



MANAGEMENT: DSSF

BRANCH: SMP

TECHNICAL ASSESSMENT OF EXPERIMENTATION

ATEX type: a

Reference number 2482

The ATEX request defined below:

- requester: VICAT Company, Tour Manhattan, 6, Place de l'Iris - 92095 Paris La Défense.
- experimental project: The process is intended for the construction of facade walls for 1st and 2nd category residential buildings, buildings falling under the Labor Code and Public Access Buildings, within the construction limit R+1 with light weight roof and for a story height below 2.92 m. The process can be used in seismic zone 1 to 3.
- technical purpose of the experiment: Process of self-supporting, non-structural blocks made of BIOSYS hemp concrete and completed by a reinforced concrete pillar-beam system.

This technique is defined in the file registered with the CSTB under number ATEX 2482 and summarized in the attached identification summary sheet,

results in a:

TECHNICAL ASSESSMENT FAVORABLE TO EXPERIMENTATION

Important note :

This favorable assessment is only valid for a number of projects for a period of years, 2 until March 09 2020. It is also only valid if the recommendations made in § 4 below are respected.

This Assessment WHICH HAS NO TECHNICAL ADVISORY VALUE within the meaning of the decree of March 21, 2012, is based on the following considerations :

1°) Security

1.1 - Stability and user safety.

The blocks do not have sufficient strength to be load-bearing (compressive strength of 0.2 MPa) and are not masonry, only the linkage allow the vertical loads to be supported and the bracing of the structure. This linking is created using linking blocks with 15 x 15 cm² cells. This allows 4HA12 to be used with HA5 or 6 support steel spaced 15 cm apart. This linkage is designed in accordance with standard NF EN 1992-1-1.

In accordance with standard NF EN 1998-1 §5.4 "Design for DCM class", an intermediary reinforcement must be used between the corner supports along each face of the pillar. The method does not allow the correct implementation of these intermediary reinforcements (dimensions of the cells), the DCM class cannot be attained and therefore seismic zone 4 cannot be covered by the BIOSYS process.

1.2 - Fire safety.

The method ensures the compliance of the fire-safety regulations for the intended field of use, within the scope of validity of the CERIB Classification Report No.009241. The latter is used to certify REI30 fire resistance performance under the conditions given in this document. The vertical load of these walls is limited to 25 kN/m for a maximum height of 3.00 m.

The method was also fire tested in accordance to standards NF EN 13823 and NF EN ISO 1716. It has a B-s1, d0 classification according to standard 13501-1.

This document consists of two pages and two appendices; which may only be cited in full.

1.3 - Worker safety.

The safety of the workers is ensured by the use of handling devices and compliance with the requirements described in the technical file.

2°) Feasibility

The production of the blocks must be subject to continuous self-inspection. Regarding the compliance of these elements, the factory quality assurance plan must be provided by the requester.

The method is implemented using specific techniques. A site Quality Assurance Plan must therefore be established, and integrate the conditions of acceptance of supports, tolerances, details of singular points, implementation, etc.

3°) Risks of disruption The impact tests carried out showed that the process met the requirements of standard NF P08-302 "Exterior walls of buildings - Impact resistance - Test methods and criteria".

Solidity can be ensured if reinforced concrete inner bracing walls or masonry are used to stabilize the facades and limit their movement. Beams rigid enough to transfer the gravitational loads to the pillars without the fillings are to be expected.

4°) Recommendations

It is recommended that:

- Specify that the process cannot be scaled to DCM class and therefore the area of use is limited to seismic zone 3;
- Integrate the conclusions of the test reports and studies into the Technical File:
 - A grain-size of 10 mm is recommended by the CERIB;
 - In accordance with the Liten CEA Tech report, specify in the Technical File that the use of the block is limited to areas with moderate, cold or mountain climates, excluding areas with mild and humid climates in accordance with standard FD P20-651. The method must not be used within 5 km of a coastline.
- Specify the interior coating that can be applied to the block (moisture barrier, plasterboard, etc.);
- Indicate that only VPI RENOPASS CHAUX GF can be used as exterior coating;
- Specify that a gable strut is mandatory as long as no bracing system provides their stability;
- Provide quality assurance plans (QAP) for the factory production of the blocks and a work site QAP describing the implementation of the process.

5°) Reminder:

The applicant must send the CSTB, at the latest at the beginning of the work, an identity sheet for each site completed, specifying the address of the site, the names of the parties concerned, the specific inspections to be carried out and the main specifications at completion.

In conclusion, and subject to the implementation of the above recommendations, it is understood that :

- Safety is seemingly assured;
- Feasibility is probable ;
- The risk of disruption is minimal.

Champs-sur-Marne, le 03/08/2018
The Chairman of the Committee of
Experts,

Ménad CHENAF

TECHNICAL ASSESSMENT OF EXPERIMENTATION APPENDIX
Reference ATEX No.2482 of March 22, 2018

IDENTIFICATION SUMMARY SHEET ⁽¹⁾

Applicant :

VICAT Company,
Tour Manhattan, 6, Place de l'Iris - 92095 Paris La Défense.

Definition of the technique purpose of the experiment :

BIOSYS is a process for producing facade walls composed of 300 mm thick hemp concrete blocks, installed by dry interlocking (non-masonry) combined with a reinforced pillar-beam concrete support structure.

The blocks are therefore self-supporting and non-structural. Loads are lowered by the concrete structure made with special BIOSYS blocks (chain blocks).

The process is not suitable for the construction of basement or underground walls.

It is intended for the construction of building facade walls R+1 maximum with stories less than 2.92m high and located in seismic zones 1 to 3.

Employment in the following areas is not covered:

- Zones delimited by a prefectural decree made for the application of article L 133-5 of the Construction and Housing Code (risks linked to termites);
- Both mild and humid climate zones (see standard FD P20-651) ;
- Areas located less than 5 km from the ocean.

The first row of blocks is interlocked on prefabricated concrete footings which are laid on the base with a mortar bed. Then, the other rows are assembled by simple interlocking (with staggered joints) until reaching a story height. The concrete reinforcements are then placed in the designated areas provided for this purpose.

The process can be combined with concrete floors such as joists and masonry filler block, masonry or reinforced concrete slabs and traditional or industrial frames.

The outer wall is coated with VPI RENOPASS CHAUX GF.

(1) The complete description of the technique is given in the file submitted to the CSTB by the applicant and registered under number ATEX 2482 and in the package leaflet (C.F. Appendix 2) that the manufacturer is required to communicate to users of the method.



ATEx No.2482

**APPENDIX 2 OF THE TECHNICAL EXPERIMENTATION ASSESSMENT
Reference ATEx No. 2482**

SUMMARY DESCRIPTION

This document of 43 pages in total including :

- The technical file of 40 pages,
- A 3-page appendix,

Title:

Technical file related to the TECHNICAL EXPERIMENTATION ASSESSMENT (ATEx) No. 2482
relating to BIOSYS hemp concrete blocks by the company VICAT

dated 04/04/2018

has been registered with the CSTB under number ATEx 2482

TECHNICAL FILE

BIOSYS hemp concrete block masonry wall

Title:

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6, Place de l'Iris
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DEFENSE

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BIOSYS



CO-EFFICIENCY

VICAT SYSTEM

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1 DESCRIPTION

1.1 Principe

The process under the trade name BIOSYS consists of hemp concrete blocks implemented by simple dry interlocking combined with a reinforced concrete support structure (posts / beams) poured in the blocks provided for this purpose.

The BIOSYS construction process is protected by a patent registered under the number FR10/02585.

The BIOSYS construction process consists of 4 products:

- STANDARD hemp concrete block,



Image 1 : top view of the standard block



Image 2 : bottom view of the standard block

- hemp concrete block PILLAR,



Image 3 : top view of the pillar block



Image 4 : bottom view of the pillar block

- hemp concrete block DOUBLE PILLAR,



Image 5 : top view of the double pillar block



Image 6 : bottom view of the double pillar block

hemph concrete block for horizontal linkage, called **U block**.



Image 7 : top view of U block



Image 8 : top view of U block

The blocks are self-supporting and non-structural. The BIOSYS construction process is completed by a base made of prefabricated concrete blocks.

The BIOSYS block is a full mass block made entirely of hemp concrete (in accordance with VICAT's recommendations).

1.2 Area of use

This process is intended for the construction of the facade walls of residential buildings of 1st and 2nd categories, buildings falling under the Labor Code and Public Access Buildings, subject to the following conditions:

- R+1 construction with light weight roof,
- Story height less than 2.92 m,

The system can be used in seismic zones 1 to 3.

The limitations of the area of application also result from compliance with the regulations in force applicable to these buildings.

The process can also be used for filling with a reinforced concrete pillar-beam structure sized according to Eurocode rules. In this case, it does not play any structural function.

The filling must have a height less than or equal to 2.92 m (corresponding to the height of the story between 2 floors) and must comply with the minimum construction regulations established in the general case: 1.80 m between the pillars and concrete beams in the U blocks to ensure the linkage function and maintaining the filling in the upper part (anti-tilt or overturning function).

The adjoining walls of grouped detached houses with dependent structures are excluded from the range of application. In addition, the process is not applicable for below ground walls, basements and ventilation space walls.

Employment in the following areas is not covered:

- Zones delimited by a prefectural decree made for the application of article L 133-5 of the Construction and Housing Code (risks linked to termites);
- Both mild and humid climate zones (see standard FD P20-651) ;
- Areas located less than 5 km from the ocean.

Paragraph 7.3.2 proposes minimum construction specifications providing complete calculations required for general use, only for facade walls in detached single-family houses of the first category.

In all other cases, the suitability of the system must be demonstrated by a complete design of the structure. This design must then be carried out by a design office according to the Eurocode rules (NF EN 1992 and NF EN 1998) and NF DTU 21.

All architectural styles and regional features are achievable with the BIOSYS construction system.

1.3 Fire safety

The BIOSYS construction system ensures the compliance of the fire-safety regulations for the intended area of use, within the field of application of the CERIB Classification Report No.009241. The latter is used to certify REI30 fire resistance performance under the conditions given in this document. The vertical load of these walls is limited to 25 kN/m for a maximum height of 3.00 m.

The BIOSYS blocks have been subjected to CREPIM fire tests in accordance with standards NF EN 13823 (CREPIM report No. RE 5E 1107/02/059A), NF EN ISO 1716 (CREPIM report No. RE 1E 1107/02/059A) and NF EN 11925-2 (CREPIM report No. RE 3E 1107/03/190A). Following the test results, a reaction to fire classification report according to the standard NF EN 13501-1 was established. The product has a B-s1, d0 classification.

1.4 Thermal insulation

The thermal conductivity of BIOSYS blocks has been tested for thermal resistance by the hot plate method in accordance with standard NF EN 12664 : CODEM report No. RE0917BL.

