English translation

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TECHNICAL APPRAISAL

Valid from **January 14, 2022**

to **November 30, 2024**

For the Process

COFFOR Structural Formwork

Product Family/Process : Formwork

Holder: **COFFOR FRANCE SNC**
Internet: https://www.coffor.com/

FOREWORD

The Technical Appraisal and technical application documents, hereinafter indifferently referred to as Technical Reviews, are intended to provide construction stakeholders with **elements of appraisal on the suitability for use of products or processes** whose constitution or employment do not come under traditional know-how and practices.

This document should be taken as such **and is therefore not a document of compliance or with regulations or a "quality mark" standard**. Its validity is decided independently of that of the supporting documents of the technical file (in particular any regulatory certificates).

The Technical Appraisal is a voluntary process by the applicant, which in no way changes the distribution of responsibilities of those involved in construction. Regardless of the existence or not of this Technical Appraisal, for each structure, the actors must provide or request, depending on their roles, the required supporting documents.

Since the Technical Appraisal is addressed to actors deemed to know the state of the art, it is not intended to contain any information other than that relating to the non-traditional nature of the technique. Thus, for those aspects of the process that comply with recognized state of art of implementation or sizing, a reference to these rules is sufficient.

Specialized Group n° 16 – Special Products and Process for Masonry

COMMISSION CHARGÉE DE FORMULER LES AVIS TECHNIQUES

Secrétariat : CSTB, 84 avenue Jean Jaurès, FR-77447 Marne la Vallée Cedex 2,
France Tél. : 01 64 68 82 82 - email : secretariat.at@cstb.fr

www.ccfat.fr

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Versions of document

Version	Description	Protractor	President
V1	New Appraisal Application	Philippe LEBLOND	Stéphane ESTEVE

Description

COFFOR is an integrated formwork system, with draining facings, self-stable against the pressure of fresh concrete.

The formwork is made up of two panels, with a vertical stiffening frame made of folded sheet metal sections and an expanded metal skin, linked together by metal connectors. The panels are manufactured and assembled in the factory.

By its constitution and its implementation, the COFFOR Structural Formwork process allows the construction of vertical walls, straight or curved, load-bearing or non-load-bearing, exterior or interior and crawl spaces.

Additional reinforcements can be installed on site.

Exterior cladding

Cladding of the exterior wall in raw concrete or completed by a thin coating such as paint, plaster or cladding of the exterior insulation system.

Interior coatings

Classic finishes on smooth concrete or classic finishes on insulating lining as appropriate.

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1. Opinion of the Expert Group

The Coffor Process described in Chapter II "Technical File" below was examined by the Expert Group which concluded favorably as to its suitability for use under the conditions defined below.

1.1. Accepted fields of use

1.1.1. Geographical area

This appraisal is for use in Mainland France and Overseas Departments and Regions: French Caribbean (Guadeloupe, Martinique, Saint-Bartélemy, Saint-Martin), Guyana, La Réunion, Mayotte, Wallis-et-Futuna, French Polynesia, New Caledonia).

1.1.2. Types of Constructions Covered by the Appraisal

COFFOR is intended for the construction of crawl spaces, load-bearing or non-load-bearing walls of residential buildings, public buildings, offices, health and school buildings and more generally all types of buildings for commercial, industrial or agricultural use without limitation of height.

The limitations result from the application of the design and calculation rules given in the Technical Prescriptions and from compliance with the scope of use of the fire resistance reports mentioned in this document.

The process can be used for the construction of buildings requiring seismic regulations within the framework of the French ordinance of October 22, 2010 modified (Seismicity zones 1 to 5).
The process can be used for the construction of basement walls, retaining walls, all typed of building without height limitation, as well as for the construction of low and high parapets.

1.2. Appreciation

1.2.1. Suitability of the process

1.2.1.1. Stability

The stability of the walls made with COFFOR is normally ensured in the accepted field of use and in the design and implementation conditions specified in the Technical File below.
In particular, it should be considered that the transmission of vertical loads takes place only through the core of the filling concrete.

1.2.1.2. Safety in Case of Fire

1.2.1.2.1. Fire resistance

The durations of the fire protection criteria or fire stability of a wall built with COFFOR can be justified by applying the calculation rules of standard NF EN 1992-1-2 with its French National Annex (NF EN 1992- 1-2 / NA) to the entire wall considered to be homogeneous from this point of view.

The actions due to temperature are determined according to standard NF EN 1992-1-2 with its French National Annex (NF EN 1992-1-2/NA). Mechanical actions are combined, in an accident situation, in accordance with standard NF EN 1990 with its French National Annex.
It is recalled that the design load in a fire situation cannot exceed that calculated when cold.

1.2.1.2.2. Reaction to Fire

Given the nature of the materials constituting the wall, this does not pose any particular reaction to fire problem in the accepted field of use (reaction to fire classification A1).

1.2.1.3. Prevention of Accidents during Construction

The process does not present any particular risk from this point of view.

With the precautions indicated in the Technical Prescriptions, the stability of walls during construction, in particular with regard to stresses due to wind, is suitably ensured.
Due to the cutting nature of the expanded metal surface, the use of safety gloves for handling the elements is essential. Manual handling is only possible for items of a standard story height.

1.2.1.4. Construction in Seismic Areas

The use of COFFOR in seismic zones is comprised in this document. COFFOR can be used for the construction of works requiring earthquake-resistant measures within the framework of the Order of 22 October 2010 as amended, provided that the requirements detailed in paragraph 2.4.4 are complied with.

The use of COFFOR in a zone of non-zero seismicity is possible subject to compliance with the PS-92 rules which apply to traditional reinforced concrete structures and without any derogation from any of them.

1.2.1.5. Thermal Insulation

COFFOR can meet regulatory requirements, it being understood that compliance with these requirements does not depend on the COFFOR alone and that verification by calculation, carried out in accordance with Th-U rules, must be carried out by adding another insulation.

1.2.1.6. Summer Comfort

For determining the daily thermal inertia class of buildings, which is an important factor in summer comfort, the exterior walls of COFFOR belong to the category of heavy walls with insulation added on the exterior.
Their inertia is determined by means of the TH-Bat rules and the useful surface mass to be taken into account in the exterior walls is that of the interior prefabricated wall and of the cast-in-place core.

1.2.1.7. Risk of surface condensation

From this point of view, COFFOR does not differ from traditional cast-in-place concrete walls or prefabricated walls solutions.

1.2.1.8. Acoustic isolation

Given the minimum concrete thicknesses involved, the process should not pose problems of airborne sound insulation, up to the requirements of $D_{n,T,A,Tr} \leq 30$ dB. Beyond that, a case-by-case study is necessary.

1.2.1.9. Water tightness of walls

By choosing the appropriate organization and applying the criteria defined in the Technical File, and very careful concreting (use of concreting chutes in particular), in particular in the vicinity of singular points (spandrels, connections between panels, etc.), the waterproofing of works and buildings in the accepted field of use can be considered as normally ensured.

1.2.1.10. Finish - Appearance

The outside and inside finishes are traditional finishes of concrete walls.

Their behavior should not pose any particular problem if their conditions of implementation meet the following Technical Prescriptions. However, it cannot be completely ruled out that, despite the necessary presence of bonding steels, fine cracks, with no other drawback than their appearance, may appear in the area of certain joints between uncoated shuttering panels. In the absence of bonding steels in the interior joints, cracking of the wall at the joints is likely.

1.2.1.11. Environmental data

COFFOR does not have any Environmental Declaration (DE) and therefore cannot claim any particular environmental performance. It is recalled that the DE do not fall within the scope of the examination of suitability for use of the process.

1.2.1.12. Sanitary aspects

This appraisal is formulated with regard to the holder's written commitment to comply with the regulations, and in particular all the regulatory obligations relating to products that may contain dangerous substances, for their manufacture, their integration into works in the field of use. The control of information and declarations issued in application of the regulations in force is not within the scope of this document. The holder of this appraisal retains full responsibility for such information and statements.

1.2.2. Durability - Maintenance

The constituent materials of the wall do not pose an intrinsic durability problem. The durability of interior plasterboard facings can be estimated to be equivalent to that of identical facings applied to traditional substrates.
The durability of COFFOR is equivalent to that of traditional concrete structures.

1.2.3. Environmental Impacts

End-of-life treatment is similar to traditional reinforced concrete wall processes.

1.3. Additional Remarks from the Expert Group

It is recalled that COFFOR has the particularity of using a so-called "draining" formwork, that is to say not waterproof. Tests have shown that, by complying with the provisions described in the Technical File and concerning in particular the control of the fluidity of the poured concrete, this feature does not weaken the strength of the formed concrete.

In some cases, it is possible to take into account vertical stiffening sections for the strength justifications in the final phase. This possibility is strictly limited to the cases described in §2.5.6.1 of the Technical File.

The Group draws attention to the complexity of installing additional reinforcements in the event that they are used on heights exceeding the current one-story and/or over long lengths making it difficult to insert horizontal reinforcements between the stiffeners and vertical reinforcements.
In addition, the use of COFFOR in a seismic zone is subject to compliance with the design and sizing rules provided for traditional reinforced concrete structures within the framework of the PS-92 rules and without any derogation from any of the rules.

2. Technical File

Based on the information provided by the Holder and the prescriptions of the Expert Group accepted by the Holder

2.1. Distribution

2.1.1. Contact details

COFFOR is distributed by the Holder.

HOLDER: COFFOR FRANCE SNC
ABS – CENTRE BONLIEU,
74000 Annecy, France

2.1.2. Identification

The elements of COFFOR Structural Formwork are identifiable from their exterior appearance and bear an identification sheet attached to each element before it leaves the factory.

2.2. Description

2.2.1. Principle

The COFFOR integrated structural formwork wall process, called COFFOR Structural Formwork, is intended for the construction of concrete structures.

It is characterized by the use of a stay-in-place formwork which contribute to the strength of the finished structure. Inside the formwork, it is possible to integrate reinforcements.

COFFOR Structural Formwork makes it possible to produce walls of various shapes and thicknesses, load-bearing or not. It can be used both for interior and exterior walls.

