the isolation system can accomodate large deformations without significant damage. Because the technique is one of isolation it should be noted that high levels of damping (>15-18%) are not beneficial for structures (eg. multi-storey buildings) for which higher level oscillation modes may be excited.

Characterisation of High Damping Rubber Bearings

For a correct dimensioning of damping rubber bearings, in view of an intervention of base isolation of a structure, we need to consider properly the following typical properties: horizontal stiffness [kN/mm], damping [%], horizontal displacement capacity [mm], vertical stiffness [kN/mm], vertical load capacity [kN].



The horizontal force-deflection loops for a small bearing over a range of displacements are shown in the figure above; the stiffness is seen to be higher at small deflections. The area of the loops indicates the level of damping intrinsic to the bearing.

A bearing can be designed to have the characteristics desired by adjusting:

- shear modulus of rubber compound;
- plan area;
- thickness and number of rubber layers;
- thickness of steel reinforcing plates.

Generally, an equivalent linear model is used to represent the stiffness and damping of the isolator.

High Damping Rubber Bearings

Base isolation of a structure requires an interface with the following characteristics between the foundation and the superstructure:

- low horizontal stiffness at design displacement;
- high vertical stiffness;
- capability to support the gravity load of structure over long term;
- capacity to accomodate large horizontal displacements during earthquakes and at same time support vertical load including seismic loads;
- moderate level of damping;
- capability to re-centre structure after the earthquake;
- stable stiffness and damping properties over long term;
- high initial horizontal stiffness to provide wind restraint;
- ability to function again after the design earthquake.

Simple, cost-effective and maintenance free

High Damping Rubber Bearings (HDRBs) are a simple, cost-effective and maintenance-free means of providing the isolation interface. They can be designed to withstand the design earthquakes without significant damage.
The HDRB consists of alternative layers of rubber and steel. The steel plates can greatly increase the vertical stiffness of the bearing; a ratio of around 800:1 between vertical and horizontal stiffness is typical. The plates enables the bearing to support the vertical load even under a large shear displacement.
The bearing is supporting the design vertical load even with a shear deformation sufficient to produce no overlap between the top and bottom bearing endplates. A strong bond between the rubber and steel is critically important to the correct functioning of the bearing. The rubber (usually a compound based on natural rubber) is specially formulated to give the damping required.
The use of high damping rubber avoids the need for auxiliary dampers such as viscous or elasto-plastic steel dampers in the isolation system.

Bit "High Damping Rubber Bearings" (HDRBs)

BIT's HDRBs, manufactured by DOSHIN RUBBER, are steel laminated rubber bearings made on specially formulated high damping rubber compounds.
The rubber compounds used for the production of BIT's HDRBs are characterized by a dynamic shear modulus G variable from 0,6 to 1,3 MPa and an equivalent viscous damping coefficient (at shear strain, y=1) varying from 10 to 20%. The non-linear behavior of the compounds means at low strains the modulus is higher, allowing only slight movement due to forces such as wind. The steel lamination ensures a high compression stiffness to support the vertical load.
Three different rubber compound are available as standard:

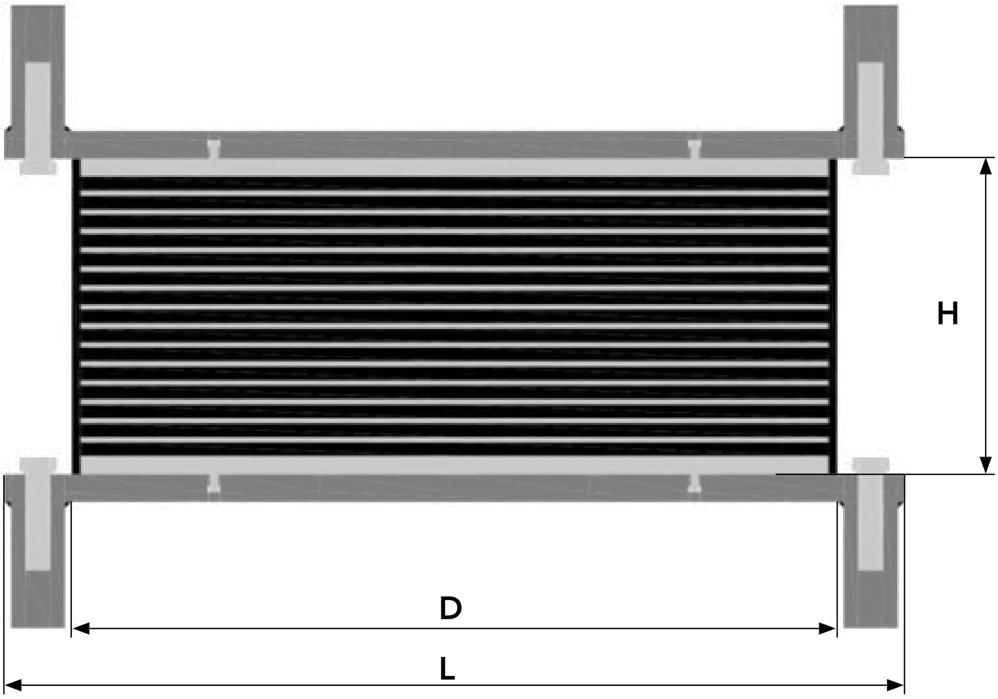
- soft compound (S), with a low modulus (G= 0,6 MPa);
- normal compound (N), with a medium modulus (G=0,9 MPa);
- hard compound (H), with a high modulus (G=1,3 MPa).