After these tests, the following value has been given for useful thermal conductivity :

$\lambda_{\text{utile}} = 0.071 \text{ W/(m.K)}$

This thermal conductivity value is guaranteed by process monitoring, details of which are given in Annex 22. This monitoring includes tests in accordance with standard NF EN 12664 : 2001 and carried out by a COFRAC accredited laboratory.

The thermal resistance calculations of the wall and the linear loss coefficients (CERIB report of 22/11/2017) were carried out in accordance with the Th-U rules of RT 2012 and standards NF EN ISO 6946, NF EN ISO 10456 and NF EN ISO 10211.

Table 1 : thermal conductivity of hemp concrete

Thermal conductivity of hemp concrete λ [W/(m.K)]	Thermal resistance of a BIOSYS R 30 cm wall [(m ² .K)/W]
0.071	4.21

Linear loss coefficients of the thermal bridges (Ψ_{moyen} [W/(m.K)]) of the masonry wall with a low floor ($\lambda_{\text{BIOSYS}}=0.071 \text{ W/(mK)}$):

Table 2 : linear loss coefficients of thermal bridges of the masonry wall with a low floor

Floor type		Ψ_{about} [W/(m.K)]	Ψ_{rive} [W/(m.K)]	Ψ_{moyen} [W/(m.K)]
	Solid slab 20cm			0.043
Low floor on ventilation space	Inter joist concrete 12 + 4 (with 80mm TMS insulation ($\lambda=0.022 \text{ W/(mK)}$) under 5cm floating screed)	0.030	0.040	0.034
	Inter joist EPS 12 + 5 (with 5cm floating screed on top)	0.298	0.077	0.207
Low floor on ground slab	20cm solid slab (with 100mm EPS insulation ($\lambda=0.032 \text{ W/(mK)}$) under 5cm floating screed)			0.030

Linear loss coefficients of the thermal bridges ($\Psi_{moyen}[W/(m.K)]$) of the masonry wall with an intermediate floor ($\Lambda_{BYOSIS}=0.071 W/(mK)$):

Table 3 : linear loss coefficients of the thermal bridges of the masonry wall with an intermediate floor

Floor type		Ψ_{about} [W/(m.K)]	Ψ_{rive} [W/(m.K)]	Ψ_{moyen} [W/(m.K)]
intermediary	Inter joist concrete 12 + 4	0.244	0.242	0.243
	Inter joist concrete 16 + 4	0.276	0.268	0.273

Linear loss coefficients of the thermal bridges ($\Psi_{moyen}[W/(m.K)]$) of the masonry wall with an high floor ($\Lambda_{BYOSIS} =0.071 W/(mK)$):

Table 4 : linear loss coefficients of the thermal bridges of the masonry wall with a high floor

Floor type		Ψ_{about} Ψ_{rive} [W/(m.K)] [W/(m.K)]	Ψ_{moyen} [W/(m.K)]
Floor high	light		0.053
	heavy: inter joist concrete 16 + 4 (with 200mm insulation ($\Lambda =0.023 W/(mK)$) above)	0.180 0.283	0.221

1.5 Sound insulation

The BIOSYS construction process can meet the requirements for insulation against outside noise.

The test report no. AC13-26043251 gives the following sound reduction index :

Table 5 : sound attenuation

Coating	R_w (C; Ctr)
15 mm outer plaster and 5 mm inner plaster	43 (-1 ; -2) dB

1.6 Fixings

The BIOSYS construction process allows objects to be fixed to the hemp concrete block wall. Tests have been carried out and a recommendation is given in Appendix 4. The recommendation enables the fixing of common objects in a building corresponding to the intended area of use. The optimal result is achieved with an FID 90 pin + panel screw diam. 6 of the FISCHER or equivalent brand.



Image 9 : FID 90 fixing pin (Fischer)

Other types of pins may be used with preliminary testing.

1.7 Components of the BIOSYS construction process

The BIOSYS construction process is composed of the following elements:

- Concrete block - BIOSYS base,
- Standard BIOSYS hemp concrete block,
- BIOSYS hemp concrete block pillar,
- BIOSYS hemp concrete block double pillar,
- BIOSYS hemp concrete U linkage block,

All elements are described below.

1.7.1 Concrete block - BIOSYS base

The first course of the hemp concrete block will be made on a concrete base. The technical and geometrical properties of this base are specified below: **Dimensional properties:**

a. Overall dimensions:

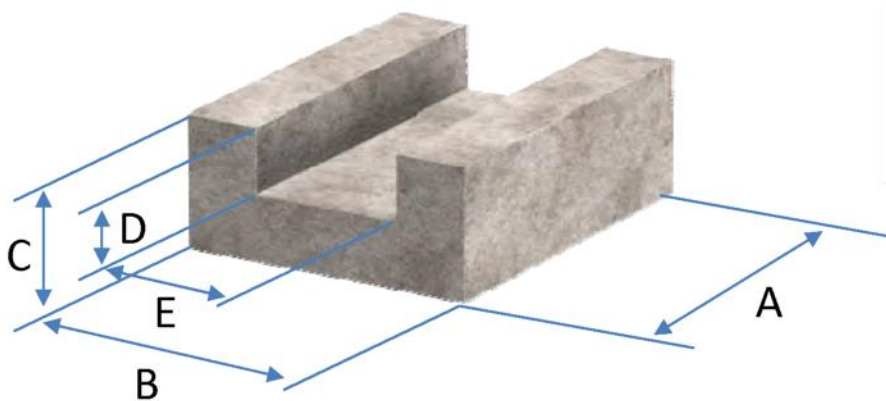
L x w x h (mm) : 250 (+/- 2) x 200 (+/- 1) x 100 (+/- 1)

b. Groove dimensions:

Width x height (mm) : 100 x 50 (+/- 0,5)

The groove is centered along the longitudinal axis of the block.

The groove of the base allows the interlocking of BIOSYS hemp concrete blocks (see illustration of the base below).



<p>A = 250 mm (+/- 2) B = 200 mm (+/- 1) C = 100 mm (+/- 1) D = 50 mm (+/- 0.5) E = 100 mm (+/- 0.5)</p>

Image 10 : model of the concrete base

Compression strength:

The compression load capacity of the BIOSYS base is 220 tons/ml. This is significantly higher than the permissible compression load of hemp concrete block.

1.7.2 Hemp concrete blocks BIOSYS

Once the first course has been completed using the starting base block, the BIOSYS construction process is composed of hemp concrete blocks.

Different types of blocks exist in order to achieve all the common and distinctive parts of a building. Each type of block is equipped with a set of grooves and tongues allowing the blocks to fit together. The blocks are reversible, so there is no designated face for the inside or outside of the building. The blocks can be cut on building sites to match the dimensions of the building. It is also possible to recreate a groove in a block on site when it has been cut perpendicular to its longest face.

1.7.2.1 Composition of BIOSYS hemp concrete blocks

BIOSYS hemp concrete blocks are composed of VICAT's Natural Prompt Cement-based bonding and building grade hemp wood. The average dry bulk density is 288 kg/m³.

1.7.2.2 Types of BIOSYS hemp concrete blocks**Standard BIOSYS block:**

It is used the assembly of standard walls.

- Length: 600 mm (0/-7)
- Width: 300 mm (+/-1)
- Height: 308 mm (+/-1)
- groove / tongue: width 100 mm (+/- 0.5) height or depth 50 mm (+/- 1)



Image 11 : 3D model of the standard block

BIOSYS pillar block:

It is used for the formation of concrete pillars (angles, stiffeners, etc.).

- Length: 600 mm (0/-7)
- Width: 300 mm (+/-1)
- Height: 308 mm (+/-1)
- groove / tongue: width 100 mm (+/- 0.5) height or depth 50 mm (+/- 1)
- 150 mm x 150 mm square recess (+/- 2)



Image 12 : 3D model of the pillar block

BIOSYS double pillar block:

It is used for the formation of concrete pillars (adjoining posts and stiffeners).

- Length: 600 mm (0/-7)
- Width: 300 mm (+/- 1)
- Height: 308 mm (+/- 1)
- groove / tongue: width 100 mm (+/- 0.5) height or depth 50 mm (+/- 1)
- 150 mm x 150 mm square recess (+/- 2)



Image 13 : 3D model of the double pillar block

BIOSYS U block:

It is used for the formation of concrete beams and lintels.

- Length: 600 mm (0/-7)
- Width: 300 mm (+/- 1)
- Height: 308 mm (+/- 1)
- groove / tongue: width 100 mm (+/- 0.5) height or depth 50 mm (+/- 1)
- Recess of 150 mm (+/- 2) x 220 mm (+/- 5) along the entire length.



Image 14 : 3D model of the U block

1.7.2.3 Accessories and tools

The BIOSYS construction process can sometimes necessitate filling a void, for example, between 2 blocks when the layout specifies it. In the case of a void less than or equal to 10 cm, hemp concrete will be made on site and placed in this void. The production of hemp concrete on site requires the use of the materials described below. The production of hemp concrete on site is in accordance with the VICAT guidelines.

> **Materials for making hemp concrete on site :**

- Bundle of building grade hemp wood: enables hemp concrete to be produced on site if needed. The binder needed is VICAT's Natural Prompt Cement.
- VICAT Prompt Natural Cement: enables hemp concrete to be produced on site if needed. The material to use is hemp wood.
- TEMPO setting retarder from VICAT, if necessary.

The tools required to perform the BIOSYS construction process are the mason's standard tools. However, the following specific tools may be required.

> **Specific Tools:**

- Retaining Pins: Allows level adjustment and alignment of BIOSYS blocks before pouring the concrete and during curing.
- Hand saw, electric saw, chain saw and band saw: allow easy cutting of BIOSYS hemp concrete blocks.
- Specific grooving machine: allows the creation of an interlocking groove in BIOSYS hemp concrete blocks.



Image 16 : holding pin



Image 15 : BIOSYS electric grooving machine

1.7.3 Concrete pillar / beam structure

As explained in the first part (A. DESCRIPTION - 1.Principle), the BIOSYS construction process is based on a reinforced concrete pillar/beam structure embedded in the BIOSYS hemp concrete block wall.

The characteristics of this column/beam structure are described below.

We differentiate, for the design of this, 2 cases : Outside seismic zones (1 and 2) and seismic zone 3.

1.7.3.1 Concrete type

The concrete used is ready-mix concrete in accordance with standard NF EN 206/CN and the following specifications:

- Compressive strength category: C25/30
- Exposure category: to be determined according to Eurocode 2 without taking into account protection by the blocks

Note: In accordance with standard NF EN 1996-1 and its national annex, the coating can be reduced by up to 10 mm, corresponding to the layer of rendering material applied to the exposed face of the block.

- Consistency category: S4
- Max. particle size: 10 mm
- Without vibration

1.7.3.2 Design of the concrete structure

> **Frames**

Steel of ductility category A or B to be adapted according to the seismic zone and the purpose of the structure.

> **Design**

Outside seismic zones (1 and 2)

In the absence of seismic requirements, the structure is designed in accordance with standard NF EN 1992 1-1 (and its national annex) and NF DTU 21.