COFFOR Structural Formwork consists of two panels, interconnected by steel connectors placed every 20 cm and perpendicular to the walls (see Exhibit 1 in the appendix). These connectors ensure the stability of the walls against the pressure of the fresh concrete.
Each of the panels consists of a vertical frame made of galvanized steel profiles on which is fixed by clinching a panel made of Expanded metal.

Production of COFFOR Structural Formwork is ensured by a set of machines from galvanized steel strips, steel rollers for the connectors and smooth steel reinforcements in accordance with §2.3. The panels are assembled manually in the factory.

COFFOR Structural Formwork system can be implemented alone or can be combined on site with components such as frames and pre-frames, or even complete joinery blocks. It authorizes incorporations and reservations of all types: piping, electricity, etc.

Its facings can be coated:

- Exterior side: either by any type of sprayed plaster, or by a covering with, in this case, constructive provisions in accordance with those recommended by the Technical Appraisal of the covering used;
- Interior side: either by a sprayed coating, or by a facing that is glued or screwed, or by a lining facing.

2.2.2. Characteristics of components

2.2.2.1. Composition of COFFOR Structural Formwork

2.2.2.1.1. Drainage Grid (Expanded Metal)

Expanded metal made from an R 240 steel strip in hot-dip galvanized steel Z 275 (Standard NF A 36-321), minimum thickness 0.50 mm; standard dimensions 2700 mm (up to 4500 mm) x 1100 mm, ribs every 100 mm. On request, the factory produces panels 900 mm, 700 mm, 500 mm and 300 mm wide.

2.2.2.1.2. Vertical Stiffeners

Profiles over the entire height of the panel, cold bent from a steel strip R 240 in hot galvanized steel Z 140 (standard NF A 38-322), minimum thickness 0.6 mm with 4 longitudinal ribs and double folding at the ends to improve rigidity. The stiffeners have a steel section of 60 mm² which is equivalent to a reinforcement of 8 mm in diameter. They are placed every 20 cm (center to center). When two panels are juxtaposed, these profiles are spaced horizontally by less than 3 cm (center to center), since the profiles of the ends of the panels are positioned in the factory at 1.5 cm from the edges of the panels.

2.2.2.1.3. Horizontal Connectors

Steel connectors (R 240 steel strip with a minimum thickness of 14 mm and a minimum width of 1.4 mm). The characteristics of the steel for the facing, the framework and the connection are as follows:

- 415 MPa ≥ Tensile Strength ≥ 305 MPa ;
- 450 MPa ≥ Yield Point ≥ 215 MPa ;

- Elongation ≥ 31% ;
- Steel Hardness : minimum 55-60 on Rockwell B scale

2.2.2.1.4. Horizontal Reinforcements

Smooth steel reinforcements Fe 400 or equivalent with a minimum Ø of 5 mm which pass through the profiles every 20 cm alternately.

2.2.2.2. Role of the components constituting the COFFOR Structural Formwork

2.2.2.2.1. Role of Connectors

The two faces of the COFFOR Structural Formwork are connected by connectors placed alternately every 20 cm.
The position of the connectors confers favorable confinement for the good behavior of the concrete under seismic stress, by preventing the concrete from bursting.

2.2.2.2.2. Role of Vertical Stiffeners

The profiles play a triple role:

- They stiffen the walls, which is essential for easy handling during transport and installation;
- They allow good resistance of the walls in the provisional phase under the pressure due to the fresh concrete;
- They contribute to the strength of the wall in the final phase given their bonding to concrete.

2.2.2.2.3. Role of Expanded Metal

The expanded metal allows excess water to escape from the concrete by gravity. Taking into account the presence of stiffeners on the one hand, of the expanded metal on the other hand, their good bonding to concrete and their respective sections, the COFFOR Structural Formwork process does not require the implementation of a trellis anti-fissure..

2.2.2.3. Constitution of COFFOR Structural Formwork

For the construction of buildings with COFFOR Structural Formwork, the following factors must be taken into account:

- Geometry of the structure;
- Type of wall ;
- Possible association with the system of components for openings;
- Type of coating.

2.2.2.3.1. Geometry of the Structure

The COFFOR Structural Formwork is made up of elements placed one next to the other so as to constitute, on the two facings, a continuous set. To adapt to the geometry, panels are available, the height of which corresponds to the height of the story (order from the factory); standard widths are 110cm wide and 90cm wide. When the length of the wall does not exactly match these dimensions or one of their compositions, they are easily cut on site with a grinder.

A 15 mm overlap is made between the adjacent COFFOR panels..

The maximum height of the panels is 450 cm.

The angles are left open to allow the introduction of local reinforcements (corner columns). They are then closed by corner pieces having the height of the wall (see Exhibit 7). Likewise, to make a cross wall, the panels are put together so as to allow the easy introduction of reinforcing bars.

Vertically, the formwork is adapted to the height of the wall and, if necessary, to the thickness of the floor upper slab.

2.2.2.3.2. Type of Wall

The heights of the walls made with COFFOR Structural Formwork are variable according to need with a maximum of 450 cm for a row of panels.

The two sides of the COFFOR panel are similar.

The connectors allow the panel to be folded up for transport.

2.2.2.3.3. Association COFFOR Structural Formwork/components for openings

When installing the panels, it is necessary to provide the components of the openings, doors and windows. These must be compatible with the COFFOR Structural Formwork for, in particular:

- Renew and extend its constructive provisions (resumption of concrete pressure);
- Remain homogeneous with the characteristics of the implementation of COFFOR Structural Formwork;
- Tolerate the constraints of the implementation of COFFOR Structural Formwork related in particular to the draining power of the formwork faces.

The cutting of panels for the openings is done on site.

2.3. Principles of Production and Production Control

2.3.1.1. Principle of production

COFFOR Structural Formwork is manufactured in a factory in Romania, by the company PROINVEST GROUP, 1, Granitei Street, 705200 Pascani, Romania.

The machines used by the company PROINVEST GROUP are of American and French origin (clinching machines).

- The manufacture of COFFOR Structural Formwork panels is carried out using specific machines. The machines are organized and equipped for:
- Ensure receipt of raw materials (steel strip and reinforcing wire);
- Continuously manufacture the components (expanded metal, stiffeners and connectors);
- Assemble the formwork (according to order);
- Pack the formwork (for shipment).

Raw materials from different suppliers are received and checked upon arrival at the factory.

(a) The manufacture of expanded metal involves 4 operations:

- After loading the strip, the press lances the metal continuously;
- The ribs that will strengthen the expanded metal are formed;
- The metal is expanded;
- At the end of the line, the metal is cut to the desired length and placed on a transfer table.

(b) The manufacture of stiffeners involves 3 operations:

- After loading the strip, drilling of the latter;;
- After drilling, forming in several stages to continuously form the longitudinal ribs and give the final shape to the stiffener;
- At the end of the line, the profile is cut to the desired length and placed on a transfer table.

(c) The manufacture of connectors involves two operations:

- The steel strip is drilled and ribbed;
- It is cut to the desired length and falls into a container which will be transported to the assembly tables.

(d) The manufacture of horizontal reinforcements is done in two stages.

- The wire is first continuously straightened and cut to length according to the production plan;
- The wires, once straightened, are introduced automatically into a machine which will fold and cut them as needed;

The folded wires are placed on a transfer table that will be transported to the assembly tables.

(e) The clinching of the profiles with the expanded metal is done by an automated clinching line. The clinching line produces COFFOR single panels. The clinching technique is a technique of mechanical assembly of metal sheets. The principle of clinching is to connect two metal sheets by stamping between a punch, guided by a press, and a die and ejected by a finger. The sheets locally undergo cold plastic deformation, forming a very resistant connection point.
Single panels are quality checked to verify proper crimping. If necessary, screws can be added to the stamping points which would appear fragile.

(f) The assembly of the COFFOR formwork, that is to say two single panels connected by connectors, is carried out manually on an assembly table.

The assembled panels are subject to a second quality control.

The packaging for shipment includes:

- Grouping of formwork by type;
- Placing on pallets and strapping;
- Packing.

2.3.1.2. Production Control

The manufactured formwork undergoes:

- A control of the dimensions: length, width and thickness (with the following tolerances Length ± 1 cm, Width ± 5 mm, Thickness ± 2 mm); control frequency 1 out of 10 panels manufactured ;
- A composition check, i.e. the correct number of connectors (number of connectors per m² and their positioning in accordance with the technical sheet); control frequency 1 out of 10 panels manufactured;
- Particular control of clinching; control frequency 1 out of 10 panels manufactured.

Laboratory tests have shown that the particular nature of the expanded metal produced by COFFOR factories (its thickness - minimum 0.50 mm, the size of the openings and the inclination of the metal in these openings) allows good evacuation of the excess water from the concrete and good pressure resistance of the concrete.

2.3.1.3. Transport

The panels are transported in folded position, on pallets. In the case of pallet handling by lifting devices, the pallets are taken by straps, with spacers so as not to deform the formwork located at the top of the pallets.

The implementation of COFFOR on site is done mainly by hand. A COFFOR panel weighs 11 kg / m2, i.e. for a panel measuring 270 cm x 110 cm, for example, less than 33 kg.

2.4. Design Layout

2.4.1. Bearing capacity under vertical loads

Concrete walls must be designed in accordance with section 12 of standard NF EN 1992-1-1, except for skin reinforcements which are not necessary. The stability of the wall must be justified by the application of chapter 12.6.5.2 of this document, taking into account the following requirements:

For the justification under normal loads, the resistant section to be taken into account is that of the core of the filling concrete.
The calculation of the slenderness of the wall is carried out taking into account the total thickness of the walls. Geometric slenderness
must not exceed 25.

The normal resistant force per meter of wall length, expressed in MN / m, consisting of a concrete core of thickness tc is calculated as follows:

$$N_{RD} = \frac{\Phi . f_{ck}}{\gamma_M} . t_c$$

Where :

- f_{ck} is the compressive strength of the constituent concrete of the core, in MPa;
- t_c is the thickness of the concrete infill core, in m;
- Φ is a factor taking into account the eccentricity of the loads applied in the direction tc as well as the second order effects, calculated according to formula 12.10 of §12.6.5.2;
- Υ^M is the partial safety factor.

