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Valid from **May 182021**

to **November 30 2023**

On the process

BIOSYS interlocking hemp blocks

Holder **:SociétéVICAT**

Internet: http://www.solution-biosys.fr

Descriptor :

A method of building masonry walls with interlocking 30 cm thick hemp concrete blocks. The blocks are assembled by dry interlocking and are associated with a reinforced concrete supporting structure of the post-and-beam type cast in specific blocks provided for this purpose.

BIOSYS interlocking hemp concrete blocks are intended for the construction of distributed insulation facade walls.

Specialised Group No. - Special 16products and processes for masonry

Product family/Process: Biobased block walls

COMMISSION CHARGÉE DE FORMULER LES AVIS TECHNIQUES

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FOREWORD

Technical Notices and Technical Application Documents are intended to provide those involved in construction with guidance on how to design and construct works using construction products or processes that are not part of traditional know-how and practice.
At the end of a collective evaluation, the technical opinion of the commission pronounces on the suitability for use of the products or processes in relation to the regulatory and usage requirements which the work to be built must normally satisfy.

Document versions

Version	Description	Rapporteur	President
V1	First Version.	Philippe LELBOND	Orhan ERGÜN

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1. Opinion of the Specialised Group

The Specialised Group n° 16 - Special products and processes for masonry of the Commission in charge of formulating Technical Opinions examined, on 24 November 2020, the **BIOSYS interlocking hemp blocks** process, presented by the company VICAT. It formulated the following Technical Opinion on this process. The opinion has been formulated for use in metropolitan France.

1.1. Brief definition

1.1.1. Brief description

A method of building masonry walls with interlocking 30 cm thick hempcrete blocks. The blocks are assembled by dry interlocking and are associated with a reinforced concrete supporting structure of the post-and-beam type cast in specific blocks provided for this purpose.

BIOSYS interlocking hempcrete blocks are intended for the construction of distributed insulation facade walls.

Exterior cladding

Multi-layer performance coatings in accordance with the NF DTU P1-226.1 standard: VPI Rénopass Chaux Clair coating body and VPI Rénopass Chaux GF finish.

Cladding solution on an aluminium frame, in accordance with CSTB 3194-V2, fixed in the reinforced concrete columns.

Interior linings

Plasterboards glued or on metal framework according to DTU traditional plaster25.41, sprayed according to DTU and 25.1 mortar coating according to DTU (26.1including lime and hemp-lime coating, etc...).

In the case of the addition of a thermal insulation complement from the inside, a plasterboard-insulation lining structure on a metal frame according to DTU 25.41.

1.1.2. Identification

The hempcrete blocks are on wrapped pallets and are identified by a plastic label attached to one of the blocks. This marking includes :

- Identification of the production plant ;
- The date of manufacture ;
- The number of blocks per type.

1.2. OPINION

1.2.1. Accepted area of use

This process is intended for the construction of buildings for current use in the sense of the DTU 20.1for residential buildings of 1st and 2 nd families, buildings covered by the Labour Code and establishments receiving the public within the limits of R+1 construction (floor height ≤ 3.00 m) with a light roof.

The process can also be used for infilling or renovation provided that a column-beam structure is reproduced in accordance with standard NF EN 1992-1-1 and that it complies with the standard constructional provisions relating to load-bearing walls, i.e. maximum column spacing of 1,8 M and horizontal chaining every 3 M.

The other limitations result from compliance with the regulations in force applicable to these buildings.

The process can be used for the construction of buildings subject to seismic requirements located in zones 1 to 3, subject to the application of the prescriptions listed in paragraph 1.2.3.2.

The accepted exhibition conditions are as follows:

- For walls insulated from the inside, or with distributed insulation, to type I to IV walls defined in the chapter of 3the part of 3the standard P 10-202 reference DTU20.1 "Guide for the choice of the types of facade walls according to the site";
- For externally insulated walls, those defined by reference to the technical opinion of the insulation system and the The BIOSYS blocks wall can be considered as a traditional masonry of concrete blocks according to the "General conditions of use of the thermal insulation systems from the outside being the subject of a technical opinion" (CSTB booklet of 1833March 1983).

The BIOSYS process is not intended for the construction of basement walls, retainer walls or underground walls.

1.2.2. Assessment of the process

1.2.2.1. Compliance with applicable laws and regulations and other fitness for purpose

Stability

The strength and stability of the process are normally ensured within the accepted field of use subject to the additional provisions given in the Technical Prescriptions (§1.2.3).

Safety in case of fire

Fire resistance

The process allows to comply with the fire regulations for the intended field of use, within the limits of the validity of the Fire Laboratory Assessment n°027104 and the CERIB Classification Report n°021602. The latter allow to attest respectively to a fire resistance classification REI30 and to a fire-stop performance EI90 in the conditions given in these documents, and recalled in chapter B of the technical file.

The degree of fire resistance is verified by considering the concrete column-beam system alone, without taking into account the blocks as additional protection. The fire stability is checked by applying the standard NF EN 1992-1-2.

The laboratory assessment n°027104 validates a REI30 performance for the BIOSYS hempcrete block wall including a cast-in-place load-bearing structure when it is stressed by loads in a fire situation respecting the admissible values determined in the CERIB calculation note n°022272 and in compliance with the NF EN 1992-1-1 standard.

Reaction to fire

BIOSYS interlocking hempcrete blocks alone have been tested for reaction to fire in accordance with the NF EN standard and13823 the NF EN ISO standard at 11925CREPIM. They are classified B-s1, d0 according to NF EN 13501- in accordance 1 with classification report n°1495/01/075A.

BIOSYS interlocking hempcrete blocks with VPI Rénopass Lime coating have a reaction to fire classification of B-s1, d0 according to the NF EN 13501-1 standard in accordance with the FCBA classification report n°-21/RC-29.

Installation in seismic zones

The use of the process in seismic zones is covered in this document. The process can be used for the construction of works requiring earthquake-resistant provisions within the meaning of the modified 2010 Order of October 22, provided that the requirements detailed in paragraph 1.2.3.4.

Prevention of accidents during implementation

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

Provided the precautions indicated in the Technical Prescriptions are taken, the stability of the walls during construction, particularly with regard to wind loads, is adequately ensured.

The different blocks in the range have the following masses:

Type *of block*	Mass (kg)
Solid block	21
Post block	18
Double post block	16
U or lintel/bond beam block	15

These masses are lower than the maximum load under handling conditions established by the NF X35-109 standard at kg.25

Thermal insulation

The process can meet the regulatory requirements, it being understood that the heat losses do not depend on the process alone and that a calculation check, conducted in accordance with the "Th-bat rules", must be carried out in each case on the basis of the indications given below.

The thermal resistance of the masonry wall of the process is defined as follows:

Thermal conductivity of hempcrete λ utile ($W.m^{-1}.K^{-1}$),	Thermal resistance of the 30 cm interlocking hempcrete block wall ($m^2.K.W^{-1}$)
0,071	4,21

The thermal resistances are defined by the CERIB technological consultation n°013455.

It is to be reminded that these values are only valid for BIOSYS blocks benefiting from a certificate as described in the Technical File, subject to regular self-checks of the dry density of the constitutive material.

The linear heat loss coefficient of the thermal bridge at a column, determined in accordance with the Th-bat rules and the standards NF EN ISO 6946, NF EN ISO 10456 and NF EN ISO is10211, 0.0430 W/(m.K).

The thermal resistance of the wall as a function of the column spacing can be determined from the following formula:

$$Ravec_{post} = \frac{1}{\left(\frac{1}{Rs\ without\ post}\right) \frac{0,17}{Centre\ distance}} - 0,17$$

Acoustic insulation

Acoustic tests were carried out to assess the acoustic insulation against airborne noise.

The sound reduction for a wall with a 15 mm plaster outer skin and a 5 mm plaster inner skin is Rw (C; Ctr) = (43-1; -2) dB according to classification report no. AC13-26043251.

Since the regulations concern the final performance of the structure, the satisfaction of the latter with regard to airborne noise from the outside space can be estimated by applying the NF EN ISO 12354-3 standard from the intrinsic performance of the products measured in the laboratory.

Impact resistance

The process has been tested for safety impact resistance on wall elements in accordance with standard P 08-. 302. It meets the criteria for C2 and H2 classification, in accordance with CERIB test report no. 027453.

Waterproofing of external walls

The watertightness of the facade walls is adequately ensured, provided that the exposure conditions defined in article 4.2 of part 3 of the DTU are respected 20.1.

The BIOSYS block has been tested for water absorption by capillary action in accordance with standard NF EN 772-11. The average absorption coefficient is Cw,s = g/m²2,8.s. This value is equivalent to that of common aggregate concrete blocks.

Hygrothermal behaviour

In view of the feedback and know-how developed by the association Construire en Chanvre (CenC) and transcribed in the Chanvre Professional Rules and 2004 validated by the Agence Qualité Construction (AQC), the hygrothermal behaviour of the wall is satisfactory, subject to compliance with the recommendations concerning the interior and exterior cladding.