Three standard compounds

BIT's HDRBs are identified by the mark DSH followed by a letter (S, N or H to indicate the type of compound - soft, normal or hard) and 2 numbers; the first representing the diameter in millimeters while the second indicates the total thickness of rubber in millimeters.
BIT, together with its partner for manufacturing partner (DOSHIN RUBBER), can develop alternative rubber compounds to satisfy different design requirements and can design seismic isolators to all the international standards.
The information provided is intended for preliminary calculations. BIT would discuss with its clients their application and would be happy to consider any adjustments to the geometry and connection details of the bearings to suit the project requirements.

Compounds for every needs

BIT can develop alternative rubber compounds to satisfy different design requirements and can design seismic isolators to all international standards.



LEGEND:

D = diameter

$\mathbf{d}_{max}$ = maximum horizontal displacement (including seismic actions)

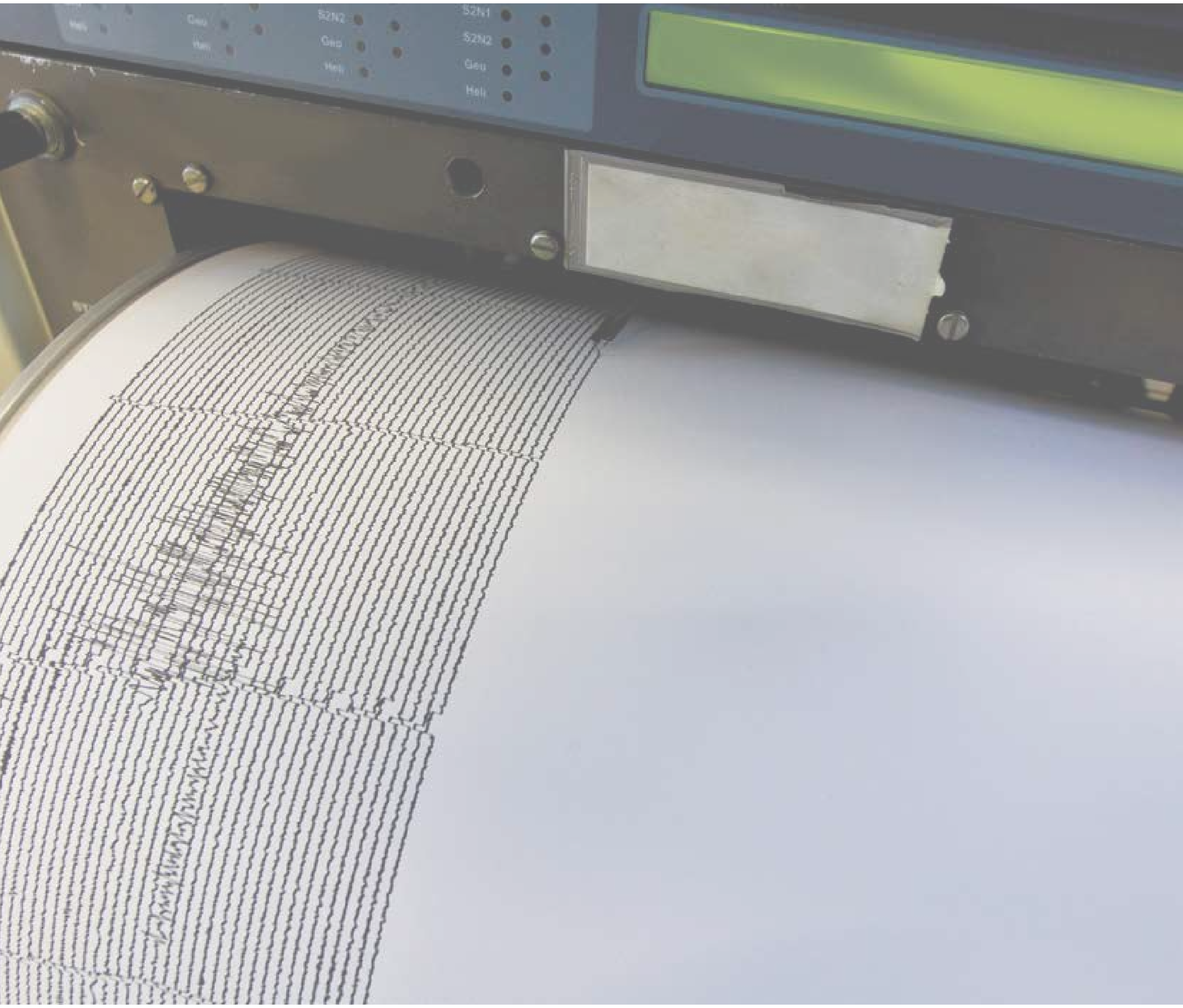
$\mathbf{F}_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement

