Technical Assessment 16/06-513

Revision of Technical Assessment 16/03-455

Notification :

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Wall with integrated formwork

COFFOR
Structural Formwork

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Commission in Charge of Issuing Technical Assessments
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Specialised Group no. 16
Special products and systems for masonry

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CSTB le futur en construction

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Specialised Group no. 16 of the Commission in Charge of Issuing Technical Assessments examined, on June 16, 2006, the special wall procedure "COFFOR Structural Formwork", presented by COFFOR FRANCE Company. Concerning this procedure, it formulated the following Technical Assessment. This Assessment cancels and replaces Technical Assessment no. 16/03-455. This Assessment has been formulated for applications in European France and in the "DOM-TOM" (Overseas Departments and Territories).

1. Brief description

1.1 Brief description of the system

The system consists of an integrated formwork, with draining facing panels, self-bracing with relation to the pressure from the fresh concrete.

The formwork consists of two panels with vertical stiffening framework of press-formed steel sheet sections and skin of expanded metal, connected to each other by articulated loops in zigzag pattern. The panels are manufactured and assembled in the factory.

Due to its constitution and to its implementation, the COFFOR structural formwork system makes it possible to build vertical walls, straight or curved, bearing or non-bearing, outside or inside.

The complementary reinforcing bars can be installed on the worksite if the bars come singly or in pairs, or in the factory at the assembly of the formwork panels in the case of welded wired fabric.

Coverings:

Outside: Spread coating or insulated cladding elements.

Inside: Spread coating or facing of bonded or screwed panels.

1.2 Identification of the elements

The COFFOR Structural Formwork elements can be identified by their outside appearance and they carry an identification sheet, attached to each element before it leaves its factory.

2. Assessment

2.1 Accepted field of application

Walls of buildings for residential use, for offices and for public establishments within the limits resulting from the necessary verifications, case by case (stability, thermal, acoustic,...).

2.2 Assessment of the system

2.21 Compliance with the laws and rules in force and other qualities of suitability for the application

Stability

The stability of the buildings constructed, using this system, can be normally provided by applying the method of corroboration by the calculation defined in the Technical Specification Book.

Use in seismic zone

It is possible to use the system in non-zero seismicity zones by complying with the PS 92 Rules that apply to traditional structures of reinforced concrete, and no waivers are permitted from any of those rules.

Fire safety

The durations of the fire resistance or fire stability requirement criteria of a wall built using the COFFOR Structural Formwork System can be corroborated by applying the FB calculation Rules (DTU* P 92-701) to the single concrete shell which constitutes the core of the wall.

The fire reaction rating of the outside covering is that of the coating.

Prevention of accidents during construction and servicing

The system constitutes no obstacle to the utilisation of the usual accident prevention measures. Because of the prickliness of the faces of the expanded metal, it is indispensable to wear safety gloves when handling the elements.

Manual handling is only possible for elements with a regular storey height.

Heat insulation

The statutory requirements can normally be met, it being noted that meeting them essentially depends upon the associated inside or outside insulation work.

Checks are to be carried out by applying the "Th U" Rules and taking into account, when necessary, any cold bridges, corresponding to connections with the floorings and bearing partitions.

Sound insulation

The sound absorption coefficient of a separating wall can be estimated by applying the law of acoustic mass; this leads, for a pink noise, to 56 dB for a concrete wall 16 cm thick and to 60 dB for a concrete wall 20 cm thick and, for road noise, to 52 dB and 56 dB respectively.

With relation to insulating the façades against noises coming from the outside space, this depends on the organisation of the heat insulation of the walls. Since overlaid insulation is used, the concrete wall, from this point of view, is not different from a traditional concrete wall.

Sealing the outside walls

Such sealing can be considered as normally provided by applying the specifications for outside covering by sprayed coating.

Risks of surface condensation

From this point of view, the system is not different from traditional shuttered concrete wall methods.

Well-being in the summer

From this point of view, the system is not different from traditional shuttered concrete wall methods.

Finishes - appearances

The finishes provided are:

- on the outside, a sprayed coating or insulated cladding elements.
- on the inside, a coating with cement or plaster or a plaster facing panel.

2.22 Durability-Servicing

The compaction of the poured concrete should cause no problem since, to a certain degree, the formwork makes it possible to verify the quality of its filling.

It is considered that the durability of the wall constructed with the COFFOR Structural Formwork is equivalent to that of shuttered concrete walls to which it is similar, and the durability of the associated inside and outside facings is equivalent to that of the same facings applied on traditional substrates.

* D.T.U. – Documents Techniques Unifiés *(Unified Codes of Practice).*

2.23 Manufacture and construction

Produced in a specially equipped closed factory, the manufacture is partially automated. Because of the meticulous character of certain operations, the production requires self-inspection.

The construction work requires accurate positioning of the formwork elements and specific training of the construction crews. This is why the holder of this Assessment must provide technical assistance for the use of the system (dissemination of the Technical Assessment, compliance with the specifications attached to it) and particularly at the start-up of jobs on the site.

2.3 Technical Specification Book

2.31 Design specifications

- The design of the concreted walls in the elements of the COFFOR Structural Formwork must meet the rules of DTU 23.1 as well as the BAEL calculation rules.
- The corroboration of the stability and strength calculations shall be constituted according to the usual methods (BAEL rules) on the poured concrete section alone, without taking into account the possible participation of the steel reinforcements of the formwork faces nor of the stiffening sections except within the strict limits of the cases set down in § 5.6 of the Technical File. In the cases where the weakest section of the vertical reinforcements required makes it possible to use stiffening sections as reinforcements in definitive phase, it is a good idea just the same to install all the complementary reinforcement bars necessary to transmit the forces between panels or between the COFFOR panels and the other elements of the structure. Furthermore, in this case, the section of these stiffening sections cannot be taken into account to corroborate the strength of the panels under the forces applied against their plane (transversal bracing).
- The use of the COFFOR Structural Formwork system in seismic zone requires a design and a sizing according to the specifications in the PS 92 Rules. In this regard, the system's particularity shall never justify dispensing with the verifications and obligations set down in these rules for reinforced concrete structures.
- To prevent the appearance of rust spots or chips on the facing's coating, it is indispensable to galvanise the zigzag metal rebar sections as described in § 2.1 of the Technical File.
- The complementary screws for fixing the expanded metal formwork faces to the vertical stiffening sections shall be protected against corrosion (zinc or cadmium coating).
- The application of the outside coating shall comply with the Specifications of Article 9.2. of DTU 26.1.

2.32 Production specifications

- Before delivering the formwork panels, an operator shall make sure that all the extremities of the bracing rods in zigzag are within the stiffening sections.

2.33 Construction specifications

- The concrete shall be poured in compliance with the Specification Book of DTU 23.1.
- Next to the joints between the panels of the COFFOR Structural Formwork, in addition to the coating dividing joints, during the works, a coating continuity reinforcing bar, at least 10 cm wide, shall be attached.
- The system shall be installed by qualified contracting firms, having received specific training.
- The fluidity of the concrete must be corrected whenever laitance leaks tend to become excessive.
- For application in the DOM-TOMs, the methods for applying the outside coating are the methods applied there for traditional substrates.

Conclusions

Overall evaluation

The use of this system in the accepted application field is favourably assessed.

Validity

Until June 30, 2010

For Specialised Group no. 16
The Chairman
E. DURAND

3. Complementary remarks from the Specialised Group

This Technical Assessment revision comprises products, the formwork facings of which are connected by transversal braces (COFFOR 3G variant) as an alternative to the connection by reinforcing bar (rebar) loop sections in zigzag pattern.

The reader is reminded that this system has the particularity of utilising a so-called « draining » formwork, that is, a non-sealed formwork. Tests have shown that, by applying the provisions described in the Technical File and, in particular, mastering the fluidity of the poured concrete, this particularity does not weaken the formwork enclosed concrete.

In certain cases, this revision makes it possible to take into account vertical stiffening sections to corroborate the strength in definitive phase. This possibility is strictly limited to the cases described in § 5.6.1 of the Technical File and under the conditions set down in the Assessment's Technical Specification Book.

The Group draws attention to the complexity of installing complementary reinforcing bars in cases where they would reach heights exceeding the regular height of a storey and/or major lengths, rendering it difficult to insert horizontal reinforcing bars between the stiffening sections and the vertical reinforcing bars.

