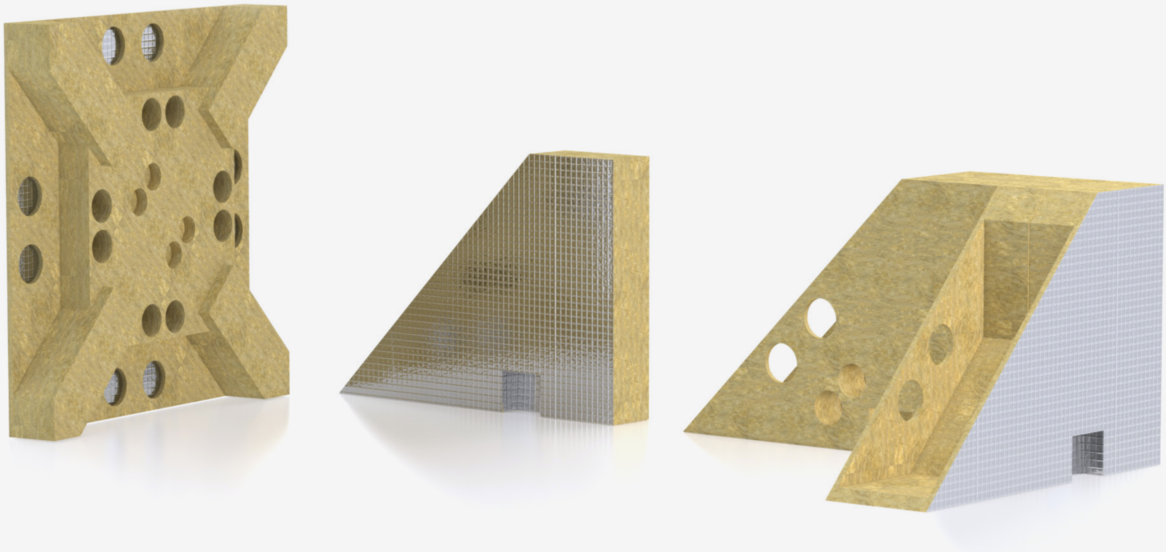
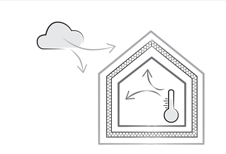
X-SEAL

Complete system for air tightening and thermal-acoustic comfort





COMFORT AND DURABILITY

The rock wool structure and aluminium finish ensure acoustic and hermetic performance while protecting the heart of the X-RAD system

PRE-SHAPING

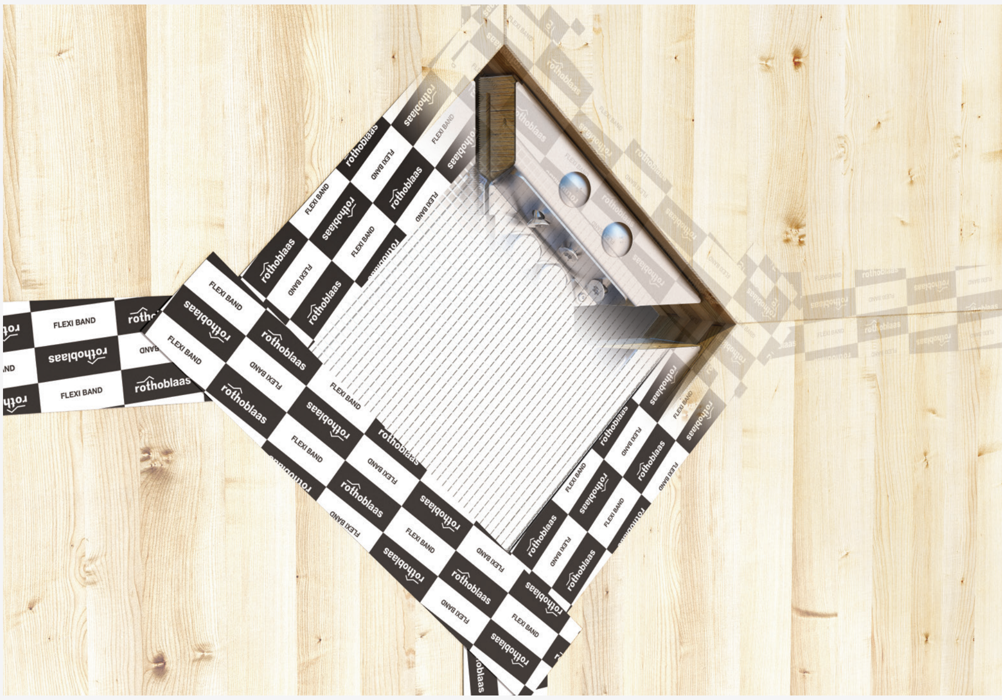
Thanks to the shape which perfectly fits X-ONE and X-PLATE, the quick closure of the construction node is optimal and does not need further filling materials

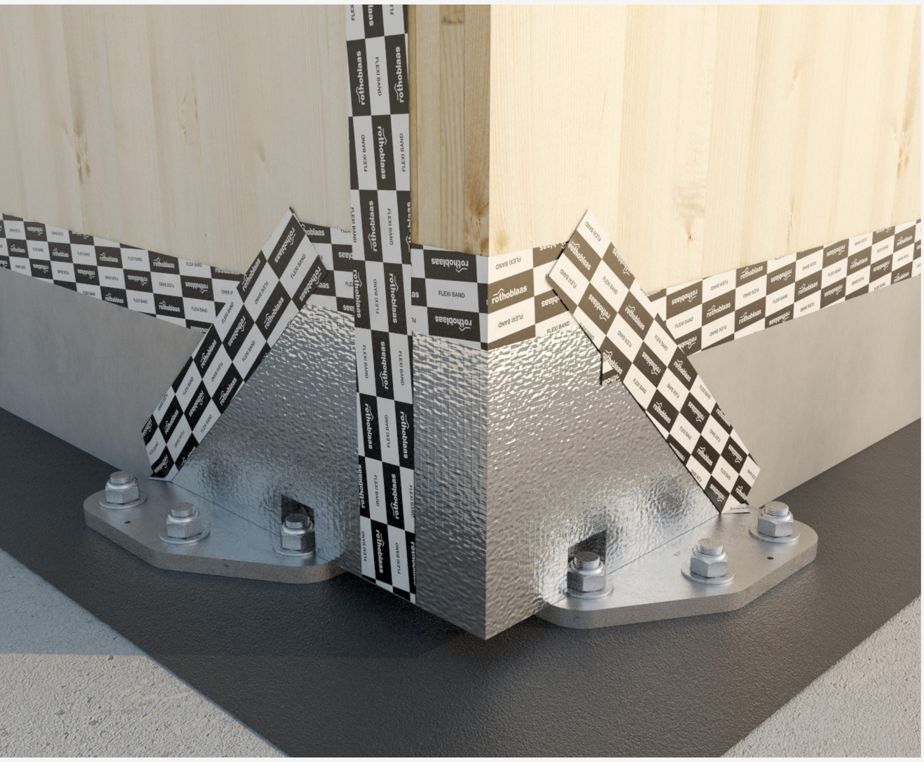
PRACTICAL

The use of X-SEAL in combination with the range of rothoblaas acrylic tapes ensures quick execution and a perfect preservation over time of the seal characteristics against air and wind

DID YOU KNOW THAT...?

