

DAU

15/095 G

Documento de adecuación al USO

Trade name

Geoconnect[®]
MP

Generic type and use

Dowel connector used to transfer shear loads between concrete structural elements: beams, slabs or floors to walls, piles or supports, without relative displacement between them.

Holder of DAU

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Control of editions

Edition	Date	Sections where changes have been made regarding the previous edition
A	24.11.2015	Creation of the document.
B	24.02.2016	Geometric model for the design of the concrete edge reinforcement adapted after the issue of ETA for the product: changes in chapter 5.2.2 and 8.1.1.
C	05.12.2018	Epoxy coating on fixed reinforcement and plates: changes in chapters 1.1, 2.1, 2.2, 3.1 and 5.2.2.
D	30.05.2019	Incorporation of resistance to fire assessment.
E	24.11.2020	Revision and technical update of the DAU in accordance with current editions of reference documents (CTE updates and other reference standards). Extension of the validity of the DAU until 23.11.2025.
F	28.11.2022	Update that affects several parts of DAU document, according to the following new documents: <ul style="list-style-type: none"> • Código Estructural (Royal Decree 470/2021), referred in present DAU as Structural Code. • ETA 16/0064 of 20.07.2022, issued as per EAD 050019-00-0301 and TR 065.
G	01.03.2024	Expanded range of dowel bar diameter: new sizes 18 mm and 50 mm. Chapter 6.1.2 (Execution sequence) modification.

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1. System description and intended uses

1.1. Definition of the constructive system

Geoconnect® MP dowel connectors are joint devices to transfer shear loads between slabs, beams or floors and walls, piles or supports¹, made of reinforced concrete without relative displacement between them.

Walls, piles or supports are built before the execution of the slabs, beams or floors.

The use of Geoconnect® MP dowel connectors facilitates the execution of the joint, which does not require the construction of corbels or other auxiliary elements of connection.

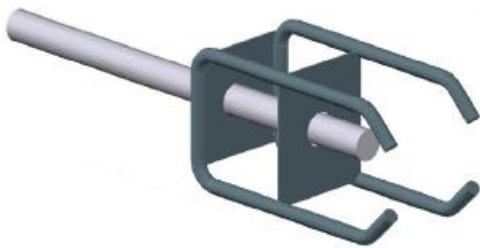


Figure 1.1: Geoconnect® MP dowel connector.

Geoconnect® MP dowel connectors are composed of the following components:

- Male part: a dowel bar for connection and a fixed reinforcement.
- Filling material: resin or mortar with low shrinkage.

Where resistance to fire is required, Geoconnect® Fire is supplied in accordance with section 2.3 as a component of the dowel connector.

The dowel bar of the Male part is inserted in a hole previously made in the wall, pile or support, with a diameter between 3 mm and 5 mm greater than the dowel bar diameter, and which has previously been filled with resin or mortar with low shrinkage. Once the filling material be hardened, the concrete slab, beam or floor can be poured, assuring the minimum concrete cover foreseen in the project (from 20 mm to 30 mm).

The material used to fill the hole in the wall, pile or support does not contribute to the mechanical performance of the system, it is only used for stabilizing the dowel bar during the installation process.

The dowel connector is designed to transfer -mainly- shear loads between the wall, pile or support and the slab or beam when there is not relative movement between them.

Specifications of the Male part are given in section 2.1.

Two types of Geoconnect® MP dowel connectors exist -type I and G- according to the steel type -stainless or galvanized- of the dowel bar. The use of one or another type is defined by the required protection against corrosion (see section 1.2).

The Male part fixed reinforcement is made of steel B 500 S according to article 34.2.a of Structural Code². The fixed reinforcement can be maroon epoxy coated during the manufacturing process reaching a coating 100 µm thick of mean value and 80 µm thick of minimum value.

Eight different dimensions of Geoconnect® MP dowel connectors exist depending on the dowel bar diameter, which allow to select the product according to the conditions of load and geometry of the joined structural elements.

It is assumed that structural elements joined by Geoconnect® MP dowel connectors are properly designed and verified. In this DAU, the design specifications related to the fitness for use of the dowel connectors are defined, but not those related to the verification of these structural elements.

Additional reinforcements installed in-situ around the dowel bar are defined according to each particular project.

The nominal width of the joint between constructive elements can be designed between 0 mm and 60 mm. The joint width refers to the distance between concrete elements, not to the relative displacement between them, with the purpose that possible constructive irregularities and/or the effect of the concrete shrinkage, as well as the possible installation of a lining between elements, are considered in the calculation of the connectors' strength.

1.2. Intended uses

Geoconnect® MP dowel connectors are mainly used to join the following structural elements, where transfer of shear loads is required and there is not relative movement between elements:

- Between beams or solid or lightened slabs -of a floor, roof or foundation-, shuttering slabs (pre-slabs) or one-way or two-way spanning slab floors,
- and
- walls, piles or concrete supports,

taking into account that walls, piles or concrete supports are built prior to beams, slabs, shuttering slabs or floors.

¹ See section 1.2 for an exhaustive list of structural elements joined by Geoconnect® MP dowel connectors.

² Código Estructural (Royal Decree 470/2021).

The use of Geoconnect® MP dowel connectors avoids placing corbels at the wall, pile or support to bear the slab, beam or floor.

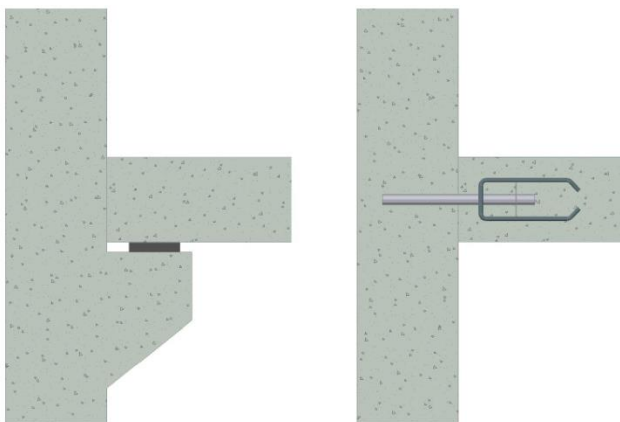


Figure 1.2: Geoconnect® MP dowel connector replacing corbels.

In addition to the specified main intended use, Geoconnect® MP dowel connectors are also used in the following joints:

- Ramp slabs to supports, where the latter have been previously executed. This joint is carried out in the same way as for slabs to retaining walls.
- Foundation slabs to retaining walls. In this case the dowel connector is used to prevent movements at the slab edges. Loads are transferred to the soil through the slab.
- Between walls on the same plane. Dowel connectors are placed aligned in the vertical of the wall edge and rotated 90° around its axis in relation to the standard installation position (in replacement of corbels). No loadbearing performance is required for this use, it is only intended for control of relative movements.
- Between slabs or floors to pile retaining walls, when a waterproofing barrier is placed between them. Waterproofing barrier continuity at the edge of the slab or floor is satisfied due to the protection against corrosion of the Geoconnect® MP dowel connectors. Joints with ribbed bars not protected against corrosion do not allow for such a continuity.

³ Examples of typical environments for a corrosivity category C1 and indoor exposure in a mild climate: heated buildings with clean atmosphere (offices, shops, schools, hotels, etc.).

⁴ Examples of typical environments for a corrosivity category C2 and indoor exposure in a mild climate: atmospheres with low levels of air pollution (rural areas mostly).

Examples of typical environments for a corrosivity category C2 and outdoor exposure in a mild climate: buildings without heating where condensation may occur (warehouses, sport centers, etc.).

⁵ Examples of typical environments for a corrosivity category C3 and indoor exposure in a mild climate: manufacturing plants with high

The concrete types to be considered for the joined structural elements are: HA 25, HA 30 and HA 35, in accordance with article 33.6 of Structural Code.

Geoconnect® MP dowel connectors are intended to be used in the following exposure conditions:

- Type G: indoor exposure. Corrosivity category C1³ or very low, according to table 80.1.a of Structural Code and UNE-EN ISO 12944-2.

Categories of low, medium and high corrosivity (C2⁴, C3⁵ and C4⁶ respectively, according to table 80.1.a of Structural Code and UNE-EN ISO 12944-2) are excluded for type G dowel connectors.

- Type I: indoor and outdoor exposure with moderate air pollution. Corrosivity category C3 or medium, according to table 80.1.a of Structural Code and UNE-EN ISO 12944-2. Categories C1 -very low- and C2 -low- are included.

Category of high corrosivity (C4) is excluded for type I dowel connectors.

Geoconnect® MP dowel connectors can be used under fire exposure when installed together with Geoconnect® Fire in accordance with section 2.3 and the design criteria given in section 5.3.2.

1.3. Limitations of use

The next table shows the dimensional limits of the structural elements joined by Geoconnect® MP dowel connectors, regarding the minimum thickness of the slab, beam or floor, and of the wall, pile or support.

Geoconnect® MP reference	Minimum thickness of the slab, beam or floor (mm)	Minimum thickness of the wall, pile or support (mm)
GC-MP-18	180	250
GC-MP-20	180	250
GC-MP-22	180	250
GC-MP-25	200	300
GC-MP-30	200	300
GC-MP-35	250	350
GC-MP-40	250	350
GC-MP-50	250	350

Table 1.1: Dimensional limits of the elements joined by Geoconnect® MP dowel connectors.

humidity and some air pollution, for instance: food processing plants, laundries, brewery plants, dairy plants.

Examples of typical environments for a corrosivity category C3 and outdoor exposure in a mild climate: urban and industrial atmospheres, with moderate sulphur dioxide levels. Coastal areas with low salinity.

⁶ Examples of typical environments for a corrosivity category C4 and indoor exposure in a mild climate: chemical plants, swimming pools, coastal vessels and shipyards.

Examples of typical environments for a corrosivity category C4 and outdoor exposure in a mild climate: industrial and coastal areas with moderate salinity.

The use of Geoconnect® MP dowel connectors has not been considered subject to cyclic loading in such a way as to cause fatigue or other related phenomena.

Performance of Geoconnect® MP dowel connectors has not been assessed in areas where seismic requirements apply.

