

Resists PGA's
greater
than **1g**

Modula Seismic Isolation

Think Vertical, Think Modula

THE SEISMIC RESISTANT VERTICAL STORAGE SYSTEM

The seismic resistant vertical storage system

What anti-seismic means for a Modula storage system

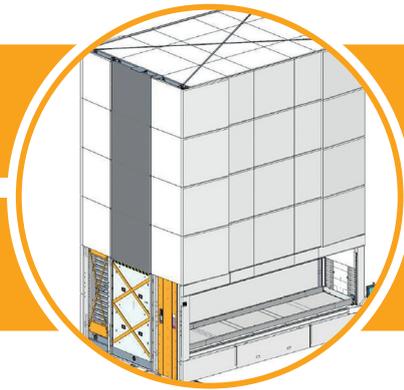
Following the earthquake in Emilia (Italy) in 2012, Modula got to work on a solution that should be able to withstand earthquakes and thus guarantee:

GOODS PROTECTION

PERSONNEL SAFETY

SYSTEM INTEGRITY

QUICK RESUMPTION OF ACTIVITIES



It took 4 years of in-depth studies, calculations and computer simulations to develop the revolutionary seismic isolation system we know today. These calculations and simulations were all validated by tests carried out at the Eucentre in Pavia, the main European center for training and research in earthquake engineering.



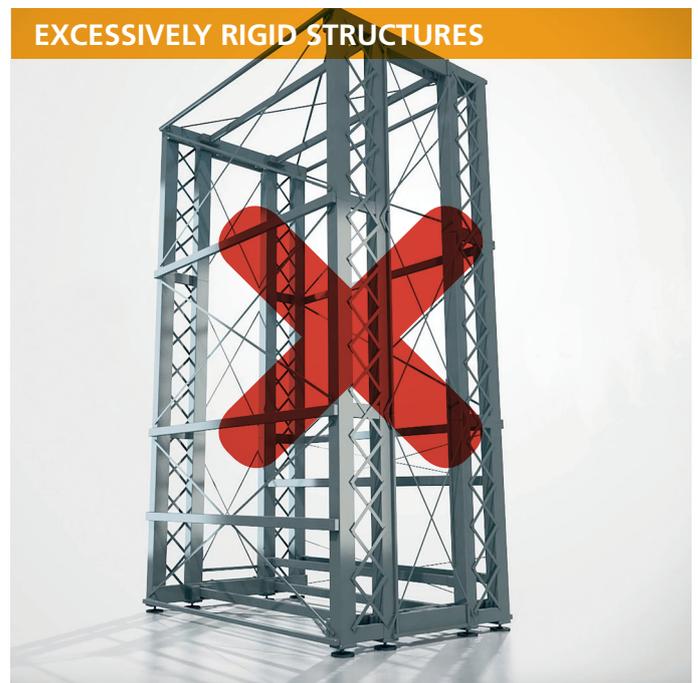
The concept

Modula's approach was to combine anti-seismic and seismic isolation solutions.

The first concern the reinforcement of the storage system's structure, while the second relate to its isolation from the energy produced by the accelerations generated by earthquakes.

Modula chose to avoid excessively stiff structures, so that the storage system does not weigh too much, and to focus the analysis on the movement of earthquakes as well as the effects of the accelerations involved, especially of the horizontal component of peak ground acceleration (PGA).

The seismic isolation system comes into play only in the event of earthquakes and it is important to highlight that in non-seismic situations the device does not affect the operation of the storage system in any way.



Regulatory framework

A quick look at the laws in force

In Italy, seismic risk and the consequent regulations were based on a seismic classification of the area until 2018.

For example, Italy was divided into 4 seismic zones and specific regulations were applied according to that classification.

Today the situation has changed, although one may still hear about this classification. Since 2018 **seismic zones** are only considered together with the parameters to be used in civil and industrial design:



The Italian Ministry of Labor **approves** structures exclusively if designed according to the following hierarchy of technical standards (circular letter no. 21346 of 13/09/1995):

- 1) Binding EU legislation
- 2) Binding national laws and technical standards
- 3) Higher-ranking standards issued at the European level, such as EN standards
- 4) Standards issued at national level, such as the UNI standards
- 5) Voluntary “good practice” standards issued by European or Italian bodies and/or manufacturers’ associations, if any.