2.4.2. Bracing – Shear Walls

The structural design with Coffor is the same as with formwork or other formwork systems (aluminum, wood or other). It complies with standard NF EN 1992-1-1 of Eurocode 2.
In addition, in this case, the section of the stiffeners cannot be taken into account to justify the resistance of the panels under the forces acting in their plane (bracing).

2.4.3. Essential Data

The essential data necessary for the above checks are summarized below.:

Characteristic compressive strength of concrete (MPa)	f_{ck}	25
Characteristic tensile strength of concrete (MPa)	f_{ctk}	1,8
Characteristic shear resistance of concrete (MPa)	f_{cvk}	0,45
Yield strength of steel (MPa)	f_{yk}	400 or 500
Behavior coefficient	q	2
Partial safety factor on the strength of the concrete	Υ_C	1,5 for durable or transient actions and 1.3 for seismic actions
Partial safety factors on the strength of steels	Υ_S	1,15 for durable or transient actions and 1.0 for seismic actions

2.4.4. Use in seismic areas

Walls mounted using the COFFOR process can be used for the realization of main structural elements of buildings subject to seismic requirements:

- In seismic zones 2, 3 or 4 within the meaning of the decree of October 22, 2010 relating to the classification and the earthquake-resistant construction rules applicable to buildings of the so-called "normal risk" class, subject to compliance with the NF standard. P 06-014 ("PS-MI 89 revised 92 rules") which provides, in the case of small buildings of simple shape defined in this standard, construction provisions whose application ensures compliance with PS 92 rules without the need for verification by calculation:
  - It is recalled that the buildings covered by this standard must be at most of the R + 1 + attic type, of simple shape both in plan and in elevation (setbacks to be avoided) and braced by walls distributed around the perimeter of the floors.
  - For these small buildings, the length of the panels in each direction, expressed in meters, must not be less than the quotient of the total surface S built on the ground, in square meters, by the coefficient k given in §2.8 of the NF standard P06-014
- In seismic zones 1 to 5 within the meaning of the decree of October 22, 2010, subject to compliance with standard NF EN 1998-1.

- In this case, the determination of the forces induced by the seismic actions on a COFFOR panel is carried out on the assumption of a homogeneous section equivalent to the substituted shuttering wall. The behavior coefficient to be taken into account must comply with §5.2.2.2 of standard NF EN 1998-1.
- The calculated shear force must be compared to the design resistant shear forces that can be mobilized depending on the type of connection (horizontal or vertical) and the load case studied. The purpose of this check is to determine the type of connection to be used for the panel studied, making it possible to reproduce the monolithism of the wall.

Only the elements making it possible to constitute horizontal and vertical chains of a minimum thickness of 15 cm can be used.
In accordance with standard NF EN 1998-1, §9.5.4, in seismic zone the cross section of the longitudinal reinforcements of the chains must not be less than 300 mm² nor represent less than 1% of the cross section of the chains. The application of standard NF P 06-014 of the models given in §2.4.2 above, considering partial safety coefficients corresponding to seismic actions, and a value of the behavior coefficient equal to 1.5.

2.5. Construction Steps

The process of construction of a wall with COFFOR Structural Formwork panels is simple and can be carried out by 2 people.

The installation must comply with the Coffor user manual.

2.5.1. Layout and Blocking

The alignment of the panels is traced in chalk on both sides.
Planks or battens are nailed to the ground to indicate the positioning of one face of the COFFOR panels. It is usually not necessary to make a second alignment of the other side of the panel, although this can facilitate placement.

2.5.2. Positioning of Panels – Provisional Support

The COFFOR Structural Formwork panels are placed on the starting bars, the verticality of which must first be checked and straightened if necessary.

Each panel is temporarily held vertically with wooden (battens or boards) or metal (profiles, angles or tubes). The minimum length of these bracing elements is 1.80 m.

The positioning of COFFOR Structural Formwork panels should preferably start from the corners and from the doors.
When the length of the wall does not correspond to a multiple of the width of the panels, the last panel is cut with a circular saw to fit the length of the wall.

2.5.3. Consolidating Panels

When all the panels are placed, they are joined together: pieces of wood (battens or boards) or metal (profiles, angles or tubes) spaced from each other by approximately 1.00 m, are fixed horizontally by using galvanized steel wire.

An alignment board is preferably placed on top of the panels.

The adjacent panels are preferably superimposed over 1.5 cm (see Exhibit 3) and screwed every 40 cm vertically. Otherwise, they will be tied together every 40 cm with galvanized steel wire.

The horizontal battens can be installed on one side only, using a wire which is tied around one or two stiffeners of the adjacent COFFOR Structural Formwork panels.

Another method is to place battens face to face on both sides of the panels: the wire then connects the two pieces through the expanded metal.
In this manner, on a 4.00 m wall, there will be four rows of horizontal securing pieces, including the bottom batten of the panels.

2.5.4. Final Adjustment of Panels

When all the wall panels have thus been mounted and secured to each other, the final adjustment is carried out with pieces of wood (battens or boards) or metal (profiles, angles or tubes) which serve as props.

The provisional retaining pieces are removed and replaced by the final props placed approximately every 2.00 m.

Verticality is checked using the level or plumb line.

2.5.5. Closing the Edges of Doors and Windows

Window openings are made with a circular saw.

The edges of doors and windows are closed preferably by metal profile bent in a U-shape (thickness 0.6-0.7 mm) with legs of 7 cm on each side that can be supplied by the COFFOR factory in same time as the panels. When ordering, the required lengths must be indicated.

Alternatively, one can use pieces of wood whose width is equal to the thickness of the COFFOR Structural Formwork panel.

If several doors and windows have the same dimensions, templates can be made to save time.

However, the fastest and most efficient solution is the installation of pre-frames supplied by the carpentry supplier.

2.5.6. Placing Reinforcing Bars

Once the panels are well stabilized, if necessary, placing of additional reinforcements to the COFFOR Structural Formwork is done

2.5.6.1. Reinforcements in the current part of the wall

In the event that the section of the HA 500 type vertical reinforcement required by the calculations is less than 2 cm²/m, the vertical profiles of the COFFOR Structural Formwork can act as reinforcement.

Anti-fissuring mesh is not necessary.

If it is necessary to add additional vertical reinforcements, these vertical reinforcements are prepared in advance and delivered to the site by the reinforcement supplier or they can be shaped directly on the site.
If it is necessary to introduce horizontal reinforcements, they are slid and rest on the connectors.

The combined participation of traditional HA reinforcements with stiffeners is not intended for this process.

2.5.6.2. Reinforcement at the corners and around the openings (vertical ties)

The details of the reinforcement at end of walls, in the corners and around the openings (chaining) are identical to those of traditional reinforced concrete walls. The forming of the steels can be delivered by the supplier or done on site.

After installation of the current reinforcement of the walls, vertical bars (columns) and horizontal U-shaped bars are placed in the corners and openings and tied between them.

The principle constructive instructions are illustrated in the appendix.

2.5.7. Carrying out the Various Steps of Construction

The implementation of the various stages of construction are described in the implementation manual of COFFOR which is provided on request.

2.5.8. Crawl Space

The Coffor panel for crawl spaces (Coffor CS) is different from the standard panel for walls. One side of the panel is higher than the other.

The constructive instructions for the use of Coffor for crawl spaces are the same as for walls except for the positioning of the panels.

The panels are laid horizontally instead of being laid vertically.

The higher face is placed outside and serves as edge formwork (see appendix).

The Coffor crawl space user manual gives instructions for implementation.
The principle constructive instructions are illustrated in the appendix.

2.5.9. Closing the Corners

The corners are closed with COFFOR corner pieces delivered from the factory (single folded panels) to the right dimensions.

The COFFOR corner piece consists of a single COFFOR panel folded at 90 °.

In the absence of factory-delivered corner pieces, single panels can be folded on site. For example, for a corner of 15 cm x 15 cm:

- Cut from a single panel of the correct height, a piece 34-36cm wide (the middle of the distance between two C profiles must correspond to the middle of the corner);
- At the edges of the corner, strike the metal reinforcements of the panels using a hammer and a chisel, then bend the panel at 90 °;
- Secure the corner panel in position and screw it to the adjacent panels.

Fixing of the corner piece is preferably done:

- On the interior side with a batten placed vertically on the height of the angle. This batten is tied around the stiffeners of the COFFOR Structural Formwork panels of the corner;
- On the outside with wooden battens or brackets spaced about one meter apart and tied around the stiffeners. In the absence of COFFOR Structural Formwork corner pieces, wooden planks can be used to close the corners.

2.5.10. Secondary Works

Electrical ducts and plumbing (heating, piping, etc.) can be placed and poured in concrete in the middle of the panels unless legal provisions prohibit it.
For the connections (sockets, etc.), small openings are made in the metal deployed on site.

2.5.11. Checking before Concreting

Before pouring concrete, it is necessary to check:

- The alignment of the COFFOR Structural Formwork;
- The correct installation of the props (struts) for the holding of the COFFOR Structural Formwork;
- The closing of corners, edges of doors and windows;
- The position of the reinforcement;
- The inclusion of the secondary works (ducts, pimping, etc.)
- The cleanliness of the recovery surface.

These precautions contribute to good quality and consistency of execution.

2.5.12. Concrete Pouring

Concreting is carried out with ordinary concrete complying to standard NF EN 206 / CN. The minimum concrete class is C25 / 30. The exposure classes are adapted to the living conditions of each part of the structure in accordance with standard NF EN 206 / CN.

The outer wall reinforcement coverings must comply with the requirements of section 4 of standard NF EN 1992-1-1 and its National Annex. The only specific requirements for COFFOR are:

- Size of the aggregates between 0 and 15mm in order to guarantee correct filling of the stiffeners;
- S4 consistency (slump between 160 to 210 mm).

During the pouring phase, it is necessary to roughly float the walls and recover the excess concrete that has passed through the expanded metal.

Concreting can be done with a pump, a bucket or a shovel. The drop height is the height of the wall. Concreting must be done in passes of approximately 70 cm.