1.4. Use differences of Geoconnect® MP and Geoconnect® LL

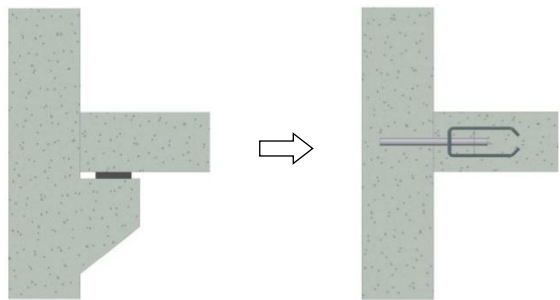
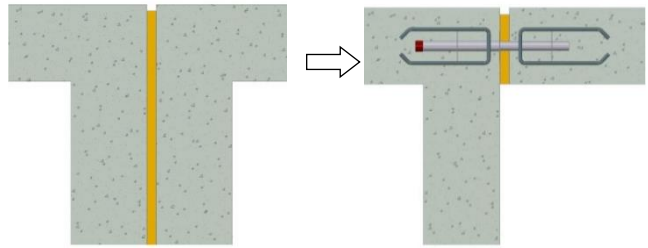
Product	Reference document	Generic type and intended use	Example
Geoconnect® MP	DAU 15/095	Dowel connector used to transfer shear loads between: beams, slabs or floors to walls, piles or supports, without relative displacement between them.	 <p>(*) Example of replacement of a corbel by a Geoconnect® MP dowel connector between a floor slab and a wall (fixed connection).</p>
Geoconnect® LL	DAU 15/096 ETA 16/0064	Dowel connector used to transfer shear loads between: slabs, slabs and beams or supports, and between walls, across an expansion joint between building parts	 <p>(*) Example of replacement of a double column by a Geoconnect® LL dowel connector in an expansion joint (connection with possibility of movement).</p>

Table 1.2: Use differences of Geoconnect® MP and Geoconnect® LL.

Connector Geoconnect® MP forms a fixed joint between the elements to join (without relative displacement between them), whereas connector Geoconnect® LL forms an expansion joint, with restricted vertical movement and with free relative displacement along the axis of the dowel bar (one direction) or with free movement on the horizontal plane of the dowel bar (two directions).

Connector Geoconnect® MP -unlike connector Geoconnect® LL- does not dispose of reinforcement, nor edge reinforcement on the side of the wall, piles or supports. Therefore, concrete crushing on the wall has to be checked, as an additional verification, for the connectors Geoconnect® MP.

The performances of the products Geoconnect® MP and Geoconnect® LL and the methodology for its determination specified in the respective documents

DAU/ETA are therefore different and not interchangeable.

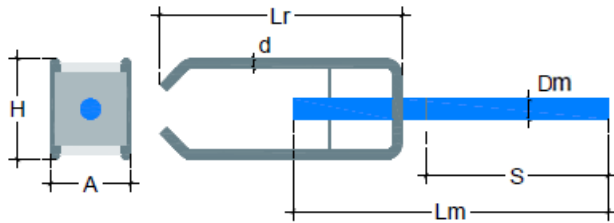
Consequently, the user should consult in each case the following documents:

- For a fixed connection between a horizontal element and a vertical element: the connector Geoconnect® MP should be used and the declared performances in DAU 15/095 should be taken.
- For a connection of two elements with an expansion joint between them: the connector Geoconnect® LL should be used and the declared performances in DAU 15/096 should be taken.

2. System components

The characteristics of Geoconnect® MP dowel connector (Male part) and of the filling material are specified in this section.

2.1. Male part



D_m	Dowel bar diameter	d	Reinforcement bar diameter
L_m	Dowel bar length	L_r	Reinforcement bar length
S	Overhung	H	Height
		A	Width

Figure 2.1: Male part.

Dimensions of the Male part (mm)							
Reference	Dowel bar			Fixed reinforcement			
	D_m	L_m	$S_{(1)}$	d	L_r	H	A
GC-MP-18	18	300	180	10	210	110	85
GC-MP-20	20	320	190	10	260	110	85
GC-MP-22	22	350	205	10	260	110	85
GC-MP-25	25	390	225	12	300	125	100
GC-MP-30	30	450	255	12	300	125	100
GC-MP-35	35	520	290	16	350	140	120
GC-MP-40	40	580	320	16	350	140	120
GC-MP-50	50	710	385	20	400	175	150

(1) Minimum overhung (for a concrete cover of 30 mm).

Table 2.1: Dimensions of the Male part.

Steel type of the Male part		
Characteristic	Standard	Steel
Dowel bar	Type I	EN 10088-3 X2CrNiMoN22-5-3 (1.4462)
	Type G	UNE EN ISO 683 2 42CrMo4
Reinforcement	Table 34.2 of Structural Code	B 500 S

Table 2.2: Steel type of the Male part.

The plates are made from 1,5 mm thick sheets of steel S235 according to UNE-EN 10025-2 and can be maroon epoxy coated reaching a coating 100 µm thick of mean value and 80 µm thick of minimum value.

The Male part is supplied with the dowel welded to the fixed reinforcement.

2.2. Filling material

The filling material is used to fix the Male component of the Geoconnect® MP dowel connector into the hole drilled in the wall, pile or support.

An epoxy resin or a mortar with low shrinkage from those available on the market may be used. The resin Fischer VL under ETA 10/0352 and ETA 15/0239 is recommended by Steel For Bricks GZ SL.

2.3. Geoconnect® Fire

Geoconnect® Fire consists of a mineral wool panel (20 mm or 30 mm thickness) coated with an intumescent layer of 2,5 mm thickness, with the dimensions shown in table 2.3. Technical specification of Geoconnect® Fire is identified and kept at ITEC.

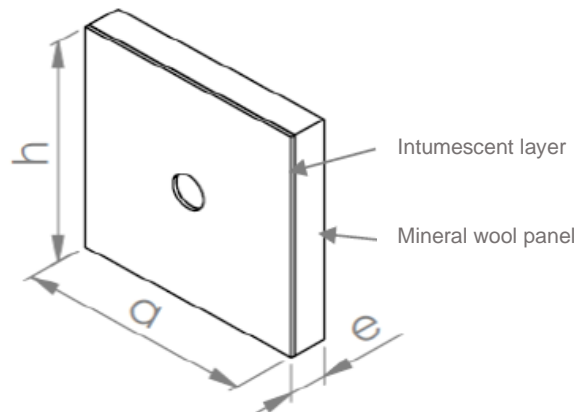


Figure 2.2: Geoconnect® Fire.

Dowel bar diameter (mm)	Geoconnect® Fire		
	Hole diameter (mm)	Minimum height (h) (mm)	Minimum width (a) (mm)
18 (GC-MP-18)	19		
20 (GC-MP-20)	21		
22 (GC- MP-22)	23	160	160
25 (GC- MP-25)	26		
30 (GC- MP-30)	31		
35 (GC- MP-35)	36	170	170
40 (GC- MP-40)	41		
50 (GC-MP-50)	51	180	180

Table 2.3: Dimensions of Geoconnect® Fire.

3. Manufacturing and production control

3.1. Manufacturing

The elements for the Male part (steel dowel bar, fixed reinforcement and plate) are acquired from authorized suppliers.

The steel bar cut to size is carried out at the premises of Steel For Bricks GZ SL.

A layer of epoxy resin can be applied to the fixed reinforcement and to the plate by means of a spraying process and subsequent baking.

The dowel bar and the fixed reinforcement are separately manufactured at the factory and assembled on site, while the filling material is bought on the open market following the specifications from Steel For Bricks GZ SL.

Dowel connectors are designated by Steel For Bricks GZ SL by the following description:

- GC MP xx I; or GC MP xx G.

With the following meaning:

- GC MP: Geoconnect® MP dowel connector.
- xx: diameter of the dowel bar in millimetres (see table 2.1).
- I or G: material of the dowel bar, according to:
I: stainless steel; G: galvanized steel (see table 2.2).

3.2. Production control

Steel For Bricks GZ SL ensures conformity of the components that form the dowel connector with the specification given in chapter 2 by the implementation of the Control Plan agreed with the ITeC.

This Control Plan establishes the controls to be carried out on each of the components and the manufacturing processes.

The production control of the dowel connectors involves the raw materials, manufacturing process and finished product. This production control has been audited by the ITeC.

Information related to the Control Plan is gathered in the Technical Dossier of the DAU.

Steel For Bricks GZ SL has a quality management system for the design, manufacture, and commercialisation of connectors, in accordance with the requirements of the ISO 9001 standard. The system is audited and certified by DET NORSKE VERITAS.

3.3. Control on construction site

During the execution of works, the person in charge of the site will carry out the controls given in table 3.1 to verify that the system installation conforms to the works design, taking into account the criteria laid down in chapters 5 and 6.

The following controls will be performed during the execution of the works:

Controls on construction site			
Characteristic	Method of control	Acceptance criteria	Number of samples
Dimensional compatibility: - Minimum thickness of the slab, beam or floor. - Compatible width (joint between beams) - Lateral concrete cover - Distance between bars	Dimensional verification	Conformity with the works design documentation	100%
Distance and position of the dowel connectors	Dimensional verification	Perpendicular to the joint plane	100%
Location of the dowel connectors in relation to the joined elements	Dimensional verification	Bottom part of the bent element: match the color code mark position with the project specifications	100%
Local concrete cover	Dimensional verification	From 20 mm to 30 mm	100%
Additional reinforcements: - Amount - Position	Calculations verification	Design shear strength ($A_s \cdot f_{yd}$) higher than or equal to the shear load transferred by the dowel. Running all along the available slab edge, observing the minimum concrete covers	100%
Amount of vertical reinforcement between dowel connectors	Calculations verification	Higher than 3,3 cm ² /m	100%
Installation of Geoconnect® Fire	Verification of the units' number and dimensions (for each dowel connector)	According to the project	100%

Table 3.1: Controls on construction site.

4. Storage, transportation and site reception

4.1. Storage

Geoconnect® MP dowel connectors are stored by Steel For Bricks GZ SL before their transportation to the construction site.

Storage conditions will be controlled both at storehouse and in construction site in such a way that dowels are not damaged before their installation.

Current legislation on occupational risk prevention must be complied with for the proper storage, handling and transportation of the dowel connectors.

4.2. Transportation

Geoconnect® MP dowel connectors are transported in packages of different sizes according to the model and the amount requested.

The dowel bar and its corresponding reinforcement are separately included in the same package.

4.3. Control of site reception

The conditions of the supplied material must be verified, at least by means of visual inspection, at the time of site reception. In particular, the following aspects are to be considered:

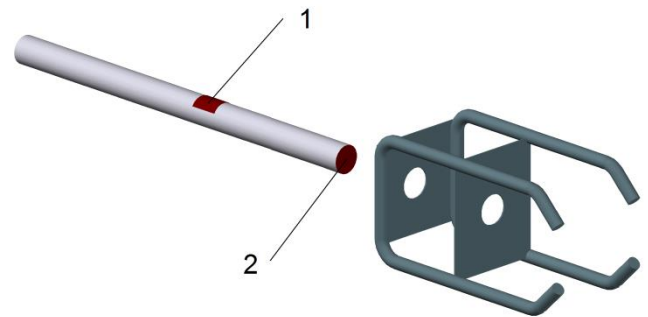
- Folds, surface defects or deviations in geometry of the dowel bars are not permitted.
- Manufacturer's documentation must be provided to ensure that the supplied product is according to its specification.
- Visual verification that dowel connector diameter corresponds to that requested. Dowel bars have the following color code at the bar end, according to the diameter:

Color codes for the dowel bars	
Reference	Color
GC-MP-18	Magenta
GC-MP-20	Red
GC-MP-22	Black
GC-MP-25	Blue
GC-MP-30	Purple
GC-MP-35	Green
GC-MP-40	Orange
GC-MP-50	Pink

Table 4.1: Color codes for the dowel bars.

