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European Technical Assessment

ETA 11/0266
of 07.09.2015

General part

Trade name of the construction product	**Compact Habit® concrete prefabricated building unit**
Product family to which the construction product belongs	Concrete prefabricated building unit
Manufacturer	**COMPACT HABIT SL** Marbusca, parcel·la 27 Polígon Industrial "La Cort" ES08261 Cardona Catalonia, Spain
Manufacturing plant(s)	Marbusca, parcel·la 27 Polígon Industrial "La Cort" ES08261 Cardona Catalonia, Spain
This European Technical Assessment contains	56 pages including 5 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) 305/2011, on the basis of	Guideline for European Technical Approval (ETAG) Nº 23 *Prefabricated building units*, Edition August 2006, used as European Assessment Document (EAD)
This European Technical Assessment replaces	European Technical Approval ETA 11/0266 with validity from 30.06.2013 to 22.01.2017

General comments

Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document.

Specific parts of the European Technical Assessment

1 Technical description of the product

1.1 Definition of the construction product

This ETA refers to the three-dimensional monolithic precast Compact Habit® building unit made of high strength concrete and optionally combined with metal members.

Compact Habit® unit is a parallelepiped whose 4 usually major faces (2 walls, structural ceiling and floor) are ribbed reinforced concrete faces, and its 2 usually minor faces at each end of the unit are open. These 2 faces, that eventually constitute the façades of the building, are shuttered with the shuttering solution designed for each project.

The maximum and minimum dimensions of the unit for a nominal or a slightly modified[1] production, as well as its weight, are specified in table 1:

Unit dimensions (mm)	Nominal production		Slightly modified production	
	Minimum	Maximum	Minimum	Maximum
Length of unit	1.000	15.000	---	16.800 [2]
Length of floor cantilever (at each end of the unit)	0	2.500	---	---
External width	3.100	5.000	3.000	5.100
Internal width	2.700	4.600	2.600	4.700
External height	3.040	3.500	3.000	---
External height with supports[3]	3.060	3.520	3.020	---
Internal height	2.640	3.100	2.600	---
Maximum span of each wall or roof and ceiling opening	0	According to the particular calculation	---	---
Approximate weight of the unit (kg/m^2)				
• With a slab 52 mm thick between ribs	640	According to the particular geometry	---	---
• With a slab 80 mm thick between ribs	900			
• With a EPS doubled slab	940			
• Weight reduction % by using lightweight concrete	10			

Table 1: Main dimensions and weight of the Compact Habit® unit.

Compact Habit® unit layout is structurally flexible. The list of possible structural solutions of the unit is shown in clause A2.1 in annex 2. Some examples of design options of the Compact Habit® unit are shown in figure 1.

[1] A slightly modified production is achieved by minor modifications of the manufacturing machinery.
[2] The increase of the length, from 15.000 mm to 16.800 mm, is only reached in units with cantilever.
[3] It is the height in service conditions (thickness of the compressed cushion + casing = 20 mm).

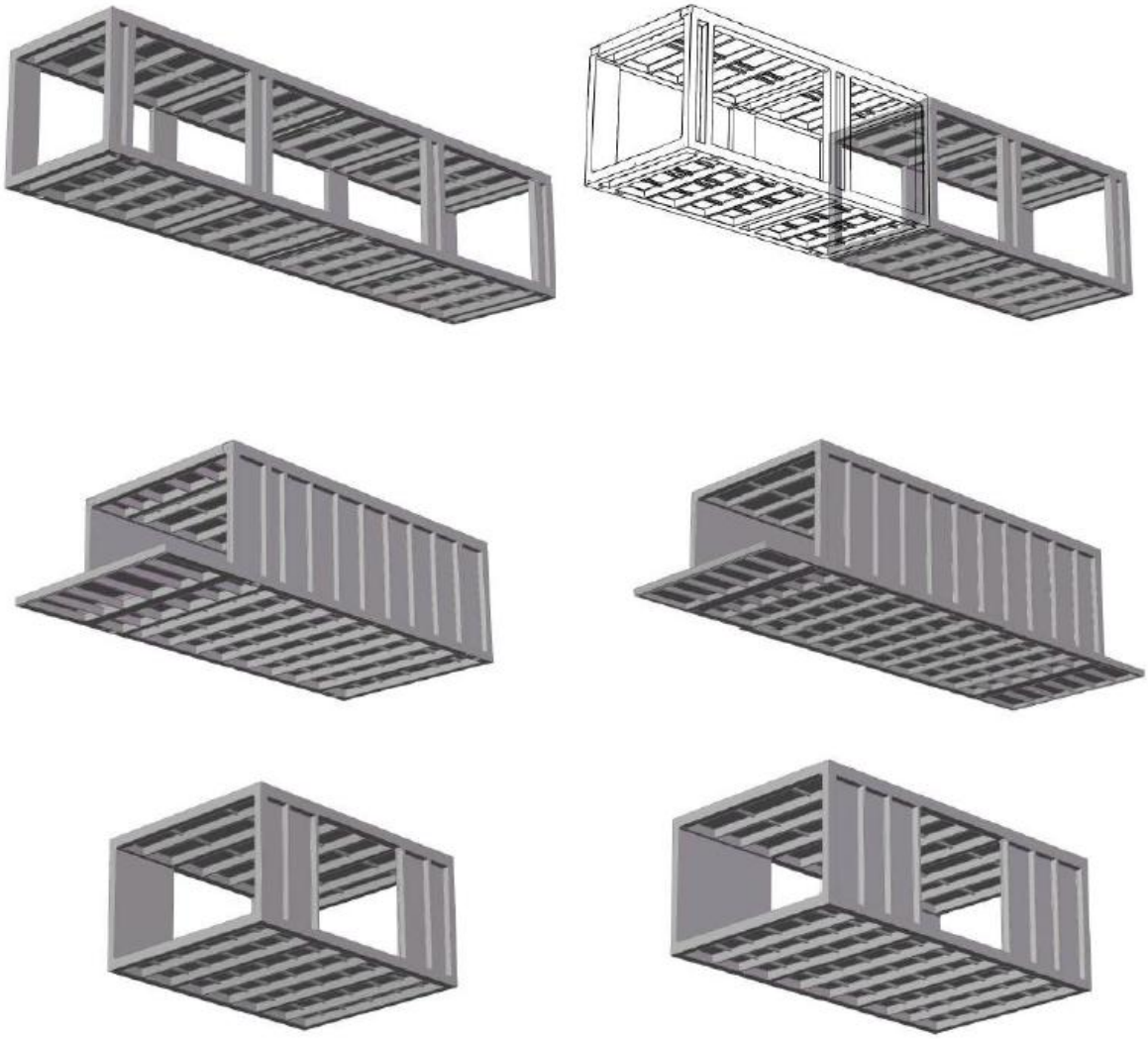


Figure 1. Examples of design options of the Compact Habit® unit.

The criteria involved in the structural design of the Compact Habit® units (list not exhaustive) are the following:

- Dimensions of the unit.
- Type and dimensions of the structural section.
- Openings in walls, floor and structural ceiling.

The structural performances of Compact Habit® units are specified in annex 3. The general methodology for structural design and verification of a building based on Compact Habit® units is shown in annex 4. The main elements of the manufacturing process of Compact Habit® units, foundation elements and relevant design and installation criteria are shown in annex 5.

Compact Habit® unit is completed with the internal linings, the external claddings, glazings and roofing, and all the set of components and finishings needed to respond to all applicable thermal, acoustical, water tightness, airtightness and fire safety requirements of each building. All these components are not part of Compact Habit® unit covered by this ETA.

Prefabricated concrete or metal stairs used to communicate the unit with the upper and lower unit are not part of the Compact Habit® covered under this ETA.

Compact Habit® unit shows the following main features:

- Structural unit.
- Self-supporting unit during transportation and execution on site; no ancillary temporary supports are needed during the construction of the building.
- Relocateable unit. The assembled building from Compact Habit® units can be disassembled in the different Compact Habit® units.
- The design of the unit does not depend on the position of the unit within the building: the unit is used in ground floor, intermediate floors or top floor, or at the end or at the center of the building. Therefore, Compact Habit® unit is classified as unit type A, B, C, D1 and D3 [4], according to classification set by ETAG 023.
- The unit shows a series of "closed" or fixed characteristics (they cannot be modified), and some other characteristics which are "open" (they can be specified in the project, within predefined ranges). In the latter case, the designer will set the value of these characteristics, taking into account all specific requirements of the building and the design criteria imposed by the use of Compact Habit® system in the project, so Compact Habit SL will manufacture the unit under these specifications. The design criteria of Compact Habit® system are detailed in the manufacturer's technical documentation and its most relevant items are summarised in clause A5.2 of annex 5 and annex 4 of ETA.

The structural design of Compact Habit® unit is based on 4 longitudinal reinforced beams at the edges of the unit, and a ribbed pattern perpendicular to them. A slab is placed between ribs. Different configurations of unit which meet these basic criteria are possible. Openings in walls, floor or ceiling are also possible, as well as cantilevers.

The dimensioning of walls, floor, ceiling and openings in all the possible configurations depends on the specific structural calculation of the unit and of the building.

The use of metal members (hot rolled products of structural steel according to EN 10025) in the Compact Habit® unit combined with the reinforced concrete main structure is optional. The metal members are normally used as columns when large openings are required according to the specific design of the unit or building.

The metal members are partially embedded in the concrete structure. They are naked (unprotected) in the non-embedded part.

The dimensioning of the composite steel and concrete structure is in accordance with EN 1994-1-1.

Thermal insulation products made of expanded polystyrene (EPS) in accordance with EN 13163 [5] can be used in walls, floor and structural ceiling. Its density and thickness can vary for each particular building project. The thermal insulation is added to the unit during its manufacturing process in the factory.

The structural sections (ribbed reinforced concrete patterns) which can conform the 4 major faces of the Compact Habit® unit are summarized in figure 2. See also annex 1 for the details on the variants of each configuration and the related reinforced beams.

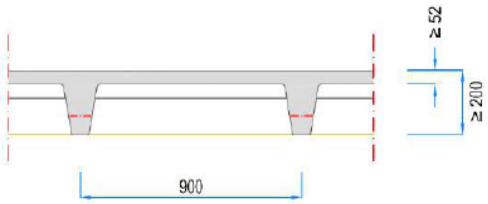
[4] The unit is not classified as D2 because it can never be a pitched unit. A pitched roof can be built with a specific roof structure laid on top storey unit.

[5] *EN 13163: Thermal insulation products for buildings. Factory made expanded polystyrene (EPS) products. Specification.*

Note: the dimensions of the drawings in this ETA are expressed in mm, except otherwise specified.

Configuration No 1: Section with trapezoidal ribs. For walls, floor and ceilings.

Inner side (floor) and outer side (ceiling)



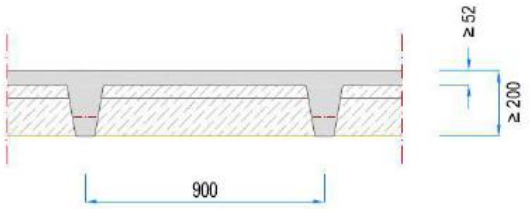
Outer side (floor) and inner side (ceiling)

Notes:

- For walls the ribs are usually in the outer side, but can also be in the inner side.
- Span ribs is usually ≤ 900 mm, but can be > 900 mm if duly justified.

Configuration No 2: Section with insulation between trapezoidal ribs. For walls, floor and ceilings.

Inner side (floor) and outer side (ceiling)



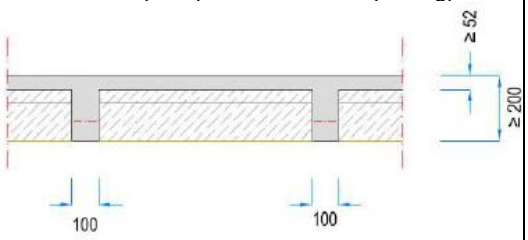
Outer side (floor) and inner side (ceiling)

Notes:

- For walls the ribs are usually in the outer side, but can also be in the inner side.
- Span ribs is usually ≤ 900 mm, but can be > 900 mm if duly justified.

Configuration No 3: Section with insulation between rectangular ribs. For walls, floor and ceilings.

Inner side (floor) and outer side (ceiling)



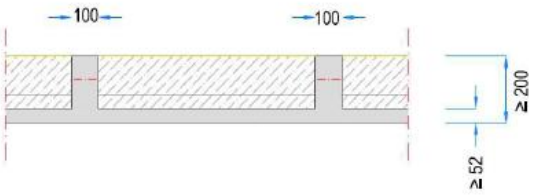
Outer side (floor) and inner side (ceiling)

Notes:

- For walls the ribs are usually in the outer side, but can also be in the inner side.
- Span ribs is usually ≤ 900 mm, but can be > 900 mm if duly justified.

Configuration No 4: Section with insulation between rectangular ribs. For ceilings.

Outer side



Inner side

Configuration No 5: Sandwich section with insulation. For walls, floor and ceilings.

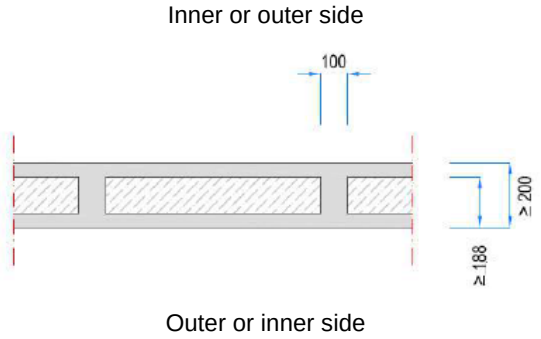


Figure 2. Structural sections of the Compact Habit® unit.

Compact Habit® unit may comprise a cantilever extension of its floor and ceiling in one or both ends of the unit, to allow for balconies in the building. This cantilever floor is mainly based on the same ribbed reinforced pattern of the unit, though its depth decreases to allow for rain evacuation. Its maximum span is specified in table 1.

Basic constitution of Compact Habit® unit using the configuration No 1 of structural section is shown in figure 3.

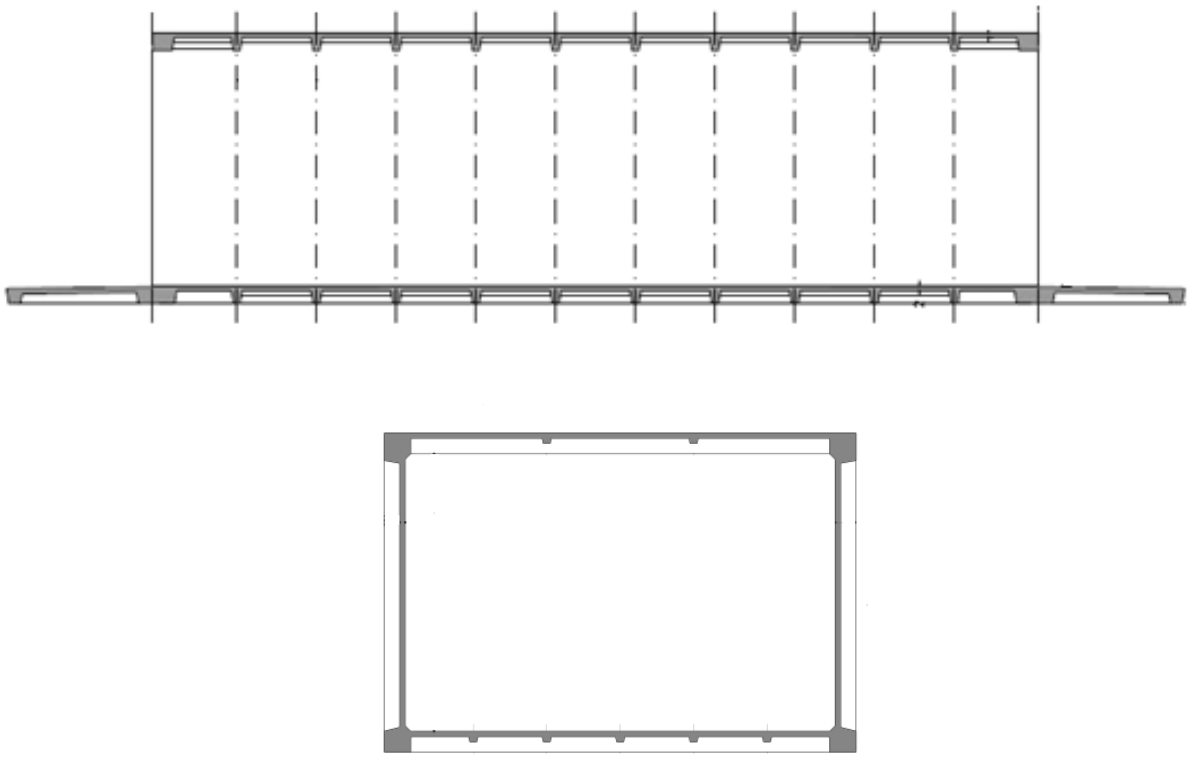


Figure 3. Side and front elevation of Compact Habit® unit.

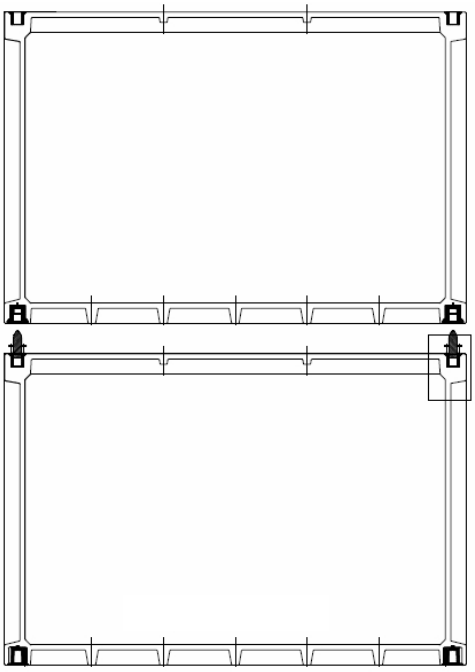
Compact Habit® unit integrates the following connection elements to adjacent units, both vertically and horizontally:

- Vertical connection between units (positioning and shear cones): the connection between a unit and its upper unit is achieved through a metal cone which penetrates on metal casings integrated both in the lower and the upper unit.

  The unit is provided with the number of positioning and shear cones required in each case, depending on the specific conditions:

  - The mechanical performances of the cone are specified in annex 3.
  - The minimum number is 2 positioning and shear cones on each floor and unit: these will necessarily be placed on opposite vertices of the unit.
  - If higher horizontal actions are foreseen in the building, the number of positioning and shear cones can be increased.
  - The cones are placed at 125 mm from the lateral edge and at least 250 mm from the transverse edge.

