DOSHIN®
RUBBER ENGINEERING

SEISMIC ISOLATION

BASE ISOLATORS

Design according to

BS EN 15129

SEISMIC ISOLATOR HDRB & LRB · DOSHIN RUBBER ·
CE

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DOSHIN RUBBER ENGINEERING

Company Overview

DOSHIN RUBBER PRODUCTS (M) SDN BHD

Doshin Rubber is one of the leading rubber manufacturers in specialized rubber products for civil engineering applications and is also a subsidiary of Kossan group of companies, a public-listed company in the stock exchange of Malaysia (Bursa Malaysia). Located in Klang, Malaysia, Doshin Rubber designs, manufactures and tests a wide range of rubber products such as seismic bearing, structural bearing, marine dock fender, and expansion joint. Over 40 years, Doshin Rubber has branded ourselves as committed manufacturer through accreditations of our production and testing capability to international standards such as ISO 9001 and ISO 17025. Doshin Rubber has obtained the CE Marking certification for seismic isolation products such as the Lead Rubber Bearing (LRB), High Damping Rubber Bearing (HDRB) and Friction Pendulum Bearing which means that the manufacturing and testing procedures are in full conformity to European Union (EU) Standards. Our full in-house testing facilities have the capacity to test seismic bearing up to 2000 mm in diameter or maximum shear movement of + 1200 mm. We have one of the world's largest testing facilities to achieve 50 000 kN of compression force and 4 000 kN shear for combined compression and shear test of seismic isolators. We have experienced teams working together to provide unique solutions tailored to suit the needs of different project requirements respectively.

1.0 BASE ISOLATION

1.1 Importance of Base Isolation

Base isolation offers important advantages over a conventional protection method 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. This is particularly important for buildings with important contents such as hospitals or 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. While it is usually cheaper to apply base isolation in new structure, it is also plausible to use base isolator for seismic retrofitting of existing structure.

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 addition, it does not disrupt the architectural layout of the superstructure which makes base isolation an ideal choice for seismic retrofitting of historical monuments.

Base isolation concept typically calls for separation of whole of the superstructure 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 as the term 'base isolation' suggested.

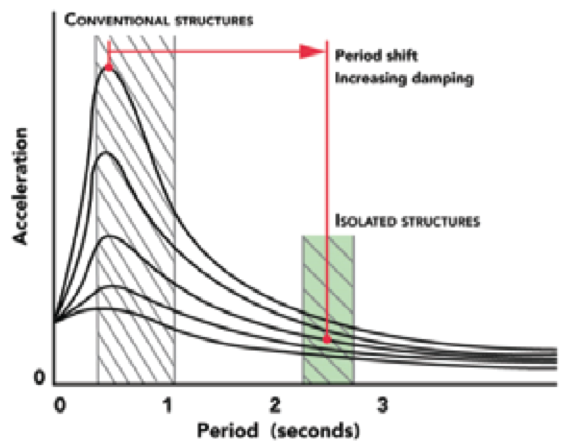
In a base isolated building, the structure is isolated from its foundations so as to minimize the effect of ground motion on the superstructure and, thereby, reduce its force and deflection response. The difference in how conventional structures and base isolated structures respond to earthquakes is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

Savings in the superstructure can be expected through a reduction of forces due to the isolation system. This reduction of forces allows for greater flexibility in space planning and reduced footprint of structural elements. As a whole, it also reduces the lateral load resisting elements of the foundations.

1.2 Concept of Base Isolation

Base isolation is achieved by mounting the structure on a system of supports which gives relatively lower stiffness in 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.

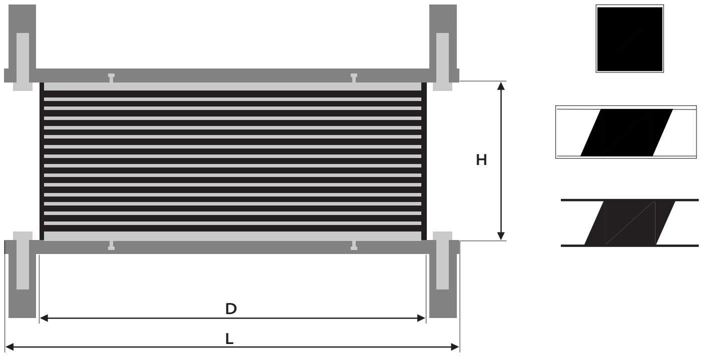
The figure below shows that the period lengthening greatly reduces the acceleration response compared with that of a typical conventional structure. It also shows that the response to input excitations at the isolation period, and the amplitude of the horizontal movement of the structure. It is important 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 decouples the building from ground motion thus reducing the transmission of forces onto the structure.



Therefore, during an earthquake, the structure moves virtually as a rigid body on the isolators. The deformation is concentrated at the isolation interface. Unlike the superstructure, the isolation system can accommodate large deformations without significant damage.

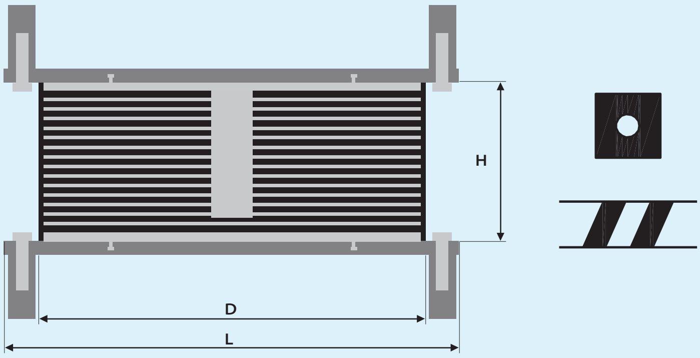
Two types of elastomeric based seismic bearings are contained within this catalogue; namely:

2.1 High Damping Rubber Bearing (HDRB)



D	=	Diameter
d_{max}	=	Maximum horizontal displacement (including seismic actions)
$F_{z,d}$	=	Maximum vertical load (non- seismic) at ULS with zero horizontaldisplacement
$N_{Ed, max}$	=	Maximum vertical load including seismic load combinations
K_v	=	vertical stiffness
K_h	=	effective horizontal stiffness at = 1
T_r	=	Totalheight of rubber