The mark of the color code at the dowel bar end (mark num. 2 in figure 4.1) will always be at the fixed reinforcement side.

The same color code is placed on the dowel bar, showing the distance at which the fixed reinforcement is to be installed from the surface of the wall, pile or support, once the dowel bar has been inserted into the hole. Such a distance is specific for each project (see also figure 4.1).



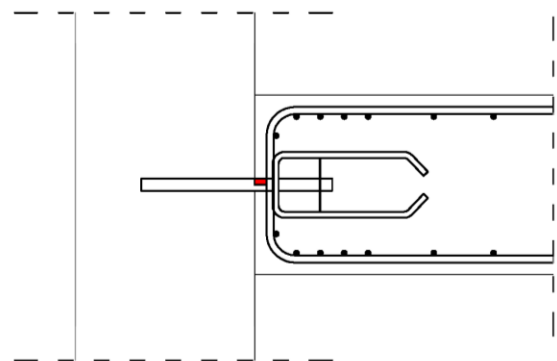
- 1: Color code mark on the dowel bar surface.
- 2: Color code mark at the dowel bar end.

Figure 4.1: Position of the color code marks of the dowel bar.

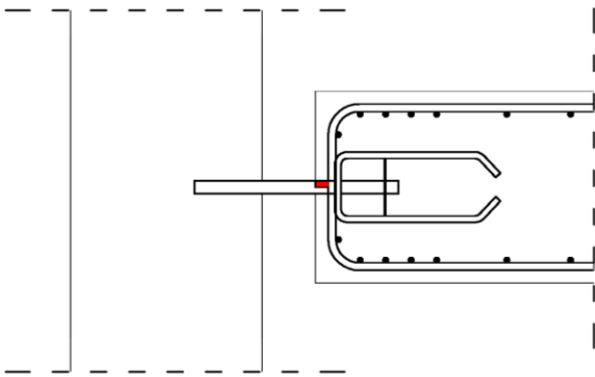
Two different scenarios are possible depending on the joint width (see figure 4.2):

- When the joint width is equal to zero (scenario 1), the distance from the edge of the mark num. 1 to the dowel bar end without the color mark num. 2 is the penetration depth of the dowel bar into the wall.
- When the joint width is other than zero (scenario 2), the distance from the edge of the mark num. 1 to the dowel bar end without the color mark num. 2 is the sum of the joint width and the penetration of the dowel bar into the wall.

In both cases the width of the mark corresponds to the concrete cover of the fixed reinforcement in the beam, slab or floor.



Scenario 1: Joint width equal to zero.



Scenario 2: Joint width other than zero.

Figure 4.2: Position of the fixed reinforcement depending on the joint width.

5. Project criteria

5.1. Design criteria

5.1.1. Distance between adjacent connectors

The distance between adjacent dowel connectors is defined from the outcome of calculations (see section 5.2).

The joint between structural elements can be assumed as a linear support provided that dowel connectors are subject to the same or similar load and the maximum distance between them is 8 times the thickness of the joined concrete element (beam, slab or floor).

However, this distance may be higher when joining a floor made of prefabricated joists placed parallel to the joint direction. In such a case, dowel connectors are placed at the end of the transversal beams, being the distance between dowel connectors the distance between these beams, usually higher than 8 times their thickness. Nevertheless, distance between dowel connectors must be backed with the calculations outcome.

No minimum spacing between adjacent dowels resisting a same relative movement is specified in theory. However, in order to take into account the eventuality for the compressed struts originating from two adjacent dowels to intersect, a penalty shall be applied in the case of slabs, where the spacing of the dowels is less than 1,5 times the thickness of the concrete element connected by them. The penalty shall consist of one of the following:

- The allowable shear forces are reduced by a coefficient equal to $0,67 \cdot e/h$,
- or
- The cross section of the reinforcing steel is increased by a coefficient equal to $(2 - 0,67 \cdot e/h)^3$,

Where:

e: spacing between two adjacent dowels.

h: thickness of the slab.

5.1.2. Depth of embedment

The depth of embedment of the dowel bar in the wall, pile or support is the dimension Overhung (S) given in table 2.1 minus the foreseen joint width (w). It is in any case equal or greater than 6,5 times the diameter of the dowel bar (D_m).

5.1.3. Position of the dowel connector

The minimum thickness of the slabs where the dowel connector is to be installed is given in table 1.1 according to the dowel connector size.

The most appropriate position for the installation of the dowel connector is the bottom part of the supported element (slab, beam or floor) observing the minimum

concrete covers, in order to get the bigger failure cone. However, in most cases the dowel connector is installed at half the edge of the slab due to the high density of the reinforcements and due to the necessary room to place the fixed reinforcement of the dowel connector. The supporting element (wall, pile or support) is compressed.

In the case of slabs formed from shuttering slabs, designer will pay particular attention to allow the installation of the dowel connector reinforcement bars and those of connection between the prefabricated concrete element and the in-situ poured concrete.

Installation of more than one dowel connector at the end of a beam is allowed.

Elements interfering with the concrete cone around the dowel connector (openings, ductwork for pipe penetration, etc.) will be avoided.

5.1.4. Filling material

The material used to fill the hole made in the wall, pile or support does not contribute to the mechanical performance of the dowel connector, it is only used for stabilizing the dowel bar during the installation process.

An epoxy resin or a mortar with low shrinkage may be used as filling material.

5.2. Structural safety

5.2.1. Performance of the dowel connector

Performance of the dowel connector, expressed by means of the design shear strength of the connection, will be defined case-by-case for each project by the technical department of Steel For Bricks GZ SL. This value is the lowest from those obtained in the verification of the following failure modes, depending on the element where the possible failure occurs:

- In the slab, beam or floor:
 - Concrete edge failure (see section 5.2.2 of DAU).
 - The verification of the through-the-thickness failure mode is not part of the performance verified by Steel For Bricks GZ SL; this verification falls therefore under the responsibility of the designer responsible for the project.
- In the dowel bar:
 - Shear failure combined with the bending moment (see section 6.2.5 and 6.2.8 of UNE-EN 1993-1-1 and articles 6.2.5 and 6.2.8 of Annex 22 of Structural Code). The plastic resistance of the cross section will be verified by identifying the stress distribution that is in equilibrium with the stresses and moments

without exceeding the elastic limit of the steel, said distribution being compatible with the associated plastic deformations (see section 6.2.1(6) of UNE-EN 1993-1-1 and article 6.2.1(6) of Annex 22 of the Structural Code).

- In the wall, pile or support:
 - Yielding failure of the dowel bar or local compression failure of concrete (see section 5.2.3 of DAU).

The steel yield strength of the dowel bar claimed by the steel supplier will be used for calculations, being it significantly higher than the minimum value given in the product standard.

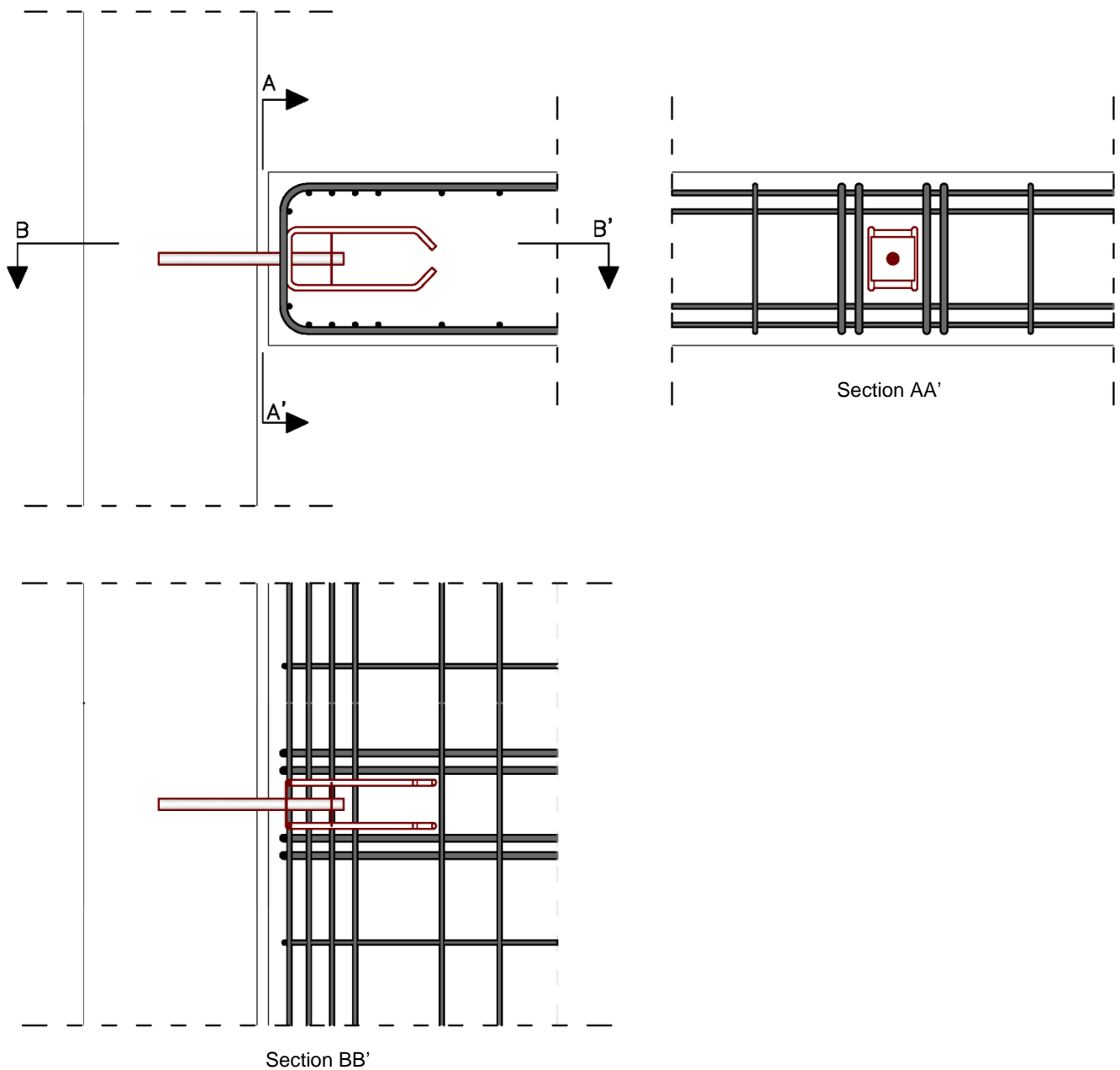


Figure 5.1: Arrangement of the concrete edge reinforcement and edge beam around Geoconnect® MP.

5.2.2. Concrete edge reinforcement

The purpose of the concrete edge reinforcement arranged at both sides of the dowel bar is assuring the transfer of loads to the parts of the concrete subject to compression.

