AWARD

Cladding system for ventilated building fronts with ceramic tiles KERABEN

Manufacturer:
KERABEN, S.A.

C/ SERRANO
GALVACHE, 4
28033 MADRID
Spain

Head Office:
Ctra. Valencia - Barcelona, km. 4,3.
12520 NULES (Castellón)
Spain

Tel. 964 659 500
Fax. 964 659 503
E-mail: keraben.systems@keraben.com
http:// www.keraben.com

C.D.U: 69.022.325
Bardage
Cladding Kit

17 April 2008

VERY IMPORTANT

DECISION No. 511

THE DIRECTOR OF INSTITUTO DE CIENCIAS DE LA CONSTRUCCIÓN EDUARDO TORROJA,

- by virtue of Decree No. 3652/1963, dated 26 December, issued by the Presidency of the Government, authorising Instituto de Ciencias de la Construcción Eduardo Torroja to issue the TECHNICAL APPROVAL DOCUMENT for the non-traditional BUILDING materials and procedures used in construction and public works, and Order No. 1265/1988, dated 23 December, issued by the Ministry of Relations with Parliament and the Office of the Secretary of the Government, which governs the award thereof,

- in consideration of article 5.2, section 5 of the Technical Building Code (hereinafter called TBC) on compliance with the TBC of innovative products, equipment and systems, which provides that a building system is compliant with the TBC if it has been technically approved for its anticipated use,

- In consideration of the application made by the trading company KERABEN, S.A. for the award of a TECHNICAL APPROVAL DOCUMENT for the **cladding system for building fronts with KERABEN ceramic tiles,**

- by virtue of the current statutes of l'Union Européenne pour l'Agrément technique dans la construction (UEAtc),

- taking into account the reports drawn up after visits to work sites by representatives of Instituto de Ciencias de la Construcción Eduardo Torroja, the reports on the tests performed at the IETcc, and the observations made by the expert committee in its session of 13 May 2008,

HAS DECIDED

To award the TECHNICAL APPROVAL DOCUMENT number 511 for the **cladding system for ventilated building fronts with ceramic tiles to KERABEN**, taking into consideration that,

The technical assessment that has been made shows that the system is COMPLIANT WITH THE TECHNICAL BUILDING CODE as long as the entire content of this document and, in particular, the following terms and conditions are observed:

GENERAL TERMS AND CONDITIONS

This TECHNICAL APPROVAL DOCUMENT endorses only the building system proposed by the applicant and, as provided in current legislation, it must be accompanied by the official building project and be carried out by the corresponding works management. The building project will be what considers in each case the actions the system transmits to the general structure of the building, ensuring that they are admissible.

In each case, KERABEN, S.A., in accordance with the architectural project for the building front drawn up by the architect who has completed the project, will provide the graphic definition from the technical point of view of the project for the ventilated front, together with sufficient technical assistance to carry out the technical project of the ventilated front, with a definition for the execution thereof, including all the necessary information about each part.

The technical project for the ventilated front must include a calculation report explaining the appropriate behaviour of the substructure with regard to the anticipated actions.

In general, consideration must be given in the project and in the execution of the building work to all the provisions of current legislation. Reference is made here to the TBC as a reminder.

CONTROL AND MANUFACTURING CONDITIONS

The manufacturer must apply the self-control system currently applied to raw materials, the manufacturing process and the finished product, in accordance with the indications given in section 5 of this document.

CONDITIONS OF USE AND APPLICATION AT THE BUILDING SITE

The cladding system for ventilated fronts with KERABEN ceramic tiles has been designed for the exterior cladding of building fronts by fastening to a metal substructure using fixing devices. The system does not contribute to the stability of the building.

The on-site application of the system must be carried out by KERABEN, S.A. or by specialised, qualified companies recognised by the former and under its technical control. Through its KERABEN SYSTEMS department, KERABEN, S.A. will guarantee that the use of the system is carried out under the conditions and fields of application covered by this document in compliance with the observations made by the expert committee. A copy of the updated list of installation companies approved by KERABEN, S.A. will be available at the IETcc. In accordance with the foregoing, this document applies exclusively to the work that has been carried out by KERABEN, S.A. or by qualified companies approved thereby.

All the necessary provisions on the stability of the buildings must be adopted during the assembly work, as well as on the falling hazard of overhead loads, personal protection and, in general, consideration must be given to the provisions of current regulations governing occupational health and safety.

VALIDITY

This technical approval document number 511 is valid for a five-year period on the condition that:

- The manufacturer does not modify any of the product specifications indicated in this technical approval document.
- The manufacturer performs a systematic autocontrol process on its production as indicated in the technical report.
- The institute performs an annual verification to confirm compliance with the foregoing conditions, visiting one of the more recent projects if it considers it appropriate.

If the result of the monitoring process is favourable, the IETcc will issue an annual certificate, which must be attached to the technical approval document for it to be valid.

Consequently, this document must be renewed before 13 May 2013.

Madrid, 13 May 2008

THE DIRECTOR OF INSTITUTO DE CIENCIAS
DE LA CONSTRUCCIÓN EDUARDO TORROJA

Juan Monjo Carrió.

1. PURPOSE

Cladding of ventilated building fronts with ceramic tiles by KERABEN, S.A., fixed to a vertical aluminium substructure fastened to the supporting wall.

2. PRINCIPLE AND DESCRIPTION OF THE SYSTEM

The tiles are fixed to the vertical substructure with stainless steel clips. The substructure is made up of struts fastened to the supporting wall and/or the building structure with adjustable brackets (see figure).

The typical composition of the ventilated front with ceramic tiles by KERABEN, S.A. consists of the following layers:

1. Ceramic tile by KERABEN, S.A.
2. Ventilated air chamber in which thermal isolation not supplied by KERABEN, S.A. is usually fitted.
3. Supporting substructure made of aluminium and fastened to the supporting wall. The substructure, which is not supplied by KERABEN, S.A., is made up of the following:
   - Brackets.
   - Vertical section.
   - Clip plate.
   - Clips.

The tiles are fixed mechanically to the vertical substructure by inserting the clips into the grooves on the edges of the ceramic tile.

The system can include insulation, which must be defined by the building project in compliance with the TBC, regarding energy saving (DB-HE) and noise protection (DB-HR).

The system uses the corresponding fixing devices, spacing the tiles from each other with vertical and horizontal seals. The seals between the tiles must always be open. The vertical seal must be between 3 and 7 mm and the horizontal seal must be between 4 and 6 mm.

This cladding system can be applied to supports made of masonry work, concrete or metal structures in new building work and in refurbishment work.

The substructure of the system is fastened to the building structure and to the supporting wall using brackets. The brackets are positioned alternately on both sides of the vertical section at a maximum distance of 1.0 m. They are doubled up when so required by the corresponding calculation and at least every 3.5 m approximately, coinciding with the horizontal structure of the building (girders and/or edges of the top slab) when the building structure is made up of pillars and top slabs.

3. MATERIALS AND PARTS

3.1 **Tiles**

The ceramic tiles have a thickness of 30 mm and are made of clays, silica, fluxing material, colouring agents and other materials, generally used to cover floors, walls and building fronts. They are manufactured by grinding, sifting, shaping and humidification, etc. and they are moulded by pressing at ambient temperature. They are then dried and fired in furnaces at high temperatures.

The faces of the tiles are impermeable and the tiles themselves are practically impermeable on their sides and backs (a.a. ≤ 0,5%). They have a glass fibre mesh adhered to the back of the tile with polymeric adhesive to prevent detachment if the tile breaks.

Decision 96/603/CE of the Commission, dated 4 October 1996, which provides the list of products classified under class A1 (no contribution to fire), includes ceramic products.

Their physical, mechanical and geometric specifications correspond to the following classification, according to the UNE-EN 14411:2004 standard, which is applicable to ceramic tiles, including the tiles that are supplied mounted on tiles or layers, with water absorption, $E \leq 3\%$, according to group A1 of the UNE-EN 14411:2004 standard for cladding interior and exterior walls and floors:

- According to their composition: ceramic tile.
- According to their mechanical resistance, they are defined as follows: compliant with the UNE-EN 14411:2004 standard; in other words, the fracture modulus will be > 35 N/mm^2.

3.1.1 *Dimensional specifications*

The standard dimensions of manufacture of the tiles are given in the following table:

TILE DIMENSIONS				
Reference	**Length** (mm)	**Width** (mm)	**Thickness** (mm)	**Weight** (kg)
100 x 50	1000	500	13	≈ 15

For the same thickness, other dimensions of tiles that are smaller than these can be supplied, with the same tolerances, as long as the loads owing to the action of the wind at which the tiles are

working are lower than those given in this document.

The geometric requirements of the tiles are as follows:

TILE GEOMETRY				
Length	**Width**	**Thickness**	**Straightness of edges**	**Out-of-square**
Tolerance (%)	Tolerance (%)	Tolerance (%)	Tolerance (%)	Tolerance (%)
± 0.2 %	± 0.2 %	± 5 %	± 0.2 %	± 0.2 %

3.1.2 *Physical and mechanical properties*

The physical properties of the tiles are given in the following table:

Property	**Value**	**Unit**	**Test**
Density	≈ 2,4	g/cm^3	
Bla fracture modulus	≥ 35	MPa	UNE-EN 14411:2004 On a sample of 100 x 50 x 30 mm
Fracture stress	≥ 30	MPa	UNE-EN ISO 10545-1:1997 On a tile of 1000 x 500 mm
Coefficient of thermal expansion	$7 \cdot 10^{-6}$	K^{-1}	UNE-EN ISO 10545-8:1997
Reaction to fire	A1		Decision 96/603/CE

3.1.3 *Identification:*

The identification label on the pallet indicates the following:

- Manufacturer's trademark.
- Colour and texture.
- Date of manufacture.
- Nominal dimensions.
- Quantity of tiles of the corresponding nominal dimensions.
- Identification label with logo and DIT number.
- Identification code of the batch of manufacture (traceability, date of manufacture, etc.).

