REPORT 1.2.5

BEST PRACTICE REPORT ON METHODS, SKILLS AND COMPETENCES IN RELATION TO CLAY PRODUCTS

EXECUTION OF SELF-SUPPORTING FACADE WITH VENTILATED AND NON-VENTILATED BRICK EXPOSED FACE

Content

1. INTRODUCTION

1. Background

2. The BIMclay project was born with the purpose of producing and developing didactic materials based on the BIM methodology, which address the challenges related to Life Cycle Analysis (LCA) of clay products, to serve as a training base for professionals in the ceramic sector. To this end, it is necessary to define and compile the most suitable execution systems and placement methods for clay products.
3.
4. The first task of the BIMclay project "O1. *Establishment of common learning outcomes on clay placement methods, Life Cycle Analysis (LCA) and regulations*" encompasses a number of specific tasks among which we find the elaboration of this report.
5.
6. This best practice report addresses the establishment of skills and competencies, as well as the definition of the most sustainable and environmentally friendly implementation processes.

2. ENVIRONMENTAL CONSIDERATIONS

The Environmental Product Declarations (EPDs) are the clearest, most rigorous and internationally accepted way to provide the environmental profile of a product throughout its life cycle.

The EPD "***Ladrillos cerámicos cara vista. Pieza "U" según la Norma UNE-EN 771-1***" (*Execution of self-supporting façade with ventilated and non-ventilated brick exposed face*) has been verified and published in AENOR's GlobalEPD program.

The EPD of ceramic face bricks has been carried out according to the LCA methodology with quantified environmental information of its entire life cycle. That is to say, the EPD of ceramic face bricks is of the "cradle to grave" type, as can be seen in the following table, which includes the life cycle stages considered.

Etapa de producto	A1	Suministro de materias primas	X
	A2	Transporte a fábrica	X
	A3	Fabricación	X
Construcción	A4	Transporte a obra	X
	A5	Instalación / construcción	X
Etapa de uso	B1	Uso	X
	B2	Mantenimiento	X
	B3	Reparación	X
	B4	Sustitución	X
	B5	Rehabilitación	NR
	B6	Uso de energía en servicio	X
	B7	Uso de agua en servicio	X
Fin de vida	C1	Deconstrucción / demolición	NR
	C2	Transporte	X
	C3	Tratamiento de los residuos	X
	C4	Eliminación	X
	D	Potencial de reutilización, recuperación y/o reciclaje	MNE

X = Módulo incluido en el ACV; NR = Módulo no relevante; MNE = Módulo no evaluado

This EPD has been developed and verified according to the UNE-EN 15804 and UNE-EN ISO 14025 standards and the Product Category Rules (PCR) for fired clay products used in the construction of AENOR's GlobalEPD programme.

The EPD functional unit is defined as 1 tonne of ceramic facing brick with an average reference service life of 150 years.

The EPD details the formulation to be used (conversion factor) to transform the functional unit from a ton of ceramic facing brick to a square meter of facade.

3. CONSTRUCTIVE CONSIDERATIONS

3.1. Description of the self-supporting façade construction system

The self-supporting façade construction solution is characterised by the fact that the outer leaf of the enclosure is executed passively in front of the building structure, starting from a firm element (foundation, basement wall head, first floor slab edge beam, etc.) and using the brick wall itself as a self-supporting element. The entire weight of the outer leaf of the façade is transmitted by compression from the factory to the starting element.

From the structural point of view, the self-supporting façade solution supported on itself is more effective than conventional brick solutions supported floor by floor in the slabs. The accumulation of the gravitational load contributes greatly to the stability of the factory against horizontal actions, reducing the cost of auxiliary devices and the risk of wall cracking. This type of solution does not require any auxiliary unloading device, nor does it need to interrupt its continuity with horizontal joints, up to approximately 10 or 15 floors, depending on the structural calculation of the façade.

In addition to the gravitational load, the rest of the resources necessary to achieve the conditions of stability, resistance and cracking control required by the regulations are achieved through the use of auxiliary elements: reinforcement, which increases the resistance to horizontal flexion of the factory by preventing cracking, and retention anchors to the building structure (slab fronts and pillars), which provide the necessary reaction in the supports for stability against horizontal actions. The auxiliary elements required in each particular case, as well as their dimensioning and arrangement, must be determined by means of structural analysis.

