

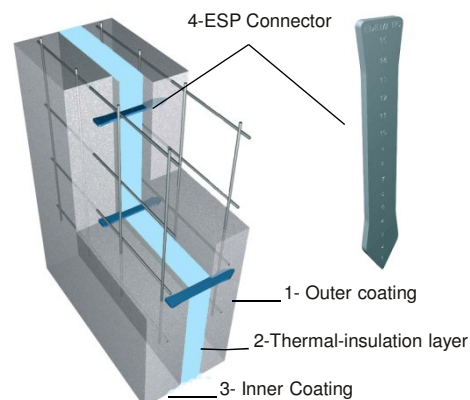
Connector for Thermal Insulating Panels

Edilmatic ESP

10-2009 Edition

GENERAL INFORMATION

ESP connector is a new connecting system allowing the realization of Multilayer or Ventilated cladding Sandwich panels, preventing from creating thermal bridges. This type of panels consists of two concrete layers (the outer wall is supported and the inner one is supporting) between which a thermal-insulation material is inserted. ESP connector, appropriately prepared, connects the two concrete layers by crossing the thermal-insulation layer and supports the outer panel. The used thermoplastic material, typical of very low heat conductivity, allows a correct distribution of the temperatures inside the panel preventing from creating thermal flux. The connector has very good mechanic properties (tensile transverse and shearing strength) and its particular configuration makes insertion in any type of thermal-insulation material very easy.



DIMENSIONS

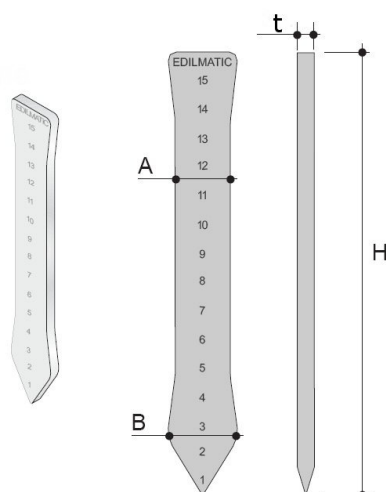


Table 1
Dimensions of ESP connector

Pin Type	A	B	t	H
ESP 120	28	34	5	180
ESP 170	34	40	7	230

The dimensions are in mm

ESP 120 and/or **ESP 170** marks refer to the total amount of the thermal-insulation material thicknesses and the concrete layer making up the outer hanging panel. Such amount cannot be more than 120 mm for ESP 120 Connectors and 170 mm for ESP 170 Connectors

In any case the thickness of the thermal-insulation panel can be **60 mm max.** for **ESP 120** and **100 mm max.** for **ESP 170**.

MECHANICAL SPECIFICATIONS OF THE MATERIAL

ESP Connectors are manufactured with thermoplastic material: it is a polyamide-66 compound, 50% reinforced with fiber glass, heat-stabilized, for injection molding. Such material is typical of a very low heat conductivity (excellent to avoid thermal flux) and good flexibility allowing the insert to "follow" the displacements between the concrete walls due to thermal expansions of the panels.

Table 2 shows the mechanical characteristics of the material.

All experimental tests to establish the mechanical characteristics of ESP connection have been carried out at the **University of Brescia**.

Table 2
Mechanical characteristics of the material

Mechanical characteristics	
Elastic Module (ISO 527) ESP 120 Pin	11500 MPa
Elastic Module (ISO 527) ESP 170 Pin	9200 MPa
Fusion temperature (DSC ISO 11357)	260 °C
Flammability (UL 94)	class HB
Thermal conductivity	0,3 W/m ² K

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TECHNICAL DATA

As already explained, **ESP** Edilmatic connector are made of fiber reinforced thermoplastic material. For the characterization both of material and product, an experimental campaign was carried out in order to establish the mechanical and physical properties of the connector in different situations of potential use. All technical test reports concerning also the behavior of the connector in basic environments and at different temperatures are available at Edilmatic. Below you can find a summary of the experimental results obtained from the connector with the indication of the resistance performances to shearing and individual tensile stress for the 2 types.

MECHANICAL BENDING CHARACTERISTICS

The results of the bending test made on Connectors oriented towards the main inertia axes (sideways and flat down) are shown in the tables near here.

The results are shown in the tables 3 and 4.

Table 3
Flexural strength
ESP 120 CONNECTOR

	L_0 [mm]	Ultimate Load [kN]
SIDEWAYS turned Connector	125	2,565
FLAT DOWN turned connector	80	1,04

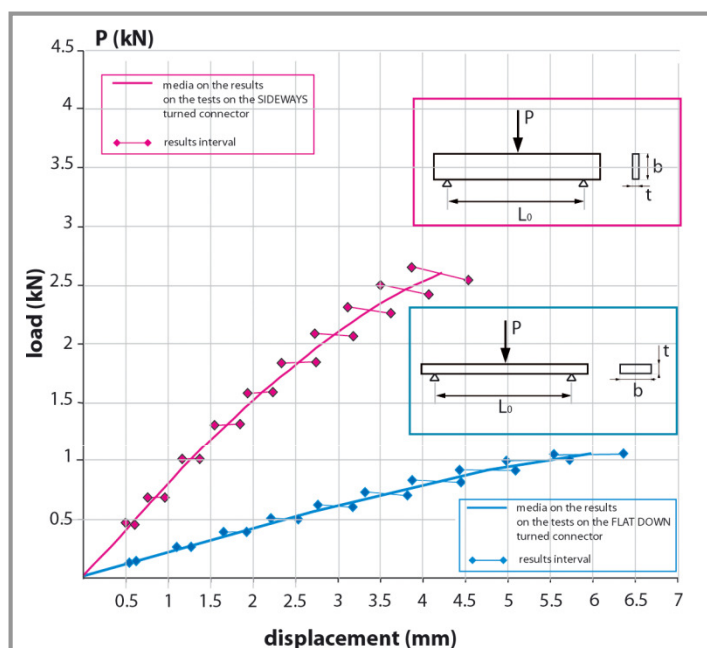
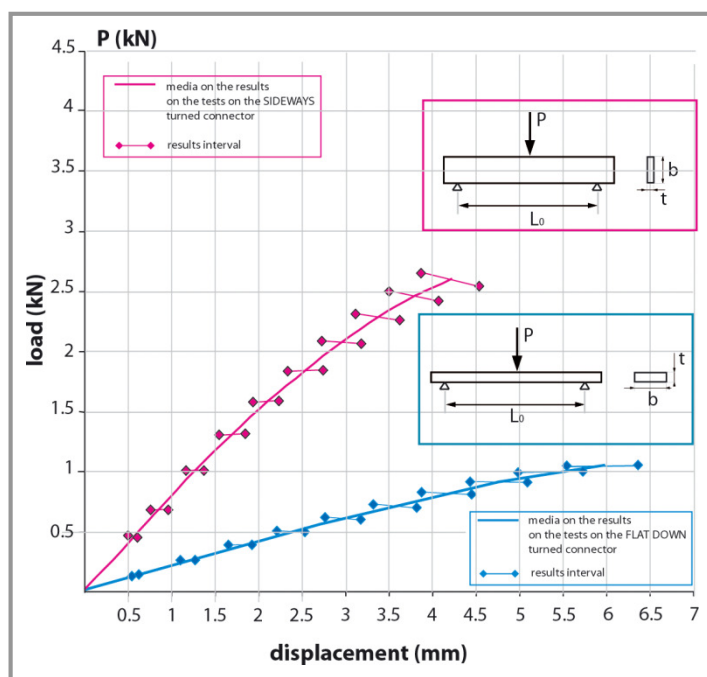