3.2 **Substructure for fixing the tiles**

3.2.1 *Sections and brackets*

The vertical sections and brackets are made of extruded aluminium and must comply with the technical specifications of the levels of quality of T5-treated aluminium alloy 6063, whose basic specifications are as follows:

Physical properties:

- Specific weight: 2.70 g/cm^3.
- Coefficient of linear expansion: $23{,}6 \cdot 10^{-6}$ K^{-1} (20/100 ºC)
- Elasticity modulus: 70,000 MPa (average of traction and compression moduli).
- Poisson coefficient: 0.33.

Mechanical properties:

ALLOY AND TREATMENT	R_m (Mpa)	$R_{p0.2}$ Mpa	**A** %	**Brinell hardness**
6063 T5	≥175	≥ 130	≥ 8	

According to UNE-EN 755-2:1998 for extruded sections.

Section specifications

The typical strut dimensions are shown in figure 5 and those of the brackets in figure 6.

	Dimensions (mm)	Cross-section (cm^2)	Perimeter (mm)	Weight (kg/ml)	x_c (mm)	I_{xc} (cm^4)	y_c (mm)	I_{yc} (cm^4)
Vertical section	30 x 45 x 2.6	296.43	240.43	0.80	22.50	3.72	12.56	9.21
60 x 80 bracket	60 x 80 x 5	680.20	276.80	1.84	14.61	44.50	24.52	21.70

Identification:

- Manufacturer's trademark.
- Manufacturing code, which enables traceability.
- Nominal dimensions and material.
- Identification label with logo and DIT number.

3.2.2 *Clip plate for fixing the clips*

To fix the ceramic tiles to the vertical substructure, various mechanical fixing devices are used. The clip plate holds the clips that are positioned in the various grooves in the tile.

The clip plate must be made of A2 AISI 304 stainless steel and have a general thickness of 2.15 mm (± 0,15 mm). Its dimensional specifications must be as shown in figure 7.

3.2.3 *Clips for fastening ceramic tiles*

The clips must be made of extruded aluminium and comply with the technical specifications for the levels of quality of T5-treated aluminium alloy 6063 and have the dimensional specifications shown in figure 8 (± 0,15 mm).

3. 3 **Nuts and bolts**

- Fixing the vertical section to the brackets:

  DIN 7504k Self-tapping screw made of A2 stainless steel with a 5.5x19 hexagonal head.

- Connection of the clip plate to the vertical section:

  Self-tapping screw made of A2 stainless steel with a diameter of 4.2 mm and a length of 14 mm, DXP361 type by ETANCO or similar.

Nuts and bolts specifications

Class product	Screws - Rods - Bolts				Nuts	
	Resistance class	Resistance to traction Rm N/mm^2	Elasticity limit $R_{p0,2}$ N/mm^2	Elongation at fracture A mm	Resistance in test load S_p	
					Type-1 nuts (m ≥ 0,8d) N/mm^2	Narrow nuts (0,5d ≤ m < 0,8d) N/mm^2
A2	50	≥ 500	≥ 210	≥ 0,6·d	≥ 500	≥ 250
	70	≥ 700	≥ 450	≥ 0.4·d	≥ 700	≥ 350
	80	≥ 800	≥ 600	≥ 0.3·d	≥ 800	≥ 400

M8	Resistance class	Tightening torque N·m	Fracture limit kN	Elasticity limit kN	Resistance section mm^2
	50	7.8	18.3	7.7	36.6
	70	17.5	25.6	16.4	
	80	22.0	29.2	21.9	

3.4 **Fixing devices for the supporting wall**

The type, composition and number of fixing devices for fastening the brackets to the supporting wall will be defined according to the base support material and the stress that is transmitted to it, which must be shown in the technical project for the ventilated building front.

These figures must be provided by the person responsible for the system, depending on the recommendations given by the fixing device manufacturer for each base support material.

In general and for the more common cases, the following options are given:

- Fixing device for joining the brackets to the wall:

  This will be used when the base material is solid, perforated or hollow or light concrete

  Threaded metal expansion fixing device with a high load capacity, FIXBOLT or similar, in zinc-plated steel with a thickness of 5 microns, lag screw with a metric hexagonal head made of 6.8 quality steel (60 kg/mm2) 8x80 DIN 933 and a large special washer for fastening to concrete, hollow and solid materials.

Chemical fixing device made up of an 8x80 rod, nut sieve, washer and resin, by Hilti or similar.

- Fixing device for joining the brackets to the edges of the top slab:

  Threaded metal expansion fixing device with a high load capacity, FIXBOLT or similar, in zinc-plated steel with a thickness of 5 microns, lag screw with a metric hexagonal head made of 6.8 quality steel (60 kg/mm2) 8x80 DIN 933 and a large special washer for fastening to concrete, hollow and solid materials.

4. TILE MANUFACTURE

The process for manufacturing the tiles takes place at the KERABEN, S.A. factory in Nules (Castellón) and generally includes the following successive stages:

- Dispensation and wet mixing of the raw materials that will make up the ceramic tile support.
- Atomisation of the grinding products to shape the wet powder.
- Pressing to shape the tile support to which the decoration can be applied.
- Decoration (enamel, silkscreen printing).
- Firing.
- Machining (grinding) and resistance test.
- Classification.
- Machining (scraping and meshing).
- Packaging and storage before shipment.

5. QUALITY CONTROL

5.1 **Tiles**

At its factory in Nules (Castellón), KERABEN, S.A. has implemented a quality assurance plan in compliance with the provisions of the company's quality assurance system as approved by SGS on the certificate number ES-0256/1994 in accordance with the UNE EN ISO 9001:2000 standard.

Frequency of the internal controls of the raw material, manufacturing procedures and finished product are established in the internal autocontrol procedures with the knowledge of the IETcc.

5.1.1 *Raw materials*

The suppliers of each raw material provide a certificate with the specifications that define their product in accordance with the specifications and technical datasheet required by KERABEN, S.A.

KERABEN, S.A. performs an additional sampling and testing of the physical and chemical specifications of the raw materials on reception:

- humidity (%), chemical analysis, linear contraction, granulometric distribution and rejection, presence of carbonates, loss through calcination and plasticity.

5.1.2 *Processes*

PROCESS	CONTROL
Preparation of pastes	**Humidity control of the raw materials, verification of the ball size of the grinding material, density and viscosity of the slip from the wet mills, rejection, determination of the slip particle size, humidity control of the atomisation process and granulometric distribution, temperature control of the drying gases in the atomiser, linear contraction.**
Pressing	**Pressing pressure, weight of the parts, apparent density, mechanical resistance, output temperature of the parts from the post-pressing dryer, deviation of orthogonality.**
Enamelling and decoration	**Density and viscosity of the slip, enamel and silk screen printing.** **Weight of the application.**
Firing	**Control of the temperature, gas atmosphere inside the furnaces during the firing cycle.** **Dimension control when they are taken out of the furnace and water absorption.**
Machining	**Dimension control when they come out of the machining processes.**
Classification	**Surface appearance control, determination of the dimension of deviations regarding length and width, straightness of sides, orthogonality, flatness of surface and twisting.**
Grooves and meshing	**Determination of the dimension of deviations regarding the position and width of the groove.** **Control of the meshing.**

5.1.3 *Finished products*

100% inspection of the dimensional and surface specifications of the tiles and sampling to determine the physical and chemical properties of the batch, as specified below:

- Physical properties:
  Water absorption (%).
  Resistance to bending (N/mm^2).
  Hardness against surface scratching (Mohs scale).
  Resistance to enamelled surface abrasion.
  Thermal shock resistance.
  Resistance to cracking.
  Resistance to frost.

- Chemical properties:
  Resistance to stains.
  Resistance to domestic cleaning products and swimming pool additives.

Resistance to acid and alkalis.

All the controls and inspections are regularly recorded in registers as provided by the quality assurance system procedures. The tests on finished products are performed in accordance with the UNE-EN ISO 10545 standards.

5.2 Quality control of building front fixing devices

These parts are not manufactured by KERABEN, S.A. Consequently, suppliers are required to provide a certificate with each supply on the technical specifications and compliance with the respective standards.

The controls performed by KERABEN, S.A. on brackets, struts, clip plates and clips on reception are as follows:

- General aspect and finished.
- Dimensions.
- Verification of the technical specification certificate.

5.2.1 *Fixing devices*

The fixing device supplier must guarantee that the fixing device system products have passed the internal manufacturing and final product controls in accordance with the corresponding internal procedures and standards. The supplier must also guarantee that all the products comply with the material specifications and load values indicated in the supplier's current manuals and catalogues, as long as they are installed in accordance with the supplier's recommendations and instructions.

Where applicable, the fixing device must bear the EC marking.

6. PACKAGING, TRANSPORT, STORAGE AND HANDLING

The tiles are distributed on wooden pallets, strapped in packs of no more than 3 units with several points of adhesive between each one to prevent rubbing. During palletisation, 2 blocks must be formed with cardboard separators between both blocks. Finally, the pallet must be perfectly strapped and packaged.

The tiles must be placed in the middle of the transport so that they do not move in order to avoid damage during transport.

The material must be unloaded as near as possible to the place of use in order to avoid unnecessary carrying. To prevent the deterioration of the surface from rubbing with sharp particles, the tiles must not be slid along on top of each other, but rather lifted one by one.

The materials must not be knocked about during the loading process or during handling and they must not be dropped.

Gloves must be worn when handling the tiles during transport and installation.

7 . SET-UP

7.1 General specifications

Fixing the tiles to the aluminium structure must be carried out by specialised personnel with the aforementioned fixing devices so that the tile is not exposed to stress and has sufficient freedom of movement.

7.1.1 *Fixing system*

The fixing system must anticipate the dilation of the tiles and be defined in accordance with the following:

- Wind loads
- Maximum distances between the tile fixing points
- Tile format

The devices for fixing the substructure to the support must be calculated to withstand the stress that is transmitted. Accordingly, the condition and type of the support must be studied to enable the correct choice of fixing device, as described in section 3.4.

