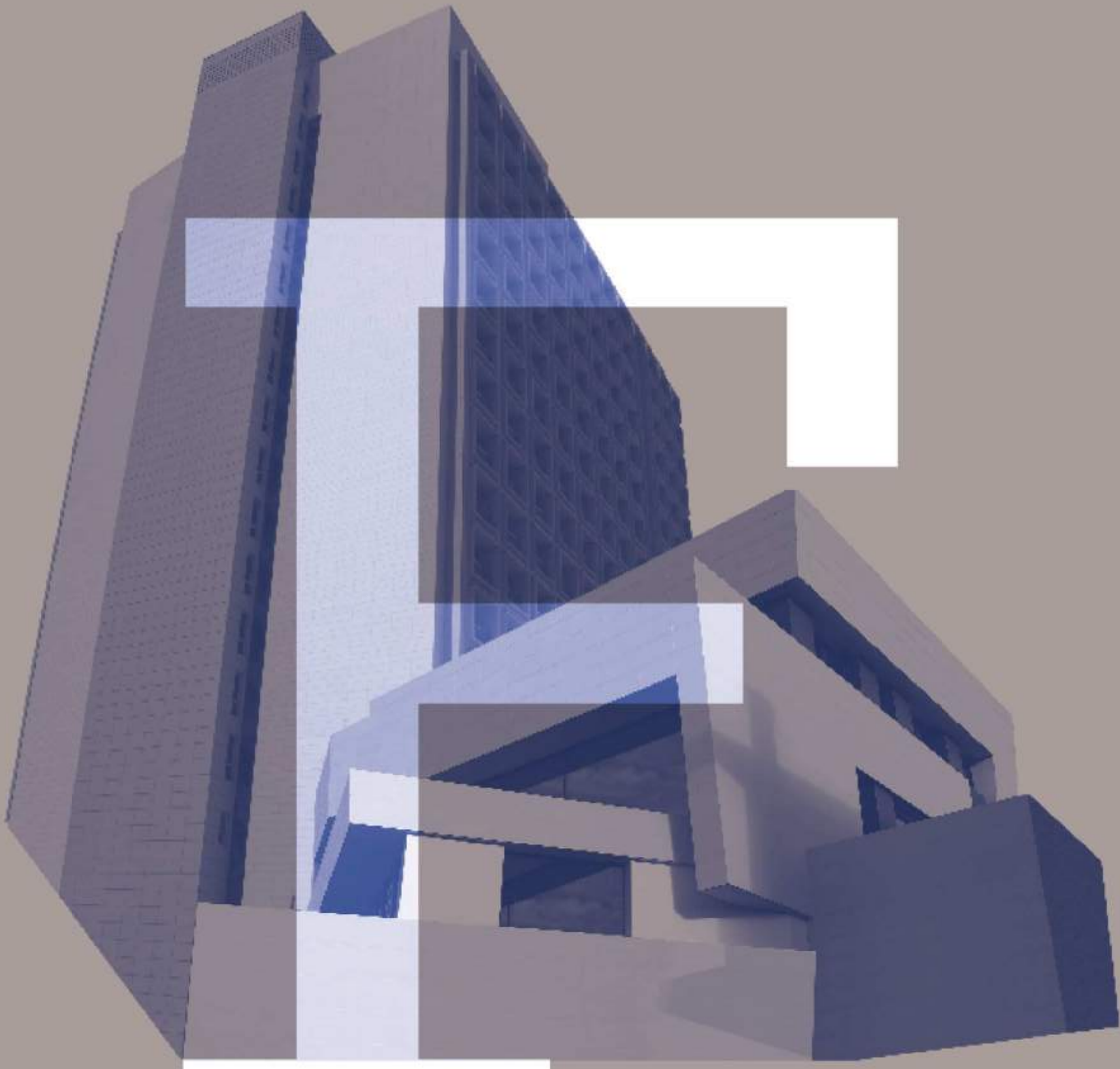
TECHNICAL DOSSIER

GRUPO GRECO GRES INTERNACIONAL



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GRECO GRES
INTERNACIONAL
GROUP

Our products.

At the Greco Gres internacional group we currently manufacture and distribute two well-differentiated wide ranges of products. On the one hand the rustic stoneware range called Klinker Greco and on the other hand, our Venatto products.

Within the Venatto range, we can distinguish our ceramic flooring products (Venatto polished, Venatto texture and the innovative Arttek range), and on the other hand, the Frontek range created for covering façades. The Frontek range is the main reason for drafting the current technical report.

Therefore, from this point on we will focus on the production, management, distribution and finishing of the Frontek range.

2 PRODUCTION PROCESS

The manufacturing process of the Frontek ceramic piece is developed in a series of successive stages, which can be summarized in the following production phases:

- PHASE 1: Raw material preparation.
- PHASE 2: Shaping and raw drying of the piece.
- PHASE 3: Firing process.
- PHASE 4: Additional treatments.
- PHASE 5: Grading and packing.

PHASE 1: Raw material preparation.

The process begins with a careful selection of the raw materials that make up the paste (Fundamentally clays and feldspars). These raw materials are first collected in an area specifically enabled for this purpose inside the factory, and later on transported for milling.

Prior to use, these raw materials are subjected to various quality control procedures: after reception control, they are subjected to a basic homogenisation pre-treatment to ensure the continuity of their essence and characteristics.

Grinding.

Once the first mix with the various components of the ceramic paste has been carried out, it is subjected to a process of wet grinding (continuous or discontinuous ball mills).

The resulting material from the grinding process presents some fragmentation, keeping both the aggregates and agglomerates of particles. The resulting size of its particles is less than 200 microns.

Atomization.

The process of atomization is a process of slip drying (The slip is the material obtained after milling) by which a suspended powder in the form of thin drops contacts hot air to produce a solid product with low water content.

The moisture content of the suspension (slip material), is usually around 0.35-0.40 water kg. /solid dry mass kg. After the process of atomization this water content is reduced to 0.03-0.04 water kg. /solid dry mass kg.

PHASE 2: Forming and raw drying of the piece.

Kneading.

The Kneading process consists of mixing the slip intimately with the atomized dust. This achieves a plastic mass which is easily shaped by extrusion.

Pigment Application.

It's a sub-phase which takes place parallel to the main process and becomes part of this main process just before the extrusion of the mass that makes up the piece. A percentage calculation (dry adjustment) of the different metal oxides to be added to white clay is calculated. A small part is mixed with the original slip after taking into account the desired final colour. Then, two large pumps drive and add pigment to the mix before sending everything to the extruder.

Extrusion.

Basically, the procedure for shaping a piece through extrusion processes can be achieved by making a column of plastic paste go through a matrix that forms a piece constant in size.

The equipment needed for this process consists of three main elements: the propulsion system, the matrix and the cutter. The propulsion system used by Greco Gres Internacional for the manufacture of the Frontek ceramic pieces is the propeller system.

***Drying*.**

The already shaped ceramic pieces then undergo a process of drying (0.5-0.8%), to reduce the moisture content to a sufficiently low level and in this way, the firing phase can be properly applied.

The pieces are then introduced at several levels inside the dryer, whilst moving horizontally on the rollers, and the burners located on the sides of the dryer apply hot air inside the chamber counter current to the movement of the pieces.

PHASE 3: Firing.

The firing of ceramic products is one of the most important stages in the manufacturing process, since many of the ceramic product's final characteristics are defined at this stage. Characteristics such as: mechanical resistance, water absorption, dimensional stability, resistance to chemical agents, etc. are defined at the firing phase.

The key variables to consider at the firing stage are fundamentally, the thermal cycle (temperature-time), and the atmosphere of the furnace. Both of them should be adapted to the ceramic product.

The firing process subjects the pieces to a thermal cycle, causing a series of reactions and changes in the piece, and leading to alterations in its micro-structure this applies the final desired properties.

The piece enters the firing process at a level of moisture below 0.8% to prevent fracture by gasification. First, the piece is sprayed with external air injection tubes with the purpose of cooling it quickly to avoid fragile areas and thus, preventing possible fractures in the material. Then the temperature increases gradually up to a maximum of 1200 °C and the piece is cooled down until it exits the furnace.

PHASE 4: Additional treatments.

The ceramic piece is transported to two large polishing machines (This depends on the size of the piece) these machines provide in a progressive manner the desired finishing touch to the material. During this process, the material is visually supervised and classified for the first time when some defective pieces or pieces presenting damage, or small cracks are set aside from the rest of the pieces.

PHASE 5: Grading and Packing.

Finally, grading and packing signal the end of the manufacturing process of the ceramic product.

Grading is achieved by means of several automatized systems that use mechanical equipment. This provides a dimensional control over the different pieces and a superficial view. As a result, the product is controlled both, in terms of its dimensional consistency, and external appearance.

Through the whole process the ceramic piece and the machines used for manufacturing purposes go through various quality controls that guarantee optimal quality in terms of the finished product, and the production process of the product.

3

FRONTEK

CERAMIC PIECE

The exclusive Frontek piece, developed from ceramic extrusion, has excellent technical qualities for façade cladding: great hardness, lightness, high resistance and durability, low water absorption and, excellent performance against climate and environmental agents.

With honeycomb-shaped structure and a cleft at the top and at the bottom, it is a piece that facilitates fastening to a metal sub-structure as it allows to be placed in several ways and ensures it is fixed in an optimum manner without possible cuts or additional perforations that can weaken its resistance.

With a weight of 32 kg / m2, the Frontek piece has multiple dimensional formats (40.5 x 80, 40.5 x 100, 40.5 x 60, 24.7 x 100, 30.7 x 100, - omega – 30 x 120, 49.7 x 100...), in addition, alternative formats can be produced on request.

The Frontek piece or panel, is available in over 40 different finishes presenting a wide range of textured, polished solutions and graphic designs that simulate metallic finishes in stone or wood in the ceramic piece itself. In addition, the range "volume" is also produced and it replaces the conventional smooth finish of the piece with alternative creative finishing (clefts on the front, rounded-shapes, etc.).

On the other hand, the Frontek piece has two different designs. Both can be chosen for any of the finishes we mentioned earlier. Both pieces have the same technical characteristics, are made of the same material and offer similar placing performance when it comes to using them in the substructure systems which are explained in paragraph 4 of the present technical report. These two pieces are the standard Frontek piece and the Frontek omega piece.

1. Standard Frontek piece.
2. Omega Frontek piece.

As far as placing the Frontek piece, there are two installation procedures in practise: Fixing and ventilated façade cladding system. The two procedures will be described in paragraphs 4 and 5 of this technical report.

4 Fixing or Fastening System

The façade is the first architectural barrier protecting the building from external aggressions. By fixing to the façade the Frontek ceramic piece we can achieve an enclosure with additional thermal and acoustic protection compared to that performance offered by traditional enclosures. Furthermore, the Frontek piece provides improved results against moisture and humidity. On the other hand, aesthetically speaking it brings extra light, colour, and a considerable improvement over the maintenance and the durability of the traditional façade.

In the cladding system, the Frontek piece is directly placed on the enclosure, supported by specific fasteners..

Elements that make up the system.

The Frontek piece fixing system for façade cladding is composed of the following elements (numbered from the external side or outside of the enclosure to its interior):

1. Frontek ceramic Piece.
2. Fixing Clip Ref. 1008: responsible for transmitting the plate’s own weight to the building’s substrate enclosure. These clips are manufactured in AISI 304 stainless steel.
3. Nylon sieve with fitting guide used only for ceramic enclosures.
4. Chemical fastener.
5. Cementing Adhesive: for greater system stability, it is applied to the plate’s own internal side. Any cementing adhesive used must have a minimum C2 rating (in compliance with the existing European standard UNE EN 12004).

Assembly process.

In the following section, it is necessary to differentiate between the two parallel assembly processes that should be taken into consideration, depending on the type of substrate enclosure of the building we are aiming to fix with the ceramic piece: fitted on concrete enclosure or fixed on ceramic enclosure.

- **Fixing process on ceramic enclosure.**

Firstly we would need to perform a bracket or substrate check. A general check diagnosing the state of the substrate base should be performed in order to obtain a general assessment of the situation. It will be necessary to restore or reinforce the substrate if we detect that some elements are not properly adhered.

Then we will follow with the layout of the different pieces, this phase being a crucial phase to achieve an optimal final result. To do this, we will signal or mark the position of each of the pieces avoiding the small ones and refraining ourselves from performing cuts in the shape of gun.

