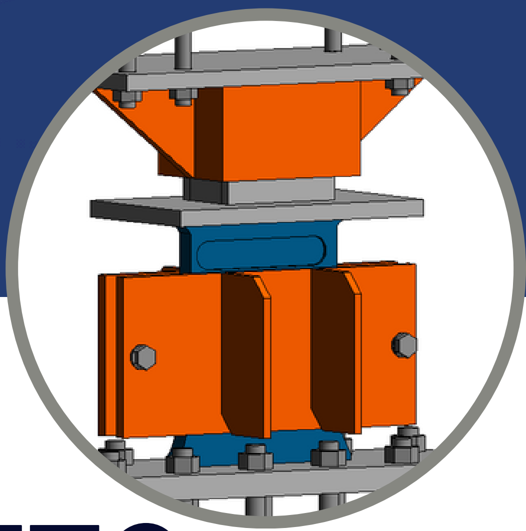
SEISMIC PROTECTION SYSTEM



SHEAR LINK BOZZO

ENGINEERING & DESIGN SUPPORT
PROJECTS WITH SEISMIC PROTECTION
SYSTEMS

SMART TECHNOLOGY WILL BUILD THE FUTURE

Data Sheet Shear Link Bozzo

Contents

SLB DEVICES

PERÚ / info.peru@slbdevices.com

INTERNATIONAL / info@slbdevices.com

www.slbdevices.com

1 PATENT

These devices belong to the Buckling Delayed Shear Link (BDSL) range, covered by a patent filed with the United States Patent and Trademark Office under code 17/967,199, registered to SLB Devices SL.

US012180741B2

(12) **United States Patent**
Bozzo Rotondo et al.

(10) **Patent No.: US 12,180,741 B2**
(45) **Date of Patent: Dec. 31, 2024**

(54) **BUCKLING DELAYED SHEAR LINK**

(71) Applicants: **Luis Miguel Bozzo Rotondo**, Barcelona (ES); **Guillermo Bozzo Fernández**, Barcelona (ES)

(72) Inventors: **Luis Miguel Bozzo Rotondo**, Barcelona (ES); **Guillermo Bozzo Fernández**, Barcelona (ES)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 242 days.

(21) Appl. No.: **17/967,199**

(22) Filed: **Oct. 17, 2022**

(65) **Prior Publication Data**

US 2024/0125137 A1 Apr. 18, 2024

(51) **Int. Cl.**
E04H 9/02 (2006.01)

(52) **U.S. Cl.**
CPC ***E04H 9/021*** (2013.01)

(58) **Field of Classification Search**
CPC E04H 9/02; E04H 9/021; E04H 9/0215; E04H 9/0237; E04H 9/024; E04H 9/025; E04B 1/36; E04B 1/98
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,823,522 A *	4/1989	White	E04H 9/023	248/596
4,959,934 A *	10/1990	Yamada	E04H 9/0237	52/573.1
5,533,307 A *	7/1996	Tsai	E04H 9/0237	52/167.3
5,630,298 A *	5/1997	Tsai	E04H 9/021	52/167.3
5,971,347 A *	10/1999	Tsai	F16F 15/02	248/618
6,085,471 A *	7/2000	Axon	E01D 19/02	52/167.7
6,799,400 B2 *	10/2004	Chuang	F16F 7/12	188/371
6,948,284 B2 *	9/2005	Chiang	E04H 9/0235	52/167.1
7,290,375 B2 *	11/2007	Kemeny	E04H 9/0237	52/167.6

(Continued)

FOREIGN PATENT DOCUMENTS

CN	106193360 A *	12/2016	E04H 9/021
CN	106193752 A *	12/2016	E04H 9/021

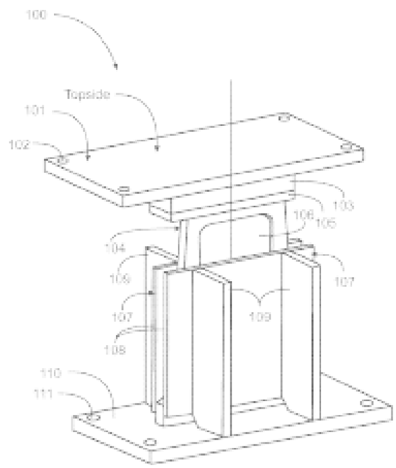
(Continued)

