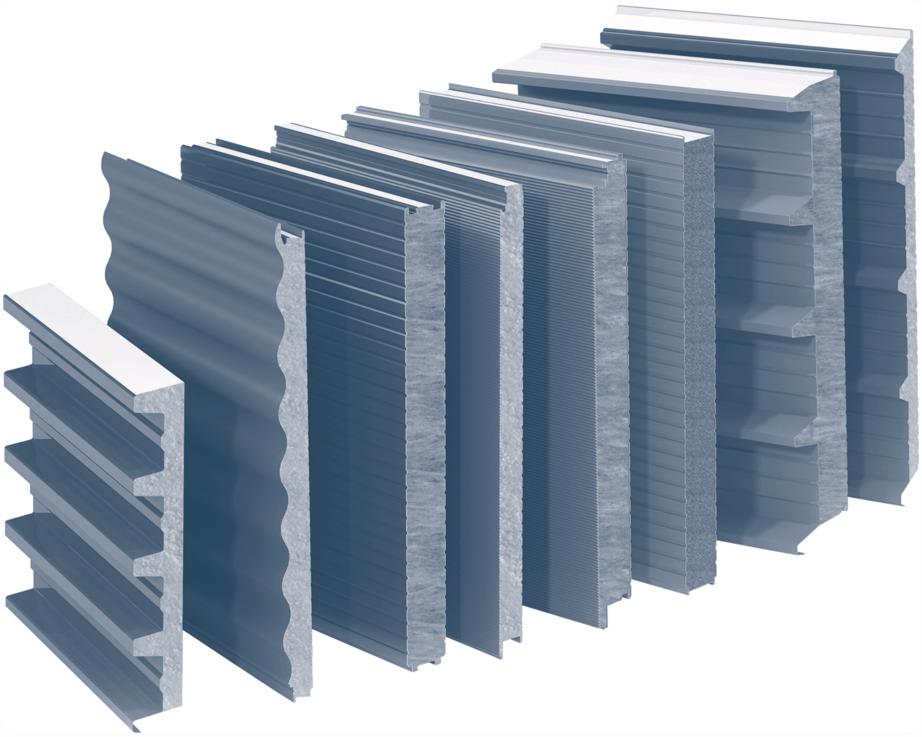
HANDBOOK
SANDWICH PANELS

HANDLING, STORAGE AND ASSEMBLY
FOR DESIGNERS / INSTALLERS / END USERS



ISOLPACK® isometal ISOTECNICA RWP INTERNATIONAL

INDEX

PREMISE

This **Technical Manual** collects experiences of **Isolpack - Isometal - Isotecnica - R&WPI** from now on "The Producers". Deepening the knowledge of the **pre-insulated panel in its various configurations** can be of great help for all those who will have to use it, therefore a careful reading is recommended that will offer useful information on the values and limits of the product itself without setting rules for its use and assembly which will be determined, solely, by the competence and professionalism of Planner / Installers / End Users).
The manual is intended for both end users and experienced professionals in the sector and has the sole objective of providing as many useful suggestions as possible for the best use of the **sandwich panel**, notes for ideal handling and manipulation, limits in use, suggestions for the calculation that said Users must make before purchasing and installing the sandwich panel.
The Manufacturers are never aware of the final destination of the product sold, of the methods of use, of the equipment available to the assembly teams, of the specificities of each individual site and of all the factors that can be decisive for obtaining a "standard result" of art ", for this reason every choice (architectural, technical, constructive, etc.) will be left solely to the expertise and professionalism of Planners / Installers / End Users, specifying that no responsibility can be attributed to the Manufacturers even for what is contained in this manual.
The information contained in this technical manual is provided in the current state of knowledge of the Manufacturers and will not have the value of a contractual guarantee and may be subject to change at any time and without any notice or communication of any kind. The products to which the manual refers must be stored and used according to the rules of hygiene, safety and good industrial practice, according to the technical indications of the supplier and in compliance with the provisions of the law.

1. GENERAL DESCRIPTION

The sandwich panels consist of one or two metal facings with an interposed polyurethane core (PUR) - (PIR) - (Glass wool or rock wool).
The PUR - PIR insulation is poured in the liquid state on a continuous cycle line so it ensures adequate homogeneity, rigidity, thermal insulation characteristics, mechanical self-supporting performance for the product. The geometry of the section, characterized by the staving, micro-ribbing and the edges of the panel, is obtained through the cold profiling technique of the coils (therefore NOT drawing).
The metal facing of the panels, which make up the external faces of the sandwich panels, can be made up of galvanized, pre-painted steel, natural or pre-painted aluminum, stainless steel and copper.
The sandwich panels create continuity between them through joints of different geometric section, the simplest with male and female interlocking for visible fastening screws, overlapping for hidden fastening screws or consisting of two pre-painted steel casings foamed on site and without any therefore connection in the complete absence of thermal bridges.

2. MATERIALS

2.1 INSULATING FOAMS

EXPANDED POLYURETHANE (PUR):
The term polyurethane indicates a vast family of thermosetting polymers in which the polymer chain is made of urethane bonds. They are obtained by reaction of a diisocyanate (aromatic or aliphatic) and of a polyol, catalysts are added to improve the performance of the reaction and other additives that confer improving characteristics to the material. PENTANE Expanding agent: acts as an expanding agent and is a substance capable of producing a cellular structure through a foaming process.

CHARACTERISTICS: high level of thermal insulation obtainable; optimal thickness-cost-performance ratio; considerable mechanical resistance and stability over time; lightness; reduced water absorption; it does not favor the onset of condensation and mold.

POLYISOCYANURATE (PIR):
Polyisocyanurate foams have a higher concentration of methylene dephenyl diisocyanate than polyurethane (PUR).

CHARACTERISTICS: Compared to PUR, PIR foam, although less dimensionally stable, guarantees greater resistance to compression with superior compactness and monolithicity of the panel, combines many characteristics of polyurethane and above all allows the achievement of severe fire classifications. It allows to obtain the class B-s1, d0 and the EI and REI classes.

2.2 MINERAL AND GLASS WOOL

Mineral (rock) wool: the rock wool production process begins with the melting of volcanic rock at a temperature of 1500 °C, after a rigorous geological selection of the raw material. The fibers are fixed with resins.
Glass wool: it is produced using 70% recycled glass with the addition of quartz sand, limestone, borate and soda. Everything is fixed with resins, which do not seriously affect the air and the environment.
The insulators in the various types of wool are processed, during the panel production, by cutting them into parallelepiped sections and then orienting the fibers perpendicular to the surface of the gluing plane on the metal facings. This solution gives the sandwich panel discrete characteristics of mechanical resistance.
The various types of wool combine four fundamental qualities: Fire Protection, Incombustibility, Thermal Insulation, Sound Absorption.

2.3 METALLIC PARAMENTS

The metal facing constitutes the external surface of the panel in contact with the environment. The choice of this element is exclusively the responsibility of the Planner / Installer / End User of the product according to the use for which it will be intended (roof; wall; false ceiling; partitioning, etc.) and the place where it will be installed (internal; external; area mountainous; industrial area; in the presence of brackish air; particular agricultural environment; etc.). The choice, as usual, takes place on the basis of the technical characteristics evaluated by the Planner or according to the resistance to corrosion and therefore to the expectations of durability of the product, sometimes for purely aesthetic reasons. The Manufacturer's recommendation to Planners / Installers / End Users is to choose between one type of facing and another, taking into account, mainly, environmental factors (direct exposure to the action of the wind; solar radiation; positive or negative temperatures that can be reached in the specific place; industrial environments with the presence of aggressive chemical elements dispersed in the atmosphere; distance from the sea; agricultural environments in the presence of farms; etc.). In addition to the above, the choice of metal facings must always take the utmost account of factors such as the typical expansions / elongations of the chosen metal which can lead to permanent deformations in the finished product after its installation.

3. PRODUCT CHARACTERISTICS

3.1 SHAPE AND THICKNESS

The sheet metal of the metal facings can be corrugated, slatted, micro-ribbed or smooth; which one to use, among the various types of finish, will depend solely on the choice of the user according to the intended application of the product; however, the Manufacturers advise against the use of the smooth facing (although it can be produced, upon specific request, without any surcharge, but without the manufacturer's guarantee), as it presents a high risk of highlighting undulations in the metal due to the lamination processes, or to the foam casting which takes place in successive alternating phases. In the construction of cold rooms this purely aesthetic condition is accepted as it is considered to be amply compensated by the functionality that derives from the cleaning and sanitation operations (HACCP).
The slatted or micro-ribbed solution assumes greater value where the Planner prefers to have a greater stiffness of the metal support, albeit minimal.

3.1.1 Sandwich panels dimensional tolerances

Table n° 1

DIMENSIONAL TOLERANCES (In accordance with the standard EN 14509 and C.G.V. Aippeg)		
Deviations (mm)		
Length	L ≤ 3000 mm	± 5 mm
	L > 3000 mm	± 10 mm
Working width	± 2 mm	
Thickness	D ≤ 100 mm	± 2 mm
	D > 100 mm	± 2 %
Perpendicularity deviation	6 mm	
Misalignment of the internal metal facings	± 3 mm	
Metal sheet coupling	F = 0 + 3 mm	
L = length; D = panel thickness; F = support coupling.		

3.2 JOINT TYPE

Since the early 1970s, at the dawn of the birth of the insulated panel, the mandatory rule has been established that the roof panels must be installed with slopes equal to or greater than 7%, while the wall panels must be mounted vertically. Subsequently, proposals were made with wall panels mounted horizontally with not fully satisfactory results (for this reason the Manufacturers do not recommend this type of installation). The types of joints vary according to the model of panel chosen. All guarantee a good seal against atmospheric agents but must never be considered perfectly watertight and airtight.
The Manufacturer's recommendation to Planners / Installers / End Users is to choose the type of joint and therefore the panel model after a thorough prior technical assessment of the desired performance of the product. Technically, to obtain perfect insulation between the external and internal environment, it is necessary to interpose open cell gaskets, silicone cords or switch to shaped panel models to receive the foaming of the joint in place. Alternatively, the Designer must opt for the use of special models upon request, for which the Manufacturer guarantees perfect airtightness. The joints are divided into three families: "dry joints"; "Special"; "Foamed", the latter two are used for particular applications, such as cold rooms or controlled atmosphere environments, where air tightness and thermal bridges are key elements in the design choice. The "dry joint" type, the cheapest and most widespread, is in turn divided into three distinct solutions: visible fastening screws, fastening screw hidden inside the joint and finally "labyrinth".

TYPES:

- Dry joint with corrugation fixing system (roof);
- male female dry joint with visible fixing screw and vertical installation (wall);
- male female dry joint with hidden fixing screw and vertical installation (wall);
- male female labyrinth dry joint and vertical installation (wall);
- foamed joint and v ertical installation (wall);
- male female dry joint with visible fixing screw and horizontal installation (wall - ONDA – Zeroklass Leonardo RWPanel).

4. ENVIRONMENTAL FACTORS

In order to obtain adequate functional, aesthetic and durability performance from the “sandwich panel”, the Manufacturer recommends that Planners / Installers / End Users carefully study the environmental parameters of the places where the product will be installed. The considerable variability of conditions and their possible combinations make it impossible to define in advance the prescriptions valid for each situation; the role of the Planner remains essential for the preventive evaluation of each individual project / work in order to identify which actions are to be taken into consideration and adopt the appropriate measures and design choices.
The choice of the type of panel is not limited to an evaluation of the mere mechanical resistance required for the design actions, the study must take into account decisive environmental factors such as:

- *Thermal insulation;*
- *acoustic insulation (sound insulation and sound absorption);*
- *corrosion on metal facings;*
- *irradiation, thermal expansion and concentration of U.V. rays;*
- *condensation formation;*
- *passive fire protection;*
- *mechanical resistance: wind action;*
- *mechanical resistance: snow action;*
- *mechanical resistance: seismic action.*

4.1 THERMAL INSULATION

The insulating materials, by their specific nature (structural constitution and physical characteristics of the components), are bad conductors of heat, therefore capable of attenuating and reducing the intensity of the thermal flows that pass through them to very low values. The theoretical efficiency of a material is defined by the “coefficient of thermal conductivity” or “thermal conductivity” indicated with the letter λ Lambda.
Consider a homogeneous wall with flat and parallel faces, the latter subject to two different temperatures: there will be a passage of heat, exclusively by conduction, from the higher temperature face to the lower one. Experimentally it is found that the amount of heat that passes is directly proportional to the surface concerned, to the temperature difference between the faces, to time, and inversely proportional to the thickness of the wall.
When using the “sandwich panel” in construction, the Manufacturer recommends to Planners / Installers / End Users the utmost attention in the preventive evaluation of the performances offered by the chosen insulating material, remembering that the calculation must always consider the natural decay that the product undergoes during the course some years.
Insulating materials can be divided according to their structure (fibrous, alveolar or granular) or according to their origin (mineral, vegetable and synthetic).

The following rule applies: the lower the coefficient λ, the better the insulating capacity of the material.

4.1.1 Coefficient of thermal transmission “U”

The thermal conductivity coefficient λ refers to the material while the thermal transmission coefficient U refers to the “system”, to composite walls, to a wall made up of several materials. The U value (thermal transmission coefficient or conductance) is reported in the catalogs of the “sandwich panel”. The heat transmission coefficient U is defined as the amount of heat that passes through a wall with a front surface of 1 m^2 of thickness S and with a temperature difference between the two opposite faces equal to 1 ° C in 1 hour.
For panels subject to CE marking only, thermal transmittance occurs according to the European standard EN 14509 and must take into account not only the thermal conductivity of the insulating material of the core but must also consider the effect of the joints between the panels and the corrugations. The declared value must consider the aging effects of the insulating material.

On catalogs the value of U is expressed in $\frac{W}{m^2 \cdot k}$

Where k is the temperature difference of the faces expressed in degrees kelvin.

The following rule applies: the lower the U coefficient of the panel, the lower its heat losses.

The methods of insulation and the type of construction in general depend primarily on the client’s personal preferences. A low-energy construction is not achieved through a specific construction model or a specific architectural form but above all through low U coefficients. A decisive factor for a low energy consumption building is the compactness of the construction itself. To minimize the energy needs of a building, it is advisable to minimize the surface area, this means that the building must be constructed as compactly as possible without joints, recesses and protrusions, etc. Otherwise the energy consumption will be relatively high despite the good thermal insulation and the costs necessary to ensure good thermal insulation on a larger surface will also increase proportionally. A useful example to prove the above is by examining an industrial building in prestressed concrete with wing tiles on which a curved panel is installed compared to the same building with **ISOLPACK TECTHUM** roofing where the intrados of the flat panel reduces by up to 28% the volume of air to be heated with really considerable economic savings.

4.1.2 The thermal bridges

Correct application of thermal insulation is an essential condition to be able to achieve the desired effects of energy saving, cost reduction and increased comfort. For the thermal insulation of building envelopes, not only the U coefficients of the structural elements are decisive, but also - and to a large extent - the configurations of the details. Thermal bridges must be absolutely avoided as they not only lead to energy dispersion but also technical problems such as the formation of mould caused by condensation. Thermal bridges create a minimum resistance to the flow of heat which for this reason is strengthened precisely in their correspondence, particularly lowering the temperatures of the surfaces with the related problems of condensation and the formation of moulds.
The Manufacturer recommends that Planners / Installers / End Users pay the utmost attention in combining each single panel with the one previously laid, taking care to verify that the pitch of three panels placed side by side in the final position and fixed always give the sum of the useful pitch of the single panel multiplied by three and never higher than an indicator of a safe thermal bridge with the relative consequences.

4.2 SOUNDPROOFING - SOUND INSULATION AND SOUND ABSORPTION

The problems of acoustics are divided into two important phenomena that characterize matter. These are sound insulation and sound absorption. The soundproofing materials work to reduce the “quantity” of sound that can be heard from inside or outside a room, while when it is necessary to reduce the level of the echo and of the sound waves that travel within a certain space it is necessary sound absorption.

4.2.1 Sound insulation

The concept of soundproofing material is strictly connected to the law of mass which means that the higher its specific weight a material is much more soundproofing The “sandwich panel” of the **ISOLPACK ECOLINE** series or **R&WPI** series **ZEROKLASS** with mineral wool insulation (wool of rock - glass wool) represents the optimal solution as it is heavier than those in **PUR / PIR**.
Remember that the human ear, in addition to perceiving only a part of the pressure variations that are the basis of the acoustic phenomenon, has a sensitivity that varies with the frequency perceiving sounds of the same level in a different way depending on the frequency.

In order to have a reference framework, the auditory sensations corresponding to different sound pressure levels, expressed in decibels, at a frequency of 1000 Hz are reported below.

- 0 dB: hearing threshold;
- 20 dB: perception level;
- 35 dB: sleep disturbance;
- 55 dB: difficulty in conversation;
- 90 dB: hearing damage for long exposures;
- 120 dB: pain threshold and temporary hearing loss.

The soundproofing power R is the quantity, measured in the laboratory, which makes it possible to predict the propagation of sound from an environment in which there is a source to another (receiver), despite being separated by a certain building element, which can be a wall exterior, an attic, a frame. This R value is not sufficient to define the degree of performance of a certain element, as its performance on site will certainly be lower. It is therefore important to have an index that allows for a synthetic and on-site evaluation of the soundproofing power; this index is called Rw. A 100 mm thick Fibermet panel has a Rw soundproofing power of 34.7 dB. The greater the thickness of the panel, the greater the sound insulation.

The sound insulation classification was obtained according to the EN 10140-2: 2010 - EN 717-1: 2013 standard.

The Manufacturer recommends that Planners / Installers / End Users prepare accurate surveys and calculations in projects / works that involve soundproofing since the sandwich panels proposed, although equipped with precise certifications, do not guarantee the exact correspondence to the specific need that only the Planner will be able to calculate.

4.2.2 Sound Absorption

The concept of sound-absorbing material is to hinder reflection therefore the least possible reflection of the acoustic energy they receive. Also in this case the “sandwich panel” of the **ISOLPACK ECOLINE** series or **R&WPI** series **ZEROKLASS** with mineral wool insulation (rock wool - glass wool) represents the optimal solution given the fibrous nature of the insulation applied in combination with the microperforation of the metal sheet. Acoustic absorbers mainly respond to the needs of environmental acoustic correction that occur when there is the need to modify the reverberation times inside an environment and to act in this way on the frequency response of the room in question. In fact, reverberation and its characteristics affect the correct intelligibility of words and sounds.
Acoustic absorption is the most important parameter in the acoustic correction of environments. In principle, the choice of the type of hole pattern on the panel also affects the acoustic properties. As a rule, for example, an increase in the percentage of perforation also leads to an increase in sound absorption. However, in the presence of drilling percentages higher than 25%, the values change only to a limited extent.
The index that allows for a synthetic and on-site evaluation of the soundproofing power; this index is called α_w. A 150 mm thick LITHOS 5 panel has α_w = 0.95 of soundproofing power.

The sound absorption classification was obtained according to ISO 354: 2003 - ISO 11654: 1997.

In general, the total sound absorption follows this logic:
case 1)
total absorption α = 1 (Fibrous materials. Very thick mineral wool mats without metal facings, anechoic chambers);
case 2)
total acoustic reflection: α = 0 (not micro-perforated sandwich panels);
case 3)
Partial acoustic absorption from α = 0 to α = 1 (e.g. micro-perforated sandwich panels α_w= 0.95 close to the total absorption value).

Also in this case, the Manufacturer recommends that Planners / Installers / End Users prepare accurate surveys and calculations in projects / works that involve sound absorption since the sandwich panels proposed, although equipped with precise certifications, do not guarantee the exact correspondence to the specific need that only the Planner will be able to calculate.

It is necessary to underline that the micro-perforation of the metal support, which is carried out to favour sound absorption by the sandwich panel, brings the metal core of the cladding into contact with the environment and in particular the ferrous metal surfaces could show rusting of the internal part of the holes. . This condition is not considered a product defect but an inevitable result of the production process. Alternatively, metal facings in micro-perforated aluminum or stainless steel can be used.

Where sound insulation / sound absorption needs require the total drilling of the internal support of the panel, the Manufacturers suggest to Planners / Installers / End Users to order panels with this support at least 0.65 mm thick which guarantees an adequate minimum mass.

4.3 CORROSION AND DURABILITY OF THE PRODUCT

Chemical and physical phenomena represent reasons for simple alteration or degradation of the metal supports that make up the product casing, in this case the panels undergo photodegradation and corrosion phenomena due to their permanent exposure to external agents.

The manufacturer of the "**sandwich panels**" recommends to Planners / Installers / End Users in-depth preventive assessments of the exposure and environmental conditions to which the products will be subjected.

In order to obtain the greatest durability, functionality, efficiency of the panel, the choices of the Planner aimed at contrasting or at least mitigating the effects of the aforementioned phenomena will be decisive.

Corrosion due to exposure in industrial atmospheres * (note to reader: only applies to roofing)

Chemical corrosion is caused both by some gases (sulfur dioxide, sulfur oxide, nitrogen oxide) present in the air, leaking from chimneys, chimneys and / or vents and by the saltiness present in marine environments. In the presence of metal roofs, the corrosive phenomenon is triggered by the water that stagnates in the presence of a low slope of the aquifer. The film of water that remains on the roof dissolves the aggressive elements dispersed in the atmosphere which, upon coming into contact with the metal support, corrode it. To increase the resistance to chemical corrosion, metal elements are used made with special corrosion resistant alloys (aluminum; stainless steel; zinc titanium etc.); further protection is obtained by applying synthetic resins, enamels, zinc to the surface of the metals.

Corrosion by differential ventilation

The corrosive process is determined when on the surface of a metal an electrical potential difference is established between a more oxygenated part (aerated) and a part that is less so. The more aerated areas are cathodic than the less aerated ones which, being anodic, corrode. The phenomenon can occur, for example, in pre-painted metal roofing sheets or walls. In any points of discontinuity in the painting, mostly due to careless removal of any metal residues during the assembly phases, a greater oxidation occurs which will trigger a localized corrosive process "pitting or pitting" that evolves with an extremely fast over time, much higher than what could be found for an unprotected metal sheet. The solution to this problem is to take extreme care in cleaning the construction site, especially for the roofs.