2.2 Lead Rubber Bearing (LRB)



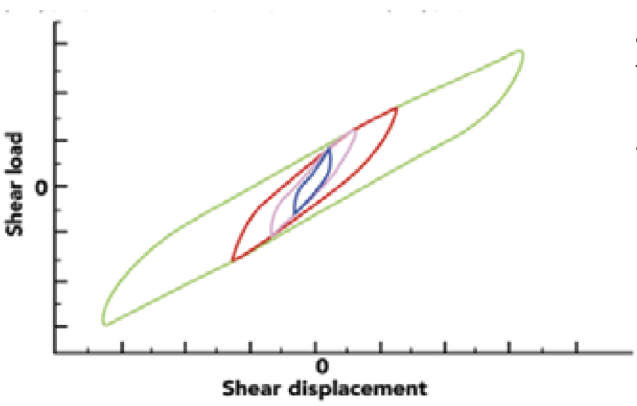
D	=	Diameter
d_{max}	=	Maximum horizontal displacement (including seismic actions)
$F_{z,d}$	=	Maximum vertical load (non- seismic) at ULS with zero horizontal displacement
$N_{Ed, max}$	=	Maximum vertical load including seismic load combinations
K_h	=	effective horizontal stiffness at = 1
T_r	=	Totalheight of rubber

Both HDRB and LRB are rubber-based seismic bearing, made of layers of steel plates and rubber layers. The major difference between the two is that in HDRB, the hysteresis damping solely depends on the formulation of the rubber compound, i.e. the mechanism of rubber in energy dissipation. In LRB, the damping is provided when the lead core yields.

3.0 CHARACTERIZATION

3.1 Characterization Of Seismic (Elastomeric) Rubber Bearings

For a correct dimensioning of elastomeric seismic bearings regardless of whether they are High Damping Rubber Bearing (HDRB) or Lead Rubber Bearing (LRB), 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] and vertical load capacity [kN].



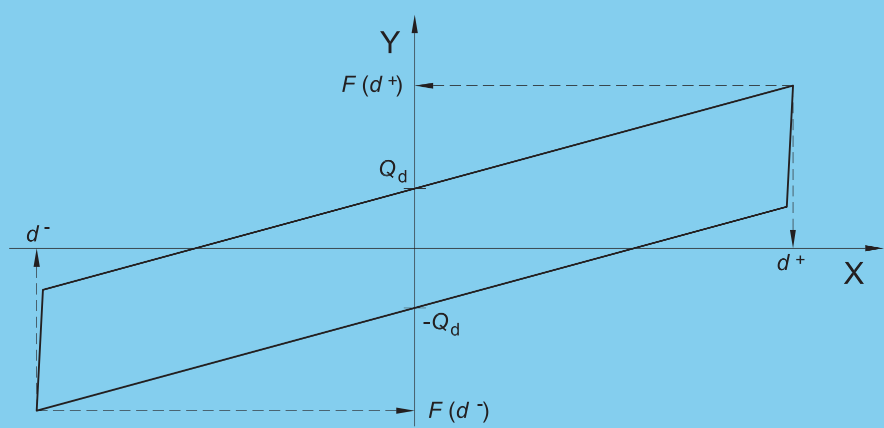
The horizontal force-deflection loops for a typical bearing over a range of displacements are shown in the figure on the left ; the stiffness is seen to be higher at small deflections. The area of the loops indicates the level of damping intrinsic to the bearing.

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

- Shear modulus of the rubber compound;
- Plan area;
- Thickness and number of rubber layers; and
- Thickness of steel reinforcing plates.

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

Schematic force-displacement loop for LRB



$$K_2 = \frac{F(d^+) - F(d^+/2)}{d^+} - \frac{F(d^-/2) - F(d^-)}{d^-}$$

Key

X Displacement

Y Force

3.2 High Damping Rubber Bearing (HDRB)

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 accommodate 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.

High Damping Rubber Bearing (HDRB) is a simple, cost-effective and maintenance-free device that provides 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. The plates enable the bearing to support the vertical load even under a large shear displacement. 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 performance especially 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.

Doshin Rubber's HDRBs are steel laminated rubber bearings made on specially formulated high damping natural rubber compounds. The rubber compounds used for the production of Doshin Rubber's HDRBs are characterized by a dynamic shear modulus G variable from 0.6 to 1.1 MPa and an equivalent viscous damping coefficient (at shear strain, y=1) varying from 10 to 20%. The non-linear behavior of the compounds characterizes that at low shear strain the shear 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 compounds are available as standard:

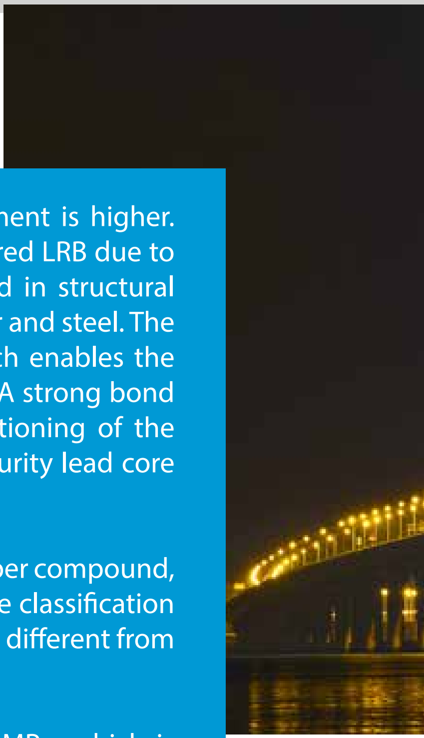
- Soft compound (S), with a low modulus (G=0.6 MPa);
- Normal compound (N), with a medium modulus (G= 0.9 MPa);
- Hard compound (H), with a high modulus = (G=1.1 MPa).

Despite having a rather comprehensive list of HDRB sizes, Doshin Rubber is able to 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. We would be pleased to discuss with our clients on their application and it is highly possible to consider for any adjustments to the geometry and connection details of the bearings to suit the project requirements. For further information or additional remarks, kindly refer to our technical department.

3.0 CHARACTERIZATION

3.3 Lead Rubber Bearing (LRB)



Lead Rubber Bearing (LRB) is used when the energy dissipation requirement is higher. Although this is also achievable by HDRB, some structural designers preferred LRB due to the established analysis model that has been well accepted and adopted in structural analysis. Similar to the HDRB, LRB also consists of alternative layers of rubber and steel. The steel plates can greatly increase the vertical stiffness of the bearing, which enables the bearing to support the vertical load even under large shear displacement. A strong bond between the rubber and steel is critically important to the correct functioning of the isolator. In LRB, the hysteresis damping is greatly influenced by the high purity lead core rather than the rubber.

Doshin Rubber's LRBs are steel laminated rubber bearings made on soft rubber compound, usually with dynamic shear modulus G of 0.4 MPa. Please be noted that, the classification of dynamic shear modulus of S, N and H compound for LRB could be slightly different from the HDRB's.