In windows or gaps, it is important to pay attention and respect symmetries or similarities. To facilitate this process, it is advisable when working on site to signal the position of the pieces with blue chalk.

Placement of the first fixing line: We should guide ourselves with the signals of our initial layout, and start drilling the upper part of the pieces to be used first, taking into account that the first print run (provided that rests on the ground) does not require clamps or clips at the bottom.

In order to do so, the drilling is done and subsequently the nylon sieve with the guide is placed and left ready for the application of the chemical product.

Once we have prepared a section long enough in extension to consume a full chemical load, we apply the cementing adhesive to both the wall and the piece so it is adhered properly to its position.

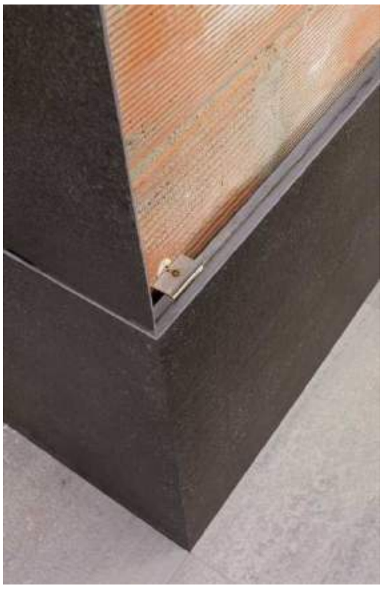
Then we will place the fixing clips, by introducing the recommended amount of chemical product in each case into the container of the sieve, and subsequently we will place the clip. The fastener stem of the clip provides enough room to raise, thus facilitating its introduction into the slot so it is possible to then lower it down until the internal base of the clip rests in the piece. Working in this way is essential in order to gain some freedom when it comes to respecting the joint.

The system is designed so the same clip placed on a corner is able to secure two pieces. However, it should be the management of the project in question the one responsible for assessing the need for a larger number of fastening points.

On the other hand, to avoid excessive consumption of the chemical product that is left drying inside the piece, it is important to leave available a sufficiently large area of the plate we have placed so we have enough room to install the clips continually until we fully consume the chemical cartridge.

The same procedure will be repeated and applied to the rest of the pieces until we complete the whole fixing area.

We can modify the corners and cut the ceramic piece with tools such as a miter saw in order to achieve an improved aesthetic result.



- **Fixing process on concrete enclosure**

The procedure for fixing on concrete enclosure or enclosures of any other solid materials, will be similar to the procedure of fixing ceramic enclosures described above. However, we need to take into account that it is not necessary the use of the nylon sieve.

In these cases, it will be indispensable to clean thoroughly the area where we have applied the drill. The dosing of the Chemical product must be exceptionally precise as we will find that an excessive amount of product can disturb the exact placing of the piece.

For concrete facades it is important to turn the clip at the very moment of its introduction in order to achieve an effective assignment of the chemical product within the drill.

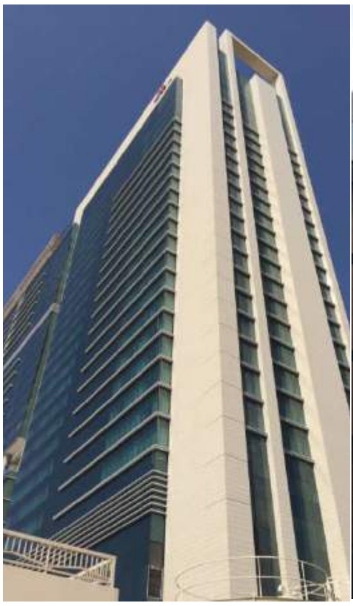

- **Recommendations in the Fixing process**

The following observations should be taking into account for both fixing / fitting processes. In both cases, if we consider the placement of the fastening clip the amount of plumb correction of the substrate is limited, and therefore this modification must be monitored and verified by the project managers of the project in question.

On the other hand, it is not recommended in any of the two cases the pointing or grouting of the ceramic plates. The joint always must be kept open.

5

Ventilated Façade System




The façade is the image of the building that wraps. Ultimately, your image and business card.

With the emergence of the technical building code (CTE), and the European regulation of construction and building products, new demands for buildings have been generated, affecting in a very direct manner the cladding the building itself, the façade.

During the last few years there has been great progress in terms of developing new systems and constructive solutions for façades. One of these solutions is the ventilated facade.

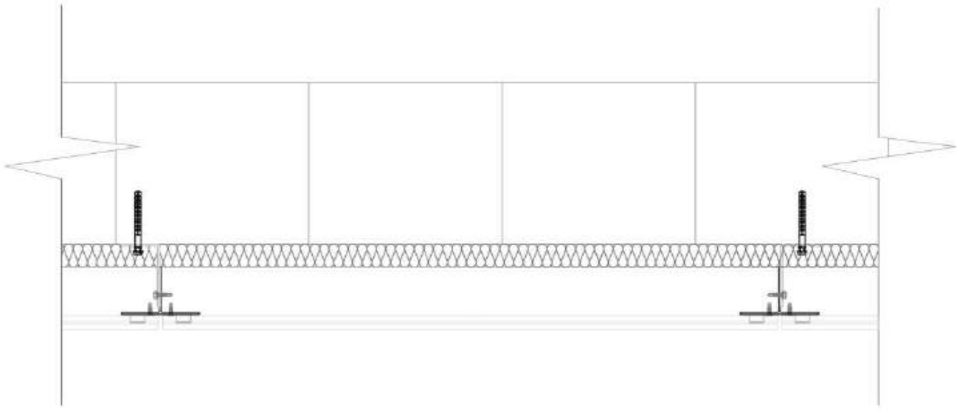
A ventilated façade can be defined as a façade that fits a more or less thin rigid coating separate from the supporting system of the building, but attached to the system by means of a metal sub-structure, to be able to transmit the actions due to the wind, the own weight of the building and tensions of thermal origin.

Due to this separation between the façade and the wall supporting system, the ventilated facade leaves between the ceramic and the bearing area a space which allows the flowing of a stream of air that is, at least 4 cm thick.

The main objective of having a ventilated façade is to protect the building, creating a second skin that protects the constructive elements of the building when faced against external atmospheric agents. The ventilated façade also provides a well-looked after aesthetic look to the building and improves its maintenance.

The Frontek Ventilated façade

The Frontek ventilated façade is a coating system of the external enclosure of the building. It consists of first, an insulating material which is usually attached to the wall of enclosure that we want to coat, and second a load-bearing metal sub-structure fastened to the supporting wall, where we place the Frontek ceramic plates, through metallic support. This system generates a ventilated air chamber between the wall bracket and the Frontek ceramic piece.



The Frontek ceramic pieces, which make up the exterior coating of the ventilated façade system itself, respond to the reception of the horizontal actions directly applied on them and transmit these horizontal actions to the metallic sub-structure. These ceramic pieces present excellent resilience against bending, to values exceeding 6000 Newton and able to withstand any kind of atmospheric conditions. At the same time, the Frontek ceramic pieces offer an innovative aesthetic function based on its image, singularity and well-defined identity perfectly suited to the contemporary architectural culture.

Greco Gres Internacional has developed two different systems for fitting the Frontek ventilated façade. Its components and Assembly process are explained below separately.

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Plus System and Omega Plus System.

The system commercially known as Frontek Plus has been developed with the intention of being used as cladding or coating for ventilated façades on buildings using extruded Frontek and Frontek Omega ceramic material plates (as described in part 3 of this technical report).

- **Elements that make up the system.**

The Frontek system plus and Omega plus façade cladding or coating system is composed of the following elements, numbered from the outside face of the enclosure to its internal side:

1. Frontek ceramic piece. (Standard or Omega model).

2. Ventilated air chamber in which thermal insulation is normally installed and not supplied by the manufacturer Greco Gres.

3. Load-bearing sub-structure fastened or fixed to the substrate. This sub-structure, provided by Greco Gres Internacional, S.L., is made up of:

    3.1. Stainless steel clamps for fixing the panels to the vertical sub-structure.

    3.2. Vertical sub-structure "T" of aluminium profiles fixing the clamps panels and brackets to the substructure.

3.3. Aluminium brackets to transfer loads from the sub-structure to the substrate by means of fastening brackets. There are two types of brackets according to the amount of load they are able to cope with:

3.3.1. Support brackets. They are used to fix the vertical profiles to the substrate, and therefore, bear the weight of the system itself.

3.3.2. Retaining brackets bear wind loads and wind suction pressures. Its placement depends on the layout of each project.

On the other hand, at the base of the brackets we can include a piece of polypropylene in order to eliminate thermal bridges and thus making significant energetic improvement to the system. At these fixing, attaching points between the brackets and the supporting base it is likely we could find small, but numerous thermal bridges. Plastic parts prevent such heat transmission, and at the same time, as it is a material capable of absorbing vibrations, improve structural stability against possible dilation and seismic activity.

3.4. Screws, Nuts and bolts for fastening the elements of the sub-structure. For fastening the Frontek system several types of screws are used according to their specific position in the sub-structure. We can distinguish the following:

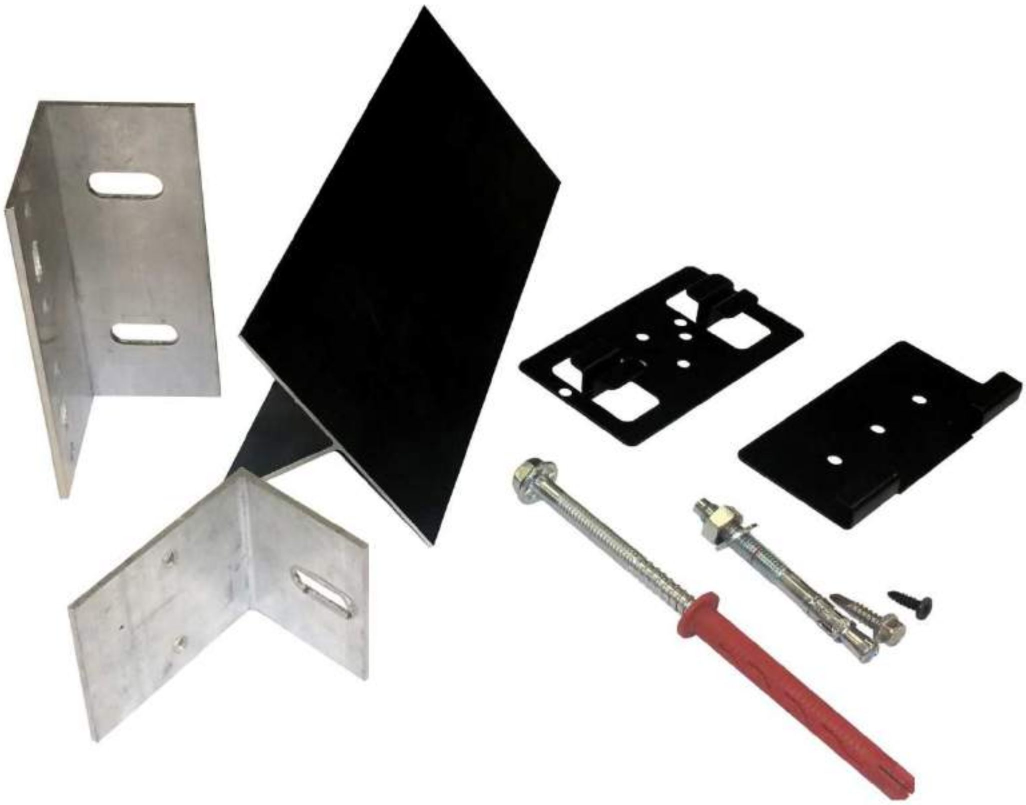
3.4.1. The clips or clamps fastened to the vertical T profile use A2 Stainless steel flathead self-drilling screws ø 4,2 y L=14 mm.

3.4.2. For fastening the vertical profile and the brackets Stainless steel A2 DIN 7504 K hex head self-drilling screws are used ø 5,5 and L=22 mm.

3.4.3. Fastening the sub-structure to the support: to join the brackets to the substrate or structure. For fastening this, two types of screws can be used depending on the type of material the substrate is made of. In this way, the lag M10 screw can be used for ceramic walls. And the M8 expansive screw in the case of concrete structures.

