Tecnología Avanzada de Construcción

mZtec panel system
TECHNICAL SPECIFICATIONS

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MZtec panel System

Technical Specifications

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1. INTRODUCTION

MZTEC is a construction structural system based on a set of undulated expanded polystyrene panels backed on both sides with a basic reinforcement consisting of highly resistant steel mesh and corrugated bars attached to one another by electrically welded steel connector rods.

These panels are installed on site in accordance with the layout of walls, partition walls and beams in the design and are fitted "in situ" by shotcreting with a mechanical or pneumatic projection tool.

The panels thus fit in with the structural elements in the vertical and horizontal enclosures of the building. The load-bearing capacity should be calculated in accordance with the code requirements for structural concrete.

This system uses wet-mix joints as the join between the different elements in the system is continuous. Thus there are no horizontal or vertical joints once the concrete has been sprayed.

MZTEC is an open system as it can be combined with other traditional and non-traditional construction systems such as one-way or waffle slabs, semi resistant joists, hollow-core slabs, in-situ slabs, or metal joists.
These panels are placed on site, according to the walls layout, partitions and slabs according to the project design.
The structural design calculations are justified in every project according to the local building codes.

The functions in the constructive elements of our construction technology are:
1 - Continuous thermal insulation of high capacity;
2 - Suitable structural strength to support all types of loads;
3 - Implementation of horizontal and vertical enclosures;
4 - Continuous waterproofing;
5 - Fire resistance according to building code;

Currently MZtec System has approval in different countries such as Spain or Bangladesh to build up to six stories, with the assumptions established in the following chapters.

2. HISTORY OF USE

MZtec constructive technology has been globally developed for more than 30 years and can be summed up as a single structural element that forms the basis of a constructive system of

reinforced concrete, with its varied and well-known resistance performance, yet very light weight with a high level of thermal insulation.

During the past 30 years, under different trademarks, the constructive system based on panels of "EPS + steel + concrete" has been used as a "streamlined construction system" in countries such as: USA, Mexico, Guatemala, Panama, Puerto Rico, Dominican Republic, Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile and Argentina in the Americas.

With regards to the European Community, they have been used in the great majority of its countries, but mainly in Portugal, Spain, Italy, Switzerland, Ireland and Germany. There have also been a lot of buildings constructed with this technology in many African countries, and there is an abundant history of certificates of technical conformity for its use in Algeria, Tunisia, Morocco, Libya, Egypt, Angola, Nigeria and Ghana, the Ivory Coast and Gabon among others. In Asia there have also been various constructions in the Arab Emirates, Saudi Arabia, Malaysia, India, etc.

From our records, over the last few years just in Spain and Morocco more than 800,000 m2 of buildings have been constructed of all different types. Listed below are details of a selection of the most relevant buildings that we have on our register.

	Year	Description	Floors	City	Country
	2003	Industrial Building 9,000 m2	1	Toledo	Spain
	2004	Bungalow type Resort Hotel	1	Huelva	Spain
	2005	85 Flats [used in closing walls, and interior partitions]	15	Gerona	Spain

	2005	Silicon Wafer Manufacturing Plant - Silicio Solar. 30,000 m2	1	Puertollano	Spain
	2005	32 Homes with foundations and special structure	3	Málaga	Spain
	2006	Detached Family Home 350 m2	2 + basement	Malaga	Spain
	2006	500 Homes Social Housing	5	Tangiers	Morocco
	2007	1000 Homes Social Housing	5	Martil	Morocco
	2008	450 Homes Social Housing	2	Seville	Spain
	2008	170 flats	6	Zaragoza	Spain
	2009	24 Semi-detached Houses	2 + basement	Tenerife	Spain
	2008	32 Semi-detached Houses	2	Burgos	Spain

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	2006	72 Flats	8	Madrid	Spain
	2008	Univeristy Residences (UAM) 7,000 m2	3	Madrid	Spain
	2008	Shopping Centre	2	Madrid	Spain
	2008	Nursery School	2	Cadiz	Spain
	2009	Sports Centre	2	Madrid	Spain
	2010	Professional Recording Studio	1	Madrid	Spain
	2011	Interior lining of tunnel 30,000 m2	-	Estepona	Spain
	2012	Electric Substation - Iberdrola	1	Madrid	Spain

	2012	Social Housing	1	Mali	Mali
	2012	University Mixed Structure	5	Cordoba	Spain
	2013	2 Police constables building	2	Bengaluru	India

3. DESCRIPTION

The basic element of the construction system is the corrugated panel of expanded polystyrene that has steel mesh attached on both sides interlinked by electro-welded connectors.

The core thickness of expanded polystyrene can vary from 3 cm to 30 cm, depending on the architectural project needs.

The mesh is composed of 20 longitudinal bars of plain galvanized steel of minimum 2.5 mm diameter on each side. For the slab elements, the mesh consists of 6 bars of corrugated steel with a minimum diameter of 5 mm on each side and the remaining 14 bars of plain galvanized steel with a minimum diameter of 2.5 mm. In the secondary direction there is a bar of plain galvanized steel with a diameter of 2.5 mm every 75 or 150 mm according to the calculation.

The mesh protrudes 50 mm on opposite sides, in such way that the overlap between them ensures the continuity for juxtaposition of the frames without the need for placing additional joint elements.

The mesh pieces are connected to each other through a minimum of 40 bars of 3 mm in diameter by panel breadth, arranged in groups of 6 connectors every 15 cm, for each 1200 mm wide plate. The number of connectors as well as the diameter to be used in the panel will increase if necessary on the basis of the calculation of each particular case.

For wall joints between enclosures that form an angle between themselves, the continuity is resolved by means of angular mesh supplied for that purpose.

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It is important to mention that all the processes involved in the manufacture of the elements that compose the MZtec System are permanently subject to controls required by existing ISO standards.
MZtec panels are completed with a layer of micro concrete of 3 cm thickness on each side minimum, after which they can be used horizontally or vertically since they possess the ability to resist centered and eccentric compression, bending and shear forces. They are used as a resistant element and for the transmission of the horizontal loads from wind or earthquake as well.

They are used as load-bearing walls and one way slabs or two way slabs for spans length up to circa 6 meters. MZtec system is designed according to the local building codes similar than concrete traditional structures.

They can be used as soil retaining walls, checking in each case that the resultant bending moments of active earth pressure are lower than the moments allowed of the composite section; vertical panels can be arranged perpendicular to buttresses which will be reinforced with steel according to the calculations.

On the slabs the thickness of the compression layer of concrete is 5 cm minimum. The thicknesses are measured from the external part of the wave of expanded polystyrene.

4. COMPOSITION OF THE PANELS

The structural enclosure panel is made up of a layer of undulated expanded polystyrene with a density of 12-15kg/m^2 and a standard width of 1,200 mm as a maximum.

The thickness of the expanded polystyrene may vary between 4 cm and 30 cm depending on the requirements of the architectural design. The thickness of the expanded polystyrene plus the concrete layer, which is 30 mm on each side, makes up the total thickness of the wall. The depth of the EPS undulation is 15 mm and each one is separated from the next one by 75 mm. Thus along its length there are 13 curved waves and 3 waves with inverted curvature (to identify the panel) for each panel with a nominal width of 1,200 m maximum.

The reinforcement of the panel is designed in accordance with the local building codes and requirements for every project.
The mesh is compound by plain galvanized steel bars from 2.5 mm to 3 mm diameter and/or corrugated steel bars 5 mm diameter.

The connectors are compound by plain galvanized steel bars from 3 mm to 4 mm diameter. Independently of the structural design, every panel has a minimum reinforcement indicated as follow.

The meshes are made up of 20 longitudinal steel bars on each side. The longitudinal panel reinforcement will be designed considering a minimum reinforcement of 20 plain galvanized bars 2.5 m diameter. There are transverse plain galvanized steel bars, 2.5 mm in diameter, each 75 or 150 mm.

The resultant reinforcement grid measures 75 x 75 mm or 75 x 150 mm.
The meshes have an extension of 38 mm at opposite ends in such a way that when two panels are joined together they overlap. Thus they ensure they are placed side by side without the need for additional elements to join them up.

These meshes are joined together by 40 electrically welded steel connectors per linear meter of panel minimum.
Once the structural enclosures have been plastered they can be used vertically as load-bearing walls in buildings since they have the capacity to resist concentrated and eccentric compression as well as flexure and shear stress.

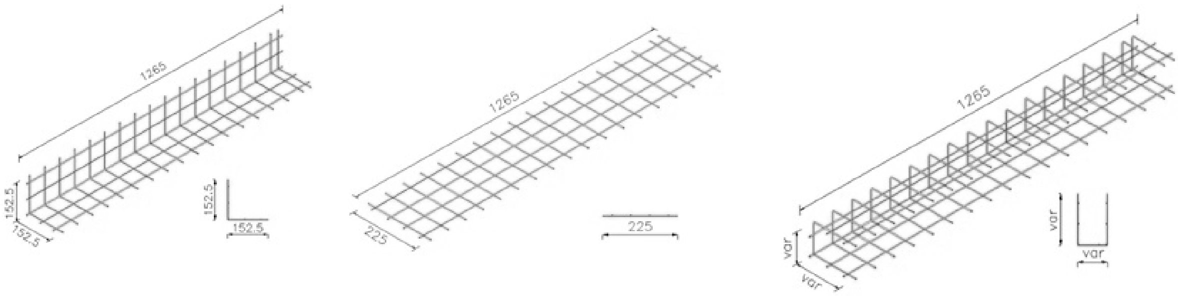
Where enclosures meet at an angle, continuity is resolved by angular meshes supplied for such a purpose.

There are different galvanized meshes to reinforce MZtec system.
All of them are compound by galvanized steel wires with 2,5 mm in diameter and grid dimension 75 cm x 75 cm.

- Flat Mesh (MP): Used for straight joints between panels.

- Angular Mesh (MA): Uses in perpendicular joints between wall-wall and wall-slab. The angle can be adapted by hand.

- “U” Mesh (MU): Used for reinforcing edges and openings.



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Picture 1. Detail of reinforcement mesh

5. TYPICAL CONFIGURATIONS

Most common configuration of the panels is indicated below as a reference.

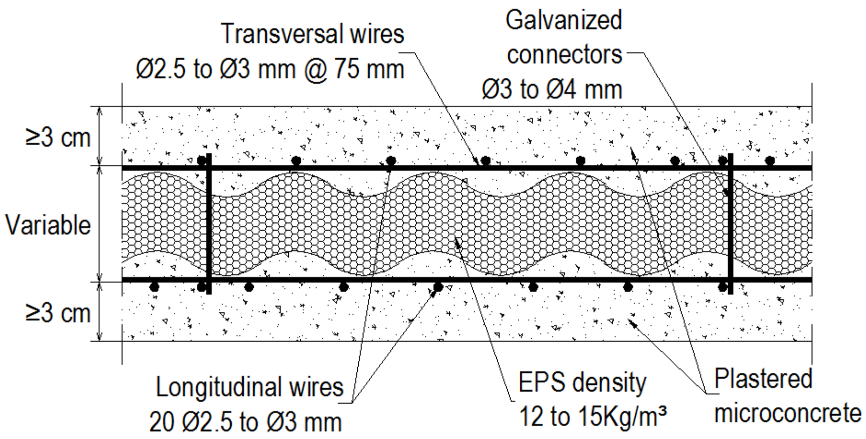
5.1 MZN Panels for load bearing walls

MZN panel is designed as a vertical enclosure with structural capacity, in order to use in buildings constructed entirely MZtec system or in combination with traditional systems (slabs, beams, columns or slabs).
The thickness of the expanded polystyrene may vary between 4 cm and 30 cm depending on the requirements of the architectural design. The thickness of the expanded polystyrene plus the concrete layer, which is 30 mm on each side, makes up the total thickness of the wall. The depth of the EPS undulation is 15 mm and each one is separated from the next one by 75 mm. Thus along its length there are 13 curved waves and 3 waves with inverted curvature (to identify the panel) for each panel with a nominal width of 1,200 mm.

The meshes are made up of 20 longitudinal steel bars on each side made of plain galvanized steel wire with 2.5 mm diameter. There are transverse plain galvanized steel bars, 2.5 mm in diameter, each 75 mm.
The resultant reinforcement grid measures 75 x 75 mm.

The meshes have an extension of 38 mm at opposite ends in such a way that when two panels are joined together they overlap. Thus they ensure they are placed side by side without the need for additional elements to join them up.
These meshes are joined together by 40 electrically welded steel connectors per linear meter of panel minimum.

Once the panels are installed on site, micro concrete must be plastered with 30 mm thickness in each side by means of pneumatic machines. Dimensions are measured from the crest of the EPS wave.



Picture 2. Detail of MZN wall panel

Technical features

	Standard width (m)	EPS Thickness (cm)	EPS Density (kg/m^3)	Surface mass (kN/m^2)	U (W/m^{2º}K)	Total thickness (cm)
MZN-40	1,200	4	12-15	1,83	0,801	11,5
MZN-50	1,200	5	12-15	1,83	0,664	12,5
MZN-60	1,200	6	12-15	1,84	0,568	13,5
MZN-80	1,200	8	12-15	1,84	0,440	15,5
MZN-100	1,200	10	12-15	1,84	0,359	17,5
MZN-120	1,200	12	12-15	1,85	0,303	19,5
MZN-140	1,200	14	12-15	1,85	0,262	21,5
MZN-160	1,200	16	12-15	1,85	0,231	23,5
MZN-180	1,200	18	12-15	1,86	0,207	25,5
MZN-200	1,200	20	12-15	1,86	0,187	27,5
MZN-250	1,200	25	12-15	1,87	0,151	32,5
MZN-300	1,200	30	12-15	1,88	0,126	37,5

Minimum reinforcement	
Longitudinal Rebar	20Ø2,5 mm (plain galvanized steel fy = 620 MPa)
Transversal Rebar	Ø2,5 mm@75 mm (plain galvanized steel fy = 620 MPa)
Connectors	6Ø3 mm per row - Step 150 mm (plain galvanized steel fy = 620 MPa)

Notes:

The panel height is manufactured according to requirements of the project.
Minimum micro-concrete thickness 3 cm per side.
U: overall coefficient of heat transfer
Ra: Overall sound reduction index

5.2 MZR Panels for load bearing walls

MZR panel is designed as a vertical enclosure with structural capacity, in order to use in buildings constructed entirely MZtec system or in combination with traditional systems (slabs, beams, columns or slabs). MZR panel is based on the MZN panel configuration with additional corrugated steel bars with higher strength.

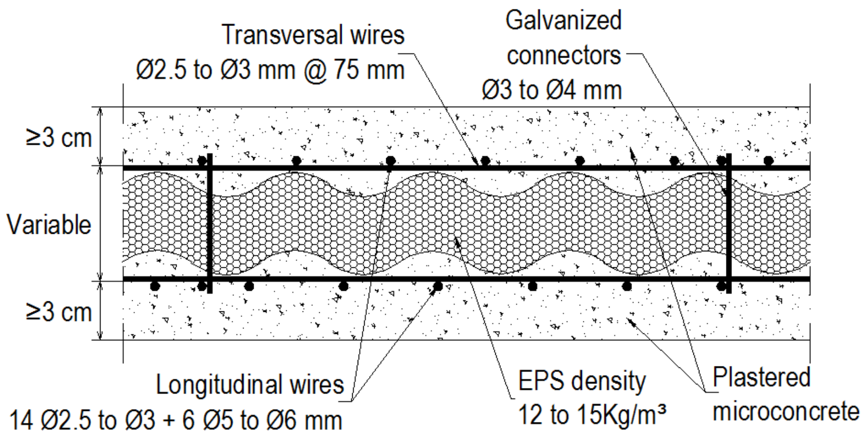
The thickness of the expanded polystyrene may vary between 4 cm and 30 cm depending on the requirements of the architectural design. The thickness of the expanded polystyrene plus the concrete layer, which is 30 mm on each side, makes up the total thickness of the wall. The depth of the EPS undulation is 15 mm and each one is separated from the next one by 75 mm. Thus along its length there are 13 curved waves and 3 waves with inverted curvature (to identify the panel) for each panel with a nominal width of 1,200 mm.

The meshes are made up of 20 longitudinal steel bars on each side made of 14 plain galvanized steel wire with 2.5 mm diameter and 6 corrugated steel bars 5 mm diameter.. There are transverse plain galvanized steel bars, 2.5 mm in diameter, each 75 mm.

The resultant reinforcement grid measures 75 X 75 cm.
The meshes have an extension of 38 mm at opposite ends in such a way that when two panels are joined together they overlap. Thus they ensure they are placed side by side without the need for additional elements to join them up.
These meshes are joined together by 40 electrically welded steel connectors per linear meter of panel minimum.

MZR panel can be used as retaining walls for ground floors with a height of up to 3 metres while ensuring in each case that the resulting bearing moments of the active pressure are less than the permissible moments in the composite section. They may include perpendicular vertical panels as buttresses which should be reinforced with corrugated bars in accordance with calculations.

Once the panels are installed on site, micro concrete must be plastered with 30 mm thickness in each side by means of pneumatic machines. Dimensions are measured from the crest of the EPS wave.



Picture 3. Detail of MZR wall panel

Technical features

	Standard width (m)	EPS Thickness (cm)	EPS Density (kg/m^3)	Surface mass (kN/m^2)	U (W/m^{2º}K)	Total thickness (cm)
MZR-40	1,200	4	12-15	1,83	0,801	11,5
MZR-50	1,200	5	12-15	1,83	0,664	12,5
MZR-60	1,200	6	12-15	1,84	0,568	13,5
MZR-80	1,200	8	12-15	1,84	0,440	15,5
MZR-100	1,200	10	12-15	1,84	0,359	17,5
MZR-120	1,200	12	12-15	1,85	0,303	19,5
MZR-140	1,200	14	12-15	1,85	0,262	21,5
MZR-160	1,200	16	12-15	1,85	0,231	23,5
MZR-180	1,200	18	12-15	1,86	0,207	25,5
MZR-200	1,200	20	12-15	1,86	0,187	27,5
MZR-250	1,200	25	12-15	1,87	0,151	32,5
MZR-300	1,200	30	12-15	1,88	0,126	37,5

Minimum reinforcement	
Longitudinal Rebar	6Ø5 mm (corrugated steel fy = 500 MPa) 14Ø2,5 mm (plain galvanized steel fy = 620 MPa)
Transversal Rebar	Ø2,5 mm@75 mm (plain galvanized steel fy = 620 MPa)
Connectors	6Ø3 mm per row - Step 150 mm (plain galvanized steel fy = 620 MPa)

Notes:
The panel height is manufactured according to requirements of the project.
Minimum micro-concrete thickness 3 cm per side.
U: overall coefficient of heat transfer
Ra: Overall sound reduction index

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5.3 MZF Panels for slabs

MZF panel is designed as a horizontal enclosure with structural capacity, in order to use in buildings constructed entirely MZtec system or in combination with traditional systems (slabs, beams, columns or slabs). MZF panel has the same configuration than MZR panel but with a minimum 50 mm concrete thick in one side of the panel (compression layer).

The thickness of the expanded polystyrene may vary between 4 cm and 20 cm depending on the requirements of the architectural design. The thickness of the expanded polystyrene plus the concrete layer, which is 30 mm on each side, makes up the total thickness of the wall. The depth of the EPS undulation is 15 mm and each one is separated from the next one by 75 mm. Thus along its length there are 13 curved waves and 3 waves with inverted curvature (to identify the panel) for each panel with a nominal width of 1,200 mm.

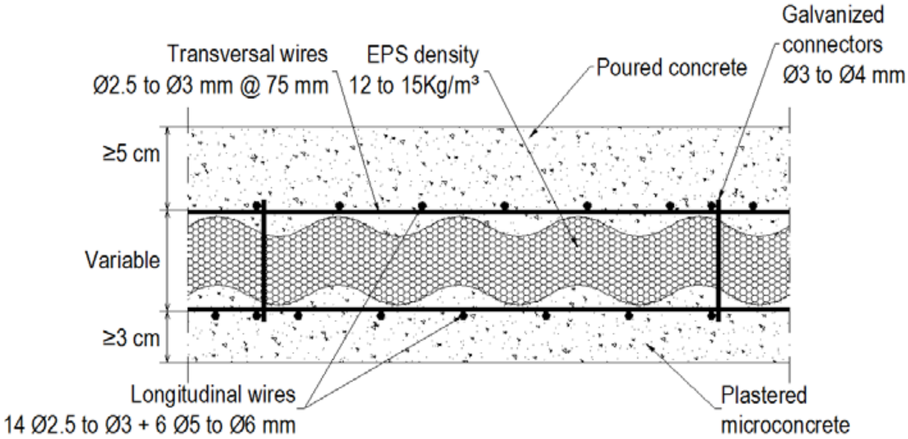
The meshes are made up of 20 longitudinal steel bars on each side made of 14 plain galvanized steel wire with 2.5 mm diameter and 6 corrugated steel bars 5 mm diameter.. There are transverse plain galvanized steel bars, 2.5 mm in diameter, each 75 mm.
The resultant reinforcement grid measures 75 X 75 cm.

The meshes have an extension of 38 mm at opposite ends in such a way that when two panels are joined together they overlap. Thus they ensure they are placed side by side without the need for additional elements to join them up.
These meshes are joined together by 40 electrically welded steel connectors per linear meter of panel minimum.

MZF panels have the capacity to resist flexure and shear stress. They also serve to transmit and distribute horizontal loads to the vertical load-bearing elements.
As a general rule MZF panel can be used for 5-6 meters span length, being necessary the structural design according to the local building code.

When the slabs are supported along their four edges, supplementary corrugated reinforced bars can be installed perpendicular to the corrugated bars 5 mm in diameter in the MZtec panel meshes in order to form a two-way slab.

One the panels are installed on site, 30 mm thickness micro concrete must be plastered in the inferior side and each side by means of pneumatic machines and 50 mm normal concrete must be poured in the upper side (compression layer). Dimensions are measured from the crest of the EPS wave.



