AUGUST 2020

DOUBLE WALL

technical manual

australprecast®

The Guide to be used by Qualified Structural Engineers, Architects, Builders and Associated Industries.

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The design of the Austral Precast Double Wall must be carried out by a suitably qualified and experienced structural engineer, who considers both the performance of the walls and their role in the structural behaviour of the building as a whole.

This material has been prepared in the context of relevant Australian Standards, the National Construction Code (NCC), the Building Code of Australia (BCA) and the French specific regulation for the Double Wall in accordance with Eurocode 2.

Users should make themselves aware of any recent changes to the referenced documents and to local variations or requirements.

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AUSTRAL PRECAST DOUBLE WALL

1

AUSTRAL PRECAST DOUBLE WALL

1.1 General

Austral Precast Double Wall is a permanent formwork system with all the quality and efficiency advantages of precast manufacture, together with the engineering benefits of in-situ construction.

The Double Wall is a structural wall that consists of a pair of thin precast reinforced concrete shells, connected by a steel lattice girder (trusses). The trusses are fabricated from reinforcing bar and span the cavity between the two precast shells.

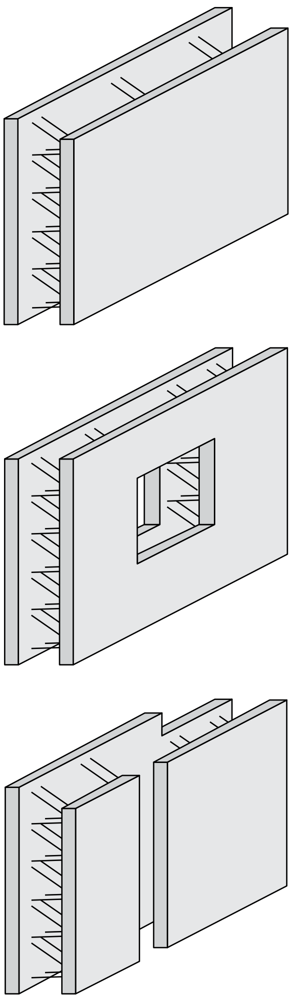


Figure 1.1 – Double Wall Possibilities

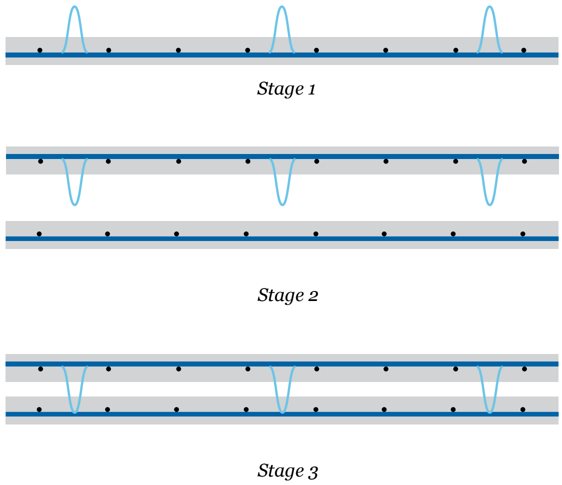


Figure 1.2 – Double Wall Manufacturing Stages

The first shell is cast as a slab on a vibrating table with mesh, connecting trusses and spacers to control the overall thickness of the wall.

Once the first shell has cured to sufficient strength, it is inverted and lowered into the second shell whilst maintaining the void between shell, vibrated and cured.

Additional steel reinforcement, edge forms, openings and cast-in components may be incorporated into the Double Wall panel in the factory as part of the system. On site, panels are placed into final position, braced temporarily, edge forms and adjacent panel and slab reinforcement connections are completed and the core cavity is filled with premixed concrete to create a monolithic concrete structure.

The result is a permanent formwork system with a high quality surface finish that is designed for fast and economical site construction processes with flexibility for individual planning and architectural objectives.

Site placed footing reinforcement — Wall structural reinforcement — Truss — Splicing Steel — Concrete — Core-fill Concrete

AUSTRAL PRECAST DOUBLE WALL

1.2 Features and Benefits

The major advantage of double wall over other systems is that the majority of structural components that are required to achieve the design application are integrated in the factory under strict quality-controlled conditions, ready for delivery and installation to site. Many items can be incorporated into the wall in the factory including:

- Lifting points
- Structural reinforcement in each precast shell
- Formwork for cut-outs such as windows, doors and other penetrations
- Cast in items including pull-out bars, ferrules, conduits, electrical outlets, etc.

Typical Features

- Overall Dimensions: up to 3.50m x 13.00m
- Overall Wall Thickness: 170,180,200,220,250,300,350 and 400 mm
- Precast Shell Thickness: 50 to 70mm
- Typical mass: 250 to 375 kg/m²
- Maximum total mass: 12,000kg per panel
- Reinforcement: All reinforcement integrated for columns, beams, lintels, etc.
- Cast-In items: Integration of inserts for props, electrical outlets, conduits, etc.
- Formwork: Integration of formwork for openings where specified
- Finish: Class 2 steel table finish both sides of wall (AS3610)

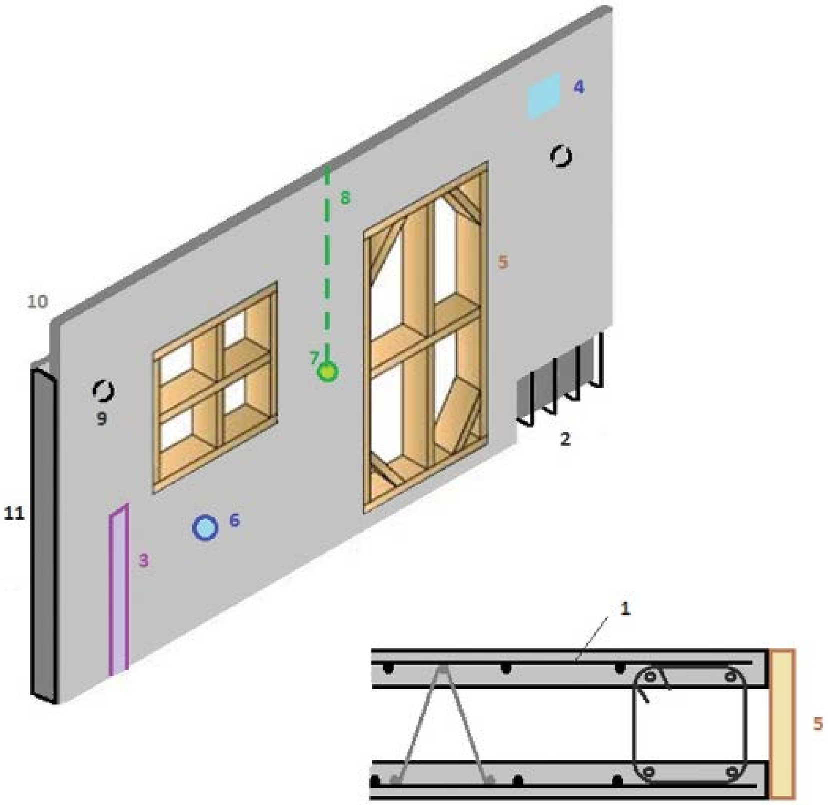
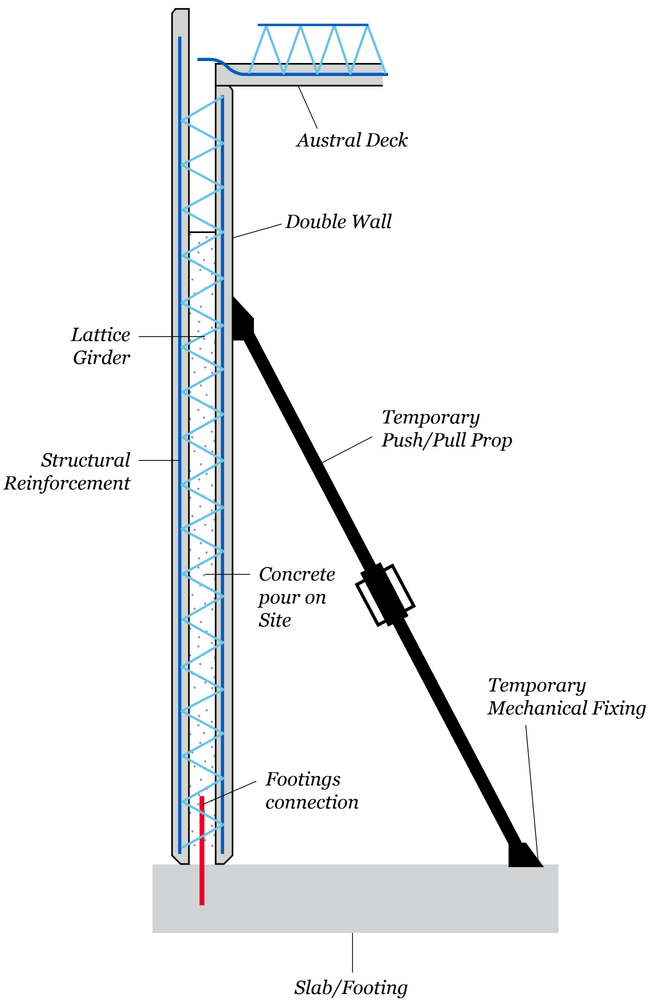


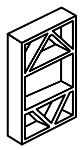
Figure 1.3 – Double Wall Features

1 Precast Shell Reinforcement
2 Exposed lapping reinforcement
3 Keybox
4 Void / Opening 5 Timber shutter
6 PVC void
7 Electrical outlet
8 Electrical conduit
9 Bracing Ferrule
10 Extended shell
11 End shutter

AUSTRAL PRECAST DOUBLE WALL

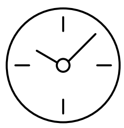
DOUBLE WALL IS THE IDEAL TECHNICAL SOLUTION FOR CONSTRUCTION OF SUBSTRUCTURE AND SUPERSTRUCTURE STRUCTURES, INCLUDING IN SEISMIC AREAS.



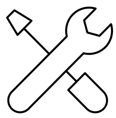


Integration of formwork shutters, electrical outlets, services voids, etc.

Less pain for your workers



Short delays between order and delivery



Specific equipment available for purchase

Figure 1.4 – Double Wall Solution

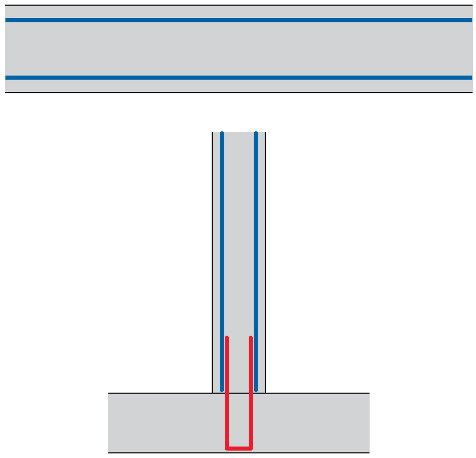
Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

AUSTRAL PRECAST DOUBLE WALL

1.3 Design Conversion

Converting traditional in-situ walls to Double Wall is simpler than traditional solid wall precast. Double Wall behaves like a traditional cast in-situ reinforced wall. The designer simply needs to understand the intended use of wall (occupancy, fire ratings, acoustics, environmental, geotechnical, durability, etc.) and loading conditions (design loads) to calculate the required reinforced concrete design. From here, the designer calculates equivalent steel in the shells and required joints for each element and check this against the design criteria.

Pour In-Situ Wall



Double Wall

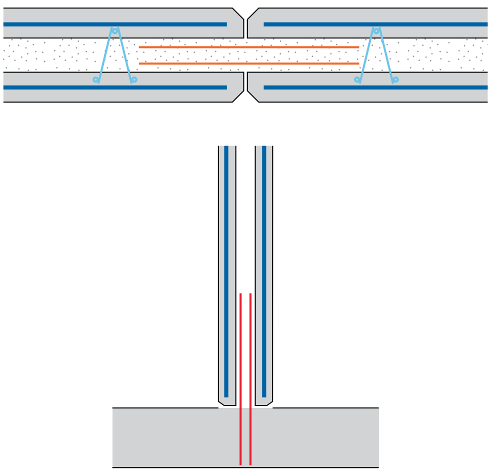


Figure 1.5 – Pour In-Site and Double Wall Equivalent

1.4 Installation Process

Installation of Double Wall has many advantages over other systems. The majority of structural components are installed in the factory thus reducing the on-site labour required for handling both steel and formwork. Wall elements are lifted into the installation position by crane and secured by temporary props or braces. The joint splicing steel is placed inside the core cavity of the wall and subsequent wall elements are placed and secured into position. Once elements have been placed into position, the core of the wall is filled with concrete to complete the process.

Figure 1.6 – Double Wall Installation Process

Day 1:

Panels delivered to site, craned into position, secured into final position and joint reinforcement installed.

Day 2:

Double Wall core is wet immediately prior to concrete placement and core filled according to pouring schedule.

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

AUSTRAL PRECAST DOUBLE WALL

Installation Advantages

No hot works, no dowel voids

Double Wall is a safer and faster construction option as there are fewer activities and hence fewer people required on site. No grouting or patching of dowel voids is required. Hot-works are eliminated on-site for the installation of Double wall as there is no welding of plates for panel to panel connections on site.

Surface finish

The finished product quality of Double Wall supersedes other walling systems. The manufacturing process is such that each shell is cast on a steel pallet, giving a Class 2 Finish from the steel face that is ready for surface preparation treatment for painting as supplied from the factory. No rendering is required. This can give significant benefits in both overall cost and time for the customer.

Water resistance capabilities

Double Wall is suitable for construction where water-resistance is required and capable of withstanding a hydraulic water pressure of up to 0.2MPa (20m water head). Water resistance is maintained by the properties of the Double Wall, meeting the requirements of AS 3735-2001 Concrete Structures for retaining liquids.

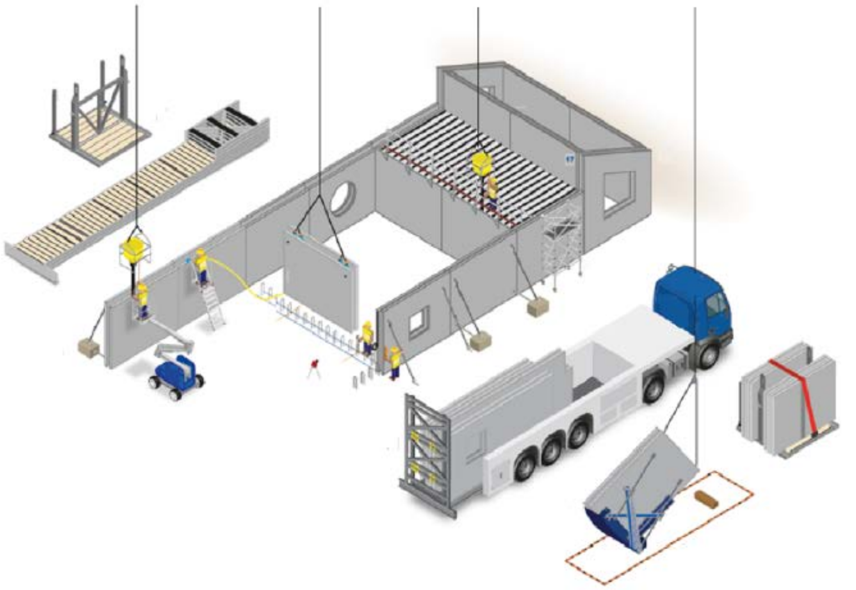
Handling and Transportation

Other advantages include reduced transport and crane requirements in comparison to traditional precast as each shell has maximum thickness of 70mm from the factory, reducing the overall mass of the wall.

AUSTRAL PRECAST DOUBLE WALL

The Double Wall can be used for interior and exterior walls.

The maximum Dimensions are 3.5 x 13m



When the Double Wall is greater than 3.5m in height,
panels are transported horizontally and then rotated on site:

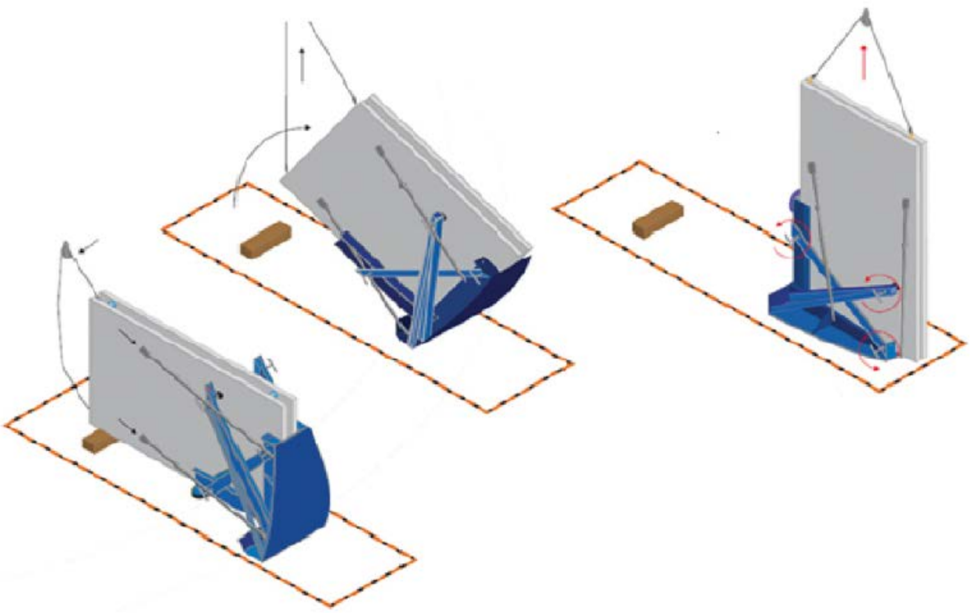


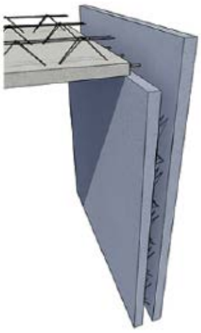
Figure 1.6 – Panel Rotation

AUSTRAL PRECAST DOUBLE WALL

1.5 Applications

Double Wall is a versatile product with a wide variety of applications where reinforced concrete may be used. These include, but are not limited to:

- Retaining walls
- Basement walls
- Shear walls
- Lift and stair shaft core walls
- High rise façade and infill walls
- Tanks and silos
- Underground walls
- Structural and non-structural walls
- Perimeter and boundary walls
- Noise walls
- Industrial, residential and commercial buildings
- Car parks
- Public buildings
- Civil and government infrastructure



DESIGN REGULATIONS

2

DESIGN REGULATIONS

2.1 Australian Regulations

The proposed structural services will be designed and installed in accordance with the National Construction Code, and the relevant Australian Standards.

Specifically, the relevant acts, codes and standards include, but are not limited to, the following:

- AS1170 Part 0 – Structural Design Actions – General Principles
- AS1170 Part 1 – Structural Design Actions – Permanent, imposed and other actions
- AS1170 Part 2 – Structural Design Actions – Wind Actions
- AS1170 Part 4 – Structural Design Actions – Earthquake Loads
- AS1379-2007(+A2) Specification and Supply of Concrete
- AS1657 Fixed Platforms, Stairways, Walkways and Ladders
- AS2159 Piling – Design and Installation
- AS 2550.1 Cranes, Hoist and Winches – Safe use – General Requirements
- AS 2550.4 Cranes, Hoist and Winches – Safe use – Tower Cranes
- AS 2550.5 Cranes, Hoist and Winches – Safe use – Mobile Cranes
- AS 2550.10 Cranes, Hoist and Winches – Safe use – Mobile elevating work platforms
- AS2870 Residential Slabs and Footings
- AS3600-2018 Concrete Structures
- AS3610.1-2018 Formwork for Concrete
- AS3610-1995 Formwork for Concrete
- AS3700 Masonry Structures
- AS3735 Concrete Structures for Retaining Liquids
- AS3850 Prefabricated Concrete Elements
- AS4055 Wind Loads for Housing
- AS4671 Steel Reinforcing Materials
- AS4678 Earth Retaining Structures

2.2 International Regulations

Where a design calculation for Double Wall is not defined in the Australian Standards, the calculation may be referenced to the Double Wall regulations in France and/or Europe. The relevant international codes and standards include, but are not limited to:

- French Regulation for Double Wall
  CPT M.C.I. – CSTB Cahier 3690-V2 - July 2014
  Cahier des prescriptions techniques communes aux precédés de murs à coffrage intégré
  (Technical Specifications for Walls and Integrated Formwork)
- EN 1990:2002+A1 – Eurocode – Basis of Structural Design
- EN 1991-1-1 – Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings
- EN 1991-1-2 – Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire
- EN 1992-1-1 – Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings

2.3 Other Austral Precast Documentation

The following documentation in support of this Technical Manual is available via the Austral Precast website **www.australprecast.com.au**

- Double Wall Product Brochure
- Double Wall Installation Manual
- Double Wall Picture Book
- Double Wall Case Studies
- French Regulation for Double Walls - CPT M.C.I. - Cahier CSTB n° 3690-V2-July 2014

DESIGN GUIDE

3

DESIGN GUIDE

3.1 Stability

Double Walls are specified according to the usual rules of resistance of materials and reinforced concrete, complying with standard AS3600-2018 – Section 11 Design of Walls, with, if need be, verification of the shape stability. The requirements given in this document are in addition to, or for some cases, a substitute for these rules. The connections must ensure mechanical continuity between:

– The foundation and the Double Wall;
– Adjoining Double Walls;
– The Double Wall and structures belonging to the same structural system (eg. floors, columns, beams, etc...)

After filling the concrete core, the Double Walls are considered a Monotholic Wall, so the calculations made by the Structural Engineer are identical to In-Situ Walls. Only, verification of the Joint Connections and the Shear are necessary.

3.2 Characteristics of Materials

3.2.1 Concrete - Precast Shells

The factory-made precast conforms to the AS3600-2018 – Section 3 - with a minimum characteristic compressive strength of concrete *f'c* > = 50 MPa.

The minimum compressive strength for the precast shells for delivery to site is 20 MPa.

3.2.2 Concrete - Internal Core

The concrete of the internal core must conform to the specifications of the project to be carried out and at least to those of the standard AS3600-2018 – Section 3.

The characteristic strength f'c in compression at 28 days is at least >= 25 MPa:

– For a core thickness less than or equal to 90mm, use a micro-concrete with the largest nominal dimension of the aggregate Dmax equal to 12 mm,
– For a core thickness greater than 90mm, use a concrete with a larger nominal dimension of the aggregate Dmax equal to 16 mm.
– The consistency class collapse to the Abrams cone of at least 160/180 mm

3.2.3 Concrete - Double Wall Concrete Resistance in Compression

For the determination of the compressive strength capacity of the current section of the Double Wall, the characteristic resistance equivalent to the compression of the concrete is f'ceq taken into account for the total thickness of the wall, corresponding to the minimum resistance of the shells or of the core

f'ceq = min (f'c Shells; f'c Core)
In accordance with the French CPT MCI – Article 1.1.1.1.

3.2.4 Reinforcement

The reinforcement integrated into the Double Walls comply with standard AS3600-2018 – Section 3. Reinforcing steels are in D500N designation grade and Ductility Class N in accordance with AS4671.

3.2.5 Girders

Metal reinforcing Girders or reinforcement cages ensure the connection between the two prefabricated shells.

Girders or reinforcement cages are spaced no more than 600mm apart. This is critical to ensure that the formwork does not fail due to hydrostatic pressure of pouring core concrete.

The girders are of triangular section with a lattice sinusoidal and the reinforcement cages are of section rectangular with bracing frames.

The minimum diameters are:

– Diagonal wire: 5 mm
– Bottom chord: 5 mm
– Top chord: 8 mm

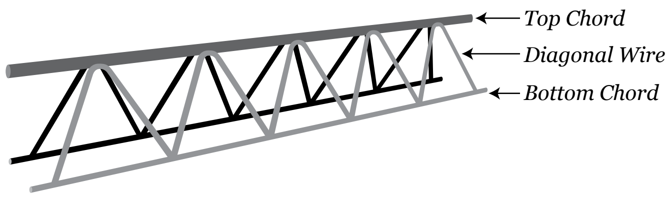


Figure 3.1 – Girder detail

Girder, top and bottom chords are in D500N designation grade and ductility Class N in accordance with AS4671 with height tolerance of : + 1 / -3 mm on this dimension, in accordance with the tolerances of this Design Guide.

Note: The top and bottom chords of the girder can be included in the cross-sectional area of reinforcement parallel to their orientation (typically vertical bars), and consequently, reduce the amount of reinforcement required in the bar mat or mesh.

DESIGN GUIDE

3.2.6 Double Wall Lifting Hooks

The Lifting Hooks are manufactured in R250N designation grade and Ductility Class N in accordance with AS4671 and tested in accordance with AS3850. The lifting hooks are assembled in the first shell, with main tension bars cast into each of the prefabricated shells. The lifting hook consists of a main tension bar (looped) welded to a cross bar near the top of the lifter for lifting capacity, with a complementary spacer bar at the bottom for maintaining the separation of the end of the tension bar.

The lifting hooks have the following characteristics:

– Main bar diameter: 16mm
– Lifting Capacitites (WLL):
  Tension: 32.3kN
  Rotation: 16.6kN
  Shear: 6.8kN

For further details on capacity and lifting, please see Section 6.