With the self-supporting facade construction system, exposed brick façades broaden their scope of application, being able to be used both residential or office buildings, with panels of modest geometric proportions, and industrial or commercial buildings, with panels of large proportions.

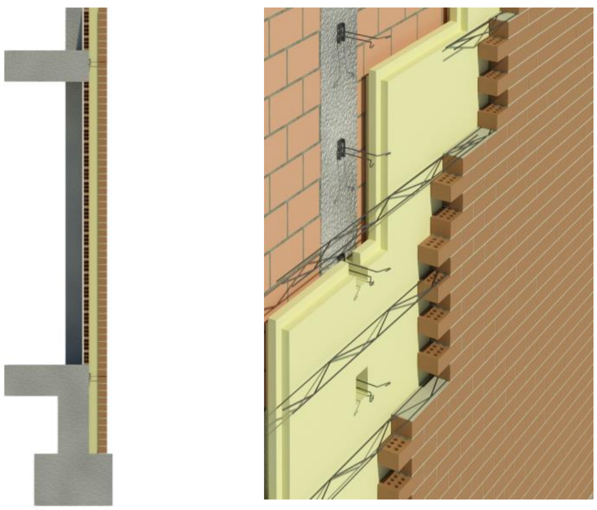
In addition to its good structural behaviour, from a functional point of view, this façade presents an excellent hygrothermal behaviour as it allows the passage of an air chamber and continuous thermal insulation in front of the structure, thus avoiding thermal bridges in the fronts of slabs and pillars.

The elimination of the cold bridges from the fronts of floor and pillars reduces the energy demand of the building, as well as the risk of formation of surface condensations at these points, allowing the construction of buildings with a very high level of energy efficiency.

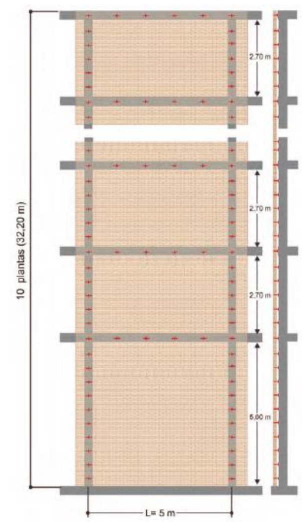
Likewise, if the requirements of impermeability make it advisable, self-supporting facades made of facing brick allow ventilation of the air chamber, achieving a facade with the advantages of ventilated facades (with a higher degree of impermeability and a lower risk of formation of interstitial condensation in the enclosure) and other additional advantages associated with facing brick (such as durability, low maintenance, etc.).

For all the above reasons, this construction system is the optimum solution for facing brick façade for the construction of Nearly Zero-Energy Buildings and Passivhaus.

On the other hand, from the constructive point of view, as the use of platelets to cover the fronts of slabs and pillars is not necessary, nor of cut pieces or special pieces to adjust the stakeout to the height of each floor, the execution process is simplified, the performance on site is improved and a perfect finish of the façade is achieved. In addition, this construction system allows a perfect lead and flatness of the outer leaf of the façade to be achieved, regardless of the geometric deviations of the structure, as well as homogeneity in the tonality of the cloth of the façade.



Scheme of the self-supporting facade of facing brick
Source: HISPALYT (www.hispalyt.es)



Continuity of the outer leaf cloth with visible face up to 10 floors, according to structural calculation
Source: GEOHIDROL, S.A. (www.geohidrol.com)

Figure - Construction system of self-supporting facade of facing brick

3.2 Auxiliary elements

The stability and resistance of the self-supporting façade against horizontal actions is resolved with retention anchors and tendel reinforcement, which have a structural function in self-supporting façades.

3.2.1. Retention anchorages

The retention anchors are necessary by connecting the outer sheet of facing brick to the structural elements of the building (pillars and fronts of slabs) guarantee the stability of the facade wall against horizontal actions.

The anchors are made of stainless steel and consist of two parts:

- Socket: piece that is fixed to the structure and has a groove where the omega will be inserted.
- Omega: piece that joins the exposed brick wall and the socket.