  The main function of these cones is to allow for the positioning of the units on top of each other and to provide the necessary vertical continuity of the building, i.e., resisting horizontal stresses acting on each storey as a result of horizontal actions (mainly wind and seismic actions).



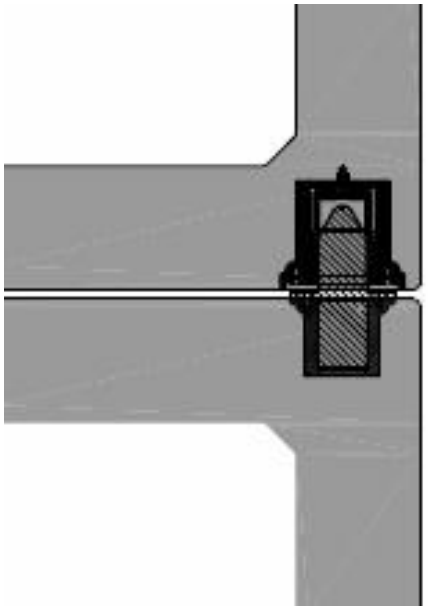
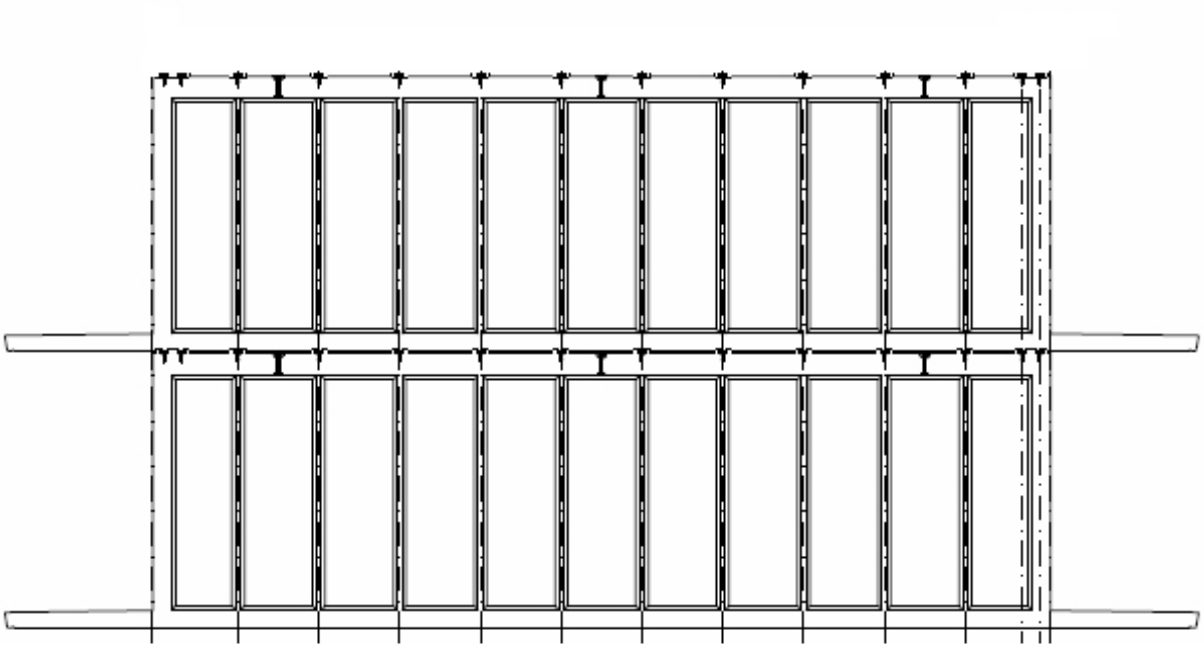
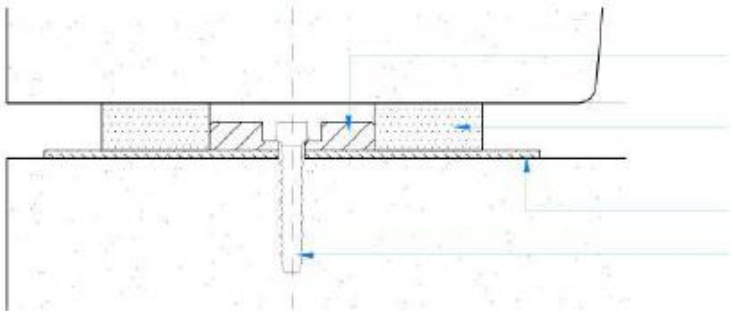


Figure 4. Vertical connection of units through positioning and shear cones.

- Vertical supports of units: vertical loads are transmitted to lower units through structural supports uniformly distributed along longitudinal perimeter beams of units. The number of supports needed in each unit diminishes with the number of units of the building above the unit.





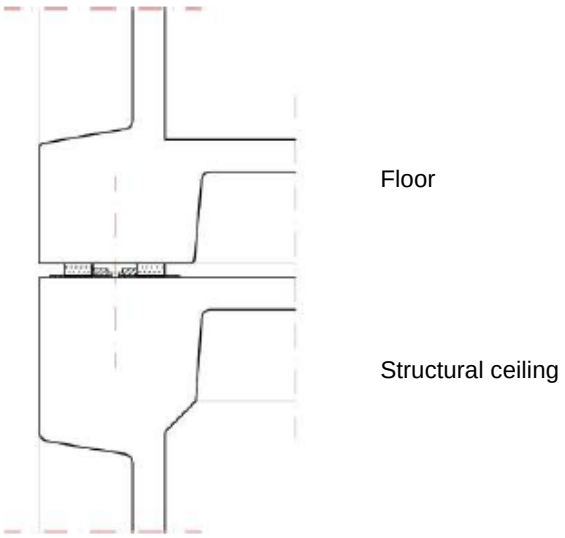


Figure 5. Vertical supports of units.

- Vertical anchorage (between units): This connection is used when vertical tensile efforts between units are expected (e.g. in some seismic situations). The connection is based on a threaded rod which is fixed to an embedded nut. This rod is hereinafter fixed with another nut.
  - It will be placed in areas with a doubled rib or in reinforced areas in front of tensile efforts, and the nearest to structural axis of walls. The area must be reinforced in front of eccentric bending and shear.
  - The anchorages in the unit can be placed symmetrically or asymmetrically as regards to any axis.

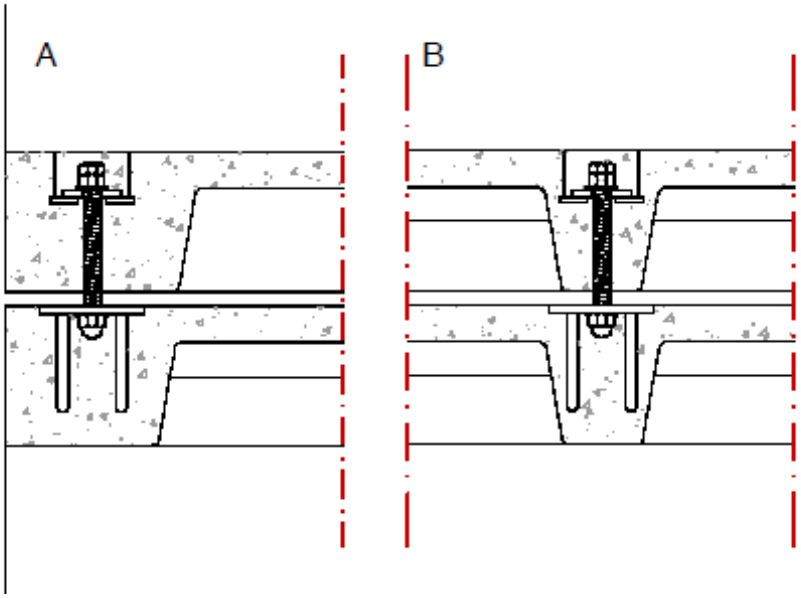


Figure 6. Longitudinal sections of vertical anchorage. Extreme and intermediate rib of the unit.

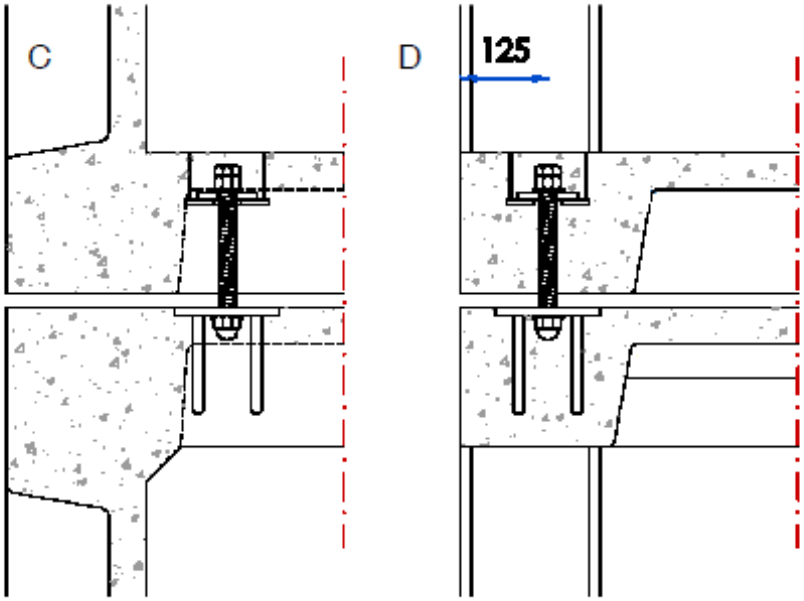


Figure 7. Transverse sections of vertical anchorage. Without openings and in the reinforced slab of an opening.

- Horizontal connection (between laterally adjacent units):

  The system offers two possible solutions for lateral connection, both based on metal bolts:

  Solution 1: connection elements encased on the top horizontal surface of the two units to be connected (see figure 8a).

  This connection is designed to act as a ball-and-socket joint thanks to the clearance in all directions between the bolt and its fixing washers, while restraining the movement in the longitudinal direction of the bolt.

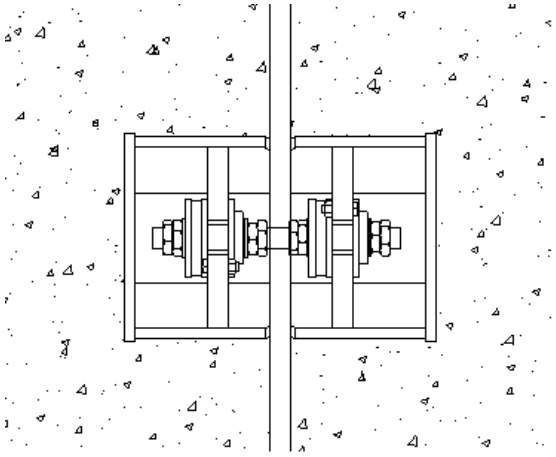


Figure 8a: Horizontal connection on structural ceiling (solution 1 of horizontal connection of units).

Solution 2: connection elements placed on the front vertical surface of the two units to be connected (see figure 8b). They are generally placed on the top vertices of the units, though they could also be placed on the lower vertices.

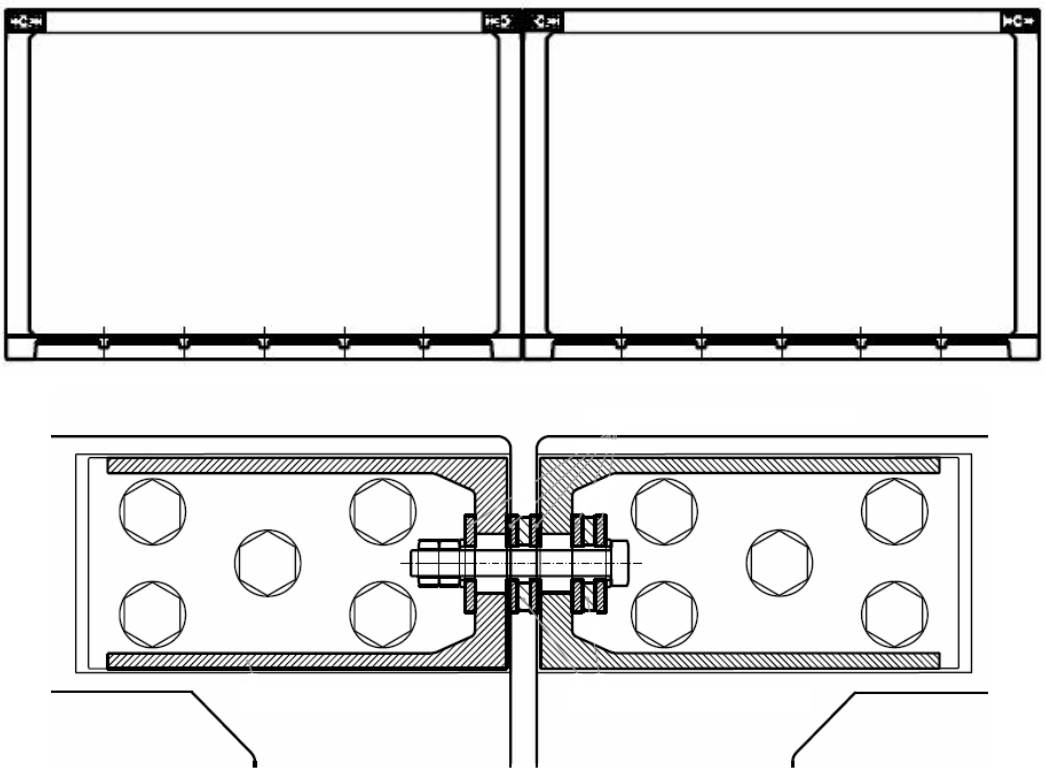


Figure 8b: Horizontal connection placed on façades
(solution 2 of horizontal connection of units).

The function of these connections is solely to create a horizontal continuity between the columns of units that compose the building, in order that these columns move unitarily in front of horizontal seismic actions, to prevent the clashing of the columns of units in the event of seismic movements of the building.

The vertical connections, the vertical supports and the horizontal connections (solution 1 and solution 2) include an intermediate elastic layer aimed at avoiding a rigid connection between units and therefore aimed to improve the acoustic insulation between units of the building.

This elastic layer consists of different structural cushions made of knitted stainless steel filaments. The thickness, dimensions and knitting density is specific of each of the 3 types of connections. The work conditions of these cushions are set through prestressing applied on the bolts in horizontal connections, and through the calculation of the number of necessary vertical supports on each storey (thus its service stress), in order that these supports work in their linear and admissible range of deformation.

These connection elements are integrated in the unit (they are installed before pouring the concrete in the manufacturing plant):

- Anchors of vertical supports: they are placed on the upper face of longitudinal beams of the unit, aligned with the ribs of the unit.
- Anchors of the plates for horizontal connections.
- Anchors of the plates and nuts for vertical connections.
- The project may require additional integrated elements in the unit, that will have to be considered in the project according to the positioning and other criteria specified for the system, and be integrated in the unit before pouring the concrete.

Finally the unit integrates the anchors for the handling and transportation of the unit:

- Anchors for handling the unit: they are placed on the upper face of longitudinal beams of the unit, at half span between the ribs of the unit (3 or 4 anchors on each longitudinal beam).
- Anchors for fixing the unit to the trailer: they are placed on the bottom of the walls of the unit, and they allow for the fixing of the unit to the trailer.

A detailed specification of all these connection elements is included in annex 2. This annex also details the specifications of structural constituent materials of Compact Habit® unit.

Full characterisation of the product and materials is included in the Manufacturer's technical dossier (MTD), a copy of which has been deposited with the ITeC.

1.2 Ancillary components of Compact Habit®: precast foundation components

The system offers three possible solutions for the execution of the foundations. The requirement for all of them is that the positioning of the vertical connection element with the first Compact Habit® unit meets the required geometric tolerances which make it possible its correct insertion.

Solution 1: foundation carried out on site

The foundation is executed on site and it includes the following components:

- Sheath and stirrups: this element is prepared at the factory and it is placed on site by embedding it on the top plane of the foundation before concreting.
- Steel case: inserted into the sheath to ensure correct positioning of the units and to ensure its proper horizontal levelling between other supporting points.

See more details in annex 2.

Solution 2: foundation beam

Compact Habit® precast foundation beams that are placed on site on top of a spread footing foundation designed specifically for each building and poured on site. These spread foundation is tied by perpendicular beams of reinforced concrete poured on site.

See more details in annex 2.

Solution 3: precast foundation

Precast foundation element, which only needs a shallow layer of concrete (10 cm aprox.) poured on site to level the soil. This foundation solution is intended to make the whole building, including foundation, removable and relocateable.

This precast foundation consists of the following components:

- Linear precast foundation: they show two variants, depending on whether they occupy a central position on the building or they are placed on its edge. Central precast foundation has a double row of connection anchors, whereas edge precast foundation has one row of connection anchors. Dimensions and reinforcements are identical in both cases (see annex 2).
- Precast ties: precast reinforced concrete ties that connect perpendicularly the linear foundation lines. They are connected to the precast foundation by means of threaded anchors.

See more details in annex 2.

2 Specification of the intended use(s) in accordance with the applicable EAD

Compact Habit® unit is intended for use in any building if the regulatory requirements are meet.

Compact Habit® units, once piled-up and connected, constitute the structure and basic layout of the building, which consists of an array of independent and interconnected units. This system permits the modularity of the building and it is conceived to achieve a good acoustic insulation performance between units.

This configuration leads to the duplication of structural and compartmentation elements between units: the unit has a structural ceiling which is independent of the floor of the unit above, the same applies to walls between contiguous units.

The structure of the building needs to be completed with all supplementary insulation systems, installations, shutterings, internal and external finishes required to meet the specific requirements of the building (thermal and acoustic insulation, watertightness, fire safety, aesthetic, etc.).

All these systems are not part of Compact Habit® unit covered by this ETA and, therefore, the properties and performances of the unit stated in this ETA refer to the naked unit plus the thermal insulation between the ribs in the structural section, which is part of the unit. Nevertheless, Compact Habit SL integrates in the production of the unit all supplementary insulation systems, installations, shutterings, internal finishes required to meet the specific requirements of each building, while the façade cladding and roofing are generally executed on site.