7.1.2 *Ventilation*

Consideration must be given to the existence of a continuous air chamber of at least 3 cm in thickness, ventilated by natural upward convection behind the cladding.

Regardless of the position of the building front and the type of seals, the ventilation of the front is guaranteed by the air inlet opening at the bottom of the cladding, lintels and the outlets at the window sills and finishes at roof level.

The amount of the opening for ventilation must be based on the height of the building:

- minimum: 20 cm^2/ml.
- height $h \leq 3$ m: 50 cm^2/ml.
- height $3 < h \leq 6$ m: 65 cm^2/ml.

- height 6 < h ≤ 10 m: 80 cm^2/ml.
- height 10 < h ≤ 18 m: 100 cm^2/ml.

7.2 **Installation**

The sequence of the set-up operations must be as follows:

- Staking out.
- Application of brackets.
- Application of sections.
- Application of the installation, where applicable.
- Application of clip plates and clips at the bottom of the building front.
- Successive application of clip plates, clips and tiles from bottom to top and application of seals.

7.2.1 *Staking out*

The building front must be staked out to check the planimetry of the support that is to be cladded, checking the plane for the correct choice of the fixing device.

The distance between the axes of the sections will depend on the tile format, with an approximate maximum separation distance of 100 cm, in accordance with the definitions given in the project as based on calculations.

Specifications of the supporting wall regarding verticality and flatness must meet the conditions provided in the TBC, as well as in the corresponding current legislation and standards.

7.2.2 *Application of brackets*

The brackets must first of all be fitted to the corresponding supporting wall using appropriate fixing devices.

The brackets must be applied and distributed in line vertically and counterweighted, distributed between the edges of the top slab. The vertical distance will depend on the type and state of the support and on the loads that have to be transmitted, where the said distance must always be less than 100 cm if the support so allows.

7.2.3 *Application of the vertical sections*

The vertical sections will be applied at an approximate maximum distance of 100 cm between sections.

The flatness of the struts of extruded aluminium must be guaranteed by an appropriate fixing device system to ensure that the cladding system planimetry is correct.

The vertical sections must be perfectly in line and fastened with fixed mounting holes to the brackets in order to guarantee the correct movement of the substructure and planimetry.

The minimum horizontal seal between vertical struts will be 2 mm per linear metre of section.

7.2.4 *Application of insulation*

When applied, the entire exterior face of the supporting wall and the resistance structure of the building must be covered in accordance with the project specifications.

7.2.5 *Application of clip plates, clips and tiles*

First of all, the clip plate is applied and bolted to the vertical section with two bolts.

We then attach the base clips to the clip plate and position the ceramic tile on the lower clips, fitting the top legs of the clips into the piece. The top clips are then fitted perfectly into the top grooves and the clip plate is then inserted. After this operation, the parts are then stabilised.

The same procedure is then applied to the upper levels.

7.2.6 *Seals*

The seals between the tiles must always be open. The vertical seal must be between 3 and 7 mm and the horizontal seal must be between 4 and 6 mm.

The building dilation seals must always coincide with a vertical seal of the building front system by means of a double section.

8. REFERENCES OF USE

The manufacturer provides the following building work as references:

- Recosan Offices (office building) Vall de Uxó (Castellón), 450 m^2 (2006).
- Municipal Library of Ermua (Bizkaia), 1.000 m^2 (2006).
- Añuri Office Building, Añezcar (Navarra), 200 m^2 (2006).
- Hotel ABBA, HUESCA, 1.100 m^2 (2006).

- "Juan Carlos I" Apartment Block , Talavera de la Reina, 2.500 m^2 (2007).
- "Reyes Católicos" Apartment Block, Talavera de la Reina, 6000 m^2 (2007).
- Hotel in Algeciras (Cádiz), 700 m^2 (2007).
- "Suite La Marquesa" Residence for the Elderly, Jerez de la frontera (Cádiz), 400 m^2 (2007).
- Refurbishment of the "El Madrugador" Building, Pto. de Sta. Maria (Cádiz), 8000 m^2 (2007).
- Refurbishment of Hospital Gran Vía, Castellón, 4000 m^2 (2008).
- Hotel Playa Cotobrom, Almuñecar (Málaga), 1300 m^2 (2008).
- "Picasso" Apartment Block, Jerez de la Frontera (Cádiz), 3300 m^2 (2008).

The IETcc has made several visits to the building work and completed questionnaires with users, all with satisfactory results.

9. CALCULATION CRITERIA

The actions are defined in accordance with the TBC DB-SE-AE on Structural Safety - Building Actions. For the calculation, the following is considered:

- The ceramic tiles must withstand the wind load (pressure/suction) transmitted through the substructure and the fixing devices to the support, which must withstand the said stress. The tiles, substructure and fixing devices must withstand the stress produced by the wind, as well as their own weight.

- The deflection of the ceramic tiles must be equal to or less than 1/150 of the distance between the fixing points.

- The deflection of the sections must be equal to or less than 1/150 of the distance between the fixing points.

- The weight of the tiles is distributed between the lower clips which, together with the clip plate, must transmit the loads as anticipated.

10. TESTS

The following tests have been performed at Instituto de Ciencias de la Construcción Eduardo Torroja (IETcc) (Report No. XXXXX according to the UNE-EN ISO 10545 standards, the EOTA Technical Report TR 001 and the draft version of the EOTA *"Guideline for European Technical Approval of Kits for external wall claddings. Part 1: Ventilated cladding elements and associated fixing devices"*.

10.1 **Ceramic tile identification tests**

10.1.1 *Geometric*

Test performed in accordance with the UNE-EN ISO 10545-2:1998 standard.

The maximum, minimum and average values for the various measurements taken of 10 tiles with nominal dimensions of 1000 mm x 500 mm x 13 mm.

- Length:	Maximum value	L = 1.000.11mm
	Minimum value	L = 999.01 mm
	Average value	L = 999.75 mm
- Width:	Maximum value	a = 499.67 mm
	Minimum value	a = 499.40 mm
	Average value	a = 499.57 mm
- thickness:	Maximum value	e = 13.76 mm
	Minimum value	e = 12.36 mm
	Average value	e = 13.10 mm
- Straightness = 0.20 %		Maximum valueR
edges:	Minimum value	R = 0.00 %
	Average value	R = 0.03 %
- Orthogonality:	Maximum value	R = 0.15 %
	Minimum value	R = 0.00 %
	Average value	R = 0.06 %

All the results obtained are within the tolerance limits defined by the manufacturer.

10.1.2 *Apparent density*

According to the UNE-EN ISO 10545-3:1997, the following has been obtained:

$$D_{ap} = 2.36 \text{ g/cm}^3.$$

10.1.3 *Water absorption*

According to the UNE-EN ISO 10545-3:1997 standard, the average water absorption value is:

$$W = 0.29 \%$$

10.2 **Mechanical specifications**

10.2.1 *Tile bending test*

Tests performed in accordance with the UNE-EN ISO 10545-4:1997 standard.

The test has been performed on 5 tiles with nominal dimensions of 1000 mm x 500 mm x 13 mm, applying a load to the centre of the tile.

The space between supports was 980 mm. The fracture stress values obtained were as follows:

Maximum fracture stress: σ_{max} = 34.70 MPa
Minimum fracture stress: σ_{min} = 31.05 MPa
Average fracture stress: $\sigma_{average}$ = 33.22 MPa
Constant wind pressure [1]: P_v = 743.7 kp/m^2

10.3 ***Durability***

Each durability test determines the fracture load and the fracture stress for 5 tiles with nominal dimensions of 1000 mm x 500 mm x 30 mm, in accordance with the definitions given in section 10.2 after the accelerated ageing test has been performed.

10.3.1 *Heater at 80°C*

The tiles are kept in a heater at 80°C for 28 days and 56 days, with the following results for the fracture stress and fracture load:

a) *Heater 28 days*

Maximum fracture stress: σ_{max} = 36.41 MPa
Minimum fracture stress: σ_{min} = 30.15 MPa
Average fracture stress: $\sigma_{average}$ =32.46 MPa
Constant wind pressure [2]: P_v = 687.0 kp/m^2

b) *Heater 56 days*

Maximum fracture stress: σ_{max} = 33.88 MPa
Minimum fracture stress: σ_{min} = 29.46 MPa
Average fracture stress: $\sigma_{average}$ = 31.43 MPa
Constant wind pressure [2]: P_v = 705.0 kp/m^2

10.3.2 *Saturation and drying*

The ceramic tiles are subjected to the action of the following cycle, as defined in the UNE-EN 494:1995 standard, test 7.3.5:

- Immersion in water at ambient temperature for 18 hours.
- Drying in heater at 60 ± 5ºC for 6 hours.

After 50 cycles, the results for the fracture stress and fracture load are as follows:

Maximum fracture stress: σ_{max} = 33.80 MPa
Minimum fracture stress: σ_{min} = 28.10 MPa
Average fracture stress: $\sigma_{average}$ =31.24 MPa
Constant wind pressure [2]: P_v = 672.8 kp/m^2

10.3.3 *Frost-Defrost*

Test consisting of the following frost-defrost cycle, as defined in the UNE-EN 494:1995 standard, test 7.4.1:

- Cooling in freezer at - 15ºC for 3 hours.
- Immersion in water at ambient temperature for 3 hours.

The fracture stresses and fracture load obtained for the ceramic tiles after 50 cycles are as follows:

Maximum fracture stress: σ_{max} = 39.64 MPa
Minimum fracture stress: σ_{min} = 28.98 MPa
Average fracture stress: $\sigma_{average}$ =33.91 MPa
Constant wind pressure [2]: P_v = 693.7 kp/m^2

There was no fracturing of the grooves on the tiles.