Retention anchorage
Source: GEOHIDROL, S.A.(www.geohidrol.com)

These anchors only prevent movement in the direction perpendicular to the plane of the wall, thus preventing it from tipping over due to wind pressure and suction. However, they allow vertical and horizontal movement in the plane of the wall, avoiding the transmission of loads from the slabs and allowing the movements due to the retraction or expansion of the wall due to humidity.

The anchors must have the appropriate length depending on the thickness of the chamber and the façade. There are anchoring devices to be able to incorporate large thicknesses of thermal insulation in the chamber, maintaining its continuity in the forging fronts.

In order to guarantee the correct mechanical functioning of the anchorage, the omega must penetrate at least 4 centimetres into the factory. There are anchors on the market with a design of the omega wires, with a straight and a curved section, which allows the operator to check their correct placement visually and immediately. An anchorage is considered correct if the wires protruding from the piece are straight and parallel. In this way, the operator only has to check that the wires protruding from the brick do not have any curvature.

	
Correct placement	Incorrect placement
Correct/incorrect positioning of anchors GEOANC® *Source: GEOHIDROL, S.A. (www.geohidrol.com)*	

While the amount and arrangement of the retention anchors must be defined for each project by means of a structural calculation, they are normally placed every 60 cm in the vertical direction (columns) and every 1 m in the horizontal direction (front of slabs).

3.2.2. Armadura de tendel

The placement of reinforcement on factory walls increases the bending strength of the wall and also serves to prevent possible cracking of brick factories. The increase in the bending strength of the factory is directly proportional both to the cross-section and strength of the reinforcement and to its effective width.

Although the amount and arrangement of the reinforcement must be defined for each project by means of a structural calculation, it is usually necessary in the first two rows of the facade start and in the facade cloth every 60 cm (approximately every 10 rows, depending on the brick). It also needs to be placed in parapets, lintels and corners.

In order for the reinforcement to be effective, it must be correctly positioned and overlapped so that there can be an efficient transfer of forces between adjacent reinforcement. The transmission of forces through adjacent reinforcement requires three essential conditions in the end zone: coating, adhesion and overlap length.

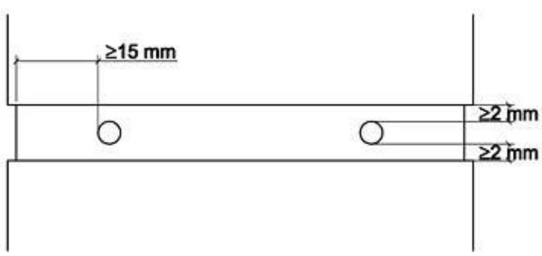


Figure - Coating to the reinforcement
Source: CTE, DB SE-F.

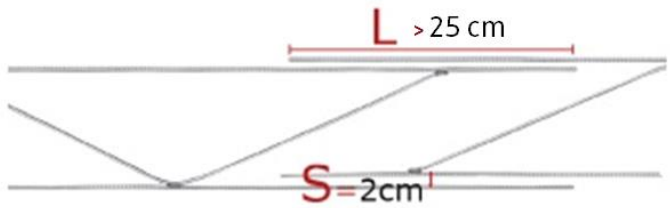


Figure - Length of overlap (L) and lateral separation distance (S).
Source: CTE, DB SE-F

In order to guarantee the three conditions necessary for good mechanical behaviour of the reinforcement (covering, adhesion and overlap length), there are reinforcement on the market with a modified geometry at the ends and a series of devices that facilitate the correct placement of the reinforcement and its control after the execution of the wall. The particularities of these reinforcements are described below:

- **Reinforcement ends design:** the geometry in the form of a plug and with a recess in the wires of the ends, which allows the overlapping of the reinforcements without the need for manipulation by the operator, guaranteeing the conditions of lateral covering between the overlapping reinforcements and the length of the overlap.

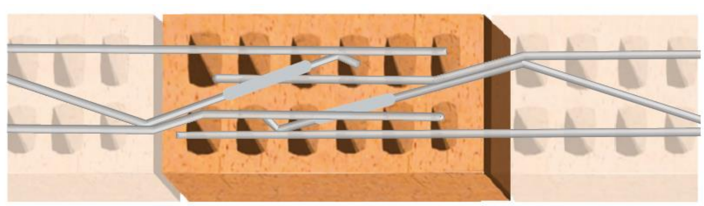


Figure - Reinforcement end design with plug-in structure and wire recesses.
Source: GEOHIDROL, S.A.(www.geohidrol.com)

- **Separators:** elements of cylindrical geometry arranged in the transversal wires that allow the placement of the reinforcement on the brick before pouring the mortar, guaranteeing the thickness of the horizontal joint and the mortar covering of the reinforcement.