Electrochemical corrosion of metals by effect of "bimetallic contacts"

It can occur in the case of contact with different metals, for example those constituting the sealing elements, fixing accessories and support of a cover. The phenomenon occurs when in the presence of electrolyte solutions that are in contact with two different metals, so that a difference in electric potential is determined between them. The behaviour of the bimetallic pair is that of a cell with one metal acting as an anode and the other as a cathode and over time involves a more or less pronounced dissolution of the anodic part. This type of corrosion is called "galvanic corrosion". The interposition of gaskets made of non-conductive materials between two metals reduces or eliminates, in the case of complete insulation, corrosion due to direct bimetallic contact. However, it should be borne in mind that chemical corrosion situations can occur on a roof caused by the flow of rainwater. An example of this type are the corrosive processes that are created on the gutters and downspouts in steel or aluminum underneath copper roofs, caused by the oxides of this metal in solution in rainwater.

Corrosion due to surface impurities

The phenomenon normally occurs for metal alloys where the presence of impurities consisting of metals with cathodic behaviour with respect to the base metal determines in the presence of water a galvanic couple which leads to the dissolution of the part of metal surrounding the impurity.
These localized corrosion phenomena are often characteristic of aluminum alloys as this metal exhibits an anodic behaviour with respect to its main alloying metals.

Corrosion due to stray currents

It is an electrochemical corrosion process that occurs on those structures, or in any case parts made of metal of a building, which are traversed by stray currents, i.e. by those currents dispersed by the network of the building's electrical system, or which arrive through the land (especially in the vicinity of railway lines and tramways). The input areas of the current on the metal element normally have a cathodic behaviour,the output areas have an anodic behaviour and therefore can corrode. The phenomenon can also determine, in relation to the difference in electrical potential that is created between the parts, relevant corrosive processes. Let's see below the behaviour with regard to corrosion of some types of materials used for the manufacture of roofing sheets.

4.3.1 Containment of corrosive metal phenomena

We see below (table n° 2) the behavior with regard to corrosion of some types of materials used for the manufacture of roofing slabs.
The UNI EN 10169 standards report the classification of the environment and the relative speed of corrosion.

Table n°2 - The corrosion behavior of some types of materials used for the manufacture of roofing slabs.

CATEGORY RESISTENCE CORROSION	CATEGORIES CORROSION	TYPE OF ATMOSPHERE					
		RURAL (EXTERNAL)	URBAN (EXTERNAL)	INDUSTRIAL (INTERNAL - EXTERNAL)	SEA (EXTERNAL)	POLLUTED AND HUMID	SEASHORE
RC1	C1 - VERY LOW						
RC2	C2 - LOW	POLLUTION CONTAINED LOW CONDENSATION					
RC3	C3 - NORMAL		MEDIUM POLLUTION	LOW SO_2	LOW SALINITY		
RC4	C4 - HIGH			MODERATE SO_2	MODERATE SALINITY		
RC5	C5 - I - VERY HIGH			HIGH SO_2		SEVERE POLLUTION	
	C5 - M - VERY HIGH				HIGH SALINITY		VERY HIGH SALINITY

The manufacturer of the "sandwich panels" considers it essential and therefore informs Planners / Installers / End Users of the need to periodically inspect the product (at least annually documented), for a normal check of its state of maintenance. The panels must be periodically cleaned to avoid stagnation of water, condensation, impurities, organic material such as leaves, etc. or in any case substances harmful to the durability of the metal support. If degradation phenomena are detected it is necessary to proceed with an immediate extraordinary intervention in order to restore the initial general conditions (eg restoration of the paint in correspondence with local abrasions or scratches).

Cleaning can be done with water, but in the case of a pressure jet it must not be too close and perpendicular to the surfaces (especially in the case of pre-painted zinc steel supports); in addition, near the joints the water jet must have an adequate inclination to prevent the pressure from creating infiltrations or compromising the seal.

Adequate periodic maintenance must be reserved for the fixing systems (tightening screws where necessary, following any expansion or structural movements, checking for any oxidation of the angular cutting parts and checking the state of the seals).

In the event of the presence of aggressive agents, particular care must be taken in inspecting the panels in order not to affect their durability.

If there are dents or scratches due to accidental causes, the surface must be promptly restored and painted

In the case of environments with high humidity levels or in the presence of water leaks, clean the surface thoroughly with products that respect the painted surface using a non-abrasive brush.

4.3.2 Containment of corrosive paints and colors

The insulated metal "**sandwich panels**" mainly have two metal sides that correspond to the front facing the external environment and the front facing the internal environment; the choice of the quality of the painting of the metal facing is a determining factor that the Planners / Installers / End Users are called upon to carry out already in the design phase of the building envelope, carefully evaluating at least all the factors / indications that are collected in this technical manual as " GENERAL NOTES", which are to be considered a useful handbook which in any case cannot replace the expertise of the Designers/ Installers/End Users.
The requirements of the two supports can have very different characteristics; the quality of the coating must be evaluated and chosen on the basis of the predetermined performance according to the exposure and environmental conditions.

The market offers a wide range of paints with different characteristics and in some cases with durability guarantees strictly related to the conditions of use. This "technical manual" proposes, in this chapter, some notes for general information only, but recommends specific technical insights that can be obtained directly from the steel mills producing the raw material, the only ones able to offer safe and guaranteed solutions.

A) PRE-PAINTING

The pre-painting process takes place according to a continuous cycle called coil coating (painting in roll). During this treatment, a first layer of paint called Primer containing epoxy resins with high resistance to corrosive conditions caused by humidity and aggressive chemicals is applied to the metal strip. The primer layer is the anticorrosive layer par excellence but it cannot also be used as a finishing layer as it is not resistant to ultraviolet rays (it crumbles). Therefore a second layer of paint is applied to protect the primer. The real corrosion barrier is the primer as the final paint is permeable. The primer on both sides is applied only when the tape is to be pre-painted on both sides. In the most common cases of tape pre-painted on one side only, the primer is applied only on the side that will be completed with the final paint, while on the other side a layer of back - coat is applied which represents a paint of lower valence than the primer. . The back-coat layer must never be considered a protective element of the metal support.
It is important to remember that the pre-painting can be carried out in a multitude of colours chosen by Planners/ Installers / End Users who will refer to standard tables (eg RAL) but the final shade can undergo variations (tolerances) even sensitive depending on the color , brilliance, pigment etc. For this reason it is not possible to combine panels ordered with the same color but in different periods because differences in shades may occur, sometimes perceptible even to the naked eye, although the raw material originates from the same supplier, with the same color code, same RAL reference, but obtained from different "painting baths".
IThe Manufacturers, upon specific request of Planners / Installers / End Users, subject to a surcharge, supply the pre-painted panels equipped with peelable film for the protection of the elements during

the various phases of handling, transport etc; this precaution is recommended and considered useful to preserve the perfect integrity of the panel until assembly is completed (in any case the film must be removed within 6 weeks from the date of preparation - notice of goods ready - and in no case the panels must be exposed to Sun). If Planners / Installers / End Users deem to avoid this application, the Manufacturers will not be liable for any damage that the product may suffer.

Paints normally consist of four main components:

1. Solvents: *solvents are used to give fluidity allowing the paint to run. This property allows for a smooth, moist film to be created before drying and curing. The solvents, once their work is finished, disperse and do not remain in the finished product (sandwich panel).*

2. Binders: *Binders are polymeric materials that give the paint its true structure, which is why paints are generally classified based on the type of binder polymer used.*

The main types of **binders** are

polyester (PE - HD SUPER POLYESTER). *Standard polyester. Good flexibility, good outdoor resistance and excellent cost / performance ratio. Modified polyester (HD) excellent resistance to chalking and very limited color variation over time*;

polyurethane (PU). *Films with high hardness and very elastic resistant to aggressive chemical and atmospheric agents, abrasions*;

polyvinylidene fluoride (PVDF). *Resistance to ultraviolet rays (high sunshine) and chemical agents (industrial environments)*;

polyvinyl chloride (Laminated PVC). *Recommended for interiors with frequent washing, possibility of having non-toxic films and for occasional contact with food. Very flexible.*

3. Pigments: *the pigments used for coils paints are generally inorganic. They give the colorimetric appearance to the paint and contribute to corrosion resistance and protection*.

4. Additives: *additives are included in the chemical formulation of the paint to modify aspects such as the fluidity of the paint, the polymerization time, UV absorption and gloss.*

B) PAINTS - APPLICATIONS

Polyurethane (PU)

It is a very smooth material with high thickness, it is increasingly used for applications where duration is important, Overall thickness (including the primer) 55 µm, greater than standard polyesters. Excellent resistance to corrosion, as well as resistance to UV rays. PUR-PA prepainted is used in severe marine and industrial environments specific for pollutants of chemical origin. It resists temperatures well (max 80 ° C on the surface of the panel) and is not recommended with very dark colours (see the temperature and color chapter).

CORROSION CATEGORY EN 10169 - level RC5
UV PROTECTION CATEGORY EN 10169 - level RUV4

Polyvinyl chloride (PVC-P)

Superior class “plastisol” polyvinyl chloride (PVC) coating characterized by organic multilayer materials that guarantee optimal protection. Final thickness up to 200µm including the primer, it guarantees excellent resistance to abrasion. Specially developed for roofs or walls that require strong corrosion protection over time, it resists well to almost all solvents except acetone (ketones). This material is not to be confused with “plasticized” or “laminated” PVC. Suitable for internal walls not exposed to UV rays.

CORROSION CATEGORY EN 10169 - level RC5
UV PROTECTION CATEGORY EN 10169 - level RUV2

Plasticized polyvinyl chloride PVC (F)

It is a pre-painted plasticized laminate consisting of a pre-made PVC film with a thickness of 100µm, it is not a product applied in line with the coil coating system. Recommended for interiors with frequent washing, possibility of having non-toxic films and for occasional contact with food. Suitable for internal walls not exposed to UV rays.

CORROSION CATEGORY EN 10169 - level RC5
UV PROTECTION CATEGORY EN 10169 - level RUV2

Polyvinylidene fluoride (PVDF)

Polyvinylidene fluoride (PVDF) is the alternating homopolymer of vinylidene fluoride. PVDF is a high performance partially fluorinated thermoplastic polymer, characterized by good characteristics of chemical resistance to strong acids and oxidants, high solubility in polar solvents, resistance to ultraviolet rays and thermal applicability range: -40 ° C / 150 ° C . PVDF is soluble in polar solvents and very resistant to UV radiation. It is also used as a main component in anti-corrosion paints in the industrial sector. It is only recommended for exterior cladding and facade walls, where color durability is an important factor, especially on prestigious buildings. Overall thickness (with primer included) 25/35 µm

CORROSION CATEGORY EN 10169 - level RC4
UV PROTECTION CATEGORY EN 10169 - level RUV4

Super polyester (HD)

It is a modified standard polyester which improves UV and corrosion resistance. This type of paint is suitable for all roofing and wall applications. HD polyesters are usually associated with a minimum zinc coating of 200g / m^2. Overall thickness (including primer) 25 µm

CORROSION CATEGORY EN 10169 - level RC3
UV PROTECTION CATEGORY EN 10169 - level RUV4

Polyester (PE STANDARD)

It represents the most economical standard choice by combining a reasonable duration: excellent cost / performance ratio. Overall thickness (including primer) 25 µm. Recommended by manufacturers for environments that are not excessively polluted.

CORROSION CATEGORY EN 10169 - level RC2
UV PROTECTION CATEGORY EN 10169 - level RUV2

(Note: 1 micron (µ) corresponds to 0.001 mm)

Table n°3

Categories legend of corrosion and protection	
THE ENVIRONMENT ACCORDING TO THE EN 10169 STANDARD	
Subdivision into:	
RURAL AREA (RC2)	low level of pollution
URBAN AREA (RC3)	moderate level of pollution - modest content of sulfur dioxide and chlorides
INDUSTRIAL AREA from (RC3) to (RC5)	high level of pollution
MARINE AREA (RC3-RC5)	to be divided into three situations: (RC3) low salinity from 10-20 km from the coast, (RC4) medium salinity 3-10 km from the coast, (RC5) high salinity from 0 to 3 km from the coast)
THE FACTOR - UV RAYS	
Subdivision into:	
AREA NORTH	of the 37th parallel (RUV3)
SOUTH ZONE	of the 37th parallel (RUV4)
ALTITUDE	HIGH ALTITUDE 900 meters above sea level (RU3)
ALTITUDE	HIGH ALTITUDE 2100 mt above sea level (RU4)
In the classification of UV radiation behaviour, RUV4 is the best and RUV1 is the weakest class.	

Picture n°1

4.4 THERMAL EXPANSION IN SANDWICH PANELS

4.4.1 Effects of thermal expansion

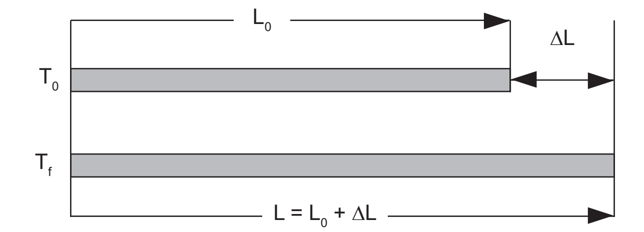
During their useful life, sandwich panels can be subjected to significant temperature gradients, Planners / Installers / End Users must always take the effects of temperature into consideration since, **as reported in EN 14509, the temperature can cause tensions and / or greater deformations by wind, snow or an imposed load.**

The Planner, already in the design phase, must, based on his calculations, make a choice of the types and thicknesses of the metal facing of the panel after having appropriately calculated the phenomenon of thermal expansion of the metals used, a phenomenon deriving from the effect of the variation thermal.

The stress state induced by thermal expansion is an inevitable physical phenomenon as well as its effects which will be more or less evident with the result of compromising not only the aesthetics, but also the static characteristics of the panel. In addition to the design phase, it is recommended to take into account any temperature differences between adjacent elements during the assembly phase (see chapter 5 "RECOMMENDATIONS FOR HANDLING AND ASSEMBLY OF PRE-COATED METAL PANELS").

Table n °4: indicates the coefficients of thermal expansion for some materials

Material	COEFFICIENT OF EXPANSION λ	
STEEL	12 X 10^{-6}	$°C^{-1}$
STAINLESS STEEL AISI 304	17 X 10^{-6}	$°C^{-1}$
COPPER	17 X 10^{-6}	$°C^{-1}$
ALUMINUM	24 X 10^{-6}	$°C^{-1}$



T_0 = Initial temperature (°C)
T_f = Final temperature (°C)
ΔT = Temperature difference = T_f - T_0 (°C)
L_0 = Initial length (a T_0)
L = Final length (a T_f)
ΔL = Length difference
λ = Linear expansion coefficient - (1/°C)

Illustration n° 1

The installer, adequately informed, must comply with assembly / fixing methods that provide for variable elongation of the facings according to the values of the thermal expansion coefficients. Special precautions must be taken for panels with mixed metal faces: aluminum-steel, copper-steel.

The main causes of the expansion or contraction of the substrate are due to direct solar radiation and daily and seasonal temperature variations.

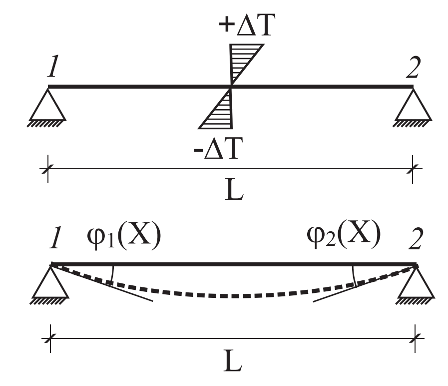


Illustration n° 2 – Deformation due to temperature gradient

The effects of temperature can be divided into:

- Short-term effects (stresses due to the thermal gradient (see illustration 2), wrinkling of the sheet;
- Long-term effects (ageing).

The manufacturer of the "**sandwich panels**" does not provide rules, as it limits itself to the supply of what is ordered, but reminds Planners / Installers / End Users that thermal stresses and deformations have much more marked effects when the product is in the following conditions:

✓ Dark-coloured external metal cladding (RG < 75);
✓ external metallic facing subjected to high solar radiation (climatic zone);
✓ thicknesses less than 6/10 mm;
✓ panels longer than 5000 mm;
✓ use of PIR foams.

A similar indication also comes from the EN 14509 standard which suggests paying particular attention in designing and installing dark-coloured panels (RG < 75) and provides three color classes and the relative design temperature to be assumed on the face exposed to solar radiation. The following temperature values (T_D) are recommended for tests at the Limit State of Operation, while they represent the minimum for tests at the Ultimate Limit State.

✓ Class 1 very light colours RG= 75-90 (T_D=55°C);
✓ Class 2 light colours RG= 40-74 (T_D=65°C);
✓ Class 3 dark colours RG= 8-39 (T_D=80°C).

The classification is based on the reflectance value of the metal coating, i.e. its ability to reflect a portion of the incident light. The parameter used in EN14509 is the "degree of relative reflection" RG, which takes magnesium oxide as a reference (RG = 100).
Table 3 shows the values obtained from a test program carried out by Isolpack on ten types of RAL colors. The reflectance is expressed by means of the SRI (Solar Reflectance Index) parameter which, as an example, is equal to 0 for a black surface, and equal to 100 for a white surface.

N.B. The values may undergo deviations due to the process variables, the different type of support and the related conditions of application online. Any discrepancies found in the surveys, due to the above variables, cannot be a reason for charging the Producers, as is known, differences in shades must be accepted, sometimes perceptible even to the naked eye, although the raw material originates from the same supplier, with identical color code, same RAL reference, but obtained from different "painting baths".
N.B. Planners / Installers / End users adequately informed of the contents of Table 3 will make the choice of the desired color at their sole discretion, aware of the tensions and deformations that the panels may undergo in relation to the chosen color.

Colours	SRI
RAL 9010	89
RAL 9002	75
RAL 9006	41
RAL 9007	38
RAL 1011	36
Roof Tile	27
RAL 3009	22
RAL 6005	18
Forest Green	15
RAL 7012	10
RAL 8019	4

Table n° 3

4.4.2 Effects of irradiation

Another element to be taken for the estimation of the project temperatures is found in **paragraph 3.5.2 of the Technical Standards for constructions referred to in the Ministerial Decree of 17 January 2018.**

These propose a general zoning of the Italian territory in which local aspects to be evaluated individually are not taken into account. Italy is divided into 4 zones and, for each zone, the maximum and minimum temperature is expressed as a function of the reference altitude - as -, expressed in meters above sea level (see illustration 3).

Illustration n° 3

AREA I

Valle d'Aosta, Piedmont, Lombardy, Trentino-Alto Adige, Veneto, Friuli Venezia Giulia, Emilia Romagna.

$T_{min} = -15-4 \cdot a_s / 1000$ [3.5.1]

$T_{min} = 42-6 \cdot a_s / 1000$ [3.5.2]

AREA II

Liguria, Tuscany, Umbria, Lazio, Sardinia, Campania, Basilicata.

$T_{min} = -8-6 \cdot a_s / 1000$ [3.5.3]

$T_{min} = 42-2 \cdot a_s / 1000$ [3.5.4]

AREA III

Marche, Abruzzo, Molise, Puglia.

$T_{min} = -8-7 \cdot a_s / 1000$ [3.5.5]

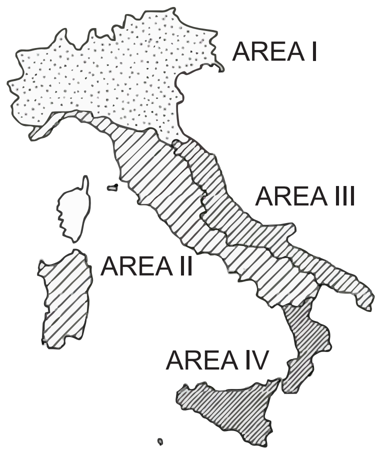
$T_{min} = 42-0.3 \cdot a_s / 1000$ [3.5.6]

AREA IV

Calabria, Sicily.

$T_{min} = -2-9 \cdot a_s / 1000$ [3.5.7]

$T_{min} = 42-2 \cdot a_s / 1000$ [3.5.81]



To define the external surface temperature it is necessary to add the contribution provided by solar radiation which can be estimated from the following table:

Table n° 6 - Contribution of solar radiation.

SEASON	NATURE OF THE SURFACE	TEMPERATURE INCREMENT	
		North-East exposed surfaces	South-West or horizontal exposed surfaces
SUMMER	Reflective surface	0 °C	18 °C
	Bright surface	2 °C	30 °C
	Dark surface	4 °C	42 °C
WINTER		0 °C	0 °C

PRACTICAL SUGGESTIONS TO CONTAIN THE EFFECTS OF THERMAL EXPANSION

Sandwich panels can therefore run into different problems due to thermal expansion - such as bubbles, wrinkling, longitudinal or transverse bending, buckling - detectable, in particular, with the use of PIR foams. Furthermore, assembly difficulties are possible if the surface is subjected to direct radiation during this phase (with consequent deformation and difficulty interlocking) which, in addition to causing aesthetic anomalies, could compromise the structural capacity of the panel-support structure system, the Manufacturer recommends adopting the following precautions:

- ✓ **Avoid dark colours;**
- ✓ **avoid the use of long panels when particular architectural needs require dark colors;**
- ✓ **Dark metal facings subjected to solar radiation must have an adequate thickness (minimum 0.6 mm) and paints with a thickness higher than the standard;**
- ✓ **The Planner, having calculated the maximum thermal expansion to which the coating can be subjected, must choose and indicate fixing solutions that allow all the planned deformations; and impose measures of the panels less than mm. 5000;**
- ✓ **If high deformations of the external facing are expected, it is preferable to adopt a panel that includes fixing with visible screws rather than models with hidden fixing.**

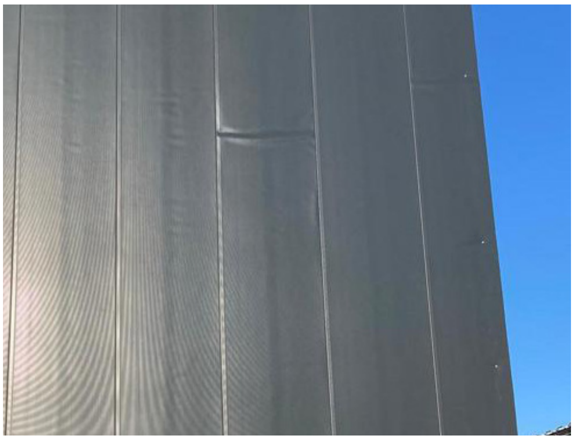
Insulated panels are subject to expansion, elongation and possible deformation in the presence of a temperature range on the metal supports which designers/installers/end users must take into consideration during the design and selection of the panels. This phenomenon especially affects dark colored panels installed on façade. For the detail RAL - expansion (see Table n° 3.)
The consequence of the expansion acts on the straightness of the panel, causing bending and deformations which can affect the functionality and the aesthetic appearance.
The designers/installers/end users must provide an assembly that allows the system to absorb the linear elongations (see drawing) and the tensions of the support due to high surface temperatures and rapid thermal shocks which can cause undulations, imperfections and/or wrinkling phenomena for which the producers cannot be held responsible in any way.