We therefore speak of **structural design** in compliance with good practice standards.

“Manufacturers must demonstrate the load bearing capacity of their products, **applying the most appropriate methods, including specific experimental tests, to verify and/or validate their anti-seismic behavior.**”

The standards applied by Modula

Modula solutions are fully compliant with the regulatory framework, in particular:

REF. 1	REF. 2
NTC (Italian Technical Construction Standards) updated in february 2018	Circular no. 617 of 02/02/2009

These standards relate to seismic isolation as a means for reducing the horizontal seismic response of a structure.

According to these standards, anti-seismic systems must:

- Be able to support vertical loads
- Have low horizontal stiffness
- Ensure energy dissipation
- Be able to re-center the system
- Be sufficiently stable and rigid laterally.

System lifespan

Nominal lifespan of a system: this is the number of years a routinely maintained structure should be able to be safely and efficiently used for its intended purpose.

The actual lifespan of a system is calculated as follows:

$$L \times C_u = \text{Nominal lifespan} \times \text{Coefficient of use}$$



**OUR SOLUTION IS CERTIFIED BY MODULA
FOR A LIFESPAN OF 35 YEARS**

Three different solutions

AS 0

SOLUZIONE AS 0
This solution, adopted for all Modula LIFT and SLIM storage systems, ensures a basic level of seismic resistance.

IS 2

SOLUZIONE IS 2
This solution isolates the storage system with progressive resistance feet.

IS 3

SOLUZIONE IS 3
This solution isolates the storage system with progressive resistance feet plus a non-linear damper.

Distinctive components of isolated storage

	IS 2	IS 3
REINFORCED CROSS-SHAPED ELEMENTS	●	●
REINFORCED CROSSBARS	●	●
REINFORCED TIE RODS	●	●
REINFORCED ELEMENTS IN THE BAYS	●	●
CROSS-SHAPED ELEMENTS ON THE STAIRS	●	●
CROSS-SHAPED ELEMENTS BETWEEN THE UPRIGHTS	●	●
ANTI-TIP SYSTEM	●	●
FEET PROVIDING PROGRESSIVE RESISTANCE + SLIDING PLATE	●	●
PROGRESSIVE DAMPING SYSTEM		●

To determine which solution would be best, it is essential to submit the questionnaire with the required information to Modula's technical department. A seismic risk analysis report will be returned.

