BMTPC
PACS
PERFORMANCE APPRAISAL CERTIFICATION

MODULAR TUNNEL-FORM

User should check the validity of the Certificate by contacting Member Secretary, BMBA at BMTPC or the Holder of this Certificate.

Name and Address of Certificate Holder:
M/s Outinord Formworks Pvt. Ltd,
No. 635, 6th Floor, Pentagon II
Magarpatta City Pune – 411013

Performance Appraisal Certificate No.

PAC No **1018-S/2015**
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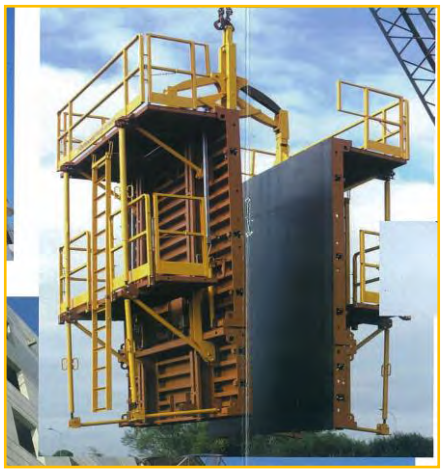

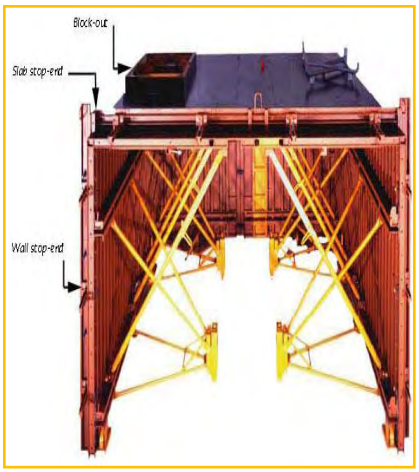

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PERFORMANCE APPRAISAL CERTIFICATE

FOR

MODULAR TUNNELFORM

ISSUED TO

M/s OUTINORD FORMWORKS PVT. LTD.

STATUS OF PAC 1018-S/2015

S. No.	Issue No.	Date of Issue	Date of renewal	Amendment		Valid up to (Date)	Remarks	Signature of authorized signatory
				No.	Date			
1.	2.	3.	4.	5.	6.	7.	8.	9.
1	01	21-07-2015	21-07-2016	--	--	20-07-2016	---	Outgoing
2	02	21-07-2016	21-07-2018	—	—	20-07-2018		Outgoing
3		14.10.2022	14.10.2023			13.10.2023		Outgoing

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PART 1 CERTIFICATION

1.1 CERTIFICATE HOLDER: M/s Outinord Formworks Pvt. Ltd,
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1.2 DESCRIPTION OF SYSTEM

1.2.1 Name of the System– Modular Tunnel Form

1.2.2 Brand Name – TMPH

1.2.3 Brief Description – Tunnel formwork is a mechanized system for cellular structures. It is based on two half shells which are placed together to form a room or cell. Several cells make an apartment.

With tunnel forms, walls and slab are cast in a single day. The structure is divided into phases. Each phase consists of a section of the structure that will cast in one day. The phasing is determined by the programme and the amount of floor area that can be poured in one day. The formwork is set up for the day's pour in the morning. The reinforcement and services are positioned and concrete is poured in the afternoon. Once reinforcement is placed, concrete for walls and slabs shall be poured in one single operation. The formwork is stripped the early morning and positioned for the subsequent phase. The formwork is manufactured in a fully automated plant.

This formwork is manufactured in France and there is no plant in India. All materials are brought from France.

A sketch of the standard tunnel form is shown in **Fig. 1**.

The on-site implementation of 24 hour cycle is divided into following operations.

1. Stripping of the formwork from the previous day.
2. Positioning of the formwork for the current day's phase, with the installation of mechanical, electrical and plumbing services.
3. Installation of reinforcement in the walls and slabs.
4. Concreting and if necessary, the heating equipment.

1.2.4 Types of Formwork System

1.2.4.1 *TMPH Modular Tunnelform*

1. Tunnel forms are room size formworks that allow walls and floors to be casted in a single pour. With multiple forms, the entire floor of a building can be done in a single pour. Tunnel forms require sufficient space exterior to the building for the entire form to be slipped out and lifted up to the next level.

This tunnelform consist of inverted L- shaped half tunnels (one vertical panel and one horizontal panel) joined together to create a tunnel. Articulated struts brace the horizontal and vertical panels. These struts enable the adjustment of the horizontal level of the slab and simplify the stripping of the formwork. The vertical panel is equipped with adjustable jacking devices and a triangular stability system. Both devices are on wheels.

A range of spans is possible by altering the additional horizontal infill panel's dimensions. Due to the distribution of the horizontal beams on the vertical plank, the formwork also cast staggers and offsets in the layout of the walls as well as differing wall thicknesses. The half-tunnels shall be equipped with back panels to cast perpendicular shear walls or corridor walls. Assembly and levelling devices ensure that the formwork surfaces are completely plumbed and levelled.

A sketch of the modular tunnelform is shown in **Fig. 2.**

2. Standard characteristics

Standard dimensions: TMPH & Modular

Unit width: from 2.40 m to 6.00 m
Type 1 horizontal panel: from 1.20 m to 1.60 m
Type 2 horizontal panel: from 1.80 m to 2.40 m
Type 3 horizontal panel: from 2.40 m to 3.00 m
Span which can be adjusted by fitting an additional panel measuring between 0.05 and 0.60 m
Package length: Up to 12.50 m in length as a function of the hoisting facilities and availability
Basic length: 1.25 m
Average weight: 90 Kg/m^2
Handling: Lifting triangle or sling
Transportation: 180 m^2 per truckload.

1.2.4.2 *Wallforms*

Wallforms are temporary molds in which concrete is poured in order to build a structure. Once the concrete is poured into the formwork and has set, the formwork is stripped to expose s perfect finished concrete. These forms constitute a system approach for construction and are particularly suited to build structural walls, columns, bridge piers, culverts etc. This system adopts well to daily work-phase of both repetitive and non-repetitive tasks. The equipment used each day is productive and is reused in subsequent phases. The four daily operations

which outlines the daily production cycle for wall form equipment are identical to those for tunnelform equipment with the exception that it is solely used for casting concrete walls. The slabs are cast as a secondary phase. The existing equipment can be adapted on a day-to-day basis by the addition of standard elements and corner-wall formwork to take into account different wall configurations on site. All safety and stability devices shall be fully integrated in to the standard version of wallform equipment.
A sketch of the wallform is shown in **Fig. 3.**

1.2.4.3 *B 8000 Wallforms*

1. These wallforms are tools specially designed to be used on specific buildings and structures. This vertical wallform panel is a multi-purpose formwork system. This system has been designed and developed to ensure that it is simple and quick to assemble and position the following:

- A full range of standard dimensioned components
- Multiple combination of panels for simple adoption to specific configurations
- Basic standard equipment incorporates complete safety, circulation
- and stability equipment
- Caliper –device opposing wallform packages are craned into position in one lift.

A sketch of the *B 8000 W*allform is shown in **Fig. 4.**

2. Standard characteristics
Standard dimensions*:*
Standard height: 2.80m
Upper extension: 0.50m
Lower extension: 1.00-1.50m
Average weight: 135 Kg/m^2
Assembly: 0.80 H/m^2 of formwork
Use: 0.15 to 0.30 H/m^2 of formwork, depending on complexity
Wind stability: by prop
Access: inner ladder accessed via hatch
Superposition: up to 22.5 m with specific engineering performed to determine hoisting and stability characteristics
Transportation: 24 wall forms per container/ truckload

1.2.4.4 *Angle Formwork*
Inner and outer angle configurations are designed to attach to 1.25m wall forms to obtain a 160mm wall. Spacers shall be installed for producing wall thicknesses.

1.2.4.5 *Back Panel*
The back panel allows pouring of cross walls, other walls, walls and slab in one operation.

1.2.4.6 *Slab Stop End and Wall stop*

These can be adjusted to fit the lengths of wall and slabs. These remain fixed to the form during all handling operations.

1.2.4.7 *Kicker Form*

In order to guide the walls of the upper floor precisely above the walls of the floor below, a kicker form is fixed to the tunnel form before pouring the concrete. Slab and starting walls are then poured during the same phase.

1.2.4.8 *Box Out*

During each phase, window box out, door box out and slab box out are mounted on the tunnel using a magnetized system.

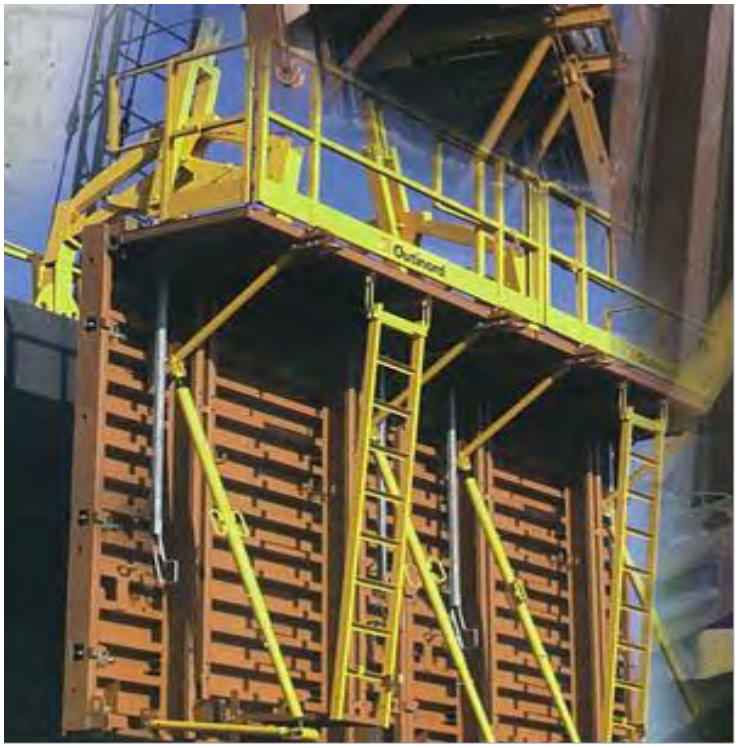


Fig. 1

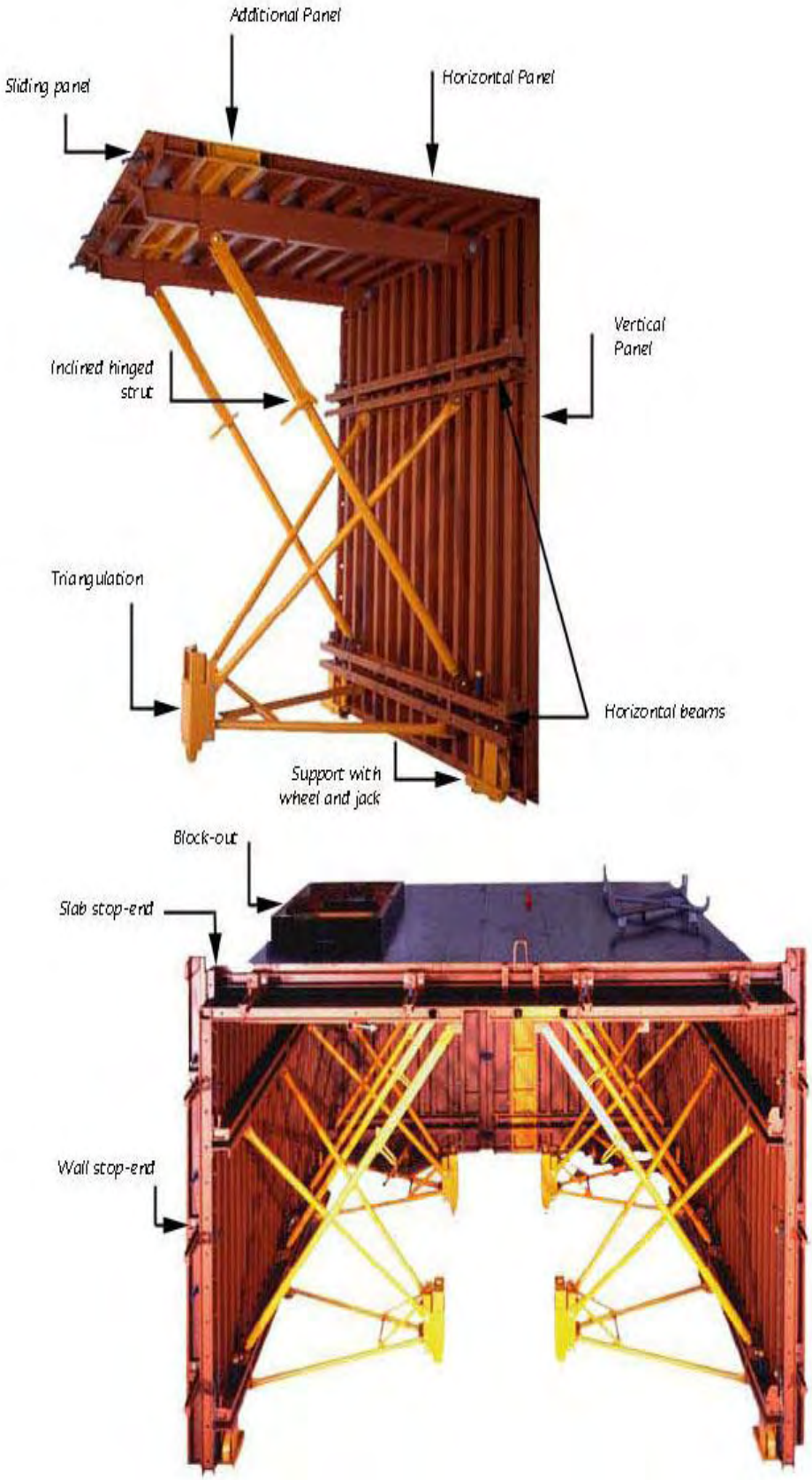

Additional Panel
Sliding panel
Horizontal Panel
Vertical Panel
Inclined hinged strut
Triangulation
Horizontal beams
Support with wheel and jack
Block-out
Slab stop-end
Wall stop-end

Fig. 2

Fig. 3

Fig. 4.

1.2.5 Tolerances

1.2.5.1 *Manufacturing Tolerance T*

The manufacturing tolerance T shall be the sum of the permissible manufacturing deviations, positive and negative, of the structural member concerned.

Thus $T = m_{pos} + m_{neg}$ where m_{pos} is taken as equal to $m_{neg} = ½T$. The values to be adopted for ½ T are given in **Table 1**.

Table 1

Specified dimension of the member in mm	½ T in mm
< 200	4
400	5
600	6
800	7
1000	9
1500	11
2000	13
3000	16
5000	20

Intermediate values should be determined by linear interpolation.

1.2.5.2 *Positional Tolerance P*

The positional tolerance P is composed of the measuring tolerance P_1 and the positioning tolerance P_2.

1.2.5.3 *Measuring Tolerance P_1*

The measuring tolerance P_1 is the sum of the permissible measuring deviations, positive and negative, for the relevant grid lines or other reference lines in relation to the specified location of these lines. The values to be adopted are given in Table 2, the permissible positive deviation being taken as equal to the permissible negative deviation = ½ P_1.

Table 2

Specified distance between two grid lines or other reference lines in m	½ $P_{1.}$ in mm
1	2
2	3
5	4
10	5
20	7
50	12
100	20

Intermediate values should be determined by linear interpolation.

1.2.5.4 *Positioning tolerance P_2*

The measuring tolerance P_2 is the sum of the positioning deviations, positive and negative, for the relevant concrete face of the structural member in relation to the grid lines or other reference lines set out on the job. The values to be adopted are given in **Table 3,** the permissible positive deviation being taken as equal to the permissible negative deviation = ½ P_2.

Table 3

Specified distance from the concrete face to the set out grid line or other reference lines in mm	½ P_2. in mm
< 200	6
400	7
600	8
800	9
1000	11
1500	13
2000	15
3000	18
5000	22

Intermediate values should be determined by linear interpolation.

This table is not applicable to top and under surfaces of floors and beams *(see Clause I.2.5.7)*

1.2.5.5 *Vertical Concrete surfaces*

Vertical concrete surfaces should additionally conform to the requirement of not being inclined by more than 0.3% with respect to the vertical.

1.2.5.6 *Floor and Beam Surfaces*

Notwithstanding the requirement of Clauses 1.2.5.2 to 1.2.5.7, the permissible deviation, both positive and negative, of top and under surfaces of floors and beams at supports on, or connections to, columns or walls shall not be allowed to exceed 8 mm.

1.2.5.7 *Combination of tolerances*

It is not possible to combine tolerances linearly in order thereby to arrive at the largest or the least deviation of the dimensions or the position of a structural member.

1.3 CHARACTERISTICS OF THE SYSTEM

1.3.1 *Maximum span between walls*

Maximum span between walls shall be 5.60 m without accessory units and 7.00 m with accessory units.

1.3.2 *Height of the formwork*

The forms are designed for floor to ceiling height of 2.51 m minimum with the possibility to increase this by action of the leg jacks or with the use of movable panels in the event of extra heights.

1.3.3 *Appearances of the faces after form removal*

The surfaces obtained allow direct application of finishing paint or wallpaper after sanding off the fins at the joints connecting the units and smoothing with paint filler.

1.3.4 *Working rhythm using the system*

Under average temperature conditions, with the use of ordinary cement, the normal rhythm is two days per cycle with one day and two nights for drying and setting of the concrete.

1.3.5 *Manpower necessary for execution of the process*

The time required for execution shall vary according to the cell plan. For a type cell consisting of two formed wall surfaces and a floor surface, the average time is less than one & one half hours per square meter of building i.e. an average unit time less than 45/100 hour to the square meter formed. This time includes the form removal, oiling, displacement of the units, formwork and adjustment.

1.4 ASSESSMENT

1.4.1 Scope of Assessment

1.4.1.1 Scope of assessment included suitability of form work to the specified requirements for use in building construction as:

i) Load bearing wall
ii) Non-load bearing wall
iii) Shear Wall
iv) Slab

1. 4.2 Basis of Assessment

Assessment of the suitability of formwork is based on:

i) Agreement No. 2569 relating to New Materials and Non-traditional Construction Processes between Cashiers of the C.S.T.B, Paris, France and Outinord, Company, S.A given in Annex I.
ii) Case studies of the projects carried out by various agencies throughout the world including India using Outinord Formwork.
iii) Design of the Formwork submitted by the manufacturer
iv) Quality Management Manual and Maintenance Manual followed by the manufacturer
v) Quality Assurance Scheme followed by the Certificate holder for process control is given in Annex II.

1.5 USES OF THE TUNNELFORM AND ITS LIMITATIONS

1.5.1 Uses

Designed to cast concrete load-bearing walls and slabs in a single monolithic pour, tunnel forms are suited for the construction of following structures:

i) Multiple residential dwellings
ii) Housing projects
iii) Garden apartments
iv) Town homes
v) Condomiums
vi) Hotels etc.

1.5.2 Limitations

i) The floor spans executed with movable forms shall not be more than 5.60 m, unless accessory units are used.
ii) The thickness of vertical in-situ walls shall not be more than 120 mm, unless justified by special provisions.

1.5.3 Special Aspects of use:

1) The structures to be constructed using Outinord Formwork System shall be in accordance with the specifications prescribed in the Agreement No. 2569, Formwork & Technology Brochure and designed by competent structural Engineers.
2) Mechanical, Plumbing and Electrical services shall be governed by the provisions and details given by the manufacturer and good engineering practices shall be followed.
3) Outinord Formwork System should be used only with technical support or supervision by qualified engineers and builders, based on structural designs complying with prevailing standards and specifications; this is applicable even for low-rise and affordable mass housing to provide safety of structures.
4) It is strongly recommended that structural engineers and building designers associated with Outinord Formwork System should be thoroughly familiar with the various structural aspects. It is also recommended that architects and construction Engineers who undertake building design and construction gain familiarity with the characteristics of Modular Tunnelform and Wallform and their applications.

1.6 CONDITIONS OF CERTIFICATION

1.6.1 Technical Conditions

1. The formwork of suspended floor shall be built by the “movable forms’ without any special units being wedged between these forms.
2. The required flatness conditions are nevertheless more difficult to obtain in the case of suspended floors with very long spans where it is necessary to put in tables between the “movable forms”, and it

would seem reasonable to limit the use of the system to floors with a maximum span of 5.60m, sufficient moreover, for the majority of applications in the field of housing construction.

3. The number, the arrangement and the condition of wind bracing walls shall be such that the horizontal stability of the work is ensured during construction.
4. It is obligatory that these wall be built of in-situ concrete to the cross walls by reinforcement starter bars where the buildings are higher than six levels.
5. A periodic check of the concrete's hardening shall be carried out prior to removing forms (by the crushing of cubes taken from the concrete used for building the floors and preserved under identical conditions).
6. The design of the forms does not make it possible to check the homogeneity of the concreting while it is being done and it seems prudent, under these conditions, to limit the minimum thickness of the poured walls to 120mm.
7. Heating of the rooms formed by the tunnels using forced air-heating units can help speed up construction, but it requires constant support in order to be prepared for the risks which could result during form removal in the case of an insufficient treatment of the concrete.
8. Outinord shall provide necessary training to the technical persons of the agency engaged for design and construction of the structures.
9. The Certificate holder shall provide a detailed Quality Assurance System for production and execution of the system in the field.

1.6.2 Handling of User Complaints

1.6.2.1 The Certificate holder shall provide quick redressal to consumer/user complaints proved reasonable & genuine and within the conditions of warranty, if provided by it to customer/purchaser.

1.6.3 Certification

On the basis of assessment given in Part III of this Certificate & subject to the conditions of certification, use & limitations set out in this Certificate and if selected, installed & maintained as set out in Part I & II of this Certificate, the Modular Tunnelform covered by this Certificate are fit for use set out in the Scope of Assessment.

PART 2 CERTIFICATE HOLDER'S TECHNICAL SPECIFICATIONS

2.1 GENERAL

2.1.1 The PAC holder shall manufacture the form work in accordance with the requirements specified in the i) Agreement No. 2569 relating to New

Materials and Non-traditional Construction Processes between Cashiers of the C.S.T.B, Paris, France and Outinord, Company, S.A. and the Formwork & Technology Brochure.

2.2 SPECIFICATIONS FOR THE MODULAR TUNNELFORM SYSTEM & DESIGN INFORMATION

2.2.1 Technical Specifications

The Modular Tunnelform System consist of inverted L- shaped half tunnels (one vertical panel and one horizontal panel) joined together to create a tunnel. These forms are made up of factory cut, 80mm x 80 mm angle sections in accordance with the line of building forms. The panels are built of 3 mm sheet steel, stiffened by folded sheet metal sections.

2.2.2 Raw Materials Specifications

2.2.2.1 (i) Hot dip galvanized steel sheet – 3 mm thick shall conform to IS 277:2003/ NF A 35-503
(ii) Angle section – 80mm x 80mm x 6 mm shall conform to IS 2062:1999
(iii) Cold rolled U-sections – 60mm x 30 mm shall conform to IS 2062:1999.

Mechanical properties:

Yield stress	: ≥ 23.5 daN/mm^2
Breaking load	: ≥ 36 daN/mm^2
Elongation	: ≥ 20%

2.2.2.2 *Steel for spacer pins*

Apart from the requirements given in para 2.2.2.1, the steel used for the manufacture of the spacer pins, the gripping mechanisms, anchoring points for the rear stabilizing and adjusting mechanisms shall guarantee a KCV resilience of at least – 20ºC, of 28J, in accordance with the standard EN 10045-1.