The LRB contained in this catalog is based on rubber compound of 0.4 MPa, which is typically used. However, Doshin Rubber is able to develop alternative design for different project requirements to satisfy different design standards or site requirement. Similar to the HDRB, we would be pleased to discuss with our clients on their application and it is highly possible to consider for any adjustments which is impossible to list them all in the catalog for selection.

LEAD RUBBER BEARING

4.1 Design Features

This catalogue serves for preliminary seismic bearing selection purpose. All products description and design values contained herein are accurate to our best knowledge under laboratory environment and design theory. Please contact our technical department should further information is required.

Design of the seismic bearing are shown in this section. Main steps and equations are shown. For further information or additional remarks, kindly refer to our technical department. Structural engineer has to provide essential data for bearing manufacturer to come up with the right bearing design. Determination of such data by the bearing manufacturer is not the scope of bearing manufacturer. Important design input to be made available to our technical department in order to optimize the seismic bearing design output is contained at the end of this catalogue.

4.0 DESIGN

4.1 BASIC OF DESIGN according to BS EN 15129 : 2009

4.1.1 Design shear strain due to compression by vertical loads

The design local maximum shear strain due to the compressive strain $\varepsilon_{c,E}$, corresponding to the maximum vertical load, $N_{Ed,max}$, is given by:

$$\varepsilon_{c,E} = \frac{6\ S\ N_{Ed,max}}{A_r\ E'_c}$$

S, the shape factor of the rubber layers, with internal reinforcing plates of diameter D' and rubber layer thickness t :

$$S = \frac{D'}{4t_r}$$

A_r is the reduced effective plan area due to non-seismic actions only (e.g. thermally induced actions). E'_c for rectangular devices, circular devices and annular devices with plugged hole is:

$$E'_c = 3G\ \left(1 + 2S^2\right)$$

4.1.2 Design shear strain due to earthquake-imposed horizontal displacement

The design shear strain, $\varepsilon_{q,E}$, due to the earthquake-imposed design displacement d_{bd}, is given by:

$$\varepsilon_{q,E} = \frac{d_{bd}}{T_q}$$

where T_q is the total thickness of the elastomer active during shear.

4.1.3 Buckling load at zero lateral seismic displacement

The buckling load for devices with a shape factor, $S > 5$ is given by the expression:

$$P_{cr} = \frac{\lambda\ G\ A_r\ a'S}{T_q}$$

For circular devices a' is the effective diameter D' of the device. For bearings with holes, plugged or unplugged, A_r shall exclude the area of the holes.

4.1.4 Design Shear Strain

The shear strain, $\varepsilon_{q,max}$, due to the maximum horizontal displacement, d_{bd}, shall be less than 2,5 ,

$$\varepsilon_{q,max} \leqslant 2,5$$

4.1.5 Maximum Total Design Shear Strain

The maximum total design shear strain $\varepsilon_{t,d}$ is given by the expression:

$$\varepsilon_{t,d} = K_L \left(\varepsilon_{c,E} + \varepsilon_{q,max} + \varepsilon_{\alpha,d} \right)$$

4.1.6 Buckling stability under seismic actions

$$N_{Ed,max} < P_{cr} / 2$$

For $\frac{P_{cr}}{2} > N_{Ed,max} \geq \frac{P_{cr}}{4}$, the following condition shall be satisfied:

$$1 - \frac{2N_{Ed,max}}{P_{cr}} \geq 0{,}7\delta$$

and for $N_{Ed,max} < \frac{P_{cr}}{4}$ the following condition shall be satisfied:

$$\delta \leq 0{,}7$$

where $\delta = \frac{d_{Ed}}{a'}$.

4.1.7 Roll-over stability under seismic actions

If recessed isolators or isolators with dowel connection are used by agreement of the Structural Engineer, the roll-over stability shall be checked using the following relation:

$$d_{Ed} \leq \frac{1}{\gamma_R} \frac{N_{Ed,min} \cdot a'}{\left(K_b T_b + N_{Ed,min}\right)}$$

where

$N_{Ed,min}$ is the minimum vertical force at the design seismic situation;

K_b is the horizontal shear stiffness measured at the largest test displacement;

T_b is the total height of the device;

and γ_R is a partial factor, the recommended value of which is 1,5.

4.1.8 Vertical stiffness

The total vertical stiffness, K_v, of a laminated elastomeric isolator is the sum of the vertical deflections of the individual layers given by :

$$K_v = \frac{A'}{\sum \frac{t_i}{E_{ci}}}$$

where E_{ci} is the compression modulus.

4.1.9 Horizontal stiffness

The theoretical value of the horizontal stiffness is given by :

$$K_b = \frac{GA}{T_q}$$

where

A is the total plan area of the device;

G is the shear modulus at the design shear strain due to earthquake-imposed horizontal displacement.

4.1.10 Data analysis

The equivalent viscous damping ratio ξ, shall be expressed as:

$$\xi = \frac{2H}{\pi K_b (d^+ - d^-)^2}$$

where

H is the area of the hysteresis loop.

d^+ and d^- are the maximum and minimum values of displacement.

5.1 Typical Bearing Schedule

Appendix

Minimum list of input required for the design of seismic bearing

DOSHIN RUBBER ENGINEERING	Required input	
Parameter	**Lower bound**	**Upper bound**
Axial load		
(a) Average long term		
(b) Max long term		
(c) Min long term		
(d) Max short term		
(e) Min short term		
Shear displacement		
(a) Non-seismic d_0		
(b) Maximum seismic (including non-seismic) d_M		
(c) Total maximum displacement (d_{max}) including d_0 and d_M		
Rotation		
(a) Total non-seismic		
(b) Seismic inclusive of rotation in (a)		
Effective shear stiffness @ d_M		
Effective damping ratio @ d_M		
***Information for anchorage design**		
Total height constraint, if any		
Seating area constraint, if any		
Upper plinth material strength		
Lower plinth material strength		
**Note: If information is not given, detail of anchorage design will be excluded*		

6.0 TABLES

6. 1 Lead Rubber Bearing

G = 0.4 Mpa, Damping 13%

Maximum Displacement = 400 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
700	400	200	462	3,500	2,000	0.6722	42	0.8809	13 %
800	400	199	457	4,900	2,700	0.8949	60	1.1966	13 %
900	400	200	442	6,300	3,500	1.1336	73	1.5018	13 %
1000	400	195	417	7,900	4,300	1.4360	88	1.8873	13 %
1100	400	196	410	9,600	5,300	1.7319	104	2.2635	13 %
1200	400	200	402	11,500	6,300	2.0208	121	2.6270	13 %