Risk of surface condensation

Due to the distributed insulation of this wall and the possibility of efficient correction of thermal bridges, the risk of surface condensation is limited.

In addition, the BIOSYS process complies with the chapter of the 6DTU P420.1 on wall insulation.

Summer comfort

For the determination of the thermal inertia class of dwellings, which is an important factor for summer comfort, the external walls of this process belong to the category of distributed insulating walls. The determination of the inertia class is to be carried out according to the "Th-I" rules.

Indoor air quality

The volatile pollutant emissions of BIOSYS are classified A+ according to the decree n°2011-321 of March 23 relating 2011 to the labelling of construction products.

Environmental data

There is an Environmental Declaration (ED) verified by an independent third party for this process mentioned in paragraph C1 of the Technical File established by the Applicant. It is reminded that this ED does not fall within the scope of the examination of the suitability for use of the process.

Health aspects

The present notice is formulated with regard to the written commitment of the holder to respect the regulations, and in particular all the regulatory obligations relating to products that may contain dangerous substances, for their manufacture, their integration into the works of the accepted field of use and the operation of these. The control of information and declarations issued in application of the regulations in force does not fall within the scope of this notice. The holder of this notice retains full responsibility for this information and declaration.

1.2.2.2. Durability - Maintenance

The wall materials do not pose any intrinsic durability problems. The durability of interior gypsum board cladding can be expected to be similar to that of identical cladding applied to traditional substrates.

Subject to a strict respect of a minimum delivery time of 28 days, the durability of BIOSYS block masonry is equivalent to that of traditional concrete block masonry of the same nature.

The material used has been tested for resistance to mould growth (see Report No. DEV0713-003). Under the test conditions, the material is considered to be resistant to mould growth.

Freeze-thaw tests were also carried out on the BIOSYS block in accordance with the NF EN 771-3 standard. The loss of mass after cycling is less than the 1% prescribed by the standard. Moreover, no alteration of the specimens was observed and the compressive strength of the blocks was not altered by the cycles.

1.2.2.3. Manufacturing

The production is carried out in the VIEILLE MATERIAUX factory in Mérey-sous-Montrond (25). It requires the usual controls specific to the manufacture of these blocks. These controls are monitored by an external organisation.

1.2.2.4. Implementation

Dry stacking does not pose any particular problem. Implementation requires strict compliance with the provisions of the Technical File, particularly with regard to the quality of the concrete used and the execution of the external coating, which must be applied by specialised companies.

1.2.3. Technical requirements

1.2.3.1. Design and calculation conditions

Reinforced concrete beam and column structures shall be designed in accordance with EN 1992-1-1 and its national annex.

In a fire situation, the maximum load determined according to traditional regulatory fire testing methods for reinforced concrete beam-column frames must be taken into account.

The support of the floors in the final phase is to be considered as a reinforced concrete beam.

1.2.3.2. Manufacturing conditions

The compressive strength of the blocks, measured as specified in EN 772-1, must meet the following conditions:

Block	Dry density of concrete (kg/m3)	Characteristic compressive strength (MPa)
BIOSYS block	≤ 302	≥ 0,2

Dimensional tolerances on block thickness : (-2; +2) mm, block height (-2; +2) mm, length (-7; +7) mm.

The 28 minimum storage time for the blocks before delivery must be respected.

1.2.3.3. Conditions of implementation

In addition to the installation instructions given in the Technical File, the following instructions must be observed concerning :

- Safety on site: when the walls being erected are not braced by other walls perpendicular to their plane (and connected to each other by the harpooning of the blocks), they must, because of their relative instability, be supported during the erection until the floor hight is completed;
- As the technique requires the first course to be laid on a very flat and level base, the flatness and horizontality must be checked on the periphery of the work (or on a part of the work delimited by dividing joints) using istruments whose measuring accuracy is compatible with that of the work to be carried out;
- When pouring the concrete for the posts, a check must be carried out on the holding pins and the watertightness of the post feet. The concrete pouring is limited to a maximum height of 2,15M;
- The assembly of the blocks must allow for a minimum joint offset of 10 cm.
- The singular points of the structure (corners, lintels, openings) must be made using special blocks;
- When installing a prefabricated floor, it must be supported at the edge.

In all cases, the rendering body should be reinforced with a generalized fibre glass mesh, pressed into the first layer. The mesh used should have a minimum TRaME rating of $_1$TRaME$_{122}$.

The holder of the present Notice must provide training and assistance for the implementation of walls composed of BIOSYS blocks, to companies and individuals who wish to do so (dissemination of the Technical Notice, respect of the prescriptions attached to it, etc.).

1.2.3.4. Use in seismic zones

In seismic zones, the design is carried out by considering the process as a column-beam system. The applicable rules are those provided for in the decree of 22 October 2010: either the NF EN 1998-1 standard, or the PS-MI 89-92 for buildings covered by it.

In the first case, the justification in the seismic zone must be carried out according to the principle of low dissipative structural behaviour (ductility class L) in accordance with the standard NF EN 1998-1-1. The effects of the actions are calculated on the basis of the method of equivalent lateral forces or the modal response defined in §4.3.3.1 of the standard NF EN 1998- 1-1. The calculation spectrum is determined by applying a behaviour coefficient q =1.5 for class DCL.

Overall assessment

The use of the process in the accepted field of application (cf. paragraph 1.2.1) is favorably assessed.

1.3. Remarks by the Panel

The group reminds that the coatings referred to on the exterior are only those indicated in the Technical File and are reinforced by a mesh over the whole wall surface.

2. Technical File

From the file drawn up by the holder

2.1. Commercial data

2.1.1. Contact details

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2.2. Principle of the process

The BIOSYS interlocking hemp block process is a bio based construction system, composed of hempcrete blocks that are dry assembled thanks to the grooves & tongues on their faces. Self-supporting, these blocks do not allow the absorption of mechanical constraints. A reinforced concrete post and beam structure cast in specific hemp blocks ensures structural resistance.

2.3. Components of the process

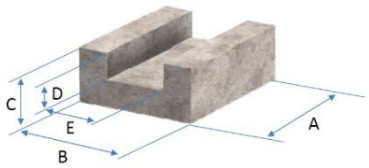
The BIOSYS construction process consists of the following elements:

- Concrete block - BIOSYS footing;
- BIOSYS standard hempcrete block ;
- BIOSYS hempcrete block post ;
- BIOSYS double-post hempcrete block ;
- BIOSYS U. or lintel / bond beam hempcrete block

All the constituent parts are described below.

2.3.1. Concrete block - BIOSYS footing

The first foundation of the hempcrete block will be made on a concrete footing. The technical and geometrical characteristics of this footing are specified below:



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

Compressive strength

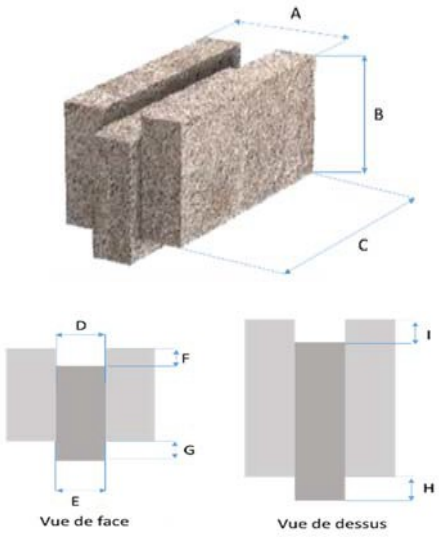
The permissible compressive load of the BIOSYS footing is 220 tonnes/ml. This load is considerably higher than the compressive load of the hempcrete block.

Once the first foundation has been made using the concrete footing block, the BIOSYS construction process consists of hempcrete blocks.

Different types of blocks are available to meet all the common and special requirements of a building. Each type of block is equipped with a set of grooves and tongues allowing the blocks to be fitted together. The blocks are reversible, i.e. there is no side reserved for the inside or outside of the building. The blocks can be re-cut on site to fit the dimensions of the building. It is also possible to recreate a groove in a block on site when it has been cut.

2.3.2. Standard block

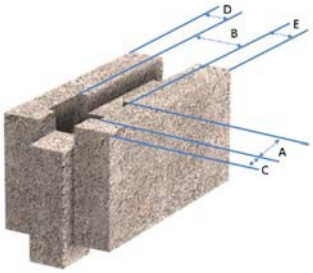
The basic block is used to build the common parts of the walls.