$\mathbf{N}_{Ed,max}$ = maximum vertical load including seismic load combinations

$\mathbf{K}_v$ = vertical stiffness

$\mathbf{K}_h$ = effective horizontal stiffness at $\gamma = 1$

$\mathbf{T}_r$ = total height of rubber



TECHNICAL INFORMATION

Soft Compound (standard) - G=0,6 MPa

DISPLACEMENT 100 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 300/52	300	100	2300	1400	840	0.8	52	138	400
DSH-S 350/50	350	100	3700	2400	1130	1.2	50	136	450
DSH-S 400/54	400	100	5000	3300	1310	1.4	54	136	500
DSH-S 450/54	450	100	8200	5600	1970	1.8	54	136	550
DSH-S 500/56	500	100	10600	7400	2240	2.1	56	134	600
DSH-S 550/56	550	100	11600	9800	2610	2.5	56	130	650
DSH-S 600/54	600	100	15500	13200	3120	3.1	54	129	700
DSH-S 650/54	650	100	18300	18300	4110	3.7	54	139	750
DSH-S 700/50	700	100	19200	19200	4980	4.6	50	130	800
DSH-S 800/60	800	100	21000	21000	5140	5.0	60	140	900
DSH-S 900/52	900	100	24700	24700	7970	7.3	52	127	1000
DSH-S 1000/56	1000	100	28400	28400	9580	8.4	56	131	1100
DSH-S 1100/64	1100	100	30200	30200	9710	8.9	64	139	1200
DSH-S 1200/51	1200	100	34000	34000	15090	13.3	51	121	1300

DISPLACEMENT 150 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 300/76	300	150	1500	800	580	0.6	76	180	400
DSH-S 350/75	350	150	2400	1300	750	0.8	75	167	450
DSH-S 400/78	400	150	3400	2000	910	1.0	78	164	500
DSH-S 450/78	450	150	5700	3500	1360	1.2	78	164	550
DSH-S 500/77	500	150	7700	4900	1630	1.5	77	157	600
DSH-S 550/80	550	150	9600	6300	1830	1.8	80	166	650
DSH-S 600/81	600	150	12100	8200	2080	2.1	81	163	700
DSH-S 650/81	650	150	16900	11500	2740	2.5	81	181	750
DSH-S 700/80	700	150	19200	14500	3110	2.9	80	175	800
DSH-S 800/84	800	150	21000	20500	3670	3.6	84	174	900
DSH-S 900/78	900	150	24700	24700	5310	4.9	78	163	1000
DSH-S 1000/84	1000	150	28400	28400	6390	5.6	84	169	1100
DSH-S 1100/80	1100	150	30200	30200	7770	7.1	80	160	1200
DSH-S 1200/85	1200	150	34000	34000	9050	8.0	85	165	1300