Table 4
Flexural strength
ESP 170 CONNECTOR

	L_0 [mm]	Ultimate Load [kN]
SIDEWAYS turned Connector	150	7
FLAT DOWN turned connector	110	2.36



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COMPARISON WITH MECHANICAL SPECIFICATIONS TO BENDING STRESS

Table 5 – Flexural stress Values for DOWN FLAT turned connectors

	Average Thickness t [mm]	Average Width b [mm]	Span L₀ [mm]	Ultimate Load P_{u,p} [N]	Ultimate Elastic Stress σ_{u,p} [MPa]
Pin ESP120	5.04	19.75	80	1043	248
Pin ESP170	7.31	33.58	110	2368	218

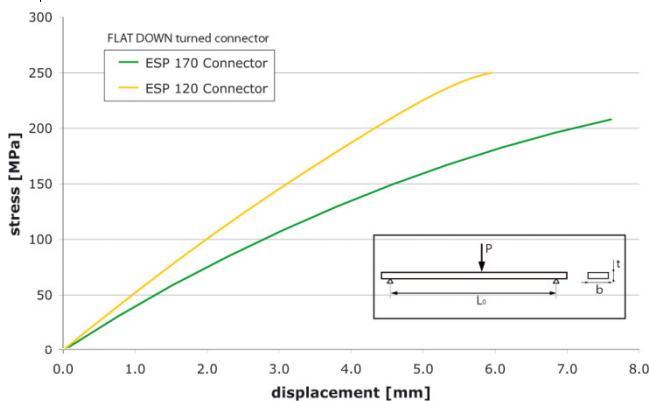
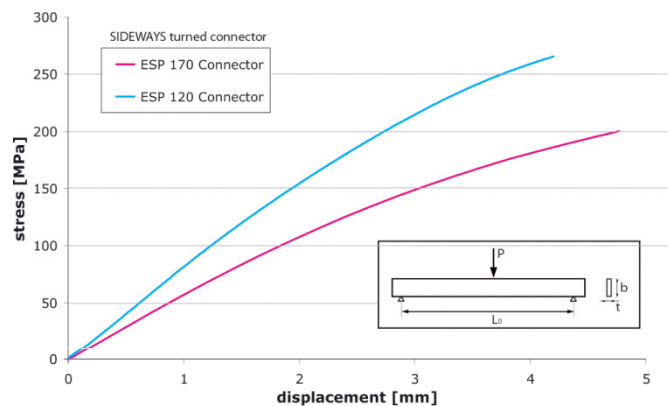


Table 6 – Flexural stress Values for SIDEWAYS turned connectors

	Average Thickness t [mm]	Average Width b [mm]	Span L₀ [mm]	Ultimate Load P_{u,p} [N]	Ultimate Elastic Stress σ_{u,p} [MPa]
Pin ESP120	4.81	19.43	125	2553	267
Pin ESP170	7.23	33.58	150	7164	198



CONNECTION SHEAR STRENGTH

Table 5 shows the results of the shearing tests made on the connection. We have specified a **maximum design load** and a **maximum design displacement** which have to be admitted as amount of the effects due to the weight of the part of external panel supported by the Connector and due to thermal deformations. A safety coefficient equal to 2 has been adopted for the differential displacement between inner and outer panel.

Table 7 Shearing Strength

	Thickness of insulating Panel i [mm]	Ultimate Load P_u [kN]	Ultimate Displacement δ_u [mm]	Design Load P_{Rd} [kN]	Design Displacement δ_{Rd} [mm]
ESP120 Connector	[mm]	[kN]	[mm]	[kN]	[mm]
SIDEWAYS turned Connector	50	1,90	4,80	1,30	2,40
	60	1,29	4,80	0,87	2,40
FLAT DOWN turned Connector	50	0,87	8,40	0,38	4,20
	60	0,61	8,40	0,28	4,20
ESP170 Connector	[mm]	[kN]	[mm]	[kN]	[mm]
SIDEWAYS turned Connector	80	4,28	6,78	3,00	3.39
	100	3.4	7.05	2.3	3.52
FLAT DOWN turned Connector	80	1,01	16,2	0,7	8,1
	100	0.79	23.35	0.52	11.67

$$P = \alpha \frac{EJ}{L^3} \delta \quad \text{con} \quad L = i + 2t$$

$$J = \frac{1}{12} bt^3 \quad \text{For FLAT DOWN turned Connection}$$

* $\alpha_{\delta/3}$ = Secant stiffness coefficient corresponding to a displacement equal to 1/3 of the last displacement δ_u