The following paragraph suggests minimum construction requirements providing complete calculations required for general use, only for facade walls. The intermediary structure (pillars, beams, cross-walls, floors) remains in all cases designed in the traditional way according to the load distribution.

Hypotheses:

- R+1 construction with light weight roof (timber frame),
- Hemp blocks only used as the facade wall,
- Maximum span of floors: 5 m
- Joist-masonry filler block floor types
- Maximum story height: 3 m
- Maximum opening: 2.5 m

- Permissible stress of the foundation: 0.3 MPa,
- Maximum Permanent Loads (dead load included),
 - Floor loads (including covering) : 370 kg/m²,
 - Roof loads (framework + roofing + insulation) : 100 kg/m².

Foundations:

The foundations are made up of 50 cm wide, 30 cm high strip foundations and reinforced with 3 HA 10 rods on the top and bottom with HA 8 frames every 20 cm.

Reinforcement of pillars and beams:

Maximum pillar center distance : 1.20 m The reinforcement of the pillars consists of 4 HA 10 rods with HA 5 frames spaced every 15 cm..

The beams are reinforced by 4 HA 10 rods with HA 5 frames spaced every 15 cm.

Maximum pillar center distance : 1.80 m

The reinforcement of the pillars consists of 4 HA 10 rods with HA 5 frames spaced every 15 cm..

The beams are reinforced by 4 HA 10 rods with HA 6 frames spaced every 15 cm.

Additional requirements:

In the case of openings longer than 1.80 m (and shorter than 2.50 m), the reinforcement and horizontal linkage dimensions (15 x 20 cm²) mentioned above are no longer valid and must be specifically calculated. However, the dimensions and reinforcement of the posts remain the same.

The continuity of the steel (construction angles, coverings, foundation connections, etc.) must respect the rules of the craft.

Seismic zones (zone 3)

In the presence of seismic requirements, the seismic forces are taken by all the facade and cross-walls. The design of the structure must systematically be validated by a design office and carried out in accordance with NF EN 1998-1 (and its national annex). Only concrete structural elements (pillars/beams) are considered for the resistance of walls made of BIOSYS hemp concrete blocks.

The behavior coefficient must not exceed 1.5 (in accordance with the requirements of standard NF EN 1998-1 and its national annex).

The following paragraph suggests minimum construction requirements providing complete calculations required for general use, only for facade walls in seismic zone 3.

Hypotheses:

- Configuration of the construction in plan and elevation complying with the 6 criteria defined in the CPMI rules.
- R+1 construction with light weight roof (timber frame),
- Hemp blocks only used as the facade wall,
- Maximum span of floors: 5m,
- Joist-masonry filler block floor types
- Maximum story height: 3m,
- Center distance of pillars: 1.20m maximum,
- Maximum opening: 2.5m,
- Floor category: A, B, C or D,
- Permissible stress of the foundation: 0.3 MPa,
- Maximum Permanent Loads (dead load included),
 - Floor loads (including covering) : 370 kg/m²,
 - Roof loads (framework + roofing + insulation) : 100 kg/m².

Foundations:

The foundations are made of:

- 70 cm wide, 30 cm high strip foundations and reinforced with 3 HA 10 rods on the upper and lower surfaces with HA 8 frames every 20 cm.

- 50 cm wide, 30 cm high, reinforced by 3 HA 10 rods on the upper and lower surfaces with HA 8 frames every 20 cm, provided that the installation of the pillars in both directions is secured by a 15 cm thick reinforced slab, following the diagram below, or by a bidirectional network of tie beams (at least one tie beam in each direction halfway between the opposite facades).

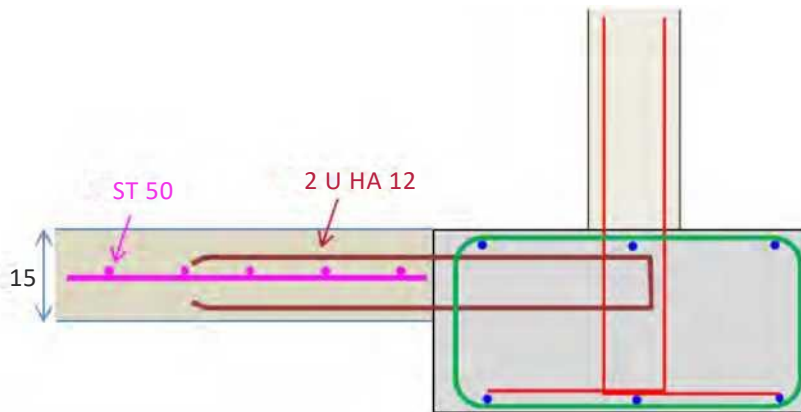


Figure 17: detailed linkage footing / reinforced slab

Reinforcing columns and beams:

Reinforcing columns consists of 4 HA 12 beams with HA 6 frames placed every 15 cm (6 in.).

Note: in the event of a simple single floor construction, the reinforcing can be reduced to 4 strand HA 10 with HA 6 frames placed every 15 cm (5 in.).

The side linkages are reinforced with 4 HA 12 beams with HA 6 frames placed every 15 cm (5 in.).

The openings longer than 1.20 m (3 ft. 11 in.) (and shorter than 2.50 m or 8 ft. 2 in.) are occasionally authorized (an opening in the facade), as long as they are reinforced with double columns with reference to the above mentioned reinforcement. The dimensions for horizontal linkage of the beams and their reinforcements should be appropriate for the opening to distribute the vertical load downward.

The principles of rebar positioning and especially the horizontal tying linkage / columns and the coatings, must follow the implementation rules defined in the CPMI for the horizontal and vertical linkage.

1.7.3.3 Exterior coating

Body Coat

Applying the cement Body Coat that's rich in lime VPI® RENOPASS CHAUX CLAIR which has the following characteristics:

- Concrete adherence: > 0,2 MPa
- Compression resistance: CS II
- Capillary action: W 1
- Water vapor permeability: $\mu < 35$
- Fire behavior A1

The application is done in accordance with the manufacturer's recommendations with a glass frame marouflage (5x5 mm² or 2x2 in²), making use of a CSTB FRAME certificate and showing the following results. T ≥ 1 ; Ra ≥ 1 ; M = 2 ; E ≥ 2.

The thickness of this layer should be around 10 mm (4 in.).

Finishing

After drying for a minimum of 3 days (7 days is recommended) application of a lime rich finishing coat VPI® RENOPASS CHAUX GF which has the following characteristics:

- Concrete adherence: ≥ 0,3 MPa

- Compression resistance: CS II
- Capillary action: W 2
- Water vapor permeability: $\mu < 35$
- Fire behavior A1

Devil float finish:

Use a trowel with a size of approximately 15 mm (6 in.) with a straight edge and careful clamping according to the manufacturer's recommendations.

Scrape evenly with a nail trowel or trowel edge as soon as the plaster has pulled sufficiently.

Thickness of the finish after the grating: around 10 mm (4 in.).

Troweled finish

Use a trowel with a size of approximately 10 mm, straightening with a straight edge according to the manufacturer's recommendations.

Trowel until the coating is sufficiently smooth.

Singular points:

300 x 300 mm² glass tissues must be pasted on the body of the coating at a 45° angle to the bay angles.

The rods placed on at angles must be lined in the body of the coating to the level of all the construction angles.

The lintel rods must be lined in the body of the coating on the level with the lintel and the inferior angle located on the first row's level.

This configuration of coating has been the subject of follow up tests and pull tests at 6 months (record VPI 17/0011 of 10/19/2017) after ensuring its compatibility with the support that shows dimensional variations greater than the limits mentioned in the norm NF EN771-3/CN (see the verbal process CERIB no. 7069 and 7070).

1.7.3.4 Interior coat

The interior coat consists of a complex made up of a vapor sealing layer and a plaster board that provide resistance to the spreading of vapor Sd 5 times greater than that of the exterior coat and it is applied following the manufacturer's recommendations for this kind of support. Any other solution, making it possible to respect this ratio of 5 between the Sd of the inner lining and that of the outer lining, can be implemented.

In dry and moderate climates, the interior coat can be reduced to plaster board or plaster layer. This kind of lining can also be used in cold or mountainous climates as long as it is done on a case by case basis.

1.7.4 Production - inspection

The production of BIOSYS hemp concrete blocks is done in a dedicated factory at Mérey-sous-Montrond (25). This factory was installed in April of 2016 and was specially conceived for molding BIOSYS hemp concrete blocks. It is the product of the collaboration between VIEILLE Matériaux and QUADRA (concrete block machine manufacturer)

A series of inspections is performed throughout the production process. These inspections are described below.

1.7.4.1 Production

BIOSYS hemp concrete blocks are created with a mixture of a quick setting concrete from VICAT and from building hemp provided by the hemp provider EUROCHANVRE in Arc-les-Gray (70). The starting blocks and footings are produced in the VIEILLE MATERIAUX factory at Mérey-sous-Montrond (25).

The production of the PAQ object detailed in appendix 23.

The production process is broken down as follows:

- Hemp storage in dedicated and protected hoppers.

- Storage related to quick setting concrete in silo.



Figure 18: hemp storage hopper and quick setting cement silo

- Mix the two components, then add water, after weighing (the three components) in a double horizontal mixer.



Figure 19: concrete block center

- Transport of the concrete obtained by weight from a dosing hopper



Figure 20: Side view of the block press from the hemp concrete arrival side

- Product released into a compartmented conveyor
- Release from conveyor into the mold
- Calibration by constant pressure and time



Figure 21: Side view of the block press from the hemp concrete exit side

Demolding and removal



Figure 22: view of the entirety of the press and the driver's cab

- Storage for a 1 day minimum on the mold board.
- Placement on pallet for transport and labeling (with production factory and production date)
- Safe storage for drying. Drying is considered to be satisfactory when the volumetric mass is below 400 kg/m³
- Protection of the pallets with a wrap on the upper portion

The column blocks, the double column blocks, and the linking blocks (U blocks) are produced from standard blocks with the help of special machines.

1.7.4.2 Inspections

In this paragraph the entirety of the inspections carried out are described. Those which concern the production tools and especially the weight/distribution scales. They are equally related to the primary materials. There is also a whole series of inspections carried out during the production of different hemp concrete blocks as well as the concrete footers.

1.7.4.2.1 *Weight / distribution scales*

The weight and distribution scale ensemble is controlled and calibrated in accordance with regulations (Regulation NF EN 45501) and this is performed by an outside company with and COFRAC accreditation to perform these kinds of tests.

1.7.4.2.2 *The hemp*

The inspection of the grain size and the amount of dust is assured by the hemp provider (in accordance with the applicable professional regulations). The hemp provided by EUROCHANVRE received the title "building-hemp" by the Hemp Construction labeling commission since 11/27/2015 under the number 00/003/001.

With each delivery of hemp, an test of its water content is performed.