Maximum Displacement = 350 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
700	350	175	417	3,700	2,000	0.7747	42	1.0125	13 %
800	350	173	378	4,900	2,700	1.0312	59	1.3697	13 %
900	350	171	364	6,300	3,500	1.3274	72	1.7482	13 %
1000	350	169	350	7,900	4,300	1.6612	86	2.1725	13 %
1100	350	175	353	9,600	5,300	1.9428	102	2.5281	13 %
1200	350	168	354	11,500	6,300	2.4108	121	3.1319	13 %

Maximum Displacement = 300 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
650	300	150	343	3,200	1,700	0.7909	41	1.0528	13 %
700	300	150	343	3,700	2,000	0.0907	41	1.1816	13 %
800	300	148	338	4,900	2,700	1.2134	59	1.6100	13 %
900	300	148	329	6,300	3,500	1.5353	72	2.0208	13 %
1000	300	150	322	7,900	4,300	1.8808	86	2.4591	13 %
1100	300	147	313	9,600	5,300	2.3169	103	3.0145	13 %
1200	300	144	301	11,500	6,300	2.8161	120	3.6469	13 %

Maximum Displacement = 250 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
550	250	125	303	2,000	1,200	0.6663	36	0.9505	13 %
600	250	125	303	2,700	1,400	0.8003	36	1.0844	13 %
650	250	125	303	3,200	1,700	0.9426	36	1.2268	13 %
700	250	125	286	3,700	2,000	1.0982	46	1.4647	13 %
800	250	122	281	4,900	2,700	1.4703	58	1.9436	13 %
900	250	120	272	6,300	3,500	1.9051	71	2.5000	13 %
1000	250	124	284	7,900	4,300	2.2805	87	2.9816	13 %
1100	250	126	283	9,600	5,300	2.7059	103	3.5208	13 %
1200	250	128	297	11,500	6,300	3.1703	120	4.1063	13 %

Maximum Displacement = 200 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
450	200	120	295	1,400	700	0.4545	36	0.7505	13 %
500	200	100	263	1,800	1,000	0.6906	36	1.0469	13 %
550	200	100	250	2,200	1,200	0.8328	35	1.1942	13 %
600	200	100	250	2,700	1,400	1.0076	35	1.3589	13 %
650	200	100	250	3,200	1,700	1.1856	40	1.5890	13 %
700	200	100	250	3,700	2,000	1.3777	46	1.8366	13 %

Maximum Displacement = 150 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
450	150	75	213	1,400	700	0.7554	35	1.2244	13 %
500	150	75	213	1,800	1,000	0.9332	35	1.4032	13 %
550	150	75	213	2,200	1,200	1.1328	35	1.6018	13 %
600	150	75	213	2,700	1,400	1.3501	35	1.8192	13 %
650	150	75	213	3,200	1,700	1.5865	40	2.1249	13 %

6. 2 Lead Rubber Bearing

G = 0.4 Mpa, Damping 19%

Maximum Displacement = 400 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
700	400	200	501	3,500	2,000	0.6762	76	1.0544	19 %
800	400	199	457	4,900	2,700	0.8995	98	1.3923	19 %
900	400	200	442	6,300	3,500	1.1398	124	1.7622	19 %
1000	400	195	417	7,900	4,300	1.4430	143	2.1739	19 %
1100	400	196	410	9,600	5,300	1.7393	163	2.5699	19 %
1200	400	200	402	11,500	6,300	2.0301	195	3.0066	19 %

Maximum Displacement = 350 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
700	350	175	417	3,700	2,000	0.7793	74	1.2021	19 %
800	350	173	378	4,900	2,700	1.0366	96	1.5892	19 %
900	350	171	364	6,300	3,500	1.3347	122	2.0458	19 %
1000	350	169	350	7,900	4,300	1.6691	140	2.4974	19 %
1100	350	175	353	9,600	5,300	1.9527	171	2.9291	19 %
1200	350	168	354	11,500	6,300	2.4218	195	3.5835	19 %

Maximum Displacement = 300 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
650	300	150	372	3,200	1,700	0.7839	60	1.1824	19 %
700	300	150	343	3,700	2,000	0.9150	72	1.3983	19 %
800	300	148	338	4,900	2,700	1.2196	96	1.8671	19 %
900	300	148	329	6,300	3,500	1.5436	122	2.3642	19 %
1000	300	150	322	7,900	4,300	1.8897	140	2.8266	19 %
1100	300	147	313	9,600	5,300	2.3286	171	3.4924	19 %
1200	300	144	301	11,500	6,300	2.8309	205	4.2517	19 %

Maximum Displacement = 250 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
550	250	125	303	2,200	1,200	0.6711	59	1.1408	19 %
600	250	125	303	2,700	1,400	0.8049	59	1.2747	19 %
650	250	125	303	3,200	1,700	0.9472	59	1.4170	19 %
700	250	125	286	3,700	2,000	1.1034	72	1.6760	19 %
800	250	122	281	4,900	2,700	1.4478	95	2.2506	19 %
900	250	120	272	6,300	3,500	1.9154	120	2.9208	19 %
1000	250	124	284	7,900	4,300	2.2914	140	3.4270	19 %
1100	250	126	283	9,600	5,300	2.7195	171	4.0792	19 %
1200	250	128	297	11,500	6,300	3.1870	205	4.7877	19 %

Maximum Displacement = 200 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
450	200	120	295	1,400	700	0.4545	36	0.7505	19 %
500	200	100	263	1,800	1,000	0.6920	41	1.0999	19 %
550	200	100	263	2,200	1,200	0.8455	46	1.3096	19 %
600	200	100	250	2,700	1,400	1.0133	58	1.5941	19 %
650	200	100	250	3,200	1,700	1.1917	65	1.8389	19 %
700	200	100	250	3,700	2,000	1.3842	72	2.1012	19 %

Maximum Displacement = 150 mm

Diameter (D)	Total Max Displacement (d_{max})	Total Rubber Height (T_r)	Total Height (inclusive Endplates) (H)	Maximum Axial Load ($F_{z,d}$)	Nominal Axial Load (N_{ED})	Post-elastic Stiffness @ 100% (K_d)	Characteristic Strength (Q_d)	Effective Stiffness @ 100% (K_h)	Damping (ζ)
mm	mm	mm	mm	kN	kN	kN/mm	kN	kN/mm	%
450	150	75	213	1,400	700	0.7554	35	1.2244	19 %
500	150	75	213	1,800	1,000	0.9350	40	1.4734	19 %
550	150	75	213	2,200	1,200	1.1364	46	1.7490	19 %
600	150	75	213	2,700	1,400	1.3577	58	2.1331	19 %
650	150	75	213	3,200	1,700	1.5946	65	2.4585	19 %