* $\alpha_{\delta/6}$ = Secant stiffness coefficient corresponding to a displacement equal to 1/6 of the last displacement δ_u

$$J = \frac{1}{12} tb^3 \quad \text{For SIDEWAYS turned Connector}$$

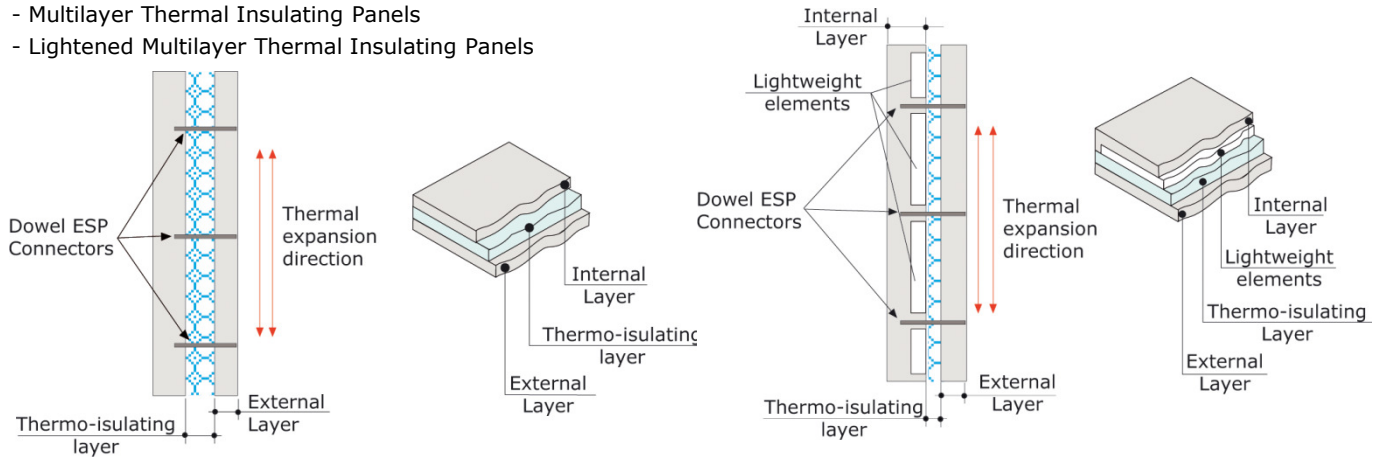
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DESING DETAILS – GENERAL SPECIFICATIONS

At the present time two types of Thermal Insulating Panels are available on the market:

- Multilayer Thermal Insulating Panels
- Lightened Multilayer Thermal Insulating Panels



PROJECT DETAILS – ARRANGEMENT

ESP Connectors are designed to be inserted in the thermal-insulation elements. The distribution and the number of connectors in the panels vary according to the type of Connector that is characterized by a **Maximum Design Load** and by a **Maximum Design Displacement**. Such data have to be assumed as amount of the effects due to the weight of the portion of outer panel supported by the Connector and due to thermal deformations. During positioning, the ESP Connectors have to be oriented so that they are stressed by the weight of the outer concrete layer according to the maximum inertia axis and in the direction of the bigger thermal expansion of the elements. The figures below show two types of panels, horizontal and vertical, with the schematization of the **ESP** Connectors arrangement, compared with the panel orientation, the direction of the biggest thermal expansion and the inertia axes.

From a design point of view, to determine the number of connectors, a Service Load is assumed (C_U) based on which the minimum number of connectors to be positioned both in standard panels and in lightened panels is established according to the thickness of the insulating material and to the thickness of the outer concrete layer. The suggested Service Load C_U is shown in the table, for the different connectors.

Table 6 shows the Service Load values C_U for each type of connector according to the thickness of the insulating material i and the suggested positioning distances.

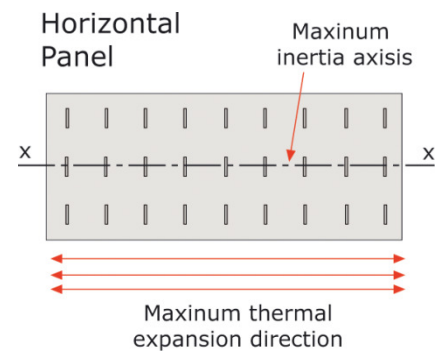
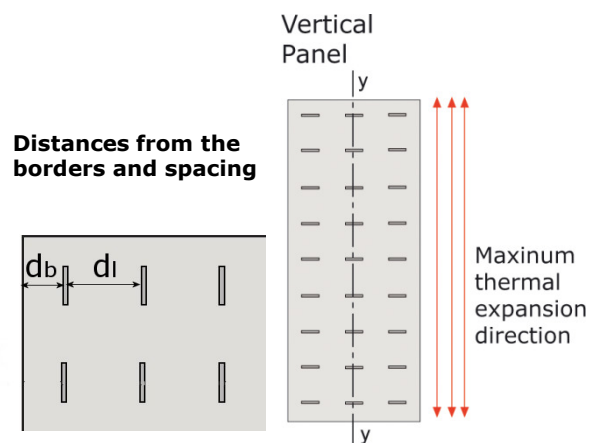


Table 8 – Static Loads

Connector Type	Thickness of insulating layer i [mm]	Service Load C_U [kN]	Max. distance between centers (suggested) $d_{l,max}$ [mm]	Min. distance from the border (suggested) $d_{b,min}$ [mm]
ESP 120	60	0,3±5%	600	100
	70	0,6±5%	600	100
ESP 170	80	0,5±5%	600	100
	90	0,4±5%	600	100
	100	0,3±5%	600	100





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PROJECT DETAILS - EXAMPLES

EXAMPLE 1 – MULTILAYER THERMAL INSULATING PANEL - ESP 120 CONNECTORS

Panel length: $L_u = 10000\text{mm}$
 Panel width: $L_a = 2500\text{mm}$
 Thickness of outer concrete layer: $Sp = 50\text{mm}$
 Thickness of the heat-insulating elements: $i = 60\text{mm}$

Calculation of the Outer Concrete Layer weight:

$$P = \gamma_{cls} \cdot L_u \cdot L_a \cdot Sp = 2500 \cdot 10 \cdot 2,5 \cdot 0,05 = 3125\text{kg}$$

According to Table 8, **ESP 120 connector** ($i=60\text{mm}$) should be used with a Service Load equal to $C_u=30\text{kg}$

The total amount of connectors is equal to:

$$\text{total connector amount} = 3125/30 = 104 \text{ connectors}$$

- Vertical rows:

with $d_l=600\text{mm}$ (max. suggested spacing) and $d_b=100\text{mm}$ (min. distance from the border) we have:

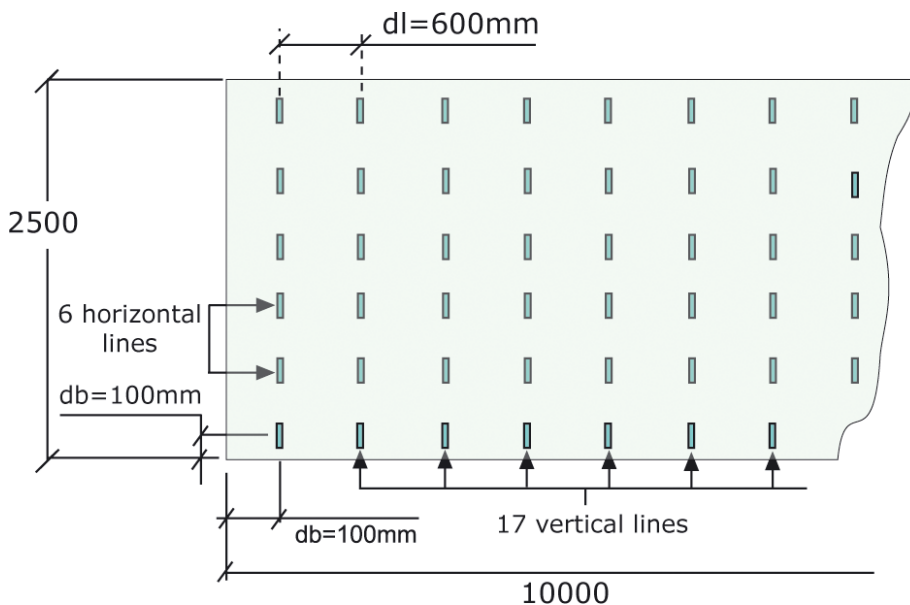
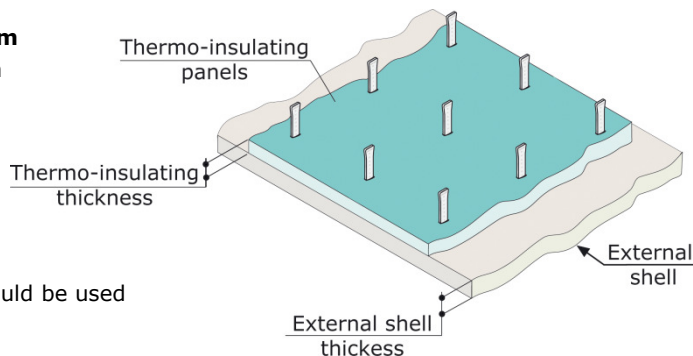
$$9800\text{mm} / 600\text{mm} = 16,3 \text{ spaces equivalent to } 17 \text{ Vertical rows}$$

- Horizontal rows:

$$\text{Horizontal rows} = 104/17 = 6,2$$

So, we will choose **6 Horizontal rows**

$$\text{Total amount of connectors} = 17 \text{ Vertical rows} \times 6 \text{ Horizontal rows} = 102 \text{ connectors}$$



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PROJECT DETAILS - EXAMPLES

EXAMPLE 2 – LIGHTENED THERMAL INSULATING PANEL –ESP 120 CONNECTORS

The project for the positioning of ESP Connectors in thermal cut-off panels with lightening elements is absolutely different from the case of multiwall panels. In fact, we have no reference distances and the positioning of the connectors, according to the Maximum Applicable Loads, must be done in the perimeter areas (chords) and in the interspaces between the lightening elements (pilasters).

Panel length : $L_u = 10000\text{mm}$
 Panel width : $L_a = 2500\text{mm}$
 Thickness of the outer concrete layer : $Sp = 60\text{mm}$
 Thickness of the heat insulating elements : $i = 60\text{mm}$

Calculation of the Outer Concrete Layer:

$$P = \gamma_{cls} \cdot L_u \cdot L_a \cdot Sp = 2500 \cdot 10 \cdot 2,5 \cdot 0,06 = 3750\text{kg}$$

According to Table 8, **ESP 120 Connectors** ($i=60\text{mm}$) should be used

Because the Service load **Cu** is equal to **30kg**, we will choose a total amount of connectors equal to:

$$\text{total amount of connectors} = 3750/30 = 125 \text{ connectors}$$

So, **125 Connectors** must be arranged in the perimeter areas and in the chords between the lightening elements.

It is up to the designer to choose the spacing of the connectors.

In the example, supposing the presence of four lightening elements, we will have to arrange the **125 connectors** in **5 Vertical rows and 2 Horizontal rows**.

It is possible to establish an indicative spacing for the positioning of the Connectors, considering the total perimeter development of the horizontal and vertical chords and taking care of the minimum distances from the border d_b .

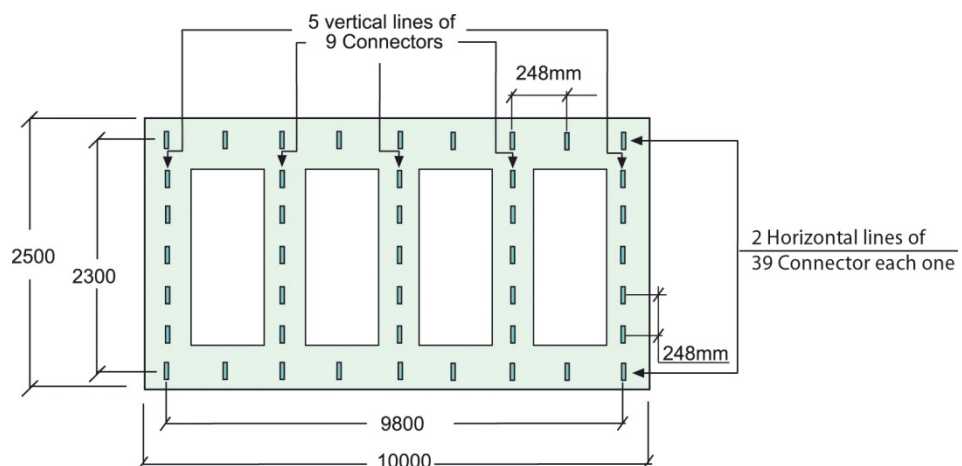
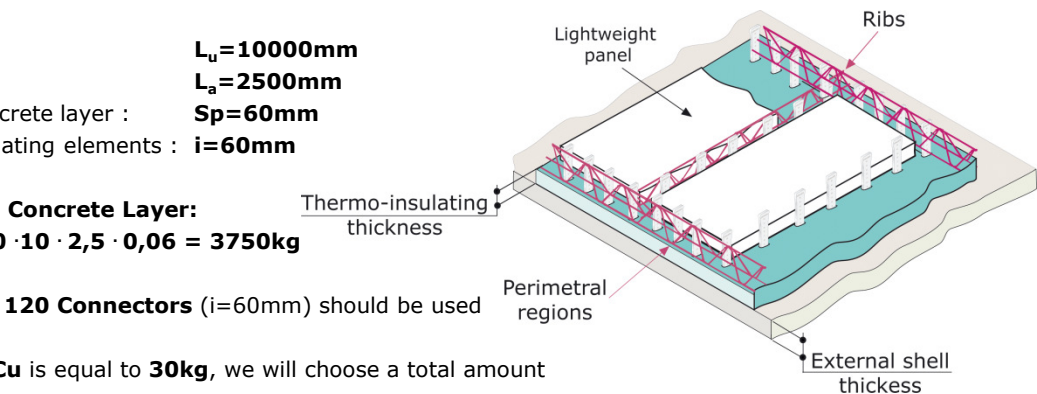
We obtain: $(9800 \times 2) + (2300 \times 5) = 31100\text{mm}$ representing the development of the useful surfaces for the positioning of the connectors.