10.4 Aptitude test for using the system

10.4.1 Resistance to hard body impact test

Test performed in accordance with the specifications provided in the draft version of the EOTA *"Guideline for European Technical Approval of Kits for external wall claddings. Part 1: Ventilated cladding elements and associated fixing devices"* (January 2006 edition) section 5.4.4.1 *"Resistance to hard body impact"*.

To perform the test, an installation of tiles with nominal dimensions of 1000 mm x 500 mm x 13 mm was used, fixed to the aluminium substructure as described in the technical report. In turn, the substructure was fixed to the test bench. The separation between struts was 1,000 mm.

A second unit was made with an intermediate section, in which the tiles were fixed by means of a polyurethane fixative.

The test was performed by hitting the tiles with steel balls of 0.5 and 1 kg. The following results were obtained for the two solutions that were tested:

a) Tiles fixed mechanically at the ends (4 fixing devices)

Impact energy	
1 joule	fracture without detachment
3 joules	fracture without detachment

[1] Constant wind pressure corresponding to the minimum fracture stress.
[2] Constant wind pressure corresponding to the minimum fracture stress.

10 joules	fracture without detachment

b) Tiles fastened mechanically at the ends (4 fixing devices) with a central section

Impact energy	
1 joule	no fracture or cracks
3 joules	cracks but no fracture
10 joules	fracture without detachment

10.4.2 Resistance to soft body impact test

Test performed in accordance with the specifications provided in the draft version of the EOTA *"Guideline for European Technical Approval of Kits for external wall claddings. Part 1: Ventilated cladding elements and associated fixing devices"* (January 2006 edition) section 5.4.4.2 *"Resistance to soft body impact"*.

To perform the test, an installation of tiles with nominal dimensions of 1000 mm x 500 mm x 13 mm was used, fixed to the aluminium substructure as described in the technical report. In turn, the substructure was fixed to the test bench. The separation between struts was 1000 mm.

The test was performed by hitting the tiles with sacks of 3 and 50 kg in weight. The tiles were situated on an deformation-proof bench. The following results were obtained for the two solutions that were tested:

Impact energy	
10 joules	no fracture or cracks
3 x 60 joules	no fracture or cracks
300 joules	fracture without detachment

10.4.3 Hygrothermal behaviour test

Test performed in accordance with the specifications provided in the draft version of the EOTA *"Guideline for European Technical Approval of Kits for external wall claddings. Part 1: Ventilated cladding elements and associated fixing devices"* (January 2006 edition) section 5.4.7 *"Hygrothermal behaviour"*.

To perform the test, an installation of three tiles with nominal dimensions of 1000 mm x 500 mm x 13 mm was used, fixed to the aluminium substructure as described in the technical report. In turn, the substructure was fixed to a supporting wall with a separation between struts of 1000 mm.

The test was performed in two phases: the first was a heat-rain; and the second was heat-ice.

a) Heat-rain

The unit was subjected to 80 cycles, where each cycle consisted of the following:

- Heating to 70 ± 5ºC for 1 hour to reach the temperature and 2 hours of maintenance.
- Sprinkled with water for 1 hour.
- Drained for 2 hours.
- Pause of 10 minutes ± 1 minute.

After the 80 cycles, there were no apparent faults in the tiles or permanent deformations to the fixing devices or sections of the substructure.

b) Heat-ice

The unit was subjected to 5 cycles, where each cycle consisted of the following:

- Heating to 50 ± 5ºC for 1 hour to reach the temperature and 7 hours of maintenance.
- Cooling to 20 ± 5ºC for 1 hour to reach the temperature and 14 hours of maintenance.

After the 5 cycles, there were no apparent faults in the tiles or permanent deformations to the fixing devices or sections of the substructure.

10.4.4 Tests on the substructure. Vertical section

Considering the aluminium section of a length of 1.50 m on two supports, applying a load to the central section in accordance with the force of the wind and having obtained its load-deformation curve, the profile, when working elastically, withstands a total load of 1.40 kN, which is equivalent, for a separation between struts of 1.0 m and a separation between supports of 1.0 m, to 420 kp/m^2.

10.4.5 *Pressure-suction tests on the fixing devices*

Test performed according to the internal procedure of the DIT laboratory to determine the resistance to suction from the wind of the fixing devices of ventilated fronts.

To perform the test, a tile with nominal dimensions of 1000 mm x 500 mm x 13 mm was used, fixed to 2 aluminium sections in accordance with the

specifications given by the manufacturer and as described in the technical report.

Two series of three tests were performed, one series with the loads applied in the direction of the wind pressure and another with the loads applied in the direction of the suction caused by the wind.

a) Resistance to the force of the wind

The test ends when the groove on the tile breaks, obtaining an average fracture load of 2.30 kN, equivalent to a consistent wind pressure-suction of 464 kp/m^2.

b) Resistance to wind suction

The test ends when the groove on the tile breaks, obtaining an average fracture load of 1.69 kN, equivalent to a consistent wind pressure-suction of 338 kp/m^2.

10.4.6 *Vertical load test*

The test was performed in accordance with the specifications provided in the draft version of the EOTA *"Guideline for European Technical Approval of Kits for external wall claddings. Part 1: Ventilated cladding elements and associated fixing devices"* (January 2006 edition) section 5.4.2.6.2 *"Resistance of vertical load"*.

To perform the test, a unit comprising a tile with nominal dimensions of 1000 mm x 500 mm x 30 mm was used, fixed to the aluminium substructure, which was in turn fixed to the test bench with a separation of 975 mm.

A deflection gauge was then positioned in the centre of the tile to measure the vertical movements of the tile under a static load corresponding to the weight of the plate elements (30 kg).

After 24 hours, there were no apparent deformations or damages to the tile or the fixing devices.

10.5 System durability tests

10.5.1 *Suction fatigue test*

The test was performed according to the internal procedure of the DIT laboratory to determine the resistance to suction fatigue from the wind of the fixing devices of ventilated fronts.

The tests were performed by applying a load at a frequency of 0.5 Hz over 25,000 cycles.

After the fatigue test, the initial static wind suction test was performed. The test was performed on three ceramic tiles and obtained an average fracture load value of 1.74 kN, equivalent to a consistent wind pressure of 347 kp/m^2.

11. ASSESSMENT OF THE APTITUDE FOR USE

11.1 **Compliance with national regulations**

11.1.1 ***SS - Structural safety***

The system for cladding ventilated building fronts with KERABEN ceramic tiles does not contribute to the stability of the building.

The rear wall, the support for the tile cladding, must comply with the standards that correspond to the essential requirements for structural safety and consideration must be given to the actions and loads that correspond to the incorporation of the ventilated front.

The connection between the substructure of the system and the rear wall must be anticipated so that the extreme limit stresses and the durability limit values are not exceeded during the period of use.

11.1.2 ***FS - Fire safety***

The composition of the wall, including, where applicable, the installation, must comply with the TBC, basic fire safety document (DB-SI) regarding stability in the event of fire, as well as the reaction to fire of the materials used in its composition.

In accordance with Decision 96/603/CE of the Commission, dated 4 October 1996, the products made of fired clay obtain a fire classification of class A1 (no contribution to fire) without the need for tests.

The material meets the requirements of the CTE-DB-SI (SI-2 section 1.4) regarding exterior propagation for exterior building front cladding materials and cladding materials for the interior surfaces of the ventilated chambers of building fronts.

The vertical development of the air chamber will be limited to 3 heights or 10 m when any of the materials used in its composition do not have a B-s3, d2 or higher class of reaction to fire, in compliance with the CTE-DB-SI, SI-1 section 3, on "Hidden spaces. Passage of installations through fire compartment elements", where it must be divided by a firewall element.

11.1.3 ***SU - Safety of use***

For the lower areas of the buildings, next to areas that may be used by the general public, there should be an intermediate vertical section to which the tiles must be fastened by means of an adhesive fixative as described in test 10.4.1.

This section may not be considered for resistance to wind suction.

11.1.4 ***HS - Health safety***

The complete solution for the wall must guarantee the minimum level of impermeability required for the building to which it is incorporated, as described in the TBC, basic health safety document (DB-HS), in order to meet the basic requirement for protection from damp (HS 1, section 2.3).

Based on the definition of the system given in the technical report and depending on the required level of impermeability, the ventilation of the air chamber may be increased as described in the CTE-DB-HS (HS-1, section 2.3).

Special care must be taken with the design of the building fronts, the incorporation of the windows and lighting elements, as well as the correct solution for the special points, such as exterior fixing devices, etc. to achieve the appropriate watertightness at the said points, avoiding the accumulation and filtration of water.

The verification of the limitation of surface and interstitial condensation humidity must be carried out in accordance with section HE-1 (limitation to the demand for energy) of the CTE-DB-HE (HE-1, section 3.2.3).

The parts of the system, as declared by the manufacturer, do not contain or release hazardous substances in accordance with national and European legislation.

11.1.6 ***HR – Noise protection***

The complete wall solution and, basically, the supporting wall and the installation must meet the requirements of the CTE-DB-HR regarding noise protection.

11.1.5 ***HE - Energy-saving***

The complete wall building solution must meet the requirements of the TBC, basic energy-saving document (DB-HE), regarding hygrothermal behaviour.

As described in the technical report, for the intents and purposes of calculating the thermal transmittance, as described in Appendix E of the CTE-DB-HE, the system air chamber will be considered as a "highly ventilated air chamber" and the total thermal resistance of the wall will be obtained by deducting the thermal resistance of the air chamber and the other layers between the air chamber and the exterior atmosphere, including an exterior surface resistance that corresponds to the air when there is no wind, equal to the interior surface resistance of the same elements (HE-1, Appendix E).

11.2 Use of the product. Set-up and limitations to use

11.2.1 *Set-up*

Before the installation of the system, the type and state of the support must be checked to define the type and number of fixing devices.

Consideration must be given, during the execution of special points such as the wall below windowsills, lintels and frames etc., to their watertightness and their prior waterproofing, if necessary, as well as the correct drainage of water to avoid accumulation.