This additional reinforcement next to the dowel connector installed in the slab, beam or floor must conform to the following specification:

- Resistance to concrete edge failure at Ultimate Limit State ($V_{Rd,ce,ULS}$) provided by the reinforcement is determined as follows:

$$V_{Rd,ce,ULS} = V_{Rd,ce,1} + V_{Rd,ce,2} \leq A_s \cdot f_{yd}$$

Where $V_{Rd,ce,1}$ is the force transmitted by the hook and $V_{Rd,ce,2}$ is the force transmitted by bonding action along the straight part of the stirrup.

$$V_{Rd,ce,1} = X_{1,1} \cdot \sum \Psi_i \cdot A_s \cdot f_{yk} / \gamma_{c,ULS}$$

$X_{1,1}$ = specific factor for this connection

$X_{1,1} = 0,21$ (see section 8.1.1).

Ψ_i : factor that accounts for lateral distance of bars to the dowel.

$$\Psi_i = 1 - 0,2 \cdot (\ell_{c,i} / c_i)$$

$\ell_{c,i}$: distance from the dowel bar center to the axis of the considered stirrup.

c_i : vertical distance from dowel bar center to the slab edge.

$$V_{Rd,ce,2} = \pi \cdot d_s \cdot \sum \ell'_{1,i} \cdot f_{bd}$$

d_s : diameter of the stirrup.

$\ell'_{1,i}$: effective anchorage length of the considered stirrup.

$$\ell'_{1,i} = \ell_{1,i} - \ell_{1,min}$$

$\ell_{1,i}$: anchorage length of the considered stirrup.

$$\ell_{1,min} = (0,5 \cdot d_b + d_s)$$

d_b : mandrel diameter of the stirrup.

f_{bd} : design value of the ultimate bond stress of the ribbed bars (see section 8.4.2 of EN 1992-1-1 and article 8.4.2 of Annex 19 of Structural Code).

$$f_{bd} = 2,25 \cdot \eta_1 \cdot \eta_2 \cdot f_{ctd}$$

Where:

$$\eta_1 = 1,0$$

$$\eta_2 = 1,0$$

$$f_{ctd} = f_{ctk;0,05} / \gamma_{c,ULS} = 0,7 \cdot f_{ctm} / \gamma_{c,ULS}$$

$$f_{ctm} = 0,3 \cdot f_{ck}^{2/3}$$

$$\gamma_{c,ULS} = \gamma_c$$

$$f_{bd} = 2,25 \cdot 0,7 \cdot 0,3 \cdot f_{ck}^{2/3} / \gamma_{c,ULS}$$

- The arrangement of the concrete edge reinforcement at both sides of the dowel bar follows the geometric model shown in figure 5.2.

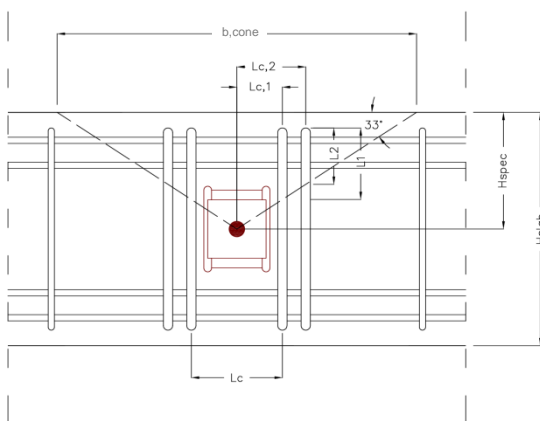


Figure 5.2: Geometric model of the concrete edge reinforcement arrangement at both sides of the dowel bar.

This geometric model corresponds to the following calculation considerations:

- The concrete cone starts at the center of the dowel connector ($h_{cone} = h_{slab} / 2$).
- The angle of the concrete struts is 33° ($b_{cone} = (2 \cdot h_{cone}) / \tan 33^\circ$).

- Consideration of the force transmitted by the hook: the force transmitted by the hook is weighted if the concrete cone resulting from the calculation model does not include completely the part of the stirrup affected by the hook. This occurs when the length of the stirrup inside the concrete cone is less than the sum of half the mandrel diameter of the stirrup and the diameter of the stirrup ($0,5 \cdot d_b + d_s$).

This weighting is introduced in the formula of the force transmitted by the hook by a reduction coefficient, expressed by means of the quotient between actual length and theoretical length.

- The tensile strength ($A_s \cdot f_{yd}$) will not be lower than the design shear force transmitted by the dowel.
- They can be closed links or cross-ties ("U" shaped). When cross-ties are placed, the horizontal bars will have a length at least equal to the anchorage length corresponding to the used type of stirrup.
- Both for closed links and cross-ties, they will run along all the available edge of the structural element in which they are placed, always observing the concrete cover to the upper and lower side (20 mm minimum and 30 mm maximum).
- Rebars of the fixed reinforcement do not contribute to the resistance to concrete edge failure.

The design values of the serviceability shear force related to cracking ($V_{Rd,ce,SLS}$) for concrete edge failure are obtained from the following expression:

$$V_{Rd,ce,SLS} = V_{Rk,ce,SLS} / \gamma_{c,SLS}$$

where:

$$V_{Rk,ce,SLS} = X_2 \cdot V_{Rk,ce,ULS}$$

X_2 : specific factor for this connection.

$$X_2 = 0,58 \text{ (see section 8.1.1)}$$

$V_{Rk,ce,ULS}$: characteristic value of the resistance for concrete edge failure at Ultimate Limit State.

$$\gamma_{c,SLS} = 1,0$$

$$V_{Rd,ce,SLS} = 0,58 \cdot V_{Rk,ce,SLS}$$



Figure 5.3: Arrangement of the cross-ties of the concrete edge reinforcement and edge beam reinforcement. Three-dimensional view.

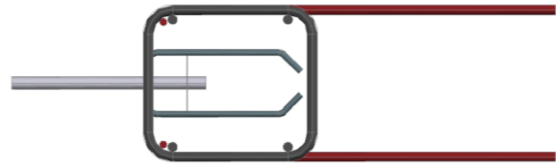


Figure 5.4: Arrangement of the concrete edge reinforcement with cross-ties. Elevation.

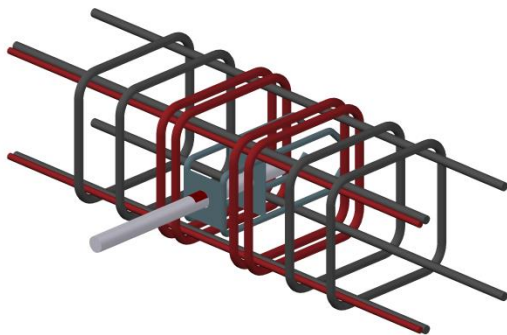


Figure 5.5: Arrangement of the closed links of the concrete edge reinforcement and the edge beam reinforcement. Three-dimensional view.

Notes:

- Concrete is not shown in the figures for ease of understanding.
- The given reinforcements arrangement is only an example.

5.2.3. Yielding failure of the dowel bar or local compression failure of concrete

Verification of the yielding failure of the dowel bar or of the local compression failure of concrete is carried out by means of a joint model that analyses the forces exerted on the concrete of the slab, pile or support, as well as on the dowel bar.

The principles of the theory of partially loaded areas under consideration of a region D ⁷ (see article 6.7 of Annex 19 of Structural Code) are applied to define the limiting value of the concrete submitted to compression. In addition, the strut and tie model under consideration of a continuous deep beam (see article 5.6.4 of Annex 19 of Structural Code) is applied for the verification of the sufficiency of the tensile reinforcements placed in the wall.

As the applied load rises, a displacement of the equilibrium reactions in the concrete cross-section occurs, which results in an increase of the bending

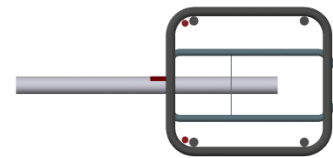


Figure 5.6: Arrangement of the edge reinforcement with closed links. Elevation.

moment on the dowel bar until its failure after formation of a yield hinge.

It is necessary to check the limiting strength values of both verifications for each configuration (joint width, dowel bar diameter, concrete strength, thickness of the wall, pile or support, etc.) in order to define the worst-case.

Tabulated shear strength values are given in DAU for informative purpose, obtained from the yielding failure of the dowel bar or local compression failure of concrete of the wall, pile or support, for standard conditions of joint width, thickness of the wall, pile or support, dowel bar diameter and yield strength of the dowel bar steel (see tables 5.1 and 5.2).

Shear strength values given in tables 5.1 and 5.2 are only valid for Geoconnect[®] MP dowel connectors subject of this DAU. Interpolation between intermediate values is allowed; extrapolation is not allowed.

⁷ A region D, or region of discontinuity, is a structure or part of a structure in which the general theory of bending is not valid, i.e. Bernoulli-Navier or Kirchoff hypothesis are not applicable. The regions of application of concentrated loads or reactions form regions of static discontinuity.