This test is performed as follows (the frying pan method):

- Removal upon delivery,
- Weighing the sample,
- Drying to a constant mass,
- Weighing the dried sample,
- Determination of the water content with the following formula:



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- $W = 100 \times ((M-M_s)/M_s)\%$
- $W =$ water content (%)
- $M =$ sample mass
- $M_s =$ dry sample mass

This test makes it possible to refine the water dosage adjustment.

1.7.4.2.3 The cement base: Quick setting cement

The entirety of the security data, the material consistency is provided by VICAT with each delivery. The cement is stored in a protected environment (dedicated silo).

1.7.4.2.4 BIOSYS hemp concrete blocks

The BIOSYS block are submitted to several tests at different phases of its production.

- After demolding: visual inspection (no appearance of visual defects)
- Storage on production board: test of its length dimensions (tolerance of 600 0/7 mm) in the first hour of production after demolding,
- Block placement on pallet and labeling,
- Storage in in safe environment,
- Dimension test for each side of a type of block produced, being 16 blocks for every 1000 produced,
- Dry volumetric mass inspection on 3 products chosen at random out of 16 the production of 2000 products.

The dry volumetric mass inspection is performed as follows:

- Drying the product
- Drying in a 80°C oven,
- Drying the product until a constant mass is reached,
- Determination of the dry volumetric mass with the following formula:
 - Volumetric mass = block mass / block volume

For column blocks, double column blocks, and linking U blocks, a dimension inspection is performed each day during the first hour.

- **Column block** dimension inspection. This inspection only takes into account the sides of the column and the position of the column:

- Measurement of sides A, B, C, D, and E (see the diagram below) in accordance with the dimensions described below

A = B = 150 mm (+/- 2)
C = D = E = 75 mm (+/- 2)

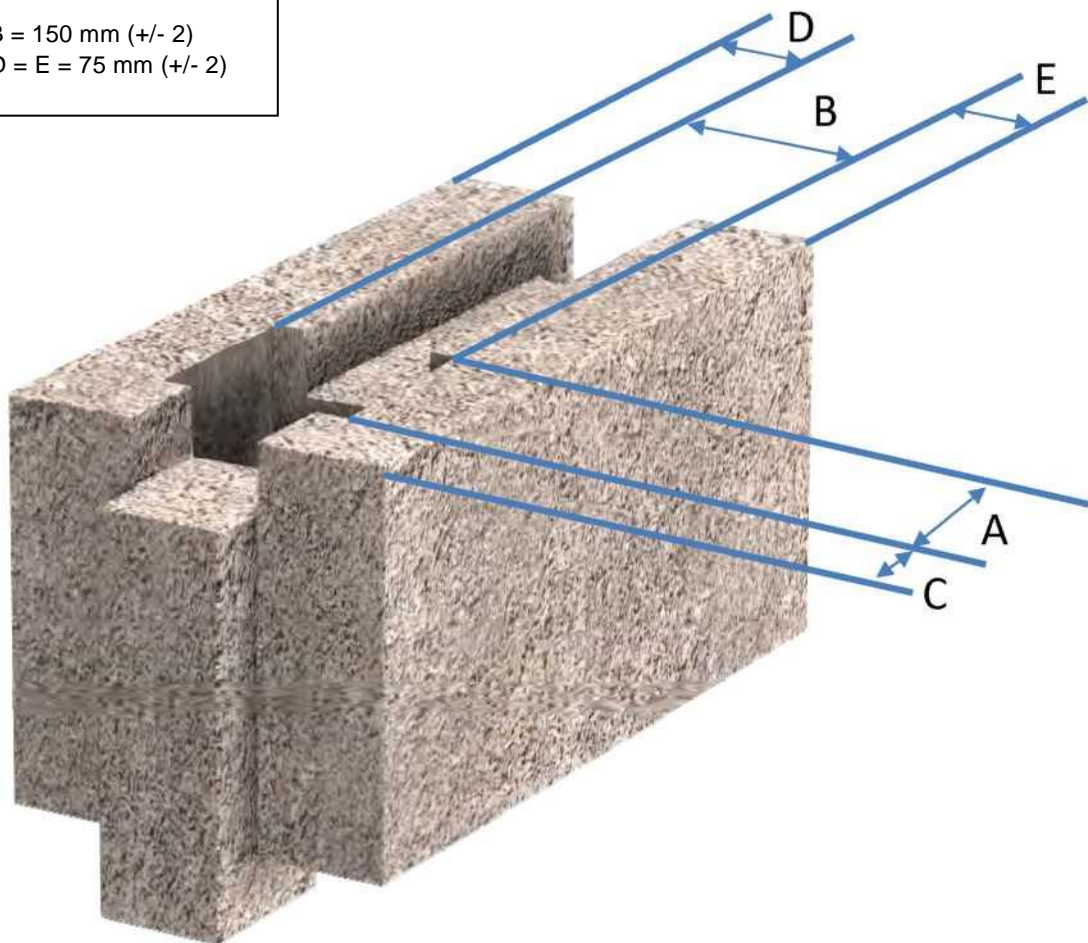


Figure 23: dimensional tolerance of block columns

- **Double column block** dimension inspection. This inspection only takes into account the sides of the column and the position of the column:
 - Measurement of sides A, B, C, D, E, F, G, H, I, and J (see the diagram below) in accordance with the dimensions described below.

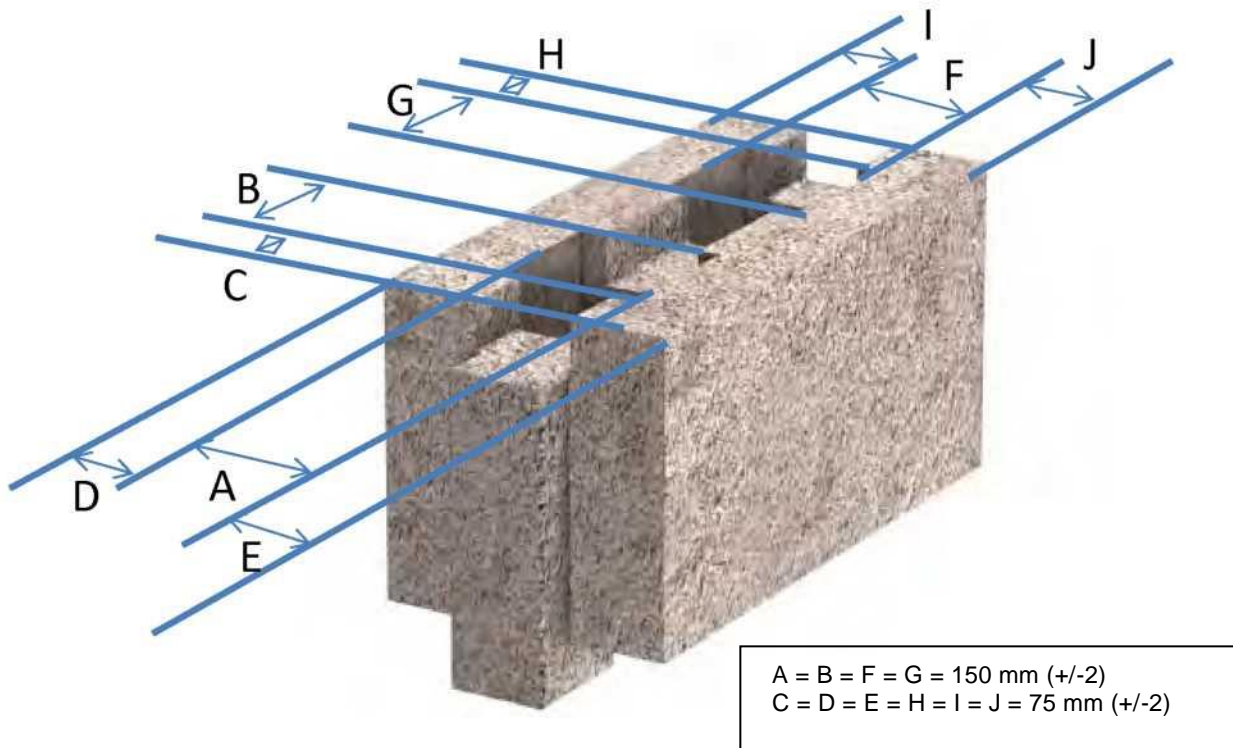


Figure 24: dimensional tolerance of double block columns

- Dimensional control of **linkage block (trough block)**. This inspection only takes into account the sides of the trough and the position of the trough:
- Measurement of sides A, B, C, and D (see the diagram below) in accordance with the dimensions

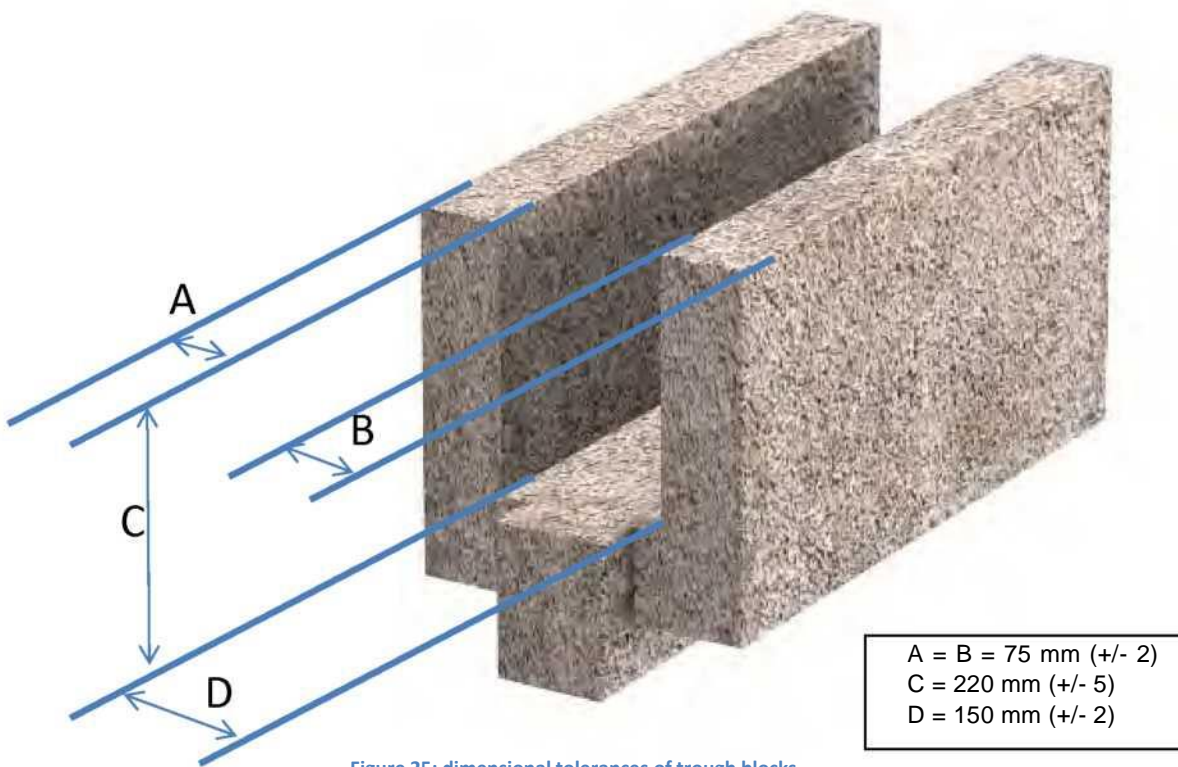


Figure 25: dimensional tolerances of trough blocks

1.7.4.2.5 Footer

The blocks that make the footer are made of concrete and are manufactured by VIEILLE MATERIAUX by an industrial press:

- The concrete used to produce the base footers is the same as those used for NF certified concrete blocks.
- The tests for the aggregates and for the concrete are performed in the framework of the manufacture standard inspections for NF concrete blocks.
- The dimension inspection for each manufacture series rhythm is performed for every 1000 products:
 - Measurement of sides A, B, C, D, and E (see the diagram below) in accordance with the dimensions described below

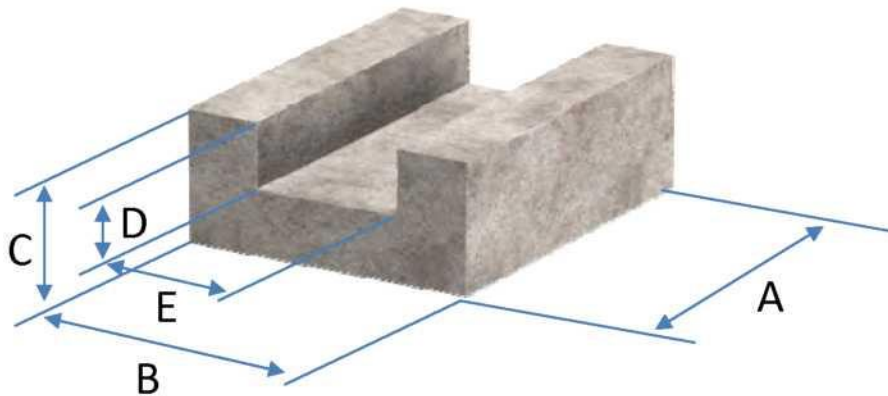


Figure 26: dimensional tolerances of the footer

A = 250 mm (+/- 2)
B = 200 mm (+/- 1)
C = 100 mm (+/- 1)
D = 50 mm (+/- 0.5)
E = 100 mm (+/- 0.5)

1.8 Implementation

1.8.1 Support preparation

- Placement of the enforcements while waiting for the casting of foundations
- Verification that the support is level
 - Place the footers around the exterior of the foundation on a bed of waterproof mortar.
- Protection against moisture increases is provided by putting down a level strip.

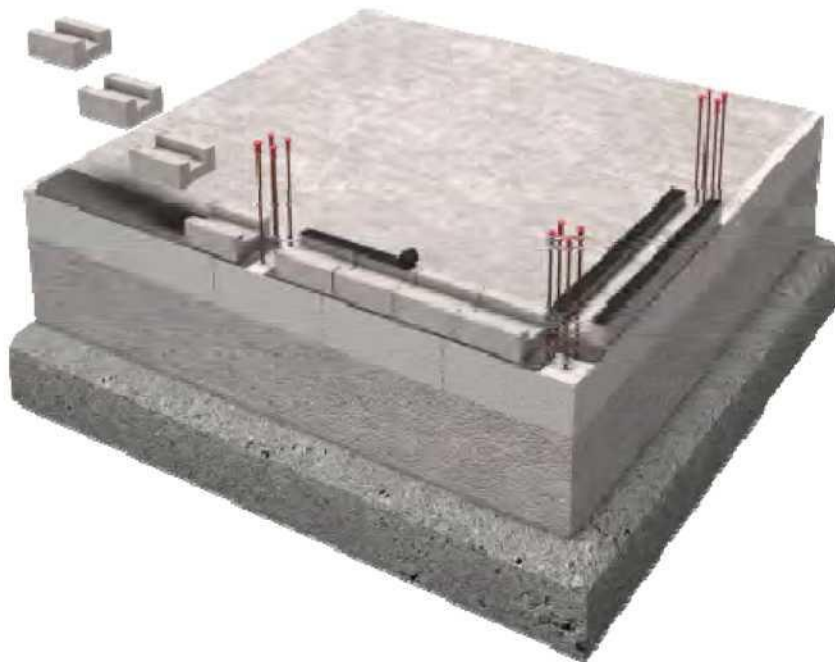
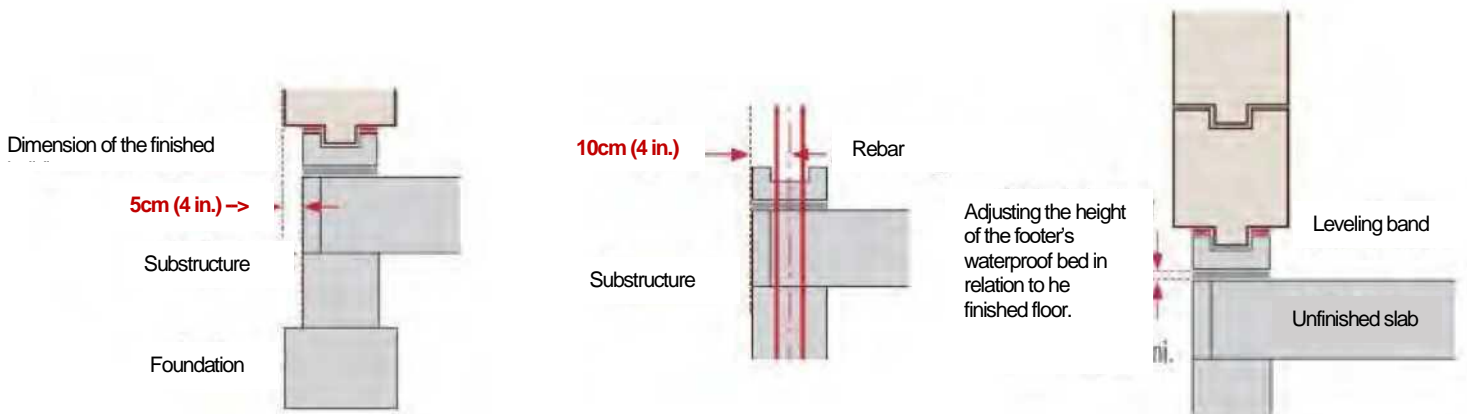


Figure 27: Foundation system view

1.8.2 Wall assembly

1.8.2.1 First row of wall assembly (on the footer)

The first row of the panels is placed by interlocking the tongues on the BIOSYS hemp concrete blocks in the grooves in the footer blocks.

1.8.2.2 Assembly of corners

The blocks interlock at the corners. The tongues are cut at the corner level to allow cross placement. The remaining openings after assembly of the wall are covered by stacks of blocks. The tongues that stick out from the facade are cut off.

1.8.2.3 Assembly of following rows

- The blocks are placed by a simple offset interlocking joint (20 cm or 8 in. minimum).
- It's necessary to take the layout into account for openings, windows, and doors.
- Filling spaces between two blocks.
 - Case 1: above 10 cm (4 in.): cutting and creation of the block with the help of a special tool in the grove of the side of the block.



Figure 29: assembly of running wall with space greater than 10 cm (4 in.) remaining

- Case 2: less than or equal to 10 cm (4 in.): cast the space and pour a hemp concrete block (following Vicat regulations).



Figure 30: assembly of running wall with space less than 10 cm (4 in.) remaining

- Cut the block column for interlocking continuity.

1.8.3 Create columns with frames.

- Column in the running wall, column in corner, column for openings (door and window).

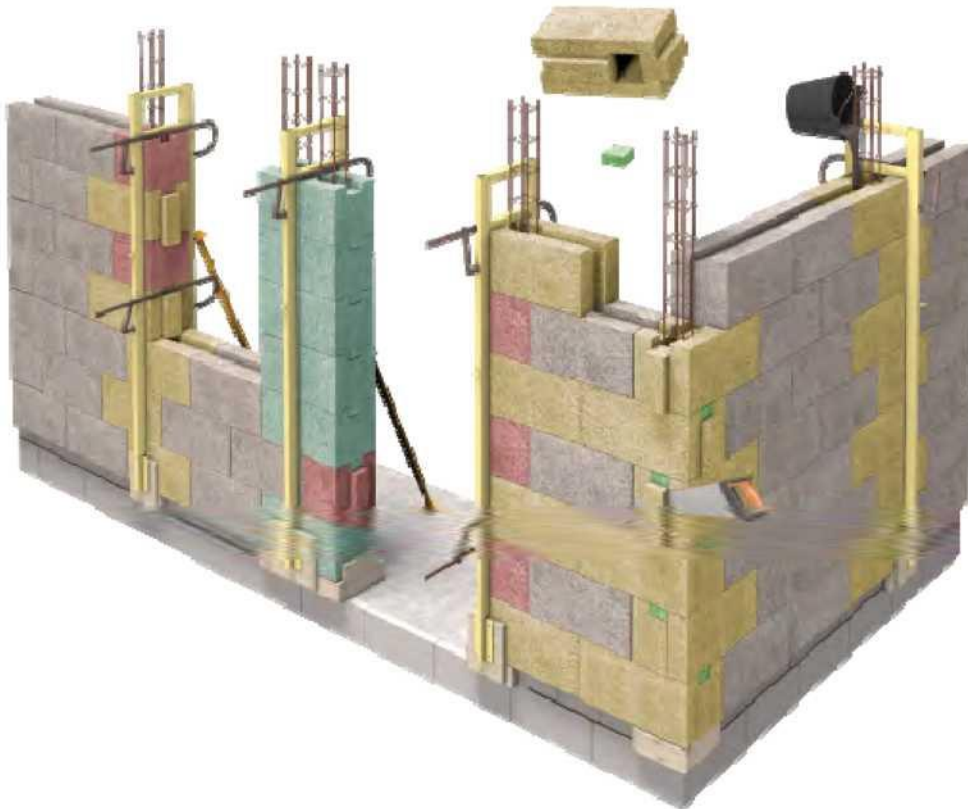


Figure 31: View of different types of columns

- Cut the tongues to a crossed placement and return to cover the remaining openings.
- Placing the frames shims makes it possible to ensure minimal coating.
- Casing the foot of the column.

- Put the holding clamps in place and use a level
- Cast the concrete in the columns.

1.8.4 Casting the concrete

Casting the concrete for single and double post blocks is performed using a 2.15 m high pass maximum. The concrete is set without vibration.

1.8.5 Joining with the rest of the whole work

1.8.5.1 Floors

The floors are made with girders and flooring tiles.