Furthermore, the use of the system in seismic zone is subject to compliance with the design and sizing rules specified for traditional reinforced concrete structures within the framework of the PS 92 Rules and without the possibility of waivers to any of those rules.

The Rapporteur of Specialised Group no. 16
M. CHENAF

A. Description

1. Nature and intended use

The COFFOR system of walls with integrated structural formwork, called “Coffrage-Structural COFFOR” (COFFOR Structural Formwork) is designed to build walls for buildings for residences, offices, public establishments.

It is characterised by the use of an embedded structural formwork that can contribute to the strength of the finished structure. Inside the formwork, it is possible to incorporate reinforcing bars.

The COFFOR Structural Formwork makes it possible to build walls of various shapes and thicknesses, bearing or non-bearing. It can also be applied both for inside and outside walls.

The COFFOR Structural Formwork consists of two panels, connected to each other by HA 5 steel rod rebar sections every 20 cm, in zigzag pattern, embracing the stiffening sections of the structural formwork (Figure 1). These zigzags stabilise the walls with relation to the pressure from the fresh concrete. In the structural formwork, COFFOR 3G, the two faces are connected by galvanised steel reinforcing bar (rebar) loop sections, perpendicular to the panels. They function in the same way as the zigzag rebar loop sections. Each of the panels is composed of a vertical framing of galvanised sheet steel sections upon which is clipped an expanded metal skin.

The COFFOR Structural Formwork is manufactured by a group of machines from galvanised steel strips and galvanised steel reinforcing bars for the zigzag yoke sections. The panels are assembled in the factory by specific machines.

The COFFOR Structural Formwork system can be installed alone or it can be associated with components such as casework and subcase elements, even complete joinery units. With it, incorporations and service recesses of all kinds are possible, i.e. piping, electricity, telephone, TV, etc.

Its facings can be covered:

- on the outside, either by a sprayed coating, or by insulating cladding elements with, in this case, constructive arrangements in compliance with those recommended by the Technical Assessment for the insulated cladding elements used.
- On the inside, either by a sprayed coating, or by a facing of bonded or screwed panels, or by a liner facing.

2. Materials (see Figure 1)

2.1 Composition of the COFFOR Structural Formwork system

- *Facing:* 1 Draining expanded metal sheet

  Expanded metal, made from R 240 steel strip, of hot galvanised steel Z 275 (Standard NF A 36 321), minimal thickness 0.45 mm, standard dimensions 2500 mm (cut out according to the needs) x 600 mm, with ribs every 100 mm.

- *Framing*: 2 Vertical stiffening sections

  Sections, press-formed cold, from steel strip R 240 of hot galvanised steel Z 225 (Standard NF A 38-322), 0.6 mm thick with 5 longitudinal ribs and one double fold at the extremities to improve the rigidity.

- *Connection*: 3 Rebar loop sections in zigzag pattern

  Concrete reinforcing bar of galvanised steel Fe500 or equivalent, at least 5 mm in diameter.

  Guaranteed elastic limit: 500 N/mm²

  Tensile strength: 700 N/mm²

- *Connection with loop sections 3G*

- *Hot galvanised steel rebar B1, 3 mm in diameter*
  Plain steel rebar for concrete, S500, 5 or 6 mm in diameter
  Guaranteed elastic limit: 500 N/ N/mm²
  Tensile strength: 700 N/mm².

2.2 Function of the elements constituting the COFFOR Structural Formwork

Function of the zigzag loop sections

The two faces of the COFFOR Structural Formwork are connected by loop sections in zigzag pattern that alternately clasp the stiffening sections on both formwork faces. They are positioned between the stiffening sections and the expanded metal.

All the way up the formwork, the zigzags are positioned alternately every 20 cm.

The positioning of the zigzag loop sections confers a restraint, favourable to the proper behaviour of the concrete under seismic load.

As a variant (3G), the vertical sections are spaced every 20 cm (on-centre) as against 23 cm in the zigzag version. The plain concrete rebar S500 is straight and crosses through the sections every 20 cm. The galvanised steel rebar, re-curved twice on each side, constitutes a loop section connected on the 2 faces of the panels while winding around the plain concrete rebar. Horizontally and vertically, the steel rebar loop sections are spaced a maximum of 40 cm.

Function of the stiffening sections

The sections have a triple function:

- Stiffening of walls, which is indispensable for easy handling during transportation and positioning in the structure.
- Stability of the walls in provisional phase under the pressure due to the fresh concrete.
- Contribution to the strength of the wall in definitive phase, given their bond to the concrete.

Function of the expanded metal

By gravity, the expanded metal lets the excess water escape from the concrete. Given the presence of the stiffening sections on the one hand, and of the expanded metal on the other hand, their proper bond to the concrete and their respective cross-sections, the COFFOR Structural Formwork does not require the incorporation of an anti-crack welded wire fabric.

3. Constitution of the COFFOR Structural Formwork

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

- The geometry of the structures,
- The type of walls,
- The possible association of components for openings with the system,
- The type of outside covering.

3.1 Geometry of the structure

The COFFOR Structural Formwork is composed of elements, positioned one next to the other so as to constitute, on the two facings, a continuous unit. To adapt to the geometry, standard panels are available, 122 cm wide, by 99 cm, 76 cm, 53 cm and 30 cm for the version with zigzag, along with standard panels 110 cm wide by 90 cm, 70 cm, 50 cm and 30 cm in the Structural Formwork COFFOR 3G version.

When the wall length does not exactly correspond to these dimensions or to one of their compositions, a complement of expanded metal is added on the worksite by self-tapping screws, screwed into the stiffening sections through the ridges in the expanded metal. The additions shall not exceed 20 cm wide (this installation flexibility enables a considerable time savings on the worksite). Another faster method is to cut out a panel of the necessary width on the site.

The angles are left open to make it possible to introduce reinforcing rods at particular points. Afterward, they are closed by the wall height angle pieces. In the same way, to deal with a bearing partition wall, the panels are juxtaposed so as to enable easy insertion of the reinforcing bars.

Vertically, the formwork is adapted to the wall height and, when necessary, to the thickness of the flooring slab (Figure 2).

The standard and regular panels contain vertical stiffening sections every 23 cm, and zigzag rebar every 20 cm that alternately clasp the vertical stiffening sections. In the Structural Formwork COFFOR 3G version, the vertical stiffening sections are positioned every 20 cm and the steel rebar loop sections, every 40 cm at least.

3.2 Type of wall

The wall heights made with COFFOR Structural Formwork vary according to the need. The two formwork faces are the same. The zigzags make it possible to fold the panel over for transportation.

3.3 Association of components for openings with the COFFOR Structural Formwork

One advantageous alternative, for simplifying the work, can be the incorporation, during installation of the panels, of more or less complete opening components. In every case, these shall be compatible with the COFFOR Structural Formwork, that is, in particular, they shall:

- continue and extend their structural arrangements (assumption of the concrete pressure);
- remain homogeneous with the characteristics of the installation of the COFFOR Structural Formwork;
- be compatible with the dimensional tolerances and the assumption of the concreting play space of the COFFOR Structural Formwork;
- tolerate the installation restrictions of the COFFOR Structural Formwork, related in particular to the draining capacity of the formwork faces.

Generally speaking, it may be noted that the incorporation of the openings makes it possible to better fix the joinery to the structure (it should be noted that the joinery is fixed with the aid of reinforced lugs or braces, with lengths such that their anchorings in the concrete extend beyond the vertical stiffening section of the contiguous panel rim).

4. Production

The COFFOR Structural Formwork is manufactured by DALIAN COFFOR DEVELOPMENT CO, Dalian, China, to which the ISO 9001 Standard (2000) was granted on January 23, 2003 for the manufacture of the COFFOR Structural Formwork panels, as well as for the manufacture of the production and assembly machines.

The COFFOR Structural Formwork panels are made with the aid of specific machines. The factories are organised and equipped for:

- acceptance inspection of raw materials (steel strip and reinforcing rods and wires),
- continuous manufacture of the components (expanded metal, stiffening sections and yoke sections),
- assembling the formwork (according to composition),
- packing the formwork (for shipping).

The raw materials, coming from the various suppliers are acceptance inspected when they arrive at the factory.

(a) The manufacture of the expanded metal comprises 3 operations:

- After loading the strip, the press incises the metal on a continuous basis.
- The ribs that reinforce the expanded metal are formed.
- The metal is expanded.