Primary Examiner — Kyle J. Walraed-Sullivan
(74) *Attorney, Agent, or Firm* — Donald R. Boys; Central Coast Patent Agengy LLC

(57) **ABSTRACT**

A buckling delayed shear link (BDSL) has a second metal base plate, a first metal base plate, a metal core plate rigidly joined orthogonally to the second metal base plate, an axial relief assembly having matching slip fit channels and extensions, a first restraining assembly restraining one side of the core plate and a second restraining assembly restraining the other side of the core plate. The first metal base plate is enabled to move vertically freely over a distance relative to the rigid assembly of the second metal base plate, the core plate, and the first and second restraining assemblies by virtue of the axial relief assembly, and lateral movement of the first metal base plate relative to the second metal base plate transfers a shear component of force to an upper end of the core plate.

27 Claims, 9 Drawing Sheets



2 EXPERIMENTAL TESTING

SLB devices have undergone extensive experimental testing, enabling their progressive development through four generations. Their real–experimental behavior has been demonstrated with high accuracy. The devices are widely validated through multiple laboratory investigations, with the most relevant highlighted below:

INEC	Portugal	2000
ISMES	Milan Italy	2001
Pontificia Universidad Católica del Perú	Peru	2013 2014 2015
Universidad Federico II	Naples Italy	2016
Instituto de Ingeniería de la UNAM	Mexico	2018
Laboratorio LADICIM	Cantabria Spain	2020
Laboratorio Universidad de Lima	Peru	2022 2023 2024
Laboratorio APPLUS,	Barcelona	2025

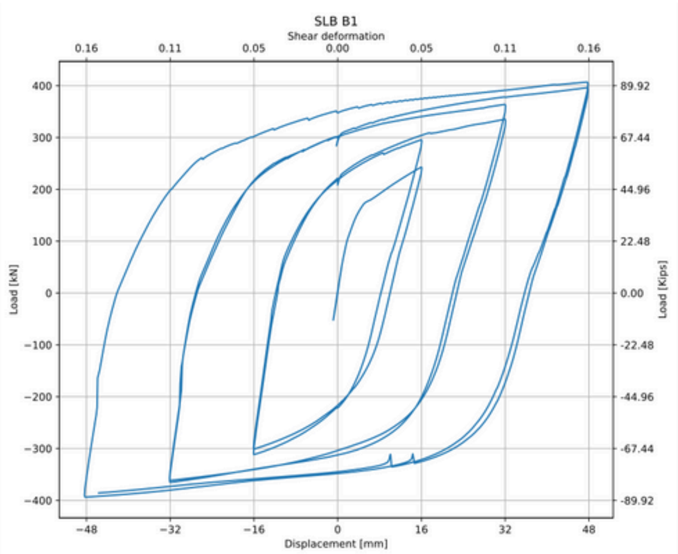


Figure 1. Shows the hysteretic response of the 4th Generation SLB Devices tested in Cantabria (2020)

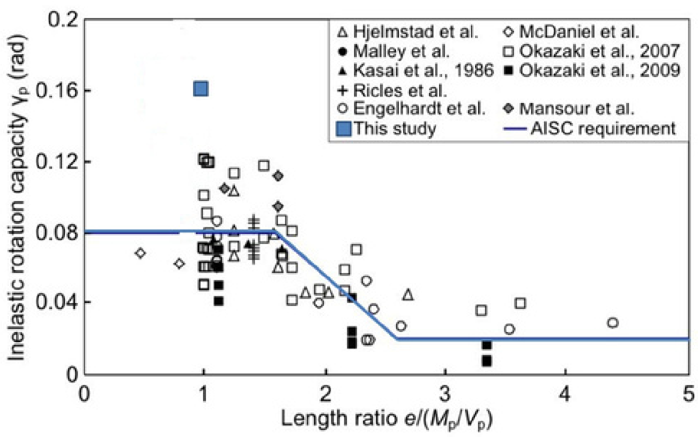


Figure 2. Inelastic rotation capacity versus length ratio of shear links. Cantabria tests in blue square