7.0 MATERIAL SPECIFICATION

7.1 Mechanical and Physical Properties of High Damping Elastomers

Property	Requirement		Test Method
	Moulded Sample	Test piece from device [d]	
Tensile strength (MPa), min.	12	10	ISO 37 Type 2
Elongation at break (%), min.	400	350	ISO 37 Type 2
Tear resistance (kN/m), min	. 7		ISO 34[c] Method A
Compression set 70 °C, 24 h, max.	60		ISO 815 Type A 25% compression
Ozone resistance[a] Elongation 30 % - 96 h 40 °C ± 2 °C	no cracks		ISO 1431-1
Accelerated air oven ageing[b] Maximum change from unaged value			ISO 188, Method A
Hardness (IRHD)	-5, +8		ISO 48
Tensile strength (%)	± 15		ISO 37 Type 2
Elongation at break (%)	± 25		ISO 37 Type 2

NOTE Because the ozone and ageing tests are checks that appropriate antidegradants have been included, not tests related to service performance, their effectiveness necessitates that the conditions should be appropriate to the elastomer used in manufacture of the devices.

a The ozone concentration shall be appropriate to the elastomers used. For natural rubber based vulcanisates, 25 pphm shall be used and for polychloroprene based vulcanisates 100 pphm. For other elastomers, the values shall be agreed between the manufacturer and the structural engineer. For elastomers with no unsaturated carbon-carbon bonds, an ozone test need not be performed.

b Ageing condition shall be chosen appropriate to elastomers used. For natural rubber based vulcanisates, 7 days at 70 °c shall be used and for polychloroprene based vulcanisates, 3 days at 100 °c . For other elastomers, the values shall be agreed between the manufacturer and the structural engineer.

c If the legs of the test piece extend without the initial cut growing, the method shall be modified to reduce the extension and ensure cut growth by either increasing the width of the legs or fixing a flexible but relatively inextensible reinforcement to the test piece; the reinforcement shall leave a gap of 5 mm where the tear is expected to grow.

d Test pieces from complete finished isolators shall be taken from the first internal layer and from the layer at the centre of the isolator.




8.1 Testing Method Accordance to EN 15129

Test	Type test requirements	Factory production control test requirements
Capacity in compression under zero lateral displacement	Support N_{Sd} . No defects visible. See 8.2.1.2.6.	N/A
Compression stiffness	Report value. See 8.2.1.2.8.	Within ± 30% of type test value. No defects visible. See 8.2.1.2.8
*Horizontal characteristics K_b and ξ_b (or K_2 and Q_d) under cyclic deformation	Report strain dependence. At design displacement, d_{bd}, values within ± 20% of design value. See 8.2.1.2.2	Values within ± 20% of required values. See 8.2.1.2.2
*Horizontal stiffness under a one-sided ramp loading (Required if cyclic horizontal stiffness and damping from production control test not measured at shear strain amplitude close to value corresponding to, d_{bd})	Report value at design displacement, d_{bd}. See 8.2.1.2.2	Within ± 20 % of adjusted type test value. See 8.2.1.2.2
Variation of horizontal characteristics K_b and ξ_b (or K_2 and Q_d) with frequency	Report variation. Maximum variation ± 20 %. See 8.2.1.2.3	N/A
*Variation of horizontal characteristics K_b and ξ_b (or K_2 and Q_d) with temperature	Report variation. Maximum variation within limits set in 8.2.1.2.4	N/A
Dependence of horizontal characteristics K_b and ξ_b (or K_2 and Q_d) on repeated cycling	Dependence within limits specified in 8.2.1.2.5	N/A
*Lateral capacity under maximum and minimum vertical loads	Force-displacement curve increasing up to $\gamma_b d_{Ed}$. No defects. See 8.2.1.2.7.	N/A
Change of horizontal characteristics K_b and ξ_b of the isolator (or K_2 only for LRB manufactured using low damping elastomer) due to ageing	Change ≤ 20 %	N/A
Creep[a] test under vertical load	Total Creep rate < 20 % per decade. See 8.2.1.2.10.	N/A

[a] Optional test
N/A = Not Applicable

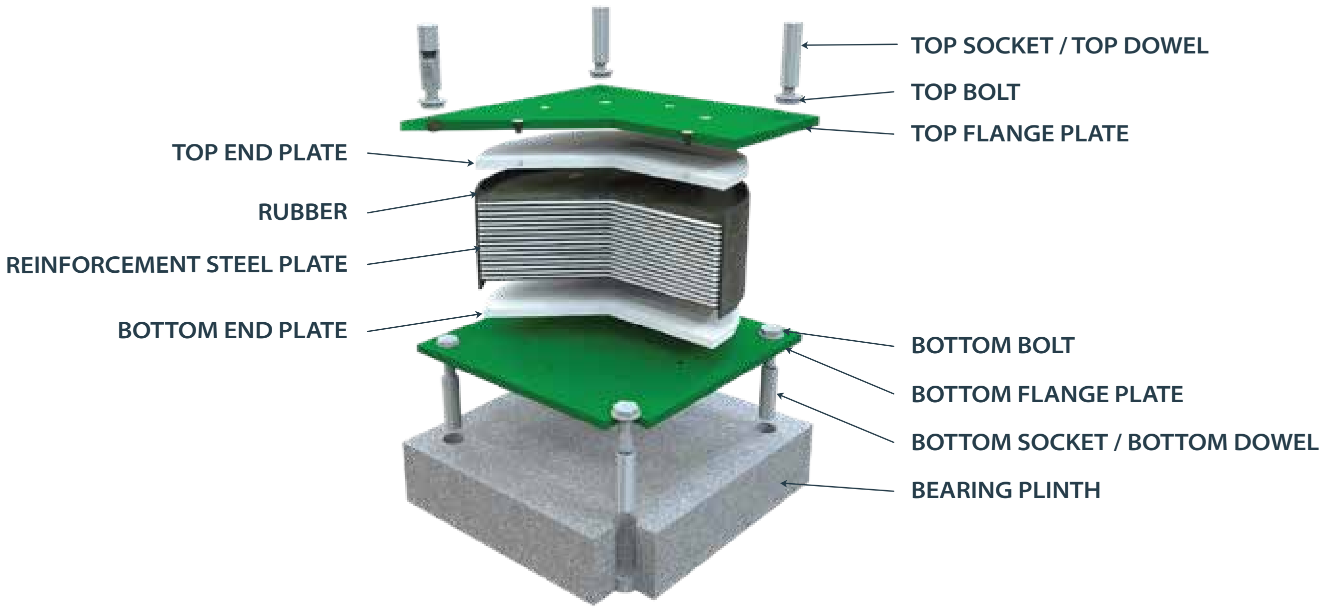
*For low damping bridge isolators subjected to small seismic actions, only the tests marked with * shall apply.
See 8.2.1.2.11 for requirements.