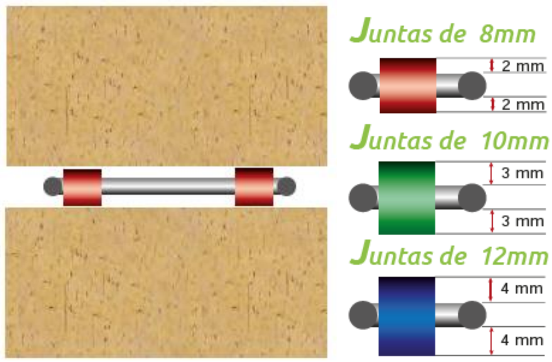
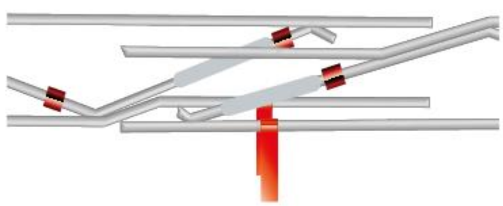


Figure - Separators
Source: GEOHIDROL, S.A. (www.geohidrol.com)

- **Cores:** strips of laminated paper arranged on the wires at the ends, which serve as witnesses to facilitate the correct length of overlap and for subsequent control of amounts and correct execution by a simple visual inspection. In this way, to guarantee the overlap of contiguous armatures, the operator will only have to superimpose the strips of laminated paper of the two armatures to overlap.



Devices SAO
Source: GEOHIDROL, S.A. (www.geohidrol.com)

For the placement of the reinforcement follows the following process:

1. The armour is centred on the bricks of the partition, making the cores of the two adjacent armours coincide and leaving these cores visible on one side of the brick partition.
2. Subsequently the mortar is poured over the brick covering the frame.
3. In the corners the following process will be followed:
    - One of the longitudinal wires of the armour is cut.
    - The reinforcement is then bent at the required angle in the corner.
    - The ends of the cut wire are then bent inwards.
    - Finally, the armour is placed by overlapping it with the adjacent reinforcements.

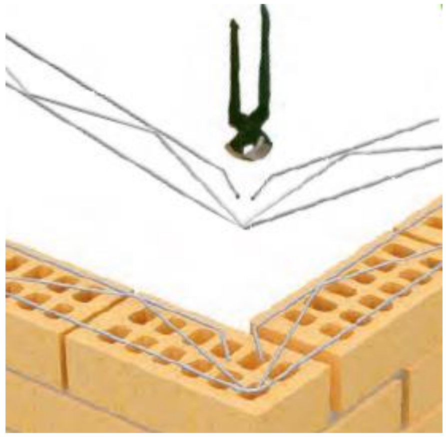
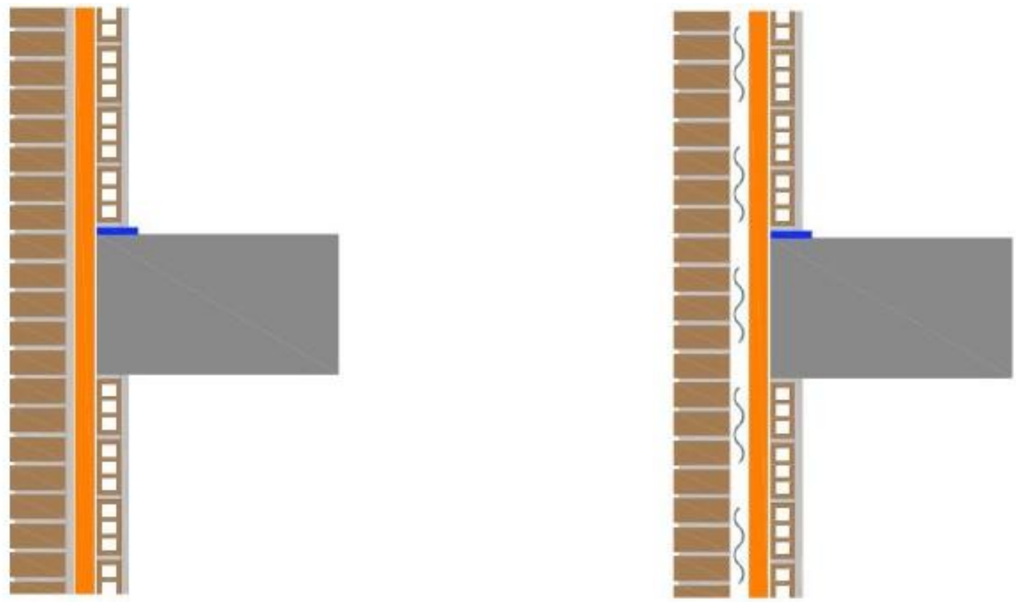