Picture 4. Detail of MZF slab panel

Technical features

	Standard width (m)	EPS Thickness (cm)	EPS Density (kg/m^3)	Surface mass (kN/m^2)	U ($W/m^{2º}K$)	Total thickness (cm)
MZF-40	1,200	4	12-15	1,83	0,801	11,5
MZF-50	1,200	5	12-15	1,83	0,664	12,5
MZF-60	1,200	6	12-15	1,84	0,568	13,5
MZF-80	1,200	8	12-15	1,84	0,440	15,5
MZF-100	1,200	10	12-15	1,84	0,359	17,5
MZF-120	1,200	12	12-15	1,85	0,303	19,5
MZF-140	1,200	14	12-15	1,85	0,262	21,5
MZF-160	1,200	16	12-15	1,85	0,231	23,5
MZF-180	1,200	18	12-15	1,86	0,207	25,5
MZF-200	1,200	20	12-15	1,86	0,187	27,5
MZF-250	1,200	25	12-15	1,87	0,151	32,5
MZF-300	1,200	30	12-15	1,88	0,126	37,5

Minimum reinforcement	
Longitudinal Rebar	6Ø5 mm (corrugated steel fy = 500 MPa) 14Ø2,5 mm (plain galvanized steel fy = 620 MPa)
Transversal Rebar	Ø2,5 mm@75 mm (plain galvanized steel fy = 620 MPa)
Connectors	6Ø3 mm per row - Step 150 mm (plain galvanized steel fy = 620 MPa)

Notes:
The panel height is manufactured according to requirements of the project.
Minimum micro-concrete thickness 3 cm per side.
U: overall coefficient of heat transfer
Ra: Overall sound reduction index

5.4 MZC non-load-bearing vertical panels

MZC panel is designed as a non-load bearing wall to be used as a closings and partitions in buildings with steel or concrete frame.

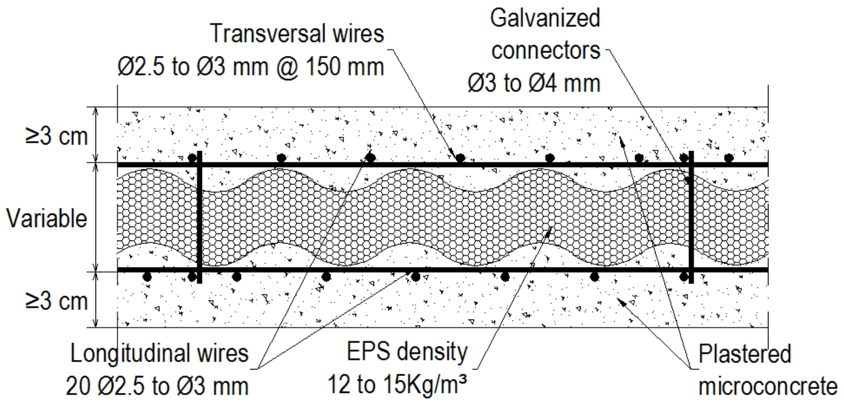
The thickness of the expanded polystyrene may vary between 4 cm and 30 cm depending on the requirements of the architectural design. The thickness of the expanded polystyrene plus the concrete layer, which is 30 mm on each side, makes up the total thickness of the wall. The depth of the EPS undulation is 15 mm and each one is separated from the next one by 75 mm. Thus along its length there are 13 curved waves and 3 waves with inverted curvature (to identify the panel) for each panel with a nominal width of 1,200 mm.

The meshes are made up of 20 longitudinal steel bars on each side made of plain galvanized steel wire with 2.5 mm diameter. There are transverse plain galvanized steel bars, 2.5 mm in diameter, each 150 mm.

The resultant reinforcement grid measures 75 x 150 mm.
The meshes have an extension of 38 mm at opposite ends in such a way that when two panels are joined together they overlap. Thus they ensure they are placed side by side without the need for additional elements to join them up.

These meshes are joined together by 40 electrically welded steel connectors per linear meter of panel minimum.

Once the panels are installed on site, micro concrete must be plastered with 30 mm thickness in each side by means of pneumatic machines. Dimensions are measured from the crest of the EPS wave.



Picture 5. Detail of MZC wall panel

Picture 6.

Technical features

	Standard width (m)	EPS Thickness (cm)	EPS Density (kg/m^3)	Surface mass (kN/m^2)	U (W/m^{2º}K)	Total thickness (cm)
MZC-40	1,200	4	12-15	1,83	0,801	11,5
MZC-50	1,200	5	12-15	1,83	0,664	12,5
MZC-60	1,200	6	12-15	1,84	0,568	13,5
MZC-80	1,200	8	12-15	1,84	0,440	15,5
MZC-100	1,200	10	12-15	1,84	0,359	17,5
MZC-120	1,200	12	12-15	1,85	0,303	19,5
MZC-140	1,200	14	12-15	1,85	0,262	21,5
MZC-160	1,200	16	12-15	1,85	0,231	23,5
MZC-180	1,200	18	12-15	1,86	0,207	25,5
MZC-200	1,200	20	12-15	1,86	0,187	27,5
MZC-240	1,200	24	12-16	1,87	0,157	31,5
MZC-260	1,200	26	12-15	1,87	0,145	33,5
MZC-300	1,200	30	12-15	1,88	0,126	37,5

Minimum reinforcement	
Longitudinal Rebar	20Ø2,5 mm (plain galvanized steel fy = 620 MPa)
Transversal Rebar	Ø2,5 mm@150 mm (plain galvanized steel fy = 620 MPa)
Connectors	6Ø3 mm per row - Step 150 mm (plain galvanized steel fy = 620 MPa)

Notes:
The panel height is manufactured according to requirements of the project.
Minimum micro-concrete thickness 3 cm per side.
U: overall coefficient of heat transfer
Ra: Overall sound reduction index

6. HABITABILITY AND CONFORT FEATURES

6.1 Thermal insulation

It is said that two enclosures are thermally equivalent when they have the same value of thermal isolation. As an illustrative example we indicate the following values of thermal transmittance K expressed in W/m2ºC for different classes of traditional construction enclosures, and their relation with a wall with 11,5 cm total thickness (5 cm EPS) made with our technology using Class III EPS, which represents a value of K = 0.752. This relation will show by how many times this MZtec wall is a better thermal isolator of minimum thickness and density against any of the ones mentioned in the following table:

Type of enclosure	Thickness (cm)	K (W/m2ºC)	Ratio
Reinforced concrete	27.5	2,51	3,34
Common solid brick	15.0	2,91	3,87
Double wall of common solid brick w/ 3m air chamber	30.5	1,47	1,95
Double wall of solid fairface brick and hollow brick 8 cm opening w/ 3m air chamber.	25.0	1,86	2,47
12 cm hollow brick w/ 3cm air chamber and common plastered brick	30.0	1,9	2,53
Hollow concrete blocks	19.0	2,7	3,59

6.2 Acoustic insulation

Acoustic isolation constitutes one of the advantages the system offers to achieve excellence in comfort in accordance with the most demanding conditions and meeting with the building code.
Some relevant test carried out is indicated in following chapters.
In the case of special acoustic isolation the problem can be solved with the use of special panels that have a layer of mineral wool of variable thickness and density according to necessity inserted in the expanded polystyrene.

6.3 Fire resistance

Resistance to fire typical of this typology, verified in the trials carried out in different laboratories, more than satisfies the requisites required by the strictest of regulations. For example, a finished 10 cm thick wall, obtained from a 4 cm expanded polystyrene panel, has a resistance to direct fire of 110 minutes (Institute of Material Research and Trials, Chile).

Expanded polystyrene is a poorly inflammable material and needs great volumes of combustive air (approximately 150 times its own volume) for the fire to destroy it completely. Therefore since it is confined it cannot burn. In addition, the quality of expanded polystyrene used by MZtec is type F self-extinguishable according to standards DIN 4102, so the material itself avoids the tendency from the beginning of the combustion.

The relevant composing fraction of its combustion gases, from a toxicological point of view, is like in wood, Carbon monoxide, but in a very limited amount. According to DIN standards, emission of Carbon Oxide during the combustion of different materials is the following:

- Wooden fiber: 69.000 ppm at 600 ºC

- Wood: 15,000 ppm at 600 ºC
- Cork: 29,000 ppm at 600 ºC
- Expanded polystyrene F: 1,000 ppm at 600 ºC

As can be observed in the previous table, exhalation of carbon monoxide is between 15 and 69 times less than with wood and its derivatives as construction materials.

6.4 Physical chemical stability

Expanded polystyrene as well as micro concrete are materials of great physical-chemical stability. In addition, the absence of empty spaces and biodegradable materials in the interior of the MZtec walls and floors, prevent the development of any type of insect colony.

The appropriate water-resistant insulating capacity happens thanks to the low absorption of the material components. The micro concrete cement achieves it through its strength in vertical insulating layers and the compaction that is obtained by the pneumatic projection of the same; the polystyrene, inherent in its own sealed closed cell structure and in total immersion tests for 28 days verifies absorption of only 2% by weight.
The absorption test is done at the Institute Eduardo Torroja, carried out according to UNE EN 1609 casts an absorption W = 0,028 kg/m2.

6.5 Resistance to water vapor diffusion

Resistance to water vapor diffusion of MZtec walls is a lot greater than most walls of traditional construction. If for example, we make a comparison with a wall of 20 cm vibrated concrete blocks and calculate the resistance Rv according to common methods in engineering this results in the following values without considering any element as vapor barrier:
Calculated permeability

Expanded polystyrene,	δ = 0,003750 g/mhkPa
Cement Mortar:	δ = 0.0150 g/mhkPa
Hollow concrete blocks	δ = 0.0520 g/mhkPa
Interior plaster:	δ = 0.0600 g/mhkPa
Exterior plaster	δ = 0.0487 g/mhkPa

Results:

-Concrete block wall 20 cm	Rv = 3,801 m2 hkPa/g
-MZtec wall MZN 60	Rv = 20 m2 hkPa/g

The raise in resistance to water vapor diffusion provided by MZtec wall in this case is equal to 5.2 times.

This resistance to vapor diffusion of MZtec walls is centralized reinforced cement mortar that coats each one of the sides of the panel and that because of its pneumatic application technology results very compact and with very low porosity.

7. MZTEC SYSTEM FEATURES COMPARED WITH TRADITIONAL SYSTEMS

MZtec system is the only technology which streamlines the implementation of effectiveness and efficiency at the same time.

By using normal and well known materials (reinforced concrete to withstand force and expanded polystyrene to provide thermo-acoustic insulation), utilised in such way that their properties are enhanced, and satisfying all the building requirements that must be fulfilled, especially in the case of housing.

In this regard, it is worth mentioning that the main and fundamental requirement to be met by a construction destined for housing is the thermal insulation, the essential reason of its very existence.

And it is a result of the fulfillment of that particular condition that arises the need to satisfy other requirements, namely: mechanical resistance, structural capacity, ease of implementation, the rational use of resources, architectural flexibility, fire resistance, good sound absorption; although each one has its importance, none of them reach that of the thermal insulation, and illustrates in this aspect the fact that if a house were to meet all the "secondary" requirements but had poor thermal insulation, such housing would be unsatisfactory for its occupants, regardless of the full compliance with all the other aspects.

This significantly affects the habitability of housing conditions and helps lower the cost of thermal conditioning, as much in summer as in winter, even in extreme conditions. This virtue has been testified through a myriad of constructions in the most diverse countries, with harsh weather conditions (Equatorial Africa, Antarctica and Siberia).

Associated with the high thermal insulation property mentioned can be found the advantageous total absence of thermal bridges due to the total continuity of the expanded polystyrene in the whole outer surface of the dwelling.

7.1 Economy - rational use of resources - ease of execution

This is the point where the degree of industrialization reached by the system predominantly influences the implementation of civil works.

And it must be pointed out that even the most conservative and traditional systems, whose methods for various reasons we have grown accustomed to, also have their own degree of industrialization, aimed at optimizing the utilization of resources during execution.

It is therefore clearly rational to subject the MZtec system to critical judgement in light of the concepts that have sustained the use of the systems until now called traditional, this analysis not necessarily only being theoretical, but predominantly practical, since the number of constructions made in the entire world more than justifies such an attitude:
in all the places in which it was used, it satisfied all the requirements, resulting in a better alternative for the implementation of housing, either from an economic or technical point of view.

The main consequence of the features that make the rationality translates into an important economy in all the areas in which the construction system has interference.

7.2 Indirect savings - evaluation

The reduction of total costs that provoke the use of MZtec technology in place of traditional construction systems is clearly calculable by comparing direct costs of labour and materials.
However, there are a number of additional significant indirect savings when using our technology that are grouped into the following points:

Overheads
The reduction of grey work (foundations-structure-vertical enclosures-coverings- cable chasing in installations) leads to reduction in administrative costs lead time allows a reduction in administrative costs, energy for the movement of equipment, salaries of foremen, site managers and supervisors, depreciation of machinery, scaffolding, repairs, vans and cars for inspection and site managers, as well as financial expenses costs, financing and service interests.

This reduction in period of grey work that is closely related to the possible higher speed execution normally reaches 50%. In this way and considering that the grey work represents between 40 and 50% of the total work period, it would be possible to reduce the duration of the works by approximately 22%. If we consider that a construction company has general weighted expenditure of 15% of the sum of materials and labor, the application of the MZtec system will enable it to be reduced to 11.70%.

Secondary costs
Understood as the provision of labor and materials to cover the channels made in the walls by the installation of electricity, water and gas, its participation in the reduction of total costs can be perfectly determined. By way of illustration, for a unit of 60 m2 a daily 1 worker and 1 helper are required to cover up all the channels; this leads in a reduction in costs of 1.40 %.

Opening pipes

The opening of pipes that installers must do on traditional brick walls uses up labor that is non-existent when this technology is employed. It can be considered that for the example that we are analyzing 2 day helper are needed for the labor of opening the channels and cleaning the work area; this in economic terms leads to a reduction of 1.20 %.the requires 2 days helper for the work of opening of gutters and cleaning of work area; this in economic terms leads to a reduction of 1.20%.

Difference in hours paid-hours worked: as result of the systematization of tasks, and based on the experiences of construction companies that have replaced the traditional technology with the MZtec system, it is possible to affirm that the best savings due to better use of the working day is equal to 6.25%. This means that a saving of half an hour per working day has been saved on assignment of tasks during the period corresponding to the grey building work.

If we consider that the participation of the labour force in the total cost of work out is 45%, this aspect will mean a saving of: 0.0625 x 45% x 50% = 1.40% of the total cost.

Cleanliness on site

This item has a particular importance given that the system has a single wet stage which is the application of the micro-concrete cement, while the elevation of walls is dry and with manipulation of clean elements that do not produce debris. In addition, during the installation stage, there is no opening of channels and therefore there is no generation of debris with the consequent need of their collection and subsequent removal.

The volume of debris that is produced with a building made with factory bricks is normally 0.12 m3 per m2 covered, and the manpower that must be employed in cleaning and hauling is 3-HH/m3.

The cost of dumping in Spain is approximately 20 €/m3 so the total cost of this item represents an economic impact of more than 2.00%.

Less total surface to equal floor space

Using MZtec technology enables a significant reduction in the thickness of the exterior and interior walls of a dwelling. By way of example, consider the thickness of the exterior walls of a traditional dwelling of 28 cm (double wall with air chamber) with a thermal transmittance K = 1.90 W/m2 ° C and interior walls of 12 cm in total thickness, compared to MZtec outer walls of 15 cm of total thickness with K = 0.39 W/m2 ° C and 10 cm thick interior walls. In this case, with equal useful floor area, a construction made with MZtec presents a decrease of total surface area equal to 5.74%.

Summing up the points listed above we obtain the indirect saving that, in addition to the reduction of direct costs, can be considered to exceed 15% and it is the reason why, MZtec

technology can also be used in lieu of the traditional building systems in those countries where the cost of labor is very low.

7.3 Architectural flexibility

This aspect, although secondary, gains importance in some housing categories in that the architectural variables play a predominant role. This is so given that the functional needs as regards the daily habitability of the house are more variable with the habits, family composition and other characteristics of each customer.

For these reasons it should be considered as a genuine and important virtue the possibility of providing a constructive system for a wide range of architectural styles, as in the case of MZtec, whose possibilities in this regard are virtually unlimited, as well as simple.

With the MZtec system the most diverse architectures can be achieved and proof of this is that all over the world buildings have been made which represent the most disparate cultures, from houses of traditional and modern architecture to temples and churches of varying architectural styles as well as industrial constructions.

7.4 General maintenance – adaptability with other building systems

Cconstructions with MZtec, once finished, require significantly less maintenance than usual. This is because it has a superior water-resistant insulating capacity resulting in longer duration of plasters and paints. It also helps towards greater mechanical resistance, which implies the absence of cracks in buildings.

As regards to the adaptability to combining it with other building systems, experience has shown that its capacity is not only wide but easy to implement, adapting to the more rational solutions for any type of join and combinations.

The constructive system is open. That is to say that it can combine or integrate with all other types of traditional or non-traditional building systems.

The user of a home built with this technology can extend, modify, remove or add walls, or even add floors to their home with total safety.

This aspect has made it most appropriate for work on the rehabilitation of historic buildings. In Spain we have many cases where this technology is attached to buildings built in the 15th century, providing the benefits of thermal insulation and stiffening qualities.

Given that the core of the panel is expanded polystyrene, it may be the most appropriate way which fully respects the traditional architecture of the place. In this way, we will have buildings that will perfectly integrate to the local urban landscape, but with all the properties of structural strength and thermal-acoustic construction elements of the 21st century.

Nobody would notice any difference from the formal point of view, between a home built today with this technology and one built 300 years earlier.

Neither would anybody be able to distinguish with the naked eye whether or not the house that is built with our technology is a traditional construction method or not.

In the Latin culture, it is very important that the walls of a house sound solid when they are hit. It is for that reason that the constructions with MZtec technology are highly valued by the users and also by the developers since they do not have elements that undermine its market value in any way.

The walls are highly resistant and they show it in their visual appearance as such.

8. MATERIAL

The different parts which make up the panels in the MZTEC System are manufactured in expanded polystyrene (EPS) and steel mesh.

8.1 Expanded Polystyrene

Expanded polystyrene is a thermoplastic material produced by polymerization of styrene. EPS as a material is made by fusing a number of expanded polystyrene beads produced during a molding process which uses steam heat.

Expanded Polystyrene

Nominal Density	12-15 kg/m^3
Thermal Conductivity	0,039 W/m·K
Resistance to steam	0,15 m·Hg·m^2·day/g·cm
Reaction to fire	According to UNE –ENE 13501-1:2007
Compressive stress at 10% de deformation	$\sigma_{10} \geq 50$ kPa
Flexural strength	$\sigma_B \geq 100$ kPa
Designation Code	EPS EN 13163 T1 L1 W1 S1 P3 DS(N)5 DS(79/)=)1BS100

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The thickness of the core of expanded polystyrene panels MZtec is such that thermal insulation obtained for the enclosure, complies with the requirements of the building codes.
EPS manufacturing is processed in three steps:

1. Pre - expansion.
2. Maturation and molding. EPS 650FF is heated by steam at 100°C in a pre - expander.

The foaming agent present in the polystyrene beads vaporizes and mixes with steam.
The gas mixture so produced subsequently softens the beads and expands them to 30 - 40 times to its initial size. In maturation process the foaming agent and steam condense in the cells of the pre-foamed beads causing partial vacuum, which is compensated by the diffusion of air into the beads. The maturation period could be between 3 and 24 hours. In the molding process the matured pre-foamed beads can further be processed by direct steam to the desired shape molding.

Suppliers:
-Basf
http://www.plasticsportalasia.net/wa/plasticsAP~en_GB/portal/show/content/products/foams/styropor_productline
-Sabic
http://www.sabic.com/corporate/en/productsandservices/plastics/epsflameresistantgrades.aspx
Considering the thermal conductivity certified according to UNE-EN 13163:2002 for density 12-15 kg/m3, are the following values of heat transfer coefficient RSI, having considered that the thickness of the micro concrete thermal conductivity is equal to 1.4 W/m^2 C:

Vertical closing	
Horizontal flow	
Panel type	**RSI (W/m^2 C)**
MZN-40	0,801
MZN-50	0,664
MZN-60	0,568
MZN-80	0,440
MZN-100	0,359
MZN-120	0,303
MZN-140	0,262
MZN-160	0,231
MZN-180	0,207
MZN-200	0,187

8.2 Steel

The corrugated bars used in the panels have 500 MPa yield strength.
The plain steel bars are galvanized have 620 MPa yield strength and 700 MPa ultimate strength.
The corrugated reinforced bars installed on site are designed for 500 MPa yield strength.
Minimum elongation > 5 %
Minimum weight of galvanized material in plain bars: 40 - 50 gr/m^2.
Suplliers:

-Socitrel
http://www.socitrel.pt/es/html/arame_zinc_industria.html

8.3 Micro concrete

The pneumatic mortar or structural micro-concrete mixture that is to be projected must complete the requirements listed below:

Ease of application
It should be able to be applied in layers around 25 mm thick without causing landslides, with fluidity and plasticity.

Adequate resistance
It must provide the necessary resistance to meet the structural functions that it will be submitted to.

Low shrinkage curing
To avoid cracking caused by the evaporation of the excess water in the mix.
To satisfy all the above conditions it is necessary to provide a mixture low in water content and a sand and cement ratio between 3.5 and 4.5.

The unit content of normal Portland cement will vary depending on the required calculation resistance, grain size of sand and the chosen arid-binder ratio resulting in general in a value comprising from 350 Kg/m³ to 400 Kg/m³.

It is recommended that the ratio water/cement by weight does not exceed 0.65 including moisture-free sand.
In the event that additives are necessary due to low workability of mix obtained with these dosages, add a water reducer, in the proportions recommended by the manufacturer.

When the concrete is produced on-site, it will be convenient to add 12.5 mm of polypropylene fiber for each 0.90 kg m3 of mixture. Its purpose is to provide an anti-shrinking setting network and at the same time increasing the tenacity of the micro-concrete.

Curing it is of fundamental importance, as in all the concretes with a large surface area and little volume due to the action of the atmospheric agents. Proper curing consists of allowing the process of hydration of the cement to take place, avoiding the premature evaporation of the free water, which it is necessary to maintain surface moisture (often sprayed with water), taking special care with direct exposure to solar radiation and wind during the first 24 hours of settlement.

It is an important factor for the final quality of the produced cement mortar to be worked by foot, strong compaction provided by means of pneumatic application; this also influences the high resistance characteristics achievable.