These 3 operations can be done simultaneously on one or two machines on a continuous basis and they are cut to length after the second or third step.

(b) The manufacture of the stiffening sections comprises 2 operations:

- After loading the strip, the press performs various foldings to continuously form the longitudinal ribs and give the definitive shape to the stiffening section.
- Continuous forming of the lugs that will be clipping the expanded metal to the stiffening section.

(c) The manufacture of the rebar loop sections comprises two operations:

- The rod or wire is first straightened continuously and cut to length according to the production drawing.
- Once they are straightened, the rods or wires are inserted in a press that forms the loop sections into zigzag pattern.

(d) The formwork assembly comprises:

- The manual positioning of the loop sections and of the other sections,
- The positioning of the expanded metal,
- The clipping of the lugs by the machine or manually,
- The assembled panels are sent on to quality control that verifies the proper clipping of the lugs and, if necessary, adds screws at locations which seem weak.

Packing for shipment comprises:

- grouping the formworks by type,
- placing on pallets and hoopping them,
- placing them within the packing.

Production quality control operations

The manufactured formworks undergo:

- a check on the dimensions : length, width and thickness,
- a check on the composition,
- a special check on the lugs.

All these quality control operations are carried out by following quality control instruction sheets, by an independent team.

Transportation

The panels are transported in folded position, on pallets. In case of handling by lifting machines, the pallets are seized by straps, with spacers so as not to deform the formworks located at the upper part of the pallets.

5. Construction work

The procedure for the construction work is simple.

A wall using COFFOR Structural Formwork panels can be easily erected by 2 persons.

There are various methods for placing the COFFOR Structural Formwork in position. The method described here seems the quickest and requires no special accessory except for façade scaffolding and trestles, timber boards, galvanised steel wire and a circular saw.

5.1 Layout and blocking

Boards or battens are nailed on the ground to indicate the positioning of one face of the COFFOR panels. It is not necessary to do a second alignment of the other face of the panel, although that might facilitate the positioning.

5.2 Positioning the panels – provisional support

The COFFOR Structural Formwork Panels are fitted over projecting vertical reinforcing rods which first of all need to be checked to make sure that they are vertical and then straightened if necessary.

On a provisional basis, each panel is held vertically with timber pieces (battens or boards) or metal pieces (sections, L-sections or tubes). The minimal length of these bracing elements shall not be less than 1.80 m.

The COFFOR Structural Formwork panels shall preferably be positioned beginning from the angles and from the doors.

Whenever the length of the wall does not correspond to a multiple of the width of the panels, the last panel is to be cut with a circular saw to adjust to the length of the wall.

5.3 Consolidating the panels

When all the panels are installed, they are consolidated with wood pieces (battens or boards) or metal pieces (sections, L-sections or tubes), spaced from each other at approximately 0.80 to 1 m. Then they are fixed horizontally with the aid of galvanised steel wire.

It is important to place an alignment board at the top of the panels.

The horizontal battens can be installed on a single side, with the aid of a steel wire that is bound around one of the two stiffening sections of the neighbouring COFFOR Structural Formwork panels.

Another method is to place battens face to face on both sides of the panels. The steel wire then links the two pieces through the expanded metal.

In this way, on a wall 2.50 to 3.00 m, there will be four rows of consolidating pieces, including the batten at the bottom of the panels (Figure 3).

Since the COFFOR Structural Formwork system is used as a skin reinforcement (anti-cracking), there are arrangements to provide continuity of the panel in the two directions, horizontal and vertical (Figure 4).

5.4 Final adjustments of the panels

When all the wall panels have, in this way, been erected and consolidated to each other, a final adjustment is performed with wood pieces (battens or boards) or metal pieces (sections, L-sections or tubes) which are used as bracing.

The provisional restraining pieces are removed and are replaced by the final stays positioned every 2 m approximately.

The verticality is checked using a level or a plumb line.

5.5 Closing the rims of doors and windows

The opening for windows is done using a circular saw.

Rims of doors and windows are closed preferably with wood pieces, the width of which is equal to the thickness of the COFFOR Structural Formwork panel.

In case several doors and windows have the same dimensions reusable mock-up can be made to save time.

However, the fastest and most efficient method is to install subframes, supplied by the joinery supplier.

5.6 Installing the reinforcing bars

Once the panels are correctly stabilised, reinforcing bars, complementary to the COFFOR Structural Formwork, are installed.

5.61 Reinforcing bars in the regular part of the wall

In case the cross-section of the vertical reinforcing bars, type HA 500, required by the calculations, is less than 0.5 cm^2/m, the vertical sections of the COFFOR Structural Formwork, can act as reinforcements, except for those that provide the continuity of the panels as described in § 5.3 above. An anti-cracking welded wire fabric is not necessary.

If it is necessary to add complementary vertical reinforcing bars, such vertical reinforcing bars are prepared in advance and delivered to the worksite by the reinforcing bar supplier or, they can be directly crafted on the worksite.

The vertical reinforcing bars shall be grouped in pairs, connected to each other by 2 (or 3 or 4 according to the wall height) horizontal bars, welded or bound to the vertical reinforcing bars.

Each pair of vertical reinforcing bars is slid into the stiffening sections of the COFFOR Structural Formwork (Figure 5).

The horizontal reinforcing bars are then inserted between the vertical reinforcing bars and the stiffening sections (Figure 6).

These horizontal reinforcing bars rest on the horizontal zigzags, connecting the two faces of the COFFOR Structural Formwork panel and positioned every 20 cm.

Because of the installation as described above, the vertical reinforcing bars and the regular horizontal reinforcing bars in the walls are not bound.

5.62 Reinforcing piece at the extremities and next to the openings (vertical ties)

The details of the reinforcement elements in the angles and around the openings (tying) are the same as for traditional walls of reinforced concrete.

After positioning the regular reinforcing bars of the walls, vertical bars (posts) and horizontal bars in U-shape, are placed in the angles and the openings, and bound together (Figures 7 and 8).

5.7 Closing the angles

The angles are closed with COFFOR Structural Formwork angle panels, delivered from the factory. In the absence of angle panels delivered from the factory, panels of expanded metal can be press-formed on the site.

Preferably, the angle panels are fixed:

- On the inside with a batten placed vertically all way up the angle. This batten is bound around the stiffening sections of the COFFOR Structural Formwork panels of the angle.
- On the outside with braces spaced about one meter apart and bound around the stiffening sections. If there are no braces, timber panels, bound around the stiffening sections can be used.

If there are no COFFOR Structural Formwork angle panels, timber boards can be used to close the angles.

5.8 Post-shellwork building trades

The electric ducts and the plumbing (heating, piping) can be positioned within the panels.

For the connections (current receptacles, etc.), small openings are made in the expanded metal.

5.9 Checking before concreting

Before pouring the concrete, it is necessary to verify:

- the alignment of the COFFOR Structural Formwork,
- the correct positioning of the stays (knee braces) for the stability of the COFFOR Structural Formwork,
- the closing of the angles, of the doors and of the windows,
- the positioning of the reinforcement elements,
- the incorporation of the work of the posts-shellwork building trades,
- the cleanliness of the surfaces where new concreting connects to earlier concreting.

These precautions contribute to correct quality and continuing uniformity of execution.

5.10 Pouring the concrete

The concreting is done with ordinary concrete.

The only instructions specific to the COFFOR system are:

- dimension of the granules from 0 to 20 mm so as to guarantee correct filling of the stiffening sections,
- very plastic consistency (TP in the sense of Standard P 18-305: slump from 10 to 15 cm).

During the pouring phase, it is necessary to roughly float-spread the walls and to recover the excess concrete which will have passed through the expanded metal.

The concreting can be done with a pump, with a grab bucket or with a shovel loader.

If the concrete is pumped, it is preferable to fix an elbow and elbow support so as to attenuate the concrete's falling speed.

It is important to monitor the pouring at the joining points, reveals and zones containing reinforcement elements, and this can be improved as the work goes along by an external vibration with a rammer or by internal vibration with the aid of a poker vibrator. It is important to avoid placing the poker vibrator in contact with the expanded metal. The poker's diameter shall not exceed 25 mm.