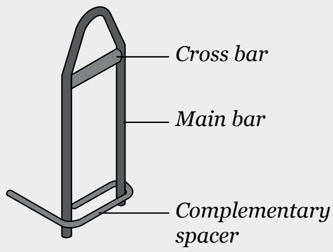


Figure 3.2 – Double Wall Lifting Hook

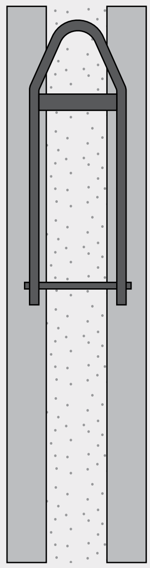


Figure 3.3 – Double Wall Lifting Hook (as cast in panel)

3.3 Exposure Classifications

The exposure classification for a surface of a member shall be determined from Table 4.3 and Figure 4.3 as per AS3600-2018(+A2).

Where concrete members are cast in rigid formwork under repetitive procedures, with demonstrated process control systems including supervision, the cover shall be not less than the value given in Table 4.10.3.3 of AS3600-2018, as appropriate to the exposure classification and f ‘c.

Exposure Classification	*Required Cover mm (c_{min})*				
	Characteristics Strength (f ‘c)				
	20 MPa	*25 MPa*	*32 MPa*	*40 MPa*	*> 50 MPa*
A1	20	20	20	20	20
A2	(45)	30	20	20	20
B1	–	(45)	30	25	20
B2	–	–	(50)	35	25
C1	–	–	–	(60)	45
C2	–	–	–	–	60

Table 3.3 – Exposure Classification

Note: Bracketed figures are the appropriate covers when the concession given in Clause 4.3.2 relating to the strength grade permitted for a particular exposure classification is applied.

The strength class of the concrete and the required cover (given by the formwork face of prefabricated shells horizontally cast on industrial formwork) allows to modulate the recommended structural class with a view to the determination of the minimum concrete covers with regard to durability.

DOUBLE WALL REQUIREMENTS

4

DOUBLE WALL REQUIREMENTS

4.1 Tolerances

In accordance with the French CPT MCI – Article 1

For product design, the following tolerance values shall be adopted by default from the French Standard:

- ΔHraid+ : Tolerance LESS on Girder height : +1mm
- ΔHraid- : Tolerance MORE on Girder height : -3mm
- Δbp1+ : Tolerance MORE on shell 1 thickness (bp1) : 3mm
- Δbp1- : Tolerance LESS on shell 1 thickness (bp1) : 3mm
- Δbp2+ : Tolerance MORE on shell 2 thickness (bp2) : 3mm
- Δbp2- : Tolerance LESS on shell 2 thickness (bp2) : 3mm
- Δb+ : Tolerance MORE on Double Wall thickness (b) : 3mm
- Δb- : Tolerance LESS on Double Wall thickness (b) : 3mm
- Δe1+ : Tolerance MORE on concrete Cover e1 : 2mm
- Δe1- : Tolerance LESS on concrete Cover e1 : 2mm
- Δe2+ : Tolerance MORE on concrete Cover e2 : 2mm
- Δe2- : Tolerance LESS on concrete Cover e2 : 2mm

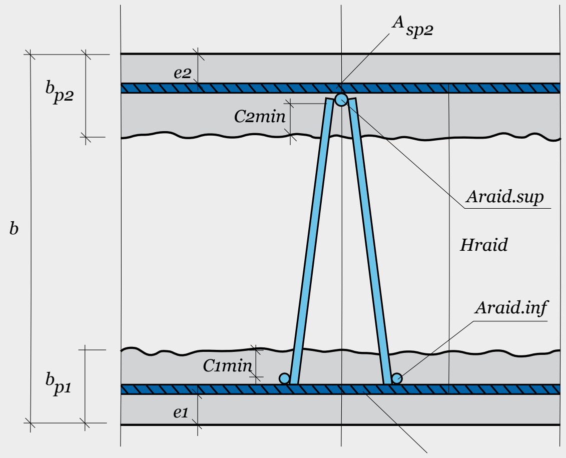


Figure 4.1 – Tolerances Reference

4.2 Internal Concrete Cover for the Girders

In accordance with the French CPT MCI – Article 1.1.1.6

The concrete cover of the girders must make it possible to meet the requirements to resist the hydrostatic pressure when concreting the core.

The minimum concrete cover C1,min of the lower longitudinal reinforcements of the girder is on the inside face side of the first shell and the concrete cover C2,min of the upper longitudinal reinforcements of the girder, on the inside face of the second shell is minimum 15 mm.

(See Figure 4.2) Additional minimum cover of 17mm may be used in order to increase the girder spacing.

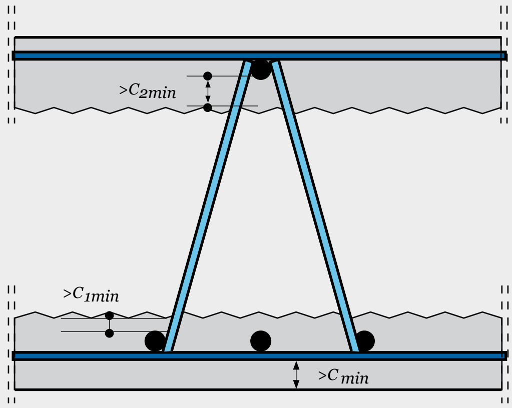


Figure 4.2 – Internal Concrete Cover - Girder to Core

Site placed footing reinforcement · Wall structural reinforcement · Truss · Splicing Steel · Concrete · Core-fill Concrete

DOUBLE WALL REQUIREMENTS

4.3 Double Wall Thickness

In accordance with the French CPT MCI – Article 1.1.1.4

The minimum thicknesses considered in this paragraph are minimum values with all tolerances exhausted.

- Shells : The minimum thickness results from the concrete cover requirements and the tolerances of execution on this dimension and the positioning of the reinforcements.
- Core : The minimum thickness bn, min is : 60 mm.

This minimum thickness corresponds to a nominal thickness bn of 70 mm with the default values of the tolerances.

The thicknesses of the prefabricated shells must conform to the following inequalities:

$$b_{p1} \geq C_{1,min} + e_1 + \Phi_{tp1} + \Phi_{raid,inf} + \Delta_1$$

$$\Delta_1 = \sqrt{(\Delta e_1^{+})^2 + (b_{p1}^{-})^2}$$

$$b_{p2} \geq c_{2,min} + (b_{nom} - e_1 - \Phi_{t1} - H_{raid}) + \Phi_{raid,sup} + \Delta_2$$

$$\Delta_2 = \sqrt{(\Delta e_1^{-})^2 + (b_{p2}^{-})^2 + (\Delta b^{+})^2 + (\Delta H_{raid}^{-})^2}$$

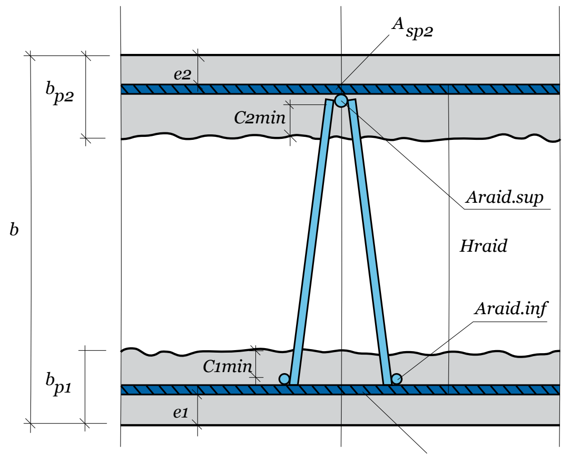


Figure 4.3 – Setting dimension

4.4 Shell Reinforcement

In accordance with AS3600-2018: Article 11.7.1
Minimum reinforcement :

Walls shall have a reinforcement ratio (p_w) –

a) In the vertical direction, of not less than the larger of 0.0025 and the value required for strength, unless the design axial compressive force does not exceed the lesser of 0.03f'c and 2MPa where the limit may be reduced to 0.0015; and

b) In the horizontal direction, of not less than 0.0025, except that for a wall designed for one-way buckling [using clause 11.4(a)] and where there is no restraint against horizontal shrinkage of thermal movements, this may reduced to zero if the wall is less than 2.5m wide, or to 0.0015 otherwise.

DOUBLE WALL REQUIREMENTS

4.5 Austral Precast Double Wall Configuration

Austral Precast can manufacture Double Wall with the following configurations:

- Double Wall Overall Wall Thickness (mm)
  170, 180, 200, 220, 250, 300, 350, 400 mm
- Double Walls Overall Dimensions:
  - Minimum : 0.70 m x 3.00 m,
  - Maximum : 3.50 x 13 m,

  The layout is function of:
  - the capacity of the crane (maximum 12t)
  - the capacity of the lifters (3t per lifter)
  - the storage area,
  - the architectural data.
- Double Walls Shells Thicknesses: 50, 55, 60, 65, 70 mm.

  The thickness of the prefabricated shells are dependant upon the concrete cover, diameter of refinforcement closest to the external face of the shell and production tolerances

  Table 4.1 below shows the shell thicknesses for each of the DW shells for given cover and reinforcement specification:

Minimum Shell Thickness (mm) – with 14mm lifting hooks												
Concrete Cover			20	20	20	20	20	25	25	25	25	25
Φ bars REO			6	8	10	12	16	6	8	10	12	16
Shell 1			55	60	60	60	65	60	65	65	65	70
Shell 2	20	6	55	60	60	55	55	50	55	55	55	60
	20	8	60	60	60	60	60	60	55	55	65	60
	20	10	60	60	60	60	60	60	60	65	65	60
	20	12	60	60	60	65	60	60	65	65	65	60
	20	16	65	70	70	65	65	70	65	65	65	70
	25	6	65	60	60	60	65	60	65	65	60	60
	25	8	65	60	60	70	65	70	65	65	65	70
	25	10	65	60	70	70	65	70	65	65	65	70
	25	12	65	70	70	70	65	70	65	65	N/A	70
	25	16	N/A	70	70	70	N/A	70	No	No	N/A	70

Table 4 – Shell Thickness for specified cover and reinforcement.

DOUBLE WALL REQUIREMENTS

The following table shows the possibilities for the thickness of the core, bn,min in accordance with French CPT MCI - Article 1.1.1.12:

Core Thickness, bn,min , for given Double Wall and Shell Thickness (mm)														
Shells mm		*50*	*55*	*60*	*65*	*70*	*Core Thickness*	*Shells mm*		*50*	*55*	*60*	*65*	*70*
170	*50*	65	No	No	No	No		*250*	*50*	150	145	140	135	130
	55	No	No	No	No	No			*55*	145	140	135	130	125
	60	No	No	No	No	No			*60*	140	135	130	125	120
	65	No	No	No	No	No			*65*	135	130	125	120	115
	70	No	No	No	No	No			*70*	130	125	120	115	110
180	*50*	75	70	65	No	No		*300*	*50*	200	195	190	185	180
	55	70	65	No	No	No			*55*	195	190	185	180	175
	60	65	No	No	No	No			*60*	190	185	180	175	170
	65	No	No	No	No	No			*65*	185	180	175	170	165
	70	No	No	No	No	No			*70*	180	175	170	165	160
200	*50*	95	90	85	80	75		*350*	*50*	250	245	240	235	230
	55	90	85	80	75	70			*55*	245	240	235	230	225
	60	85	80	75	70	65			*60*	240	235	230	225	220
	65	80	75	70	65	No			*65*	235	230	225	220	215
	70	75	70	65	No	No			*70*	230	225	220	215	210
220	*50*	120	115	110	105	100		*400*	*50*	300	295	290	285	280
	55	115	110	105	100	95			*55*	295	290	285	280	275
	60	110	105	100	95	90			*60*	290	285	280	275	270
	65	105	100	95	90	85			*65*	285	280	275	270	265
	70	100	95	90	85	80			*70*	280	275	270	265	260

Figure 4.5 – Core Thickness for Given Wall Dimensions and Shell Thickness

PRINCIPLES OF CALCULATION

5

PRINCIPLES OF CALCULATION

5.1 Wall Joints

Horizontal and vertical joints are positioned so as not to reduce the stiffness of the wall in its preferred carrier direction:

- for walls subject to bending in the vertical plane, the horizontal joints are arranged in the immediate proximity of the diaphragms (slabs, beams, etc), unless otherwise specified. Vertical joints have no impact.
- for walls subject to bending in the horizontal plane, the vertical joints are arranged in the immediate proximity of the stiffeners (columns, walls perpendicular, etc), unless otherwise specified. Horizontal joints have no impact.

5.2 Section Resistant in Compression

The section resistant to compression ratio is calculated by considering the total thickness of the wall, reduced by the width of the possible chamfers, if:

- the joint has a minimum thickness of 30 mm,
- the laying is carried out on a resistance setting mortar at least equal to the value f'ck,n taken into account in the calculations.

Otherwise, the strength section is reduced to the concrete section of the core only (see Figure 5.2).

The shear-resistant section is in all cases equal to the section of the concrete of the core.

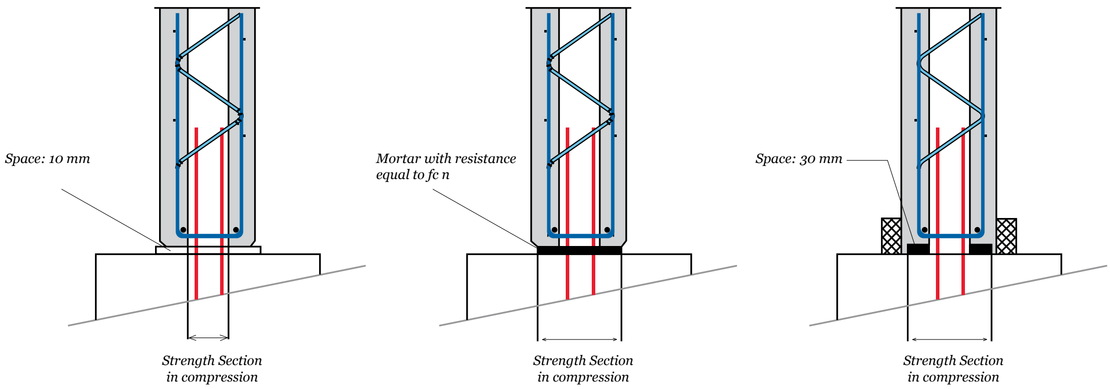


Figure 5.1 – Examples of compressive strength section.

Foot joints at bottom of panel are generally of the "hinged" type. The stresses must be balanced at the joints considering:

- the characteristic resistance of the concrete of the core f'c
- reinforcements anchored beyond the joint
- the useful section resistant to the forces which is that of the concrete of the core

In cases where the joint has a minimum thickness of 30 mm or in the case where the joint is made on a strengthening mortar of resistance at least equal to the characteristic value in compression of the cast-in-place core f'c, taken into account in the calculations, the compression-resistant section is calculated by considering the total wall thickness b *(see Figure 5.1).*

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

PRINCIPLES OF CALCULATION

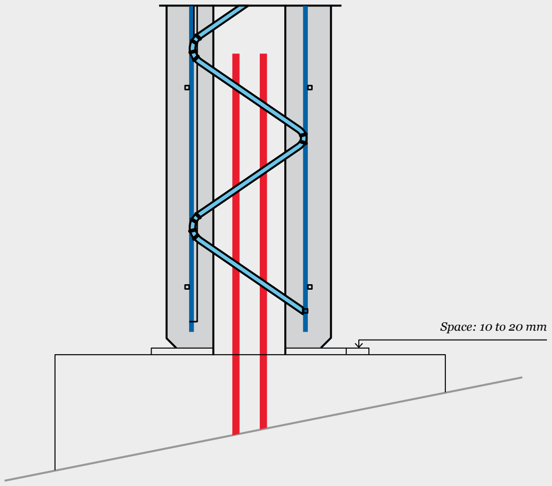


Figure 5.2 – Bottom Connection of Common Walls (hinged)

5.3 Verification of Joint Connection Capacity

In accordance with the French CPT MCI – Article 1.1.1.8

In the case of walls subjected to notable shear stresses (bracing, earthquake, ...), the checks to be carried out are as follows:

– Checking the shear strength of the reduced cross-section at the joint,

– Checking of the monolithic wall:

• verification of the overlap of the connecting reinforcement with those incorporated in the prefabricated shells,

• Checking the shear strength on the bonding contour at the interface between the core and the prefabricated shell.

5.3.1 Joint Shear Strength – Reduced Cross Section

Verification of the shear strength at the joint should be carried out as follows:

The resistive cutting force VRd,c at the joint is compared with the shear force requiring calculation VEd at the right of the joint.

The value to be used for v_{min} is equal to 0,35 * f'ck, n ^0.5 / γ_c.

When the last condition of shear resistance is not verified, the connecting frames should be arranged by assimilating the reduced cross-section at the right of the joint.

The shear check is then carried out taking into account the following hypothesis : the values of the two coefficients c and µ depending on the roughness of the interface are equal to 0.5 and to 0.9, respectively.

The calculation value of the shear stress at the joint is given by the following expression:

$$V_{Rd,j} = c \times f_{ctd,n} + \mu \times \sigma_n + \rho \times f_{yd} \times (\mu \sin \alpha) \leq 0{,}5 \times \upsilon \times f_{cd,n}$$

Equation 6.25: EN 1992.1.1-2004 - Section 6.2.5
Shear at the interface between concrete cast at different times

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

PRINCIPLES OF CALCULATION

With:

- fcd, n : the design value of the compressive strength of the concrete of the cast-in-place core defined in section 3.1.6 of NF EN 1992-1-1 and its National Annex NF EN 1992-1-1 /N / A,
- fctd, n : the design value of the tensile strength of the concrete of the cast-in-place core as defined in Article 3.1.6 of Standard NF EN 1991-1-1 and its National Annex NF EN 1991-1-1 / N / A,
- fyd : the design yield strength of reinforced concrete steel equal to fyk / γs,
- fyk : the characteristic elasticity limit of reinforced concrete steel,
- γs : the partial safety factor for steel,
- γc : the coefficient of reduction of the strength of the concrete.

It is given by the following expression:

$$\upsilon = 0{,}6\left(1 - \frac{f_{ck,n}}{250}\right)$$

σn : the stress generated by the minimal external normal force at the interface capable of acting at the same time as the shearing force,

ρ : the ratio Alj / Aj (Alj being the cross-section of reinforcement crossing the interface and Aj the area of the joint).

α : the angle of inclination of the linking reinforcement at right angles to the joint (refer to Figure 5.14)

5.3.2 Joint Shear Strength – Shell to Core Interface

1. *Verification of the Reinforcement Overlapping:*

   The concrete cover of reinforcements between those of the shells of the Double Wall and those of the cast-in-place core shall comply with standard AS3600-2018.

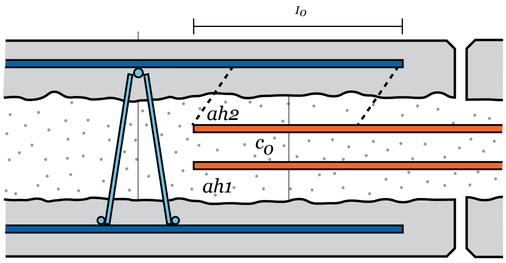


Figure 5.3.1 – Schematic of concrete cover to the reinforcement at the joint.

PRINCIPLES OF CALCULATION

2. Verification of the Shear Strength on the Connection Contour to the Right of the Joint:

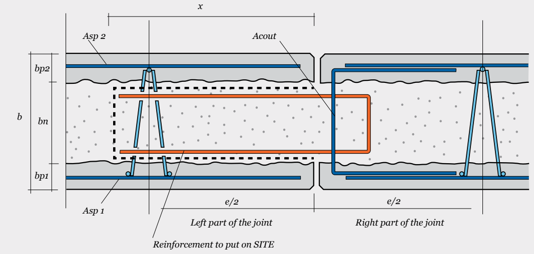


Figure 5.3.2 – Connection with reinforcement of the ends (stitched connection).

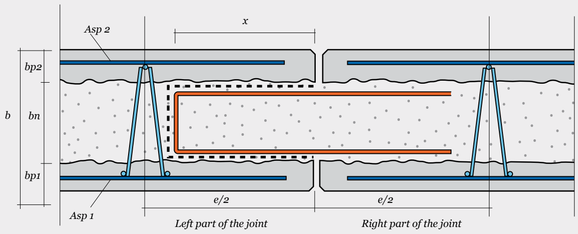


Figure 5.3.3 – Connection without reinforcement of the ends (hinged connection).

Figures 5.3.2 and 5.3.3 illustrate the principle of connection with or without reinforcement to the abutments.

In the most common case where stitch reinforcements are made with U at the ends of the Double Walls and the reinforcement sections are therefore identical on the two seam planes, the resistive forces are determined on the basis of the following expression:

$$V_{Rdi} = \left[c f_{ctd,n} \text{ x } 2x + \mu \left(\sigma_n + \rho f_{yd} \right) \text{ x } 2x \right] \text{ x } 1$$

With:

– c : the coefficient of cohesion,

– μ : the coefficient of friction.

The shear checks are carried out taking into account the following hypothesis : the values of the two coefficients c and μ depending on the roughness of the interface

Correspond to the case of a “smooth” type take-up surface: *c equal to 0.20 and μ equal to 0.60.*

The coefficients c and μ are presented in Table 1 as a function of the calculation stress with respect to the ultimate limit states : combinations of actions in durable or transitory (fundamental) situations.

Under dynamic or fatigue loads, the values of the coefficient c should be halved.

Combination E.L.U	*Situation Durable*	*Situation accidental (seismic)*
c	0.20	0.10
μ	0.60	0.60

Table 1 – Values of coefficients c and μ

– σ_n : the normal stress at the interface resulting from a compression effort,

– f: the tensile strength of the concrete of the cast-in-place core,

– f_{yd} : the design yield strength of reinforced concrete steel;
ρ : the percentage of Acout reinforcements passing through the prefabricated shell / cast-in-place interface over the distance x,

– x : the distance from the end of the reinforcement to the end of the prefabricated sheet (Figures 5.3.2 and 5.3.3).

In the expression of the above resistant force, the influence of the shrinkage of the cast-in-place concrete is neglected.

Note : The connection without reinforcement at the ends is incompatible with beam-wall use (Figure 5.3.3).

PRINCIPLES OF CALCULATION

5.4 Verification of Vertical Load Capacity

The vertical load design capacity φNu for the various wall thicknesses, wall heights and support conditions are shown in the Design Axial Load Capacity Charts, below.

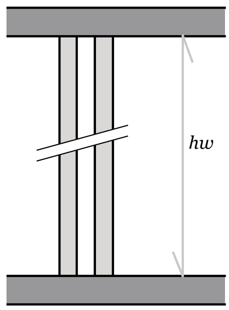
The design capacities have been calculated in accordance with AS 3600-2018 Clause 11.5.