The maximum number of storeys from a building using Compact Habit® units is made of is determined by the structural verification of such a building. This number of storeys is normally conditioned by the horizontal actions acting on the building: in 1 column buildings the limiting criterion is generally the action of wind, whereas in 2 or more column buildings seismic actions are generally more limiting (these design criteria are developed in clause A5.2 of annex 5.

The unit constitutes the basic module for the lay-out of the building, considering its main dimensions as specified in table 1. Larger rooms within the building may be created by:

- laterally unifying 2 or more units of the same storey of the building. This unification is achieved by means of openings on the walls of each pair of units (see related criteria in clause A5.2 of annex 5),

  or by

- Providing vertical communication between contiguous units through openings in their floors and structural ceilings. Vertical communication of the building can also be achieved by means of structures that are alien to the piling of Compact Habit® units like self-supporting elevator wells or stairs structurally independent of the building structure.

Buildings based on Compact Habit® units may start on:

- Foundations: based either on Compact Habit® foundation beams on Compact Habit® precast foundation elements, or on foundation executed on site.
- Existing substructure (alien to Compact Habit® system), either subterranean or not: in this case an intermediate specific beam is needed that includes all connection elements between the existing substructure and Compact Habit® unit.

In any case the building based on Compact Habit® units needs a base surface which meets the dimensional tolerances and integrates all connection elements of Compact Habit® system.

The provisions made in this ETA are based on an assumed working life of the concrete prefabricated unit for the intended use of 50 years when installed in the works. These provisions are based upon the current state of the art and the available knowledge and experience.

The indications given as to the working life of the construction product cannot be interpreted as a guarantee, but are regarded only as a means for choosing the appropriate products in relation to the expected economically reasonable working life of the works.

The assessment of Compact-Habit system carried out according to ETAG023 refers to its use as non-dissipative structures ($q \leq 1,5$ accordingly to Eurocode 8 – EN 1998-1). In annex 3 of this ETA some specific criteria are given according to Spanish seismic regulation (NCSE-02).

3 Performance of the product and reference to the methods used for its assessment

The assessment of Compact Habit® unit for the intended use considering the basic requirements for construction works 1, 2, 3, 4, 5 and 6 was performed following the Guideline for European Technical Approval 023 for *Prefabricated building units* (edition August 2006).

As said in chapter 1.1, Compact Habit® unit shows the following variants:

- Dimensional variants, within the ranges defined in table 1.
- Design options (see figure 1 and figure A2.1).
- Structural sections (see figure 2 and annex 1).

3.1 Characteristics of the system

3.1.1 Mechanical resistance and stability (BWR 1)

The mechanical properties of the Compact Habit® units will be declared in accordance with the following methods described in Guidance Paper L[6]:

- Method 3b for structural concrete and/or steel sections, in which the producer has designed and produced those elements following the provisions of the client's order, in accordance with the National Provisions applicable to the works.
- Method 2 for vertical and horizontal connection elements, vertical supports, handling and rising elements, which consists in the determination of properties by means of the EN Eurocodes (with the results expressed as characteristic values or design values).

The input data for the producer to determine the mechanical properties of the structural concrete and/or steel sections in accordance with method 3b using Eurocode 2 [7] and Eurocode 4 [8], are

[6] *Guidance Paper L: Application and use of Eurocodes. November 2003.*

[7] *EN 1992-1-1 Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings*.

shown in annex 1 (type of structural section) and in annex 2 (characteristics of the constituent materials). The resistance of the connections between Compact Habit® units in accordance with method 2 is shown in annex 3.

The structural design and verification of the building shall be made according to the criteria shown in clause A5.2 of annex 5.

Compact Habit® unit permits the satisfactory construction of the intended building's configurations (see figure 1 and annex 2), provided that the buildings are designed and executed according to the criteria defined in the manufacturer's technical dossier, whose main elements are highlighted in this ETA.

3.1.2 Safety in case of fire (BWR 2)

3.1.2.1 Reaction to fire

The reaction to fire classification of the components of Compact Habit® system according to EN 13501-1 are specified in table 2, based on the provisions of Decision 96/603/EC[9].

Component	Classification
Reinforced concrete sections of the Compact Habit® unit:	---
• without insulation	Class A1
• with insulation between ribs	According to the reaction to fire of the type of insulation used
• with insulation in the sandwich structural sections	According to the reaction to fire of the type of insulation used
Steel member of the Compact Habit® unit	Class A1
Foundation beam	Class A1
Precast foundation	Class A1

Table 2: Reaction to fire classification of the Compact Habit® system.

Different connection elements of Compact Habit® system are wholly metal elements, so they are also classified as Class A1.

3.1.2.2 Resistance to fire

Resistance to fire of Compact Habit® unit must be determined for each unit or building design.

The three hereinafter situations are presented according to the materials the unit is made of:

a) Compact Unit exclusively made of reinforced concrete:

The resistance to fire of each specific design of Compact Habit® unit will be determined by Compact Habit SL according to Eurocode 2 rules, taking into account the cross-section geometries, tolerances and covers specified in annex 2, and the following considerations:

- Walls: to apply the criteria for columns of EN 1992-1-2[10] to the ribs of the structure. Additionally, the thickness of the flat slab can be considered for EI requirements.
- Floor and structural ceiling: to apply the criteria for reinforced ribbed slabs of EN 1992-1-2[10].

[8] *EN 1994-1-1: Eurocode 4: Design of composite steel and concrete structure. Part 1-1: General rules and rules for buildings.*

[9] Decision 96/603/EC, establishing the list of products belonging to Classes A 'No contribution to fire', modified by Decision 2000/605/EC.

[10] *EN 1992-1-2 Eurocode 2: Design of concrete structures. Part 1-2: General rules – Structural fire design.*

The resistance to fire of the naked Compact Habit® unit can reach R30 for the lower dimensions of the range. Higher resistance to fire levels can be achieved by the Compact Habit® units by increasing the section of concrete that protects the reinforcements, following the rules set by EN 1992-1-2[10].

Some configurations of structural sections for walls, floor and structural ceiling are possible: trapezoidal ribs, rectangular ribs and sandwich sections; with the ribs facing outwards or inwards, and with or without insulation (see annex 1 for details).

When selecting the internal lining of the system, the most limiting structural sections will be those in which the ribs face inwards, because the main reinforcing rebars are placed on the ribs of the structural section.

On the other hand, it is also to be noted that the fact that the units are box-like elements implies that between 2 contiguous units the separating wall or floor will always be doubled. This duplication may have an adding effect in terms of EI criterion of resistance to fire and it does not have an adding effect in terms of R criterion (the R performance of the double wall is the same as the R performance of each wall, i.e, R30).

These criteria are generic and they are to be considered and adapted to the specific conditions and requirements of each building, once the internal lining and flooring of the unit is specified in the project.

b) Compact Habit® unit made of composite steel and concrete structure:

The resistance to fire of the Compact Habit ® unit when naked and unprotected steel members are part of the concrete reinforced structure is, in general, limited to the resistance to fire of such steel members. The resistance to fire of the composite steel and concrete structure for each design of Compact Habit® unit and building is to be determined in accordance with EN 1994-1-2[11].

c) Compact Habit® unit with a fire protective rendering:

A rendering for fire resistant applications (TECWOOL F® of TECRESA Proteccion Pasiva SL which benefits of the ETA 11/0185) can be used. The rendering is spray applied to the exterior surface of the concrete units.

The exterior surface of the Compact Habit® unit is protected from the exterior environmental conditions. Therefore, the intended use categories of the protective rendering correspond with the types Z_1 or Z_2 in accordance with ETAG 018-3: *Fire protective products. Part 3: Renderings and Rendering kits intended for fire resisting applications*.

The resistance to fire of the Compact Habit® unit with a fire protective rendering is determined by the combination of the concrete structural sections performance and the fire protective rendering performance for each design of unit and building.

In all these three situations mentioned above (exclusively reinforced concrete, composite steel and concrete structure, and fire protective rendering) the connections between Compact Habit® units (both the anchoring elements and the connection elements) are always embedded in a thick block of reinforced concrete (main perimetral beams of the unit), that protects these elements from a fire coming from the interior of the building. The concrete cover can exceed that of reinforcing elements so resistance to fire class R30 or higher (under specific verification) can be achieved from the point of view of connection between units.

3.1.2.3 External fire performance

The external fire performance of Compact Habit® unit has not been assessed, since the unit is never the outmost external layer of the envelope of the building.

[11] *EN 1994-1-2 Eurocode 4: Design of composite steel and concrete structures. Part 1-2: General Rules. Structural fire design.*

The façade cladding and roofing selected for each building will have to meet the applicable external fire requirements of such building.

3.1.2.4 Fire compartmentation

Fire compartmentation of Compact Habit® unit has not been assessed. The elements of the unit that eventually may act as fire compartmentation of the building are the walls of the unit (double wall resulting from considering the walls of each of the adjacent units) and the floors of the unit (structural ceiling + floor), including all internal lining and flooring specified in each particular project.

3.1.3 Hygiene, health and environment (BWR 3)

3.1.3.1 Vapour permeability and moisture resistance

The hygrothermal properties of the constituent materials of Compact Habit® units are specified below:

- Reinforced concrete (EN 12524):
  - Design thermal conductivity: 2,50 W/m·K
  - Water vapour diffusion resistance factor μ: 130 (dry), 80 (wet)
- Steel members (EN 12524):
  - Design thermal conductivity: 50 W/m·K
  - Water vapour diffusion resistance factor μ: ∞
- Insulation: the thermal conductivity and the water vapour diffusion resistance factor are taken from the DoP (Declaration of Performance) of the insulation.
- Fire protective rendering (ETA 11/0185): the thermal conductivity and the water vapour diffusion resistance factor are taken from the DoP (Declaration of Performance).

The hygrothermal behaviour of the building based on Compact Habit® units strongly depends on the hygrothermal properties of internal linings and external claddings of the building, that are alien to Compact Habit® unit. The project will have to verify the hygrothermal behaviour (surface and interstitial condensation), considering indoor and outdoor ambient conditions.

This verification will have to consider the following conditions, that are specific of a building based on Compact Habit® units:

- The configuration of the structural section to be used (see annex 1), the orientation of the ribs (facing inwards or outwards) in ribbed faces, as well as the existence or not of insulation in these sections.

  The thickness of the insulation in the structural sections will be defined according to each project, and generally it will correspond with the thickness of the ribs.

- The following air cavities can be formed, whose dimensions will be in accordance with the dimensions of the structural section:

  Exterior face of the unit:

  - Between two contiguous units, in the vertical direction of heat flux (one or two ribbed faces without insulation).
  - Between two contiguous units, in the horizontal direction of heat flux (one or two ribbed faces without insulation).

- Between the external cladding of the building and the external ribbed outwards face of the wall of the unit: low ventilated air chamber[12].

Interior face of the unit:

- Between the internal suspended ceiling and the lower ribbed inwards face of the structural ceiling of the unit.

- The building can be finished with internal floorings, wall linings and ceilings, and an external façade cladding depending on each particular building project.

3.1.3.2 Watertightness (internal and external finishings)

The watertightness of Compact Habit® unit has not been assessed, since the unit is never the outmost external layer of the façade or the roof of the building, and it is neither the internal finishing layer and, therefore, the unit does not bear this watertightness function.

The façade cladding, the roofing and the internal finishings selected for each building will have to meet the applicable watertightness requirements of such a building.

3.1.3.3 Content and/or release of dangerous substances

The content and/or release of dangerous substances of Compact Habit® unit has not been assessed.

According to the manufacturer's declaration, Compact Habit® unit fulfils current Spanish regulations in the field of dangerous substances.

In addition to the specific clauses relating to dangerous substances contained in this ETA, there may be other requirements applicable to the products falling within its scope. In order to meet the provisions of the EU Construction Products Regulation, these requirements need also to be complied with, when and where they apply.

3.1.4 Safety in use (BWR 4)

3.1.4.1 Slipperiness of floor finishes

The slipperiness of floorings of Compact Habit® unit has not been assessed, since the flooring solutions are alien to Compact Habit® unit.

The flooring solution selected for each works will have to meet the applicable slipperiness requirements.

3.1.4.2 Falling due to changes in level or sudden drops

The floor of Compact Habit® shows no changes in level, except when a lower level is required in order to provide the installation of auxiliary elements, for instance: a shower tray.

The flooring solution selected for each works will have to meet the applicable continuity requirements.

The prefabricated concrete or metal stairs providing the vertical communication between units throughout the openings in floor and structural ceilings are not part of the Compact Habit® unit.

3.1.4.3 Resistance to eccentric loads, including impact resistance

The resistance to eccentric loads and impacts of Compact Habit® units is satisfactory for the intended uses.

[12] The level of ventilation will eventually depend on the design of the external cladding and the dimensions of the structural section.

The internal wall lining solutions selected for each building will have to meet the applicable requirements of resistance to eccentric loads and impact loads, which will generally depend on the use of the building.

The fixing of suspended loads on the building shall observe the following criteria:

- Fixings from inside the unit: light loads will be fixed on the internal finishings, according to the specific fixing criteria defined by the supplier, while heavier loads can be fixed from the unit, provided that the fixing does not interfere with main structural reinforcements.
- Fixings from outside the unit (façade and roofing): these fixings can only be anchored on vertical and horizontal perimeter beams of the unit.

The allowed positions, distances and depths for mechanical or chemical fixings in accordance with the type of structural section of the unit, is detailed in the technical dossier of the manufacturer, and it is supplied as part of the instructions.

3.1.5 Protection against noise (BWR 5)

3.1.5.1 Airborne sound insulation

The airborne sound insulation of Compact Habit® unit has not been assessed.

3.1.5.2 Impact sound insulation

The impact sound insulation of Compact Habit® unit has not assessed.

When assessing the acoustical behaviour of a building based on Compact Habit® units, the following specific conditions of Compact Habit® system should be taken into account:

- The unit is a monolithic (continuous) tridimensional unit (it shows no joints) except for its openings.
- The separation wall and floors between two contiguous units are always duplicated, both in the vertical and horizontal direction of the building. On the contrary, the shuttering consists of a single leaf when the unit occupies the perimeter of the building.
- The connections between units, both vertically and horizontally, integrate different deformable layers, intended to prevent a rigid connection between units and, therefore, to improve the acoustic insulation between the units.

The acoustic performance (airborne and impact sound insulation) of the building will always be complemented and dependant on the finishing solutions adopted in the project.

3.1.5.3 Sound absorption

The sound absorption of the internal surfaces of Compact Habit® unit has not been assessed, because the unit has always internal finishings which are not part of the unit's specification. These internal finishings must be specified in the project to meet the applicable sound absorption requirements.

3.1.6 Energy economy and heat retention (BWR 6)

3.1.6.1 Thermal resistance

Thermal insulation performances of walls, floor and structural ceiling of Compact Habit® unit and of the building made of units, shall be calculated according to EN ISO 6946 [13] for each specific project. The thermal insulation mainly depends on the type of structural section used, the thermal conductivities (see clause 3.1.3.1) and the following criteria:

[13] *EN ISO 6946: Building components and building elements. Thermal resistance and thermal transmittance. Calculation method (ISO 6946).*

- Type of structural sections (see annex 1): ribs shape and distance, orientation of the ribs (facing inwards or outwards), air chambers, span ribs, thickness of concrete between ribs, insulation, etc.
- Internal and external surface resistances.
- Special attention must be paid to the air chambers (dimensions, air flow direction, etc.).
- The combination of concrete sections, metal members and insulations can create thermal bridges in the Compact Habit® unit. Metal anchorages for the connection of units are inserted in corner beams of the units, which consist of a thick section of concrete and, therefore, these anchorages do not act as thermal bridges.
- Thermal resistance of the unit is to be completed with the thermal resistance of the internal lining and external cladding which will be specified in the project.

3.1.6.2 Air permeability

The air permeability of blind parts of Compact Habit® unit is null, since it is a and jointless unit.

The air permeability of the finished Compact Habit® unit will depend on the glazing system (and its sealing to the unit) that will be adopted in each project to close the openings of the buildings.

3.1.6.3 Thermal inertia

The characteristics of Compact Habit® unit related to the calculation of the thermal inertia of the building are shown hereinafter:

- Surface mass (kg/m^2): to be calculated in each building project in accordance with the type of structural sections to be used.
- Specific heat capacity (kJ/kg·K):
  - Reinforced concrete: 1,0
  - Steel member: 0,45
- Thermal resistance of walls, structural ceiling and floor: to be calculated in each building project in accordance with the type of structural sections used (see clause 3.1.6.1).

3.1.7 Durability, serviceability and identification

3.1.7.1 Durability

The assessment of the durability of Compact Habit® units distinguishes between precast elements (units and foundation elements) and metal members partially embedded in concrete elements.

- Precast elements: the assessment is based on the methodology of Eurocode 2, taking into account the following characteristics of the system:
  - Concrete cover of precast elements, c_{min} (see annex 2).
  - Factory production control, referred to this concrete cover, $\Delta c_{dev} = 0$ (see annex 2).
  - Water/cement ratio of concrete (≤ 0,48), CEM I cement.
  - High strength concrete (C50/60).
  - High content of cement in concrete (≥ 275 kg/m^3).
  - Slab geometry of cantilever elements. This condition can only be applied to balcony slabs, while all other structural elements of the system are considered as linear.
  - Assessment is carried out considering concrete unit without any type of rendering or cladding. The actual service conditions of the unit are that the unit is always sheltered by internal linings (floors, walls and ceilings) and external claddings.

Considering all previous conditions, precast elements of Compact Habit® unit can be used for structural class S4 and up to exposure class XC4, for an assumed working life as defined in section 2 of ETA. Special attention must be paid to ensure these classifications in the front of cantilevers.

As for Compact Habit foundation elements:

- Solution 1: the vertical nominal cover of the reinforcement is 40 mm. The horizontal cover is given by the design of the foundation.
- Solution 2 and 3: their nominal cover (c = 35 mm) is in general not sufficient when the element is in direct contact with soil. In such cases project specific protection measures should be considered, as it is stated in clause A5.2 of annex 5 of ETA.

- Metal members embedded in concrete elements: the assessment is based on the methodology of Eurocode 3 and Eurocode 4, taking into account the following:
  - It is not necessary to apply a protective treatment to the steel members in front of corrosion to structures in interior environment in which the relative humidity does not reach 80 %. Otherwise, the protective treatment against corrosion according to the relevant part of EN ISO 12944[14] shall be applied.

    The application methods of the protective treatments in the manufacturing plant are in accordance with EN 1090-2[15].

