User's Guide

MK STRUCTURE

E03FFN

Construcción

IMPORTANT:

Any safety provisions as directed by the appropriate governing agencies must be observed when using our products.

The pictures in this document are snapshots of situations at different stages of assembly, and therefore are not complete images. For the purpose of safety, they should not be deemed as definitive.

All of the indications regarding safety and operations contained in this documents, and the data on stress and loads should be respected. ULMA Construcción's Technical Department must be consulted anytime that field changes alter our equipment installation drawings.

The loads featured in this document, related to the basic elements of the product, are approximate.

Our equipment is designed to work with accessories and items produced by our company only. Combining such equipment with other brands is not only dangerous without having made all corresponding verifications, it also voids any or all our warranties.

The company reserves the right to introduce any modifications deemed necessary for the technical development of the product.

Safety note

Control note

Warning note

Information note

1. PRODUCT DESCRIPTION

The MK System is a product designed for heavy-duty structures of high load-bearing capacity mainly used in civil engineering.

Its main feature is its versatility to configure all types of structures such as gantry structures, formwork carriers and tunnel structures, shoring structures, horizontal and vertical formwork, other structures for formwork support, climbing brackets, slab perimeter protection structures and other applications.

The core item for all these solutions is the Waler MK. Its elaborated design and the combination with various accessories, both unique of the MK system as well as shared with other ULMA products, enable to adapt it to all those above mentioned applications.

With the MK Structure system, two or more load-bearing structures are formed in one direction, the so-called main axis. These structures are braced to each other giving the required stability to the whole as well as absorbing wind loads acting on the structure in perpendicular direction to the main axis.

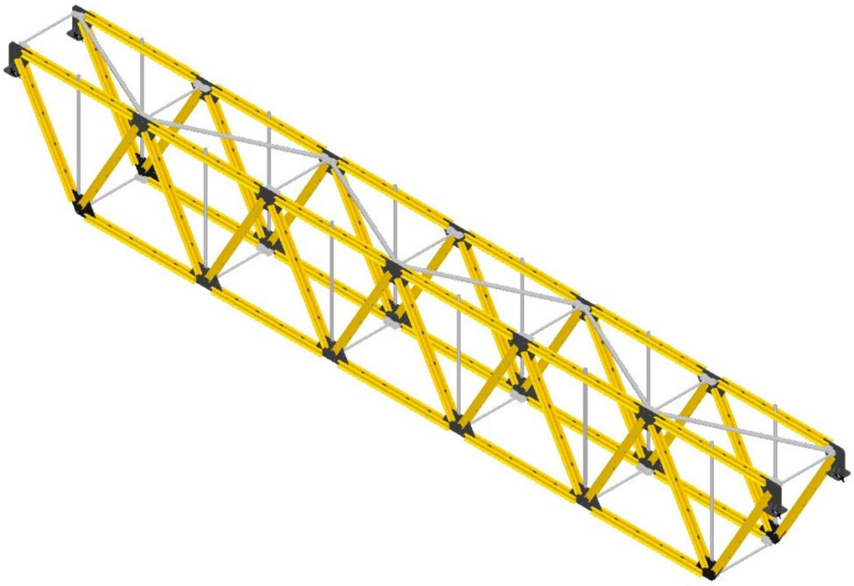
Depending on their field of application, mainly two structure types are distinguished:

- MK Truss Structure
- MK Form Carrier Structure

In the following, the two structure types are described in detail.

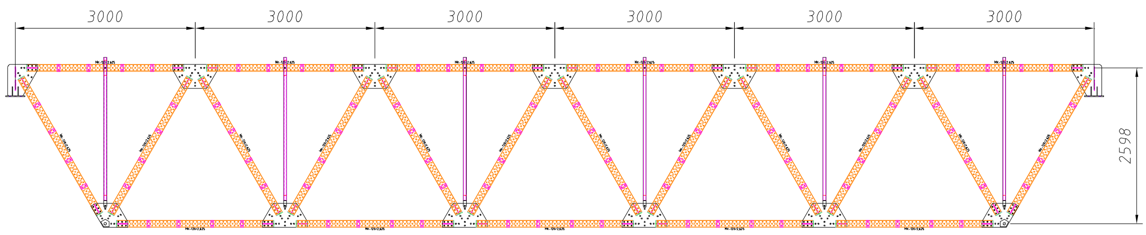
1.1. MK TRUSS

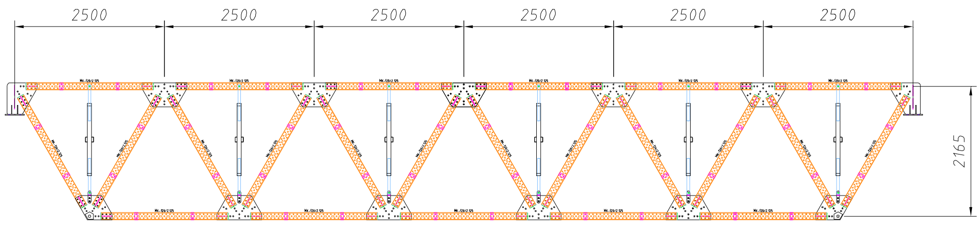
A truss structure, bi- or multi-supported, supports the formwork and absorbs the loads acting on the formwork. The formwork systems commonly used with the MK Truss Structure are Enkoform VMK or Enkoform H-120.



The typical truss form of the structure is achieved with equilateral triangles consisting of Walers MK and Nodes MK assembled in the same plane. These structures are braced to each other with joints and tubes. Depending on the required load-bearing capacity of the truss, the main axis can be reinforced with push-pull props and tubes.

The Waler MK range allows assembling trusses of different load-bearing capacities. The most optimum load-bearing capacity-weight ratio is the one given by a distance of 3 m between nodes axes and 2.6 m between waler axes.

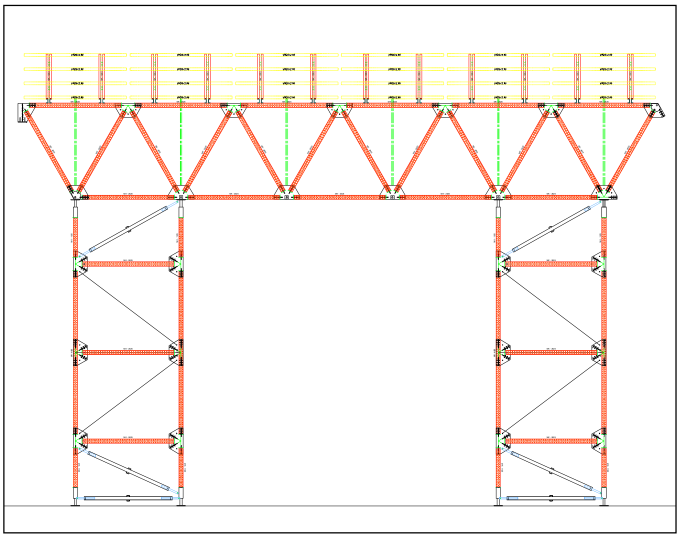




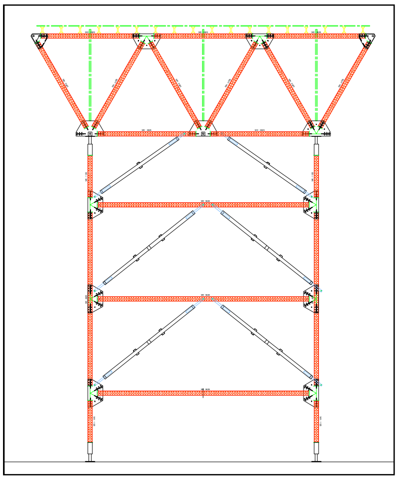
If the span of the upper boom (or element that works at compression) is sought to be reduced or the bending capacity to be increased, a vertical tube is used to make the structure bear higher loads.

The spans possible to cover with the MK Truss Structure change depending on the waler length used. Moreover, the permissible working load changes depending on the layout of the truss structure.

The combination of the MK Truss Structure system with the MK Shoring system offers an even wider range of solutions as shown in the following figures.