3.5. Polyurethane sealant: A line of sealant is applied between the vertical T-profiles and the ceramic panels to achieve a flat final surface and prevent the panels from banging. A single component polyurethane sealant similar or equivalent to Sista Solyplast SP-101 is used.

3.6. Accessories for treating singular issues. Depending on the singularity of the cladding or coating surface, singular points specific to each project may occur and would require an alternative solution.



- **Assembly process.**

The implementation on-site of the system must be performed by companies qualified and specialised in the installation of ventilated façades. In any case, Greco Gres Internacional, S.L., offers all the necessary information to carry out the project and to execute the ventilated façade, providing solutions to queries that can be generated during the project and execution phases.

Prior to the installation of the system, the type and the state of the substrate needs to be verified and diagnosed in order to define the type and number of fastening areas. The type of fastening has to be adapted to the substrate, and it may be necessary for the Installer or technician to replace the fastener initially defined on the project. This type of decision should be approved by project management. In addition, protective gloves should be used when handling or manipulating panels.

The assembly itself is carried out with the fastening elements previously described, in a way that the panel is not subjected to pressure or tension and has freedom of movement allowing possible dilation caused by temperature, moisture, etc. The operation sequence onsite should be as follows:

1. Layout

The façade will be laid out, checking the evenness of the substrate to be cladded, verifying the flatness for a proper fastener choice.

The axis of the vertical profiles will be placed depending on the dimensions of the Frontek cladding panels, at a distance equal to or less than 105 cm, depending on the format of the panel and according to what is defined in the plans and justified by calculations.

The characteristics of the substrate, for both overhang and flatness, must comply with the conditions established in the CTE, as well as the relevant current standards and regulations.

In addition to this the layout of the sub-structure will be defined according to wind loads, maximum distances between the fastening points of the panels, the format and dimensions of the panels and the dilation of both the building and its components among other factors.

2. Bracket placement.

First, the support brackets will be fixed to the supporting wall or girders and / or edges of the slab using suitable fasteners.

The brackets will be installed, aligned vertically, distributed between the edges of the slab. The vertical distance will depend on the type and condition of the substrate as well as the loads to be transferred to it. Provided that the substrate allows so, this will be less than 110 cm.

3. Vertical profiles placement.

Firstly, the vertical profiles in "T" are fixed to the support brackets with three screws, one placed on a fixed hole and the other two on mounting holes and subsequently to the retaining brackets by means of one of the screws positioned on the mounting hole. The screws, nuts and bolts to be used is described in the previous section of "elements of the system plus" in this technical report.

The vertical profiles, lined up perfectly, will be fixed to the brackets with fixed mounting holes in such a way that they guarantee adequate movement of the sub-structure and proper levelness.

The web of the vertical profile overlaps with the wing of the bracket at between 50 mm and 60 mm and therefore, the minimum distance of the screws on the edge of the profile is 35 mm.

The distance between the vertical profiles must be equal to or less than 105 cm.

The minimum horizontal joint between vertical profiles will be 2 mm for each linear metre of profile.

4. Installation of thermal insulation

An adequate protection of the building through the use of insulation in ventilated façades is essential. The ventilated façade should not only play an aesthetic role, but it should also be functional across the whole construction and isolate thermally and acoustically the inside of the building.

The main difference between a ventilated façade and a conventional façade is that an air chamber is generated between the ventilated façade, the cladding or coating and the insulation. It results in the system being more energetically efficient and addresses insulation issues as the ventilated façade continuous enclosure insulation, including the edges of the slab, and ultimately achieving elimination of thermal bridges and condensation problems. i.e., insulation guarantees the correct thermal behaviour of the solution. (This point will be developed later in the section "advantages of the ventilated façade" of this technical dossier).

Therefore, although thermal insulation does not constitute part of the Frontek ventilated façade kit, it is nevertheless an important element that must be the subject of study and consideration by project management according to the specifications of the project. The main reason being that the correct choice and application of this element in our building system plan, will ensure the optimal energetic performance of our façade. Always in compliance with the demands of the CTE DB-HE (core document of energy saving of the technical building code and its supporting document DA DB-HE-1).

On the other hand, the selected insulating material or source will be an essential requirement to ensure safety in the event of the Frontek ventilated façade kit catching fire. To comply with this point, it will be necessary to adapt the choice of our insulation provisions to the decision 94/611/CE which applies to the European regulation 305/2011 of the Council on the construction products classified in class A "without contributing to fire" without having the need to test them.

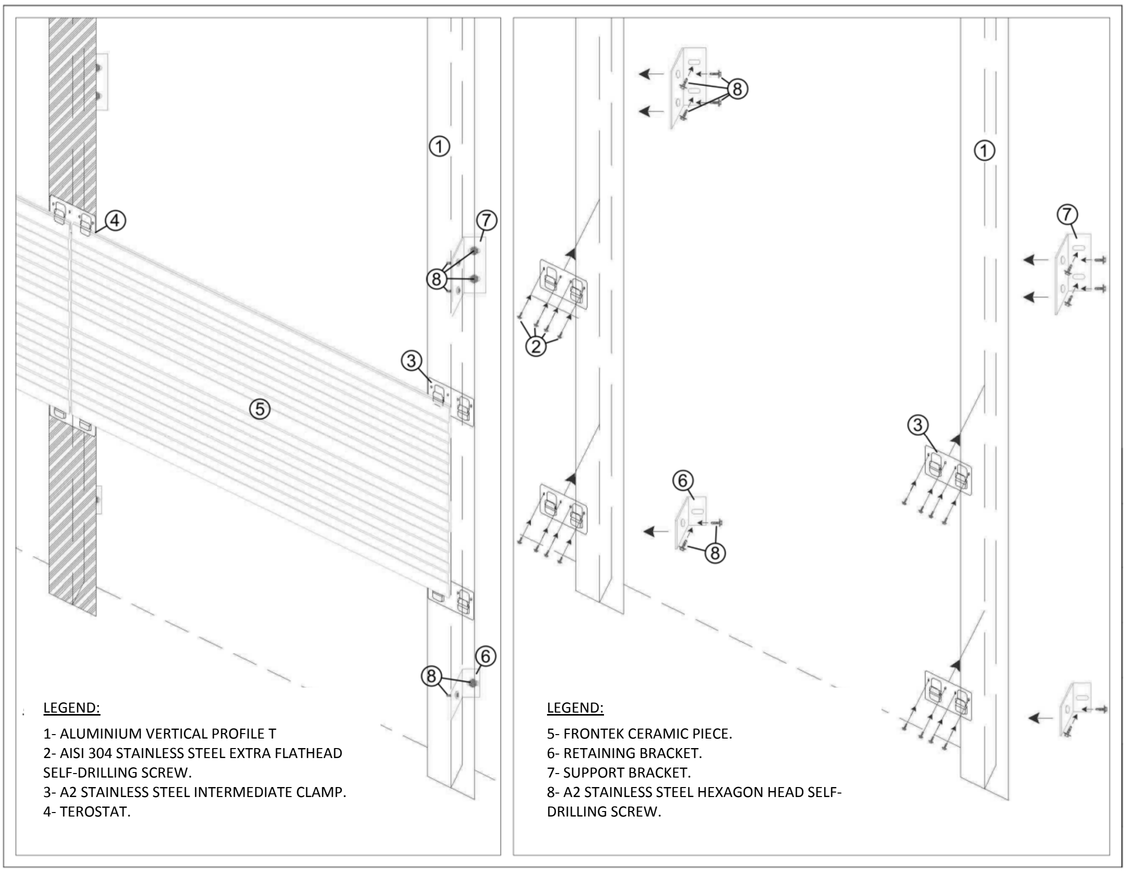
Taking into account these considerations, Greco Gres international group S.L. recommends the use of non-hygroscopic, waterproof, insulation that may be classified as safety class A in the event of fire.

5. Lower clamp or clip fastening to the façade supporting base and successive upper panel and upper clamp fastening fitting them perfectly into the upper groove.

The lower clamps or clips will be installed first, screwing them to the vertical profile. A line of polyurethane sealant will be applied between the profiles and the ceramic panels. The ceramic panel is then positioned on the lower clamps or clips, fitting the upper arm of the clamps onto the piece. Then the upper clamps or clips are positioned, fitting them perfectly into the upper groove. In this way the pieces will be stabilised.

The same procedure will be used on the upper levels.

On the other hand, when executing or working at unique points such as sills, lintels, jambs, parapets, etc., their water-tightness and waterproofing properties should be taken into account, if necessary, as well as proper water removal, preventing it from accumulating.

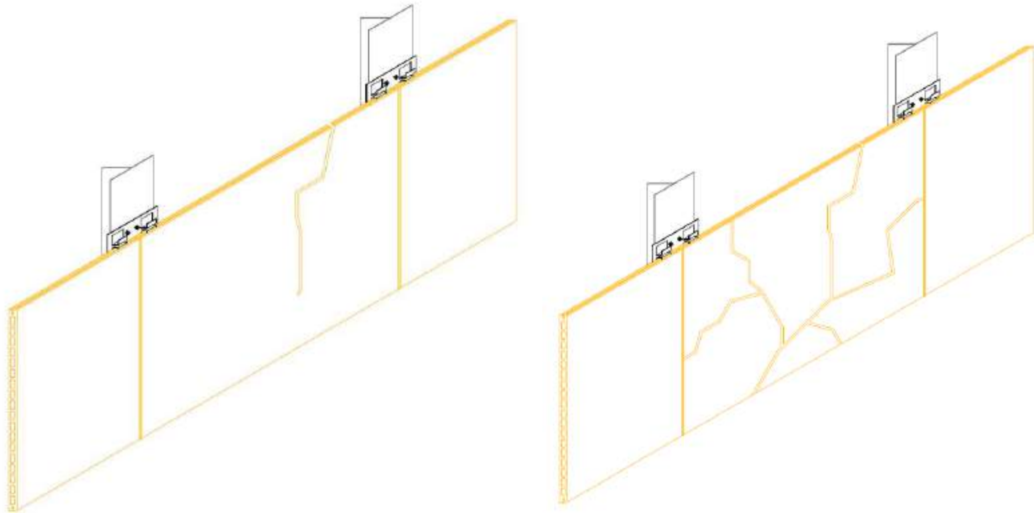


- **Durability and replacement parts.**

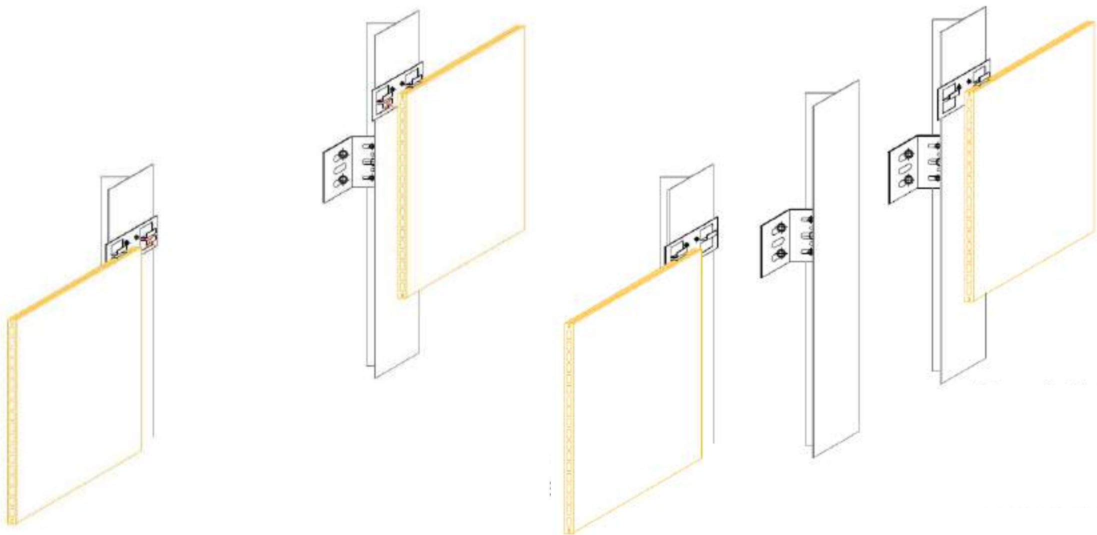
Having completed different durability tests (explained in the testing section of the present technical report) and on-site observation, the system behaves satisfactorily and complies with requirements relative to durability.