The indicative spacing for the positioning of the connectors is:

$$31100\text{mm} / 125 = 248\text{mm}$$

For the horizontal rows we have: $9800\text{mm} / 248\text{mm} = 39$ connectors each Horizontal row

For the vertical rows we have: $2300\text{mm} / 248\text{mm} = 9$ connectors each Vertical row



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PROJECT DETAILS - EXAMPLES

EXAMPLE 3 – MULTILAYER THERMAL INSULATING PANEL - ESP 170 CONNECTORS

Panel length : $L_u = 10000\text{mm}$
 Panel width : $L_a = 2500\text{mm}$
 Thickness of outer concrete layer : $Sp = 60\text{mm}$
 Thickness of the heat-insulating elements: $i = 80\text{mm}$

Calculation of the Outer Concrete layer weight:

$$P = \gamma_{cls} \cdot L_u \cdot L_a \cdot Sp = 2500 \cdot 10 \cdot 2,5 \cdot 0,06 = 3750\text{kg}$$

According to Table 8, **ESP 170 connector** ($i=80\text{mm}$) should be used with a Service Load equal to $C_u = 50\text{kg}$

The total amount of connectors is equal to:

$$\text{total connector amount} = 3750 / 50 = 75 \text{ connectors}$$

- Vertical rows:

with $d_l = 600\text{mm}$ (max. suggested spacing) and $d_b = 100\text{mm}$ (min. distance from the border) we have:

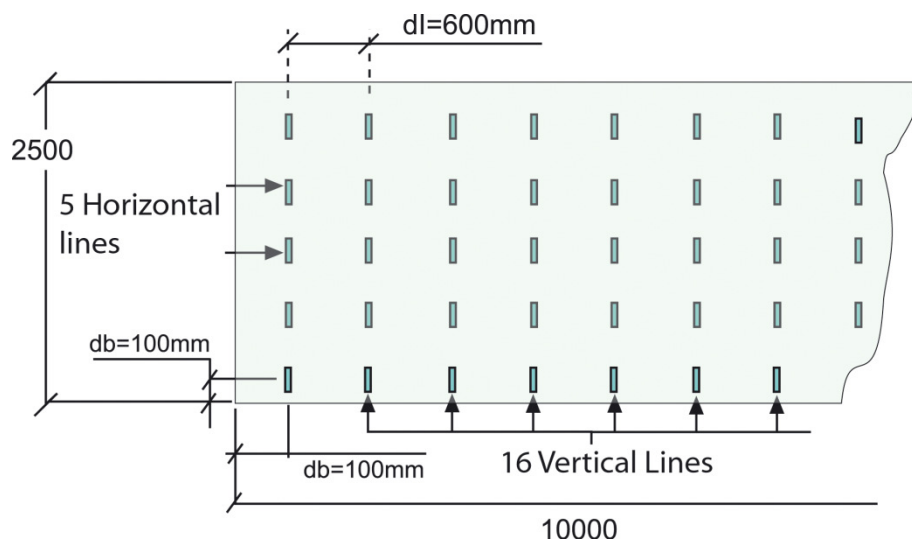
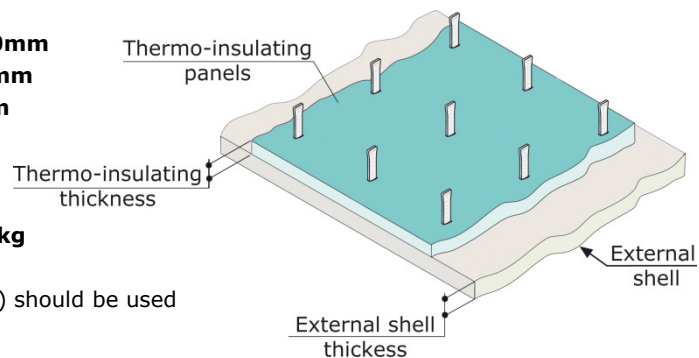
$$9800\text{mm} / 600\text{mm} = 16,3 \text{ spaces equivalent to 16 Vertical rows}$$

- Horizontal rows:

Horizontal rows = $75 / 16 = 4,6$ to round off

So, we will obtain, **5 Horizontal rows**

$$\text{Total amount of connectors} = 16 \text{ Vertical rows} \times 5 \text{ Horizontal rows} = 80 \text{ connectors}$$



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PROJECT DETAILS - EXAMPLES

EXAMPLE 4 – LIGHTENED THERMAL INSULATING PANEL –ESP 170 CONNECTORS

Panel length: $L_u = 10000\text{mm}$
 Panel width: $L_a = 2500\text{mm}$
 Thickness of the inner concrete layer: $Sp = 60\text{mm}$
 Thickness of the heat insulating elements: $i = 80\text{mm}$

Calculation of the Outer Coating weight:

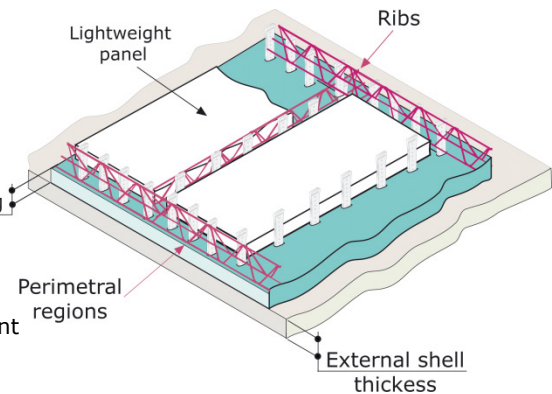
$$P = \gamma_{cls} \cdot L_u \cdot L_a \cdot Sp = 2500 \cdot 10 \cdot 2,5 \cdot 0,06 = 3750\text{kg}$$

Thermo-insulating thickness

According to Table 8, **ESP 170 connector** ($i=80\text{mm}$) should be used

Because the Service load **Cu** is equal to **50kg**, we will have a total amount of connectors equal to:

$$\text{total amount of connectors} = 3750 / 50 = 75 \text{ connectors}$$



So, **75 Connectors** must be arranged in the perimeter areas and in the chords between the lightening elements.

It is up to the designer to choose the spacing of the connectors.

In the example, supposing the presence of four lightening elements, we will have to arrange the **75 connectors** in **5 Vertical rows and 2 Horizontal rows**.

It is possible to establish an indicative spacing for the positioning of the Connectors, considering the total perimeter development of the horizontal and vertical curbs and taking care of the minimum distances from the border d_b .

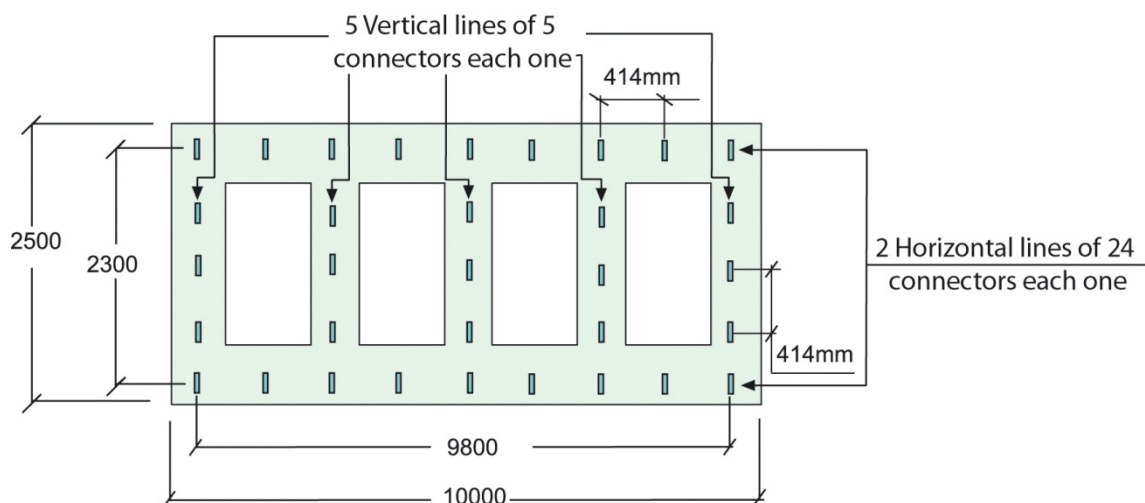
We obtain: $(9800 \times 2) + (2300 \times 5) = 31100\text{mm}$ representing the development of the useful surfaces for the positioning of the connectors.

The indicative spacing for the positioning of the connectors is:

$$31100\text{mm} / 75 = 414\text{mm}$$

For the horizontal rows we have: $9800\text{mm} / 414\text{mm} = 24 \text{ connectors each Horizontal row}$

For the vertical rows we have: $2300\text{mm} / 414\text{mm} = 5 \text{ connectors each Vertical row}$



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ADDITIONAL TEST ACTIVITIES

As already explained, Edilmatic ESP connectors are manufactured with fiber reinforced thermoplastic material. To characterize both product and material an experimental campaign was carried out in order to determine mechanical and physical specifications of the connector in different situations. All technical reports of the performed tests concerning the behavior of the connector in basic environments and at different temperatures are available at Edilmatic. Here below a summary of the experimental results obtained from the connector Type ESP120.

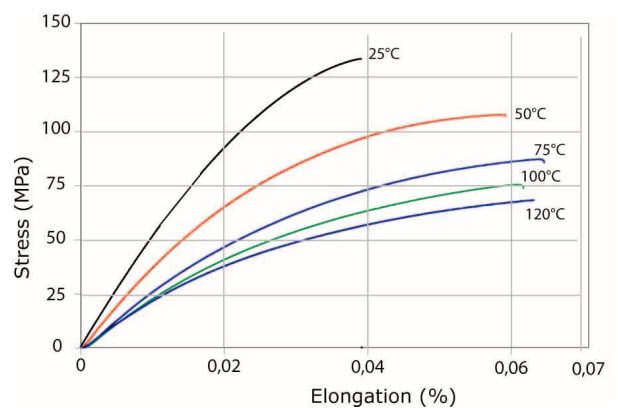
MECHANICAL PROPERTIES TO TENSILE STRESS

ESP connectors have undergone many uniaxial tensile stress tests to measure the mechanical resistance at four different temperatures between room temperature and 120°C.

Table 3 shows the results obtained from the tensile stress tests made on the Connector, while the diagram shows the stress-average elongation curves of the connector at different test temperatures.