The use of premixed mortar in industrial mortar plants (micro-concrete) is accepted. This product is manufactured by various companies that are in possession of an officially recognized quality seal, and must comply specifically with the requirements of the MZtec technology such as:
a) Guarantee minimum compression strength of 16 N/mm2 for the non-structural elements (MZC) or 25 N/mm2 for the structural elements (MZN/MZR/MZF).
b) To be projectable in layers of about up to 25 mm of thickness without lift

The basic composition of the micro-concrete usually involves the following components:

Arids
Lime or siliceous of controlled particle size and humidity always lower than 1.00 % and from quarries that possess certified product quality. Can be used for the fractions Limestone Mineral Powder (Filler), AF-T-0/2C y AF-T-0/4C

Cement
33 or 43 grade Portland cement

Additives
Fluidifiers and polypropylene fiber.
Formulations must comply with the provisions laid down in the regulations in force with respect to the durability.
The implementation that is recommended for these mortars are as follows:
Adjust the system of the projection machine which regulates the water pressure and its dosing through the hydrometer.

The mixing water (around 15% on dry sample) leads to a runoff of up to 180 ± 5 mm measured on a shaking platform S/UNE IN 1015-3 (roughly equivalent to a settlement in the cone of Abrams of 140 mm). Thus the consistency obtained is adequate for its projection.

The application of micro-concrete must always be performed in 2 phases, leaving the open pore between them by means of a teeth trowel or similar to achieve the required finish on application.

Four possible basic procedures exist:

1. The manual application of micro concrete with traditional masonry tools to render mode.
2. Application using manual pneumatic devices of "Hopper gun" type or manual plasterers, which can be for walls or ceilings.

3. The application of micro-concrete through plastering pump machines similar than the one used for mortar with continuous screw (stator-rotors twister) or piston plastering compressors.
4. Application of micro-concrete by pouring micro concrete into an appropriate system of formwork that contains the panel. With a proper dosage a 30 mm thick filling can be made.
All the procedures are perfectly valid and their use depends on the resources available and the magnitude of the work to be done.

The MZtec system has perfectly developed each one of the possibilities.
Suppliers:
-Local companies

9. QUALITY CONTROL

Quality control is carried out on the raw materials which make up the panels and on the finished product itself and the installation of the system on site.

9.1 In Plant

9.1.1 Raw Material

9.1.1.1 Expanded Polystyrene

The expanded polystyrene is in possession of CE marking, filling the characteristics certified according to UNE-ENE 13163:2002
Production in the plant is controlled with regard to the following aspects

1) *Visual*
There is a 100% visual check on material received in the plant, which includes:
- Integrity of the block
- The purchase order corresponding to the transport document
- A check of the marking on each block.

2) *Dimensional*
Every 5 blocks received in the plant undergoes a dimensions check where it is measured with a tape measure and checked for a tolerance of +2 cm. It is also checked for visible damage.

3) *Density*
Once they have been measured, they are weighed with a Class I electronic balance in order to calculate a quotient relating to their weight and volume to establish their density.

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The density calculated from the weight on the balance must not be lower than 90 % of the nominal weight for the item.

4) *Inflammability*
From each batch a sample is taken for the purpose of verifying compliance with the quality of the raw material F

9.1.1.2 Steel

The steel is tested according to the criteria established in the building code.
The control of steel properties will be carried out in accordance with the supplier´s certified report which accompanies each delivery of materials along with a laboratory certificate on which the properties of the steel are stated. The internal quality control plan stipulated in the industrial plant´s Quality Control Manual and external control by a licensed laboratory consist of the following procedure:

The MZtec plant manager will check there is a certificate of origin and conformity with the requested quality requirements.

The steel, which must be provided by a certified supplier, is controlled with regard to the following aspects:

1) *Visual*
There is a 100% visual check on material received in the plant, which includes:
-The purchase order corresponds to the transport document.
-Labelling
-Finish
-Weldability
-Mechanical properties.

2) *Dimensions*
1 coil of wire out of every five delivered undergoes a control. The diameter is checked against the caliber and a one-meter length of wire taken from the coil is weighed on a Class I balance.

3) *Mechanical test*
Samples from the steel mesh are taken on a monthly basis from the production Turing that period. These are submitted to a total of 20 traction test and separation test on welding points. These tests are carried out internally in the production plant on all the different types of steel mesh produced. The internal tests are recorded in the production Logbook.

9.1.2 Finished panel

The following checks are carried out on the finished panel:

1) *Dimensions*
Finished panels are checked with a tape measure for a dimensions tolerance equal to 1/500.

2) *Welding*
A visual inspection is carried out with regard to the welding on the connectors. The connectors which have not been welded correctly by the automatic machine are welded manually.

9.1.3 Steel

The corrugated steel bars used in the construction work will be controlled in accordance with the criteria set out in the building code with regards to a standard control. The test on steel must be carried out by a licensed external laboratory.

9.1.4 Storage

MZtec panels should be stacked horizontally in piles on strips of wood resting directly on the ground. For each pile there will be at least two strips or wooden planks. These will be a maximum of 2.80 meters apart. Each pile should be no more than 35 panels high.
They can also be stacked by resting on one of their edges.
They should be protected from the wind as they are likely to be blown away due to their Light weight and cause an accident.
It is also inadvisable to expose the panels to sunlight for long periods of time.

9.1.5 Transportation and acceptance on site

Panels will be transported in horizontal piles resting on supports strips a maximum of 2.00 meters apart. Each pile can be up to 35 panels high.
Panels can be handled by means of a fork lift truck with two forks, or using cranes or other lifting devices. The panels will be attached at two points for lengths up to 6 meters and at three points for lengths between 6 and 8 meters.

9.2 On site

The quality control shall be applied with the same specifications as the common engineering practice does with structural elements of concrete and steel systems.

The provisions of MZtec technical documents must be strictly considered. The concrete made on site as well as the concrete supplied from a plant batch must be controlled according to the criteria established in the building code. On receipt of the concrete and micro concrete the corresponding packing slip must be requested, tests must be carried out by an external accredited laboratory. As a reference, the following parameters have been established for carrying out the controls according to European building code:

-Batch: Concrete supplied or made on site in a week.
-Extension of the batch: 50 m3
-Number of mixes to control: 2 mixes per batch.
-Number of samples per mix:
3 sample test to break at 24 hours.
3 sample test to break at 7 days
3 sample test to break at 28 days.
The specimens must be molded on-site. The transport of fresh concrete or micro concrete will not be accepted by the external laboratory, it is obligatory to take the samples on-site molding the cylindrical (15x30 cm) or cubic (15x15x15 cm) sample test for concrete and prismatic (4x4x16 cm) or cubic (7x7x7 cm) for micro concrete, which must be carefully cured and preserved until its tested.

Sampling of the concrete will be carried out according to UNE 83300:84 or the equivalent standards in every country. Testing shall be carried out by certified laboratories.
When the concrete is supplied by a batch plant in possession of a Quality Seal officially recognized by the government, it is not necessary to perform the control of reception of material components on site. Otherwise it shall be verified:

Sand
Shall be checked at least once during the execution of the work or when the terms of delivery vary:
-Particle size
-Maximum size of the grains
-Content of fine aggregate according to UNE 7050 or equivalent
-Organic matter content according to UNE 7082 or equivalent and other impurities.

Water
The water for the mix must meet the requirements of building code.

Cement
The cements must be certified by a quality seal.
The consistency may be measured in a cone of Abrams or interchangeably in a vibrating platform.
The corrugated steel bars to be fitted on site will be controlled according to the building code in force. In the reception of steel, the corresponding manufacturer's warranty certificate shall be requested, and tests shall be carried out by an external accredited laboratory. The following parameters have been set for carrying out the control:

Consignment
Material supplied only once to the work place, of the same description and origin.

Batch

20 tonnes of Steel with 6 mm diameter

Extension of batch
20 tonnes
In each batch the following tests will be carried out:
-Two tests of equivalent sections
-Two comparisons of geometric characteristics of the bumps
-Two tests of folding – unfolding
In the course of the work on at least on two occasions shall be determined in a specimen of each delivery:
-Elastic limit
-Breaking load
-Elongation of break

10. BUILDING CONTROL DOCUMENTS

Each inspection visit made by the MZtec system monitor leaves evidence of this through the Installation Control Sheet.

This sheet describes the fundamental aspects of the control of execution. It must be signed by the work manager or person in charge of building work as well as by the MZtec monitor, who will leave the original and take a duly signed copy. The builder shall remedy defects identified according to comments or special instructions which may be recommended. These visit sheets are numbered consecutively on the occasion of each work Inspection.

Once the work is completed, the Quality Control Sheet must be filled out in which will be downloaded all aspects relating to the Protocol of Control of works. It will be drawn up by the supervisor appointed by the supplier of the MZtec system. In such document will be reflected the controls practiced during the course of the work in accordance with the control procedures imposed by the manufacturer in the implementation of the MZtec system on site.

The quality control of tests of micro-concrete and steel should be performed by an external laboratory that is in possession of the quality stamp.

The decisions arising from the control of resistance of the concrete will be applied in accordance with the building code in force. In the case that tests are required for additional information, the tests will be made breaking samples extracted from the hardened micro-concrete.

Given that the thickness of the micro-concrete layers varies between 30 and 37,5 mm as a minimum due to the wavy shape of the base plate of EPS, a sample will be extracted cut by a

circular saw of 120 mm in diameter from which will be cut a prismatic cylinder of 30x30x12 cm.

The evaluation of the resistance of the specimen will be carried out considering the local building code.

11. STRUCTURAL DESIGN

MZtec system is a constructive system based on a set of structural panels of undulate expanded polystyrene, basic rebar, attached to their faces, made up of high resistant steel mesh and corrugated bars, linked by welded steel connectors.

Buildings constructed with MZtec Building System are designed as structures formed by horizontal and vertical elements that constitute the pre-industrial shell once the panels in situ have been plastered. These vertical and horizontal elements behaves as composite sections due to the fact that the two micro concrete layers are linked steel galvanized wire connectors with a final configuration depending on the structural design.

All these qualities are made possible by the combination of its three component materials (Expanded polystyrene, steel and micro concrete) which together can be considered as a Insulated Structural Panel (ISP).

This panel has mechanical properties that depending on the micro-concrete compressive strength and the thickness of expanded polystyrene core meet the strengths requirements.
In this way, structures can be made multi-story buildings with a limitation that will be given mainly by the capacity load limit vertical load-bearing elements.
The response of the section compound by MZtec system is similar to a homogeneous section of reinforced concrete following the assumptions of the present chapter.

11.1 General design requirements

All general design requirements are designed in accordance with the local building code and the specific consideration of this document for MZtec system.

All applied loads required for structural design are determined in accordance with the provisions of building code.

Design parameters required for the structural design of foundation elements conform to the provisions of local building code.

11.2 Basic considerations

11.2.1 General

All buildings and structures are designed and constructed in conformance with the provisions of the local building code. The buildings and portions thereof support all loads including dead load specified in this chapter and elsewhere in building code.

A structure made up of MZtec system ordinarily are described as an assemblage of framing members and components arranged to support both gravity and lateral forces.
Design of buildings and components thereof for gravity loads conform to the requirements of building code in force.

Dead load of MZtec system shall be design according to the values indicated in the technical specifications.

Every MZtec system building, structure or portions thereof is designed to resist the lateral load effects, such as those due to wind or earthquake forces, in compliance with the requirements prescribed in building code.

11.3 Foundation design requirements

The design and construction of foundation, foundation components and connection between the foundation and superstructure conform to the requirements and applicable provisions of building code.
MZtec system walls are considered as pin jointed structures in the wall and foundation connection. All sort of foundations are possible to use with MZtec system.

11.3.1.1 Retaining Wall Design

MZtec walls shall be used as retaining walls for ground floors with a height of up to 3 meters while ensuring walls are designed to resist the lateral pressure of the retained material, under drained or undrained conditions and including surcharge, in accordance with building code and established engineering practice.

11.4 Loads

The minimum design forces including dead load, live load, wind and earthquake loads, miscellaneous loads and their various combinations are designed in accordance to building code. These loads are applicable for the design of buildings and structures in conformance with the general design requirements provided in building code.

For Earth quake forces design in MZtec system buildings, the Response Modification Coefficient R shall be considered as Bearing Wall System with Lateral Force Resisting System compound by concrete shear walls according to the building code.

11.5 Materials

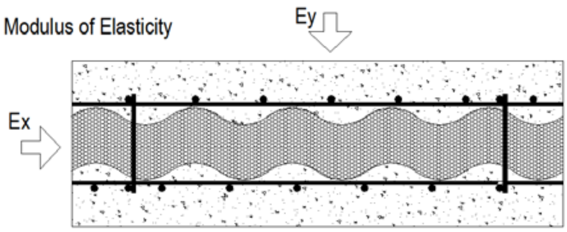
Steel reinforcement shall conform to the provisions of building code.
Modulus of elasticity E_s for reinforcement shall be taken as 200 kN/mm².

Concrete mix proportions shall be such that the concrete is of adequate workability and can properly be applied correctly as indicated in MZtec specifications.

The durability of the micro concrete conforms the specifications of building code.
Strength of micro concrete shall be based on f'_c determined in accordance with the provisions of building code or with a minimum of 25 MPa.

According to the test results, to assimilate a MZtec section to an homogenous concrete gross section, the flexural rigidity for the transversal direction is limited to Ey = 3.000 MPa and it is calculated within the scope of elastic state.

For the transversal direction, modulus of elasticity *Ex* will be considered similar than traditional concrete values specified in the local building code.



Picture 7. Detail of modulus of elasticity directions

11.6 Analysis and Design - General Considerations

11.6.1 General

The buildings constructed with the MZtec system are conceived as structures formed by large vertical and horizontal elements that constitute the grouped pre-industrialised panels once concreted on site. These large vertical and horizontal elements work as composite sections due to the linkage provided with the steel connectors, so that the two layers of plastered micro concrete work on the basis of solidarity as a composite section.

Vertical Elements

The join between each of the elements is structured in such way that the transversal rigidity of each vertical element is negligible compared to the rigidity in the plane. In order to give stability to the buildings, it is necessary for the panels to be placed in two directions in such way that, in addition to supporting the load of the floor slabs, transverse stability is provided in two directions, along with the possible existing cross bracing on each floor. Each case would be studied for the transmission of the horizontal loads through the slabs or from the possible cross bracing.

To obtain the design strength of the panels, all the possible eccentricities in calculating the strength will be taken into account, thermal effects, imperfections, etc, given in the European guideline “Common Guidelines of the UEAtc for the technical construction procedures for heavy prefabricated panels.”

Horizontal elements

In terms of the horizontal elements that constitute the framework, these are also considered to be anchored to their supports, i.e. they are considered isostatic so they do not transmit moment from the embedment to the vertical support elements at any time. The flexural rigidity of the same is limited to consideration of a longitudinal elasticity module equal to 3000 MPa, and is calculated within the zone of elasticity behaviour.

The moment of inertia I depends on the thickness of the panel selected in each case. The behaviour of the panel is studied below in Elastic State I (with no cracking) and indicates the value of the rigidity module ExI of the complete range of MZtec panels. The inertias have been calculated taking into consideration the thickness of the panel plus a thickness of 5 cm for the compression layer and a thickness of 3 cm as interior covering in the tension side.

The mechanical behaviour of the panels is reflected in diagrams of interaction of direct reading. Such diagrams have been found by taking the maximum deformations corresponding to the Ultimate State Limit, according to the conventional assumptions of the calculation of sections to break and calculating the stresses that are produced, following the same procedure than traditional reinforced concrete structures.

In general, it is practical to assimilate the behaviour of the sections formed by the MZtec system to homogeneous sections of reinforced concrete. To verify the centred compressive strength, the ideal thickness of that section is 7 cm which is the sum of the thicknesses of each of the mortar layers. To verify the bending strength, in the same way, the panel made with MZtec technology is considered as a equivalent reinforced homogeneous section of concrete.

The below assumptions and calculations have been verified by means of test programs obtaining a very good correlation between the proposed model and experimental results.

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11.6.2 Bending design

Strength design of members for flexure and axial loads are based on assumptions given in this chapter and satisfy compatibility and equilibrium requirements.
Strains in the steel and the concrete are assumed directly proportional to the distance from the neutral axis.
MZtec slabs are considered as pin jointed structures.
The flexural analysis is based in the following hypothesis:

1. The neutral axis in sections is completely within the layer of concrete compression, so compression is fully absorbed by that material.

2. The tensile forces are absorbed, as in the traditional slabs, by rebars.
According to the test, once MZtec panels are plastered have a behavior similar to a homogenous gross section of concrete.

Tensile strength of micro concrete is neglected in calculations of flexural strength of MZtec elements.

The calculation of composite sections can be made according to the theory of State Limits as defined in the hypotheses mentioned above or in State I considering that the neutral axis of the section is the centre of gravity and the volume of the tensile stress is absorbed by the lower layer of micro-concrete. Of course it will always be the case with the panel frame that there must be sufficient size to absorb the resulting tensile stress. Whichever of these paths are taken, similar values are obtained for the verification of the resistant sections.

For Ultimate State Limit, the maximum deformation of the steel is considered the value of 10‰ and the more compressed fibre is considered 2‰.
When the slab is supported on all four edges and the ratio of longer and shorter span length is between 0.5 and 2, the behavior of the slab generates bending moments in both directions x and y. In that case, MZtec two-way slab is designed by applying the well-known theory of elasticity of thin plates for the boundary conditions corresponding to external link conditions, or also by means of simplified methods that derive from it established in engineering practice.

In case the initial area of tension reinforcement in the panel (1,66 cm2 per direction in the inferior side) is not enough to meet the minimum tension reinforcement, additional deformed bars rebar shall be added.

The slab is considered as pin jointed in every support. There is no considered continuity between spans.

11.6.3 Shear design

The shear response of MZtec system panel is similar than a gross concrete section,
The shear reinforcement in the panels is as a minimum 6 connectors@ 15 cm per 1.200 mm width. Shear analysis is designed following the local building code. As an alternative could be use the equations based on ACI 318-08, Eurocodes or any other methodology established in engineering practice for shear design of concrete sections.

As a reference following shear calculations are based on European Building Code EHE 08:

$$V_{rd} \leq V_{u2}$$

Vrd is the factorized effective shear stress
Vu1 is the maximum shear oblique compression of the concrete section
Vu2 maximum shear tension in the section.
The equations to obtain the maximum shear values for the panels are as follows:

$$V_{u2} = V_{cu} + V_{su}$$

$$V_{su} = z \, sen \; \alpha \, (\, cotg \, \alpha + cotg \, \theta \,) \Sigma A_{\alpha} \, f_{y\alpha,d}$$

$$V_{cu} = \left[\frac{0,15}{\gamma_c} \xi \, (\, 100 \, \rho_l \, f_{ck} \,)^{1/3} - 0,15 \, \sigma'_{cd} \right] b_0 \, d \, \beta$$

$$\beta = \frac{2 \, ctg \; \theta - 1}{2 \, ctg \; \theta_e - 1} \qquad if \; 0,5 \leq ctg\vartheta < ctg\vartheta_e$$

$$\beta = \frac{ctg \; \theta \; - \; 2}{ctg \; \theta_e \; - \; 2} \qquad if \; ctg\vartheta_e \leq ctg\vartheta \leq 2,0$$

Where,
d, distance form extreme compression fiber to centroid of compression reinforcement in mm
b_0, effective width in mm
α=90º
θ, angle between compression strut and axis of the element

$$0,5 \leq ctg\vartheta < 2$$

$f_{y\alpha,d} = f_{yd} / 1,15$
z, lever arm in mm
α_l, angle between shear reinforcement and axis of the element
σ'_{cd}, axial stress in the half section

$$\sigma'_{cd} = \frac{N_d}{A_c} \leq 0,30 \, f_{cd} \leq 12 MPa$$

N_d, Axial force
A_c, Area of concrete

$$\xi = 1 + \sqrt{\frac{200}{d}} \leq 2$$

ρ_l ratio of tension reinforcement= $As/b_0 d$

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$f_{cd} = f_{ck} / \gamma_c$
$\gamma_c = 1,5$
A_α, area of tension reinforcement per unit length
$f_{yd,}$ specified yield strength of shear reinforcement
$f_{cv,}$ Shear effective compression strength $f_{cv} = f_{ck} \leq 15$ N/mm2

11.6.4 Deflection

MZtec slabs are designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely.

Deflections shall be those which occur immediately on application of the load evaluated by the usual methods or formulas for elastic deflections, considering the effects of cracking and reinforcement on member stiffness.

Immediate deflection shall be computed with the modulus of elasticity E_c= 3000 MPa for MZtec elements and with the effective moment of inertia I_e as follows, but not greater than I_g.

$$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr}$$

where

$$M_{cr} = \frac{f_r I_g}{y_t}$$

$$f_r = 0.62\sqrt{f'_c}$$

Additional long-term deflection resulting from creep and shrinkage of flexural members shall be determined by multiplying the immediate deflection caused by the sustained load considered, by the factor

$$\lambda = \frac{\in}{1 + 50\rho'}$$

where ρ' □is be the value at mid span for simple and continuous spans, and at support for cantilevers. Time-dependent factor $\in$ for sustained load shall be equal to

5 years or more	2.0
12 months	1.4
6 months	1.2
3 months	1.0

Deflections computed for MZtec slabs shall not exceed the limits stipulated in building code.
In the construction phase, , a camber of 2% of span length must be applied MZtec two-way slab before pouring the concrete on the compression layer to reduce the instant deformations.

11.6.5 Axial and flexural design

MZtec elements are considered as an equivalent rectangular concrete sections with symmetrical main reinforcement to be designed for axial compressive and flexural design.

The area of concrete for compressive is designed as the sum of concrete layers.
Following the guidelines of the calculation for a rectangular section with symmetrical double reinforcement, direct reading interaction diagrams can be made that greatly facilitate the reading of the behaviour of mZtec walls in cases from Simple Bending to simple Compression, in other words from Domain 2 until 5.

Iteration diagram for the typical configurations of MZtec walls are indicated below.

11.6.6 MZtec walls for dynamic loads

MZtec system is not a frame structure with rigid joints. MZtec system is modeled as bearing walls with infinitely rigidity in both directions of the building (each and every wall gives rigidity in its longitudinal direction) and slabs are always design with pin jointed supports, i.e. there is no moment transfer in wall-slab joints. The seismic tests carried out, verified these assumption.
The seismic loads shall be designed in such a way that the horizontal loads are resisted by the walls per each direction. The walls shall be reinforced if required for that reason.