As far as possible part supplying needs for replacing a broken part, panel or piece, these steps should be followed.

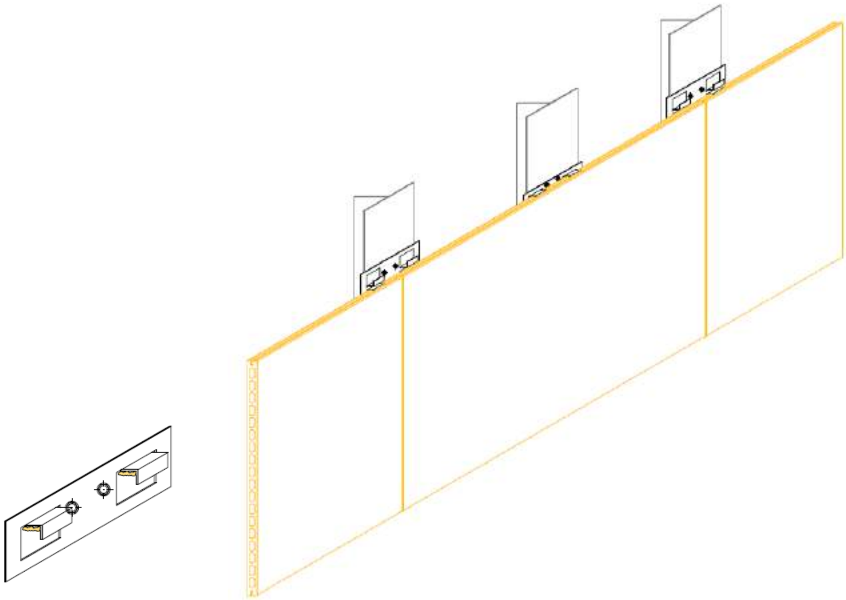
1- Initial state: broken ceramic piece. Finish breaking the piece so it can be easily removed.



2- Remove the arms that fix or fasten the clamps onto the broken piece or panel and install an intermediate vertical profile.



3- Place a clamp or clip ready and cut to fasten or fix the panel or piece, and insert the new panel or piece where the previous panel was located into the lower clamps and whilst applying support over these, screw the upper clamps into the vertical profile.



Super Plus System and Omega Super plus.

The system known by the trade name Frontek Super Plus was developed for use as cladding for ventilated façades on buildings. It is made from extruded porcelain ceramic panels Frontek and Frontek Omega (developed in part 3 of this technical report).

- **Elements that make up the system.**

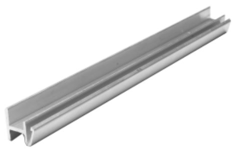
The Frontek super plus and Omega plus cladding system for façades is composed of the following elements (numbered from the external side or outside of the enclosure to its interior:

1. Frontek ceramic piece or panel. (Standard or Omega model).

2. Ventilated air Chamber in which thermal insulation not supplied by the manufacturer Greco Gres is installed.

3. Load-bearing substructure fixed to the substrate. This sub-structure, supplied by Greco Gres Internacional, S.L., is made up of:

    3.1. Aluminium brackets to transfer loads from the sub-structure to the substrate fastening the panels to the horizontal profiles and placed by pressure with screwing.



    3.2. Vertical and horizontal tubular profiles.

    3.3. Aluminium brackets to transfer loads from the sub-structure to the substrate by means of fasteners. There are two types of brackets depending on the loads they are able to support:

        3.3.1. Supporting brackets, which bear the wind loads and the weight of the system itself.

        3.3.2. Retaining brackets, which only bear wind loads. The placement of these brackets depends on the layout for each project.

On the other hand, we can apply to the base of the brackets a line of sealant between the vertical T-profiles and the ceramic panels to achieve a flat final surface and prevent the panels from banging. This would also improve the energetic efficiency of the system and remove thermal bridges. At these attachment points by means of steel brackets we may find small, but numerous, thermal bridges. The plastic parts prevent the transmission of heat, and at the same time, constitute a material capable of absorbing vibrations and improve structural stability against dilation and possible seismic activity.

3.4. Screws, Nuts and bolts for fastening the elements of the substructure. For the attachment of the Frontek system several types of screws are used according to their position in the substructure. The following are distinguished:

3.4.1. A2 Stainless steel DIN 7504 K Hexagon head self-drilling screws ø 5,5 y L=22 mm are used to fix the vertical and horizontal profiles to the brackets.

3.4.2. Fasteners at the joining with the substrate: The type, position and number of fasteners to fix the brackets to the substrate are defined based on the supporting base and the stresses transferred to it. Nonetheless, two types of screws are used, the Hilti lag screw can be used for ceramic walls, and the expansive MTH screw in the case of concrete structures.

3.5. Polyurethane sealant: A line of sealant is applied between the vertical T-profiles and the ceramic panels to achieve a flat final surface and prevent the panels from banging. A single component polyurethane sealant similar or equivalent to Sista Solyplast SP-101 is used

3.6. Profiling Accessories: mounting plates are fixed or placed and these allow the horizontal profiles and angles to achieve a degree of continuity and therefore, for these to meet in corner points. In the same way, to achieve continuity between vertical profiles the use of an internal tubular profile is recommended.

3.7. Accessories for handling unique points. Depending on the uniqueness of the substrate to be coated or cladded. Unique points found specific to each project may require an alternative solution.

- **Assembly process.**

On-site installation of the system must be performed by qualified companies specialising in the assembly of ventilated façades. In any event, Greco Gres Internacional, S.L. will provide all the information necessary to carry out the project and execute the ventilated façade. If requested, it will provide technical support during the planning and execution stages.

On-site, it is necessary to check the type and condition of the substrate, as well as whether the fasteners indicated in the technical plans are suitable for the same. In the event that the planned fasteners are not adequate, they must be replaced, with the approval of the site manager, taking any necessary precautions with regard to the position and number of fasteners. Furthermore, when manipulating ceramic plates protective gloves should be used.

Assembly is carried out using the fixing devices described above, so that the panel is not subject to stress and has sufficient freedom of movement. On-site procedure should be carried out in the following manner:

1. Layout

The façade will be laid out, checking the evenness of the substrate to be cladded, verifying the flatness for a proper fastener choice.

The axis of the vertical profiles will be placed depending on the dimensions of the Frontek cladding panels, at a distance equal to or less than 105 cm, depending on the format of the panel and according to what is defined in the plans and justified by calculations.

The characteristics of the substrate, for both overhang and flatness, must comply with the conditions established in the CTE, as well as the relevant current standards and regulations.

2. Installation of brackets.

First, the brackets will be fixed to the supporting Wall or girders and / or edges of the slab using suitable fasteners.

The retaining brackets will then be installed, aligned vertically, distributed between the edges of the slab. The vertical distance will depend on the type and condition of the substrate as well as the loads to be transferred to it. Provided that the substrate allows so, this will be less than 110 cm.

3. Installation of the vertical profiles.

The T-profiles or vertical profiles will be fixed to the supporting brackets with the three screws described in the section “elements of the Super plus system”. One of the screws should be placed on a fixed hole and the remaining two on a mounting hole allowing for adjustment with a distance between them equal to or less than 105 cm.

The flatness of the extruded aluminium profile structure must be guaranteed by a suitable fixing system, with the aim of ensuring that the cladding system is level.

The vertical profiles, lined up perfectly, will be fixed to the brackets with fixed and mounting holes in such a way that they guarantee adequate movement of the sub-structure and proper levelness. The minimum horizontal joint between vertical profiles will be 2 mm. for each linear meter of profile.

4. Installation of the Thermal Insulation.

An adequate protection of the building through the use of insulation in ventilated façades is essential. The ventilated façade should not only play an aesthetic role, but it should also be functional across the whole construction and isolate thermally and acoustically the inside of the building.

The main difference between a ventilated façade and a conventional façade is that an air chamber is generated between the ventilated façade, the cladding or coating and the insulation. It results in the system being more energetically efficient and addresses insulation issues as the ventilated façade continuous enclosure insulation, including the edges of the slab, and ultimately achieving elimination of thermal bridges and condensation problems. i.e., insulation guarantees the correct thermal behaviour of the solution. (This point will be developed later in the section "advantages of the ventilated façade" of this technical dossier).

Therefore, although thermal insulation does not constitute part of the Frontek ventilated façade kit, it is nevertheless an important element that must be the subject of study and consideration by project management according to the specifications of the project. The main reason being that the correct choice and application of this element in our building system plan, will ensure the optimal energetic performance of our façade. Always in compliance with the demands of the CTE DB-HE (core document of energy saving of the technical building code and its supporting document DA DB-HE-1).

On the other hand, the selected insulating material or source will be an essential requirement to ensure safety in the event of the Frontek ventilated façade kit catching fire. To comply with this point, it will be necessary to adapt the choice of our insulation provisions to the decision 94/611/CE which applies to article number 20 of the European regulation 89/106CEE of the Council on construction products, and classified in class A "without contributing to fire" without having the need to test them.

Taking into account these considerations, Greco Gres international group S.L. recommends the use of non-hygroscopic, waterproof, insulation that may be classified as safety class A in the event of fire.

5. Installation of horizontal profiles.

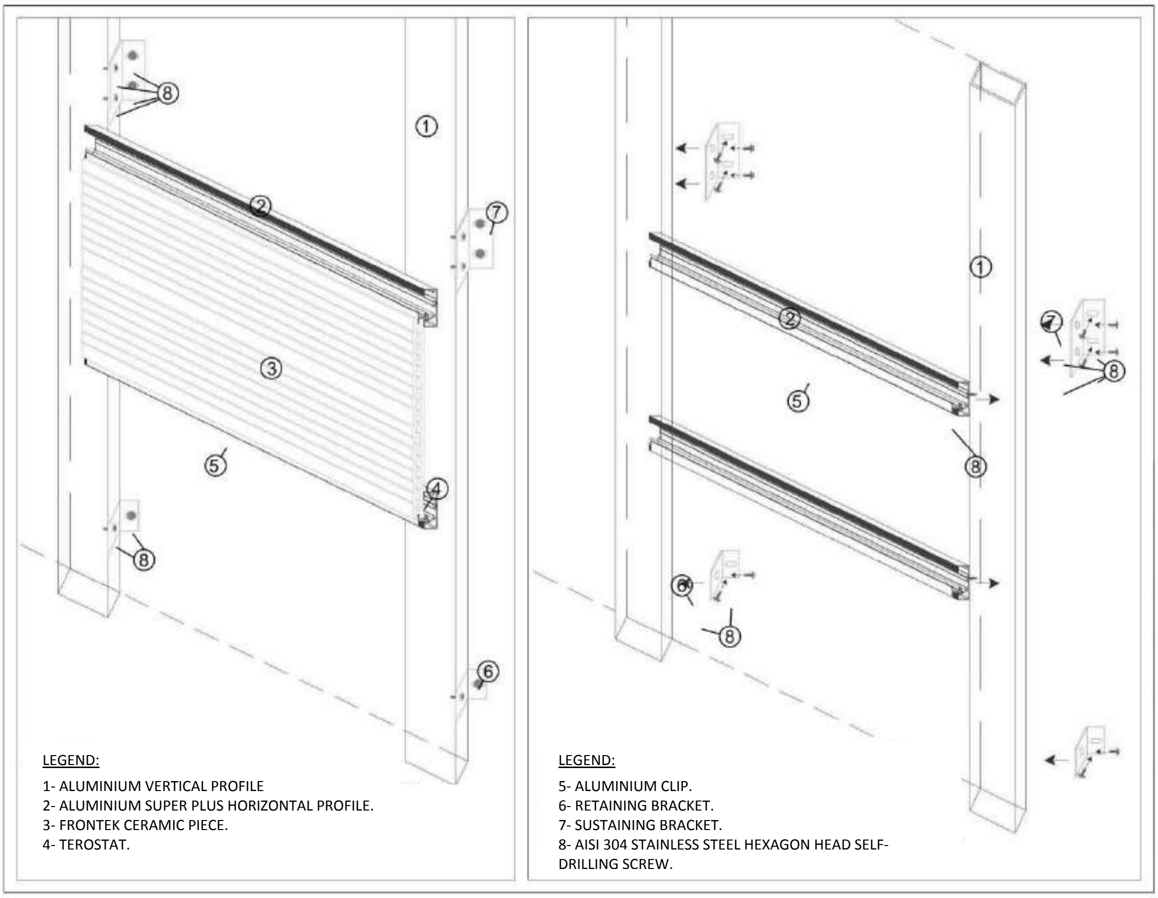
The lower clamps will be installed first, screwing them to the vertical profile. A line of Polyurethane sealant (as described in the elements section) will be applied to the profiles on which the panel will rest. The minimum vertical joint between profiles will be 2 mm. for each linear metre of profile.