2.2.2.3 Specifications for steel

Specification EN 10025	**Description**
Steel Sheets	M. S. Sheets (IS 2062:1999)
3 mm	3 mm
4 mm	4 mm
5 mm	5 mm
6 mm	6 mm
8 mm	8 mm
Flat Profile	M. S. Flats
20mm x 5mm	20mmx5mm / 30mmx6mm / 50mmx5mm
30mm x 6mm	30mm x 6mm

45mm x 5mm	45mm x 5mm
50mm x 5mm	50mm x 5mm
50mm x 12mm	50mm x 12mm
60mm x 6mm	65mm x 6mm
60mm x 8mm	63mm x 8mm
70mm x 10mm	75mm x 10mm
80mm x 10mm	75mm x 10mm
100mm x 15mm	100mmx16mm
120mm x 10mm	125mmx10mm
"L" Profile	'L' Angles
20mm x 20mm x 3mm	20mmx20mmx3mm
50mm x 30mm	50mmx50mmx5mm
50mm x 50mm x 5mm	65mmx65mmx6mm
70mm x 50mm	75mmx75mmx6/8mm
60mm x 60mm x 6mm	90mmx90mmx8mm
80mm x 60mm x 7mm	100mmx100mmx10mm
80mm x 80mm x 8mm	"I" Beam
100mm x 75mm x9mm	120 mm
120mm x 80mm x8mm	35mm x 35mm x 3mm
Round Tube	Round Tube (IS 1239:2004)
14 mm	20 mm x 2.6mm
16 mm	OD 33.7mm x 2.6/3.2mm
18 mm	OD 41mm x 2mm
20 mm	OD 48.3mm x 2.9/ 3.2mm
	OD 60mm x 3.25mm
	OD 75mm x 3.25mm
Square Profile /	Square. Tube
16 mm	40x40x3mm / 50x50x3mm / 60x60x3mm
	50x50x5
UPN Profile	UPF Profile
40mm x 20mm	51mm x 25mm x 4mm
50mm x 25mm	60mm x 30mm x 4mm
70mm x 40mm	60mm x 60mm x 4mm
100mm x 50mm	65mm x 42mm
120mm x 120mm	120mm x 50mm x 5mm
140mm x 140mm	
40mm x 40mm x 4mm	

2.2.3 Design Hypotheses And Information

2.2.3.1 *Design Hypotheses*

The wall forms shall be designed to simultaneously resist the stress caused by the following:

- Their own weight and their handling

- Operating loads
- Movement of staff
- Concrete pressure
- Climatic loads caused by wind.

The essential elements to be considered are:

- The gripping mechanisms;
- The concreting platform and its access;
- The protection against risks of falling at a height from the platform
- The structural frame and the formwork face.

Design Criteria is given in Annex XIV.

2.3 DESCRIPTION AND UTILIZATION OF THE FORMWORK SYSTEM

2.3.1 Description Of The Formwork System

The Outinord formwork system consists of the following elements:

2.3.1.1 *The Starter Forms*

These forms are made up of factory cut 80mm x 80 mm metallic angle sections (or larger, if necessary) in accordance with the line of the building walls. These angle sections, marked with respect to one another, are assembled on the working site in accordance with the indications of an assembly plan having the same markings. They are erected by means of steel support wedges on the tunnel form prior to concreting of the walls and the slab. Their location automatically ensures the correct positioning of the wall and the frames.

2.3.1.2 *The Movable Forms*

The standard form unit (half-shell) take the form of a right hand dihedral, whose vertical plane is made up of a storey–height panel, less 4 cm s (or more, if necessary) and the horizontal plane of a panel representing the half-span of the floor slab (maximum 2.80 m for a slab span of 5.60 m).
The panels are built of 3 mm sheet steel, stiffened by folded sheet metal sections, welded every 250 mm; these are assembled rigidly one to the other by bolts which enable slight deformations of the dihedral,. These are usually 2.50 m long. The wind bracing of the two panels is ensured by two diagonals having a length adjustable by screw jacks; these jacks are fitted with an adjustable stop so that when the screws are at the stop, the dihedral is perfectly straight.

The standard form unit shall be also equipped with the following devices:

i) At the base of the vertical panel, two screw jacks permitting adjustment of the height and level of the upper panels
ii) At the key of the upper horizontal panel; a tubular knee brace, also fitted with a screw jack, permitting height adjustment. This knee-brace, which is hinged, is folded towards the vertical panel after assembly of the various units;
iii) Two horizontal cross pieces, incorporated in the height of the

vertical panel are pierced with holes top permit passage of the spacers ensuring adjustment of the wall thickness;

iv) The lateral extremities of the panels shall be made of 60mm x 30 mm, cold rolled U-sections which carry the connecting devices making it possible to ensure the correct flush fitting of consecutive units. Assembly is carried out using spring levers;

v) The end of the horizontal panel, built of an 80mm x 80 mm, steel angle section, carries the key locks permitting the assembly of two units face to face;

vi) At form removal, the half-shells, weighing from 6 to 700 kg (depending on the surface), shall be removed on the service platforms using light, 4-wheel dollies (two dollies are sufficient to handle a form surface of 500 m^2);

vii) The half-shells shall be supported on the dollies by means of two lugs welded to the dolly base and two telescoping props, also form part of the dolly;

viii) The half-shells shall be cleaned on the dollies on the service platforms then hosted out by the crane to be set up on the next higher storey (the dollies stay on the platform to be reused immediately.

2.3.1.3 *Service Platforms*

These platforms shall be built of a timber floor fastened with lag bolts to metal trusses forming a console. Each truss shall be composed of upper horizontal steel I beam about 5.25 m long unto which three 40/49 tubes are welded to form a triangular beam. These trusses, arranged in consoles between two successive stores, already poured, shall be assembled in pairs using 40/49 tubes to form a triangular beam.

The usual platform width, outside the building, is about 2.85 m; a guard railing shall be set up at the outside edge of the platform floor.

2.3.1.4 *Special Units*

The maximum width of the horizontal panels of the usual form units is 2.80 m, making possible the execution of floors having a span up to 5.60 m. When a greater span is required, some additional horizontal panels can be inserted between the opposite half-shells. These panels, built in the same manner as the normal units (stiffened sheet steel) are fitted with four tubular legs equipped with screw jacks.

2.3.2 Utilization of the Formwork System

2.3.2.1 At each stage, utilization of the system requires the following successive operations:

i) The placing of the vertical wall reinforcement of the floor and possibly the door frames provided for in the erection drawing;

ii) Dismantling of the movable form units of the preceding storey. This shall be carried out in two stages:

a) Loosening of the normal units (half-shells), by removal of the

spacers passing through the walls, by unlocking the tunnel keys and disassembly of the sections. This work is executed in principle by two non-specializes maneuvers.

b) Striking and removal of the forms. This shall be carried out by using the special dolly and two maneuvers in the tunnel and by two other maneuvers at the new location (usually on the storey above).

This suite of operations shall be carried out by bringing the dolly under the half-shell to be removed and then working the different jacks for the striking operation itself. The leg jacks are lifted first, then a slight deformation of the half-shell is provoked by working the diagonal bracing jacks (shortening). This deformation is sufficient to strip the form progressively. It the drops down automatically onto the dolly.

The dolly half-shell assembly shall then be rolled across the service platform where the form is cleaned and oiled with a sprayer, then picked up with a crane and hoisted to its new location site, the dolly remaining in place. The half-shell design makes it possible to remove the whole side of a tunnel, then to prop the slab near the key before removing the other half, permitting if necessary, a faster rotation of the equipment.

iii) Reassembly of the units on the floor above.

This assembly consists of the following operations:

a) A half-shell shall be positioned on its leg jacks and knee brace, and adjustment shall be squared by blocking the diagonal bracing jacks, then adjustment of the height and plumb by working the leg jacks and the knee brace jack.
b) The half-shells shall be assembled together.
c) The opposite half-shells shall be positioned, and adjacent half-shells of the ‘tunnel’ half-shells shall also be positioned using the same procedure.
d) The half-shells shall be blocked by constituting the two faces of the wall on the ‘starters’ with the help of the lower spacers; the upper spacers shall be tightened without being forced, only after verification of the general adjustment; positioning of the butt end forms of the walls and floors.
e) The keylocks solidifying the opposite half-shells shall be positioned and blocked. If necessary, a light action on the knee brace and diagonal bracing jacks shall be used to bring the locking units into line.
f) The starter forms shall be positioned and blockouts, if necessary for anticipated door and window frames.
g) The overall adjustment and finish making–up shall be verified, if necessary, after lifting of the knee braces.
h) The suspended floor shall be reinforced and concrete shall be poured in the walls and slab.

iv) The service platform shall be removed and this platform shall be installed on the storey above.

2.4 HANDLING , STORAGE AND ASSEMBLY OF THE TUNNEL FORMWORK SYSTEM

2.4.1 24 Hour Cycle

2.4.1.1 The 24 Hour cycle defines the works to be done each day. To establish this cycle, the overall structure is divided into a number of more or less similar construction phases, corresponding to a day's work. The necessary manpower and equipment are then determined according to the size of these phases. To reach maximum efficiency, the phases done every day are similar.

The cycle is divided into the following activities:

- Initial striking operations
- Movement of forms
- Final preparation
- Pouring

However, early removal of formwork for wall is possible with proper design of concrete mix, accelerated warm curing and using suitable chemical admixture.

The implementation of 24 Hour Cycle shall be in accordance with IS 456:2000 – Code of practice for plain and reinforced concrete. However, the structural engineer shall furnish details about the actual process of removal of formwork after casting of concrete.

Details of 24 Hour cycle along with relevant Bar Charts are shown in Annex. III & IV

2.4.2 Process of delivery, Handling , Storage & Assembly of the tunnel form

2.4.2.1 Process of delivery

Process of delivery of the Tunnel form from the manufacturer's plant to the construction site in India shall generally be as under:

i) The Indian company shall forward the Schedule of Quantities along with structural drawings giving specific time of completion and technical specifications (slab thickness, ceiling height, wall thickness) etc. of the proposed work to the manufacturer.
ii) The manufacturer shall advise the Indian company how to optimize the structure in order to use the tunnel form effectively.
iii) The manufacturer shall then submit the quantity of formwork material needed to meet the requirement specified by the client.
iv) The order shall be placed once the Indian company and the manufacturer agree on the structure and quantity of material.
v) The material shall then be delivered to the site and a technician/site engineer will assist the Indian company to achieve the daily cycle.

2.4.2.2 Handling , Storage & Assembly

Upon its arrival at site, the equipment shall be loaded, stored and assembled as follows;

i) The vertical panels shall be set on the ground on timbers in the order of the packages. When there is enough room, all the equipment shall be

ii) spread out (speeds up greatly the assembly);
iii) Some of the equipment shall be supplied to the panels (positioning lugs, inclined hinged struts, triangulation), and their fixing shall begin;
iv) At about the same time, the horizontal panels shall be supplied one by one at the position of the vertical panels and assembled;
v) The half tunnels shall be brought together and assembled. Either the assembly shall be permanent and the half tunnels are bolted together and some alignment fishplates are added in the profiles or the assembly is temporary and swelling ties are set in place and tightened;
vi) The lifting beam shall be supplied and bolted in place;
vii) The tunnel packages shall be set vertical using a crane and the special assembly lifting rings. *The lifting triangles shall not be used to right the tunnel forms;*
viii) The equipment for the hand rails shall be set in place;
ix) Once the assembly is complete and if time allows, a pre-assembly can be accomplished to check everything. This shall save time during first cycle.

Details of Assembly along with illustrations is given in Annex V.

2. 4.3 Kickers (Curbs)

The kickers are short concrete walls, usually built at the same time as the slabs on which they lie, at the location of the future real-size walls

Details of Kickers along with illustrations is given in Annex VI.

2.4.3.1 *Roles of the Kickers*

The tunnel methodology relies on the use of the kickers. The kickers have several roles:

i) *Kickers to guide the positioning of the forms*

After the floor is cleared, the forms are brought in with the crane and pushed against the kickers using crow bars. Later on the bolting of the ties between the forms will ensure that they are properly set against the kickers.

ii) *Kickers to facilitate the stripping of the forms*

At the time of pouring, the bottom of the vertical panel of the tunnel form is located a few centimeters above the slab level (typically 6 cm = 2.5 cm from bottom of form to bottom of wheel + 3.5 cm for the stripping of the form and lack of flatness of the slab). This allows lowering of the form i order to strip it.

In general, the kickers are 8 cm tall (good practice). However, it is sometimes useful to make them taller, e.g. when the ceiling in the building to be built is slightly higher than the one in the previous building (reuse of the some tunnel forms with taller kickers).

iii) Kickers to provide a support on which to draw the level

The kickers provide a support on which the level can be drawn. The line facilitates the adjustment of the forms; the bottom of the tunnel is simply set flush with that line by using the jacks. The line drawn on the kickers corresponds to the height of the ceiling minus the height of the vertical panel (excluding wheels and jacks)
The level of the line on the kicker should not be directly measured from the slab (as the slab is not always very smooth) but rather materialized using a point of reference.

2.4.3.2 *Making of the Kickers*

The kickers are usually cast along with the slab, using kicker forms, concrete crosses and some clamps. The kickers need to be vibrated and troweled flat and flush with the kicker forms to get a nice finishing with the tunnel forms. The concrete crosses are set in place along with the reinforcements. Then, once all the reinforcements are finished, the kicker forms are installed and held using the clamps.
The concrete crosses are positioned above the walls that are being cast, in between the forms, to hold the kicker forms (when the location of the walls is the same floor to the next). There are two types of concrete crosses, some with four branches and some with three according to whether the cross is located in a middle wall or at the end of the slab. As the concrete crosses define the thickness of the walls and of the slab, it is sometimes necessary to make crosses with branches of different sizes (when the walls superimposed and/or the slab have different thicknesses for instance)

i) *Number of concrete crosses*

The number of concrete crosses is chosen so that the kicker forms are stable. Typically – one cross for every 3.5m of kicker form and three crosses for an angle.

ii) *Making of the concrete crosses*

The concrete crosses are made using a mold and are cast every day. Both types of crosses (3 & 4 branches) are made using the same mold, by adding a piece of form inside the mold. The mold for the concrete crosses is scraped and oiled. The mold is closed (casting position).

2.4.3.3 *Foundation Kickers*

i) With concrete crosses

When the foundation slab is cast in place, the foundation kickers are made in a similar manner as those for the floors above, using concrete crosses (held by small concrete sumps cast beforehand).

ii)Without concrete crosses

However, if the foundation technique does not allow the use of concrete crosses, the kickers can be set on the slab without using crosses.

iii) *Rule of 3-4-5 to position accurately the kickers*

When the main axis of the construction has been materialized, the perpendicular axis can be drawn using the 3-4-5 rule:

1. Draw the main axis along with the position of the perpendicular axis (point A)
2. From A, materialize 4m along the main axis (point B)
3. Find point C which is 3m away from A and 5m away from B. AC gives the perpendicular.

2.4.4 Hanging of the Forms to the Crane

2.4.4.1 *The Asymmetrical Triangle*

The asymmetrical lifting triangle is designed to move packages of tunnel forms. It is linked to the tunnel forms via two steel rods – a main one, the lifting bolt which is bolted underneath the horizontal panel on the lifting beam and another smaller steel rod (a few centimeters only) that fits in a hole on the horizontal panel that blocks the rotation of the triangle on the form.

The lifting triangle is designed so that it can be set in place with the center of the gravity of the tunnel still inside the building. The stripping platforms are not designed to take the total load of a tunnel longer than 2.50m. Once the lifting boat has been unscrewed from the half-tunnel form, it has to be held up using the hook fixed on the frame of the lifting triangle, to avoid bending it, or damaging the tunnel roof. A welded ring shall be added to the triangle that allows to handle it with its base horizontal (easier to set on the form). The welded ring cannot take the load of a tunnel form.

The asymmetrical triangle is used:

1. With stripping platform
2. Without stripping platform, for buildings up to 3 storey high without staggers between spans, and with tunnelform packages longer than
3. 2.50m. When the length of the package is too small (1.25m), the lifting triangle can no longer be used. Some lifting hooks are then incorporated to the package so that it can be lifted with chains.
4. For packages of 2.50m, an additional wedge is added to the lifting triangle.

2.4.4.2 *Movement of Forms*

The forms can be lifted by the crane via some cable or chains. The greater the angle of the chains, the bigger the load in the chains and in the lifting rings. The angle made by the chains should never be more than 60º.

Details of Hanging of the Forms along with illustrations is given in Annex VII.

2.4.5 Initial Striking Operation

- The curtains are opened and the heaters removed
- The kickers are stripped
- The opposite slab stop-end is removed and fixed to the other side

- The roof locks are operated
- The ties are removed
- The jacks are raised until the half-tunnel rests on its wheels
- If the form sticks to concrete, the ‘clic-clac’ system of the struts is opened, thus lowering the horizontal panel.
- This in turn removes adhesion and the form drops on its wheels. The ‘clic-clac” is closed again.

Details of Initial Striking Operation along with illustrations is given in Annex VIII.

2.4.6 Setting in Place

- The level of the bottom of the vertical panel of half-tunnel is drawn on the kickers;
- The half-tunnel is pushed out through the façade;
- The form is scraped and oiled;
- The lifting triangle is bolted;
- The half-tunnel is completely pulled out;
- The slab that was stripped is propped;
- The tunnel form is set down on the last jacks on the slab;
- The bottom of the vertical panel is set flush with the line drawn on the kicker;
- The other jacks are lowered to the slab;
- The verticality of half-tunnel is adjusted by turning the triangulation jack bolt. The reference shall be given by a plumb line on magnetic support;
- The second half-tunnel is pushed out and the lifting triangle bolted;
- The second half-tunnel is brought in front of the first one;
- As it was done for the first tunnel form, the triangulation wheels are lowered along with the extreme jacks;
- The tunnel form is set on the slab, the bottom of the vertical panel is set flush with the line drawn on the kicker and the other jacks are lowered;
- The verticality of half-tunnel is set using the triangulation jack;
- The horizontal panel of the first half-tunnel provides an easy mean of checking the verticality of the second half form;
- The roof locks between the forms are bolted;
- The tunnel form is brought above its position;
- While the tunnel form is still in the air, the triangulation wheels are lowered;
- The jacks at the extremities of the tunnel form and that will rest on the slab are lowered;
- The tunnel form is lowered on the jacks and the lifting triangle is unbolted;
- The electricity is integrated in to the walls;
- The wire mesh is prepared for the ties and plastic cones;

- The ties are inserted partly into the tie-holes;;
- The plastic cones are installed on the ties and the tips of the ties are set flush with the ends of the cones;
- The door blockouts and wall stopends are set in place;
- The door blockout and wall stopend are levelled using the plumb line;
- The ties are completely tightened and the triangulation wheels are raised;
- The concreting starts with the inside walls and the external walls are then poured;
- Finally, the slab is poured with the kickers, starting from the cold joint;
- The slab is surfaced with a straight edge sliding on the kicker forms;
- The plastic curtains are closed and the heaters are started;
- The tunnel form is lowered through the gap;
- The bottom of the vertical panel is set flush with the line drawn on the kicker using the jacks;
- The verticality of half-tunnel is set using the triangulation wheel
- The roof locks are bolted.
- The ties are pushed completely through the tunnel forms and loosely bolted on the other side;
- The slab is scraped and oiled;
- The slab stopends are set in place;
  The wallform is hung to the crane and stripped;
- The wallform is scraped and oiled;
- The wallform isset in place;
- The jacks are lowered, thus pushing the wallform against the half-tunnel and the form is unhooked;
- The concrete crosses are set in place at the location of the walls;
- The kicker forms are installed on the concrete crosses.

Details of Setting in Place along with illustrations is given in Annex IX.

2.4.7 Propping

2.4.7.1 *Propping of the Slabs*

When using tunnel forms in a 24 Hour cycle, the concrete has little time to dry, even though the setting of concrete is accelerated (by heating and/or using the accelerator). Thus it is necessary to get some props in place as soon as the first tunnel is removed to prevent deflection. The position and number of props is governed by

- The concrete strength
- The architecture of the structure
- The loads applied on the structure

Typically, one prop every 2m of tunnel is sufficient for a regular width.

i) Propping methodology:

- The first half-tunnel is stripped;
- The slab is propped while the second half-tunnel is in place;
- The second half-tunnel is stripped once the slab is propped.

The props stay in place for several days. It is good practice to leave the props in place two floors below the one where the forms are set so that the concrete reaches a sufficient strength.

However, it would be necessary to place proper props, typically one prop at every 2 m for regular width may be sufficient. It would be necessary to leave the props in place for several days before the concrete gained required strength.

2.4.7.2 *Transmission of the load by the half-tunnel forms*

Once the roof locks are bolted, most of the load is transmitted through the jacks close to the tunnel wall.

Raising the triangulation wheels insure that no load at all is exerted on the middle of the slab; all the load is directly transmitted to the walls below.

Since all the weights are concentrated on the jacks, it should be checked before pouring that those jacks have been lowered to the ground.

i. The triangulation wheels must be raised before pouring
ii. The jacks close to the tunnel wall must be lowered.

Details of Propping along with illustrations is given in Annex X.

2.4.8 Ties

The forms are held together using ties. There are two types of ties:

a. Standard ties
b. Conical ties

The ties are designed to take the force resulting from the pressure of the concrete on the forms, via the horizontal beams. The number of ties depends on the length of the form. There are two ties on the height of the tunnel form.

c. Insertion of tie.

2.4.8.1 *Standard ties*

i. Bolt that does not turn when tightening the tie (square end that goes inside the beam and prevents rotation).
ii. Bolt that is turned to tighten the tie (round end that turns inside the beam and allows tightening).

Plastic cones are used to protect the standard ties in order to strip them. These cones are also used to set the thickness of the walls. They are put in advance on the ties that are partially inserted in the forms. The tip of the tie is then set flush with the end of the cone.

iii. Standard tie partially inserted
iv. Plastic cone flush with tie

Different methods used for removal of plastic cones are:

v. Removal using a hammer

vi. Cone extractor with a mace
vii. Cone extractor ‘”corkscrew”

2.4.8.2 *Conical ties*

The conical ties are only threaded close to the tip. The rest of the tie is smooth and conical so that it can be stripped. This removes the need for plastic cones. Furthermore, the conical tie is tightened in one operation. The thickness of the wall is set by the length of the tie once it is completely tightened.

The conical tie is used along with two plates that are bolted to the forms:

- A plate with nut
- A plate without nut

The plate without nut is bolted on the side where the tie is inserted and the plate with nut on the other side, where the threaded part enters the nut. Both plates are bolted to the forms from the start.

2.4.8.3 *Concrete cones*

Both types of ties leave some holes in the walls (small ones with the conical ties and bigger ones with the plastic cones of the standard ties. These holes are to filled using concrete cones once the forms are stripped:

1.Concrete cones for conical and standard ties
2. Mold to cast the concrete cones on site (at least one pour one day)

2.4.8.4 *Installation process*

The hole must be cleaned with no trace of grease.

a) Dampen the hole and the concrete cone especially in hot and dry weather;
b) Make a plastic mortar—excess water damages the quality of the setting mortar;
c) Bard the concrete cone and hole with setting mortar or resin;
d) Insert the barded concrete cone in the hole with a rotating movement;
e) Position the concrete cone by tapping lightly on the large end;
f) Carry out the surface fitting with mortar or resin.

Details of Ties along with illustrations is given in Annex XI.

2.4.9 Protection Platforms

2.4.9.1 There are four main types of platforms:

i)Stripping platforms

The stripping platforms are used as protections for the open façade through which the forms are stripped. The stripping platforms artificially extend the slab in front of the tunnelforms. They provide the necessary safety for the workers around the forms especially during the stripping.

The stripping or dismantling platform is slightly inclined backward when moved with the crane. This is to facilitate its setting in place.