For the dynamic analysis of MZtec buildings, the finite analysis elements method is used to evaluate the forces in the walls.

The structure is discretized bar-type elements generating a complex system of points called nodes which make a grid called a mesh. This mesh contains the material and structural properties. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area.

MZtec walls shall be modeled as a homogeneous rectangular gross section wall with the equivalents geometrical and mechanical properties specified in this document for MZtec system.
The stresses in the elements shall be checked not to be higher than the maximum admissible for concrete and tension reinforcement respectively.

Basic reinforcement of the panels should be increased with deformed bars or galvanized steel mesh in case more area of tension reinforcement is required.
In case of being higher, reinforcement shall be needed to install on site. The quantity and position of the reinforcement (rebars or galvanized mesh) shall be specified in the project drawings.

11.6.7 MZtec beams

For openings with a span length higher than 2 times the height the lintel, in case of being a structural wall, the reinforcement bar shall be designed according to the flexure design indicated previously.
MZtec walls designed as deep beams shall conform the specifications established in building code.

11.6.8 Exposure condition and reinforcement cover

The thickness of the plastered layers in MZtec elements shall be designed to meet the requirements specified in building code.

12. MZTEC SYSTEM STRENGTH

According to the calculations established before, MZtec system strength for different forces are shown below.
For the calculations, the technical specifications of the panels detailed previously in this document has been considered.
Due to the different configurations of MZtec elements, the minimum reinforcement has been considered in the below tables for every panel.

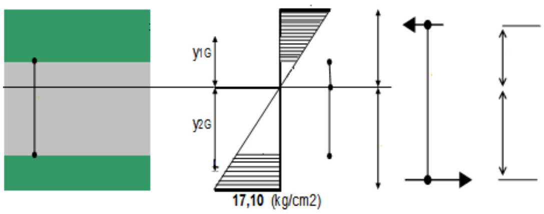
The area of tension reinforcement has been considered only the integrated rebar of the panel (no additional rebar).

12.1 Flexure strength

Ultimate State Limit

Panel Type	EPS Thickness (cm)	Top layer (cm)	Bottom layer (cm)	Width (cm)	D (cm)	x lim (cm)	Mu (kN.m/m)	Ma (kN.m/m)
BPF -100	10	5,6	3,6	100	16,7	2,78	13,1	7,6
BPF -120	12	5,6	3,6	100	18,7	3,12	14,6	8,5
BPF-140	14	5,6	3,6	100	20,7	3,45	16,2	9,4
BPF-160	16	5,6	3,6	100	22,7	3,78	17,8	10,3
BPF-180	18	5,6	3,6	100	24,7	4,12	19,3	11,2
BPF-200	20	5,6	3,6	100	26,7	4,45	20,9	12,1

State I (elastic estate, no crack)



Picture 8. Detail of forces equilibrium of Elastic State.

Panel Type	EPS Thickness (cm)	Compresion layer (cm)	Tension layer (cm)	Width (cm)	cdg (cm)	y1g	y2g	I (cm4)	ExI (kN.cm2)	W min (cm3)	Ma (kN.m/m)
BPF -100	10	5,6	3,6	100	10,69	5,71	8,89	48.562	1,46E+07	4544,05	7,8
BPF -120	12	5,6	3,6	100	11,90	6,50	10,10	62.236	1,87E+07	5227,99	8,9
BPF-140	14	5,6	3,6	100	13,12	7,28	11,32	77.663	2,33E+07	5918,62	10,1
BPF-160	16	5,6	3,6	100	14,34	8,06	12,54	94.842	2,85E+07	6614,24	11,3
BPF-180	18	5,6	3,6	100	15,56	8,84	13,76	113.775	3,41E+07	7313,67	12,5
BPF-200	20	5,6	3,6	100	16,77	9,63	14,97	134.461	4,03E+07	8016,09	13,7

Bending
One way slab

Panel Type	Ma (kN/m2)	Admisible load (kN/m2) / deflexion (cm)							
		2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00
BPF -100	7,8	9,9	6,9	5,1	3,9	3,1	2,5	2,1	1,7
		0,03	0,05	0,07	0,09	0,11	0,14	0,17	0,2
BPF -120	8,9	11,4	7,9	5,8	4	3,5	2,9	2,4	2,0
		0,03	0,04	0,06	0,08	0,1	0,12	0,15	0,2
BPF-140	10,1	13	9	6,6	5,1	4	3,2	2,7	2,2
		0,03	0,04	0,06	0,07	0,09	0,11	0,14	0,2
BPF-160	11,3	14,5	10,1	7,4	5,7	4,5	3,6	3	2,5
		0,03	0,04	0,05	0,07	0,08	0,1	0,13	0,2
BPF-180	12,5	16	11,6	8,6	6,6	5,2	4,2	3,5	2,9
		0,02	0,03	0,05	0,06	0,08	0,1	0,12	0,1
BPF-200	13,7	17,5	12,2	9	6,9	5,4	4,4	3,6	3,0
		0,02	0,03	0,04	0,06	0,07	0,09	0,11	0,1

Note: Admissible loads for dead and live load. Slab load is already considered
Not considered additional rebar on site

Bending
Two way slab
lx/ly=1

Panel Type	Admisible load (kN/m2) / deflexion (cm) lx/ly= 1							
	2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00
BPF -100	18,4	12,23	8,51	6,09	4,43	3,25	2,37	1,71
	0,18	0,27	0,35	0,47	0,6	0,74	0,89	1,06
BPF -120	20,47	13,67	9,56	6,9	5,07	3,77	2,8	2,70
	0,15	0,22	0,29	0,38	0,49	0,6	0,73	0,87
BPF-140	22,64	15,17	10,67	7,75	5,74	4,31	3,25	2,44
	0,13	0,18	0,25	0,32	0,41	0,5	0,61	0,72
BPF-160	24,94	16,77	11,85	8,65	6,45	4,89	3,73	2,84
	0,11	0,15	0,21	0,27	0,35	0,43	0,52	0,62
BPF-180	27,25	18,37	13,02	9,55	7,17	5,46	4,2	3,24
	0,09	0,13	0,18	0,24	0,3	0,37	0,45	0,53
BPF-200	29,56	19,97	14,2	10,45	7,88	6,04	4,68	3,64
	0,08	0,12	0,16	0,21	0,32	0,39	0,46	0,54

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Bending
Two way slab
lx/ly=0,8

Panel Type	Admisible load (kN/m2) / deflexion (cm) lx/ly= 0,8							
	2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00
BPF -100	12,11	7,86	5,3	3,63	2,49	1,68	1,07	0,61
	0,19	0,27	0,37	0,48	0,61	0,75	0,91	1,08
BPF -120	13,53	8,85	6,02	4,19	2,93	2,03	1,37	0,86
	0,15	0,22	0,3	0,39	0,5	0,61	0,74	0,88
BPF-140	15,03	9,88	6,78	4,77	3,39	2,41	1,68	1,12
	0,13	0,18	0,25	0,33	0,41	0,51	0,62	0,74
BPF-160	16,61	10,99	7,59	5,39	3,88	2,8	2	1,4
	0,11	0,16	0,21	0,28	0,35	0,44	0,53	0,63
BPF-180	18,2	12,09	8,4	6,01	4,37	3,2	2,33	1,67
	0,09	0,14	0,18	0,24	0,3	0,38	0,45	0,54
BPF-200	19,79	13,19	9,21	6,63	4,86	3,6	2,66	1,95
	0,08	0,12	0,16	0,21	0,27	0,33	0,4	0,47

Bending
Two way wall capacity
lx/ly=0,7

Panel Type	Admisible load (kN/m2) / deflexion (cm) lx/ly= 0,7															
	2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00	6,50	7,00	7,50	8,00	8,50	9,00	9,50	10,00
BPN-80	4,63	3,22	2,36	1,81	1,43	1,16	0,96	0,8	1,3	1,12	0,98	0,86	0,76	0,68	0,61	0,55
	0,14	0,23	0,36	0,53	0,76	1,07	1,46	1,95	3,19	4,05	5,07	6,28	7,71	9,38	11,32	13,55
BPN -100	5,38	3,74	2,75	2,1	1,66	1,35	1,11	0,93	0,8	0,69	1,14	1	0,88	0,79	0,71	0,64
	0,12	0,19	0,28	0,41	0,59	0,81	1,1	1,46	1,91	2,47	3,84	4,74	5,79	7,02	8,44	10,08
BPN -120	6,15	4,27	3,14	2,4	1,9	1,54	1,27	1,07	0,91	0,78	0,68	0,6	1,01	0,9	0,81	0,73
	0,1	0,15	0,23	0,33	0,46	0,64	0,86	1,14	1,48	1,9	2,4	3,01	4,49	5,42	6,5	7,74
BPN-140	6,7	4,65	3,42	2,62	2,07	1,68	1,38	1,16	0,99	0,85	0,74	0,65	0,58	0,52	0,88	0,8
	0,08	0,12	0,18	0,26	0,37	0,51	0,68	0,89	1,16	1,48	1,87	2,34	2,89	3,54	5,09	6,04
BPN-160	7,4	5,14	3,78	2,89	2,28	1,85	1,53	1,28	1,09	0,94	0,82	0,72	0,64	0,57	0,51	0,88
	0,07	0,1	0,15	0,22	0,3	0,41	0,55	0,72	0,94	1,19	1,5	1,87	2,31	2,82	3,42	4,86
BPN-180	8,1	5,62	4,13	3,16	2,5	2,02	1,67	1,41	1,2	1,03	0,9	0,79	0,7	0,62	0,56	0,51
	0,06	0,09	0,13	0,18	0,25	0,34	0,46	0,6	0,77	0,98	1,23	1,53	1,88	2,29	2,77	3,32
BPN-200	8,8	6,11	4,49	3,44	2,72	2,2	1,82	1,53	1,3	1,12	0,98	0,86	0,76	0,68	0,61	0,55
	0,05	0,07	0,11	0,16	0,22	0,29	0,38	0,5	0,64	0,82	1,02	1,27	1,55	1,89	2,28	2,73

12.2 Shear strength

Walls

Compression layer thick	30mm	fyd 90	400N/mm2	K	1
Inferior layer thick	30mm	A90	0,283mm2/mm	b0	1200mm
fck	25N/mm2	As	98,00mm2/mm	γc	1,5

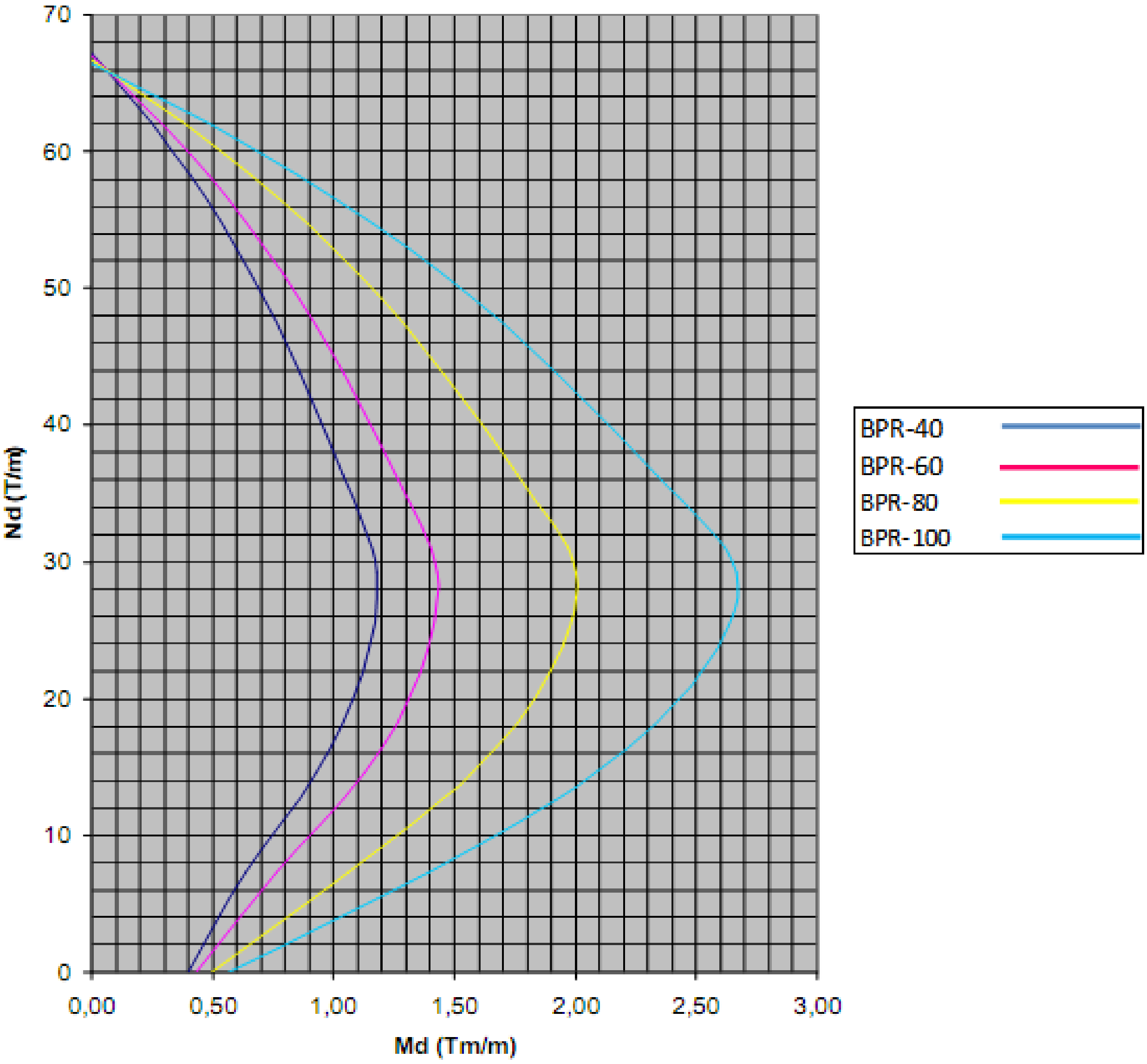
Panel Type	EPS Thickness (mm)	d (mm)	ξ	ρ	Vu1 (kN)	Vsu (kN)	Vcu (kN)	Vu2 (kN)	Vrd, adm (kN/m)
BPN-40	40	86	2,527	0,001	244,00	7,76	16,83	24,59	21,85
BPN-50	50	96	2,445	0,001	244,00	7,85	16,70	24,55	21,83
BPN-60	60	106	2,375	0,001	244,00	7,94	16,58	24,52	21,80
BPN-80	80	126	2,261	0,001	244,00	8,03	16,46	24,49	21,77
BPN-100	100	146	2,171	0,001	244,00	8,12	16,35	24,47	21,75
BPN-120	120	166	2,098	0,001	244,00	8,21	16,23	24,45	21,73
BPN-140	140	186	2,038	0,001	244,00	8,30	16,12	24,42	21,71
BPN-160	160	206	1,986	0,001	244,00	8,39	16,01	24,40	21,69
BPN-180	180	226	1,941	0,001	244,00	8,48	15,90	24,39	21,68
BPN-200	200	246	1,902	0,001	244,00	8,57	15,80	24,37	21,66

Slabs

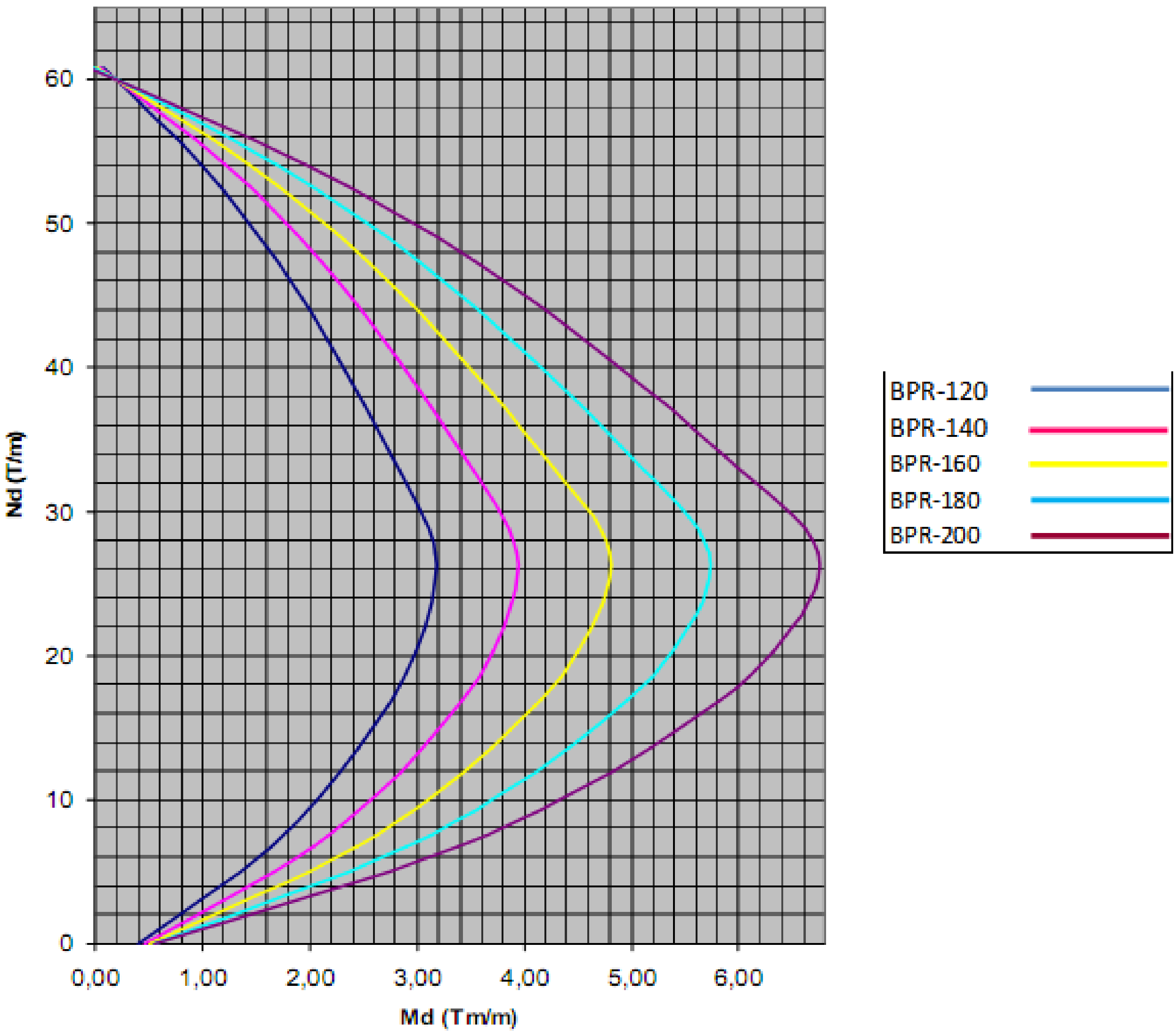
Compression layer thick	50mm	fyd 90	400N/mm2	K	1
Inferior layer thick	30mm	A90	0,283mm2/mm	b0	1200mm
fck	25N/mm2	As	187,00mm2/mm	γc	1,5

Panel Type	EPS Thickness (mm)	d (mm)	ξ	ρ	Vu1 (kN)	Vsu (kN)	Vcu (kN)	Vu2 (kN)	Vrd, adm (kN/m)
BPF-100	100	167	2,094	0,002	357,33	15,11	25,59	40,71	33,92
BPF-120	120	187	2,034	0,002	357,33	16,92	24,86	41,78	34,82
BPF-140	140	207	1,983	0,002	357,33	18,73	24,23	42,97	35,80
BPF-160	160	227	1,939	0,002	357,33	20,54	23,69	44,23	36,86
BPF-180	180	247	1,900	0,002	357,33	22,35	23,22	45,57	37,97
BPF-200	200	267	1,865	0,002	357,33	24,16	22,80	46,96	39,13

12.3 Interation diagram Axial and flexure strength



Picture 9. Interation diagram of MZR-40 to MZR- 100



Picture 10. Iteration diagram of MZR-120 to MZR- 200

13. FIXATION TO WALLS

From the structural resistance point of view, MZtec walls are designed to resist dominant compression loads that are represented in the interaction diagrams M-N characteristic of each type of panel depending on its EPS thickness.

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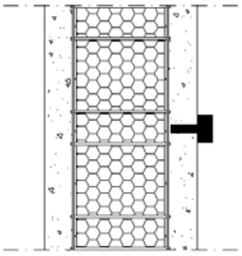
For cases of concentrated loads at isolated points, the criterion for calculation is the checking of the contact pressure between bolt and walls, in such way that it does not exceed the stress calculation of the concrete, that for f' ck = 25 N/mm2 corresponds to a value of

f' cd = 0.85 x f' ck = 14.2 N/mm2.

This is exactly the same as for the testing of fixings in a traditional reinforced concrete wall. The load capacity of the bolt anchored with drills shall be limited to the thickness of the layer of concrete in the area of inclusion, which for MZtec walls is equal to 35 mm.

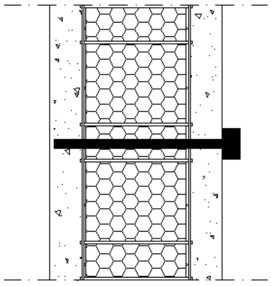
The formula used is: N = f' cd x e x Φ / 4, which corresponds to the compression on the projection of the area of the bolt on the face of concrete plus lever arm force of this cut to the centre of gravity of the section.

Fixation Diameter (mm)	N adm (kN)
8	2,67
10	3,90
12	4,69
14	5,47
16	6,25
18	7,03
20	7,81
22	8,60
25	9,77
30	11,72



For more important concentrated loads, the through-bolt can be used. In this case the fixing capabilities table will transform, e.g. for a thickness of 90 mm EPS mm (MZN 90) the values are given in the table below.

Fixation Diameter (mm)	N adm (kN)
8	1,00
10	1,27
12	1,53
14	1,78
16	2,04
18	2,29
20	2,55
22	2,80
25	3,18
30	3,82



Similarly in the case of fixation on single-sided, the expression of load capacity arises from considering the combination of shear, as normal tension in the bolt section, plus the tension caused by the force of translation of the strength of shear to the barycenter, in this case, considering the wall as a whole, i.e. the total thickness.