6. Installation of clamps and panels.

Use inferior Clamps or clips to fit the panels on to the horizontal profile. The ceramic panel is then positioned on the lower clamps, fitting the upper arm of the clamps onto the piece. Then the upper clamps are positioned, fitting them perfectly into the upper groove. In this way the pieces will be stabilised.

The same procedure will be used on the upper levels.

On the other hand, when executing or working at unique points such as sills, lintels, jambs, parapets, etc., their water-tightness and waterproofing properties should be taken into account, if necessary, as well as proper water removal, preventing it from accumulating.



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- **Durability tests and part replacements.**

Having completed different durability tests (explained in the testing section of the present technical report) and on-site observation, the system behaves satisfactorily and complies with requirements relative to durability.

As far as possible part supplying needs for replacing a broken part, panel or piece, these steps should be followed:

1- Initial state: broken ceramic piece or panel.

2- Check those pieces or panels adjacent to the fractured piece you want to substitute and eliminate the vertical joints using this space to be able to work with the damaged piece or panel.

3- Remove the damaged piece or panel and replace it for another one in perfect condition, place it exactly where the broken piece was.

4- Empty the space where the vertical joints are located and clip or clamp the new piece, make sure it is completely stabilised.

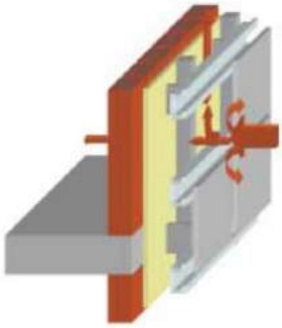
1. Reduces thermal breaks therefore, improving thermal insulation. As a result the thermal efficiency of the building is improved both in the winter and the summer:

In summer:

The Frontek ventilated façade system provides effective insulation against extreme heat, thanks to the sum of its different parts.

The first element involved in in providing effective insulation is the Frontek ceramic piece or panel itself, as it protects the rest of the system from the direct action of the Sun's rays.

The heat generated from solar rays inside the Frontek ceramic piece heats the air accumulated inside the chamber decreasing its density, and making this air rise, making it flow inside the chamber and drawing out the hot air.

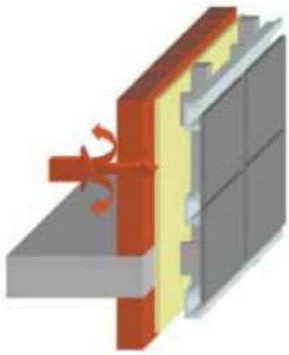


SUMMER BEHAVIOR

In winter:

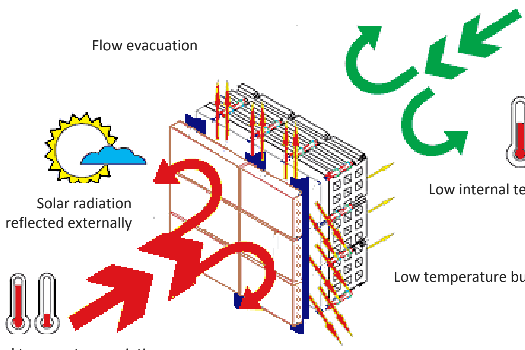
Through cold seasons the Frontek ventilated façade system works differently, as through these seasons high temperature is located inside the building, and therefore the first barrier preventing heat loss will be the supporting wall and then, the type of thermal insulation installed on its external side.

Finally the rising of hot air will keep the insulating system dry, while the Frontek ceramic coating acts as heat accumulator and protective barrier so that both the insulation and the enclosure may not be affected by cold temperatures.



WINTER BEHAVIOR

VENTILATED FAÇADE



BEHAVIOR OF THE VENTILATED FACADE WITH EXTERNAL INSULATION

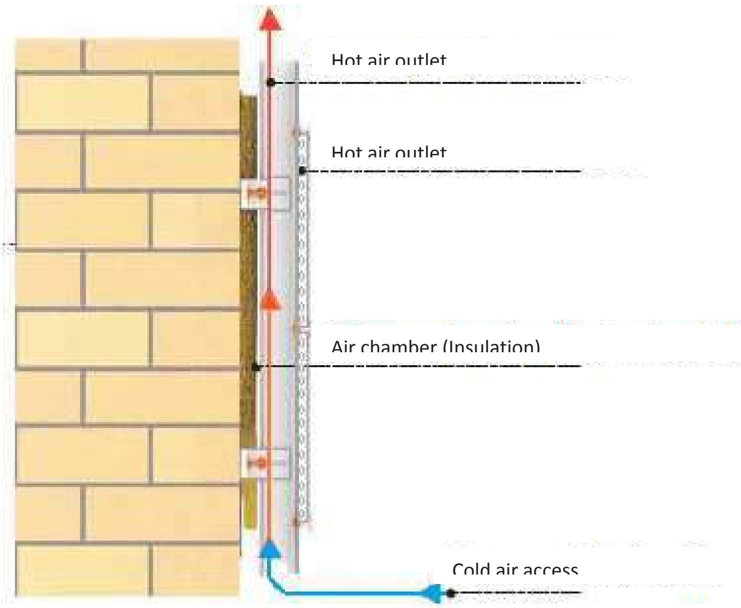
2. Elimination of condensation.

Any built partition that separates two spaces with different temperature, generates a heat flow from the warm side to the cold zone. This heat difference, can bring condensation due to air humidity, dew point or the temperature at which water vapour condenses.

To prevent condensation it is important that none of the areas of the enclosure fall to temperatures below dew point or that the humidity level is sufficiently low.

The Frontek ventilated façade system meets these requirements, as the difference in temperature between the interior and the external surface of the thermal insulation is controlled through the barrier of the Frontek ceramic panel or piece and the existing air Chamber between the piece itself and the thermal insulation.

On the other hand, the continuous air flow in the chamber, eliminates any possible condensation that may occur on the surface of the thermal insulation.



3. Thermal bridges elimination and energy efficiency improvement.

A determining factor in the insulation of the buildings is the elimination of possible thermal bridges. Thermal bridges can be understood as those elements of high thermal conductivity in direct contact with the outside that serve as bridge for high or low temperatures to enter the building.

The Frontek ventilated façade system eliminates possible thermal bridges due to the continuity of the thermal insulation and its ceramic coating.

Eliminating thermal bridges means an improvement of those ventilation properties generated by the air Chamber in the ventilated facade leading to energy savings of approximately 30% and which we will show with a theoretical example of the calculation of energy losses in a conventional enclosure and the ventilated facade Frontek.

According to the supporting document to the basic document of the energy saving technical building code DA DB-HE/1 "calculation of the characteristic parameters of the surrounding thermal transmittance", edited by the General direction of architecture, housing and soil of the Secretary of State of infrastructure, transport and housing that depends on the Ministry of development, it says that for the purposes of calculating thermal transmittance, the air chamber shall be considered a "highly ventilated air chamber" and the total thermal resistance of the enclosure is obtained by disregarding the thermal resistance of the air chamber and other layers between the air chamber and exterior atmosphere, and including the exterior surface resistance corresponding to still air, equal to the interior surface resistance of the same element ".

In this way the Frontek ventilated facade system improves the coefficient of thermal transmission "U" of the building enclosure, since according to this support document, the coefficient of heat transfer of own building enclosure is diminished by increasing thermal resistance convection in the outer side of the window which offers the ventilated facade system Frontek.

Frontek ventilated façade energy saving example.

Calculating for example the estimated energy savings for an enclosure externally made of perforated brick of 15 cm. with an insulated panel density of 30/50 Kg/m3, and 10 cm hollow brick, the finish of the interior of the enclosure is made of a plaster panel area 800/1000 Kg/m3.

We define the thermal conductivity values of each of the elements as those indicated on the CTE WEB site reference "Handbook of constructive solutions - materials", the following:

1. Perforated Brick: 0,35 W/m K
2. Insulated Panel: 0,025 W/m K
3. Hollow Brick: 0,32 W/m K
4. Plaster Panel: 0,25 W/m K

In order to calculate the thermal resistance of each of the elements, we consider the thickness of each item divided by their thermal conductivity value (data provided in the previous paragraph). Thus, for our example of enclosure, the following data would be estimated:

1. Perforated brick : 0,15 m / 0,35 = 0,43 m^2 K / W
2. Insulated Panel: 0,05 m / 0,025 = 2 m^2 K / W
3. Hollow Brick : 0,1 m / 0,32 = 0,31 m^2 K / W
4. Plaster Panel: 0,01 m / 0,25 = 0,04 m^2 K / W

Once we have obtained the thermal resistance for each element and to calculate the thermal resistance of the enclosure, we have to consider the sum of all the thermal resistance values of the different elements present:

R= 0,43 + 2 + 0,31+ 0,04 = 2,78 m^2 K / W

For the calculation of the coefficient of thermal transmittance "U", we have to apply the following formula: U = 1 / R when applying the formula to the example enclosure the results, would be:

U = 1/2,78 = 0,36 W/m^2 K

Considering the previous example, a traditional facade with a "U" 0.36 coefficient, it would mean that each degree °C of difference between the interior and exterior of the building has an energetic cost of 0.36W / m2, if we consider a typical temperature in the summer inside the building to be 20°C and outside the building 40°C, the energy loss of the enclosure would be 7.2 W/m2.

In the same way, if we consider an outside temperature of -5°C in winter and a temperature of 20° C inside the building, the energy loss of the enclosure would be 9 W/m2.

Our ventilated façade system, provides the building with a ventilated air chamber placed between the enclosure and the system itself. In the summer season the system achieves a decrease of temperature in this Chamber of air and in the winter increases temperature due to own the air recirculation is achieved. In this way, reduces the difference in temperature between the inside and the outside of the window, the system becoming similar to a second skin of protection for the building.

The reduction achieved with our facade system ranges between 5 ° C and 10 ° C. Thus, in summer gets reduce temperature affecting enclosure outside an average of 7 ° C, causing the energy loss to be 4, 68w/m2, in the event of the winter gets 7 ° C increase approximately the outside temperature of the enclosure, causing loss to be 6, 48W/m2.

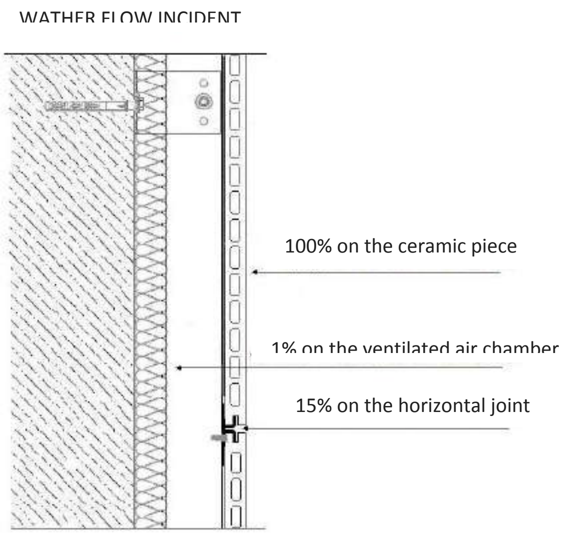
If we compare the energy loss that occurs in each of the cases, you can check that with our facade system Frontek ventilated can be superior to 30% energy savings.

Obviously, from the point of view of energy saving have deemed the singular points of the building. These being the most significant for the assessment of the project from the point of view of energy efficiency.

4. Waterproofing.

The Frontek ceramic piece or panel and the air chamber offer very effective waterproofing properties. This is due to the small open joints that form the system, its verticality and the Frontek ceramic panels' railing itself. All these factors provide a perfect situation of water tightness, and the small amount of water that could penetrate through the joints of the system, is eliminated due to the air Chamber's own ventilation.

We would also need to consider the low rate of water absorption the Frontek ceramic panel or piece presents, which is less than 0.5%, something we need to bear in mind as regards to this matter.