9.0 RESTRAINT & ANCHORAGE

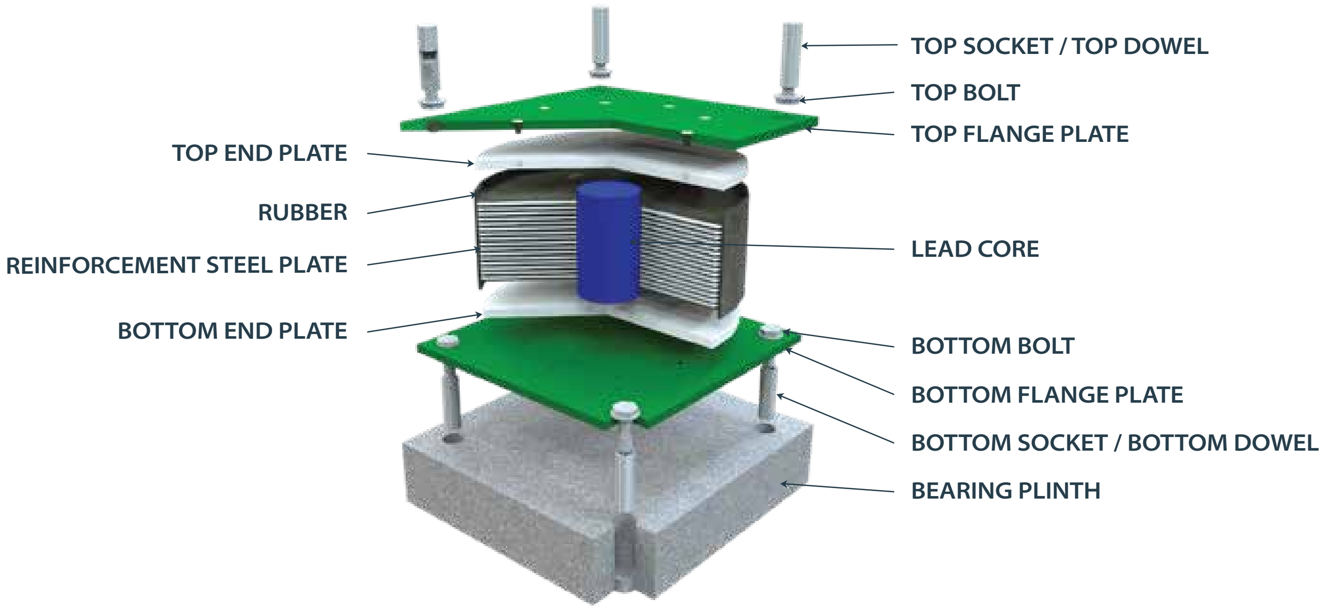
9.1 Restraint & Anchorage Design

Sometimes, certain project requires the High Damping Rubber Bearing and Lead Rubber Bearing to transmit horizontal loads from the superstructure to the substructure. As such, the High Damping Rubber Bearing and Lead Rubber Bearing needs to be fixed in the required direction in order to restrain itself from movement. Usually, these horizontal forces are orginated from wind load, braking force, centrifugal force on curved elevated span, etc. It should be noted that such approach must be designed cautionsly in order not to interfere with the effiency of the isolation system during seismic movement.

High Damping Rubber Bearing (HDRB)



Lead Rubber Bearing (LRB)

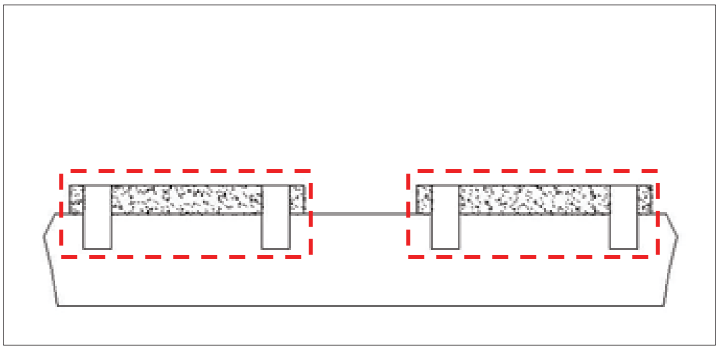


10.1 Bearing Installation

10.1.1 Installation - Bearing With Steel

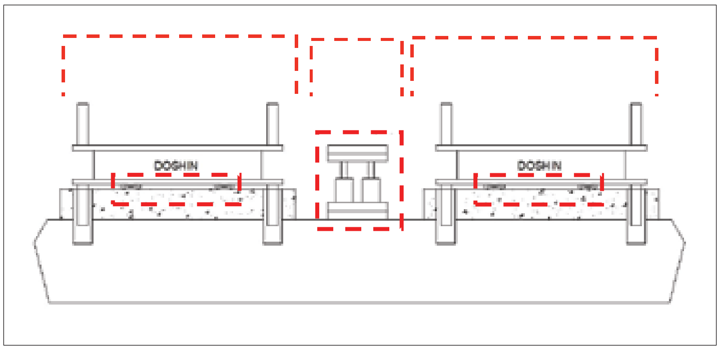
STEP 1 :

Prepare block out / recess holes using template / PVC pipes and cast the bottom plinth according to the required height and size.



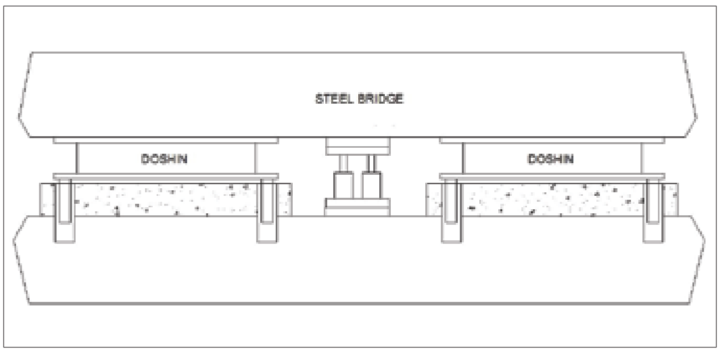
STEP 2 :

Place the Bearing on the bottom plinth. Use shim plates to ensure bearing reaches the required height.
Place the hydraulic jacks / temporary support at designated location.