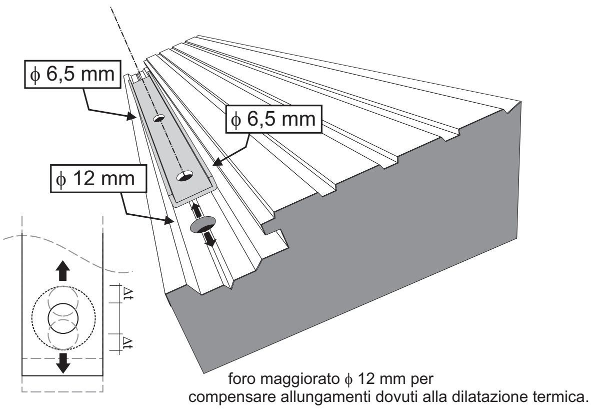
Manufacturers recommend:

• Avoid using dark colored panels, especially with significant lengths (over 5 m).
• Choose a suitable thickness for use and for the calculated deformations.
• Evaluate suitable mobile fastening systems that compensate expansions (see drawing).

The consequences of choosing certain panel types and colors and implementing operations that can minimize the risk of deformation are to be considered in full and sole responsibility of the designers/installers/end users.

Picture n° 2: deformed wall





In order to avoid this phenomenon, the designers/installers/users will have the burden of adopting the solution deemed most suitable for their specific case of use. In the figure, a possible solution to the problem, providing that all the requirements already listed in this handbook must be met.

EXAMPLE OF EXTERNAL SHEET EXPANSION CALCULATION

Panel length: 10 m
Material: prepainted galvanized steel (class 2 color)
Exposure: South
Location: Turin (a_s=295 m a.s.l.)

STEP1: Calculation of the minimum outdoor temperature

In the absence of specific static surveys for the installation site, the approach of the Technical Standards for Construction is followed for the calculation (§3.5.2).
Piedmont → ZONE I
$T_{min} = -15 - 4 \cdot a_s /1000 = -15 - 4 \cdot 295 /1000 = -16{,}2\ °C$

STEP2: Calculation of the maximum outdoor temperature

According to the table reported on EN14509, the maximum temperature is:
Class 2 color → Tmax =65°C
We now compare this value with that proposed by the NTC2018.
Piedmont → ZONA I
$T_{max,1} = 42 - 6 \cdot a_s /1000 = 42 - 6 \cdot 295 /1000 = 40{,}2\ °C$

To this temperature value must be added the contribution due to solar radiation from table 3.5.I of the Technical Standards which, for the case in question, is 42 °C.

Ultimately we get:
$T_{max} = 40{,}2+42 = 82{,}2\ °C$

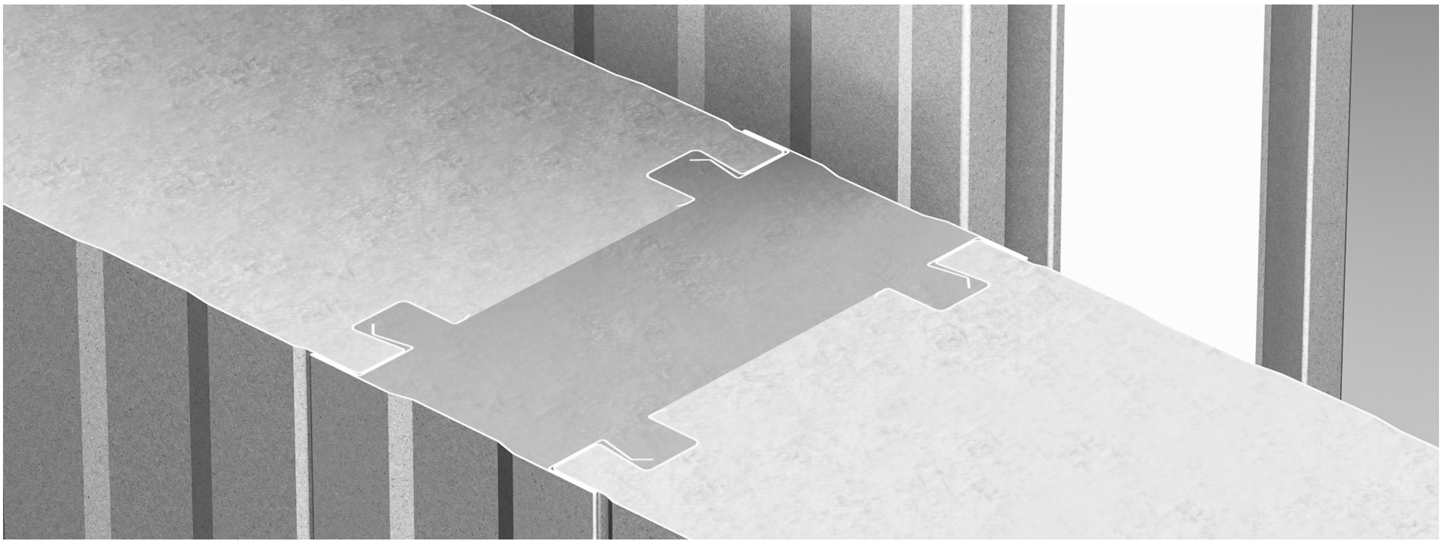
The most conservative value obtained from the calculation proposed by the NTC is chosen to be 82.2 ° C

STEP3: Calculation of the maximum expansion of the sheet

The expansion range to which the panel will be subjected:
∆L= 12·10-6 (°C-1) x [82,2 – (– 16,2)] (°C) x 10 (m) = 12·10-6 (°C-1) x 98,4 (°C) x 10 (m) = 11,8 mm

In the above example, Planners / Installers / End users must necessarily adopt a fixing solution that allows the expansion and contraction of the sheet, avoiding dangerous constraints that could compromise the aesthetic and functional characteristics of the product (see fixing solutions in the paragraph "Fixing methods and systems for wall panels").

Picture n° 3: In the example shown in the figure the WFJ panel fixing is able to compensate for the movements due to thermal expansion without generating thermal bridges.



4.5 CONDENSATION: THE STEAM CONTAINED IN THE AIR

4.5.1 Formation of condensate

Air has the ability to store a certain amount of water in the form of steam. This capacity is a function of temperature and pressure. Normally the air in an environment is not in saturation conditions but contains a quantity of water lower than the maximum where condensation phenomena occur.

Surface condensations are formed when the air, at a certain temperature and with a certain level of humidity, cools when it comes into contact with surfaces that are at a lower temperature. In these cases, if the water vapour contained in the air is higher than the saturation amount for the new lower temperature, the excess vapour condenses into droplets.

When the outside temperatures are high compared to the internal ones, such as in the cold rooms, a tendency for the steam is created to move by diffusion towards the inside.

4.5.2 Environmental conditions that generate condensate

In an environment the human presence leads to an increase in humidity, with an estimated contribution of about 120-150 gr. of water per hour per person, due to breathing and transpiration. The overcrowding of an environment automatically leads to the formation of a lot of humidity. Even the material stored in the warehouses / cold rooms generates the release of humidity which results in the formation of surface condensation on the metal surface of the insulating panels, another critical condition can be caused by the casting of internal concrete flooring of a building that releases considerable quantities of humidity which, where adequate ventilation has not been foreseen, is stratified on the intrados of the roof and then becomes dripping condensate.

4.5.3 Planning

Planners / Installers / End users must first carefully evaluate the condensation phenomenon before making choices on the type of “sandwich panels” to be adopted in the construction of a building. Especially when it comes to cold rooms, eliminating the possibility of condensation avoids negative consequences and damage to the cell while an optimal situation will be obtained when the layers of thermal insulation are arranged as far as possible outward and at the same time layers that oppose to the diffusion of steam on the internal side. The pressure variations that occur in a refrigerated or heated industrial building during testing and / or heating operations must be compensated for both in cold rooms or in controlled temperature rooms. For this type of applications it is preferable to use s**andwich panels with foamed joint**, hermetic by nature, which prevent condensation or the latest generation “**sandwich panels” equipped with special sealing gaskets in EPDM** which, correctly laid, perform the vapour barrier function. Panels with dry, vertical or labyrinth joint should be avoided, which in no case can guarantee the necessary tightness and therefore give rise to the condensation phenomena treated.

4.6 PASSIVE FIRE PROTECTION

Polyurethane foams are not flammable but, like all plastic materials of organic nature, they are combustible and burn in contact with the flame. In case of fire, polyurethane develops fumes and combustion gases whose composition varies according to both the characteristics of the foam reaction to fire (formulation, density, etc.) and the fire conditions (ventilation, temperature, etc.). The experiments show that the composition of the combustion gases developed by polyurethane foams does not generally differ from that of the gases developed by wood. Their ignition temperature is generally below 500 ° C. Planners / Installers / End users must provide protection from direct fire for the walls of the panels - generally already covered by metal supports - as well as the entire perimeter that may be exposed by adopting suitable precautions even during the installation of the same as any assembly errors represent potential sources of ignition.

The fire behaviour of structures is the set of physical transformations of a material or building element subjected to the action of fire. It is characterized by the thermal properties of the materials and the methods of their use in the structures themselves. There are two aspects to consider:

- **reaction to fire:** which indicates the behaviour that any material, piece of furniture or building component manifests in the presence of a fire (it burns, does not burn, burns little, makes smoke, drips);
- **fire resistance:** it is the ability of a building element or structure to maintain the required stability, tightness and thermal insulation during a certain period.

The Manufacturers have numerous fire resistance certificates issued by authorized laboratories, according to nationally and internationally recognized standards.

4.6.1 Reaction to fire

For the classification of reaction to fire of building materials, reference is made to the **EN 13501-1** standard **(Fire classification of products and building elements)**. The legislation establishes:

- **test methodologies**
- **classification of materials**
- **product certification procedure for reaction to fire.**

In the legislation, the materials are classified according to **Euroclasses A1, A2, B, C, D, E, F.**

The materials classified **A1** and **A2** are incombustible, class **B** are non-flammable, while class **F** is in the specific case of sandwich panels, **not tested for fire**.
The European legislation takes into consideration two further parameters of considerable importance for fire prevention purposes. The first parameter deals with the emission of fumes where the values indicated in the standard are:

- **(S1) Poor smoke emission,**
- **(S2) Moderate smoke emission**
- **(S3) Strong smoke emission.**

While the second parameter deals with the presence of dripping or incandescent particles that develop during combustion and that can spread the fire (unlike the Italian standard, this index allows us to know the behaviour in the individual material with regard to this aspect). The values indicated are:

- **(d0) Absence of burning drops,**
- **(d1) Few burning drops and / or incandescent particles**
- **(d2) Many burning drops and / or incandescent particles.**

4.6.2 Fire resistance

Fire resistance is one of the fire protection measures to be pursued to ensure an adequate level of safety of a construction work in fire conditions. It concerns the load-bearing capacity in case of fire, for a structure, for a part of the structure or for a structural element as well as the compartmentation capacity in case of fire for the structural separation elements (e.g. walls, floors, ...) and non-structural (e.g. doors, partitions, ...).

The main parameters for evaluating fire resistance are:

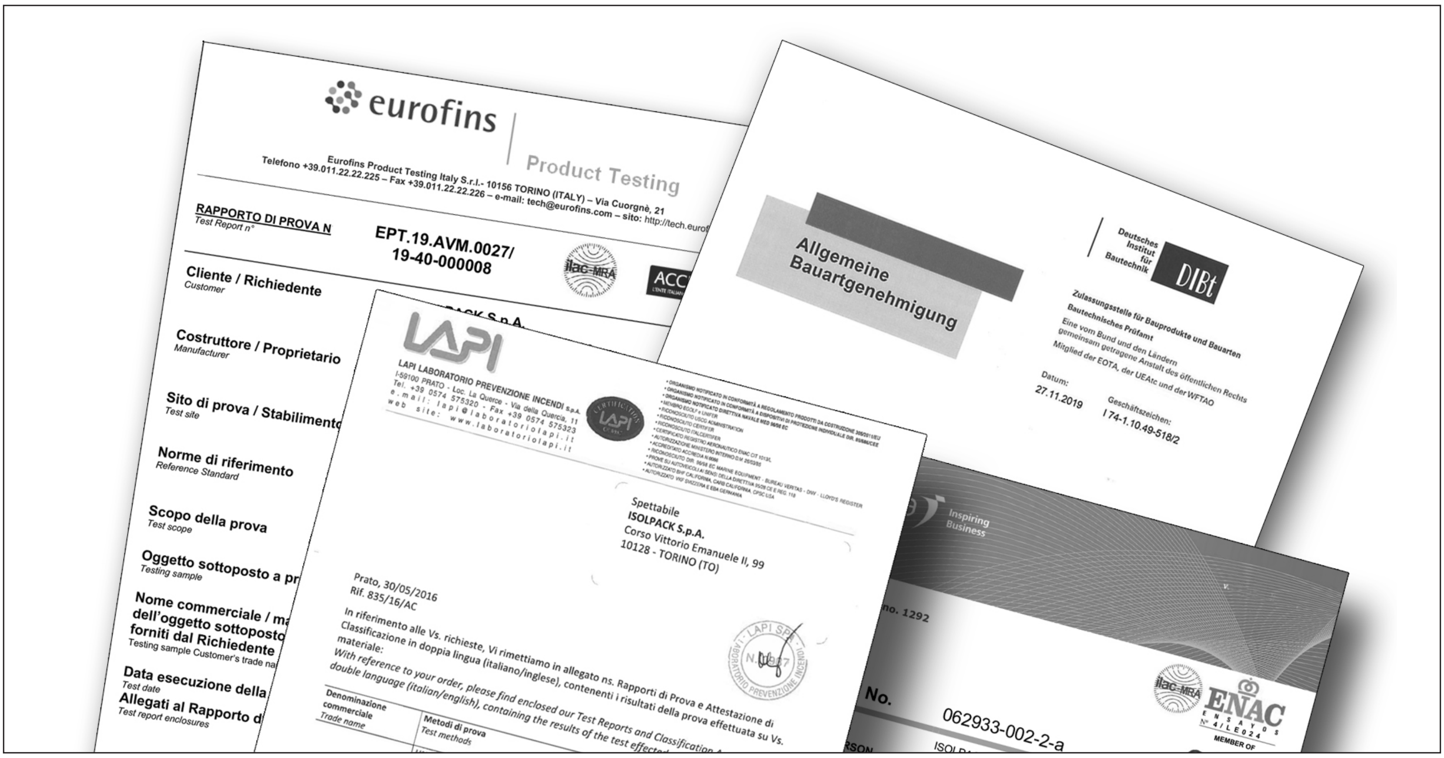
- **resistance R**: aptitude to maintain mechanical resistance under the action of fire;
- **tightness E:** aptitude not to let through or produce flames, vapours or hot gases on the unexposed side;
- **thermal insulation I:** aptitude to reduce heat transmission.

The **REI** symbol followed by a number (n) identifies a constructive element that maintains for a determined time n the mechanical resistance, the resistance to flames and hot gases, the thermal insulation. The number (n) indicates the fire resistance class, calculated and commensurate with the specific design fire load characterizing the compartment analyzed.

The fire resistance classes are: **10, 15, 20, 30, 45, 60, 90, 120, 180, 240 and 360**, and express the time, in minutes of exposure to the nominal curve **ISO 834**, during which the resistance fire must be guaranteed.

**THE CERTIFICATES ARE SUBJECT TO CONTINUOUS UPDATES,
FOR FURTHER INFORMATION OR REQUESTS FOR CERTIFICATES
CHECK THE WEBSITES:
www.isolpack.com - www.isometal.it - www.isotecnica.com - www.rwpi.it (or contact the sales offices of the Manufacturers)**

Picture n° 4: some Manufacturers' certificates issued by authorized laboratories, according to nationally and internationally recognized standards.



4.6.3 Reading of the reference values of the standard

Planners / Installers / End users must carry out an in-depth preliminary assessment of the final use for which the "sandwich panels" will be intended and then choose the product with the most suitable characteristics by reading the code for the panels and formalizing, before placing the order, the desired certification for the specific model identified:

X – sY - dZ where:
X = product class (A1; A2; B; D; E; F)
Y= behaviour tested for smoke emission (s1; s2; s3)
Z= behaviour tested for dripping inflamed particles (d0; d1; d2)

The panels of the "Producers" have obtained different classifications including:

Mineral wool panels for walls or roofs: A2 – s1 – d0
PIR panels for wall or roof: B – s1 – d0

4.6.4 Classification of resistance to external fire

The $\mathbf{B}_{\mathbf{ROOF}}$ certification represents the specific assessment of the risk of propagation to external fires of roofs and of the reaction to fire class. The identification of the test method used is generally indicated with **(T1), (T2), (T3)**, where the numerical progression does not indicate a higher and lower resistance to fire but the different test method. **(T3)** - Ignition with embers, wind and heat administration..

Picture n° 5: roofing made with Isolpack Lithos 5 fire certified sandwich panels.

4.7 MECHANICAL RESISTANCE: GENERAL ASPECTS OF THE SANDWICH PANEL

The **sandwich panel** is made up of several elements: metal facing on one or both sides, insulating core: **(PUR or PIR polyurethane foam, mineral wool or glass wool).** These elements, taken individually, have a minimal capacity to withstand loads while the union of these components, to the point of forming a monolithic element, allows to achieve good self-supporting results and to withstand accidental loads even though without ever being able to assume the function of contributing to the statics of the building on which they are installed. A very important feature is the adhesion capacity of the polyurethane to the metal support

The factors that determine the mechanical strength of a sandwich panel are the following:

- **PANEL THICKNESS:** for the double sheet panel (or bimetallic) this is the most important factor. Generally speaking, the higher the thickness, the greater its range. This concept is based on the principle of the geometric property of a body, where with the same material, the further the material is from the axis passing through its center of gravity, the more the moment of inertia and consequently the capacity increase;

- **SHEET THICKNESS:** it is an important factor for all types of panels, but crucial only for single sheet panels;

- **METAL QUALITY:** in most cases standard steels are used, however in particular cases, when the strength limit is due to the breaking limit and not to deformations, special steels are chosen.

- **GEOMETRY OF THE SHEETS:** the cross section of the metal element is a determining factor that characterizes the panels, their moment of inertia and consequently the carrying capacity that the element can guarantee;

- **DENSITY OF THE INSULATION:** the increase in the density of the insulation contributes to the improvement of the performance of the double sheet panels.

Designers / Installers / End Users are reminded that sandwich panels are designed for orthogonal actions to the panel plane. The Manufacturers do not offer any guarantee for the use of the panels as elements resistant to actions that act in their plan since such use is considered incorrect and can give rise to damages of various kinds.

Picture n° 6: bending tests on wall panel at Isolpack's laboratory / Vinovo plant (TO)

4.7.1 Action of the wind - example of calculation

Designers / Installers / End users must always calculate in advance the actions attributable to the wind. In the absence of specific statistical surveys referring to the installation site it is possible, for the Italian territory, to refer to the Technical Regulations for Construction **(referred to January 2018)** and the related explanatory circular dated **21 January 2019**. It is important to remember that correct assembly always involves installing the sandwich panels by positioning the leeward joints, therefore placed in the opposite direction to the prevailing wind.

EXAMPLE OF CALCULATION OF THE WIND ACTION

For the calculation, reference will be made to the procedure reported in the Ministerial Decree of 17 January 2018. Update of the «Technical standards for constructions» for brevity, hereinafter referred to as "NTC2018" and its application circular of 21 January 2019, n. 7 C.S.LL.PP. Instructions for the application of the "Update of" Technical standards for construction "" referred to in the ministerial decree of 17 January 2018 hereinafter referred to as "Circular 2019".

BUILDING DATA (see illustration n° 4)

- Location: Turin (z = 295 m s.l.m.);
- Plan dimensions 15x40 m;
- Eaves height 11 m – Ridge height 12 m;

Illustration n° 4

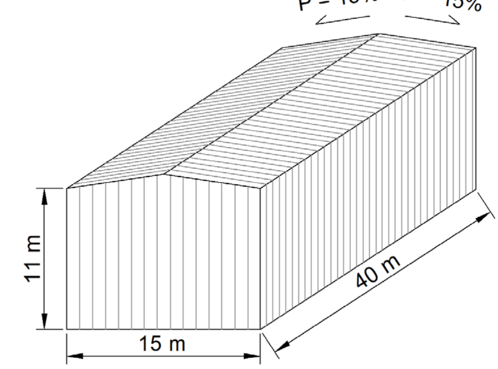


Table n° 7

ZONE	DESCRIPTION	$V_{b,0}$ [m/s]	a_0 [m]	k_s
1	Valle d'Aosta, Piedmont, Lombardy, Trentino Alto Adige, Veneto, Friuli Venezia Giulia (with the exception of the province of Trieste)	25	1000	0,40
2	Emilia Romagna	25	750	0,45
3	Tuscany, Marche, Umbria, Lazio, Abruzzo, Molise, Puglia, Campania, Basilicata, Calabria (excluding the province of Reggio Calabria)	27	500	0,37
4	Sicily and the province of Reggio Calabria	28	500	0,36
5	Sardinia (area east of the straight line connecting Capo Teulada with the island of Maddalena)	28	750	0,40
6	Sardinia (area to the west of the straight line connecting Capo Teulada with the island of Maddalena)	28	500	0,36
7	Liguria	28	1000	0,54
8	Province of Trieste	30	1500	0,50
9	Islands (with the exception of Sicily and Sardinia) and open sea	31	500	0,32

Table n° 8

Table 3.3.III - Terrain roughness classes	
Terrain roughness classes	Description
A	Urban areas in which at least 15% of the surface is covered by buildings whose average height exceeds 15 m.
B	Urban (not class A), suburban, industrial and wooded areas.
C	Areas with widespread obstacles (trees, houses, walls, fences, etc.); areas with roughness not attributable to classes A, B, D
D	a) Sea and related coastal strip (within 2 km of the coast); b) Lake (with a maximum width of at least 1 km) and relative coastal strip (within 1 km from the coast); c) Areas without obstacles or with at least isolated obstacles (open countryside, airports, agricultural areas, pastures, marshy or sandy areas, snow-covered or frozen surfaces, etc.).