3.1.7.2 Serviceability

When the building based on Compact Habit® units is designed following the criteria defined in clause A5.2 of annex 5 and taking the structural properties of the system as specified in clause 3.1.1, the deformation of the structural elements of the building meet the values given below:

Deformation condition	Value
Sway deformation	height/250
Floor and structural ceiling deformations (L= span)	
- Instantaneous (imposed load)	≤ L/360
- Final (instantaneous + long term deformations due to permanent loads)	≤ L/300
Deformation of lintels (L'=span of lintel)	≤ min (L'/360,10 mm)

Table 3: Maximum deformations of Compact Habit® unit (SLS).

Additionally, the following criteria must be taken into account:

- Attention should be paid to avoid damages in the concrete during its pouring in the cast due to efforts applied to the steel member by consecutive pouring steps. In order to avoid them, the connection between steel and concrete will not be submitted to deformation until the concrete resistance reaches at least 20 N/mm^2.
- The building structures carried out with Compact Habit® units are not submitted to fatigue actions since: they do not support elevator loads; wind load do not produce vibrations; and the pedestrian traffic do not produce oscillations.

[14] *EN ISO 12944: Paints and varnishes. Corrosion protection of steel structures by protection paint systems.*

[15] *EN 1090-2: Execution of steel structures and aluminium structures. Part 2: Technical requirements for steel structures.*

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

According to the Decision 2003/728 of the European Commission[16], system 1 of AVCP (see EC delegated regulation (EU) No 568/2014 amending Annex V to Regulation (EU) 305/2011) applies to Compact Habit® unit.

5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD

All the necessary technical details for the implementation of the AVCP system are laid down in the *Control Plan* deposited with the ITeC[17] and the factory production control shall be in accordance with it (the Control Plan specifies the type and frequency of checks/tests conducted during production and on the final product).

Products not manufactured by the manufacturer of the unit shall also be controlled according to the Control Plan.

Where materials/components are not manufactured and tested by the supplier in accordance with agreed methods, then they shall be subject to suitable checks/tests by the kit manufacturer before acceptance.

Any change in the manufacturing procedure which may affect the properties of the product shall be notified and the necessary type-testing revised according to the *Control Plan.*

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by the Catalonia Institute of Construction Technology.

Institut de Tecnologia de la Construcció de Catalunya

Ferran Bermejo Nualart

Technical Director, ITeC

[16] *2003/728/EC - Commission Decision of 3 October 2003, published in the Official Journal of the European Union (OJEU) L 262of 14/10/2003.*

[17] The *Control Plan* is a confidential part of the ETA and only handed over to the notified certification body involved in the assessment and verification of constancy of performance.

ANNEX 1: Details of structural sections (ribbed patterns and slabs)

A1.1 Configuration No 1: structural section with trapezoidal ribs

This structural section applies to walls, floor and structural ceiling. In walls, the ribs can face inwards or outwards. The span between ribs is usually lower than 900 mm, but can be higher to 900 mm if it is justified in the structural calculations.

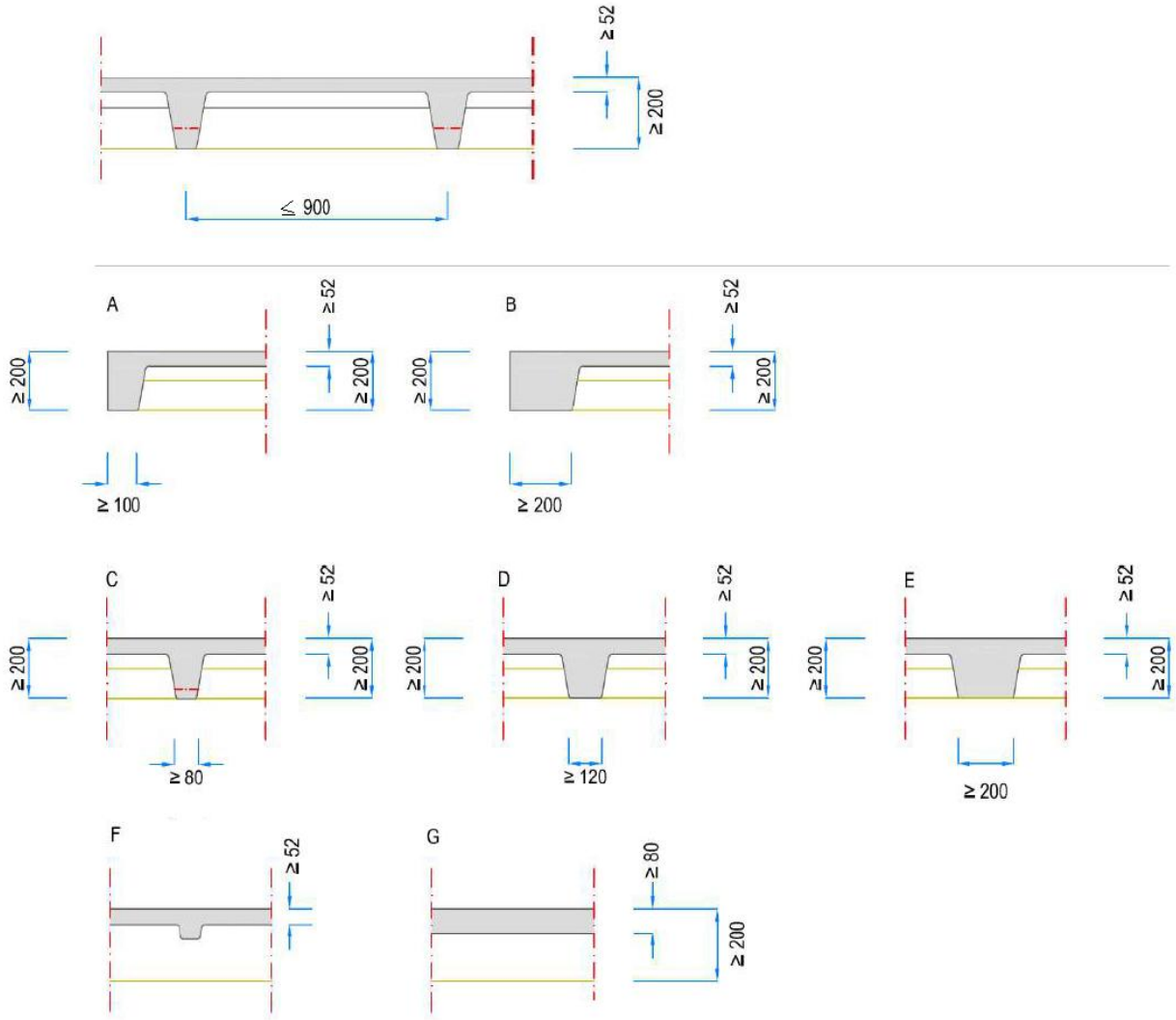


Figure A1.1: Structural section with trapezoidal ribs.

A1.2 Configuration No 2: structural section with insulation between trapezoidal ribs

This structural section applies to walls, floor and structural ceiling. In walls, the ribs can face inwards or outwards. The span between ribs is usually lower than 900 mm, but can be higher to 900 mm if it is justified in the structural calculations.

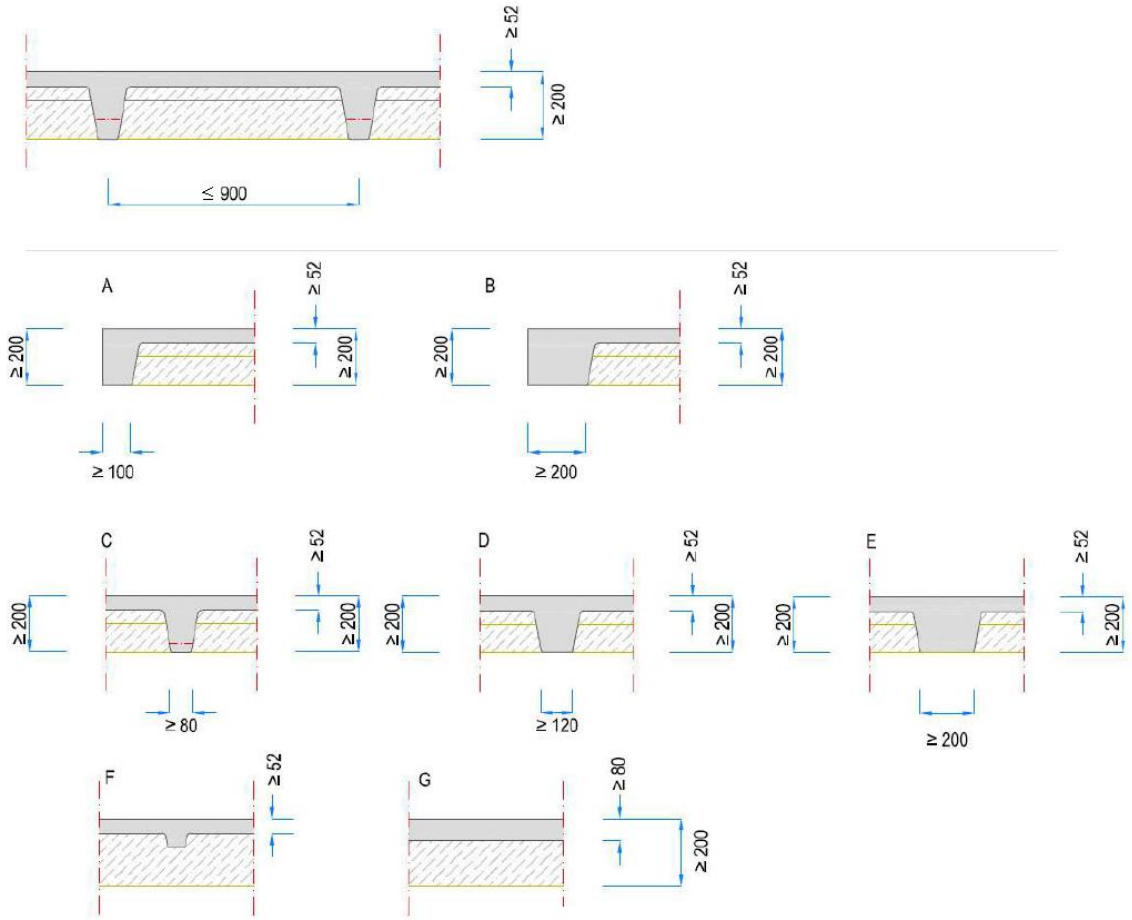


Figure A1.2: Structural section with insulation between trapezoidal ribs.

A1.3 Configuration No 3: structural section with insulation between rectangular ribs

This structural section applies to walls, floor and structural ceiling. In walls, the ribs can face inwards or outwards. The span between ribs is usually lower than 900 mm, but can be higher to 900 mm if it is justified in the structural calculations.

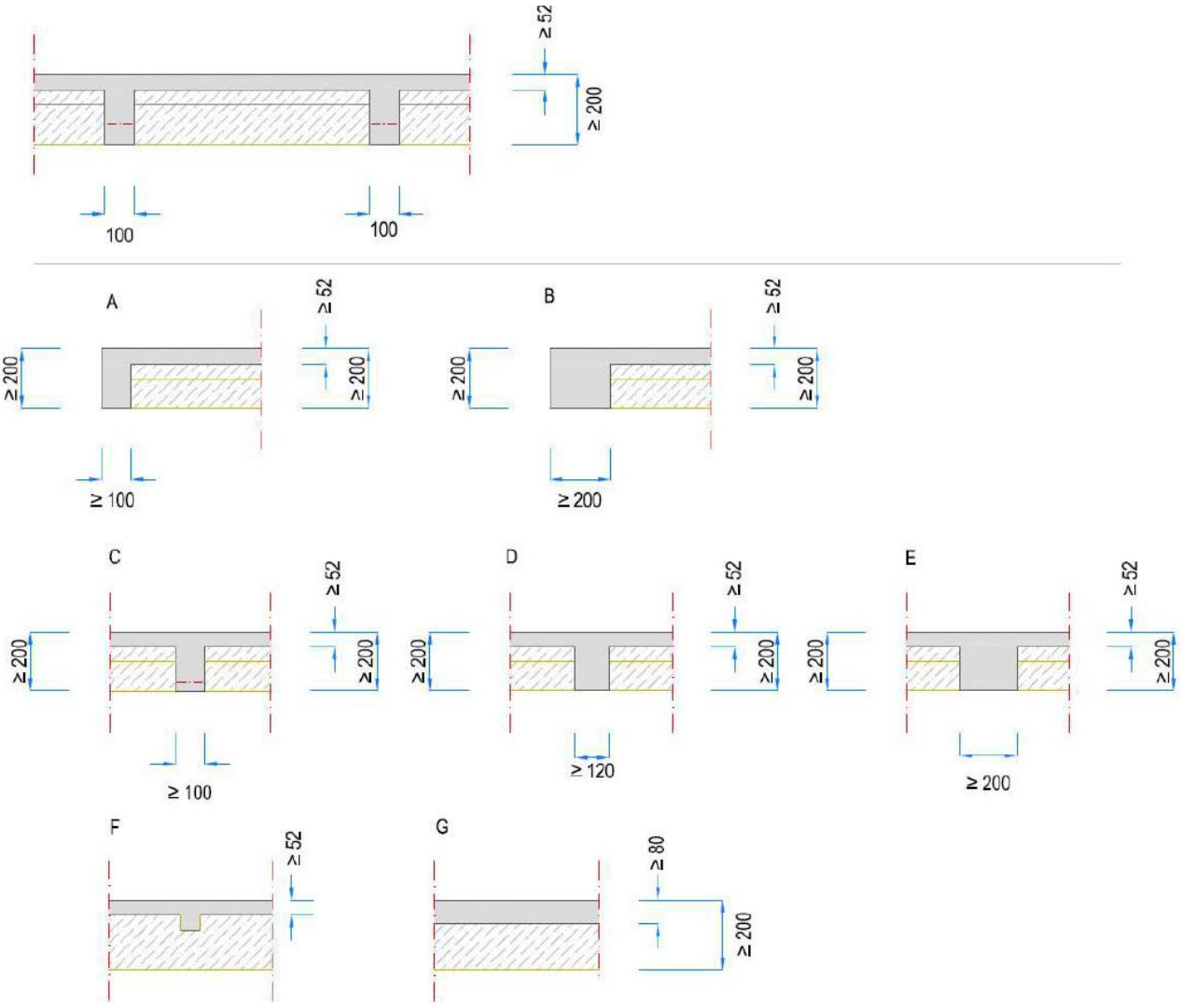


Figure A1.3: Structural section with insulation between rectangular ribs.

A1.4 Configuration No 4: structural section with insulation between rectangular ribs facing outwards in structural ceilings

This structural section applies to structural ceiling with ribs facing outwards. The span between ribs is usually lower than 900 mm, but can be higher to 900 mm if it is justified in the structural calculations.

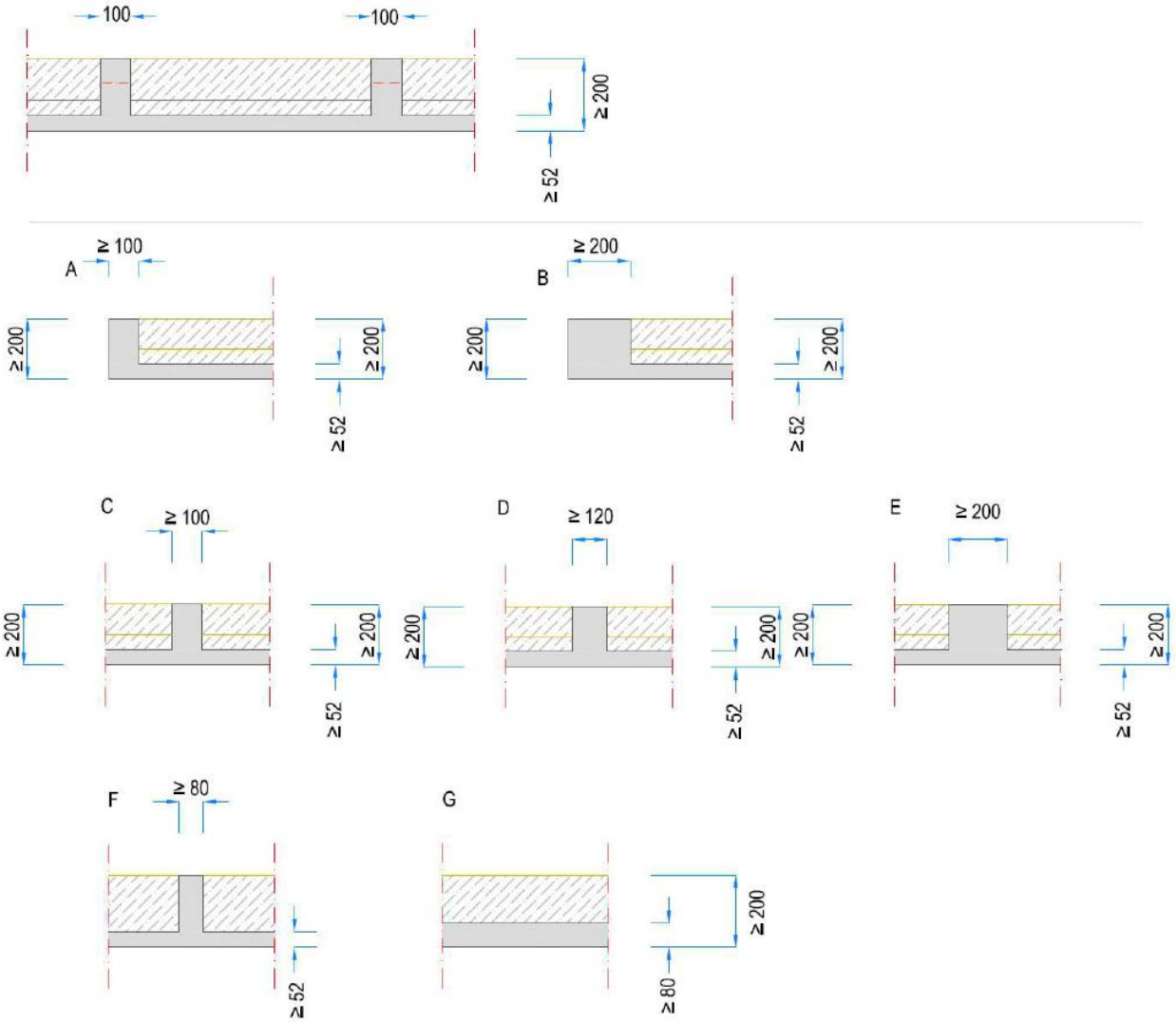


Figure A1.4: Structural section with insulation between rectangular ribs facing outwards in structural ceiling.