Solution combining the MK Truss Structure and MK Shoring system



Solution combining the MK Truss and MK Form Carrier Structure

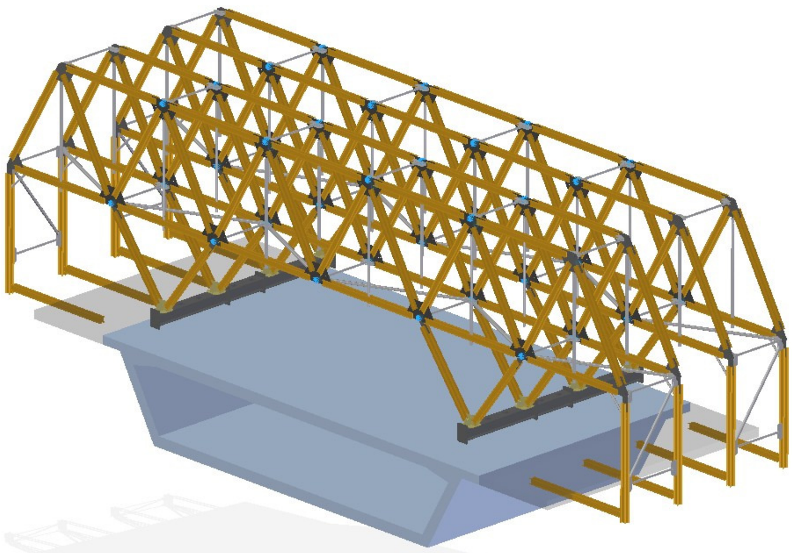
1.2. MK FORM CARRIERS

The following types of form carriers can be erected with the MK system:

- Deck flange form carrier
- Parapet form carrier
- Vertical formwork carrier
- Cut-and-cover tunnel form carrier

1.2.1. DECK FLANGE FORM CARRIER

In the case of metallic bridges which are made up of pre-cast components or of a pre-cast centre part, it is common to build the wings in a subsequent stage. This can be done with deck flange form carriers. These are heavy-duty form carriers as the jacks are able to withstand a maximum load of approximately 360 kN. Due to the load borne by the structure, the forward-moving of the form carrier is achieved by means of pull or push auxiliary devices.



A deck flange form carrier with these properties usually consists of the following parts:

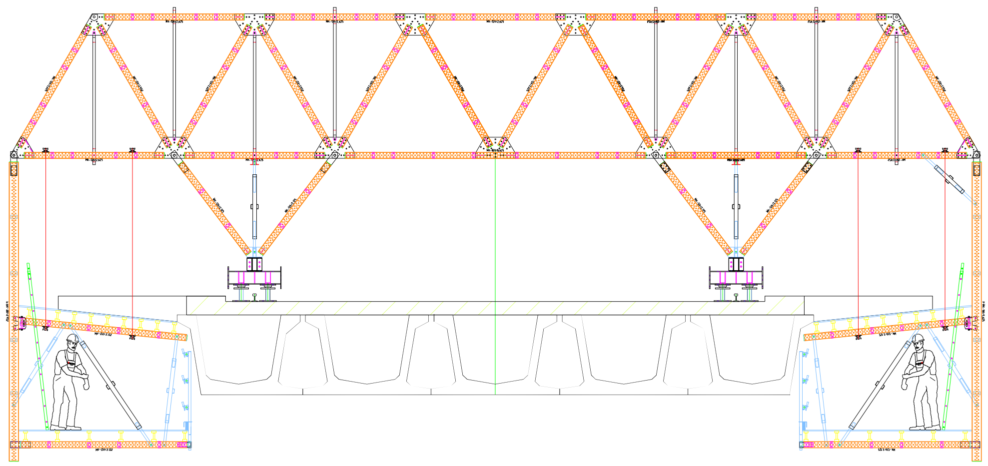
- Main structure: structure bearing the concrete load.
- Forward-moving structure: secondary structure which effects the movement and bears the forces during such.
- Bracing: components that withstand wind effects and transverse movements.
- Formwork: part in touch with the concrete shaping it, allowing its adjustment and opening if this is required for the movement of the structure.
- Rolling and levelling system: components that enable the rolling of the truss and its levelling at a specific place, as well as its stripping.
- Safety items and access: walkway platforms, handrails etc., depending on the requirements of each project.

There are two types of deck flange form carriers:

- Those where the rolling system is part of the form carrier (i.e. integrated in the secondary structure) or
- Those where the rolling system is not part of the form carrier.

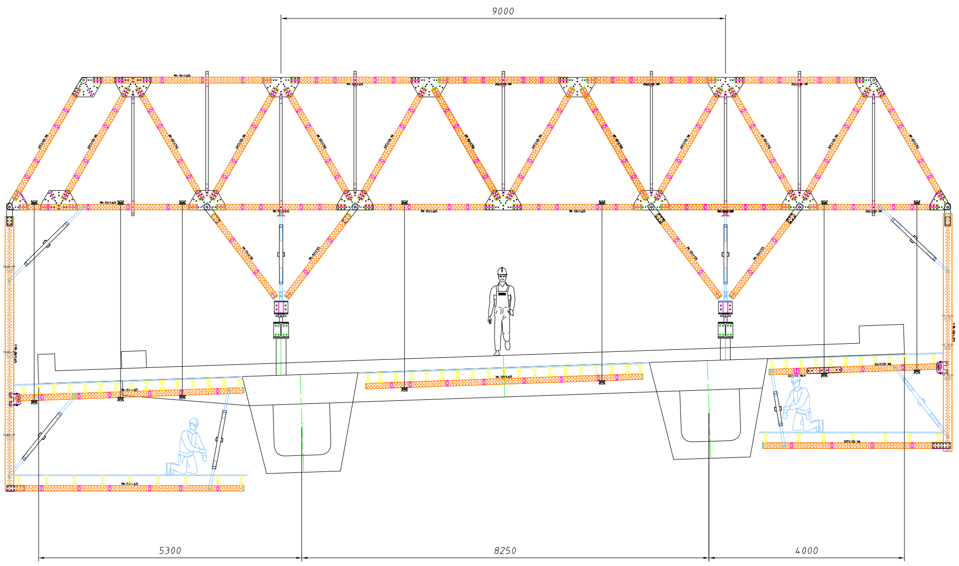
A further distinction may be the requirement to cast both wings at the same time or one after the other.

In the first case, the rolling system rests on a guide rail to move the formwork to subsequent casting positions. It can be applied in those cases where there is a solid base (pre-fabricated or pre-cast) to support the guide rail and the levelling jacks on.



Deck flange form carrier for a bridge with a pre-cast core

In the second case, it is the other way around. The bogie forms part of the secondary structure and the rolling system is fixed to the bridge. This is rather common where there is no pre-cast structure (e.g. metallic bridges).

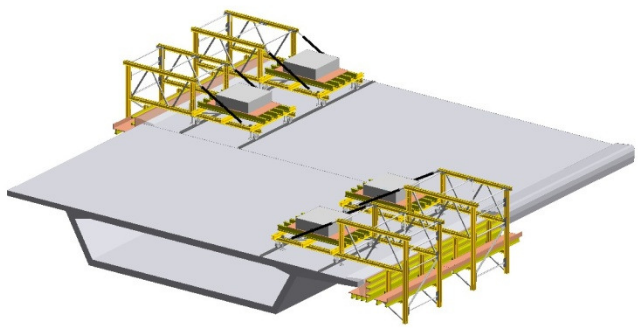


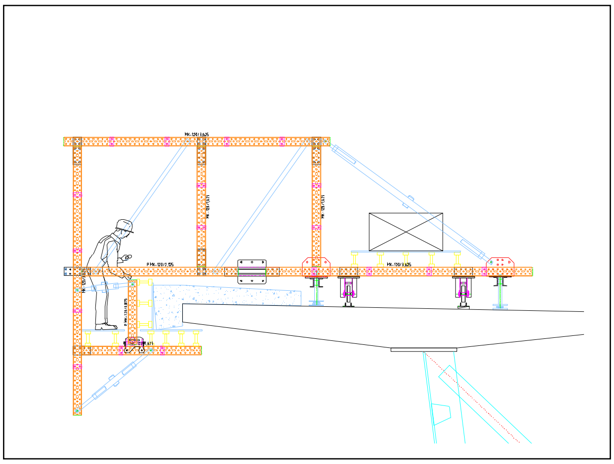
Deck flange form carrier for a metallic bridge

1.2.2. PARAPET FORM CARRIER

This form carrier is a lighter version of the previous one. It is used for applications with lower load-bearing and forward-moving capacities. Unlike the one mentioned beforehand, the parapet form carrier can be moved manually and requires a solid base where the guide rail rests on. The jacks of this form carrier type are able to withstand a maximum load of approximately 150 kN.