3 ACTUAL APPLICATIONS

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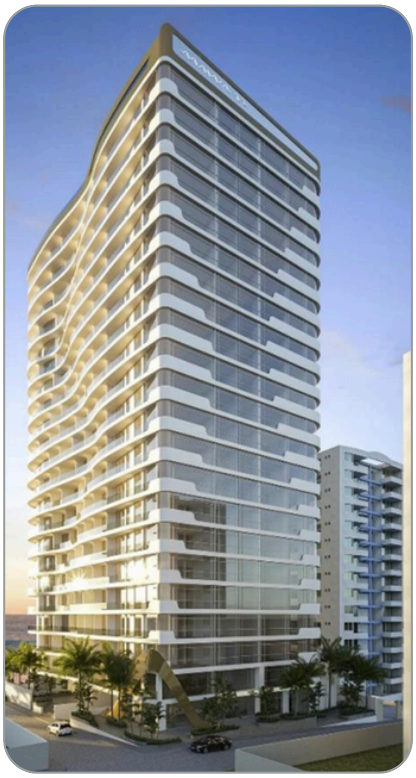
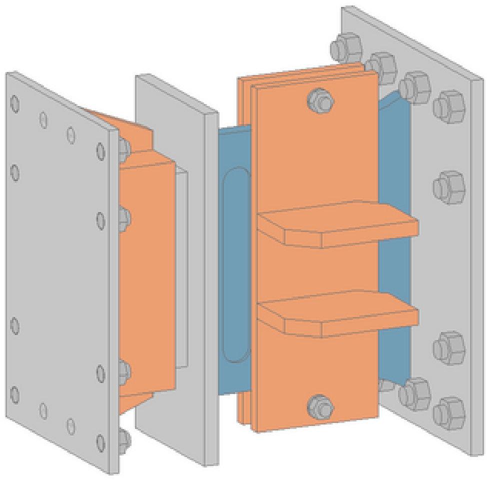
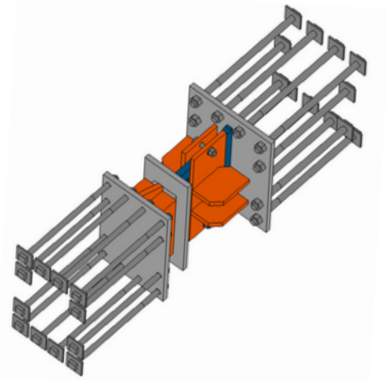
HYBRID COUPLING BEAMS

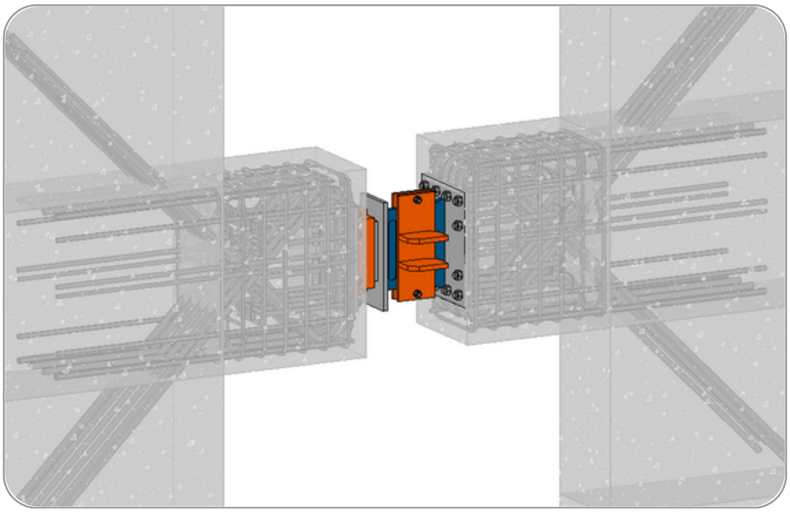
Hybrid coupling beams are composed of a cantilever plus a BDSL damper. This system allows for a significant reduction in the beam's cross-section and reinforcement compared to conventional concrete coupling beams. This is because the dampers perform exceptionally well under shear loads, unlike reinforced concrete, making it a highly efficient system for resisting lateral loads.