A1.5 Configuration No 5: Sandwich structural section with insulation

This structural section applies to walls, floor and structural ceiling. The span between ribs is usually lower than 900 mm, but can be higher to 900 mm if it is justified in the structural calculations.

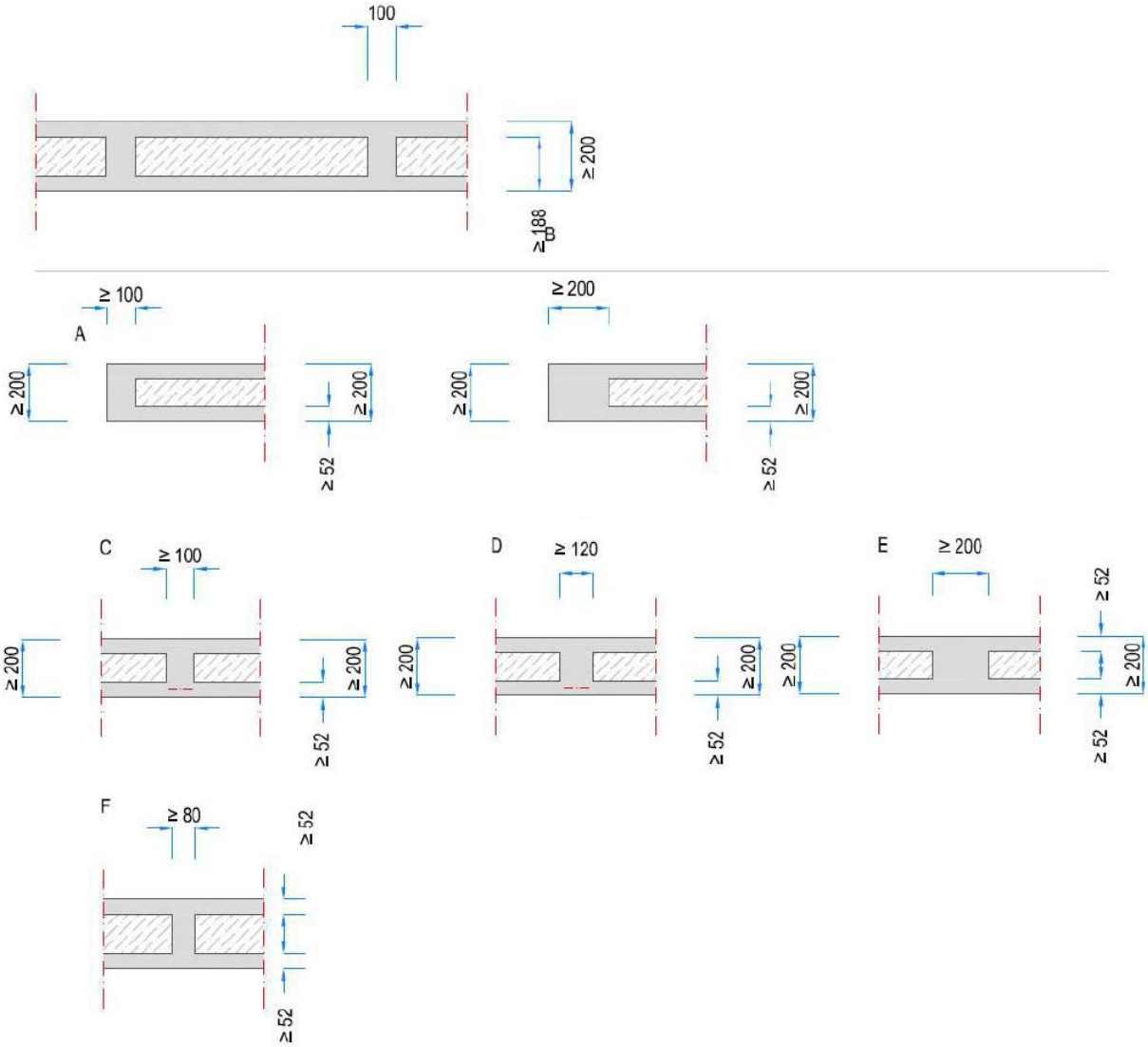


Figure A1.5: Sandwich structural section with insulation.

ANNEX 2: Description of Compact Habit® unit

A2.1 Possible structural solutions of Compact Habit® units

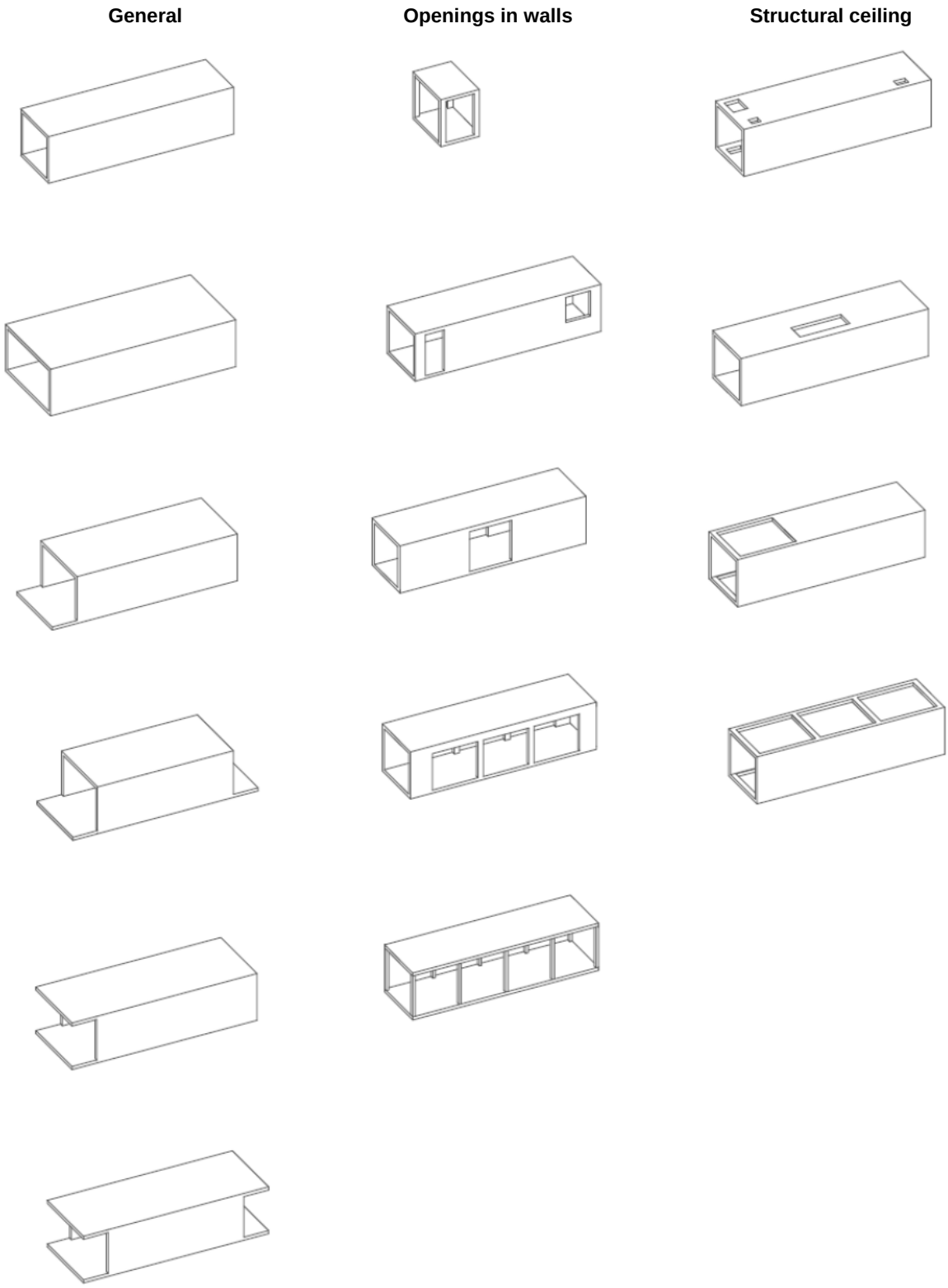


Figure A2.1: Possible structural solutions of Compact Habit® unit.

A2.2 Characteristics of constituent materials of the Compact Habit® units

Compact Habit® unit is made of the following basic materials:

- High resistance self-compacting concrete C50/60 (f_{ck} ≥ 50 N/mm^2) conforming to EN206-9 [18].
- Weldable steel reinforcement bars B500S (f_y ≥ 500 N/mm^2), typically ∅ (6, 8, 10, 12, 16 mm).
- Weldable steel mesh B500T (f_y ≥ 500 N/mm^2) ∅ 5 mm.
- Different anchoring and connection elements (see clauses A2.5A2.7 of this annex 2):
  - Positioning cones (vertical connection between units).
  - Vertical supports between units.
  - Horizontal connection plates between contiguous units.
  - Vertical connection between contiguous units.
  - Anchors for handling the unit.
  - Anchors for fixing the unit to the trailer.
- Stainless steel knitted cushions of different thicknesses, dimensions and mesh densities, which constitute the elastic layer integrated in the 3 types of connections between units (see clause A2.6 of this annex 2).

A2.3 Characteristics of the Compact Habit® units

The main dimensions and characteristics of Compact Habit® unit are shown in table 1.

Table A2.1 included below shows the main relevant tolerances of the unit[19], related with the achievement of a correct dimensional coordination of the building based on Compact Habit® units.

Property	Property of the unit	Value	Tolerance
Main dimensions of the unit (mm)	Length	≤ 16.800	± 10
	Cantilever length (in both sides of the unit)	≤ 2.500	± 10
	Exterior width	≤ 5.100	± 5
	Interior width	≤ 4.700	± 10
	Exterior height	≤ 3.500	± 6
	Exterior height with supports	≤ 3.520	± 6
	Interior height	≤ 3.100	± 10
Unit geometry (mm)	Levelling of supporting surfaces[20]	on 3.600	± 3
	Orthogonality of the faces of the units. Orthogonal levelling. Non alignment of perimeter	--	± 10
	Linearity of the faces	on 10.000	± 6

[18] EN 206-9 *Concrete Part 9: Additional rules of self-compacting concrete (SCC).*

[19] The whole set of tolerances to control the production of the unit are specified in the *Control Plan of Compact Habit®.*

[20] The system includes the possibility of correction on-site of this levelling, if needed, by means of metal plates up to a maximum correction of 10 mm.

Property	Property of the unit	Value	Tolerance
Opening's dimensions (mm)	Width of the openings on front and rear façades of unit	on 1.000	± 2
	Height of the openings on front and rear façades of unit	on 1.000	± 2
	Width of the openings in lateral walls of the unit	on 1.000	± 2
	Height of the openings in lateral walls of the unit	on 1.000	± 2
Positioning of the connection elements (junction between units and handling elements) (mm)	Positioning and shear cones (horizontal position)	--	± 1,0
	Positioning and shear cones (vertical position)	--	± 6
	Vertical supports between units (horizontal position)	--	± 8
	Vertical supports between units (vertical position), in 3.600 mm	--	± 2,5
	Elements of lateral connection between units[21] (vertical and horizontal position)	--	± 10
	Handling elements (horizontal position)	--	± 10
Concrete covers of reinforcement (mm), c_{min}	Unit (interior conditions)	20	Δc = - 0 + 5 [22]
	Unit (exterior conditions)	30	Δc = - 0 + 5

Table A2.1: Dimensional tolerances of the Compact Habit® unit.

A2.4 Characteristics of Compact Habit® foundation elements

A2.4.1 Solution 1: Compact Habit® foundation carried out on site

The connection between the foundation and the building is done by means of the following components:

- Sheath & stirrups:
  - Sheath: it is made of steel and it has a diameter of 200 mm, 150 mm or 125 mm, in accordance with the results of the calculation. It is embedded in the foundation after concreting and it has sufficient clearance to allow for the exact positioning of the connection element.
  - Stirrups: 4 stirrups welded on the sheath surface placed in two levels (at 40 mm and 95 mm from the upper surface), steel B500S and Ø 8 mm, 325 x 205 mm; they act as the anchoring and reinforcement of the foundation connection points.

  The sheath & stirrups element is placed at an angle of 45º as regards the direction of the foundation element.

[21] The system considers the following possibilities to regulate the position of horizontal connection plates on site, if needed:
- In vertical direction (z): ± 10 mm
- In horizontal direction following the plane of the façade (x): ± 10 mm
- In horizontal direction perpendicular to the façade (y): ± 10 mm

This regulation capacity is valid both for solution 1 and solution 2 of horizontal connection.

[22] These tolerances result from the tolerance of the height of the reinforcement element and the tolerance of its positioning into the mould. The value Δc = - 0 requires the application of a high level of production control.

When the reinforcements are not subject to requirements on the value of its covers, the tolerances of these reinforcements are ± 10 mm.

- Metallic case: piece of steel S275JR 5 mm thick, consisting of a ∅ 90 mm and 125 mm cylinder that will receive the shear connection cone having an upper plate ∅ 250 mm with 4 perforations that allow for the passage of the fixing mortar. This case is inserted into the sheath after concreting and its meant to allow the correct positioning of the connection with the unit (with the required positioning tolerances of the system) and the proper horizontal levelling with other supporting points.
- Filling material: high strength mortar (30 N/mm^2 at 24h, 74 N/mm^2 at 28 days) without shrinkage, to fill the volume between the metallic case and the sheath.

The reinforcement of the foundation at the vertical connection points will be designed case by case considering the geometry of the foundations, type of concrete, etc.

A2.4.2 Foundation Solution 2: Compact Habit® foundation beams

Precast beam with the same length as the unit, width of 550 mm / 600 mm and height of 350 mm. Folded stirrups are unfolded on site so they hang from its lower face and they allow for the connection of the beam to the foundation cast on site (these unfolded stirrups also act as a provisional support of the beam during the concreting of the foundation).

The function of this beam is to permit the connection of Compact Habit® building to its foundation, which is dimensioned for each project. The upper face of these beams has all characteristics needed for connecting the unit to it: a flat horizontal surface and all system's integrated elements of connection.

The beam of foundation integrates the following connection elements:

- Anchors of vertical supports (same anchor used in the units).
- Cylindrical case for inserting the positioning and shear cones (same anchor used in the units).
- Handling anchors; the service tensile load of each anchor is 50 kN.
- Anchors with an M16 thread, that are used to suspend the beam during installation in order to control the correct levelling of its upper face within the specified tolerances.

This beam shows two variants:

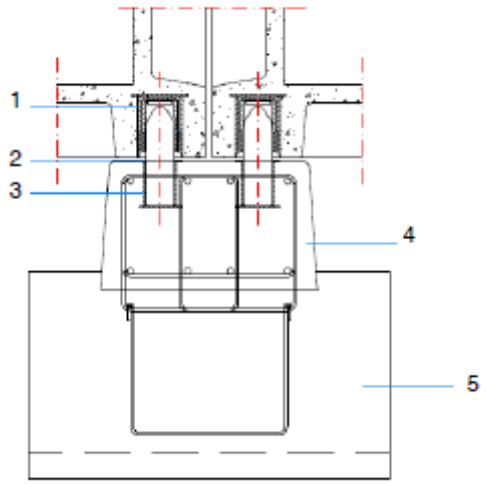
- *Double foundation beam,* used in a central row of the foundation: this beam shows a double set of integrated connections, one for each of the 2 units that will be connected to it.
- *Single foundation beam,* used in the edges of the foundation: it shows a single set of integrated connections, as only one unit will be connected to it.

Thus these two variants only differ to each other on the number of integrated connections (single or double).

The foundation of the building will require transverse connections between spread footing foundation lines: both elements will get their reinforcements properly tied up before concreting.

Standard dimensions of transverse elements are: width = 400 mm, height = 500 mm (+ 70 mm layer of concrete for soil preparation purposes).

Note: dimensions are expressed in mm in all figures in this document.



1. Cylinder embedded in the unit to be connected
2. Cone
3. Lower case
4. Beam
5. Foundation in situ

Figure A2.2: Detail of the connection between Compact Habit® foundation beam and in-situ foundation element.

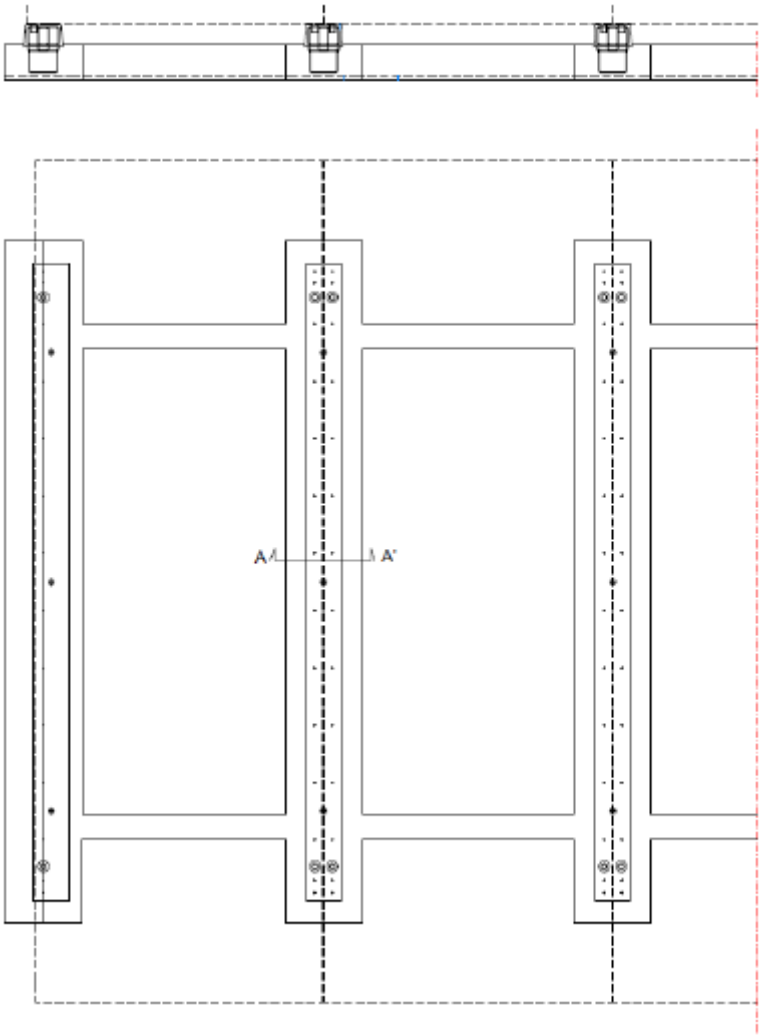


Figure A2.3: General view of a building foundation based on Compact Habit® foundation beams.