Simplified design method:
Height to thickness ratio <= 30 (doubly reinforced walls)
Structure up to 12m in height

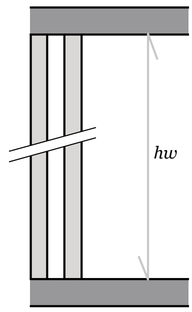
Method for Walls Subject to Vertical Compression Forces, as follows :

*Design axial compressive strength = φ * Nu (kN/m), where:*

- *φ = 0.65,*
- *Nu = the ultimate strength (kN/m) = (tw – 1.2 * e –2 * ea) * 0.56 * f'c * 10^3*
- *tw = Wall concrete thickness (m) = overall thickness,*
- *e = the eccentricity of the load (m)*
  - *= 0 for continuous floor slab, (minimum tw = 0.05)*
  - *= 0.166 tw for discontinuous floor slab,*
- *ea = additional eccentricity (m) = (Hwe)^2 /(2500 * tw)*
- *Hwe = the effective height of wall (m)*
  - *= 0.75 Hwe where wall restrained against rotation top and bottom by floors*
  - *= 1.0 Hwe where wall not rotationally restrained top and bottom*
- *tw = 30 maxi,*
- *hw = Unsupported height of wall (m)*
- *f'c = Concrete compressive strength (MPa)*



Case 1



Case 2

Figure 5.4 – *Load Cases*

Reinforcement						
cm²	*1,5%*	*2,5%*	*3,5%*	*4,5%*	*5,5%*	*6,5%*
170	2,55	4,25	5,95	7,65	9,35	11,05
180	2,70	4,50	6,30	8,10	9,90	11,70
200	3,00	5,00	7,00	9,00	11,00	13,00
220	3,30	5,50	7,70	9,90	12,10	14,30
250	3,75	6,25	8,75	11,25	13,75	16,25
300	4,50	7,50	10,50	13,50	16,50	19,50
350	5,25	8,75	12,25	15,75	19,25	22,75
400	6,00	10,00	14,00	18,00	22,00	26,00

Yield Stress		*500 MPa*		*Coefficient 0,80*		
KN/m	*1,5%*	*2,5%*	*3,5%*	*4,5%*	*5,5%*	*6,5%*
170	61	102	143	184	224	265
180	65	108	151	194	238	281
200	72	120	168	216	264	312
220	79	132	185	238	290	343
250	90	150	210	270	330	390
300	108	180	252	324	396	468
350	126	210	294	378	462	546
400	144	240	336	432	528	624

Figure 5.5 – *Minimum Reinforcement Ratio for walls, p_w = 0.0015 (AS3600-2018 - 11.7.1)*

PRINCIPLES OF CALCULATION

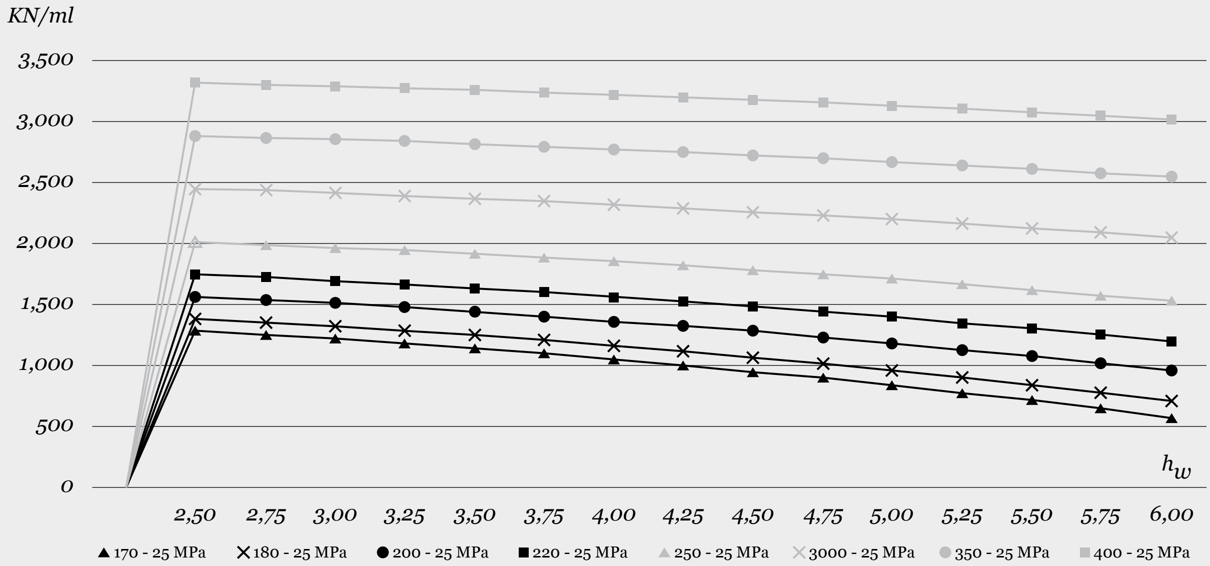


Figure 5.6 – Vertical Loads Capacities Only for the Concrete – 25 MPa – Continuous Floor Slab – Wall Restrained Against Rotation. **(Case 1)**

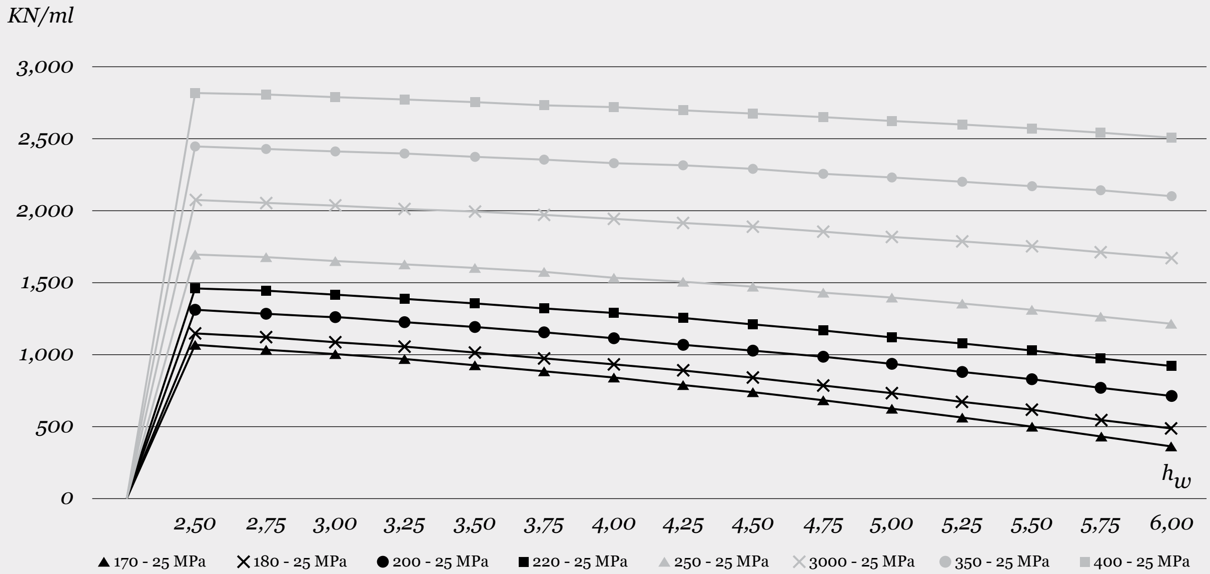


Figure 5.7 – Vertical Loads Capacities Only for the Concrete – 25 MPa – Discontinuous Floor Slab – Wall Restrained Against Rotation. **(Case 2)**

PRINCIPLES OF CALCULATION

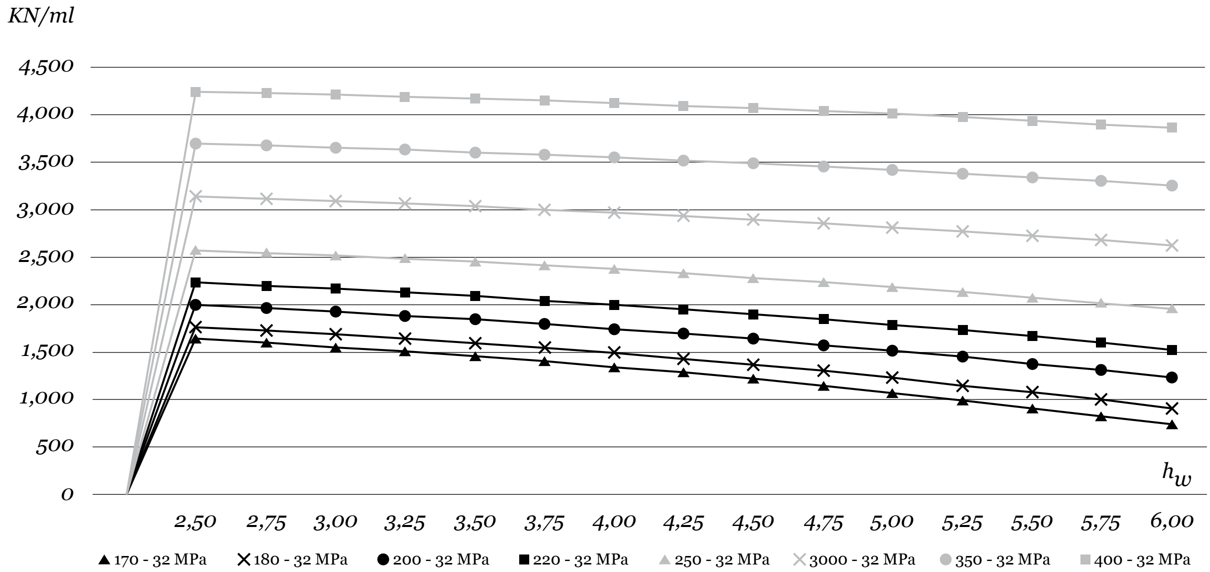


Figure 5.8 – Vertical Loads Capacities Only for the Concrete – 32 MPa – Continuous Floor Slab – Wall Restrained Against Rotation. **(Case 1)**

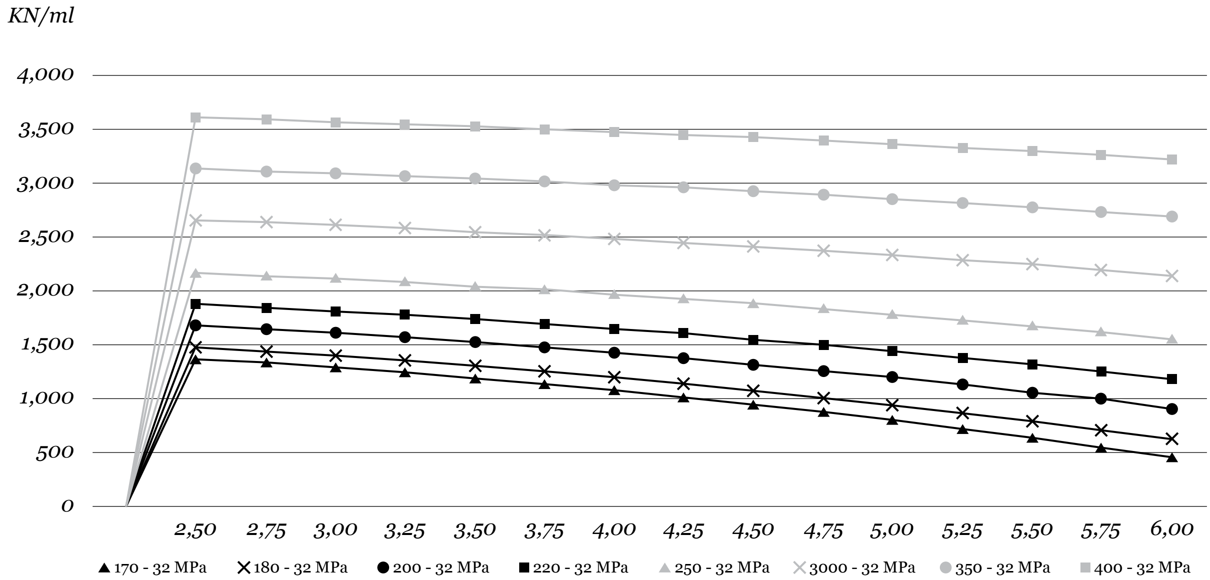


Figure 5.9 – Vertical Loads Capacities Only for the Concrete – 32 MPa – Discontinuous Floor Slab – Wall Restrained Against Rotation. **(Case 2)**

PRINCIPLES OF CALCULATION

5.5 Verification of Horizontal Load Capacity

The capacity of a wall subjected to a lateral load (wind or earthquake) is given in Figure 5.11 right.

It has been calculated on the basis of a simply-supported beam spanning vertically between floor supports, with reinforcement N12 - 150 mm spacing and concrete strength 25 MPa:

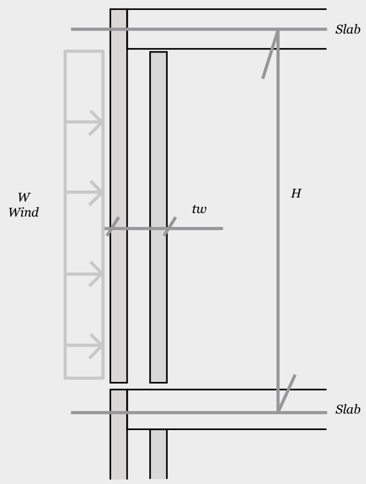


Figure 5.10.

Capacities are given for N12 vertical reinforcement – 150 mm spacing.

Higher capacities can be achieved by increasing the size of the vertical reinforcement.

The capacity is given by the formula:

Design Capacity, **w = 8 * φ *Mu / H² / 10** (kPa), where :

- Mu = fsy * d * Ast * (1 – (0,60 * Ast * fsy / (f'c * b * d * 100)) (kN.m/m)
- φ = 0.80,
- H = Design span for bending (m) = Height between Centre of Floor Slabs,
- b = Design width (m) = 1.00,
- d = Depth to tensile reinforcement (m) = tw / 2
- tw = Wall concrete thickness (m),
- Ast = Area of Vertical Reinforcement (cm^2/m) = 7,54 cm^2/ml,
- f'c = Concrete compressive strength (MPa),
- fsy = Yield strength of reinforcement (MPa).

PRINCIPLES OF CALCULATION

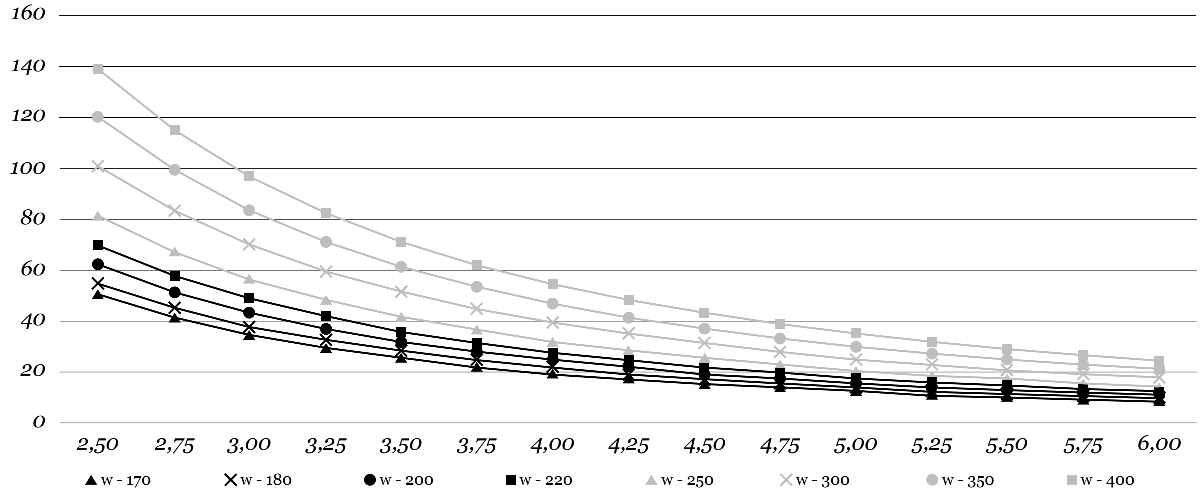


Figure 5.11 – Lateral Load Capacities ... w ... -f'c = 25 MPa

5.6 Retaining Wall Capacity

Calculation Hypothesis		
Weight of the Earth	*18,0*	*kN/m3*
Live Load on the Earth	*5,0*	*kN/m2*
Concrete Strength at 28 days	*25*	*MPa*
Reinforcement	*500*	*MPa*
Concrete Cover for First Layer		

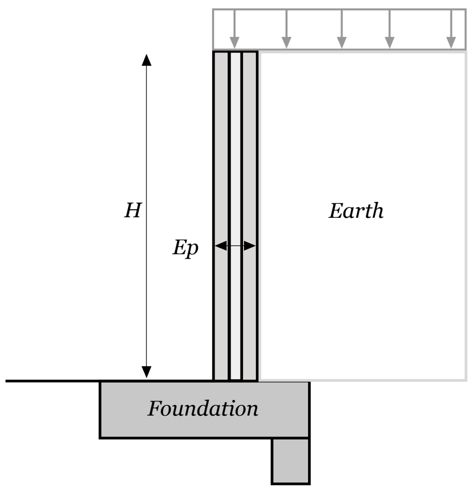


Figure 5.12

Solution in Double Walls				
Height DW	*Thickness DW*	*Shells Thickness*		*Kg/m² Reinforct*
H	*Ep*	*Earth*	*Opposite*	
m	*cm*	*cm*	*cm*	*Kg/m²*
1,50	20	5,50	5,50	10
1,75	20	5,50	5,50	10
2,00	20	5,50	5,50	9
2,25	20	5,50	5,50	8
2,50	25	5,50	5,50	9
2,75	25	5,50	5,50	9
3,00	25	5,50	5,50	9
3,25	25	5,50	5,50	10
3,50	25	5,50	5,50	10
3,75	30	5,50	5,50	11
4,00	30	5,50	5,50	11
4,25	30	5,50	5,50	13
4,50	35	5,50	5,50	13
4,75	35	5,50	5,50	15
5,00	35	5,50	5,50	17

PRINCIPLES OF CALCULATION

5.7 Construction Principles

In accordance with the French CPT MCI – Article 1.1.1.8

a) Connection Reinforcement

The joint reinforcement connection is arranged so as to respect a minimal 15 or 30 mm according to the exposure class of the structure.

The internal concrete cover (cg) of the reinforcement is counted from the inside face of the prefabricated shells to the external diameter of the reinforcement.

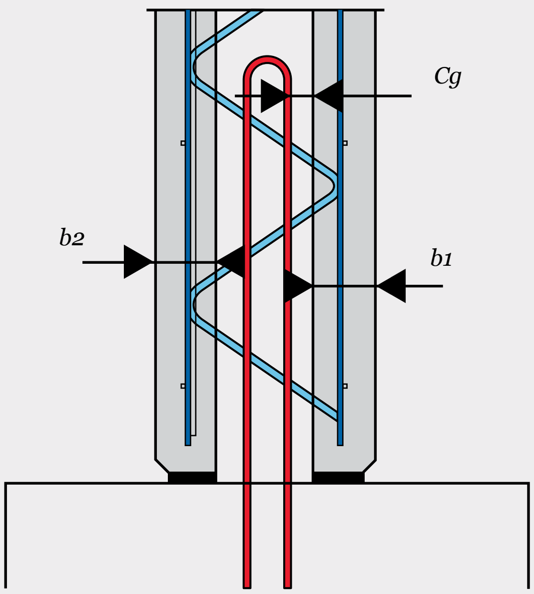


Figure 5.13 – Joint Reinforcement in a Double Wall

b) Connections between Double Walls:

Typical drawings of connections between elements are presented below.

These connections may be of the type :

- Hinged: linking reinforcements are added only in the core,
- Stitched (reinforced): this is a hinge connection to which a stitch reinforcement is added connecting the two prefabricated shells, in edge of each panel,
- Fixed: Capability to transfer moment through connection

c) Use of Girders in-lieu of Reinforcement:

The reinforcement of vertical free edges can be realised in walls with Double Walls using girders.

The peripheral belt links are integrated in the prefabricated shells of the Double Walls.

The constructive closure U could replaced by girders

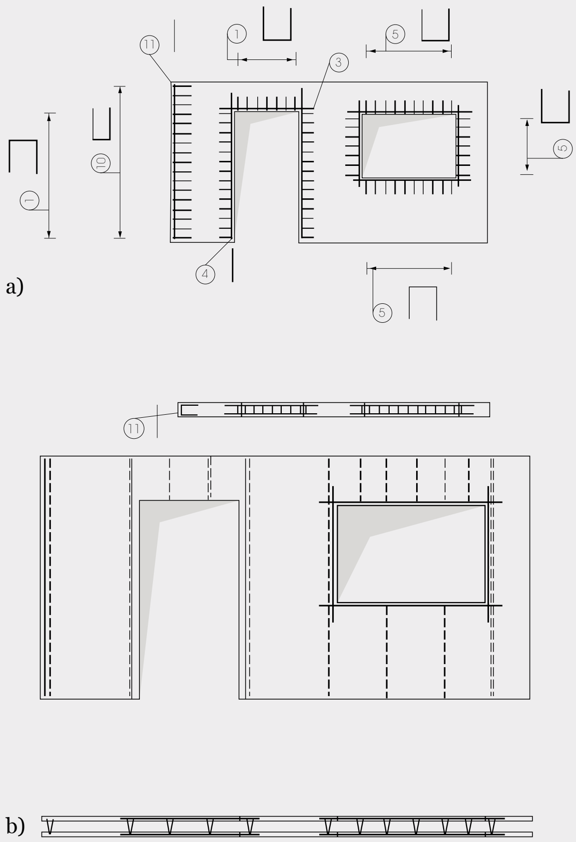


Figure 5.13.1 – Schematic diagrams of equivalent solutions for reinforcement of vertical free edges : (a) traditional solution, (b) Double Wall solution

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

PRINCIPLES OF CALCULATION

Structural reinforcements made up of frames, pins or stirrups can also be made in walls with Double Walls using girders.

The bars are either reinforced in the prefabricated shells of the Double Walls or replaced by the bars of the girders, if the reinforcement section is equivalent.

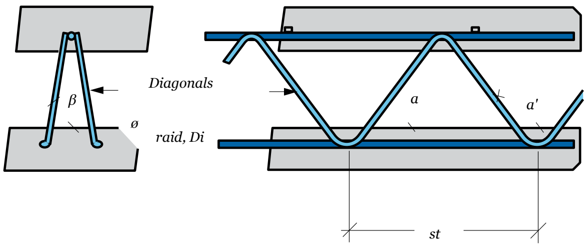


Figure 5.14 – Girder geometry

$$A_{s,eq} = 4.Fs.\ \frac{\sin\alpha.\sin\beta}{S_t} / f_{yk}$$

With :

– F_s : force resistant to the plane of oblique shear calculated in the following way:

$$F_S = Min\ (A_{raid,Di} \cdot R_{e,Di}; F_w)$$

– f^{yk} : characteristic limit of elasticity of the steel of the girder,

– $R_{e,\ Di}$: apparent yield strength of the girders diagonal,

– $A_{raid,\ Di}$: section of the diagonal of the girders,

– F_w : resistance of the welding of the sinusoids to the longitudinal reinforcement of the girders,

– β : angle of inclination of the diagonals in the transverse plane.

d) Reinforcement Overlapping in the Core:

The reinforcement is either integrated into the Double Walls or implemented in the cast-in-place section on site.

When used in the cast-in-place, the maximum number of bars is 2 per bed and the maximum diameter φmax is given by the following expressions:

– for horizontal reinforcements, the maximum diameter of the reinforcements is equal to *(Figure 5.15 - left)*:

$$\Phi max = \frac{b_{n,min} - e_0 - a_{h1} - a_{h2}}{2}$$

– for vertical reinforcements, the maximum diameter of the reinforcements is equal to *(Figure 5.15 - right)*:

$$\Phi max = \frac{b_{n,min} - e_0 - a_{v1} - a_{v2}}{2}$$

With :

– $b_{n,\ min}$: the minimum thickness of the cast-in core, all tolerances depleted,

– e_o =

• 0 if the reinforcements are joined

• 1.70 * D^{max} if the reinforcements are spaced.

The free nominal distances between the horizontal connecting reinforcement disposed at right angles to the joint and the inner face of the first or second prefabricated shell are denoted ah1 and ah2.

PRINCIPLES OF CALCULATION

The free nominal distances between the vertical connection reinforcement at right angles to the joint and the inside face of the first or second prefabricated shell are denoted av1 and av2.

By taking into account the dimensional and positioning variations of the reinforcement, the nominal distances are given by the following expressions:

$$a_{h1} = \max(25\text{mm}; 1{,}7D_{max}) + a_{e1,min} - 15\text{mm}$$
$$a_{h2} = \max(25\text{mm}; 1{,}7D_{max}) + a_{e2,min} - 15\text{mm}$$
$$a_{v1} = \max(25\text{mm}; 1{,}4D_{max}) + a_{e1,min} - 15\text{mm}$$
$$a_{v1} = \max(25\text{mm}; 1{,}4D_{max}) + a_{e2,min} - 15\text{mm}$$

With :

– ae1 min the minimum free distance between the connecting reinforcement at the joint and the inside face of the first prefabricated shell,

– ae2 min the minimum free distance between the connecting reinforcement at the joint and the inside face of the second prefabricated shell.

These distances are taking the values 15 mm or 30 mm according to the exposure class of the structure, the conditions of connection.

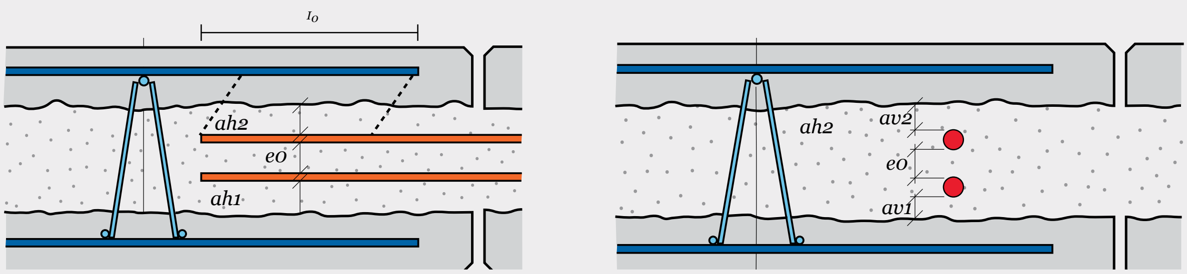


Figure 5.15 – Reinforcement at Joint

Note: the minimum thickness of the core, $b_{n,min}$, is calculated from the nominal thickness of the core, b_n, minus the lower and upper tolerances of the overall wall thickness, Δb^-, and the precast shells, $\Delta b_{p1}+$ and $\Delta b_{p2}+$ respectively:

$$b_{n,min} = b_n - \sqrt{(\Delta b^-)^2 + (\Delta b_{p1}^+)^2 + (\Delta b_{p2}^+)^2}$$

These arrangements make it possible to ensure, with all exhausted tolerances, a space of 25 mm between the reinforcements and the inside face of the closest prefabricated shell.

The two reinforcements can be replaced by an equivalent reinforcement section.

In the bending zone, the overlap lengths of the reinforcement will be increased by 20% to take account of the positioning tolerances of the reinforcements in the core.

Site placed footing reinforcement — Wall structural reinforcement — Truss — Splicing Steel — Concrete — Core-fill Concrete

PRINCIPLES OF CALCULATION

5.8 Special Design Cases

5.8.1 Special Case for Columns

See AS3600-2018 Section 10 and in accordance with French CPT MCI - Article 1.1.2.2.

The reinforcement is made in the same way as for a traditional walls: horizontal and vertical reinforcement with joining the prefabricated shells.

Ends of double walls will be systematically closed by U.