"Mawa 22" Manta - Ecuador







3 ACTUAL APPLICATIONS

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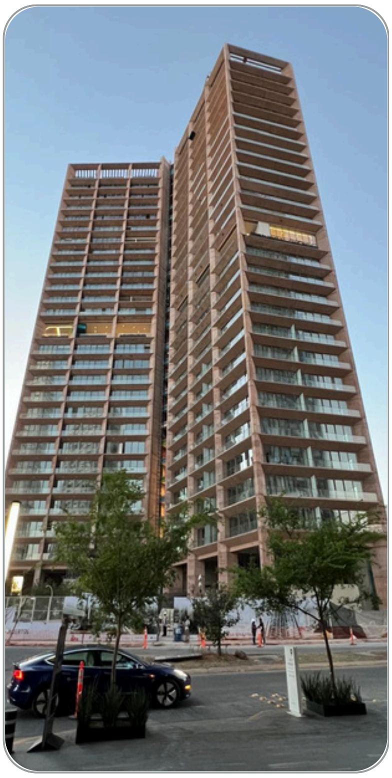
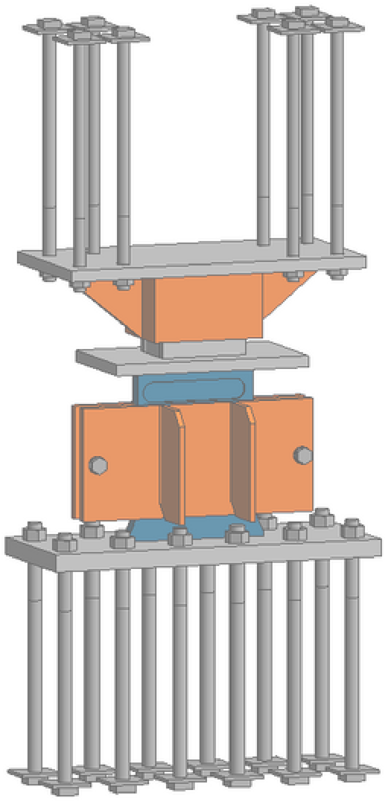
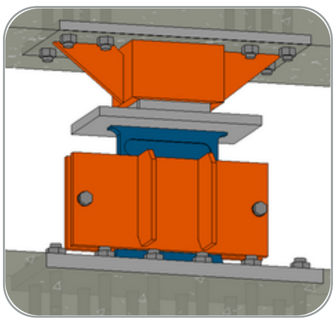
UNCOUPLED WALLS

Uncoupled Walls help add stiffness in strategic areas of the structure to reduce interstory drift, control torsion or stiffen specific zones. Thanks to the system's connection, which does not transfer axial load, they can be placed freely within the structure without the need to extend them down to the foundation to transfer vertical loads.



Towe "Legacy" Guadalajara- Mexico





3 ACTUAL APPLICATIONS

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CHEVRON BRACES

Chevron braces serve the same function as Uncoupled Walls but allow the visual field to remain more open. They are also more common in steel structures.

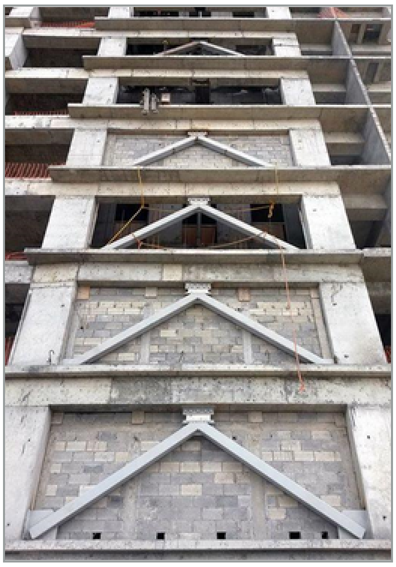
Disipado"Universidad Católica de Santa María" Arequipa - Peru