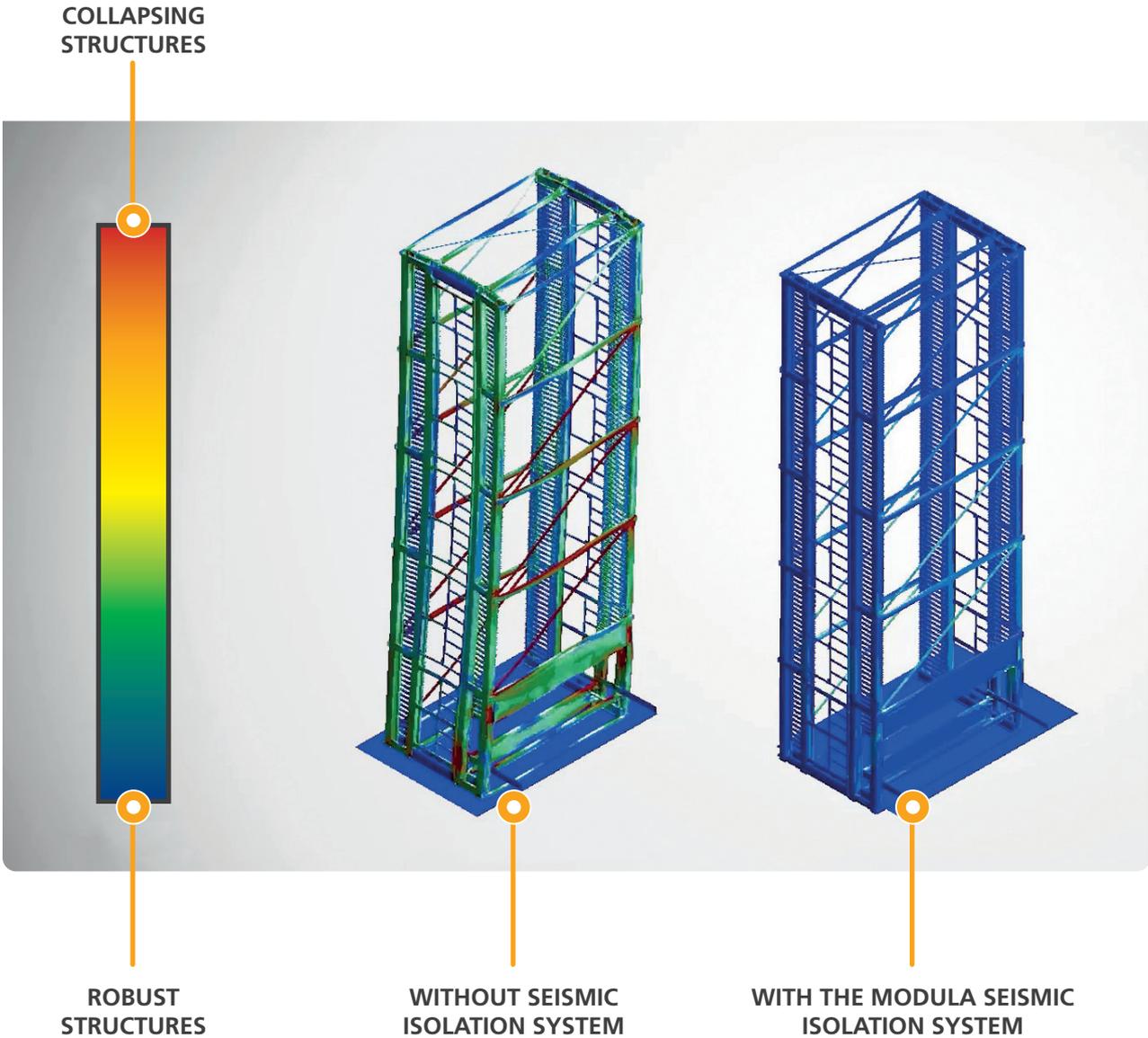
Test results

PGA's greater than 1g

Tests showed that the storage system withstood horizontal accelerations greater than 1g.

- No damage to the storage system
- No damage to the trays
- Minimum shifting of the trays (which remain on the support shelves in their original position)
- Return to normal operation

THESE SOLUTIONS PROTECT THE PERSONNEL, THE GOODS AND THE STORAGE SYSTEM



Solutions IS 2 and IS 3

Seismic isolation system

The IS 2 and IS 3 solutions are related to the concept of **seismic isolation**. The principle is to minimize the forces transmitted from the ground to the storage system structure. The isolation system dissipates the energy produced by the accelerations resulting from the seismic event, transferring just a percentage of this