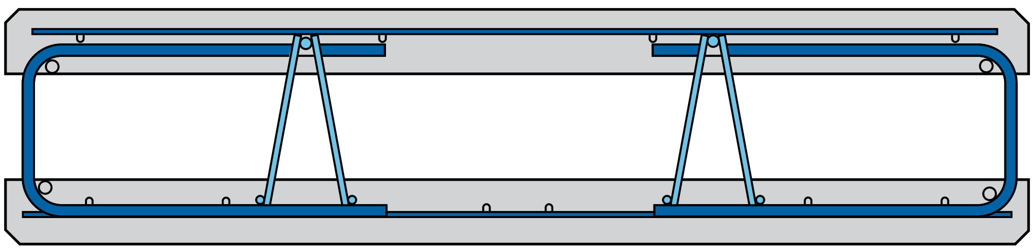


Figure 5.16 – Resistant column section by concrete alone

Special cases of columns requiring structural reinforcement:

These columns can be made in double wall but the provisions of reinforcement will be via common reinforcement of in-situ columns, as shown in Figure 5.17 whereby each longitudinal bar should be held by transverse reinforcement.

Every bar or bundle of bars placed in a corner should be held by transverse reinforcement. Bars within a compression zone should be no further than 150mm from a restrained bar in accordance with *article 9.5.3 of standard NF EN 1992-1-1 and its national annex.*

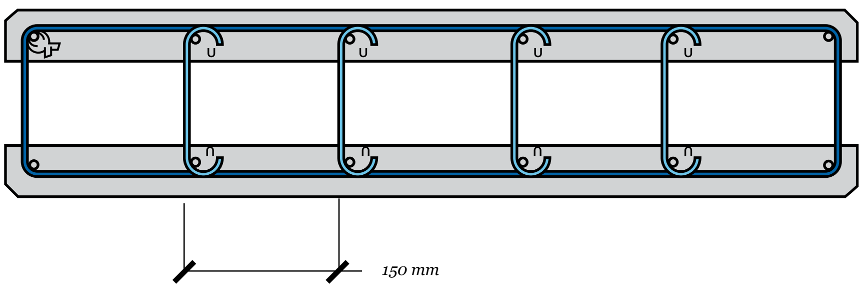


Figure 5.17 – Column requiring structural reinforcement

In addition, reinforcement sections must comply with the joining conditions.

PRINCIPLES OF CALCULATION

5.8.2 Special Requirements for Beams

See AS3600-2018 – Section 8 and in accordance with the French CPT MCI – Article 1.1.2.3

The concrete section taken into account in the calculation is the total thickness of the beam.

Integrity section:

This verification consists in ensuring the monolithism of the whole section by determining the shear stresses which are exerted at the interface of the precast shell/cast-in place core and connecting reinforcement.

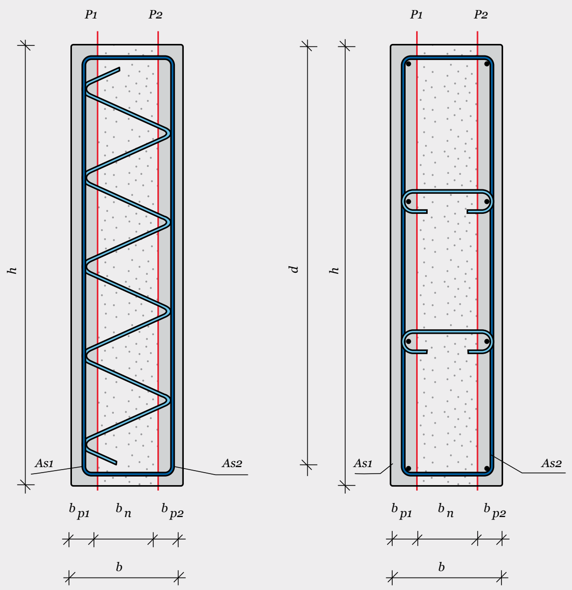


Figure 5.18 – Shear Plans in the Section of a Beam

It can be assumed that the sliding force g1 per unit length relative to the width of the first prefabricated shell (on the shear plane P1) is equal to:

$$g1 = max\left(\frac{V_{Ed}b_{p1}}{zb}\right);\left(\frac{V_{Ed}A_{s1}}{zA_s}\right)$$

It can be assumed that the sliding force g2 per unit length relative to the width of the first prefabricated shell (on the shear plane P2) is equal to:

$$g2 = max\left(\frac{V_{Ed}b_{p2}}{zb}\right);\left(\frac{V_{Ed}A_{s2}}{zAs}\right)$$

With:

- VEd : the shear force requiring calculation at the ELU, in kN,
- As : the quantity of tensile reinforcements equal to the sum of the steels As, p1 in the first prefabricated shell and steels As, p2 of the second prefabricated shell (in cm²),
- Z : the lever arm of the section, taken as 0.9 d (d being the useful height of the section), in m.

From this we deduce the maximum shear stress τEd,max which is exerted on the stitch planes (P1 or P2) (in MPa):

$$\tau_{Ed,max} = 10^{-3}\,\frac{max(g1\,;\,g2)}{0{,}6h}$$

With: h = Total height of the beam in metres.

Note: the expressions of g1 and g2 above are valid in the common part. The coefficient 0.60 was chosen to estimate the interface shear share to be resumed.

The connection by the concrete alone is systematically reinforced by girders crossing the plane of recovery. It should be checked at the interface between the two concretes that the calculation limit value of the shear stress τEd,lim is such that:

$$\tau_{Ed,lim} = max\begin{cases} \upsilon_{Rdi} = cf_{ctd,n} + \rho_{\alpha}f_t\,(\mu sin\alpha + cos\alpha) + P_{\alpha'}f_{t'}\,(\mu sin\alpha' + cos\alpha) \\ 0{,}5\upsilon dcd{,}n \end{cases}$$

With :

- fcd, n: the design value of the compressive strength of the core filling concrete as defined in Article 3.1.6 of Standard NF EN 1992-1-1 and its National Annex NF EN 1992-1-1 / N / A,
- Fctd, n: is the value of the design tensile strength of the core filling concrete as defined in Article 3.1.6 of Standard NF EN 1991-1-1 and its National Annex,
- VRd, i: the calculation value of the shear stress at the interface,

The available stress ft in each diagonal of the girder is such that:

$$f_t = min\left(\frac{R_{e,Di}}{ys}\,;\,\frac{F_w}{A_{Di}\,ys}\right)$$

Site placed footing reinforcement — Wall structural reinforcement — Truss — Splicing Steel — Concrete — Core-fill Concrete

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- Re, Di : is the apparent yield strength of steels,
- γs : the partial safety coefficient on steel,
- Fw : resistance of the welding of the sinusoids to the longitudinal reinforcements of the girders,
- ADi : is the section of a diagonal of the girders,
- υ : is a coefficient of reduction of the strength of concrete defined as follows:

$$\upsilon = 0{,}6\left(1 - \frac{f'ck,n}{250}\right)$$

The coefficients c and μ depend on the roughness of the interface and are defined in article 6.2.5 of standard NF EN 1992-1-1.

The surfaces will be classified as smooth with EC2 equal to 0.20 and μ equal to 0.6.

The values of c and μ are those of article 6.2.5 of standard NF EN 1992-1-1 in the case of a smooth recovery surface with the following mining: $c = c_{EC2} / 1{,}1$ (c Equal to 0.18).

Under dynamic or fatigue loads, the values of the coefficient c must be halved in accordance with Article 6.2.5 (5) of the NF EN 1992-1-1 standard and Its National Annex.

α and α' are the inclinations of the diagonals of the girders with respect to the connection plane in the longitudinal direction.

ρa and ρa' are the percentages of the transverse reinforcements anchored on either side of the recovery plane at angle α or α', calculated as shown below.

Note: In the expression of the above shear stress, the influence of shrinkage of the cast-in-place concrete is neglected.

Appendix IV illustrates the principle of calculating the shear stress limit τEd, lim.

The recovery plane can be reinforced by tightening the girders or by arranging reinforcement girders to increase the value of ρ (Appendix IV).

If the limiting value of the shear stress is such that τEd, lim is greater than the stress vmin equal to 0.35. Fck, eq 0.5 / γc as indicated in the National Annex NF EN 1992-1-1 / NA (6.2.2 (1))

Note: then it is necessary to have transverse reinforcements of shear force.

Support verifications :

The reinforcement anchor rules are those of NF EN 1992-1-1 and its National Annex.

Article 9.2.1.4 applies for end support and Article 9.2.1.5 applies for intermediate support.

At the supports (on the first connecting rod), the calculation width bapp is calculated according to the type of support :

- Case 1 : bapp = bn corresponds to the thickness of the core of the double wall (Figure 5.20)
- Case 2 : bapp = b - bp1 - ch2 or b - bp2 - ch1 corresponds to the total reduced thickness of a thickness of prefabricated shell and a possible chamfer width (Figure 5.21)
- Case 3 : bapp = b - ch1 - ch2 corresponds to the reduced total thickness of the possible chamfer widths (Figure 5.22).

With:

- b : the total thickness of the double wall
- bn : the thickness of the cast-in-place core,
- bp1 : the thickness of the first prefabricated shell
- bp2 the thickness of the second prefabricated shell
- ch1 the width of the chamfers of the first prefabricated shell
- ch2 the width of the chamfers of the second prefabricated shell.

The bapp value then allows the calculation of the shear reinforcement on support (articles 8.4.4 and 9.2.1.4 of standard NF EN 1992-1-1) and the verification of the connecting rod according to article 6.5. 4 of the NF EN 1992-1-1 standard.

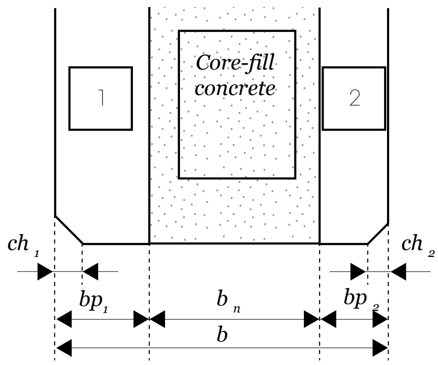

Figure 5.19 – Geometry of Beam Walls.

PRINCIPLES OF CALCULATION

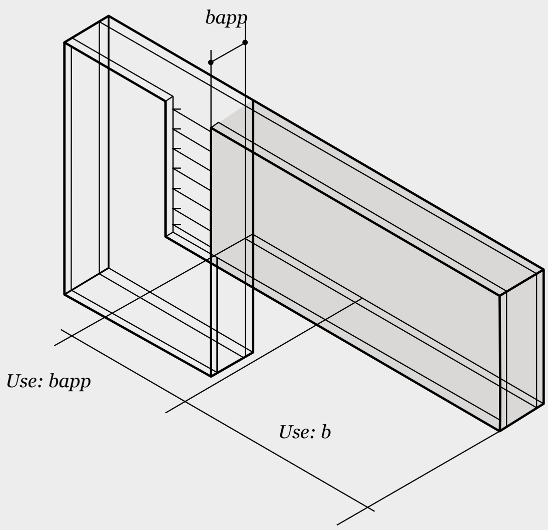

Figure 5.20 – Beam Support - Case 1

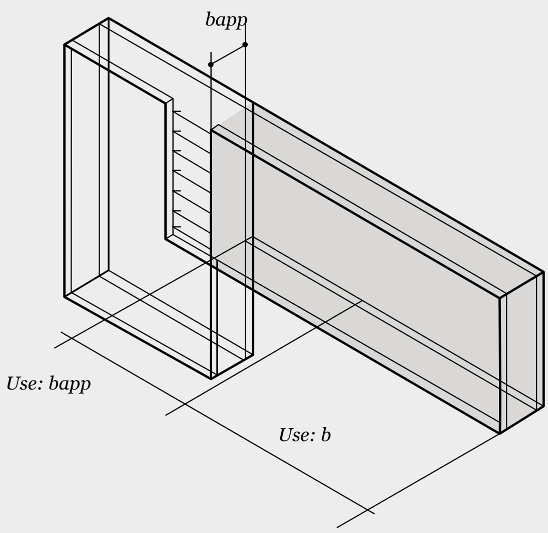

Figure 5.21 – Beam Support - Case 2

PRINCIPLES OF CALCULATION

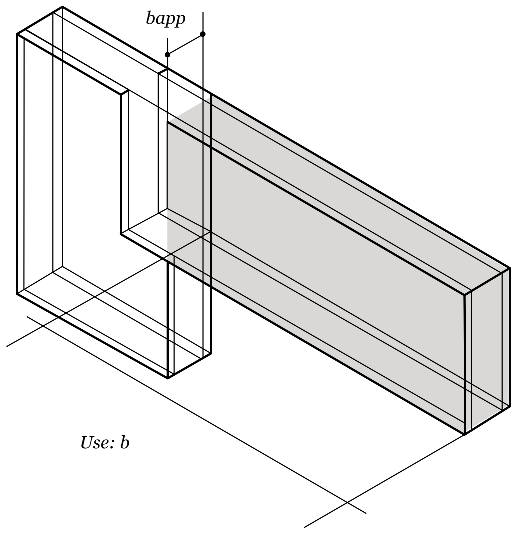

Figure 5.22 – Beam Support - Case 1

The construction of the support must comply with the common requirements (see paragraph 1.1.1.1).

Torsional strength :

Note : as for slender beams, it is necessary to avoid making the elements in Double Walls in torsion, in particular because of the deformations that results. However, where this can't be avoided, Article 6.3 of NF EN 1992-1-1 and its National Annex shall apply.

Torsional stresses must be taken into account in the dimensioning of the beams, considering a beam width equal to:

– Or the thickness bn of the core (in the case of a joint of the type case 1 above),

– either the total thickness decreased by a prefabricated shell thickness and a possible chamfer width (b - bp1 - ch2 or b - bp2 - ch1) in the case of a joint of the type 2 case above,

– or the total thickness decreased by the possible chamfer widths (b - ch1 - ch2) in the case of a joint of the type 3 above.

If the width of the chamfer (ch1 or ch2) is less than 1/10 of the smallest dimension of the section taken into account in the calculation of the torsion, then the presence of this chamfer is neglected.

Justification of reinforcement under beam support:

See the French Regulation for Double Walls – CPT M.C.I. – Cahier CSTB n° 3690-V2-July 2014.

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5.8.3 Special requirements for Beam Walls

In accordance with the French CPT MCI – Article 1.1.2.4

The “beam-walls” are straight beams of constant cross-section whose cross-sectional height is greater than one third of the scope in accordance with Article 5.3.1 (3) of the NF EN 1992-1-1 standard.

All the requirements of standard NF EN 1992-1-1 and its National Annex for the Design of beam-walls must be checked and the following justifications.

The checks relate mainly to points :

- verification of the overall stability of the beam-wall,
- verification of singular points (joints between walls),
- verification of the feasibility to put the reinforcement in the core.

Checking overall stability:

Consideration should be given to the effects of lateral instability of the beam-walls by a minimum thickness of the double wall.

The minimum thickness of the double wall shall be at least equal to:

$$b \geq 0{,}14 \times L \times \sqrt[3]{\frac{p_{Ed}}{f_{ck,eq}h}}$$

With :

- PEd : the load applied per unit length of the wall under the combinations of actions taken into account in the ELU calculation,
- H : the height of the beam-wall,
- L : the span of the beam-wall,
- Fck, eq : the characteristic resistance equivalent to the compression of the concrete for the total thickness of the wall with integrated formwork.

This verification is not to be carried out in the case of wall panels with integral formwork effectively stiffened by integral upper and lower structure of the support.

In the case of the presence of joints and whatever their positions, only the thickness of the core is taken into account for this verification.

Otherwise, the total thickness of the double wall is taken into account.

In the event that this check is not satisfied, the core at the joints shall be increased either by :

- Thickening of the wall with integral formwork forming a beam-wall,
- the partial or complete opening of the joints between walls, that is to say the opening, on one or two prefabricated shells, of the joints which will be filled to reconstitute the section.

In all cases, the thickness retained must be sufficient to ensure the correct operation of the reinforcements and their continuity.

Checking singular points (joints between walls with integrated formwork):

The constructional provisions at the joints shall comply with the requirements of paragraph principle of verification of connections at the joints.

Annex III proposes a numerical application on the principle of verification of the connections between walls with integrated formwork.

The ends of the double walls constituting the beam-walls shall be fitted with U reinforcement.

If there is no justification for the strength of the connection, a beam-wall must be enclosed in an double wall (no joints).

In all cases the cross-section of the linking reinforcements shall be at least equal to the section of horizontal or vertical reinforcements determined in accordance with *Article 9.7 of Standard NF EN 1992-1-1 and its National Annex.*

Note: all joints with beam-walls must be Stitched, whether vertical or horizontal, especially at floor level.

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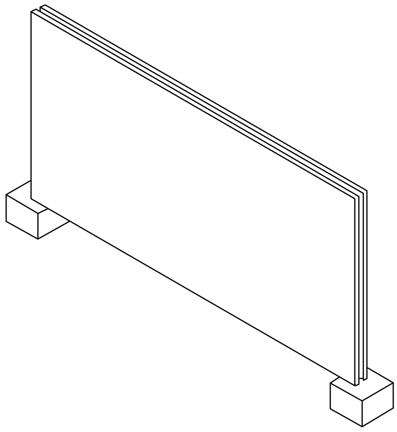
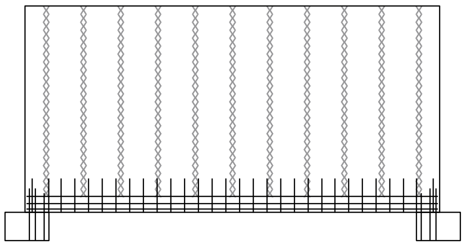
Case 1: Integrated beam-wall, with complete integration of the tie-rod in the double wall.

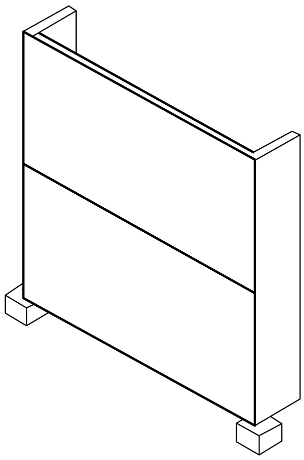


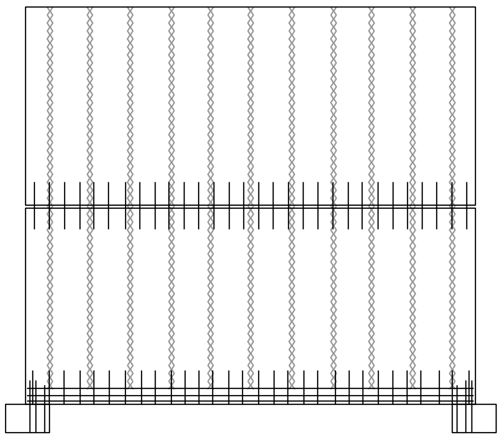


– This solution does not require special checks due to the absence of joint, apart from checking the spill if necessary.

– Put a space of 30 mm between foundation and Double Wall.

Case 2: Wall beam made of several integrated walls with horizontal joint.





– This solution requires verification of the joint with the shear force.

– The type of connection is chosen as a function of the force to be taken up among the stitched connections.

– Put a space of 30 mm between foundation and Double Wall.

– **Observation:** this type of configuration requires the presence of concrete stiffeners at the ends of the beam-wall.

– **Note:** Case 2 is more difficult for site installation

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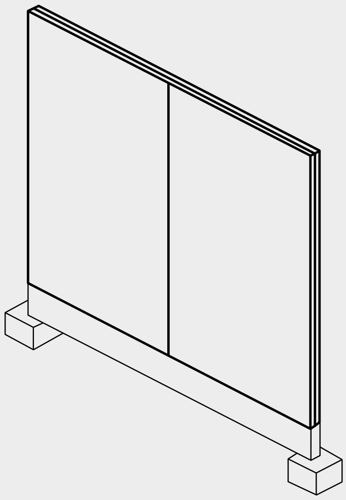
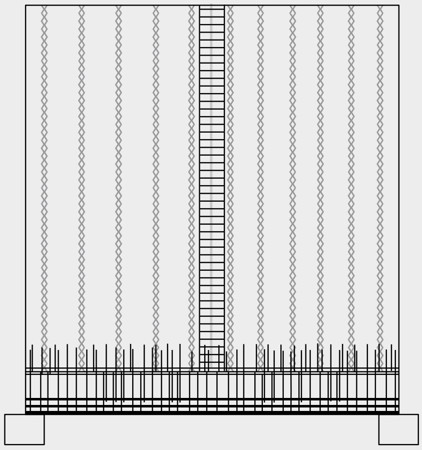
Case 3: Beam-wall with multi Double Walls and Vertical Joint.



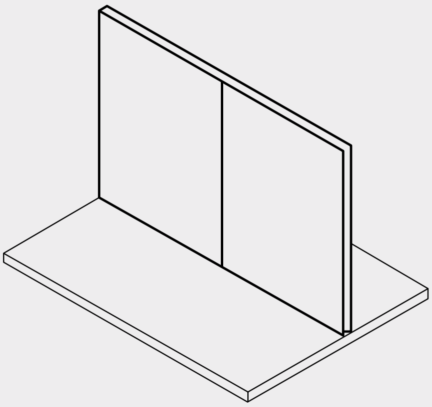


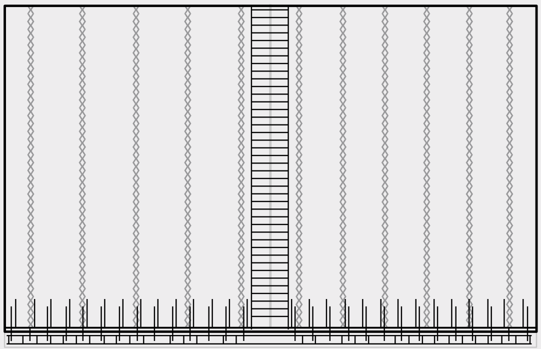
– The area of the tie rod is made in a traditional way or with the aid of a prefabricated part, the upper zone consists of walls with integrated formwork.

– This type of configuration requires verification of the resistance of the joints to the shear force.

– The types of connections are chosen as a function of the effort to be taken up among the stitched connections.

Case 4: Beam-wall with the lower floor.





– The tie-rod of the girder is placed in the thickness of the slab or in the lower part of the double wall.

– This type of configuration requires verification of the resistance of the joints to the shear force.

– The types of connections are chosen as a function of the effort to be taken up among the stitched connections.

– **Note:** 20% extra reinforcement provided in the horizontal joint to transfer the bending moment load *(refer to French Article 1.1.1.12)*

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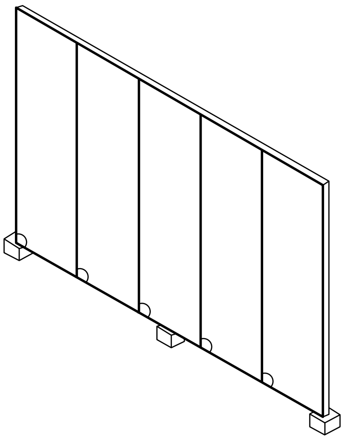
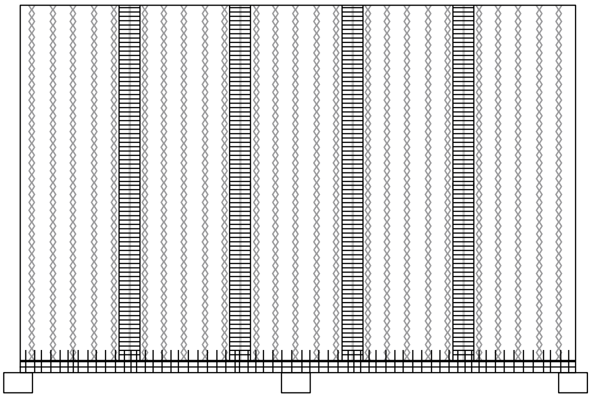
Case 5: Wall beam made entirely of double walls with continuity on one or more spans.





– The tie-rods of the beam-wall are integrated in the lower and upper part of the walls with integrated formwork, and are connected to the joints.

– A pull box in the lower part allows to split the lower threads at the right of the joints.

– Put a space of 30 mm between foundation and Double Wall.

– This type of configuration requires verification of the resistance of the joints to the shear force.

– The types of connection are chosen as a function of the force to be taken up among the stitched connections.

– Note: 20% extra reinforcement provided in the horizontal joint to transfer the bending moment load *(refer to French Article 1.1.1.12)*

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5.8.4 Cornices

In accordance with the French CPT MCI – Article 1.1.2.5

– Low Cornices:

The low-profile cornices made of double walls are incorporated into the walls of the last level integrated formwork and are made by the extension of the latter above the roof.

Depending on whether the seal is protected by an engraving, a cover, or a strip of metal flashing, the inside face of the cornice in formwork or pour in situ.

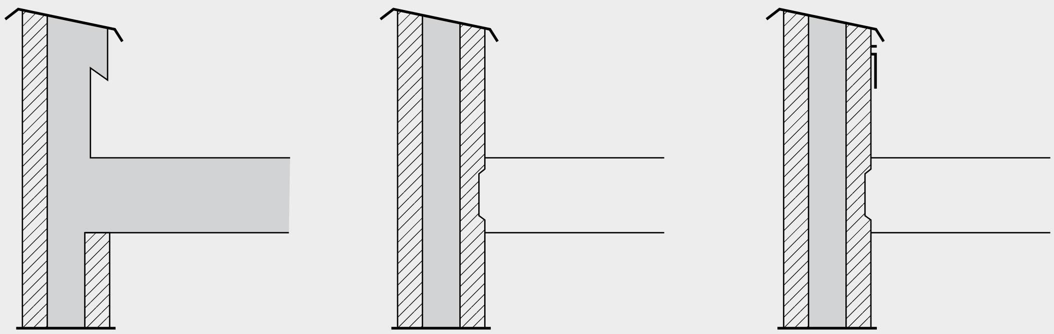

Figure 5.23 – Waterproofing

The reinforcement of the cornice is integrated partially or totally in the wall with integrated formwork.