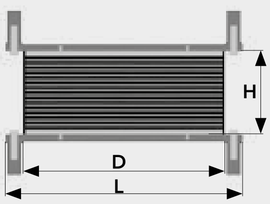
Soft Compound (standard) - G=0,6 MPa

DISPLACEMENT 200 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 350/100	350	200	1800	800	560	0.6	100	207	450
DSH-S 400/102	400	200	2600	1300	690	0.7	102	200	500
DSH-S 450/102	450	200	4300	2400	1040	0.9	102	200	550
DSH-S 500/105	500	200	5600	3300	1190	1.1	105	197	600
DSH-S 550/104	550	200	7400	4500	1400	1.4	104	190	650
DSH-S 600/108	600	200	9100	5700	1560	1.6	108	191	700
DSH-S 650/108	650	200	12700	8100	2050	1.8	108	212	750
DSH-S 700/100	700	200	16700	10900	2490	2.3	100	205	800
DSH-S 800/108	800	200	21000	15100	2850	2.8	108	208	900
DSH-S 900/104	900	200	24700	24000	3980	3.7	104	199	1000
DSH-S 1000/112	1000	200	28400	28400	4790	4.2	112	207	1100
DSH-S 1100/112	1100	200	30200	30200	5550	5.1	112	202	1200
DSH-S 1200/102	1200	200	34000	34000	7550	6.7	102	187	1300

DISPLACEMENT 250 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 400/126	400	250	2100	900	560	0.6	126	236	500
DSH-S 450/126	450	250	3500	1700	840	0.8	126	236	550
DSH-S 500/126	500	250	4700	2400	990	0.9	126	227	600
DSH-S 550/128	550	250	6000	3300	1140	1.1	128	223	650
DSH-S 600/126	600	250	7800	4500	1340	1.3	126	215	700
DSH-S 650/126	650	250	10900	6400	1760	1.6	126	238	750
DSH-S 700/130	700	250	12900	7800	1910	1.8	130	238	800
DSH-S 800/132	800	250	18300	11600	2340	2.3	132	242	900
DSH-S 900/130	900	250	24700	18300	3190	2.9	130	235	1000
DSH-S 1000/126	1000	250	28400	27700	4260	3.7	126	226	1100
DSH-S 1100/128	1100	250	30200	30200	4860	4.5	128	223	1200
DSH-S 1200/136	1200	250	34000	34000	5660	5.0	136	231	1300



LEGEND:

D = diameter
d_{max} = maximum horizontal displacement (including seismic actions)
$F_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement
$N_{Ed,max}$ = maximum vertical load including seismic load combinations
K_v = vertical stiffness
K_h = effective horizontal stiffness at $\gamma = 1$
T_r = total height of rubber

Soft Compound (standard) - G=0,6 MPa

DISPLACEMENT 300 mm

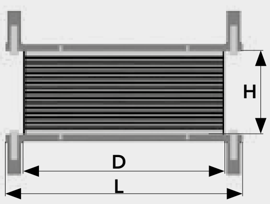
Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 450/150	450	300	2900	1200	710	0.6	150	272	550
DSH-S 500/154	500	300	3800	1700	810	0.8	154	267	600
DSH-S 550/152	550	300	5000	2500	960	0.9	152	256	650
DSH-S 600/153	600	300	6400	3300	1100	1.1	153	251	700
DSH-S 650/153	650	300	8900	4900	1450	1.3	153	277	750
DSH-S 700/150	700	300	11100	6300	1660	1.5	150	266	800
DSH-S 800/156	800	300	15500	9300	1980	1.9	156	264	900
DSH-S 900/156	900	300	23200	14500	2660	2.4	156	271	1000
DSH-S 1000/154	1000	300	28400	21700	3480	3.1	154	264	1100
DSH-S 1100/160	1100	300	30200	27600	3890	3.6	160	265	1200
DSH-S 1200/153	1200	300	34000	34000	5030	4.4	153	253	1300

DISPLACEMENT 350 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 550/176	550	350	4400	1900	830	0.8	176	320	650
DSH-S 600/180	600	350	5400	2500	940	0.9	180	316	700
DSH-S 650/180	650	350	7600	3800	1230	1.1	180	316	750
DSH-S 700/180	700	350	9300	4800	1380	1.3	180	308	800
DSH-S 800/180	800	350	13400	7500	1710	1.7	180	296	900
DSH-S 900/182	900	350	19900	11800	2280	2.1	182	307	1000
DSH-S 1000/182	1000	350	28400	17500	2950	2.6	182	302	1100
DSH-S 1100/176	1100	350	30200	24100	3530	3.2	176	286	1200
DSH-S 1200/187	1200	350	34000	31200	4120	3.6	187	297	1300