The value of the wind pressure acting on the building can be estimated using the formula shown on the NTC2018 (§3.3.4):

$$p = q_r \cdot c_e \cdot c_p \cdot c_d$$

STEP1: Calculation of the value of the “reference kinetic pressure” q_r (§3.3.4 NTC2018)

Where:
ρ = 1,25 kg/m^3
$\mathbf{v_r = v_b \cdot c_r}$ → (z = 295 m s.l.m. < a_0 = 1000 m s.l.m) → $v_r = v_{b,0} \cdot c_r$ = 25 m/s

The value of $\mathbf{c_r}$ was assumed to be equal to 1 (return time 50 years) and the value of $\mathbf{v_{b,0}}$ was obtained from table 3.3.I of the **NTC2018**.

STEP2: Calculation of the “exposure coefficient” c_e (§3.3.7 NTC2018)

Assuming that the building is located in the industrial area from table 3.3.III of the NTC2018, the soil roughness class B is assigned.

Once the distance from the coast is known (greater than 100 km), it is possible to assign exposure category IV to the site in question (see image 3.3.2 of NTC2018). Once the exposure category is known, it is possible to obtain the parameters for calculating the exposure coefficient.

In the case in question, the height above ground of the building z is equal to 12 m less than 200 m so the formula 3.3.7 of the NTC08 is used:

Since z = 12 m → z_{min}= 8 m, assuming c_t = 1 we obtain:

$\mathbf{c_e(12)}$ = $0{,}222^2 \cdot 1 \cdot \ln(12/0{,}30) \cdot [7+1 \cdot \ln(12/0{,}30)]$ = **1,943**

STEP3: Calculation of the “pressure coefficient” c_p (§C3.3.8.1.1 Circular 2019)

PRESSURE COEFFICIENT FOR THE WALLS

The pressure coefficient is specific for each side of the building and depends on the wind direction considered. The planner’s aim is to check all the possible combinations for each wall and to extrapolate the most onerous case.

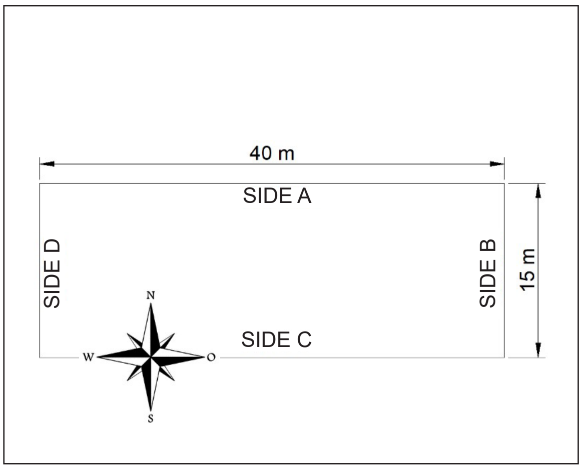
Assuming for the case in question a double symmetry of the building, it is possible to reduce the combinations to two possible cases.

In the case in question, we will consider the example of a global verification of the wall.

The value of the coefficient is a function of the relationship between h (height of the building) and d (length of the parallel side) to the wind direction.

By convention, the coefficients that identify a wind thrust from the outside inwards are assumed to be positive, while those that identify a thrust from the inside outwards are negative.

Illustration n° 5



CASE 1: Wind from the East - h/d = 12/40 = **0,3**

- Windward face (SIDE D)
  for h/d<1: $\mathbf{C_{pe}}$ = 0,7+0,1· h/d = + 0,73 *(table C3.3.I Circular 2019)*
- Downwind face (SIDE B)
  for h/d<0,5: $\mathbf{C_{pe}}$ = -0,5 - -0,8 · h/d = - 0,26 *(table C3.3.I Circular 2019)*
- Downwind face (SIDE A and C)
  for h/d<1: $\mathbf{C_{pe}}$ = -0,3 - 0,2 · h/d = - 0,36 *(table C3.3.I Circular 2019)*

To the above calculated coefficients we must add those due to any internal pressures. The calculation of internal pressures is addressed in chapter C3.3.8.5 of the Circular 2019 and depends on the openings on the walls of the building. For the example in question we will consider the case that there are openings distributed uniformly on the walls of the building (case 3) therefore it is possible to assume the internal pressure coefficient equal to c_{pi} = +0.20 or c_{pi} = -0.30 depending on the heaviest combination. In summary, a summary image is shown below with the coefficients obtained for case 1, for each face the most unfavourable internal pressure value was considered (see illustration n° 6).

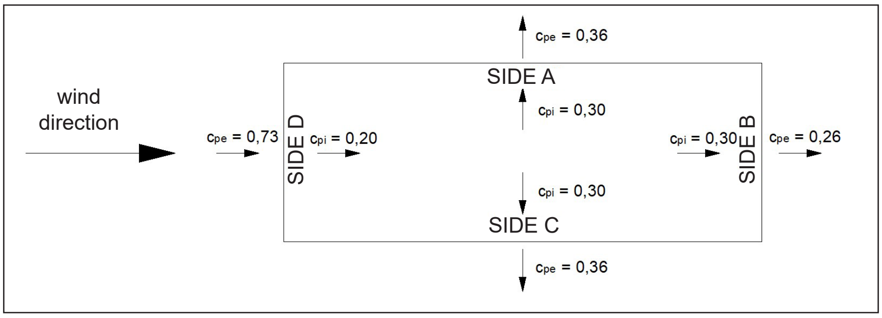


Illustration n° 6

CASE 2: South wind - h/d = 12/15 = **0,8**

- Windward face (SIDE C)
  For h/d<1: $\mathbf{C_{pe}}$ = 0,7+0,1· h/d = + 0,78 *(table C3.3.I Circular 2019)*
- Downwind face (SIDE A)
  For h/d<0,5: $\mathbf{C_{pe}}$ = -0,5 - -0,8 · h/d = - 0,14 *(table C3.3.I Circular 2019)*
- Downwind face (SIDE B and D)
  For h/d<1: $\mathbf{C_{pe}}$ = -0,3 - 0,2 · h/d = - 0,46 *(table C3.3.I Circular 2019)*

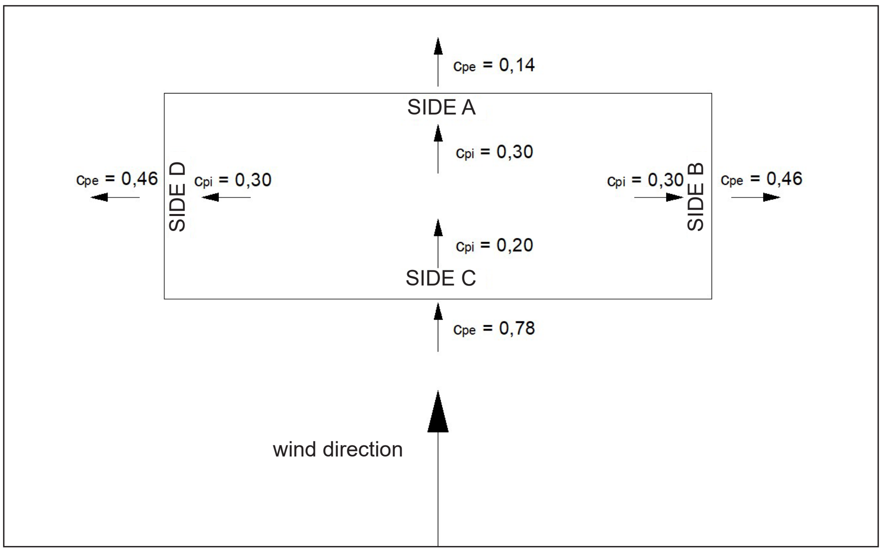


Illustration n° 7

For the internal pressure coefficients, the considerations of case 1 apply. Below is a summary image with the coefficients obtained for case 2.

It is advisable to find the maximum pressure coefficients for each wall both in depression and in pressure. In particular, assuming that the wall sandwich panels are fixed to a barrack structure inside the building, the maximum wind pressure is useful for the dimensioning of the panel-holding structures while the maximum depression is decisive in the verification of the fixings.

Summarizing the results obtained are:

- Maximum global pressure coefficient on the short sides (B and D) in the direction from the outside to the inside:
  $c_p = c_{pi} + c_{pe}$ = 0,93 (from case 1)
- Maximum global depression coefficient on the short sides (B and D) in the direction from the inside to the outside:
  $c_p = c_{pi} + c_{pe}$ = - 0,76 (from case 2)
- Maximum global pressure coefficient on the long sides (A and C) in the direction from the outside to the inside:
  $c_p = c_{pi} + c_{pe}$ = 0,98 (from case 2)
- Maximum global depression coefficient on the long sides (A and C) in the direction from the inside to the outside:
  $c_p = c_{pi} + c_{pe}$ = - 0,66 (from case 1)

Note: The coefficients thus calculated are the envelope of two cases that are not actually contemporary. This procedure is valid for the verifications concerning the single wall but in general they are wrong for the global verifications of the structure.

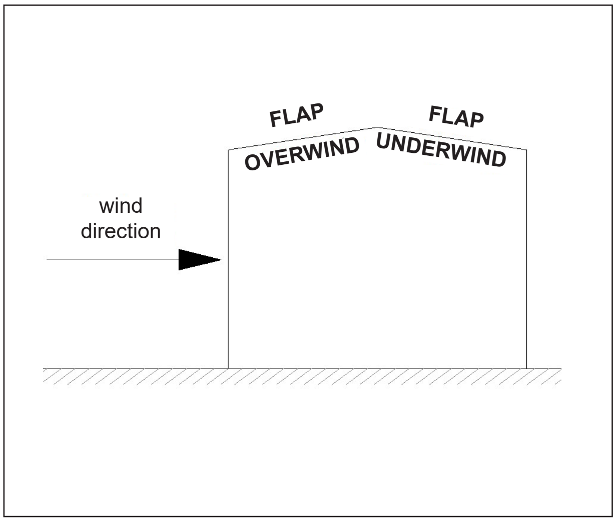
COEFFICIENT OF PRESSURE FOR COVERAGE

The calculation of the pressure coefficient for the case in question (double pitch roof with an inclination greater than 5 °) is described in paragraph C3.3.8.1.4 of the Circular 2019 (see Illustration n° 8).

CASE 1: Wind from the East (orthogonal to the ridge)

Let us consider the case of wind direction orthogonal to the ridge. For the calculation of the global pressure coefficient on the A (windward) pitch, reference can be made to figure C3.3.8 of the 2019 Circular. For the B (leeward) pitch, reference is made to figure C3.3.12 of the 2019 Circular.

Illustration n° 8



Note that the pressure coefficients are given with both signs. Similarly to what has been seen in the case of the positive coefficients walls correspond to an action of the wind from the outside towards the inside, those with a negative sign represent the depressions.
Nel caso in esame le falde hanno inclinazione pari a 15° dunque si ottengono i seguenti valori di coefficiente di pressione:

FLAP OVERWIND	FLAP UNDERWIND
c_{pe+} = 0,20	c_{pe} = - 0,60
c_{pe-} = - 0,60	

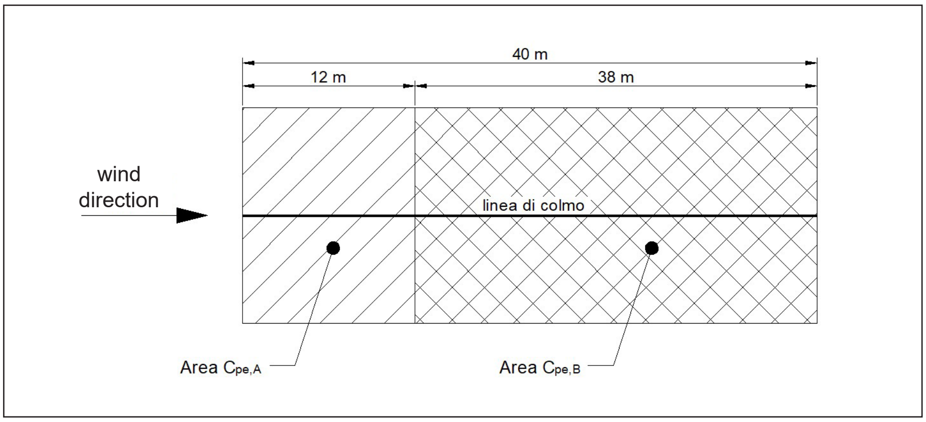
CASE 2: South wind (parallel to the ridge)

For the estimate of the pressure coefficients, reference is made to figure C3.3.13 of the 2019 Circular. From which we obtain:

$c_{pe, A}$ = -0,90 $c_{pe, B}$ = -0,45

The coefficient $c_{pe,A}$ must be assumed for a water table length equal to the minimum between b / 2 and h. In this case b / 2 is equal to 20 m and h equal to 12 m, therefore we consider 12 m. In the remaining areas, on the other hand, the coefficient $c_{pe,B}$ is considered (see illustration n° 9).

Illustration n° 9



As already seen for the calculation of the pressure coefficients for the walls, possible internal pressures must be taken into account. For the case in question (openings distributed uniformly) the internal pressure coefficient is c_{pi} = +0.20 or c_{pi} = -0.30 depending on the most onerous combination.

The pressure coefficients obtained for estimating the maximum pressures and maximum depressions on the roof are shown below.

- Maximum global pressure coefficient on the roof in the direction from the outside to the inside:

  $c_p = c_{pi} + c_{pe}$ **= 0,20 + 0,20 = +0,40 (from case 1)**

- Maximum global pressure coefficient on the roof (over an extension of the pitch equal to 12 m) in the direction from the inside to the outside:

  $c_p = c_{pi} + c_{pe}$ **= -0,30 - 0,90 = -1,20 (from case 2)**

STEP4: Calculation of the "dynamic coefficient" cd (§3.3.9 NTC2018)
For the industrial buildings in which the case in question falls, it can be assumed as a precaution equal to 1.

STEP5: Calculation of the characteristic wind pressure (§3.3.4 NTC2018)
Once the coefficients have been calculated, it is possible to obtain the value of the wind pressure on external walls and roofs. The planner will have to identify the most onerous action depending on the verification carried out.

Wind action on the walls

✓ Maximum wind pressure (to check the panel support structure)
- Long sides (A and C) in the direction from the outside to the inside:
  $p = q_r \cdot c_e \cdot c_p \cdot c_d$ **= 390 · 1,943 · 0,98 · 1 = 742,6 N/m² = 75,7 kgf/m² (from case 2)**
- Short sides (B and D) in the direction from the outside to the inside:
  $p = q_r \cdot c_e \cdot c_p \cdot c_d$ **= 390 · 1,943 · 0,93 · 1 = 704,7 N/m² = 71,9 kgf/m² (from case 1)**

✓ Maximum depression (to check fixings)

- Long sides (A and C) in the direction from the inside to the outside:
  $p = q_r \cdot c_e \cdot c_p \cdot c_d$ = 390 · 1,943 · 0,66 · 1 = 500,1 N/m² = 51,0 kgf/m² (from case 2)
- Short sides (B and D) in the direction from the outside to the inside:
  $p = q_r \cdot c_e \cdot c_p \cdot c_d$ = 390 · 1,943 · 0,76 · 1 = 575,9 N/m² = 58,7 kgf/m² (from case 1)

✓ Tangential wind action (§3.3.5 NTC2018)
In the case in question, the use of wall panels with smooth external sheets is assumed. From table 3.3.XIX of the 2019 Circular we obtain the value of the friction coefficient c_f equal to 0.01.

$p_f = q_r \cdot c_e \cdot c_f$ = 390 · 1,943 · 0,01 = 7,6 N/m² = 0,8 kgf/m²

It is noted that this action is negligible in the case of a smooth wall like the one under examination. This value can however be used for the shear check of the fasteners.

Wind action on the roof

✓ Maximum wind pressure (to check the panel support structure)
$p = q_r \cdot c_e \cdot c_p \cdot c_d$ = 390 · 1,943 · 0,40 · 1 = 303,1 N/m² = 30,9 kgf/m²

✓ Maximum depression (to check fixings)
$p = q_r \cdot c_e \cdot c_p \cdot c_d$ = 390 · 1,943 · 1,20 · 1 = 909,3 N/m² = 92,7 kgf/m²

✓ Tangential wind action (§3.3.5 NTC2018)
In the case in question, the use of sandwich panels with corrugated sheets is assumed. From table 3.3.XIX of the 2019 Circular we obtain the value of the friction coefficient c_f equal to 0.03.
$p_f = q_r \cdot c_e \cdot c_f$ = 390 · 1,943 · 0,03 = 22,7 N/m² = 2,3 kgf/m²

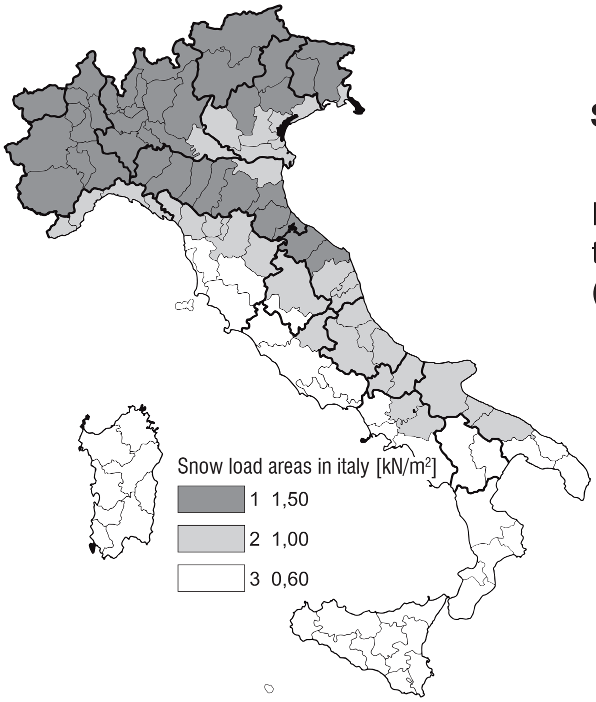
4.7.2 Action of snow - example of calculation

Planners / Installers / End users must always take full account of the action of the snow which, combined with the action of the wind, represents a determining factor for the correct choice of the type and thickness of the roofing panels. Do not neglect the calculation of the values deriving from the subsequent melting of the snow to dimension an appropriate water disposal system.

The reference legislation in Italy is the D.M. 17/01/2018

Italy is divided into 3 load areas (see illustration n° 10) where the snow load on the ground is respectively about 60 - 100 - 150 kg / m² (for ordinary constructions below 1500 m of altitude).
The above values must be multiplied by some coefficients which take into account:

- Exposure The shape of the roof (single-pitched, multi-pitched, cylindrical, etc.): for pitched roofs it is between 0.8 (flat roof) and 0 (roofs with an inclination> 60 °);
- the structure itself: it is between 0.9 (windswept area) to 1.1 (sheltered area);
- Of the possible reduction of the snow load due to its melting: generally set equal to 1.



SNOW LOAD AREAS IN ITALY

Italy is divided into 3 load areas where the snow load on the ground is respectively about 60 - 100 - 150 kg / m² (for ordinary constructions below 1500 m of altitude).

Illustration n° 10

EXAMPLE OF CALCULATION OF THE SNOW LOAD

For the calculation, reference will be made to the building considered for the calculation of the wind action (see illustration n° 11).

BUILDING DATA:

- Location: Turin (z = 295 m a.s.l.);
- Plan dimensions 15x40 m;
- Eaves height 11 m – Ridge height 12 m.

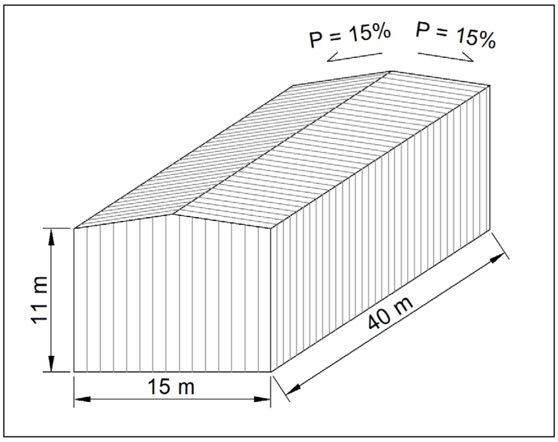


Illustration n° 11

The weight of the snow “q_s” acting on the roof is calculated according to the indications given in the Technical Regulations for Construction of 2018.

$$q_{sk} = q_{sk} \cdot \mu_i \cdot C_E \cdot C_t$$

STEP1: Calculation of the value of q_{sk} “snow load on the ground” (§3.4.2 NTC2018)

The building falls in zone I - Alpina, the **“q_s”** value is obtained according to its altitude above sea level according to the formula:

q_{sk} = 1,39 · [1 + (as/728)2] = 1,39 · [1 + (295/728)2] = 1,62 kN/m²

STEP2: Calculation of the value of μ_i “coverage form coefficient” (§3.4.3 NTC2018)

For slopes of less than 30 ° the μ_i value is equal to 0.8.