The most common applications for parapet form carriers are the construction of protection parapets for bridges or solutions that do not require high load-bearing capacity, mainly projects with formwork tables.





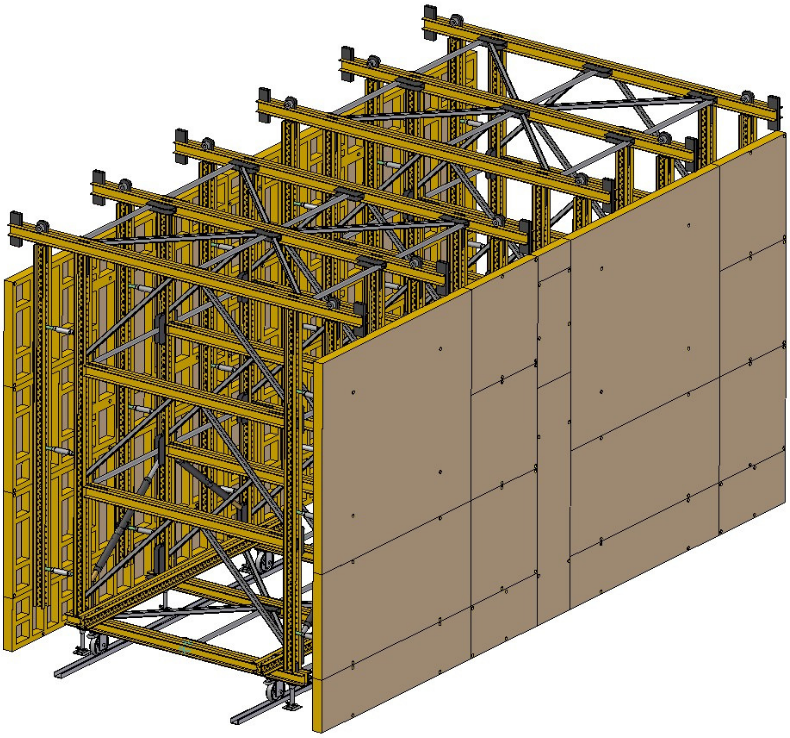
Form carrier for bridge parapets

A parapet form carrier usually consists of the following parts:

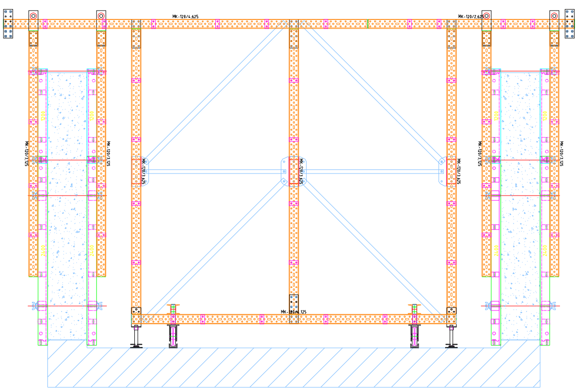
- Main structure: structure bearing the concrete load.
- Bracing: components that withstand wind effects and transverse movements.
- Formwork: part in touch with the concrete shaping it, allowing its adjustment and opening if this is required for the movement of the structure.
- Rolling and levelling system: components that enable the rolling of the truss and its levelling at a specific place, as well as its stripping.
- Safety items and access: walkway platforms, handrails etc., depending on the requirements of each project.

1.2.3. VERTICAL FORMWORK CARRIER

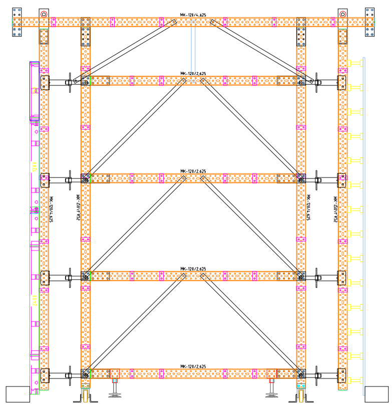
The main feature that distinguishes the vertical formwork carrier from others is that the vertical loads acting on the structure are exclusively caused by the self-weight of the structure. Its load-bearing and forward-moving capacities are still lower than the ones of the above mentioned form carriers. The jacks of this form carrier type are able to withstand a maximum load of approximately 60 kN.



As the parapet form carrier, the vertical formwork carrier can be moved manually and requires a solid base where the guide rail rests on. It is mainly used in the construction of single-sided or double-sided concrete walls. In the case of single-sided walls, there are considerable horizontal loads which must be taken into account when using the vertical formwork carrier.



Vertical formwork carrier for double-sided walls

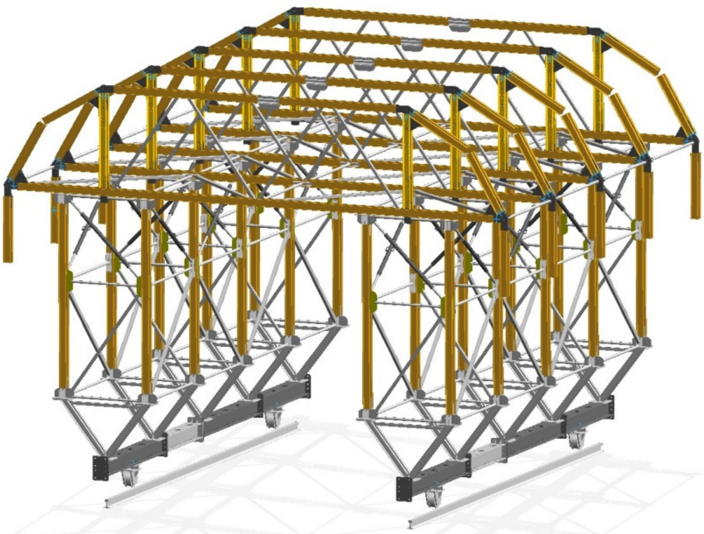


Vertical formwork carrier for single-sided walls

1.2.4. CUT-AND-COVER TUNNEL FORM CARRIER

The solution with the MK system for cut-and-cover tunnels can be regarded another type of form carrier adapted to the particular requirements of tunnel construction where the structure must adapt to the vault shape of the tunnel. This form carrier type also applies to applications where walls and slabs are cast at once as it is the case of rectangular section tunnels.

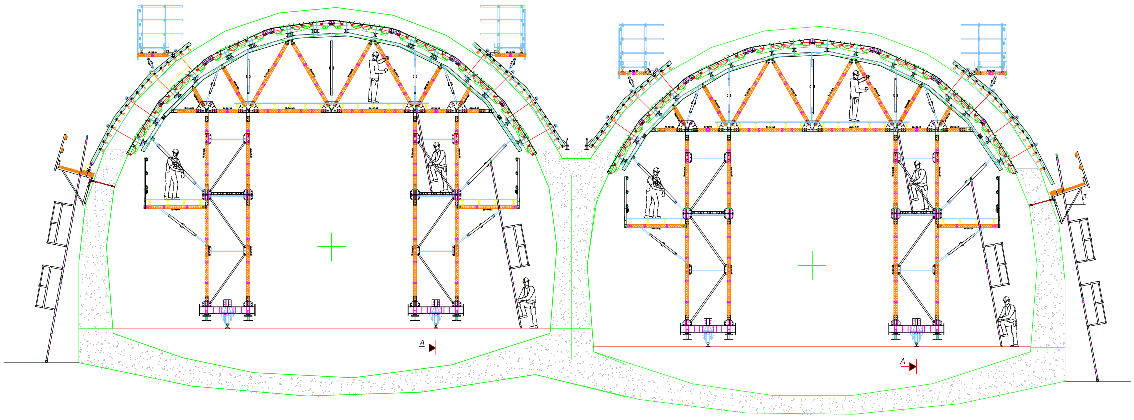
Vaulted tunnels are usually not cast at once but in stages: first the gables then the top part of the vault. Cut-and-cover tunnel form carriers are complemented with swivel parts to facilitate the stripping and forward-moving of the structure.