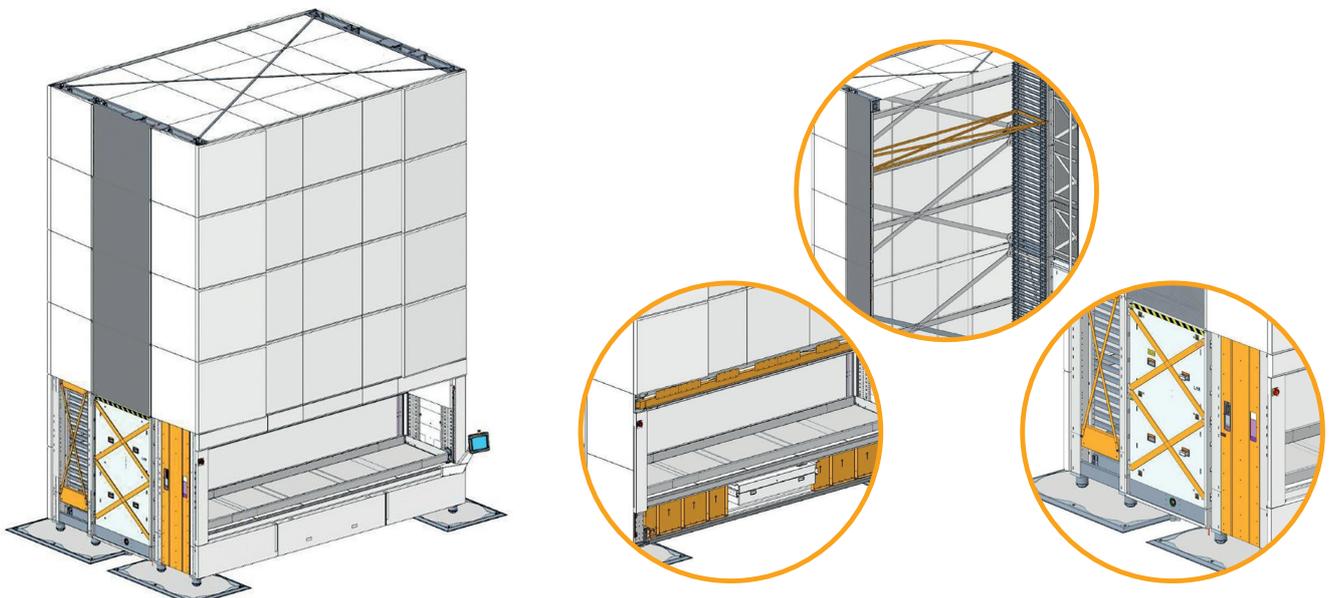
energy to the structure: thanks to the reduced friction between the progressive resistance feet and the sliding plates, the system tends to be displaced laterally only to a limited extent.

By considerably reducing the accelerations transmitted to the storage system, and with them the stresses exerted on the load-bearing elements of the racking, the risk of the trays being displaced and falling is eliminated. Falling trays would not only cause damage to the goods stored in the system but may also damage the structure itself and cause objects to be dropped, thereby jeopardizing the safety of personnel.

The elimination of the risk of the trays falling is certainly the most important advantage of a system equipped with seismic isolation technology. The seismic isolation system consists of:

- A controlled and progressive friction contact system (IS2 and IS3) comprised of a pad placed between the feet and the steel plates that serve as support bases.
- A damping system with non-linear progressive springs (IS3) to limit horizontal movements while remaining within the acceleration range the structure can withstand.
- An electronic emergency stop device controlled by an accelerometer, available as an option for all solutions.

In non-seismic situations the seismic isolation system does not affect the regular operation of the storage system. Its installation does not require any special modifications: the sliding plates and the anti-tip system must be anchored to the floor, while all the other elements are an integral part of the storage system structure.



Components of the two seismic isolation solutions

Soluzion IS 2



Foot with controlled-friction pads.

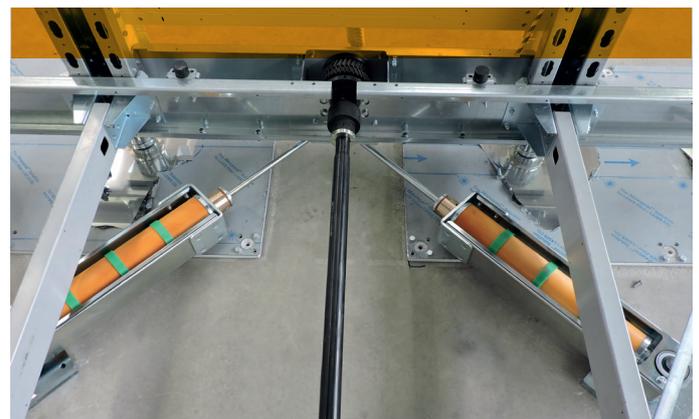


Surface on which the foot is placed and slides.