STEP3: Calculation of the value of C_E “exposure coefficient” (§3.4.4 NTC2018)

For the calculation, reference is made to table 3.4.I of the NTC2018 which is shown below (see table n° 9).

Table n° 9

Table 3.4.I - C_E values for different exposure classes		
TOPOGRAPHY	DESCRIPTION	C_E
Windswept	Flat unobstructed areas exposed on all sides, with no taller buildings or trees.	0,9
Normal	Areas where there is no significant snow removal on the building by wind, soil, other buildings, or trees.	1,0
Protected	Areas where the construction under consideration is significantly lower than the surrounding terrain or surrounded by taller buildings or trees.	1,1

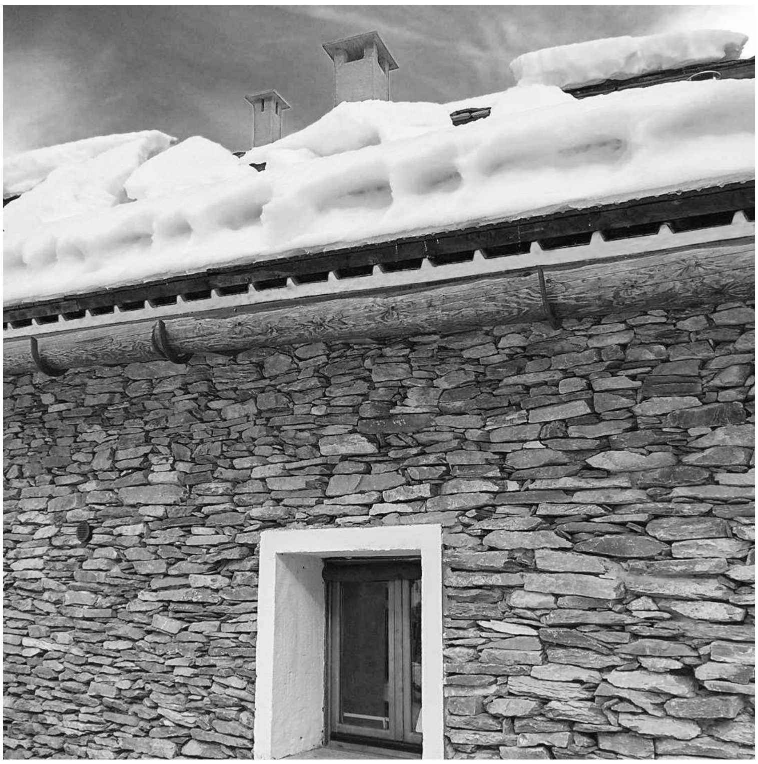
The C_E value is obtained from the table, which is equal to 1.

STEP4: Calculation of the value of C_t "thermal coefficient" (§3.4.5 NTC2018)

In the explicit explanatory part of the ministerial decree, there is a consensus on the value of the inferior thermal coefficient at the unit. The only case in which this coefficient is provided is 1.2 at the same time as the internal temperature is maintained at 0 ° C (adjacent to the refrigerated cells). In the case in question, the thermal coefficient C_t is assumed to be 1.

STEP5: Calculation of the snow load on the roof (§3.4.1 NTC2018)

$$q_{sk} = q_{sk} \cdot \mu_i \cdot C_E \cdot C_t = 1{,}62 \cdot 0{,}8 \cdot 1 \cdot 1 = 1{,}30 \text{ kN/m}^2 = 132 \text{ kgf/m}^2$$



Picture n° 7:
roofing of a refuge located in an Alpine area (2000 m asl) and made with sandwich panels on which wooden battens and shingles were laid.

4.7.3 Notes on seismic action

Earthquakes act through a succession of ground vibrations that cause a shift at the base of buildings. Unlike wind and snow, seismic action is not a force but an acceleration imposed at the level of the foundations. Despite this, there are different approaches that make it possible to evaluate the seismic action using “**equivalent static**” forces, the extent of which is estimated with the aim of producing the same effects as an earthquake. It is intuitive to deduce how these static forces are proportional to the seismic acceleration and to the mass of the structure.

By their nature, sandwich panels are very light elements and, moreover, they are not included among the “**structural**” construction elements. These considerations often raise doubts as to whether, when, and possibly in what way it is necessary to take into account the seismic action on the sandwich panels. In this part of the manual we want to clarify this aspect, in the light of the indications contained in the Italian legislation.

In all applications, sandwich panels can be classified as non-structural building elements. This consideration derives from the fact that their stiffness, strength and mass are not such as to significantly influence the structural response. It is important to underline that this does not mean that they should be underestimated, in fact the panels are significant elements for the purpose of safety and / or safeguarding people.
According to the Technical Standards for Construction, the seismic force acting on non-structural elements, due to the mass of the element, is evaluated with the following formula (§7.2.3 NTC2018), which factors are shown on table 10.

$$\mathbf{F_a = (S_a \cdot W_a) / q_a}$$

Table n° 10

FACTOR	DESCRIPTION
F_a	*is the horizontal seismic force distributed or acting in the center of mass of the non-structural element, in the most unfavorable direction, resulting from the distributed forces proportional to the mass;*
S_a	*is the maximum acceleration, dimensionless with respect to that of gravity, which the non-structural element under-goes during the earthquake and corresponds to the limit state under examination (§3.2.1) ;*
W_a	*is the weight of the element;*
q_a	*is the behavior factor of the element.*

In addition to the force calculated above, due to the mass of the panel alone, it must be borne in mind that in production plants often the sandwich panel constitutes the support on which systems of different nature are fixed. It follows that the force calculated previously must be added to that due to a system constrained to the infill or partition panel.
The action due to the systems can be assimilated to a load distributed along the surface of the panel, the entity of which is:

$$\mathbf{Q_i = 2 \cdot F_{ai} / S} \qquad \textit{(§7.2.4 NTC2018)}$$

Where with $\mathbf{F_{ai}}$ is the force of competence of each component of the system and **S** is the surface of the panel. This distributed load must be applied both orthogonally and tangentially to the plane of the panel, in order to evaluate which of the two is the most unfavourable condition. The requirement that is required by the legislation is that the stability of the element is verified under the action of the force $\mathbf{F_a}$ in the appropriate calculation condition.
Below is an example of calculating the seismic action on infill panels of a building.

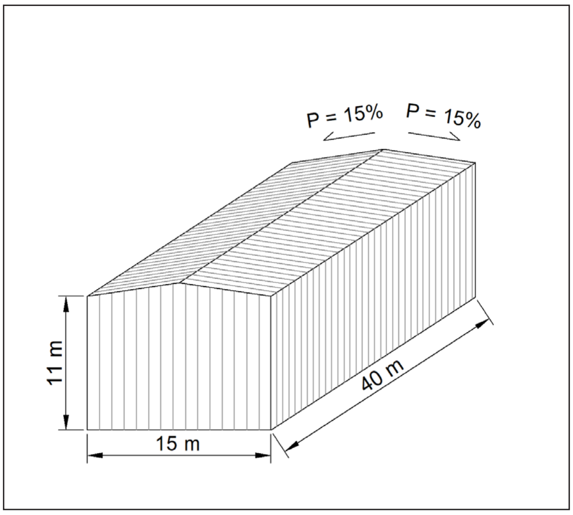
Example of seismic action calculation

For the calculation, reference will be made to the building considered for the calculation of the action of wind and snow (see illustration n° 12). The equivalent static action due to the earthquake acting on the walls will be calculated and will be compared with the action of the wind. In fact, these forces must not be assumed simultaneously, therefore it is legitimate to consider the greater of the two as the main action.

BUILDING DATA:

- Location: Turin (z = 295 m a.s.l.);
- plan dimensions 15x40 m;
- Eaves height 11 m – Ridge height 12 m;
- Infill panels sp. 120 mm weight 14 kg/m^2.

Illustration n° 12



Calculation of the maximum acceleration S_a
The maximum expected acceleration depends on the type of limit state considered and the location of the construction site.

Influence of the limit state on S_a

For non-structural elements, such as infill and internal partitions, the requirement of **"stability" at the limit state of life protection is required** (§7.3.6 NTC2018). This limit state corresponds to a probability of exceeding, in the reference life of the construction, equal to 10%. In other words, for ordinary class two constructions, the target earthquake is an earthquake which, statistically, occurs once every 475 years in the project area.

Influence of the site on S_a
The National Institute of Geology and Volcanology provides the values of $\mathbf{a_g}$ and $\mathbf{F_0}$ as a function of the site coordinates and the considered return time. For the building in question, located in the province of Turin, the following values are obtained:

$\mathbf{a_g}$ = 0,055 g (g is the gravitational acceleration equal to 9,81 m/s^2);
$\mathbf{F_0}$ = 2,760;

The coefficient **S** takes into account the specific stratigraphy of the site and particular topographical conditions. Its value is obtained from the multiplication between S_S *(stratigraphic coefficient table 3.2.IV of the NTC2018) and* S_T *(topographic coefficient table 3.2.III NTC2018). For the calculation, the building is considered to be built on coarse-grained soil (category B tab. 3.2.II NTC2018) and flat surface (category T1 tab.3.2.III NTC2018) from which*:

$$\mathbf{S = S_S \cdot S_T = 1{,}20 \cdot 1{,}00 = 1{,}20}$$

Calculation of S_a

$$S_a = a_g \cdot S \cdot F_0 \cdot \eta = 0{,}55 \cdot 1{,}20 \cdot 2{,}76 \cdot 1 = 1{,}82\ g$$

Where for the calculation of a conventional viscous damping coefficient equal to 5% has been assumed.

Calculation of the seismic force

It is considered that the external cladding is made with a wall panel sp. 120, with both support plates sp. 0.6 mm. For this type, the mass W_a is worth 14 kg/m^2.

The magnitude of the equivalent static force due to the earthquake is:

$$F_a = (S_a \cdot W_a) / q_a = (1{,}82 \cdot 14) = 25{,}50\ kgf/m^2$$

Where q_a is the behaviour factor of the element. This factor takes into account the response of the element to the earthquake and is a value greater than or equal to 1. The explanatory circular of 2019 allows the use of a value equal to 2 for internal and external walls. In favour of safety, and in the absence of specific studies on the seismic response of the element, the value 1 was adopted in the calculation.

Comparison with the action of the wind and final considerations

The force just calculated must be applied to the panel for stability checks and therefore for the calculation of the fixings and the ultimate strength of the panel.

We now want to compare this force with the action of the wind, previously calculated for the same building. The maximum wind load is:

$$q_{vmax,k} = 75{,}7\ kgf/m^2$$

Given that the calculated seismic action refers to the SLV (life safety limit state), framed in the Ultimate Limit State, for the comparison to be correct, the wind action must be multiplied by the partial safety factor for the actions at the limit state last which is worth 1.5 (considering the wind as the main action).

$$q_{vmax,d} = 1{,}5 \cdot q_{vmax,k} = 1{,}5 \cdot 75{,}7 = 113{,}6\ kgf/m^2$$

The action of the wind is more than 4 times greater than that of the earthquake. This result is due to two main aspects:

- Sandwich panels are very light elements for which the seismic action is unlikely to determine the verification of the panels and fixings when the action of the wind is present;
- Piedmont is a region with low seismicity, in other areas of Italy heavier values of the seismic action could be obtained.

We want to emphasize how the seismic verification can however be useful in estimating a design load for the internal panels, not directly affected by the action of the wind. Furthermore, the legislation specifies how the static force due to the earthquake must be applied, alternately, both vertically and horizontally. This force in the vertical direction, added to the panel's own weight, can be used to check the stability of the panel at a peak load.

5. RECOMMENDATIONS FOR HANDLING AND ASSEMBLY OF PRE-COATED METAL PANELS

The Manufacturers strongly recommend to Planners / Installers / End Users to carefully read and strictly follow the General Conditions of Sale, Handling, Storage of sandwich panels **published by AIPPEG**. They represent the whole of the experiences of most of the builders of these products and are recognized by professionals and builders as comparable to reference standards to be adopted, exclusively, in the world of those who use pre-insulated sandwich panels.

Purely as an indication, the Manufacturers, leaving to Planners / Installers / End Users the burden of providing the site personnel with the operational provisions deemed most suitable, also in relation to the specific situations of each individual site, wish to provide some non-binding information to consider oneself simple suggestions.

5.1 PACKAGING AND PROTECTION

The panels are delivered in packages, each consisting of a certain number of superimposed panels and the number per package is defined according to:

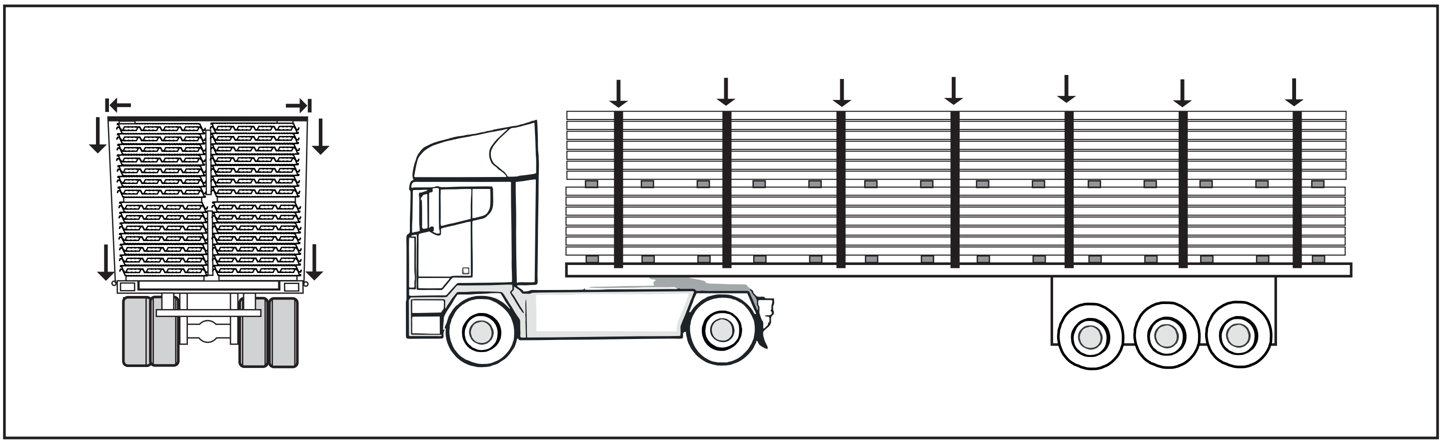
- Type of panel;
- panel thickness;
- length of the panels;
- type of means of transport;
- optimization of the loading plan.

To maintain their integrity, especially of an aesthetic nature, the panels have temporary protection systems. Upon request, during the manufacturing phases, the above materials can be protected with an adhesive polyethylene film on the prepainted surfaces.

5.2 TRANSPORT OF PANELS AND UNLOADING

When the transport is carried out by Planners / Installers / End Users, it will be essential that they refer to the provisions of the UNI 10372-2004 standard paragraph 9.9.2 therefore ensure the use of suitable means that allow the perfect support of the packages on the loading surface with appropriate wooden or plastic foam spacers (aligned vertically). Each column of parcels will be secured to the means of transport by means of transversal fastenings with belts (never ropes) at an appropriate distance between center and which in any case never exceeds a distance of three meters (see illustration n° 13), covered loads are recommended. The binding must guarantee adequate pressure to keep the load still but never be excessive to avoid that the weight on the lower packs added to an excessive pressure exerted in the binding points by the belts can cause small deformations of the product which, moreover, are considered admissible and cannot give rise to disputes of any kind.

Illustration n° 13



The unloading phase of the packages of panels must also strictly follow these instructions since only the use of suitable lifting systems guarantees the perfect integrity of the panels.
When unloading is carried out with an overhead crane, crane, mobile crane, the use of ropes, chains, metal cables, iron wire and even the strapping that may sometimes be present must be avoided, but only nylon bands of adequate width (min 20cm) to be applied on a distribution slingbar in order to avoid "bottlenecks" and to guarantee the division of the package weights on several points (see illustration n° 14).

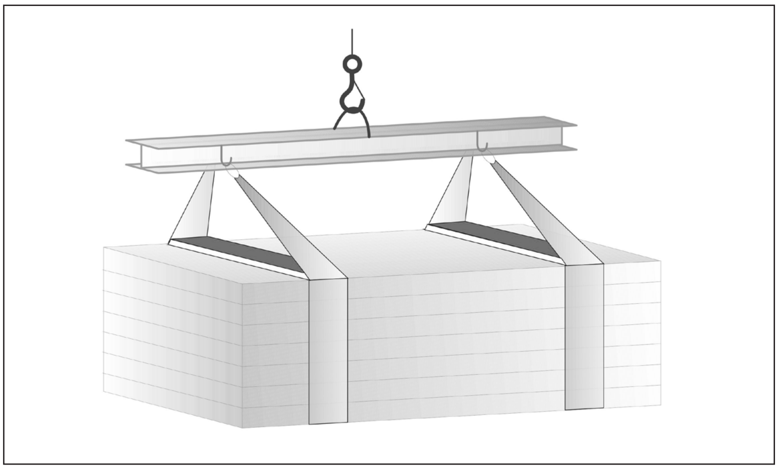


Illustration n° 14

In the case of unloading by means of forks, excluding the case of lifters with multiple side forks, maximum caution is essential since the probability of damaging the last panel at the bottom if not the entire package are very high also due to the natural package assumes, by its own weight, when its length is not proportional to the distance between the forks of the vehicle; unloading with fork means statistically causes frequent damage such as abrasions or scratches of the surfaces for which the manufacturers do not respond.

5.3 RECEIPT OF MATERIALS AND SITE MEASURES

When the load of panels reaches the installation site Planners / Installers / End users must:

- Check the exact correspondence of the quantities of all items to the shipping document;
- verify and approve dimensions, colours of products;
- attest the absence of damage due to transport, etc.;
- in the presence of deficiencies, damages, defects of the panels and / or accessories, put a written note on the transport document and have it signed by the driver;
- as already discussed, the unloading and lifting methods at height must comply with the criteria indicated above but, if any shortcomings on the construction site only envisaged the use of a forklift truck, it will be essential that it is arranged with the widely spaced forks placed under the center of the package. If the pack of panels is too long (over four times the center distance of the forks), two equidistant forklifts must be used (see illustration n° 15a).
  In any case, the Producers will not be liable in any way for the damage that the products may suffer.

Illustration n° 15a

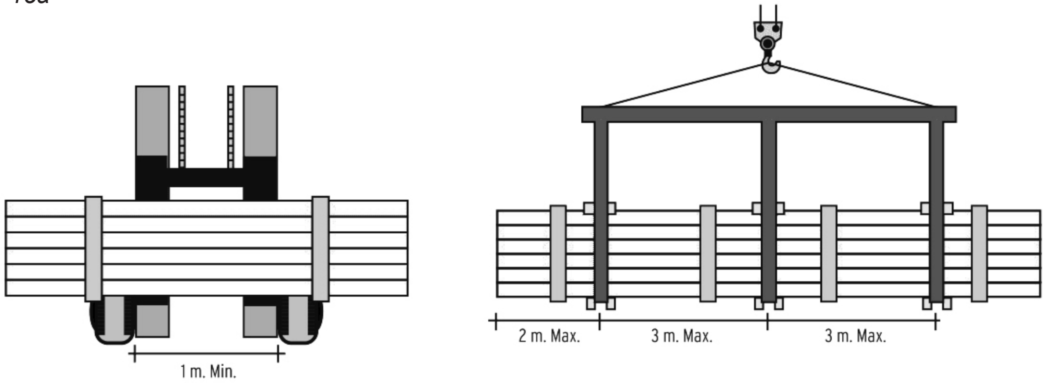
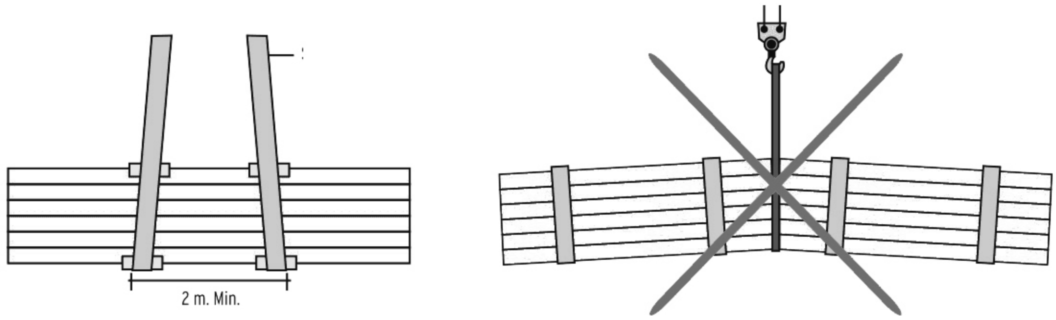


Illustration n° 15b



- to prevent the panels from being damaged during lifting, unload the packages one at a time;
- inspect the route that the lifter will have to travel on site to make sure that the path is free of ruts and holes that would damage the material with the inevitable jolts;
- if a crane is used, nylon belts of adequate width (min 20cm) must be used positioned on at least two points along the length of the pack; as already indicated, “bottlenecks” must be avoided, therefore it is recommended to use wooden planks or other types of spacers positioned in the upper and lower part of the pack in correspondence with the straps to protect the edges of the upper and lower panels (see illustration n° 15b);
- in the case of panels longer than 6 meters, a distribution slingbar must be used.

5.4 STORAGE

As mentioned in the paragraph dedicated to thermal expansion, the panels exposed to direct sunlight can bend and consequently make assembly difficult. For this reason, the packages must never stand in the sun before their installation but must be placed in a shaded area (illustration n° 16).

Planners / Installers / End users, before proceeding to collect the panels, must define the area in which the products will be stored, whether indoors or outdoors, since it is essential to adopt appropriate measures (comply with the UNI 10372-2004 standard paragraph 9.9.3) aimed at avoiding the formation of surface condensation or the infiltration and stagnation of humidity, rainwater, etc. which can cause damage to the metal supports and / or the paint.