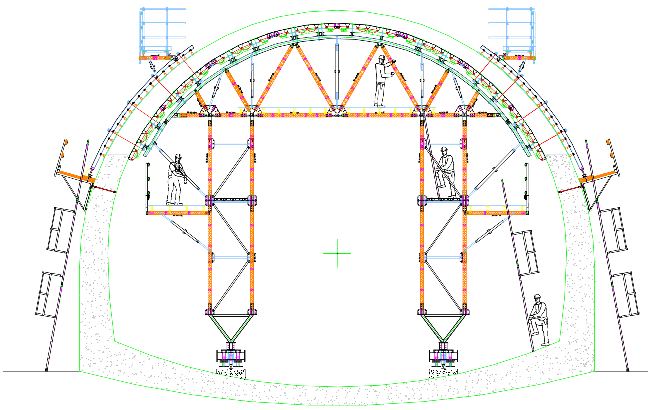
An all-round solution for cut-and-cover tunnels combines the MK Structure system for the top part of the vault with the MK Shoring system. A cut-and-cover tunnel form carrier usually consists of the following parts:

- <u>Main structure:</u> structure bearing the concrete load, both the vertical as well as the horizontal loads.
- <u>Forward-moving structure:</u> secondary structure which effects the movement and bears the forces during such.
- <u>Bracing:</u> components that withstand wind effects and transverse movements.
- <u>Formwork:</u> part in touch with the concrete shaping it, allowing its adjustment and opening if this is required for the movement of the structure.
- <u>Rolling and levelling system:</u> components that enable the rolling of the truss and its levelling at a specific place, as well as its stripping.
- <u>Safety items and access:</u> walkway platforms, handrails etc., depending on the requirements of each project.

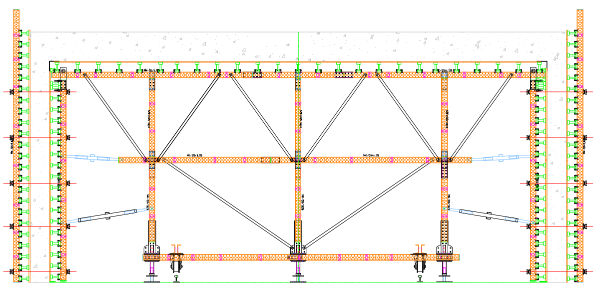
Cut-and-cover tunnel from carriers vary depending on aspects such as the load-bearing capacity and the area where it is supported on and moved forward. Two types of cut-and-cover tunnel form carriers are distinguished regarding a restricted or free support area. In all cases, the rolling system forms part of the form carrier, i.e. it is integrated in the bogie.



Cut-and-cover tunnel form carrier with free support area



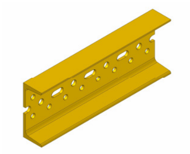
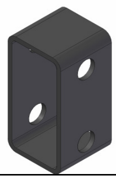
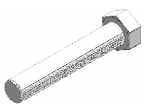
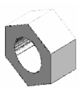
Cut-and-cover tunnel form carrier with restricted support area

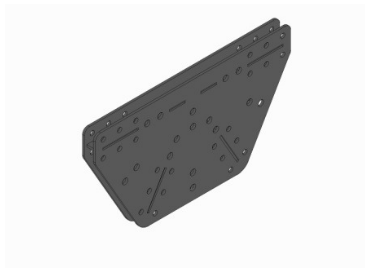
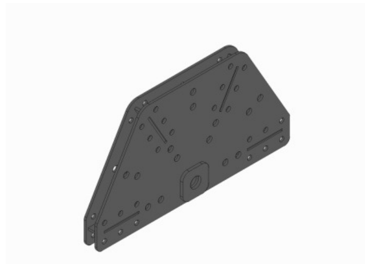
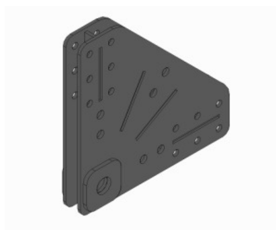


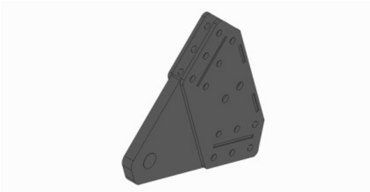
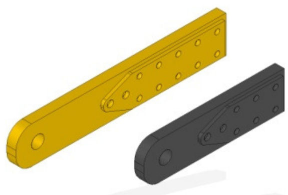
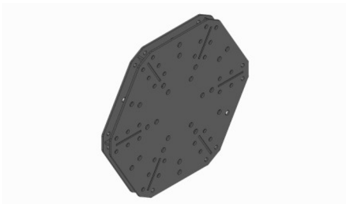
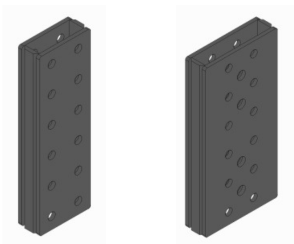
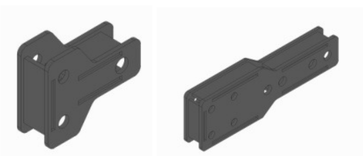
Form carrier for slab and wall in rectangular section tunnel

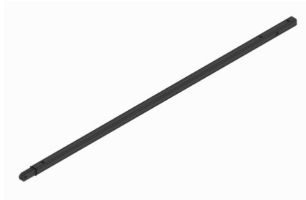
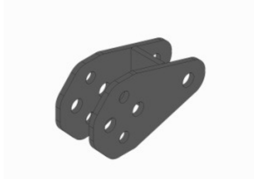
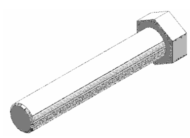
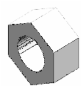
2. SYSTEM COMPONENTS AND ACCESSORIES

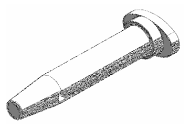
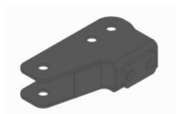
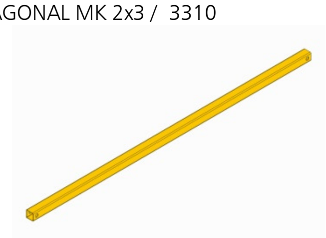
2.1. GRAPHIC DESCRIPTION

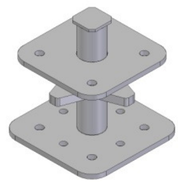
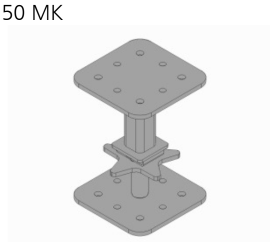
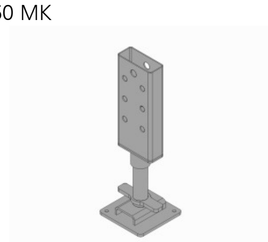
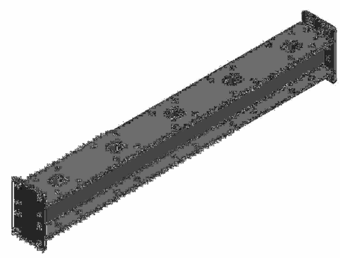
Item no.	Weight (kg)	Item name
		WALERS AND PROFILES MK-120
1990104	6	PROFILE MK-120 / 0.5
1990105	7.5	PROFILE MK-120 / 0.625
1990106	9.1	PROFILE MK-120 / 0.75
1990107	10.7	PROFILE MK-120 / 0.875
1990163	97.6	PROFILE MK-120 / 7.875 
1990209	29.4	WALER MK-120 / 1.125
1990211	35.4	WALER MK-120 / 1.375
1990213	41.9	WALER MK-120 / 1.625
1990215	48.3	WALER MK-120 / 1.875
1990217	54.3	WALER MK-120 / 2.125
1990219	60.5	WALER MK-120 / 2.375
1990221	68.6	WALER MK-120 / 2.625
1990225	80.9	WALER MK-120 / 3.125
1990229	93.4	WALER MK-120 / 3.625
1990233	107.6	WALER MK-120 / 4.125
1990237	120.1	WALER MK-120 / 4.625
1990239	126.3	WALER MK-120 / 4.875
1990245	146.7	WALER MK-120 / 5.625 
1990200	0.46	SPACER TUBE MK-120 / 52 
0241690	0.17	BOLT M16x90 DIN-931-8.8 
0241600	0.03	NUT M16 DIN-934-8 