The longitudinal reinforcement of the cornices is right of each vertical joint by reinforcements of equivalent cross-section in the core.

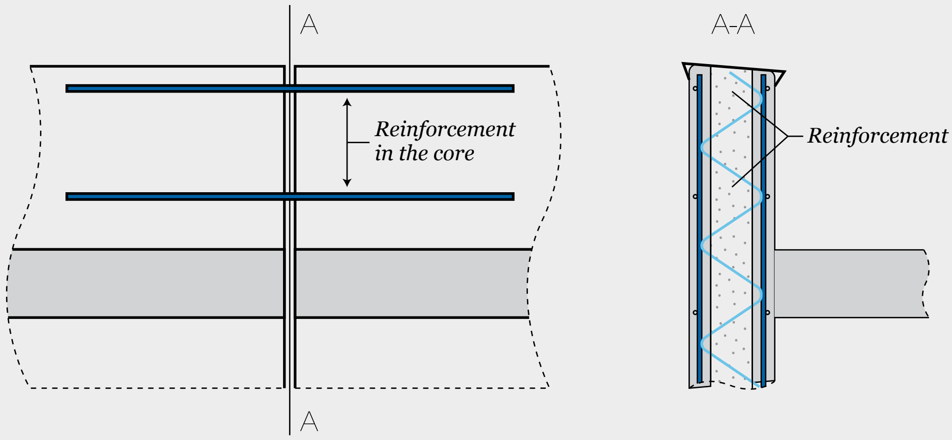

Figure 5.24 – Reinforcement of Cornice Joint

PRINCIPLES OF CALCULATION

– High Cornices:

The high cornices can be incorporated into the walls of the last level of integrated formwork and be made by extending them above the roof.

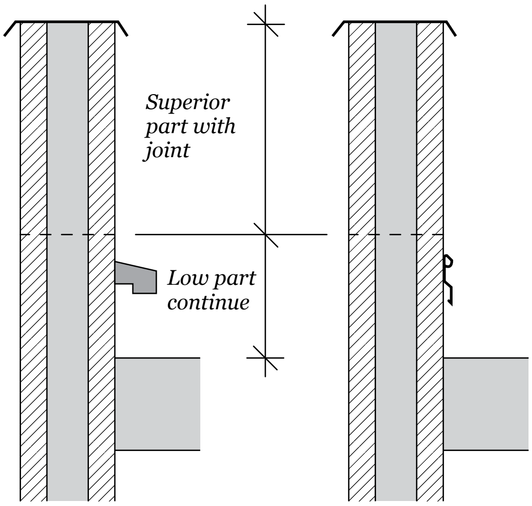

Figure 5.25 – Continuous High Cornices

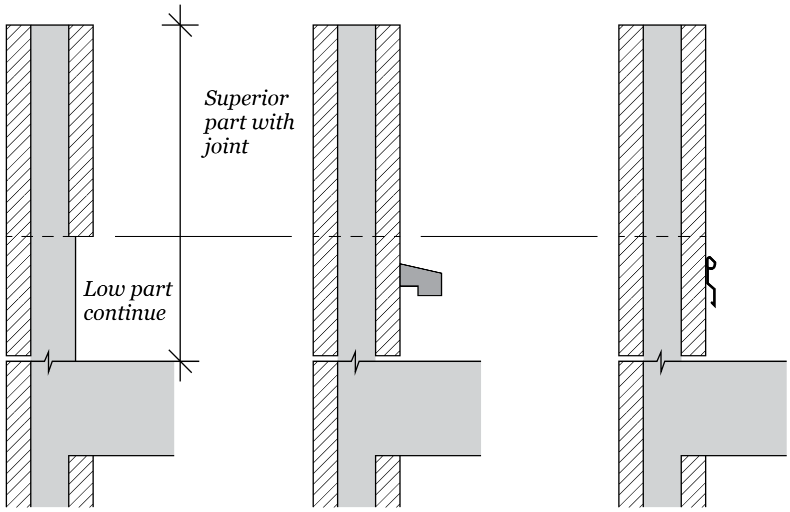

Figure 5.26 – High Cornices made by complementary parts above the roof

PRINCIPLES OF CALCULATION

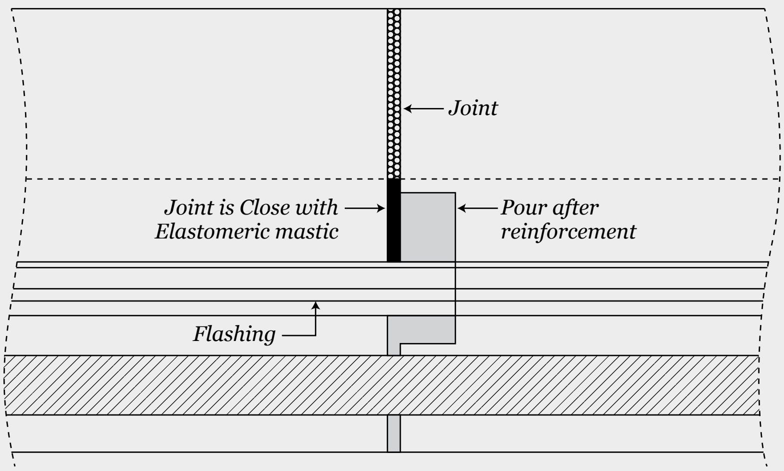

Figure 5.27 – Detailed description of high cornices

The high cornices are made up of:

- of a low part continuously identical of the low cornices,
- a fractional upper part free of connecting reinforcement and the joints of which remain empty throughout the thickness of the walls.

  This last arrangement will be obtained by inserting into the joint, at the time of filling the walls, a polystyrene board passing through the entire thickness of the wall and disposed over the height of the fractionation. This is to avoid cracking through expansion and contraction.

  Fractional joints will be spaced no more than 8 meters in dry or high-temperature regions, 12 meters in wetlands.

  They can be with joints of walls with integrated formwork and will have a width of 20 mm.

  If they are spaced 4 meters in dry or high-temperature regions, 6 meters in wet or temperate regions, the width of the fractionation joints can be reduced to 10 mm.

- **Feasibility of cornices reinforcement:**

  On the height of the lower continuous part, the double walls are equipped to the right of the joints of an opening arranged on the roof side, allowing the continuous reinforcement of the cornices.

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5.8.5 Special Case for Inclined Walls

In accordance with the French CPT MCI – Article 1.1.3

The double walls can be used in a structure **with a minimum inclination of 75°** with respect to the horizontal.

Walls can be inclined at 45 ° in the case of walls used for roofing.

The implementation arrangements remain identical to the vertical walls.

Particular precautions for blocking at the base of walls will be taken in the provisional phase of assembly and filling to oppose the horizontal movement (Squares, brackets, ...).

The panel base should be checked in the temporary phase.

Except in special cases, the two prefabricated shells will be reinforced on foot by a reinforcement bar of 6 mm with a spacing e of at least 30 mm, a standard arrangement which is appropriate in the general case.

Figure – Inclined Wall (maximum inclination 45 degrees relative to the horizontal plane)

5.8.6 Special Case - Elements Stress to their Plane

In accordance with the French CPT MCI – Article 1.1.4

5.8.6.1 Common Requirements

– **Fixed with waiting reinforcement:**
  The calculation of the resistive moment must take into account the reduction of the lever arm with respect to the case of a pour in situ wall, due to the position of the reinforcement in the core.

– **Monolithism - Verification of the shear stress at the prefabricated shell / Core pour on site:**
  The presence of two planes of concrete requires verification to establish the monolithism of the section.

  The stress tangent to the prefabricated shell / cast in situ core interface is taken conventionally equal to:

$$\tau_{Ed} = \frac{V_{Ed}}{l \times 0.9d}$$

With:

– VEd: the shear force acting at the evaluated ELU for a strip of width l,

– d: the useful height.

However, when the cross-section of the wall is completely compressed, and when the verification of the wall's hold against the second-order effects is non-dimensional, the shear stress τEd at the prefabricated shell / cast-in-place interface can be evaluated by the formula:

$$\tau_{uc} = \frac{V_{Ed} \times S}{l \times I}$$

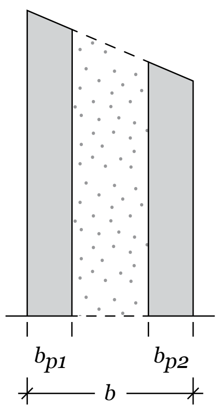

Figure 5.28 – Section and thickness of a wall with integral formwork. Include other dimensions – l, d, etc.

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S being the static moment of the thickness section bp1 (or bp2) with respect to the center of gravity of the section, and I the moment of inertia of the section of height b assumed to be homogeneous.

If we consider a unit width l = 1, then τEd is written:

$$\tau Ed = 6.V_{Ed}.b_{p1}.(b-b_{p1})/b^3 \text{ (ou } \tau_{Ed} = 6.Vu.b_{p2}.(b-b_{p2})/b^3\text{)}$$

This constraint must be compared with the value of the maximum shear stress calculated using the method presented below. If necessary, reinforcements must be fitted.

5.8.6.2 Particular Requirements for bi-hinged elements in 1st level of basement

The specific provisions for the walls stressed perpendicular to their plane may be dispensed with if :

- the elements are bi-hinged,
- they are used in 1st level of basement (free height less than 3 m)
- there exists at least one superstructure level,
- they are in a non-immersed situation,
- the use does not make the waterproofing of the wall.

5.8.6.3 Basement Walls

The solicitations in both directions can be envisaged provided that adequate constructive provisions are adopted.

The connection to the foundations is usually designed as a hinged connection with take-up frames arranged in the cast-in-place, except Special cases of FIXED connections.

Reinforcement at the floor level are located in the cast-in-place concrete or can be integrated into the double wall using reinforcement boxes.

The connections at the vertical and / or horizontal joints not subjected to bending are of the hinged type.

5.8.6.4 Retaining Walls

Reinforcement can be integrated into the double wall (FIXED connection - see details 9) or in the cast-in-place part (FIXED connection - see details 8).

Vertical joints not subjected to bending are reinforced with the aid of hinged-type reinforcement.

Drainage or weep holes are carried out according to the rules of the art. In the contrary case, the walls are subjected to hydrostatic pressure and the prescriptions of the paragraph “Treatment of the waterproofing plan”.

5.8.6.5 Silos or Storage

For the dimensioning of panels intended for silos, the “Professional rules for the design and calculation of concrete silos”, in compliance with the common requirements of double walls apply.

The bottom connections are FIXED, the vertical or horizontal connections between panels depend on the design of the structure.

5.8.6.6 Special Requirements for Swimming Pools

The requirements of subparagraph “Treatment of the sealing plane” are applied : sealing by concrete or “Liner” type sealing membrane.

The walls are FIXED on the floor by a mechanical solution with or without concreting.

The choice will be made as a function of the constraints of site and the solution of sealing that will be retained.

For overhead structures, the corner connections will be FIXED.

For solutions blocked in the head by a slab or tie-rods, the corner connections can be :

- HINGED for works whose sealing is not ensured by the concrete alone,
- STITCHED CONNECTION or FIXED for structures whose waterproofing is ensured by concrete alone.

PRINCIPLES OF CALCULATION

5.8.6.7 Polygonal Walls (non-flat walls)

They are calculated on the same bases as the pool walls.

When the angle between the facets is greater than or equal to 150 °, the incidence of the facets on the behavior of the pool is negligible.

Consequently, secondary phenomena due to horizontal tensile forces, which may occur at the vertical joints, are neglected.

All the stresses are determined as for a basin of circular shape FIXED in foot.

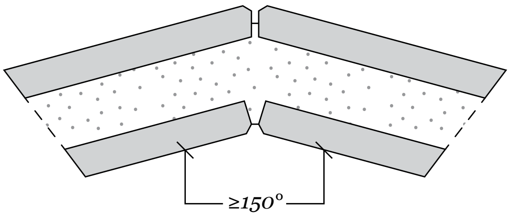


Figure 5.29 – Minimum angle between facets

When the angle between the facets is less than 150°, secondary horizontal bending moments develop at the current part of the walls and in the angles of the facets.

The efforts are then determined by a modeling of the pool in facets and are taken into account in the justification of the common steels and the steels of connections.

Reference may also be made to detail 17.2, Annex X.

5.8.6.8 Basement Walls

The current case corresponds to the walls working in vertical bending between the foundation and the covering slab, the whole of the structure functioning as a structure (frame or gantry).

The vertical connections are hinged. The connection between the walls and the cover slab is considered as FIXED.

It is recalled that the waterproofing of these structures must be ensured.

5.9 Seismic Adequacy

In accordance with the French CPT MCI – Article 1.1.1.14

Design for Earthquake Actions is specified in AS1170.2 with structural performance (*Sp*) and structural ductility factors (μ) specified in AS3600-Table 14.3. Double Wall can be designed as a limited ductile structural wall with Sp= 0.77 and μ=2 as per AS3600-2018 Table 14.3 or simpler details.

Note: Walls designed in accordance with Section 14.4 and 14.6 and above 4-storeys preclude the use of L-grade reinforcement. Double Wall can be produced with an N-grade bar mat and N-grade girder (excluding diagonal bars).

Minimum vertical and horizontal reinforcement ratio of 0.0025 as per clause 14.6.7.

The following provisions apply only to walls considered as primary seismic elements, walls forming part of the structural system resistant to seismic actions, modeled in the analysis for the seismic calculation situation and fully designed and studied in detail for Earthquake resistance in accordance with AS3600 – Section 14 – Design for Earthquake Actions.

The determination of the forces induced by the seismic actions on a panel of wall with Double Walls and the respect of the ductility criteria are carried out on the hypothesis of a homogeneous section equivalent to the substituted pour in situ wall.

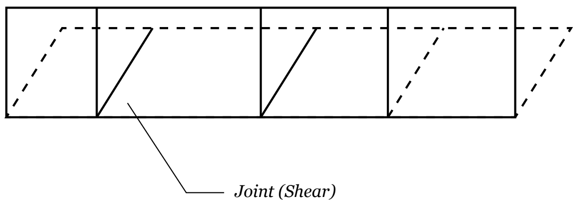


Figure 5.30 – Diagram of monotholic behavior of panels

PRINCIPLES OF CALCULATION

Suitable tie-rods and tie-beams from the calculation can be integrated into the double walls.

- **Principle of verification of walls with integrated formwork under seismic stresses:**

  The determination of the forces induced by the seismic actions on a double wall panel is carried out on the hypothesis of a homogeneous section equivalent to the substituted wall.

  The coefficient kp should be taken as 1.

- **Local stability:**

  In the case where the wall is free on one of these sides, reference may be made to verifying the shape stability of the beams-walls.

  In the absence of justifications by calculation, walls with integrated formwork can be assimilated to a wall of equivalent homogeneous cross-section, provided that the provisions and justifications set out in the following paragraphs correspond to the default case.

- **Connections between walls with integrated formwork in a common area:**

  In the absence of specific calculation of the connections :

  – horizontal connections are prohibited,

  – For vertical joints, clearance should be provided as in Figure 5.31, in which horizontal reinforcement is placed through the opening so that lapping may extend beyond the edge girders. The cross-section of the connecting reinforcement is that determined for the substituted substructure wall, increased by the ratio :

  Total thickness / total thickness decreased by a prefabricated shell thickness, or (b / (b-bp)).

  The opening must be accessible for placement of reinforcement and removal of formwork for inspection once concreting the core has been completed.

The section of the vertical bars per linear meter of opening is at least equal to one third of the section per linear meter of the horizontal reinforcements of the prefabricated shell.

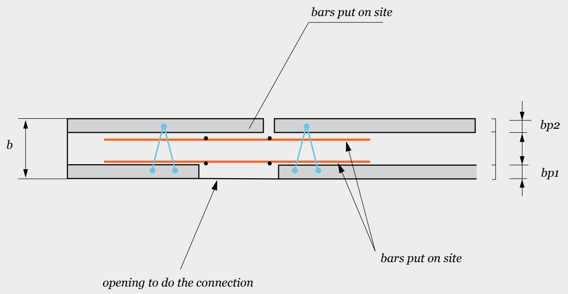


Figure 5.31 – Vertical connection in seismic zone without justification by calculation

In the case of justifications of the connections by calculation, the shear force requiring calculation must be compared with the resistant shear forces which can be mobilized in, depending on the type of connection (horizontal or vertical) and the load case studied.

This verification is intended to determine the type of connection to be used for the panel studied, making it possible to reproduce the monolithicity of the wall.

- **Connections between Double Walls at the edge of a slab:**

  In order to ensure that the Double Walls does not slip under the dynamic loads must be checked on the basis of the core of the double wall.

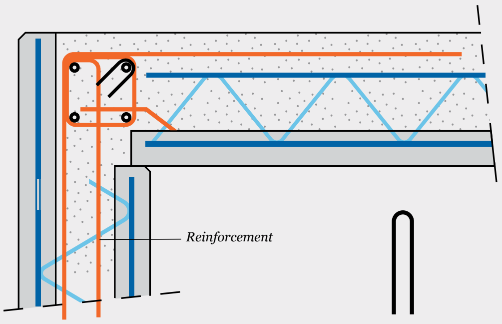


Figure 5.32 – Example of horizontal tie-beam

PRINCIPLES OF CALCULATION

In the case of use of suspended slabs in seismic situations, the requirements are those defined by the Professional Rules for Suspended Slab Flooring with Reinforcement Boxes.

- **Connections at the intersection of two or more Double Walls :**

  The intersections of walls necessitate systematically the use of a vertical tie-beams.

  This tie-beams can be incorporated into the double wall or implemented by means of reinforcement boxes. The choice between these two solutions will depend on the cross-section of the tie rod, the thickness of the Double Walls and the constraints of implementation.

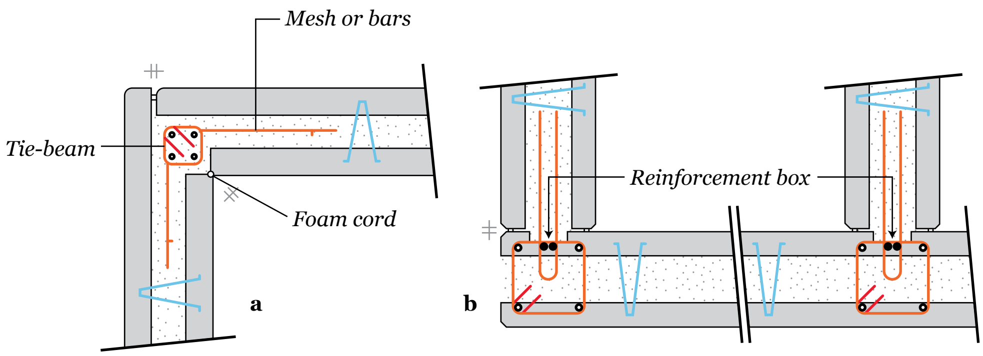


Figure 5.33 – Vertical chaining (a) in the cast-in-place core, (b) carried out by reinforcement boxes

Note: The minimum reinforcement arrangements in seismic zones can lead to thickness incompatible with the smallest core thicknesses. An increase in the total thickness of the elements of double walls is then necessary.

- **Requirements for the shaping of reinforcements:**

  The stirrups of beams and columns must comply with the constructive provisions defined in the AS3600-2018(+A2) standard.

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

PRINCIPLES OF CALCULATION

5.10 Fire Adequacy

AS3600-2018(+A1) – Section 5

The criteria for classification of fire resistance for structural adequacy, integrity and/or insulation of a Double Wall can be verified individually according to one of the following three methods and compared with the whole wall considered as homogeneous.

The joints between Double Walls whose width remains less than or equal to 20 mm are neglected for the calculation of temperatures (see Figure 5.34).

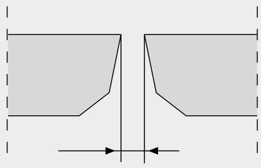


Figure 5.34 – Joint width less than or equal to 20 mm in the case of fire walls

– **Fire Resistance Periods for Insulation**

Austral Precast Double Wall are concrete with an effective thicknesses in the range from 180 mm to 400 mm.

The Fire Resistance Period (FRP) for Insulation of 240 minutes is achieved due to the minimum wall thickness being greater than 175mm in accordance with AS 3600-2018, Section 5 Design for fire resistance, Table 5.7.1.

Fire Resistance Periods (FRPs) for Walls for Insulation	
FRP or insulation min	Effective thickness mm
30	60
60	80
90	100
120	120
180	150
240	175

– **Fire Resistance Periods for Structural Adequacy**

The Fire Resistance Period for Structural Adequacy shown in the table below.

The figures in the table right are generated in accordance with Australian Standard AS 3600, Section 5 Design for fire resistance, Table 5.7.2.

Any concrete wall must be designed to achieve a Fire Resistance Period for structural adequacy, integrity and insulation of not less than the required fire resistance level(2) (FRL) as specified in The National Construction Code – Building Code of Australia, Specification 3. Type A Fire- Resisting Construction.

PRINCIPLES OF CALCULATION

Fire Resistance Period (FRP) for Structural Adequacy Austral Precast Double Wall							
Overall Wall Thickness, mm	*Shell Thicknesses on side exposed to fire, mm*	*Fire Resistance Period (FRP) for Structural Adequacy, mins*					
		Axis Distance	Loading	N*F / NU = 0.35	Axis Distance	Loading	N*F / NU = 0.7
		A, mm	Wall Exposed on One Side	Wall Exposed on Two Sides	A, mm	Wall Exposed on One Side	Wall Exposed on Two Sides
220	70	40	180	180	35	120	120
260	70	55	240	240	55	180	120
320	70	55	240	240	60	240	180
370	70	55	240	240	60	240	240
390	70	55	240	240	60	240	240

Definitions and References :

1. Fire resistance period (FRP)

Time, in minutes, for a member to reach the appropriate failure criterion (i.e., structural adequacy, integrity and/or insulation) if tested for fire in accordance with the appropriate Standard.

Source Australian Standards, Concrete Structures, AS3600-2018, Clause 5.2.5

2. Fire resistance level (FRL)

Fire resistance periods for structural adequacy, integrity and insulation, expressed in that order. NOTE : Fire resistance levels for structures, parts and elements of construction are

specified by the relevant authority, e.g., in the Building Code of Australia (BCA). Source Australian Standards, Concrete Structures, AS3600-2018, Clause 5.2.4

3. AS 3600 Clause 5.2.2 defines Axis distance, a_s as the "distance from the centre-line axis of a longitudinal bar or tendon to the nearest surface exposed to fire".

PRINCIPLES OF CALCULATION

5.11 Thermal Adequacy

Austral Precast Double Wall has high thermal mass.

The high thermal mass in a building constructed with Austral Precast Double Wall will experience a heating and cooling cycle which contributes passively to achieve the comfort zone.

The Double Wall will store the heat energy for an extended period, gradually releasing it over time.

In winter, high thermal mass buildings will remain relatively warm, while in summer, they will remain relatively cool.

The high thermal mass will provide natural thermal comfort levelling out the temperature reducing the dependence on heating and cooling systems.

In winter, heat trying to pass through the Double Wall will become trapped in the wall and will slowly pass back into the room. In summer the reverse occurs. Heat trying to pass through the wall from the outside will become trapped in the wall and will slowly pass back out of the building.