5. Acoustic insulation.

It is evident that the acoustic characteristics of a facade depend on its insulation properties as well as the different surfaces it is composed by. Other factors of influence are its carpentry and blind parts, this is where the Frontek ventilated facade system comes directly into play, as with the fitting of our Frontek system we can achieve acoustic improvements of around 4dBA in mid-high frequencies (1000 Hz).

In the same way, the Frontek ventilated facade system, reduces those vibrations caused by wind loads since its own enclosure serves as protective shield.

6. Other benefits of the ventilated façade system.

In addition to those mentioned above, we can enumerate further advantages offered by the Frontek ventilated façade such as the following:

- Optimizes the use of the load-bearing wall thermal inertia.
- Fixes flatness bugs on the substrate on which it is based.
- Insulation is lighter as a result
- It is insensitive to that amount of corrosion caused by polluting agents
- Low maintenance cost and easy to keep clean.

The “Frontek” ventilated façade system of exterior cladding composed of the elements described in paragraphs 4.2." "" Plus System Elements "and 4.3." "Superplus System Elements" of the present report, have been thoroughly tested in order to demonstrate their technical feasibility. They have also been tested in order to obtain the different technical suitability so it is certified that these systems meet current requirements and regulations. In any case, the requirements are those classified as "Guideline for European technical approval of kits for ventilated façade external wall claddings" by the ETAG 034 guide (April 2012 Edition).

The present document shows in a summarised way those tests that have been carried out both to the ceramic piece or panel, and also to sub-structural elements and the system itself. The document also shows the procedure followed and the different qualifications awarded to the Frontek system.

All testing controls have been carried out at the Eduardo Torroja Institute for Construction Science (IETc), endorsed by the Spanish development Ministry. In addition, different tracking control and testing procedures are performed internally (specified in the European Regulation No. 305/2011 for construction products), and some tests carried out by an external laboratory (Applus) for the study of the chemical properties of the elements that form the sub-structure of the system.

1. **Frontek Ceramic panel or piece testing.**

Ceramic panels are carried out in accordance with the UNE-EN 14411 standard as extruded tile with low water absorption presenting therefore the following characteristics:

Table 1. PIECE OR PANEL		
Classification		
Manufacturing method	Extrusion (Group AI)	
Water absorption (E)	≤3% (Group AI)	
Dimensional Properties		
Length and width tolerance	± 0,2*	%
Thickness tolerance	± 7,0*	%
Straightness of sides	± 0,2*	%
Orthogonality	± 0,4*	%
Surface Flatness	± 0,2*	%
Physical properties		
Apparent density	≈2,3	g/cm^3
Water absorption	≤0,5	% (weight)
Safety in the event of fire	A1**	
Flexural Strength	≥25*	MPa
Linear thermal expansión coefficient	$\leq 5 \cdot 10^{-6}$	K^{-1}

* Values obtained were greater than those required by the standard.
** Following the decision taken by the Commission 96/603/CE, 4 October 1996 annex to this report.

The ceramic panel or piece is subjected to different performance tests that may certify its quality and features through the production process. If it is an already finished and complete ceramic panel the tests cover the whole process. Some of these controls are:

- Chemical testing requested from the supplier of raw materials. In addition, periodic sending of samples for further testing and study purposes in an external laboratory.
- Valuation on reception of raw materials taking into account: colour, cohesion, contraction, density and calcimetry of the elements.
- Grinding process, density and viscosity control (With Ford Cup n°4), water-conductivity.
- Processing of atomized, and residual moisture in thermal scale.
- Extrusion process, continuous pressure and size control of the piece.
- Drying process, automated continuous monitoring of the process values (temperature, humidity / moisture, pressure, etc.)
- Firing process, automated continuous control of the following values temperature, oven pressure and size of the ceramic piece.
- Polishing and milling process, control of size, superficial control of ceramic pieces.

Finally, internal testing takes place with samples selected at random from each batch of finished material.

2. Testing of the elements that make up the metallic sub-structures for each of the systems plus and Super plus.

Tests are carried out to the different elements that compose the sub-structures both chemically (providing those features that intrinsically form the material that makes up the element: aluminium or steel) and those features brought by the geometry and size of the element itself.

- Intrinsic characteristics of the materials.

The vertical and horizontal profiles, aluminium brackets and clips or clamps that make up the Frontek systems sub-structures are studied chemically collecting their basic features which can be seen in the following table:

Table 2. ALUMINIUM DATA	
Designation	
Symbolic	EN AW-AI MgSi
Numeric	AW 6063
Treatment	T5
Norm	UNE-EN 755-2:2016 UNE-EN 12020-1:2009
Physical data	
Specific weight	2,7 g/cm^3
Linear Thermal expansion coefficient	$23{,}6 \cdot 10^{-6}\ K^{-1}$ (20/100º C)
Elasticity module	69.500 MPa
Poisson's ratio	0,33
Mechanical data	
Tensile strength (R_m)	≥ 175 N/mm^2
Elastic limit ($R_{p0,2}$)	≥ 130 N/mm^2
Elongation (A)	≥ 8 %

In similar fashion, AISI 304 Stainless Steel fixing clamps or clips are studied obtaining the following basic features:

Table 3. STAINLESS STEEL DATA	
Designation	
ATSM	AISI 304
Numeric	1.4301
Symbolic	X5CrNi18-10
Norm	UNE-EN 10088-2:2015
Physical data	
Specific weight	7,93 g/cm^3
Linear thermal expansión coefficient	17,3·10^{-6} K^{-1} (20/100º C)
Elasticity module	190.000 MPa
Poisson's ratio	0,33
Mechanical data	
Tensile strength (R_m)	540 - 750 N/mm^2
Elastic limit ($R_{p0,2}$)	≥ 230 N/mm^2
Elongation (A)	45 %
Brinell scale	183

- Geometric and dimensional characteristics.

They vary for each element. The following tables are organised by element showing these characteristics:

- Framework of Vertical Profiles made of extruded aluminium 6063 T5 2mm. thick. (System Plus)

Table 4. VERTICAL PROFILE SPECIFICATIONS.									
PROFILE	Section (mm^2)	Perimeter (mm^2)	Weight (kg/ml)	X_c (mm)	L_{xc} (cm^4)	R_{xc} (mm)	y_c (mm)	I_{yc} (cm^4)	R_{yc} (mm)
Profile T 60x100	290,48	357,39	0,783	50	9,55	18,13	47,00	14,27	22,17

Dimensional characteristics of the vertical profiles can be observed in its technical form, annexed to this document. (Annex 1 "Technical data profile").

- Vertical and horizontal profile (Super Plus system)
  The sub-structure of the Super plus system is formed by vertical and horizontal extruded aluminium profiles (6063 T5). The vertical profiles with a T-section and a thickness of approximately 2 mm. The horizontal profiles with an open L-section and a thickness of approximately 2.5 mm. The geometrical and mechanical properties of the profiles with tolerances according to the UNE-EN 755-9 standard are:

Table 5. CHARACTERISTICS OF T-SECTION VERTICAL AND L-SECTION HORIZONTAL PROFILES.									
PROFILE	Section (mm^2)	Perimeter (mm^2)	Weight (kg/ml)	X_c (mm)	L_{xc} (cm^4)	R_{xc} (mm)	y_c (mm)	I_{yc} (cm^4)	R_{yc} (mm)
Vertical profile 40 x 40	304,00	304,00	0,803	20	7,73	15,5	20,00	7,73	15,5
Horizontal profile 26 x 75	402,96	423,15	1,270	25,28	25,79	25,30	33,11	4,42	10,47
Horizontal Starter Profile	347,67	311,21	0,913	12,87	16,45	21,75	21,99	6,27	13,43

- Clips for fixing the ceramic panels (Super Plus system)
  The clamps for fixing of the panels to the horizontal profiles are extruded aluminium (6063 T5) with rough finish.

- Brackets: Two types of adjustable brackets are used to fix the vertical profiles to the substrate. As already explained in paragraph 3 of the current technical report, support brackets which bear the wind loads and the weight of the system itself and retaining brackets, which only bear wind loads. The following table shows the main mechanical and geometrical characteristics of the brackets used to fix the Frontek system.

Table 5. CHARACTERISTICS OF THE BRACKETS								
ITEM	Section (mm^2)	Perimeter (mm^2)	X_c (mm)	L_{xc} (cm^4)	R_{xc} (mm)	y_c (mm)	I_{yc} (cm^4)	R_{yc} (mm)
ECI 108-60 / 100-60 /102-60 / 104/60	321	220	37,5	11,83	19,2	17,48	7,55	15,33
ECI 108-80 / 100-80 / 102-80 /104-80	381	260	39,2	25,97	26,1	25,8	8,16	14,6
ECI 108-100 / 100-100 / 102-100 /104-100	441	300	40,5	47,57	32,8	34,5	8,61	13,9
ECI 108-120 / 100-120 / 102-120 /104-120	501	340	41,5	77,88	39,4	43,5	8,95	13,4

The dimensions of the brackets can be observed in its datasheet, it is annexed to this document. (Appendix 2 "technical specifications brackets).

- Clamps :The clamps main function is to fix or fasten ceramic panels or pieces fixing them to the vertical profiles. Clamps are AISI 304 stainless steel made with a general thickness of 1 mm. The technical characteristics of clamps are reflected in the annex 3 "Clamps technical sheet"

- Screws: In order to fasten the Frontek system several types of screws are used. The following are distinguished:

  - Fasteners at the joining with the substrate: We can use two types of screws to fix the brackets to the substrate depending on the characteristics of the substrate. Therefore, the M10 lag screw can be used for ceramic walls and the expansive M8 screw in the case of concrete structures. (Testing of technical properties attached to annexes 4 and 5 of this report)

  - To fix the vertical profile to the brackets and the horizontal to the vertical profile in the Superplus system: A2 Stainless steel hexagonal head self-drilling screw DIN 7504 K ø 5,5 y L=22 mm are used. Its main features are shown on the following table and in annex 6 "Technical nuts and bolts" of the present report.

Table 6. SCREW TO FIX PROFILES TO THE BRACKETS	
Description	Hexagonal head self-drilling screw
Standard	DIN 7504K UNE-EN ISO 15480
Nominal Diameter	5,5 mm
Length	22 mm
Material	A2 Stainless Steel (AISI 304)
Standard	EN-ISO 3506-1
Resistance Class	70
Tensile strength (R_{m})	700 MPa
Yield strength ($R_{p0,2}$)	≥ 450 MPa
Elongation at fracture (%)	≥ 0,4 d
Torque (N·m)	4,1

- To fasten or fix the clamps or clips to the vertical profile T, A2 Stainless steel flat head self-drilling screws ø 4,2 y L=14 mm are used. Its main features are shown on the following table and in annex 6 "Technical nuts and bolts" of the present report.

Table 7. SCREW TO FIX CLAMPS TO THE VERTICAL PROFILES	
Description	Flat head self-drilling screw
Nominal diameter	4,2 mm
Length	14 mm
Material	A2 austenitic stainless Steel (AISI 304)
Standard	EN-ISO 3506-1
Resistance class	50
Tensile strength (R_{m})	500 MPa
Yield strength ($R_{p0,2}$)	≥ 210 MPa
Elongation at fracture (%)	≥ 0,6 d
Torque (N·m)	2,0

In addition it is recommended that the screwdriver should be used with depth and torque control. Turning speed of 1,800 to 2,500 min-1, with an axial strength of 250 N (UNE-EN ISO 10666).

- Polyurethane Sealant (Terostat): A line of sealant is applied between the vertical T-profiles, horizontal profiles in the case of the Super plus system, and the ceramic panels to achieve a flat final surface and prevent the panels from banging as a result of vibrations. However, resistance tests performed to the system and explained in the following point of this report were carried out without a polyurethane sealant or any other type of epoxy resin. Use a single component polyurethane sealant similar or equivalent to Sista Solyplast SP-101 with the following properties.

Table 8. POLYURETHANE SEALANT	
Description	Single-component polyurethane sealant
Type	Sista Solyplast SP-101
Density	1,37 g/ml
Hardness	53 Shore
Modulus of elasticity	1,60 N/mm^2 (NF-P8506)
Elongation at fracture	300 % (NF-P8506)
Adhesion	≥ 1 MPa
Temperature resistance	-30 ºC a + 90 ºC
Skin formation	30 – 40 minutes
Curing time	2-3 mm/24 hours

3. Testing the system.

All testing controls have been carried out at the Eduardo Torroja Institute for Construction Science (IETc), to ensure the suitability of the system. These tests demonstrate the technical suitability of the Frontek ventilated façade system. This document shows the procedure followed to carry out these tests and the different results achieved by Frontek Plus and Frontek Super plus in each of the tests.

a. Resistance to wind loads and wind suction.