STEP 3 :

Launch the steel structural above the Bearing.



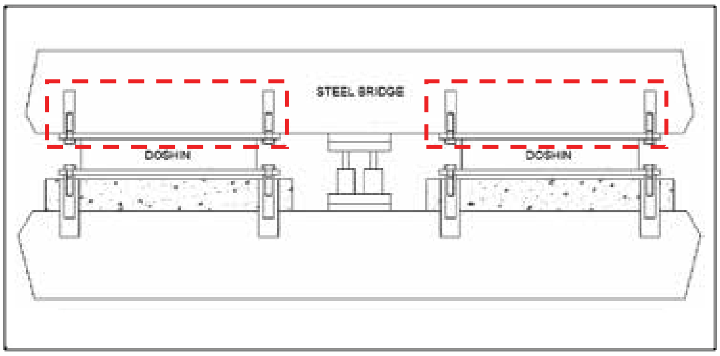
10.0 INSTALLATION

10.1 Bearing Installation

10.1.1 Installation - Bearing With Steel

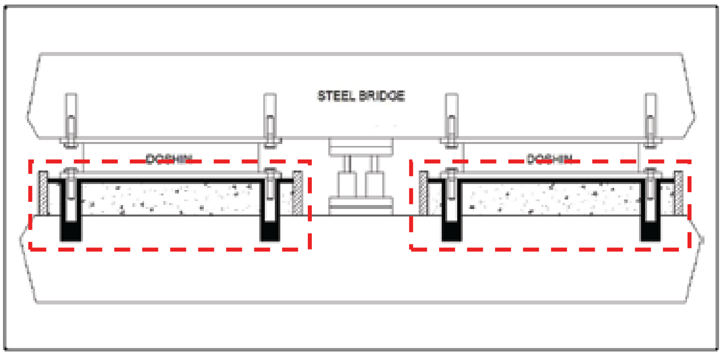
STEP 4 :

Tighten the bolts at the top attachment plate to its respective torque value.



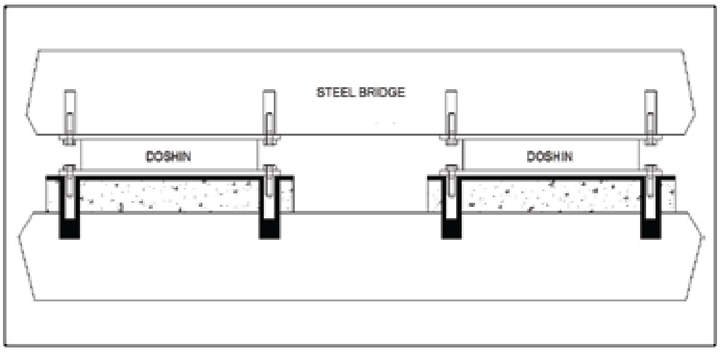
STEP 5 :

Prepare formwork for grouting. Using approved grout material, grout the bottom anchor plate using manual pouring method.



STEP 6 :

Remove the hydraulic jacks / temporary support after the grout has achieved the required strength.

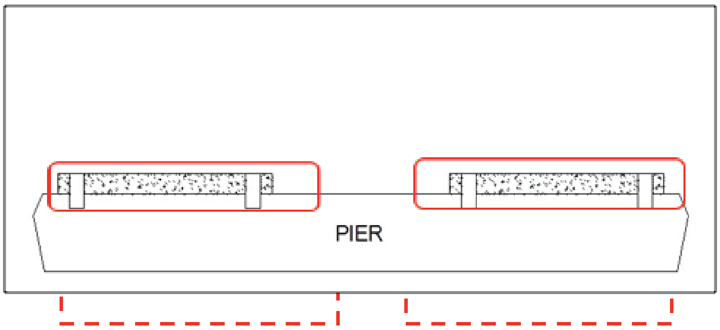


10.1 Bearing Installation

10.1.2 Installation - Bearing With Concrete

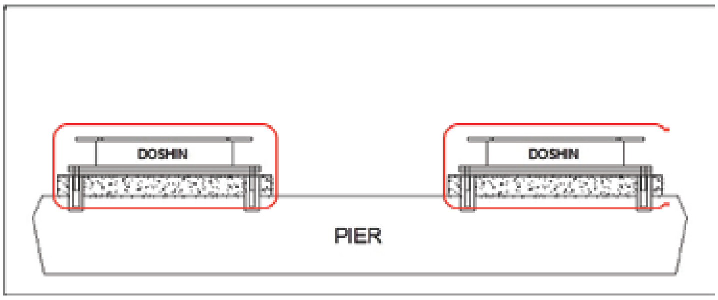
STEP 1 :

Prepare block out/ recess holes using template / PVC pipe and cast the bottom plinth according to the required height and size.



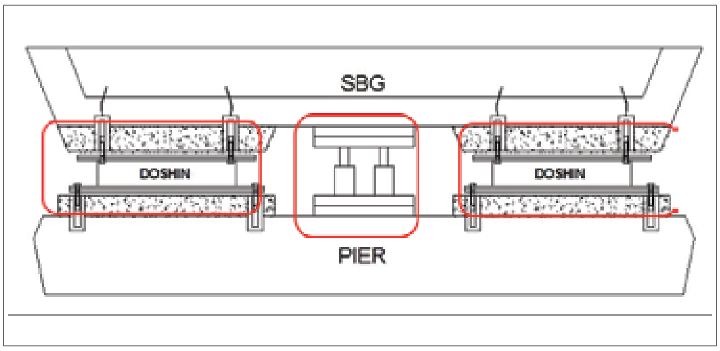
STEP 2 :

Place the Bearing on the bottom plinth. Use shim plates to ensure bearing reaches the required height. Place the hydraulic jacks / temporary support at designated location.



STEP 3 :

Launch the super structural above the Bearing. The hydraulic jacks will absorb the load of the beam first. Gradually decrease the height of the hydraulic jacks until the desired grouting height is achieved. Tighten the bolts at the top and bottom attachments plates to their respective torque values.