The recommendations given in section 6 of the technical report must be applied for handling the tiles. In addition, when handling the tiles, protective gloves must be worn.

11.2.2 *Limitations to use*

The aspects regarding the calculation as provided in section 8 of this document refer to the scope of application of the basic structural safety document regarding actions on the building of the TBC (DB-SE-AE).

For the cases that are not included in the scope of application of the said basic document or when wind action higher than that considered in the CTE-DB-SE-AE is anticipated, a specific study must be performed to determine the action of the wind.

11.3 Waste management

The TBC does not specify requirements for waste management; however, for the waste produced during the manufacturing processes and the set-up of the system, especially adhesives and installation and waterproofing products, the instructions given by the manufacturer must be observed in accordance with the current standards for each product.

For the intents and purposes of waste management, the tiles will be considered as "inert waste". The aluminium of the sections must be recycled, including the parts rejected during the

set-up and when the ventilated front system is disassembled.

11.4 Maintenance and service conditions

In accordance with the durability tests performed and the visits to the site, it is considered that the system behaves satisfactorily in accordance with the requirements for durability, as long as the building front, installed as per the description given in this document, is subjected to appropriate use and maintenance, as provided in the TBC.

In order to clean the tiles, the manufacturer's recommendations must be applied, where the cleaning process is similar to that used for natural stone tiles.

11.5 Issues regarding appearance and aesthetics

The results of the resistance to ultraviolet radiation suggest that the colour stability is satisfactory over time for Western Europe.

12. CONCLUSIONS

The tile manufacturing process of ... includes a quality assurance control that comprises the following:

- An autocontrol system whereby the manufacturer checks the suitability of the raw materials, manufacturing process and product control process.

- External verification of the manufacturing process by accredited external laboratories.

Considering that the manufacturing process and set-up is sufficiently proven in practice, together with the results of the tests, the suitability of the use of the system proposed by the manufacturer is given a favourable report, with the comments made by the expert committee in this DIT.

THE AUTHORS

Tomás Amat Rueda, PhD in Civil Engineering

Rosa Senent Architect

12. COMMENTS BY THE EXPERT COMMITTEE

The main comments made by the expert committee in its meeting at Instituto de Ciencias de la Construcción Eduardo Torroja on 13 May 2008[3], were as follows:

- It is recommended that Keraben, S.A. should provide specific consultancy services for the suction values to which the tiles may be subjected, determining the number of bolts for fixing the clip plates to the vertical struts and the vertical struts to the brackets, as well as the correct torque for the bolts as defined in the technical report.

  Depending on the specific location of the building, its shape and dimensions, the wind pressure and suction values at certain points may be higher than those given in the current standards, which should be taken into account in the calculations.

- It is recommended that KERABEN, S.A. should provide consultancy services for the design and execution of special points and openings.

- Depending on the type and state of the support, the most appropriate fixing device must be used.

[3] (3) The expert committee was made up of representatives from the following organisations and institutions:

- ACCIONA INFRAESTRUCTURAS INGENIERIA.
- AENOR.
- Consejo Superior de los Colegios de Arquitectos de España (CSCAE).
- Control Técnico y Prevención de Riesgos (CPV).
- DRAGADOS.
- Escuela Universitaria de Arquitectura Técnica de Madrid (EUATM).
- FCC Construcción, S.A.
- FERROVIAL AGROMAN.
- INTEC Control de Calidad.
- Instituto Técnico de Inspección y Control, S.A. (INTEINCO).
- Laboratorio de Ingenieros del Ejército.
- Spanish Ministry of Housing.
- SOCOTEC IBERIA.
- QUALIBÉRICA.
- Universidad Politécnica de Madrid (UPM).
- Instituto de Ciencias de la Construcción Eduardo Torroja (IETcc).

- It is recommended that, during the installation work, the struts are fitted first, followed by the insulation, where applicable.

- Since the sections are not continuous, special care must be taken with the levelling of the sections.

- All the metal elements included in the system must not cause corrosion problems.

- For exceptional conditions of high exposure to the presence of chlorides, the use of an AISI-316 stainless steel is recommended for the fixing devices, nuts and bolts and clip plates.

- The use of plastic washers is recommended to avoid contact between the aluminium of the sections and the zinc-plated steel of the fixing devices to prevent galvanic corrosion.

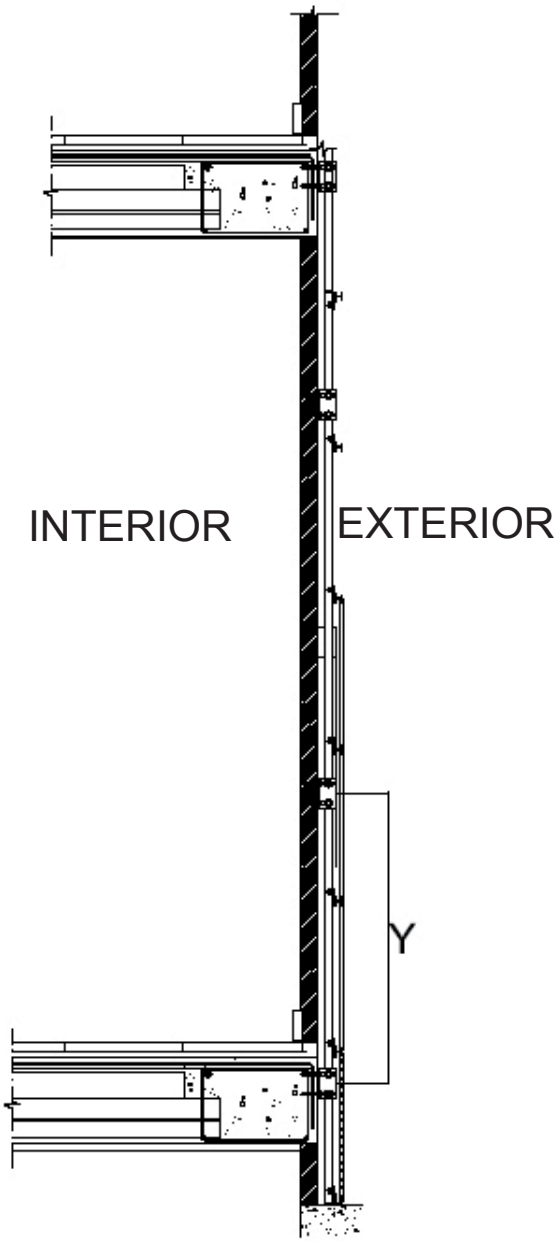
- The cladding seals must be taken into account in relation to the building dilation seals.

- The cladding systems for ventilated building fronts do not guarantee the watertightness of the wall with the exterior layer of cladding only. Whatever the case, the overall behaviour of the complete wall should be studied in accordance with the TBC, basic health safety document (DB-HS) in relation to perfection from damp (HS-1).

- When the building front is in an area with high levels of rainfall and exposed to low temperatures, the upper grooves of the tiles should be sealed with silicone.

- A copy of this technical approval document should be included in the building manual.

FIGURE 1: VERTICAL SECTION



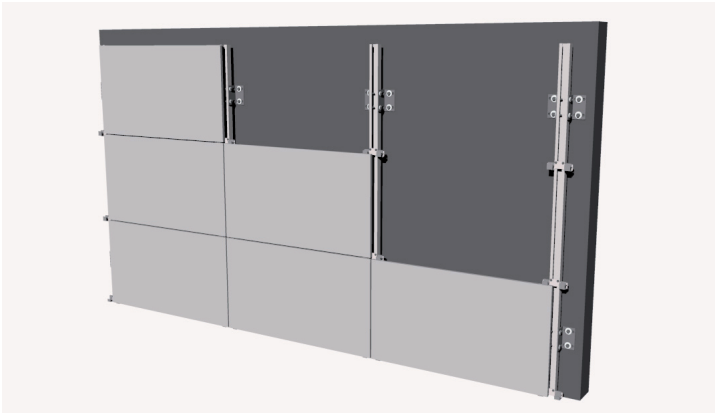
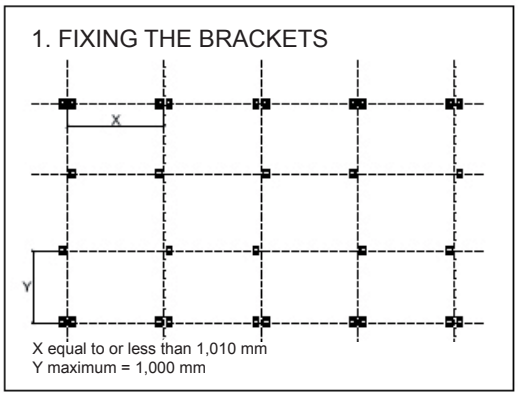
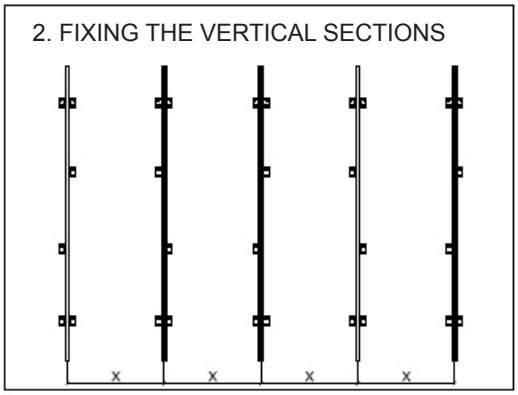
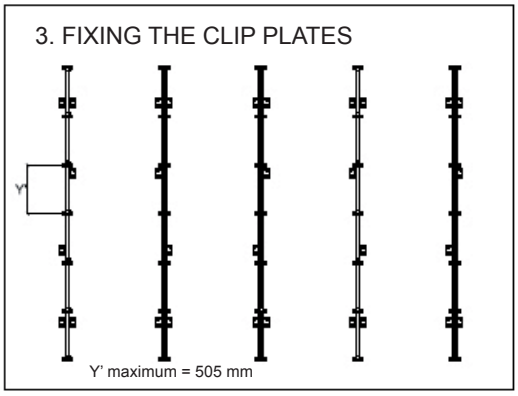