Once the platform is in place, the side jacks are unscrewed in order to

prevent the platform from moving sideways. Furthermore, the platform should be properly set in place using wooden wedges at the top and bottom. And should be secured at its bottom using either a supplied steel chain with a plate that is fixed to a tie hole or using a prop.

ii) *Gable wall scaffolds*

The Gable wall scaffolds are used to support the gable wall forms. They are fixed on gable shoes. Some holes are left in the upper part of gable walls for the gable walls of the next level. Once the scaffolds and the shoes have been removed, the holes are filled with concrete cones.

a. Every time part of a level is finished in concrete, the gable wall scaffolds are removed to the next level.
b. The gable shoes are sometimes located above or besides an opening in the façade. When this is the case, the lintel should be properly reinforced and minimum distances should be followed.
c. There is at least one shoe per steel frame located within 41 cm left or right of the frame axis. The forbidden zone should be marked with paint.
d. When possible, the holes for the ties are also used to fix the gable shoes. To do so, the distance x from the hole axis to the top of the slab above should be comprised between 35 & 55 cm.

iii) *Circulation platforms*

When there is no wall to be cast and it is still necessary to have access, a circulation platform can be set in place. There are basically two types of such platforms:

a. Horse-head platforms that are attached to the edge of the slab;.
b. V shaped platforms that transmit the loads to the slab below via inclined struts.

iv)Platforms on slab openings

It is often necessary to often fill holes in the slab to enable people to work on it. A special platform can be set in place for that purpose.

c. Platform held by steel U profiles resting on steel rods going through the walls;
d. Platform held by steel Z profiles resting on the slab.

The platform is made of steel frames are supplied to the site.

Details of Protection Platforms along with illustrations is given in Annex XII.

2.4.10 Concreting

2.4.10.1 *Stopping of the Concrete (Slab and Wall stop-ends, Cold-joint)*

The concrete is stopped by using slab stop-ends on the horizontal panels and wall stop-ends on the vertical panels. However, it often happens that the whole slab cannot be cast the same day. In this case, temporary stop-ends have to be installed, allowing the reinforcement steel to pass.

i)Slab stop-ends

The slab stop-ends are used to stop the concrete at the perimeter of the slabs. These are generally bolted to the forms but they can also be held in place using magnets. Many shapes can be designed for balconies, for instance.

ii) *Wall stop-ends*

The wall stop-ends are bolted to the form and are used to stop the concrete at the extremities of the walls. These can be linked to narrow horizontal strips in order to make full height openings.

iii) Cold-joint

A large floor is typically divided into several phases and the same equipment is re-used for each phase. In order to do so the half-tunnel form location at the intersection of the phases stays in place during the concrete pour, creating a cold-joint. One-fifth of the span is poured during the first phase and the remaining four-fifth phases are poured subsequently

2.4.10.2 *Windows and Doors Box-outs*

2.4.10.3 *i)Window box-out*

The setting in place of a window box-out using magnets can be decomposed as follows:

a. The position of the box-out is drawn on the form, the wire mesh to be cut before hand
b. Some magnets are set on the lintel line minus the thickness of the box-out
c. The box-out is assembled on the ground and positioned on the lintel Magnets
d. Some magnets are set on the side to prevent it from moving sideways
e. The magnets are bolted (or nailed) to the box-out.

ii) Door box-out

The setting in place of a door box-out using magnets can be decomposed as follows:

a. The position of the box-out shall be drawn on the form, the wire mesh shall be been cut before hand
b. The box-out shall be assembled on the ground and the magnets shall be bolted(or nailed) to it, with the magnet handles raised so that the magnet does not adhere to the form
c. The box-out is raised against the form and levelled using the bottom jack.
d. Once the box-out is in place, the magnets handles are lowered.

Details of Concreting along with illustrations is given in Annex XIII.

2.4.10.3 *Order of Pouring*

The concrete shall be poured so as to stabilize the tunnels. Typically, the internal walls shall be first poured (walls with half-tunnel forms on both sides), then the external walls and finally the slab and kickers. The gable wall shall not be poured first.

These operations shall be repeated for each row of tunnel form.

When pouring the walls it is good practice to stop the concrete slightly before reaching the level of the slab. This leads to a better finishing of the slab, especially if the concrete sets rapidly.

2.5 ANTI-CORROSION PROTECTION

The wall forms shall be protected via an anti-corrosion procedure, except for the formwork faces. The same applies to the gripping mechanisms. All the mechanical, adjusting, maintenance and other mechanisms shall be lubricated.

2.6 MARKING

2.6.1 *Marking of the wall form*

Each wall form shall have a label, mechanically engraved and fixed on the structural frame or a direct paving on a primary component. This label shall include:

- The model reference
- The name of the manufacturer or its acronym
- The date and year of manufacture
- The weight of the equipped wall form per square meter
- The load bearing capacity of the gripping mechanism
- The maximum permissible pressure of concrete

2.6.2 *Marking of the Gripping Mechanism, the Spacer Pins, the Stops and the Rear Stabilizers*

- The factory code
- The year of manufacture
- The manufacturing batch number

2.7 INSPECTION

The manufacturer shall be able to justify an inspection of the manufacturing and of the finished products at the time of the supply of material.

2.8 HEALTH AND SAFETY

The Outinord Formwork System's relevant manuals and instructions shall be consulted for guidance for health and safety requirements such as personal protective clothing, protective glasses etc.

2.9 CHOOSING SIZE AND THICKNESS

Appropriate size and thickness of the formwork panels shall be chosen to suit the structural, fire, acoustic and thermal requirements of the structure.

2.10 MAINTENANCE AND REPAIR REQUIREMENTS

Maintenance and Repair Manual shall be given by the PAC holder to the client. Over baked powder coating for high quality and smooth finishes shall be applied**.**

2.11 GUARANTEES/WARRANTIES PROVIDED BY THE PAC HOLDER

PAC holder shall provide necessary guarantees/ warranties. A brochure giving relevant details and warrantee detail shall be made available to the client.

2.12 SERVICES PROVIDED BY THE PAC HOLDER TO THE CUSTOMER

2.13 MANUALS

2.13.1 Operating Manual

An operating manual shall be included with each delivery of the material. The manual shall give the following information to the user:

- The nomenclature of the parts, accessories and their weights;
- The rules for assembling of the individual parts or for deploying the wall forms and lifting of the wall forms;
- All the possibilities of the inter-assembly of the wall forms; wall forms with additional components and the corresponding weights;
- The handling, storage and transportation instructions;
- The operating modes for stabilization and use, the corresponding weights and the values of the stress to be exerted on the anchoring points of the stabilizing systems (fixation on the slabs);
- The recommendations for maintenance;
- The limits of use, specially the permissible pressure of concrete;
- The measures to be taken to ensure safety for wind speeds

2.13.2 Other Manuals

All the manuals relating to Quality, TMPH, Wallform, Maintenance and Repair, Health and Safety etc. shall be provided for each project incorporating the Outinord Formwork System.

2.14 DATA SHEET

The wall forms shall be delivered with a data sheet providing information, which should allow the user to handle and stabilize them in proper conditions, and a summary of the essential operations taken from the operating manual.

2.15 RESPONSIBILITY

- Specific design using Outinord Formwork System is the responsibility of the designer with the instructions, supervision and guidance of Outinord.
- Quality of installation of the system on site is the responsibility of the trade persons engaged by the agency.

PART 3 BASIS OF ASSESSMENT AND BRIEF DESCRIPTION OF ASSESSMENT PROCEDURE

3.1 ASSESSMENT

.1.1 The assessment has been done as per provisions of the standards listed in Part V of this Certificate.

3.1.2 The assessment of the system is based on the formwork manufactured, used and installed as per statement given in the PAC. At present, the formwork is not manufactured in India. However, assessment of the suitability of formwork manufactured as load bearing wall, shear wall, floor/ roof slab etc. is based on

i) Agreement of the Outinord System by the French Government CSTB.
ii) Regulations for Concrete as per Netherlands Standard NEN 3862.
iii) Application of accelerated curing to Apartment Formwork System – Advisory Note from British Cement Corporation
iv) Case studies and Certificate from Users of the system all over the world.
v) Quality Assurance Scheme followed by the Certificate holder for process control
vi) The PAC is being issued for a period of one year which will be reviewedwaq23waqw3aqqqqqqqqq based on the input from the manufacturer about the formwork being used in India from time to time.

3.2 LABORATORY TESTS PERFORMED FOR ASSESSMENT

3.2.1 Testing of samples by Foreign Laboratory/ Institute

3.2.1.1 i) Hot Air Curing concept
ii) Thermal curing Tests
iii) Calculation of strength at stripping hour

3.3 USAGE OF THE SYSTEM

M/s Outinord has stated that it has supplied/sold the Tunnel Formwork in 66 countries enabling construction of over 8 million apartments worldwide. Details of the Formwork System supplied by the manufacturer for construction of apartments in India are given below:-

S.No.	Project	Agency
1.	Construction of apartments at Mumbai in 2000	M/s Runwal Group, Mumbai
2.	Construction of apartments	M/s B G Shirke

	complexes at Navi Mumbai, and Tirupati in 2001	Construction Technology Pvt. Ltd., Pune
3.	Construction of apartments at Chennai in 2008	M/s L&T South City Projects Ltd., Chennai
4.	Construction of Slum Rehabilitation at Nashik – In progress	M/s Pawar Patkar Construction Pvt. Ltd., Nashik , Maharashtra

PART 4 STANDARD CONDITIONS

This certificate holder shall satisfy the following conditions:

4.1 The certificate holder shall continue to have the product reviewed by BMBA.

4.2 The product shall be continued to be manufactured according to and in compliance with the manufacturing specifications and quality assurance measures which applied at the time of issue or revalidation of this certificate. The Scheme of Quality Assurance separately approved shall be followed.

4.3 The quality of the product shall be maintained by the certificate holder. Complete testing facilities shall be installed for in-process control.

4.4 The product user should install, use and maintain the product in accordance with the provisions in this Certificate.

4.5 This certificate does not cover uses of the product outside the scope of this appraisal.

4.6 The product is appraised against performance provisions contained in the standards listed in Part-V. Provisions of any subsequent revisions or provisions introduced after the date of the certificate do not apply.

4.7 Where reference is made in this Certificate to any Act of Parliament of India, Rules and Regulations made there under, statutes, specifications, codes of practice, standards etc. of the Bureau of Indian Standards or any other national standards body and the International Organization for Standardization (ISO), manufacturer's company standards, instruction/manual etc., it shall be construed as reference to such publications in the form in which they were in force on the date of grant of this Certificate (and indicated in Part V to this Certificate)

4.8 The certificate holder agrees to inform BMBA of their clients with details of construction on six monthly basis.

4.9 The certificate holder agrees to provide to BMBA feedback on the complaints received, the redressal provided, and the time taken to provide redressal on complaint to complaint basis as soon as redressal is provided. BMBA agrees to provide the certificate holder the user feedback received by it, if any.

4.10 If at any time during the validity period, PACH is unable to fulfill the conditions in his PAC, he should on his own initiative suspend using the PAC and notify Chairman, TAC the date from which he has suspended its use, the reason for suspension and the period by which he will be able to resume. He shall not resume without the prior permission of BMBA. He shall also inform, simultaneously, his agents, licensees, distributors, institutional, government, public sector buyers, other buyers and all those whom he has informed about his holding the PAC. He shall also inform all those who buy his product(s) during the period of suspension. He shall provide to BMBA at the earliest the list of who have been so informed by him.

4.11 In granting this Certificate, BMBA takes no position as to:

(a) The presence or absence of patent or similar rights relating to the product;
(b) The legal right of the Certificate holder to market, install or maintain the product;
(c) The nature of individual installations of the product, including methods of workmanship.

4.12 BMTPC and the Board of Agreement of BMTPC (BMBA) take no position relating to the holder of the Performance Appraisal Certificate (PACH) and the users of the Performance Appraisal Certificate (PAC) respecting the patent rights / copy rights asserted relating to the product / system / design / method of installation etc. covered by this PAC. Considerations relating to patent / copy rights are beyond the scope of the Performance Appraisal Certification Scheme (PACS) under which this PAC has been issued. PACH and users of this PAC are expressly advised that determination of the Claim / validity of any such patent rights / copy rights and the risk of infringement of such rights are entirely the responsibility of PACH on the one hand and that of the users on the other.

4.13 It should be noted that any recommendations relating to the safe use of the product which are contained or referred to in this Certificate are the minimum standards required to be met with when the product is installed, used and maintained. They do not purport in any way to restate or cover all the requirements of related Acts such as the Factory Act, or of any other statutory or Common Law duties of care, or of any duty of care which exist at the date of this Certificate or in the future, nor is conformity with the provisions of this Certificate to be taken as satisfying the requirements of related Acts.

4.14 In granting this Certificate, BMTPC and BMBA does not accept responsibility to any person or body for any loss or damage, including personal injury, arising as a direct or indirect result of the use of this product.

4.15 The certificate holder indemnifies BMBA, its officers and officials involved in this assessment against any consequences of actions taken in good faith including contents of this certificate. The responsibility fully rests with the certificate holder and user of the product.

4.16 The responsibility for conformity to conditions specified in this PAC lies with the manufacturer who is granted this PAC. The Board (BMBA) will only consider requests for modification or withdrawal of the PAC.

4.17 The PAC holder shall not use this certificate for legal defense in cases against him or for legal claims he may make from others.

Dr. Shailesh Kr. Agarwal
Chairman, TAC
& Member Secretary, BMBA
Building Materials and ... Promotion Council
Ministry of Housing & Urba... ...n, (Govt. of India)
Co... ...dhi Road,
New...

Place: New Delhi
Date of issue: .....

for and on behalf of
Chairman TAC &
Member Secretary, BMBA

PART 5 LIST OF STANDARDS & CODES USED IN ASSESSMENT

5.1 Standards - These Standards are referred for carrying out particular tests only and do not specify the requirement for the whole product as such.

5.1.1 IS 277:2003 -- Code of practice for galvanized steel sheets
5.1.2 IS 456:2000 -- Code of practice for plain and reinforced concrete
5.1.3 IS 2062:1999 --Specifications of structural steel for general structural purposes
5.1.4 IS 14687:1999 – Falsework for concrete structures
5.1.5 NF EN 10002 (Part 1):2001 –Tensile testing of Metallic materials
5.1.6 NF EN 10045 (Part 1):1990 –Charpy impact test of Metallic materials

5.2 Company Standards of the PAC holder – The branded design & specifications of the raw materials and finished product are as submitted by the manufacturer. The PAC holder has to make available the company standards to the consumers according to which testing have been done.

CERTIFICATION

In the opinion of Building Materials & Technology Promotion Council's Board of Agreement (BMBA) **Modular Tunnel Formwork** is satisfactory if used as set out above in the text of the Certificate. This Certificate **PAC No. 1018-S/2015** is awarded to **M/s Outinord Formworks Pvt. Ltd., Pune.**

The period of validity of this Certificate is from 21-07-2015 to 20-07-2018 and extended further from 14-10-2022 to 13-10-2023.

This Certificate consists of a cover page and pages 1 to 99.

On behalf of BMTPC Board of Agreement, Chairman, Technical Assessment Committee (TAC) of BMBA & Member Secretary, BMTPC Board of Agreement (BMBA) Under Ministry of Housing and Urban Affairs, Government of India

Place: New Delhi, India

Date: 14.10.2022

PART 6 ABBREVIATIONS

Abbreviations

BMBA	Board of Agreement of BMTPC
BMTPC	Building Materials and Technology Promotion Council
CPWD	Central Public Works Department
ED	Executive Director of BMTPC
IO	Inspecting Officer
MS	Member Secretary of BBA
PAC	Performance Appraisal Certificate
PACH	PAC Holder
PACS	Performance Appraisal Certification Scheme
SQA	Scheme of Quality Assurance
TAC	Technical Assessment Committee (of BMBA)

Performance Appraisal Certification Scheme - A Brief

Building Materials & Technology Promotion Council (BMTPC) was set up by the Government of India as a body under the Ministry of Housing &Urban Poverty Alleviation to serve as an apex body to provide inter-disciplinary platform to promote development and use of innovative building materials and technologies laying special emphasis on sustainable growth, environmental friendliness and protection, use of industrial, agricultural, mining and mineral wastes, cost saving, energy saving etc. without diminishing needs of safety, durability and comfort to the occupants of buildings using newly developed materials and technologies.

During the years government, public and private sector organizations independently or under the aegis of BMTPC have developed several new materials and technologies. With liberalization of the economy several such materials and technologies are being imported.

However, benefits of such developments have not been realized in full measure as understandably the ultimate users are reluctant to put them to full use for want of information and data to enable them to make informed choice.

In order to help the user in this regard and derive the envisaged social and economic benefits the Ministry of Housing &Urban Poverty Alleviation has instituted a scheme called Performance Appraisal Certification Scheme (PACS) under which a Performance Appraisal Certificate (PAC) is issued covering new materials and technologies. PAC provides after due investigation, tests and assessments, amongst other things information to the user to make informed choice.

To make the PACS transparent and authentic it is administered through a Technical Assessment Committee
(TAC) and the BMTPC Board of Agreement (BMBA) in which scientific, technological, academic, professional organizations and industry interests are represented.

The Government of India has vested the authority for the operation of the Scheme with BMTPC through Gazette Notification No. 1-16011/5/99 H-II in the Gazette of India No. 49 dated 4th December, 1999.

Builders and construction agencies in the Government, public and private sectors can help serve the economic, development and environmental causes for which the people and Government stand committed by giving preference to materials and technologies which have earned Performance Appraisal Certificates.

Further information on PACS can be obtained from the website: www.bmtpc.org

ANNEX I

(Clause 1.4.2)

Agreement of New materials and Non-traditional Construction Process (decision No. 2569)

7 DEC. 1964

III 1/11

Cahiers of the C.S.T.B PARIS - FRANCE No.85 F4 1967 744	AGREMENT OF NEW MATERIALS AND NON-TRADITIONAL CONSTRUCTION PROCESSES	CDU: 69.022; 69.025
Société OUTINORD	O U T I N O R D	STRUCTURE
59 ST. AMAND LES EAUX 5 bis, rue Henri Barbusse	DECISION No. 2569	MAIN STRUCTURES

SIMPLE AGREMENT (renewal)

The Scientific Director of the Centre Scientifique et Technique du Batiment,

Considering the decree 54-444 dated April 20, 1954, setting out the tasks and rules of organization, operation and verification by the Centre Scientifique et Technique du Batiment, modified by decree 56-1124 dated November 1956,

Considering the decree dated September 3, 1958, setting forth the conditions of the agrément and of the operation of the examination committees set up within the C.S.T.B. concerning this subject,

Considering the request presented by the Société OUTINORD, 5 bis, rue Henri Barbusse, Saint-Armand-les-Eaux (59), to have the OUTINORD process approved as a main stucture process, which has been described in the technical extract no. 2569 accepted by this Company,

And on the proposition of the Agrément Committee,

D E C I D E S

That the main stucture system utilizing the OUTINORD formwork system manufactured by the OUTINORD Company, S.A. at Saint-Amand-les-Eaux, and described in technical extract no. 2569, is approved as a "main structure process" in accordance with the following conditions:

Utilisation specifications.

The formwork of suspended floors must be built by the direct assembly of "movable forms" without any special units being wedged between these forms.

The number, the arrangement, and the execution of windbracing walls must be such that the horizontal stability of the work is ensured during construction.

It is obligatory that these walls be built of in-situ concrete, connected to the crosswalls by reinforcement starter bars where the buildings are higher than six levels.

A periodic check of the concrete's hardening must be carried out prior to removing forms (by the crushing of cubes taken from the concrete used for building the floors, and preserved under identical conditions).

Use limitation.

The floor spans executed with movable forms such as defined in technical extract no. 2569 must not exceed 5.60 m.

- Unless justified by special provisions, the thickness of vertical in-situ walls must be equal to or greater than 0.12 m.

This agrément cancels and replaces agrément no. 1860; it shall be submitted for renewal on October 15, 1969.

Made in Paris, November 10, 1966

G. BLACHERE,

The Director of the C.S.T.B.
Chief Engineer of the Pont et Chaussées

TECHNICAL EXTRACT

I. PRINCIPLE

The OUTINORD process is a metallic formwork system permitting the construction of buildings with load bearing transversal reinforced concrete walls, and reinforced concrete solid slab suspended floors.

The walls and suspended floors of each storey are poured in situ over the whole surface without interruption between two consecutive expansion joints.

The standard formwork units (movable forms) are usually assembled and adjusted during the first phase, by using special metal rules (starter forms) materializing the construction wall line, and equipped with devices making it possible to install the door and window frames. These rules can also be integrated with the forms.

Handling operations are facilitated by the use of service access platforms, also standardized, arranged one level below the concrete pouring level.

During construction, the windbracing of the building is ensured by the elevator shaft walls.

II. DESCRIPTION OF THE EQUIPMENT

The OUTINORD formwork system consists of the following elements:

1. The starter forms.

These forms are made up of factory cut, 80 x 80 mm metal angle sections (or larger if necessary) in accordance with the line of the building walls. These angle sections, marked with respect to one another, are assembled on the working site in accordance with the indications of an assembly plan having the same markings. They are erected by means of steel support wedges on the tunnel form prior to concreting of the walls and the slab.

Their location automatically ensures the correct positioning of the wall and the frames.

2. The movable forms.

The standard form unit (half-shell) take the form of a right hand dihedral, whose vertical plane is made up of a storey-height panel, less 4 cm (or more if necessary) and the horizontal plane of a panel representing the half-span of the floor slab (maximum 2.80 m, for a slab span of 5.60 m.)

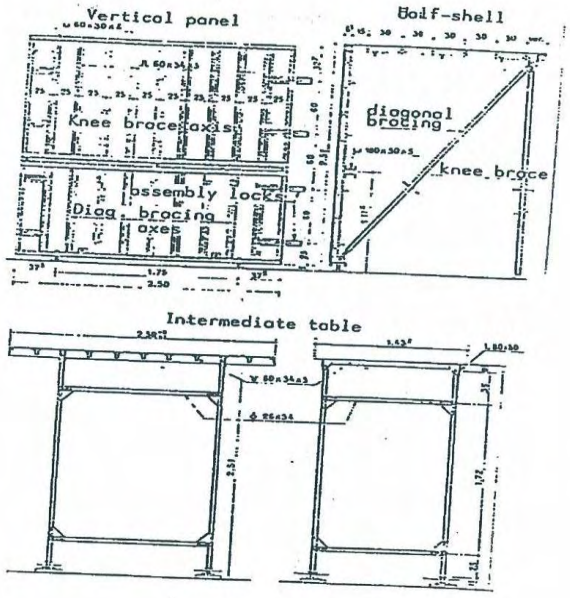
The panels are built of 3 mm thick sheet steel, stiffened by folded sheet metal sections, welded every 25 cm; they are assembled rigidly one to the other by bolts which enable slight deformations of the dihedral; they are usually 2.50 m long.

The windbracing of the two panels is ensured by two diagonals having a length adjustable by screw jacks; these jacks are fitted with an adjustable stop so that when the screws are at the stop, the dihedral is perfectly straight.

The preceding standard form unit is also equipped with the following devices:

-- At the base of the vertical panel: two screw jacks permitting adjustment of the height and level of the upper panels;

-- At the key of the upper horizontal panel: a tubular knee brace, also fitted with a screw jack, permitting height adjustment. This knee brace, which is hinged, is folded toward the vertical panel after assembly of the various units.



Two horizontal cross pieces incorporated in the height of the vertical panel are pierced with holes to permit passage of the spacers ensuring adjustment of the wall thickness.

The lateral extremities of the panels are made of 60 x 30 mm, cold rolled U-sections which carry the connecting devices making it possible to ensure the correct flush fitting of consecutive units. Assembly is carried out using spring levers.

The end of the horizontal panel, built of an 80 x 80 mm, steel angle section carries the key locks permitting the assembly of two units face to face.

-- At form removal, the half-shells, weighing from 6 to 700 kg (depending on the surface), are removed on the service platforms using light, 4-wheel dollies (two dollies are sufficient to handle a form surface of 500 m2);

-- The half-shells are supported on the dollies by means of two lugs welded to the dolly base and two telescopic props, also part of the dolly;

-- The half-shells are cleaned on dollies on the service platforms, then hoisted out by the crane to be set on the next higher storey (the dollies stay on the platforms to be reused immediately).

3. Service platforms.

These platforms are built of a timber floor fastened with lag bolts to metal trusses forming a console.