Soluzion IS 3

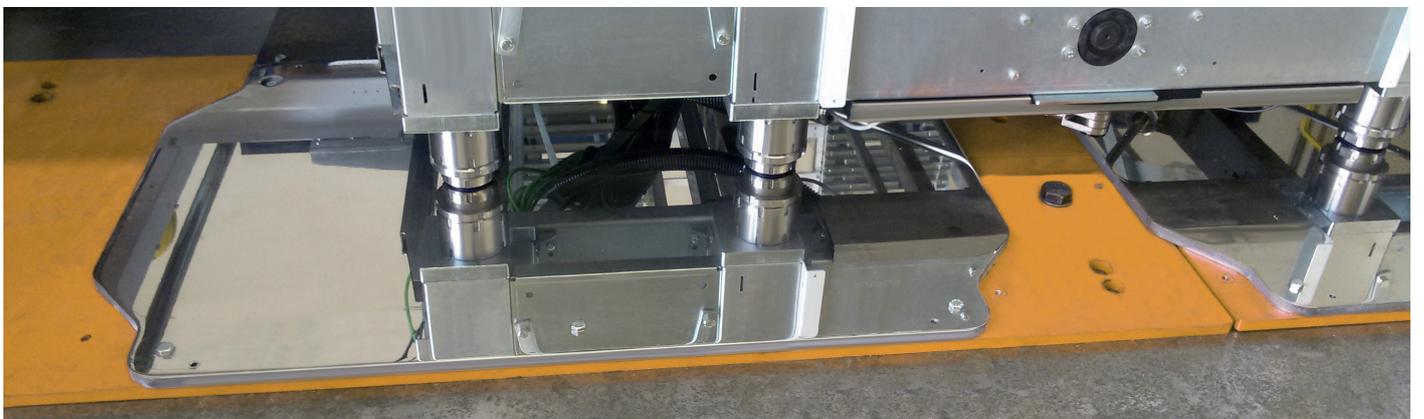
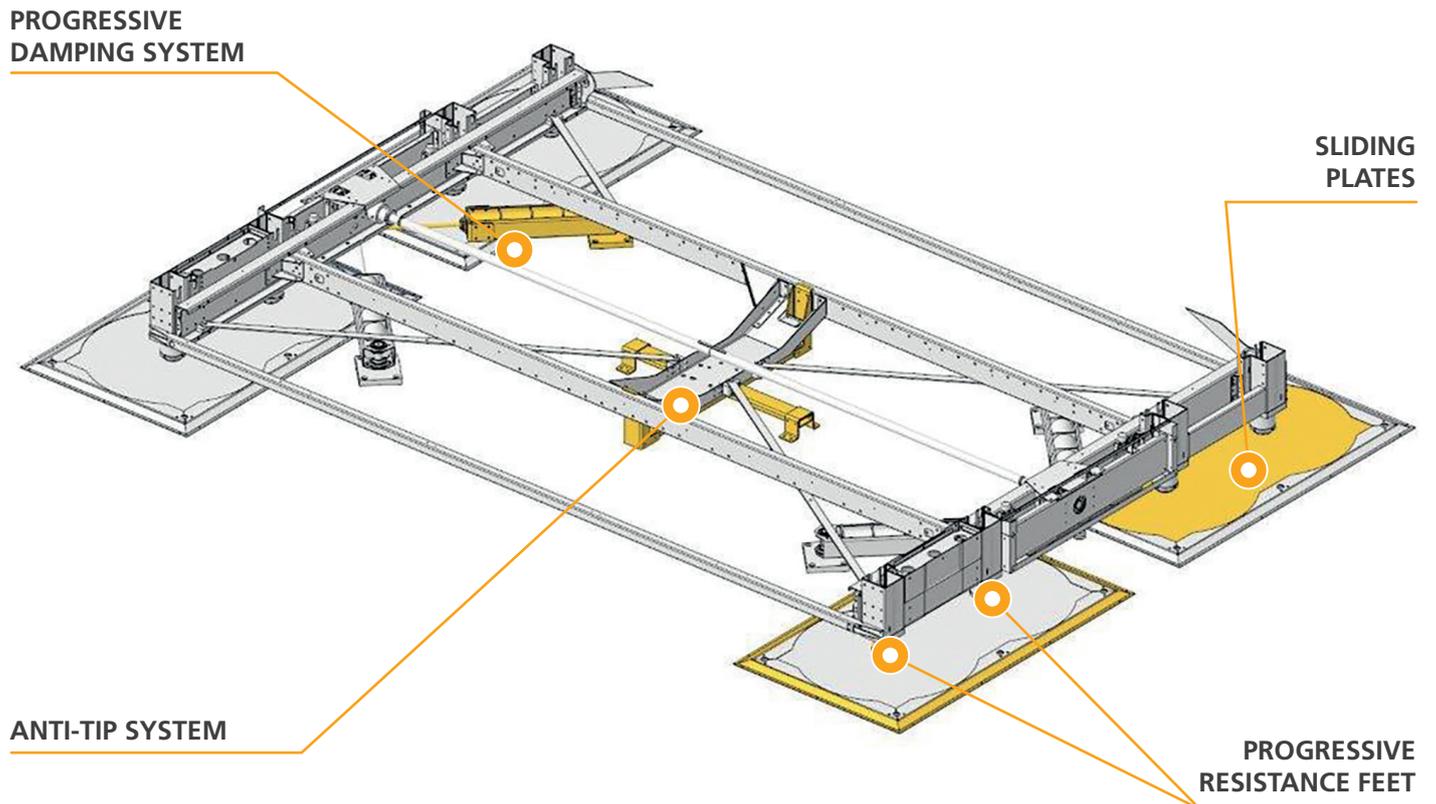
Progressive damping system.