For higher force levels located area around the fixing point can be filled with concrete b mean of melting the a EPS of the area, in such a way as to be able to increase the capacity of the shear bolts by limiting the contact pressure to the indicated values. Also, and in a similar way to what has been said regarding single-sided fixings, that for extraordinary or accidental loads the calculated values may increase in the relationship 1 / 0.85 = 1.176 , i.e. 17.6 %.

14. TEST REPORTS AND SUITABILITY

14.1 Observations of compression tests

The basic evaluation tests for flexo-compression strength capabilities is performed on samples of panels, in situ, at various heights from 2.50 m to 4.00 m, although there are tests conducted on short samples, on which the minor effects lose significance.

The support of the samples used in the trials is always anchored at the bottom (free rotation) and simply supported at the top (free vertical displacements and rotations) and the load is applied in a distributed manner on a line parallel to the sides. The vertical edges of the samples remain free during all the tests. This configuration implies, against minor external loads, a slimness which is not consistent with the panels in real cases.

The reasons for the differences are, briefly: the proper support, that in real cases, either by linking with the foundations or by continuity with the adjacent floor boards, is more akin to elastic attachments and not simple joints with free spin and, on the other hand, the situation of the vertical free edges, rarely found in practice and that substantially changes the nature of the minor demands to be verified in the panel, that are, in short, the determinants.

The behavior of a wall to compression corresponds with greater adjustment of a rigid plate supported by its four edges. And in this regard we simply mention that the critical loads of such settings exceed the minimum by more than double the corresponding to the same demand as bar, as is the case of the tests used.

We have to bear in mind that, in real cases, the existence of perpendicular walls contributes towards increasing the rigidity, and therefore the capacity of the global load.

14.2 Observations of flexion tests

The tests use proper beam supports to analyses the flexion capacity of the element and in this respect it is necessary to highlight that transverse deformations are not disabled in them, so vertical displacement configurations should be offset from the corresponding reductions corresponding to assimilate them to the behavior of a panel supported at its four edges.

Another feature of fundamental importance, when evaluating the results of flexion tests, is that in all cases the panel retained a huge capacity of elastic recovery, even in a limit state or at breaking point. Even when the plastic section was unable to absorb more loads, on withdrawing it was consistently verified that the greater part of the energy absorbed by the section was stored as elastic deformation energy, the part tending to return to its original equilibrium position, in a most significant manner (40-50%).

14.3 Summary of significant test results

14.3.1 Centered and eccentric compression

An enormous amount of tests have been done on panels of different thickness and heights, and the representative results of all tests are shown below:
Centered Compression
-4 cm Panel – Height 240 cm – Maximum linear load = 760 kN/m
-6 cm Panel – Height 400 cm – Maximum linear load = 590 kN/m
-6 cm Panel – Height 300 cm – Maximum linear load = 1130 kN/m
-8 cm Panel – Height 270 cm – Maximum linear load = 1340 kN/m

Eccentric Compression (with eccentricity of 1/3 total thickness)

-4 cm Panel – Height 240 cm – Maximum linear load = 566 kN/m
-6 cm Panel – Height 300 cm – Maximum linear load = 707 kN/m
-6 cm Panel – Height 400 cm – Maximum linear load = 360 kN/m
-8 cm Panel – Height 270 cm – Maximum linear load = 680 kN/m

14.3.2 Simple bending

The flexion trials have in general been done in different configurations, which is why the ultimate representative momentums of the tested panels are shown.
-4 cm Panel: 3 cm compression layer – Ultimate Momentum = 8,1 kNm/m
-7 cm Panel: 3 cm compression layer – Ultimate Momentum = 12.2 kNm/m
-8 cm Panel: 3 cm compression layer – Ultimate Momentum = 12 kNm/m
Rupture deflection = Light/100 (*)

(*) Keep in mind the sample's basis is simply supported on the extremes, thus the transversal deformation is not limited and the deflexion is not that of the behavior of the plates to flexion.

14.3.3 Cutting test (shear stress)

The shear stress shown by the trials is referred to the total thickness of the panel:
-4 cm Panel (10 cm total) = 1.5 MPa
-8 cm Panel (15 cm total) = 1.3 MPa

14.3.4 Horizontal load test contained in the plane

The capacity of the panels against this stress is such that the trials are always stopped because of failure of the anchorage elements, even though these values are high enough to limit a more than acceptable behavior.
-50/100 kN to 2.40 m height –4 cm Panel
In trials with alternate cyclic horizontal load, values of 350 kN (4 cm Panel) have been reached.

14.3.5 Soft impact test

Panels 4 cm thick have received impacts of 1250 Joules (50 Kg weight with a falling altitude = 2.50) recovering the instantaneous deflections and without presenting any damage exceeding regulation requirements.
The 2 m fall of the 3.5 Kg steel sphere makes impressions on the cement mortar's surface that are imperceptible.

14.3.6 Eccentric vertical load test

Panels with a 4 cm thick EPS cores have supported, in compliance with standards, bending moments of 300 Nm for 24 hours without any type of consequences.

14.3.7 Seismic test

A housing prototype built totally with panels (walls, slabs, stairs and covering) at horizontal accelerations of 10 m/s2, with variable frequencies including the structure's own, registering absolutely no type of damage or fissure.
For example, it is considered that a standard earthquake in a high risk area is considered one that implies horizontal acceleration designs of around 3.5 m/s2.

14.3.8 Weld separation test

Compliance was verified with requirements of the standard UNI ISO 10-287 and concordant for the resistance of the welded points. In every case a resistance of over 2.26 times the comparison force required by the standard was obtained (0.3 of the resistance to breakage of the bar of smallest diameter).
Minimum separation load of the trial series = 1.66 kN
Comparison load = 0.74 kN

14.3.9 Outdoor impermance test

The panels have been classified as E (the highest) after been exposed to 140 mm/h precipitations with 106 km/h winds during 24 + drying + 72 hours.

14.3.10 Trial of resistance to fungus development

The results of these trials show a better behavior of panel surfaces than traditional alternatives, verifying level 0 (free microorganism growth substrates) in the described surfaces, against level 1 (disperse Microorganisms) in samples of traditional rubblework.

14.3.11 Fire Resistance

Different trials have thrown out consistent results with respect to the ignition capacity of the described technology and some significant results are:
-60 minutes at 2500 ºC without vapor emission or production of flames (6 cm panel with 35 mm cement mortar).
-4 cm panel with 25 mm cement mortar
Fire Resistance Level:

Structural Adequacy =	241 min
Integrity =	241 min
Insulation =	172 min

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• None of the trials threw results inferior to F90 (90 minutes of resistance to fire).

14.3.12 Ballistic impacts

In no case did projectiles coming from short guns go through the plates of any thickness, even with calibers such as .357 Magnum or .45 Auto. The same occurs with projectiles of the Brenneke caliber 12 type (gun: Franchi SPAS) shooting distance = 5.50 m.

14.4 Description of most representative test

14.4.1 One-way slab response

a) Objective of test

It is studied the mechanical response of panels submitted to a series of vertical loads which produce flexural stress.

b) Test set up

The following panels are concreted: one MZR-100 panel, MZR-140 panel and two MZR-200 panels with a compression layer of 5 cm thickness and the inferior layer of 3 cm thickness. The dimensions of the panels were 3.00 x0.60m; 3,60x0.60, and 4.00x0.60m, respectively.
Four tests were carried out with the following span length:
2.80 m for the MZR-100 panel, 3.40 m for the MZR-160 panel and 3.80 for the two MZR-200 panels. Each panel was placed beneath the load rig in order to test flexure. Loads were applied to three points across the span and were applied until breaking point was reached. A 20 kN Amsler jack was used to carry out the rest and was operated by an AMSLERPM-103 force gauge.

A flexometer situated in the middle of the lower surface of the panel was used to read the flexure and was removed before the panel broke. A data recording system was used during the test to record the load and displacement values. The test was completed when the breaking load was reached.

c) Results obtained

On studying the load-deformation curve it can be concluded that the panel sections functions as a composite section comprised of two slabs of 5 cm and 3 cm joined by the join reinforcement which work together, being the EI rigidity module in the elastic area, which corresponds to the values provided by the manufacturer in accordance with its calculation forecast.

14.4.2 Compression response

a) Objective of test

This is a study the mechanical behavior of panels submitted to vertical loads from higher parts in a building.

b) Test set up

Two compression tests were carried out in order to study the mechanical behavior of the MZR-50 and MZR-80 prefabricated panels when subjected to vertical loads from higher parts of a structure. The panels had a solid head placed at a height of 15 cm.

Each test panel was placed perfectly straight between the plates of a press and a concentrated load was applied over the whole width of the panel via a metal profile.
The press was operated by an AMSLER PM-103 force gauge, which controlled the speed of the load application. The load was increased at a speed of 50 kN/min until breaking load was reached.

c) Results obtained
In both cases the load was increased at a steady speed until the panel failed. The MZR-50 panel broke due to buckling under a load of 380 kN.
The MZR-80 panel broke under a load of 360 kN with the failure occurring in a break located at the head. In both case, the two layers of concrete acted jointly with no changes or lateral deformations observed.

14.4.3 Flexure response

a) Objective of test
The study was to establish if a sheet consisting of a series of panels behaves in a similar way to a slab supported on its four sides. The panels are supported on the four sides of their surface including a corrugated reinforcement in both directions.

b) Test set up
A slab consisting of MZF-120 panels was taken. It was a total of 20 cm thick and its calculated on-site dimensions were 3.90 mx3-90m. The slab was rested on a metal frame with four supports and propped up along its sides. The load was achieved by placing a pool tank on the slab and checking the level of the water with a scale on a strip inside the pool. Loads were applied at intervals of 100 kp/m^2 until 715 kp/m^2 were reached.

This load was maintained for 5 minutes and afterwards the flexure was measured.
Five flexometers were used to reads the flexures: the first one in the center of the slab and the other four in the middle at quarter of the way of the total span from the edge. Accuracy for readings was within a hundredth of a millimeter

c) Results obtained
From the flexometer readings in the center and quarter of the way across from the edge it is established the deformations are of the same size, so it can be deduced that the sheet is acting in the two directions and the two layers of concrete are acting jointly.

14.4.4 Shear stress response

a) Objective of test

To check the loads from the flooring are transmitted to vertical panels, where the horizontal panels which act as slabs join with the vertical structural panels. This is to verify how greatly they resist sheer stress

b) Test set up

A load rig was set up in the shape of an H and two vertical PR 400 panels were taken with two 3 cm layers of concrete. The panels were 1.125 m wide and 1.10 m high and joined halfway up by another PR, here the concrete was 5 cm thick on the upper face and 3 cm on the lower face. It had a length of 1.05 m, which was the clear space between the vertical panels, and a width of 1.125 m.

14.4.5 Horizontal stress response

a) Objective of test

The behavior of vertical panels is studied in the face of a horizontal load in the plane of the panel, which represents the force of the wind or an earthquake.

b) Test set up

Two MZF-40 panels were taken which had 3 cm layers of concrete on either face and were 2.6 m high. They were placed in a base support measuring 2.60mx0.40mx0.40m. this was anchored to the test facility floor to prevent the support moving during the test.
The joins between the panels as well as with the support were carried out in accordance with the detailed constructive layout of the system.
The horizontal load was applied to a side on the upper part of the panel using a hydraulic Jack with a maximum load capacity of 200 kN. An AMSLERPM-103 force gauge was used to apply the load. This device had speed control at intervals of 30 kN

c) Results obtained

When the 30 kN load was applied, cracks appeared along a 1/3 of the length of the base support as the required stronger reinforcement was not available. A vertical fracture began to appear as a continuation to the fissure in the support.

The panel began to break free from the support at loads between 30kN and 60Kn. The test was concluded when the base support broke at a load of 70kN.

The wall formed by the two panels remained upright with no sign of a fracture or crack. This was different to the horizontal panel joining, the wall with the base support, with a fracture running a third of its length, i.e about 0.80 m long.

The test confirms that two layers of concrete joined by the basic reinforcement act jointly under the force of the horizontal stress along the plane of the panel. They resist a breaking moment of 182kN in a panel width of 0.80m, the behavior of the wall thus being valid and in accordance with structure calculations.

14.4.6 Slab panel deformation

a) Objective of test

To study whether the flexures or deformations which are produced by permanent loads and overloads acting on a panel correspond to those defined in accordance with the theoretical calculation model which the manufacturer has supplied

b) Test set up

The MZF-80 panel had a upper layer of 5 cm which acted as a structural topping and a lower layer of 2.5 cm. The panel was 1.125 m wide and 3.80 long. An overload of 3kN/m^2 was evenly applied. Two flexometers were placed in the center of the panel and at 10 cm from the end edges of the slab.

c) Results obtained

The flexometers gave flexure ridings of the same size, the average value being 6.27 half an hour after applying the load. The load was maintained for 24 hours with no significant increase in flexure; when the load was removed, the deformation disappeared with only a slight deformation of 0.7 mm remaining. Thus it was verified that the flexures produced coincided with the theoretical calculation.

14.4.7 Test on flexure in two slab panels

a) Objective of test

To evaluate the extent of stress transmission via the joint between two slab panels while studying the mechanical behavior of slabs submitted to flexure at the same time.

b) Test set up

The set was made up of two PR-80 panels with a width of 1.125 and a length of 3.20 m and covered with an upper layer of concrete 5 cm thick and a lower layer 2.5 cm thick. The two panels were bi-supported on cylinders 50 mm in diameter with a length of 2.80 m between supports. They were joined together as described in the system, i.e. shotcreted together “in situ” and with the lateral reinforcement which connect to the adjacent panel.

Only one of the panels was submitted to the load rig. The load was applied via profiles placed in the two centre thirds. A 200kN Amsler jack was used to carry out the test and was operated by an AMSLER PM-103 force gauge.
The flexures four flexometres were placed in the centre of the openings and at 5 cm from the ends of each of the panels. Accuracy for readings was within a hundredth of a millimetre. A data recording system was used during the test to record the load and deformation values. The flexometers were removed before the breaking load was reached.

c) Results obtained

It can be seen from the graphs which show the flexure attained for each of the indicated points on the panels that the load-deformation curves for the flexometers located either side of the joint are very similar. The graphs for the points show an increase in flexure as the load is increased, even when the differences in the deformation between the two points at the ends are significant.

When a load of 25kN is reached, the flexometres are removed. The flexure values for such a load are 24.87 mm; 16.18mm; 14.50 mm; and 5.26 mm when the load is then increased. To the naked eye it could be seen that both slabs became deformed up to a load of 39kN, with the slabs remaining deformed at such a value; no fracture appeared in the length of the join at such a value
The test shows us that the join between slabs transmits the loads transversely to the adjacent panel, but it also tells us the transverse transmission of the load in this type of panel is less than in the panels in the complete concrete section. Applying a direct load in a specific point is thus unadvisable for such systems

14.4.8 Tests regarding suitability for mechanical use of the System

a) Objective of test.
To study the mechanical behaviour of the joins between horizontal and vertical panels. Some were submitted to vertical loads from the upper parts of the building itself, plus the weights and overloading from the slab corresponding to the horizontal panel.

b) Test set up
The tested structure was a rig made up of vertical elements, MZR-40 panels with a 30 mm concrete covering, 1.125 m wide and 3.40 m high and joined together by starter bars in both support bases. The slab panel was a MZR-80 with concrete covering of 50 mm on the upper layer, 25 mm on the lower level and a length of 4.20 m. this horizontal panel was placed at a height of 2.60 m from the base. Concrete was then projected in accordance with the specifications in section 5.3. The test equipment corresponds to the diagram in the following figure.

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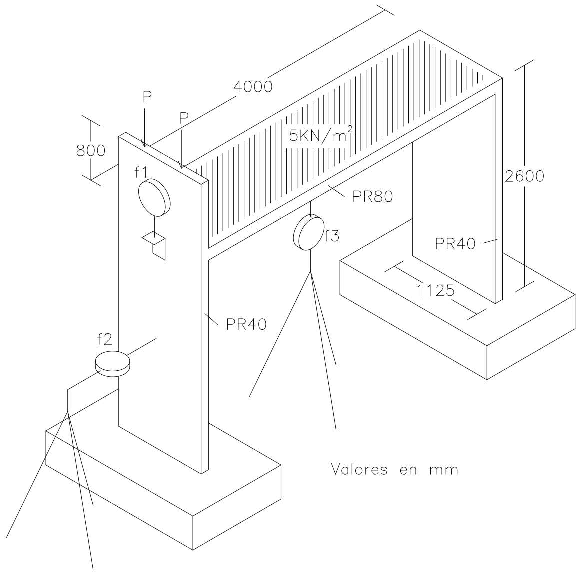

Picture 11. Test equipment for suitability for mechanical use of the system

To prevent displacement while the load was being applied, a metal brace was placed on the vertical panels below the horizontal panel. The 0.65 m walls sticking out above the horizontal panel were left free-standing and without support.

The rig was anchored to the test facility floor by means of special metal rods where the support base as installed. These rods were soldered to plates and embedded in the support base, were inserted in holes in the test facility floor and were attached to the floor via the plates. Thus potential movement of the rig was prevented during the test.

Before applying loads to the vertical panel, the slab was loaded with 5kN/m, applied in the form of blocks of concrete. The load was left for 24 hours and afterwards the deformations were measured.

A load was then applied to the panel by means of hydraulic jacks. Two jacks each with a maximum capacity of 400 kN were placed on the upper panel. The axes of the two jacks were above the axis of the panel, the head of which had previously been shotcreted to a height of 10 cm. In order to distribute the loads along the edge of the panel, the jacks were held on a solid steel sheet 4 cm thick and 12 cm wide which was placed along the upper edge of the panel.
An AMSLER PM -103 force gauge was used to apply the load. This device had load speed control at intervals of 50 kN up to 375 kN. The speed the load was applied at was 50kN/min

To read the flexures, three flexometers were used with accuracy for readings within a hundredth of a millimeter. These were used to read the flexures which were produced in the center of the opening of the slab and at the mid-point on the lower panel, perpendicular to its plane. The third

flexometer measured the movement in the lower panel compared to the upper panel, or the flattening of the join, which is actually one and the same thing. Likewise, this flattening was measured by an extensometer at 40 cm from the base, which was used to take readings from the two points on the panel.

c) Results obtained

As the upper panel didn't have any lateral support and the slab was subject to an overload of 5kN/m^2, 60% more than the theoretical load taken into consideration, there was a significant twisting in the upper pane. Applying the load made the panel break due to compression flexure resulting in a fracture on its external surface. The test was completed with a load of 375 kN, this being the load to take into consideration for buildings of 4 stores and a separation between supports of 5 m, the load of 100kN/ml therefore having a greater load coefficient,3.6 times the size, and with the upper panel having no bracing.

14.4.9 Seismic response of the building

a) Objective of test

This project has attempted to reproduce experimentally the seismic actions, which the system would be exposed in real situations. Analyze the seismic behavior of the connection between walls of consecutive floors , and the connection between the roof with walls of the last floor , different from the connection walls - slabs of the first floor.

b) Test set up

There was constructed a module of 2 floor. It was used 3 LVDT. The LVDT D1 and D2, they measure the vertical absolute displacements of the central point of the slabs corresponding to the first and second level, respectively, whereas the LVDT D3 measures the lateral absolute displacement of the central point of the axis 2, before the eventual existence of buckling in the wall. The weighing of the module was carried out using a cell of hung load of the crane. Transport of the module from the construction site towards vibrator Table, it was realized by means of the crane bridge.

To try to represent the real conditions in the test of seismic simulation, they added in every level sacks of sand of 30kg each one, that they represented the following loads:
Mortar thrown in the base of every ceiling (not applied in the module): 2000x0.03 = 60 kg/m2.
Finishing: 100 kg/m2 (Norm of Loads (Charges) And 020).

25 % of overload in the floor (flat) 1: 0.25x200 = 50 kg/m2
25 % of overload in the roof: 0.25x100 = 25 kg/m2
In the seismic test of the module, there was sign in using the seismic corresponding to the component "L" of the earthquake happened on May 31, 1970 in Chimbote, Peru, with 30 seconds of duration in his stronger part.

Since the module presents major density of walls that a real construction, had to carry out the corrections to the seismic accelerations.
The instrumentation used in the seismic simulation test were 6 accelerometers to measure accelerations, 6 LVDT (D1 @ D6) to measure lateral displacement absolute and 7 LVDT (D7 @ D13) to measure relative displacement, apart from the accelerometer A0, D0 and the LVDT pressure dynamic meter, characteristic of the shaking table platform.

c) Results obtained

None of the earthquake test phases opened or prolonged fissures than previously had been formed by drying shrinkage. Neither cracks were formed in the openings, nor the second floor.

14.4.10 Seismic response of partition walls

a) Objective of test

The aim was to determine their seismic behavior and the effectiveness of partition walls dividing the rooms in a vaulted building and their connection to the vault.

b) Test set up

Earth quake “mayo70” was used as the one utilized in the module test , although this time 3 phases were applied, eliminating the “light earthquake”.
Each one of these was preceded by free vibration tests, consisting in the application of pulses similar to the ones, aiming to obtain the vibration period (T) and the damping ratio (☐) of the partition wall when faced with seismic actions perpendicular to its surface.
To simulate the shoring determined by the transversal vaults and the ceiling slabs in real building, we used a metal vault which prevented deformity due to bending in the upper beam and the foundation, leaving only the columns of the vault and the partition wall free to move.

c) Results obtained

The partition wall of the system and its connectors to the concrete vault (dowels from 6mm to 25cm of diameter), successfully passed the test of seismic load transversal to the surface, appearing fissures only on the partition wall-column interface, which increased as the earthquake became more intense.
When faced with a "catastrophic" earthquake, the partition wall supported a load of 140%, higher than the standard load, in case where was located in an essential structure (hospital, school, etc..), so that the partition wall system can be used without problems.

14.4.11 Fire resistance classification

Horizontal panels
Test performed in the Technology Centre for Wood (Spain), as stated in record no .F 358/03.02. in accordance with the standard UNE 23093:1981. To a slab consisting of MZTEC MZR-120 panels with 50 mm cover layers of concrete, and 30 mm as a lower layer with plastering 10 mm thick. The

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slab was 5.00x5.00 m and was exposed to fire in its middle square section measuring 4.00x4.00 m at the sides.

The slab was constructed as specified in the system´s descriptive report, submitted to an overload of 320 kg/m^2 fire stability was achieved in > 60 minutes with fireproofing and non-emission of inflammable gases. The test was then stopped.