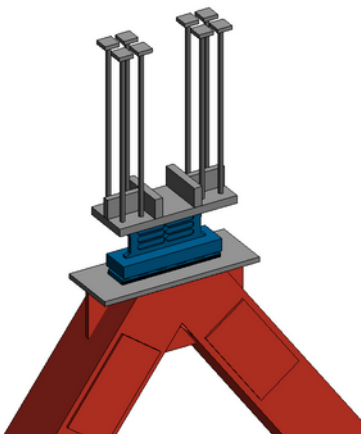
"IE 0074 Belaunde Terry" Lima - Peru

"Universidad Nacioal Hermilio Valdizan" Huánuco - Peru

"Reservorio Qhapacñan" Cajamarca - Peru

Towe "Paradox" Guadalajara- Mexico

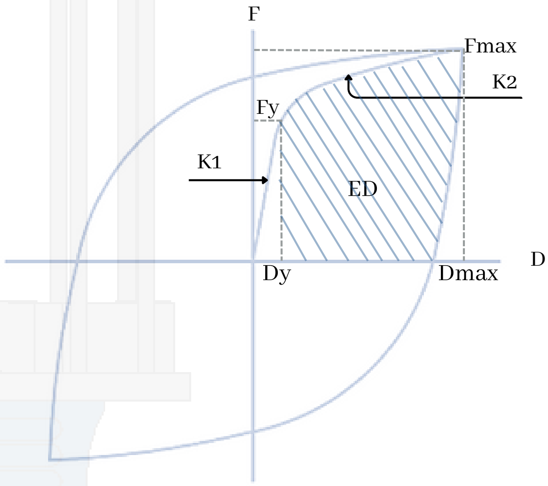




4 NUMERICAL MODELLING

To numerically model metallic yielding dampers, such as SLBs, analysis programs like ETABS and SAP2000 have incorporated nonlinear properties such as Multi-Linear Plastic and Plastic (Wen), which are capable of simulating the behavior of these devices because they account for the Bauschinger effect (Wai Fah Chen, 1988)—that is, the reduction of the compressive yield limit observed in metals like steel due to prior plastic deformation.

K1:	Initial stiffness
K2:	Post-yield stiffness
Fy:	Yield force
Fmax:	Maximum force
Dy:	Yield displacement
Dmax:	Maximum displacement
ED:	Dissipated energy
As1 = As2	



SLB devices have several generations: the third generation reaches maximum displacements of 3 cm under full cyclic loads, the fourth generation up to 5 cm, and the fifth generation ranges from 6 to 10 cm depending on the type.
The following table presents the properties of the third- and fourth-generation devices.

SLB DEVICES	Displacements
Third Generation	3 cm
Fourth Generation	5 cm
Fifth Generation	ranges from 6 to 10 cm

We have developed our own plugin to automatically draw the devices in the ETABS program. In addition, this tool allows for the preliminary design of the devices, provides reinforcement quantities for the structural elements involved—such as beams or walls—and, finally, generates construction drawings with full detailing. The plugin is totally free, in order to get it contact **info@slbdevices.com**

Download the SLB Plugin & Design Tools

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THIRD-GENERATION DEVICES

Design Parameters for SHEAR LINK BOZZO Devices						
Devices	**K1 (KN/cm)**	**K2 (KN/cm)**	**Dy (mm)**	**Fy (KN)**	**FMÁX (KN)**	**ED (KN.cm)**
SLB2 6_2	363.33	9.75	0.98	35.6	69.01	87.08
SLB2 6_3	397.8	10.75	1.031	41	79.21	99.25
SLB2 6_4	421.73	11.65	1.065	44.9	88.58	108.31
SLB2 6_5	439.6	12.78	1.078	47.4	96.67	115.18
SLB2 8_2	592.87	13.86	0.811	48.1	92.76	119.78
SLB2 8_3	676.27	15.38	0.858	58	107.57	141.77
SLB2 8_4	737	16.28	0.9	66.3	120.87	159.39
SLB2 8_5	784.27	17.43	0.927	72.7	133.29	173.71
SLB2 10_2	893.4	19.15	0.761	68	128.71	168.89
SLB2 10_3	1039.13	21.57	0.78	81.1	148.63	198.84
SLB2 10_4	1149.53	22.96	0.809	93	166.26	224.54
SLB2 10_5	1237.8	14.93	0.906	112.2	182.26	246.55
SLB2 15_2	1571.47	31.17	0.648	101.8	199.61	258.66
SLB2 15_3	1961.47	37.36	0.643	126.1	240.45	318.16
SLB2 15_4	2290.27	42.03	0.654	149.7	276.57	373.16
SLB2 15_5	2575.6	45.69	0.67	172.5	310.13	424.52
SLB2 20_2	2073.33	37.83	0.601	124.6	243.14	316.64
SLB2 20_3	2630.13	46.27	0.597	156.9	298.3	396.26
SLB2 20_4	3105.53	53.03	0.606	188.3	348.53	470.63
SLB2 20_5	3520.2	58.63	0.62	218.4	395.71	540.18
SLB3 25_2	3214.07	58.98	0.606	194.8	383.5	494.69
SLB3 25_3	4046.67	70.69	0.589	238.2	457.15	602.54
SLB3 25_4	4783.2	81.04	0.585	279.6	526.49	703.7
SLB3 25_5	5447.47	90.85	0.586	319	592.39	799.88
SLB3 25_6	6064.13	99.65	0.589	357.1	655.63	891.48