The expanded metal walls of the COFFOR Structural Formwork system make it possible to drain off the excess water when pouring. With a usual water/cement ratio, the system makes it possible to maintain a satisfactory workability of the concrete for the pouring by eliminating certain of the negative effects related to water which is in excess of what is necessary for hydrating the cement paste (sweating, increased creep,…).

5.11 Finishing the wall

On the outside, it is possible to use traditional hydraulic or sprayed façade coatings, the bond of which is also facilitated by the expanded metal's rough surface.

The composition of the coating, the number of coats and their thicknesses are governed by the rules in force.

External facings of wood, stone, etc.… are possible.

On the inside, it is possible, for example, to use plaster, the bond of which is facilitated by the expanded metal's rough surface or, bond panels of BA 13 using dabs. Naturally, it is possible to use panels of wood, tile, marble, etc.… When inside insulation is necessary, it can be directly applied to the walls.

6. Facings and coverings

6.1 Inside facings

Given the rough surface of the concrete, the inside face is finished either with a panel of plaster BA 13 or other material, bonded by dabs, either using a sprayed coating of cement mortar or of plaster, performed in compliance with the DTUs in force.

6.2 Outside coverings

The instructions for application are the same as for the coatings or insulated cladding elements on traditional walls.

7. Marketing and using the system

The system is marketed by POLYFINANCE COFFOR HOLDING SA throughout the world and by its subsidiary COFFOR France that distributes it in France.

The system is utilised and integrated by building contracting firms.

B. Results of experiments

1. Compressive strength test on pier

Test elements

Tests of compressive strength under concentrated load (Contract no. 95-422/01 of February 21, 1996) were carried out at CSTB on COFFOR Structural Formwork walls (at the time, called "DIPY" formwork), dimensions 220 x 77 x 16 cm, on regular non-insulated elements.

Reference tests were carried out on non-reinforced concrete piers, with substantially the same dimensions (220 x 76 x 14).

In the two cases, the filler concrete was B25 concrete, the strength and modulus of deformation of which were measured on cylindrical test pieces, kept in the open air under the same conditions as the piers (average breaking stress 37.0 N/mm^2).

Results

After concreting, the DIPY (COFFOR) piers, between stiffening sections, had a maximal deflection bulge of 1 cm toward the outside (maximal effective thickness, 18 cm) so that their real average thickness was able to be estimated as 17 cm.

The average breaking stress measured was 17.6 N/mm^2 for the DIPY (COFFOR) piers and 17.5 N/mm^2 for the reference piers and the corresponding moduli Ei of elasticity were 36140 N/mm^2 and 26940 N/mm^2 respectively.

2. Concreting test

These tests were carried out by the Company, DIPY Formwork, in Calais, France, on November 15, 1996.

7 standard control panels were concreted. The objectives were:

a) to verify the behaviour under concreting with a fluid concrete formula;

b) to measure the deformation of the panels next to the vertical stiffening sections.

Test units

The 7 standard panels were formworks of wall shells with insulation and air layer.

They were concreted with a very fluid concrete, with Abrams cone slumping close to 17 cm.

The concrete was poured with a bucket with sleeve coupling, 200 mm in diameter, in a single concreting phase for all the panels.

Results

Setting up these 7 test panels makes it possible to remark as follows in each field.

Even with a very considerable fluidity, the losses of laitance through the expanded metal apertures remain very limited.

The expanded metal is deformed under the concrete's impact. It no longer deforms once the formwork is filled. In case very substantial deformation takes place (very rarely), it is possible to re-work it, once the whole wall shell has been poured, by forcing the expanded metal inward by a few strokes of the rammer.

3. Bending and bonding test

Two types of tests were carried out in the laboratory of the Mechanical Test, Study and Design Division of CSTB in November 2002:

- Bending test on a COFFOR panel to examine the participation of the stiffening sections on the bending strength.
- Bonding tests of the metal sections to the concrete constituting the panels by direct tension applied to the panels for various lengths of anchorings of the sections.

C. References

As of today, more than 2,000,000 m² have been installed with the COFFOR Structural Formwork; under the old name DIPY, mostly outside the European Union Countries.

The COFFOR system is covered by a favourable "Appréciation Technique d'Expérimentation" (ATEx) (Technical Experimentation Assessment) for the construction of an individual home in Tahiti using the metal stiffening sections as reinforcement elements to assume the bending forces in definitive phase.

The following can be mentioned among the latest installations in France:

Contracting firm	Developer	City	Application	Quantity (m^2)	Date
MGO Sepèmes les Vallons	COVARIM	Valbonne	10 homes	2000	2003
Bati-Ouest	Bati-Ouest	La Réunion	Homes	2350	2003
SPIE SCGPM Arcueil	BNP Paribas (bank)	Paris	Reinforcement of façade walls	450	2004
Carita Construction	Clinique Jeanne d'Arc (hospital)	Arles	Extension to the hospital	800	2005
AMG Marseilles	Circuit du Castellet	Le Castellet	Cloakrooms	600	2005