X-RAD is an innovative system that requires intelligent, fast and practical solutions also to optimise thermo-hygrometric and acoustic performance. For this reason X-SEAL has been developed.
This is a pre-shaped closure that is suited to the morphology of the X-ONE and X-PLATE components. X-SEAL guarantees air and wind tightening, reduces the transmission of acoustic vibrations through the air and attenuates the single-point thermal bridge.





INSULATION

The specific density of rock wool in the X-SEAL system optimally solves the single-point thermal bridge

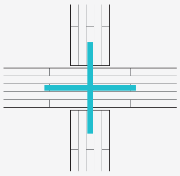
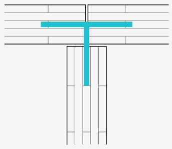
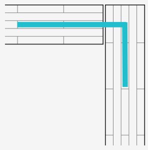
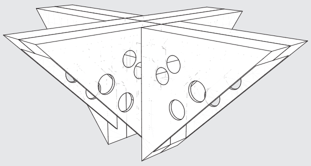
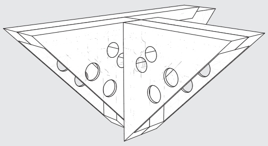
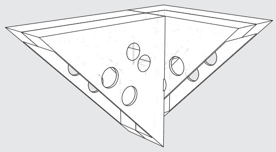
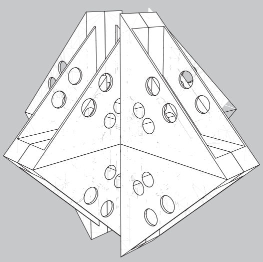
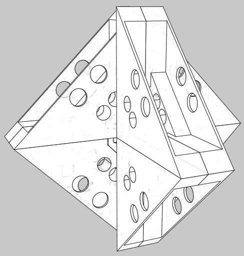
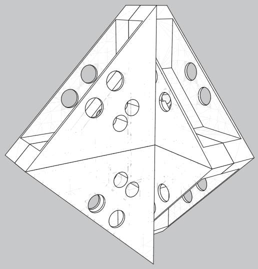
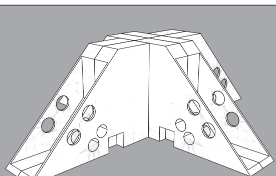
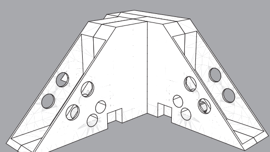
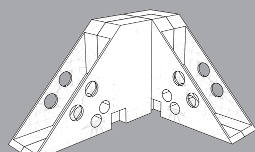
HERMETIC

The system components are all perfectly pre-shaped, thus guaranteeing, together with acrylic tapes sealing, perfect air tightness of the node

PROTECTION

At the ground connection, the use of X-SEAL and self-adhesive protection membranes for the CLT panels guarantees durability to the structure

X-SEAL SYSTEM COMPONENTS

SHAPE X	SHAPE T	SHAPE G
		
X-SEAL TOP		
 code **XSEALTX100 / TX120 / TX140** no. 8 components	 code **XSEALTT100 / TT120 / TT140** no. 5 components	 code **XSEALTG100 / TG120 / TG140** no. 4 components
X-SEAL MID		
 code **XSEALMX100 / MX120 / MX140** no. 16 components	 code **XSEALMT100 / MT120 / MT140** no. 9 components	 code **XSEALMG100 / MG120 / MG140** no. 6 components
X-SEAL BASE		
 code **XSEALBX100 / BX120 / BX140** no. 8 components	 code **XSEALBT100 / BT120 / BT140** no. 5 components	 code **XSEALBG100 / BG120 / BG140** no. 4 components

The X-SEAL system uses the same logic as the X-PLATE plates. Each configuration is characterised and described by:

- LEVEL: indicates whether it is base level B (BASE), mid-floor M (MID) or roof T (TOP)
- NODE: indicates the type of node (X, T, G, J, I, O)
- THICKNESS: indicates the thickness of the panel that can be used. There are three families of standard thickness: 100 mm - 120 mm - 140 mm. It is possible to use all thicknesses of panels between 100 mm and 200 mm, combining the base components for standard thicknesses with SPACER elements, with thicknesses between 5 and 10 mm.

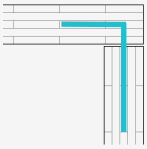
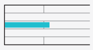
X-SEAL BASE

X-SEAL MID

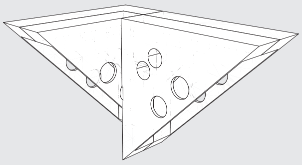
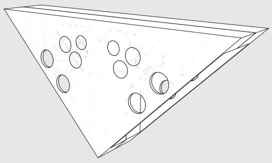
X-SEAL TOP

INSTALLATION MANUAL FOR THE X-SEAL SYSTEM

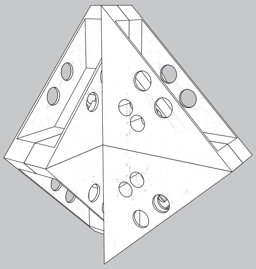
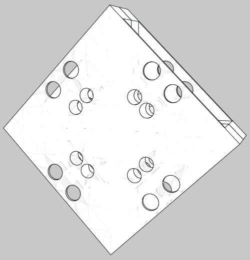
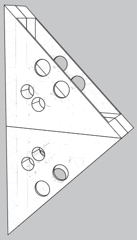
Can be downloaded from www.rothoblaas.com or using the QR-CODE on the box.