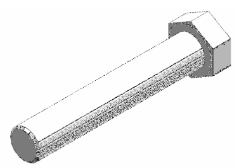
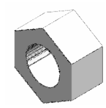
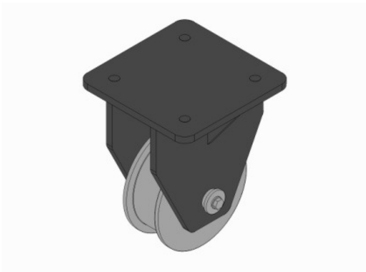
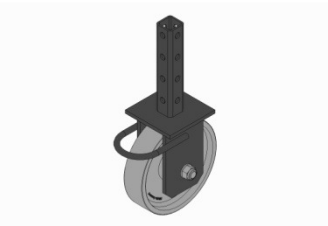
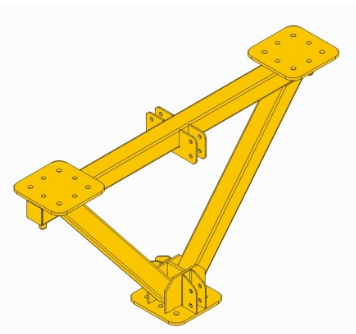
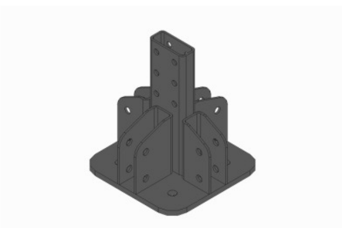
Item no.	Weight (kg)	Item name
		NODES AND TRUSS ITEMS
1990485	30.8	NODE 180 MK 
1990480	31.8	NODE 180 D40 MK 
1990420	24.0	NODE 120 MK 
1990390	18.8	NODE 90 MK 
1990360	16.0	NODE 60 F MK 

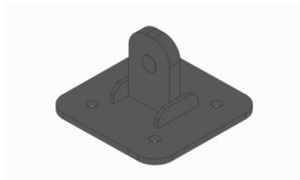
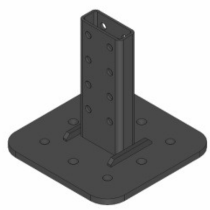
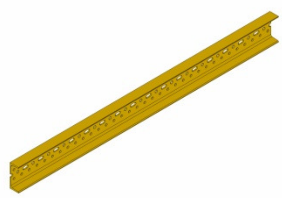
Item no.	Weight (kg)	Item name
1990361	21.4	NODE 60 M MK 
1990300 1990301	15.0 23.0	AXIAL NODE M D40 MK AXIAL NODE 90º M D40 MK 
1990665	50.5	NODE 360 MK 
1990365	40.2	NODE 60 SUPPORT MK 
1990395 1991200	6.5 9.1	ORTHOGONAL JOINT MK ORTHOGONAL JOINT MK-180 
1990590 1991458	1.5 5.2	AXIAL NODE M D20 MK AXIAL NODE M 2-D20 MK 

Item no.	Weight (kg)	Item name
1990404	19.5	V BRACING TRUSS MK 
1990403	1.3	JOINT PUSH-PULL PROP E-NODE MK 
0242010 0242015	0.30 0.50	BOLT M20x100 DIN-931-8.8 BOLT M20x150 DIN-931-8.8 
0242000	0.06	NUT M20 DIN-934-8 
1980120	1.1	PIN D40x85 
9023102	0.04	SAFETY PIN D 7x50 
		PUSH-PULL PROPS E
1960210 1960100 1960110 1960115 1960130 1960125 1960410	10.6 14.1 18.8 24.1 33.4 38.1 45.0	PUSH-PULL PROP E 0.51-075 PUSH-PULL PROP E 0.75-1.05 PUSH-PULL PROP E 1-1.55 PUSH-PULL PROP E 1.51-2.2 PUSH-PULL PROP E 2.15-2.75 PUSH-PULL PROP E 2.7-3.3 PUSH-PULL PROP E 3.25-4 

Item no.	Weight (kg)	Item name
0252070	0.28	PIN E20x70 
0250000	0.03	COTTER PIN R/5 
		JOINTS AND BRACING ITEMS
1990521	3.8	U SECONDARY AXIS MK 
1990421	2.7	U SECONDARY AXIS END MK 
1990605 1990608 1990613 1990618 1990623	1.9 2.7 4.5 6.2 7.9	HORIZ. TUBE MK 0.75/ 550 HORIZ. TUBE MK 1/ 800 HORIZ. TUBE MK 1.5/ 1300 HORIZ. TUBE MK 2/ 1800 HORIZ. TUBE MK 2,5/ 2800 
1990614 1990628 1990611 1990612 1990615 1990620 1990619 1990622 1990626 1990630 1990625 1990629 1990633	7.7 19.4 6.1 7.2 8.3 10.5 10.1 12.2 17.9 20.9 17.2 19.7 22.5	DIAGONAL MK 0.75x1.5 / 1396 DIAGONAL MK 0.75x3 / 2845 DIAGONAL MK 1x1 / 1110 DIAGONAL MK 1x1.25 / 1300 DIAGONAL MK 1x1.5 / 1508 DIAGONAL MK 1x2 / 1954 DIAGONAL MK 1.5x1.5 / 1818 DIAGONAL MK 1.5x2 / 2201 DIAGONAL MK 1.5x2.5 / 2624 DIAGONAL MK 1.5x3 / 3071 DIAGONAL MK 2x2 / 2524 DIAGONAL MK 2x2.5 / 1x3 / 2900 DIAGONAL MK 2x3 / 3310 

Item no.	Weight (kg)	Item name
1990401	3.6	NODE-WALER 90º JOINT MK 
1990402	3.7	WALER-WALER 90º JOINT MK 
		LEVELLING AND FORWARD-MOVING ACCESORIES
1990550	40.2	JACK 360 MK 
1990515	37.7	JACK 150 MK 
1990506	7.4	JACK 60 MK 
1990530 1990551 1990552 1990553	115.0 161.0 207.0 253.0	JACK WALER MK 0.5 / 1000 JACK WALER MK 1 / 1500 JACK WALER MK 1.5 / 2000 JACK WALER MK 2 / 2500 

Item no.	Weight (kg)	Item name
0242460	0.30	BOLT M24x60 DIN-931-8.8 
0242400	0.11	NUT M24 DIN-934-8 
1990655	89.0	WHEEL 100 MK 
1990660	19.3	WHEEL 15 MK 
1990645	93.0	TRIANGULAR BASE CARRIER 1500 MK 
1990504	25.9	HEAD JOINT MK 

Item no.	Weight (kg)	Item name
1990374	25.5	HEAD JOINT 74 MK 
1990400	17.0	PLATE NODE HEAD MK 
1990405	15.7	HEAD JOINT MK 
1990570	0.85	HANDRAIL HEAD MK 
		PROFILES MK-180
1990017	44,10	PROFILE MK-180/2,125
1990021	54,50	PROFILE MK-180/2,625
1990025	64,90	PROFILE MK-180/3,125
1990029	75,40	PROFILE MK-180/3,625
1990037	96,30	PROFILE MK-180/4,625
1990045	117,10	PROFILE MK-180/5,625
1990061	159,00	PROFILE MK-180/7,625
1990085	222,00	PROFILE MK-180/10,625
		