A = 300 mm (± 2)
B = 308 mm (± 2)
C = 600 mm (± 7)
D = 100 mm (± 3)
E = 100 mm (± 3)
F= 50 mm (± 3)
I = 44 mm (± 3)
G = 48 mm (± 3)
H = 38 mm (± 3)

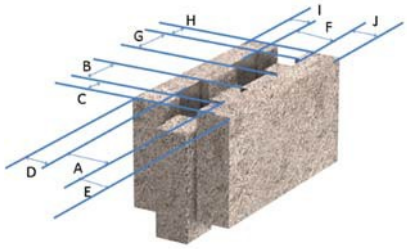
2.3.3. Accessory blocks

The column block is used to form concrete columns (angles, stiffeners, etc.). The square reservation is mm 150x 150 mm



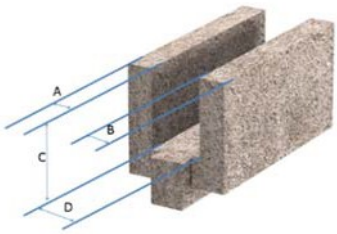
A = B = 150 mm (± 2) C = D = E = 75 mm (± 5)

The double-post block allows the construction of adjoining posts.



A = B = F = G = 150 mm (±2)
C = D = E = H = I = J = 75 mm (±5)

Finally, the U-block is used to form concrete beams and lintels.



A = B = 75 mm (± 5)
C = 220 mm (± 5)
D = 150 mm (± 2)

2.4. Manufacturing - controls

2.4.1. Raw materials

BIOSYS hempcrete blocks are obtained by moulding a concrete based on Prompt Natural Cement from VICAT and building hemp hurd.

2.4.2. Manufacture of blocks

The blocks and the starting blocks are manufactured at the VIEILLE MATERIAUX factory in Mérey-sous-Montrond (25). Manufacturing is subject to a QAP.

The manufacturing process can be broken down as follows:

- Storage of the shredded hemp hurd in a dedicated and sheltered hopper and storage of the Prompt Natural Cement binder in a silo;

- Mixing of the two components plus addition of water, after weighing (of these three components) in a mixer;
- Transport of the concrete obtained in a dosing hopper by weighing;
- Discharge into a drawer compartmentalised by product;
- Pouring the drawer into the mould ;
- Pressure calibration and hold time ;
- Demoulding and disposal ;
- Storage for a minimum of one (1) day on a moulding board;
- Palletized for transport and labelled (with factory and date of manufacture) ;
- Storage under cover for drying. Drying is considered satisfactory after a drying period of 28 days.
- Protection of the pallets with a film on top.

Post blocks, double post blocks and U-blocks are machined from the standard blocks using special machines.

2.4.3. Checks

2.4.3.1. Weighing / distribution scales

Control and calibration of the production tool (weighing and distribution scales) in accordance with the regulations in force (standard NF EN 45501) and this by an external organisation with COFRAC accreditation for this type of test.

2.4.3.2. Raw materials

All safety data, controls and conformity of Prompt Natural Cement are provided monthly by VICAT. The binder is stored in a protected environment (dedicated silo) and complies with NF P15-314:1993.

The control of grain size, water content, density and dust content is carried out by the hemp mill. This control is carried out according to the recommendations of the RILEM Technical Committee of March (282017Recommendation of the RILEM TC 236-BBM: characterisation testing of hemp shiv to determine the initial water content, water absorption, dry density, particle size distribution and thermal conductivity).

2.4.3.3. Finished products

The blocks constituting the footing are made of concrete and manufactured by VIEILLE MATERIAUX on an industrial press:

- The concrete used to make the footings is the same as that used to make the NF concrete blocks;
- The checks on the aggregates and concrete are carried out as part of the checks on the standard production of NF concrete blocks;
- Dimensional inspection at each production run at the rate of one inspection every 1000 operations. The

BIOSYS block undergoes several checks at different stages of its manufacture:

- After demoulding: visual inspection (no defects in appearance);
- Storage on the production board: dimensional control of its length (tolerance (600-7; +7) mm) within the first hour of production after demoulding;
- Storage under cover :
- Dimensional control of all block dimensions on all products of an operation, i.e. blocks16 all operations1000;
- Control of the dry density on products randomly 3taken 16from an operation every operation.2000

For the post, double post and U-block, a dimensional check is carried out on each machining day within the first hour.

- Dimensional check of the column block. This check only concerns the dimensions of the post and the position of the post;
- Dimensional check of the double-post block. This check only concerns the dimensions of the posts and the position of the posts;
- Dimensional check of the U-block. This check only concerns the dimensions of the reservation and the position of the reservation.

The thermal performance of the blocks is checked by measuring the dry thermal conductivity according to NF EN 12664:2001 at a frequency of 3 tests spread over 2 years. The tests are carried out by an external laboratory.

2.5. Implementation

2.5.1. General principle of installation

2.5.1.1. Preparing the substrate and making the first row (figures and1 2)

The steps are as follows:

- Placement of reinforcement for the columns at the time of pouring the foundations;
- Checking the flatness of the starting surface ;
- Laying the footings on the outer edge of the base on a waterproof mortar bed;
- Protection against rising damp by laying a levelling strip;

- The first row of blocks is positioned by fitting the tongues of the BIOSYS hemp concrete blocks into the grooves of the blocks forming the footing.

The blocks form a harpoon at the corners. The tongues are cut out at the corners to allow cross-laying. Any openings remaining after the wall has been erected are filled with the off-cuts of the blocks. The tongues that protrude from the façade are cut out.

2.5.1.2. Erection of the following rows and construction of the column-beam structure

The steps are as follows:

- Laying of blocks by simple interlocking with staggered joints (minimum of cm10);
- Layout required to take account of openings, windows and doors;
- Filling of remaining gaps between blocks2:
  - Case 1 - greater than 10 cm (figure 3): cutting of the block and creation of the groove in the side of the block with specific tools;
  - Case - 2less than or equal to cm10 (figure 4): formwork of the spacing and pouring of hemp concrete according to the prescriptions mentioned in § 2.5.1.4.
- Cutting in the corner post blocks for continuity of the interlocking. The cut-outs are made using the appropriate tools mentioned in §2.5.1.4.
- Making posts with reinforcement: post in running wall, corner post, post for openings (door and window):
  - Cutting of the tongues for cross-laying at the corners and reworking to close the remaining openings;
  - Installation of the reinforcement with shimming to ensure minimum embedding;
  - Formwork at the foot of the column.
- Fitting the holding pins and locking the plumb line ;
- Pouring concrete into the columns.

The concrete is poured into the post and double-post blocks in passes of up to one metre2,15 in height, after cleaning the support interface at the foot of the post.

The concrete used is a concrete conforming to the NF EN 206/CN standard and to the following specifications:

- Compressive strength class: C25/30 ;
- Exposure class: to be determined according to NF EN 1992-1-1 without taking into account the protection by the blocks.
- In accordance with NF EN 1996-1 and its national annex, the embedding may be reduced by up to 10 mm, corresponding to the layer of rendering mortar applied to the exposed face of the block.
- Consistency class: S4 ;
- Max grain size: mm10 ;
- Vibration-free.

Concrete re-concrete is to be treated as for reinforced concrete elements (DTU 21). The surface of the concrete must be clean and treated in such a way as to obtain the desired interface quality, without however degrading the concrete zone close to this interface.

A visual check should be carried out after casting to ensure that the footer is properly filled and that there is no segregation.

2.5.1.3. Complements and tools

The BIOSYS construction process may sometimes require filling a gap, for example, between 2 blocks when the layout requires it. Above cm10, the gap is simply filled with a cut block. In the case of a gap of 10 cm or less, hemp concrete is made on site and placed in the gap. The following materials are required to produce hemp concrete on site.

The dosage for making hemp concrete on site is in accordance with VICAT recommendations.

2.5.1.4. Materials for making hemp concrete on site

- Bale of hemp fibre for building: allows the realisation of hemp concrete on the building site for possible rework. The binder to be used is Prompt Natural Cement from VICAT;
- Natural Cement Prompt from VICAT: allows the realisation of hemp concrete on site for possible rework. The aggregate to be used is hemp fibre;
- TEMPO setting retarder from VICAT, if necessary. All these

materials are available from the manufacturer.

Hemp concrete manufactured directly on site is used at ambient temperatures of 5 to 25°C. Above 25°C, special measures must be taken.

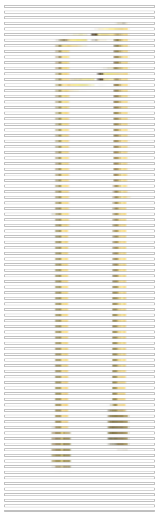
It is recommended to use the following dosage: 100 L of Hemp Building Aggregate, L25 of Prompt Natural Cement, L25 of water, and if necessary Tempo retarder. The water can be adjusted to achieve the desired consistency. Be careful not to over mix. The Tempo retarder can be dosed as follows, depending on the ambient temperature, for an application time of approximately 15 minutes:

- If T° < 15° C: bottle1 per bag or cap1 per litre2 of natural cement Prompt ;
- If T° > 15° C: bottles2 per bag or cap1 per litre of Prompt natural cement.

The tools needed to implement the BIOSYS construction process are standard mason's tools. However, the following specific tools may be necessary.