SHAPE J	SHAPE I	SHAPE O
		

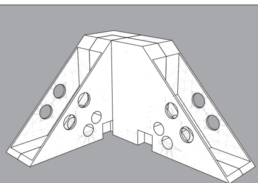
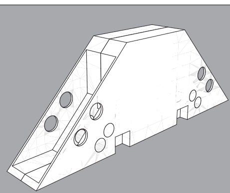
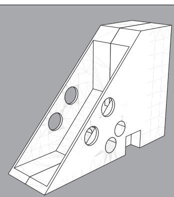
X-SEAL TOP

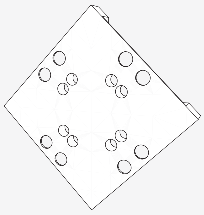
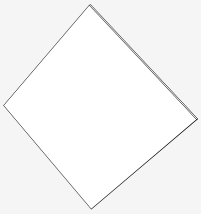
 code **XSEALTJ100 / TJ120 / TJ140** no. 4 components	 code **XSEALTI100 / TI120 / TI140** no. 2 components	

X-SEAL MID

 code **XSEALMJ100 / MJ120 / MJ140** no. 6 components	 code **XSEALMI100 / MI120 / MI140** no. 3 components	 code **XSEALMO100 / MO120 / MO140** no. 3 components

X-SEAL BASE

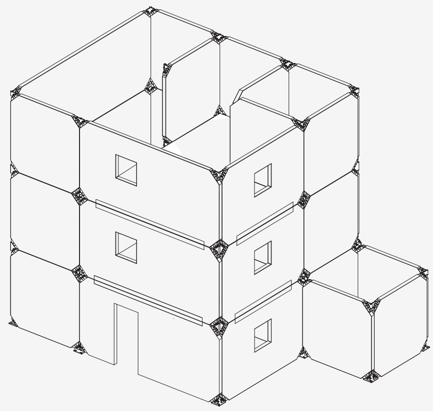
 code **XSEALBJ100 / BJ120 / BJ140** no. 4 components	 code **XSEALBI100 / BI120 / BI140** no. 2 components	 code **XSEALBO100 / BO120 / BO140** no. 2 components

X-SEAL SPARE 50 / 60 / 70	X-SEAL SPACER 5 / 10
 code **XSEALSPARE50 / 60 / 70**	 code **XSEALSPACER5 / 10**

NOTES: With the X-SEAL SPARE elements, with thicknesses of 50 - 60 - 70 mm, all components of the X-SEAL system can be obtained.
THE X-SEAL MID components belonging to the walls of the floor below must always be assembled before installing the slab panels.

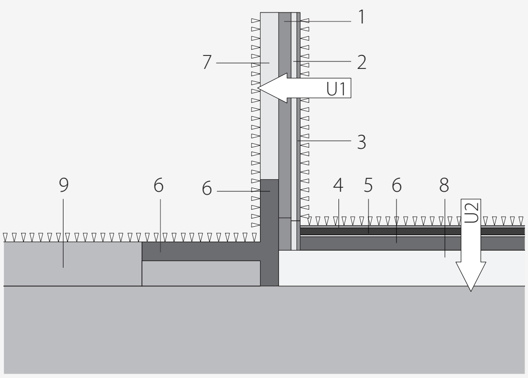
THERMO-HYGROMETRIC PERFORMANCE

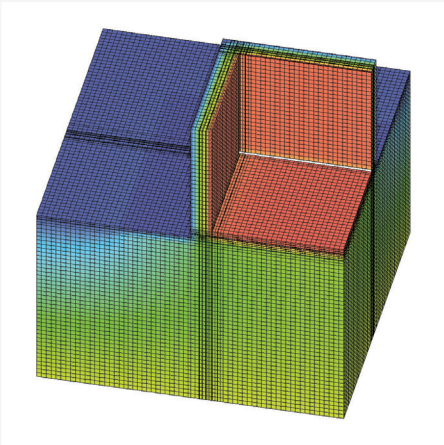
The thermal analysis of the X-RAD system is carried out in order to quantify and verify the thermal bridge associable with the single-point element so that it can be used in the calculation of the building's thermal performance.
The most unfavourable conditions on which to concentrate the study and the verification are the attachment to the ground of the BASE G element near to the corner **(A)** and the node of the wall and roof slab attachment, TOP G **(B)**.
The study is carried out using a FEM - 3D model and the calculation software Psi-Therm 3D. An overview of the study with some of the results is provided below.
To obtain the report of the complete study and further information contact the Rothoblaas Technical Office.



The stratigraphy of reference considered represents a possible standard situation which we can find in current building practice.
The 3D simulation of the thermal bridge is done with X-RAD in the configuration without X-SEAL and with X-SEAL.
In the image **(fig. 1)** we can observe the construction package and the materials considered.
The choice of specific materials makes it possible to contextualise the checks and does not exclude the use of different products.
Reference can be made to the complete test report to assess the different executive choices.

fig. 1





1. 10 cm CLT
2. 5 cm wood-fibre insulation
3. Plasterboard
4. Wood floor
5. Concrete screed
6. XPS extruded polystyrene 12 cm
7. 12 cm wood-fibre insulation
8. Concrete
9. Ground

The thermal simulations are conducted varying the thicknesses of the insulation (12 cm, 16 cm and 24 cm), trying to identify possible values that would also roughly identify possible energy classes and the related performance.
The simulations are carried out in 3 different climatic contexts that reflect the most frequent weather conditions in the northern and southern temperate zones, referring to a minimum average temperature of the coldest month (Te).

The analysis provided various data and information, including isotherms, the X (Chi) value and the fRsi value.

- X (Chi) represents the additional thermal flow of the three-dimensional thermal bridge with respect to the transmittance of the construction elements involved and two-dimensional thermal bridges of the attachments between them. The value is universal and independent of the climate data, but is affected by the insulation of the construction elements (see final report available at Rothoblaas Technical Office).
  Reference Standard: EN 10211
- fRsi represents the universal instrument for calculating the internal surface temperature (Tsi) in any place.
  While the fRsi is universal for calculated node, the internal surface temperature depends on the external climate. Using the Tsimin the danger of mould and condensation is assessed.
  Reference Standard: EN 13788

NODE 1: GROUND ANCHORING

coefficient	description	value
X Chi (16 cm)	thermal flow	- 0.330 W/node
fRsi (Te = - 5 °C)	temperature factor	0.801

Node 1 thermal flow: Chi value

insulation	wall thermal-transmittance	value
12 + 5 cm	0.190 W/m²K	- 0.380 W/node
16 + 5 cm	0.160 W/m²K	- 0.330 W/node
24 + 5 cm	0.121 W/m²K	- 0.260 W/node

Node 1 mould danger: Tsi

temperature (te)	Tsi 12 cm insulation	Tsi 16 cm insulation	Tsi 24 cm insulation
fRsi-average	*0.801*	*0.811*	*0.824*
- 5.0 °C	15.2 °C	15.5 °C	15.8 °C
0.0 °C	16.0 °C	16.2 °C	16.5 °C
5.0 °C	16.8 °C	16.9 °C	17.1 °C

NODE 1: SLAB-ROOF ATTACHMENT

coefficient	description	value
X Chi (16 cm)	thermal flow	- 0.142 W/node
fRsi (Te = - 5 °C)	temperature factor	0.744

Node 1 thermal flow: Chi value

insulation	wall thermal-transmittance	value
12 + 5 cm	0.190 W/m²K	- 0.380 W/node
16 + 5 cm	0.160 W/m²K	- 0.330 W/node
24 + 5 cm	0.121 W/m²K	- 0.260 W/node