All testing is carried out following the most unfavourable initial configuration in each case. If the test result does not confirm or match the results of the mechanical test, further testing collecting at least two results or samples will be performed:

FRONTEK PLUS	Sub-structure	Vertical distance between brackets 1000 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating Element	FRONTEK largest standard panel 1000x405x19,5 mm.
FRONTEK OMEGA PLUS	Sub-structure	Vertical distance between brackets 1000 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating element	FRONTEK OMEGA largest standard panel 1000x307x19,5 mm.
FRONTEK SUPERPLUS	Sub-structure	Vertical distance between brackets 1000 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating Element	FRONTEK largest standard panel 1000x405x19,5 mm.
FRONTEK OMEGA SUPER PLUS	Sub-structure	Vertical distance between brackets 1000 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating Element	FRONTEK largest standard panel 1000x307x19,5 mm.

The test is performed as described in the ETAG 034 part 1, section 5.4.1.1. Guide. The main objective of this test is to fully reproduce the effects of wind suction on the ventilated facade. A sample of Frontek façade is prepared in the size described above. The test consists on the following:

Wind loads are distributed uniformly on the front of Frontek's external cladding element. The test is performed in successive stages (two-stage 300 Pa and then another 1,000 Pa, then 200 Pa and from then on, with return to zero and 300 Pa after each of the returns to significant irreversible deformation (This determines if the element is suitable to use).At each stage, the load is kept constant at least for 10 s. This test continues until failure.

Finally, the results shall be measured and recorded in the form of a table or graph. Noting the permanent deformation observed after the differential pressure is reduced to zero the stage at which damage may take place.

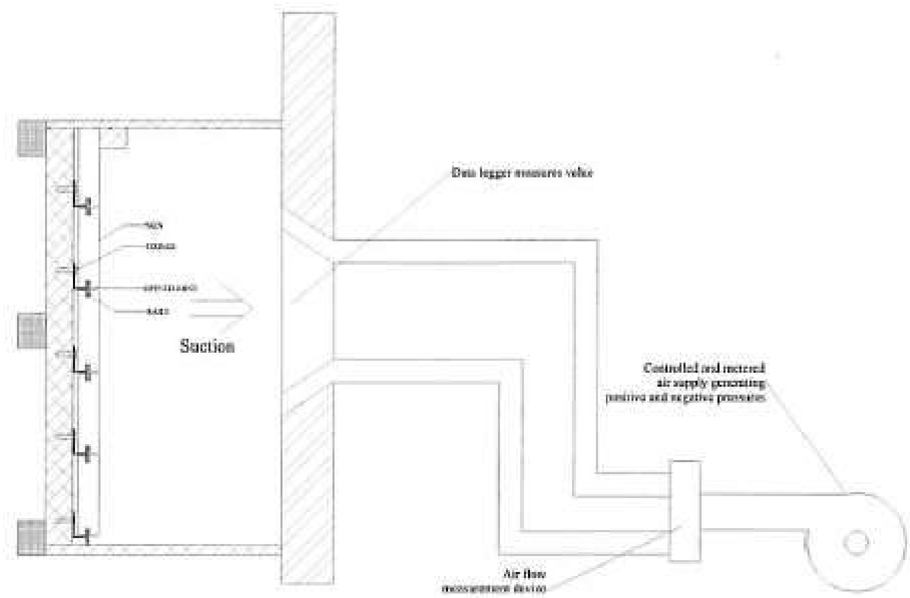


Figure 4 - Example of wind pressure and suction apparatus

The test confirms the piece has not failed, understanding that failing may be any of the following conditions:

- Breaking Frontek insulating elements
- Significant permanent deformation in any Frontek insulating element
- Fastener failure.
- Failure in the separation of the frame.

The results to the resistance to wind suction tests carried out on the Frontek system are as follows:

Table 9: RESISTANCE TO WIND SUCTION TEST RESULTS			
System	**Maximum load Q (Pa)**	**Type of Failure**	**Lower Section Maximum load (mm)**
FRONTEK PLUS	3200	No visible Failure	8.92
FRONTEK OMEGA PLUS	4000	No visible Failure	4.13
FRONTEK SUPER PLUS	4000	No visible Failure	4.50
FRONTEK OMEGA SUPER PLUS	3800	No visible Failure	10.98

Results certify the compliance of the system to wind loads, since the test, in some cases remained suspended by the instability of the test equipment, without the different systems recording visible failure.

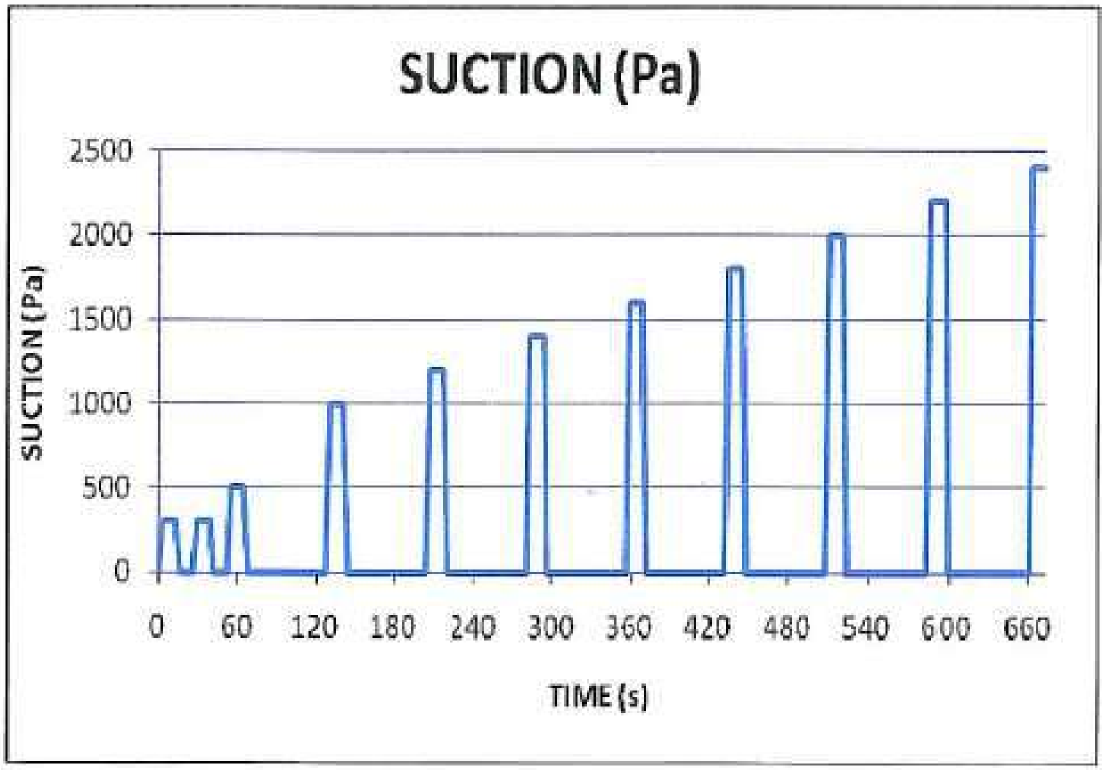


Figure 5 - Example of wind load design

b. Resistance to Wind thrust.

Frontek ventilated façade kits performance facing wind pressure is more favourable than when testing the system against wind suction (previously studied). Therefore, in accordance to paragraph 5.4.1.2 of the ETAG 034 Guide, there is no need to carry out wind pressure resistance tests as the results obtained in the wind suction test, may be regarded as valid to determine the system's behaviour against wind pressure.

c. Cladding Elements Fixing Resistance.

The test is performed as described in the ETAG 034 Guide part 1, section 5.4.2.3.1. The main objective of this test is to test fixing resistance of the Frontek panels. The test consists of the following:

The test is done in environmental conditions. Some rigid substrate samples similar to those shown below are used. A force at speed of 5 mm/min is applied to the profile (pulling from its head or top).

A minimum of 5 different tests is carried out. The results are indicated in Newtons (N).

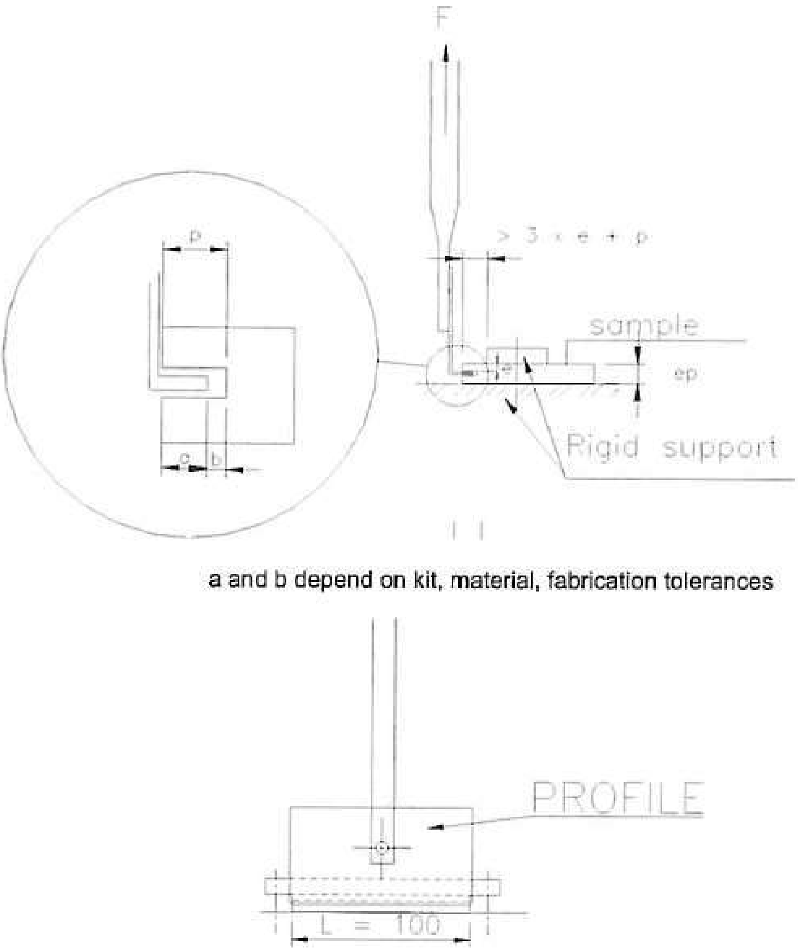


Figure 12 - Example of test of fixing

The results of the tests are as follows:

Table 10: CLADDING ELEMENTS FIXING RESISTANCE RESULTS			
Break Load (N)			Failure type
Sample	F_m	$F_{u,5}$	
FRONTEK PLUS	462,92	386,79	Deformation of the fixing element (Clamp)
FRONTEK OMEGA PLUS	361,57	195,40	Deformation of the fixing element (Clamp)
FRONTEK SUPER PLUS	1570,90	1408,80	Deformation of the fixing element (Clip)
FRONTEK OMEGA SUPER PLUS	2321,8	1952,90	Deformation of the fixing element (Panel)

Results show some degree of deformation in the anchoring system before the piece may be fractured. This means the system meets the required standards

d. Vertical Load Test

The test is performed as described in the ETAG 034 Guide part 1, section 5.4.2.3.3. The main objective of this test is to measure the system's resistance to vertical load and its own weight-bearing ability. All testing is carried out following the most unfavourable initial configuration in each case:

FRONTEK PLUS	Sub-structure	Vertical distance between brackets 500 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating element	FRONTEK largest standard panel 1000x405x19,5 mm.
FRONTEK OMEGA PLUS	Sub-structure	Vertical distance between brackets 400 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating element	FRONTEK OMEGA largest standard panel 1000x307x19,5 mm.
FRONTEK SUPERPLUS	Sub-structure	Vertical distance between brackets 500 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating element	FRONTEK largest standard panel 1000x405x19,5 mm.
FRONTEK OMEGA SUPER PLUS	Sub-structure	Vertical distance between brackets 400 mm.
		Maximum distance between vertical profiles and fixing elements depending on the size of the panels.
		Clamps or Clips fix the panels to their four corners.
	Insulating element	FRONTEK largest standard panel 1000x307x19,5 mm.