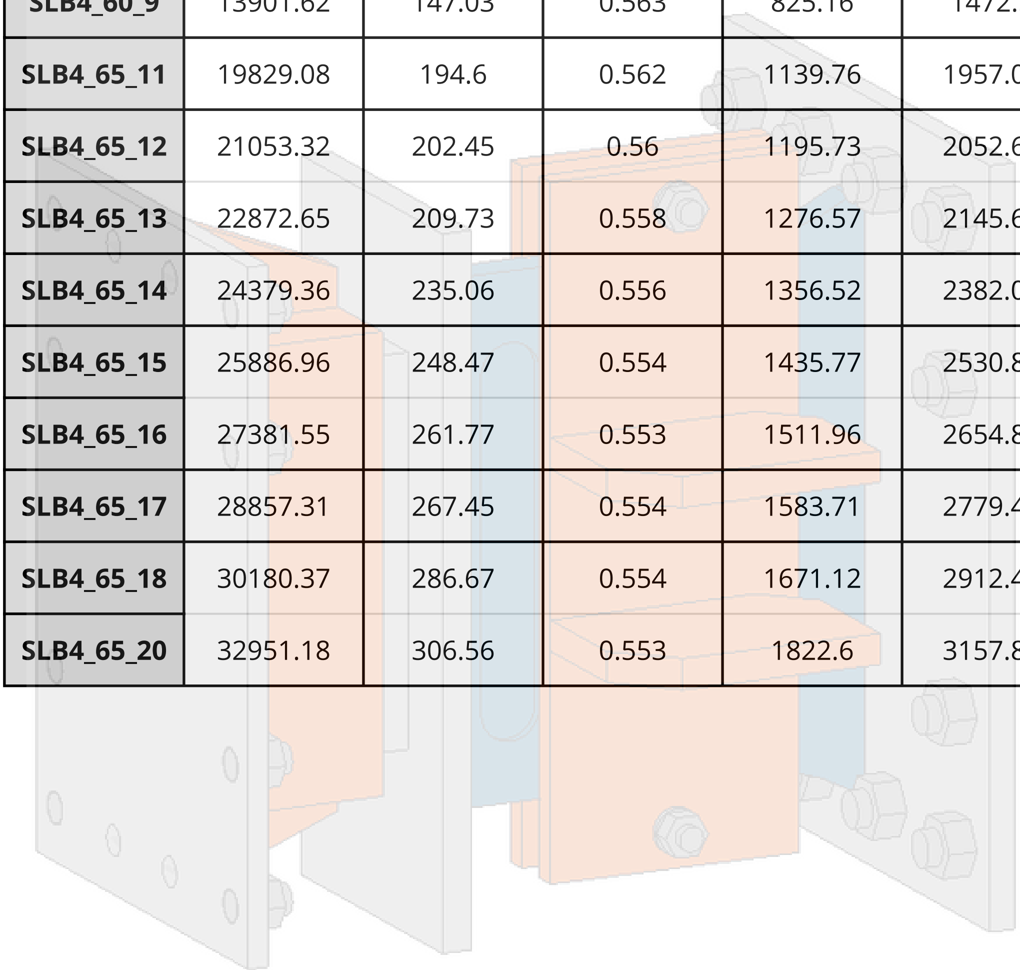
Design Parameters for SHEAR LINK BOZZO Devices						
Devices	**K1 (KN/cm)**	**K2 (KN/cm)**	**Dy (mm)**	**Fy (KN)**	**FMÁX (KN)**	**ED (KN.cm)**
SLB3 25_7	6644.13	107.41	0.594	394.5	716.83	979.51
SLB3 25_8	7191.47	114.57	0.599	430.7	776.4	1064.12
SLB3 25_9	7711.07	120.73	0.605	466.4	834.9	1145.71
SLB3 30_2	3666.73	64.22	0.578	212.1	415.33	539.19
SLB3 30_3	4717	78.76	0.563	265.7	507.23	672.79
SLB3 30_4	5661.33	92.21	0.56	316.9	594.62	799.16
SLB3 30_5	6525.67	104.99	0.561	366.1	678.62	920.34
SLB3 30_6	7336.6	116.45	0.565	414.2	759.77	1036.63
SLB3 30_7	8106.07	126.92	0.569	461.3	838.79	1149.06
SLB3 30_8	8840	135.98	0.575	508	915.5	1257.99
SLB3 30_9	9542.2	145.74	0.579	552.5	992.12	1363.85
SLB3 40_2	4571.07	76.44	0.543	248.3	482.6	634.54
SLB3 40_3	6043.67	97.23	0.531	321	609.64	817.79
SLB3 40_4	7393.67	116.17	0.53	391.6	732.2	993.03
SLB3 40_5	8650	133.79	0.533	460.8	851.48	1162.82
SLB3 40_6	9843	149.92	0.537	528.7	967.95	1327.13
SLB3 40_7	10988	165.19	0.542	595.4	1082.3	1487.36
SLB3 40_8	12091.27	179.81	0.547	660.9	1195	1643.93
SLB3 40_9	13156.07	194	0.551	725.1	1306.3	1797.11
SLB3 50_2	5479.6	88.67	0.52	284.9	551.27	730.67
SLB3 50_3	7367.13	114.64	0.512	377.5	713.65	963
SLB3 50_4	9116	138.3	0.513	468.1	871.4	1186.77
SLB3 50_5	10759.13	160.81	0.518	557	1025.7	1404.77
SLB3 50_6	12328.87	181.8	0.523	644.4	1177.3	1616.83
SLB3 50_7	13844.2	202.03	0.528	730.3	1326.8	1824.36
SLB3 50_8	15312.67	221.8	0.532	814.7	1474.5	2028.05
SLB3 50_9	16737	241.37	0.536	897.7	1621.2	2228.51