A2.4.3 Solution 3: Compact Habit® precast foundation elements

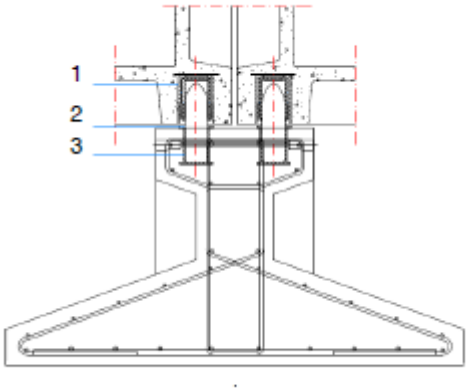
Unlike foundation beams previously described, precast foundation elements are foreseen and manufactured to be the foundation of the building, as well as to permit the connection of the units by integrating all required connection elements on its upper surface.

Precast foundation elements include the two following factory precast elements:

- Precast foundation beam: beam with inverted T cross-section, with standard dimensions of height = 821 mm, base width = 1.600 mm (this base width varies depending on the mechanical properties of the soil) and width = 550 mm (support width of unit).

  This beam also shows two variants: central foundation beam or edge of foundation beam. The difference between these 2 variants is again the double or single line of integrated connection elements to the unit.

  All anchoring, connection and handling elements are the same as in the unit. Handling anchors are dimensioned according to the mass of each beam.
- Transverse precast elements: they connect perpendicularly all foundation beams, width = 400 mm, height = 500 mm and length = 3.840 mm (it depends on the width of the unit). These elements are fixed to the web of foundation beams thanks to threaded connections.



1. Cylinder embedded in the unit to be connected
2. Cone
3. Lower case

Figure A2.4: Vertical cross-section of Compact Habit® precast foundation elements.

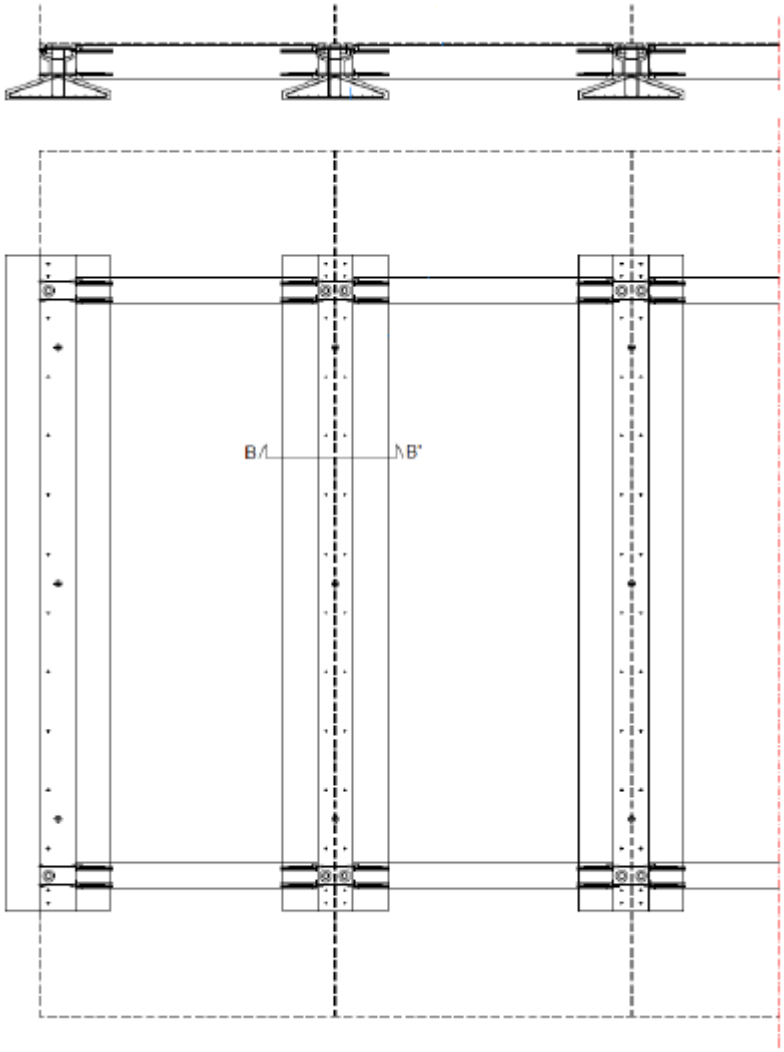


Figure A2.5: General view of a building foundation based on Compact Habit® precast foundation elements.

A2.5 Characteristics of connection and handling elements of units

A2.5.1 Positioning and shear cones for vertical connection between units

Vertical connection between two units is achieved through a trunk-conical element inserted into a metal housing integrated in the lower unit and into a metal housing integrated in the upper unit.

The components of this connection are as follows:

- Trunk-conical connecting element (positioning and shear cone): steel trunk-conical element (made of steel S275 JR) rectified to ∅ 78 mm with a conical upper end and rounded tip, length = 262 mm.

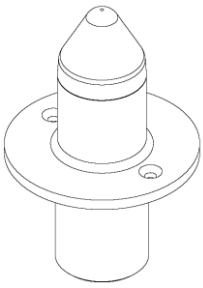


Figure A2.6: Positioning and shear cone.

- Lower cone casing integrated into lower unit: cylindrical casing made of made of steel S275 JR according to EN10025 [23] rectified to $\varnothing_{int}$ 82 mm, $\varnothing_{ext}$ 95 mm and 125 mm depth.
- Upper cone casing integrated into upper unit: double cylindrical casing made of steel S275 JR rectified to the following main dimensions: outer cylinder ($\varnothing_{int}$ 112 mm and length = 171 mm), inner cylinder ($\varnothing_{int}$ 80 mm and length = 154 mm).

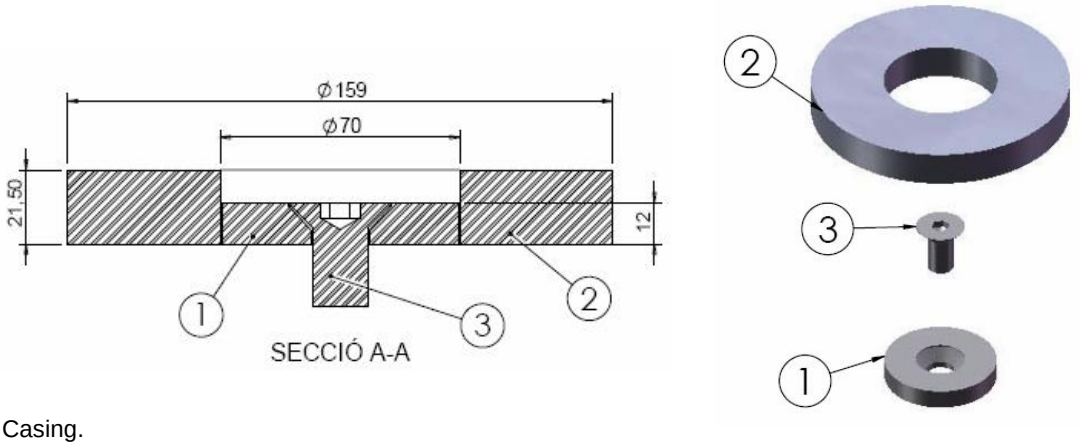
  Between inner and outer cylinder of upper cone casing, 6 cushions are inserted all along the perimeter (see tables A2.2 and A2.3).

The function of these cones, besides allowing the correct positioning and piling of units during the execution of the building, is to resist shear stresses between consecutive storeys of the building, mostly caused by wind and seismic actions.

A2.5.2 Vertical supports between units

Units are supported on unit underneath by means of point supports distributed all along the 2 longitudinal beams of the top floor of this underneath unit.

These supporting elements consists of an elastic cushion ring shaped placed on steel casing (S275JR) rectified to $\varnothing_{ext}$ 69 mm and thickness = 12 mm, which is fixed to the upper face of lower unit by means of a threaded anchor M16.



1 Casing.
2 *Metal cushion.*
3 Fixing screw.

Figure A2.7: Support element between units (casing + cushion).

[23] EN10025 *Hot rolled products of structural steels - Part 1: General technical delivery conditions.*

Supports transmit vertical loads between units. Its distribution along the unit looks for maximum homogeneity of distribution of loads in each storey. Although these supports partly contribute to shear resistance of the vertical connection between units, this contribution is neglected in the structural analysis of the building.

A2.5.3 Horizontal connection plates between laterally contiguous units

The units are laterally connected by means of one of the following solutions.

Solution 1: Horizontal connection plates on top horizontal surface

This connection consists of the following components:

- Connection plate (200 mm x 130 mm): curved plate (thickness 12 mm) welded to one back plate (10 mm) and one front plate (20 mm). All of them are made of steel S275JR.
- High resistance M20-10.9 bolt that connects the front plates of each unit.
- Cushion (see tables A2.2 and A2.3), fixed in the front plate by means of the screw and washers.

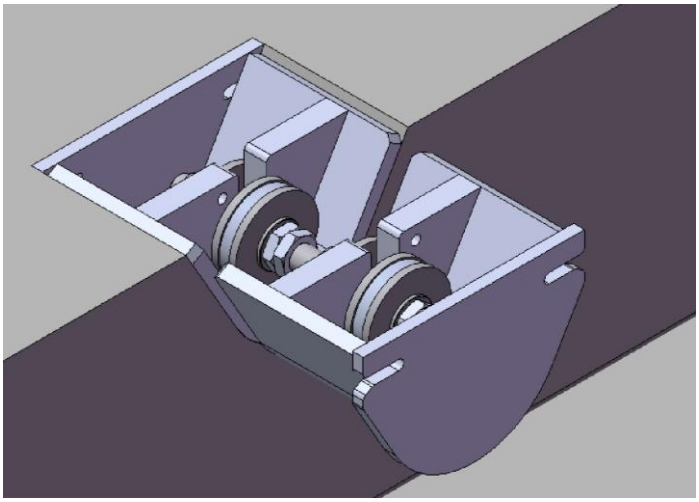


Figure A2.8: Horizontal connection placed on top horizontal surface of the units (solution 1).

Each connection plate is fixed to its concrete unit by means of the following system:

- The supporting plates are integrated in the unit before pouring the concrete.
- The supporting plates are anchored during manufacture into the concrete unit by means of 5 reinforcing bars welded into the plate (2 ∅8 mm, 2 ∅12 mm and 1 ∅16 mm).

The connection bolt (bolt, washers, etc.) is supplied by Compact Habit SL as a pre-assembled kit (the pre-assembly is done in the factory).

The number of such connections between two adjacent units is specified case by case depending on the specific seismic requirements of the building. The positioning of the connections along the unit obeys to the following general principles:

- As a minimum, one connection at each end of the unit.
- Placed at > 300 mm and < 2.000 mm from the corner.
- Minimum distance between two connections is 900 mm.

Note: all dimensions expressed from the axis of the connection.

Solution 2: Horizontal connection plates placed in façade

This connection consists of the following components:

- Connection plate: element made of cast iron EN-GJS-600-3 (EN-JS1060), 327 mm x 164 mm plate with 3 perimetral welded corbels. The plate has 5 holes to fix it to the metal plate integrated in the unit (where each hole has some capacity to adjust the relative position of the 2 units).
- High resistance M20-10.9 bolt that connects the plates of each unit.
- Cushion (see tables A.2.2 and A2.3), inserted between the 2 plates.

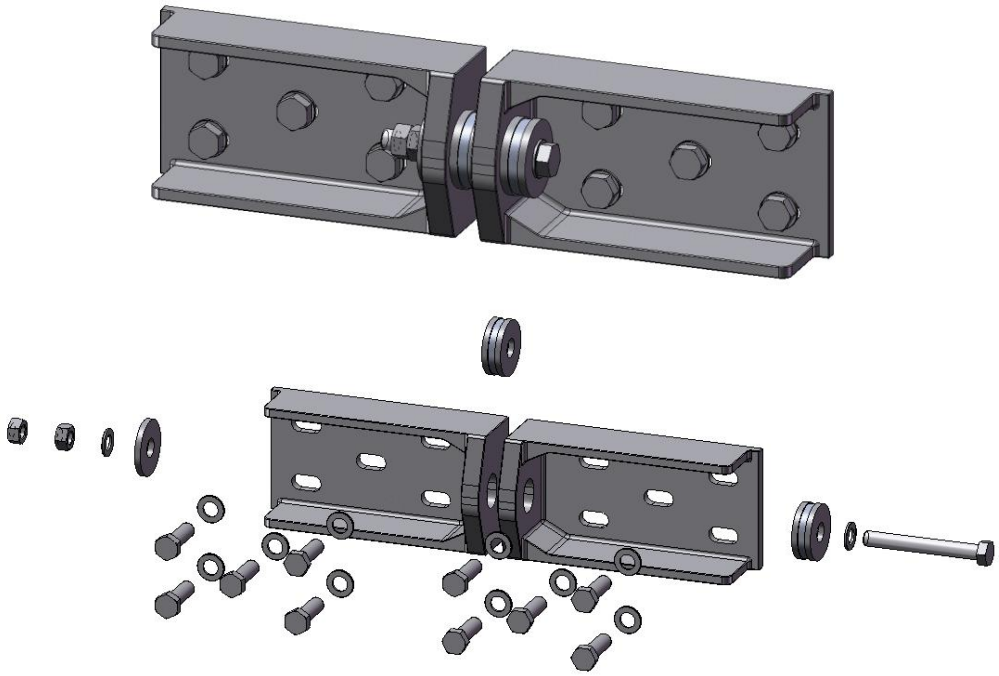


Figure A2.9: Horizontal connection plates on façades, between units (solution 2).

Each connection plate is fixed to its concrete unit by means of the following system:

- The plate is screwed to a supporting steel plate, the latter (the supporting plate) being integrated in the concrete unit before pouring the concrete.
- The supporting plate has a thickness of 20 mm and it is made of S355JR steel.
- These two plates are screwed with 5 high resistance steel screws M20-10.9.
- The supporting plate is anchored during manufacture into the concrete unit by means of 6 reinforcing bars welded into the plate (4 ∅16 mm and 2 ∅12 mm).

This description is better shown with the following drawings:

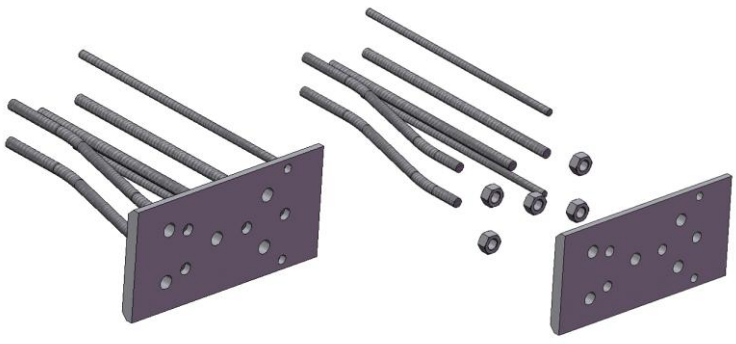


Figure A2.10: Supporting plate and its anchoring.

The function of these connections (solution 1 and 2) is establishing continuity between columns of units of the building, in order that these columns move unitarily when affected by seismic accelerations and thus preventing possible collisions between the columns of the building.

A2.5.4 Vertical connection between contiguous units

The units are connected vertically with these vertical connections when a lifting effort is expected (i.e. because of seismic actions).

This connection consists of the following components:

- Nut M24 10.9 DIN 934.
- Two rebar Ø 16 mm of steel B500B.
- Plate 150 mm x 150 mm x 12 mm with a central hole Ø 25 mm.

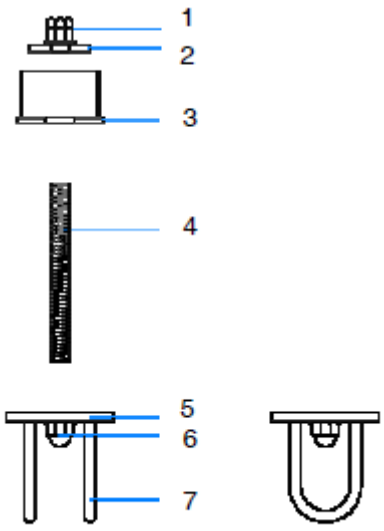
These three elements are welded and embedded in the concrete of the lower unit.

- Cylindrical case Ø 110 mm and 2 mm thick welded to a plate 120 mm x 120 mm x 8 mm with a central hole Ø 44 mm.

The case and plate are embedded in the upper unit.

- Threaded steel rod M24 10.9 DIN 934.
- Nut M24 10.6 DIN 936 and nut M24 10.9 DIN 934.
- Washer Ø 85 mm and 10 mm thick, with a central hole Ø 26 mm.

The embedded components are integrated in the unit before pouring the concrete. The threaded rod, nuts and washer are supplied by Compact Habit SL and installed on site.



1. Nut M24 10.6 DIN 936 and nut M24 10.9 DIN 934.
2. Washer Ø 85 mm and 10 mm thick, with a central hole Ø 26 mm.
3. Cylindrical case Ø 110 mm and 2 mm thick welded to a plate 120 mm x 120 mm x 8 mm with a central hole Ø 44 mm.
4. Threaded steel rod M24 10.9 DIN 934.
5. Plate 150 mm x 150 mm x 12 mm with a central hole Ø 25 mm.
6. Nut M24 10.9 DIN 934.
7. Two rebar Ø 16 mm of steel B500B.

Figure A2.11: Vertical connection between contiguous units.

These elements connect the floor of the upper unit with the structural ceiling of the lower unit.

The characteristic tensile resistance of a connection element is 254,2 kN.

A2.6 Characteristics of the elastic elements of the joints between units

The main characteristics of elastic cushions used in the connections between units are:

	Main characteristics of the steel cushions		
Connection element	Supports between units	Lateral connection between units	Vertical connection between units (Positioning and shear cones)
Dimensions (mm)	D_{int} = 70 D_{ext}=159 Thickness = 21,5	D_{int} = 34 D_{ext}= 70 Thickness = 10,5	A = 50 B = 47 Thickness = 10
Geometry	Circular (ring)	Circular (ring)	Rectangular
Drawing ref.	PUN-001-01-00-00	PUN-001-03-02-00	BPD-001-03-03-00
Weight (g)	700	85	50
∅ filament (mm)	0,23		
Type	Knitted steel filament		
Steel grade	Stainless steel AISI 304		

Table A2.2: Main characteristics of the steel cushions of the Compact Habit® system.