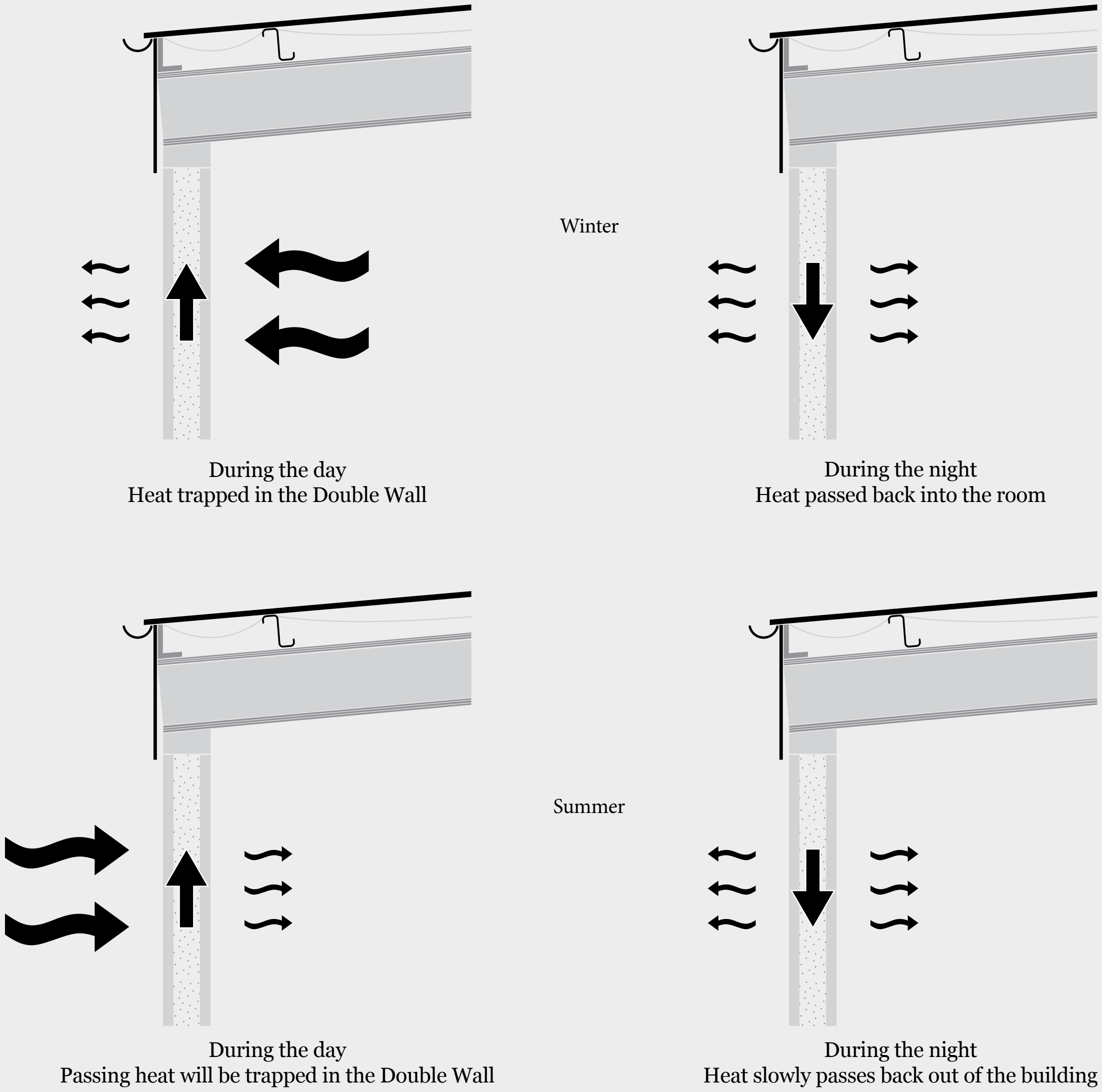


Figure 5.34 – Heat Transfer in Double Wall

PRINCIPLES OF CALCULATION

Austral Precast Double Wall can be designed to achieve energy efficiency provisions as specified in The National Construction Code Volume Two – Building Code of Australia (BCA).

The thermal resistance coefficient "The R- Value" (4) of the Double Wall system is affected by the wall thickness (its mass) and the use of insulation materials and cladding.

The mass of the precast concrete Double Wall will better thermal performance than its R Value alone would indicate.

The National Precast Concrete Association of Australia "NPCAA" has developed an R Value calculator that determines the "Mass enhanced R Value" of precast walls. A copy of the software tool can be downloaded via the NPCAA website.

www.nationalprecast.com.au/r-value-calculator

Thermal Properties, R-Value – Austral Precast Double Wall					
Thickness of Austral Precast Double Wall (mm)	200	250	300	350	400
	Thermal Resistance, R-Value m^2 K/W				
Austral Precast Double Wall Without					
External Air Film	0.04	0.04	0.04	0.04	0.04
Austral Precast Double Wall	0.14	0.17	0.21	0.25	0.28
Internal Air Film	0.12	0.12	0.12	0.12	0.12
Total	0.30	0.33	0.37	0.41	0.44
Austral Precast Double Wall with Plasterboard Lining and Additional Insulation					
External Air Film	0.04	0.04	0.04	0.04	0.04
Austral Precast Double Wall	0.14	0.17	0.21	0.25	0.28
50mm Kooltherm Phenolic Board Insulation	2.35	2.35	2.35	2.35	2.35
Internal Plasterboard	0.06	0.06	0.06	0.06	0.06
Internal Air Film	0.12	0.12	0.12	0.12	0.12
Total	2.71	2.74	2.78	2.82	2.85
Austral Precast Double Wall With Plasterboard Lining and Additional Insulation					
External Air Film	0.04	0.04	0.04	0.04	0.04
Austral Precast Double Wall	0.14	0.17	0.21	0.25	0.28
80mm Kooltherm Phenolic Board Insulation	2.80	3.80	3.80	3.80	3.80
Internal Plasterboard	0.06	0.06	0.06	0.06	0.06
Internal Air Film	0.12	0.12	0.12	0.12	0.12
Total	4.16	4.19	4.23	4.27	4.30

Definitions and References:

The R-value of a substance is its direct measure of its resistance to transferring energy or heat; R Values are expressed using the metric units (m2.K/W).

The amount of degrees kelvin temperature difference required to transfer one watt of energy per one square meter of a substance.

PRINCIPLES OF CALCULATION

5.12 Acoustic Adequacy

The sound attenuation index of a wall can be estimated as a homogeneous concrete wall using the combined concrete of the precast shells and the in-situ core concrete poured on site.

The presence of joints between the prefabricated walls is considered to have little influence on this index due to the monolithic concrete core.

NCC-2019 Volume One Specification F5.2 Table 2 states that a 150 mm thick concrete panel wall achieves an Rw + Ctr (6) not less than 50 dBA.

Hence, the weighted sound reduction index (Rw) (5) of Double Wall and its sound insulation effectiveness is not less than Rw +Ctr of 50 dBA, thus complying with the minimum requirements of the National Construction Code (NCC) Sound Attenuation Provisions, Building Code of Australia (BCA).

Therefore, all Austral Precast Double walls exceed the minimum NCC requirements.

Definitions and References:

1. The weighted sound reduction index (Rw) :

   A number used to rate the effectiveness of a soundproofing system or material. Increasing the Rw by one translates to a reduction of approximately 1db in noise level. The higher the Rw number, the better a sound resistance.

2. Rw +Ctr

   Is the weighted sound reduction index with the addition of a low frequency sound correction factor Ctr. (a negative number).

   The material sound insulation effectiveness is displayed by the Rw/Rw+Ctr values together.

PRINCIPLES OF CALCULATION

5.13 Determination Principle of Stresses on a Double Wall:

This paragraph describes the principle of determining the force applying to the right of the joint in the following cases :

- the double wall is subjected to a horizontal ponctual force F perpendicular to the thickness of the wall or to a horizontal linear load f acting on the upper part of the wall (in the case of a bracing),
- The double wall is subjected to a loading distributed at the top along its entire length (in the case of a beam).

a) In Case of a Bracing:

There are two cases:

- **Case 1:** recovery of a horizontal point load F on a wall developing a compression rod

  The design value of the shear force acting at the joint is such that:

$$V_{Edj} = \frac{F}{h}$$

With:

- F: the horizontal point load on the wall,
- H: the height of the wall,
- $V^{Ed,j}$: the shear force requiring calculation at the level of the joint.

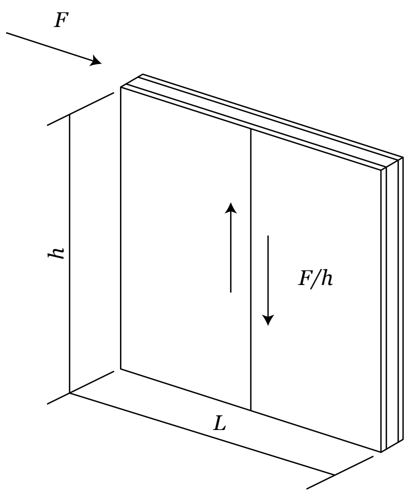


Figure 6.9 – Effort in the case of a bracing with a horizontal point load *(case 1)*.

PRINCIPLES OF CALCULATION

- **Case 2:** recovery of a linear horizontal load f on a wall developing nb compression rods.

  The design value of the shear force acting at the joint is such that:

$$V_{Edj} = \frac{f \text{ x } L}{n_b \text{ x } h}$$

With :

- f: The horizontal linear load on the wall,
- $V^{Ed,j}$: the shear force requiring calculation at the joint,
- L: the length of the wall,
- H: the height of the wall,
- Nb: the number of compression rods developed in the wall under the action of the load linear f on the wall.

The number of connecting rods nb, assuming an inclination of the rods at 45 °, is equal to the real number defined by:

$$n_b = \frac{L - h}{h}$$

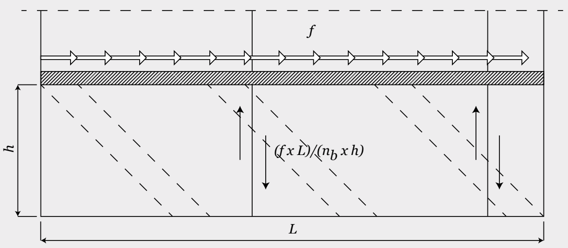


Figure 6.10 – Effort in the case of a bracing with a horizontal line load *(case 2)*.

b) In Case of a Beam-Wall:

In the general case, the shearing stress VEd, j at the joint is determined by considering the maximum value of the cutting force requiring calculation VEd, max, independently of the position of the joint.

Consequently, the shear force requiring calculation at the joints of the girder beams is therefore increased *(Figure 6.11)*.

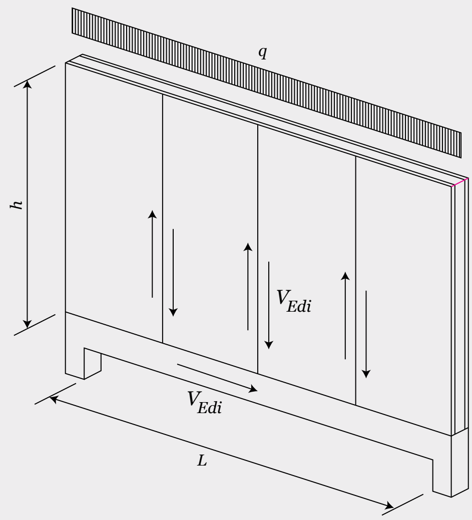


Figure 6.11 – Effort in the case of a beam-wall.

The cutting force requiring calculation at the joint is such that:

$$V_{Edj} = \frac{V_{Ed,max}}{min(h;L)} = \frac{q\,L/2}{min(h;L)}$$

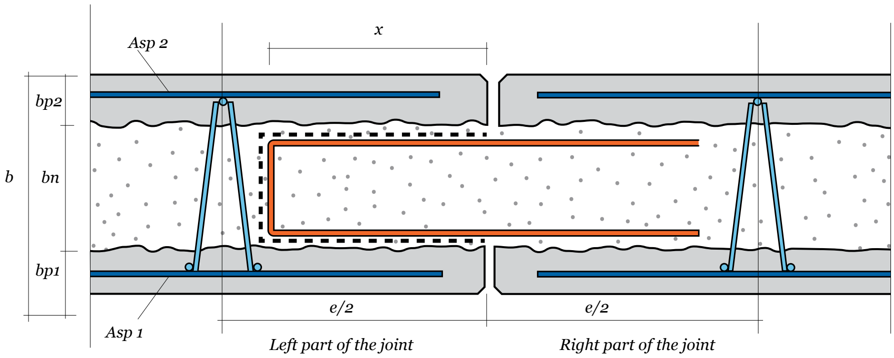
PRINCIPLES OF CALCULATION

5.14 Verification of the Connection - Calculation:

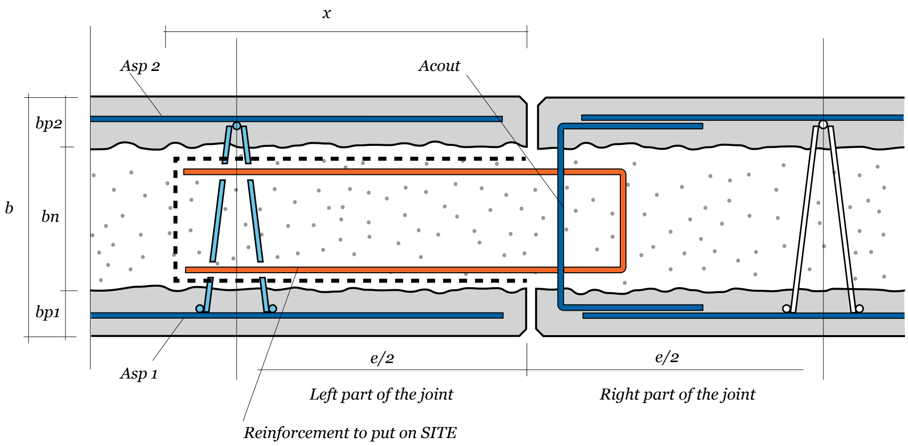
In accordance with the French CPT MCI – Annex 2

Maximum Shear Force at the Connections:

– Without "U" at the Connection: VRD = 11 850 daN/ml



– With "U" at the Connection > Stitched Connection:



VRD is depending of the diameter of the stitching "U", and the spacing of the "U":

VRD	Φ	6			8			10			12			mm
	Spacing	150	200	250	150	200	250	150	200	250	150	200	250	mm
18	Thickness Double Wall	231	194	172	346	280	241	359	359	330	359	359	359	kN/m
20		255	218	196	370	304	265	382	382	354	382	382	382	kN/m
22		279	242	220	394	328	289	406	406	378	406	406	406	kN/m
25		315	278	256	430	364	325	442	442	413	442	442	442	kN/m
30		375	338	316	490	424	385	502	502	473	502	502	502	kN/m

SITE INSTALLATION CONSIDERATIONS

6

SITE INSTALLATION CONSIDERATIONS

6.1 Core Filling

In accordance with the French CPT MCI – Article 1.1.1.13

6.1.1 Concrete Pour Discharge Height

The maximum height, Hmax, for discharging concrete shall not exceed 3 m, independent of the thickness of the core, in order to eliminate the possibility of segregation of concrete.

When panel heights are greater than this maximum height the concreting must be carried out by either inserting a flexible tube between the prefabricated shells (where the thickness of the core permits) to the required height or through an opening at Hmax as shown in Figure 6.1.

The horizontal distance between two successive pouring locations must not exceed 3.80m.

Care must be taken during placement of concrete by controlling the volume and location of concrete being poured through observation of the joints between panels and direct observation through any openings in the panels.

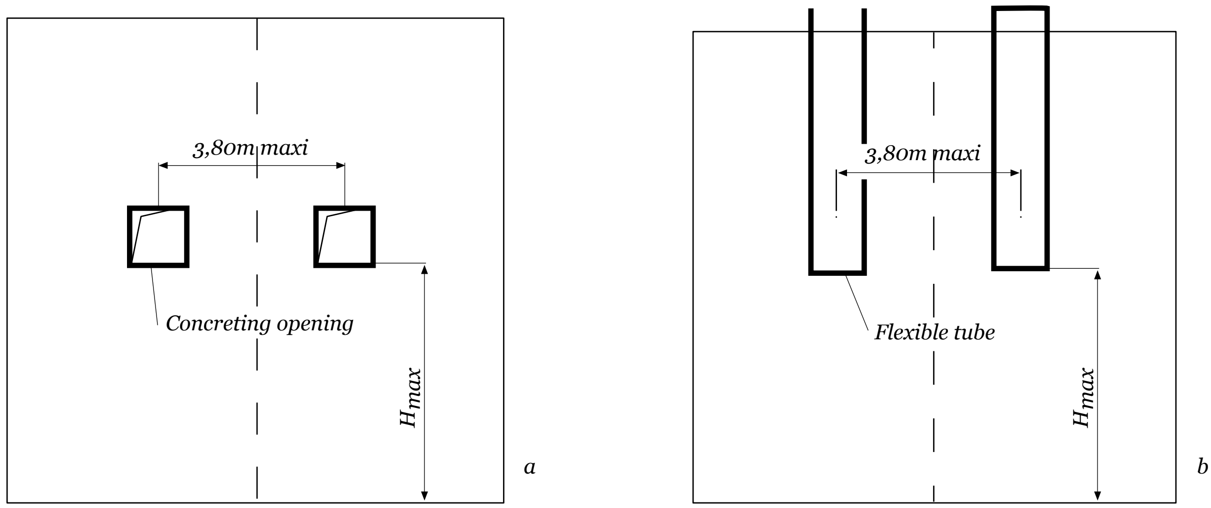


Figure 6.1 – Concrete height equivalent to (a) height under opening and (b) height under flexible tube

SITE INSTALLATION CONSIDERATIONS

6.1.2 Concrete Pour Rate

In the absence of specific documentation, the speed of concreting is limited to 0.50 m/hour under the temperature conditions provided.

Beyond this, the rate and maximum pour height must be specified on the installation plan and defined by reference to the figure 6.2 below.

The pressure applied by fresh concrete during placement is determined by the type of concrete, formwork, temperature, discharge height, vertical pour height and rate of pouring. This can be calculated as per AS3610-1995 Clause 4.4.5.1.1.

The capacity of Double Wall to resist the shear force applied by the concrete pressure, Lc, is determined by the girder, internal cover to the girder and strength of the precast shells at time of core-filling. Rates for Lc are as follows:

15.6 kN / m for a minimum concrete cover of 15 mm
18.4 kN / m for a minimum concrete cover of 17 mm

The validity of the curves presented in Figure 6.2 is conditional on a minimum compressive strength of 20 MPa at the time of placement of concrete in the core of the Double Wall prefabricated shells.

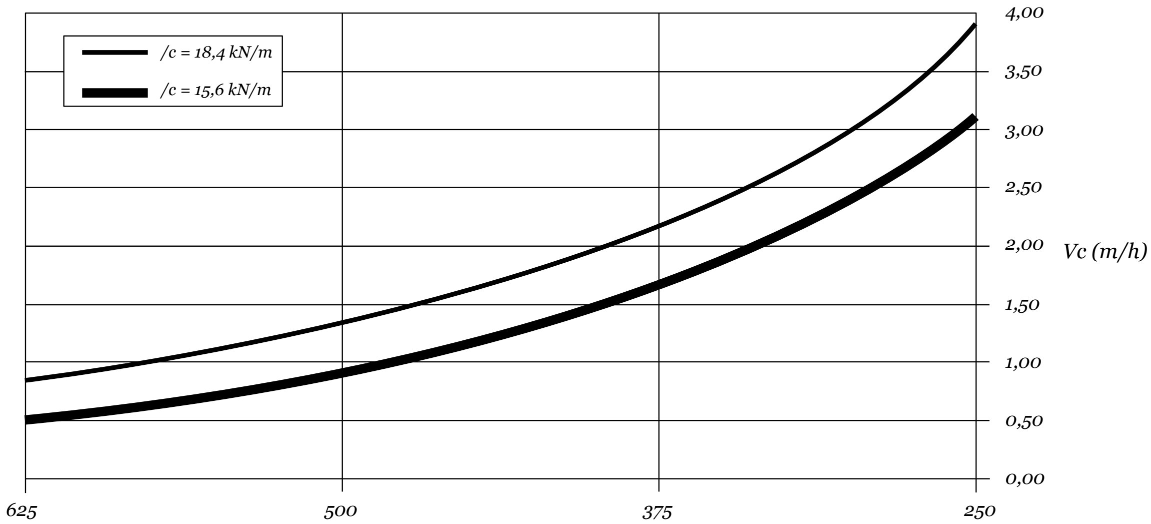


Figure 6.2 – Concrete speed as a function of the Girders Spacing

Note: Attention is drawn to the fact that particular provisions on the phasing of the walls must be taken in order to ensure that the requirements for concreting conditions described above can be met.

For example, a concreting speed of 50 cm / h implies the concreting of a height of 3 m over a period of 6 hours.

SITE INSTALLATION CONSIDERATIONS

6.2 Cast In Fasteners

It is the responsibility of the Structural Design Engineer to verify that the supporting structure, that is to say the Double Wall, is capable of taking up the loads transmitted by the anchors and includes any provisions necessary for transfer of loads.

The anchors cast perpendicular to the prefabricated shell / core recovery plan are :

– either fully anchored in the thickness of the prefabricated shell according to the manufacturer's recommendations,

– either totally anchored in the thickness of concrete poured in place (core):

  – the tensile check must be made considering the thickness to be fixed, the thickness of the plate increased by the thickness of the prefabricated shell concerned by the fixing,

  – the shear checking is carried out by considering only the thickness of the plate as the thickness to be fixed.

A peg parallel to the recovery plane is allowed only in the part poured in place, the good compactness of which will have been checked.

The contribution of shells prefabricated is ignored for the strength of the anchor.

1. *Details of Double Wall Walls Connections:*

See the Double Walls Connections documentation.

2. *Treatment of Joints:*

In accordance with the French CPT MCI – Article 1.1.5

Products for the treatment of the walls and treatment of the joints will be implemented in accordance with the specifications of the suppliers, both for the preparation of the wall and the method of application.

In particular, the walls should be prepared so as to be plane, free from leakage of cement, dirt and dust.

The Double Wall is typically supplied with a Class 2 Surface Finish (AS3610) and must be considered when choosing the type of coating that will be applied to the substrate (stain, painting, impregnation, adhesive glue for plaster plates, etc).

This section presents the treatment of vertical and horizontal joints.

a) Walls in Superstructure:

For common superstructure walls, the prefabricated weather-resistant shell is distinguished from the inside shell.

The minimum free distance of the connecting reinforcement at the joint and the inner face of the prefabricated shell is 15 mm MINIMUM.

Note: Attention is drawn to the fact that the tightness of the facade made by the joint could requires regular maintenance of the joint.

– **External Face:**

  – *Coated walls:*

  Walls insulated from the exterior or cladding do not require the treatment of joints between walls with integrated formwork.

  A sealing system of the foam cord type can be installed as a joint base when installing walls, to prevent leakage of cement during concreting.

  This cord can be removed after drying the concrete and the mortar-filled seal.

SITE INSTALLATION CONSIDERATIONS

– Rough, painted or laquered façade walls:

The rough, painted or glazed walls require the treatment of the joint using a single-component SNJF F 25 E elastic mastic which polymerizes under the action of the humidity and intended for the treatment of prefabricated facade joints exposed.

The thickness of the mastic must be at least 20 mm. The compatibility of the elastomer mastic and the foam cord should be checked.

The chamfer must remain marked.

In all cases, the compatibility of the seal treatment product and the stain or paint used should be ensured.

– Coated walls:

Walls that are treated with a coating that does not cover joints (labeled chamfer) must be subjected to the same seal treatments as walls remaining unfinished, painted or laquered.

In general, the precautions for the preparation of the support and installation must be in accordance with the suppliers requirements .

If the coating covers the joint, the elastomeric mastic is not required, the chamfer area must be filled with a mortar without shrinkage and covered with a strap.

In spite of this treatment, however, it can't be completely excluded that fine cracks, without any other disadvantage than the surface appearance, appear at the right of certain joints.

In the case of mortar coating, this must be carried out after placing a strap, and according to the precautions of preparation of the support and installation.

– Internal Face:

The joint may remain untreated if the seal is masked by cladding or lining or if the architectural constraints do not require it to be closed.

A foam cord can be installed as a joint base when installing walls, to prevent leakage of cement during concreting.

In other cases, the joint is treated with a compensated shrinkage hydraulic mortar.

The appearance of fine cracks at these joints is however possible but without any other disadvantage than the surface appearance.

– Singular Points:

– At the opening level:

The treatment of the wall / joineries junctions must be carried out in accordance with the Australian code.

The provisions adopted must ensure the continuity of the water tightness at all points, and in particular at the junctions with joineries.

Special attention must be paid to the level of the window, which is to say the connection of the sealing plane of the facade and that of the joinery.

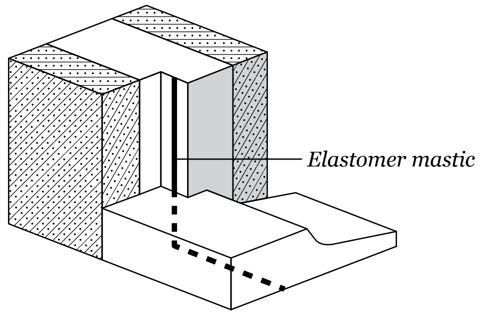


Figure 6.3 – Example with a Window

– Waterproofing Cornices:

The joints of cornices are treated identically to the common joints of façade and in continuity of these.

This treatment will be carried out over the whole contour of the cornices, outside the part protected by the seal.

– Head of Walls Protection:

In order to avoid any infiltration between the shells and the cast-on-site core, the upper part of the wall is equipped with :

– by a concrete cover,

– by a metal cover.

SITE INSTALLATION CONSIDERATIONS

b) Walls in Sub-Structure:

In the case where the joint is accessible in the construction phase and is inaccessible during the maintenance phase, the minimum concrete cover distance between the connecting frame at the joint and the inner face of the prefabricated panel ae, min of 30 mm can be reduced to 15 mm by treating the joint with a bituminous strip and that the wall is not subjected to hydrostatic pressure.

– **External Face:**

– *Walls Accessible in Construction Phase:*

To prevent water entrance, vertical and horizontal joints in contact with the water are treated with a mortar component based on cement (and resin), supplemented with a self-adhesive cold strip, resistant to tearing and water, and capable of protecting the joint from direct contact with the soil and water.

Since the joint receives this sealing treatment, the minimum free distance between the connecting reinforcement at the joint and the inside of the prefabricated shell can be reduced to 15 mm.

Drainage will be systematically applied to collect water.

– *Walls Not Accessible in Construction Phase:*

The treatment of the outer joint will be carried out by installing an impregnated and self-adhesive open cell foam sealing cord on the edge of the prefabricated exterior shell of the Double Walls.

The sealing of the joint will be complemented by continuous concreting in the area of the vertical joint.

The minimum free concrete cover between the connection reinforcements at the joint and the inside face of the prefabricated shell must be at least 30 mm, and the wall formwork must be stitched.