If pouring is done with a pump, it is preferable to attach an elbow and counter-elbow to the end of the nozzle, in order to reduce the falling speed of concrete. It is recommended to use a flexible extension of pipes to limit the fall of concrete in the COFFOR panel.

Pouring at wall end, around boards and reinforced areas should be monitored, which can be improved over time by external vibration with a mallet or by pervibration using a needle. Avoid contact of the needle with the expanded metal

The diameter of the needle should not exceed 25 mm.

The expanded metal walls with COFFOR allow excess water to be evacuated at the time of pouring.

COFFOR allows, with a usual W / C ratio (around 0.55), to maintain satisfactory workability of the concrete for pouring by eliminating some of the negative effects associated with excess water not necessary for the hydration of the concrete. cement paste (bleeding, increased creep, etc.).

The reinforcing elements and scaffolding in metal or wood are removed 7 days after the concrete has been poured.

2.6. Minimal cover and dressing

The thickness of concrete after pouring constituting the "primer" of the COFFOR process is 5 to 6 mm thick.

Outside, traditional hydraulic or sprayed facade plasters are used to create a "satisfactory" thickness of concrete. The coating must comply with NF DTU 26.1 and must have the following characteristics:

- CSII resistance class (between 1.5 and 5 MPa);
- Absorption class W1 with C ≤ 0.4 Kg / m2. min (-0.5);
- The minimum quantity of cement must be 350 kg (CEM I or CEM II 32.5, 42.5, 52.5 in accordance with standard NF EN 197-1).

Ready-Mix plasters must meet the same resistance and absorption class criteria as those of NF DTU 26.1 P1-2.

Coating thickness will be 20 mm.

2.7 Wall Finish

All coatings compatible with reinforced concrete walls can be used with COFFOR.

2.8 Technical Assistance

The Coffor user manual provides the explanations necessary for proper implementation.

If necessary, a qualified COFFR technician can be sent to the site to train staff and answer specific questions.

2.9. Reference

2.9.1 Experimental Results

2.9.1.1 Compression tests on a trumeau carried out at CSTB

Resistance tests in centered compression (contract n ° 95-422 / 01 of February 21, 1996) were carried out at CSTB on COFFOR Structural Formwork walls (at the time "DIPY" formwork) of dimensions 220 x 77 x 16 cm on common non-insulated elements. The purpose of these tests was to compare the flexural strength of a concrete wall with COFFOR formwork compared to a wall poured with traditional formwork.

Reference tests were carried out on unreinforced concrete walls of roughly the same dimensions (220 x 76 x 14).

In both cases, the filling concrete was a B25 concrete whose resistance and modulus of deformation were measured on cylindrical test pieces kept in air under the same conditions as the piers (average breaking stress 37.0 N / mm2).

After concreting, the DIPY (COFFOR) walls had, between stiffeners, a maximum deflection of 1 cm outwards (maximum effective thickness of 18 cm) so that their average real thickness could be estimated at 17 cm.

The average breaking stress recorded was 17.6 N / mm2 for the DIPY piers (COFFOR) and 17.5 N / mm2 for the reference piers, the corresponding elastic moduli Ei being 36140 N / mm2 and 26940 N / mm2 respectively.

2.9.1.2 Compression and deflexion tests carried out at the Geneva Engineering School (March 2000)

The tests carried out aimed at the following objectives:

- Observation of the behavior of the COFFOR panel during concreting;
- Resistance test of a wall-element and a slab-element;
- Measurement of the pressure exerted by the fresh concrete on the expanded metal during its placement.

The tests showed that the wall element presented a resistance corresponding to a reinforced concrete element. The breaking load was 1203 KN while the value of this load for a resistance calculation according to the SIA 162 standard is 895 KN.

The concreting test on a horizontal slab with a single COFFOR panel showed that it was possible to pervibrate the poured concrete, with little loss of cement milk through the expanded metal.

The deflexion test showed normal behavior of the reinforced concrete without breaking the bonding of stiffeners and concrete, this thanks to the ribs of the stiffeners. The breaking load was 35.5 KN.

2.9.1.3 Deflexion and bonding test carried out at CSTB (December 2002)

Two types of tests were carried out in the laboratory of the Studies and Mechanical Tests Division of CSTB in November 2002:

- Deflexion test of a COFFOR panel assembled by crimping to examine the participation of the stiffeners in the bending strength. The tests have shown a strong contribution of the metal profiles to the flexural strength. The test body (COFFOR panel without reinforcement) with a thickness of 140 mm over a span of 1900 mm withstood a breaking load of 4827 daN;
- Bonding tests of metal profiles to the concrete constituting the panels by direct traction on the profiles for different anchoring lengths of the profiles. Tests have shown good adhesion to concrete.

2.9.1.3.1 Comparative tests of COFFOR walls with reinforced concrete walls carried out at the Housing and Building National Research Center, Cairo, Egypt (December 2006)

Four tests were carried out, with and without additional reinforcement.

The test results have shown that the profiles of the COFFOR panel can be taken into account as vertical reinforcement.

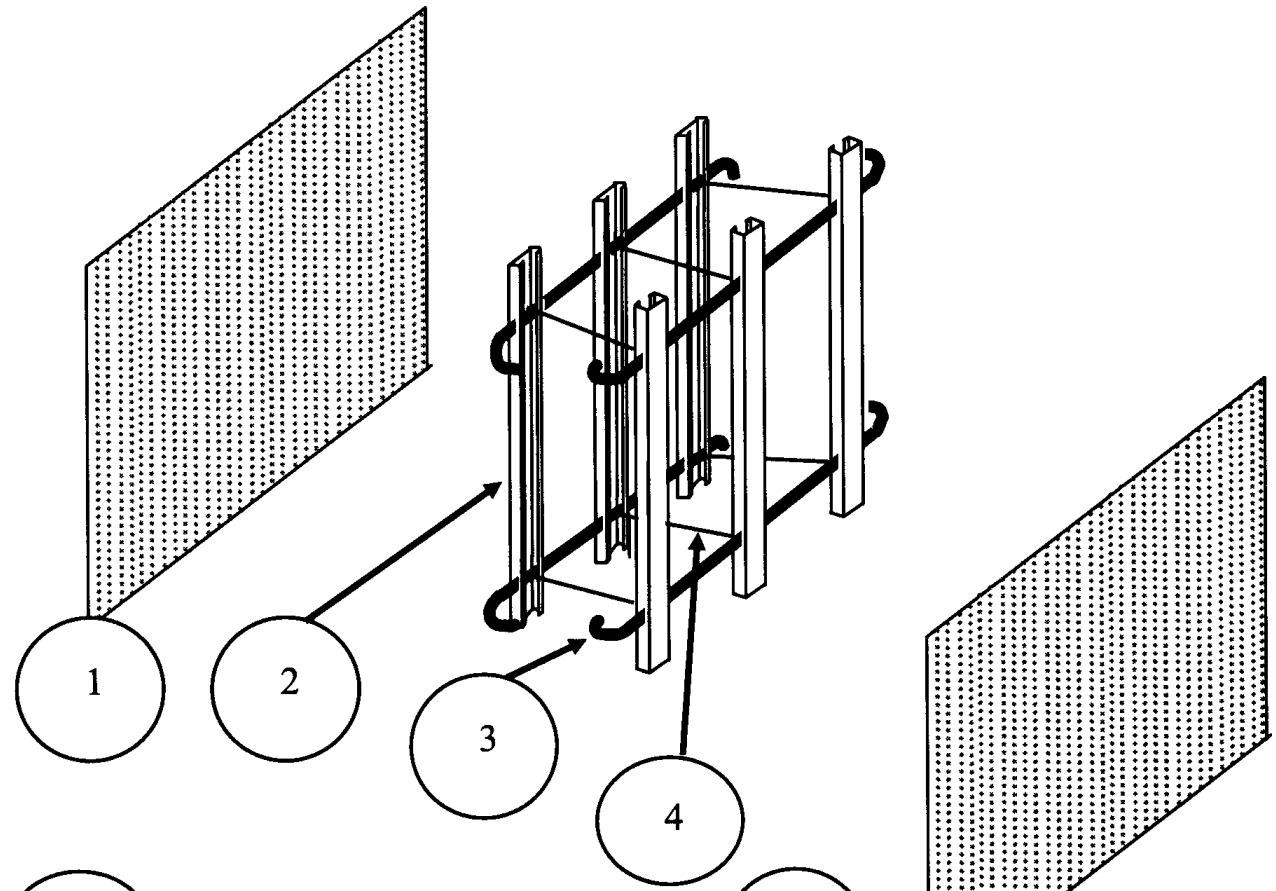
2.9.1.4 Fire resistance tests of COFFOR walls carried out by CSTB (December 2016)

CSTB's appraisal concludes that the fire stability of COFFOR integrated formwork walls does not differ from that of traditional concrete walls of the same thickness. The "R" classification of COFFOR integrated formwork walls can therefore be taken from the standard classifications provided by Eurocode 2 part 1-2.