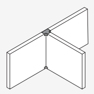
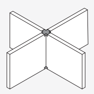
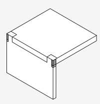
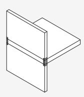
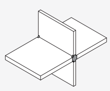
Node 1 mould danger: Tsi

temperature (te)	Tsi 12 cm insulation	Tsi 16 cm insulation	Tsi 24 cm insulation
fRsi-average	*0.744*	*0.766*	*0.800*
- 5.0 °C	13.6 °C	14.1 °C	15.0 °C
0.0 °C	14.9 °C	15.3 °C	16.0 °C
5.0 °C	16.2 °C	16.5 °C	17.0 °C

ACOUSTIC PERFORMANCE

With X-RAD the structural nodes are concentrated in single and distinct points. As regards the acoustics a targeted and calibrated study was carried out within the Flanksound Project on this new building concept in order to achieve the acoustic characterisation of the structural nodes created with X-RAD.
Rothoblaas has therefore supported research aimed at measuring the vibration reduction index K_{ij} for a variety of joints between the CLT panels, with the dual objective of providing experimental data specific to acoustic design of buildings in CLT and contributing to development of the calculation methods.
Vibration reduction index measurements were performed in accordance with EN ISO 10848. For more information and details on the design and measurement methods, see "Catalogues / Soundproofing" section in www.rothoblaas.com website.
X-SEAL avoids direct acoustic transmission through the air caused by the "emptying" of the mass of the node due to the 45° cut on the CLT panel.

SUMMARY OF THE CONFIGURATIONS TESTED WITHIN THE FLANKSOUND PROJECT

		FASTENING SYSTEM						ACOUSTIC SOLUTION			
	DETAIL	X-PLATE BASE T	X-PLATE TOP T	X-PLATE BASE X	X-PLATE TOP X	X-PLATE BASE O	X-PLATE MID O	CONSTRUCTION SEALING	XYLOFON	ALADIN STRIPE	TITAN SILENT
	45	●	●	-	-	-	-	-	-	-	-
	46	-	-	●	●	-	-	-	-	-	-
	47	-	-	-	-	●	-	-	-	-	-
	48	-	-	-	-	●	-	-	●	●	-
	49	-	-	-	-	●	●	-	-	-	-
	50	-	-	-	-	●	●	-	●	-	-
	51	-	-	-	-	●	●	-	-	-	-
	52	-	-	-	-	●	●	-	●	-	-

KEY

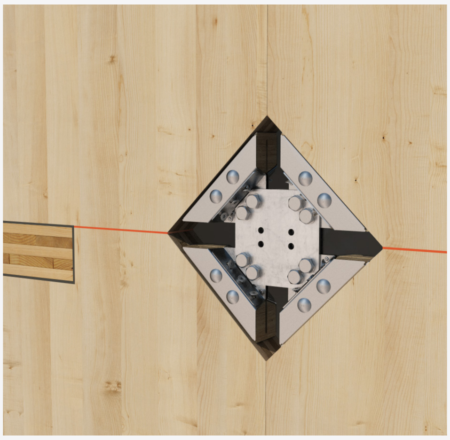
Data estimated from the experimental measurements

FOR MORE INFORMATION

- A. Speranza, L. Barbaresi, F. Morandi, *"Experimental analysis of flanking transmission of different connection systems for CLT panels"* in Proceedings of the World Conference on Timber Engineering 2016, Vienna, August 2016.
- L. Barbaresi, F. Morandi, M. Garai, A. Speranza, *"Experimental measurements of flanking transmission in CLT structures"* in Proceedings of the International Congress on Acoustics 2016, Buenos Aires, September 2016.
- L. Barbaresi, F. Morandi, M. Garai, A. Speranza, *"Experimental analysis of flanking transmission in CLT structures"* of Meetings on Acoustics (POMA), a serial publication of the Acoustical Society of America - POMA-D-17-00015.

ATTENTION TO DETAIL

Thanks to the precise location of the structural nodes at the tops of the CLT walls, X-RAD enables the non-interposition of the slabs between the walls. This entails significant benefits from the acoustic point of view, which increase with the adoption of specific profiles, providing the spaces shown in fig. 1.



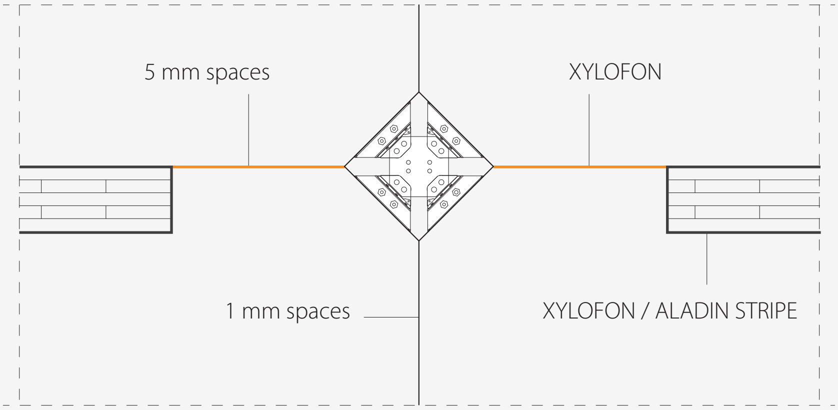


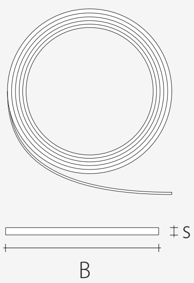
fig. 1

It is always advisable to have an interposition between the walls and slabs for the following acoustic profiles:

- **resilient acoustic profiles in PUR: XYLOFON** (fig. 1)
  Hermetic closure of the attachment between the structural elements and damping of the sound vibrations irrespective of the static or dynamic load applied, maintaining great elasticity and performance over time.
- **resilient acoustic profiles in EPDM: ALADIN STRIPE** (fig. 1)
  Hermetic closure of the attachment between the structural elements and damping of the acoustic vibrations between slab and wall. The resilient layer created dampens the sound wave otherwise transmitted by the structure vertically and horizontally.

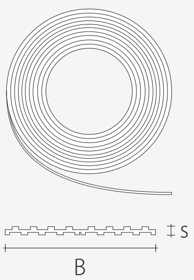
All these materials must be provided for at the stage of designing and cutting the panels.