– **Internal Face:**

The interior surface will be treated according to the same criteria as the internal facings of the superstructure walls.

c) Joint Treatment Summary:

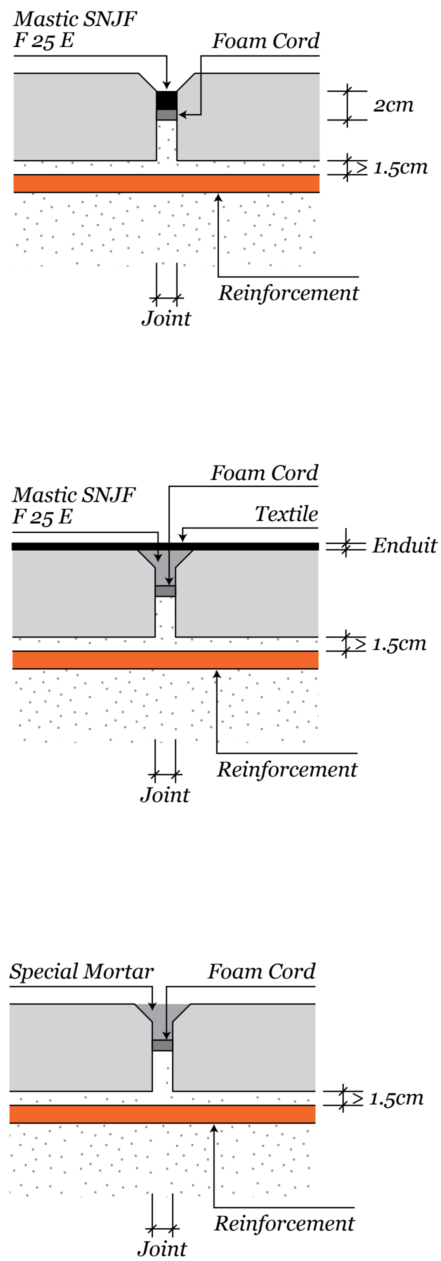


Figure 6.3 – Joint Treatments

Site placed footing reinforcement — Wall structural reinforcement — Truss — Splicing Steel — Concrete — Core-fill Concrete

SITE INSTALLATION CONSIDERATIONS

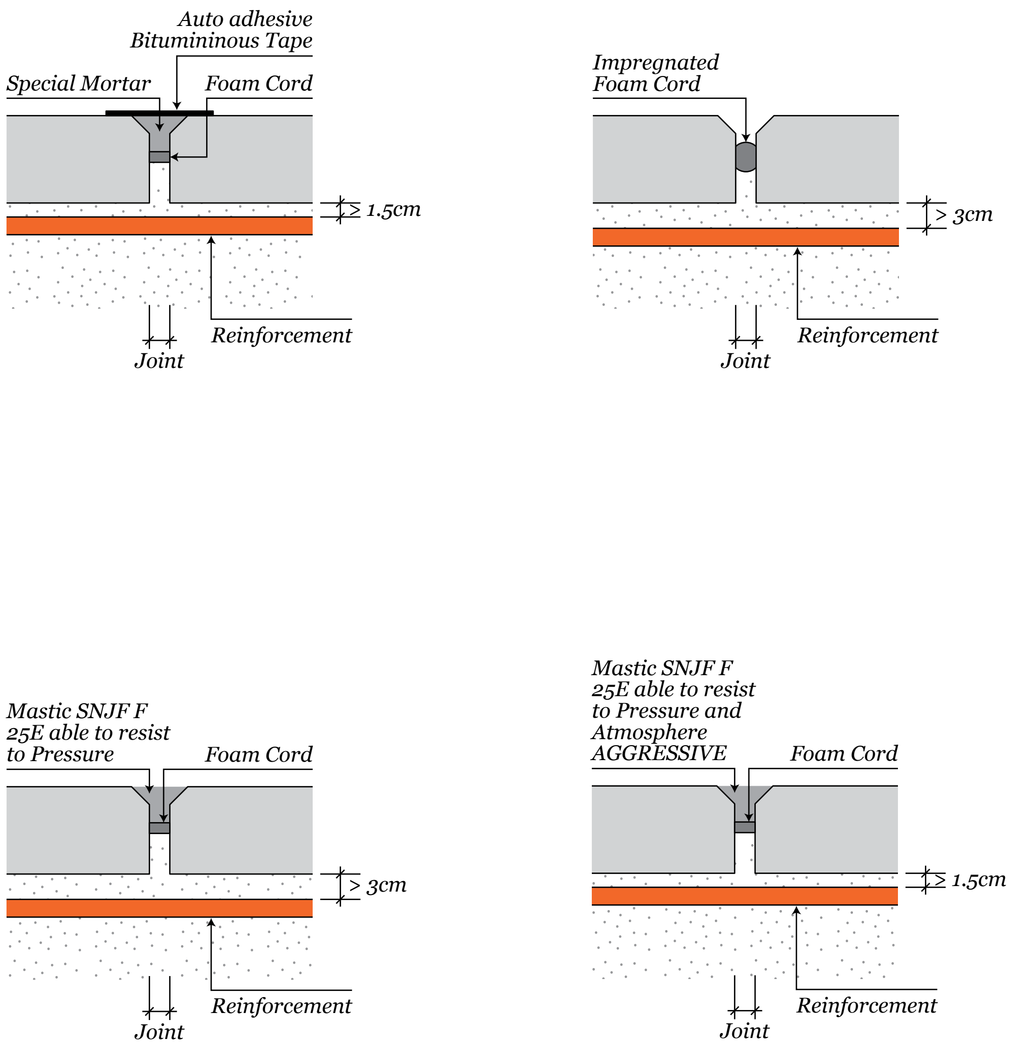


Figure 6.3 (continued)– Joint Treatments

Site placed footing reinforcement · Wall structural reinforcement · Truss · Splicing Steel · Concrete · Core-fill Concrete

SITE INSTALLATION CONSIDERATIONS

3. Minimal Thickness and Critical Length for Waterproofing:

a) Minimal Core Thickness for Waterproofing Under Hydrostatic Pressure:

The waterproofing can be ensured by the structure alone, or by a tight seal.

The joints are finished according to the destination of the structure.

The minimum wall thickness and critical path length is:

- 15 cm for structures: sealing provided by the structure alone, (A)
- 12 cm for structures: waterproofing provided by the structure supplemented by a waterproofing coating, (B)
- 12 cm for structures: waterproofing provided by a waterproofing coating, (C)
- 12 cm: Swimming pools.

Sealing by concrete (Type A structures):

To ensure a concrete-tight sealing of the Double Wall subjected to hydrostatic pressure, the connections between the wall and the foundation or the floor must be FIXED (Details 8 and 9).

Vertical or horizontal connections between two panels must be of a REINFORCED CONNECTION type (Details 13.3) or FIXED (Details 14) in order to block the cracking caused by the shrinkage of the concrete.

Near these connections, the quantity of reinforcements passing through the prefabricated / cast-in-place concrete interface must be increased by 25%.

Sealing by concrete with seam treatment (Type D structures):

If the joints are treated with an elastomer sealing gasket , with high flexibility (elongation at break of more than 400%), bonded to the joints and ensuring water tightness in contact with the vertical links may be of the conventional hinged type.

The seal is to be used as a rule on the face in contact with water.

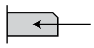
However, it can work under pressure by means of specific implementation provisions defined by the manufacturers.

Reported waterproofing (Types B and C):

The compatibility of the sealing off with the joint geometry must be checked. These joints of the walls must be filled.

Specific treatment may be required depending on the sealing off.

b) How to Calculate the Core Thickness for Waterproofing:

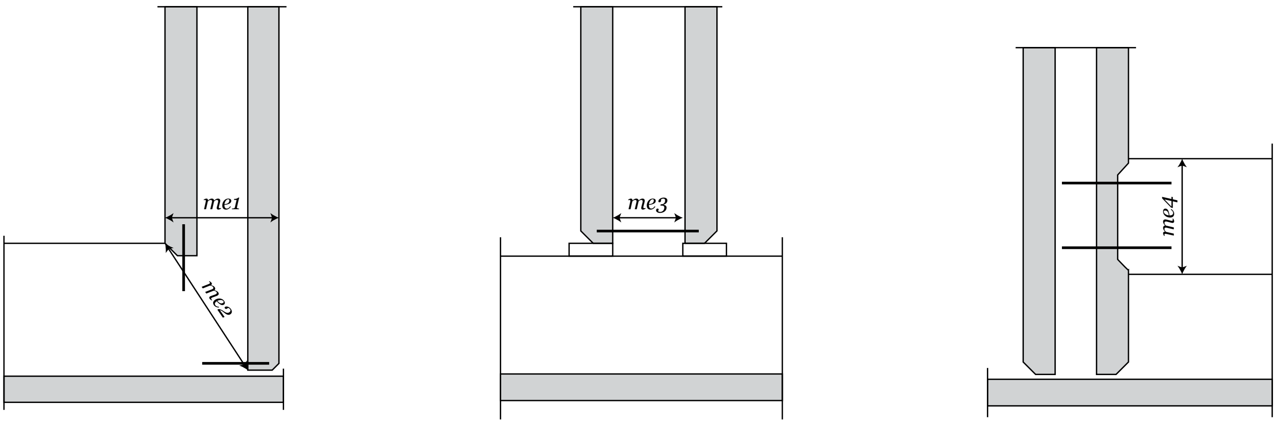

Stitch reinforcement

mei: *minimal thickness measure*

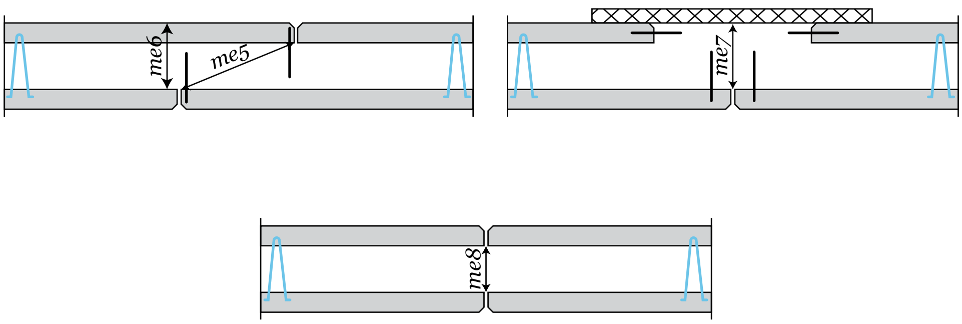
Figure 6.4 – Measurement of Thickness for Stitch Reinforcement

SITE INSTALLATION CONSIDERATIONS

Sealing by concrete (Type A structures):



Waterproofing at vertical joint:



Waterproofing at joint angles:

Figure 6.5 – Measurements for sealing

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

SITE INSTALLATION CONSIDERATIONS

Waterproofing at joint angles:

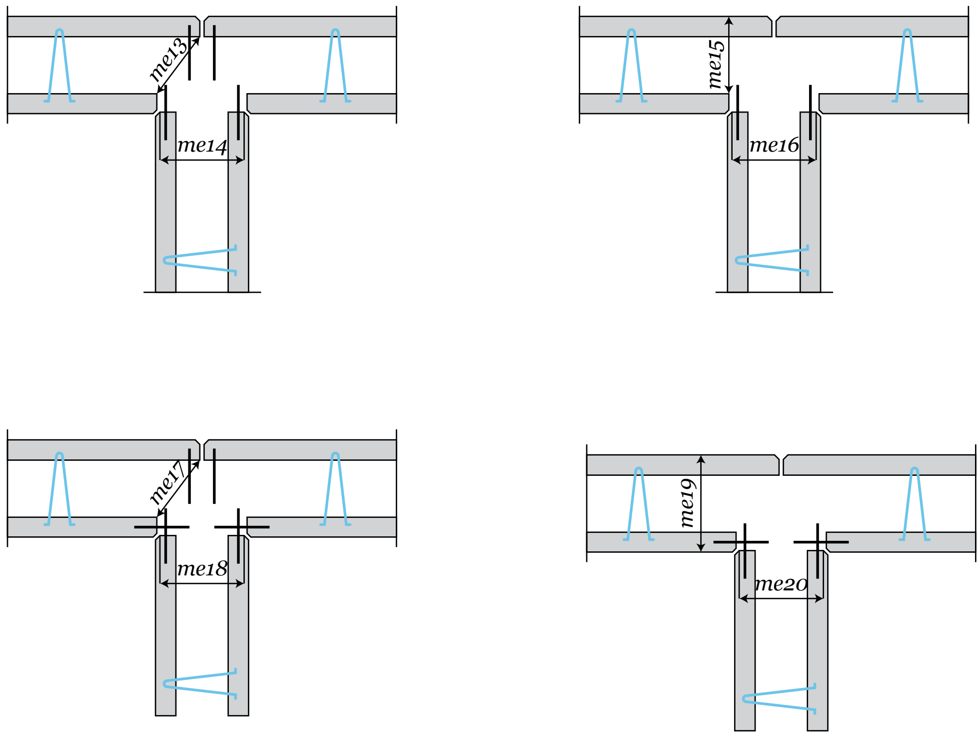


Figure 6.5 (continued) – Measurements for sealing

Site placed footing reinforcement   Wall structural reinforcement   Truss   Splicing Steel   Concrete   Core-fill Concrete

SITE INSTALLATION CONSIDERATIONS

c) Continuity of Concreting and Horizontal/Vertical Planes:

The continuity concreting of the HORIZONTAL plane is ensured by an Expanded Joint or a Waterstop joint.

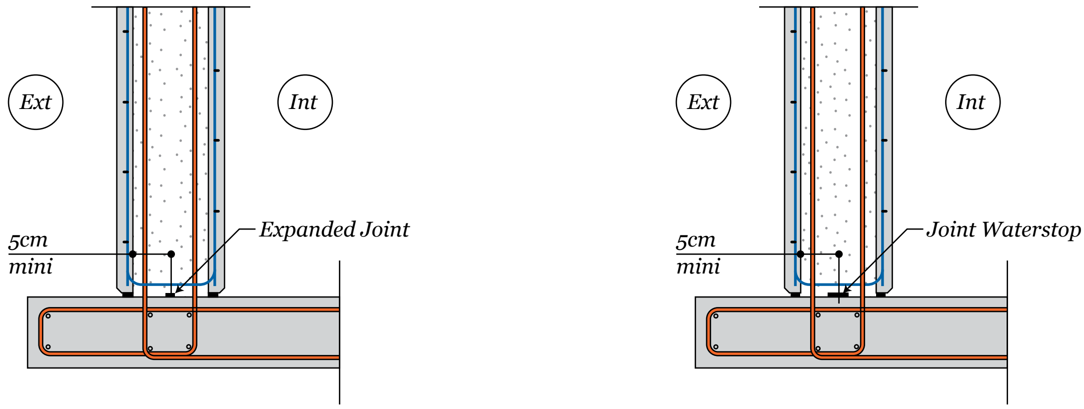


Figure 6.6 – Horizontal Joint Continuity

The continuity of concreting of the VERTICAL plane is ensured by an stop of concrete INSIDE of the DOUBLE WALL with a construction working joint put in production.

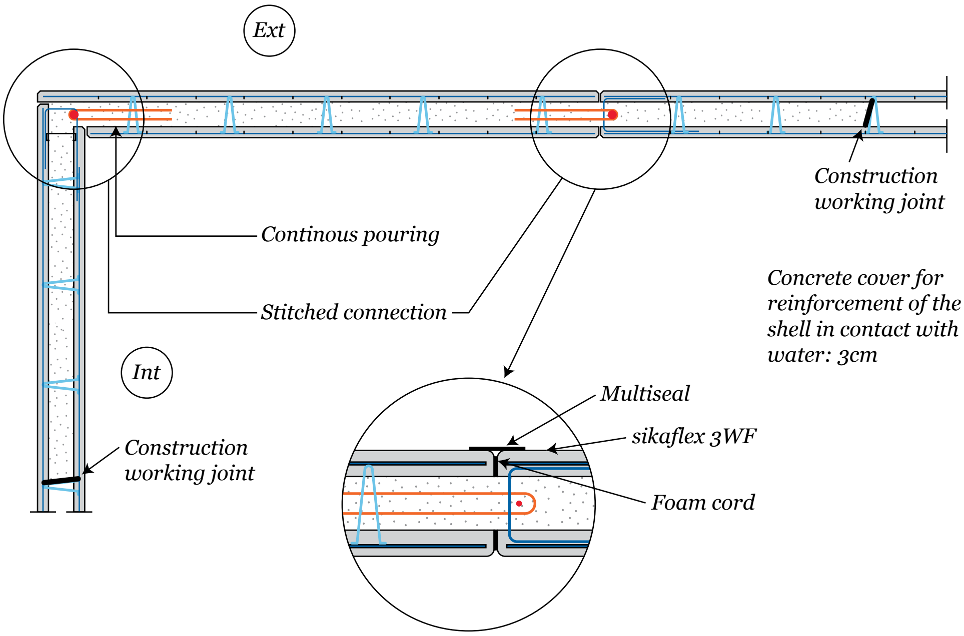


Figure 6.7 – Vertical Joint Continuity

Site placed footing reinforcement | Wall structural reinforcement | Truss | Splicing Steel | Concrete | Core-fill Concrete

SITE INSTALLATION CONSIDERATIONS

d) Internal Face in contact with Water Pressure:

The vertical and horizontal joints are closed with a SNJF F 25 E elastic mastic able to withstand hydrostatic pressures.

In the case of contact with drinking water, the joints are closed with a SNJF F 25 E elastic mastic able to withstand hydrostatic pressures and having an alimentary agreement.

The horizontal joint between the wall and the raft can have an engraving to effectively treat the precast concrete / in-place concrete contact *(see Figure 6.8)*.

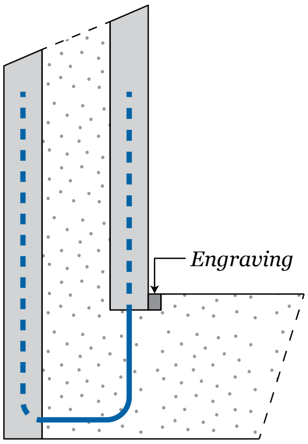


Figure 6.8 – Engraving at the connection between the wall and the foundation (engraving typically made from timber form and later filled with elastomer).

e) Inner Face in contact with Water Aggressive:

The vertical and horizontal joints are closed with a specific system, able to withstand hydrostatic pressures and contact with aggressive solutions.

This system, as well as the concrete specifications, are defined in each Technical Notice.

The horizontal seam between the wall and the raft can have an engraving to effectively treat the precast concrete / in-place concrete contact *(see Figure 6.8)*.

SITE INSTALLATION CONSIDERATIONS

6.3 Double Walls Lifting Hooks Tests in France:

a) Lifting Capacity of the Hooks:

A large number of tests were carried out in 2013 under the supervision of the C.S.T.B in order to verify the lifting capacities of the hooks in 3 lifting positions:

- Double Wall vertical lift,
- Double Wall flat lift,
- Double Wall rotating lift.

According to a test protocol defined by the Construction Administration.

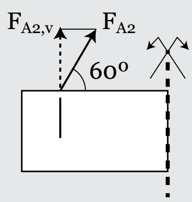
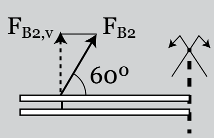
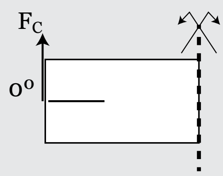
The SAFETY Coefficient on the results take account on the Tests value is : 3,00.

These tests were the subject of a test report in 2013 and an approval of the C.S.T.B. in France.

b) Results of the Tests:

Table of results for Lifting Capacity of the Hooks of the Double Walls:

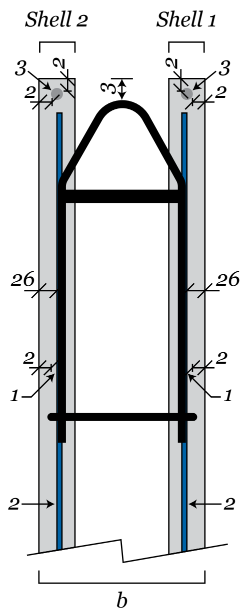
Reference Hook	*Diameter Hook Φ_1*	*Thickness Shells h_1, h_2*	*Concrete Cover c_1, c_2*	*Lifting Vertical CMUv*	*Lifting Flat CMUp*	*Rotating Wall CMUr*
D14 - H	14mm	≥ 55mm	≥ 15mm	24.6kN	5.3kN	12.4kN
D16 - H	16mm	≥ 55mm	≥ 13mm	26.8kN	6.8kN	15.4kN
D16 - H	16mm	≥ 65mm	≥ 23mm	32.3kN	6.8kN	16.6kN

Verification of Resistance Lifting Hook			
Type of Lifting	*Lifting Vertical*	*Lifting Flat*	*Rotating Wall*
Verification	$CMUv \geq \frac{(p\,A + Q)\,Y_{ed}\,Y_{pp}}{n_b}$	$CMUp \geq \frac{(p\,A + Q)\,Y_{ed}\,Y_{pp}}{n_b}$	$CMUr \geq \frac{1}{2}\,\frac{(p\,A + Q)\,Y_{ed}\,Y_{pp}}{n_b}$
CSTB Protocol			
	Configuration A2	*Configuration B2*	*Configuration C*

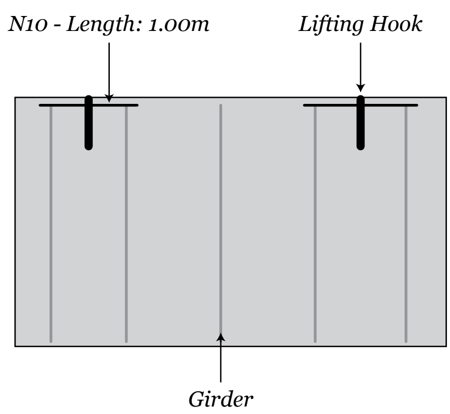
SITE INSTALLATION CONSIDERATIONS

c) Position of the Lifting Hooks:

The positions of the lifting hooks in the Double Walls are:



1. Transversal Reinforcement
2 Longitudinal Reinforcement,
3 Bars N10 mm – Length : 1.00 m



SITE INSTALLATION CONSIDERATIONS

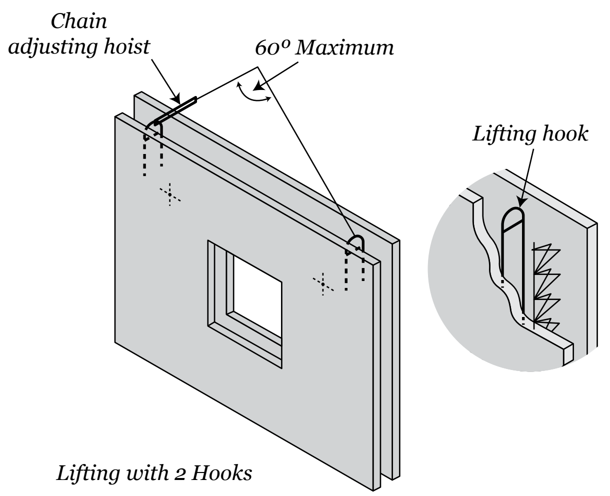
d) Capacity to Lift:

With an MAXIMUM ANGLE between the 2 Slings of 60°:

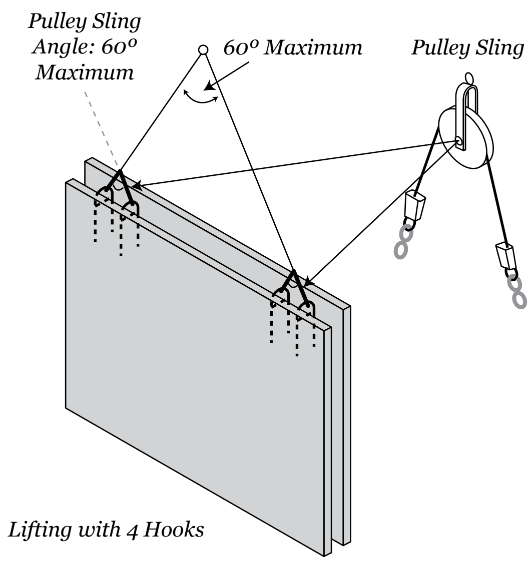
- 2 Lifting Hooks / Double Wall minimum until a weight of Double Wall INFERIOR or EGAL to:
  - 41kN for Lifting Hooks of φ14 mm, Shells >= 55 mm and Concrete Cover of 20 mm,
  - 45kN for Lifting Hooks of φ16 mm, Shells >= 55 mm and Concrete Cover of 20 mm,
  - 54kN for Lifting Hooks of φ16 mm, Shells >= 65 mm and Concrete Cover of 20 mm,

- 4 Lifting Hooks / Double Wall minimum until a weight of Double Wall INFERIOR or EGAL to:
  - 82kN for Lifting Hooks of φ14 mm, Shells >= 55 mm and Concrete Cover of 20 mm,
  - 90kN for Lifting Hooks of φ16 mm, Shells >= 55 mm and Concrete Cover of 20 mm,
  - 108kN daN for Lifting Hooks of φ16 mm, Shells >= 65 mm and Concrete Cover of 20 mm,

In this case, 2 pulley Sling are used between 2 Lifting Hooks, on each sides of the Double Walls, for distributing the loads.