In this case the IS2 solution is supplemented with an element which progressively absorbs energy.



Soluzione IS 3

SYSTEM OVERVIEW

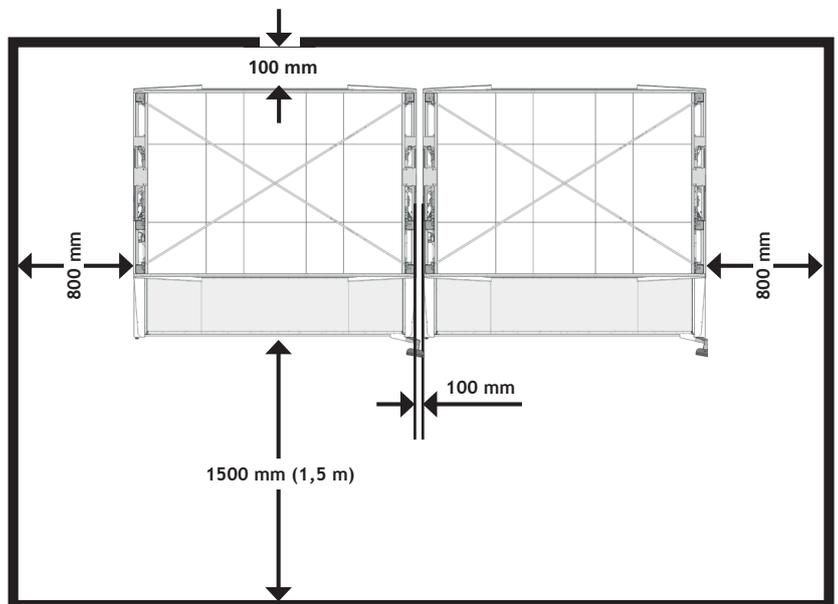
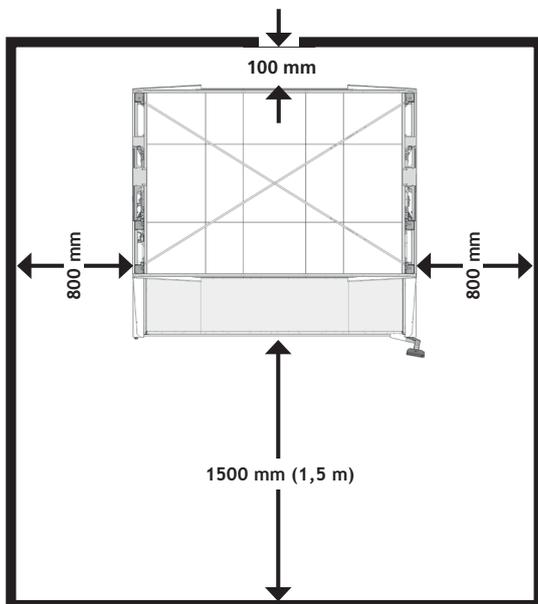


Installation



Soluzione AS 0

AS 0



Anti-seismic installations require a larger empty area around the machine compared to standard installations. This enlarged empty area is necessary to enable the movement of the storage system in case of a seismic event.