2.9.2 French Site References

Contractor	Client	Location	Quantity	Date
H2O Bâtiment	La truite Argentière	33380 BIGANOS	1000 m²	2011
H2O Bâtiment	H2O Bâtiment	31320 AUREVILLE	8000 m²	2011-2015
CIF REHABILITATION	CIF REHABILITATION	95120 ERMONT	400 m²	2012
CAUSSE BRUNET	EIFFAGE	31000 TOULOUSE	2000 m²	2013
SOGEA CARONI	SOGEA CARONI	59701 MARQ-EN-BAREUIL	200 m²	2011
BOALIA CONSTRUCTION	BOALIA CONSTRUCTION	47400 TONNEINS	200 m²	2013
QUILLE CONSTRCUTION	QUILLE CONSTRCUTION	80044 AMIENS	400 m²	2013
SOGEA TOULOUSE	SOGEA TOULOUSE	34200 SETE	200 m²	2013
LCR LAFARGE	LCR LAFARGE	38291 ST QUENTIN FALLAVIER	200 m²	2014
CEF ENTREPRISE GENERALE	CEF ENTREPRISE GENERALE	91240 ST MICHEL SUR ORGE	300 m²	2014
CIF REHABILITATION	SIRESCO	93000 BOBIGNY	840 m²	2016
DEFI	DEFI	97490 SAINTE CLOTILDE	900 m²	2016
ECURIE D'HARAVILLIERS	ECURIE D'HARAVILLIERS	85640 HARAVILLIERS	400 m²	2019
CIF REHABILITATION	MAIRIE	91180 SAINT GERMAIN LES ARPAJON	650 m²	2014
KREOL BTP	KREOL BTP	97200 FORT DE France	22000 m²	2011-2021
KHEOPS BAT SAS	KHEOPS BAT SAS	97351 MATOURY	1200 m²	2019
CONCEPT MAISON DECO	CONCEPT MAISON DECO	97400 SAINT DENIS	1100 m²	2020

2.10 Annex of Technical File – Principles of Implementation



1 Skin: grid in expanded metal

2 Vertical stiffener: C profile

3 Horizontal reinforcement

4 Steel connectors

Exhibit 1: Components of a COFFOR panel

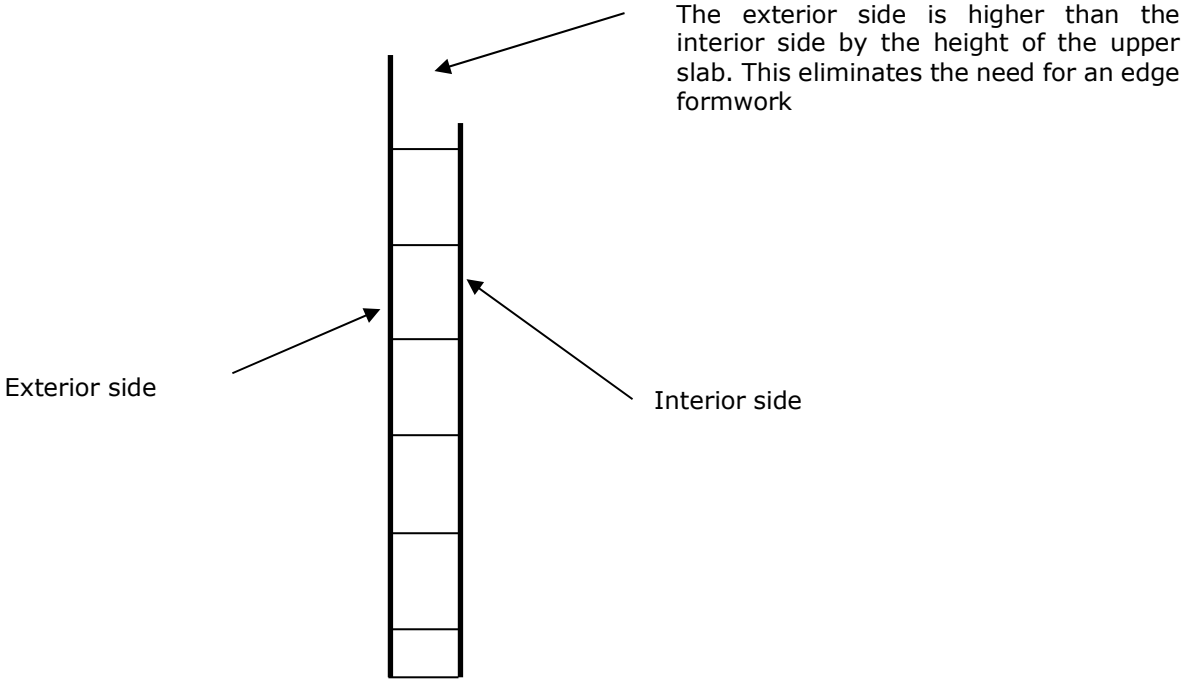
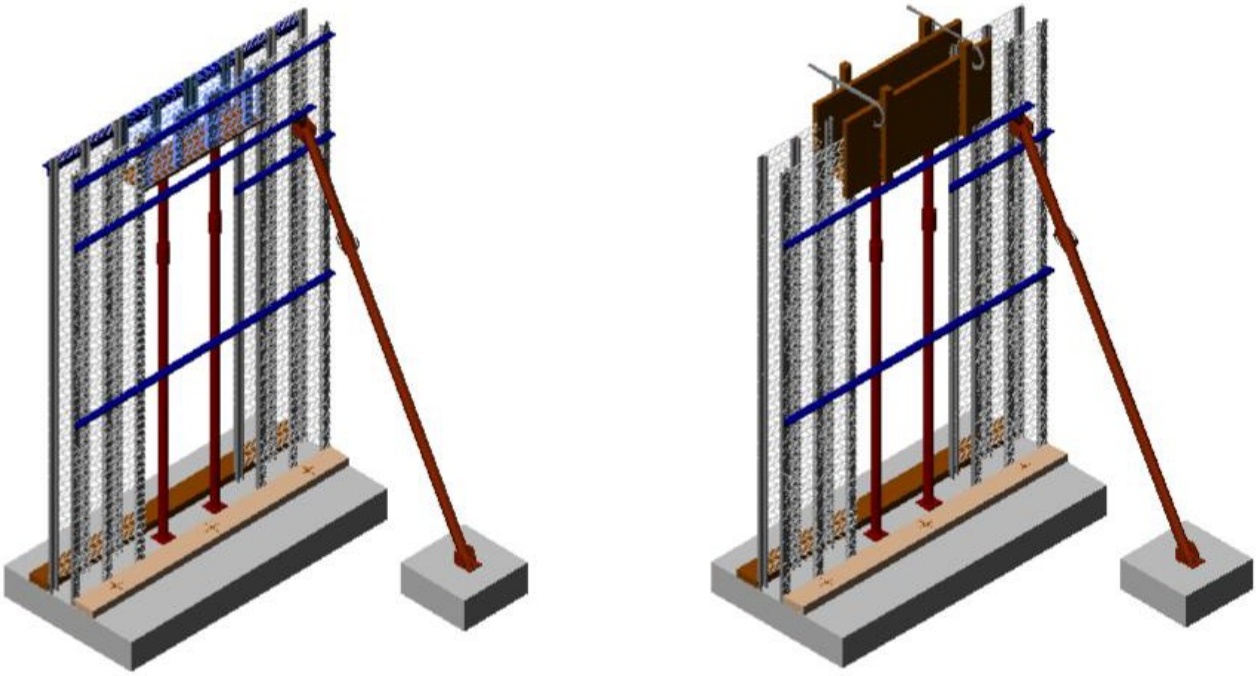


Exhibit 2 : Adaptation of the formwork to the height of the wall

Exhibit 3 : Overlap of adjoining COFFOR panels

Push-pull props or equivalent are attached to the panels at the level of the horizontal supports and on the ground, spaced every 3 m at most.

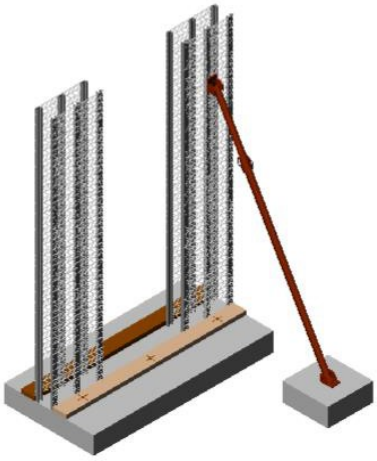
Exhibit 4 : Consolidation of panels



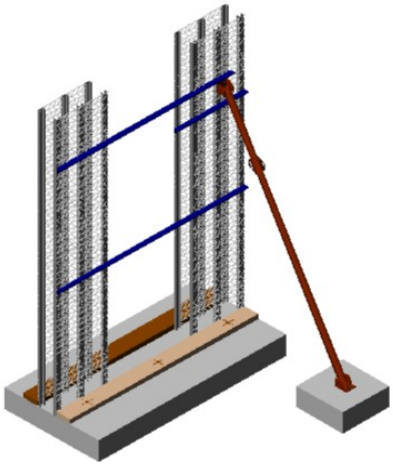
A – COFFOR panel to form a lintel

B – Use of wooden formwork

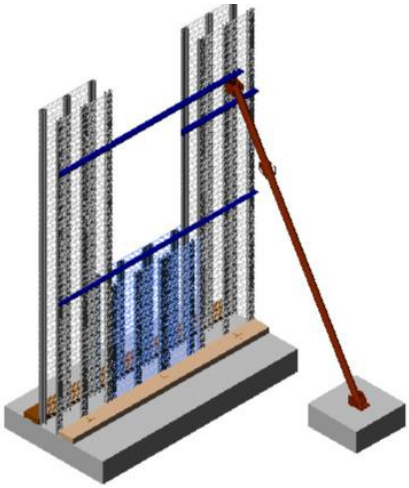
Exhibit 5 – Two methods to build the lintel of a door



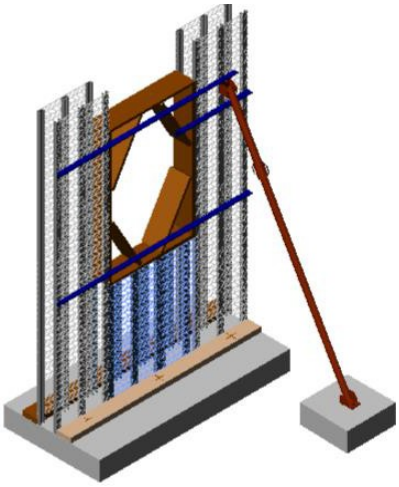
1 – Placement of COFFOR panels around the window



2 – Placement of profiles



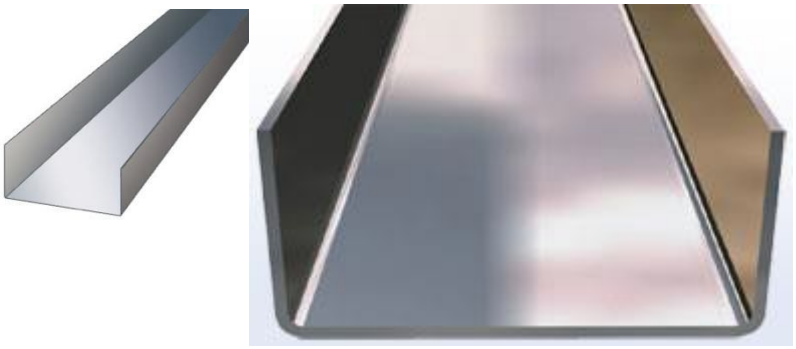
3 – Placement of the bottom of the window