Table 3
Resistance to tensile stress

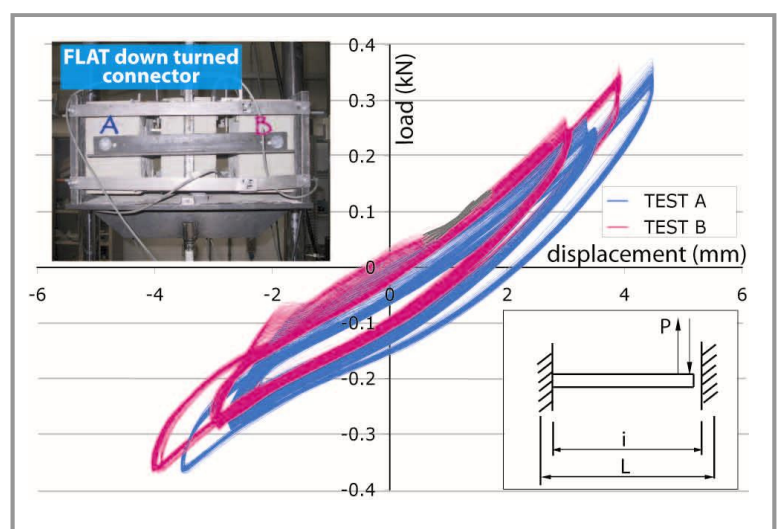
	Test Temperature	Test Temperature				
		25°C	50°C	75°C	100°C	120°C
Tensile Strength [MPa]		131 ± 2,9	103 ± 6,8	85 ± 2,2	74 ± 1,4	69 ± 2,1
Ultimate elongation [%]		3,9 ± 0,16	5,6 ± 0,73	6,4 ± 0,23	6,1 ± 0,16	6,7 ± 0,47



CYCLIC FATIGUE BEHAVIOUR

Tests have been carried out on two pairs of ESP 120 connectors, turned both SIDEWAYS and DOWN FLAT, on which the load was applied in a cyclic way in order to evaluate the working behavior in case the panel is subject to deformation due to repeated heat variations.

The diagram on the left shows the results of one of the cyclic shearing tests made on samples turned DOWN FLAT which have undergone 1250 cycles of amplitude displacement between 2,5 and 4 mm, without reaching the connection failure. The cyclic tests have shown the absence of mechanical properties decay (stiffness, resistance, dissipated energy). On the contrary the samples turned SIDEWAYS underwent 1300 cycles of increasing amplitude displacement from 0,4 to 2,3mm.





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FIRE RESISTANCE OF THE CONNECTION

INTRODUCTION

In order to determine the performance variations of Edilmatic ESP connectors in walls requiring a REI Certification, specific tests have been carried out to evaluate their technical performances if exposed to the heat, according to ISO 834 regulations.

Hereunder you can find some experimental results of tests carried out at the **POLITECNICO DI MILANO**

A complete test report is available at Edilmatic.

ABSTRACT OF THE RESULTS

Figure 1 shows the thermal profiles registered during some important steps of the test.

It was observed that only the supporting panel, if directly exposed to high temperatures, became significantly warm (measurement points T2 and T3), while the supported panel didn't showed temperature variations.

The diagram of **Figure 2** shows a significant relative displacement between the two layers of the panel portion starting approximately 2 hours after the beginning of the heating and ending after about 2h 30'.

Such displacement is due to the initial bulge of the warm side of the polystyrene layer.

Being the insulating layer constrained by the supporting fixture of the test piece, such bulge will imply a rigid rotation of the supported plate justifying the increase in the relative displacement.

With the beginning of the polystyrene decomposition, the dilatation effect and the relative displacement between the plates will stop and range on a constant value.

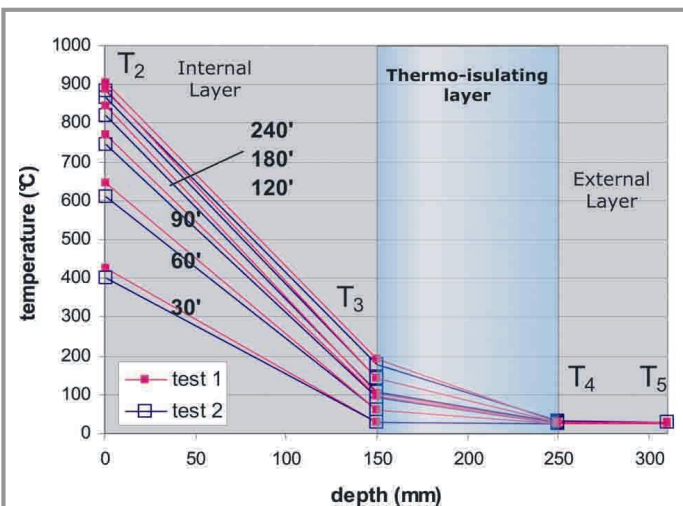


Figure 1
Thermal profiles registered inside the test piece during some significant steps.

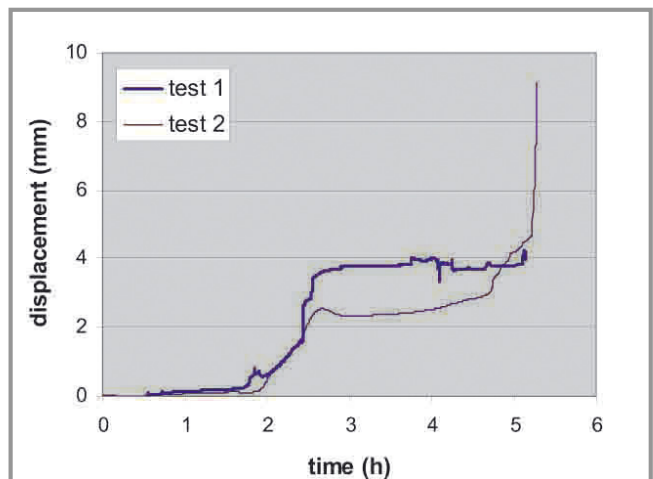


Figure 2
Sinking of the supported panel with respect to the supporting panel.



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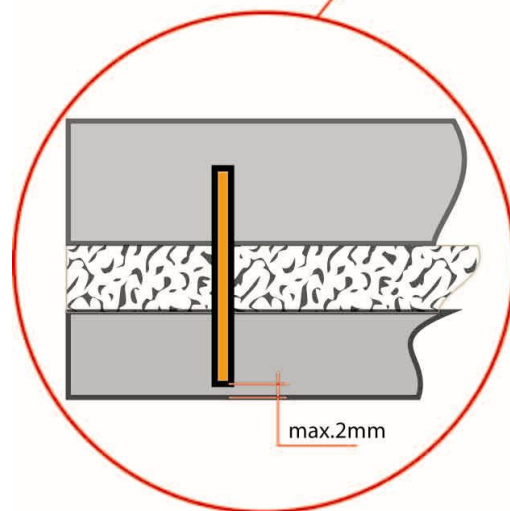
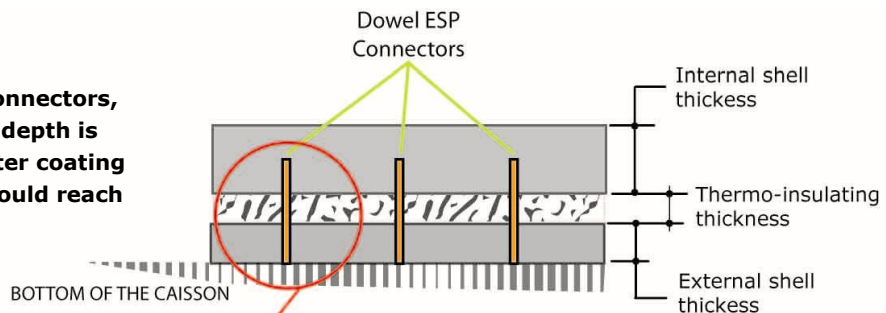
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INSTRUCTIONS FOR USE