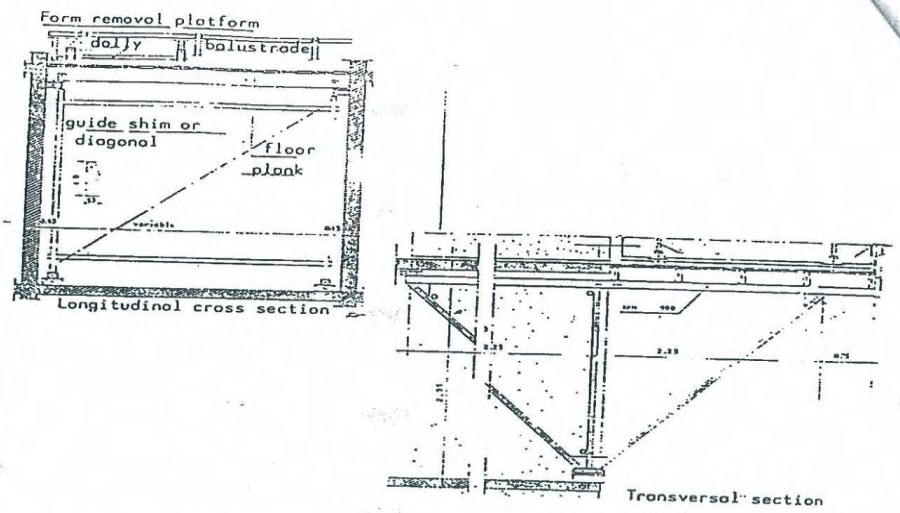
Each truss is composed of a upper horizontal steel I beam about 5.25 meters long onto which three 40/49 tubes are welded to form a triangulated beam.

These trusses, arranged in consoles between two successive stories, already poured, are assembled in pairs using 40/49 tubes to form a triangulated beam.

The useful platform width, outside the building, is about 2.85 m; a guard railing is set up at the outside edge of the platform floor.

4. Special units.

The maximum width of the horizontal panels of the usual form units is 2.80 m, making possible the execution of floors having a span up to 5.60 m.



When a greater span is required, some additional horizontal panels can be inserted between the opposite "half-shells".

These panels, built in the same manner as the normal units (stiffened sheet steel), are fitted with four tubular legs equipped with screw jacks.

III. UTILIZATION OF THE EQUIPMENT

At each stage, utilization of the system requires the following successive operations:

1. The placing of the vertical wall reinforcement of the floor, and possibly the door frames provided for on the erection drawing.

2. Dismantling of the movable form units of the preceeding storey.

This is carried out in two stages:

a) Loosening of the normal units (half-shells), by removal of the spacers passing through the walls, by unlocking the tunnel keys and disassembly of the sections.

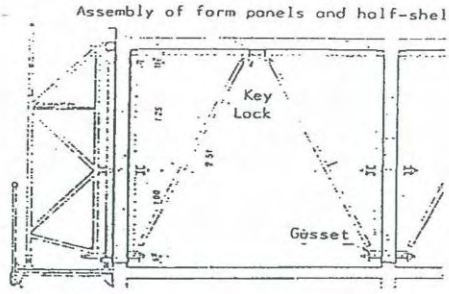
This work is executed, in principle, by two non-specialized maneuvers:

b) Striking and removal of the forms. This is carried out using the special dolly and two maneuvers in the tunnel, and by two other maneuvers at the new location (usually on the storey above).

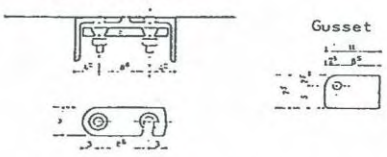
This suite of operations is carried out by bringing the dolly under the half-shell to be removed, and then working the different jacks for the striking operation itself.

The leg jacks are lifted first, then a slight deformation of the half-shell is provoked by working the diagonal bracing jacks (shortening). This deformation is sufficient to strip the form progressively. It then drops down automatically onto the dolly.

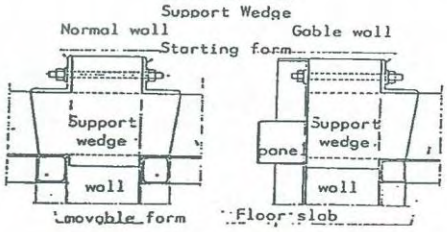
Assembly of form panels and half-shells



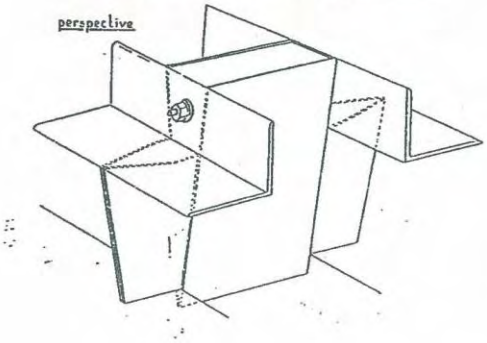
Key Lock detail



STARTING FORM

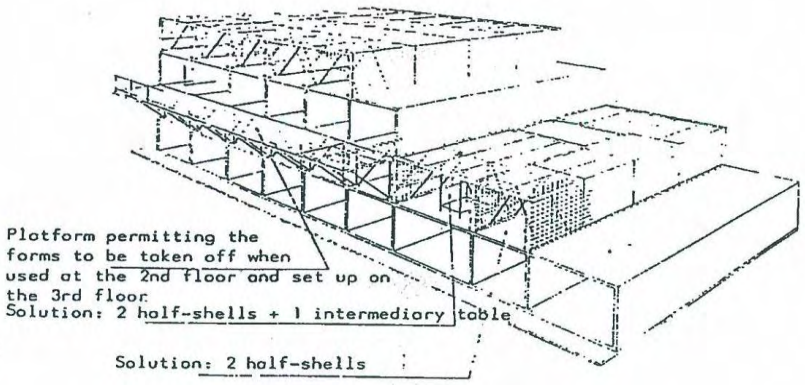


perspective



The dolly-half-shell assembly is then rolled across the service platform where the form is cleaned and oiled with a sprayer, then picked up with a crane and hoisted to its new utilization site, the dolly remaining in place.

The half-shell design makes it possible to remove one whole side of a tunnel, then to prop the slab near the key before removing the other half, permitting if necessary, a faster rotation of the equipment.



3. Reassembly of the units on the floor above.

This assembly consists of the following operations:

a) Positioning of a half-shell on its leg jacks and knee brace, squaring adjustment by blocking the diagonal bracing jacks, then adjustment of the height and plumb by working the leg jacks and the knee brace jack.

Positioning of the following half-shells, same or opposite side of the tunnel (same adjustment procedure), depending on the case;

b) Assembling the half-shells together;

c) Positioning of the opposite half-shells, and adjacent half-shells of the "tunnel" using the same procedure.

d) Blocking of the half-shells constituting the two faces of the wall on the "starters" with the aid of the lower spacers; the upper spacers are tightened without being forced, only after verification of the general adjustment; positioning of the butt end forms of the walls and floors.

e) Positioning and blocking of the keylocks solidifying the opposed half-shells. If necessary, a light action on the knee brace and diagonal bracing jacks may be used to bring the locking units into line.

f) Positioning of the starter forms and blockouts if necessary for the door or window frames anticipated;

g) Verification of the overall adjustment and finish making- up if necessary, after lifting of the knee braces;

h) Reinforcement of the suspended floor and concrete pouring of the walls and slab.

4. Removal of the service platform and installation of this platform on the storey above.

IV. CHARACTERISTICS OF THE PROCESS

Maximum span between walls.

This is 5.60 meters, unless accessory units are used.

With accessory units: 7.00 m.

Height of the formwork

The forms are designed for floor to ceiling wall heights of 2.51 m with the possibility to vary this more or less by action on the leg jacks, or with the use of movable panels in the event of extra heights.

Appearance of the surfaces after form removal.

The surfaces obtained allow direct application of finishing paint or wallpaper after sanding off the fins at the joints connecting the units and smoothing with paint filler.

Working rhythm using the system.

Under average temperature conditions, with the use of ordinary cement, the normal rhythm is two days per cycle with one day and two nights for drying and setting of the concrete.

If necessary, the cycle length can be shortened by heating of the rooms formed by the tunnels to about 50°C using forced draught hot air heaters after closing off the ends with lightweight panels; form removal can then take place after about 16 hours.

Manpower necessary for execution of the process.

The time required for execution varies according to the cell plan.

For a type of cell consisting of two formed wall surfaces and a floor surface, the average time is less than one and one half hours per square meter of building. that is an average unit time less than 45/100 hour to the square meter formed.

This time includes: the form removal, cleaning, oiling, then displacement of the units, formwork and adjustment, in other words, a complete cycle (reinforcement and concrete pouring excluded).

V. REFERENCES

This process has had numerous applications representing a total of more than 60 000 apartments constructed or in progress. Among those built by virtue of agrément No. 1860, the following can be cited:

- 657 apartments in Blois (41); Ets Billard, Paris
- 900 apartments in Rueil-Malmaison (92)
- 700 apartments in Tours (37); Ets Billard, Paris
- 431 apartments in Colmar (68); Ets Billard, Paris.
- 670 apartments in Arras (62);
- 713 apartments in Dunkerque (59);
- 428 apartments in Bethune (62); Construction Moderne Française, Chamarande;
- 432 apartments in Bethune (62);
- 585 apartments in Saint Brieuc (22);
- 427 apartments in Ris-Orangis (91);
- 317 apartments in Beauvais (60); Construction Moderne Française, Chamarande;
- 591 apartments in Nantes (44);
- 274 apartments in Reims (51);
- 269 apartments in Ivry (94);
- 700 apartments in Clairefontaine (51); Moisant Laurent Savey, Paris.
- 2 196 apartments in Velizy Villacoublay (78); Société Auxiliaire d'Entreprises, Paris:
- 307 apartments in Ponthierry (77);
- 1 437 apartments in Montereau (77);
- 662 apartments in Reims (51); Union de Travaux et d'Entreprises, Paris.
- 700 apartments in Tours (37); Société Nationale de Constructions, Paris.
- 484 apartments in Trappes (78); Terraz, Boulogne-sur-Seine.
- 541 apartments in Mulhouse (68); Ste. de Travaux Publics et Privés d'Alsace et Lorraine. Strasbourg:

In addition, the process has had considerable use abroad in the Netherlands, West Germany, England, Argentina, and Puerto Rico.

SUMMARY OF THE AGREMENT COMMITTEE REPORT

The principal observations formulated by the agrément Committee are summarized below:

1. Since the delivery of Agrément No. 1860, the only notable modification made in the process concerns the fastening device used on the "starter forms". It new design facilitates adjustment and allows concrete to be poured at the same time as the walls and floors of the preceding level.

2. Since the same date, the process has received numerous important applications which have behaved in a satisfactory manner. The inquiry carried out on these applications, with renewal of the agrément in view, confirms that the process makes it possible to execute, at interesting working rhythms, structural works having sufficient precision to do without the classic finish renderings and permit use of the most varied precast facade and partition units.

3. The required flatness conditions are nevertheless more difficult to obtain in the case of suspended floors with very long spans where it is necessary to put in tables between the "movable forms", and it would seem reasonable to limit the use of the system to floors with a maximum span of 5.60m., sufficient moreover, for the majority of applications in the field of housing construction.

4. Heating of the rooms formed by the tunnels using forced air heating units can help speed up construction, but it requires continuous supervision in order to be prepared for the risks which could result during form removal in the case of an insufficient treatment of the concrete.

5. The design of the forms does not make it possible to check the homogeneity of the concreting while it is being done, and it seems prudent, under these conditions, to limit the minimum thickness of the poured walls to 12 cm.

6. Prior to making a decision on the arrangement and the execution conditions for the windbracing walls, it would be advisable to verify that the choice will actually ensure horizontal stability of the works during the time the building is under construction.

7. It should be noted that the relatively heavy weight of the structures provides interesting acoustical comfort qualities to apartments built in accordance with this process.

The Rapporteur general
P. ROGER
C.S.T.B. Department Manager

ANNEX II

(Clause 1.4.2)

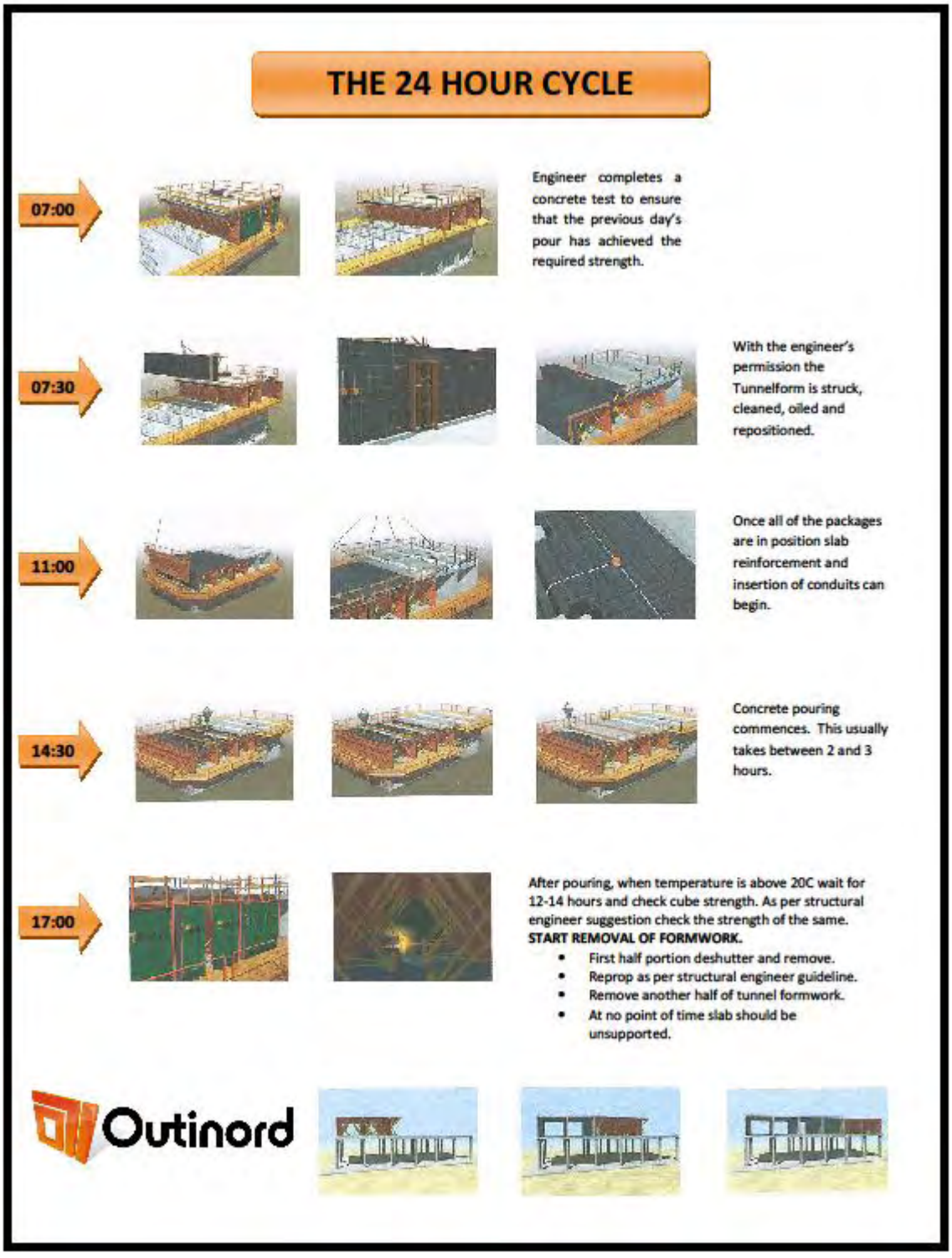
QUALITY ASSURANCE PLAN FOR TUNNEL FORMWORK

S.No.	Parameters to be inspected	Requirement Specified	Test Method	Frequency of Testing
1 Raw Material – L-profile & L-angle				
1.1	Visual	Shall be free from any surface defects cf DRG	Visual check	For Each Lot
1.2	Dimensions	Shall be as per drawings	Measuring tape/ Vernier caliper	For Each lot
2 Raw Material – M.S. Angle, Steel Tubes. Round tubes, flats etc.				
2.1	Visual	Shall be free from any surface defects cf DRG	Visual	For Each Lot
2.2	Dimension	Shall be as per drawings	Measuring tape/ Vernier caliper	For each Lot
3 Raw Material – Steel Sections				
3.1	Visual	Shall be free from any surface defects	Visual check	For Each Lot
3.2	Dimension	Shall be as per general notes for Tolerances given in drawings	Measuring tape/ Vernier caliper	For Each lot
4 Raw Material – Cold rolled U-Sections				
4.1	Visual	Shall be free from any surface defects	Visual	For Each Lot
4.2	Dimensions	Shall be as per drawings	Measuring tape/ Vernier caliper	For Each Lot
5 Raw Material – Hot Dip Galvanized steel sheet				
5.1	Visual	Shall be free from any surface defects	Visual	For each Lot
5.2	Dimensions	Shall be as per drawings	Measuring tape/vernier caliper	For Each Lot
5.3	Hot Dip Galvanizing	Coating shall not be less than 85 micron	Shall conform to EN ISO 1461	Sample check for each (supplier)
5.4	Adhesion of Galvanized Coating	Shall not peel any portion of the coating in Knife Test	Shall conform to EN ISO 1461	For Each lot
5.5	Fitments	Nut shall fit easily on bolt threads without being too loose and washer shall pass the bolt with proper fitments	Shall conform to relevant Indian Standards	For Each lot
6 Steel fabrication				
6.1	Visual	i)Shall be free from any surface defects ii) All the items shall be straight & grind finished iii)Holes shall be of exact shape & free from blurs & burrs	Visual	For Each Lot

6.2	Dimensions	As per general Tolerances given in the drawings	Measuring tape/ Vernier caliper	For Each Lot
6.3	Hole Orientation	As per general Tolerances given in the drawings	Shall conform to the drawings	For Each Lot
6.4	Diagonal	As per general Tolerances given in the drawings	Shall conform to the drawings	For Each Lot
6.5	Welding	All the steel shall be properly welded	Shall conform to relevant Indian Standards	For Each Lot
7 Assembly Work				
7.1	Visual	i)Shall be free from any surface defects ii)All the fabricated items shall be smooth, straight & grind finished iii) Holes shall be of exact shape & free from blurs & burrs. iv)Riveting in all the items shall be of exact punch	Visual	For Each lot
7.2	Dimensions	As per general Tolerances given in the drawings	Shall conform to the drawings	For Each Lot
7.3	Hole Orientation	As per general Tolerances given in the drawings	Shall conform to the drawings	For Each Lot
7.4	Diagonal	As per general Tolerances given in the drawings	Shall conform to the drawings	For Each Lot
8. Paint work				
8.1	Visual	i)Shall be free from any surface defects ii) Polyester surface coating with thickness from 60 to 300 micron iii) Liquid painting rework for all area with lack of protection	Visual	For each part
8.2	Adhesion of the powder coating painting	Validation plan closer to real condition of use 250h in salt spray stopped each 50h for high pressure cleaning	Shall be as per company requirement	

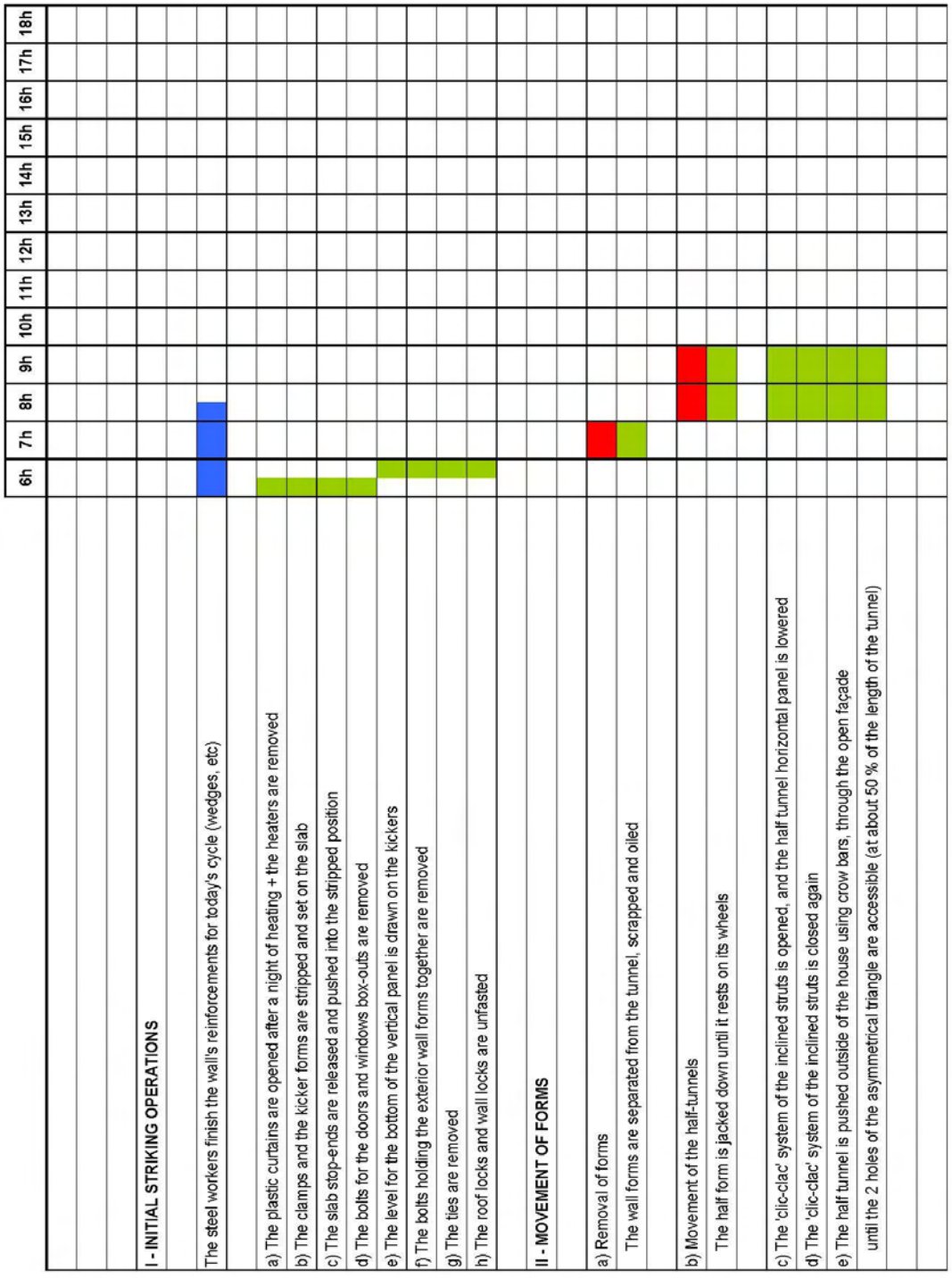
ANNEX III

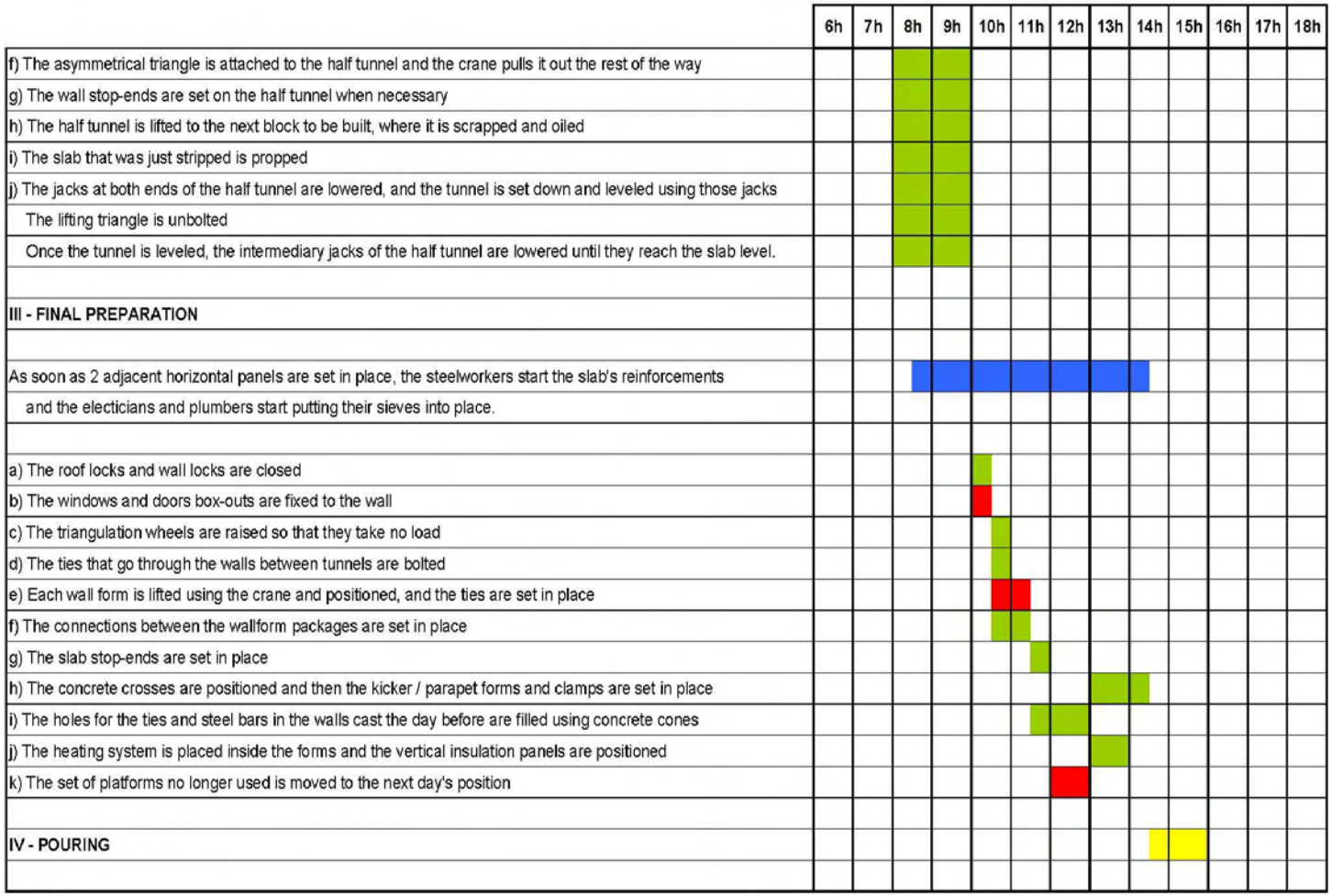
(Clause 2.4.1.1)