FOURTH-GENERATION DEVICES

Design Parameters for SHEAR LINK BOZZO Devices					
Devices	**K1 (KN/cm)**	**K2 (KN/cm)**	**Dy (mm)**	**Fy (KN)**	**FMÁX (KN)**
SLB4_10_5	2026.65	21.62	0.749	151.79	250
SLB4_10_6	2163.53	22.9	0.742	160.54	265.78
SLB4_15_5	2472.6	24.85	0.72	177.92	293.72
SLB4_15_6	2761.73	26.96	0.706	195.09	320.62
SLB4_15_7	3021.38	28.76	0.69	208.73	341.61
SLB4_20_6	3361	33.09	0.687	230.93	381.61
SLB4_20_7	3700.15	35.28	0.673	248.7	410.7
SLB4_25_6	4260.8	42.53	0.654	278.74	468.96
SLB4_25_7	4789.52	47.03	0.642	312.35	526.35
SLB4_25_8	5238.65	50.43	0.626	327.73	552.76
SLB4_30_7	5785.96	55.25	0.619	358.28	611.14
SLB4_30_8	6419.52	62.36	0.608	390.28	665.17
SLB4_30_9	6981.87	67.9	0.601	429.53	726.41
SLB4_30_10	7535.22	70.9	0.596	449.09	764.56
SLB4_40_7	7797.49	78.07	0.596	464.68	807.56
SLB4_40_8	8718.88	86.41	0.588	512.48	890.2
SLB4_40_9	9580.18	93.66	0.582	557.71	966.06
SLB4_40_10	10439.63	101.2	0.576	601.31	1035.2
SLB4_40_11	11253.53	109.93	0.571	643.06	1119.9
SLB4_40_12	12033.64	115.6	0.57	685.73	1191.3
SLB4_50_9	12289.99	120.57	0.578	709.95	1236.23
SLB4_50_10	13421.6	130.19	0.573	767.48	1343.52
SLB4_50_11	14537.41	141.39	0.569	828.4	1443.52
SLB4_50_12	15599.37	150.54	0.567	884.08	1540.02
SLB4_60_5	8891.13	91.74	0.598	531.45	932.94