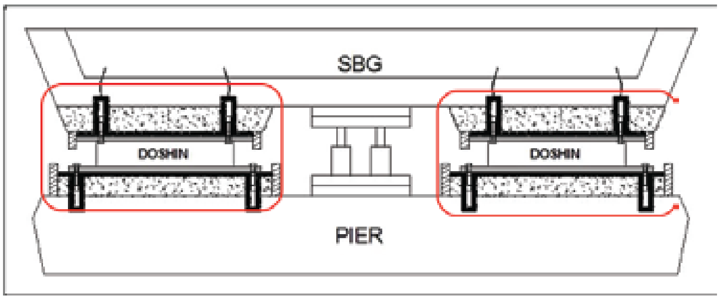
10.0 INSTALLATION

10.1 Bearing Installation

10.1.2 Installation - Bearing With Concrete

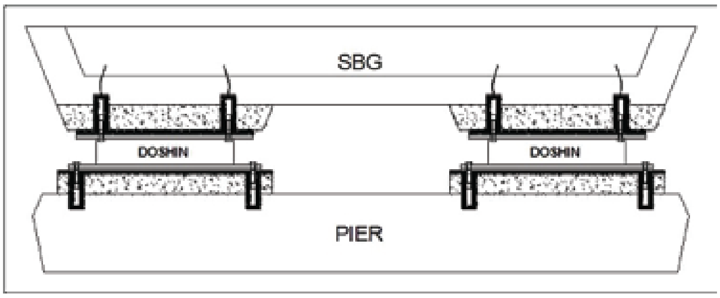
STEP 4 :

Prepare formwork for grouting. Pour the grout at the bottom plinth and top plinth through the grouting hose.



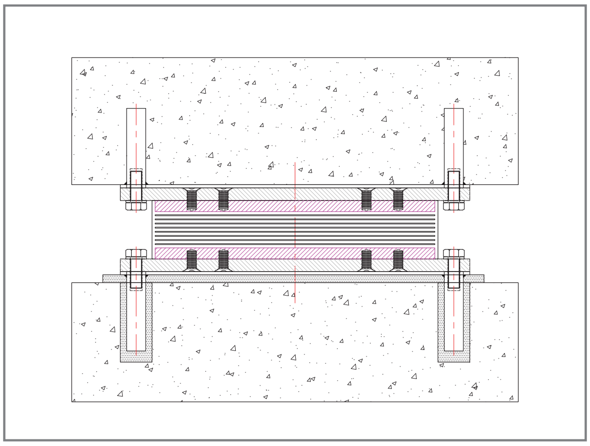
STEP 5 :

Remove the hydraulic jacks after the grouting plinth has achieved the required strength.

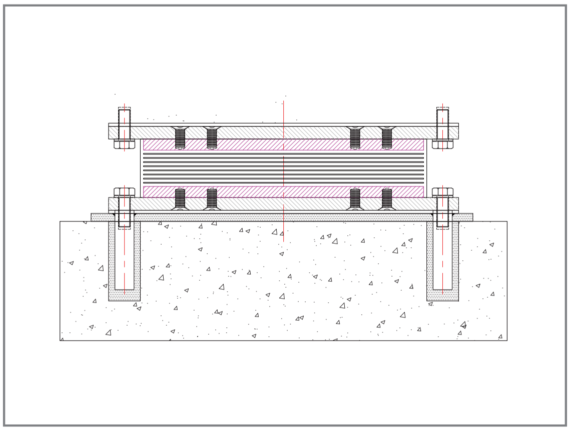


10.2 Connection Methods With Different Structural

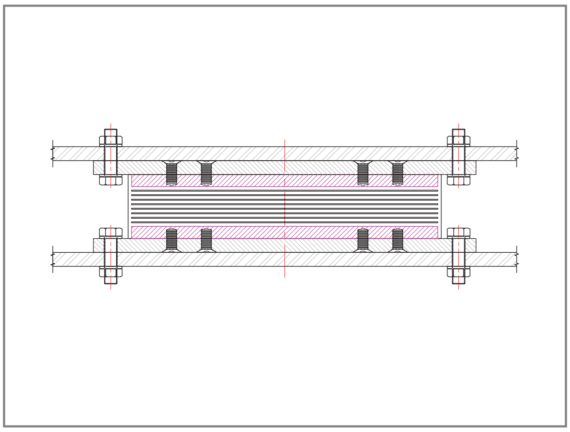
10.2.1 Concrete



10.2.2 Steel / Concrete



10.2.3 Steel

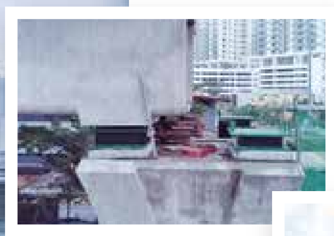


11.0 PROJECT REFERENCE

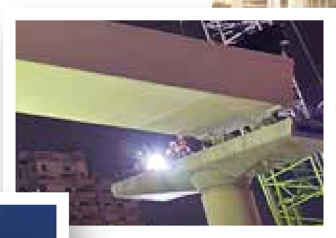
DOSHIN® RUBBER ENGINEERING

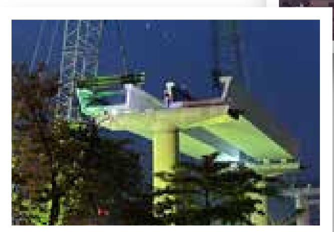
11.1 HIGH DAMPING RUBBER BEARING

KVMRT, SSP Line
MALAYSIA



LRT 3
MALAYSIA





Hospital Claudio Vicuna
CHILE

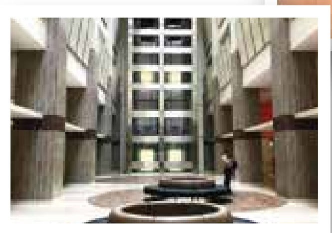


Hospital Del Salvador
CHILE

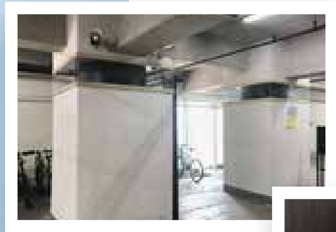

Penang Second Bridge
MALAYSIA

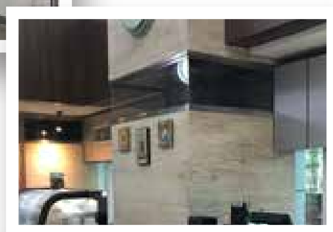


University Hospital (UI)
INDONESIA

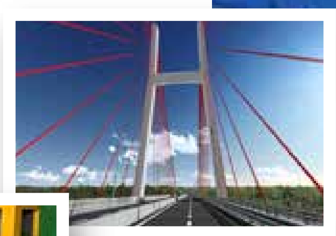


Wika Tower
INDONESIA





Cable Stayed Bridge
VIETNAM



11.2 LEAD RUBBER BEARING

DOSHIN® RUBBER ENGINEERING

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CHILE

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