FIGURE 2: INSTALLATION STAGES







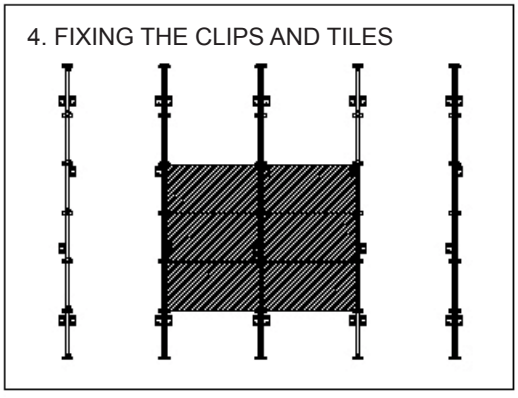
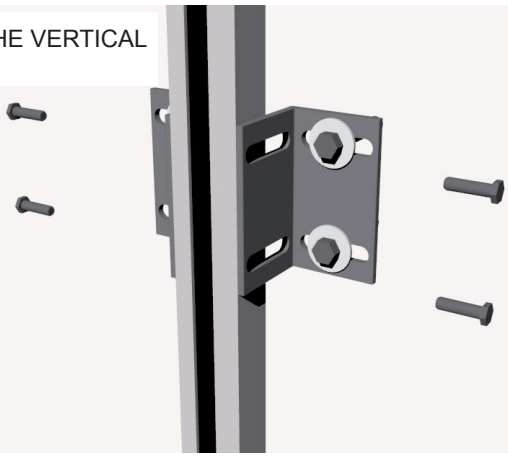


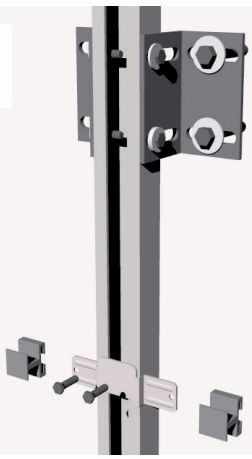
FIGURE 3: SYSTEM DESCRIPTION

FIXING THE BRACKETS

FIXING THE VERTICAL SECTION



FIXING THE CLIP PLATES AND CLIPS



FIXING THE TILES

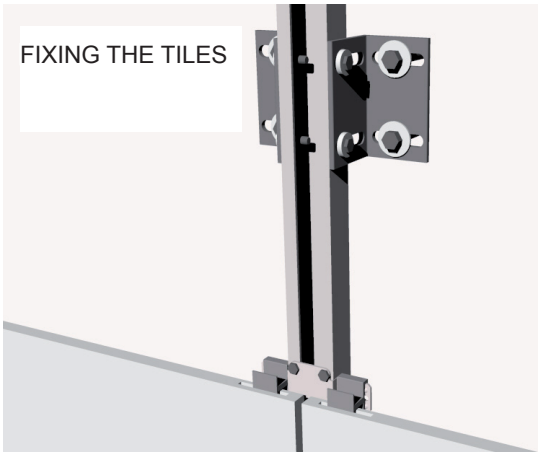
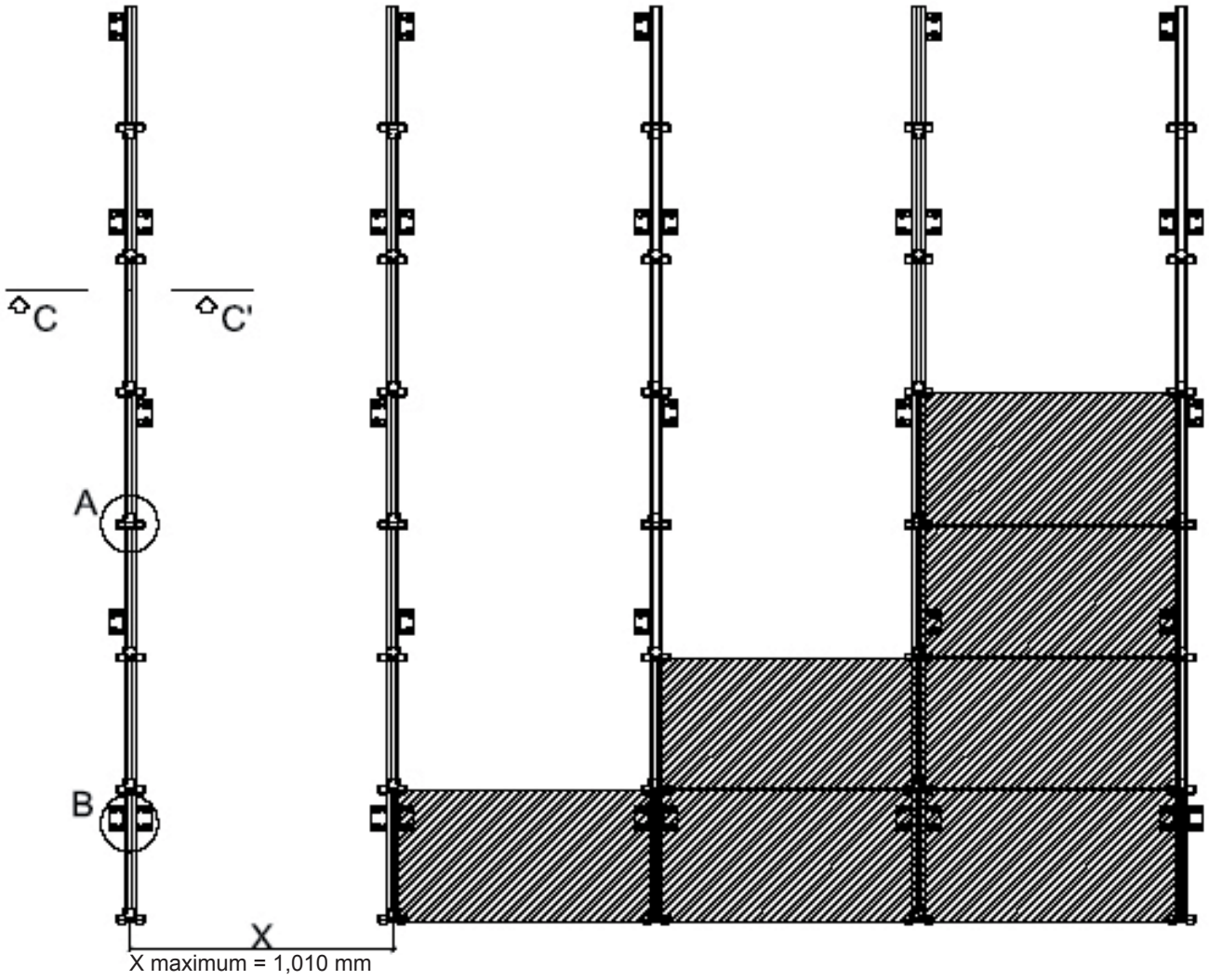
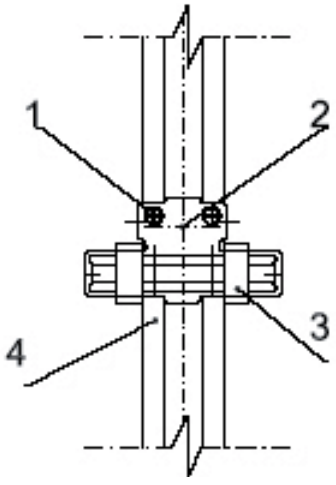