BAR CHART

ANNEX IV *(Clause 2.4.1.1)*




6h
7h
8h
9h
10h
11h
12h
13h
14h
15h
16h
17h
18h
f) The asymmetrical triangle is attached to the half tunnel and the crane pulls it out the rest of the way
g) The wall stop-ends are set on the half tunnel when necessary
h) The half tunnel is lifted to the next block to be built, where it is scrapped and oiled
i) The slab that was just stripped is propped
j) The jacks at both ends of the half tunnel are lowered, and the tunnel is set down and leveled using those jacks
The lifting triangle is unbolted
Once the tunnel is leveled, the intermediary jacks of the half tunnel are lowered until they reach the slab level.
III - FINAL PREPARATION
As soon as 2 adjacent horizontal panels are set in place, the steelworkers start the slab's reinforcements
and the electicians and plumbers start putting their sieves into place.
a) The roof locks and wall locks are closed
b) The windows and doors box-outs are fixed to the wall
c) The triangulation wheels are raised so that they take no load
d) The ties that go through the walls between tunnels are bolted
e) Each wall form is lifted using the crane and positioned, and the ties are set in place
f) The connections between the wallform packages are set in place
g) The slab stop-ends are set in place
h) The concrete crosses are positioned and then the kicker / parapet forms and clamps are set in place
i) The holes for the ties and steel bars in the walls cast the day before are filled using concrete cones
j) The heating system is placed inside the forms and the vertical insulation panels are positioned
k) The set of platforms no longer used is moved to the next day's position
IV - POURING

ANNEX V
(Clause 2.4.2)

ASSEMBLY

ASSEMBLY

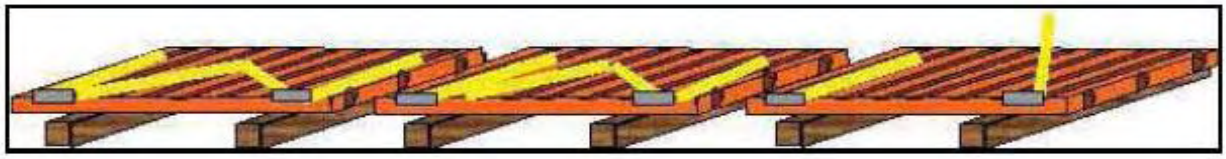
Upon its arrival on site, the equipment is loaded and stored

The panels are set on timber.

Unloading of the small packages with a Manitou and of the forms with a crane.

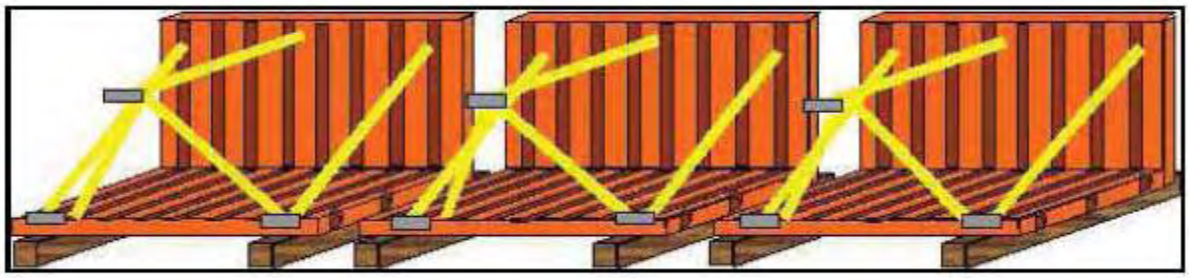
The verticals panels are set on the ground on timbers in the order of the packages. When there is enough room, all the equipment is spread out (speeds up greatly the assembly).

Some of the small equipment is supplied to the panels (positioning lugs, inclined hinged struts, triangulation), and their fixing begins.



Positioning lug bolted in place (N.B. this is a TMPH profile).

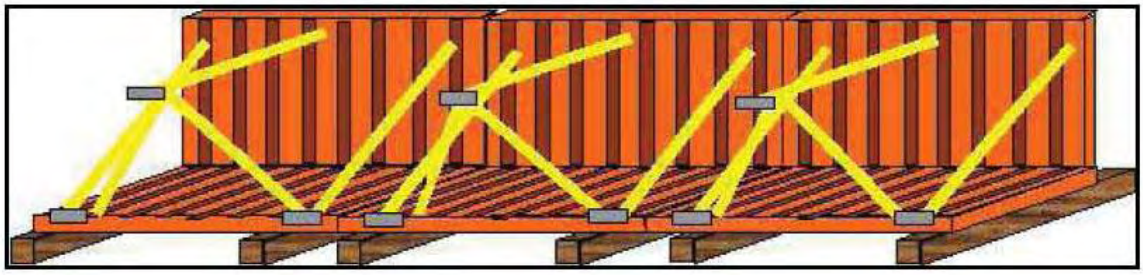
At about the same time, the horizontal panels are supplied one by one at the position of the vertical panels, and assembled.



Assembly of the horizontal panels.

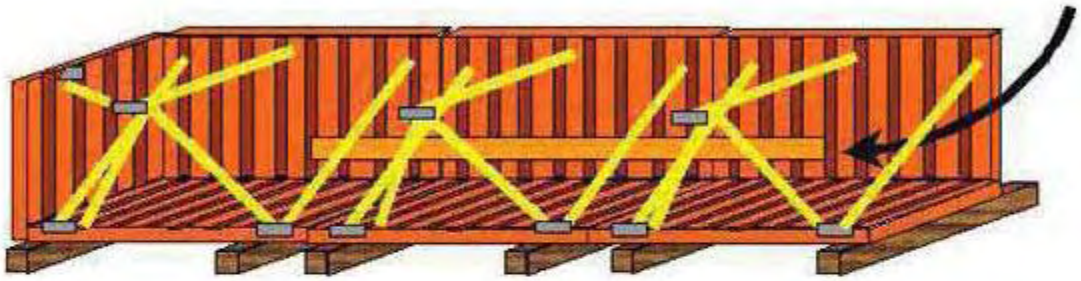
When there is enough room on site, all the forms are assembled at the same time.

The half tunnels are brought together and assembled. Either the assembly is permanent and the half tunnels are bolted together and some alignment fishplates are added in the profiles, or the assembly is temporary and swiveling ties are set in place and tightened.



The forms are brought close together. If the assembly is permanent, the forms are bolted together and some alignment fishplate are set in place and bolted in the lower and middle profiles.

6) **The lifting beam is supplied and bolted in place.**



Lifting beam for the lifting triangle.

7) **The tunnel packages are set vertical using a crane and the special assembly lifting rings. N.B. the lifting triangle is NOT USED to right the tunnel forms.**

The form is then righted...

...and set on its jacks.

8) The equipment for the hand rails is set in place.

The frames for the safety railings are set in place.

9) Once the assembly is complete and if time allows, a pre-assembly can be accomplished to check everything. This saves time during the first cycle.

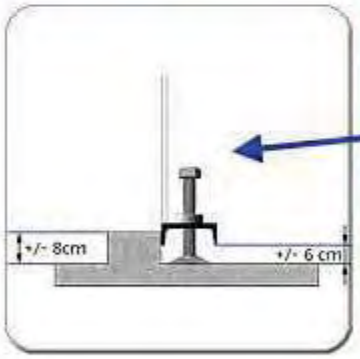
Tips: it is good to practice to write the number of the tunnel forms on both its ends, and also inside if the tunnel can be split for other modules.

When using conical ties, the forms are specialized (either male or female).

When there are many different lengths of ties, the plates without nuts and the head of their associated ties can be painted the same color.

ANNEX VI *(Clause 2.4.3.1)*

KICKERS



KICKERS (CURBS)

The kickers are short concrete walls, usually built at the same time as the slabs on which they lie, at the location of the future real-size walls

I - Roles of the kickers

The tunnel methodology relies on the use of the kickers. The kickers have several roles :

a) they guide the positionning of the forms
b) they facilitate the stripping of the forms
c) they provide a support on which to draw the level

a) Kickers to guide the positionning of the forms

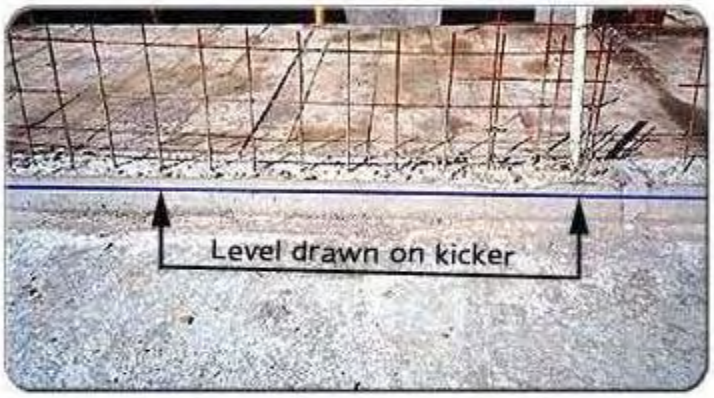
After the floor is cleared, the forms are brought in with the crane, and pushed against the kickers using crow bars. Later on, the bolting of the ties between the forms will ensure that they are properly set against the kickers.

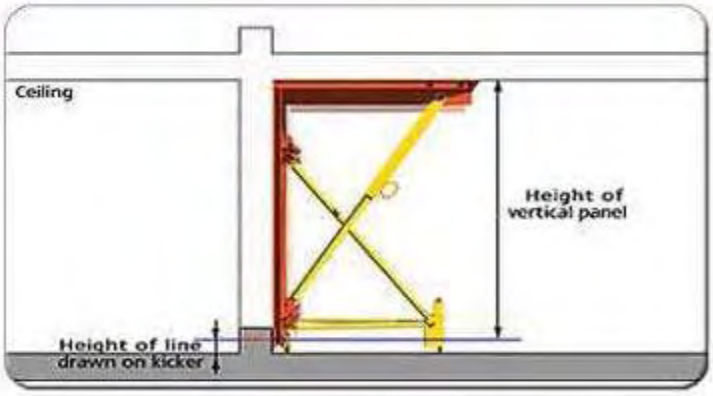
b) Kickers to facilitate the stripping of the forms

At the time of the pouring, the bottom of the vertical panel of the tunnel form is located a few centimeters above the slab level (typically 6 cm = 2,5 cm from bottom of form to bottom of wheel + 3,5 cm for the stripping of the form and lack of flatness of the slab). This allows the lowering of the form in order to strip it.

In general, the kickers are 8 cm tall (good practise). However, it is sometimes useful to make them taller, for instance when the ceiling in the building to be built is slightly higher than the one in the previous building (reuse of some tunnel forms with taller kickers).

KICKERS (CURBS)





c) kickers to draw the level

The kickers provide a support on which the level can be drawn. The line facilitates the adjustment of the forms : the bottom of the tunnel is simply set flush with that line by using the jacks.

The line drawn on the kickers corresponds to the height of the ceiling minus the height of the vertical panel (excluding wheels and jacks).

The level of the line on the kicker should not be directly measured from the slab (as the slab is not always very smooth) but rather materialized using a point of reference.

Chalk is generally used to mark the level.

KICKERS (CURBS)

II - Making of the kickers

The kickers are usually cast along with the slab, using kicker forms, concrete crosses,and some clamps. The kickers need to be vibrated and troweled flat and flush with the kicker forms to get a nice finishing with the tunnel forms.

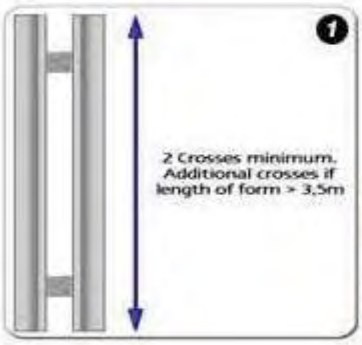
The concrete crosses are set in place along with the reinforcements. Then, once all the reinforcements are finished, the kicker forms are installed and held using the clamps.

The concrete crosses are positioned above the walls that are being cast, in between the forms, to hold the kicker forms (when the location of the walls is the same from one floor to the next).

There are 2 types of concrete crosses, some with 4 branches (**1**) and some with 3 (**2**), according to whether the cross is located in a middle wall, or at the end of the slab.

As the concrete crosses define the thickness of the walls and of the slabs, it is sometimes necessary to make crosses with branches of different sizes (when the walls superimposed and / or the slab have different thicknesses for instance).

KICKERS (CURBS)



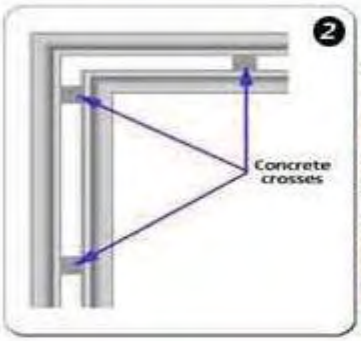
Number of concrete crosses

The number of concrete crosses is chosen so that the kicker forms are stable.

Typically :

1- one cross every 3,5m of kicker form

2- three crosses for an angle



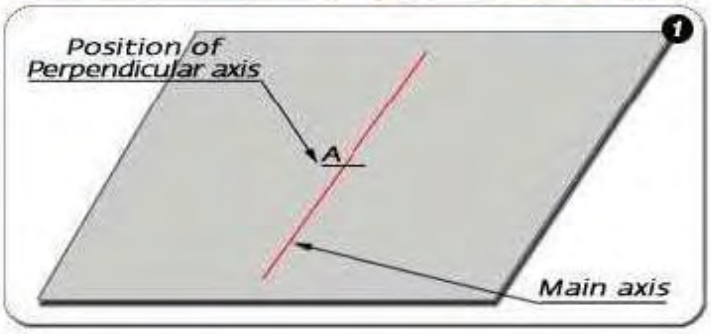
Making of the concrete crosses

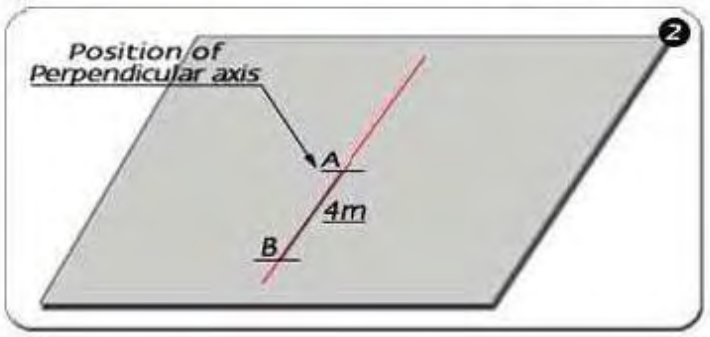
The concrete crosses are made using a mold and are cast every day.

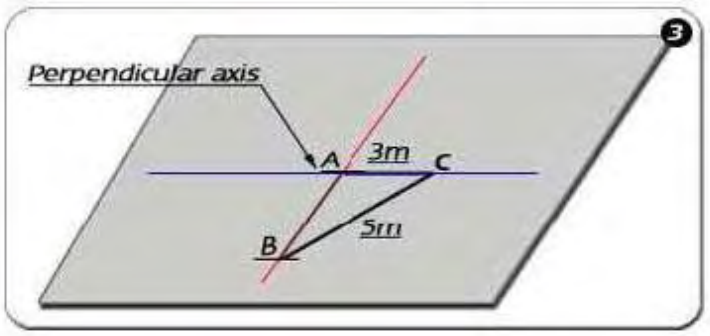
Both types of crosses (3 and 4 branches) are made using the same mold, by adding a piece of form inside the mold

3- The mold for the concrete crosses is scraped and oiled.

4- The mold is closed (casting position).







KICKERS (CURBS)

III - Foundation Kickers

With concrete crosses

When the foundation slab is cast in place, the foundation kickers are made in a similar manner as those for the floors above, using concrete crosses (held by small concrete slumps cast beforehand).

Without concrete crosses

However, if the foundation technique does not allow the use of concrete crosses, the kickers can be set on the slab without using crosses, providing a careful positionning

Rule of 3-4-5 to position accurately the kickers

When the main axis of the construction has been materialized, the perpendicular axis can be drawn using the 3-4-5 rule :

1- Draw the main axis along with the position of the perpendicular axis (point A)

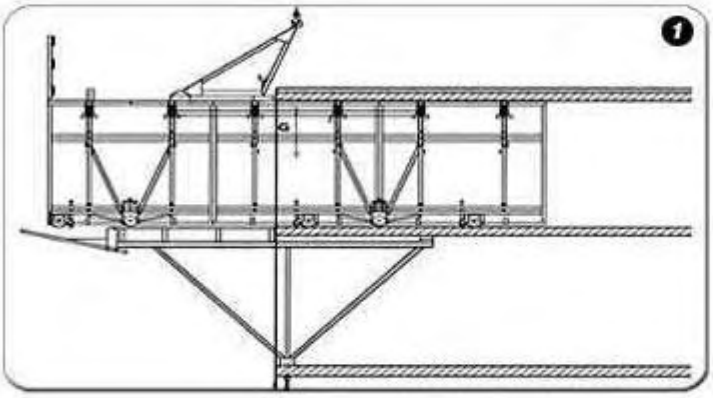
2- From A, materialize 4m along the main axis (Point B)

3- Find point C, which is 3m away from A, and 5m away from B. AC gives the perpendicular.

Remark :
This rule works for all multiples of 3,4 and 5, and all units.

Example :
(30cm, 40cm and 50cm)
(60cm, 80cm, 1m)
(30°, 40° and 50°), etc.

ANNEX VII *(Clause 2.4.4.2)*

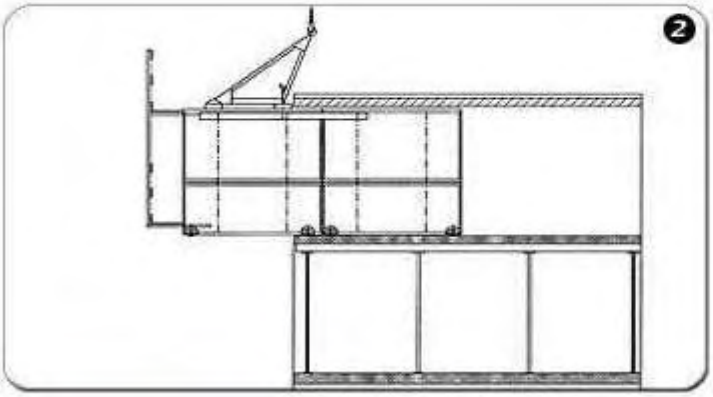


HANGING OF THE FORMS TO THE CRANE

The asymmetrical triangle is used :

1- with stripping platforms

2- without stripping platform, for buildings up to 3 story high without staggers between spans, and with tunnelform packages longer than 2.5 m.

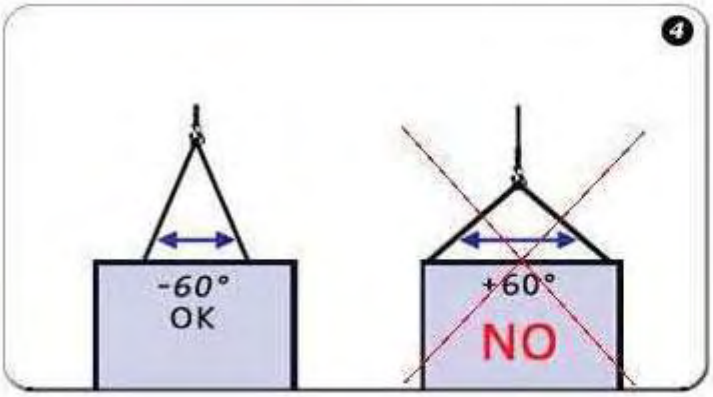


Remark :

When the length of the package is too small (1,25 m), the lifting triangle can no longer be used. Some lifting hooks are then incorporated to the package so that it can be lifted with chains.

Additional wedge on lifting triangle

3- For packages of 2,50 m, an additional wedge is added to the lifting triangle.



II - Movement of forms

The forms can be lifted by the crane, via some cable or chains.

4- The greater the angle of the chains, the bigger the load in the chains and in the lifting rings. The angle made by the chains should never be greater than 60°.

ANNEX VIII *(Clause 2.4.5)*

INITIAL STRIKING OPERATION

1- *The curtains are opened and the heaters removed*

2- *The kickers are stripped*

3- *The opposit slab stopend is removed and supplied to the other side*

4-5 *The roof locks are opened*

6- *The ties are removed*

7-8 *The jacks are raised until the halftunnel rests on its wheels*

9- *If the form sticks to the concrete, the "clic-clac" system of the struts is opened, thus lowering the horizontal panel ...*

10- *..., this in turn removes adhesion, and the form drops on its wheels. The "clic-clac" is closed again.*

ANNEX IX *(Clause 2.4.6)*

SETTING IN PLACE

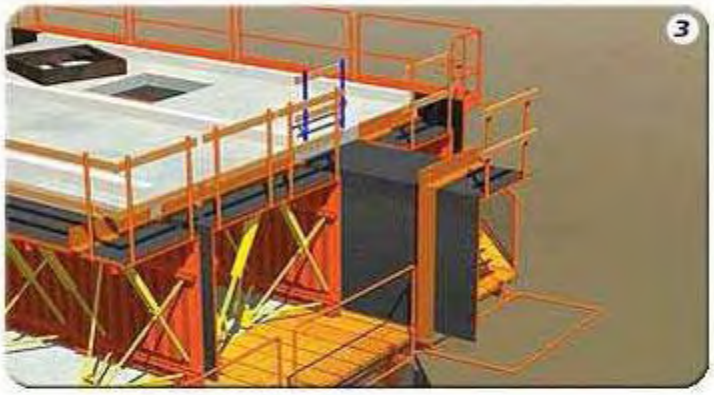
1- The level of the bottom of the vertical panel of the half tunnel is drawn on the kickers

2-3 The half tunnel is pushed out through the facade

4- The form is scraped...