XYLOFON



code	**ex code**	**version**	**B** [mm]	**L** [m]	**s** [mm]	**pcs/box**
XYL35100	D82411	**35**	100	3.66	6	1
XYL50100	D82412	**50**	100	3.66	6	1
XYL70100	D82413	**70**	100	3.66	6	1
XYL80100	D82414	**80**	100	3.66	6	1
XYL90120	D82415	**90**	120	3.66	6	1

ALADIN STRIPE

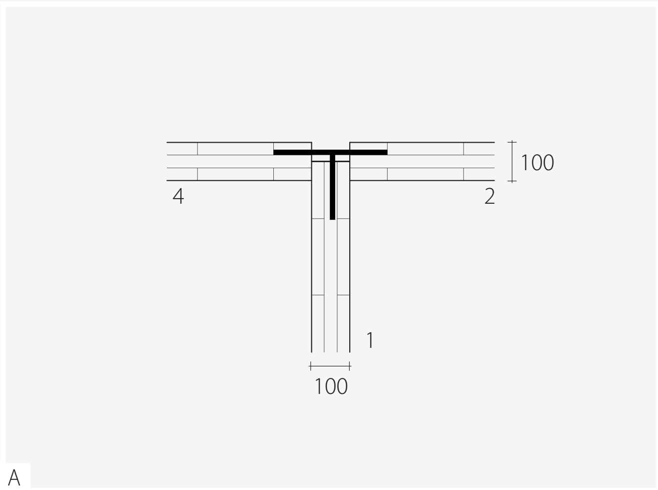


code	**ex code**	**version**	**B** [mm]	**L** [m]	**s** [mm]	**pcs/box**
ALADIN95	D82113	soft	95	50	5	1
ALADIN115	D82123	extra soft	115	50	7	1

FLANKSOUND PROJECT: ANALYSIS OF THE ACOUSTIC PERFORMANCE OF CLT STRUCTURES WITH X-RAD CONNECTIONS

WALL - WALL JOINTS

DETAIL 45 | VERTICAL T JOINT

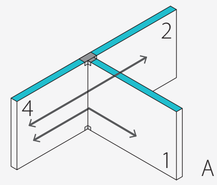


FASTENING SYSTEM

X-PLATE BASE T, X-PLATE TOP T

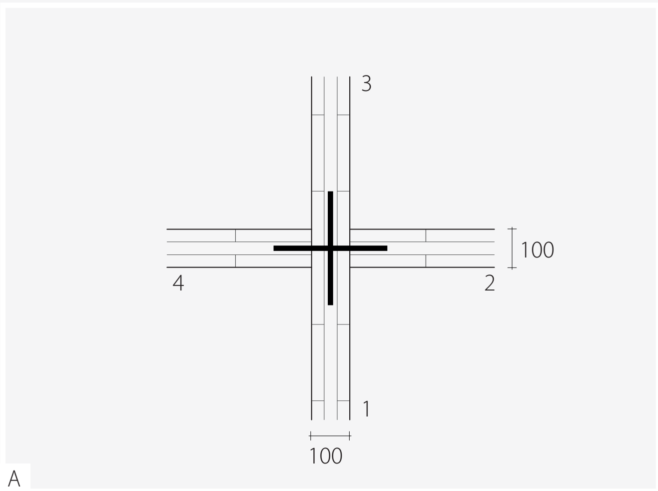
RESILIENT PROFILE

no



Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	$AVG_{200-1250}$
K_{14} (dB)	10.2	7.0	8.1	6.4	6.4	5.1	6.7	7.6	7.3	7.9	8.2	9.7	12.7	12.9	12.6	15.5	**7.3**
K_{24} (dB)	15.7	16.0	13.6	6.5	6.4	8.8	9.5	15.2	18.4	17.7	20.2	18.9	24.7	24.7	23.4	28.5	**13.5**

DETAIL 46 | VERTICAL X JOINT

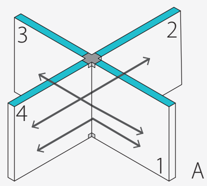


FASTENING SYSTEM

X-PLATE BASE X, X-PLATE TOP X

RESILIENT PROFILE

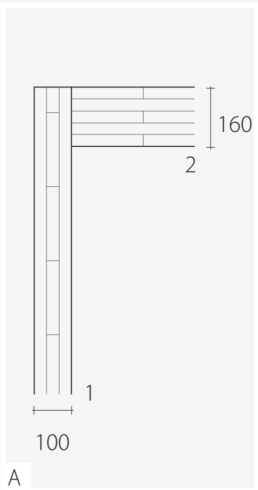
no

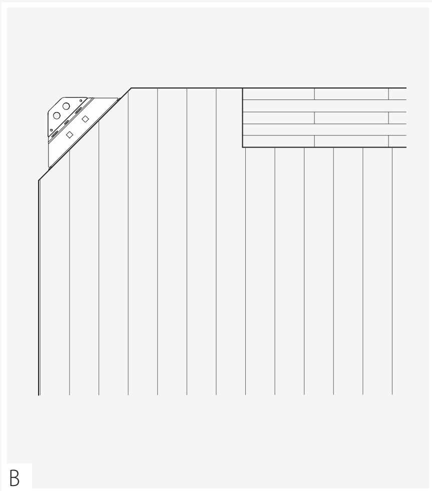


Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	$AVG_{200-1250}$
K_{14} (dB)	12.7	11.4	10.2	8.5	8.5	7.0	8.1	10.7	11.5	9.5	11.1	12.5	15.8	17.5	17.5	21.6	**9.7**
K_{24} (dB)	18.9	12.0	13.3	9.7	8.7	8.8	6.6	11.1	13.1	11.7	13.4	12.6	13.8	14.4	12.4	16.9	**10.6**
K_{13} (dB)	15.0	13.7	13.6	12.0	11.8	9.3	8.2	12.6	15.4	13.3	12.6	13.2	19.0	21.6	24.0	31.4	**12.0**

WALL - CEILING JOINTS

DETAIL 47 | HORIZONTAL L JOINT



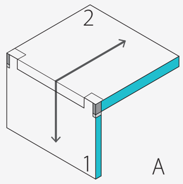


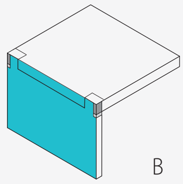
FASTENING SYSTEM

X-PLATE BASE O

RESILIENT PROFILE

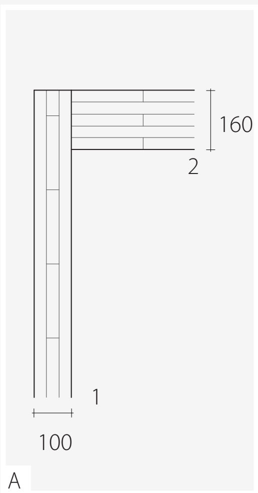
no

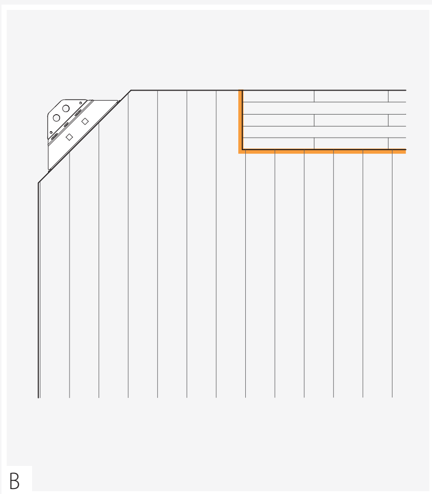




Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	AVG200-1250
K12 (dB)	13.1	13.8	14.2	10.6	11.6	12.8	12.2	10.6	12.2	9.7	8.1	11.2	9.9	10.2	11.2	13.5	**11.0**