FIGURE 4: ASPECT OF THE SYSTEM

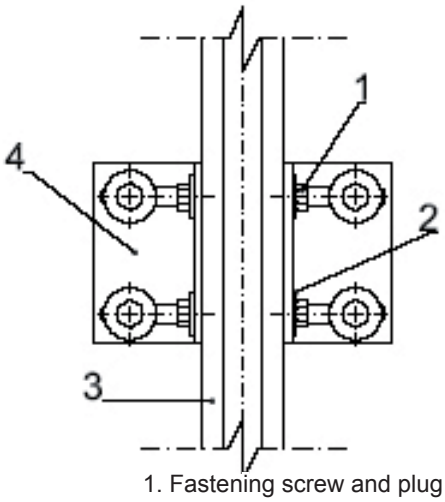


VIEW A:
FIXING THE CLIP PLATE
AND THE CLIPS



1. Self-tapping screw
2. Clip plate
3. Clip
4. Section

VIEW B:
COUPLING OF VERTICAL
SECTION TO BRACKETS



1. Fastening screw and plug
2. Washer
3. Section
4. Bracket

FIGURE 5: BRACKET

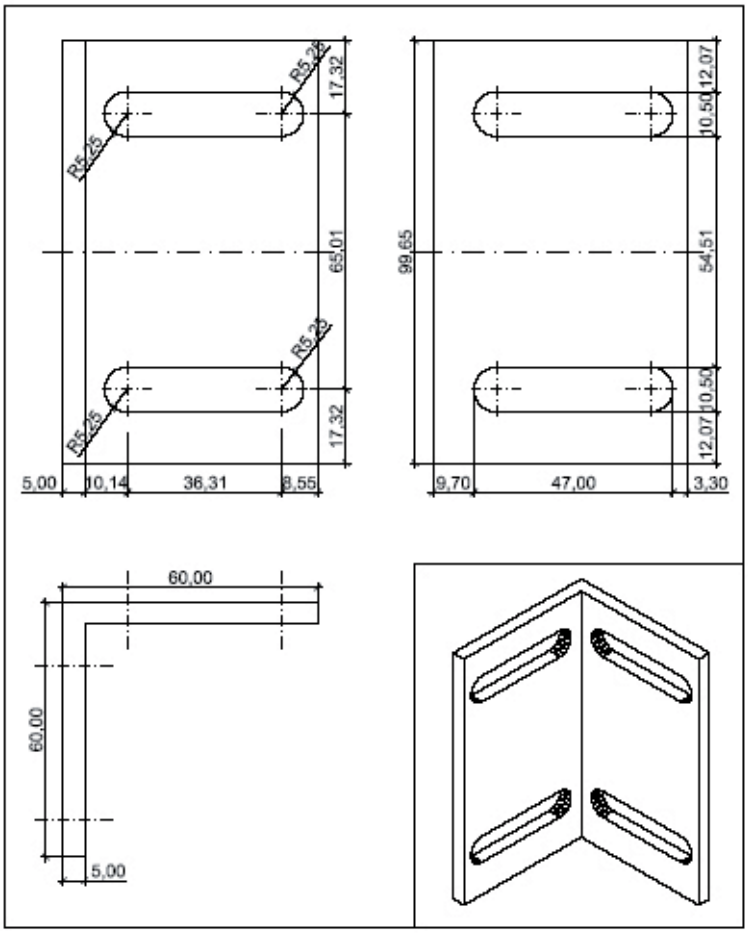


FIGURE 6: VERTICAL SECTION

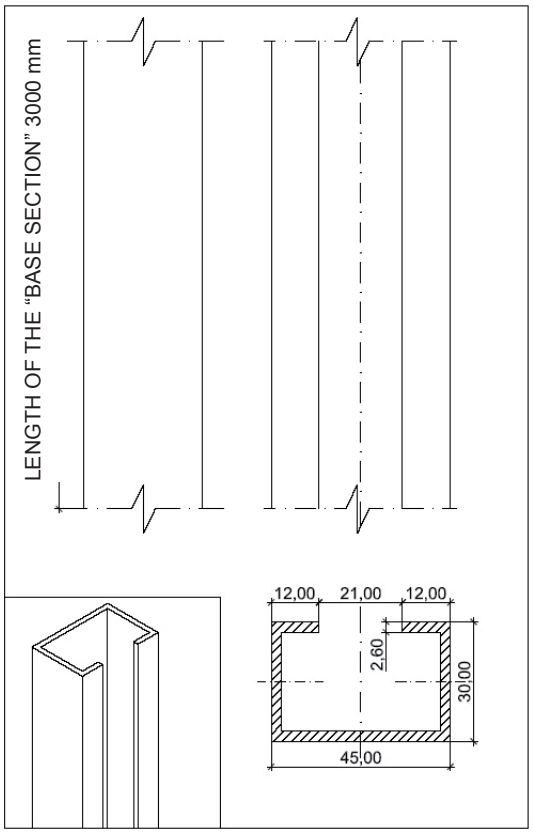


FIGURE 7: CLIP PLATE

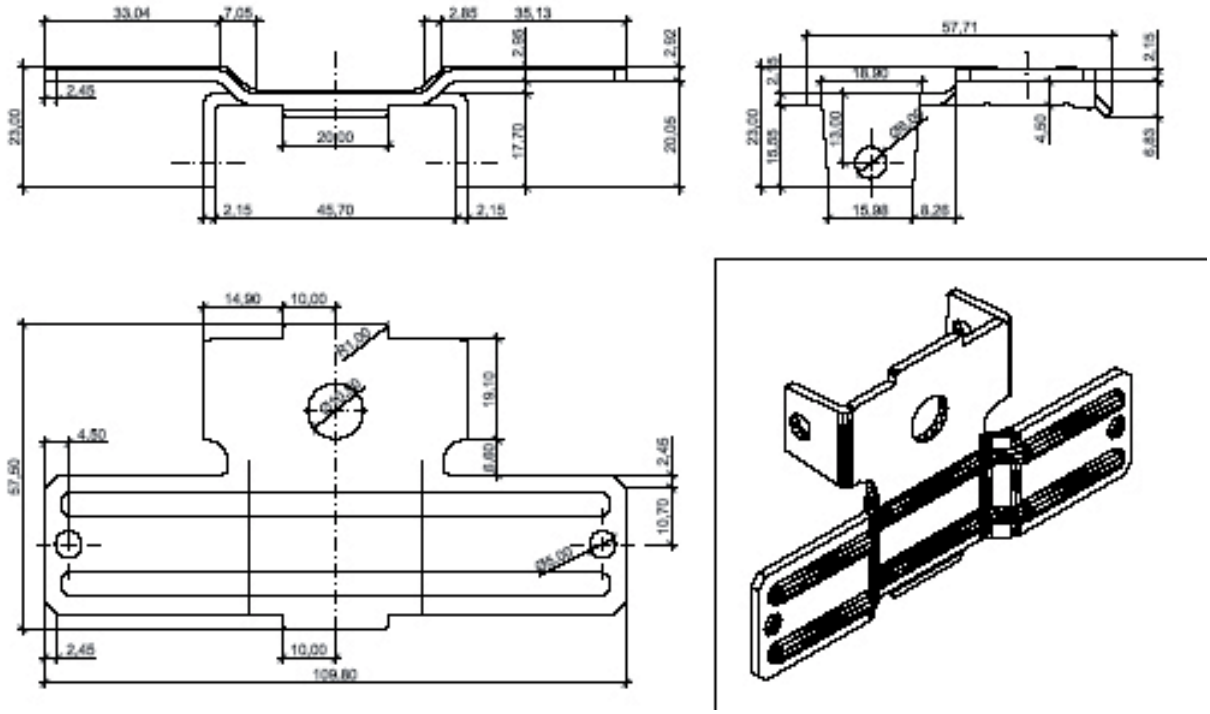
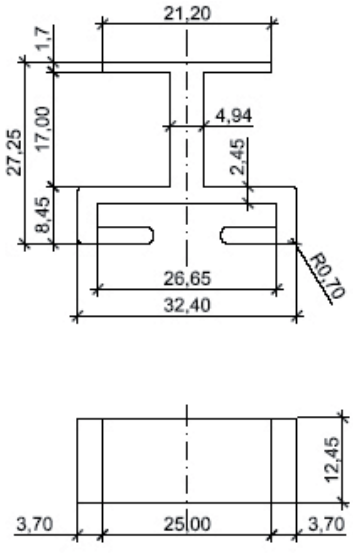
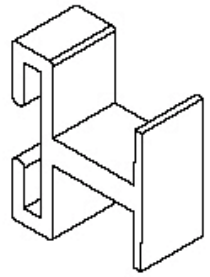


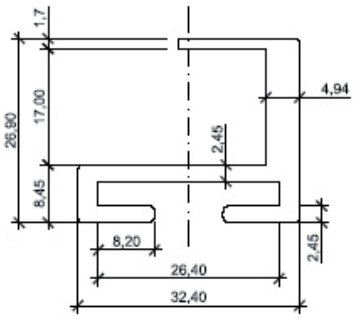
FIGURE 8: CLIPS

INTERMEDIATE CLIP





BASE CLIP



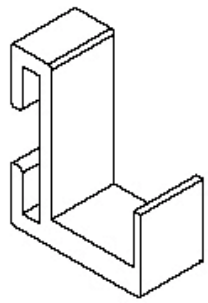


FIGURE 9: TILE AND GROOVES

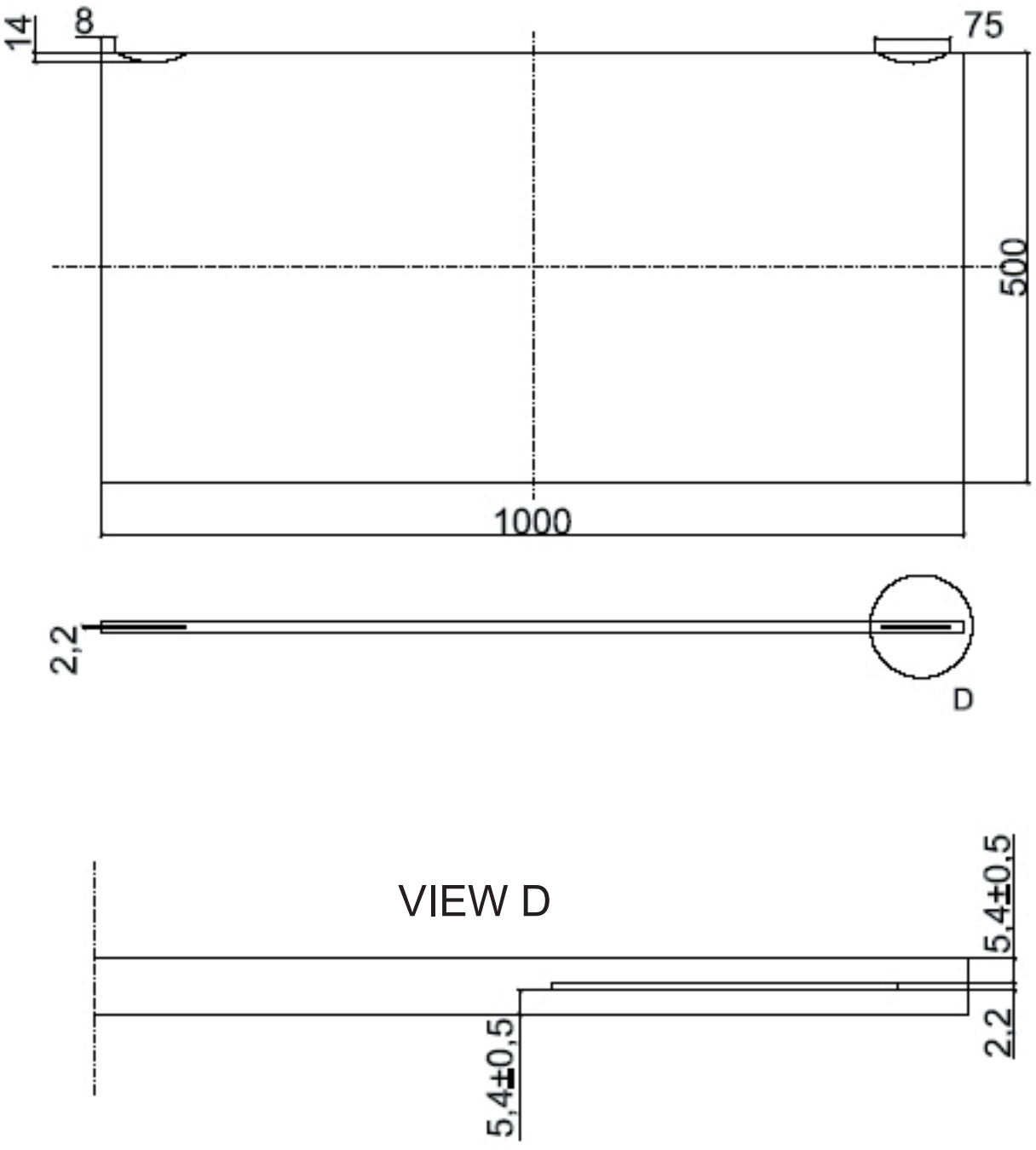
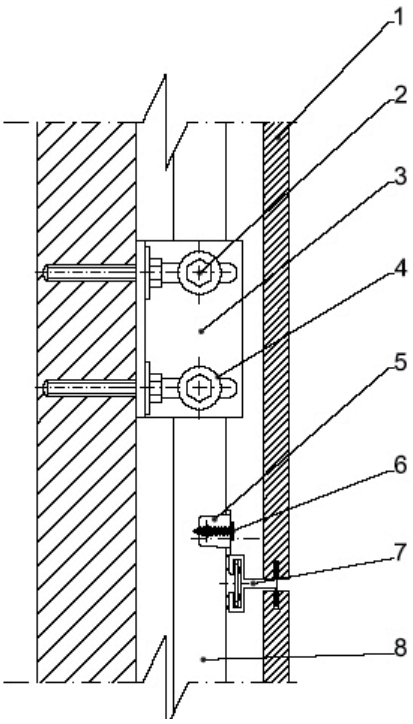
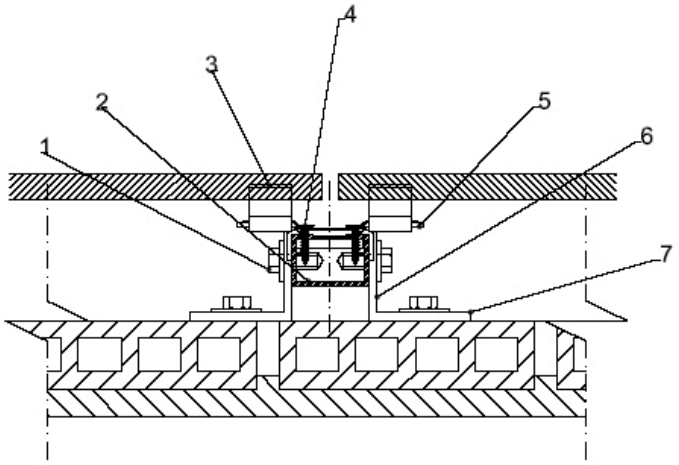