5- ... and oiled

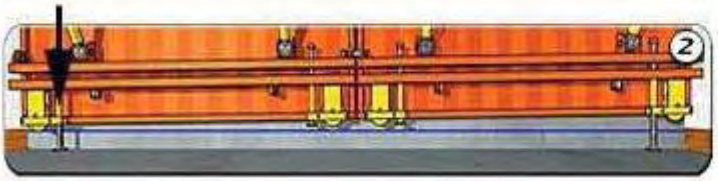
6- The lifting triangle is bolted

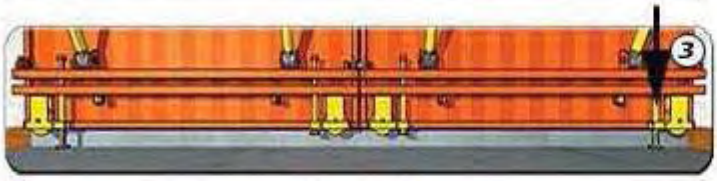


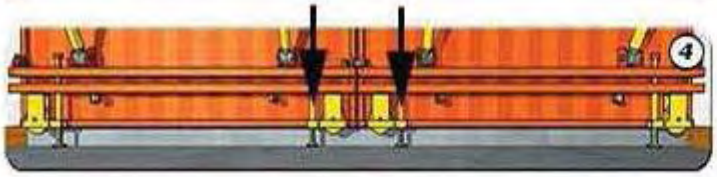
7- The half tunnel is completely pulled out

8- The slab that was stripped is propped

SETTING IN PLACE







1-5 *The tunnel form is set down on the last jacks on the slab*

2-3 *The bottom of the vertical panel is set flush with the line drawn on the kicker*

4- *The other jacks are lowered to the slab*

6 - 7 - 8 - 9 *The verticality of the half tunnel is adjusted by turning the triangulation jack bolt The reference is given by a plumb line on magnetic support.*

SETTING IN PLACE

1- The 2nd half tunnel is pushed out and the lifting triangle bolted

2-3 The 2nd half tunnel is brought in front of the first one

4- As it was done for the first tunnel form, the triangulation wheels are lowered, along with the extreme jacks

5- The tunnel form is set on the slab, the bottom of the vertical panel is set flush with the line drawn on the kicker, and the other jacks are lowered

6- The verticality of the half tunnel is set using the triangulation jack

7- The horizontal panel of the first half tunnel provides an easy mean of checking the verticality of the second half form

8- The roof locks between the forms are bolted

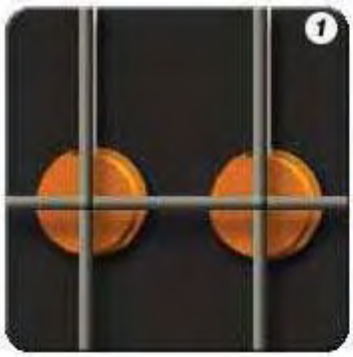
SETTING IN PLACE

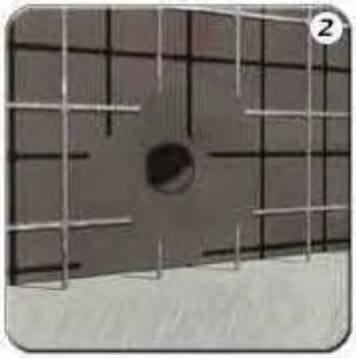
1- *The tunnel form is brought above its next position*

2-3 *While the tunnel form is still in the air, the triangulation wheels are lowered*

4-5 *The jacks at the extremities of the tunnel form, and that will rest on the slab are lowered*

6- *The tunnel form is lowered on the jacks, and the lifting triangle is unbolted*





SETTING IN PLACE

1- *The electricity is integrated into the walls*

2- *The wiremesh is prepared for the ties and plastic cones*

3- *The ties are inserted partway into the tie-holes*

4- *The plastic cones are installed on the ties ...*

5- *... and the tips of the ties are set flush with the ends of the cones*

6- *The door blockouts and wall stopends are set in place*

7- *The door blockout is leveled using the plumb line*

8- *The wall stopend is leveled using the plumb line*

SETTING IN PLACE

1- *The ties are completely tightened*

2- *The triangulation wheels are raised*

3- *The concreting starts with the inside walls*

4- *The external walls are then poured*

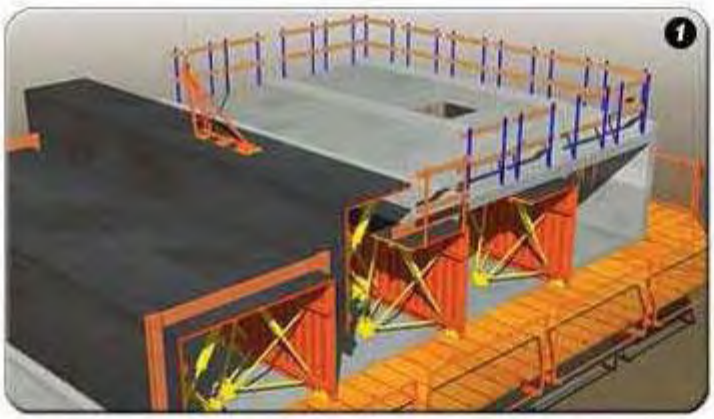
5- *Finally, the slab is poured with the kickers, starting from the cold joint*

6- *The slab is surfaced with a straight edge sliding on the kicker forms*

7- *The plastic curtains are closed*

8- *The heaters are started*

SETTING IN PLACE



1- *The tunnel form is lowered through the gap*

2- *The bottom of the vertical panel is set flush with the line on the kickers using the jacks*

3- *The verticality of the half tunnel is set using the triangulation wheel*

4- *The roof locks are bolted*

5- *The ties are pushed completely through the tunnel forms ...*

6- *... and loosely bolted on the other side*

7- *The slab is scraped and oiled*

8- *The slab stopends are set in place*

SETTING IN PLACE

1- *The wallform is hung to the crane and stripped*

2- *The wall form is scraped and oiled*

3- *The wallform is set in place*

4-5 *The jacks are lowered, thus pushing the wallform against the half tunnel, and the form is unhooked*

6- *The concrete crosses are set in place at the location of the walls*

7- *The kicker forms are installed on the concrete crosses*

ANNEX X *(Clause 2.4.7.2)*

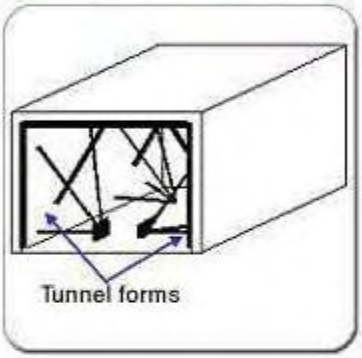
PROPPING

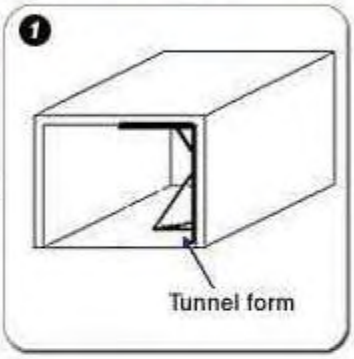
I - Propping of the slabs

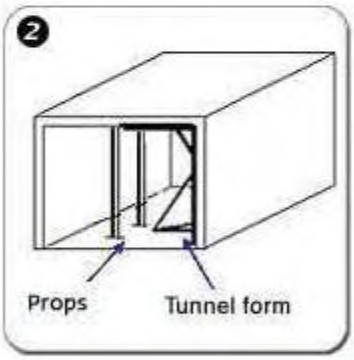
When using tunnel forms in a daily cycle, the concrete has little time to dry, even though the setting of the concrete is accelerated (by heating and/or using an accelerator). Thus, it is necessary to set some props in place as soon as the first tunnel is removed, to prevent deflection.

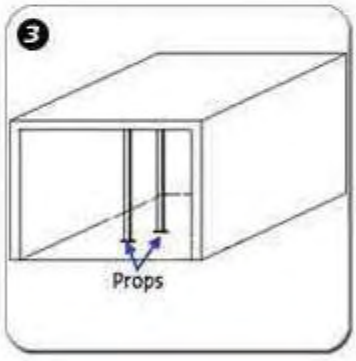
The position and number of props is dictated by :
- the concrete strength,
- the architecture of the structure
- the loads applied on the structure.

Typically, one prop every 2 m of tunnel is sufficient for a regular width.









Propping methodology :

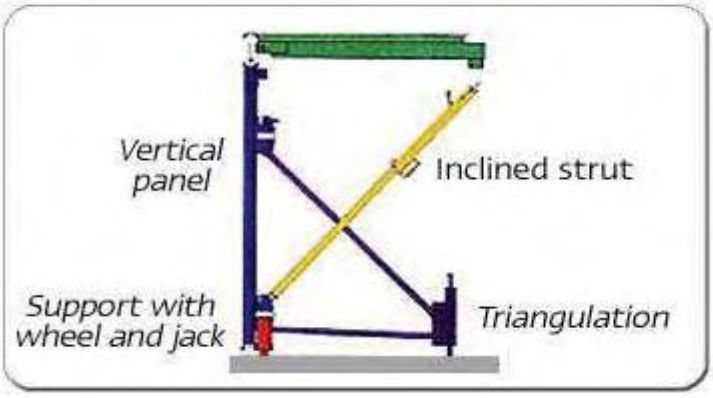
1- the first half tunnel is stripped;

2- the slab is propped while the second half tunnel is still in place;

3- the second half tunnel is stripped once the slab is propped.

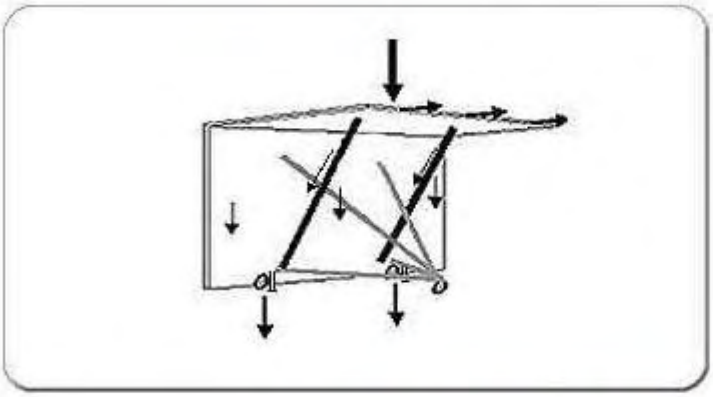
The props stay in place for several days. It is good practise to leave the props in place two floors below the one where the forms are set, so that the concrete reaches a sufficient strength.

PROPPING



II - Transmission of the load by the half tunnel forms

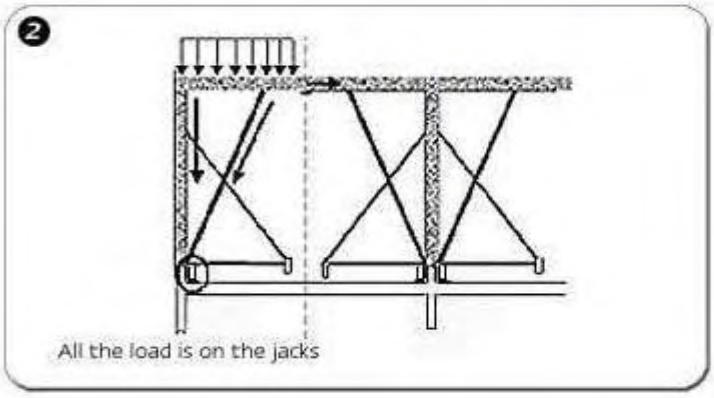
Once the roof locks are bolted, most of the load is transmitted to the jacks close to the tunnel wall.



Raising the triangulation wheels insures that no load at all is exerted on the middle of the slab : all the load is directly transmitted to the walls below.

Since all the weights are concentrated on the jacks, it should be checked before pouring that those jacks have been lowered to the ground.

1- The triangulation wheels must be raised before pouring



2- The jacks close to the tunnel wall must be lowered

ANNEX XI *(Clause 2.4.8.4)*

TIES

The forms are held together using steel ties.

There are 2 types of ties:
1- "standard" ties
2- conical ties

The ties are designed to take the force resulting from the pressure of the concrete on the forms, via the horizontal beams.
The number of ties depends on the length of the form.
There are 2 ties on the height of the tunnel form.

3- Insertion of tie.

2 ties on a vertical plan

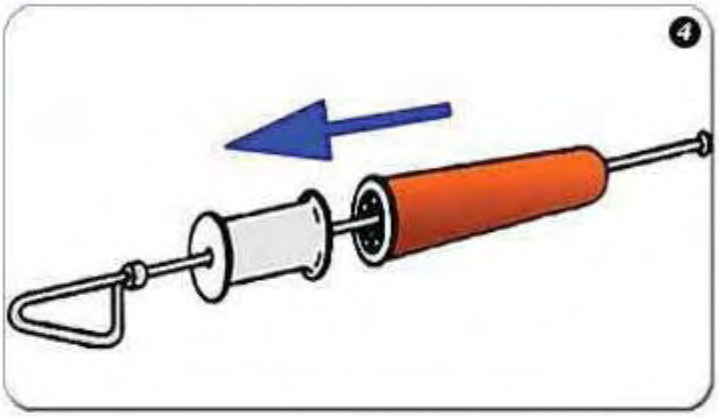
I - Standard ties

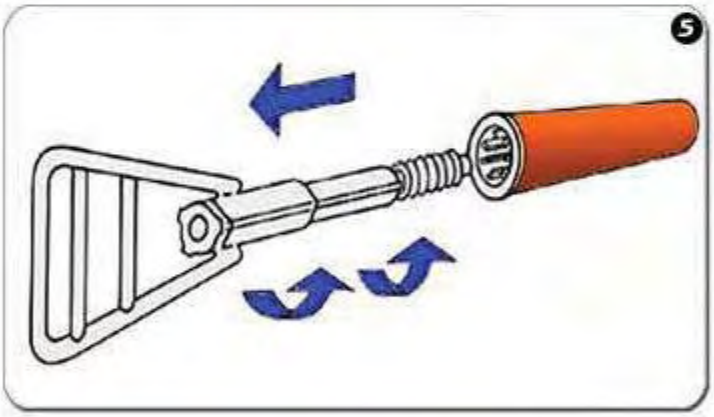
4- Bolt that does not turn when tightening the tie (Square end that goes inside the beam and prevents rotation).

5- Bolt that is turned to tighten the tie (Round end that turns inside the beam and allows tightening).

TIES

Plastic cones are used to protect the "standard ties" in order to strip them. Those cones are also used to set the thickness of the walls. They are put in advance on the ties that are partially inserted in the forms. The tip of the tie is then set flush with the end of the cone.





1- *Standard tie partially inserted*

2- *Plastic cone flushed with tie*

Different methods are used to remove plastic cones :

3- *removal using a hammer*

4- *Cone extractor with mace*

5- *Cone extractor "corkscrew"*

II - Conical ties

The conical ties are only theaded close to the tip. The rest of the tie is smooth and conical, so that it can be stripped. This removes the need for plastic cones. Furthermore, the conical tie is tightened in one operation. The thickness of the wall is set by the length of the tie once it is completely tightened.

The conical tie is used along with 2 plates that are bolted to the forms :
- a plate with nut
- a plate without nut
The plate without nut is bolted on the side where the tie is inserted, and the plate with nut on the other side, where the threaded part enters the nut.
Both plates are bolted to the forms from the start.

TIES

III - Concrete cones

Both types of ties leave some holes in the walls (small ones with the conical ties, and bigger ones with the plastic cones of the standard ties).

Those holes have to be filled using concrete cones once the forms are stripped :

1- *Concrete cones for conical ties.*

2- *Concrete cones for standard ties.*

3- *Mold to cast the concrete cones on site (at least one pour everyday)*

Installation advice :

The hole must be cleaned with no trace of grease.

a) *Dampen the hole and the concrete cone, especially in hot and dry weather.*

b) *Make a plastic mortar : Excess water damages the quality of the setting mortar.*

c) *Bard the concrete cone and hole with setting mortar or resin.*

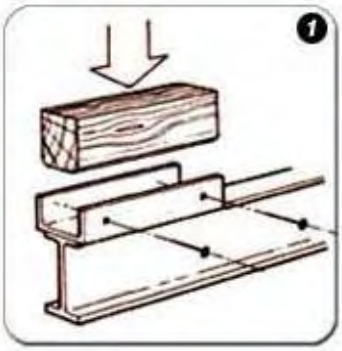
d) *Insert the barded concrete cone in the hole with a rotating movement.*

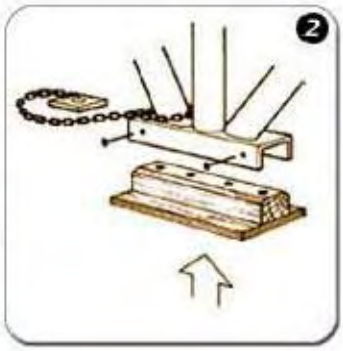
e) *Position the concrete cone by tapping lightly on the large end.*

f) *Carry out the surface fitting with mortar or resine.*

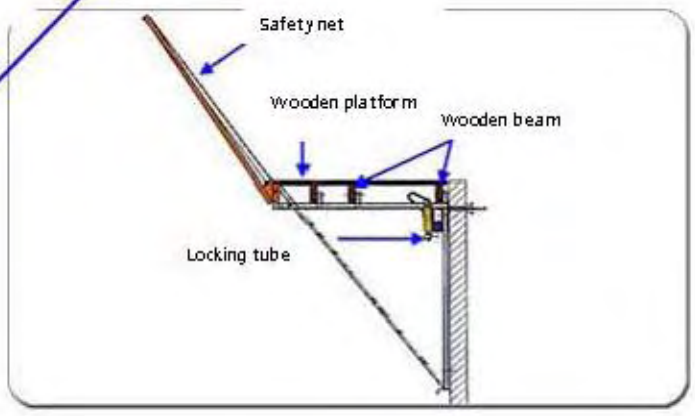
1- Wooden wedge at the top

2- Wooden wedge at the bottom and steel chain and plate





Gable shoe tied into the wall (CP3 type)



PROTECTION PLATFORMS

Once the platform is in place, the side jacks are unscrewed in order to prevent the platform from moving sideways.

Furthermore, the platform should be properly set in place using wooden wedges at the top and bottom, and should be secured at its bottom using either a supplied steel chain with a plate that is fixed to a tie hole, or using a prop.

II – Gable wall scaffolds (CP5 type)

The gable wall scaffolds are used to support the gable wall forms. They are fixed on gable shoes.

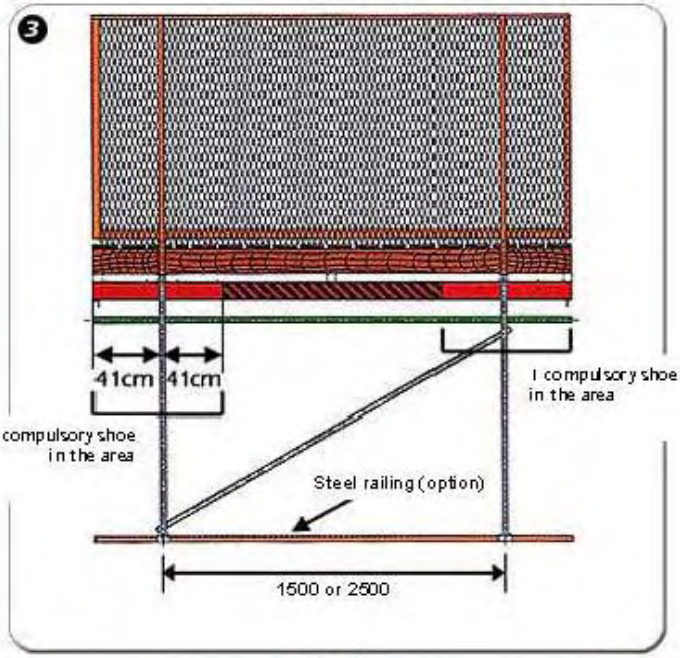
Some holes are left in the upper part of the gable walls for the gable shoes of the next level. Once the scaffold and the shoes have been removed, the holes are filled with concrete cones.

PROTECTION PLATFORMS

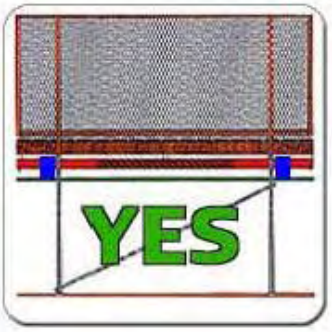
1- Every time part of a level is finished in concrete, the gable wall scaffolds are raised to the next level.

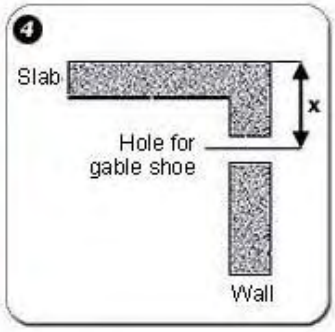
2- The gable shoes are sometimes located above or besides an opening in the façade. When this is the case, the lintel should be properly reinforced, and minimum distances must be respected.

Position of the gable shoes on the gable wall scaffold:



3- There is at least on shoe per steel frame, located within 41 cm left or right of the frame axis. The forbidden zone is marked with paint.





4- When possible, the holes for the ties are also used to fix the gable shoes. To do so, the distance x from the hole axis to the top of the slab above should be comprised between 35 and 55 cm.

PROTECTION PLATFORMS

III – Circulation platforms

When there is no wall to be cast and it is still necessary to have access, a circulation platform can be set in place. There are basically 2 types of such platforms:

1- 'horse-head' platforms that are attached to the edge of the slab

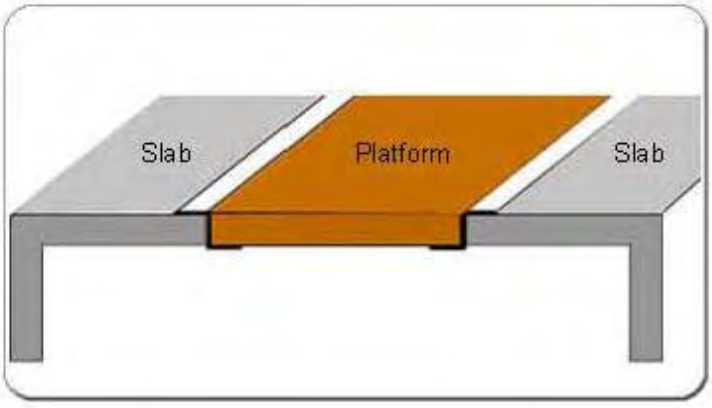
2- 'V' shaped platforms, that transmit the loads to the slab below via inclined struts.

IV – Platforms on slab openings

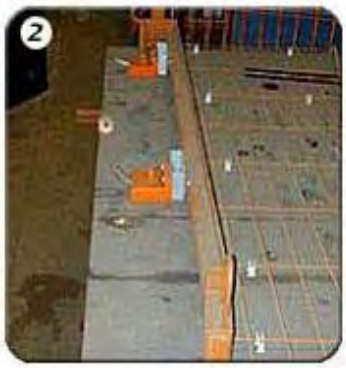
It is often necessary to fill holes in the slab, to enable people to work on it. A special platform can be set in place for that purpose.