Tabulated design shear strength values (kN) of galvanized steel Geoconnect® MP G dowel connectors.															
Yielding failure of the dowel bar or local compression failure of concrete															
Dowel	Concrete	Wall thickness (mm)	Joint width (w) (mm)												
			0	5	10	15	20	25	30	35	40	45	50	55	60
GC MP 18 G	HA-25	≥ 250	39,0	37,0	35,0	33,1	31,2	29,3	27,4	25,6	25,0	23,2	22,6	20,9	20,3
	HA-30		41,9	39,6	37,3	35,0	32,7	30,5	28,3	27,7	25,6	25,0	22,9	22,3	20,4
	HA-35		45,0	42,3	39,7	37,0	34,4	31,9	31,2	28,7	26,3	25,7	23,3	22,8	22,1
GC MP 20 G	HA-25	≥ 250	47,6	45,3	43,1	40,9	38,7	36,6	35,7	33,6	31,6	30,7	28,7	27,9	27,0
	HA-30		52,0	49,3	46,7	44,1	41,5	39,0	38,2	35,7	33,3	32,5	30,1	29,3	27,2
	HA-35		56,5	53,4	50,4	47,4	44,5	41,6	38,7	37,9	35,1	32,4	31,6	29,0	28,2
GC MP 22 G	HA-25	≥ 250	57,6	55,1	52,7	50,2	47,8	45,4	44,5	42,1	39,8	38,9	36,6	35,6	33,4
	HA-30		63,6	60,7	57,8	54,9	52,1	49,3	46,5	43,8	42,8	40,2	39,2	36,6	35,7
	HA-35		67,5	64,1	60,8	57,5	54,2	51,0	50,0	46,9	43,8	42,9	39,9	38,9	36,0
GC MP 25 G	HA-25	≥ 300	78,7	75,6	72,7	69,8	67,0	64,2	61,4	58,7	57,4	54,8	53,5	50,8	49,5
	HA-30		86,2	82,8	77,4	74,1	72,8	69,5	66,3	63,1	60,0	58,7	55,2	54,3	51,3
	HA-35		93,3	86,9	83,0	79,2	75,4	74,1	70,4	66,8	63,2	61,9	58,4	55,0	53,7
GC MP 30 G	HA-25	≥ 300	112,2	108,7	105,2	101,7	98,2	96,5	96,7	89,7	86,3	84,5	81,2	79,4	76,2
	HA-30		123,2	119,1	115,0	110,9	106,9	102,9	98,9	95,0	93,3	89,4	85,6	83,9	80,1
	HA-35		132,4	127,6	122,9	118,3	113,7	109,1	104,6	100,1	98,4	94,0	89,7	88,0	83,7
GC MP 35 G	HA-25	≥ 350	152,5	148,3	144,2	140,0	135,9	131,9	129,8	125,8	121,8	117,8	115,7	111,7	109,5
	HA-30		167,3	162,4	157,6	152,8	148,0	143,3	138,6	134,0	129,4	127,3	122,7	118,2	116,1
	HA-35		178,7	173,2	167,7	162,2	156,8	151,4	146,1	144,0	138,7	133,5	128,4	126,3	121,2
GC MP 40 G	HA-25	350	173,7	172,8	171,0	169,9	168,0	166,0	164,0	161,8	159,6	156,7	154,4	151,5	148,5
		≥ 400	200,3	195,4	190,6	185,8	181,0	176,3	171,6	169,0	164,3	159,3	157,0	152,4	149,6
	HA-30	≥ 350	217,2	211,6	206,0	200,5	195,0	189,5	186,9	181,5	176,1	170,8	165,5	162,9	157,7
HA-35	235,1		228,7	222,4	216,0	209,8	203,5	197,3	191,2	185,1	182,5	176,5	170,6	168,0	
GC MP 50 G	HA-25	≥ 350	245,9	242,6	238,7	235,0	231,5	227,6	224,4	220,6	216,8	213,5	209,8	206,2	202,8
	HA-30		295,1	291,2	286,4	282,0	277,8	273,2	269,3	264,7	260,1	256,2	251,7	247,4	243,3
	HA-35		344,2	339,7	334,1	329,0	324,1	318,7	314,1	308,8	303,5	298,9	292,1	284,5	281,0

Notes:

- Values have been calculated using the following yield strength values of dowel bar steel (N/mm²): GC MP 18 G, GC MP 20 G and GC MP 22 G = 930; GC MP 25 G and GC MP 30 G = 1.007; GC MP 35 G, GC MP 40 G and GC MP 50 G(*) = 994.
(*) The yield strength value considered for GC LL 50 G dowel bar must be confirmed by the steel supplier.
- Only interpolations between values are allowed; extrapolations are not allowed.
- Design shear strength values in the table have been provided by the Technical Department of Steel For Bricks GZ SL; ITeC has verified the input data and the applied methodology.

Table 5.1: Tabulated design shear strength values of the galvanized steel dowel connectors related to the failure in the wall.

Tabulated design shear strength values (kN) of stainless steel Geoconnect® MP I dowel connectors.															
Yielding failure of the dowel bar or local compression failure of concrete															
Dowel	Concrete	Wall thickness (mm)	Joint width (w) (mm)												
			0	5	10	15	20	25	30	35	40	45	50	55	60
GC MP 18 I	HA-25	≥ 250	36,3	34,3	31,1	29,2	28,6	26,7	24,9	23,1	22,6	20,8	20,0	18,6	18,1
	HA-30		38,6	36,3	34,0	31,7	29,5	27,3	26,8	24,6	22,6	22,0	20,0	19,3	18,8
	HA-35		43,0	38,3	35,7	33,1	30,5	30,0	27,5	25,0	24,5	22,1	21,6	19,3	18,8
GC MP 20 I	HA-25	≥ 250	44,75	42,5	40,3	38,1	36,0	33,9	31,8	29,8	29,1	27,1	26,3	24,4	23,7
	HA-30		48,4	45,8	43,2	40,6	38,1	35,6	33,2	32,5	30,1	27,3	27,1	26,4	24,1
	HA-35		55,2	49,2	46,2	43,3	40,4	37,5	34,7	34,0	31,2	30,5	27,9	27,1	24,6
GC MP 22 I	HA-25	≥ 250	54,6	50,6	48,2	45,8	43,4	42,5	40,2	37,9	35,7	34,9	32,7	31,9	29,7
	HA-30		59,8	54,9	52,1	49,3	46,5	43,7	42,9	40,2	37,6	36,7	34,2	33,3	30,9
	HA-35		62,8	59,5	56,2	52,9	49,7	46,5	43,4	42,6	39,5	36,5	35,7	34,9	32,1
GC MP 25 I	HA-25	≥ 300	68,4	65,6	62,8	60,1	57,3	54,6	52,0	51,0	48,4	45,8	44,8	42,3	41,3
	HA-30		75,6	72,3	69,0	65,8	62,6	59,4	56,3	53,2	50,1	49,2	46,2	45,2	42,3
	HA-35		80,3	76,5	72,8	69,0	65,4	61,7	58,1	57,1	53,6	50,2	49,2	45,8	44,8
GC MP 30 I	HA-25	≥ 300	98,7	95,3	91,9	88,5	85,2	81,9	78,6	77,3	74,1	70,9	67,8	66,4	63,4
	HA-30		108,4	104,4	100,4	96,4	92,5	88,6	84,8	81,0	77,3	76,0	72,3	68,7	67,4
	HA-35		117,3	112,6	108,1	103,5	99,0	94,6	90,2	85,8	81,6	80,2	76,0	71,9	70,4
GC MP 35 I	HA-25	≥ 350	137,1	130,8	126,8	122,8	118,9	115,0	115,3	109,5	105,7	101,9	100,2	96,5	92,8
	HA-30		150,3	142,6	137,1	133,3	128,7	124,2	119,6	117,9	113,5	109,1	104,7	103,4	98,8
	HA-35		161,4	155,9	150,5	141,7	136,4	134,7	129,5	124,3	119,2	118,1	109,2	107,5	102,6
GC MP 40 I	HA-25	≥ 350	178,5	173,8	169,2	164,6	160,0	155,5	151,0	146,5	142,1	137,7	135,6	131,3	127,0
	HA-30		195,0	189,6	184,2	178,8	173,5	168,2	162,9	157,7	152,5	147,4	145,4	144,3	135,3
	HA-35		211,9	201,6	195,4	189,3	183,2	177,1	171,1	165,2	163,1	157,2	151,4	145,6	143,6
GC MP 50 I	HA-25	≥ 350	245,9	242,6	238,7	235,0	231,5	227,6	224,4	220,6	216,8	213,5	209,8	206,2	202,8
	HA-30		295,1	291,2	286,4	282,0	275,2	268,5	261,8	255,2	252,4	245,9	239,3	232,9	226,4
	HA-35		328,8	321,0	313,1	305,3	297,6	289,9	282,3	274,7	267,1	259,6	252,2	244,8	242,1

Notes:

- Values have been calculated using the following yield strength values of dowel bar steel (N/mm²):
GC MP 18 I, GC MP 20 I and GC MP 22 I = 802 / GC MP 25 I and GC MP 30 I = 781 / GC MP 35 I, GC MP 40 I and GC MP 50 I(*) = 791.
(*) The yield strength value considered for the GC LL 50 I dowel bar must be confirmed by the steel supplier.
- Only interpolations between values are allowed; extrapolations are not allowed.
- Design shear strength values in the table have been provided by the Technical Department of Steel For Bricks GZ SL; ITeC has verified the input data and the applied methodology.

Table 5.2: Tabulated design shear strength values of the stainless-steel dowel connectors related to the failure in the wall.

5.2.4. Design of the dowel connector

- The design of the dowel connectors is carried out by verification of each of the following inequalities between acting shear forces and shear strength, depending on whether a verification of the Ultimate Limit State -ULS- or the Serviceability Limit State -SLS- applies.
 - $V_{Sd,u} \leq V_{Rd,u}$ (ULS in persistent or transient design situation)
 - $V_{Sd,SLS} \leq V_{Rd,SLS}$ (SLS)
 - $V_{Sd,a} \leq V_{Rd,a}$ (ULS in accidental situation)

The first inequality must be verified in all cases, while the second inequality only in such cases where cracking in the slab or floor is detrimental (for example: due to presence of continuous pavements). The third one only applies in accidental situations.

The values of $V_{Rd,SLS}$ have been obtained from tests and correspond to shear strength values at the time when cracking in the slab or floor occurs.

The data to be used for the verifications above for each Limit State are given as follows:

- Ultimate Limit States:

Partial safety factors for actions according to table 4.1 of DB-SE of CTE (Spanish Building Code).

The combination of actions for persistent or transient design situations, and accidental situations, will be defined in accordance with the criteria in article 4.2.2 of DB-SE of CTE.
- Serviceability Limit States:

Partial safety factors for actions according to table 4.1 of DB-SE of CTE.

The combination of actions for persistent and transient design situations will be defined in accordance with the criteria in article 4.2.2 of DB-SE of CTE.

5.2.5. Edge beams

Edge beams will be built along the length of the slab joint where dowel connectors will be installed. The design of these beams will be in accordance with the following hypotheses:

- The wall is a linear support for the adjacent slab.
- Dowel connectors are individual supports for the beam.

Concrete edge reinforcement bars (horizontal and vertical bars uniformly distributed) will be dimensioned in accordance with the specifications given in section 2.1 of EOTA TR 065.

When Geoconnect® MP dowel connector joins a slab and different piles, it could happen that the piles are not aligned, in such a way that the edge beam is not straight, making necessary its realignment or supplement. In this case, a specific reinforcement design will be necessary.

The Technical Department of Steel For Bricks GZ SL will design the edge beams, verifying the oblique compression, bending and shear failure, assuming a continuous beam span equal to the distance between dowel connectors.

5.3. Safety in case of fire

5.3.1. Reaction to fire

The only component of the Geoconnect® MP dowel connector that can be exposed to fire is the dowel bar, which is made either of stainless steel or galvanized steel.

Both types of dowel bars have Class A1 without the need for testing, since they are manufactured from materials included in table 1.2-1 of Royal Decree 312/2005 of 2 April 2005, amended by Royal Decree 110/2008 of 12 February 2008. Therefore, they fulfil the requirements stated in DB-SI of CTE.

5.3.2. Resistance to fire

The resistance to fire, expressed by means of the load bearing capacity, of the constructive elements connected with the Geoconnect® MP dowel connectors has been assessed R120 when the dowel connector is protected by Geoconnect® Fire.

The thickness of Geoconnect® Fire will be chosen depending on the initial joint width, in such a way that the dowel bar unprotected length is the lowest possible. When two Geoconnect® Fire units are to be used due to the value of initial joint width, they are positioned adjacent to each other with the intumescent coated layers facing the concrete elements.