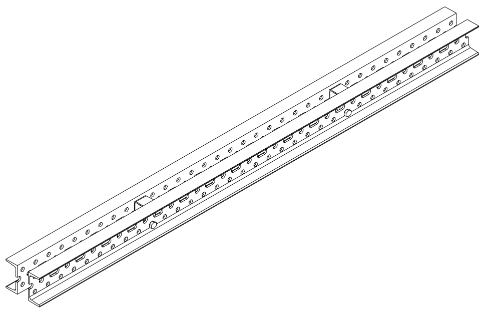
2.2. ITEMS DESCRIPTION

The following connections with bolt and nut will be shortly describes as M16, M20 and M24 in this document, meaning:

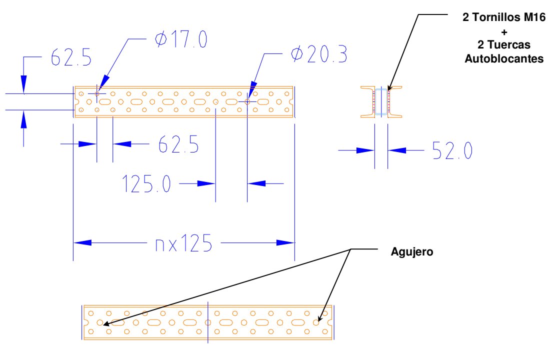
- *M16: Bolt M16 DIN 931-8.8 + Nut M16 DIN 934-8*
- *M20: Bolt M20 DIN 931-8.8 + Nut M20 DIN 934-8*
- *M24. Bolt M24 DIN 931-8.8 + Nut M24 DIN 934-8 + 2 Washers 24 DIN125*

2.2.1. WALERS MK-120

The Waler MK is the element all MK applications have in common. Its main feature is the double row of holes it provides for the connection of different parts.



The waler consists of two UPN-120 profiles joined back face-to-face. There are three rows of holes. The holes of the outer rows have a diameter of ∅17 mm and the spacing between holes of the same row and towards the other outer row is 62.5 mm.

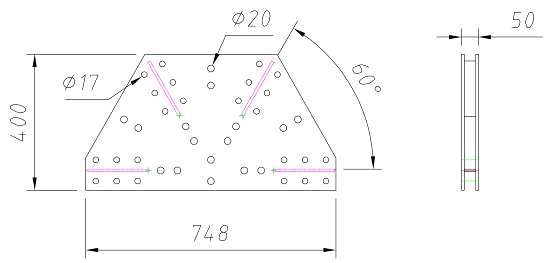


In the centre row, holes and slots alternate, the holes have a diameter of ∅20 mm, the slots have a length of 45.5 mm. The spacing between the holes in the centre row is 125 mm.

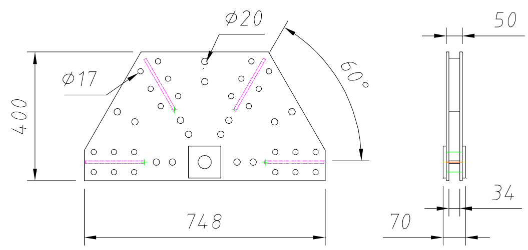
The centre rows always start and end with ∅20 mm holes.

2.2.2. NODE 180 MK AND NODE 180 D40 MK

The Node 180 MK enables to connect up to 4 walers placed at 60º. That is, two walers are connected lengthwise with a remaining gap of 375 mm between their respective ends, and the other two are placed at 60º to the previous ones. The connections are fastened with 6 bolts M16 inserted into the D17 holes.



The Node 180 D40 MK differs from the previous one with respect to the connection of another (male) item to the node centre in a hinged way pointing downwards. The connection is fastened with pins D40.

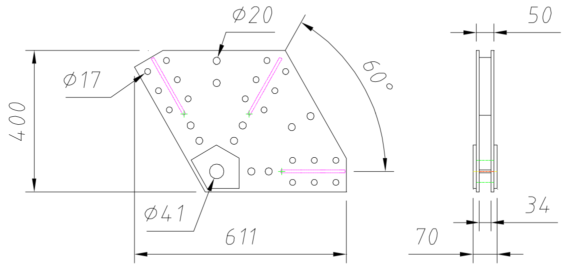


In both cases, the D20 holes are mainly used for the connection of secondary components, i.e., bracing items.

2.2.3. NODE 120 MK

This node enables to connect up to 3 walers at 60º. The connections are fastened with 6 bolts M16 inserted into the D17 holes.

The D20 holes are mainly used for the connection of secondary components, i.e., bracing items.

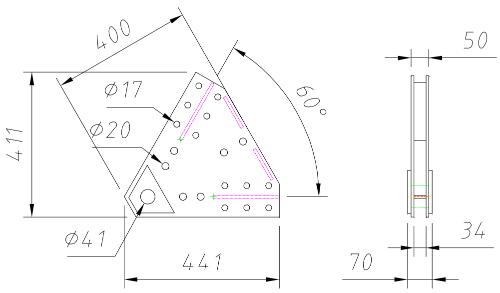


Moreover, another (male) item can be connected to the node centre in a hinged way pointing downwards. The connection is fastened with pins D40.

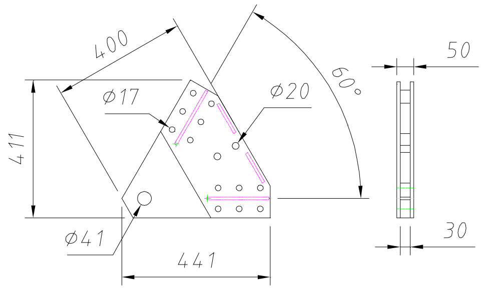
2.2.4. NODE 60 F MK AND NODE 60 M MK

These nodes enable to connect up to 2 walers at 60º. The connections are fastened with 6 bolts M16 inserted into the D17 holes.

The D20 holes are mainly used for the connection of secondary components, i.e., bracing items.

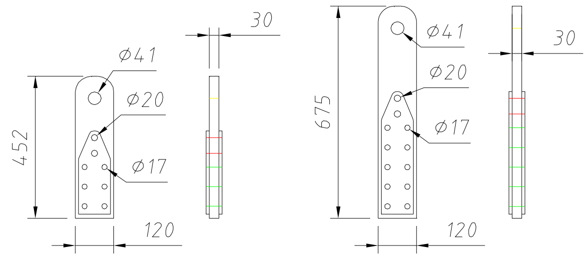


There are two node types: a female (F) and a male (M). Both enable to connect another item (male or female) to the node centre in in a hinged way with pins D40.



2.2.5. AXIAL NODE M D40 MK AND AXIAL NODE 90º M D40 MK

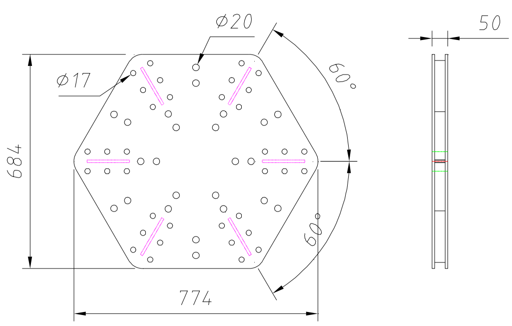
Both nodes enable to connect any waler to an already assembled structure in a hinged way. The connections are fastened with 6 bolts M16 inserted into the D17 holes. These nodes provide high load-bearing capacity.



They are male nodes connected to a female node of the structure with pins D40.

2.2.6. NODE 360 MK

This node enables to connect up to 6 walers. The connections are fastened with 6 bolts M16 inserted into the D17 holes. Two of the six walers are connected lengthwise with a remaining gap of 375 mm between their respective ends.

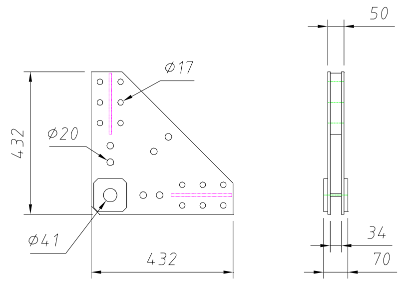


The D20 holes are mainly used for the connection of secondary components, i.e., bracing items.