Optional specific tools :

- Supporting rods: to ensure the maintenance of the plumbness and the formwork at the foot of the columns during the pouring;



- Self-saws, electric sabre saws, chain saws, band saws: allow easy cutting of the BIOSYS hemp concrete block;
- Specific grooving machine: allows the creation of an interlocking groove in the BIOSYS hemp concrete blocks that have been cut.

2.5.2. Realization of the singular points

2.5.2.1. Creation of the beam at the edge of the floor

The row at floor level is provided by the U-blocks which serve as formwork for the perimeter chaining beam. The inner wall of these U-blocks is cut to allow the continuity of the reinforcement at the corners and the installation of the floor (figure 6). The height of the cut-out allows the height of the underside of the floor to be adapted (figure 7). The installation of the concrete and reinforcement (particularly in terms of embedding) must comply with the same provisions as those mentioned in article 2.5.1.2.

2.5.2.2. Junction between facade walls and partitions

The partition walls are made of masonry or reinforced concrete. The masonry partition walls are installed flush with the BIOSYS hemp concrete block wall. The stability of the wall is ensured by its own reinforcement and its connection with the floor it supports. In the case of a reinforced concrete wall, it can be connected to the column integrated in the hemp concrete wall (figure 15).

2.5.2.3. Treatment of gables

The BIOSYS construction process accepts both traditional and industrial type frameworks.

The connection of the frame to the BIOSYS block wall is done in the traditional way. The presence of an inclined gable beam allows the anchoring of the frame to the post and beam structure (figure 9).

The implementation steps for the gable sheathing beam are as follows (Figure 10)

- Tracing the slope of the gable with a setback of cm30,8 from the finished dimension;
- Cutting the blocks with tools and a suitable guiding system;
- Creation of a groove with appropriate tools (specific electric groover);
- Installation of the U-blocks with cut-outs to ensure continuity of the reinforcement at the columns.
- Installation of the reinforcement of the gable truss ;
- Pouring of concrete.

Note: Shoring of the gable is mandatory until final bracing is assured.

2.5.2.4. Window sills

The following steps are required to make the window sills (Figure 13):

- Use of steel connected to the columns in the groove ;
- Pouring concrete into the groove ;
- Implementation of the window sill (prefabricated or made in situ by pouring concrete with a slope shape allowing water to be evacuated to the outside, fitted with a waterproof protection such as painted aluminium sheet). The geometric characteristics and the implementation of these sills must comply with the DTU 20.1.

2.5.3. Lintels

Case of the lintel in a box type block ½ lintel for roller shutter :

- Cutting of the column blocks for the installation of the ½ lintel roller shutter box;
- Installation of the ½ lintel roller shutter box ;
- Cutting out the tongue under the U-block;
- Pouring a mortar for the installation of the U-block on the ½ lintel box. Case of

the lintel in chaining block :

- Shoring for the installation of U-blocks in lintels;
- Cutting out the column blocks to fit the U-blocks;
- Cutting out the tongue under the U-block;
- Installation of the U-blocks on the strut row with cm7,5 supports on each side of the opening;
- Installation of the steels ;
- Pouring of concrete.

2.5.4. Joinery

The BIOSYS construction process accepts all types of joinery available for monomur construction systems.

2.5.4.1. Rebate installation

The rebate is made by cutting the hemp block in such a way that there is a minimum overlap between the frame and the wall. The dimensions of the cut-out are adapted to the frame of the joinery.

The sealing of the joinery is carried out in accordance with the DTU between36.5 the hemp block and the joinery.

The joinery is fixed to the structure with a sufficient number of appropriately sized screws in accordance with the DTU, through36.5, the hemp block and into the reinforced concrete framework.

In order to protect the opening from water stagnation at the bottom during installation, the company in charge of installing the joinery should also install the mud flap or a temporary protection membrane at the bottom.

2.5.4.2. Tunnel installation

The waterproofing is carried out in accordance with the DTU between36.5 the hemp block and the joinery. The joinery is fixed to the structure with a sufficient number of appropriately sized screws in accordance with the DTU in the upper and lower transoms and on each jamb, passing36.5, through the hemp block and fixed in the reinforced concrete framework.

In order to protect the opening from water stagnation at the bottom during installation, the company in charge of installing the joinery should also install the mud flap or a temporary protection membrane at the bottom.

2.5.4.3. Mixed installation (tunnel / surface)

The mixed installation is carried out by partially inserting the frame into the opening. The part of the frame (not inserted in the tunnel) projecting from the inner wall surface is fixed to the masonry as in the case of rebated installation (paragraph 2.5.2.4).

The joinery is sealed in accordance with DTU 36.5 between the concrete and the joinery. The joinery is fixed to the structure by means of a sufficient number of suitably sized metal brackets on the top and bottom rails and on each upright, in accordance with the DTU, and 36.5fixed to the reinforced concrete framework.

During installation, a minimum distance must be maintained between the cover flange of the frame and the face of the inner wall to allow for the subsequent installation of the inner lining.

In order to protect the opening from water stagnation at the bottom during installation, the company in charge of installing the joinery should also install the mud flap or a temporary protection membrane at the bottom.

2.5.5. Airtightness of the building

The airtightness of the process is ensured by the external plaster or by the internal coating.

2.5.6. Condensation in the walls

The hemp block process does not present any particular risks that could deteriorate the whole wall in the long term.

2.5.7. Reservations

The grooves for the various networks (electricity, water, etc.) are made using a groover and a suitable hole saw.

After fixing the technical ducts and boxes, these recesses must be filled with a suitable sealing product compatible with the finishing plaster.

2.5.8. Coatings

2.5.8.1. Exterior cladding

The external coating can be a multi-layer performance coating as defined by the NF DTU P1-226.1 standard, of the following type: VPI Rénopass Chaux Clair coating body - VPI Rénopass Chaux GF finish.

The coating must be applied in accordance with the manufacturers' recommendations, particularly with regard to the time between coats. The rendering body is systematically reinforced by placing a glass reinforcement with a minimum TRaME T1 Ra1 M2 E2 classification in the first pass.

Glass cloth handkerchiefs measuring 300 x 300 mm² must be inserted into the plaster at 45° at the corners of the openings. All construction corners must be covered with fabric corner strips, which must be inserted into the plaster body. Lintel strips should be set into the render body at the lintels and at the lower corner at the first course.

2.5.8.2. Interior linings

The interior linings can be the following:

- Traditional gypsum plaster applied according to DTU and mortar 25.1plaster according to DTU26.1 ;
- Plasterboards glued or on metal frame according to DTU25.41 ;
- In the case of the addition of a thermal insulation complement from the inside, a plasterboard-insulation lining complex on a metal frame according to DTU 25.41.

2.5.9. Termites

In accordance with the regulations in force, the hemp block process must be protected against termites in the departments subject to a prefectural decree (in accordance with article L.133-5 of the Code de la Construction et de l'Habitation).

In application of article R.112-3 of the French Construction and Housing Code and the decree of June 27modified2006, new buildings using the BIOSYS hemp block process must be protected against the action of termites by the implementation of a protective barrier (figure 17) between the ground and the building (part or all of the foundation).

These technologies must be installed in accordance with the requirements set out in the associated technical opinions.

2.5.10. Seismic provisions

The hemp block process can be used in structures requiring seismic provisions (in accordance with paragraph 1.2.3.4 of the Opinion)

2.5.11. Design

The design of the column-beam structure is carried out in accordance with standard NF EN 1992-1-1, supplemented by standard NF EN 1998-1-1 or the revised PS-MI 89 rules 92 for structures that must meet seismic regulatory requirements.

The calculations of the reinforcement sections are systematically validated by an engineering office.

2.5.12. Flat-rate constructional provisions

The interlocking hemp block process cannot be used as a load-bearing structural element, but only as a filling element. The structural design is to be carried out considering only the reinforced concrete column-beam system.

The hemp block process can be used in seismic zones at 13.

In order to avoid the need for a study and the full calculations required in the general case, only for the façade walls, there is also the possibility of using the rules for minimum lump sum provisions. These provisions are specified in the following paragraphs. The intermediate structure (columns, beams, dividing walls, floors) is, in all cases, traditionally dimensioned by a design office according to the forces to be taken up. The design of the structure must systematically be carried out by an engineering office for the construction of works that do not fall within the scope of the minimum constructional provisions.

2.5.12.1. Minimum standard provisions - Without seismic requirements

The following paragraph proposes minimal constructional provisions that dispense with the complete calculations required in the general case, only for the façade walls, in the absence of seismic requirements. The intermediate structure (columns, beams, partition walls, floors) remains, in all cases, dimensioned in the traditional way according to the load descent.