- Placement of linking frames
- Placement of concrete girders
- Side scaffolding
- Placement of infill between concrete girders
- Placement of linking rods
- Casting the concrete

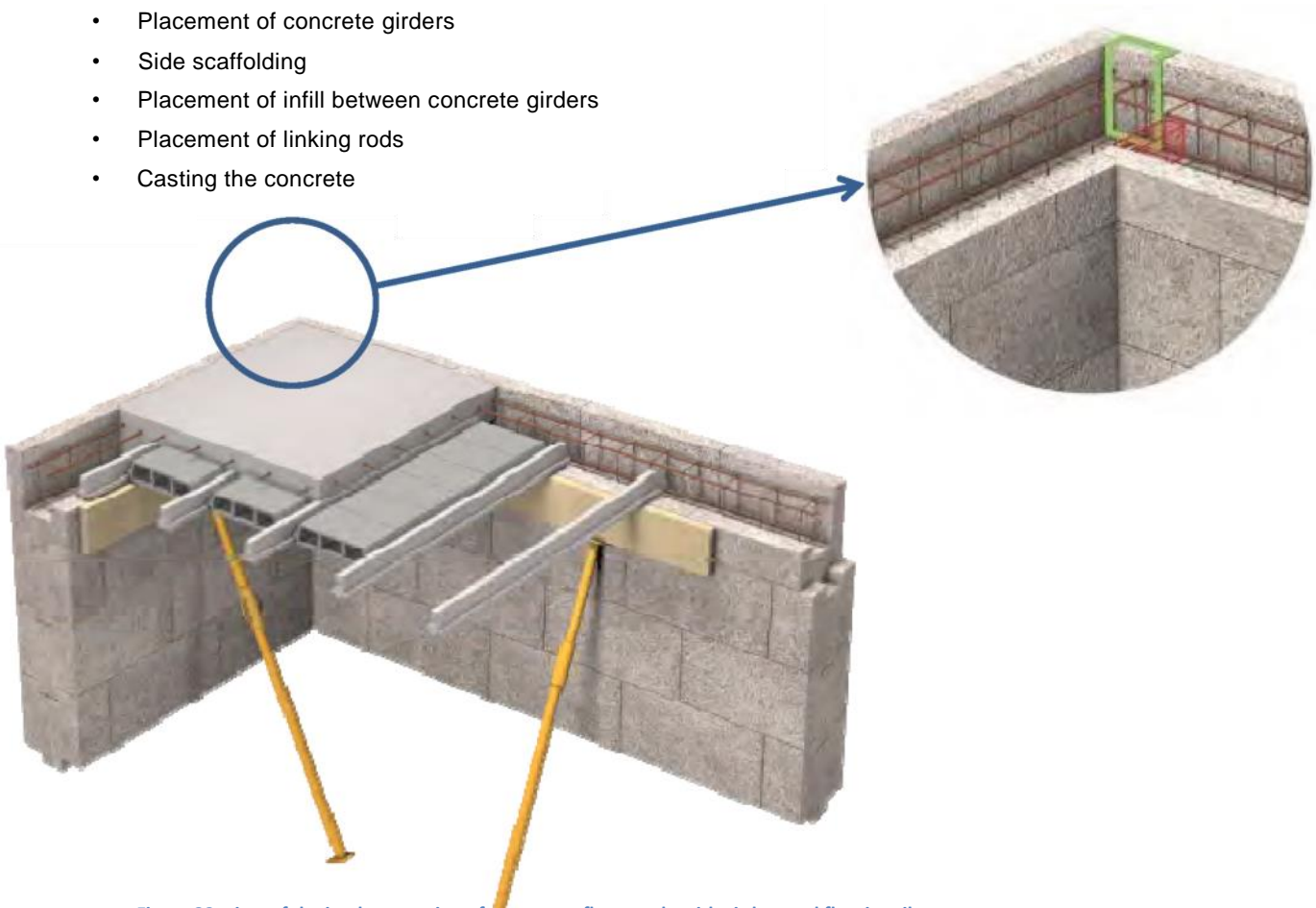
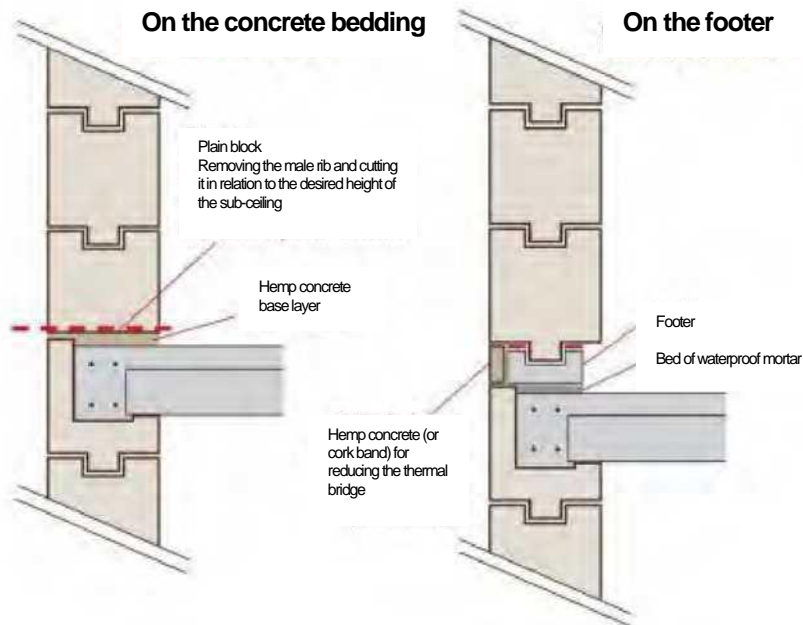
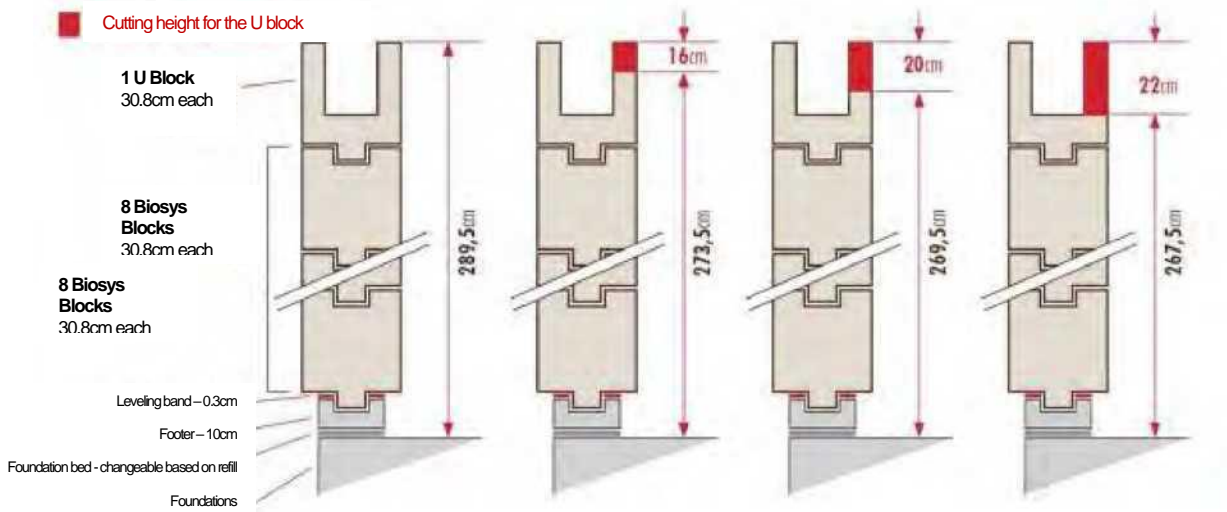


Figure 32: view of the implementation of a concrete floor made with girders and flooring tiles

The finished height under the floor is defined based on the layout



1.8.5.2 Load-bearing walls

Load-bearing walls are made out of stonework or reinforced concrete. Load-bearing walls are raised flush to the BIOSYS hemp concrete blocks masonry. The stability of the load-bearing wall is assured by its own reinforcement as well as its linkage to the floor that it supports.

1.8.5.3 Framework

The BIOSYS construction process accepts traditional or industrial types of frameworks. The joining of the framework to the BIOSYS masonry is done in a traditional manner. The presence of gable inclined column / beam structures allows for anchoring the framework to the BIOSYS hemp concrete blocks masonry.

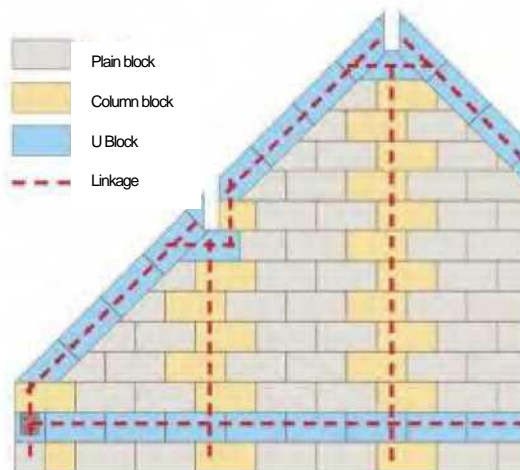


Figure 35: gable linkage guidelines for the traditional framework

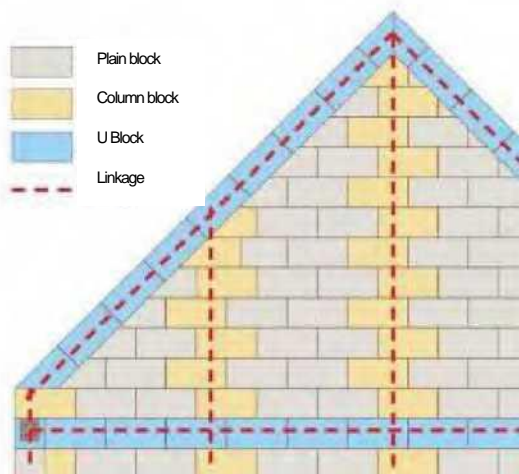


Figure 36: gable linkage guidelines for the industrial framework

1.8.6 Singular points

The construction of singular points is described below.

1.8.6.1 Treatment for Gable high linkage

- Plotting the slope of the gable with a decrease in relation to the finished side.
- Cut the blocks with a tool and guidance system.