2.2.7. NODE 90 MK

These nodes enable to connect up to 2 walers at 90º. The connections are fastened with 6 bolts M16 inserted into the D17 holes.

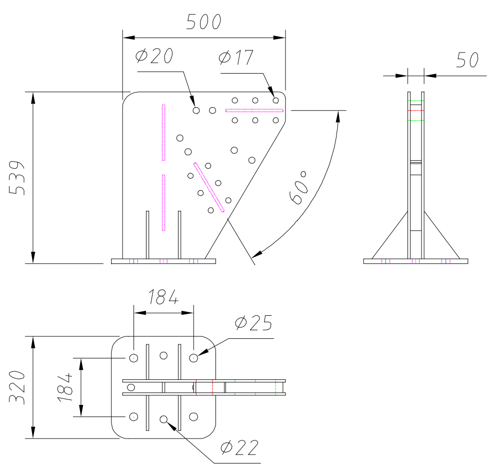
The D20 holes are mainly used for the connection of secondary components, i.e., bracing items.



2.2.8. NODE 60 SUPPORT MK

The Node 60 Support MK is a kind of foot to support the structure on something, mainly on profiles. It works as support of a bi-supported truss.

It enables to connect up to 2 walers at 60º as the Node 60 MK does. The connections are fastened with 6 bolts M16 inserted into the D17 holes.



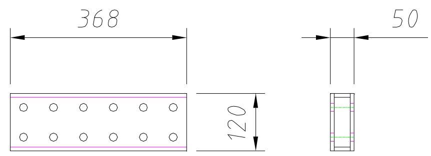
The support plate provides D25 (25 mm diameter) and D22 holes to connect other items and accessories.

2.2.9. ORTHOGONAL JOINT MK

The Orthogonal Joint MK connects up to 3 walers perpendicular to each other. The connection with the waler is fastened with 4 bolts M16 inserted into the D17 holes.

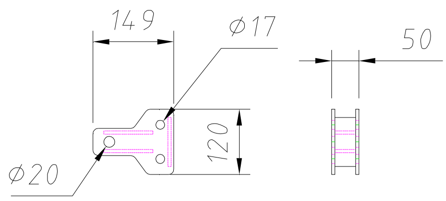
It can also connect 2 walers lengthwise. In this case, each waler is fastened with 6 bolts M16 inserted into the D17 holes .

This connector has medium load-bearing capacity and is mainly used in light form carriers.



2.2.10. AXIAL NODE M D20 MK

This node enables to connect one waler to another in a hinged way, always in the main plane. The waler and the node are fastened with 2 bolts M16 inserted into the D17 holes. Unlike the Axial Node M D40, this one does not have high load-bearing capacity.

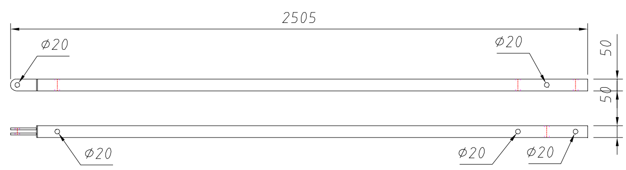


The hinged connection between the waler and the node is fastened with pins E20x70.

2.2.11. V BRACING TRUSS MK

This part serves to reinforce certain points of the structure in its main plane where loads on the structure require such a reinforcement of the waler.

It is connected to the structure with pins E20x70 inserted into the D20 holes, in front view. One side is connected to a joint and the other to the waler.



There is only one type available to brace the triangular structure of 3x3. Any other structure is reinforced with push–pull props E.

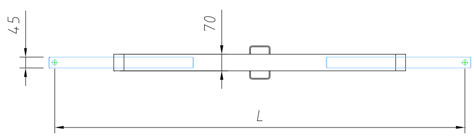
The D20 holes enable to connect other walers to the main structure, in cross section view.

2.2.12. PUSH-PULL PROP E

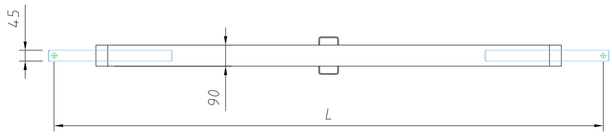
To reinforce a triangular structure other than 3x3, push-pull props E are used. The props are fastened to the structure with pins E20x70.

Push-pull props E are used to reinforce the structure in its main plane against forces acting on it.

Lengths available are those shared with other systems and their properties depend on the prop used in each case.



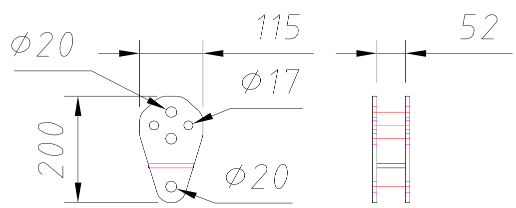
Push-Pull Prop E range up to 2.2



Push-Pull Prop E range from 2.2

2.2.13. PUSH-PULL PROP E - NODE MK JOINT

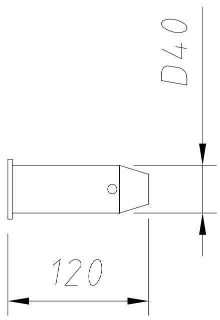
This item is used to connect the push-pull prop E to any node. The connection to the node is fastened with 2 pins E20x70, whereas the prop is fastened to the joint with only 1 pin E20x70 allowing of a hinged joint.



2.2.14. PIN D40x85

This is the item that fastens male to female node joints. It offers high load-bearing capacity joints which are used for applications where hinged joint are required.

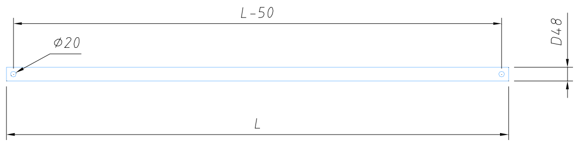
Each pin D40x85 is secured with a Cotter pin D6x42.



2.2.15. HORIZONTAL BRACES MK AND DIAGONALS MK

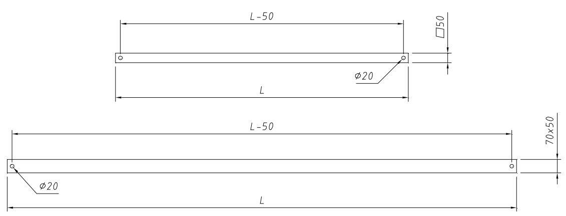
These items make the bracing of the structures.

In top view, the horizontal brace is the item placed perpendicular to the main axis of the structure to keep the distance between two adjoining structures. In order to distinguish them from the diagonals, the horizontal braces are D48 tubes.



L refers to the tube length. The number in the item name refers to the distance in metres at which the structures are kept.

The diagonals complement the bracing, providing the required stiffness to the structure.

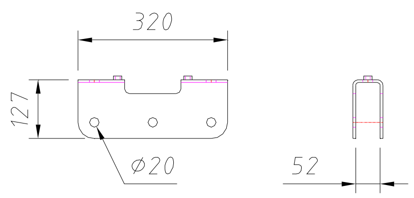


L refers to the tube length. The number in the item name refers to the vertical and horizontal projections AxB (in m) of the length of the diagonal.

2.2.16. U SECONDARY AXIS MK

This item connects horizontal braces and diagonals to the structure. It can be placed either on walers or on nodes.

It is fastened to the waler or node with bolts M20 and to the horizontal braces and diagonals with pins E20x70.

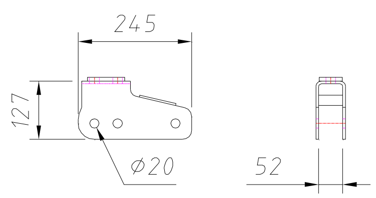


An important feature of this joint type is that it enables to connect the bracing back to the waler axis thus obtaining high load-bearing capacity bracing.

2.2.17. U SECONDARY AXIS END MK

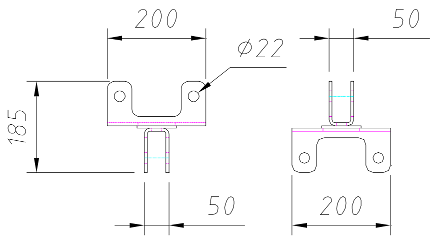
This item has the same function as the previous one but is placed at the beginning and the end of the bracing. That is why it can only be assembled on nodes.