4 – Placement of template

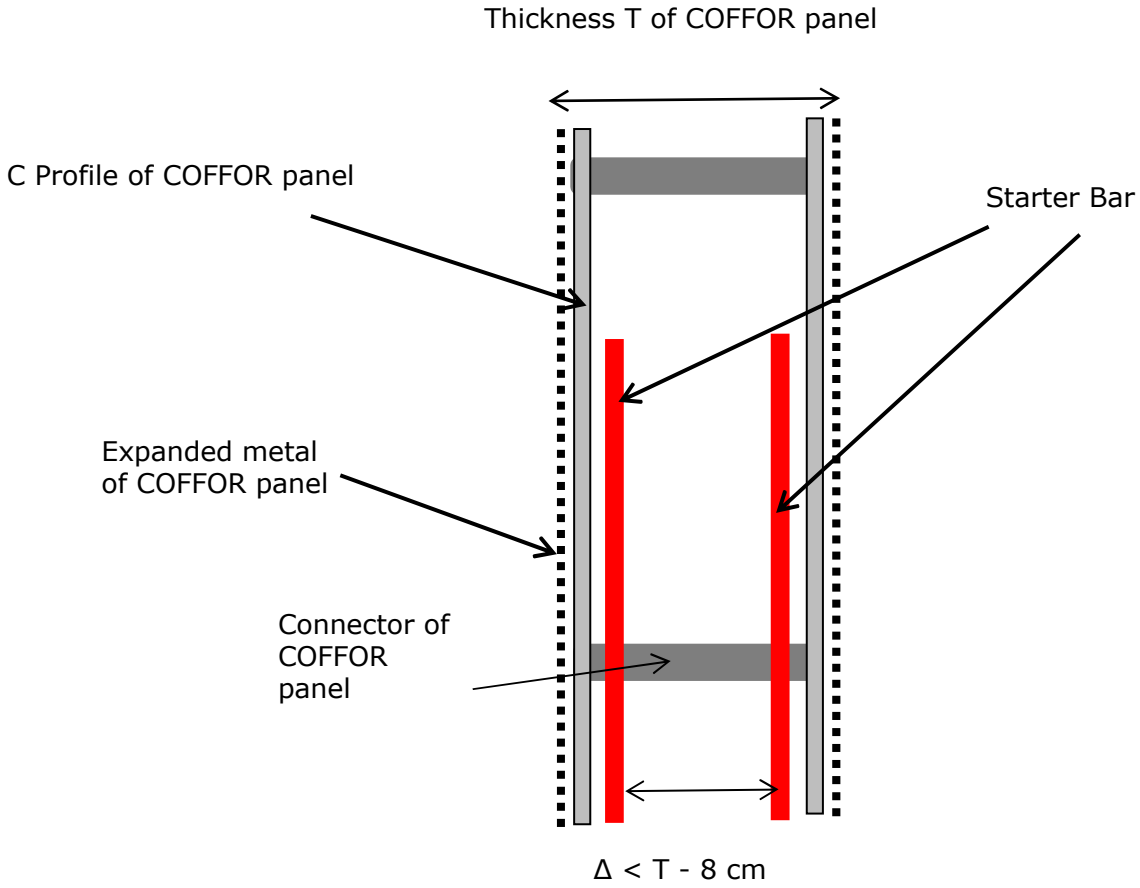
5 – Placement of the lintel over the window

Exhibit 6 – Execution of a window



The edges are closed with profiles (supplied from the factory) or wooden planks

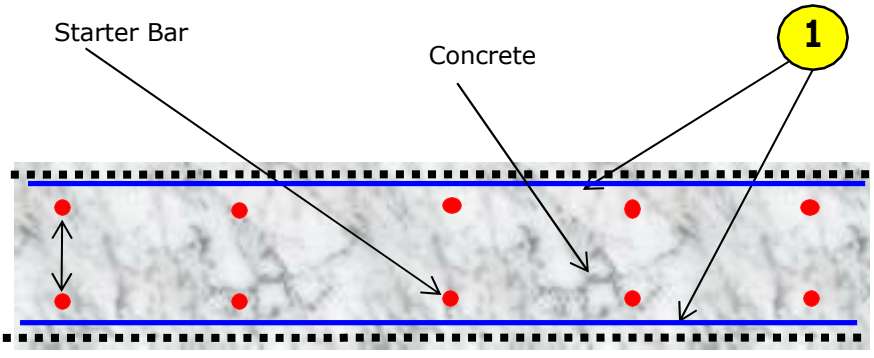
Exhibit 7 – Closing of the edges



The distance (**measured on the interior**) between the two layers of starter bar **should not exceed the panel thickness minus 8 cm**

For panel 15 cm thickness**,** maximum distance is 8 cm
For panel 20 cm thickness**,** maximum distance is 12 cm
For panel 25 cm thickness**,** maximum distance is 17 cm

Exhibit 8 – Constructive instruction for starter bar



1 Horizontal connecting reinforcement placed every 40 cm along the wall. The diameter of the reinforcements will be determined by the engineering study.