Illustration n° 16

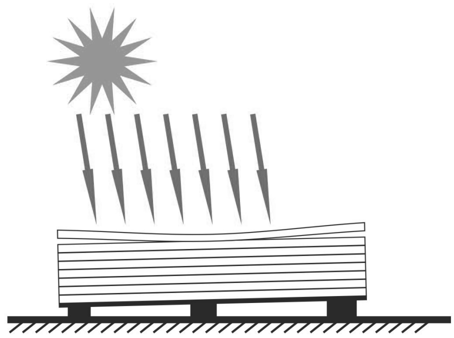
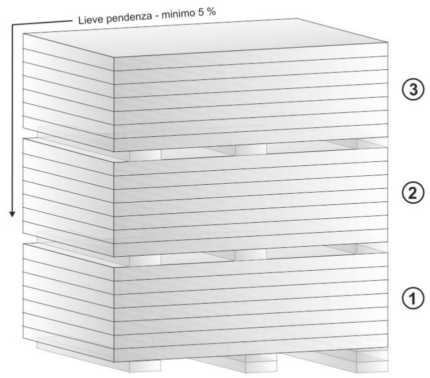


Figura n° 17



As widely reported in the **AIPPEG General Conditions**, which requires careful reading, it is recommended not to overlap the packages; where this is not possible, it is advisable to interpose spacers in wood or extruded plastic materials (aligned in a vertical line) so as to create the best conditions for ground transmission of the loads.

In the case of indoor storage, it is advisable to choose ventilated places, not dusty and not subject to sudden changes in temperature: it is also recommended to ensure that the packs are not placed on ferrous or greasy materials that can damage the metal support of the panel and / or the paint. To maintain the original performance of the product, it is advisable not to exceed 4 months of storage inside, from the date of production.

In the case of outdoor storage, it is necessary to provide a support surface inclined longitudinally in order to avoid stagnation of water or humidity, especially if the panels are not to be removed for installation in the short term; it is still advisable to use protective tarpaulins which, however, allow the recirculation of air and the outflow of any condensation (see illustration n° 18).

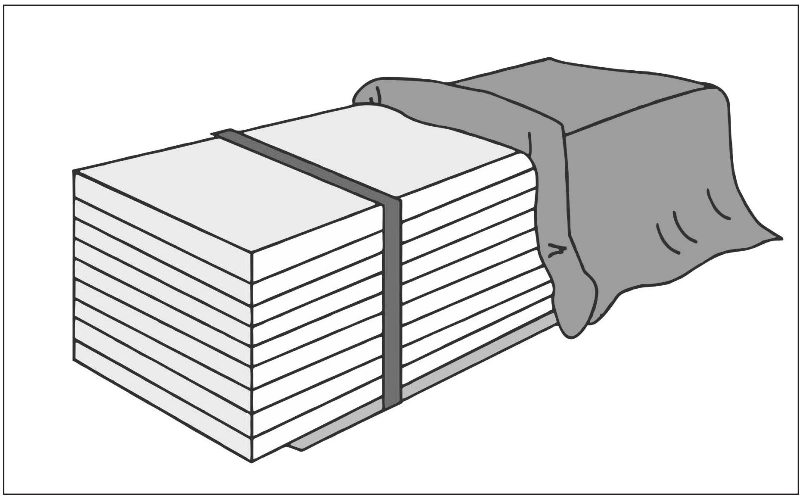


Illustration n° 18

The attention to atmospheric conditions to which the panels are exposed remains of particular importance; intense precipitation with hail can damage the metal supports, while excessive exposure to solar radiation, especially in the hottest periods, can lead to plastic deformations of the product. A panel with a dark coloured support, if exposed directly to the sun, can reach a surface temperature of 80/90 ° C. However, outdoor storage must never exceed 60 days from the date of production.

Planners / Installers / End users must take care to remove the adhesive protective film within 15days from the date of delivery (under penalty - after this period - the risk of considerable difficulty or impossibility of removing this film), while waiting for the installation, store the panels observing the procedures prescribed by **Annex A of the AIPPEG General Conditions of Sale.**

DURING THE SUBSEQUENT PHASES, PRECAUTIONS MUST BE TAKEN TO ENSURE THE FOLLOWING ASPECTS:

- PROTECTION OF THE SURFACE FROM ABRASION PHENOMENA, ESPECIALLY DURING HANDLING
- PROTECTION OF CORNERS AND EDGES AGAINST IMPACTS AND CRUSHING
- PROTECTION OF THE ELEMENTS ON WHICH THE MASS OF THE ENTIRE PACKAGE RESTS, OR THE OVERLYING PACKAGES, AGAINST PERMANENT DEFORMATION.

5.5 LIFTING AT HEIGHT

The pre-insulated panels are the ideal and lasting solution for the construction of roofs, walls, partitions, etc. and after their installation they guarantee excellent performances over time but the handling before installation requires attention and scrupulous compliance with the rules, which the **General Conditions Aippeg** clearly list, as well as the UNI 10372-2004 standard paragraph 9.9.4 to prevent the products from being damaged which, subsequently, could compromise the valuable aesthetic / functional result typical of the product.

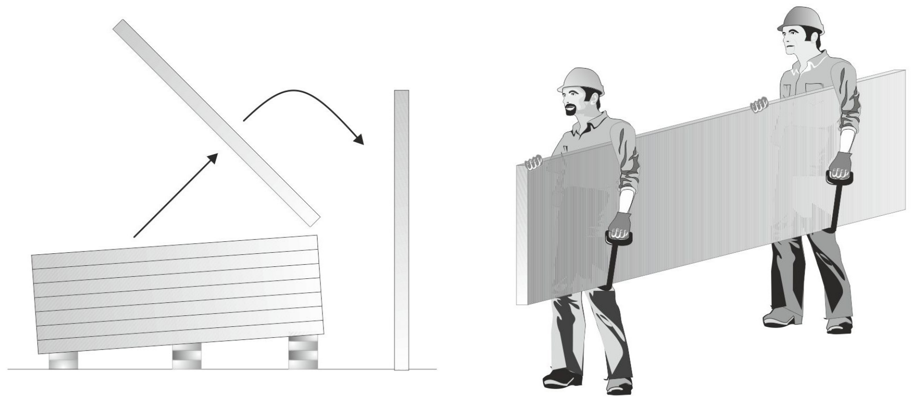
Here we report the following rules:

- Lifting at height with telescopic forklifts is only acceptable for short (<6.00 m) and light packages, the forks must be longer than the width of the packages, be spread as far as possible, the upper surface of the forks must be clean and smooth to avoid damage to the surface of the panels. Never handle more than one package at a time.

- Lifting with a crane must strictly exclude the use of ropes, chains, metal cables, while it will only be advisable to use nylon bands of adequate width (min 20cm) that must not be twisted, use a sling bar to avoid “bottlenecks” and interpose wooden boards or other spacers to protect the upper and lower edges (see illustration n° 14).

- Short and light panels can be lifted manually. But they must never be moved in a horizontal (flat) position as excessive bending could lead to breakage of the polyurethane, permanently compromising the panel itself. The handling of a panel must always be carried out vertically (cutting) so as to exploit the inertia of the element itself (see illustration n° 19).

Illustration n° 19



- Planners / Installers / End users must ensure that the handling of the elements is carried out using adequate means of protection (gloves, helmet, safety belts, safety shoes, overalls, etc.), in compliance with current regulations (incorrect handling can cause damage to people and things). In case of heavy panels, or when the panels have to be lifted in height, it is necessary to use specific lifting equipment.

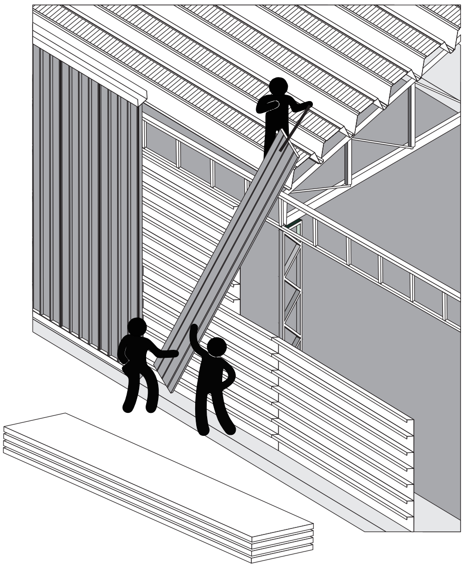


Illustration n° 20

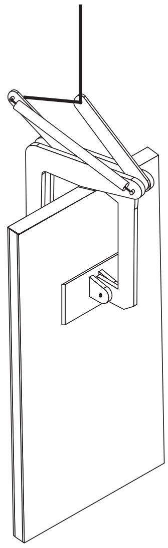


Illustration n° 21

- Various tools are available to lift the single panel at height (see illustration n° 20/21), a special “hook” can be used to be applied to the crane which acts, with the principle of a pliers, on the upper end of the panel; this method is usual for the installation of vertical walls but must be carried out with extreme skill, under the direct control of Planners / Installers / End Users since the risk of crushing the part on which the tool grips, with consequent permanent deformation, it’s possible.

- Another method used for lifting the single panel is gripping with suction cups which guarantee safe handling, however, despite being a practical and effective system, it requires some precautions in order to avoid damage. The choice of the model of the lifting device through the creation of vacuum, differs in the number of suction cups and in the calibration of the applied force, it will depend on the type (PUR / PIR foam or mineral wool), on the length of the panels, characteristics that determine the total weight and in the choice of mounting specifications. When handling panels with the suction cup system, it is necessary for the operator, who physically carries out the lifting, to follow the instructions provided on the machine by the technical office of the company that produces or rents the lifting devices, he must also calibrate the suction cups according to the needs of the case and take responsibility in the application (see picture n° 8).

Picture n° 8

Picture n° 9

- Planners / Installers / End users, since they are aware of the fact that the use of suction cups exerts a tensile load on the metal support of the panel, will have to prepare the system based on the length and weight of the panel to be handled which, obviously, will vary in in relation to the thickness of the sheets, foam or in the presence of mineral wool. The Manufacturers suggest never to apply a suction load (empty) higher than 47 gr/ cm^2, and to always insert an adequate stiffening distributor.

- Plannners / Installers / End users must therefore check the number of suction cups, their suction size, their positioning, before authorizing the use of this handling method. It is recommended to use at least two pairs of suction cups (two per side) for panels up to m. 5 in length distributed at a quarter of the length of the panel, starting from the ends, both on the right and on the left side so as to distribute the load and reduce the bending of the element. For panels up to m. 8 in length, at least three pairs of suction cups are required (three on each side) positioned at a fifth of the length, starting from the ends of the panel, the lateral ones (right and left) and a pair as much as possible on the central axis of the panel (center line). When the panels reach longer lengths up to m. 13.50 four pairs of suction cups (four per side) are indispensable to be positioned at one eighth of the length, starting from the ends, the lateral ones (on the right and left) while the two central pairs must be positioned at one fifth of the length of the panel starting from the centerline (see picture n° 9/10). If the balance wheel with suction cups is not of adequate length to satisfy the above suggestions, it is important that the pairs of side suction cups are always positioned as far as possible from the center line.

Picture n° 10

5.6 CUTTING OF SANDWICH PANELS

Panel cutting operations require the adoption of the following measures:

- masking of the area affected by the cut with adhesive tape;
- on the adhesive tape, tracing with a felt-tip pen, the cut to be made.

Carry out the cut exclusively with a nibbler / jigsaw (equipped with suction and filtration) following all the precautions and safety procedures required by current regulations.

We strongly advise against the use of the cutting disc for grinders (the high speed of rotation of the disc projects incandescent sparks on a large surrounding surface which, upon contact with the paint of the panels, burn it, compromising its integrity, not only aesthetic but above all the protective function of the underlying metal support against atmospheric agents, moreover the same sparks can trigger fires, originate fumes harmful to humans, excessive overheating of the materials).

For any type of cut that will be adopted, the Manufacturer recommends the complete removal of any residue deriving from the cut itself as well as it is important that, in panels with steel supports, the cut ends do not come into contact with complementary artefacts such as flashings, gutters. , drips, corner pieces, etc. to avoid corrosion phenomena.

5.7 OPENINGS AND HOLES IN THE SANDWICH PANELS

The creation of holes or openings in the panel, by removing a part of it, can significantly compromise the resistance characteristics of the element. Whenever it is necessary to carry out the passage of pipes, channels for systems, insertion of windows, etc. A careful analysis and evaluation of the effects resulting from the reduction of the resistant section that this operation entails is required.

The European reference standard (EN14509) does not contemplate the possibility of creating openings in the panels, therefore there are no standard procedures for evaluating the reduction in bearing capacity. Planners / Installers / End users will have to calculate and foresee the opportunity to insert adequate reinforcements to avoid problems and consequences.

The possible problems that the cuts entail can be divided into three categories:

- Local defects near the cut;
- global stability problems of the panel;
- probable partial detachment of the sheet from the insulation.

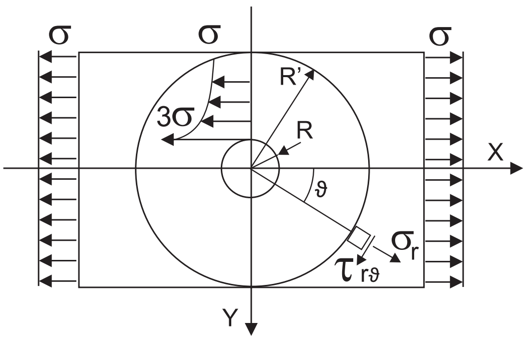


Illustration n° 22: solution of Kirsch (1898) which describes the stress state in correspondence of a hole in the hypothesis of an infinite slab and stress state.

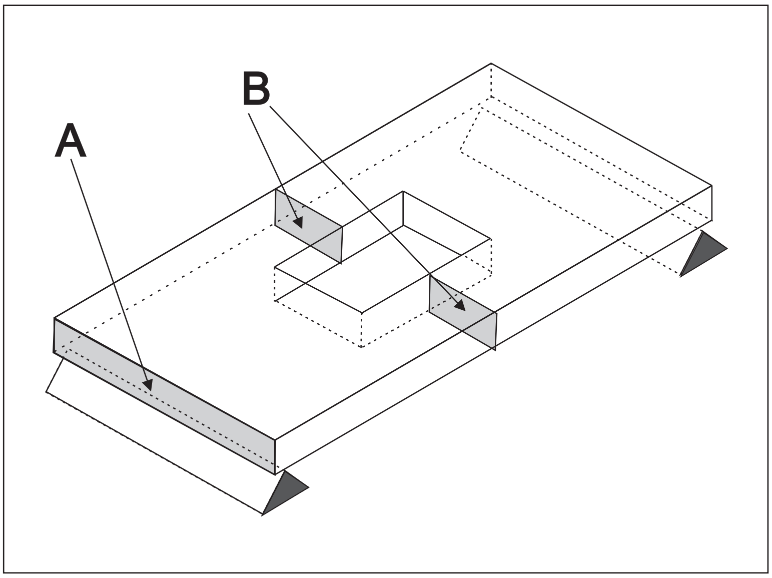
The former are due to the concentration of stresses that occur on the sheets following the reduction of the resistant section. For example, consider the case of a sheet metal subjected to a tensile stress state. Assuming that the applied tension is uniform and equal to a value σ, it is possible to verify analytically (in the hypothesis R '>> R) how the tension remains constant σ along the circumference of radius R' while, inside it, a concentration occurs voltage. The maximum is reached on the edges of the cut where the tension reaches three times the one applied (see illustration n° 22).

The phenomenon described above can lead to plasticization of the sheet near the hole and the consequent formation of permanent deformations. The effect of stress concentration is more pronounced in the edges of rectangular cuts.

5.8 GUIDELINES TO ASSESS RESIDUAL RESISTANCE

A first check to evaluate the actual bearing capacity of a panel with openings is the evaluation of the effective resistant section. The resistant section is given by the section of the intact panel from which the area in which the opening will be made must be subtracted (vedi immagine in figura n° 23). This simplified approach, which assumes a constant distribution of stresses in the remaining section of the panel, is not precautionary. In fact, assuming constant stresses, their concentration which occurs in the edges of the cut is not considered. The approach described can be used for small openings, applying this method to large openings (doors and windows) the results differ from the actual behaviour on site.

Illustration n° 23



One of the limits of the calculation method described above is to consider the panel as isolated. In the usual and recurrent building practice, the sandwich panel is used coupled with others. The degree of union between the different elements depends on the characteristics of the longitudinal joint (see illustration n° 24).

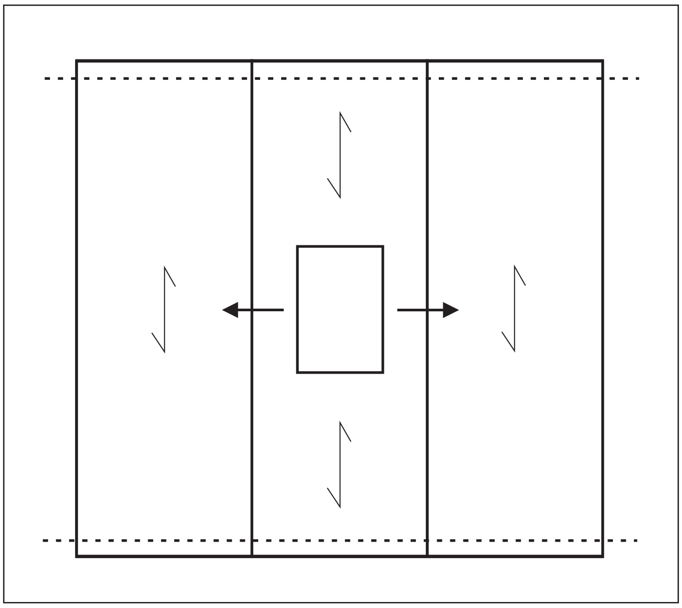


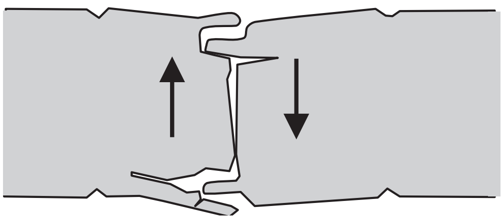
Illustration n° 24

The panels on which an unreinforced opening is made have a reduced flexural stiffness in proportion to the size of the cut itself. This phenomenon involves a redistribution of the tensions towards the adjacent panels, whose flexural stiffness has not been compromised.

From the above considerations it follows that loads are transmitted to neighbouring panels which therefore must be sized for a load greater than that of the single panel, by appropriately adding the load rate transmitted by the panel on which the openings have been made (see illustration n° 26).

In light of the foregoing, if openings are envisaged, it is advisable to reduce the admissible light value that is provided in the capacity tables. This reduction must be evaluated case by case according to the position and size of the openings themselves. To prevent the adjacent panels from undergoing an increase in load, with a consequent reduction in the useful span, it is possible to provide an adequate frame inside the hole that is able to restore the flexural rigidity of the compromised panel.

Illustration n° 25



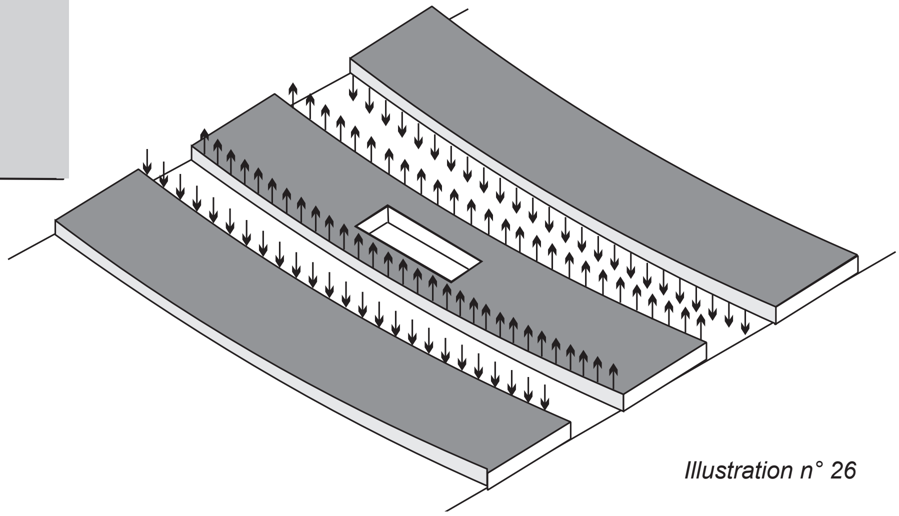


Illustration n° 26

5.9 PLAN TOOLS

Given that it will be the sole task of Planners / Installers / End Users to make the most appropriate choices for the realization of the work in compliance with the planned project, the Manufacturers wish to provide some non-binding information that can be defined as simple suggestions:

- Never make cuts or openings before installing the panel. The stresses that the panel undergoes as an isolated element, during handling and installation, can often be higher than those of operation;
- If possible, prefer the creation of circular rather than rectangular holes. With this expedient it is possible to limit the phenomenon of stress concentration in correspondence with the hole;
- avoid making holes on a panel adjacent to one in which openings have already been made;
- provide reinforcement profiles for the panel whenever a hole is to be made;
- depending on the width of the hole, where possible, it is recommended to make a cut that involves several panels rather than significantly weakening a single panel (see illustration n° 28);

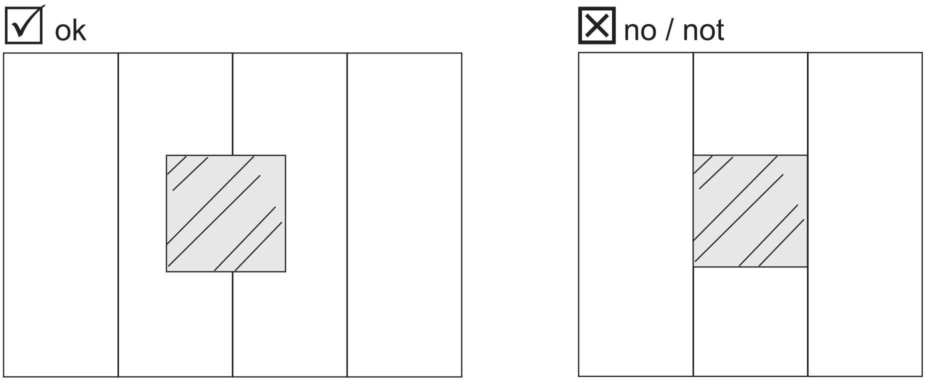


Illustration n° 27

- If the creation of the opening compromises one or more fixings, provide for distribution structures or other solutions that allow the restoration of the fixings provided (see illustration n° 28).