DISPLACEMENT 400 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-S 600/207	600	400	4700	2000	810	0.8	207	355	700
DSH-S 650/207	650	400	6600	3000	1070	1.0	207	355	750
DSH-S 700/200	700	400	8300	4000	1240	1.2	200	336	800
DSH-S 800/204	800	400	11800	6200	1510	1.5	204	328	900
DSH-S 900/208	900	400	17400	9700	1990	1.8	208	328	1000
DSH-S 1000/210	1000	400	24600	14400	2560	2.2	210	340	1100
DSH-S 1100/208	1100	400	30200	19500	2990	2.7	208	328	1200
DSH-S 1200/204	1200	400	34000	27500	3770	3.3	204	319	1300



LEGEND:

- D = diameter
- d_{max} = maximum horizontal displacement (including seismic actions)
- $F_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement
- $N_{Ed,max}$ = maximum vertical load including seismic load combinations
- K_v = vertical stiffness
- K_h = effective horizontal stiffness at $\gamma = 1$
- T_r = total height of rubber

Normal Compound (standard) - G=0,9 MPa

DISPLACEMENT 100 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 300/52	300	100	3400	2100	1070	1.2	52	138	400
DSH-N 350/50	350	100	5500	3600	1450	1.7	50	136	450
DSH-N 400/54	400	100	7500	5000	1700	2.1	54	136	500
DSH-N 450/54	450	100	10200	8500	2500	2.7	54	136	550
DSH-N 500/56	500	100	10900	10900	2860	3.2	56	134	600
DSH-N 550/56	550	100	11600	11600	3360	3.8	56	130	650
DSH-N 600/54	600	100	15500	15500	4040	4.7	54	129	700
DSH-N 650/54	650	100	18300	18300	5230	5.5	54	139	750
DSH-N 700/50	700	100	19200	19200	6370	6.9	50	130	800
DSH-N 800/60	800	100	21000	21000	6640	7.5	60	140	900
DSH-N 900/52	900	100	24700	24700	10210	11.0	52	127	1000
DSH-N 1000/56	1000	100	28400	28400	12200	12.6	56	131	1100
DSH-N 1100/64	1100	100	30200	30200	12460	13.4	64	139	1200
DSH-N 1200/51	1200	100	34000	34000	19250	20.0	51	121	1300

DISPLACEMENT 150 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 300/76	300	150	2300	1200	730	0.8	76	180	400
DSH-N 350/75	350	150	3700	2000	970	1.2	75	167	450
DSH-N 400/78	400	150	5200	3100	1180	1.4	78	164	500
DSH-N 450/78	450	150	8600	5300	1730	1.8	78	176	550
DSH-N 500/77	500	150	10900	7400	2080	2.3	77	167	600
DSH-N 550/80	550	150	11600	9500	2350	2.7	80	166	650
DSH-N 600/81	600	150	12400	12300	2690	3.1	81	163	700
DSH-N 650/81	650	150	18300	17300	3490	3.7	81	181	750
DSH-N 700/80	700	150	19200	19200	3980	4.3	80	175	800
DSH-N 800/84	800	150	21000	21000	4740	5.4	84	174	900
DSH-N 900/78	900	150	24700	24700	6810	7.3	78	163	1000
DSH-N 1000/84	1000	150	28400	28400	8140	8.4	84	169	1100
DSH-N 1100/80	1100	150	30200	30200	9960	10.7	80	160	1200
DSH-N 1200/85	1200	150	34000	34000	11550	12.0	85	165	1300

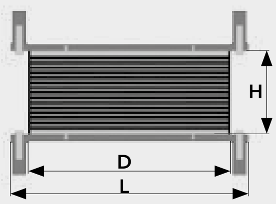
Normal Compound (standard) - G=0,9 MPa

DISPLACEMENT 200 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 350/100	350	200	2700	1300	730	0.9	100	207	450
DSH-N 400/102	400	200	4000	2000	900	1.1	102	200	500
DSH-N 450/102	450	200	6500	3600	1320	1.4	102	200	550
DSH-N 500/105	500	200	8500	4900	1530	1.7	105	211	600
DSH-N 550/104	550	200	11100	6700	1810	2.1	104	202	650
DSH-N 600/108	600	200	12400	8500	2020	2.4	108	202	700
DSH-N 650/108	650	200	18300	12100	2620	2.8	108	223	750
DSH-N 700/100	700	200	19200	16400	3190	3.5	100	205	800
DSH-N 800/108	800	200	21000	21000	3690	4.2	108	208	900
DSH-N 900/104	900	200	24700	24700	5110	5.5	104	199	1000
DSH-N 1000/112	1000	200	28400	28400	6100	6.3	112	207	1100
DSH-N 1100/112	1100	200	30200	30200	7120	7.6	112	202	1200
DSH-N 1200/102	1200	200	34000	34000	9620	10.0	102	187	1300