The following conditions shall be considered:

- Connectors loaded up to the design shear strength in accordance with this DAU 15/095, in function of the connector used, the characteristics of the connected elements and the reinforcement design, as well as the joint width.
- The concrete elements and reinforcements, as well as the local reinforcement of the connectors, must be designed or protected to have a resistance to fire R120. The minimum thickness of the concrete elements must be 200 mm with a 40 mm minimum concrete cover of the reinforcements at the fire exposed sides. The surface of the connected concrete elements must be flat and smooth to reach an adequate seal of the joint in case of fire.
- The maximum initial length of the dowel bar unprotected within the initial joint width (not covered by Geoconnect® Fire) must be 10 mm.

When the connected constructive elements are subject to resistance to fire compartmentation requirements, and these are applicable to the joint where Geoconnect® MP dowel connectors are installed, appropriate fire protective means shall be considered in the Project to achieve the required performance.

5.4. Hygiene, health and the environment

Geoconnect® MP dowel connectors do not intervene in and have no effect on the fulfilment of the proper conditions to ensure the hygiene and health of the works occupants, provided that the joint is properly covered.

5.5. Safety in use

Geoconnect® MP dowel connectors do not intervene in and have no effect on the fulfilment of the proper conditions to limit the risk for the users to be damaged in the intended use of the building, as a result of the characteristics of the design, construction, use or maintenance, provided that the joint is properly covered.

5.6. Durability

The maintenance of the dowel connectors performance during the working life of the works relates to the following components:

- Dowel bar:

Geoconnect® MP dowel connectors can be used in the following exposure conditions:

- Type G: indoor exposure. Corrosivity category C1 or very low, according to table 80.1.a of Structural Code and UNE-EN ISO 12944-2.
- Type I: indoor and outdoor exposure with moderate air pollution. Corrosivity category C3 or medium, according to table 80.1.a of Structural Code and UNE-EN ISO 12944-2. Categories C1 -very low- and C2 -low- are included.

- Structural elements of the slab, beam, floor, wall, pile or support:

Their durability depends on the fulfilment of the provisions established in article 11.1 of Structural Code, particularly with regard to:

- The definition of the aggressiveness identified due to the type of environment, in accordance to article 11.2 of Structural Code.
- The definition of the structural details and shapes that allow rain water to flow away.
- The design measures that facilitate the maintenance and replacement of the service elements (bearings, joints, drainage, etc.) having a shorter working life than the structure.

- The strategy for durability in accordance with article 11.3 of Structural Code. Among those aspects to be taken into account, the selection of a proper concrete cover for the protection of the concrete edge reinforcement should be stressed.

The working life of Geoconnect® Fire has not been assessed in the framework of this DAU and is lower than the working life of the Geoconnect® MP dowel connectors. Therefore, an adequate maintenance and repair, when necessary, of Geoconnect® Fire is required.

6. Execution, maintenance and preservation criteria

6.1. Execution criteria

6.1.1. General execution criteria

Geoconnect® MP dowel connectors will be delivered to construction site according to the characteristics of the dowel bar (type, length and diameter) and the fixed reinforcement defined in the project, and no further action is required on them.

6.1.1.1. Human and material resources for the execution

Geoconnect® MP dowel connectors positioning and tying to the formwork can be executed by the person responsible of the reinforcements' manipulation.

Special attention should be paid to the installation of the concrete edge reinforcement at both sides of the dowel connector. This reinforcement will thoroughly meet the configuration defined in the project, since the system performance depends on it.

Special means for transportation of the dowel connectors in the works are not required.

For the drilling of the holes in the wall, a drill bit or holesaw of diameter between 3 mm and 5 mm greater than the dowel bar diameter is needed. A compressed air sprayer can optionally be used to remove the dust from the holes.

An injection system is necessary to fill the holes with the resin.

6.1.1.2. Site manipulation. Safety conditions

Gloves will be used for handling the reinforcements.

The necessary preventive measures will be taken in order to avert the risks relating to the execution of the slabs and walls where the dowel connectors are placed (falls from height, cuts caused by reinforcement, hits and falls of the load during the concrete pouring, etc.)

6.1.1.3. Checking prior to installation

Those aspects given in table 3.1 must be verified previous to installation. In addition, it will be verified that no single element (drainpipe, opening, etc.) interferes with the dowel connectors.

6.1.1.4. Environmental exposure of Geoconnect® Fire

Geoconnect® Fire has not been assessed in outdoor conditions and, therefore, if during the execution it could be exposed to such conditions, adequate measures will be taken for its protection.

6.1.2. Execution sequence

- Drill the holes in the existing wall, pile or support and clean the holes by means of, for example, compressed air.

Holes depth will comply with the specifications given in the structure drawings.

- Fill the holes with resin or mortar without shrinkage (see section 2.2 of this DAU).
- Insert the dowel bars into the holes to the specified depth.
- Install the fixed reinforcement of the dowel bar at the side of the slab, beam or floor, and tie this reinforcement to the near reinforcements. This step can be done after preparing the formwork for the slab, beam or floor, but before placing the reinforcements.

The color mark in the dowel bar shows the position of the fixed reinforcement and the cover of the slab, beam or floor (see section 4.3 of this DAU). Both aspects are defined in the structure drawings.

- Prepare the formwork for the slab, beam or floor and place the reinforcements.

Usually, the edge beam reinforcement is prefabricated, so modification of the cross-ties position of this reinforcement may be necessary in order to prevent interference with the dowel bars or the reinforcements of Geoconnect® MP.

- The concrete edge reinforcement is then placed at both sides of the dowel connector. Pour and vibrate the concrete in the slab, beam or floor, once the filling material be hardened.

6.1.3. Concrete edge reinforcement installation

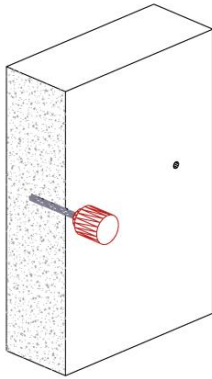
Special attention must be paid to the proper installation of the concrete edge reinforcement at both sides of the Geoconnect® MP dowel connector in the slab, beam or floor.

The position of the concrete edge reinforcement will accurately comply with the design specifications, since the dowel bar performance depends on it.

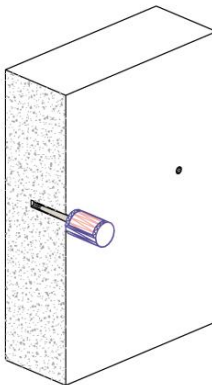
The distance between reinforcements, as well as the distance from the reinforcements to the dowel bar, will comply with the project drawings, which are to be determined in accordance with the geometric model given in section 5.2.2 of this DAU.

The distance between bars will allow for a proper concrete vibration.

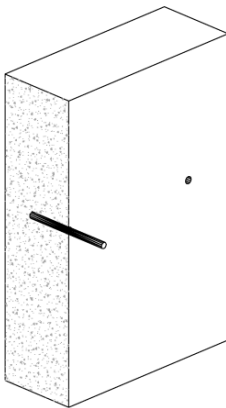
Closed links or cross-ties tilted in relation to the vertical are not allowed.



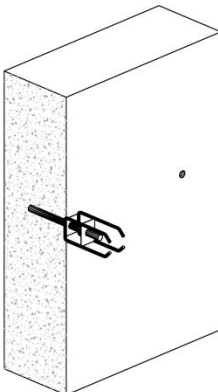
1. Drill the holes in the existing wall, pile or support.



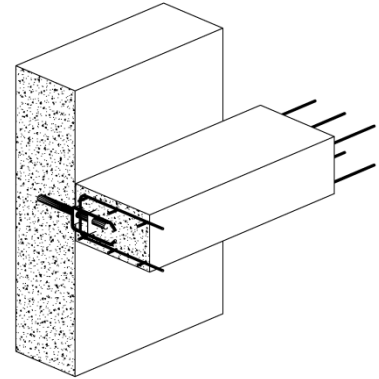
2. Fill the holes with resin or mortar without shrinkage.



3. Insert the dowel bars to the depth specified in the project.



4. Install the fixed reinforcement of the dowel bar and tie to the rest of reinforcements.



5. Pour and vibrate the concrete in the slab, support or floor, once the filling material be hardened.

Figure 6.1: Execution sequence.

6.2. Maintenance and preservation criteria

The maintenance of the structures joined with Geoconnect® MP dowel connectors must be part of the maintenance activities to be programmed and carried out by the Ownership, from the date of entry into service of the structure, in accordance with article 23 of Structural Code and in a manner consistent with criteria established in the project.

In general, it is for the Ownership to keep the complete Construction Project, as well as possible subsequent projects due to repairs, reinforcements, enlargements, etc., as well as reports related to the structure history.

In particular, structures joined with Geoconnect® MP dowel connectors must be part of the Inspection and Maintenance Plan, which establishes the actions to be carried out during their entire working life.

Regarding Geoconnect® Fire, an adequate maintenance and repair, when necessary, is required.

6.3. Measures for environmental protection

6.3.1. Waste treatment

Geoconnect® MP dowel connectors are delivered to construction site without requiring any action on them, therefore waste generation from product manipulation is not expected.

The only waste generation expected is caused by product defects due to wrong manipulation or accidental causes.

According to the Decision 2000/532/EC, as amended, in which the European List of Waste (ELW) is established, it is mandatory that products are identified with an ELW code making the users aware of the corresponding type of waste management. ELW code of the components of the Geoconnect® MP dowel connector is shown in table 6.1.

The generated waste will be handled by an authorized manager in accordance with the legislation in force (see Royal Decree 105/2008 governing the production and management of works and demolition waste).

Components of Geoconnect® dowel	ELW code
Dowel bar and reinforcement	17 04 05

Table 6.1: ELW code.

6.3.2. Installer requirements

Geoconnect® MP dowel connectors can be installed by the same workers in charge of the reinforcement works. Specialized workers are not required.

However, installation and positioning of the concrete edge reinforcement according to the project information must be carried out with great care.

7. Use references and site visits

7.1. Use references

Geoconnect® MP dowel connectors have been installed since May 2013.

The following list of construction works has been provided as references for use:

- 316 houses. Sector UZP 2.01, El Cañaveral. Madrid.
- 108 houses. Sector Espartales Norte. Alcalá de Henares (Madrid).
- 55 houses. Enlargement of Vallecas. Madrid.
- Car park in the extension of the Hospital Universitario Marqués de Valdecilla. Avenida Valdecilla. Santander.
- Residential building El Carmen. C/Eslava, C/De la Serna and Callejones de El Perchel. Málaga.
- Residential building Mirasierra. C/Jardines de la Condesa and C/Mirador de la Reina. Residential complex Mirasierra. Madrid.
- 51 houses. Valdebebas. (Madrid).
- Reconstruction and extension of a 97-dwelling building in Residencial San Mateo. Avenida Juan Carlos I. Lorca. (Murcia).
- 52-dwelling building. Partial Plan Las Rosas. Madrid.
- Service complex for a new BBVA office. C/Fresneda, C/Sauceda and C/Agüi. Las Tablas. Madrid.
- 47 houses. Partial Plan Roza Martín. Majadahonda. (Madrid).
- 47 houses. Sector El Juncal. Alcobendas. (Madrid).
- 26 houses. C/Ernest Lluch. Fuenlabrada. (Madrid).
- Recycling center in the Data Center of BBVA. C/Batanes and C/Ronda in Valdecarrizo. Tres Cantos (Madrid).
- Biodomo. Park of Science in Granada. C/Profesor Agustín Escribano. Granada.
- 35 houses. PERI Sur in San Fernando. Coslada. (Madrid).
- 99 houses. Sector Los Girasoles. Torrejón de Ardoz. (Madrid).