DETAIL 48 | HORIZONTAL L JOINT



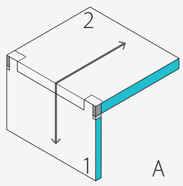


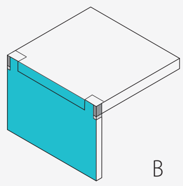
FASTENING SYSTEM

X-PLATE BASE O

RESILIENT PROFILE

XYLOFON*, ALADIN STRIPE**

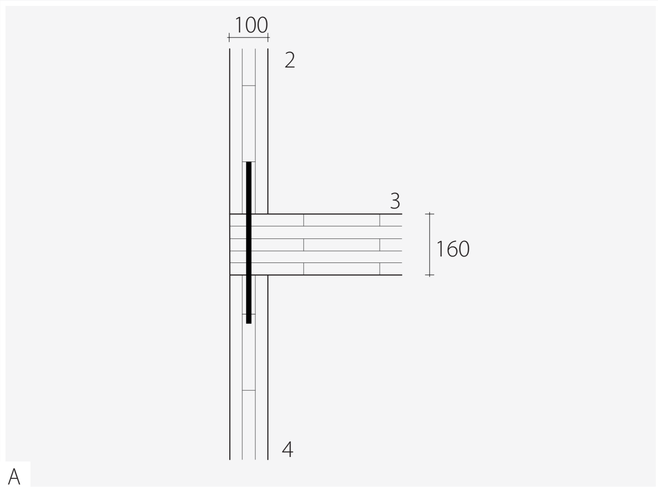




Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	AVG200-1250
K12 (dB) *	12.0	14.6	11.8	13.2	12.8	15.2	15.9	14.9	15.7	15.9	13.9	12.6	16.2	18.5	17.8	17.5	**14.4**
K12 (dB) **	16.3	13.7	14.4	13.8	13.4	12.7	11.4	10.0	13.3	14.3	13.3	14.3	15.9	13.9	16.2	21.9	**13.0**

WALL - CEILING JOINTS

DETAIL 49 | HORIZONTAL T JOINT

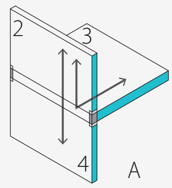


FASTENING SYSTEM

X-PLATE BASE O, X-PLATE MID O

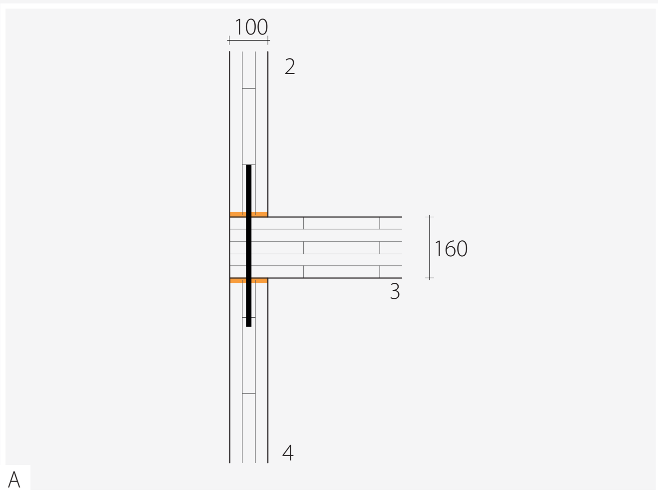
RESILIENT PROFILE

no



Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	AVG200-1250
K_{23} (dB)	17.2	13.0	13.1	10.4	9.5	7.1	7.7	7.6	8.3	9.9	11.3	13.7	17.8	18.9	19.6	23.5	**9.5**
K_{24} (dB)	24.2	20.0	20.1	17.4	16.5	14.1	14.7	14.6	15.3	16.9	18.3	20.7	24.8	25.9	26.6	30.5	**16.5**

DETAIL 50 | HORIZONTAL T JOINT

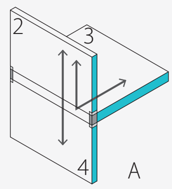


FASTENING SYSTEM

X-PLATE BASE O, X-PLATE MID O

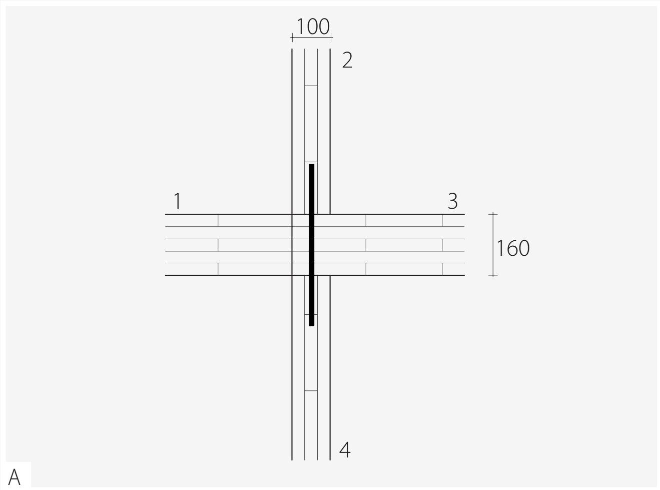
RESILIENT PROFILE

XYLOFON



Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	AVG200-1250
K_{23} (dB)	16.0	13.8	10.7	13.0	10.6	9.5	11.4	11.9	11.9	16.1	17.1	15.0	24.1	27.2	26.3	27.4	**12.9**
K_{24} (dB)	23.0	20.8	17.7	20.0	17.6	16.5	18.4	18.9	18.9	23.1	24.1	22.0	31.1	34.2	33.3	34.4	**19.9**