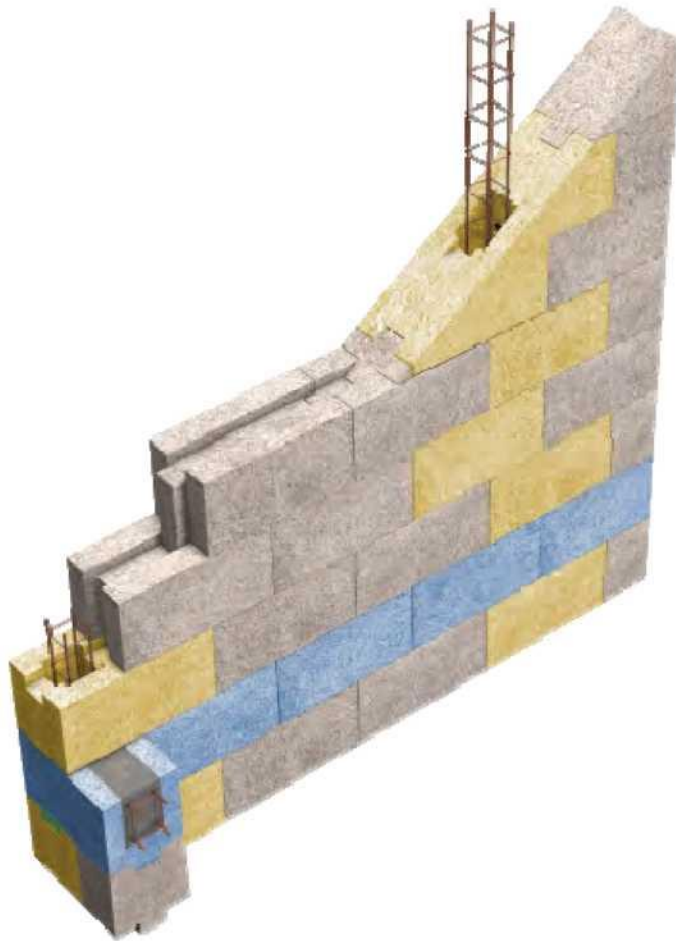


Figure 37: guidelines for cutting the gable

- Cast the concrete in the gable columns.
- Create a groove with an appropriate tool (specific electric groove cutter, see page 16).
- Placement of U blocks
- Placement of column frames
- Cutting the U blocks for consistency in the column framework.

Note: the gable shoring is obligatory as long as the final bracing is not secured.

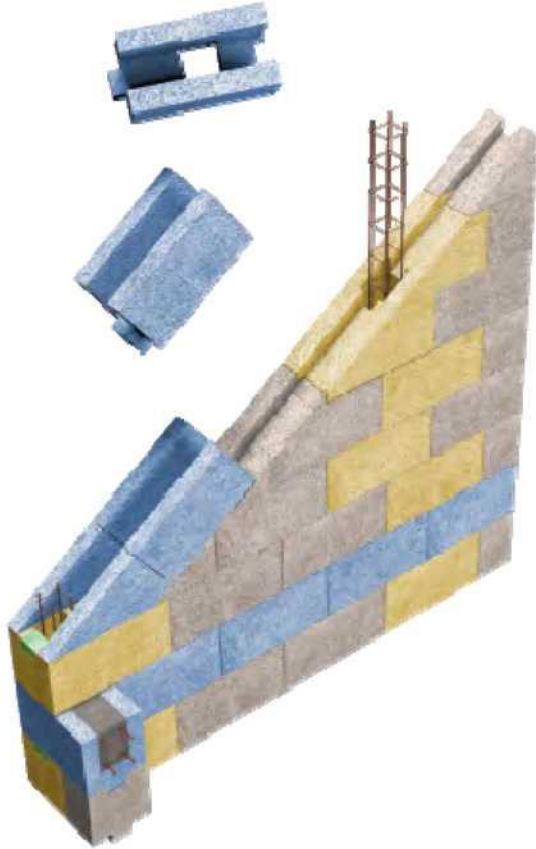


Figure 38: U block gable placement guidelines

- Placement of gable linking frames
- Casting the concrete



Figure 39: casting the gable linkage concrete

1.8.6.2 Joineries

The BIOSYS construction procedure allows all kinds of joineries available for this kind of single wall construction.

Placement applies to the bare interior

The rebate is made by cutting the hemp block so that a minimal covering is kept between the frame and the wall. The dimensions of the cut are appropriate for the frame work for joineries.

The caulking of the joinery is performed according to DTU 36.5 between the hemp block and the joinery.

Setting the joineries in the structure is performed by using screws with adapted dimensions, with high and low crossbeams and on each mounting, with an a number in accordance with DTU 36.5 traversing the hemp block and fixed in the concrete framework.

To protect the bay from standing water in the lower part after it's put in place, it is suitable for the company in charge of the joinery installation to also install a protective strip or a temporary protective membrane on the lower part.



Tunnel placement

The joinery is installed according to DTU 36.5 between the hemp block and the joinery.

Setting the joineries in the structure is performed by using screws with adapted dimensions, with high and low crossbeams and on each mounting, with an a number in accordance with DTU 36.5 traversing the hemp block and fixed in the concrete framework.

To protect the bay from standing water in the lower part after it's put in place, it is suitable for the company in charge of the joinery installation to also install a protective strip or a temporary protective membrane on the lower part.



Figure 41: diagram guideline for the installation of the tunnel carpentry

1.8.6.3 Window support

- Installation of reinforcement linked to the columns in the groove.

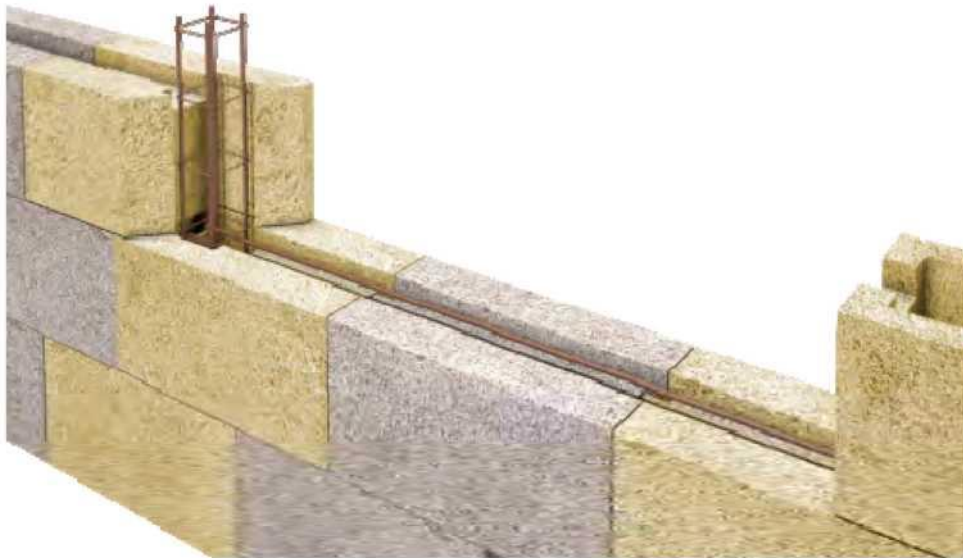


Figure 42: view of the window reinforcement and the column reinforcement

- Cast the concrete in the columns.



Figure 43: casting window reinforcement concrete

Jamb for door cast in place (in accordance with DTU 20.1).

1.8.6.4 Lintel

Case 1: lintel block with rolling shutter:

- Cut the column blocks to insert the box.
- Insert half of the rolling shutter box.
- Cut the tongue under the U block.
- Casting the installation mortar for U block installation

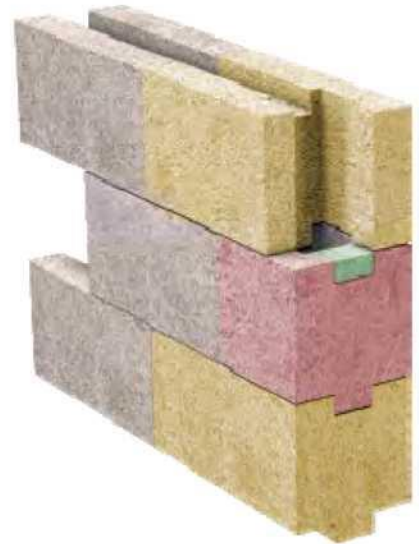


Figure 44: cutaway view of the blocks for installation of rolling shutter

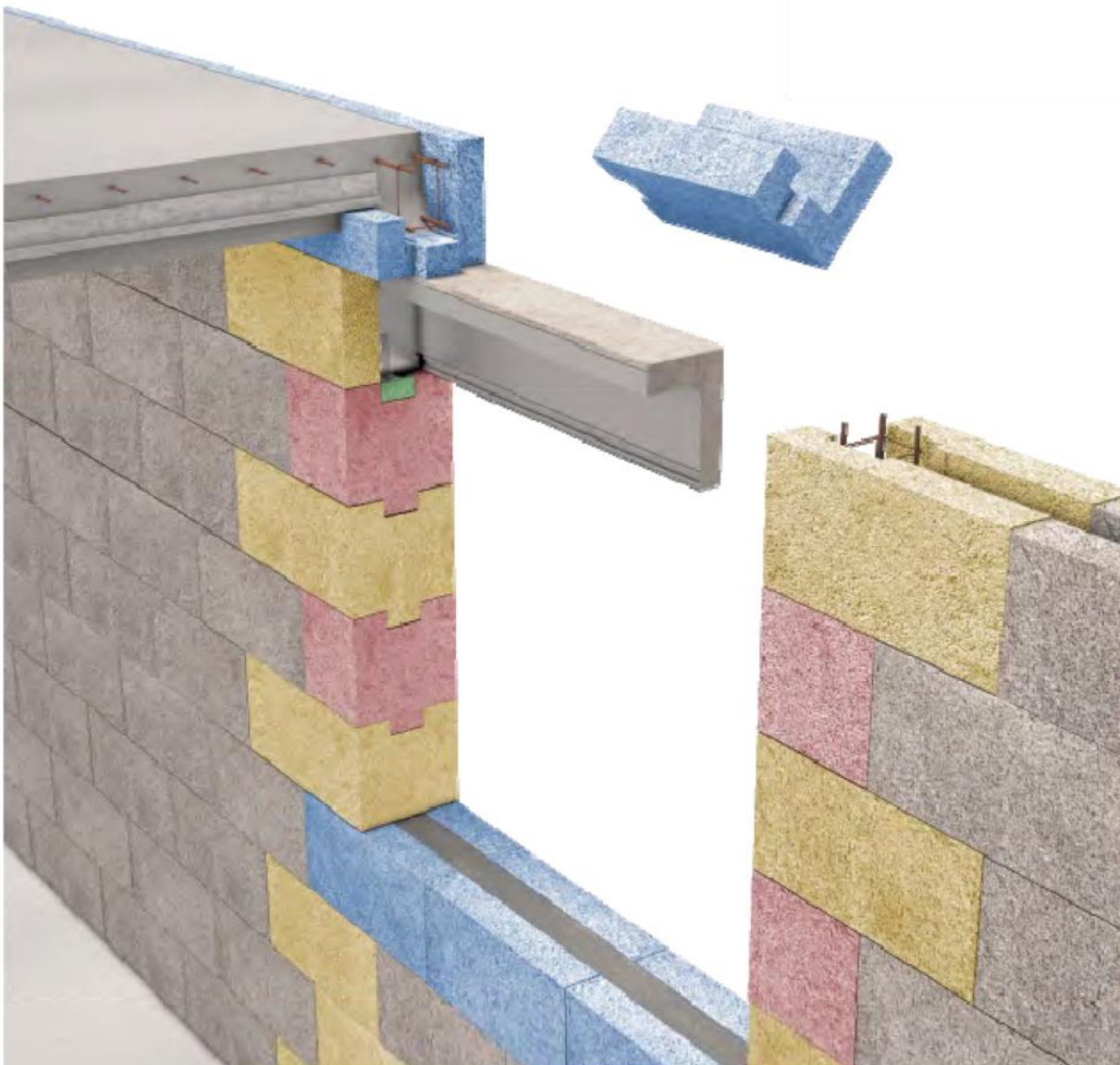


Figure 45: view of the entirety of the masonry for the window installed with a rolling shutter.