Tables and figures of the Technical File

Figure 1: COFFOR Structural Formwork

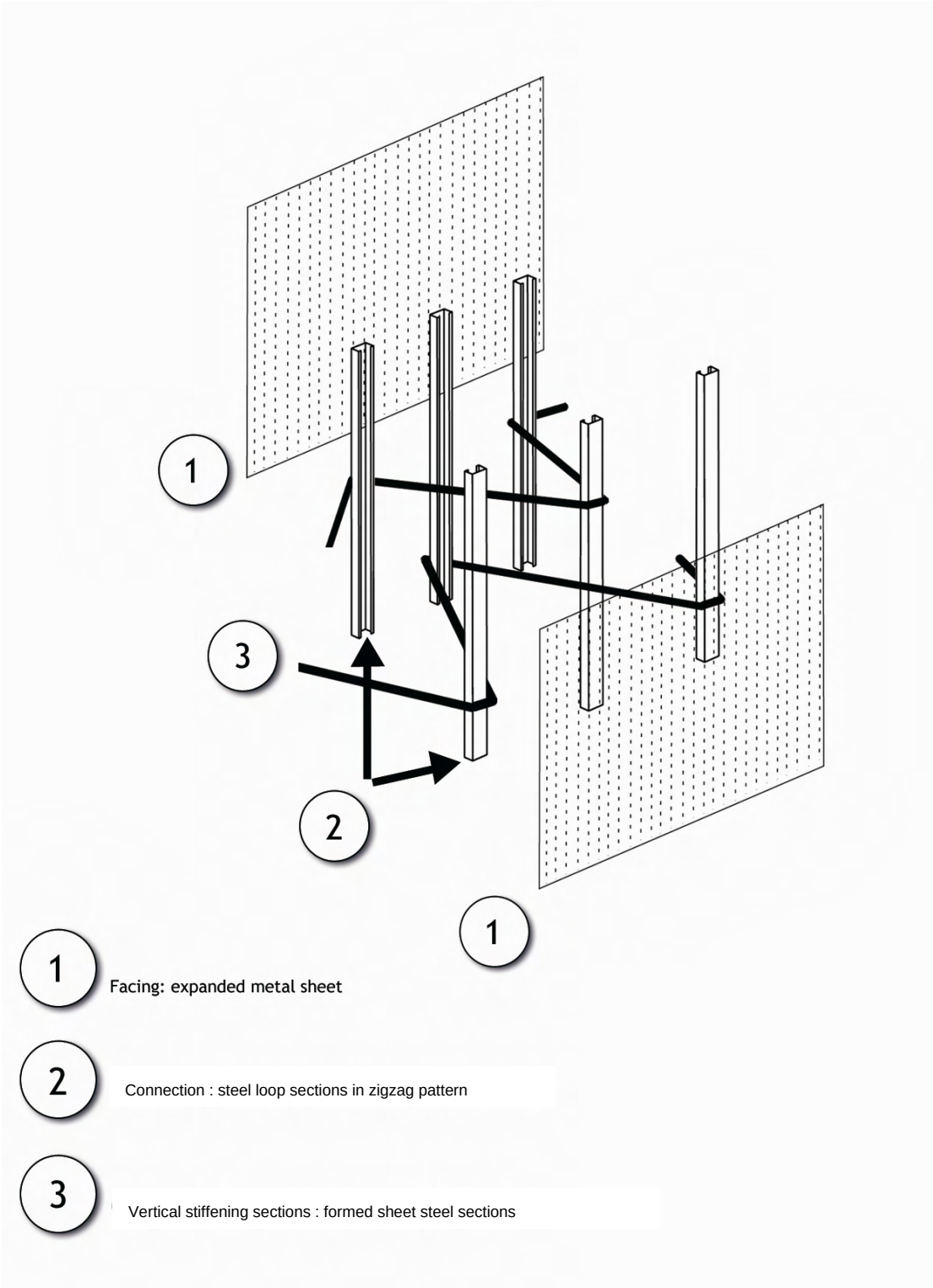
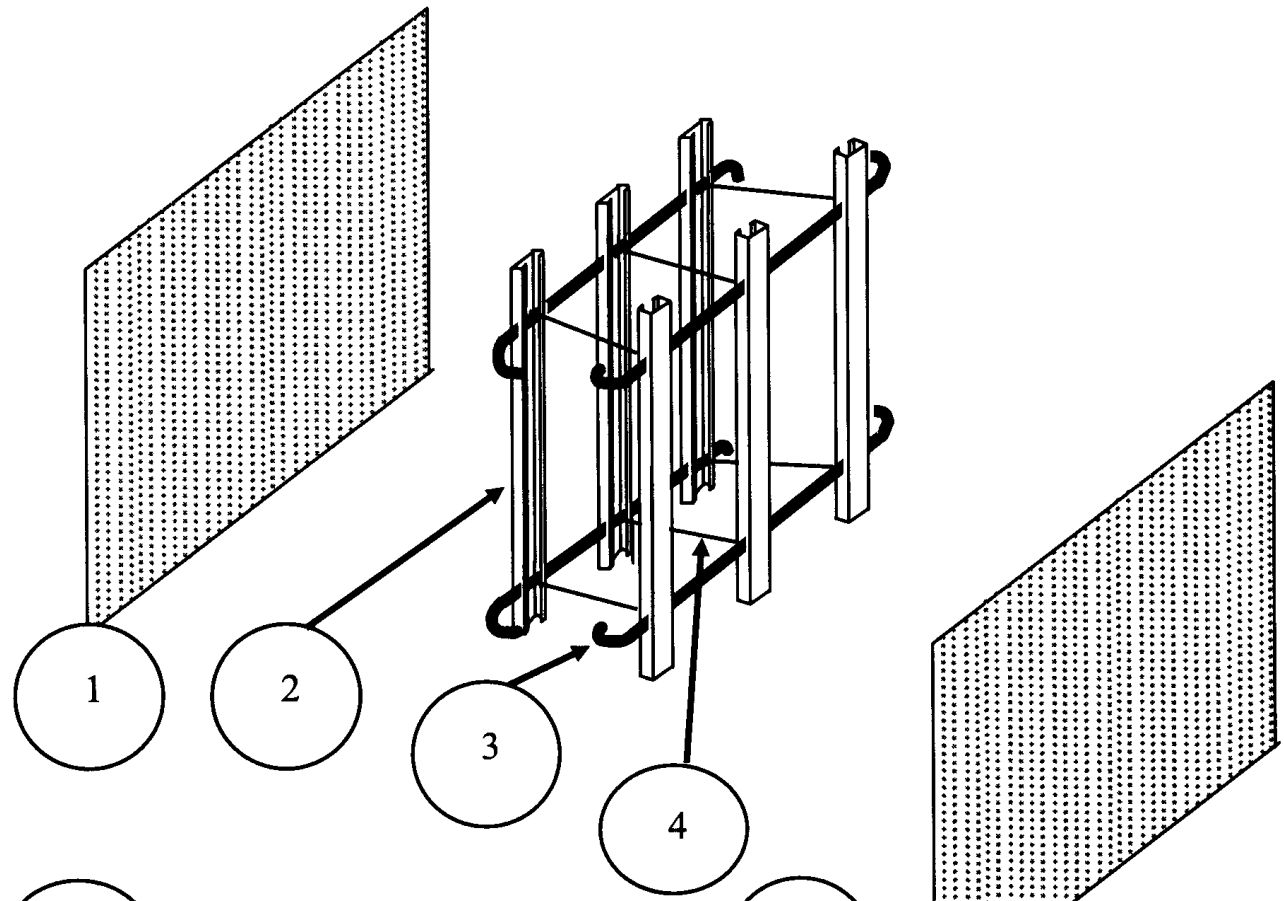