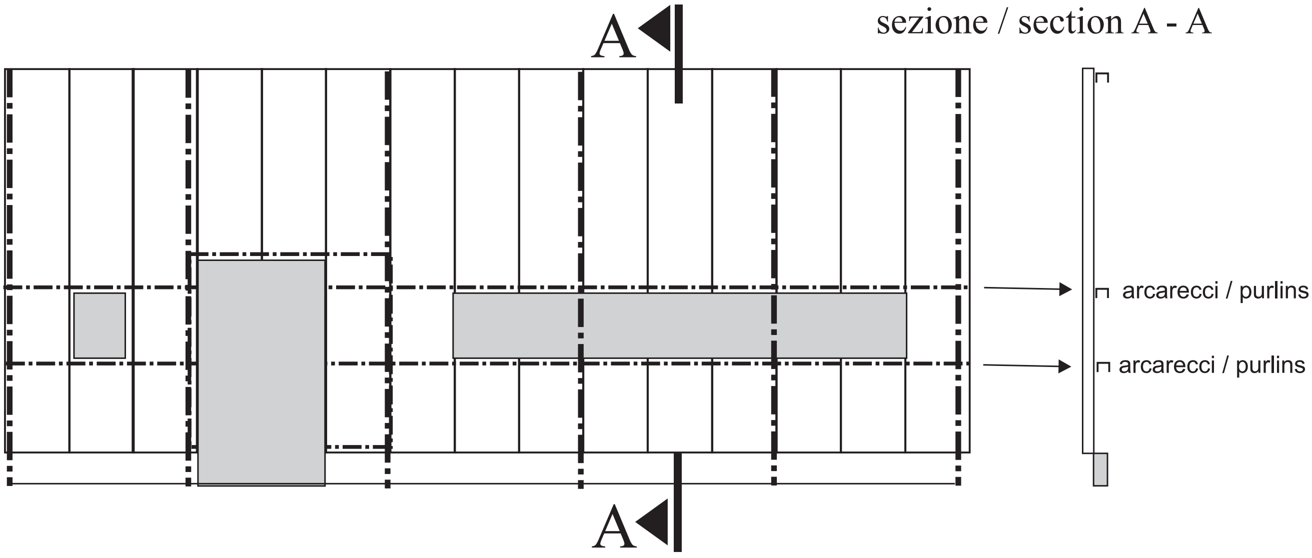


Illustration n° 28

6. WALL SANDWICH PANELS

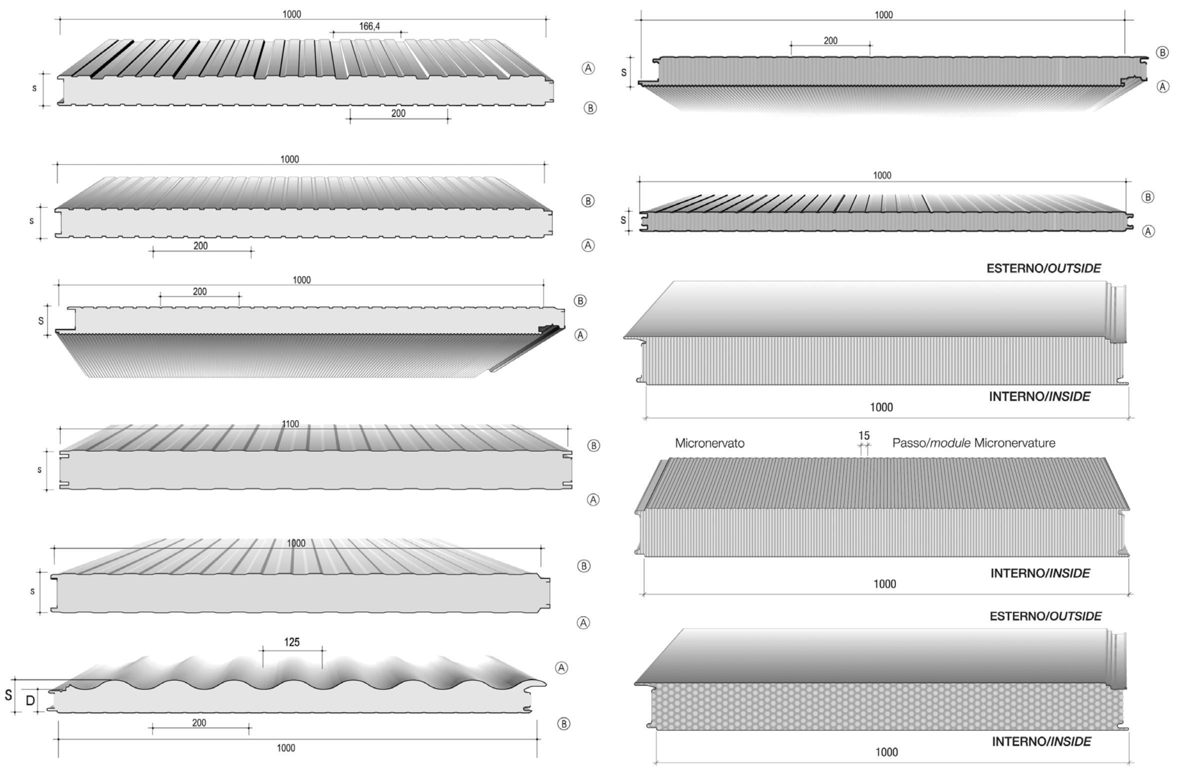


Illustration n° 29

6.1 VERTICAL PANEL INSTALLATION TO BUILD WALLS

Manufacturers recommend following simple preliminary installation procedures such as:

- ✓ check the executive drawings to verify the congruence between the project and the material supplied;
- ✓ the installer must ascertain the geometry and alignment of the structural support before installing the wall / ceiling panels;
- ✓ make sure that the elements to which the panels will be bound are coplanar and free of obstructions such as weld seams, bolts, screw heads or anything else that may hinder correct assembly;
- ✓ check that the load-bearing structures do not have construction or assembly tolerances such as to affect the installation of the panels since any deviation can affect both performance and aesthetics, compromising the final result;
- ✓ prepare flashings / base supports, corner profiles, gaskets, etc., according to the project;
- ✓ check that, in the panels where it is foreseen, the gasket is present and integrates along the entire length of the joint. For some specific cases (for example for cold rooms or in any case for applications where a strong difference in humidity or temperature is expected) implement sealing (operation to be carried out only on site) by injecting, before the juxtaposition between panels, specific silicone products between the male and female joints so as to create an almost impenetrable barrier;
- ✓ adopt, for each elevation of the facades to be covered, the direction of installation of the panels, on each facade, the wind direction must be opposite to that prevailing (insert drawing) (see illustration n° 30);

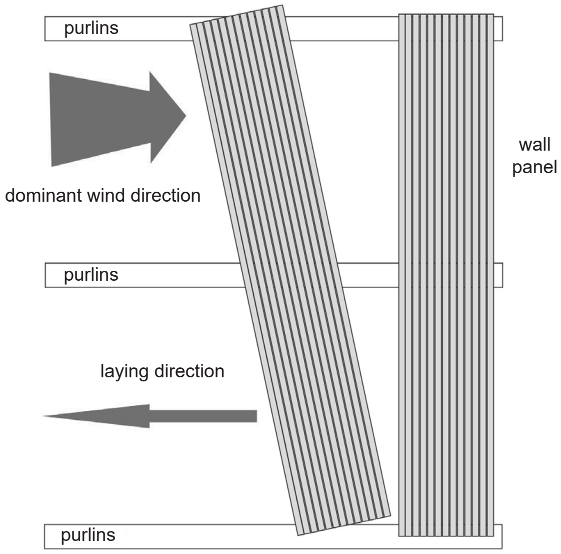


Illustration n° 30

- ✓ lift the first panel into position and press firmly on the support structure, checking the correct inclination in all directions, then lock with the screws provided by the Manufacturer. The tolerance on the verticality of the panel must respect the value of ± 2 mm; complete the fastening on the metal beams, remembering that excessive tightening of the screws leads to deformation of the external sheet (buckling) with the consequent imperfection. Planners / Installers, knowing the type of structure to which the panel will be fixed, will choose the most appropriate fastening which will also depend on the type / thickness / rib of the external sheet of the panel used (see chapter on types of fastening);

- ✓ to continue laying the wall, the second panel is placed next to the previous one with a slight inclination starting from the base and pushing it in adherence in order to obtain a perfect coupling between the joints. The subsequent operations will be similar to this however it is advisable to check the verticality of the panels after every 3-4 fixed ones.

These indications apply to laying the panel vertically without interruption, however there are cases in which, for various reasons, the cladding must be made in several sections such as, for example:

- Height of the facade greater than the panel length normally produced;
- Different coloured panels on the outside (on each band), for architectural reasons;
- Panels too long with dark color on the outside; (see chapter: PRACTICAL TIPS FOR CONTAINING THERMAL EXPANSION PROBLEMS of this manual).

The suggestion of the Manufacturers to tackle this complex problem, due to the differential temperature between the external and internal side due to which the panels tend to deform creating problems in correspondence with the intermediate supports, is to limit the length of the panels (max 5 - 6 meters in function of color) by providing expansion joints. Obviously the facade will have two or more bands delimited by appropriate section breakers. This solution is not suitable for some applications, for example cold rooms, as it is preferable not to have a continuity solution to avoid thermal bridges.

6.2 NOTES ON THE HORIZONTAL LAYING OF THE WALL PANELS

Most of the wall panel models are designed to be laid vertically: the tongue-and-groove joint was designed to ensure maximum thermal insulation and water tightness along all the joining lines between the panels. Laying in horizontal mode, which differs from the recommended standard mode, requires the design responsibility of a qualified professional, who will evaluate the feasibility conditions according to the specific conditions of the project (climatic zone of the building, solar exposure due to thermal expansion, typology of the underlying structure and all the necessary parameters) proposing the most suitable technical solution for the intervention.

Models specially designed for horizontal installation are produced (eg: mod. ONDA/Zeroklass Leonardo RWPanel) which offer adequate sealing guarantees when installed in this way; in this case the wall panels will cover one or more bays interspersed with a series of vertical joints that will become an integral part of the facade design. Expansion joints should be provided near adjacent sections in order to compensate for panel movements due to temperature variations. Each joint must be sealed and insulated.

When Planners / Installers / End Users choose to create a wall with hidden fixing panels, mounted horizontally, as a precaution it will be necessary to start the installation of the first panel at the top to go down and never in the opposite direction, in order to avoid possible (albeit minimal) infiltrations.

Once the assembly of all sides of the walls of the building has been completed, the work must be completed with all the complementary accessories (corners, sheet metal work, flashings, drips, cantonals, upholstery, etc.).

6.3 FIXING SYSTEMS FOR WALL PANELS

The fixings have the task of effectively anchoring the sandwich panel to the supporting structure; the choice of the type of fixing group takes place according to the type of structure present (metal, wood or concrete). It will be the responsibility of the Designer/Installer/End User to choose the number and position of the fasteners such as to guarantee resistance to the stresses induced by permanent or dynamic loads.

The fixings are an important element in the realization of a work. Both from a structural point of view (mechanical resistance, impermeability, durability) and from an economic point of view, in fact they affect the final cost by 2-3%. The number and placement of the fixings depends on the design and environmental variables (for example: purlin spacing, wind, building height, etc.). It will be the responsibility of the Designers/Installers/End Users to evaluate the appropriate number and type of fasteners with specific reference to the single use.

Designers/Installers/End users are reminded that the fixing of the panels on a laminated wood or simply wooden structure (especially as regards roofing panels with a high thickness of insulating foam) must be carried out with particular attention and skill, as a high tightening torque could risk causing the wooden support to collapse, while a tightening with a reduced torque could not be sufficient to hold the panels in position and therefore give rise to transversal bending of the same due to deformation from radiation, expansion thermals, etc., as already indicated in the previous paragraphs. Incorrect fixing can cause infiltration of air, rain water, condensation inside the building.

6.3.1 The shape of the head

They have the function of force transmission during the installation phase, for this reason there are different types, the most common are: **HEXAGONAL** and **TORX.**
The hexagonal head, although it is the most widely used, has the characteristic of having a very limited contact surface, only on the edge of the hexagon, and at a very high tightening torque they could easily strip. While the **TORX** screw has a greater contact and improvement surface for high tightening torques. In general, a high tightening torque is not recommended for the installation of the sandwich panels, otherwise the gaskets will crack or even the metal facing of the panel is deformed, for this reason the use of **TORX** screws is less frequent.

6.3.2 The thread

It has the function of tightening and transmitting forces and extends over the shaft of the screw. We tend to have 3 types of threads: 1) thread for wooden supports 2) thread for metal supports. Wood screws have a relatively wide and spaced thread as they screw into an organic material while sheet metal screws have thinner threads as the metal is much more compact. The diameter of the screw is usually 6.3 mm.

6.3.3 The tip

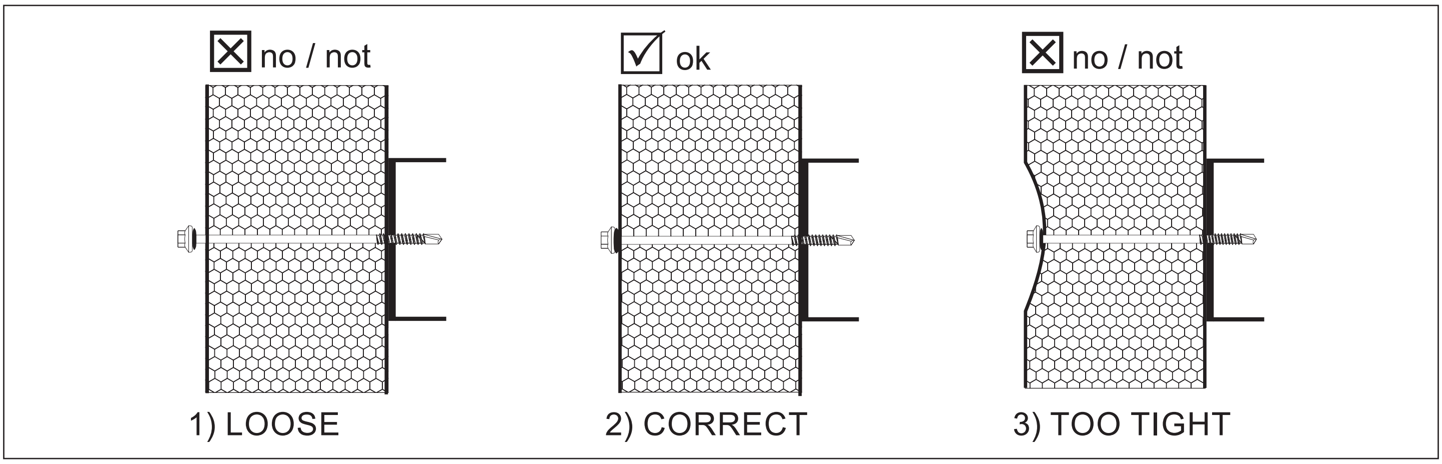
It is a very important element of the screw. Among the most used we have the “self-drilling” screws. They are used in the presence of steel supports with thicknesses between 2 mm and 5 mm and it is not necessary to drill pre-drilled holes. When the metal thicknesses of the purlin are higher we will have the “self-tapping” “self-tapping” screws with a conical shape. In this case, the steel purlin must be pre-drilled. Finally wood log bolts. If the panel is placed on wooden battens, in this case the screw in the batten must bite at least 40 mm.

6.3.4 Seals

The fixing screws must be sealed in the part of the hole to ensure the durability of the facade. The design of the sealing ring must take into account:

- Thermal fluctuations;
- water;
- acids/Alkalis/Ozone;
- UV rays. / Ageing;
- abrasions and cracks (also due to excessive mechanical tightening of the screwdriver see drawing 31);
- oblique and non-perpendicular thrusts (stresses due to external forces: air, temperature varia tions, earthquakes).

Illustration n° 31

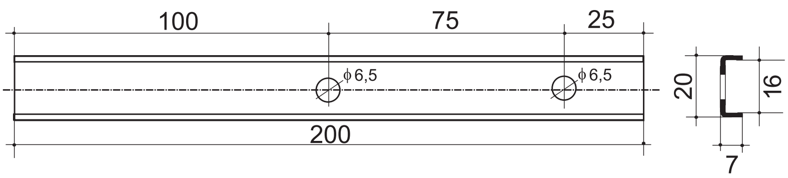


In most cases the sealing element is made of EPDM elastomer. It is a material that can be repeatedly compressed to at least twice its size and that returns to its original shape as soon as the compressive load is removed.

For the panel with concealed fastening (STAR) mounted vertically, the distribution bracket must be used for fastening. It is a steel bracket that distributes the tightness of the screw head over an area equal to the entire length of the bracket, giving a better distribution of the fastening seal on the panel.

GALVANIZED STEEL STIFFENING AND FIXING BRACKET 1,5 mm (thickness)

Illustration n° 32



This bracket also allows the possibility, where the support allows it, to install two screws for each fixing point. (see illustration n° 33).

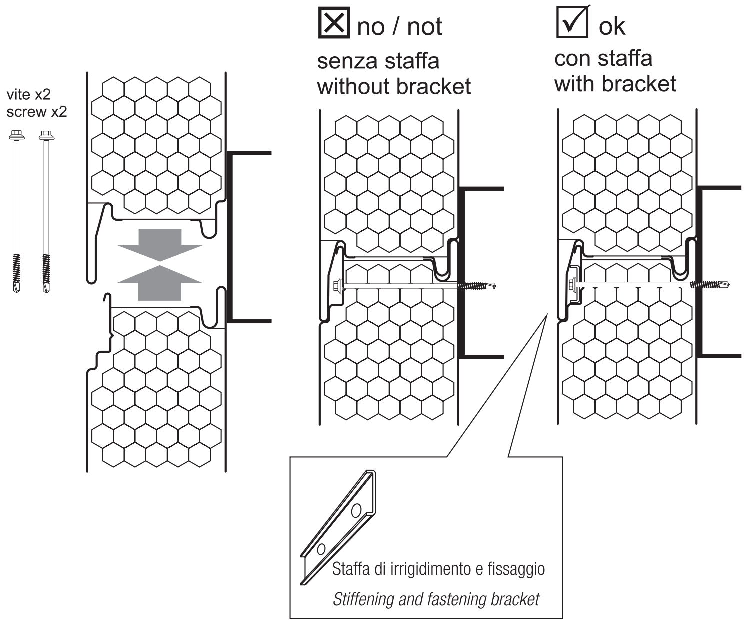


Illustration n° 33

6.4 REMINDER

- Place the packs on smooth, level, hard ground;
- packages positioned on wooden or polystyrene spacers at least 200mm wide, every 1.00m;
- the packs must be positioned slightly inclined (min. 6%), to take into account the drainage of infiltration / condensate water;
- maximum 2 or 3 parcels must be stacked in height (as transported on the truck);
- packages must be stored in sheltered places. If that’s not possible, they should be protected from rain and sun rays with rain cloths, guaranteeing, at the same time, adequate ventila tion;
- the removable protective film of the surface of the panels must not be exposed to sunlight for long time. In any case, it must be removed within 15 days from the delivery of the panels.

7. SANDWICH ROOF PANELS

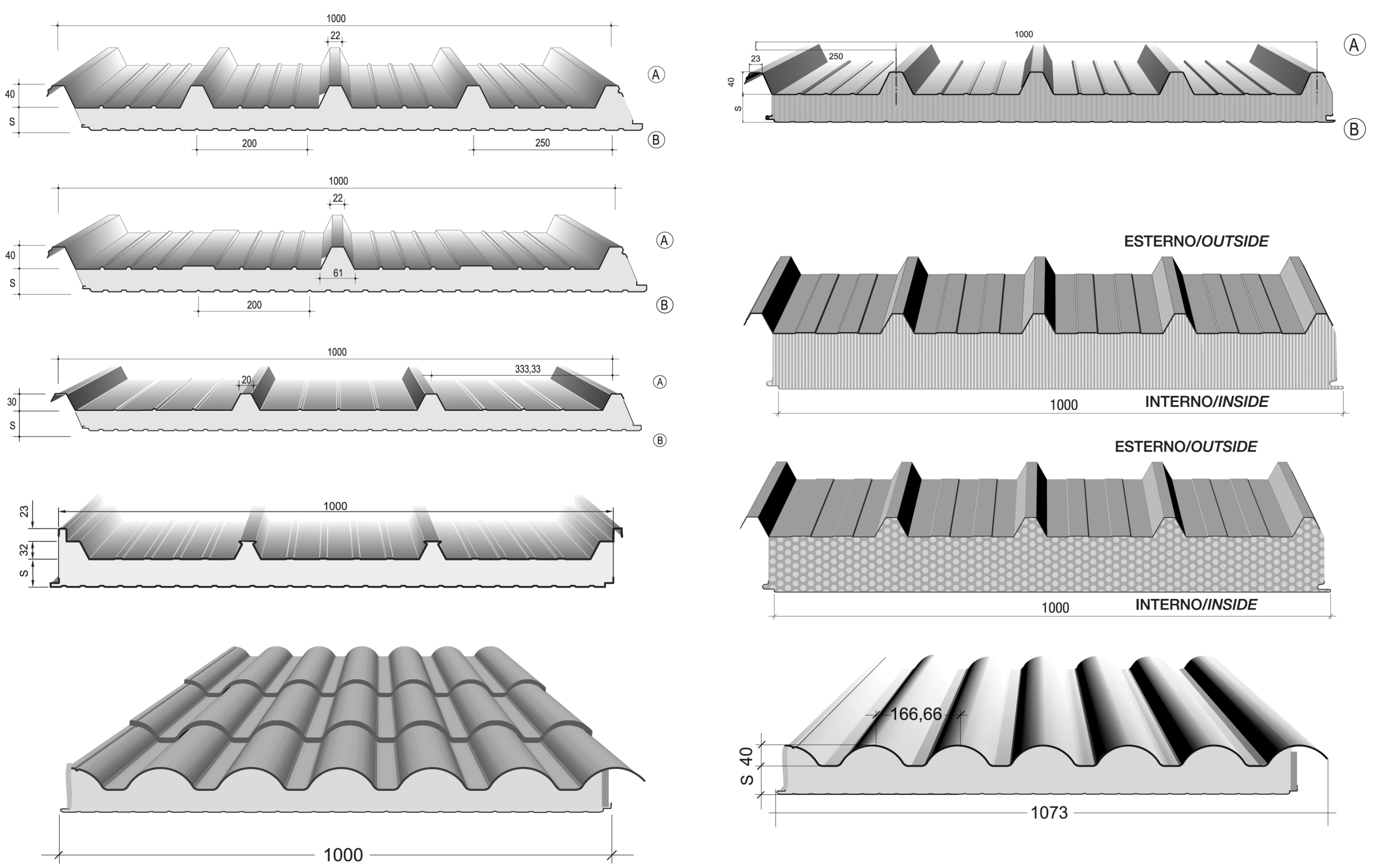


Illustration n° 34

TYPES OF ROOFING

Insulated metal panels and corrugated sheets are used in civil and industrial construction for the construction of roofs.