	Use conditions of the steel cushions		
Connection element	Supports between units	Lateral connection between units	Vertical connection between units (Positioning and shear cones)
Nominal work range/value	Between 30 kN and 130 kN. Within this range, the maximum deformation is 1,5 mm. Factory precompression stress of cushion = 800 kN.	Torque of the screwed union = 2,2 N·m.	Initial precompression of 2,5 mm.

Table A2.3: Use conditions of the steel cushions of the Compact Habit® system.

A2.7 Characteristics of the handling and transport anchorages of the units

The unit also integrates the following anchors and elements for handling and transportation purposes:

- Handling anchors: anchors with nominal tensile strength on 25 N/mm^2 concrete (strength of concrete when the unit is first handled during manufacture) is equal to 100 kN. These anchors are made of forged non galvanized steel.
- Transportation anchors: they are placed at the bottom corners of the unit and they allow for the fixing of the unit to the trailer.

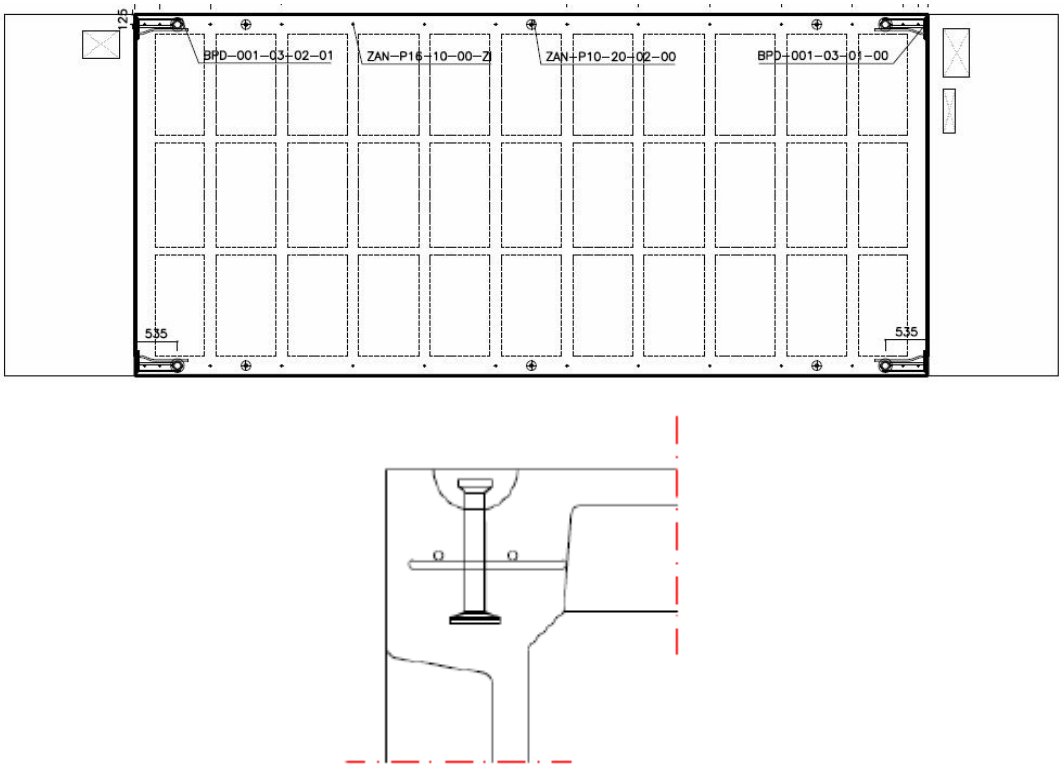


Figure A2.12: Handling anchors of the unit.

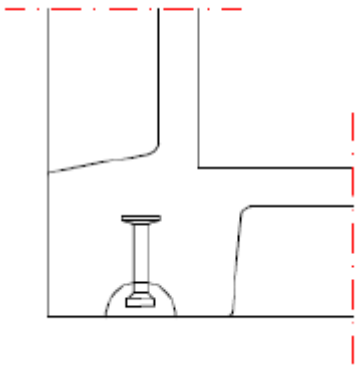


Figure A2.13: Transportation anchors of the unit.

ANNEX 3: Structural performances of Compact Habit® units and buildings based on Compact Habit® units

A3.1 Structural capacities of cross sections of Compact Habit® units

The structural capacities of cross sections of Compact Habit® units will be declared by means of the method 3b of Guidance Paper L (see chapter 3.1.1 of this ETA).

The structural cross-sections of Compact Habit® unit that constitute all its structural elements (floor, structural ceiling and walls) are shown in annex 1.

The structural capacities of each possible configuration mainly depend on the dimensions of the rib and of the slab between ribs, and of the reinforcement. These performances shall be calculated case by case for each project.

The remaining cross-sections of Compact Habit® unit are:

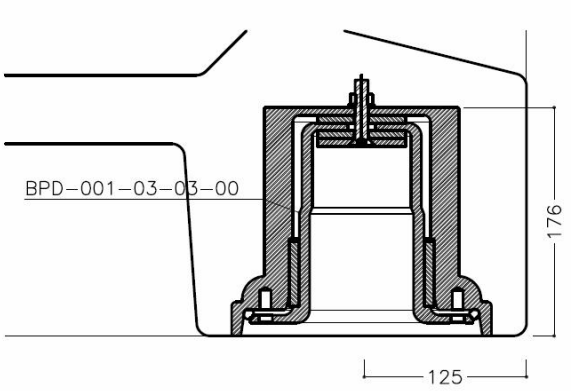


Figure A3.1: Cross-section of longitudinal floor beam of the unit.

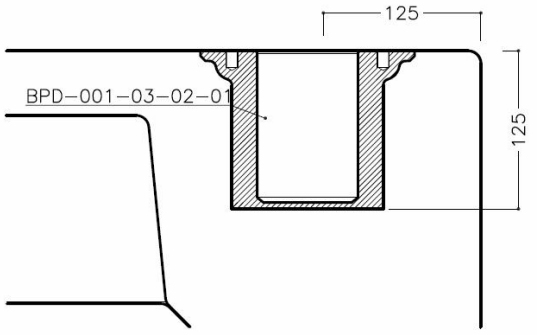


Figure A3.2: Cross-section of longitudinal ceiling beam of the unit.

A3.2 Resistance of the connections between Compact Habit® units (service values)

The structural capacities of the connections between Compact Habit® units will be declared by means of the method 2 of Guidance Paper L (see chapter 3.1.1 of this ETA).

- Service range of vertical supports: 30 to 130 kN/support.
- Shear resistance (horizontal forces) of the shear and positioning cones for vertical connection: 83,5 kN/cone.

  Note: this value is also valid for the connection between the first unit and the foundation, provided that the anchoring reinforcement of the connection into the foundation, which is designed case by case, meets this requirement.
- Horizontal connection between units (solution 1 & 2): 85,6 kN/connection (tensile strength).

Note: the resistance values of the connections (vertical and horizontal) set above result from considering the following specifications of the system:

1. Reduction factors applied to the properties of constituent structural materials of the connections and their anchoring into the concrete:
   - Factor for steel = 1,15
   - Factor for concrete = 1,50
2. The beams of the units (both the upper unit and the lower unit) in which the vertical connection between units is allocated have the following additional shear reinforcement:
   - 6 stirrups Ø6 15 cm apart (standard beam reinforcement all along the beam)
   - 6 bars Ø6 15 cm apart penetrating 25 cm into the floors and walls of the unit (along 90 cm of insertion of the shear cones in the beam)
   - 4 bars (Ø12 along 40 cm of insertion of the shear cones in the beam), meant to distribute the shear stresses of the shear cones into the beam.

- Vertical connection between units: 254,2 kN/connection (tensile strength)

A3.3 Properties of Compact Habit® system related to seismic analysis

- Ductility factor of buildings based on Compact Habit® units: μ = 2 (*low ductility* according to National Spanish seismic code NCSE-02).

ANNEX 4: General methodology for structural design and verification of a building based on Compact Habit® units (informative)

A4.1 Main project data

Actions to be considered

- Actions affecting the building:
  - Horizontal forces acting on each storey, mainly wind and earthquake actions.
  - Gravitatory actions on each floor of the building.
  - Additional loads affecting the building, which may increase the horizontal and vertical forces on the system.
- Partial factors of actions, combination of actions and any other provision established by the structural code applicable to the project.

Soil characteristics

These conditions of the soil may condition:

- The design of building foundations (see annex 2).
- The seismic actions affecting the building.

Building configuration

Design of the building configuration, which implies the specification of the:

- Number of storeys of the building.
- Number of columns of units that constitute the building.
- Openings distribution.
- Width of unit.
- Length of unit.
- Unit with/without cantilever floors (1 or 2).

A4.2 Calculation of actions and stresses acting on the defined building

- Calculation of actions affecting the building as a whole and to each of its structural elements: see previous clause A4.1.
- Stress calculation caused by these actions on all structural cross-sections.
- Check of the sufficiency of the structural capacities of the structural cross sections of the building (see annex 1), according to the procedure laid down in section A4.3 below.

A4.3 Verification

The aim is to verify that the mechanical capacities of the building configuration which is being considered adequately respond to the stresses affecting the building, both at a global level (the whole building) and at a local level of each of its structural elements, and both from the point of view of serviceability (SLS) and ultimate limit state (ULS).

This conveys to the following general verification procedure, that is to be complemented by any other specific verification carried out by the technical staff responsible for the works, based on its specific particular conditions:

A4.3.1 Verification of the structural elements of the building (floors, cantilever floors, walls and structural ceilings)

Verification that the values of the performances of floors, structural ceilings, walls and cantilever floors are higher than the calculated efforts.

It is necessary to verify the deformations of these structural elements (floors, cantilever floors and walls)

Note: Compact Habit SL may offer precalculated tables of admissible imposed loads on structural elements of the building; these tables have been precalculated for several possible values of the design variables (horizontal actions, combinations of imposed and dead loads, etc.).

A4.3.2 Verification of the deformation and resistance of the building (shear resistance)

- Verification that the limiting shear strength values of the building in SLS conditions (sway deformation of the building at each storey) are not reached.
- Verification that the shear strength resisted by the building in ULS conditions (stress exhaustion of ribs) is not reached. This verification is to be made both in the “normal” (non accidental) service conditions of the building and, if applicable, in the accidental (generally earthquake) conditions, considering all partial factors and combination factors of actions taken from applicable building codes and regulations depending on the location and specific use conditions of the building:

  1. Verification in normal service conditions: the actions to be considered are wind actions combined to any other horizontal actions (though wind actions are generally the governing factor).
  2. Verification in accidental conditions: these are generally seismic actions (the total mass of each part of the building is to be considered, i.e, the mass of the unit, the mass of any finishings and any other masses added to the building).

  The Compact Habit® building configuration under verification will be validated if the 3 conditions defined above (1 SLS condition ELS and 2 ULS conditions) are met, with a tolerance margin of + 5 %, accepted for the most stringent conditions, in one of the storeys of the building.

A4.3.3 Dimensioning of Compact Habit® units to meet the specific resistance to fire requirements

See chapter A5.2.2 c) of annex 5 of this ETA.

A4.3.4 Dimensioning of Compact Habit® precast foundation elements

These precast foundation elements are dimensioned in a case-by-case basis, based on the master design given in clause A2.4 of annex 2.

Foundation beam

In this case the foundation is executed on site and the Compact Habit® precast foundation beams act only as a connection element between Compact Habit® building and foundation executed on site.

Precast foundation element

This dimensioning of this element is made on a case-by-case basis. Taking into account that some of its characteristics are fixed, its dimensioning refers to:

- the design of the reinforcement of its upper flange,
- the definition of the width of its bottom flange, and its reinforcement.

A4.3.5 Verification of the resistance of the connections between Compact Habit® units

The verification of the sufficiency, in terms of shear strength, of the shear and positioning cones (given in clause A3.2 of annex 3) in the longitudinal and transverse direction of the unit will be carried out. If needed, the number of shear and positioning cones would be increased.

Verification and distribution of vertical supports, following the criteria given in clause A5.2.2 b) of annex 5 (*Number of vertical supports between units)*.

A4.3.6 Verification of "local" resistance of singular elements of the system

The following "local" verifications of Compact Habit® are needed, if applicable:

- Verifications of openings when more than one consecutive rib of the unit are removed (see clause A5.2.2 a) *Openings on the walls of the unit* and *Openings on the floor and structural ceiling of the unit*.

ANNEX 5: Main elements of the manufacturing process of Compact Habit® unit, foundation elements and relevant design and installation criteria

A5.1 Manufacturing

Main stages and elements of the manufacturing process of Compact Habit® units (and precast foundation elements) are:

- Design stage: the unit comprises some “fixed” characteristics, which do not depend on the project, and some other “open” characteristics (with values within known ranges). The values of the latter characteristics must be specified in the project, before starting the production of the unit.
- The following stages of production are especially relevant:
  - Dosification and preparation of high strength self compacting concrete (SCC).
  - Manufacturing of reinforcement cages and correct positioning to meet cover specifications.
  - Component’s specifications: verification of dimensional tolerances and other specifications referred to connections between units.
  - Positioning in the mould of all anchors under declared tolerances: anchors of the connection elements of units and anchors of possible additional loads and elements of the building, according to project’s specifications.
  - Concrete pouring of monolithic volumetric unit.
  - Dimensional accuracy of units: fulfilment of tight dimensional and geometrical tolerances for a correct dimensional coordination of the building.
- The structural design of the standard unit (and foundation elements) and of their anchors permit the handling of the unit when the compression strength of concrete is 25 N/mm^2.

A5.2 Design of the works

The completed buildings (the works) based on these kits remain fully under the responsibility of the user of the ETA. The user of the ETA is responsible for ensuring that the installed building meets all local regulatory requirements, and the installation shall be designed and verified according to whatever applicable national or local regulatory requirements of the Member State, by considering all the environmental actions linked to the actual use of the building and the actual geotechnical conditions of the foundation soils. For these verifications, the designer or the user of the ETA may ask to the manufacturer (ETA holder) for all data and details that are necessary.

The project should take the characteristics and performance values of Compact Habit® units specified in this ETA, and consider all design and execution criteria shown in ETA. Some of these are fixed characteristics, while some other are open characteristics (with values within a preset range) so that they are to be set in the project.

A5.2.1 Structural design for buildings based on Compact Habit® units

The building based on Compact Habit® units is to be structurally verified according to the methodology summarised in annex 4.

Structural design must consider the impact of chosen design options (openings, unit dimensions, etc.) on structural performance of Compact Habit® unit and on the structural performance of the building based on such Compact Habit® units specified in annex 3, based on the design criteria given in clause A5.2.2.

A5.2.2 Design criteria for buildings based on Compact Habit® units

The key elements of the design process of buildings based on Compact Habit® system are given below. These criteria are grouped as follows:

a) Design criteria that, once they are applied in the design stage of the building, they result in specifications for the manufacturer of Compact Habit® units and precast foundation elements. Consequently, the project must set these specifications before the manufacturing of such elements.

b) Design criteria that condition the design of the building, but do not condition the manufacturing of the precast elements.

c) Design criteria related to fire resistance performance of the building

All the above criteria are developed hereafter.

a) Criteria that condition the specification and manufacturing of Compact Habit® unit

Openings on the walls of the unit

The unit admits openings on its walls to allow for horizontal communication of the building, thanks to the removal of ribs.

Removal of ribs is subject to the following restrictions:

- The ribs that bear the raising and handling loads cannot be removed; these ribs are the ribs at either side of each handling anchor.
- The removal of ribs reduces the structural capacities of the unit. Once the distribution of wall openings in each storey of the building is chosen, this structural configuration of the building is to be verified, according to the following steps:
  - Verification of the “general” structural performance of the building (resistance and deformations): the shear strength of the unit (specified in annex 3) is proportionally diminished to the proportion of ribs being removed.
  - “Local” verifications:
    - Verification of strength of beams spanning over the openings, bearing in mind the location relative to the opening of the vertical supports of upper unit.
    - The nominal service stress of the cushions in vertical supports: if nominal service stress per support (130 kN) is reached with a + 5 % margin (< 136,5 kN), a redistribution or an increase in the number of supports will be needed.
- The shear strength of the unit depends on the number of ribs in each wall. If some ribs are removed in order to create openings, the performance of the removed ribs shall be replaced by doubled ribs.
- The reinforcement of the lintel and the lower beam of the opening is to be verified.

Openings on the floor and structural ceiling of the unit

The unit admits openings on its floor and structural ceiling to allow for vertical communication of the building by removing parts of the floor or structural ceiling ribs.

It will be necessary to differentiate between buildings made of Compact Habit® units with or without seismic requirements.

- With seismic requirements:
  - A previous tri-dimensional study of the building with the units with openings shall be done in order to identify the behaviour and the resulting efforts in each unit.
  - If the outcome of this study shows an acceptable behaviour, the geometrical data will be incorporated to the design.
- Without seismic requirements:

- When the horizontal actions are limited to the wind action the removed ribs in the floor because of the opening will be added to the first complete rib at the sides of the opening. The same procedure applies to the removed ribs of the roof, but deleting 1 rib on each side.
- It is necessary to calculate the resulting efforts in all ribs and to identify the necessary steel reinforcements of the concrete ribs.
- Additionally, in floors and structural ceilings, a longitudinal beam with the same dimensions than the first complete rib will encircle the opening.

Length and width of unit

- The length and width of the unit will be specially taken into account in the calculation of the deformability of the building and also during the transportation of the unit.
- The thickness of floor is conditioned to the distance between walls and to the openings.

Criteria referring to the addition of loads to the building

- External major loads added to the building must be self-supporting (external stairs or lifts, etc.).
- The loads of internal added elements providing the vertical communication between units throughout the openings in floors and structural ceilings (i.e.: prefabricated internal stairs) must be considered in the structural analysis of the building.
- Other elements of the building finishing can be suspended on Compact Habit® structure (façade cladding, roofing, building finishings, etc.).
- These suspended loads must be considered in the structural verification of the building, because they increase the mass of the building and/or the horizontal actions on the building.
- As for horizontal actions, it must be taken into account that the most critical direction of the horizontal plane is the direction perpendicular to lateral face of the unit, while the unit has a very high structural inertia in the direction perpendicular to front/rear façades of the unit.
- Consequently, actions added to the building must be considered in the structural analysis, once the following characteristics of these actions are identified:
  - Whether they are purely gravitational loads, that only act adding mass to the system, or,
  - they may include some horizontal component acting on the system; in such case, whether this horizontal load acts in the direction perpendicular to lateral walls of unit or perpendicular to front/rear façades of the unit.
- In any case the project will have to justify the sufficiency of the building to withstand these added actions, both locally, on the fixing areas on the unit, and at a general structural level of the building (see main steps in annex 4).