Figure 1 bis: Diagram of the COFFOR 3G



1 Facing: expanded metal sheet

2 Vertical stiffening sections: formed sheet steel sections

3 Longitudinal rebars

4 Steel connecting bar

Figure 2: Adapting the formwork to the wall height

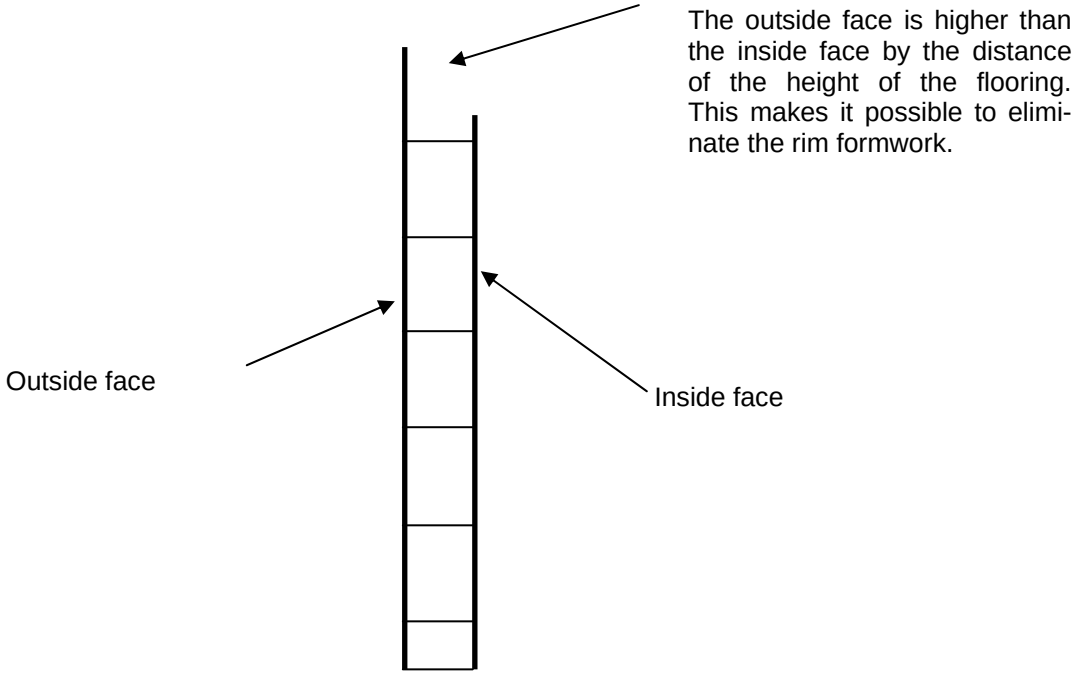


Figure 3: Consolidation of the panels

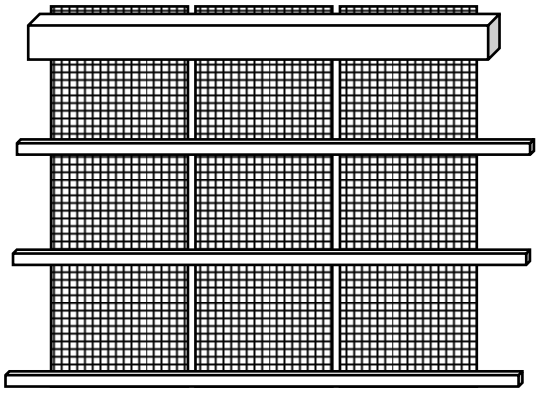


Figure 4: Horizontal junction of the panels by inserting steel U-sections

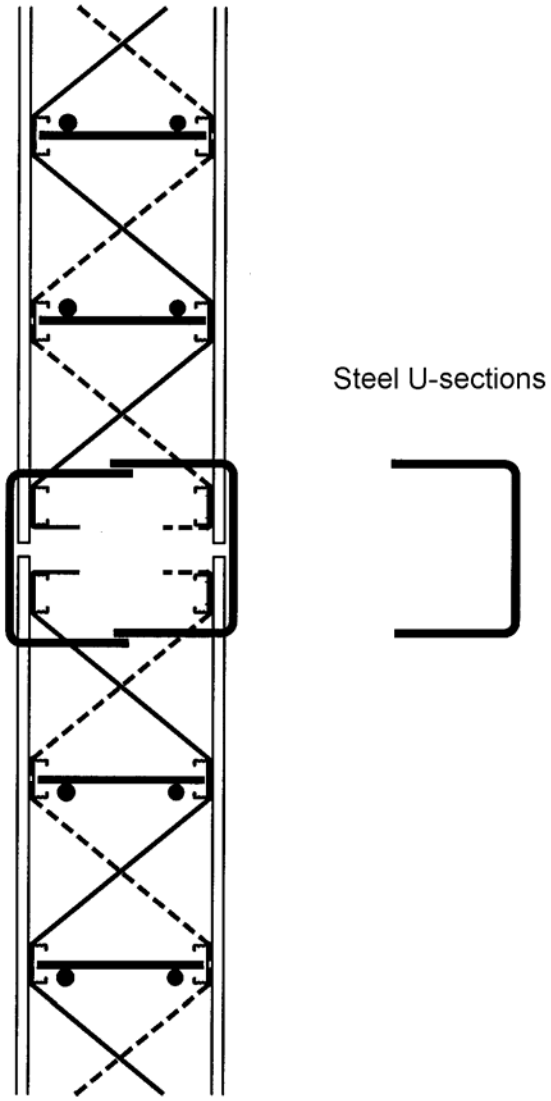


Figure 4 bis: Horizontal junction of the panels by inserting steel U-sections

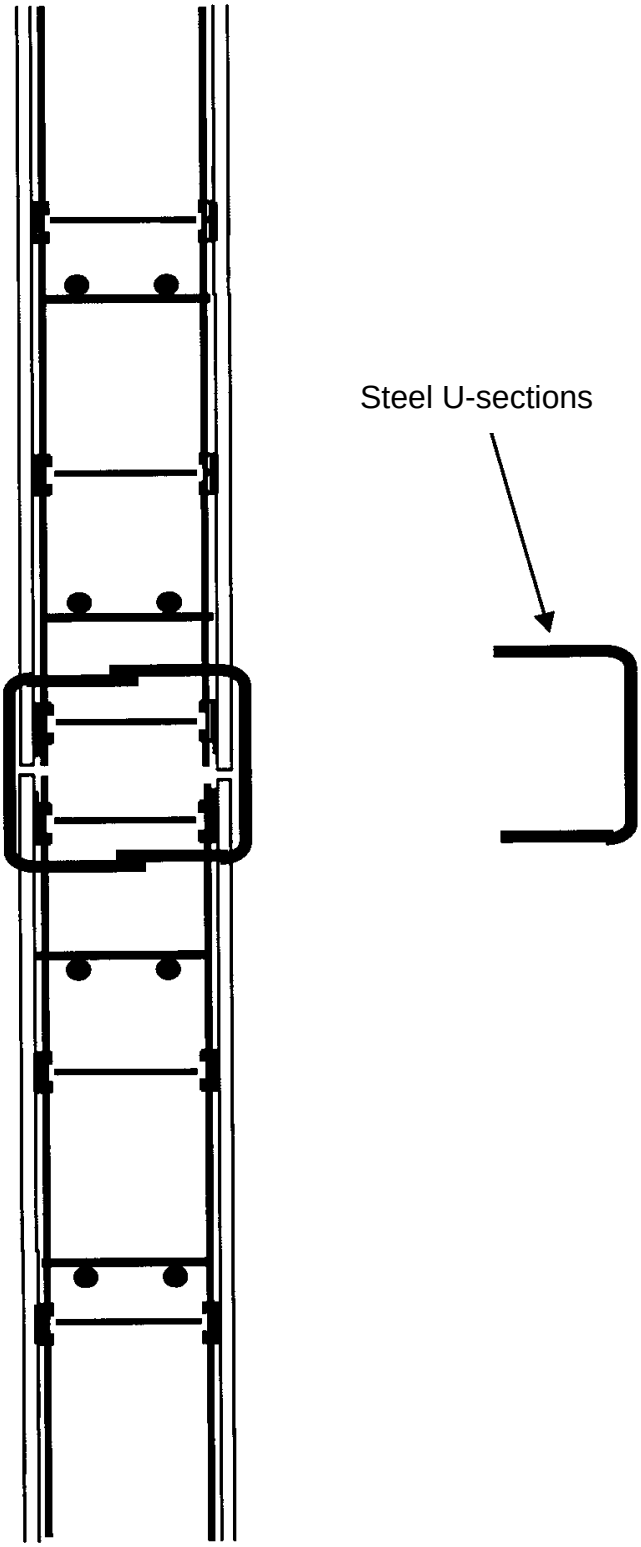


Figure 5: Inserting vertical reinforcing bars within the axis of the stiffening sections