Exhibit 9 – Constructive instruction for straight wall

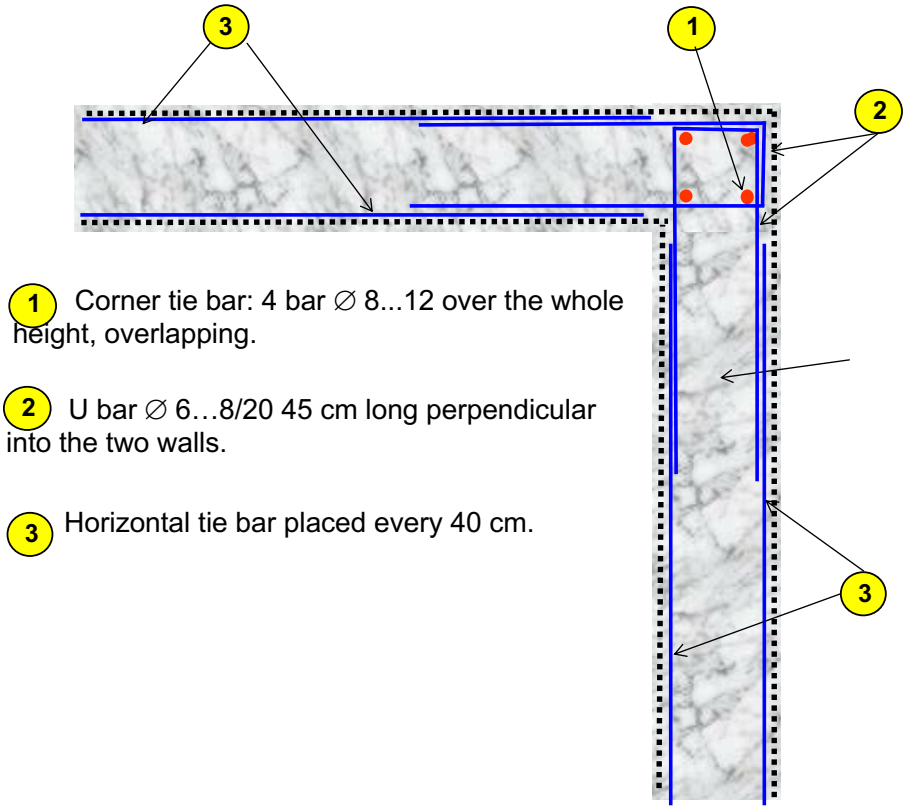


Exhibit 10 – Constructive instruction for angle walls

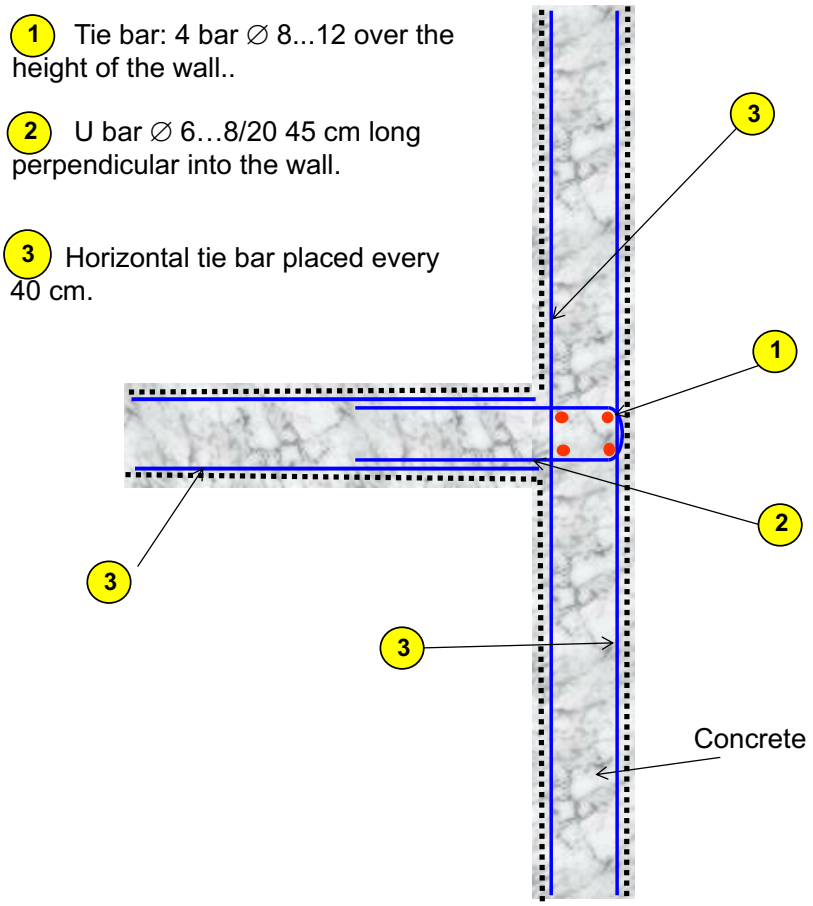


Exhibit 11 – Constructive instruction for internal/facade walls

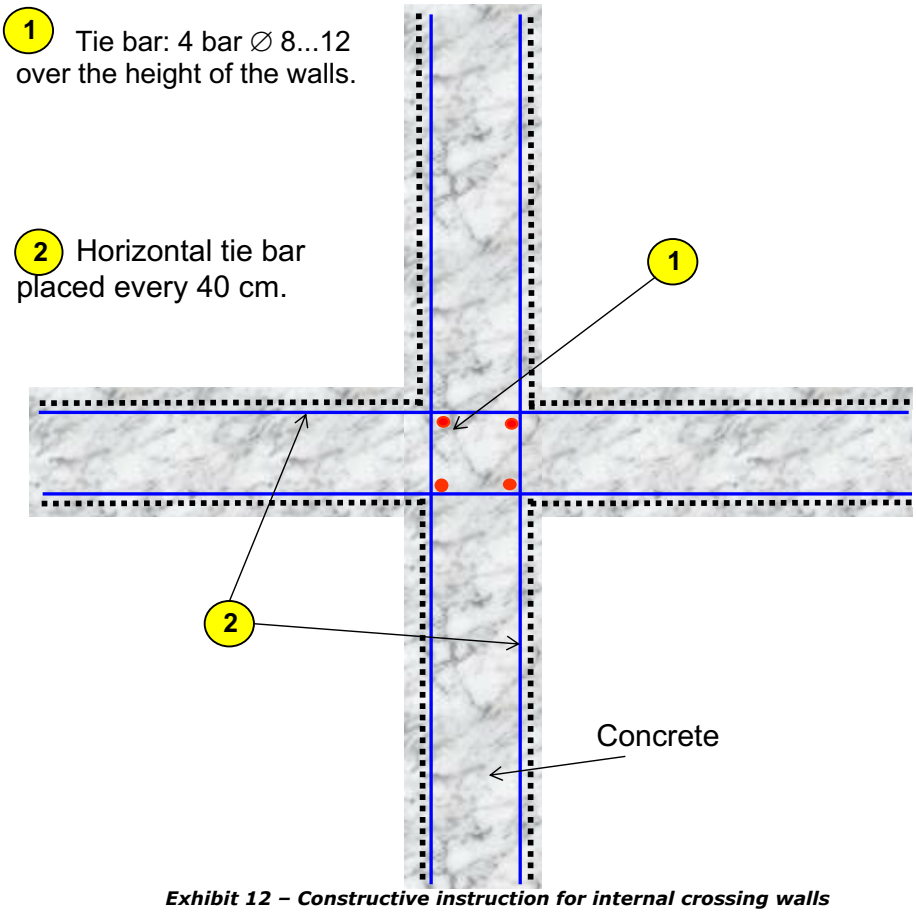
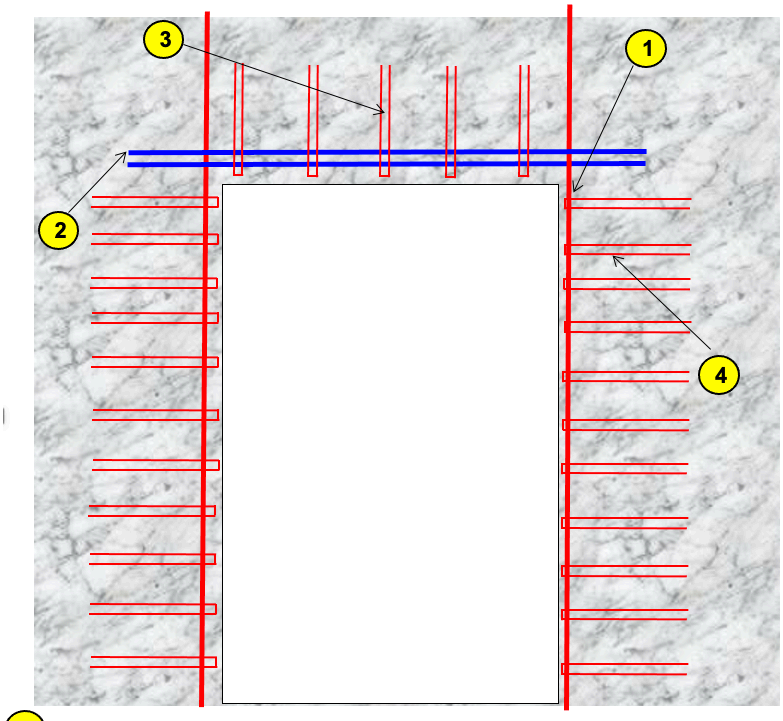


Exhibit 12 – Constructive instruction for internal crossing walls



1. Tie bar: 2 bar ∅ 8...12 over the whole wall, overlapping.
2. Lintel or beam: to be determined by the engineering study.
3. Vertical bar: to be determined by the engineering study.
4. Horizontal U bar ∅ 6..8/20 45 cm long.

Exhibit 13 – Constructive instruction for doors

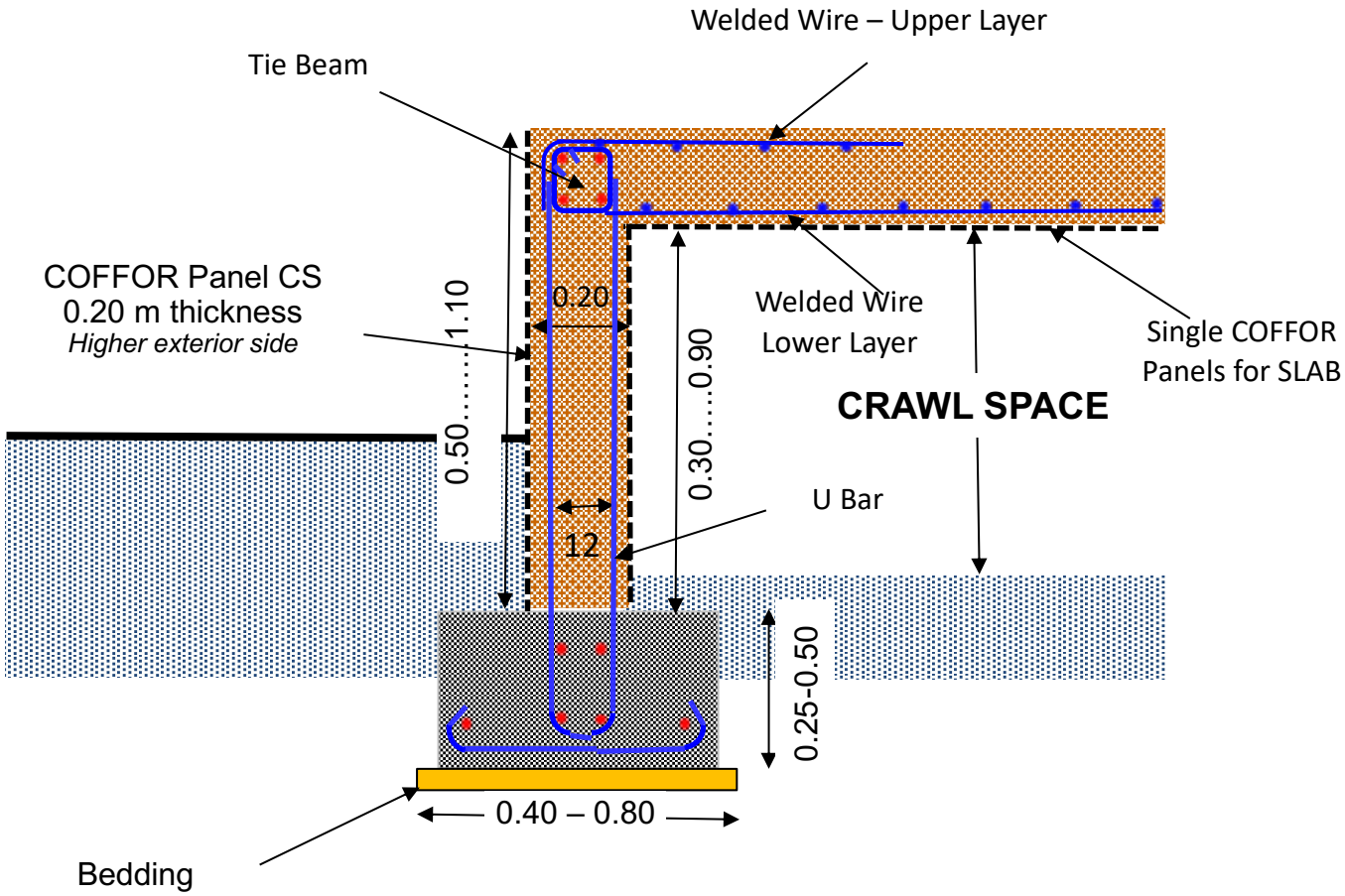
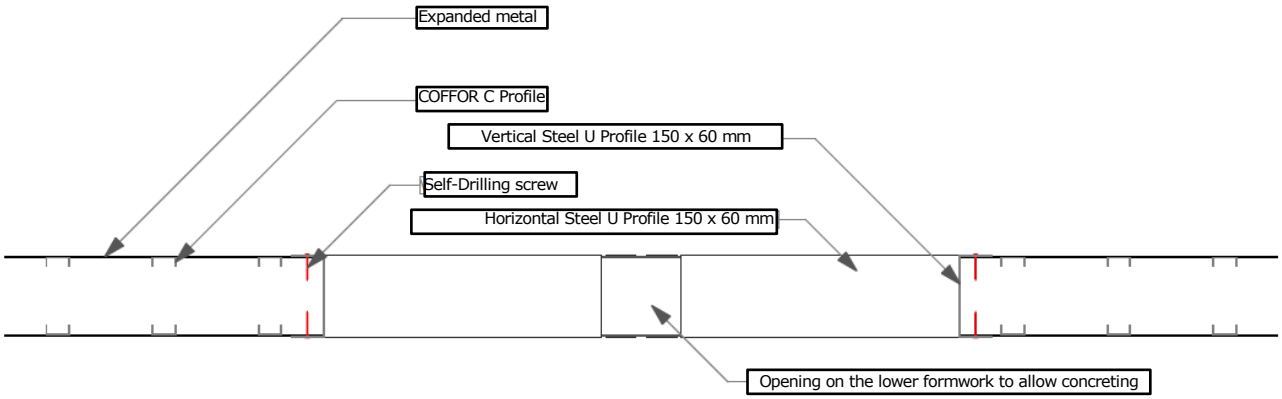