The following assumptions must be met:

Assumptions

- Construction R+1 with light roof (timber frame) ;
- Hemp blocks only used in facade walls;
- Maximum floor span: m5 ;

- Beam and slab floors ;
- Maximum floor height: m3 ;
- Posts: mm 150x mm150 ;
- Beams: mm 150x mm200 ;
- Post spacing: m 1,80maximum ;
- Maximum opening: m2,5 ;
- Permissible stress of the foundation soil: MPa0,3 ;
- Maximum Permanent Loads (including dead weight) :
  - Floor loads (incl. covering): kg/m²370 ;
  - Roof loads (frame + roof + insulation): kg/m²100.

Foundations

The foundations are made up of threaded footings cm50 wide and cm30 high, and reinforced with HA stringers3 on the upper and lower 10sides with HA 8 frames every 20 cm.

Reinforcement

In order to have a maximum column spacing of 1.80 m, the reinforcement of the columns consists of 4 HA 10 strands with HA 5 frames spaced every 15 cm. The beams are reinforced with 4 HA 10 bars with HA 6 frames spaced every 15 cm.

In the case of openings longer than m 1,80(and shorter than m2,50), the reinforcement and dimensions of the horizontal wall ties (150 mm x 200 mm) mentioned above are no longer valid and must be calculated separately. However, the dimensions and reinforcement of the columns remain valid. The continuity of the steel (construction angles, overlaps, foundation connections, etc.) must comply with the rules of the trade.

2.5.12.2. Minimum standard provisions - With seismic requirements

The following paragraph proposes minimal constructional provisions exempting the complete calculations required in the general case, only for the façade walls, in the presence of seismic requirements up to the seismic zone. The intermediate 3.structure (columns, beams, partition walls, floors) remains, in all cases, traditionally dimensioned according to the load descent.

The following assumptions must be met:

Assumptions

- Configuration of the construction in plan and elevation in accordance with the criteria6 defined in the CPMI rules;
- Construction R+1 with light roof (timber frame) ;
- Hemp blocks only used in facade walls;
- Maximum floor span: m5 ;
- Beam and slab floors ;
- Maximum floor height: m3 ;
- Posts: mm 150x mm150 ;
- Beams: mm 150x mm200 ;
- Post spacing: m 1,20maximum ;
- Maximum opening: m2,5 ;
- Soil class: A, B, C or D;
- Permissible stress of the foundation soil: MPa0,3 :
  - Maximum Permanent Loads (including dead weight),
  - Floor loads (incl. covering): kg/m,370
  - Roof loads (frame + roof + insulation): kg/m²100.

Foundations

The foundations are made up of :

- Either 70 cm wide and 30 cm high, with 3 HA 10 reinforcing bars on the upper and lower sides and HA 8 frames every 20 cm.
- Either 50 cm wide, 30 cm high, reinforced with 3 HA 10 stringers on the upper and lower faces with HA 8 frames every 20 cm, provided that the embedding of the posts in both directions is ensured by a 15 cm thick reinforced slab, or by a bi-directional network of stringers (at least one stringer in each direction at mid-façade linking the opposite façades).

Reinforcement

The reinforcement of the columns consists of 4 HA strands with12 HA frames spaced6 every cm.15

In the case of a single storey construction, the reinforcement can be reduced to 4 HA 10 ties with HA 6 frames spaced at 15 cm intervals. The peripheral ties are reinforced with 4 HA 12 ties with HA 6 frames spaced every 15 cm.

Openings longer than 1.20 m (and less than 2.50 m) are authorised on an ad hoc basis (one opening per façade), provided that they are bordered by double posts respecting the reinforcement mentioned above. The dimensions of the horizontal chaining of the beams and their reinforcement must be adapted in line with the opening to take up the vertical load.

The principles of the arrangement of the reinforcement, and in particular the beam/post connections and the overlaps, must respect the execution rules defined in the CPMI for horizontal and vertical ties.

2.5.12.3. Summary of the fixed-rate constructional provisions

	Max. column spacing	Concrete frame	
		Post reinforcement	Reinforcement of beams
Without seismic requirements	1,80 m	4 HA with 10frames HA all5 the cm15	4 HA with 10frames HA all6 the cm15
With seismic requirements	1,20 m	4 HA with 12frames HA all6 the cm15 (if single-storey construction: 4 HA 10 with HA 6 frames every cm15)	4 HA with 12frames HA all6 the cm15

2.5.13. Fasteners

The BIOSYS construction process allows objects to be fixed to the hemp concrete block wall.

Tests were carried out with a FID plug +90 panel screw of6 the FISCHER brand. The recommendation allows the fixing of common objects in a building corresponding to the intended field of use ($Nrd_{,s}$ = daN14,4, cf. report OT14418- Test reports-VICAT-FID90).

2.6. Distribution and technical assistance

2.6.1. Distribution

The BIOSYS construction process is manufactured and marketed by the manufacturer under licence from VICAT. It is the manufacturer's responsibility to set up conventional distribution networks, or to sell the products directly to users.

2.6.2. Technical assistance

VICAT can provide appropriate assistance to companies that request it. This assistance consists of a training course allowing the trainee to master the basic rules and gestures of implementation. On request, additional support directly on site is also possible.

The assistance provided cannot be equated with the design of the work, the acceptance of the supports, or a control of the rules of implementation.

2.7. Experimental results

2.7.1. Amplitude of dimensional change

- Test report: CERIB2016 of 706929/11/2016
- Test report: CERIB2016 of 707013/01/2017

2.7.2. Filling and bonding of reinforcements

Tests to validate the stability in the provisional phase and the filling quality of the concrete in BIOSYS blocks

- Test report: CERIB2016 of 00805116/02/2017

2.7.3. Tensile strength of the block walls by bending

- Test report: CERIB2017 of 00831230/03/2017

2.7.4. Fastener Compatibility

- Recommendation report: Ref. O.T. of 1441825/01/2016

2.7.5. Fire resistance

- Classification report no. 021602 of 13/02/2020
- Test report: n°021596 of 28/01/2020
- Calculation note: No. of 02227224/03/2020

2.7.6. Reaction to fire

- Test reports : : n° RE 3E 1495/01/075A, RE 5E 1495/01/075A
- Reaction to fire classification report in accordance with NF EN 13501-1: - no2013. 1495/01/075 A dated 02/05/2018

2.7.7. Impact resistance

- Test report : n° CERIB2017 of 00813806/03/2017

2.7.8. Alternate loading in the plane

- Test report : n° MRF of 172606553822/09/2017

2.7.9. Pull-out strength on the surface of the blocks

- Test report : n° CERIB2016 of 696403/11/2016

2.7.10. Thermal resistance

Determination of thermal resistance by the hot plate method

- CoDEM test report: n° RE0917BL-002 of 05/09/2017 Linear loss

coefficients of the main thermal bridges

- CERIB report : n° of 01345529/01/2019

2.7.11. Microbiological analysis

- Technical report: CONIDIA N° DEV0713-003 of 06/08/2013

2.7.12. Application of plastering solutions

- Test report: REF 17/0011 VPI of 19/10/2017

2.7.13. Compressive strength of blocks

- Test report : n° CERIB2019 of 02062404/11/2019

2.7.14. Determination of the sound reduction index R

- Test report: N° AC13-26043251 of 30/08/2013

2.7.15. Water absorption by capillary action

- Test report: No. CERIB of 02289026/06/2020

2.7.16. Structural study

Feasibility study of a single-family house with mm 150x mm150 posts

- Technical note: N004_A544_2016_VICAT_B

2.7.17. Influence of prevented shrinkage/swelling

- CERIB calculation note of 11/12/2017

2.7.18. Airtightness

- Report reference: NRJ1703731-24$ of 11/04/2017

2.7.19. Freeze-thaw

- Test report: No. CERIB of 02289126/06/2020

2.7.20. Quality assurance plan for block production

- Version of 208/04/2020

2.7.21. Standard site quality assurance plan

- Version of 208/04/2020

2.7.22. Fixing tests

Test reports	Strengths at serviceability limit Nrd,s (daN)
OT14418-Test reports-VICAT-PF 8x160	11
OT14418-Test reports-VICAT-PF 10x160	11,4
OT14418-Test reports-VICAT-FIS V rod M10	13,6
OT14418-Rapports essais-VICAT-FID90	14,4

2.8. References

2.8.1. Environmental data[1]

The BIOSYS block has been the subject of an individual Environmental Declaration (ED). This ED was established in May and2018 was subject tverification by an independent third party in accordance with the order of August31 and2015 is filed on the website: www.inies.fr