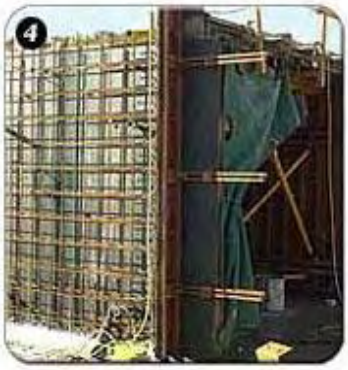
3- platform held by steel U profiles, resting on steel rods going through the walls ;

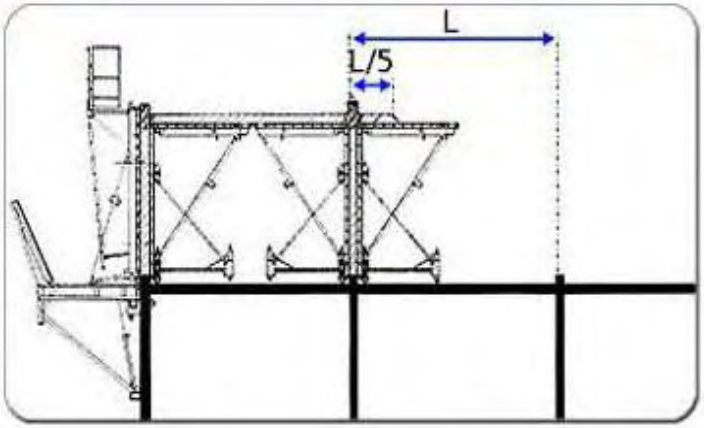
4- platform held by steel Z profiles resting on the slab.



The platform is made of steel frames that are supplied to the site, and timber (charge of client).







CONCRETING

A – STOPPING OF THE CONCRETE (SLAB AND WALL STOP-ENDS, COLD-JOINT)

The concrete is stopped by using slab stop-ends on the horizontal panels and wall stop-ends on the vertical panels. However, it often happens that the whole slab cannot be cast the same day. In this case, temporary stop-ends have to be installed, allowing the reinforcement steel to pass.

I – Slab stop-ends

The slab stop-ends are used to stop the concrete at the perimeter of the slabs.

They are generally bolted to the forms **(1)**, but they can also be held in place using magnets **(2)**. Many shapes can be designed, for balconies for instance (curved slab stop-end on picture **(3)**).

II – Wall stop-ends

The wall stop-ends are bolted to the form and used to stop the concrete at the extremities of the walls **(4)**.

They can be linked to narrow horizontal strips, in order to make full height openings **(5)**.

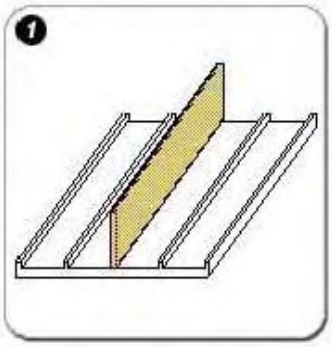
III – Cold-joint

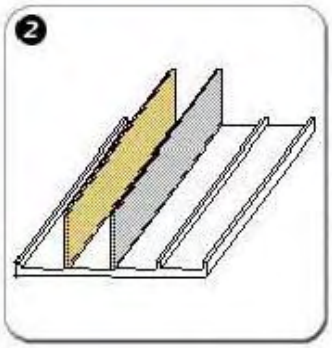
A large floor is typically divided into several phases and the same equipment is re-used for each phase. In order to do so, the half tunnel form located at the intersection of the phases stays in place during the concrete pour, creating a cold-joint. 1/5 of the span is poured during the first phase, and the remaining 4/5 are poured subsequently.

I – Window box-out (1)

The setting in place of a window box-out using magnets can be decomposed as follows:

1) The position of the box-out is drawn on the form, the wire mesh has been cut beforehand
2) Some magnets are set on the lintel line minus the thickness of the box-out
3) The box-out is assembled on the ground and positioned on the lintel magnets
4) Some magnets are set on the side of the box-out to prevent it from moving sideways
5) The magnets are bolted (or nailed) to the box-out.





B – WINDOWS AND DOORS BOX-OUTS

In order to form the windows or the doors, some box-outs are used. Those box-outs can be held using magnets, or can be bolted to the form.

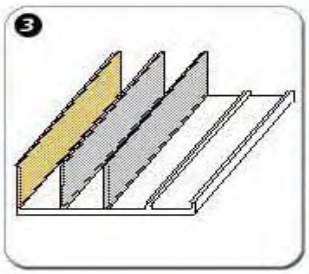
II – Door box-out (2)

The setting in place of a door box-out using magnets can be decomposed as follows:

1) The position of the box-out is drawn on the form, the wire mesh has been cut beforehand
2) The box-out is assembled on the ground and the magnets are bolted (or nailed) to it, with the magnet handles raised (so that the magnet does not adhere to the form)
3) The box-out is raised against the form and leveled using the bottom jacks
4) Once the box-out is in place, the magnets handles are lowered.

C – ORDER OF POURING (3)

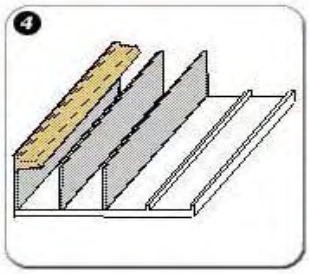
The concrete is poured so as to stabilise the tunnels. Typically, the internal walls are first poured (walls with half tunnel forms on both sides), then the external walls **(4)**, and finally the slab and the kickers **(5)**. The gable wall must not be poured first.

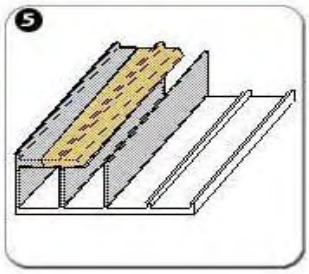


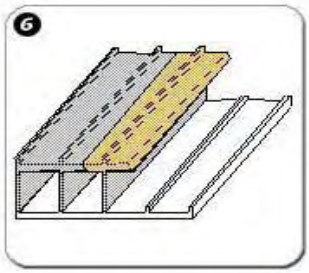
CONCRETING

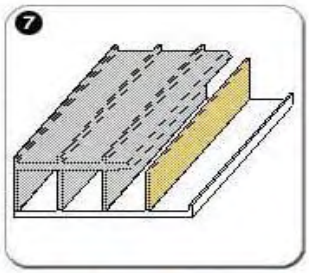
These operations are repeated for each row of tunnelform.

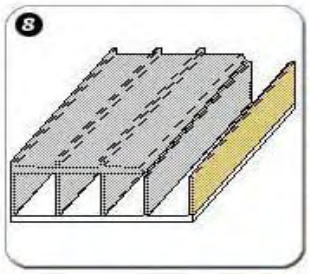
When pouring the walls, it is good practise to stop the concrete slightly before reaching the level of the slab. This leads to a better finishing of the slab, especially if the concrete sets rapidly.

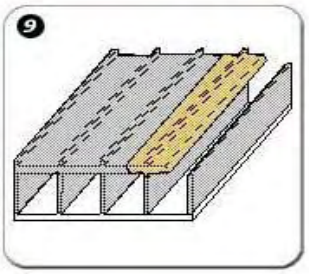


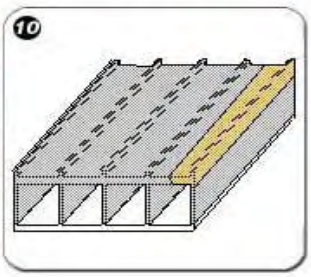












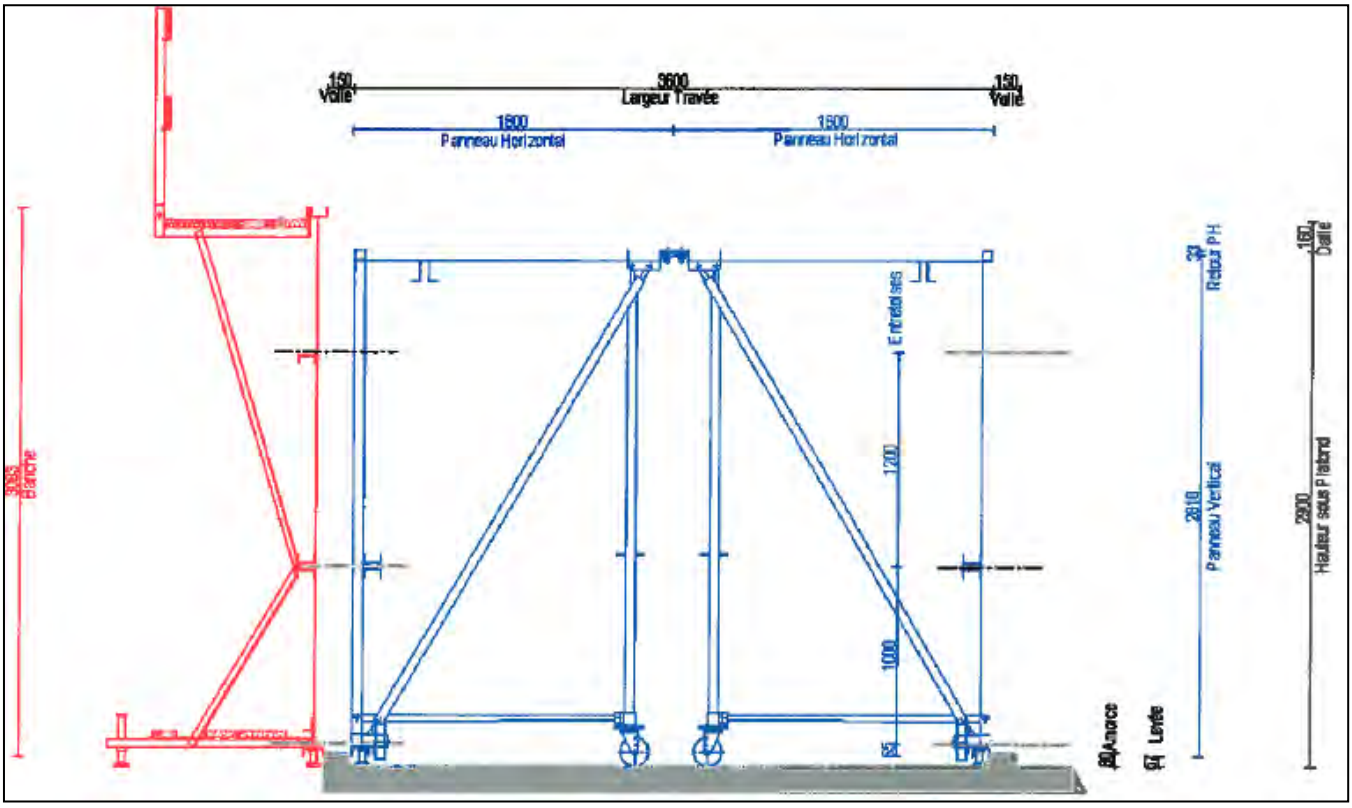
ANNEX XIV
(Clause 2.2.3)

DESIGN CRITERIA

1) PURPOSE OF THE NOTE

To study the behaviour of the profiles constituting the tunnel formwork shown hereinafter, when faced with the usages that they are subject to.

Schematic representation of the studied units:



Geometry of the profiles constituting the formwork

Hypothesis

Data: Permissible load of the formwork: P permissible = 7.2 T/m^2
Volume density of the concrete: P concrete = 2400 kg/m^3

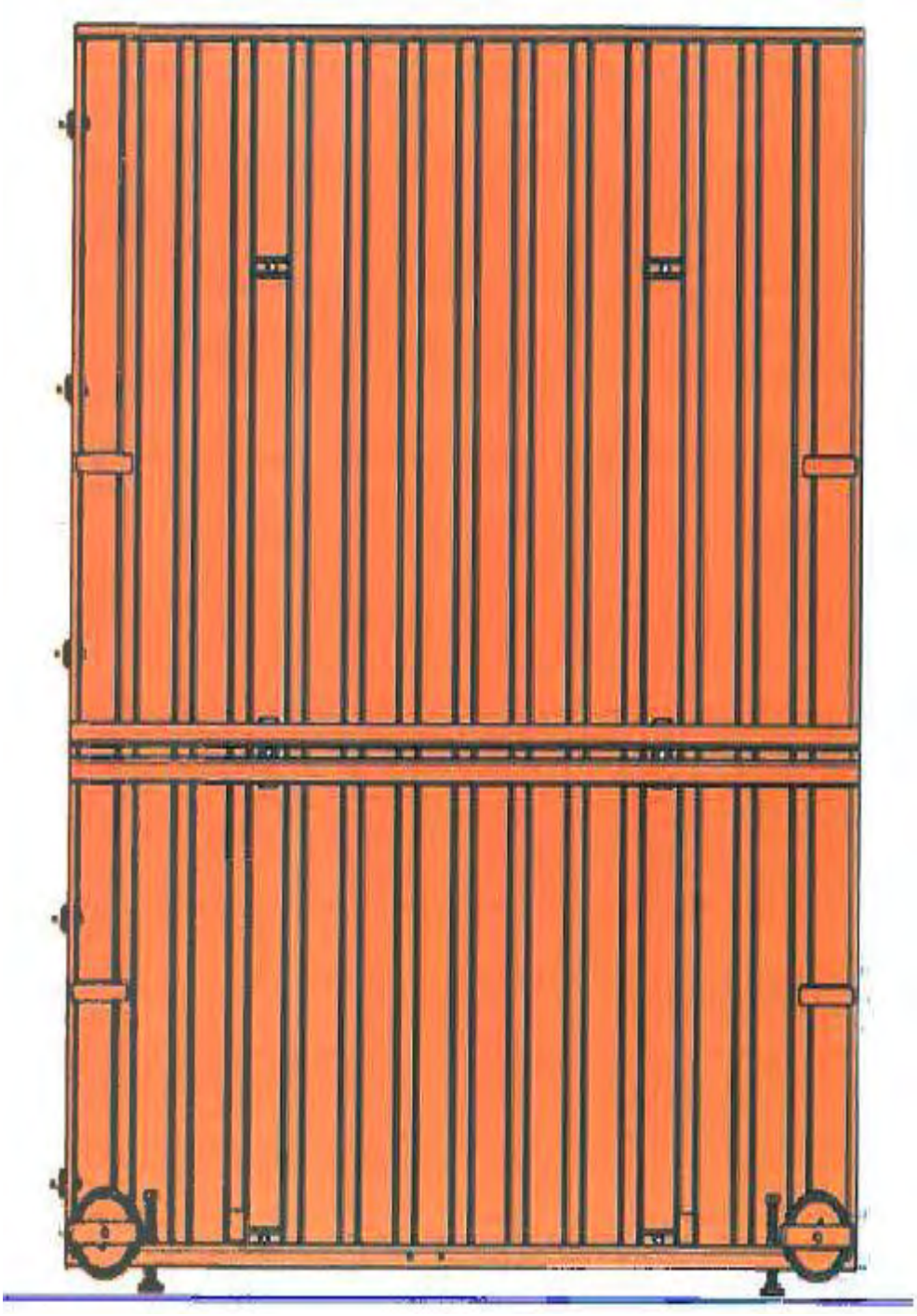
In addition, the UPF profiles are dimensioned while taking into account the thickness of the form sheet. Therefore, the load will be borne by these components.

Note: The calculations are performed on the RDM Le Mans software which uses a calculation code by the finite element method. The principle of uses

consists of discretizing the element to be verified (Geometry, property of the material etc.) and after the calculation, modelling the applicable loading case as well as these cases to the boundary conditions.

2. VERIFICATION OF THE VERETICAL PANEL

The vertical panel comprises: 1 formwork sheet (3 mm thick)
13 hat sections (60 x 50 x 2)
1 UPF (120 x 50 x 5) at the lower part of the panels
1 twin UPF (100 x 50 x 5) in the intermediate part
2 spacer reinforcements at the upper part
1 UPF (60 x 30 x 4) at the upper part

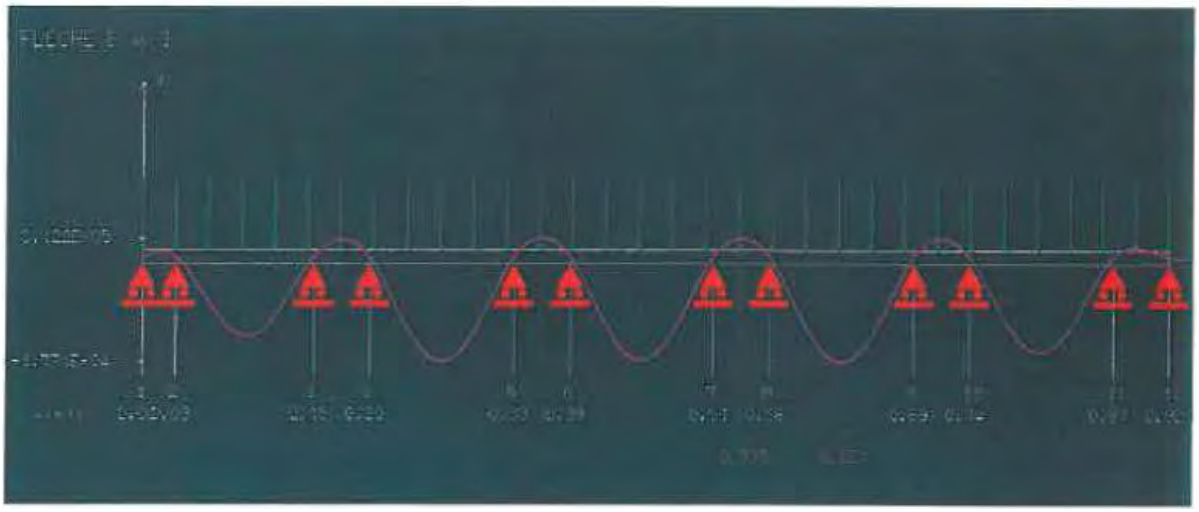


2.1 Characteristics of the sheet, with thickness 3 mm for 1 metre

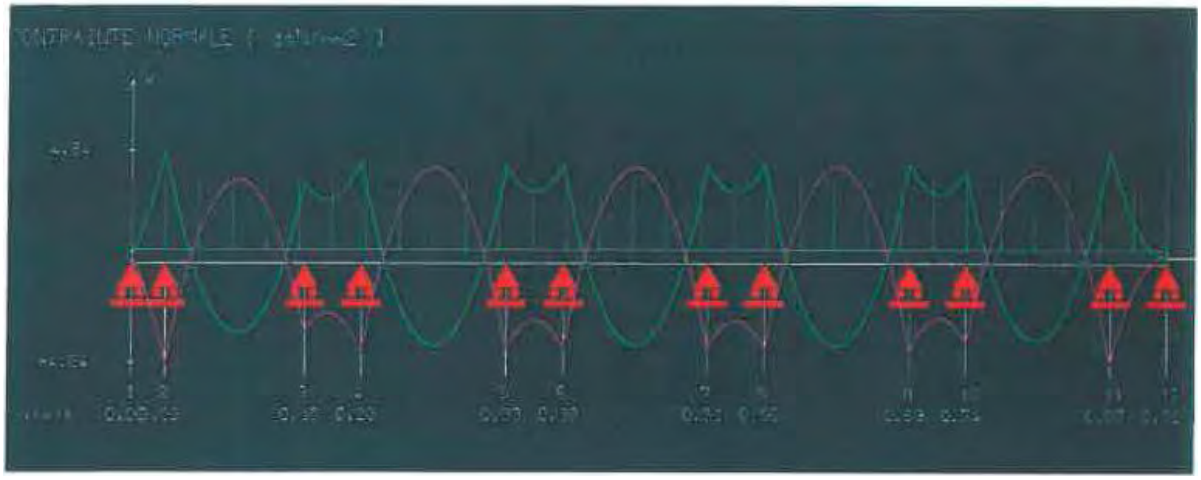
Section S = 30 cm^2 Inertia I = 0.225 cm^4 Section module I/v = 1.5 cm^3

Each stiffener (hat sections 80 x 50 x 2) = 2 supports.
The panel will be examined with a standard pitch of 179 mm.

The sheet will be calculated with a uniformly distributed load equal to the maximum pressure of 7200 daN/m2



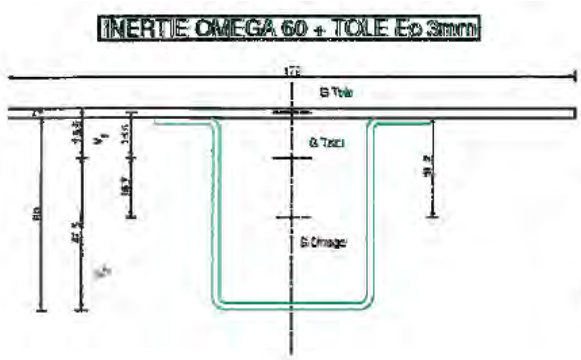
Deflection on the sheet (3 mm thick) = 0.18 mm



σ = 4.9 daN/mm2

2.2 Characteristics of hat section 60 + sheet (3 mm thick)

Inertia of hat section 60 + sheet (3 mm thick)



	Section	x	Sx
Tole	534	1.5	801
Omega	397.8	34.2	13604.76
TOTAL	931.8	15.46	14405.7

$$= \frac{14405.7}{931.8}$$

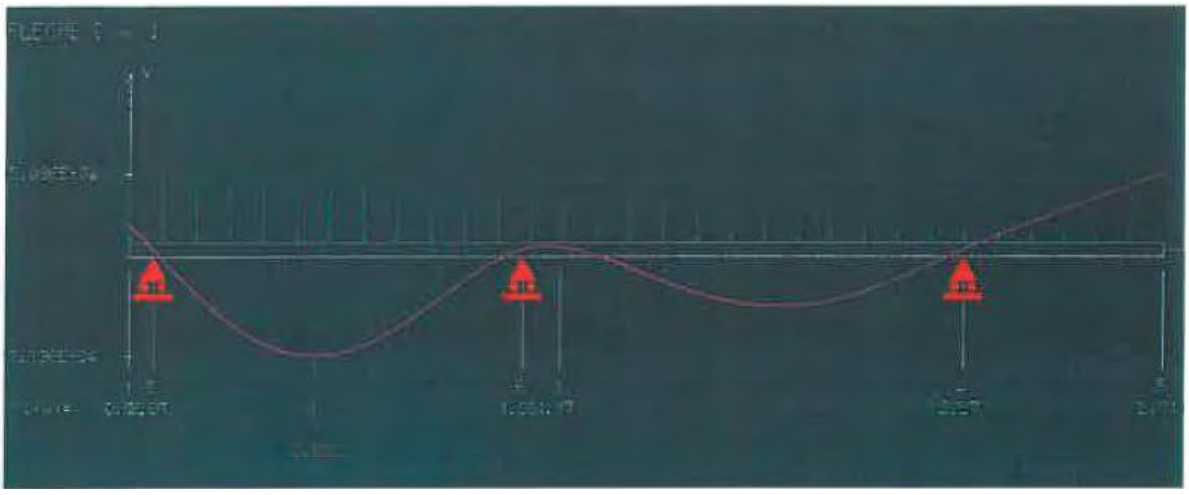
$$I = \frac{bh^3}{12} + I_{Omega} + S_1 d_1^2 + S_2 d_2^2$$

$$I = \frac{17.8 \times 0.3^3}{12} \quad 20.36 \quad + 5.34 \times 1.4^2 + 3.978 \times 1.87^2 = 44.77 cm^4$$

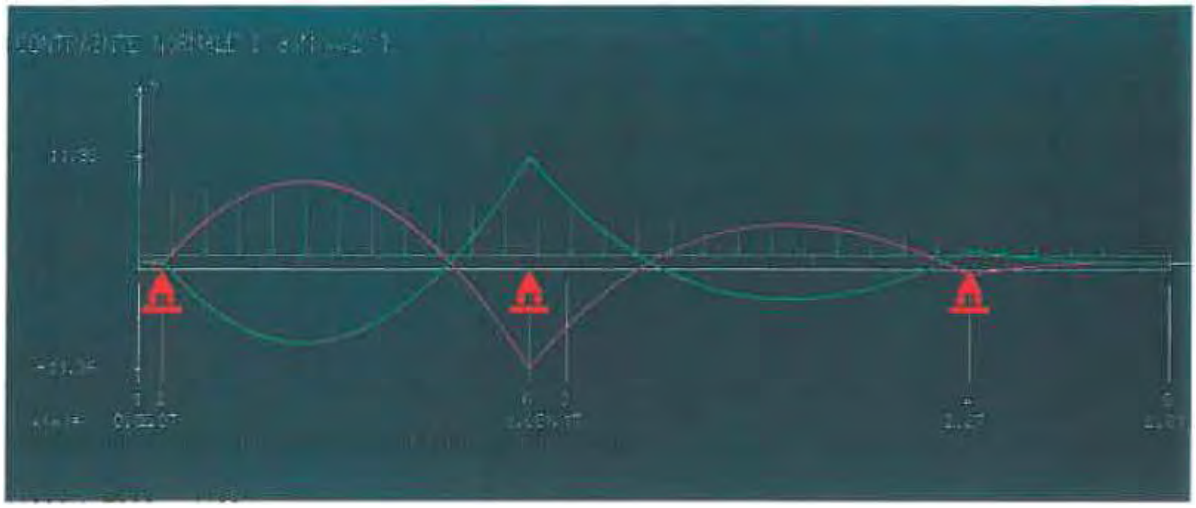
$$\frac{I}{v_2} = \frac{44.77}{4.75} = 9.42\ cm^3$$

Calculation of the pressure reported at the unit of length (179 mm), which is exerted at the base of the hat section.
P base = 7200 x 0.179 = 1289 daN/m
Loading:
Hydrostatic pressure at height

Conditions at the limits:
Simple supports at the three anchor points defined by the spacer pins.