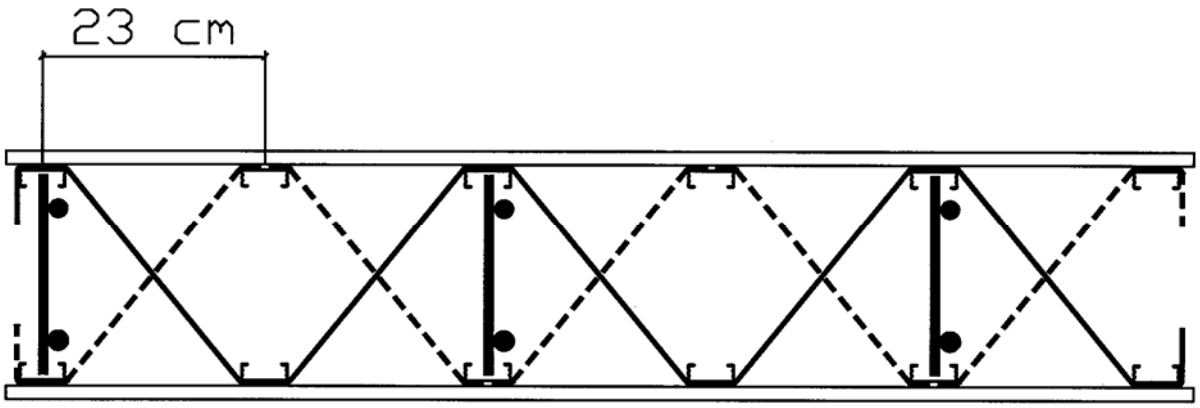


Figure 6: Inserting vertical reinforcing bars, positioned on the yoke sections

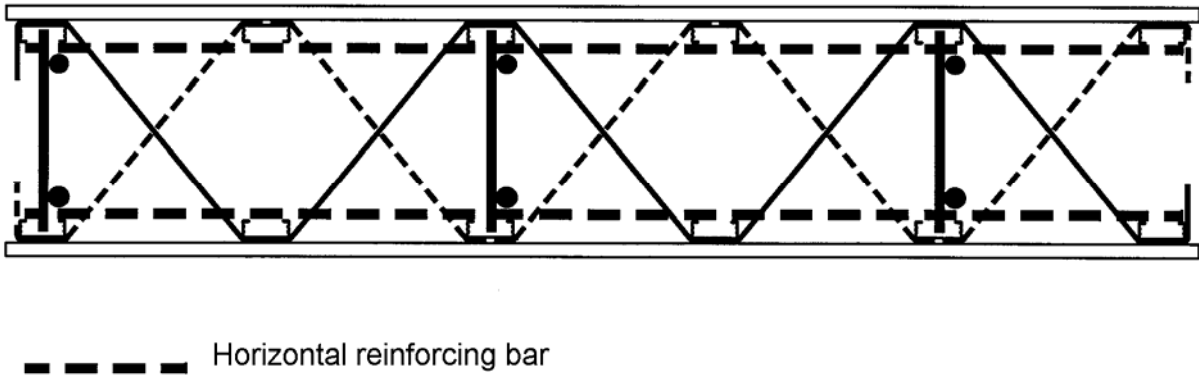
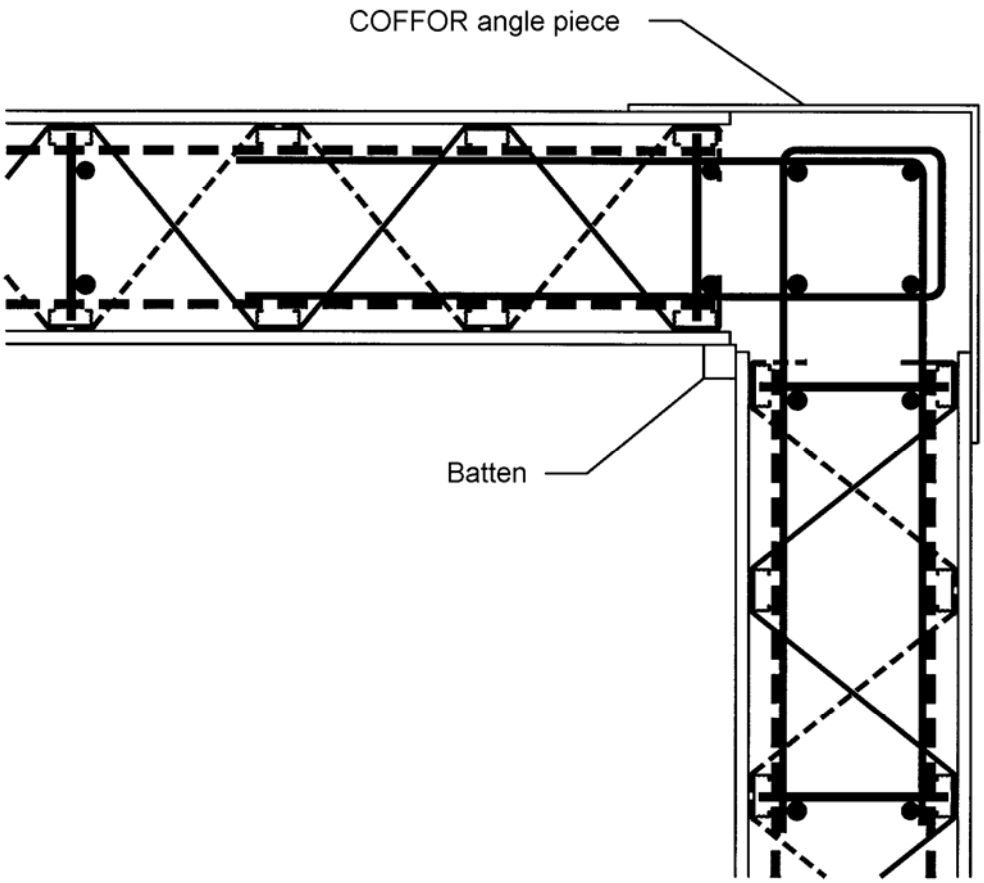


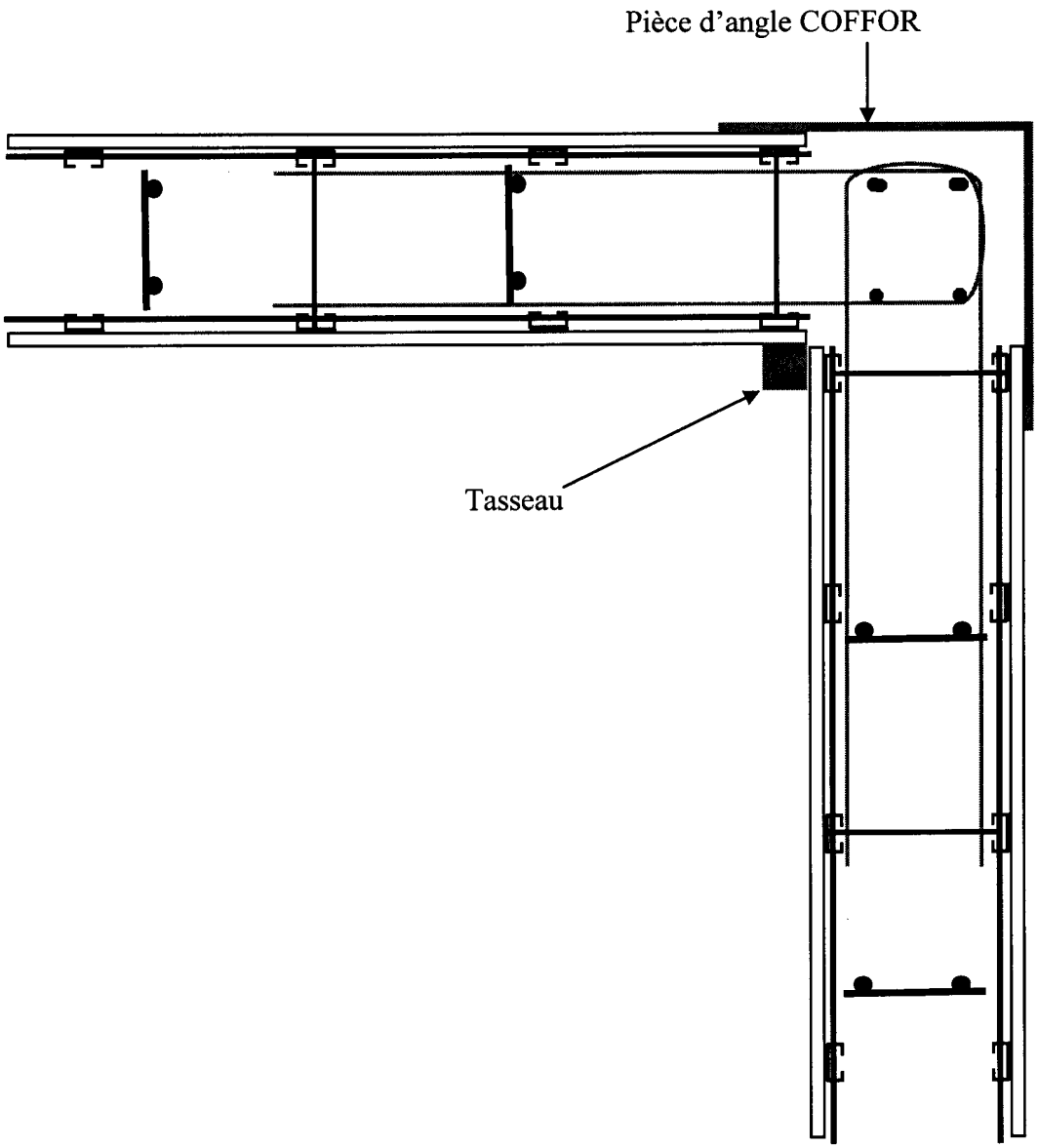
Figure 7: Insertion of the angle reinforcing bars



Instructions for installing the angle reinforcement elements

1. Positioning the COFFOR panels, leaving the angle open.
2. Screwing on a provisional board or a provisional brace (removed after concreting) inside the angle.
3. Positioning the vertical reinforcing bars, welded in pairs, which are slid into the stiffening sections.
4. In the interior wall, insertion of horizontal reinforcing bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars. The horizontal reinforcing bars rest on the yoke sections in zigzag pattern, connecting the two faces of the panels.
5. In the open angle, positioning the vertical connecting reinforcing bars (column).
6. Positioning the steel U-bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars of the walls. The steel U-bars rest on the zigzags connecting the two faces of the panel. The steel U-bars are bound to the connecting vertical reinforcing bars.
7. Closing the angle with a COFFOR angle piece.
8. (OPTIONAL) Screwing provisional braces on horizontally outside the angle (removed after concreting). The provisional braces are positioned approximately every 100 cm.

Figure 7 bis: Insertion of the angle reinforcing bars in the COFFOR 3G



Instructions for installing the angle reinforcement elements

1. Positioning the COFFOR panels, leaving the angle open.

2. Screwing on a provisional board or a provisional brace (removed after concreting) inside the angle.

3. Positioning the vertical reinforcing bars, welded in pairs, which are slid into the stiffening sections.

4. In the interior wall, insertion of horizontal reinforcing bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars. The horizontal reinforcing bars rest on the yoke sections in zigzag pattern, connecting the two faces of the panels.