[1] Not considered by the Panel in the context of this Opinion

2.8.2. Other references

Type of building	M2	Date of implementation	Address of the building
MI ground floor	110	June 18	3 Bis Rue Dieudonné Thiebault Rupt88360 Sur Moselle
MI ground floor	330	June 18	8 rue des Carrières - 70110Athesans-Etroifontaine
MI R+1	87	Sep-18	10a route de Dracy Saint Loup -71400 Curgy
MI R+1	340	Nov-18	85 - Noirmoutier Island
Single-storey office extension	100	Dec-18	Rue de Nagland - 25560Merey sous Montrond
MI R+1	340	Dec-18	85680 La Guerinière
Dwelling R+1	113	March 19	Monastère Sainte-Claire Lieudit La Dépendale - 69910Villié Morgon
MI R+1	106	Apr-19	La Fouaye -35590 Saint Gilles
MI ground floor	47	Apr-19	12 rue Chaperonière - 49100Angers
MI R+1	195	Jul-19	85 - Yeu Island
MI R+1	143	Jul-19	56 - Island of Groix
MI ground floor	120	Jul-19	70000 - Clans
MI R+1	172	August - 19	72 avenue Abel Rolland - - 81390Briatexte
Extension of an IM	64	August - 19	49 - Angers
MI ground floor	85	August - 19	59270 - Godewaersvelde
MI ground floor	64	Sep-19	Place called Le Chalet - Vern 49220d'Anjou
MI R+1	281	Sep-19	85 - Yeu Island
Extension of an IM	40	Sep-19	4 rue du Roupet - - 02Chery Les Pouilly
MI ground floor	240	Nov-19	85 - Noirmoutier Island
ERP ground floor	277	Nov-19	Pierre Chevet sports hall - Allée du bois - - 77183Croissy Beaubourg
Extension of an IM	84	Dec-19	14 rue de l'Aleu - - 78730Saint Arnault en Yvelines
Home renovation	175	Jan-20	Impasse de la ferme Mondeville91590