Deflection on the sheet (3 mm thick) + hat section (60 mm) = 0.72 mm at 502 mm from the bottom.

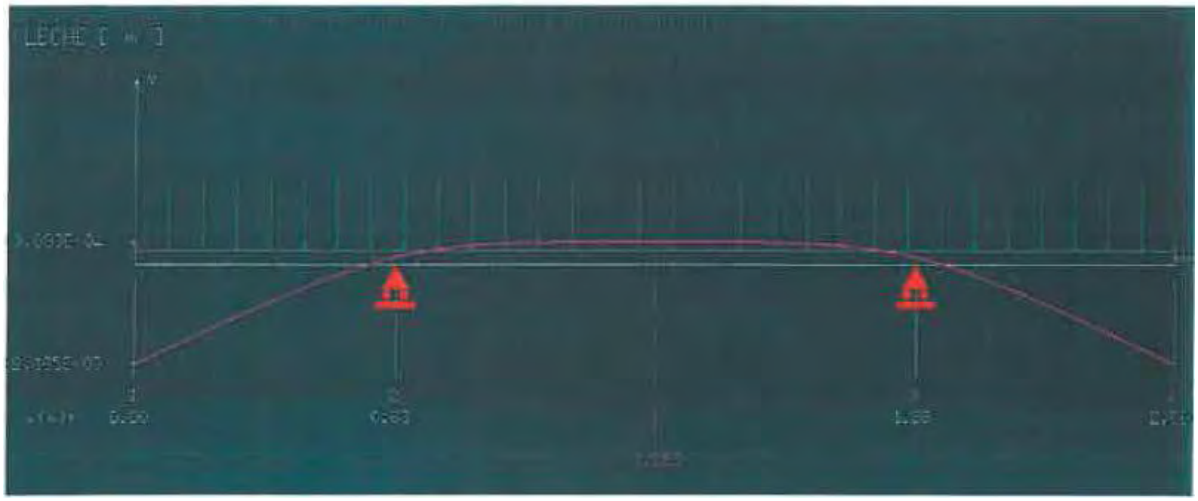


σ = 11.4 daN/mm2

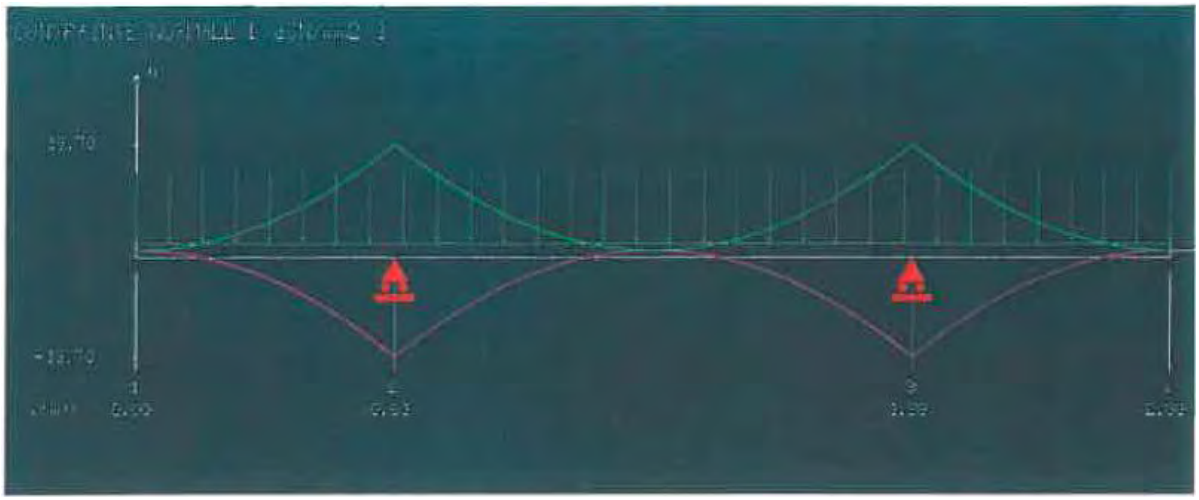
Actions at the connections: Node no. 2 = 2970 daN
Node no. 4 = 1393 daN
Node no. 6 = 5754 daN

2.3 Verification of the twin stringers

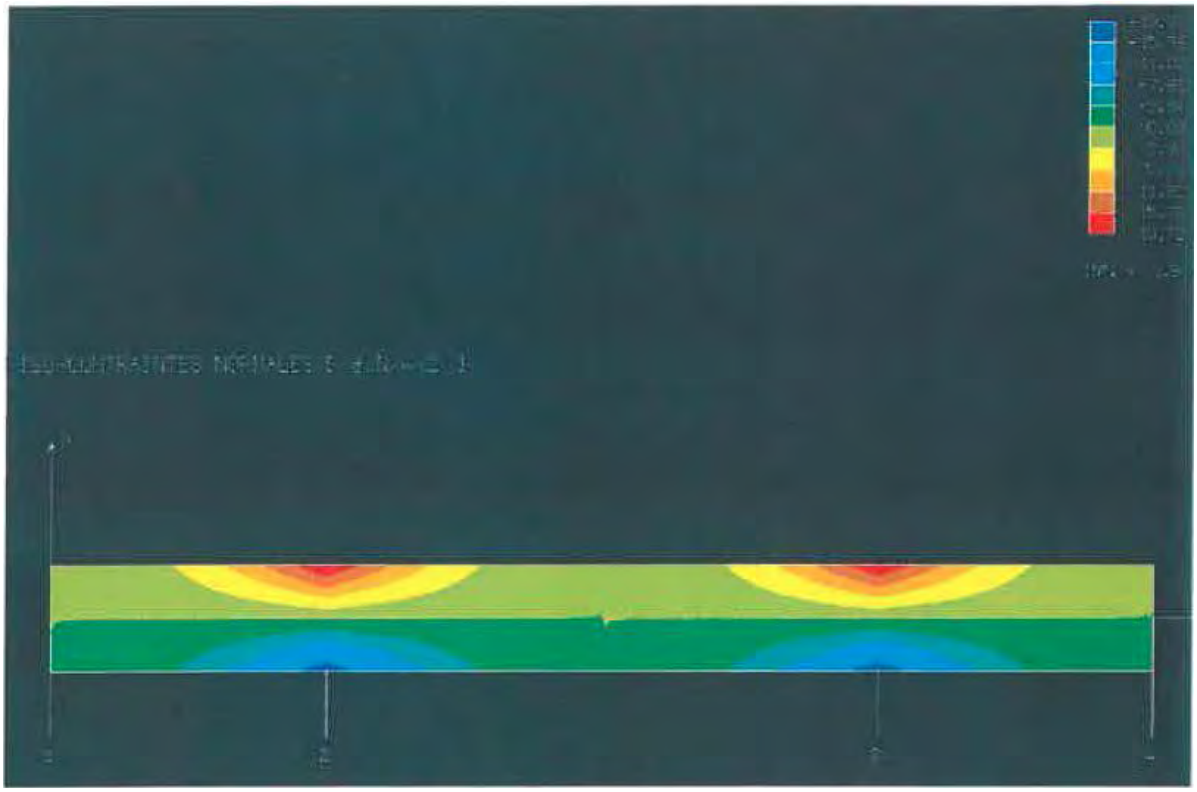
Characteristics of the sheet (3 mm thick) + 2 UPF (100 x 50 x 5) separated by 60 mm:
Section S = 21.06 cm^2 Inertia I = 563.23 cm^4 Section module I/v = 57.06 cm^3
Effectively, at a height under consideration, the pressure exerted on the associated horizontal plane remains constant throughout this level. This induces a uniformly distributed pressure on the UPF.
This time also, the problem may be related in the plan.



Deflection on the stringer = 2.2 mm

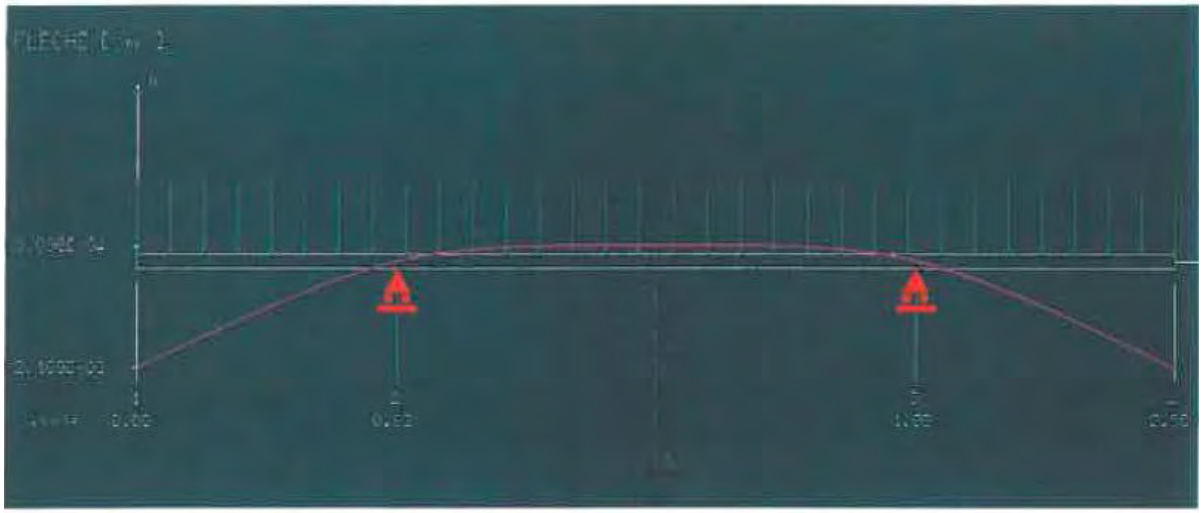


σ = 19.7 daN/mm2

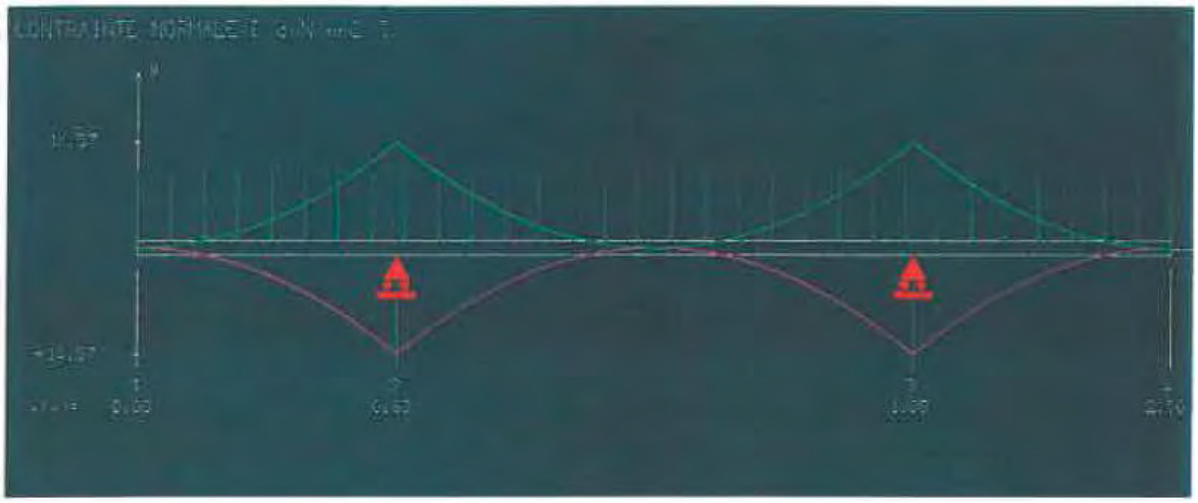


2.4 Verification of the bottom profile

Characteristics of the sheet (3 mm thick) + 1 UPF (120 x 50 x 5):
Section S = 12.88 cm^2 Inertia I = 290.25 cm^4 Section module I/v = 39.81 cm^3



Deflection on bottom profile = 2.2 mm

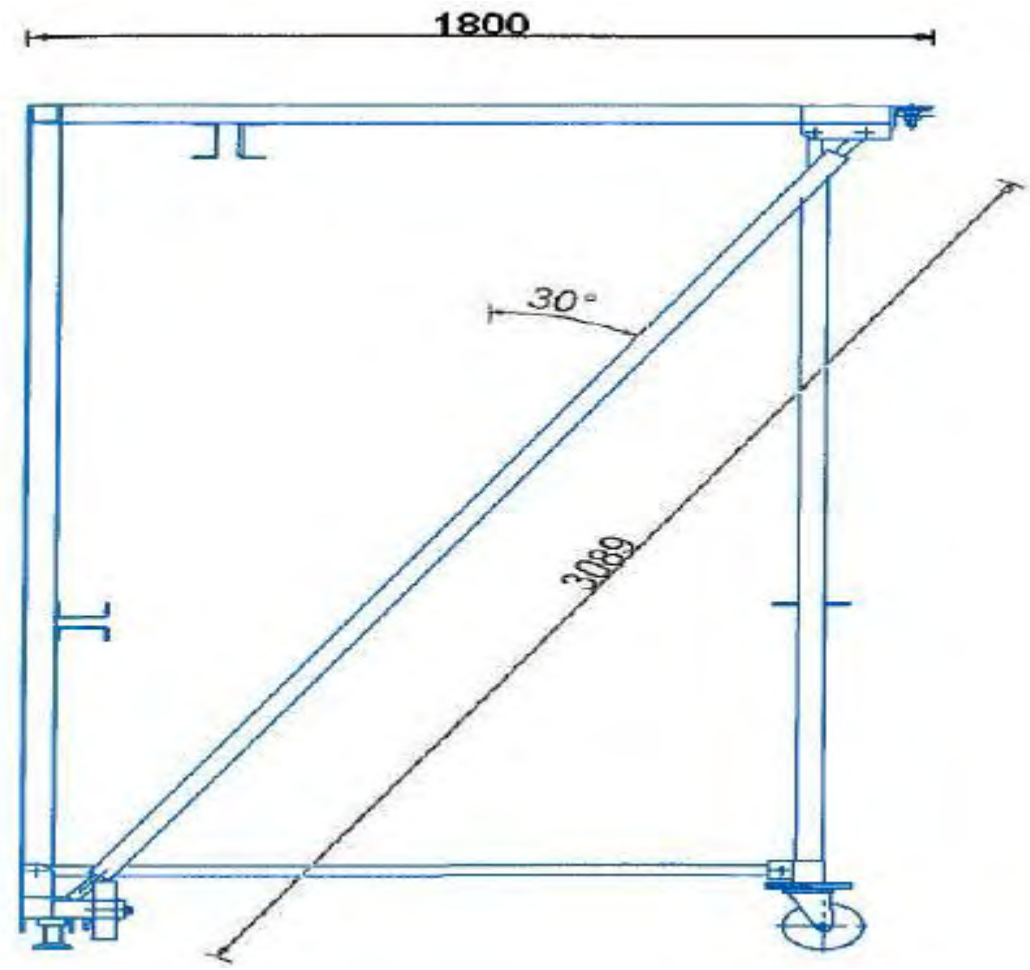


σ = 19.7 daN/mm2

3. VERIFICATION OF THE HORIZONTAL PANEL

Geometry of the profiles constituting the formwork

The horizontal panel is made of: 1 formwork sheet (3 mm thick)
13 hat sections (60 x 50 x 2)
1 peripheral UPF (60 x 30 x 4)
1 angle section (80 x 60 x 7)



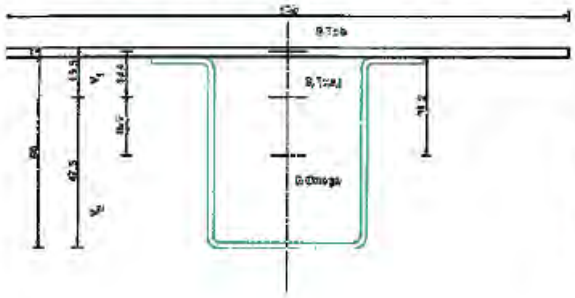
Data:

Formwork pressure = 100 daN/mm2 Safety coefficient to be applied: s = 1.33
Concrete pressure: 2400 daN/m3 s = 1.5
Setting reinforcement pressure: 100 daN/m2 s = 1.5
P worker: 75 daN/m2 s = 1.5
Thickness of the slab: 160 mm

3.1 Characteristics of hat section 60 + sheet (3 mm thick)

Inertia of hat section 60 + sheet (3 mm thick)

INERTIE OMEGA 60 + TOLE Ep 3mm



	Section	x	Sx
Tole	534	1.5	801
Omega	397.8	34.2	13604.76
TOTAL	931.8	15.46	14405.7

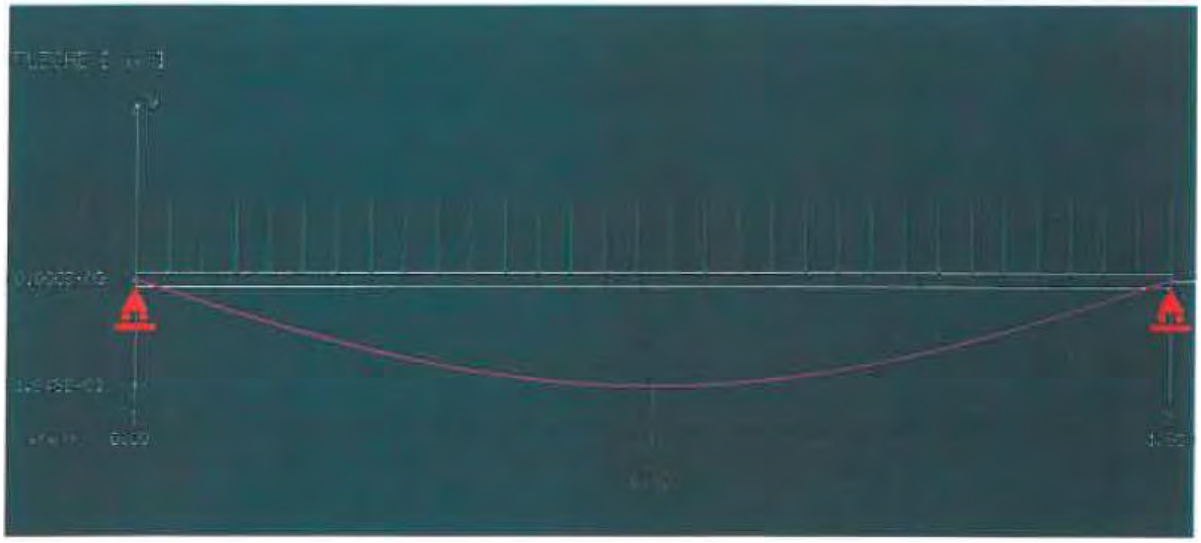
$$= \frac{14405.7}{931.8}$$

$$I = \frac{bh^3}{12} + I_{Omega} + S_1 d_1^2 + S_2 d_2^2$$

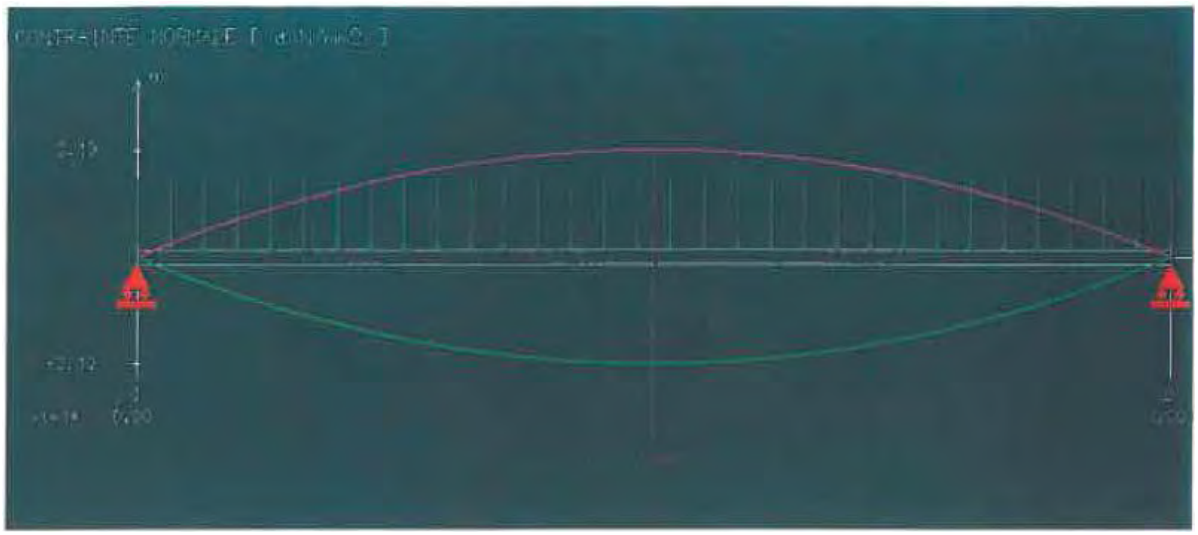
$$I = \frac{17.8 \times 0.3^3}{12} \quad 20.36 \quad + 5.34 \times 1.4^2 + 3.978 \times 1.87^2 = 44.77 cm^4$$

$$\frac{I}{V_2} = \frac{44.77}{4.75} = 9.42\ cm^3$$

Calculation of the pressure reported at the unit of length (179 mm), which is exerted at the base of the hat section.
P base = 2500 x 0.179 x 0.160 = 72 daN/m



Deflection on the sheet (3 mm thick) + hat section (60 mm) = 1.1 mm



σ = 3.1 daN/mm2

3.2 Verification of the diagonal strut

The buckling of the diagonal strut fixed on the tunnel formwork is shown above. The diagonal strut used is a cylindrical hollow pipe with an outer diameter of 60 mm for a thickness of 3.2 mm. Name of the pipe ø 50/60.

Characteristics of the pipe:
Section S = 574 mm2 Inertia I = 234700 mm4
Radius of gyration = 20.22 mm

The diagonal strut takes a load of 1.25 m.

Load on the diagonal strut:
P formwork = 100 x 1.25 x 1.33 = 166.25 daN/m
P concrete = 2400 x 0.16 x 1.25 x 1.5 = 720 daN/m
P setting reinforcement = 100 x 1.25 x 1.5 = 187.5 daN/m
P staff = 75 x 1.25 x 1.5 = 140.7 daN/m

Total load = 1214.5 daN/m I .e. for the horizontal panel 1214.5 x 1.8 = 2186.1 daN

Vertical load borne by the diagonal strut: 2186.1 / 2 = 1093 daN

F normal in the diagonal strut = 1093 / cos 30° = 1263 daN

Slenderness ratio: 308.9 / 2.022 = 153
Constraint amplification coefficient λ = 3.813
Buckling constraint:

$$\frac{1263 \times 3.813}{574} = 8.4 \text{ daN / mm}^2.$$