DISPLACEMENT 250 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 400/126	400	250	3200	1400	730	0.9	126	236	500
DSH-N 450/126	450	250	5300	2500	1070	1.1	126	236	550
DSH-N 500/126	500	250	7000	3700	1270	1.4	126	227	600
DSH-N 550/128	550	250	9000	5000	1470	1.7	128	238	650
DSH-N 600/126	600	250	11700	6700	1730	2.0	126	228	700
DSH-N 650/126	650	250	16300	9600	2240	2.4	126	251	750
DSH-N 700/130	700	250	19200	11800	2450	2.7	130	250	800
DSH-N 800/132	800	250	21000	17500	3020	3.4	132	242	900
DSH-N 900/130	900	250	24700	24700	4080	4.4	130	235	1000
DSH-N 1000/126	1000	250	28400	28400	5420	5.6	126	226	1100
DSH-N 1100/128	1100	250	30200	30200	6230	6.7	128	223	1200
DSH-N 1200/136	1200	250	34000	34000	7220	7.5	136	231	1300



LEGEND:

D = diameter

d_{max} = maximum horizontal displacement (including seismic actions)

$F_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement

$N_{Ed,max}$ = maximum vertical load including seismic load combinations

K_v = vertical stiffness

K_h = effective horizontal stiffness at $\gamma = 1$

T_r = total height of rubber

Normal Compound (standard) - G=0,9 MPa

DISPLACEMENT 300 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 450/150	450	300	4400	1800	900	1.0	150	272	550
DSH-N 500/154	500	300	5800	2600	1040	1.1	154	267	600
DSH-N 550/152	550	300	7600	3700	1240	1.4	152	256	650
DSH-N 600/153	600	300	9600	5000	1420	1.7	153	267	700
DSH-N 650/153	650	300	13400	7300	1850	2.0	153	293	750
DSH-N 700/150	700	300	16700	9500	2120	2.3	150	280	800
DSH-N 800/156	800	300	21000	13900	2550	2.9	156	276	900
DSH-N 900/156	900	300	24700	21800	3400	3.7	156	271	1000
DSH-N 1000/154	1000	300	28400	28400	4440	4.6	154	264	1100
DSH-N 1100/160	1100	300	30200	30200	4980	5.3	160	265	1200
DSH-N 1200/153	1200	300	34000	34000	6420	6.7	153	253	1300

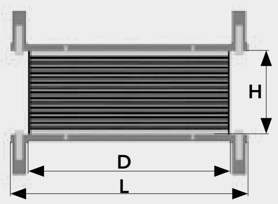
DISPLACEMENT 350 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 550/176	550	350	6600	2900	1070	1.2	176	341	650
DSH-N 600/180	600	350	8200	3800	1210	1.4	180	335	700
DSH-N 650/180	650	350	11400	5700	1570	1.7	180	335	750
DSH-N 700/180	700	350	13900	7300	1770	1.9	180	325	800
DSH-N 800/180	800	350	20100	11300	2210	2.5	180	310	900
DSH-N 900/182	900	350	24700	17700	2920	3.1	182	307	1000
DSH-N 1000/182	1000	350	28400	26300	3760	3.9	182	302	1100
DSH-N 1100/176	1100	350	30200	30200	4530	4.9	176	286	1200
DSH-N 1200/187	1200	350	34000	34000	5250	5.4	187	297	1300

Normal Compound (standard) - G=0,9 MPa

DISPLACEMENT 400 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-N 600/207	600	400	7100	3000	1050	1.2	207	377	700
DSH-N 650/207	650	400	9900	4500	1360	1.4	207	377	750
DSH-N 700/200	700	400	12500	6000	1590	1.7	200	355	800
DSH-N 800/204	800	400	17800	9300	1950	2.2	204	344	900
DSH-N 900/234	900	400	23200	13000	2270	2.4	234	379	1000
DSH-N 1000/210	1000	400	28400	21700	3250	3.4	210	340	1100
DSH-N 1100/208	1100	400	30200	29300	3830	4.1	208	328	1200
DSH-N 1200/204	1200	400	34000	34000	4810	5.0	204	319	1300