Figure - Placement of the reinforcement in the corners
Source: GEOHIDROL, S.A.(www.geohidrol.com)

4. CONSTRUCTION PROCESS

The construction process to be followed for the execution of a self-supporting facade of exposed brick, depends on whether the facade is ventilated or not ventilated. The assembly of both types of façade is detailed below.



Fachada autoportante no ventilada   Fachada autoportante ventilada

Figure - Soluciones de fachada autoportante de ladrillo cara vista en función de la ventilación de la cámara
Source: GEOHIDROL, S.A. (www.geohidrol.com)

A. IMPLEMENTATION OF THE NON-VENTILATED SELF-SUPPORTING FAÇADE

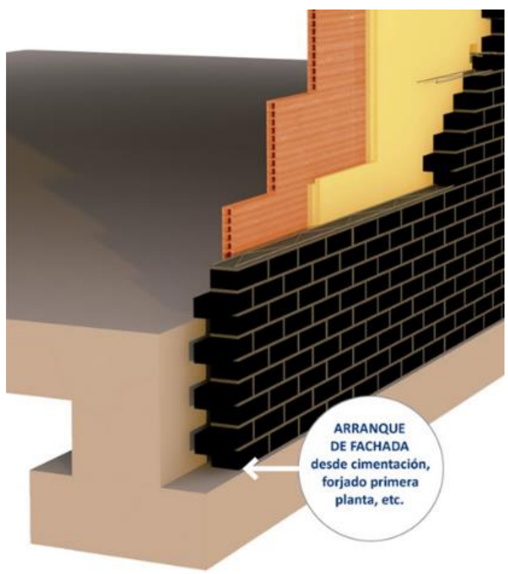
The execution is carried out from the outside to the inside according to the following process:

1. Preparation of the start and support of the sheet outside.
2. Attaching the anchors to the structure.
3. Execution of the outer leaf of the façade.
4. Application of a coating on the underside of the outer sheet.
5. Placement of the thermal insulation of the façade.
6. Execution of the inner leaf of the façade.

The construction process of an unventilated self-supporting façade is described in detail below.

1. Preparation of the start and support of the outer sheet

The starting of the outer sheet of the façade must be carried out by supporting its entire thickness on a resistant structural element with a total deflection of less than 1/1000 of the light, such as the head of a basement wall, a concrete slab, a slab edge beam or a continuous foundation footing.



Starting of the façade
Source: Hispalyt (www.structura.es)

In the case of porches or large openings, the façade can be pulled up on a load-bearing beam, with sufficient supporting points to the building structure.

2. Attaching the anchors to the structure

Prior to the advance of the outer sheet, the anchorage sockets must be fixed to the structural elements.

First of all, a 6 mm diameter hole is drilled in the structure (pillars and slabs) of the building. The socket is then fixed to the structure by means of a percussion block. The omega is then inserted into the groove of the socket. The omega is suitable for the width of the facade chamber.

The design of the anchors, with a certain freedom of movement of the omega, makes it possible to place them with a minimum of staking out.

Placement of the anchorages GEOANC® of the structure.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

3. Execution of the outer sheet of the facade

As the outer sheet of the enclosure is lifted, the anchor claws and the required tendel reinforcement are incorporated into the horizontal mortar joints. An anchorage and reinforcement must never coincide in the same row.

Lifting the outer sheet of facing brick
Source: GEOHIDROL, S.A. (www.geohidrol.com)

The placement of the brick will be carried out by rubbing, in the same way as in conventional facade systems of facing brick.