2.9. Annexes to the Technical File

2.9.1. Figures

Figure - 1Layout of the foundation, reinforcement and footing

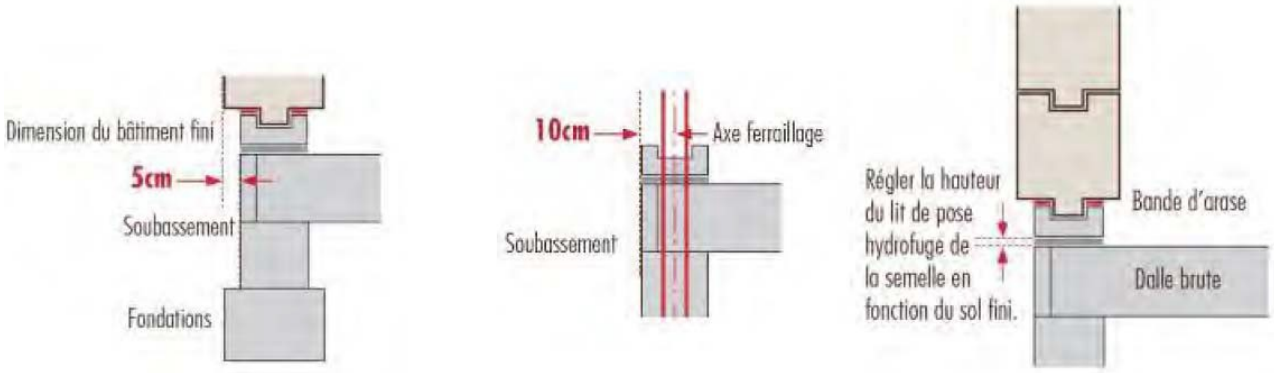


Figure -2 Overview of the starter system

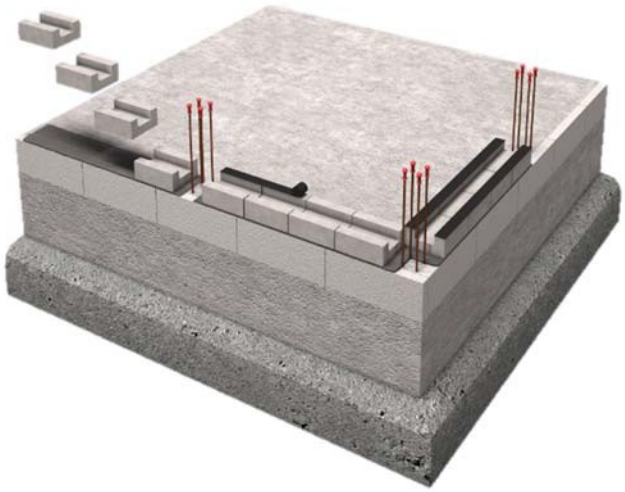


Figure - Full wall 3mounting with remaining space greater than cm10

Figure - Full wall 4mounting with less than cm10 remaining space

Figure -5 overview of the different types of poles

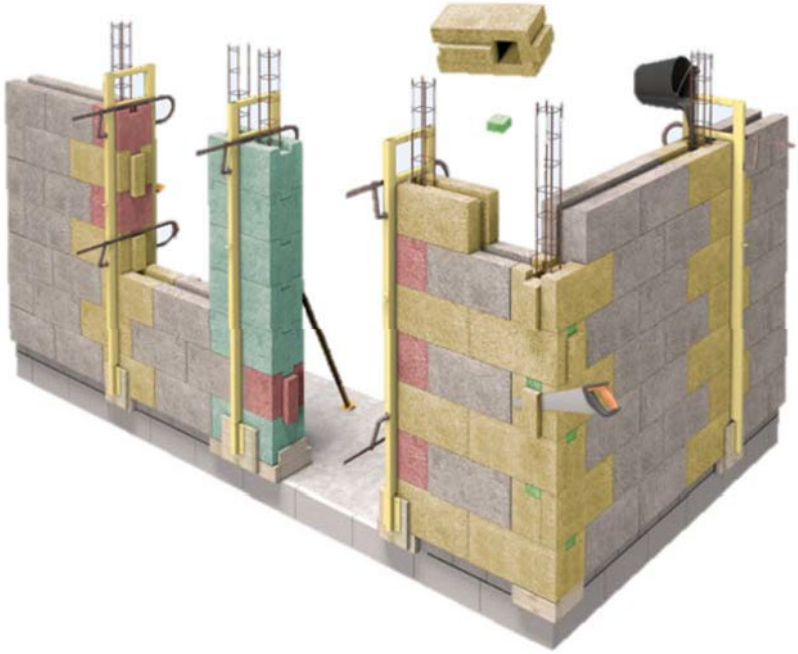


Figure -6 overview of the installation of a beam and slab concrete floor

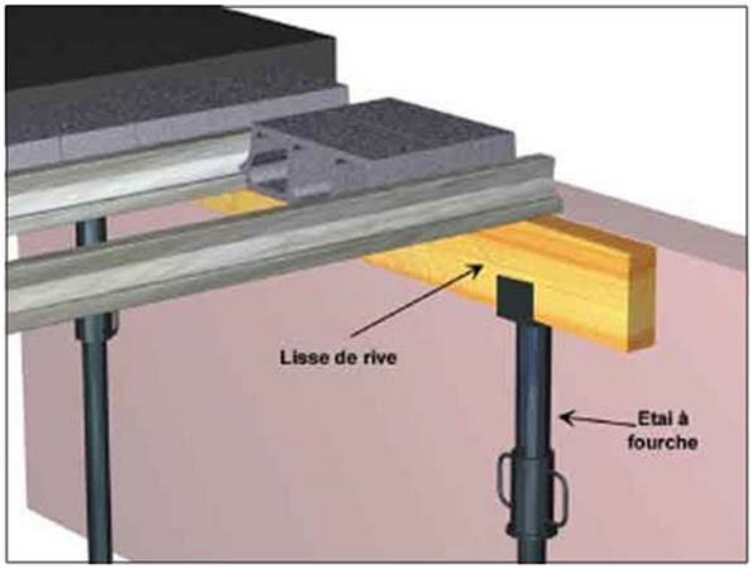


Figure - 7Layout of heights between raw slab and sub-floor

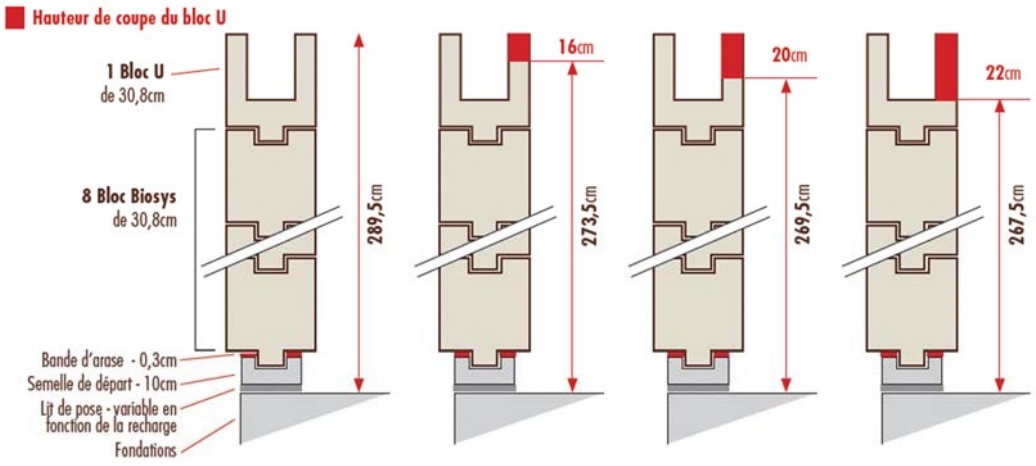


Figure - 8Principle of restarting wall on top of ground floor

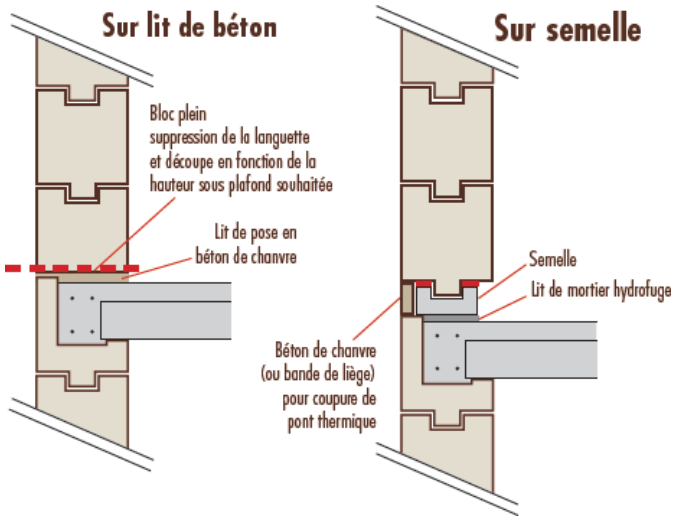


Figure - Chain-linking 9principle for gables in traditional and industrial framing