LEGEND:

D = diameter

d_{max} = maximum horizontal displacement (including seismic actions)

$F_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement

$N_{Ed,max}$ = maximum vertical load including seismic load combinations

K_v = vertical stiffness

K_h = effective horizontal stiffness at γ =1

T_r = total height of rubber

Hard Compound (standard) - G=1,3 MPa

DISPLACEMENT 100 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 300/52	300	100	5000	3000	1290	1.8	52	150	400
DSH-H 350/50	350	100	8000	5200	1760	2.5	50	145	450
DSH-H 400/50	400	100	11900	9400	2650	3.3	50	145	500
DSH-H 450/54	450	100	12700	12300	2990	3.8	54	144	550
DSH-H 500/56	500	100	13600	13600	3450	4.6	56	141	600
DSH-H 550/56	550	100	16600	16600	4600	5.5	56	141	650
DSH-H 600/56	600	100	17400	17400	5300	6.6	56	136	700
DSH-H 650/54	650	100	18300	18300	6290	8.0	54	139	750
DSH-H 700/50	700	100	19200	19200	7700	10.0	50	130	800
DSH-H 800/60	800	100	21000	21000	8090	10.9	60	140	900
DSH-H 900/52	900	100	24700	24700	12350	15.9	52	127	1000
DSH-H 1000/56	1000	100	28400	28400	14670	18.2	56	131	1100
DSH-H 1100/64	1100	100	30200	30200	15080	19.3	64	139	1200
DSH-H 1200/51	1200	100	34000	34000	23180	28.8	51	121	1300

DISPLACEMENT 150 mm

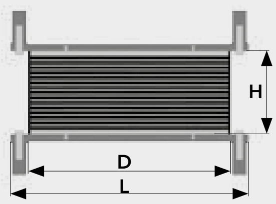
Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 300/76	300	150	3400	1700	880	1.2	76	198	400
DSH-H 350/75	350	150	5300	3000	1180	1.7	75	181	450
DSH-H 400/75	400	150	9400	5600	1770	2.2	75	181	500
DSH-H 450/78	450	150	12400	7700	2070	2.7	78	188	550
DSH-H 500/77	500	150	13600	10700	2510	3.3	77	177	600
DSH-H 550/77	550	150	16600	16400	3340	4.0	77	177	650
DSH-H 600/80	600	150	17400	17400	3710	4.6	80	175	700
DSH-H 650/81	650	150	18300	18300	4190	5.3	81	181	750
DSH-H 700/80	700	150	19200	19200	4810	6.3	80	175	800
DSH-H 800/84	800	150	21000	21000	5780	7.8	84	174	900
DSH-H 900/78	900	150	24700	24700	8240	10.6	78	163	1000
DSH-H 1000/84	1000	150	28400	28400	9780	12.2	84	169	1100
DSH-H 1100/80	1100	150	30200	30200	12060	15.4	80	160	1200
DSH-H 1200/85	1200	150	34000	34000	13910	17.3	85	165	1300

DISPLACEMENT 200 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 350/100	350	200	4000	1900	880	1.3	100	226	450
DSH-H 400/100	400	200	7000	3600	1330	1.6	100	226	500
DSH-H 450/102	450	200	9500	5200	1580	2.0	102	216	550
DSH-H 500/105	500	200	12200	7100	1840	2.4	105	225	600
DSH-H 550/105	550	200	16600	11000	2450	2.9	105	225	650
DSH-H 600/104	600	200	17400	14400	2860	3.5	104	214	700
DSH-H 650/108	650	200	18300	17600	3140	4.0	108	213	750
DSH-H 700/100	700	200	19200	19200	3850	5.0	100	205	800
DSH-H 800/108	800	200	21000	21000	4490	6.1	108	208	900
DSH-H 900/104	900	200	24700	24700	6180	8.0	104	199	1000
DSH-H 1000/112	1000	200	28400	28400	7340	9.1	112	207	1100
DSH-H 1100/112	1100	200	30200	30200	8620	11.0	112	202	1200
DSH-H 1200/102	1200	200	34000	34000	11590	14.4	102	187	1300