DETAIL 51 | HORIZONTAL X JOINT

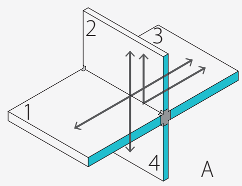


FASTENING SYSTEM

X-PLATE BASE O, X-PLATE MID O

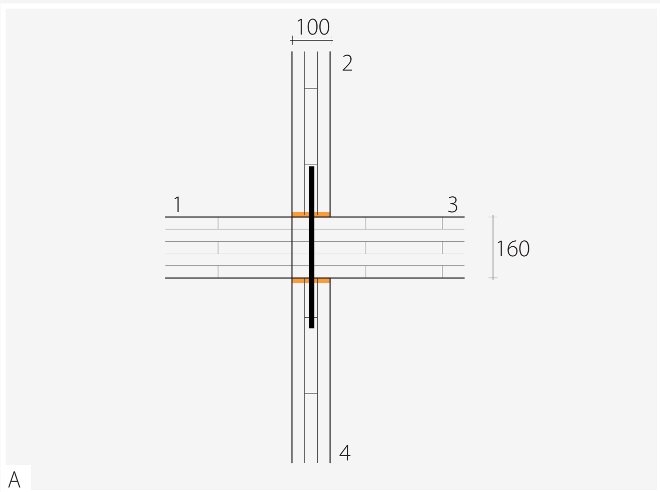
RESILIENT PROFILE

no



Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	AVG
K_{23} (dB)	19.7	17.4	15.1	12.4	11.5	9.0	9.1	10.7	12.5	11.6	14.1	16.5	20.8	23.5	24.5	29.6	**11.9**
K_{13} (dB)	13.0	11.7	11.5	10.0	9.7	7.2	6.2	10.6	13.4	11.3	10.6	11.1	17.0	19.6	22.0	29.3	**10.0**
K_{24} (dB)	19.9	13.0	14.3	10.7	9.7	9.8	7.6	12.1	14.1	12.7	14.4	13.6	14.8	15.4	13.4	17.9	**11.6**

DETAIL 52 | HORIZONTAL X JOINT

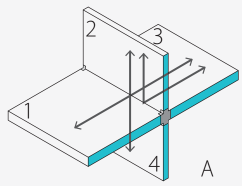


FASTENING SYSTEM

X-PLATE BASE O, X-PLATE MID O

RESILIENT PROFILE

XYLOFON



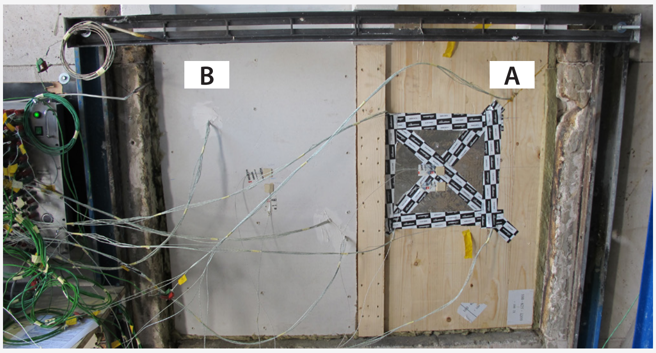
Frequency (Hz)	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	AVG
K_{23} (dB)	18.6	18.2	12.7	15.1	12.7	11.4	12.8	15.1	16.0	17.8	19.9	17.8	27.1	31.8	31.1	33.5	**15.4**
K_{13} (dB)	13.0	11.7	11.5	10.0	9.7	7.2	6.2	10.6	13.4	11.3	10.6	11.1	17.0	19.6	22.0	29.3	**10.0**
K_{24} (dB)	18.8	13.8	11.9	13.4	10.8	12.2	11.3	16.4	17.7	18.9	20.2	15.0	21.2	23.7	20.1	21.8	**15.1**

FIRE PERFORMANCE OF X-RAD CONNECTION WITH X-SEAL PROTECTION

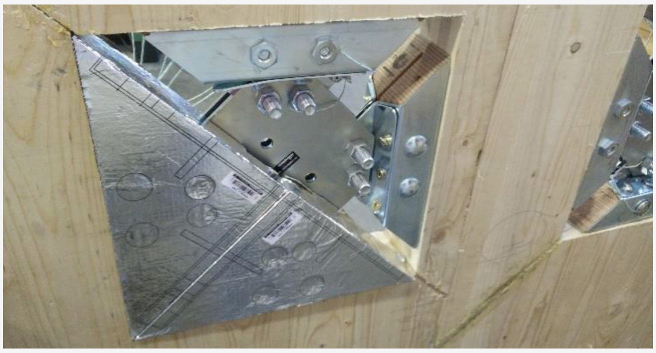
The X-RAD system involves positioning the structural connection, consisting of X-ONE and X-PLATE, on the wall axis. This allows the perfectly pre-shaped components of the X-SEAL system to adhere to the metal components of the connection, thereby ensuring hermetic and thermal-acoustic insulation. In order to understand the fire performance of this system and to verify the degree of fire protection offered by the X-SEAL components to the X-RAD system, a research programme is underway at the **Università Tecnica di Monaco (TUM)**.

A mid-floor MI node was studied at this stage, complete with X-ONE, X-PLATE and X-SEAL and its acrylic belt sealing, assembled inside a 5-layer CLT panel. Two different types of specimens were tested:

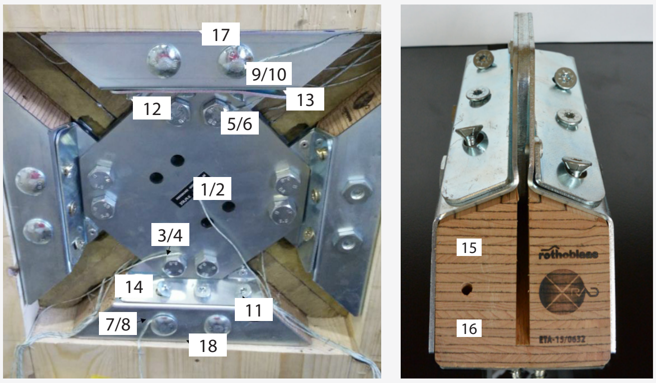
- structural wall with X-RAD system without any coating on the fire side (A)
- structural wall with X-RAD system covered with type A coated gypsum plasterboard according to DIN EN520 assembled as backing (B)



Layout of the thermocouples on the surfaces of the samples



Assembly of the X-SEAL components

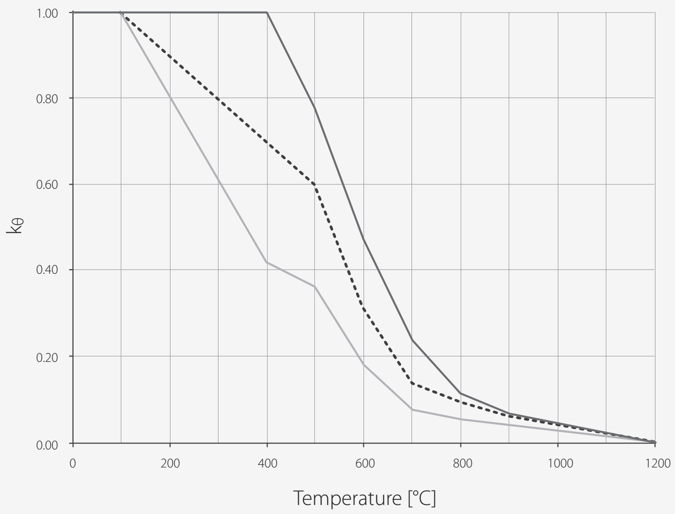


Layout of the thermocouples on X-ONE and X-PLATE

To monitor evolution of the temperatures during the test, thermocouples were installed on:

- outer surface of MI central plate
- side and upper surface of X-ONE
- head of VGS screws on X-ONE connector
- outer head of the bolts on X-ONE connector
- LVL insert head surface of X-ONE connector

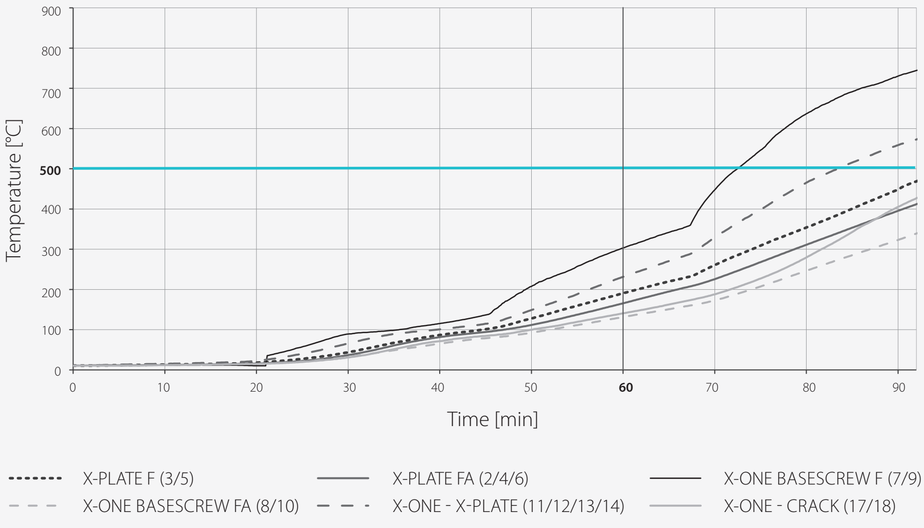
The test was conducted in compliance with the European standard EN 1363-1, which specifies the main principles for determining the fire resistance of various elements of construction when subjected to standard fire exposure conditions.



In this regard it may be useful to recall the decline of the mechanical properties of steel as the temperature increases, as described by Eurocode EN 1993:1-2. Note the significant reduction in yield stress, in elastic modulus and in the proportionality limit, when above 400°C. When 500°C have been reached, the yield stress is reduced by 20% and the elastic modulus by 40%. This temperature value is considered as the reference value during the test.

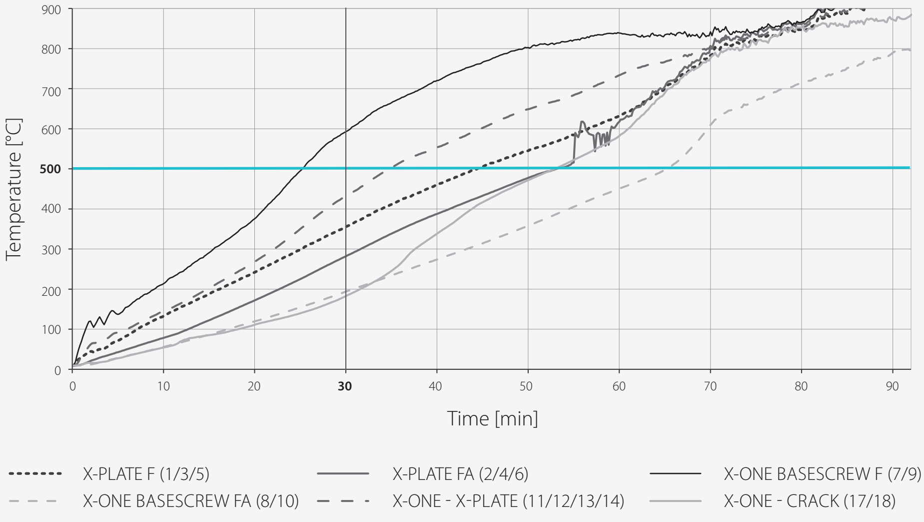
yield stress $k_{y,\theta} = f_{y,\theta} / f_y$
elastic modulus $k_{E,\theta} = E_{a,\theta} / E_a$
proportionality limit $k_{p,\theta} = f_{p,\theta} / f_y$

Evolution of the average temperatures recorded in the sample (B) coated (side exposed to fire)



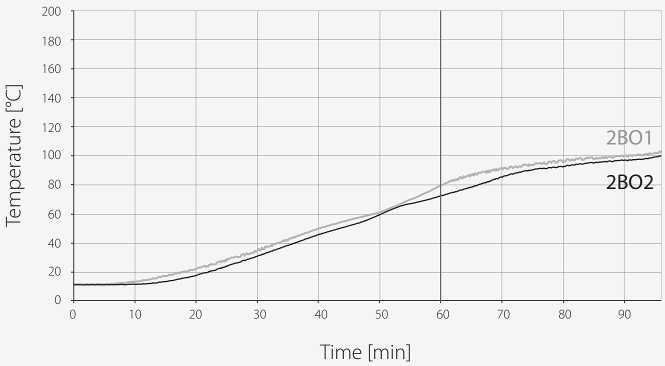
The analysis of the results highlights how all of the components in the X-RAD system maintain a **T° lower than 500°C for more than 60 min**, thus showing excellent fire performance, thanks to the protection offered by the X-SEAL system and by the coated gypsum plasterboard

Evolution of the average temperatures recorded in the sample (A) not coated (side exposed to fire)



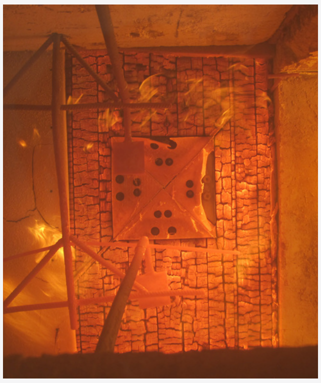
The analysis of the results highlights how most of the components in the X-RAD system (except for the most outer parts of X-ONE) maintain a **T° lower than 500°C for at least 30 min**, nevertheless showing good fire performance, thanks to the protection offered by the X-SEAL system

Evolution of the average temperatures recorded in the sample (A) not coated (side not exposed to fire)



Note the significant difference in T° recorded at **t = 60 min** between the side exposed to fire (T° ≈ 600°C) and the side not exposed **(T° ≈ 80°C)**

Fire performance of the X-RAD system in the test chamber (sample A not coated)



t = 24 min

t = 101 min