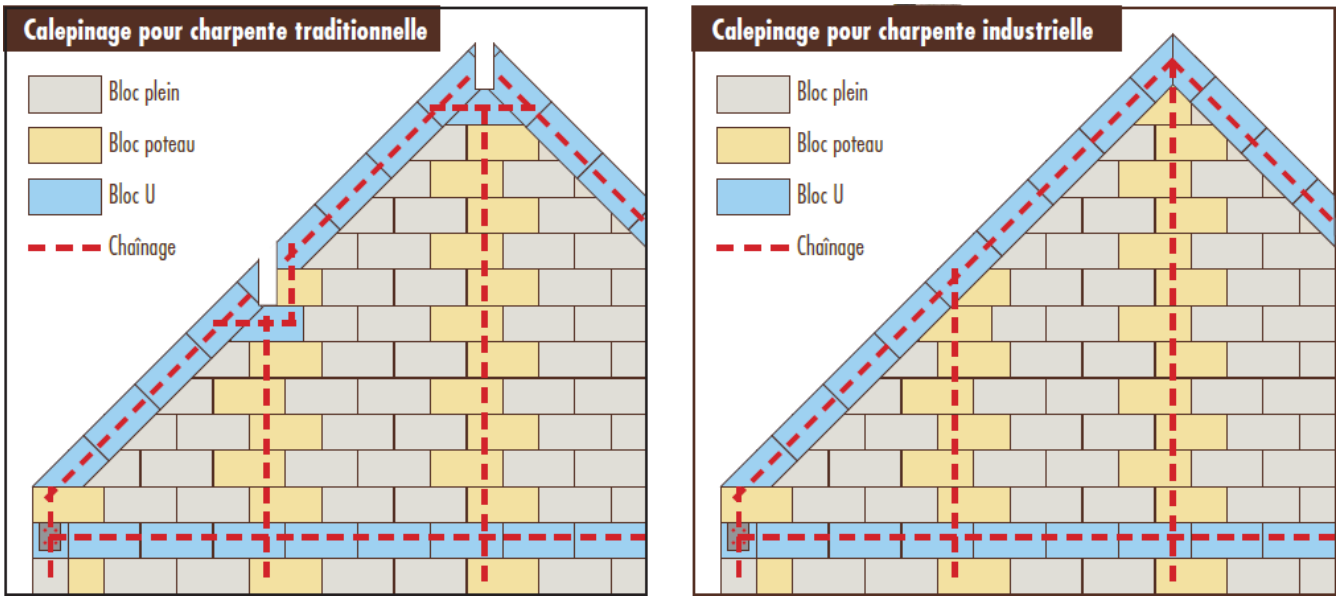


Figure - 10Principle of gable cutting, implementation of U-blocks in gable

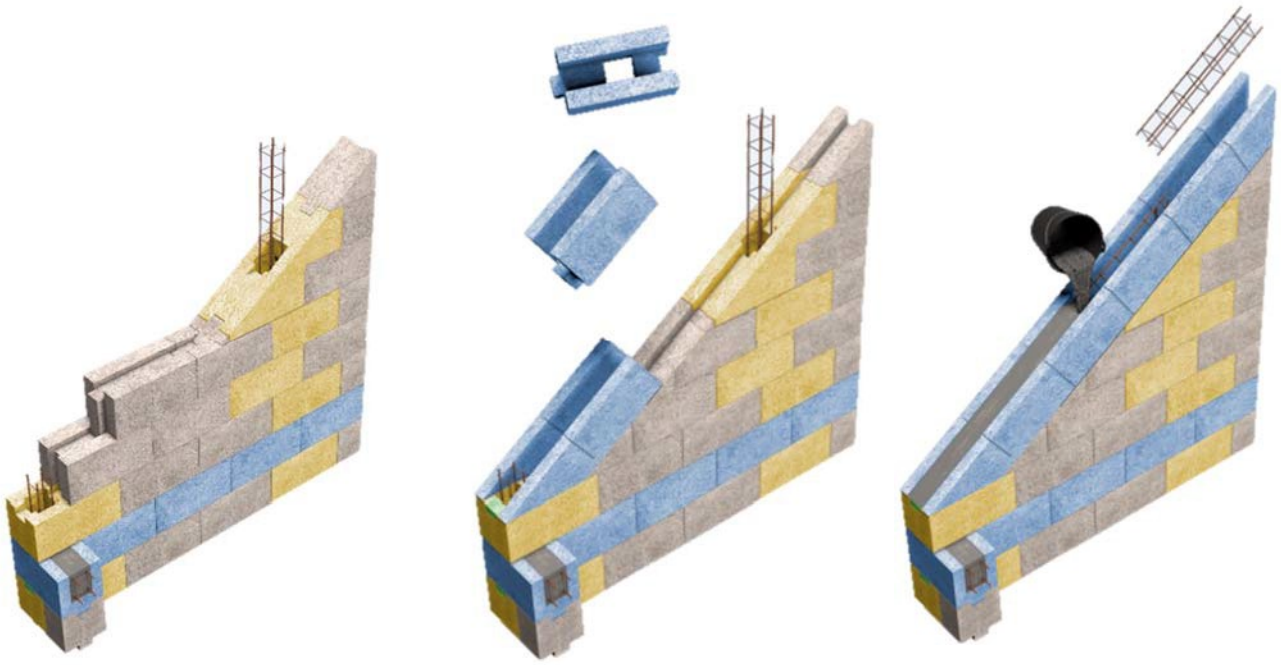


Figure -11 Schematic diagrams of rebated joinery installation

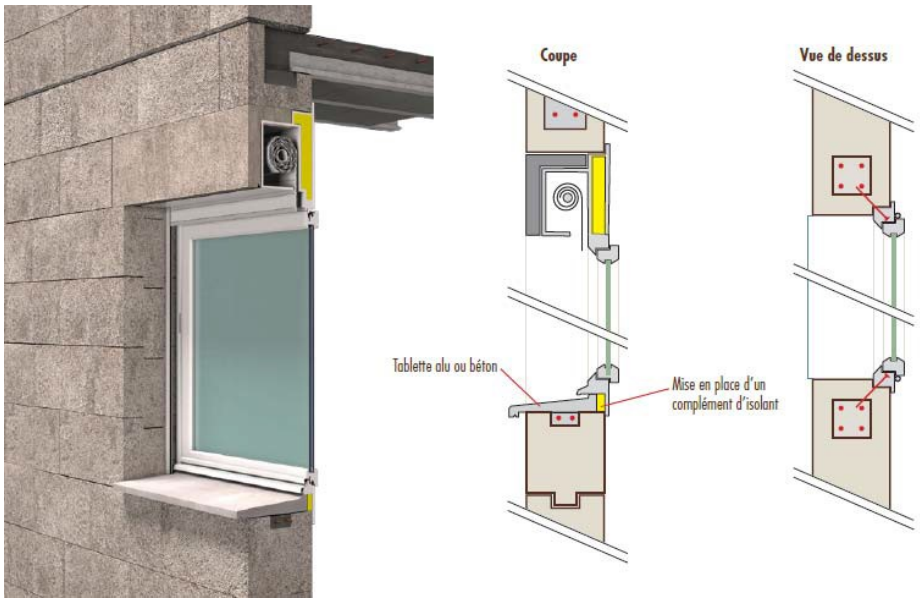


Figure -12 Schematic diagram of tunnel joinery installation

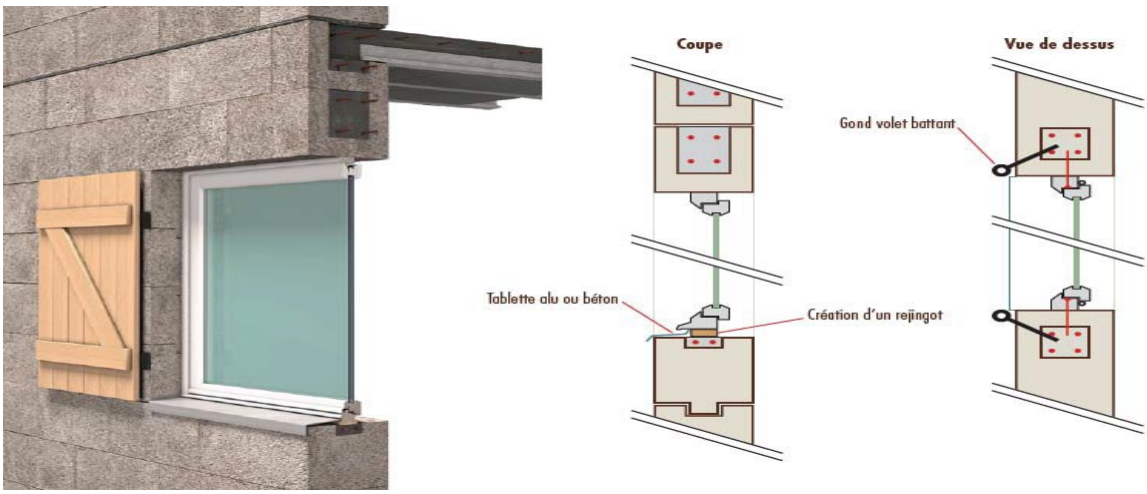


Figure13 - Principle of window sill installation

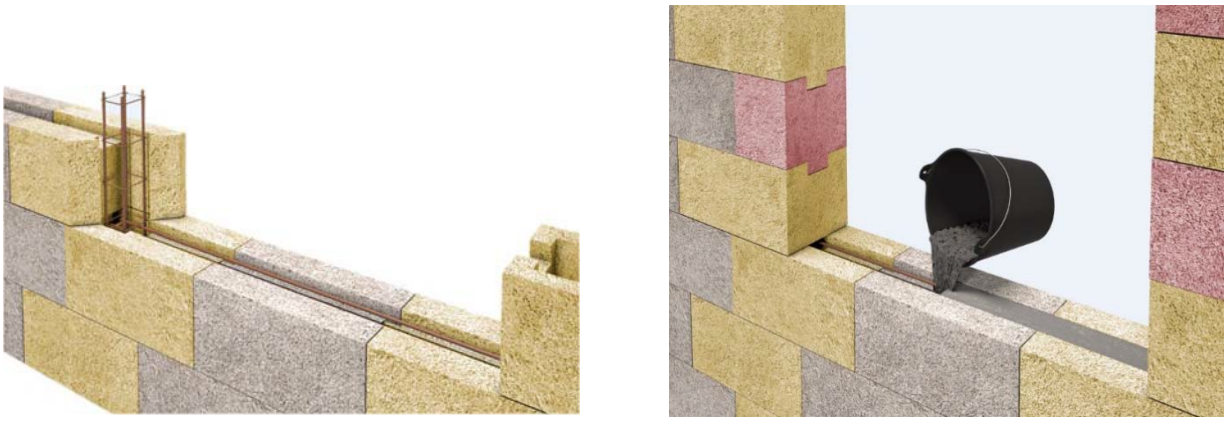


Figure14 - Principle of lintel installation

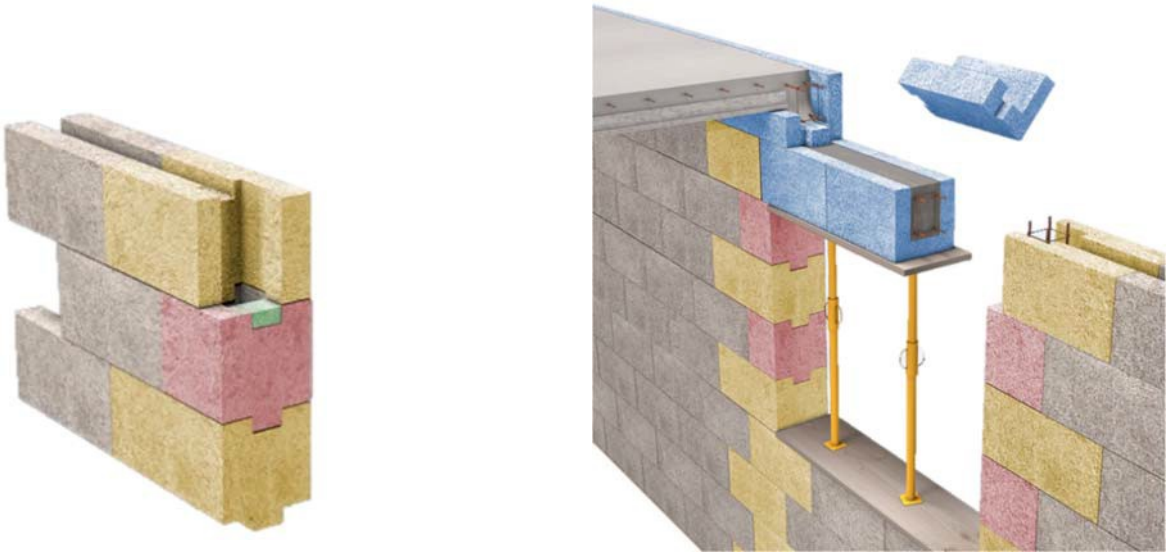


Figure15 - Installation principle for the block wall/transom wall connection

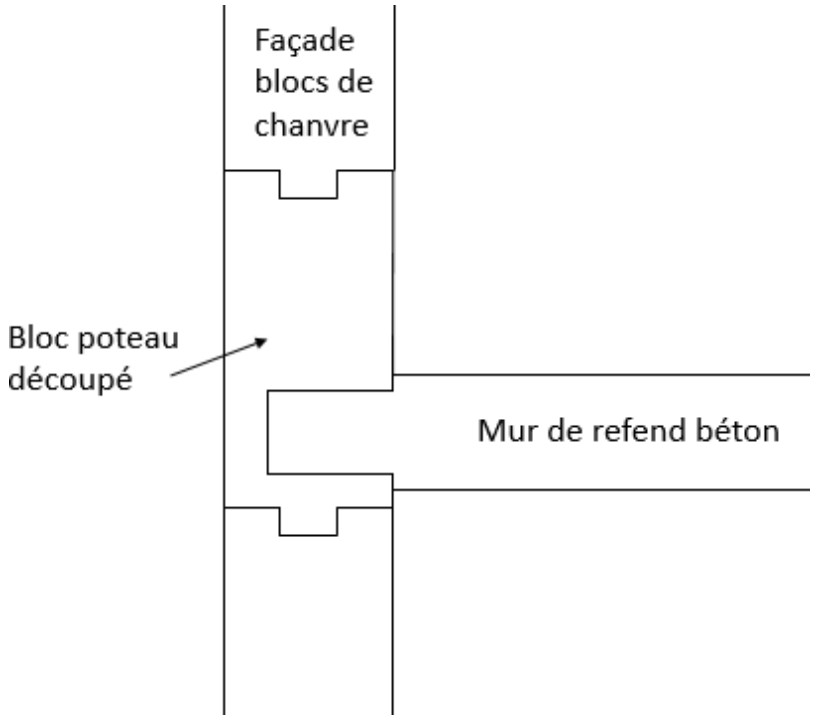


Figure16 - Example of a cladding solution for the BIOSYS process

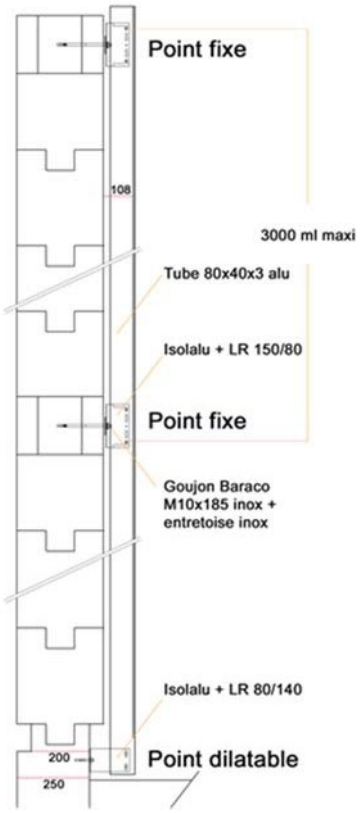


Figure17 - Integration of a physical termite barrier at the foot of the masonry