Vertical panels
Test performed in the Technology Centre for Wood (Spain), as stated in record no .F 358/03.02. In accordance with the standard UNE 23093: 1981. To a wall 3.37 m length and 3.50 m high consisting of MZR -50 panels with 30 mm cover layers of concrete on both faces plastering 10 mm thick on both faces.
The panel was submitted to a total load of 10 t and resisted 60 minutes. The load was then increased from 10 t to 30t in accordance with stipulations in report no. F 399/03 and resisted a further 60 minutes. At the end of the period mechanical stability, fireproofing and non-emission of inflammable gases were maintained and the test was halted.

Non-load-bearing panels
Test performed in the CSIRO laboratory in Australia in accordance with Australian standard 1530.4 and with certificate number 236/90. To a MZN-60 panel with two 30 mm layers of reinforced concrete, covering a surface area of 3.00x3.00 metres. It resisted the action of fire in the following way:
Structural resistance ≥ 241 minutes.
Resistance to flames > 241 minutes.

14.4.12 Acoustic isolation

Tests carried out by AUDIOTEC, with report number CTA 447/10/AER, in accordance with the standard ISO 717-1:1996, performed on projects constructed using the System.
For internal partition walls made up of MZR-100 panels and layers of HA-25 micro concrete 35 mm thick on both sides, plaster coating with 1.5 cm thickness in both sides, the acoustic isolation value abstained is 44.5 dBA

14.4.13 Thermal transmission coefficient

Test performed on a MZR-80 panel with thicknesses of concrete of 30 mm, measuring 60x60 in accordance with the standards UNE-EN92202:1989, DIN 52612 and ASTM-C518.
K = 0,50 W/m^2·ºC

14.4.14 Resistance to a soft body

A wall was formed with two panels embedded in a base support with the same sizes and in the same way as stipulated in section 12.2.4. The wall was submitted to a soft shock loading from a 50

kg sack with impacts of between 900 and 1,200 joules. The results were satisfactory as the panel was not fractured.

14.4.15 Watertightness test on the joints in the panels

Four MZR-80 panels measuring 0.50x0.50m were taken and concrete was projected onto them to cover both faces up to 30 mm. After 28 days they are submitted to a horizontal projection of water from two pistols with an output pressure of 500 kPA with nozzles of 10 mm and at a distance of 1.0 m. The water was projected towards the centre of the upper panels and 30 cm above the horizontal join for a period of 3 hours. It was verified that there was no infiltration of water, neither in the horizontal or vertical panels themselves, nor into the joins.

14.4.16 Identification tests on expanded polystyrene

Apparent density
Test carried out in accordance with UNE-EN 1602:1997 on five samples, obtaining an average value of :
d = 13,58 kg/m^3
Absorption of water
Test method in accordance with UNE-EN 1609:1997
W = 0,028 kg/m^2
Compressive strength
Test method in accordance with UNE-EN 826-1996 on 10 % deformation, obtaining an value of
δ_m = 56,95 kPa
Flexural strength
Test method in accordance with UNE-EN 12089:1997, method B. The dimensions of the samples were 200x90x30 mm number, obtaining an average value of δ_m = 127 kPa

15. ENVIRONMENTAL FRIENDLINESS OF MATERIALS

MZtec system, which main component is expanded polystyrene (EPS), is an efficient and effective thermal insulating material that can play an important role to reduce the emission of carbon dioxide to the atmosphere and, thus, positively contribute to lower the global warming. In order to make it, no CFCs or HCFCs are used as foaming agents and, therefore, the EPS does not cause any damage to the ozone layer.

MZtec system reduces the energy requirements during the life of the building since it needs less fossil fuel, what implies less CO2 emissions.

Expanded polystyrene (EPS) qualities

- Expanded polystyrene is a material biologically inert, non-toxic and stable EPS does not contribute to gas methane formation (with the corresponding greenhouse effect potential) and it does not imply any risk for underground waters due to its inert and stable nature.
- It is 100% recyclable. During the process of manufacturing MZtec, practically no wastes are created, and those that happen to be are directly recycled within the very same production plant.
- The polystyrene used for MZtec is of the kind self-extinguish; that is, fire-resistant. The material does not produce flames or toxic gases

16. INSTALLATION OF MZTEC SYSTEM

16.1 General description of MZtec system installation

The panels will be fitted on a reinforced continuous foundation in accordance with conventional calculations. The design of the foundations shall be designed according to local building code and common engineering practice.

The foundation will include star rebars consisting of corrugated steel bars 8 mm in diameter. The start rebars shall be installed as minimum as specified below and shall be increased according to calculations.

These bars will be straight and must be embedded in the foundation no less than 20 cm in accordance with the building code. They must stick out from the upper surface for a minimum length of 35 cm. They will simply be attached to the panel meshes.

The starters can also be fitted by making a hole in the foundation concrete using a power drill and attaching the bars to the concrete using epoxy adhesive.

The series of panels joined together makes up all the enclosure surfaces in the building structure: exterior walls, inside walls, flooring slabs and roof covering.

The panels are tied together via an overlap of 50 mm which the meshes have on opposite sides; these overlaps will be intertied by simply attaching the wires together at distances of about 50 cm apart. Alternatively, the panels can be joined together using staples with an automatic or manual staple gun. The join between panels where horizontal and vertical edges come together must be reinforced using angular meshes (MA) placed along their length and each of their sides.

The openings for windows and doors are made by cutting the panel while leaving a minimum clearance gap to prevent thermal bridges (about 10 to 20 mm) for frames. The frames will be attached to the meshes with staples.

Gaps opened up in horizontal or vertical surfaces in the MZtec system must be reinforced using MU- type meshes, with the width corresponding to that of the surface. These will be placed around all the edges in the gap. Likewise, all freestanding edges such as cantilevers will be reinforced using this type of mesh.

Joints between walls and floor slabs will be carried out in accordance with construction details, ensuring vertical continuity in the thicknesses of the concrete applied to the support surfaces. The floor slab outer edges will be reinforced with an “in situ” concrete beam reinforced with two bars 6 mm in diameter.

It must be ensured that the enclosure surfaces are correctly aligned and straight. This can be carried out by using strips, metal rulers, telescopic braces, or any other tool designed for such that purpose.

The ducting can then be made in the expanded polystyrene using a hot air gun and the corresponding cables or pipes can be put in place.

Once the work described above has been completed and checked, the panels are plastered. This can be carried out by using any of the 4 ways of micro concrete application indicated previously.
In case a hopper gun is used Hopper it must be connected to a suitable air compressor. Hopper guns use compressed air to impel a fresh mixture through the system. The compressor must operate at a constant pressure between 500 and 600 kPa.

It should provide 300 or 350 litres of air per minute in each one of the devices which are connected to it.
If an electro compressor is used, the following parameters should be used:

Power (HP)	**Air flow (Litre/min.)**	**Number of hopper guns**
2 ½ a 4	350 a 400	1
5 a 6	600 a 700	2 a 3
8 a 10	900 a 1000	3 a 4

If continuous projection machines are used, the position of the hydrometer should be adjusted depending on:
1) The type of pump casing
2) The flow through the casing
3) Engine rotation speed
4) Apparent weight of gunite
5) Proportion of water recommended by manufacturer of dry mix.

Concrete projection makes a continuous surface, jointless surface out of the enclosures and slabs made up of panels as well as their joins.

The pneumatic shotcrete operation can be carried out in one or two phases. The first layer will be 2 cm thick and cover the steel mesh. The second is a finishing layer which is applied until the final required thickness of a minimum of 3 cm is reached. To do so, guides can be used which may be just tubes with square cross section 20 mm or longer based on the required covering: these are used to divide the projected thicknesses of the concrete. The architectural designer is free to choose the type of plastering from conventional materials (plastering and paint on finished surfaces, plaster, spray-on plastic coating, elastomeric paint, etc).

Formwork with braces and props should be used to fit horizontal or sloped surfaces. The MZF panels for slabs can be placed on this formwork. These are then joined together via the 50 mm overlaps in their meshes. The panels are attached to one another by fastening them together or using staples with an automatic or manual staple gun. The reinforcement and starter bars for the upper stories should be put in place during this process, as described in construction details.

The openings must have 45º reinforcements in their corners. The dimensions of longitudinal reinforcement must be calculated. These reinforcements can be implemented using special meshes supplied together with MZtec panels especially for the purpose.

Galvanized U-shaped meshes are placed along the edges of each gap made in the walls. These meshes are supplied according to the thickness of the panel used as a wall.

Panels which have been cut have no overlaps on opposing sides, so when they need to be joined, flat meshes (called MP) are used to fit them close together. These special meshes are used whenever the available meshes in MZtec panels have to be cut for different reasons.

The error in the vertical alignment of a panel's (transverse) face should not be greater than 8 mm. The alignment error (being off-centre) between adjacent surfaces of superimposed panels must be less than 15 mm.

Any alignment errors which do not comply with the tolerances described above are considered an exceptional error in the execution of work. If such defects are found to be present during construction, calculations should be repeated in order to allow the affected elements to perform their role properly.

Micro concrete is plastered in the following phases:

1. First shotcreted layer in walls
2. Second shotcreted layer in walls.

3. First shotcrete in lower side of slab panels (0.5 cm thickness in such a way it doesn´t completely cover the lower steel reinforcement).

4. Pouring compression layer (braces and props should be arranged in such a way that they prevent excessive deformation in the MZF panels due to the weight of fresh concrete)

5. Second shotcrete layer in lower side of slab panels. After the compression layer concrete has got the specified compression strength a new system of braces and props is put in place and the first application of concrete can be seen. The lower layer is concreted once more until a minimum depth of 3 cm is covered while also covering up the gaps left behind by the first system of props. Two days later the formwork is removed and the gaps left behind by the braces are filled in the lower side of the slab.

16.2 Tools and machinery required

Skilsaw
Hotter machine or Propane Torch
Worm screw, metal loops, pincers, manual or automatic staplers
Brasses: are used to hold panels in place during cement application.
Basic Hand Tools: Precipitating saw, Hand level, Bolt cutter, Pliers and Wire cutters, Tape measure
Stucco screeds, plastic pipe or wire guides
Shotcrete, gunite or mortar pump
Trowels, sponges, darbys or hand tools to give desired finishing

16.3 MZtec system buildings

Following the installation phases of buildings entirely make up of MZtec system are exposed.

16.3.1 Connection with foundations

MZtec system is compatible with any type of foundation, whether strip footings, slab on the ground or pile foundation.
For hard soil, modulated buildings and well-defined loadlines could be designed on foundations based on strip footings, of which will start load-bearing walls.
In case of pile foundation, the wall will be supported on tie beams and pile cap.
MZtec system, weighing less than a traditional building, allows the reduction of concrete volume and reinforcement in foundation elements, regarding the soil condiions.

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Picture 12. Example of building with foundation using strip footings.

Picture 13. Detail of connection foundation-panel using start rebars in pile caps.

16.3.2 Setting-out and starters layout

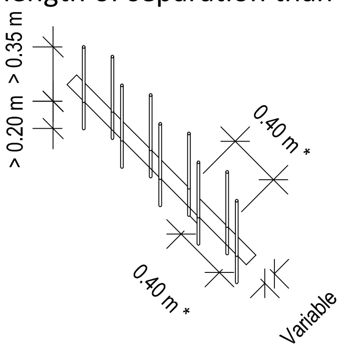
It is important to perform as accurately as possible the process of setting-out the vertical elements of the building, taking into account that, as shown in the reference panel (corresponding to the thickness of the polystyrene) must be added approximately every 10 mm by face, which is the separation of the meshes on the outer fiber of polystyrene.

There are two ways to collocate the starters:

- After the concrete placement: It is the most convenient, allowing setting-out once the concreting foundations, with the entire flat surface. Drill holes are made in the foundations, cleaning of drilling and applying epoxy. It is very important to verify that the starters are embedded at least 20 cm in the foundations. It is suitable to perform the operation in the early hours of setting of concrete.

- Prior to concrete placement: With this method the starters are completely embedded in the foundations without need of epoxy resin, but it requires setting-out to be extremely precise and the adoption of mechanisms to prevent displacement of starters during the concreting of the foundations.

All start rebars in foundations shall be installed in staggered formation, being a more reliable system in front of errors of execution. They may also be arranged in parallel, but with half the length of separation than in the staggered formation.



Picture 14. Start rebar Layout in staggered formation

Picture 15. Example of slab-on-grade-foundation with starters collocated in-situ, ie, prior to the concreting of the foundations element. Note the auxiliary longitudinal rebars, to prevent movement of the bars.

To start the process after the corresponding setting-out of the screed rail of the building, we have to start making holes in the foundations by hammer drill. Drilling is recommended after the day of

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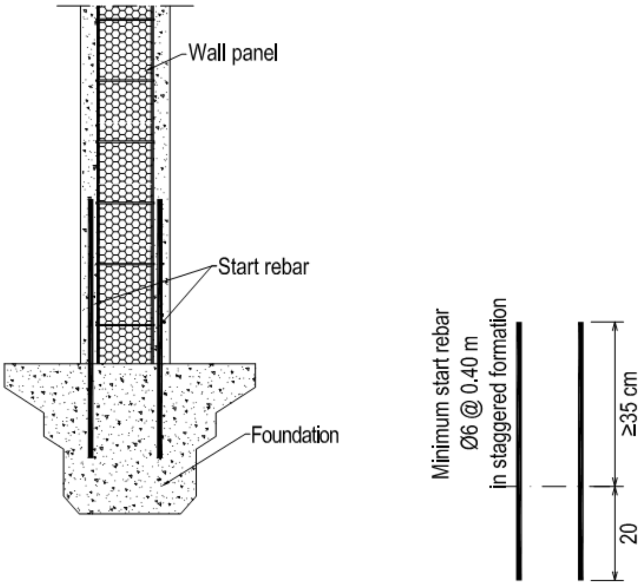
concreting, when the concrete is still fresh. Just after, it is necessary to remove concrete debris and dust from each of the holes using an air pump or a compressor.

Picture 1. Starters collocations after concreting foundations.

Picture 2. Starters collocations after concreting foundations.

The starters consist of corrugated rods of 6 mm in diameter as a minimum; it must be embedded in foundations a minimum of 20 cm and should overlap a minimum of 35 cm in the panel. The separation of 40 cm between bars is the most common, but is checked by calculation.

The start rebar could be increased regarding calculations if required



Picture 3. General details of connection with foundation.

16.3.3 Collocations vertical envelopes panels

It is important that persons responsible for assembling the building MZtec system are very methodical when it comes to following the assembly process, where remains the constructive logic we should not ignore at any time.

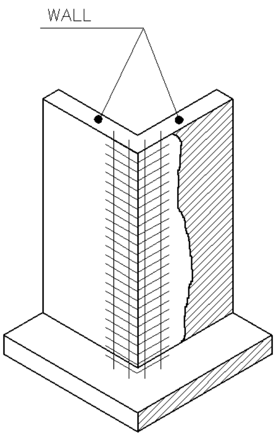
Prior to assembly, we must open the starters a little to facilitate the introduction of the vertical panels. Once done, start to assemble one of the edges of the building, carrying out complete stretch while bracing the wall by placing the first panels of the panels in a perpendicular direction, so the cores of the building are going to be formed.

It is important to tie the panels together through their vertical matched joints and starters to foundations too, so that the wind cannot move them during assembly process.

In case of very long stretches in diaphanous buildings, we will be having mud sills and struts on both sides to maintain their position and prevent displacement due to the wind.

Rigidity must be given to the joints between stretches by placing and tying of angular mesh (MA) that we will see later in details.
When panels are assembled according to these guidelines, once the slabs are placed and tied, before the shotcrete stage, it provides high strength to avoid possible movements due to wind forces.

Picture 4. Example of correct placement of vertical panels, as the longer stretch will gradually brace the wall with the first panels of the stretch perpendicular to it.



Picture 5. Figure of angular mesh (MA), which provides rigidity to the joints between vertical panels during assembly.

Picture 6. Scheme representing the correct order of assembly of the vertical envelope panels of a building. It should start assembling panels at the edge of the building. It is essential to go making operations tied between them and to the starters, as the panels are placed. Once rigid cores are formed such as the rooms of a house, it is very difficult for the wind to move the panels at place.

Picture 7. Installation of angular meshes (MA) in the edges, giving them great strength.

Picture 8. Correct installation process of vertical panels.

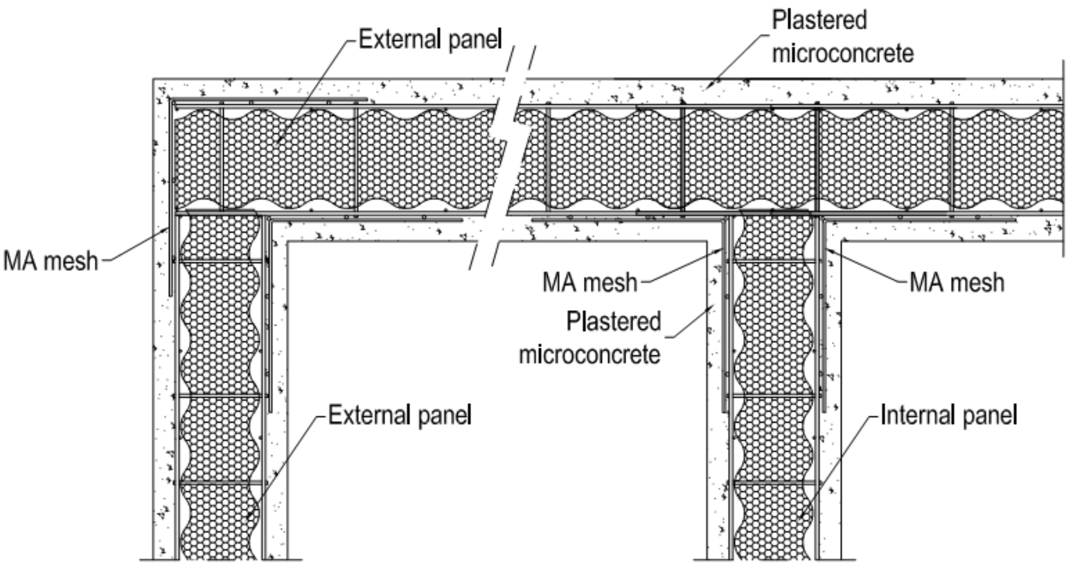
16.3.4 Panels ties

There are many methods to tie the panels together and the starters to foundations or between floors of a building. It is very important that the process of tying is done correctly to ensure proper overlap between rebars to ensure proper operation once concreting the building.

The lack of ties between panels can cause cracking once the concrete is applied, since if the mesh is loose a proper coating cannot be ensured. This condition usually occurs in the encounter between two contiguous panels and is manifested by a crack in longitudinal direction to the panel. It is not necessary to tie each and every one of the boxes on the meshes, but enough to apply some constructive logic:

- Tongue and groove joint between panels: Enough to make 4 or 5 ties along the vertical of a standard wall panel, about 3 meters high.
- Starters: Just make a tie in the middle point and at the free end of the starter, since its base is immobilized by contact with concrete.
- Mesh of linking between panels (MA, MU, MP): For angular meshes, "U" and flat meshes which make up the system, and from the standpoint of experience, we recommend a tied zig-zag at about each 4 or 5 frames. Thus, achieving a high rigidity of mesh placement because the knots have to be in a staggered formation.

Once all the knots are placed on the assembled panels, it obtains high rigidity, capable of withstanding the wind, so as the shotcrete process.



Picture 9. Cross section of wall panels where the angular meshes that must be placed in each and every one of the vertical joints can be observed.

Once having analyzed the methodology of implementation of the tied points in the meshes of the system, we will now analyze the many methods for making these connections:

- Pincers and simple wire: It is the easiest way to works of limited scope, involving the use of waste material wire, applying this in the knot and twisting by turning the pincers, while performing the cut of excess wire operating the tool. If you have enough skill and experience it is a quick method that uses economic tools.

-Automatic machine with spool of wire: This is a very fast and versatile automatic device. It has a continuous spool of wire it is responsible for dispensing and cutting. As an advantage it offers great speed and comfort, which makes it very profitable in some works of entity.

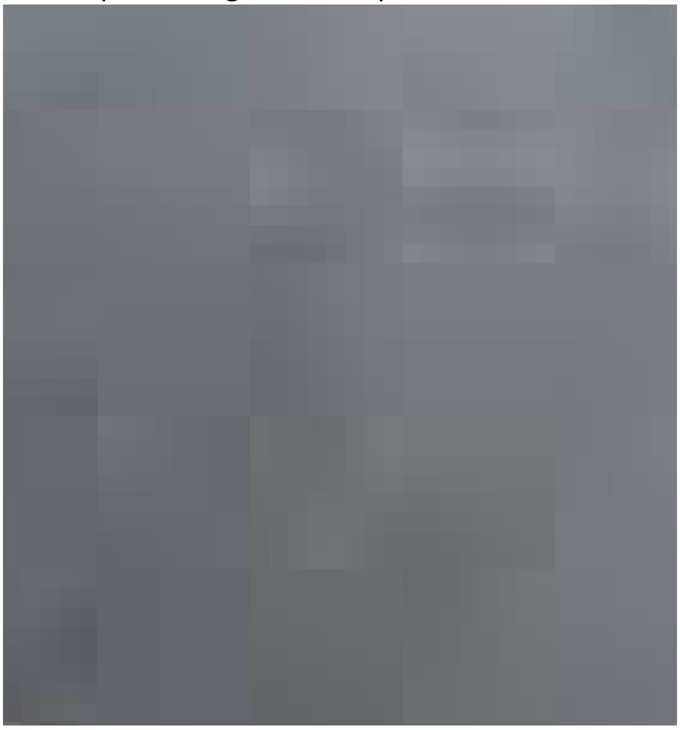
-Manual or automatic staplers: They are usually prepared for overlapping of rebars in parallel, if not always have this favourable condition. Present problems of lack of rigidity in ties, apart from the cost of the equipment. Manual machines are often too fragile.

- Worm screw and metal loops: It is an ingenious manual system based on very simple metal loops with two openings at each end, by which is introduced a hook that holds the tool. Pulling it toward the operator's body, the worm screw is responsible for coiling up the loop until the end breaks, implementing the knot. A simple and economic system with good results.