For a correct and practical use of the Edilmatic connectors, some procedures for the realization of the panels should be respected, otherwise the technical performances of the connector and consequently, the static stability of the elements in which they are used may be jeopardized.

- The fluidity of the concrete used should be adequate to the room temperature existing during the production. During summertime the concrete must be absolutely more fluid compared to winter time.
- The connectors must be inserted in the outer concrete layer immediately after casting and laying of the insulating material. It is recommended not to wait for too much time before to carry out the work. An excessive hardening of the outer concrete layer may prevent from a correct clamping of the connectors and compromise their capacity.
- During the insertion of the connectors, make sure that the insertion depth is equal to the height of the outer concrete layer (practically the connector should reach the bottom of the formwork). It is allowed to lift up the connector after the contact with the caisson bottom just of a few mm in order to avoid that the connector may show through in case of an evident shrinkage of the concrete.
- In the production of the panels it is recommended to use vibrating formwork. This will improve the quality of the panels and will optimize the clamping of the connectors, both in the outer concrete and in the inner concrete layer.

During the insertion of the connectors, make sure that the insertion depth is equal to the height of the outer coating (practically the connector should reach the bottom of the caisson).



It is allowed to lift up the connector after the contact with the caisson bottom just of a few mm in order to avoid that the connector may show through in case of an evident shrinkage of the concrete.



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CALCULATION SOFTWARE

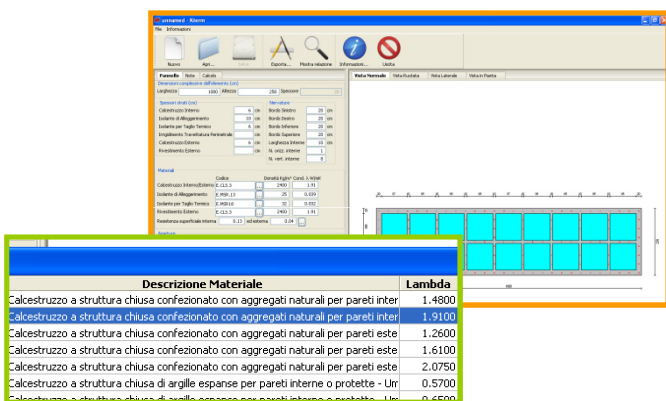
In order to help the designers in using the ESP connectors, EDILMATIC has realized calculation software for the production of thermal cut-off panels

The software provides with all information required for a correct use of the connectors according to the input data concerning panel geometry, panel stratification and type of used materials.

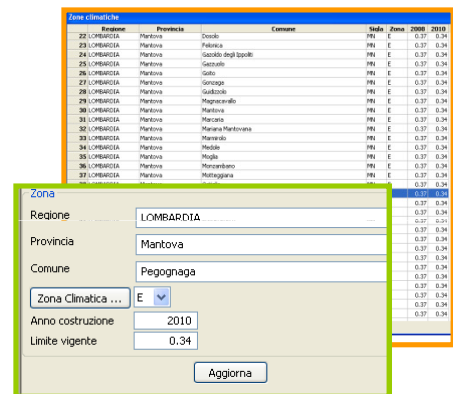
Particularly:

- Type of connector to be used
- Number of connectors to arrange
- Project DXF with positioning dimensions of the connectors
- Thermal transmittance value of the panel according to UNI EN 6946
- Limit values of thermal transmittance in the different regions and/or municipalities
- Calculation report

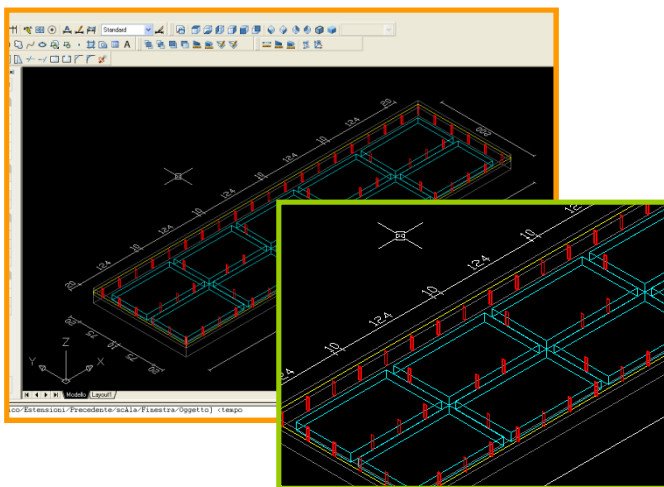
The software is certified and verified as to the calculation portion concerning the transmittance by ICMQ Institute



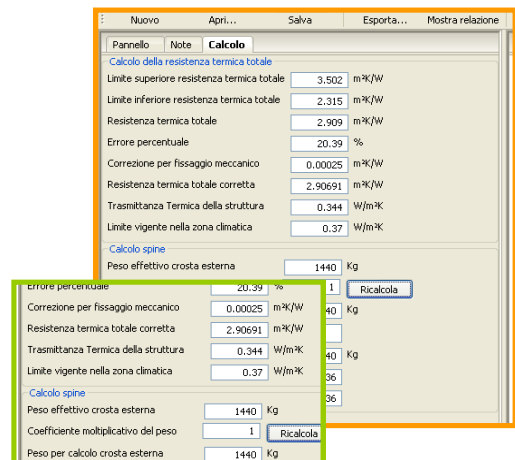
Graphic interface on line and Database of the Materials



Database of the Italian climatic areas



Export of the project in DXF (also in 3D axonometric)



Output with project data and incidence of the connector each m²