Lifting with 2 Hooks



Lifting with 4 Hooks

Lifting for Double Walls Flat Lifting:

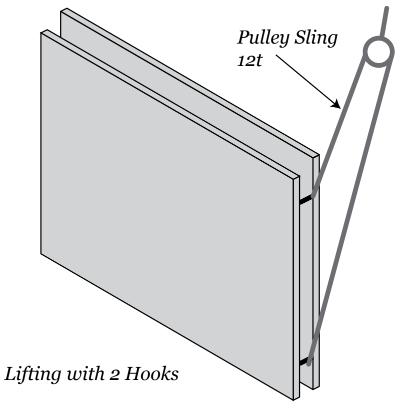
4 Lifting Hooks / Double Wall for Lifting Hooks of φ14 mm, Shells >= 55 mm and Concrete Cover of 20 mm,
(5,50 m² in 2 shells of 55 mm)

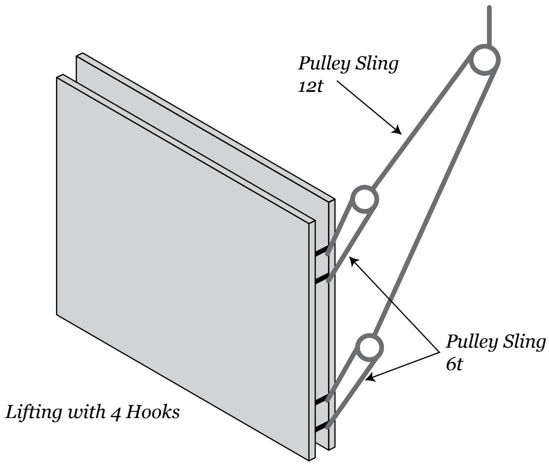
SITE INSTALLATION CONSIDERATIONS

e) Rotating Double Walls:

– 2 LIFTING HOOKS : 1 pulley sling of 12 tons, for distributing the loads

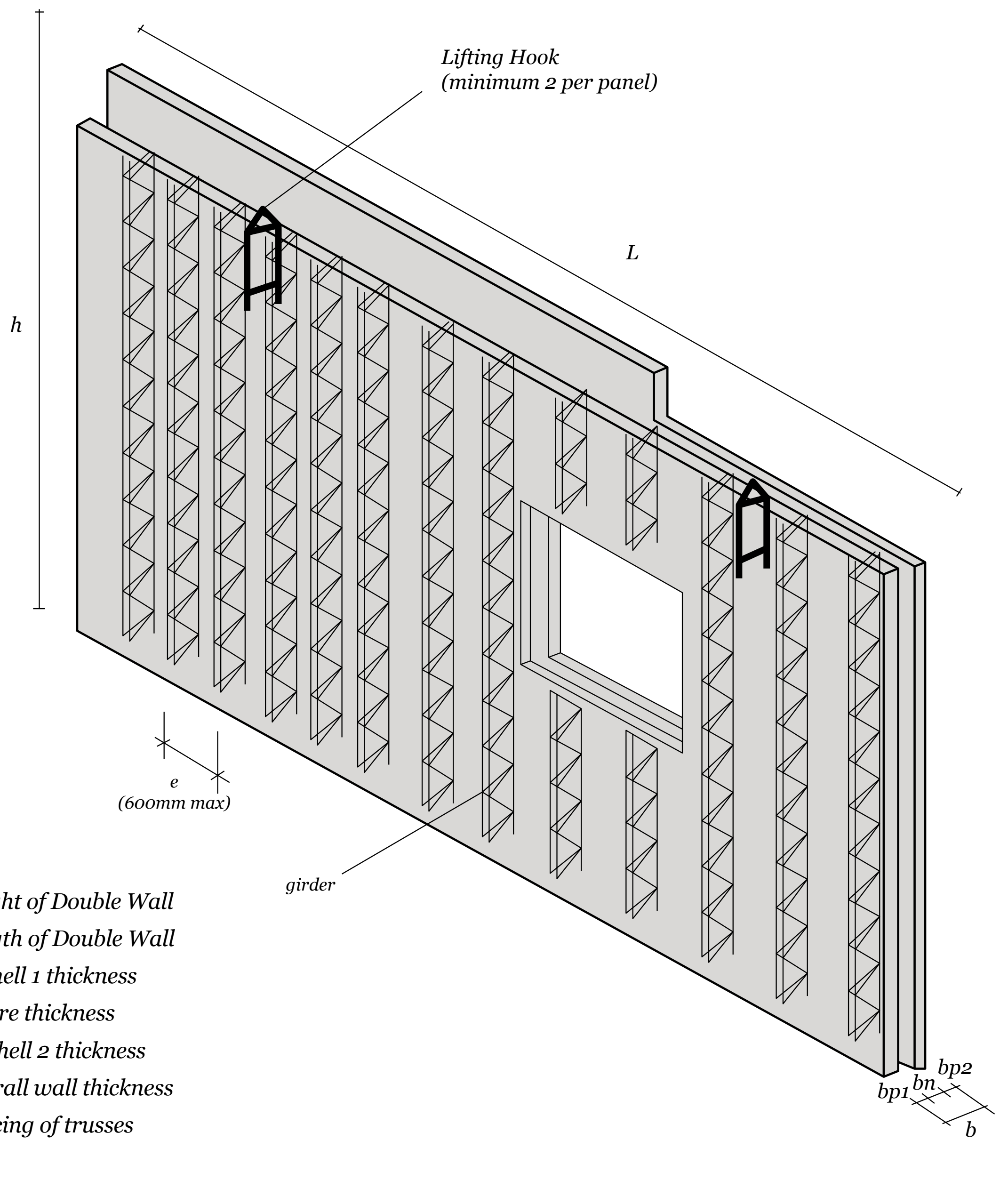
– 4 LIFTING HOOKS:
  – 2 pulley slings of 6 tons, for distributing the loads,
  – 1 pulley sling of 12 tons, for distributing the loads between the slings of 6 tons.





CONNECTION DETAILS

7.1 Typical Double Wall



h: height of Double Wall
L: length of Double Wall
bp1: shell 1 thickness
bn: Core thickness
bp2: Shell 2 thickness
b: overall wall thickness
e: spacing of trusses

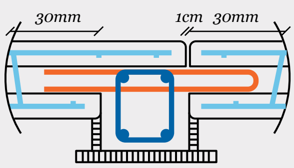
CONNECTION DETAILS

7.2 Typical Double Wall with Columns

DOUBLE WALLS AND COLUMNS

Column Pour In-Situ

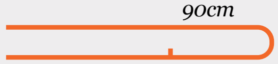
Detail 4.5 CPT MCI APP 1



Insert the connecting steel after the installation of the Double Walls and BEFORE concreting wall. Reinforcement as specific by structural engineer.

"U" in N.. - Space : mm

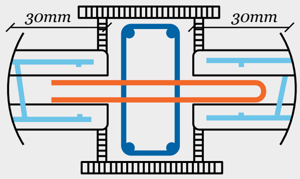
90cm



Note: Connecting reinforcement supplied by others

Column Pour In-Situ

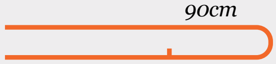
Detail 4.6 CPT MCI APP 2



Insert the connecting steel after the installation of the Double Walls and BEFORE concreting wall. Reinforcement as specific by structural engineer.

U en HA## eso L ##cm

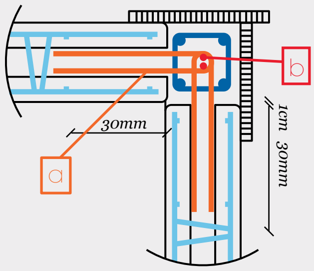
90cm



Note: Connecting reinforcement supplied by others

Column Pour In-Situ with L

APP 3



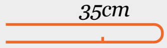
Insert the connecting steel after the installation of the Double Walls and BEFORE concreting wall. Reinforcement as specific by structural engineer.

"U" in N.. - Space : mm

a

b *2n..*

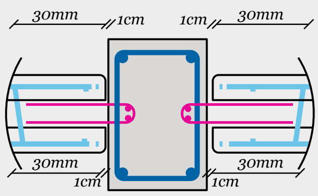
35cm



Note: Connecting reinforcement supplied by others

Precast Columns

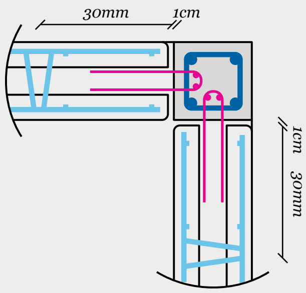
APP 5



Unfold the keybox bars before installation of the Double Walls

Precast Columns L Orientation

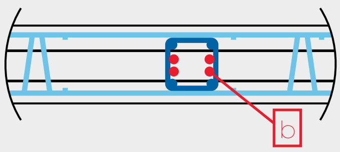
APP 6



Unfold the keybox bars before installation of the Double Walls

Column in the Double Wall

Detail 4.1 CPT MCI APP 7



b *2n..*

Note: Connecting reinforcement supplied by others

CONNECTION DETAILS

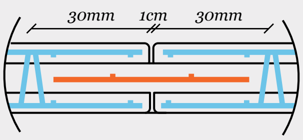
7.3 Double Wall Hinged Connections

DOUBLE WALLS < 20CM

DOUBLE WALLS ≥ 20CM

With SL92 mesh

Detail 13.1 CPT MCI APP 1

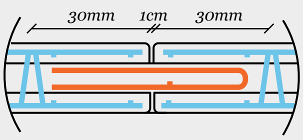


SL92

Note: Connecting reinforcement supplied by others

With "U"

Detail 13.2 CPT MCI

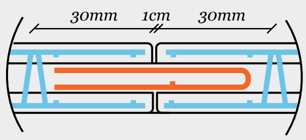


U in N6 - Space : 15cm
Type L1

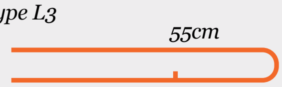
Note: Connecting reinforcement supplied by others

With "U"

Detail 13.2 CPT MCI



U in N8 - Space : 15cm
Type L3



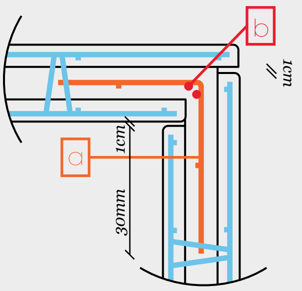
Note: Connecting reinforcement supplied by others

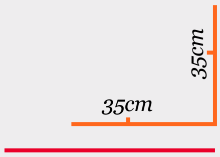
"L" DOUBLE WALLS < 20CM

"L" DOUBLE WALLS ≥ 20CM

With mesh SL92

Detail 15.1 CPT MCI AL1



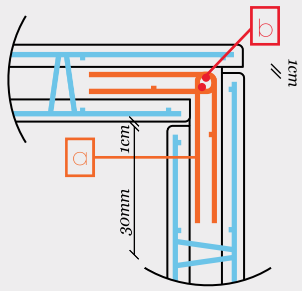


a *SL92*
b *N..*

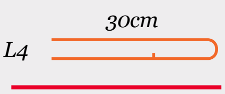
Note: Connecting reinforcement supplied by others

With "U"

Detail 15.3 CPT MCI AL2



U in N.. - Space : ..cm

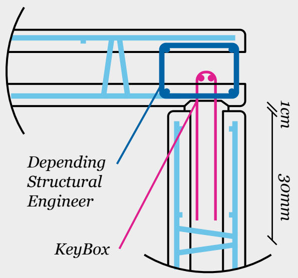


a *Type L2 or L4*
b *N..*

Note: Connecting reinforcement supplied by others

With KeyBox

Detail 15.4 CPT MCI AL3



Unfold Keybox reinforcement BEFORE DW setting up

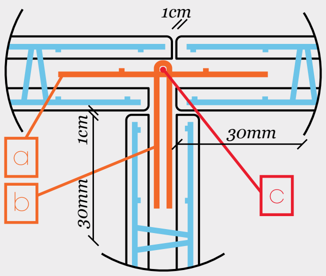
CONNECTION DETAILS

7.3 Continued Double Wall Hinged Connections

T DOUBLE WALLS < 20CM

With SL92

Detail 18.2 CPT MCI AT1



a *SL92* — *50cm*

b *U in N.. Space : ..cm*
Type L2 or L4 — *30cm*

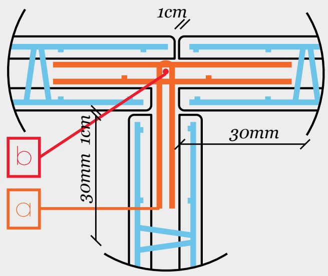
c *N..*

Note: Connecting reinforcement supplied by others

T DOUBLE WALLS ≥ 20CM

With "U"

Detail 19.2 CPT MCI AT2



U in N.. - Space : ..cm

a *Type L2 or L4* — *30cm*

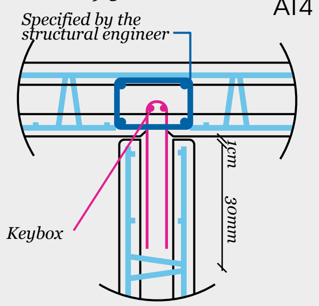
b *N..*

Note: Connecting reinforcement supplied by others

"T".. DOUBLE WALLS ≥ 200MM

With Keybox

Detail 19.3 CPT MCI AT4



Unfold Keybox reinforcement BEFORE Double Wall setting up

CONNECTION DETAILS

7.4 Double Wall Reinforced Connections

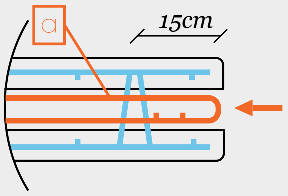
STITCHED CONNECTIONS

With "U"

Detail 13.3 CPT MCI

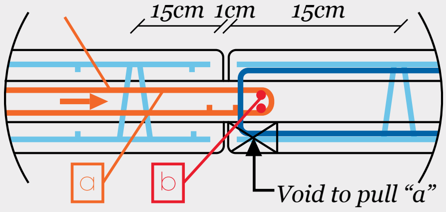
CD1

First step:



Insert reinforcement "a" after setting up the double wall.

Second step:



Pull the reinforcement "a" in the second Double Wall.
Place the bars "b" at the end of the U.

a *U in N.. - Space : ..cm*

b *N..*

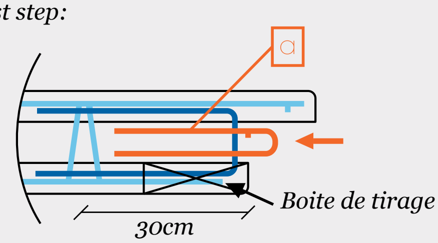
Note: Connecting reinforcement supplied by others

STITCHED CONNECTIONS L

By stitched frame

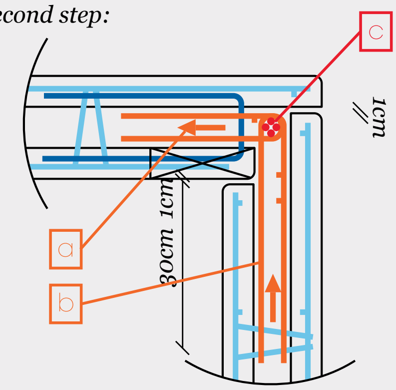
CL1

First step:



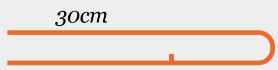
Insert reinforcement "a" after setting up the double wall.

Second step:

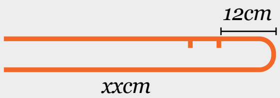


Pull the reinforcement "b" in the second Double Wall.
Place the bars "c".

a *U in N.. - Space : ..cm*
Type L2 or L4



b *U in N.. - Space : ..cm*



c *4N..*

Note: Connecting reinforcement supplied by others

CONNECTION DETAILS

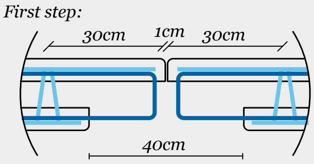
7.4 Double Wall fixed Connections

DOUBLE WALLS FIXED CONNECTION

Setting up DW after pouring slab

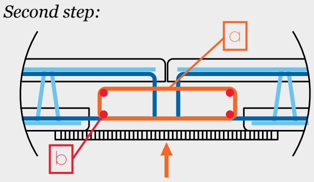
Detail 18.2 CPT MCI ED1

First step:



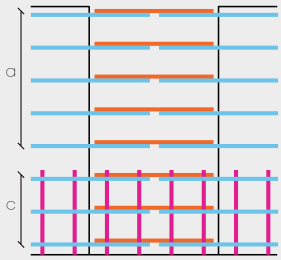
Position the double walls as above.

Second step:



Insert the reinforcement cage "a" and "c" through the U, and tie together with bars "b".

Elevation view:



Insert the cage "a" through the U into the part with reinforcement.
Put the reinforcement ligs "c" around existing reinforcement and tie with bars "b".

a *Cage in N.. - Space : ..mm*

b *4N..*

c *Ligs in N.. - Space : ..mm*

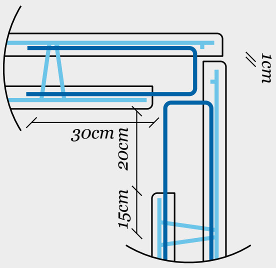
Note: Connecting reinforcement supplied by others

FIXED CONNECTION DOUBLE WALL L

Setting up DW after pouring slab

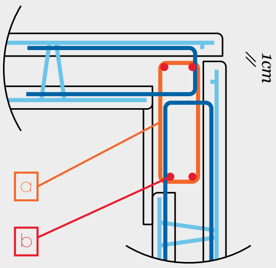
Detail 19.2 CPT MCI EL1

First step:



Position the double walls as above.

Second step:



Insert the cage "a" and ligs "c" through the U and then insert bars "b".

a *Cage in N.. - Space : ..mm*

b *4N..*

c *Ligs in N.. - Space : ..mm*

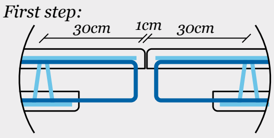
Note: Connecting reinforcement supplied by others

FIXED CONNECTION DOUBLE WALL T

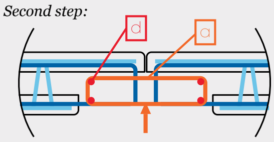
Setting up DW after pouring slab

Detail 19.3 CPT MCI ET1

First step:

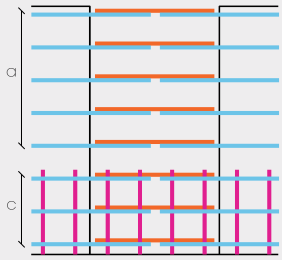


Second step:



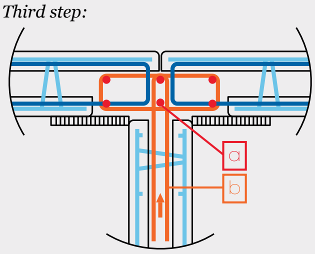
Insert the cage "a" and ligs "c"through the U, and tie together with bars "b".

Elevation view:



Insert the cage "a" and ligs "c" between the "U" and then attach with cars "d"

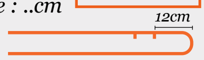
Third step:



Position the third of double wall as above.
Pull connection reinforcement "b" to the position as abbove and then attach with cars "c"

a *Cage in N.. - Space : ..mm*

b *U in N. = Space : ..cm*



c *Ligs in N. - space : ..mm*

d *6N..*

Note: Connecting reinforcement supplied by others

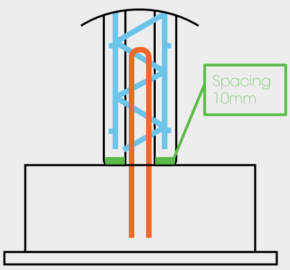
CONNECTION DETAILS

7.5 Double Wall Bottom of Panel Connections - Hinged

DOUBLE WALLS AND FOUNDATIONS AT THE FOOT

With "U"

Detail 7.2 CPT MCI AS1

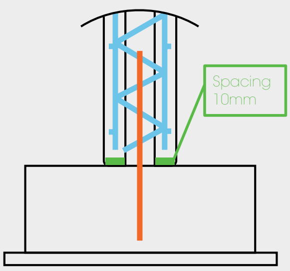


Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

With bars

Detail 7.1 CPT MCI AS2



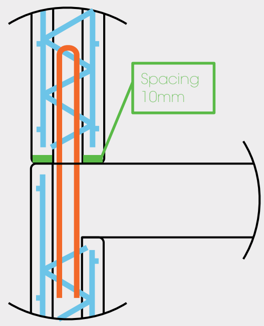
Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

DOUBLE WALLS AND SLABS AT THE FOOT

With "U"

Detail 7.2 CPT MCI AS3

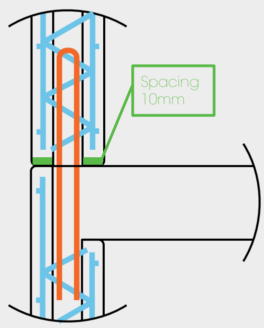


Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

With bars

Detail 7.1 CPT MCI AS4



Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

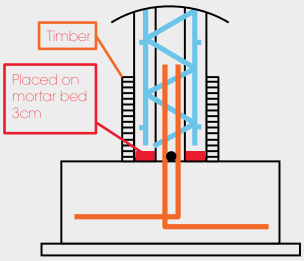
CONNECTION DETAILS

7.4 Double Wall Bottom of Panel - Fixed Connection

DOUBLE WALLS FIXED CONNECTIONS

Slab pour BEFORE setting up DW

Detail 8.2 CPT MCI ES1

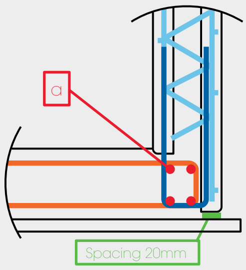


Connecting reinforcement and joint mortar to be placed before positioning panel. See structural engineer.

Note: Connecting reinforcement supplied by others

Slab pour AFTER setting up DW

Detail 9.1 CPT MCI ES3



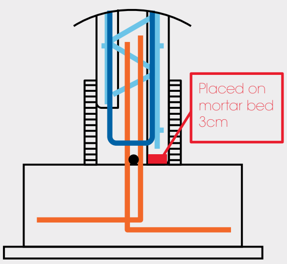
Connecting reinforcement to be placed before pouring. See structural engineer. Tie the reinforcement to the bars "a".

a *4N..*

Note: Connecting reinforcement supplied by others

Sealing by concrete

D'apres Fassicule 74 ES2

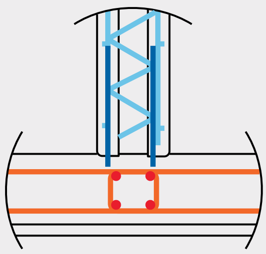


Connecting reinforcement and joint motar to be placed before positioning panel. See structural engineer. Hydrophilic expansion joint if necessary.

Note: Connecting reinforcement supplied by others

Slab pour AFTER setting up DW

Detail 9.2 CPT MCI ES4



Connecting reinforcement to be placed before pouring. See structural engineer.

Note: Connecting reinforcement supplied by others

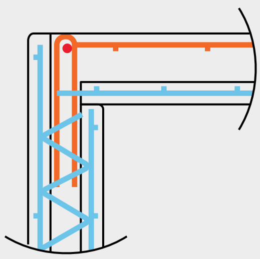
CONNECTION DETAILS

7.4 Double Wall Slab Connection - Hinged Connection

DOUBLE WALLS / AUSTRAL DECK

On side support

Detail 10.2 CPT MCI AP1

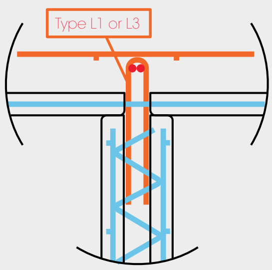


Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

On middle support

Detail 10.1 CPT MCI AP3

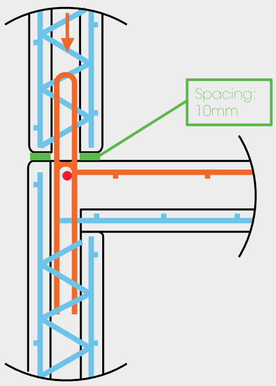


Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

On side support

Detail 10.2 CPT MCI AP2

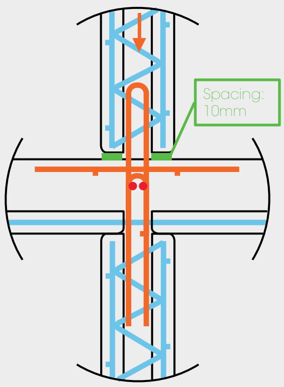


Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

On middle support

Detail 10.2 CPT MCI AP4



Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

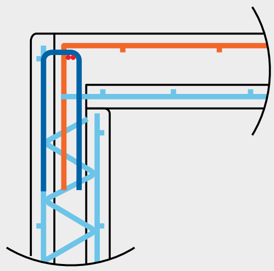
CONNECTION DETAILS

7.4 Double Wall Slab Connection - Fixed Connection

DOUBLE WALLS FIXED CONNECTION

With Austral Deck on side

Detail 11.1 CPT MCI EP1

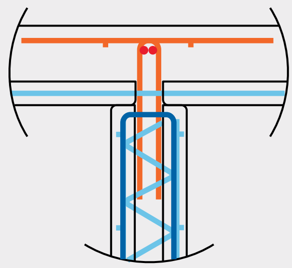


Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

With Austral Deck on middle support

Detail 11.2 CPT MCI EP2



Connecting reinforcement to be placed before pouring.
See structural engineer.

Note: Connecting reinforcement supplied by others

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With a broad product portfolio and manufacturing and sales facilities across Australia, Brickworks Building Products is uniquely placed to service the demands of the building industry.

With over 1,200 staff across Australia and New Zealand, we pride ourselves on our commitment to product, service excellence and our leadership position.

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