7.2. Site visits

A sampling has been done to construction works in which Geoconnect® MP dowels have been used, both in executed works and in execution progress.

The selected works were inspected by personnel from the ITeC, resulting in the *Informe de visitas de obra*⁸ included in the *Dossier Técnico*⁹ of DAU 15/095.

The aim of the visits has been, on one hand, to contrast the applicability of the execution instructions with the human resources and materials defined by Steel For Bricks GZ SL and, on the other hand, to identify aspects that allow the prevention of possible pathologies that could affect the executed system.

The relevant aspects identified in the site inspections have been incorporated in the project and execution criteria indicated in chapter 5 and 6 respectively.

8. Testing and calculation assessment

The fitness for use of Geoconnect® MP dowel connectors has been assessed regarding the fulfilment of the *Procedimiento Particular de evaluación*¹⁰ of DAU 15/095.

This procedure has been developed by ITeC taking into account the Spanish legislation on construction applicable in each case:

- in buildings, the basic requirements established by the CTE for each basic requirement
- in other construction fields, the relevant specific legislation,

as well as other additional requirements related to the durability and serviceability of the system.

The tests that are part of this assessment have been carried out at Applus, on samples representative of the product subject of this DAU, taken by personnel from the ITeC at the holder's facilities. All test and calculation reports, as well as the sampling report, are included in the *Dossier Técnico*⁹ of DAU 15/095.

8.1. Mechanical resistance and stability

Tests have been carried out with two objectives:

- Validation of the geometric model for calculation of the slab performance regarding the concrete edge failure.
- Validation of the methodology used for the verification of concrete and dowel bar failure in the wall, pile or support.

8.1.1. Validation of the geometric model for the design of the concrete edge reinforcement

Verification method given by EAD 050019-00-0301¹¹ March 2019. The assessment has involved double movement dowel connectors and the use of stainless steel and polypropylene sleeves. 18 couples of slabs have been tested according to dimensions and configurations given in EAD. The characteristics of the tested samples are given in table 8.1, the test results in table 8.2 and the results of the assessment in tables 8.3 and 8.4.

The results have enabled to adjust the geometric model for the concrete edge reinforcement design in such a way as to meet the requirements established in EAD.

⁸ Site visits report.

⁹ Technical Dossier.

¹⁰ Particular Assessment Procedure.

¹¹ EAD 050019-00-0301 *Dowels For Structural Joints Under Static and Quasi-static loading*, March 2019 supersedes former ETAG 030-1 *Dowels for structural joints*, April 2013. The verification method according to EAD slightly differs from that in ETAG 030-1.

Test samples characteristics						
Sample number	Dowel type	Concrete strength at test start (N/mm ²)	Dowel bar embedment depth in the wall (mm)	Joint width (w) [mm]	Dowel bar material	Sleeve material
3-20-1	GC-LL-20	26,0	155	10	Stainless steel 1.4462	Polypropylene
4-30-1	GC-LL-30	22,3	220	10	Stainless steel 1.4462	Stainless steel 1.4301
5-30-1	GC-LL-30	21,9	220	10	Stainless steel 1.4462	Stainless steel 1.4301
6-30-1	GC-LL-30	21,2	215	20	Stainless steel 1.4462	Stainless steel 1.4301
7-40-1	GC-LL-40	24,8	285	10	Stainless steel 1.4462	Polypropylene
8-40-1	GC-LL-40	26,0	285	10	Stainless steel 1.4462	Polypropylene
9-40-1	GC-LL-40	22,4	280	20	Stainless steel 1.4462	Polypropylene
11-20-2	GC-LL-20-DM	27,2	150	20	Stainless steel 1.4462	Polypropylene
13-30-2	GC-LL-30-DM	24,8	220	10	Stainless steel 1.4462	Stainless steel 1.4301
14-30-2	GC-LL-30-DM	22,6	220	10	Stainless steel 1.4462	Stainless steel 1.4301
15-30-2	GC-LL-30-DM	20,2	215	20	Stainless steel 1.4462	Stainless steel 1.4301
16-40-2	GC-LL-40-DM	20,7	285	10	Stainless steel 1.4462	Polypropylene
17-40-2	GC-LL-40-DM	21,9	285	10	Stainless steel 1.4462	Polypropylene
18-40-2	GC-LL-40-DM	27,5	280	20	Stainless steel 1.4462	Polypropylene
19-40-1	GC-LL-40	21,6	285	10	Galvanized steel 1.7225	Polypropylene
20-40-1	GC-LL-40	21,3	280	20	Galvanized steel 1.7225	Polypropylene
21-40-2	GC-LL-40-DM	20,5	285	10	Galvanized steel 1.7225	Polypropylene
22-40-2	GC-LL-40-DM	20,2	280	20	Galvanized steel 1.7225	Polypropylene

Table 8.1: Characteristics of the tested samples.

Sample number	Test results. Concrete edge failure					
	Ultimate limit state			Serviceability limit state		
	Load ($F_{u,test,ce}$) [kN]	Shear force ($V_{u,test,ce}$) [kN]	Displacement ($d_{u,test,ce}$) [mm]	Load ($F_{s,test,ce}$) [kN]	Shear force ($V_{s,test,ce}$) [kN]	Displacement ($d_{s,test,ce}$) [mm]
3-20-1	48,63	32,42	12,6	32,7	21,8	4,3
4-30-1	87,92	58,61	5,4	50,0	33,3	2,5
5-30-1	93,01	62,01	4,5	72,0	48,0	2,9
6-30-1	43,78	29,19	12,6	36,6	24,4	3,5
7-40-1	66,45	44,30	3,3		Not appreciable	
8-40-1	91,15	60,77	12,5	75,8	50,5	8,0
9-40-1	115,21	76,81	15,1	97,0	64,7	6,7
11-20-2	45,10	30,07	13,9	39,4	26,3	8,0
13-30-2	83,47	55,65	10,5	65,1	43,4	8,7
14-30-2	83,52	55,68	6,4	60,0	40,0	4,7
15-30-2	86,86	57,91	8,5	78,0	52,0	7,4
16-40-2	76,18	50,79	7,8	66,9	44,6	8,3
17-40-2	101,85	67,90	4,2		Not appreciable	
18-40-2	101,79	67,86	5,6		Not appreciable	
19-40-1	146,33	97,55	6,9	85,0	56,7	3,4
20-40-1	132,79	88,53	5,1	105,0	70,0	3,4
21-40-2	90,83	60,55	4,5	76,8	51,2	3,7
22-40-2	108,26	72,18	5,5	76,3	50,9	4,1

Table 8.2: Test results.

Sample number	Assessment of results						
	Ultimate limit state (ULS)				Serviceability limit state (SLS)		
	Shear force from ULS test ($V_{u,test,ce}$) [kN]	Shear force from calculation [kN]		$(V_{u,test,ce} - V_{u,cal,ce,2}) / V_{u,cal,ce,1}$	Shear force from SLS test ($V_{s,test,ce}$) [kN]	Shear force from ULS test ($V_{u,test,ce}$) [kN]	$V_{s,test,ce} / V_{u,test,ce}$
	$V_{u,cal,ce,1}$ (1)	$V_{u,cal,ce,2}$ (2)					
3-20-1	32,42	131,76	1,96	0,23	21,8	32,42	0,67
4-30-1	58,61	110,52	0,38	0,53	33,3	58,61	0,57
5-30-1	62,01	176,84	6,76	0,31	48,0	62,01	0,77
6-30-1	29,19	107,76	0,36	0,27	24,4	29,19	0,84
7-40-1	44,30	159,00	5,88	0,24	Not appreciable	44,30	---
8-40-1	60,77	135,16	3,78	0,42	50,5	60,77	0,83
9-40-1	76,81	212,88	12,67	0,30	64,7	76,81	0,84
11-20-2	30,07	108,16	1,95	0,26	26,3	30,07	0,87
13-30-2	55,65	160,76	3,46	0,32	43,4	55,65	0,78
14-30-2	55,68	153,52	3,15	0,34	40,0	55,68	0,72
15-30-2	57,91	145,16	2,79	0,38	52,0	57,91	0,90
16-40-2	50,79	148,04	5,19	0,31	44,6	50,79	0,88
17-40-2	67,90	186,40	8,36	0,32	Not appreciable	67,90	---
18-40-2	67,86	208,80	10,47	0,27	Not appreciable	67,86	---
19-40-1	97,55	185,12	8,24	0,48	56,7	97,55	0,58
20-40-1	88,53	183,92	8,12	0,44	70,0	88,53	0,79
21-40-2	60,55	147,40	5,14	0,38	51,2	60,55	0,85
22-40-2	72,18	179,08	7,67	0,36	50,9	72,18	0,70

$$(1) V_{u,cal,ce,1} = \sum \psi_i \cdot A_s \cdot f_{yk} \cdot (f_{cm,test,i} / f_{ck,nom})^{0,5}$$

$$(2) V_{u,cal,ce,2} = \pi \cdot d_s \cdot \Sigma l'_{1,i} \cdot 2,25 \cdot 0,3 \cdot (f_{cm,test,i} - 8 \text{ MPa})^{2/3}$$

Table 8.3: Assessment of results.

Table 8.4 shows the statistical analysis done using a normal distribution of values $(V_{u,test,ce} - V_{u,cal,ce,2}) / V_{u,cal,ce,1}$.

Statistical treatment of $(V_{u,test,ce} - V_{u,cal,ce,2}) / V_{u,cal,ce,1}$		
Mean value [kN]	Standard deviation	$X_{1,1}$ (5% fractile of $V_{u,test,ce} / V_{u,cal,ce}$ with a confidence level of 75%)
0,34	0,08	0,21

Table 8.4: Statistical treatment of $(V_{u,test,ce} - V_{u,cal,ce,2}) / V_{u,cal,ce,1}$.

The characteristic value of $V_{s,test,ce} / V_{u,test,ce}$ (see table 8.3) is 0,58. Accordingly, the design value of the corresponding cracking Serviceability Limit State ($V_{Rd,ce,SLS}$) is as follows:

$$V_{Rd,ce,SLS} = 0,58 \cdot V_{Rk,ce,ULS} / \gamma_{C,SLS}$$

where $\gamma_{C,SLS} = 1,0$.

8.1.2. Validation of the methodology used for the verification of the failure in the wall, pile or support

Ten samples have been tested composed of a concrete cube with a dowel bar embedded, reproducing the connection of the dowel bar and the wall, pile and support. A load has been applied on the dowel bar to simulate the shear force in the connection.