In all cases we recommend special attention to the proper implementation of tied points, ensuring that all wire is within the theoretical thickness, in the case of any protrusion placed in the concrete of the building, these can be entry points for corrosion to wall elements and floor slabs.

Picture 10. Example of ties through simple wire and pliers.

It is advisable to accustom the workers after completion of the knot, to compel, through a hand gesture or a hammer,that the wire is in contact with the mesh panel to prevent corrosion problems of metallic elements protruding wall once placed concrete.



Picture 11. Example of running tied points by automatic machine with continuous reel of wire.

Picture 12. Example of running tied points by automatic dispensing metal clips.

Picture 13. Example of using wire and pliers.

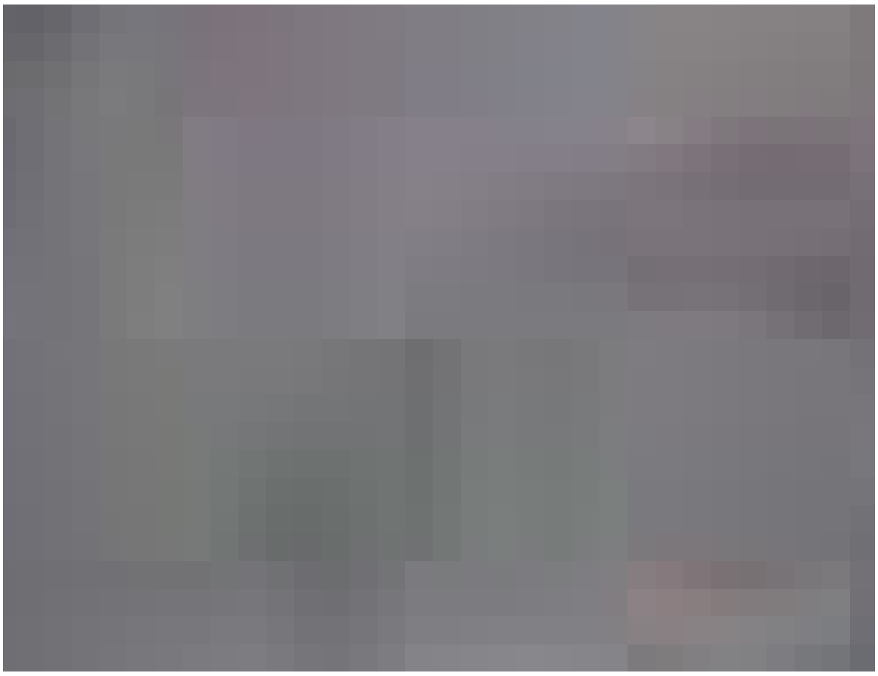
Union between sectional panels on the floor where it is very important to make a correct implementation of points tied angular meshes (MA) and overlaps between panels to avoid cracking in the concrete, caused by displacement of rebar.

16.3.5 Vertical alignment panels

Once vertical panels of envelopes are placed and before tying it is completely necessary to perform the plumbing of the same by individually placed struts, provisionally to place the slabs that rigidities the whole.
Another effective way to perform the plumbing is by longitudinal mudsill tied with wire to the mesh that will serve as a shelter for the props. To facilitate the task of plumbing it is very important, as discussed earlier in this manual, to ensure the cleanliness of the holder (slab or foundation) and its flatness and absence of imperfections as far as possible.

The panels used as exterior envelope are usually easy to plumb because they have an important section. It is more complicated to plumb the panels for interior buildings, which are usually smaller sections.

Picture 14. Detail of assembly phase of vertical panels.



Picture 15. Detail of plumbing and stabilization of vertical panels.

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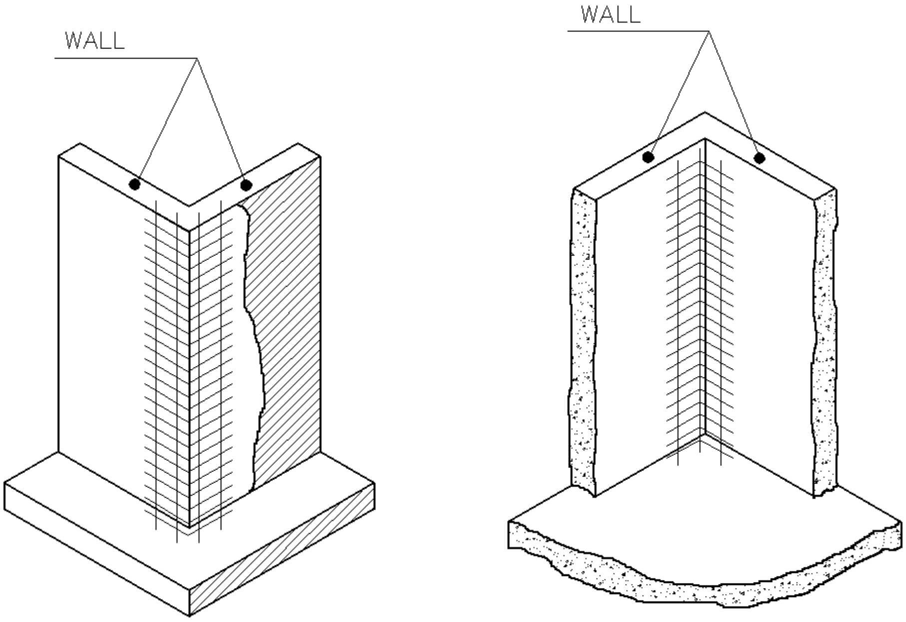
16.3.6 Installation of reinforcement meshes.

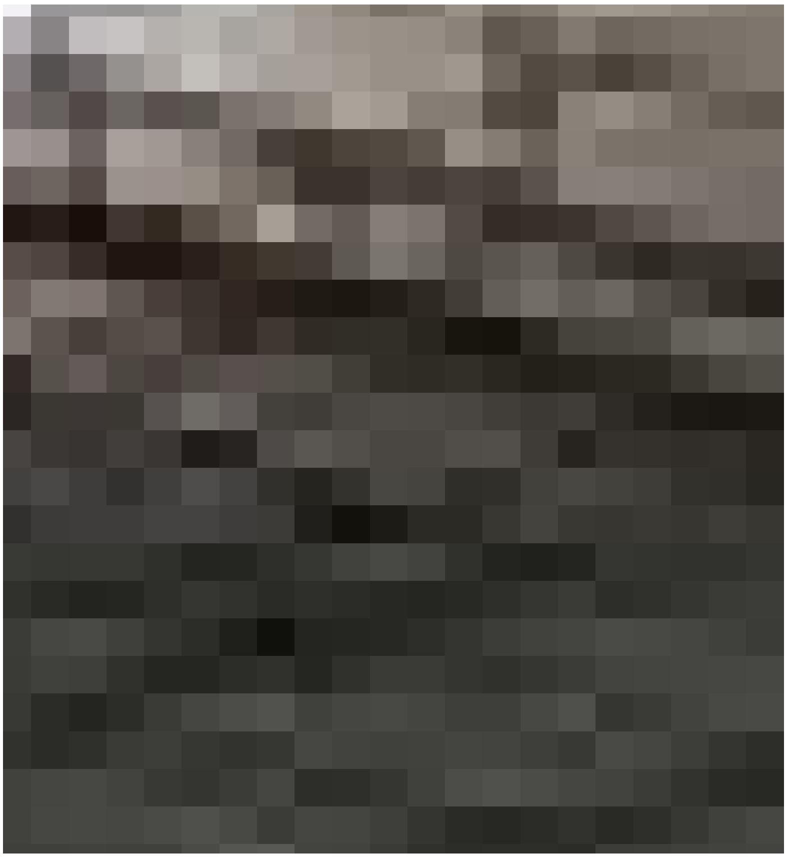
As mentioned above, it is essential for the proper functioning of all joints between panels and that brick molds of holes are properly reinforced with additional meshes that make up the system. There are several types of meshes, as described below:

- Flat Meshes (MP): These are flat type galvanized mesh that measure 0.26 x 1.16 m. Used primarily for straight joints between panels.
- Angular Meshes (MA): These are galvanized mesh which is supplied with an angle of 90 degrees and used especially in perpendicular joints between vertical panels and connections forged - wall. They can adapt to any angle by bending work.
- "U"- shape mesh (MU): These are mesh galvanized U-section, used primarily as and reinforcement of cantilever slab or free edges in the building.

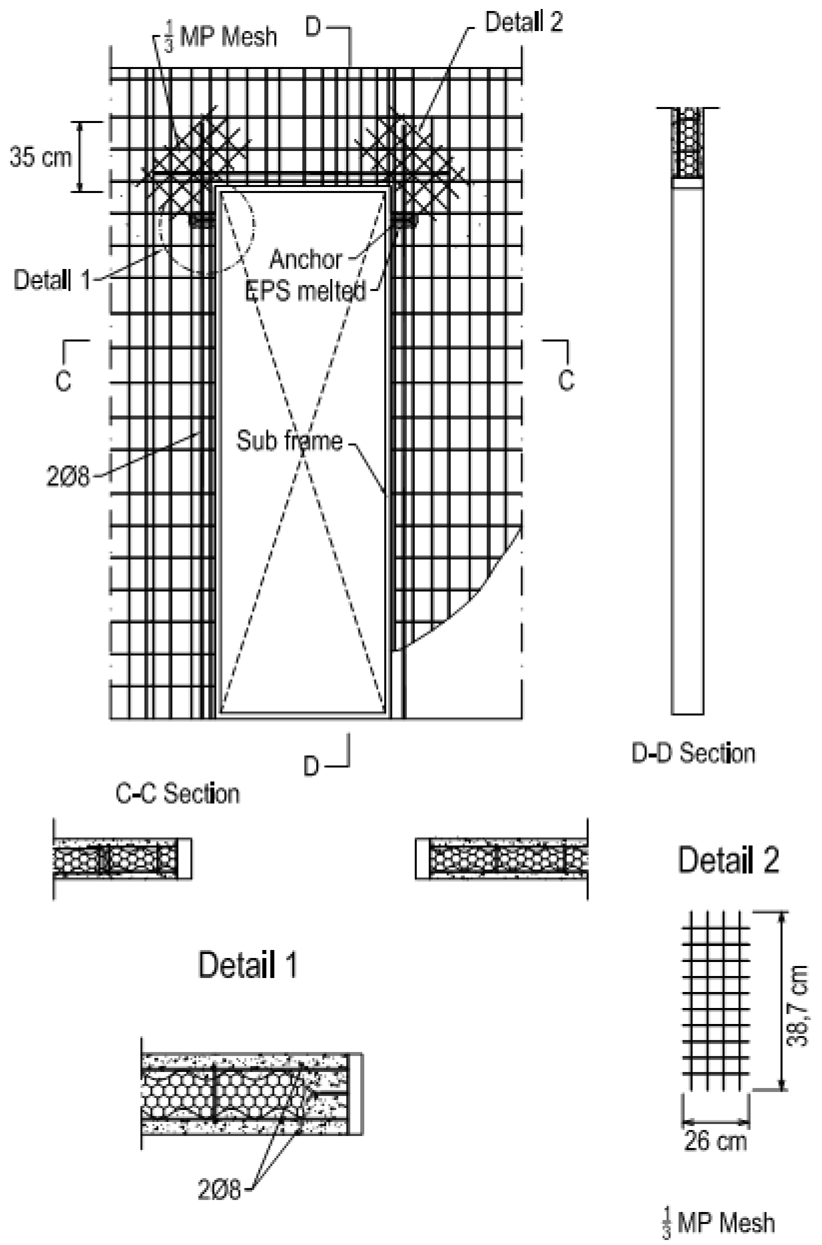
It is advisable to make the points of tying the mesh every 4 or 5 squares in staggered formation, as well as ensuring it is fully adhered to the integrative mesh panels to prevent loss of coating.



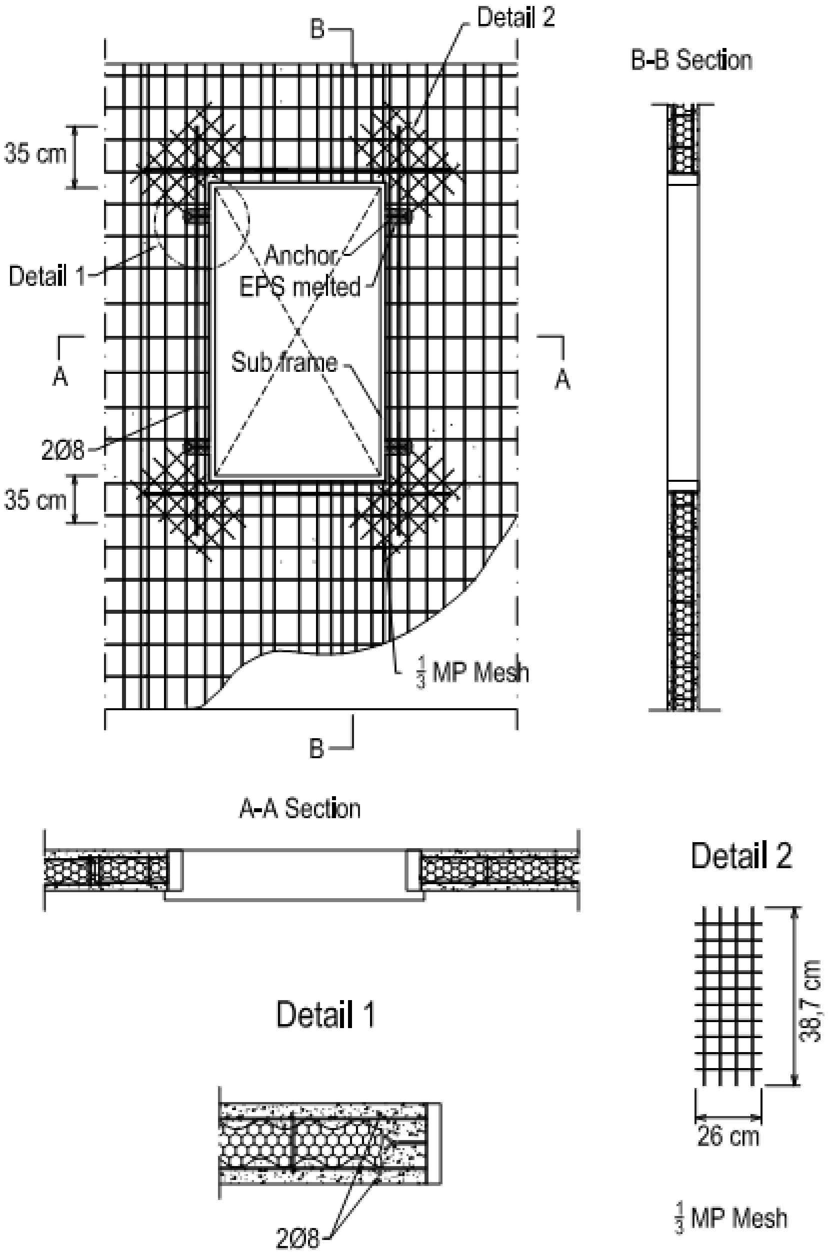
Picture 16. Reinforcement schemes corners MA type mesh. Should be arranged such reinforcements on both sides of the corners.



Picture 17. Example of hole for window with all mesh reinforcement placed.



Picture 18. Detail resolution of hollow for door. The upper corners will have flat mesh (MP) inclined 45 °, corresponding with accumulation zones of tension. One third available flat mesh is sufficient.



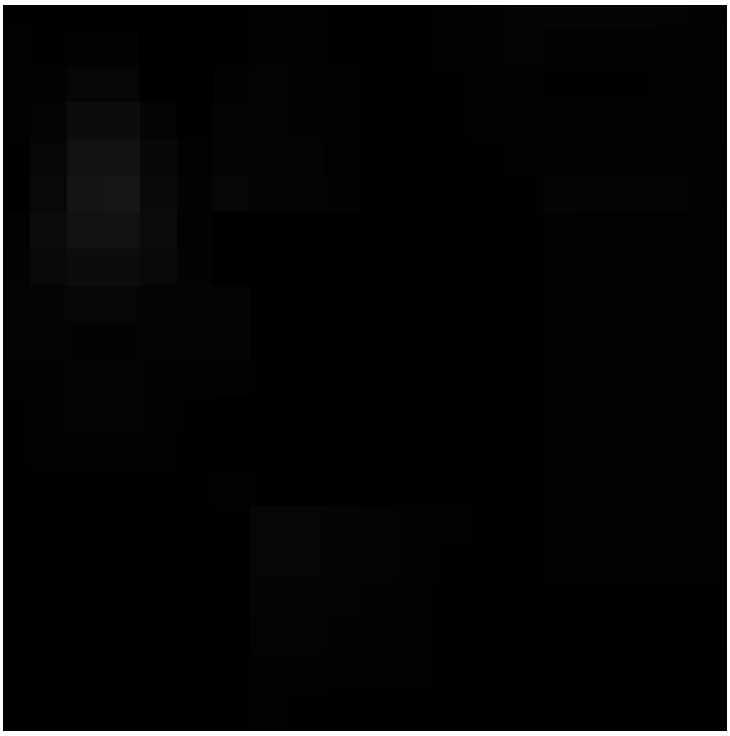
Picture 19. Detail of hollow resolution for window. The top and bottom corners provide flat meshes (MP) inclined 45 °, corresponding with accumulation zones of tension.
One third available flat mesh is sufficient.

16.3.7 Installation of slabs panel

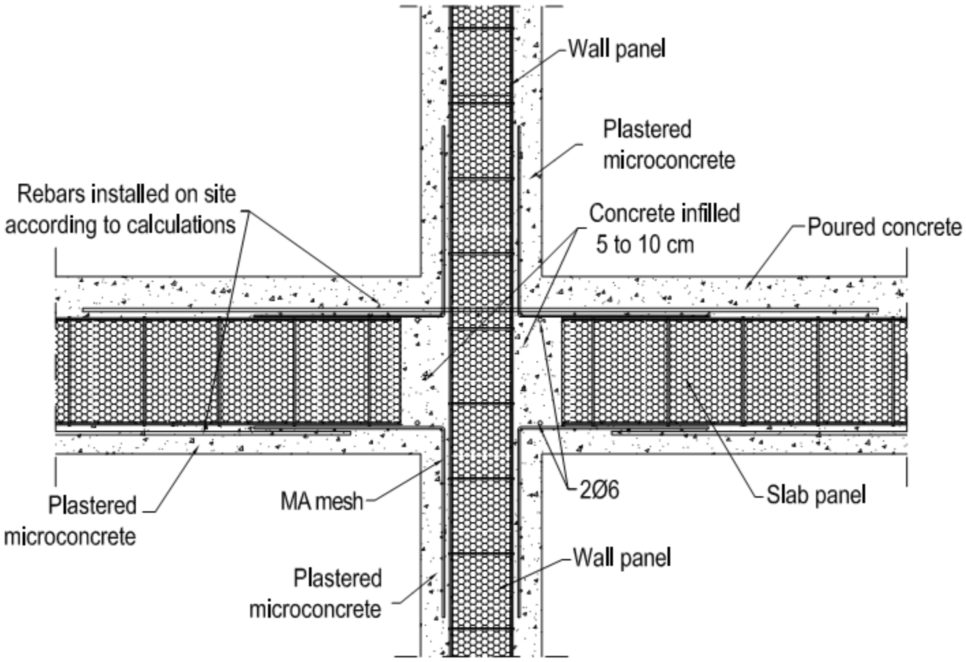
Once tied angular mesh in panels vertical envelope is necessary to place the MZF slabs, considering the main direction of the panel, which is the direction of the integrated corrugated rebars in the panel. First we have to reconsider and collocate the angular mesh, and thereafter, they rest on the panels of slab and make the respective moorings.

MZF panels are supplied 10 cm shorter than span length (5 cm in each edge), in order do not interrupt the vertical continuity of the shotcreted layer in the load-bearing vertical panels
In the panelized drawings the load-bearing walls has the same height as the top of the MZF panels, while non-load-bearing walls has the height of the underside of the slab in order to keep the continuity in the slab panel.

It shall proceed to make the tied reinforcement bar of the lower side of slab panels, If necessary by calculation, as indicated in the calculation log and the assembly drawings.
Once the slab is placed, it is recommended to apply a first layer of shotcrete on the lower side with 0,5 cm just to cover the rebar. This will follow the same steps on the vertical elements of the room. Then we can prop up the slab, which will be described below.
Once placed, we must apply a camber to the MZF panels, which is also explained in subsequent chapters.



Picture 20. Details of jointing slab with wall



Picture 21. Join detail MZF slab-MZN wall interface. We can see the continuity of the shotcreted layers of the top and bottom wall to ensure the continuity of the compression lines.

Once the angular mesh and the top rebars are installed on top, it´s time to pour the concrete in the compression layer getting a joint between slab and walls considered as pin jointed.

16.3.8 Installation of MZF panels for roofs

The solution for the implementation of MZF roofs with slabs is very similar to that used for the implementation of the slabs.

Be especially careful with the resolution of ridges, valleys and on pitched roofs, as they are points of stress concentration, and must ensure that these joints are properly overlapping with angular mesh and / or flat.

The assembly process and shotcrete is similar than horizontal MZF slab. The mix design of concrete must be adjusted to avoid lifting of concrete due to the pitch.

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Picture 22. Details of the formation of sloping roofs

Picture 23. MZF slab placed to wait to be shotcreted

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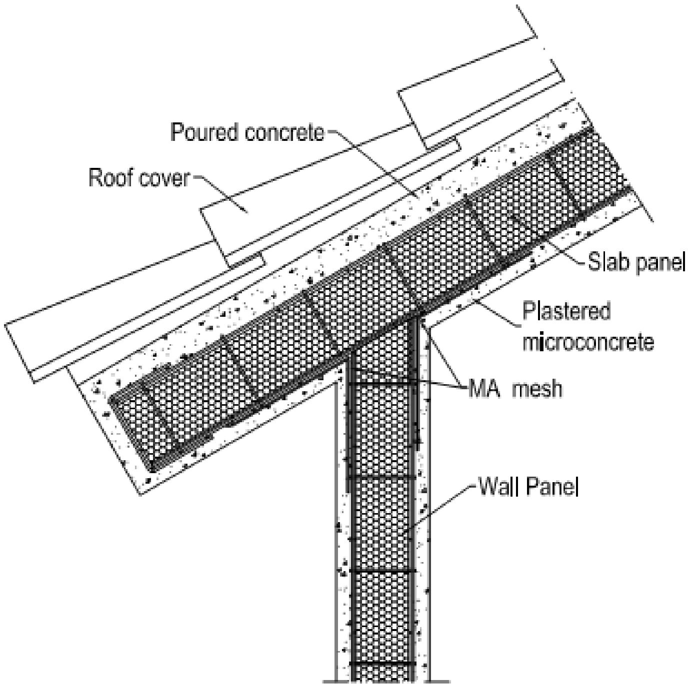


Picture 24. Joint detail sloping roof. It´s essential the correct Angular mesh fixation, which can be adapted to the angle simply by hand bending without the use of any tool.