FOURTH-GENERATION DEVICES

Design Parameters for SHEAR LINK BOZZO Devices					
Devices	**K1 (KN/cm)**	**K2 (KN/cm)**	**Dy (mm)**	**Fy (KN)**	**FMÁX (KN)**
SLB4_60_6	10457.28	108.26	0.585	624.03	1095.5
SLB4_60_7	11644.55	116.45	0.576	691.88	1213.68
SLB4_60_8	12945.52	136.53	0.568	769.03	1366.02
SLB4_60_9	13901.62	147.03	0.563	825.16	1472.5
SLB4_65_11	19829.08	194.6	0.562	1139.76	1957.04
SLB4_65_12	21053.32	202.45	0.56	1195.73	2052.63
SLB4_65_13	22872.65	209.73	0.558	1276.57	2145.62
SLB4_65_14	24379.36	235.06	0.556	1356.52	2382.04
SLB4_65_15	25886.96	248.47	0.554	1435.77	2530.86
SLB4_65_16	27381.55	261.77	0.553	1511.96	2654.85
SLB4_65_17	28857.31	267.45	0.554	1583.71	2779.47
SLB4_65_18	30180.37	286.67	0.554	1671.12	2912.47
SLB4_65_20	32951.18	306.56	0.553	1822.6	3157.88



5 MAINTAINANCE

The damper must be inspected and maintained regularly throughout its service life and/or after the occurrence of an earthquake.
If any damage is found on the device, notify the supplier immediately so that repair or replacement can be carried out by qualified technicians.

The protection measures and maintenance schedule for the device are described below:

A. WEATHER PROTECTION

Because of its molecular structure, all structural steel components must be protected against external conditions to prevent oxidation and corrosion.

B. To prevent the above-mentioned deterioration, primers or anti-corrosion products must be applied to all metallic surfaces.
This primer must be periodically checked to detect any early signs of oxidation.
The following maintenance activities—common to all steel structures—are mandatory:

I. IF THE STEEL STRUCTURE IS INDOORS OR NOT EXPOSED TO HARMFUL ENVIRONMENTAL AGENTS:

- Every 4 years, inspect the structure to identify early signs of oxidation.

Remove any degraded material and protect the affected area by locally applying an anti-corrosion primer.

- Every 10 years, remove the existing primer and repaint the entire structure.

II. IF THE STEEL STRUCTURE IS OUTDOORS OR IN A MODERATELY AGGRESSIVE ENVIRONMENT:

- Every 2 years, inspect the structure to identify early signs of oxidation.

Remove any degraded material and protect the affected area by locally applying an anti-corrosion primer.

- Every 5 years, remove the existing primer and repaint the entire structure.

III. IF THE STEEL STRUCTURE IS OUTDOORS OR EXPOSED TO A HIGHLY AGGRESSIVE ENVIRONMENT:

- Every year, inspect the structure to identify early signs of oxidation.

Remove any degraded material and protect the affected area by locally applying an anti-corrosion primer.

- Every 3 years, remove the existing primer and repaint the entire structure.

6 WARRANTY

The devices come with a standard 25-year warranty for service-level earthquakes, covering everything from inspection by our specialized personnel after a severe seismic event to subsequent replacement if necessary—provided that the devices were correctly installed and validated by our company, have been properly maintained, and have not been subjected to any misuse that could impair their performance.

7 PROJECTS WITH SLB DEVICES

+3,000
SLB Devices

7
Countries

+40
Projects

SEISMIC PROTECTION SYSTEM

Contact

Spain

Av. Bailen 71 Bis, 4th 1th
Barcelona

info@slbdevices.com

(+34) 667838004

Peru

Av. Chillón - Urb. Chacra Ce
Comas, Lima-Perú

info.peru@slbdevices.com

(+51) 920522988