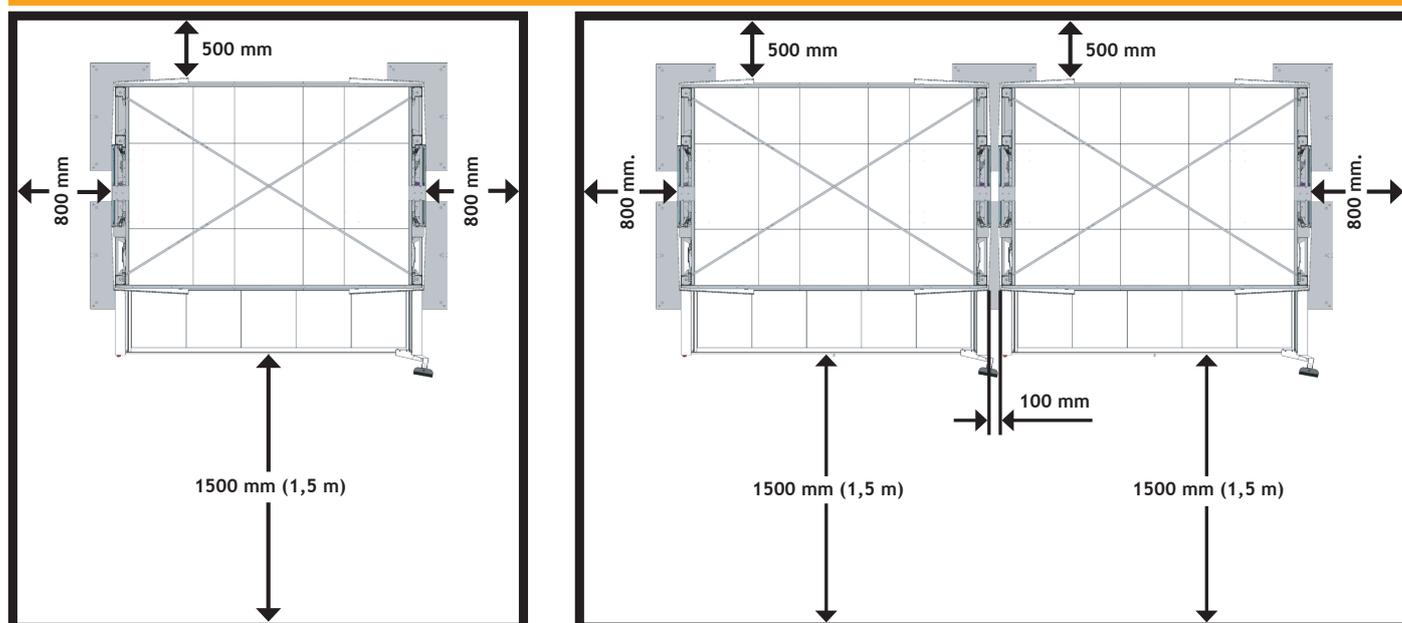
PLEASE NOTE!

The sizes in question may vary depending on the heights involved, so they should be checked with the technical department.

Soluzioni IS 2 and IS 3

IS 2

IS 3



It is necessary to increase the space around the machine by **500 mm** on each side for its **entire height**, including the surface of the sliding plates.

This buffer area around the machine **MUST BE FREE** of all objects on the ground and on the plates, including other machines or equipment (such as pipes, systems etc.).

Personnel **are allowed** to pass through these buffer areas exclusively to carry out regular warehousing activities but must otherwise leave these areas free.