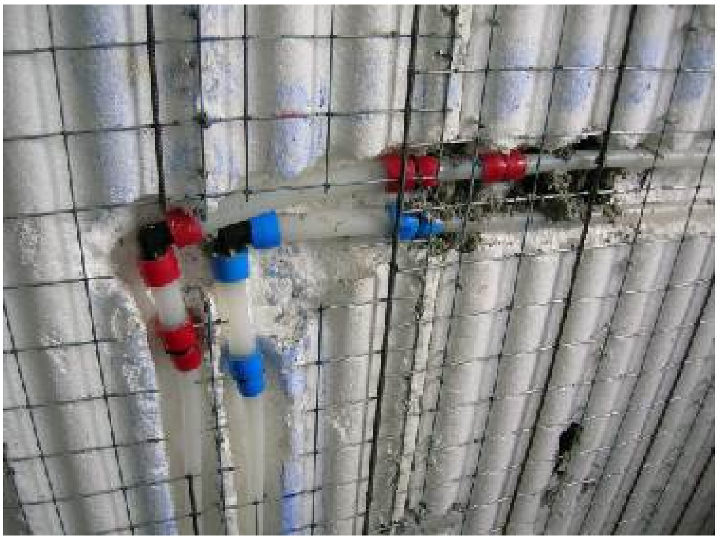
Picture 25. Construction detail of concrete cornice in MZF panel. The construction solution is identical to that for traditional slabs.

16.3.9 Facilities installations

Facilities are embedded in the EPS layer of the panels, making the channel through the application of hot air, which melts the EPS without causing residue. Hot or limited power torch is used.

The integrative mesh panel can be broken to place electrical cables or pipes to make the installation easier, having to restore the mesh with mesh later, tying flat mesh before shotcreting. Water pipes shall be polypropylene or polybutylene, but never copper, to avoid the galvanic attack when placed in contact with steel mesh. The facilities can be fixed by mortar, polyurethane foam or simple wire until the panels are shotcreted.

Picture 26. Detail of hot machine based on hot air



Picture 27. Detail of electrical and plumbing installations before shotcreting. In the left picture, the integral mesh has been cut to install the pipes. Before shotcreting flat mesh shall be added.

16.3.10 Prop up and slabs assembly - Previous preparation of shotcrete.

Once the panels that form the slab are assembled, we will proceed to make the tie points between the angular meshes placed on the walls and slab panels which have placed on them, checking at all times the realization of the tying points in the quincunx mesh, in the angular mesh joint between walls - slabs. We also verify the correct longitudinal tied slab panels.

The previous preparation for the shotcrete consists of a review of tying points mentioned above, in addition to the placement of the reinforcement bar to positive movement on the underside of the slab, if this was necessary for calculation, as indicated in assembly drawings.

Once the lower face is assembled, all reinforcement meshes needed are placed for connecting the upper surface of the slabs with the walls. Subsequently put on the reinforcement rebar to negative movement if this was necessary for calculation, as indicated in the assembly drawings.
If the operators are going to work on the slab panels, it will be necessary to make a provisional slab prop up.

Once all tied points are done, we are ready to shotcrete, starting with the walls and going through the underside of the slab, as discussed elsewhere in this assembly manual.
It´s recommended once the first layer of the wall is projected, to proceed to a minimum layer shotcrete of less than a centimeter thick on the slab underside, without being propped yet. This seeks to protect the rebars.

Picture 28. Detail of provisional prop up during the slab inferior shotcreting. All points have been properly tied, armed reinforcements were placed required by calculation and has even been projected as first layer of the walls.

Then proceed to prop up the slab, putting metal or wooden mud sills, so that the section in contact with the slab is as low as possible. These support lines are placed between 1 and 1.4 meters apart depending on the workload and the span length of the slab.

They are arranged perpendicular to the direction of the corrugated rebar built into the panel. In every support line props will be placed every meter.

Then proceed to apply a camber in the center of the opening, at 0.5 cm per meter of span length. (Example: 4 meters span length = 2 cm camber in mid span length). Finally proceed to shotcrete the first layer on the underside of the slab.

Picture 29. Detail of slab prop up after the first shotcreting phase of slab bottom side

Picture 30. Detail of slab prop up after the second shotcreting phase of slab bottom side

16.3.11 Micro concrete application with plastering machines

The shotcrete machines produce a compact design and a vibration of the concrete to be driven hardly to the support by the injection of compressed air. Previously, the concrete screed lines must be placed (with steel or mortar) to control the thickness.

Procedure to follow for shotcrete
Firstly, the vertical elements shall be shotcreted, proceeding to apply a first cover of about 2 cm thickness approximately.
The first layer will have a rough finish for easy grip with the second shotcreted layer.

Picture 31. Detail of shotcreting phase

The final covering shall be to conform the calculation job and structural drawings of the project.
To ensure the cover in the concrete layers, vertical metal screed lines shall be placed, to facilitate the concrete and screeding. The screeds shall be removed before finishing the second shotcreted layer.

Recognition of the area shall be done prior to shotcrete, since it is advisable to make the shotcrete phase without interruption.

Between the first and second shotcreted layers shall elapse the minimum time possible. For more than 3 days between the two shotcreted layers, a chemical adhesive shall be applied.

It is advisable to shotcrete the second layer the day after it was first shotcreted. Under hot weather conditions the first shotcreted layer should be watered to increase the adhesion with the

second shotcreted layer. The walls shall be shotcreted on both with the minimum elapsed time to reduce the risk of shrinkage and cracking due to dilatation, especially in exposed facades.

Picture 32. Detail of shotcreting of vertical elements.

The shotcrete of the underside of the slabs or roofs can be made after pouring the compression layer of 5 cm and once the walls props are removed after 15 days, the execution of the compression layer. Once the two layers of all the vertical elements are shotcreted, as well as the underside of the slab or roof openings, we can proceed to the pouring of the compression layer.

Picture 33. Detail of pouring phase of the compression layer of slabs

Once the compression strength is reached, the props of the slab can be removed. Then the final cover can be applied.

16.3.12 Finished applications

One of the main advantages of the system is its flexibility in a matter of finishing, fully admitting the most common finishes such as plaster, mortar, mortar monolayer, cladding stone, stucco, tiles and much more. It even admits the possibility of setting the fair-face concrete ready to paint directly. This is possible due to the small size of micro-concrete aggregate used.

MZtec system is also compatible with structural elements such as metallic and concrete beams, waffle slabs, brick walls, concrete block, prefabricated joist slabs, solid slabs, coffered slabs, etc.

Picture 34. Detail of different finishing in MZtec system

Picture 35. Detail of different construction phases in MZtec system

Picture 36. Detail of different construction phases in MZtec system

Picture 37. Detail of a finished single family house

16.4 MZtec system mixed with traditional systems

MZtec system can be installed with traditional construction systems such as concrete slabs, steel and concrete beams and also be used as closing and partitions considered as on bearing walls.

Basically the installation is built in the same way as for MZtec system buildings (i.e. MZtec system used in the building without use of traditional constructions elements: columns, beams or traditional slabs), with the particular characteristics of the joints with the traditional elements: slabs or beams.

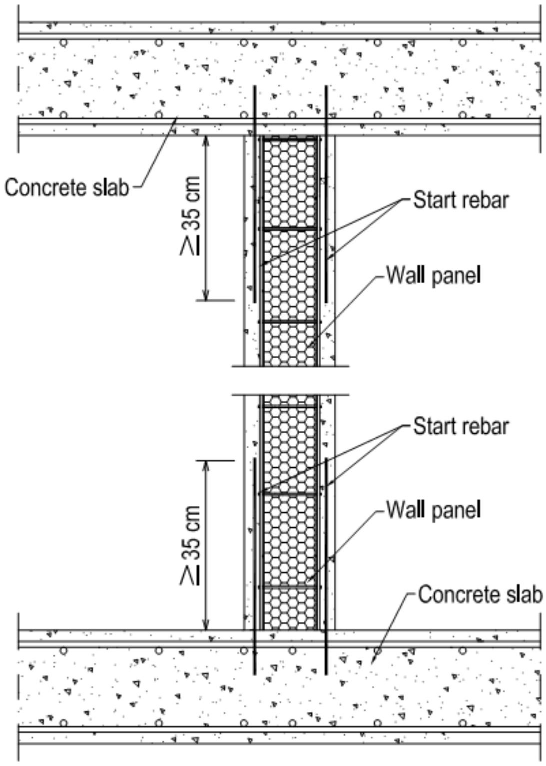
The assembly phase, shotcreting phase, reinforcement and other steps shall be performed as indicated previously in this chapter
The installation requirements for this "mixed systems" are exposed below.

16.4.1 MZtec walls used as non-bearing walls.

The application of MZtec system as non-bearing walls in buildings whose structure has been executed with the traditional system, usually reinforced concrete or steel has multiple advantages:
- High thermal insulation of the envelope.
- Reduced weight of the envelope.
- High speed of execution.
- Increase the usable area of the building, due to smaller thickness envelope.

- Absence of thermal bridges.
- High resistance to external solicitations such as wind or earthquake acting as shear walls
- Total freedom to apply finishes of any kind.
- Wide range of thermal insulation thicknesses to choose from.
- Obtain high energy efficiency of the building.
- Absence of heavy machinery in the work, thus saving money.

The panels are supplied with 5cm less than the clear height to make the layout of the panels easier.



Picture 38. Joint detail of concrete slab and MZtec non bearing wall interface

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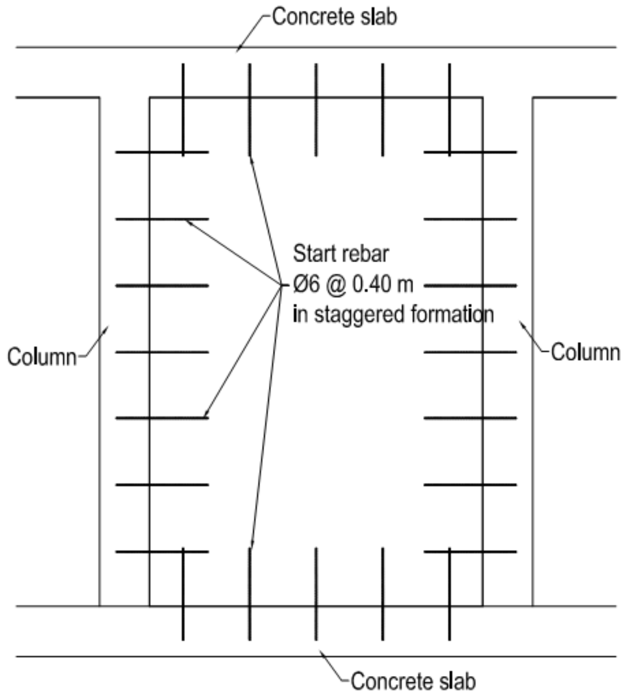


Picture 39. Joint detail of concrete slab and MZtec non bearing wall interface.
Note that all the perimeter of the wall is anchored to the existing structure

Always looking for maximum efficiency and speed of system execution, we recommend placing the starters once the structure is executed due to the fact that in case of setting out the starters before executing the slab, often it moves out and there is not good layout after concreting the slabs.

In case of placing the rebars after concreting the slab, the drills shall be done to install the star rebars with epoxy resin into the concrete, in the similar way as in MZtec system buildings.

The star rebars shall be anchoraged in the concrete slab by epoxy resin with a development length according to the specification of the manufacturer which shall have to ensure the proper anchorage of the rebar in the concrete. In any case this development length shall not be less than 10 cm.

The start rebar shall be a corrugated rebar of 6 mm in diameter each 40 cm with the development length of the 35 cm into the shotcreted layer as minimum.

As MZtec walls could be used as shear walls for horizontal loads, the panels shall be reinforced by corrugated bars or galvanized steel mesh if required by calculations according to the supplied project drawings.

We must ensure proper cleaning of the holes made through slabs by an air pump, so that these holes are perfectly clean to avoid altering the adhesion of the epoxy resin used. These drills will be conducted in slab edges and concrete supports. If metal supports are used, it shall be resolved by welding.

The panel assembly has the same specifications as describe previously.

Picture 40. Installation of facade envelopes panels. Panels are tied to the starters that are planned for slabs and concrete supports. Screed rail has also been putting to control the plumbing walls face and the concrete thickness.

To avoid thermal bridges in the envelopes by a bad slab execution (default flatness as pictured above) any holes that remain between slabs and panels can be filled with polyurethane foam.

Picture 41. Placement details of MZC envelope

Picture 42. Detail of a building before the shotcreting phase.

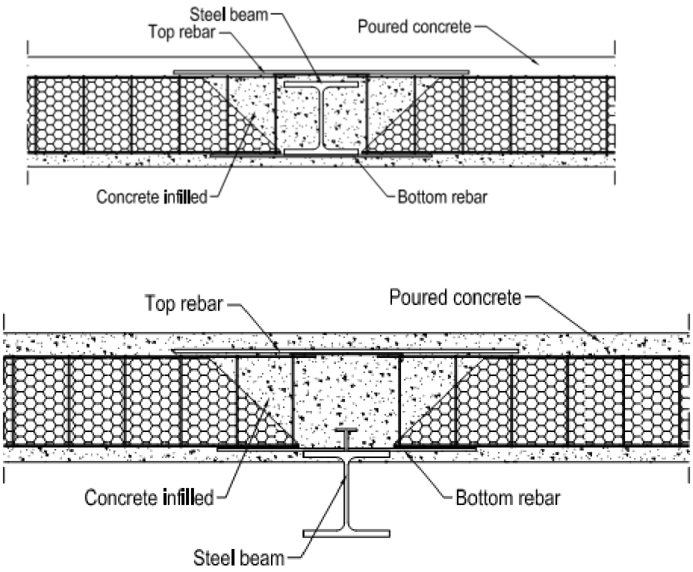
Picture 43. Reinforcement mesh details in openings in façade cladding. Note the U-shape mesh in the edges of the openings and the 45º flat mesh in the corners of the windows.

Picture 44. Projected detail of the micro-concrete. Note the use of fixing or mobile scaffolding, depending on the geometry of the building.

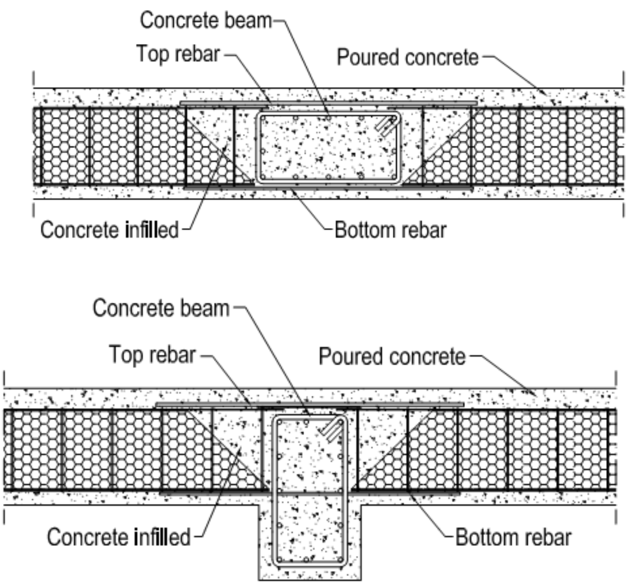
Picture 45. Details of finish floated concrete to paint directly.

16.4.2 MZtec slabs installed with traditional beams

MZtec slabs are installed with the same specifications than in MZtec system buildings.
Following the construction details when MZtec slabs are supported for concrete and steel beams are exposed.

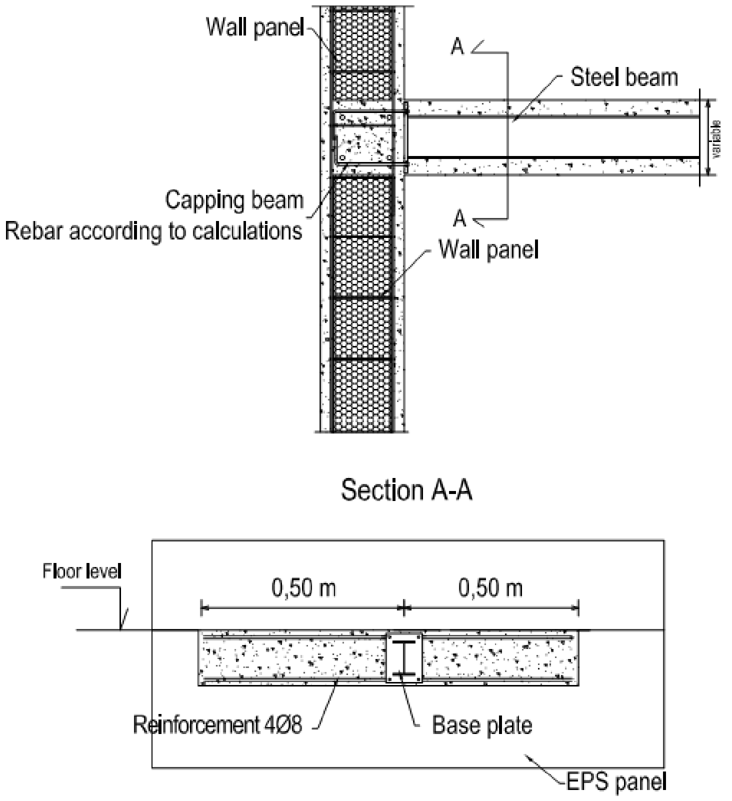


Picture 46. Joint detail of MZtec slab and steel beam interface.



Picture 47. Joint detail of MZtec slab and concrete beam interface.

In case of using concrete or steel beams in MZtec system buildings, the support of the beams shall be installed as indicated in the following construction detail.



Picture 48. Joint detail of concrete beam and MZtec wall interface.

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17. STANDARDS

ACI 318-08 Building Requirements for Structural Concrete.
Eurocode 2: Design of concrete structures
EHE 2008 Spanish Concrete Code
British Standards
ASTM a615-A615M Steel Bars for Concrete Reinforcement
ASTM C150 Portland Cement
ACI 305-99 Hot weather concreting
ACI 506-R-05 Guide to Shotcrete
ASTM C42/C42M-04, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
ASTM C1116/C1116M-08a, Standard Specification for Fiber-Reinforced Concrete.
ASTM C1140-03a, Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels.
ASTM C1141/C1141M-08, Standard Specification for Admixtures for Shotcrete.
ASTM C1385/C1385M-98(2004)e1, Standard Practice for Sampling Materials for Shotcrete.
ASTM C1398-07, Standard Test Method for Laboratory Determination of the Time Setting of Hydraulic-Cement Mortars Containing Additives for Shotcrete by the Use of Gillmore Needles.
ASTM C1436-08, Standard Specification for Materials for Shotcrete.
ASTM C1480/C1480M-07, Standard Specification for Packaged, Pre-Blended, Dry, Combined Materials for Use in Wet or Dry Shotcrete Application.
UNE-EN 13501-4: 2007: Fire classification of construction products and building elements - Classification using data from fire resistance tests on components of smoke control systems
UNE-EN 13163:2002 Thermal insulation products for buildings. Factory made products of expanded polystyrene (EPS) . Specification.
UNE 23.727-90 Reaction to fire tests of building materials. Classification materials used in construction. "
UNE 36092:1996 Steel welded fabric for concrete reinforcing.
UNE 36068:2011 Ribbed bars of weldable steel for the reinforcement of concrete.
UNE-EN 1602:1997 Thermal insulating products for building applications. Determination of the apparent density.
UNE-EN 1609:1997 Thermal insulating products for building applications. Determination of short term water absorption by partial immersion.
UNE-EN 826:1996 Thermal insulating products for building applications. Determination of compression behaviour.
UNE-EN 12089:1997 Thermal insulating products for building applications. Determination of bending behaviour.

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APPENDIX 1 -CONSTRUCTION DETAILS

Drawing	1	Geometry of EPS panels
Drawing	2	MZN wall panel
Drawing	3	MZR wall panel
Drawing	4	MZC wall panel
Drawing	5	MZF slab panel
Drawing	6	Detail of foundation interphase I
Drawing	7	Detail of foundation interphase II
Drawing	8	Joint detail of wall panel and concrete beam interphase
Drawing	9	Detail joint of wall panel and slab panel I
Drawing	10	Detail joint of wall panel and slab panel II
Drawing	11	Joint detail of wall interphase (cross section)
Drawing	12	Joint detail of a cantilever slab
Drawing	13	Joint details of non-bearing wall and slab interphase (cross section)
Drawing	14	Openings I
Drawing	15	Openings II
Drawing	16	Joint detail of wall panel and reinforced concrete slab
Drawing	17	Joint detail of wall panel and reinforced concrete beam
Drawing	18	Joint detail of wall panel and steel beam
Drawing	19	Joint detail of roof slab panel and wall panel
Drawing	20	Joint detail of start rebars for closing wall and concrete structure
Drawing	21	Joint detail of wall panel and reinforced concrete slab
Drawing	22	Different joints between slab panel and conventional beam I
Drawing	23	Different joints between slab panel and conventional beam
Drawing	24	MZtec EPS Panel. Width 1200 mm.
Drawing	25	MZtec Reinforced Panel - MZN. Electro welded mesh. Width 1200 mm.
Drawing	26	MZtec Simple Panel - MZN. Width 1200 mm.
Drawing	27	MZtec Reinforced Panel - MZR. Electro welded mesh. Width 1200 mm.
Drawing	28	MZtec Reinforced Panel - MZR. Width 1200 mm.
Drawing	29	MZtec Reinforced Panel - MZF. Electro welded mesh. Width 1200 mm.
Drawing	30	MZtec Reinforced Panel - MZF. Width 1200 mm.
Drawing	31	MZtec closing Panel - MZC. Electro welded mesh. Width 1200 mm.
Drawing	32	MZtec Closing Panel - MZC. Width 1200 mm.

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