With this construction system, the outer sheet of exposed brick is not strangled at the encounter with the slabs, but passes in front of the slabs with all their thickness, not being necessary to use platelets to cover the fronts of slabs and pillars, nor cut pieces or special pieces to adjust the stakeout to the height of each floor. This, in addition to a greater speed of execution, implies an important simplification of the constructive process.

After the execution of the facing brick wall, with a simple visual inspection, the adequate quantity and placement of all the auxiliary elements must be verified, checking the overlaps of the reinforcement by checking the coincidence of the cores, and the penetration of the anchorages in the bricks by checking that the wires protruding from the wall do not present curvature.

4. Application of a coating on the underside of the outer sheet of the façade

In order to guarantee the degree of impermeability of the façade required by the DB HS of the CTE, an intermediate coating must be applied to the inside of the outer sheet of the façade.

Its application is similar to that of a facade with conventional system.

5. Placement of thermal insulation

Once the intermediate cladding has been applied, a continuous insulation is installed from the inside, both in the field of the façade and in the fronts of the slabs and pillars. In this way, thermal bridges are eliminated from the fronts of floor slabs and pillars.

Any type of thermal insulation can be used. If the thermal insulation used were not hydrophilic, it would not be necessary to apply an intermediate coating on the intrados of the outer sheet of the facade.

6. Execution of the inner sheet

The inner sheet of the enclosure is executed last. The execution process is the same as in a conventional facade.

Lifting of the inner sheet of the façade.
Source: Hispalyt (www.silensis.es)

B. IMPLEMENTATION OF THE VENTILATED SELF-SUPPORTING FAÇADE

The execution of the ventilated self-supporting façade differs from the execution of the non-ventilated self-supporting façade in that:

- It is not necessary to apply an intermediate coating on the intrados of the outer sheet of the facade.
- Requires placing a drainage sheet at the start of the façade and leaving ventilation holes in the first and last rows at regular intervals.
- Requires leaving ventilation openings at the bottom and top of the wall. Ventilation grilles can be placed in these openings.

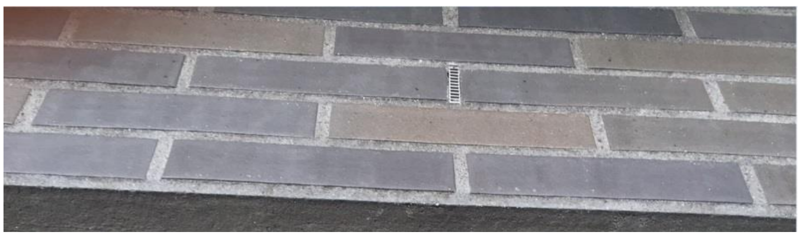


Figure - Devices for façade ventilation openings
Source: GEOHIDROL, S.A. (www.geohidrol.com)

As the intermediate cladding of the outer sheet's intrados is not necessary it is possible to reverse the execution of the facade, so we would have two possible processes of execution of a ventilated facade of brick face: from the exterior to the interior or from the interior to the exterior.

The two different construction processes for a ventilated self-supporting façade are described in detail below.

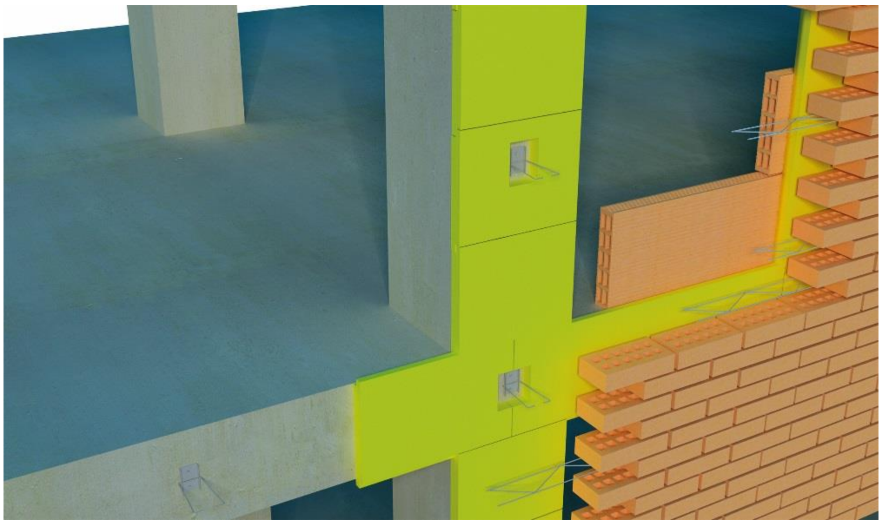
B.1. EXECUTION OF THE VENTILATED FAÇADE FROM THE OUTSIDE TO THE INSIDE

The execution is carried out from the outside to the inside according to the following process:

1. Attaching the anchorages to the structure.
2. Placement of thermal insulation on the front of the structure.
3. Execution of the outer leaf of the façade.
4. Placement of thermal insulation in the rest of the façade.
5. Execution of the inner sheet of the facade.

1 and 2. Fixing of the anchorages and placement of the thermal insulation on the front of the structure

The thermal insulation is placed on the front of the structure (pillars and slabs) at the same time as the anchors are placed. In this case the thermal insulation must be rigid.



Placement of anchorages and thermal insulation in the structure.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

3. Execution of the outer leaf of the façade

The execution of the exterior sheet is carried out in the same way as in the non-ventilated self-supporting facades, being possible in this case to remove all the possible mortar that falls into the chamber during the execution.

Lifting the outer sheet of facing brick.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

4. Placement of the thermal insulation in the rest of the façade

The thermal insulation will be placed inside once the exterior sheet has been executed. Separators shall be used to ensure separation from the outer sheet. These separators are usually made of the same material as the insulation.

Placement of the thermal insulation in the field of the facade, leaving an air chamber ventilated by the exterior, using separators of the same insulating material.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

5. Execution of the inner sheet of the facade

The inner sheet of the enclosure is executed last. The process is the same as in a conventional facade.

B.2. EXECUTION OF THE VENTILATED FAÇADE FROM THE INTERIOR TO THE EXTERIOR

The execution is carried out from the inside to the outside according to the following process:

1. Execution of the inner sheet of the facade.
2. Attaching the anchors to the structure.
3. Placement of the thermal insulation on the façade.
4. Execution of the outer sheet of the facade.

1. Execution of the inner sheet of the façade

The inner sheet of the façade is lifted first, its execution process being similar to that of a conventional façade.

Lifting of the inner sheet of the façade.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

2 and 3. Placement of the anchors and thermal insulation of the façade

Prior to the installation of the thermal insulation, the anchors will be fixed to the structural elements.

The insulation is then placed on the outside of the inner sheet and the structural elements. The most commonly used insulation in these cases is water-repellent projected polyurethane.

Fixing of the anchors to the structure and application of continuous thermal insulation on the structure and the inner sheet of the façade.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

4. Execution of the outer sheet of the facade

The execution of the outer sheet is exactly the same as in the non-ventilated self-supporting facades. In this case special care must be taken in the execution, since it is not possible to remove the mortar that has fallen into the ventilation chamber during it.

Lifting the outer sheet of facing brick.
Source: GEOHIDROL, S.A. (www.geohidrol.com)

SUMMARY. STEPS TO FOLLOW IN THE CONSTRUCTIVE PROCESS

The construction processes of a self-supporting façade are summarised below:

A. Execution of the non-ventilated self-supporting façade.

1. Preparation of the start and support of the outer sheet.
2. Fixing the anchorages.
3. Execution of the outer sheet of the façade.
4. Application of an intermediate coating on the outer sheet
5. Installation of the thermal insulation on the façade.
6. Execution of the inner sheet of the façade.

B. Execution of ventilated façade (two options):

B.1. Execution from the outside to the inside.

1. Attaching the anchors to the structure.
2. Placement of the thermal insulation on the front of the structure.
3. Execution of the outer sheet of the façade.
4. Placement of the thermal insulation in the rest of the façade
5. Execution of the inner sheet of the façade.

B.2. Execution from inside to outside.

1. Execution of the inner sheet of the façade.
2. Attaching the anchors to the structure.
3. Placement of the thermal insulation on the façade.
4. Execution of the outer sheet of the facade.

6. REFERENCES

1. Technical documentation of STRUCTURA-GHAS
https://www.structura.es/es/documentacion-tecnica/publicaciones