OTHER RESTRICTIONS

- Internal bays cannot be used at a height
- It is not possible to integrate the machine with a trolley
- Telescopic bays can be used only for trays with a capacity up to 250 kg

Software and options

Software

The anti-seismic system also includes specific management software. This is not Modula's WMS but a function of the Modula OS.

In the storage systems with seismic isolation heavier goods must be placed at the bottom to lower the center of gravity.

This approach is an alternative to the usually adopted cycle based on ABC analysis, where the most frequently handled goods are placed closer to the bay

Options

One of the significant aspects of the Modula anti-seismic solutions is the short time needed to resume operation following an earthquake.

This is possible thanks to an optional consisting of:

- An accelerometer that records seismic shocks
- A system that monitors the proper position of each tray.

The accelerometer detects all seismic shocks and records horizontal acceleration even when the machine is off; if the machine is actually moving, the operation of the storage system is immediately and safely interrupted.

At the end of the earthquake, when the machine is switched back on, an automatic procedure checks the correct position of each tray by means of special internal photocells.

If the trays are in the correct position (on the shelves), the machine can be restarted and resume normal operation. Otherwise, the intervention of Modula's technicians is required. This optional function can be installed in all solutions.

Choosing the right solution!



- **STEP 1**
Collect all relevant information from the customer (see form).
- **STEP 2**
Submit the information to Modula's technical department.
- **STEP 3**
The technical department conducts a careful analysis and returns a report suggesting the most appropriate solution/configuration for the customer.

Example of a data collection form

ITEM	DESCRIPTION	DATI	NOTES
1	Place of installation		
2	Machine configuration		
3	Intended use		
4	Subsoil class		

1*	Country, city/town, address or coordinates (Longitude, Latitude)
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2*	Type, height, number of bays, number of trays and their capacities, total weight of the storage system when fully loaded.
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Some examples of intended use: "GROUP C"	
3*	C/1 Shops and small retailers
	C/2 Warehouses and storage facilities
	C/3 Artisan or craftsman shops or workshops
	C/4 Buildings and structures for sports activities (non-profit)
	C/5 Beach resorts, spas and similar activities (non-profit)
	C/6 Stables, garages, auto workshops
	C/7 Closed or open covering structures

SOIL TYPES: A, B, C, D, E	
4*	A. Rock or other rock-like geological formation characterized by a shear wave velocity $V_{s30} > 800$ m/s, possibly including at most 3 m of weaker material at the surface.
	B. Deposits of very dense sand, gravel, or very stiff clay with thickness exceeding 30 m, characterized by a gradual increase of the mechanical properties with depth and by V_{s30} values ranging from 360 to 800 m/s (i.e., $NSPT_{30} > 50$ in coarse-grained soils and $c_{u,30} > 250$ kPa in fine-grained soils).
	C. Deposits of dense or medium dense sand, gravel, or stiff clay with thickness exceeding 30 m, characterized by a gradual increase of the mechanical properties with depth and by V_{s30} values ranging from 180 to 360 m/s (i.e., $15 < NSPT_{30} < 50$ in coarse-grained soils and $70 < c_{u,30} < 250$ kPa in fine-grained soils).
	D. Deposits of loose to medium cohesionless soil or of predominantly soft-to-firm cohesive soil, with thickness exceeding 30 m, characterized by a gradual increase of the mechanical properties with depth and by V_{s30} values < 180 m/s (that is $NSPT_{30} < 15$ in coarse-grained soils and $c_{u,30} < 70$ kPa in fine-grained soils).
	E. Type C or D soil profile with thickness not exceeding 20 m, located over stiffer material (with $V_s > 800$ m/s).

Prices and documents issued



LIFT	€
IS 2	7.500
IS 3	11.250



WHAT IS ISSUED TO THE CUSTOMER?

Solutions IS 2 and IS 3 come with a **report** on the analysis of the **structural behavior** of the Modula system. For the **AS0 solution** the report is issued **only upon request**.



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1g

Modula World



Modula is present in 5 continents with dealers and branches located in over 50 countries

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