DISPLACEMENT 250 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 400/125	400	250	5600	2500	1060	1.3	125	271	500
DSH-H 450/126	450	250	7600	3700	1280	1.6	126	256	550
DSH-H 500/126	500	250	10200	5300	1540	2.0	126	244	600
DSH-H 550/126	550	250	15200	8300	2040	2.5	126	261	650
DSH-H 600/128	600	250	17400	10800	2320	2.9	128	253	700
DSH-H 650/126	650	250	18300	14000	2700	3.4	126	241	750
DSH-H 700/130	700	250	19200	17000	2960	3.8	130	250	800
DSH-H 800/132	800	250	21000	21000	3680	5.0	132	242	900
DSH-H 900/130	900	250	24700	24700	4940	6.4	130	235	1000
DSH-H 1000/126	1000	250	28400	28400	6520	8.1	126	226	1100
DSH-H 1100/128	1100	250	30200	30200	7540	9.7	128	223	1200
DSH-H 1200/136	1200	250	34000	34000	8690	10.8	136	231	1300



LEGEND:

- D = diameter
- d_{max} = maximum horizontal displacement (including seismic actions)
- $F_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement
- $N_{Ed,max}$ = maximum vertical load including seismic load combinations
- K_v = vertical stiffness
- K_h = effective horizontal stiffness at $\gamma = 1$
- T_r = total height of rubber

Hard Compound (standard) - G=1,3 MPa

Hard Compound (standard) - G=1,3 MPa

DISPLACEMENT 300 mm

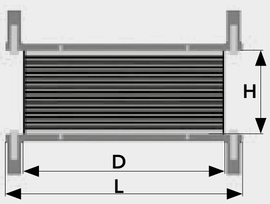
Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 450/150	450	300	6400	2700	1080	1.4	150	296	550
DSH-H 500/154	500	300	8300	3800	1260	1.7	154	288	600
DSH-H 550/154	550	300	12400	6100	1670	2.0	154	288	650
DSH-H 600/152	600	300	15800	8300	1950	2.4	152	292	700
DSH-H 650/153	650	300	18300	10600	2220	2.8	153	283	750
DSH-H 700/150	700	300	19200	13700	2570	3.3	150	280	800
DSH-H 800/156	800	300	21000	20200	3110	4.2	156	276	900
DSH-H 900/156	900	300	24700	24700	4120	5.3	156	271	1000
DSH-H 1000/154	1000	300	28400	28400	5340	6.6	154	264	1100
DSH-H 1100/160	1100	300	30200	30200	6030	7.7	160	265	1200
DSH-H 1200/153	1200	300	34000	34000	7730	9.6	153	253	1300

DISPLACEMENT 350 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 550/175	550	350	10900	4800	1470	1.8	175	321	650
DSH-H 600/176	600	350	13600	6500	1690	2.1	176	310	700
DSH-H 650/180	650	350	18300	8300	1890	2.4	180	325	750
DSH-H 700/180	700	350	19200	10600	2140	2.8	180	325	800
DSH-H 800/180	800	350	21000	16400	2700	3.6	180	310	900
DSH-H 900/182	900	350	24700	24700	3530	4.5	182	307	1000
DSH-H 1000/182	1000	350	28400	28400	4510	5.6	182	302	1100
DSH-H 1100/176	1100	350	30200	30200	5480	7.0	176	286	1200
DSH-H 1200/187	1200	350	34000	34000	6320	7.9	187	297	1300

DISPLACEMENT 400 mm

Mark	D (mm)	d_{max} (mm)	$F_{z,d}$ (kN)	$N_{Ed,max}$ (kN)	K_v (kN/mm)	K_h (kN/mm)	T_r (mm)	H (mm)	L (mm)
DSH-H 600/200	600	400	12000	5100	1480	1.8	200	346	700
DSH-H 650/207	650	400	14300	6500	1640	2.1	207	345	750
DSH-H 700/200	700	400	18100	8700	1930	2.5	200	355	800
DSH-H 800/204	800	400	21000	13500	2380	3.2	204	344	900
DSH-H 900/234	900	400	24700	18800	2750	3.5	234	379	1000
DSH-H 1000/210	1000	400	28400	28400	3910	4.9	210	340	1100
DSH-H 1100/208	1100	400	30200	30200	4640	5.9	208	328	1200
DSH-H 1200/204	1200	400	34000	34000	5800	7.2	204	319	1300



LEGEND:

D = diameter

d_{max} = maximum horizontal displacement (including seismic actions)

$F_{z,d}$ = maximum vertical load (non-seismic) at ULS with zero horizontal displacement

$N_{Ed,max}$ = maximum vertical load including seismic load combinations

K_v = vertical stiffness

K_h = effective horizontal stiffness at $\gamma = 1$

T_r = total height of rubber

MEMOS

MEMOS

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B_03_2018