Exhibit 14 – Constructive instruction for crawl space



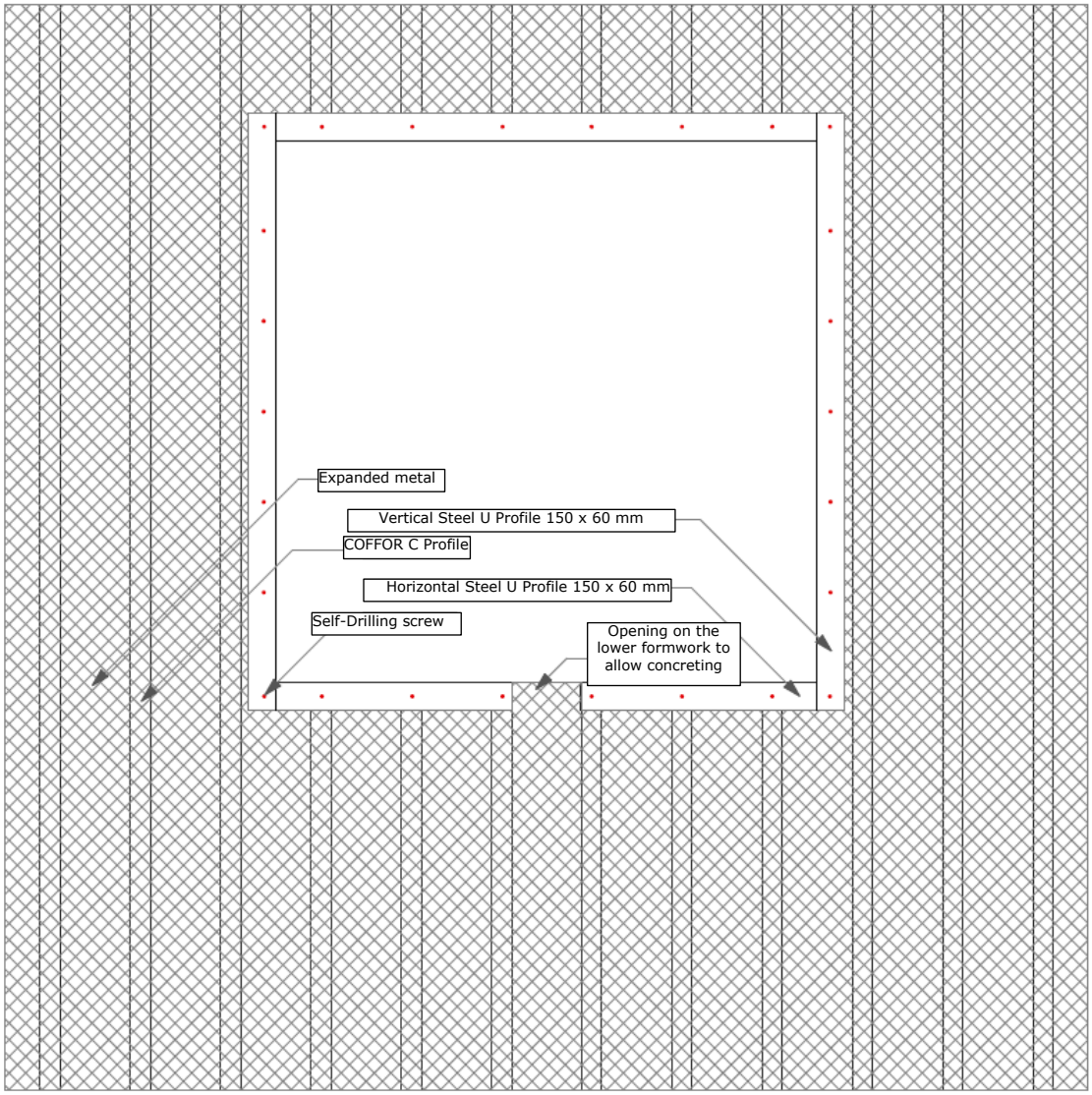
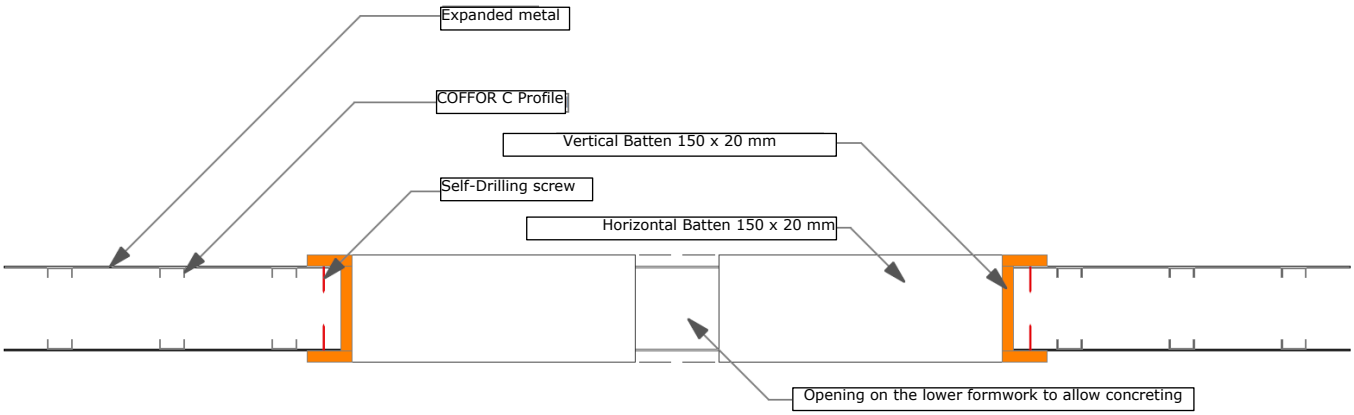


Exhibit 15 – Window opening with metal U profile



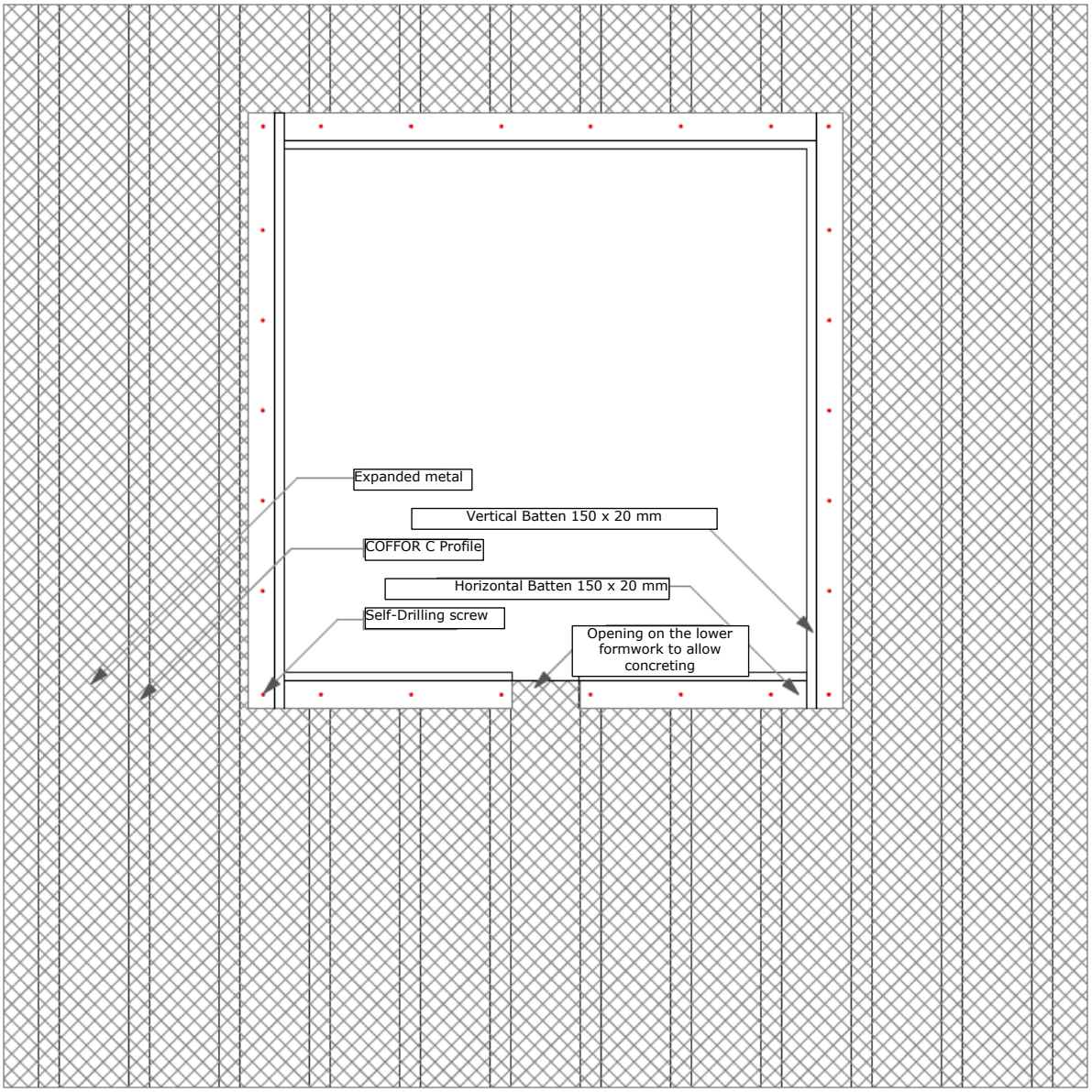


Exhibit 16 – Window opening with batten