Case 2: linkage block lintel:

- Stabilization for U block lintel installation.
- Cut the column blocks to insert the U blocks.
- Install the U blocks with 7.5 cm (3 in.) support on each side of the opening.
- Installation of reinforcing bars
- Casting the concrete
- Casting the installation mortar for U block installation



Figure 46 : détail de la coupe des blocs pour mise en œuvre du bloc U en linteau

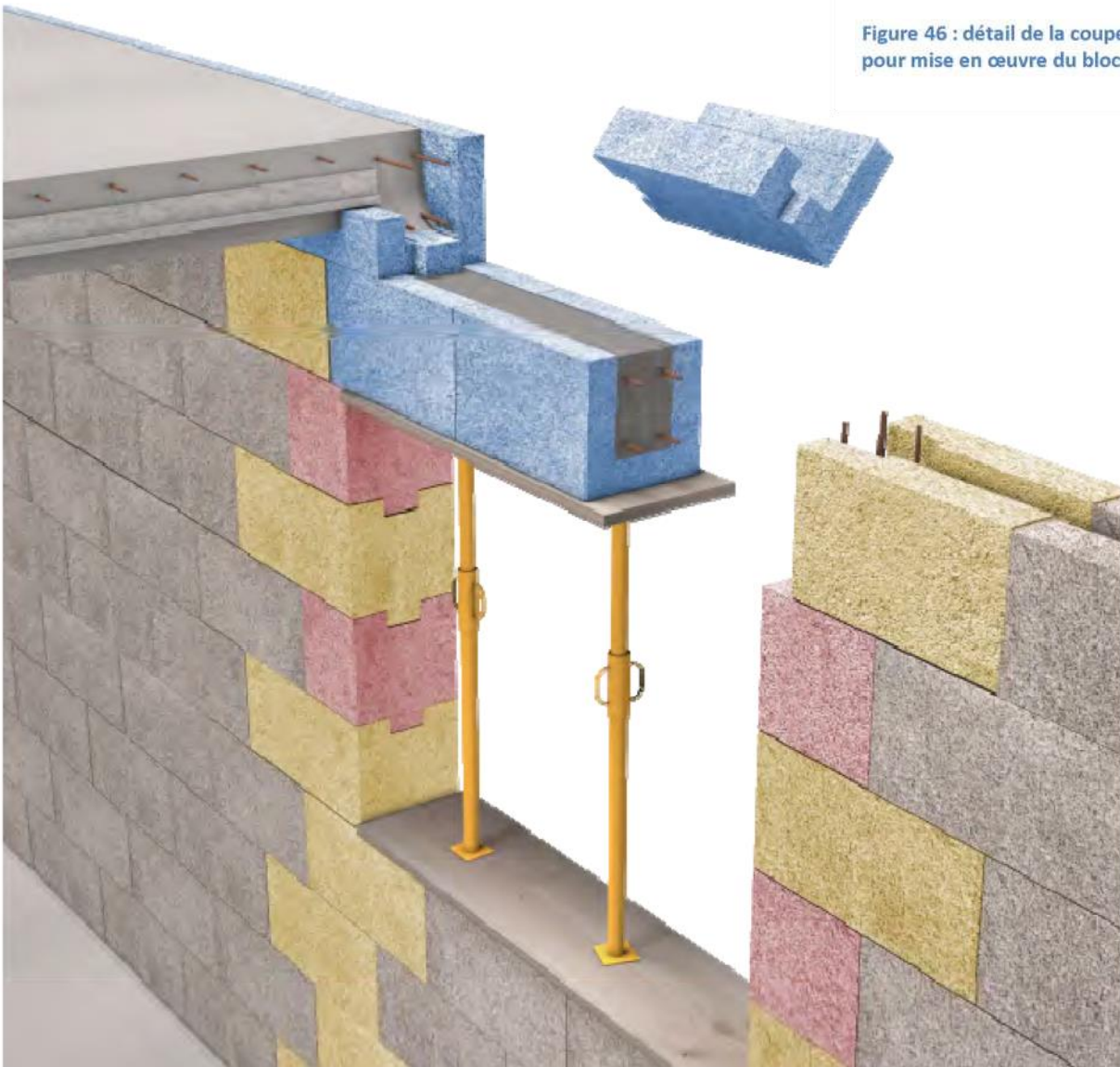


Figure 47: view of the entirety of the masonry for the window installed with a tunnel

1.9 Technique for distribution and assistance

1.9.1 Distribution

The BIOSYS construction process is manufactured and sold by the manufacture under a VICAT license. It is up to the manufacturer to put in place conventional distribution networks or to sell the products directly to the consumer.

1.9.2 Assistance technique

At the consumer's request, technical assistance for starting on the site is assured by VIELLE MATERIAUX. The provided technical assistance methods are described in index 24. Note: this assistance cannot be related neither to the work planning, nor reception of support, nor an inspection of the installation regulations.

A building site Quality Assurance Plan template is given in index 25.

This technical document is downloadable from the manufacturer's website: www.bloc-biosys.fr

2 EXPERIMENTAL RESULTS

The blocks and the BIOSYS construction process have been tested. These tests resulted in the test reports summarized below and are available in the appendixes.

Appendix 1: Dimensional variation amplitude according to NF EN 772-14

- Test result: 2016 CERIB 7069 from 11/29/2016
- Test result: 2016 CERIB 7070 from 1/13/2017

Appendix 2: Filling and adherence to the wall reinforcing bars in BIOSYS blocks to verify the stability in the preliminary phase and the concrete filling quality.

- Test result: 2016 CERIB 8051 from 2/16/2017

Appendix 3: Resistance test for the tensile strength of the walls made from BIOSYS blocks

- Test result: 2017 CERIB 8312 from 3/30/2017

Appendix 4: Test for fixture compatibility with the block

- Recommendation report Ref. O.T. 14418 on 1/25/2016

Appendix 5: Fire resistance of load bearing wall constructed with "BIOSYS" hemp concrete blocks without mortar, with vertical and horizontal reinforcement, and exposed to fire according to the normal curve.

- Test report: No. 009251 on 9/7/2017
- Ranking report No. 009241

Appendix 6: Behavior to fire test following NF EN ISO 1716

- Test reports No. RE 1E 1107/02/059A Amdt 1, RE 3E 1107/03/190A Amdt 1 and RE 5E 1107/02/059A Amdt 1
- Behavior to fire test report in accordance with regulation NF EN 13501-1: 2007 - Classification report No.: 1107/03/190 A on 7/15/2013

Appendix 7: Shock resistance test for wall elements made from BIOSYS hemp concrete blocks

- Test report: No. 2017 CERIB 008138 on 3/6/2017

Appendix 8: Alternative load test in the layout for a wall built with BIOSYS hemp concrete blocks

- Test report: No. MRF 17 26065538 on 9/22/2017

Appendix 9: Resistance to wear test for the surface of BIOSYS hemp concrete blocks

- Test report: No. 2016 CERIB 6964 on 11/3/2016

Appendix 10: Determination of the thermal resistance via the guarded hot plate apparatus method

- Test report: No. RE0917BL-002 on 9/5/2017

Appendix 11: Microbiology analysis report - technical report which followed the microbial activity on a sample of hemp remoisturized after 90 days of drying

- Technical report: CONIDIA N° DEV0713-003 on 8/6/2013

Appendix 12: Test of plastering solutions for walls mad out of BIOSYS hemp concrete blocks

- Test result: REF 17/0011 VPI on 10/19/2017

Appendix 13: Compression test for BIOSYS hemp concrete blocks

- Test report: No. 2017 CERIB 008311 on 3/30/2017

Appendix 14: Test for Rate of R acoustic weakening of a constructed wall

- Test result: N° AC13-26043251 on 8/30/2013

Appendix 15: Test of capillary water absorption in accordance with regulations NF EN 772-11 (August 2011)

- Test report: No. 2017 CERIB 7410 on 1/25/2017

Appendix 16: Study of the hygrothermic behavior of a hemp concrete wall with a concrete column

- Technical report No. DTS/LV/2017/326 index B - Project No. 10 03352 on 3/12/2018

Appendix 17: Thermic resistance determination of a construction of BIOSYS hemp concrete blocks and linear coefficient losses of the main thermal bridges

- CERIB report on 11/22/2017

Appendix 18: Study of the feasibility of an individual house with 15 x 15 columns - The load-bearing walls justified to the introduction of a column-beam frame made from reinforced concrete sunk into the BIOSYS blocks

- Technical note: N004_A544_2016_VICAT_B

Appendix 19: Calculations on the influence of prevented contraction/expansion

- CERIB calculation note on 12/11/2017

Appendix 20: Label "building-hemp" from the Hemp Construction labeling commission since 11/27/2015 under the number 001/003/001 received by the building hemp given by EUROCHANVRE**Appendix 21:** Air-tight in accordance with regulation NF EN 13829 and its Application Guide GA P 50-784

- Report reference: NRJ1703731-24\$ on 4/11/2017

Appendix 22: Process follow-up protocol.**Appendix 23:** Brick manufacturing Quality Assurance Plan**Appendix 24:** Development program.**Appendix 25:** Lot type Quality Assurance Plan

3 REFERENCES

The BIOSYS construction process has already been the subject of several buildings, which are listed below.

Site 1:

Client: Mr. and Mrs. FOURNIER

Commune: Mamirolle Department: Doubs (25)

Type : Individual house

Floors: 2

Floor space (m²) 84

Site 2:

Client: Mr. and Mrs. DELACROIX

Commune: Arçon Department: Doubs (25)

Type : Individual house

Floors: Single story Floor

space (m²) 70



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Site 3:

Client: Mr. Norbert PERRIN
Commune: Port-sur-Saône

Department: Haute-Saône (70)
Type : Individual house
Floors: Single story
Floor space (m²) 127

Site 4:

Client: Mr. REMY & Ms. PERRIN
Commune: Port-sur-Saône
Department: Haute-Saône (70)
Type : Individual house
Floors: 2
Floor space (m²) 208

Site 5:

Client: Mr. SALVI-FOURCADE & Ms. MARTIN
Commune: Fournets-Luisans
Department: Doubs (25)
Type : Individual house
Floors: 2 + Basement
Floor space (m²) 149

Site 6:

Client: Mrs. COLLARDEY
Commune: Montfort
Department: Doubs (25)
Type : Individual house
Floors: 2
Floor space (m²) 147