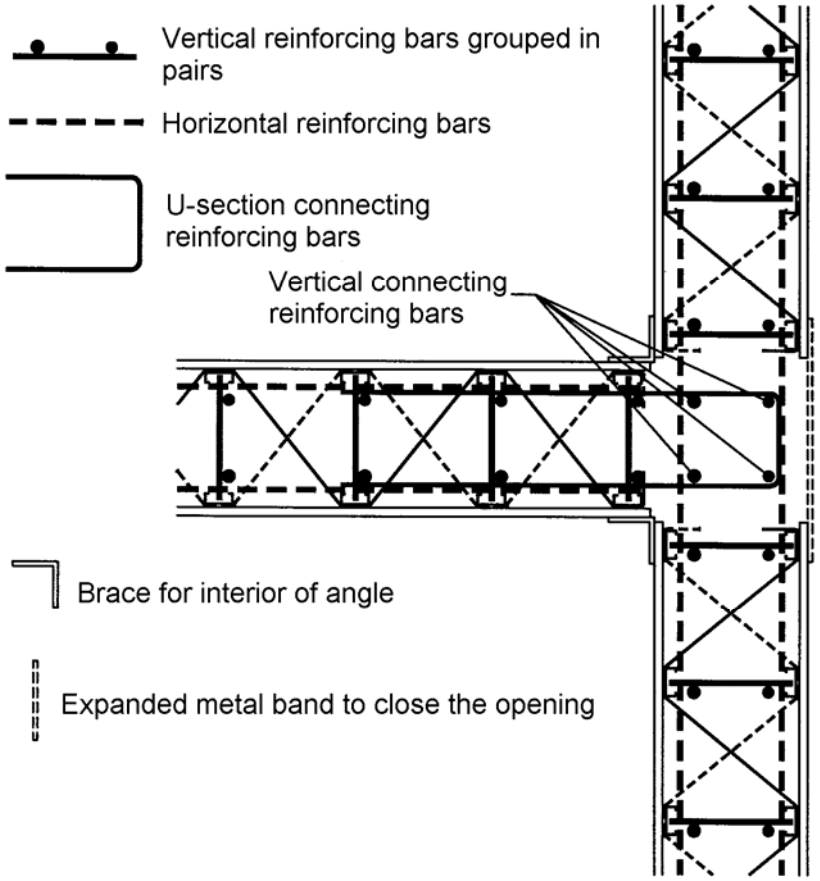
5. In the open angle, positioning the vertical connecting reinforcing bars (column).

6. Positioning the steel U-bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars of the walls. The steel U-bars rest on the zigzags connecting the two faces of the panel. The steel U-bars are bound to the connecting vertical reinforcing bars.

7. Closing the angle with a COFFOR angle piece.

8. (OPTIONAL) Screwing provisional braces on horizontally outside the angle (removed after concreting). The provisional braces are positioned approximately every 100 cm.

Figure 8: Structural arrangements for interior walls



Instruction

1. Positioning the COFFOR panels, leaving a space open for inserting the reinforcing bars.

2. Screwing the provisional braces on all the way up inside the angles (removed after concreting).

3. Installation (if necessary and according to the calculation and design by the design and engineering office) of vertical reinforcing bars, welded in pairs, which are slid into the stiffening sections of the panels.

4. In the interior wall, insertion of horizontal reinforcing bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars. The horizontal reinforcing bars rest on the yoke sections in zigzag pattern, connecting the two faces of the panels.

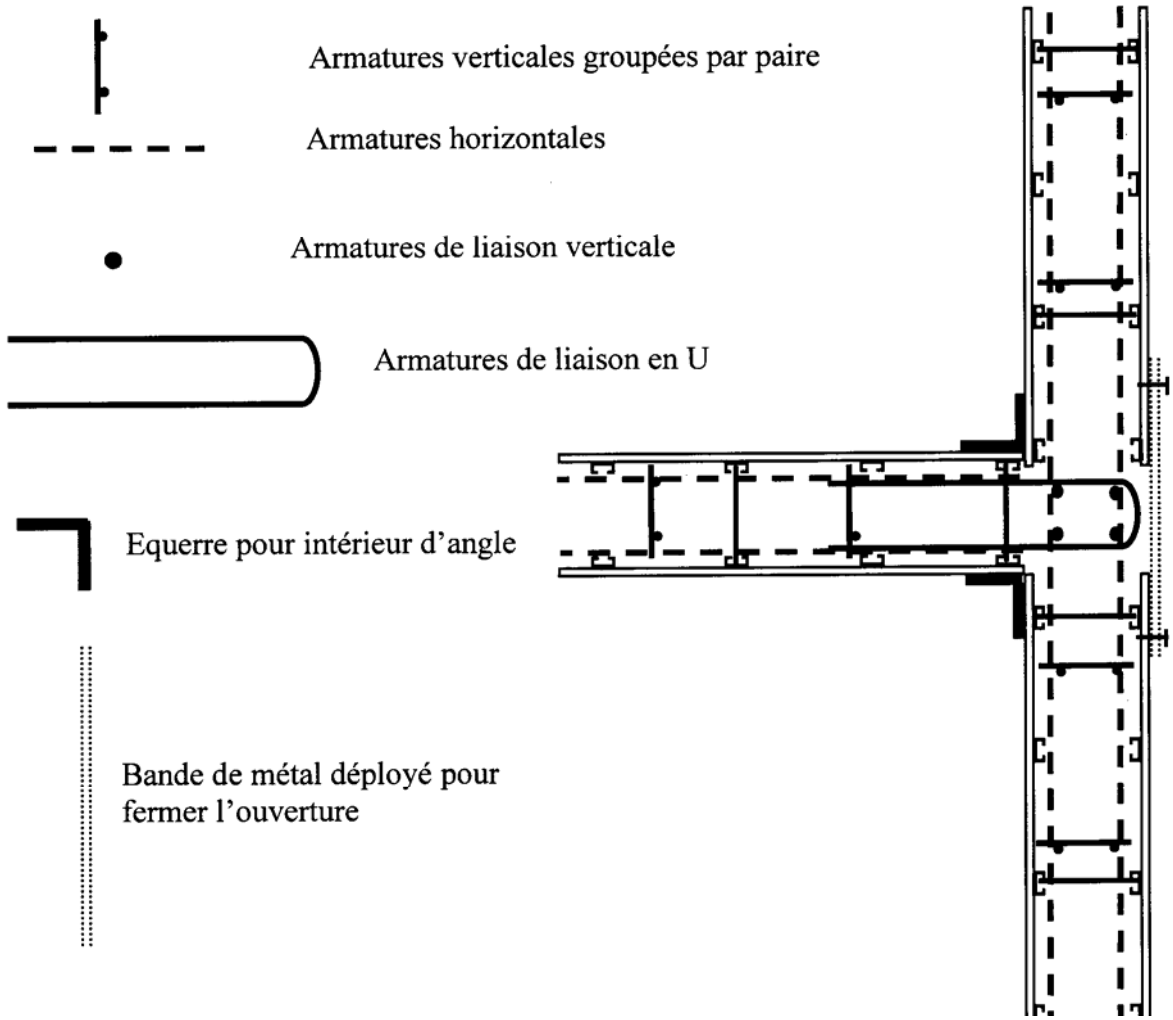
5. Installation of connecting deformed steel reinforcing bars.

6. Within the interior wall, installation of U-section bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars of the walls. The U-section bars rest on yoke sections in zigzag pattern connecting the two faces of the panel. The U-section bars are bound to the vertical connecting reinforcing bars.

7. In the façade walls, insertion of the horizontal reinforcing bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars. The horizontal reinforcing bars rest on the yoke sections in zigzag pattern, connecting the two faces of the panels.

8. Closing the opening of the wall with bands of expanded metal that are screwed onto the sections of neighbouring panels. The expanded metal ridges are to be positioned horizontally.

Figure 8 bis: Structural arrangements for interior walls



Instruction

1. Positioning the COFFOR panels, leaving a space open for inserting the reinforcing bars.

2. Screwing the provisional braces on all the way up inside the angles (removed after concreting).

3. Installation (if necessary and according to the calculation and design by the design and engineering office) of vertical reinforcing bars, welded in pairs, which are slid into the stiffening sections of the panels.

4. In the interior wall, insertion of horizontal reinforcing bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars. The horizontal reinforcing bars rest on the yoke sections in zigzag pattern, connecting the two faces of the panels.

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7. In the façade walls, insertion of the horizontal reinforcing bars which are slid between the stiffening sections of the panels and the vertical reinforcing bars. The horizontal reinforcing bars rest on the yoke sections in zigzag pattern, connecting the two faces of the panels.

8. Closing the opening of the wall with bands of expanded metal that are screwed onto the sections of neighbouring panels. The expanded metal ridges are to be positioned horizontally.