Criteria for anchoring added loads

- Anchors added during the manufacturing:
  - These anchors will be integrated in the unit before pouring the concrete during its manufacturing.
  - The anchors will always be placed on the perimeter beams of the unit or on the ribs, never on the faces of the unit, nor on its cantilever floors.
  - The anchors must be considered regarding their effects on the positioning of the reinforcement.
  - The positioning of anchors should prevent interferences with beam's reinforcement. For that reason:
    - In general, the anchors should not contact longitudinal rebars. If it happens, a constructive solution giving structural continuity of the involved rebars and sections will be provided.
    - If an anchor contacts a stirrup, this stirrup will be doubled (one stirrup at each side of the anchor), checking that the distance between these two stirrups meets the specifications of the design of reinforcement.

- The anchoring close to the horizontal connection elements or close to the handling elements should be avoided (distance ≥ 100 mm).

- Anchors placed after the manufacturing:
  - Mechanical or chemical anchors will be used.
  - The information regarding the areas suitable for placing the anchors will be provided by Compact Habit SL for each project, in accordance with the position of reinforcement and the type of structural section to be used.
  - In the design of the anchor, the edge distance provided by the anchor's manufacturer and the position of the reinforcements should be taken into account.
  - The Manufacturer Technical Dossier of Compact Habit SL includes the information as regards to the allowed areas for placing the anchors.

Number of vertical connection elements between units

Positioning and shear cones:

- The minimum number of vertical connection points (positioning and shear cones) is 2, but they can be 3, 4 or 6, according with the horizontal actions acting. The shear strength of each vertical connection multiplied by the number of connections is to be compared with the horizontal actions acting.
- The connections will be placed as distant as possible, and they will be distributed symmetrically or asymmetrically to the axis.
- The cone will be placed in the upper longitudinal beam, at 125 mm of the longitudinal exterior edge and at 250 mm of the transverse exterior edge.
- The elastic cushion of the cone will be placed in the lower longitudinal beam, at 125 mm of the longitudinal exterior edge and at 250 mm of the transverse exterior edge.

Tensile connections:

- This connection is used when tensile efforts between units are expected (i.e. from seismic actions).
- The tensile connections will be placed when there is at least a doubled rib or a reinforced area for tensile efforts and they will be distributed symmetrically or asymmetrically to the axis.
- They will be as close as possible to the structural axis of the wall.
- The surrounding area must be reinforced in front of eccentricities and shear.

Criteria of horizontal connection elements between units

- The number of horizontal connection points will depend on the solution used for lateral connection:
  - Solution 1 (connection on the top surface of upper floor): the number and positioning of connection points are defined case by case.
  - Solution 2 (connection plates on façades): 4 points placed on the 2 façades for central units of the building (2 points for end units).
- The minimum number of horizontal connection points is 4, but they can be more, according with the horizontal actions acting.
- The connections will be placed as distant as possible, and they will be distributed symmetrically or asymmetrically to the axis.
- The connection will be placed at ≥ 400 mm of the transverse exterior edge.

Number of vertical supports

The number of vertical supports and their distribution along the perimeter beams of the upper face of the unit, for each storey of the building, is specified in the project according to the following rules:

- The minimum number of vertical supports per unit is 4.
- The supports will be distributed symmetrically or asymmetrically to the axis, with priority to their position in the structural axis.

- The levelling of the support is necessary in order to support the upper unit. Plates of steel Z275 of different thickness are used for that purpose. The levelling tolerances are the following:
    - ± 1,0 mm for span between cushions ≤ 1.000 mm in a length 3.000 mm.
    - Otherwise: ± 0,5 mm for span between cushions ≤ 1.000 mm.
- The distribution of supports in a floor will be done in order to minimize the difference of load among cushions.
- The mean load per cushion will be similar in all floors. Therefore, the number of cushions will decrease from lower to upper storeys.
- To group cushions is possible.

The following figure shows an example of distribution of vertical supports in each storey, for a typical 6 storey building:

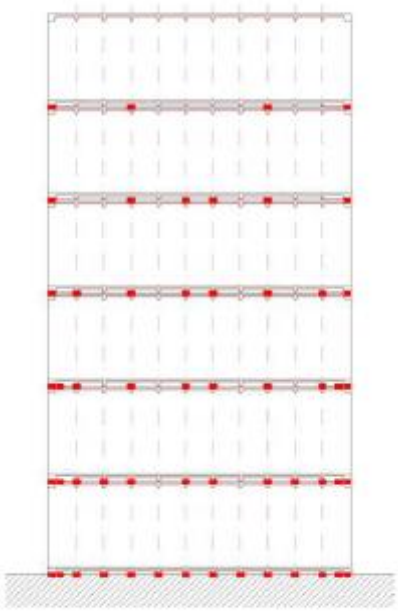


Figure A5.1: Example of distribution of vertical supports in a building.

Number and distribution of raising and handling elements

Handling of units is carried out by means of commercial forged steel anchors having a nominal tensile strength on the unit of 100 kN per anchor [24] (this value corresponds to a concrete support with 25 N/mm^2 in compressive strength).

The number of handling points depends on the mass of the unit (mass of naked unit + mass of integrated finishes), considering that the unit will be handled in production plant when concrete reaches a strength of 25 N/mm^2.

The distribution of handling anchors results from the application of the following general rules:

- Anchors are fixed on the upper face of the beams of the unit at midspan between 2 ribs.

[24] Compact Habit SL uses anchor Pfeifer 10 tons (service tensile load = 100 kN/anchor), which has the following characteristics: 200 mm anchoring depth, lower head ∅70 mm, upper head ∅46 mm (on which the crane is clamped) and ∅28 shaft. It has a security factor of 2,5 on 25 N/mm^2 reinforced concrete.

- The handling anchors will be placed as distant as possible and will be distributed symmetrically to the longitudinal axis.
- Handling anchors fixed on a lintel of an opening will be justified by calculation.
- At least 1 handling anchor will be placed for each 10 tons. The admissible load per anchor will depend on the distribution of anchors and of the mass of the unit. Calculating the handling anchors by dividing the total mass of the unit per number of anchors is not correct.
- The minimum number of handling anchors is 4, and the total number will be even.
- The centre of gravity of the unit will be used as distribution axis of handling anchors.

Rising of units is carried out by means of steel anchors partially embedded in the longitudinal beams of the floor. These anchors allow to tie up the unit to the transportation platform.

The distribution of the rising anchors results from the application of the following rules:

- The nominal tensile strength of each rising anchor is 50 kN.
- The rising anchors will be placed as distant as possible and will be distributed symmetrically to the longitudinal axis.
- At least 1 rising anchor will be placed for each 5 tons.
- The minimum number of handling anchors is 4, and the total number will be even.

b) Design criteria that condition the design of the building (but not the unit)

Maximum number of storeys

Compact Habit® system allows for the construction of the configurations of buildings defined by the structural calculation of the building. As a general rule it is important to note:

- Buildings' configurations of 1 column of units are generally limited by wind actions. When the buildings have 2 or more columns, these wind actions are distributed in as many columns, so generally wind actions is no longer the limiting condition.
- The buildings with 2 or more columns are generally limited by seismic actions, because these actions are proportional to the mass of the building, so that the seismic stresses at each column of units do not depend on the number of columns of units.

Internal lining

The basic minimum function of internal lining of units is to hide installations and provide the unit with a finishing aesthetically adequate for the use of the building. Some other functions of this lining may be:

- To complement the resistance to fire of Compact Habit® unit, when this performance is insufficient (see clause 3.1.2.2).
- To complement the thermal and/or acoustic insulation of the building envelope (see clauses 3.1.6.1 and 3.1.5, respectively).
- To provide the unit with the required level of water impermeability, in wet rooms of the building.

The internal lining solution that is adopted in the project will have to meet the applicable reaction to fire requirements, as well as all other particular applicable requirements in each case (flooring slipperiness, impact resistance, resistance to eccentric loads, etc.).

Façade cladding

The basic minimum function of façade cladding of the building is to provide it with the necessary water impermeability and with a finishing aesthetically adequate for the use of the building. Some other functions of this cladding are to complement thermal and/or acoustical insulation of the building envelope.

Depending on the external fire performance requirement applicable to the building, and the façade cladding chosen in the project, it may be necessary to protect the external face of Compact Habit® units or the metallic connections between units.

The connections that might be directly exposed to an external fire are only the horizontal lateral connections between units in façade (solution 2 according to figure 8b). It must be noted that the structural role of these unions is to coordinate the movements of the different columns of units of a building during an earthquake.

Depending on the applicable requirements of soil water permeability, it may be necessary to protect some parts of the building in contact with the terrain with adequate protection systems. Lower floor of ground floor unit of the building may require a specific thermal insulation, depending on thermal insulation requirements applicable to the building.

Vertical communication of the building

It is possible to communicate vertically contiguous units in a building by means of the openings in floors and roofs. The communication can be made by means of prefabricated stairs, ramps, etc. Those elements are not part of the Compact Habit® system. The data provided by the supplier of such elements (loads, anchorage needs, etc.) will be taken into account during the structural verifications of the building made of units.

Compact Habit® building on existing substructure

When the building based on Compact Habit® units is built on top of a concrete or steel frame structure, the following rules apply:

- The number of supports and their position will be defined in accordance with the result of the structural verification of each specific project.

Criteria for the design of in-situ foundation using Compact Habit® precast foundation beams

The in-situ foundation on top of which the Compact Habit® precast foundation beams or foundation carried out on site are to be placed, will be specifically designed for each works, under the condition that the support of the precast foundation beams is uniform in all its length (constant ballast factor on the whole length).

Foundation protection

When the nominal cover values of reinforcement of foundation elements (both in-situ elements, precast elements, see annex 2) are not sufficient for direct contact with soil, it will be necessary to consider protection solutions that will be specified case-by-case, depending on the agressivity of soil.

Criteria for roof design

Roofing is not part of Compact Habit® units; the roofing solution will be designed for each project to meet watertightness, insulation and other requirements applicable to the roof. Compact Habit® units admit both flat and pitched roof solutions.

The roofing will be fixed on the top floor of Compact Habit® building taking into account the supporting and fixing criteria specified in annex 2.

Criteria for installations design

The installation will be designed under usual criteria and they will be hidden by the internal lining specified in the project.

The vertical pass of installations through the floors of the building is made by means of a vertical external cage which passes through the balcony floors, if any, or fixed on 1 or the 2 façades of the building.

The hole on the balcony floors is foreseen in the precast element and it is made on the non-ribbed and non-structural flat parts of the slabs.

c) Design criteria related to fire resistance of the building

The resistance to fire of the units is specified in clause 3.1.2.2. Several combinations are possible (exclusively concrete reinforced structure; composite steel-concrete structure; different type and dimensions of structural section; use of protective rendering; use of insulation between ribs).

The performance of the building made of Compact Habit® units with the particular configurations selected from the mentioned combinations will be determined for each particular building project.

A5.3 Execution of the works

The following main points of the installation instructions enclosed in the Manufacturer Technical Dossier are to be taken into account.

Maximum flatness deviations admitted by Compact Habit® system

Upper face of foundation beams (or connection beams with substructure) on which the Compact Habit® building is laid on should meet a vertical tolerance of ± 1,0 mm. The same requirement applies to the upper face of Compact Habit® unit on each storey of the building.

The maximum vertical tolerance admitted by Compact Habit® system, caused by long-term deformation and subsidence, measured on a line of supports is:

- Compact Habit® system on foundations: 10 mm.
- Compact Habit® system on substructure: maximum deformation is the lowest of L/500 and 10 mm (L=span between columns).
- Maximum vertical tolerance between 2 lines of supports is 3 mm.

Levelling and marking of axis

Excavation + concrete pouring

- Excavation of the spread-footing foundation layout according to project' specifications.
- On site foundation (solution 1): the foundation is designed and executed on site. The foundation will include the factory made elements of Compact Habit® system (sheath and stirrup) described in chapter 1.3 of annex 1.
- Foundation using *Compact Habit® Foundation beams* (solution 2): pouring of a layer of non-reinforced concrete, generally of 7 cm and $f_{ck} \geq 20$ N/mm^2.
- Foundation using *Compact Habit® precast foundation elements* (solution 3): pouring of a layer of non-reinforced self-compacting concrete, generally of 10 cm (see concrete pouring chapter).

Positioning of rebars

Foundation carried out on site (solution 1)

- The positioning of the connecting element (sheath and the stirrups) is done with the tolerances of the works.
- Checking the levelling of sheath's upper faces, that should meet a tolerance of ± 5,0 mm; the central point of the sheath should meet a tolerance of ± 50,0 mm.

Positioning of foundation beams (solution 2)

- Positioning of foundation beams.
- Connection of stirrups hanging from foundation beams to in situ foundation reinforcement.

- Checking of the levelling of beam's upper faces, that should meet a tolerance of ± 1,0 mm, and level correction of the beam through the regulation settings of the positioning equipment.
- The elevation of the top face of foundation beams may be corrected by means of steel plates (rings of 1, 2, 3 and 5 mm).
- In foundations based on *Precast foundation elements*, these will be placed so that the same levelling tolerances of beam's upper faces of the *foundation carried out in site*.

Concreting of foundation (solution 1)

- Concreting according to the specific project' specifications (minimum compressive strength $f_{ck} \geq 25$ N/mm^2).
- For the precast foundation elements, concrete surface will be finished levelling with tolerance of ± 5,0 mm (minimum width of levelling is 300 mm when the unit is in the extreme of the building, and 600 mm in double supports).
- The sheath holes of the precast foundation elements will be protected to prevent concreting in them.
- The foundation of the building will be concreted as a whole in a single operation (both linear and transversal foundation elements).

Concreting of foundation (solution 2)

- Concreting according to the specific project' specifications (minimum compressive strength $f_{ck} \geq 25$ N/mm^2).
- The concrete will cover a height of at least 5 cm from the bottom of the foundation beam.
- The threads and supports of the upper face of the foundation beams will be protected to prevent concreting on them.
- The foundation of the building will be concreted as a whole in a single operation (both linear and transversal foundation elements).
- In foundations based on *Precast foundation elements*, the soil will be prepared with a layer of 10 cm of self compacting concrete, in order that this concrete will completely fill the volume underneath and around the precast element.

Verification of flatness and levelling

The correct levelling of the upper face of foundations is verified before placing the units (after concrete has cured) and, if needed, this levelling is adjusted by using metal plates on supports.

For the foundation carried out on site, the metallic case is placed into the sheath (using the metallic template) to ensure the correct positioning of the unit's cone and correct horizontal levelling between the other supporting points. The required horizontal levelling precision is of ± 1,0 mm. Once metallic cases are properly placed, the space between case and sheath must be filled using a high strength mortar (defined in section A2.4 of annex 2) and allow for 24 h in order to guarantee a mortar strength of 30 N/mm^2 prior to positioning the unit.

Lifting of the unit

- The crane is adequately positioned considering the sequence of placement of units in the building and the trajectory of crane's arm: if the crane turns leftwards to the building, each storey of the building will be mounted from its left end to its right end, and vice versa.
- The unit is hooked to the crane.
- The unit is smoothly prelifted so that nominal lifting stresses in all fixing points are reached. All fixing points are then visually inspected.

Positioning of the unit

- The crane lifts the unit and puts it close to its correct position. This position will then be adjusted by means of ropes worked manually, so that vertical connections between units are correctly aligned before initiating the descent of the unit.
- When correct positioning of the unit is reached, the crane slowly lowers the unit until the unit matches the connections of the lower element.

Settling of the unit on the supports

- The correct contact of the unit on all supports is visually verified once the unit lays on its place (without any lifting action from the crane).
- The unit is unhooked from the crane.

Horizontal connection between units

Solution1:

The horizontal connections between units placed on the upper floor will be executed once each pair of contiguous units in a storey has been placed. These connections will be torqued at its nominal values (see table A2.3 in annex 2), once all the units of each storey are correctly placed.

A gap between units must be left between adjacent units to avoid their contact.

Solution 2:

The horizontal connections between units in façade will be executed once each pair of contiguous units in a storey has been placed. These connections will be provisionally torqued at a low value of torque.

Once all the units that constitute the building have been placed and all major permanent loads of the building are acting and, thus, all short-time settlings have taken place, the horizontal connection between units will be torqued at their nominal torque value (see table A2.3 in annex 2).

A gap between units must be left between adjacent units to avoid their contact.

Execution of stairs or elements contiguous to the building

The execution of staircases, elevator structures or major elements of the building not included in Compact Habit® system will have to respect the sequence of execution of the units in the building, and not interfere with it.

Sealing of the perimeter of openings between units

The sealing solution of the perimeter of possible openings between units will be designed in a case-by-case basis according to applicable requirements of fire sealing and the relative movements between units foreseen in the building.

A5.4 Recommendations

A5.4.1 Recommendations on packaging, transport and storage

The design of the standard unit allows for its handling when the compressive strength of concrete is 25 N/mm^2.

The dimensions and masses of the finished standard unit, that are relevant for its handling and transportation, are defined in table 1 of ETA.

The unit integrates anchors placed on its lower lateral faces to fix the unit to the trailer during transportation.

The trailer is an extendable low raising platform which is equipped with an articulated system that prevents torsion stresses in the unit during transportation.

The handling of the units on site will be made by means of a mobile crane whose size and capacity will depend on the mass of the units and the size and shape of the site.

The unit is lifted directly from the trailer to the building, without any intermediate storage stage on site. The unit will be visually inspected to check that no damages have occurred during the handling, transportation and installation of the unit in the building.

A5.4.2 Recommendations on use, maintenance and repair

The manufacturer will specify in a case-by-case basis all use, maintenance and repair conditions of the building based on Compact Habit® units, according to specific building conditions (weather and use conditions and specific finishings' solutions of the building).

There are no specific use and maintenance conditions of Compact Habit® system, different to those applicable to a conventional reinforced concrete structure with metal connection elements. Therefore, regular inspections will be focused, amongst other aspects, on the state of conservation of reinforced structural parts (inspection of covers, concrete, etc.), and on the state of metal connection elements (and the state of their corrosion protection layers, if any).