ROOF STRUCTURES

Roof structures mean the load-bearing framework that allows the roof covering to be arranged and supported; they are generally suitable for the type of construction: metal carpentry, normal and prestressed reinforced concrete, laminated wood and traditional wood.

The loads acting on a structure and generating stresses to which it is subjected are divided into static and dynamic.
Static loads can be represented as forces of constant intensity which are supposed to remain unchanged over time.
Dynamic loads can be represented as forces whose intensity or line of action can vary, forces applied quickly and suddenly – seismic actions, falling bodies.

7.1 MINIMUM ROOF PITCH SLOPES AND LAYING SUGGESTIONS

The slope of a roof pitch is given by the ratio between the height difference between the eaves line and the ridge and the distance between them. This ratio is expressed as a percentage %. A roof made with pre-insulated panels must have a minimum slope of 7% (Aippeg Standards), this to ensure rapid disposal of the water which otherwise creates deposits which in the long run would damage the functionality of the roof.

In order to guarantee a quality installation, it is recommended to use materials and/or parts supplied by the panel manufacturer as they are compatible with the products purchased.

The Designer/Installer/End User must ensure that the supporting structures of the roof have been assembled in accordance with the project documentation.

Using a panel fastening that is able to compensate for the displacements caused by excessive thermal expansion becomes particularly important in cases where panels with aluminum facings are used.

Below is a diagram showing an overlapping laying sequence (see illustration n° 35).

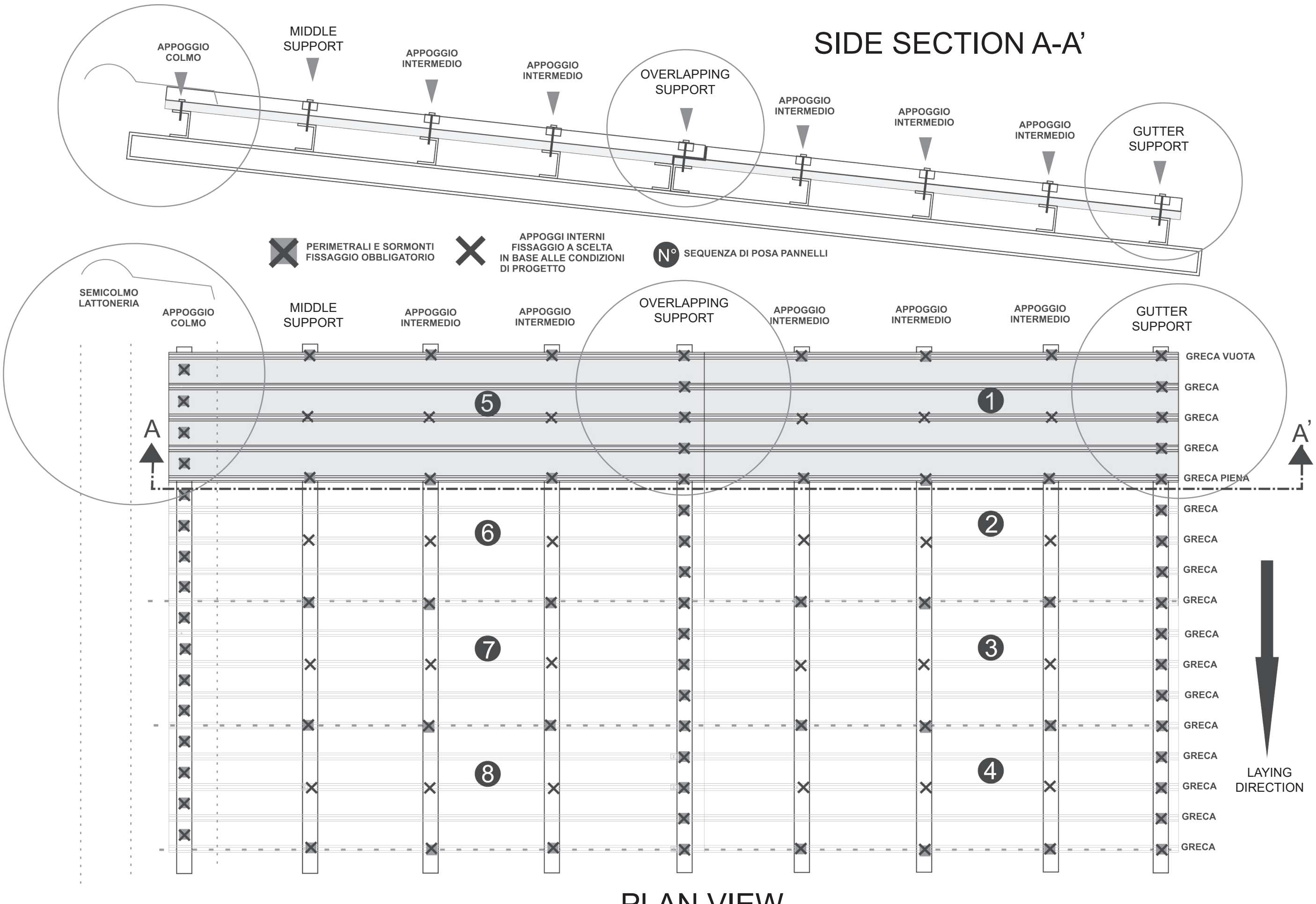


Illustration n° 35

ATTENTION: THE INSTALLATION DIRECTION OF THE PANELS SHOULD BE OPPOSITE TO THE PREVAILING WIND DIRECTION (SEE ILLUSTRATION N° 36).

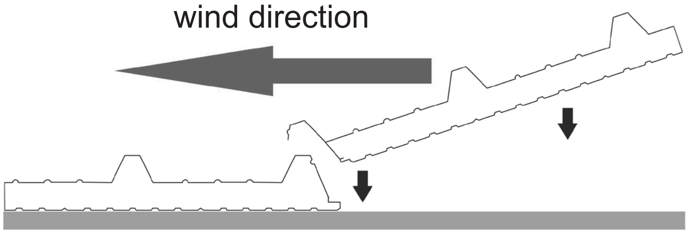


Illustration n° 36

Picture n° 11: laying of the TECHTUM panel on reinforced concrete wing beams

7.2 SINGLE-SHEET SANDWICH PANELS

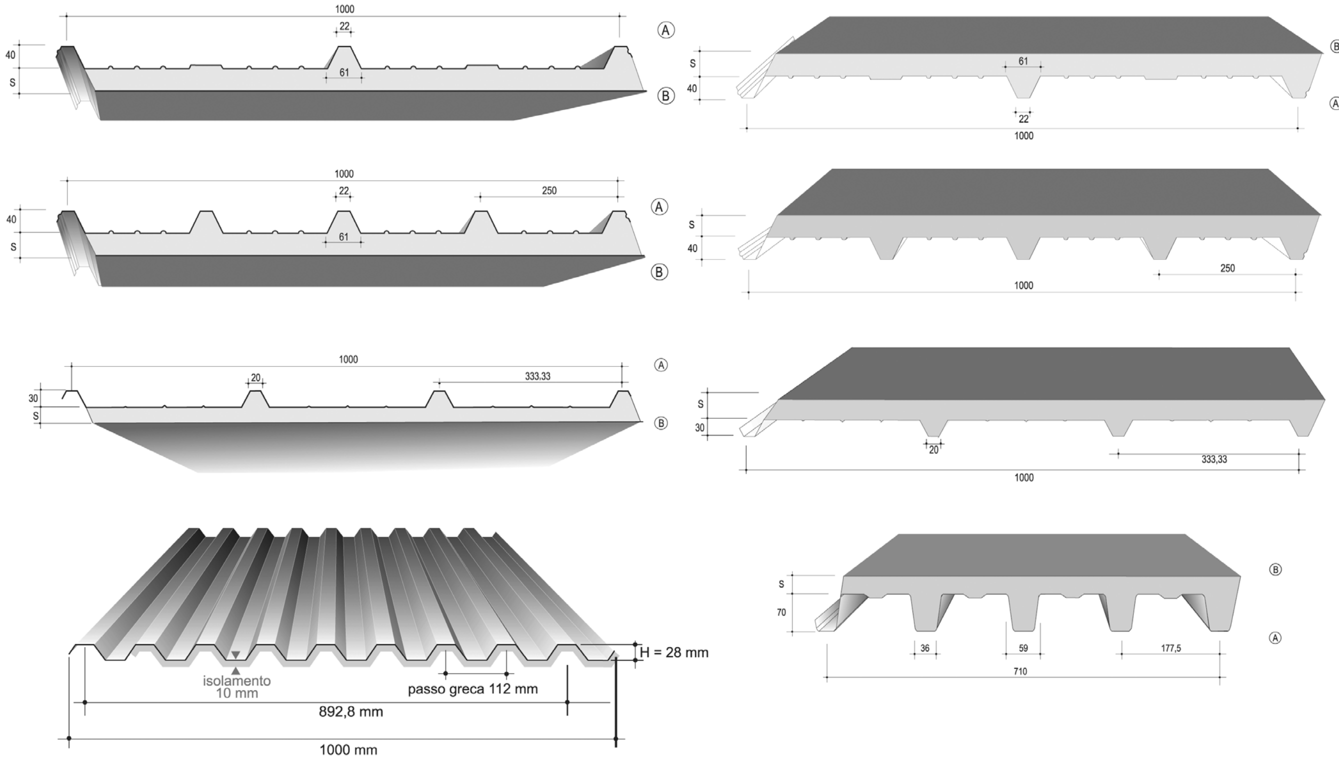
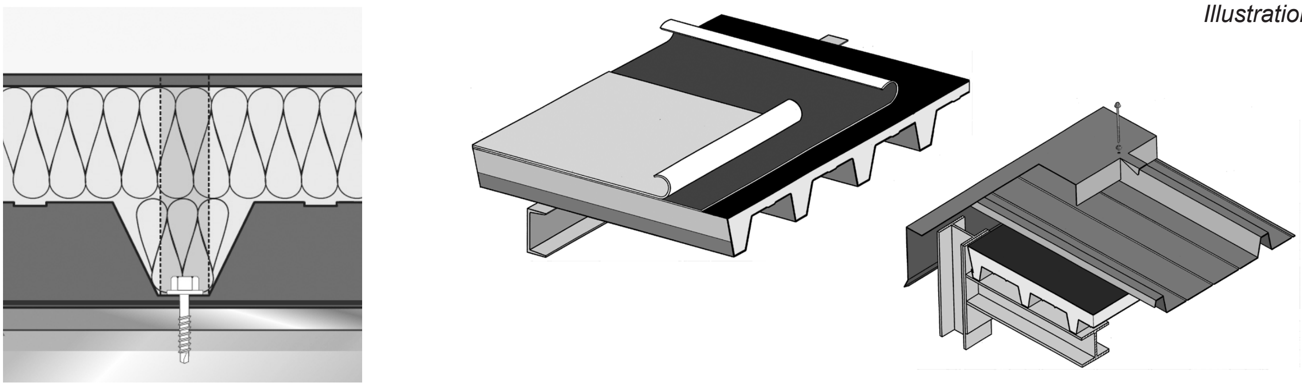


Illustration n° 37

The family of "**SANDWICH DECK**" panels consists of numerous models made with a support consisting of metal corrugated elements, cold-formed, with different section - variable height and pitch of the corrugated elements to offer a wide range of choice to Planners / Installers / Users end caps - polyurethane insulating core and a layer of bituminous paper felt or a centesimal sheet of embossed aluminum, or a fiberglass sheet and other non-metallic supports on the inside. The product lends itself to a multitude of uses and offers several advantages deriving from its characteristics which allow it to be assembled in two ways:

- With the ribs facing downwards - therefore with the possibility of creating a "flat roof" by offering the cardboard felt layer as a base for the subsequent installation of waterproofing sheaths (see illustration n° 38);
- with the ribs facing outwards where a simple economic cover is required for which a particularly accurate internal finish is not required and where the aesthetic appearance of the internal side is not particularly important.

Illustration n° 38



7.2.1 Bitumen cardboard

The bituminous felt is a material that offers good adhesion to polyurethane foams and guarantees a good adhesion of the waterproof sheath and therefore lends itself to the creation of a surface, even flat, with excellent durability characteristics. In particular, the paper felt is composed of a base of cellulose fibers and felts deriving from recycled paper and cardboard, subsequently impregnated with bituminous substance.

Planners / Installers / End Users are reminded that, by its nature, the bituminous felt undergoes a rapid deterioration of its structure if exposed to solar radiation, exposure to bad weather (simple dew, rain, snow, etc.) and alternating hot and cold temperatures.

The Manufacturers emphasize that, to avoid problems during the installation of the waterproofing mantle, critical situations of the product must be avoided:

- ✓ the product must be protected from rain and humidity, since the non-perfectly dry paper felt support prevents perfect adhesion of the bituminous membrane;
- ✓ the storage of packs of SANDWICH DECK panels is strongly recommended; before installation of the same, indoors and in a dry environment so as to avoid the absorption of moisture by the paper felt support and a possible compromise of the perfect adhesion between the waterproofing membrane and the paper felt;
- ✓ avoid exposing the mounted panels to direct sunlight for prolonged periods before applying the protective covering;
- ✓ avoid soaking the felt by exposing the mounted panels to dew, rain, snow before applying the waterproof sheath. In fact, the accelerated degradation of the cellulose-based fibers leads to a worse quality of the surface intended for the adhesion of the sheath and consequently a worse adhesion of the sheath itself;
- ✓ programming the installation of the waterproof sheath at the same time or immediately after mounting the panels ensures longevity of the product, allows you to preserve all the qualities of the single-sheet panel and thus obtain a flat surface with optimal male and female connections;

The deterioration of the paper felt support can cause contraction of the bituminous layer with effects on the foam, shrinkage of the polyurethane foam with the risk of compromising both the planarity of the panel, the quality of the roof, the functional and aesthetic finish of the male and female joints, the seal itself layers of waterproofing sheaths.

7.2.2 Centesimal embossed aluminum

The extra thin aluminum support has been introduced for use in environments where particularly aggressive corrosive agents are present, where steel, even if pre-painted, does not guarantee adequate durability.

Relevant is the use of the product in buildings for agriculture and livestock in which the demand for functionality, economy and the aesthetic aspect prevails is not of primary importance.

Designers / Installers / End users will use this family of products aware that the substrate offers good adhesion to polyurethane foams, is not walkable, requires supports of adequate width and the crushing resistance of the supporting side is modest.

The aluminum layer - having a thickness of a few hundredths - does not guarantee the typical flatness of panels equipped with a lower metal plate with a thickness of a few tenths of a millimeter, and this, sometimes, can be the reason for the formation of bubbles due to the formation of internal gases. insulating foam and the poor resistance to this thrust of the foil.

Designers / Installers / End users must take into account the aforementioned characteristics which, while on the one hand ensure good product functionality, considerable cost-effectiveness, on the other hand they are poorly indicated if the work requires aesthetic finishes according to normal industrial standards.

To avoid deformation and deterioration of **SANDWICH DECK AGRI** panels the Manufacturers suggest:

- ✓ The panels, when stored on site, must be protected from rain and humidity in order to avoid early self protective oxidation processes;
- ✓ It is strongly recommended to store the packs of **SANDWICH DECK AGRI** panels, before installation, indoors and in a dry environment so as to avoid longitudinal and / or transverse bending.

Micro-holes in the centesimal aluminum support as well as small wrinkles, more extensive wrinkles, roughness, present on the thin aluminum sheet cannot be considered defects since the production process involves drilling, stretching of the sheet which is already originally characterized by a surface embossed therefore the whole represents the natural consequence of the treatment of the foil.

7.2.3 Fiberglass

The finishing on the intrados of the panels with a fiberglass plate represents a very interesting variant where the environment has a high acid concentration (eg: pig farms, etc.).
Fiberglass is a plastic material reinforced with glass fibers that producers buy in rolls; in this case it is a semi-finished product with a rather rough finish whose purpose is exclusively functional (resistance to various particularly aggressive corrosive agents) and its use is limited to the internal surface of the panels exposed to such environments to ensure adequate durability.

Relevant is the use of the product in buildings for agriculture and livestock in which the demand for functionality, economy and the aesthetic aspect prevails is not of primary importance.

Designers / Installers / End users will use this family of products aware that the substrate offers good adhesion to polyurethane foams, is not walkable, requires supports of adequate width and the crushing resistance of the supporting side is modest.

It is important to remember that fiberglass is particularly sensitive to high temperatures with consequent undulations and yellowing of the surface; sometimes said phenomenon can originate from the processing steps which, as known, generate high heat due to the chemical reaction that originates the polyurethane.

Manufacturers deem it inadvisable to produce **SANDWICH DECK VTR** with an insulating thickness greater than 60 mm because the temperature resulting from the reaction and the dispersion time can cause the formation of unsightly bubbles and the yellowing, even if not uniform, of the surface.

Designers / Installers / End users must take into account the aforementioned characteristics which, while on the one hand ensure good product functionality, considerable cost-effectiveness, on the other hand they are poorly indicated if the work requires aesthetic finishes according to normal industrial standards.

Finally, the fragility of the fiberglass layer is highlighted, which, due to the nature of this material and the presence of the overlapping wing, is easily damaged - before or during installation - by inadequate impacts, handling and lifting, unloading trucks with unsuitable means.

It is strongly recommended that the packs of **SANDWICH DECK VTR** panels be stored, before installation, indoors and in a dry environment in order to avoid longitudinal and / or transverse bending.

7.3 NOTES FOR THE STORAGE AND HANDLING OF THE PANELS

- ✓ Storage in closed spaces must not exceed 6 months of continuous storage from the production date, while outdoors it must never exceed 60 days from the production date;
- ✓ In general, it is necessary to avoid contact with standard steel during the production, transport and site storage phases (if deposited on the forks of forklifts, for example), thus avoiding that the stainless steel surface is contaminated by standard steel, which oxidizes. The protective film will avoid contact between the two types of steel. Do not use chlorine-based cleaning products for cleaning.

N.B. The Manufacturers confirm the possibility of producing panels in mixed metals (e.g. aluminum + steel) but strongly discourage their use due to the different elongations due to thermal expansion.

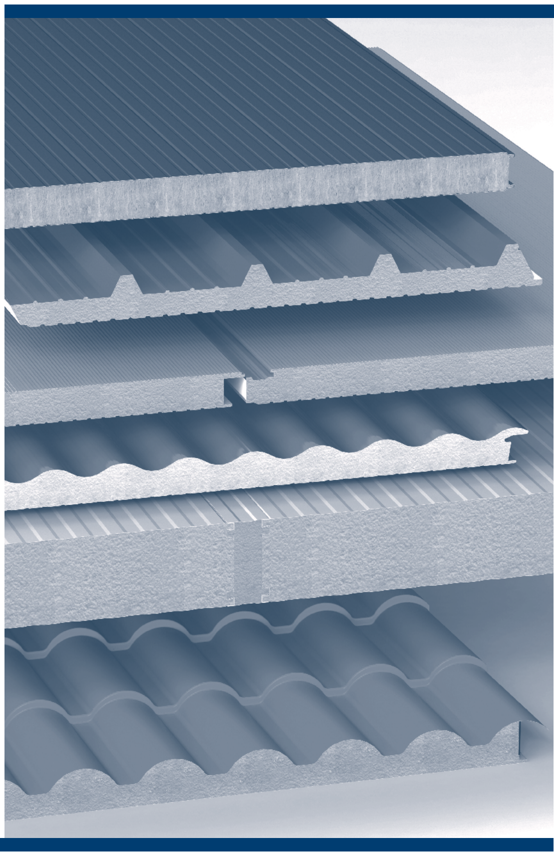
8. DISPOSAL

The sandwich panel does not require labelling, in accordance with Directive 65/548 / EEC, as it is not considered a hazardous material; the disposal of assembly residues can be disposed of by appointed companies without particular restrictions or authorizations. Metal cladding can be recycled as a steel raw material by separating it from the insulating material. More detailed instructions for the recycling of materials are available from the competent local authorities.

9. SCHEDULED MAINTENANCE OF THE BUILDING MADE OF PANELS

The building shell, like any other work, must be periodically checked by the end user in order to promptly detect any problems that may arise and be able to deal with them promptly, reducing maintenance costs to a minimum.
The check during the inspection is to be understood as directed both to the roofing and wall elements and to the complementary works present (joints, fastening devices, ridges, flashings, snow stops, gutters, ridges, etc.) and to any technological systems (chimney pots, smoke evacuators, vents, lightning protection), elements closely related to the panel, the deterioration of which can compromise its integrity over time.
If the outcome of the inspections leads to the finding of conservation problems in progress, it is necessary to proceed with an extraordinary maintenance intervention, at the care and expense of the property, in order to restore the initial conditions.

NOTE



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