Different types, diameters and embedment depths of the dowel bar have been used. The characteristics of the tested samples are shown in table 8.5, and the obtained results are shown in table 8.6.

The results have enabled to adjust the methodology used by the Technical Department of Steel For Bricks GZ SL for the verification of concrete and dowel bar failure in the wall, pile or support.

Test samples characteristics						
Sample number	Sample dimensions (length x width x height) (mm)	Dowel type	Concrete strength at test start (N/mm ²)	Dowel bar steel yield strength (N/mm ²)	Dowel bar embedment depth in the wall (mm)	Distance from the load to the wall (joint width / 2) (mm)
1a	500 x 250 x 500	GC-MP-20-G	26,3	930	160	15
1b	500 x 250 x 500		21,1	930		
2a	500 x 400 x 500	GC-MP30-G	26,3	1.007	215	20
2b	500 x 400 x 500		21,1	1.007		
3a	500 x 400 x 500	GC-MP-30-G	26,3	1.007	225	15
3b	500 x 400 x 500	GC-MP-30-I	21,1	781		
4a	500 x 400 x 500	GC-MP-40-G	26,3	994	270	25
4b	500 x 400 x 500	GC-MP-40-I	21,1	791		
5a	500 x 400 x 500	GC-MP-40-G	26,3	994	290	15
5b	500 x 400 x 500		21,1	994		

Table 8.5: Characteristics of the tested samples.

Sample number	Values obtained from the proposed methodology		Test results			Comparison between test results and design values
	Design shear strength ($V_{Rd,calculation}$) (kN)	Ultimate test shear strength ($V_{u,test}$) (kN)	Ultimate displacement (d_u) (mm)	Design shear strength (1) ($V_{Rd,calculation}$) (kN)	Design displacement (1) (d_d) (mm)	$(V_{u, test}) / (V_{Rd,calculation})$
1a	36,23	55,75	7,68	33,0 ~ 34,0	1,95 ~ 2,02	1,54
1b	33,22	51,69	10,86	31,0 ~ 33,0	2,23 ~ 2,40	1,56
2a	89,04	132,42	11,77	100,0 ~ 110,0	5,47 ~ 6,15	1,49
2b	81,73	107,41	12,90	60,0 ~ 70,0	3,11 ~ 3,74	1,31
3a	94,30	138,25	12,37	95,0 ~ 105,0	4,67 ~ 5,28	1,47
3b	74,17	107,44	9,21	60,0 ~ 70,0	2,51 ~ 3,05	1,45
4a	160,61	230,83	16,33	170,0 ~ 190,0	5,69 ~ 6,59	1,44
4b	127,40	199,53	14,71	90,0 ~ 120,0	3,85 ~ 5,26	1,57
5a	175,92	245,66	11,84	130,0 ~ 175,0	3,61 ~ 5,38	1,40
5b	155,02	221,38	16,64	145,0 ~ 160,0	4,99 ~ 5,61	1,43

Notes:

(1) Approximate values at the beginning of the nonlinearity zone of the curve force vs. displacement.

Table 8.6: Test results for the validation of the methodology for the verification of the failure in the wall, pile or support.

8.2. Resistance to fire

The resistance to fire of the concrete elements connected with Geoconnect® MP dowel connectors, protected with Geoconnect® Fire according to section 2.3, has been assessed R120 in accordance with UNE-EN 13501-2, on the basis of the tests performed in the DAU 15/096 in accordance with UNE-EN 1365-2.

A test specimen of the following characteristics was tested:

- Reinforced concrete elements (one acting as supporting structure and the other one as supported structure) with a concrete cover of the lower

reinforcement of 40 mm, connected with two dowel connectors.

- Geoconnect® dowel connectors with a dowel bar of diameter 20 mm and stainless steel 1.4462.
- One dowel connector protected with two Geoconnect® Fire 2020 and the other one protected with one Geoconnect® Fire 2020 and a block of mineral wool of 20 mm thickness.
- Joint width of 60 mm with an initial dowel bar unprotected length of 15 mm.

- Applied load according to the design shear strength of the dowel connectors.

The use differences of Geoconnect® MP and Geoconnect® LL described in section 1.4 of this DAU have been analysed, as well as the constructive characteristics such as the nominal joint width or the use limitations given in section 1.3, the dowel bar characteristics such as dimensions and material, and also the applicability of the tests performed under DAU 15/096 to the Geoconnect® MP dowel connectors, to come to the conclusion that the performance is valid for all the range of connectors and constructive solutions in accordance with the design criteria given in section 5.3.2 of this DAU.

9. Experts commission

This DAU has been submitted to the opinion of an Experts Commission, as indicated in the *Reglament del DAU* (DAU Regulation) and in the Work Instruction for the elaboration of DAU.

The Experts' Commission was constituted by representatives of different organizations and institutions, which have been chosen for their knowledge, independence and impartiality to give a technical opinion regarding the scope of this DAU.

The general list of experts that have made up the experts commissions of DAU is available on ITeC website itec.es.

Comments and observations raised by the DAU Commission members have been included in the text of the present DAU.

10. Reference documents

- Structural Code (Royal Decree 470/2021 of endorsement of Structural Code, which is the regulation that rules concrete, steel and composite -concrete/steel- structures, and repeals EHE-08 (Instruction for concrete structures) and EAE (Instruction for steel structures).
- DB-SI. Safety in case of fire.
- RD 312/2005 of 2 April 2005 amended by RD 110/2008 of 12 February 2008. Classification of the construction products and elements according to their properties with respect to reaction to fire and resistance to fire.
- RD 105/2008 of 1 February governing the production and management of works and demolition waste.
- Decision 2000/532/EC of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste.
- EAD 050019-00-0301 *Dowels for Structural Joints Under Static and Quasi-static Loading*.
- EOTA TR 065 *Design of Structural Joints With Shear Dowels*.
- ETA 16/0064 Geoconnect® LL.
- ETA 10/0352 Fischer Injection System FIS VL
- ETA 15/0239 Rebar connection with Fischer FIS VL.
- DAU 15/096. Geoconnect® LL dowels.
- UNE-EN 1365-2: Fire resistance tests for loadbearing elements. Part 2: Floors and roofs.
- UNE-EN 1992-1-1: Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings.
- UNE-EN 1993-1-1: Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings.
- UNE-EN 10025-2: Hot rolled products of structural steels. Part 2: Technical delivery conditions for non-alloy structural steels.
- UNE-EN 10083-3: Steels for quenching and tempering. Part 3: Technical delivery conditions for alloy steels.
- UNE-EN 10088-3: Stainless steels. Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes.
- UNE-EN 12944-2: Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Part 2: Classification of environments (ISO 12944-2).
- UNE-EN 13501-2: Fire classification of construction products and building elements. Part 2: Classification using data from fire resistance tests, excluding ventilation services.

Superseded by UNE-EN ISO 683-2

11. Assessment of fitness for use

Based on the following experimental technical evidence obtained during the preparation of the DAU 15/095 according to the criteria defined in the *Procedimiento Particular de Evaluación del DAU 15/095*, prepared by ITeC

- tests and calculations results,
- information from the site visits,
- factory production control,
- instructions for system installation and execution,
- project and execution criteria,

and taking into account the methodology prescribed in the *Reglament del DAU*, the authorization and the ITeC register for awarding DAU* and the indications in section 5.2 of article 5 of the CTE-*Código Técnico de la Edificación*, regarding the assessment of products

and innovative systems, it is considered that ITeC has the evidences to declare that the constructive system, executed with Geoconnect® MP dowel connector, executed according to the instructions given in this DAU, is appropriate for its use in:

- connections between beams or solid or lightened slabs -of a floor, roof or foundation-, shuttering slabs (pre-slabs) or one-way or two-way spanning slab floors, and walls, piles or concrete supports, where transfer of shear loads is required without relative movement between elements,

since it fulfils the relevant regulatory requirements on mechanical resistance and stability, safety in case of fire, hygiene and health, as well as durability and serviceability requirements.

As a result, and once this document has been submitted to the Experts Commission and their comments have been included in it, ITeC awards the DAU to the product manufactured by Steel For Bricks GZ SL.

The DAU validity is subjected to the actions and monitoring conditions specified in chapter 12 and to the use conditions of chapter 13.

(*) ITeC is an authorized organism for awarding the DAU (BOE 94, 19 April 2002) for construction products (building and civil engineering) registered in the General Register of the CTE: <https://www.codigotecnico.org/RegistroCTE/OrganismosAutorizados.html>.

DAU 15/095
Documento
de adecuación al uso



ITeC Technical Director



12. DAU monitoring

The present DAU is subjected to the surveillance actions that ITeC carries out periodically, in accordance with the *Reglament del DAU*. The purpose of this monitoring is to check that the characteristics of the product and the constructive system, as well as the execution and manufacturing conditions, are still valid for the envisaged intended uses.

If relevant changes affecting the DAU validity occur, these will result in a new DAU edition that will supersede the previous one (this new edition will take the same DAU code as the superseded one and a new letter edition).

When changes are of minor importance and they do not affect the DAU validity, these will be specified in a list of changes that will be incorporated as chapter 15 of the DAU; furthermore, these changes will be included as well in the DAU text.

The DAU user must always look up the DAU electronic version available in pdf format on ITeC website itec.es, in order to make certain of its possible revisions that may occur during its validity. This document is also available through the QR code included in the DAU stamp.

13. Use conditions of DAU

In granting the DAU, the ITeC is not responsible for:

- The presence or absence of any patent, intellectual property or similar existing rights subsisting in the product or any other product, nor rights that affect third parts or the fulfilment of obligations to any of this third parts.
- The right of the DAU holder to manufacture, supply, install or maintain the product.
- The actual works or individual batches in which the product is installed, used and maintained; including the nature, design, methods and workmanship of or related to the installation.

In addition, the DAU cannot be ever interpreted as a guarantee, commitment or responsibility of the ITeC relating to the commercial viability, patentability, registrability or innovation of the results derived from the preparation of the DAU. This is, then, the holder's responsibility to check the viability, patentability and registrability of the product.

The assessment of the DAU does not purport in any way to restate the regulatory requirements of the Health & Safety at Work or occupational risk prevention, relating to the manufacture, supply, installation, use and maintenance of this product. Therefore,

The ITeC does not accept responsibility to any person or body for any loss or damage, including personal injury, which may occur in the event of breach of the relevant requirements within the mentioned legislative framework.

14. List of changes of the present edition

The electronic version of the DAU includes, if any, the updating, changes and corrections of the present edition G of the DAU 15/095, indicating the date of incorporation, according to the format of the following table. The changes shown in the table will also be integrated in the text of the DAU, which is available on the Institute's website, itec.es.

The DAU user must always consult the DAU electronic version in order to make certain of its possible revisions, which may occur during its validity.

Number	Page and chapter	Where it was said...	It says...
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