FIGURE 10: VERTICAL SECTION



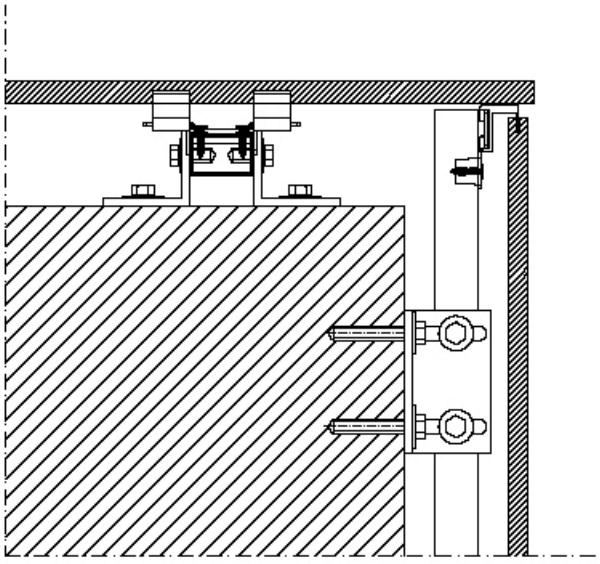
1. Ceramic tile
2. Self-tapping screw
3. Bracket
4. Washer
5. Clip plate
6. Self-tapping screw
7. Clip
8. Section

FIGURE 11: HORIZONTAL SECTION



1. Self-tapping screw
2. Section
3. Clip
4. Self-tapping screw
5. Clip plate
6. Bracket
7. Bracket

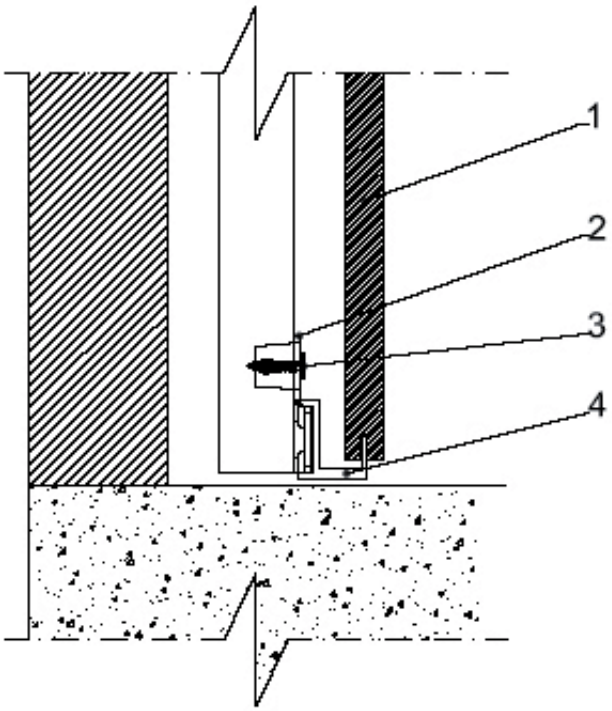
FIGURE 12: VIEW OF TOP



NB:

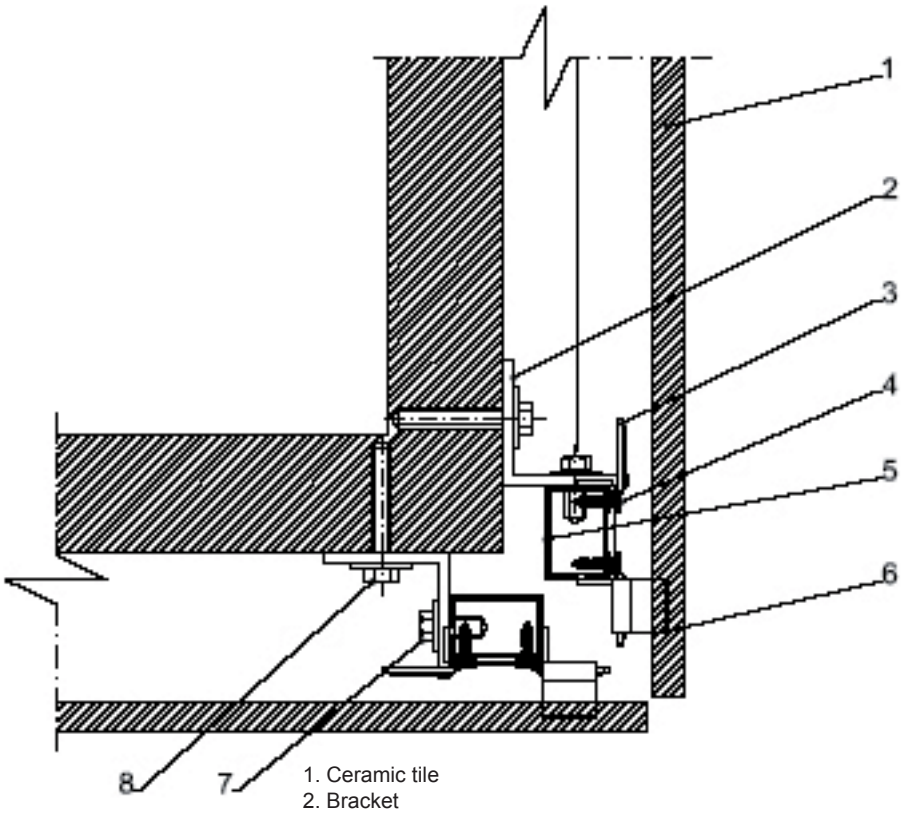
- The details of the construction shown in the figures are approximate and must be defined for each project.
- The details of the construction shown in the figures refer to the ventilated building front fixing system and may not be used to justify compliance with the other basic requirements of the TBC.

FIGURE 13: VIEW OF BASE



1. Ceramic tile
2. Clip plate
3. Self-tapping screw
4. Base clip

FIGURE 14: VIEW OF CORNER



1. Ceramic tile
2. Bracket
3. Clip plate
4. Self-tapping screw
5. Section
6. Clip
7. Self-tapping screw
8. Fastening screw and plug

FIGURE 15: VIEW OF OPENING VERTICAL SECTION

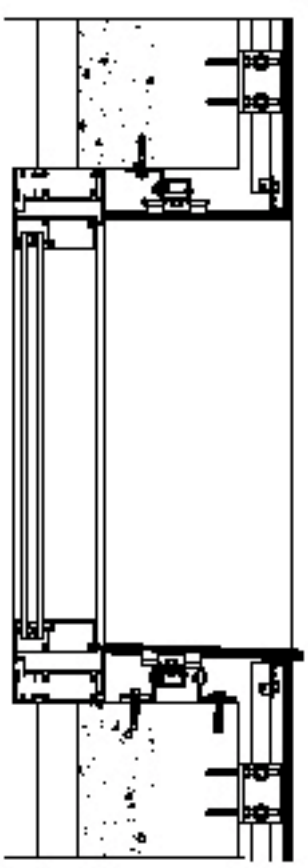


FIGURE 16: VIEW OF OPENING HORIZONTAL SECTION