Test description:

This is done under normal environmental conditions on a sample of a Frontek kit for wall claddings. First, the deviation of the profile is measured and then we install an element on the profile. Next we apply a constant load equivalent to two additional cladding elements added to the element initially installed. After an hour, the average deformation measured in the cladding elements is less than 0.1 mm. Therefore, the system meets the required standards.

e. Brackets Load Capacity Test

Brackets and their fasteners traction and shear force resistance to the vertical profile has been determined by calculations obtained from the specifications shown in Annex E of the ETAG 034 Guide part 2.

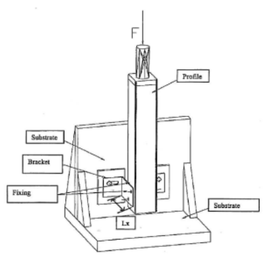


Figure E 1 – Example of test device

The objective of this test is to determine the load and wind resistance bearing capacity of the elements fastened to the substructure when applying loads of tension and shear force. A traction machine is used similar to the one shown in the figure.

Deemed the most unfavourable fastening elements (weakest design) the test is carried out with at least five samples. The results are given by a sensor placed in the extrusion machine that generates a graphical describing the strength and the movement.

The profile undergoes a succession of cycles with an increasing traction load of 10 daN each cycle. This load is applied in different sequences that monitor the loading speed in order to maintain the speed constant to < 500 daN / min. Later we can define two different values in the result: acceptable metal stress and distortion under load. From these we can obtain the brackets resistance main characteristic value. The calculation results obtained from this test are:

FRONTEK PLUS, OMEGA PLUS, SUPER PLUS AND OMEGA SUPER PLUS				
Table 11: BRACKETS VERTICAL LOAD CAPACITY TEST RESULTS				
Bracket size (e=3mm)	**F_r (daN) ΔL=0,2% de L**	**F_{1d} (daN) ΔL=1mm**	**F_{3d} (daN) ΔL=3mm**	**F_s (daN) fallo**
50 x 60 x 60	60	100	115	No visible failure
50 x 80 x 60	42	68	78	No visible failure
50 x 100 x 60	33	50	58	No visible failure
50 x 120 x 60	25.5	38.5	45.5	No visible failure
Table 12: BRACKETS VERTICAL LOAD CAPACITY TEST RESULTS				
Bracket Size (e=3mm)	**F_C (daN) ΔL=1 mm**		**F_s (daN) fallo**	
50 x 60 x 60	170		No visible failure	
50 x 80 x 60	160		No visible failure	
50 x 100 x 60	150		No visible failure	
50 x 120 x 60	149		No visible failure	
50 x 60 x 123	310		No visible failure	
50 x 80 x 123	295		No visible failure	
50 x 100 x 123	280		No visible failure	
50 x 120 x 123	270		No visible failure	

f. Resistance to soft body impact.

The test is performed as established in the ETAG 034 Guide part 1, section 5.4.4.2. The main objective of this test is to determine the resistance presented by the piece when facing a possible soft body impact. The test is performed as described by ISO 78925:1988 and consists of the following:

The points of impact are selected taking into account the different modes of behaviour the walls have. A 3 kg weight ball is thrown (at least in three places) at a height of 0.34 to 2.04 m in order to hit the wall with the intensity a soft body would (from 10 to 60 joules). Then further soft body impacts (from 300 to 400 Joules) with a 50 kg balloon at a height of 0.61-0.82m (with at least one impact directed at the centre of the piece).

After that both the area and the crack generated in the piece are written down as well as noting the presence or not of cracks or micro-cracks at the point of impact.

The results are indicated in the following table:

Table 13: RESISTANCE TO SOFT BODY IMPACT TEST RESULTS		
FRONTEK PLUS Y SUPER PLUS STANDARD PIECE 1000X405X19,5		
IMPACT		**RESULTS**
10 J	3 Kg	No damage
60 J	3 Kg	No damage
300 J	50 Kg	--
4000 J	50 kg	--

FRONTEK PLUS AND SUPER PLUS OMEGA PIECE 1000X307X19,5		
IMPACT		RESULTS
10 J	3 Kg	No damage
60 J	3 Kg	No damage
300 J	50 Kg	--
4000 J	50 kg	--

According to tests results the category for this exterior cladding kit is category IV, and therefore, the Frontek ventilated facade can be used in areas not accessible from exterior ground level.

g. Resistance to hard body impact

The test is performed as described in the ETAG 034 Guide part 1, section 5.4.4.1. The main objective of this test is to determine the amount of resistance presented by the piece when facing a possible hard body impact. The test is performed as described by ISO 7892:1988 and consists of the following:

The points of impact are selected taking into account the different modes of behaviour the walls have. A 1 kg steel ball is thrown (at least in three places) at a height of 1.02m in order to hit the wall with the intensity a hard body would (10 joules). Then further hard body impacts (from 1 to 3 Joules) with a 0.5 kg steel ball at a height of 0.20-0.61m (with at least three impacts directed at different parts of the piece).

After that both the area and the crack generated in the piece are written down as well as noting the presence or not of cracks or micro-cracks at the point of impact.

The results are indicated in the following table:

Table 14: RESISTANCE TO HARD BODY IMPACT TEST RESULTS		
FRONTEK PLUS AND SUPER PLUS STANDARD PIECE 1000X405X19,5		
IMPACT		RESULTS
1 J	0,5 Kg	No damage
3 J	0,5 Kg	Fracture without fall
10 J	1 Kg	--
FRONTEK PLUS AND SUPER PLUS OMEGA PIECE 1000X307X19,5		
IMPACT		RESULTS
1 J	0,5 Kg	No damage
3 J	0,5 Kg	Fracture without fall
10 J	1 Kg	--

According to tests results the category for this exterior cladding kit is category IV, and therefore, the Frontek ventilated facade can be used in areas not accessible from exterior ground level.

h. Safety in the Event of Fire

According to regulation UNE EN 13501-1:2007 + A1:2010, some construction and components for building products are classified according to their behaviour against fire without the need for further testing as they already appear defined in the European regulations 96/603/EC.

Both the ceramic pieces and elements that are part of the sub-structure of the systems plus and super plus are classified A1 according to European regulations 96/603/EC without the need to undergo further testing (mentioned above).

This qualification is valid provided that the insulation placed in the ventilated air Chamber is manufactured with a non-combustible material (e.g. mineral wool). Otherwise the fire reaction class would become F (NPD-provision not determined).

i. Seismic resistance.

In order to assess the Frontek ventilated facade system seismic resistance, the following considerations should be taken into account:

First, to clarify the fact that any building to be considered earthquake-proof this must have a reinforced concrete structure. Without this, no building is earthquake-proof.

In addition, we have to consider that the ventilated façade is not a load-bearing structural element of the building, but an annexed item to the supporting structure of the building that behaves as a second skin to improve the building's performance (aesthetic, energetic, etc.).

When a seismic movement is generated, damage or loads that are generated must be supported by the structure of the concrete building. Loads that generate in the ventilated facade will be transmitted to the main structure of the building. Therefore, they are the attachment points between the ventilated facade Frontek (coating of the building) and the re-inforced concrete structure of the building, which must resist and transmit the loads generated by the earthquake. These points are the fixed or fastened screws to the brackets.

The brackets used in the Frontek system, feature an earthquake-proof design. This design includes the development of a few vertical and horizontal slotted holes for bracket support and fastening the vertical profiles. These slotted holes absorb the vibration transmitted by the structure of the building when seismic movement is taking place. Thus, if the re-inforced concrete structure resists, the Frontek ventilated facade resists.

j. Hygrothermal test (thermal shock heat-rain).

With the objective of verifying the durability and functionality of the panel or piece in the various weather environments in which it can be placed, the following test is carried out in accordance with ETAG 034 Guide, section 5.4.6. According to this section, the system undergoes the following test:

First of all a sample of façade is prepared (greater than or equal to 6m 2, with a minimum width of 2.5m. and minimum height of 2.5m.) and is left a minimum of 28 days at ambient conditions. In the laboratory the dimensions and quantities of the elements that are placed in the sample are monitored and controlled.

After that at the front of the platform the testing apparatus is placed at about 10-30 m from the edges and the temperatures are measured during each cycle. The following environmental cycles are applied:

- Cycles heat-rain: The system undergoes a test of 80 cycles which comprise the following phases:

- It heats up to + 70 ° C for 1 hour and stays at + 70 ° c (±5 ° C) 10-30% of relative humidity in the air for 2 hours. (A total of 3 hours).
- Spray for 1 hour the facade with water (1 L/m2 ·min) at a temperature of 15-° C (±5 ° C)
- Let it stand for 2 hours Se deja reposar 2 horas.

- Cycles heat-cold: after 48 hours at temperature between 10 and 25 ° C and a relative humidity minimum of 50% the sample is exposed to five cycles of heat/cold for 24 hours with the following phases:
  - Exposure to 50 ° C (±5 ° C) and maximum 30% of relative air humidity. For an hour they increase temperature and stays for 7 hours (a total of 8 hours).
  - Exposure to - 20 ° C (±5 ° C) for two hours the temperature going down, and keeping it for 14 hours (a total of 16 hours).

In periods of four cycles, during the heat-rain cycles, and in each cycle during the stages of heat-cold, we can observe if there is change in the characteristics or performance of the façade (formation of blisters, detachment, Loss of Adhesion, tilt, formation of cracks or efflorescence, or any defects that can be observed directly in the piece).

In the same way the profiles and the substructure are verified in case they have suffered damage and degradation. In this case of the placement and extent of the crack produced will be recorded. The possible penetration of water into the substructure is also checked.

The results are:

- There is no damage or cracks in the coating elements that may allow the water to reach the insulation.
- No elements have been removed or deterioration being generated.

Consequently, the system is considered resistant to hygrothermal cycles.

k. Durability against ice / thaw.

The following test consists of impregnating the ceramic tiles or panels with water (by the method of vacuum), subjecting them to cycles of ice / thaw between - 5 ° C and + 5 ° C while all surfaces exposed to freezing for at least 100 cycles. Vacuum impregnation method ensures good penetration of water in the pores of the tile. Note that this temperature range is used as from 4 ° C, water reaches its maximum possible expansion by exposure to cold temperature. Considering that this is the most critical point as far as possible damages to the piece. Below this temperature the effects are the same as at 4 ° C.

The test report contains the initial tile water absorption and final absorption after the testing process. Visual examination will allow us to describe the deterioration on the face and on the sides of the tile (cracking, fractures, holes or splits), and count the number of damaged tiles.

After testing no damage has been detected on the Frontek extruded ceramic piece after 100 freezing cycles.

Frontek ventilated façade System for rehabilitation purposes.

The Frontek ventilated facade system offers some special advantages and conditions which makes it an ideal solution for the renovation of houses. These advantages include the following:

- Protection of the existing enclosure allowing an extraordinary aesthetic transformation of the building
- Enables placement without having to remove the existing enclosure.
- Significant improvement in Thermal insulation / acoustic insulation
- Elimination of Pathologies arising from the presence of humidity
- Energetic efficiency. Rational reduction of energy consumption obtaining significant savings as well as thermal well-being.
- Allows in some cases the installation of gas piping systems, downpipes, etc. in the space provided by the ventilated air chamber






Frontek Ventilated façade Cleaning and Maintenance.

Our façade systems Frontek Plus and Super Plus are constructive elements that hardly need any maintenance. An exceptional performance material that resists without alteration the passing of time, solar radiation in any type of environment, even in locations that are exposed to saline environments and urban areas with heavy traffic.

Frontek extruded ceramic porcelain pieces or panels offer a rate of less than 0.5% absorption, do not absorb dirt or moisture and dust or polluting agents that may settle on the pieces, they are eliminated once it rains on the facade. Only in environments with a high degree of urban or industrial pollution and shortage of rain it would be necessary to perform simple cleaning with water and neutral soap either by hand or with a water pressure machine, starting from top to bottom of the facade

Accidental stains the façade may suffer due to temporary agents (graffiti…) will require a specific cleaning protocol and you are welcomed to consult our technical department to ensure the use of the most suitable product and cleaning procedure for each case.

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