It is fastened to the node with bolts M20 and to the horizontal braces and diagonals with pins E20x70.

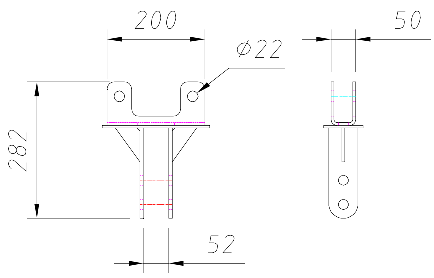


2.2.18. WALER - WALER 90º JOINT MK AND NODE - WALER 90º JOINT MK

The Waler - Waler 90º Joint enables to connect 2 walers perpendicular to each other, in the secondary axis.



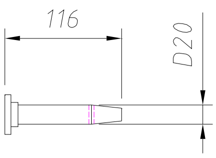
The Node -Waler 90º Joint enables to connect a waler perpendicular to a node, in the secondary axis. It complements the previous one.



Both are mainly used for applications where a structure is required to be connected perpendicularly to an already existing structure. They do not work at tension hence such loads must be avoided when using these items.

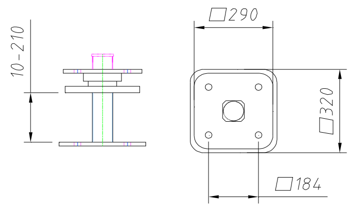
2.2.19. PIN E20x70

This item is used to fasten all connections between walers, nodes, joints, push-pull props E, horizontal braces or diagonals, respectively, where these are required to be hinged. Each pin E20x70 is secured with a Cotter pin R/5.



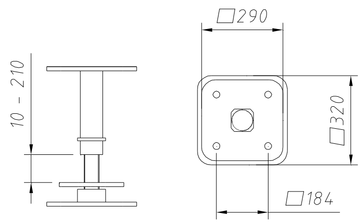
2.2.20. JACK 360 MK

The jacks are the elements which allow of the vertical adjustment, that is, the levelling of the form carrier. They are placed at the base of the carrier bogies. The Jack 360 MK is used to adjust heavy-duty form carriers. It has an adjustment range of 220 mm and a working load capacity up to 360 kN. It is fastened to the jack waler with 4 bolts M24.



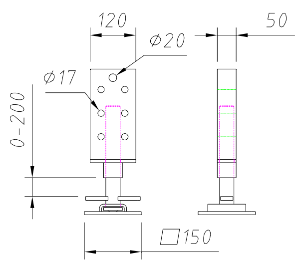
2.2.21. JACK 150 MK

The Jack 150 MK is used to level medium load-bearing capacity form carriers. It has an adjustment range of 220 mm and a working load capacity up to 150 kN. It is fastened to any END PLATE of the MK Shoring System with 4 bolts M24.



2.2.22. JACK 60 MK

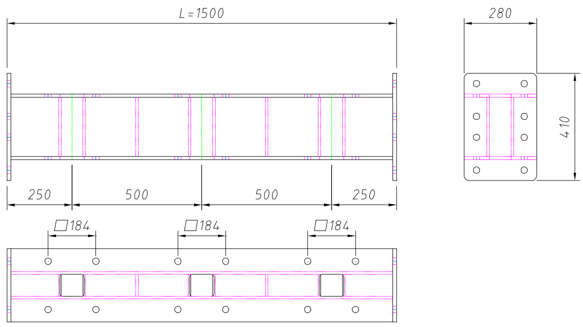
The Jack 60 kN is used to level low load-bearing capacity form carriers. It has an adjustment range of 220 mm and a working load capacity up to 60 kN. It is fastened to the walers with 4 bolts M16.



All jacks must be lubricated before use.

2.2.23. JACK WALER MK

The jack walers form the bogie of heavy-duty form carriers. The bogie length can be adjusted at an interval of every 0.5 m. The jack walers are fastened together with 8 bolts M24 inserted into the D25 holes of their end-plate joints, thus creating a longer jack waler profile.

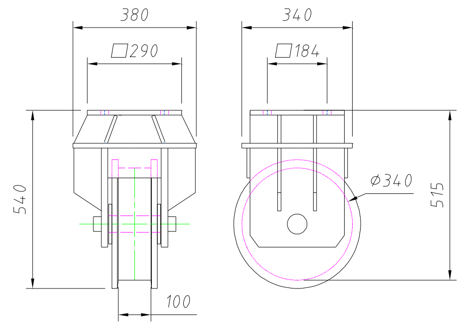


The end-plate joints which determine the layout of the form carrier structure at its base rest on the jack walers. To the other side of the jack waler, the jacks and the wheels to move the form carrier are connected and fastened with 4 bolts M24.

2.2.24. WHEEL 100 MK

The Wheel 100 MK is used for the travel of heavy form carriers. It is fastened to the jack waler that forms the bogie with 4 bolts M24 at the indicated positions.
The load-bearing capacity of the Wheel 100 MK lies between 90-100 kN to move form carriers that bear up to 360-400 kN (36-40 tons).

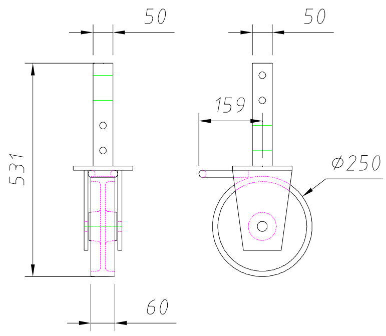
If the distance between wheel and bogie needs to be increased, a spacer can be placed between them.



2.2.25. WHEEL 15 MK

The Wheel 15 MK is used for the travel of the medium-weight form carriers. It is fastened directly to the waler that forms the structure with 4 bolts M16.

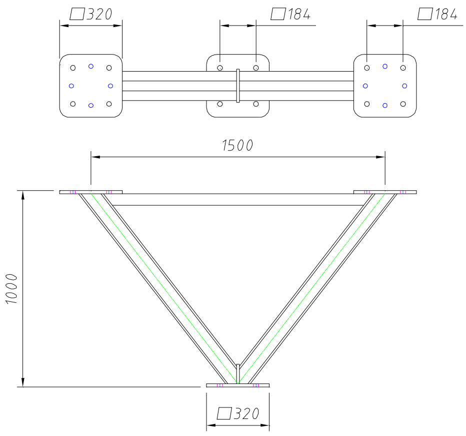
The load-bearing capacity per wheel is limited to 15 kN hence a 60 kN (6 tons) form carrier can move by 4 Wheels 15 MK.



2.2.26. TRIANGULAR BASE CARRIER 1500 MK

If there is not enough space for the support of the form carrier at the base, it can be elevated with the triangular base. It is mainly used for heavy-duty cut-and-cover tunnel form carriers.
The top is connected to the end-plate joints of the structure and the bottom to the bogie. Both joints are fastened with bolts M24.

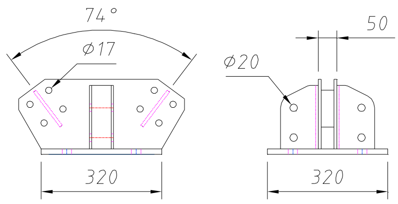
It has protrusions at both ends to stabilise and plumb the structure at erection.



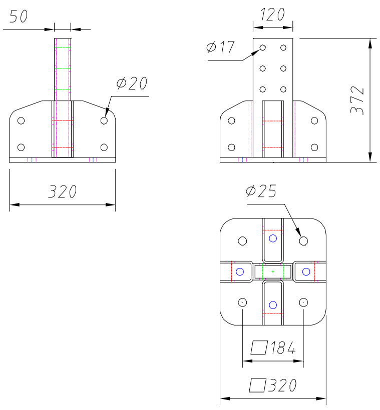
2.2.27. END JOINT 74 MK AND END JOINT MK

Both items are used to connect the structures to the bogies.

The End Joint 74 MK is applied directly on the structure when the structure itself is high enough to match/obtain? the height of the form carrier?. One end is connected to the walers with 6 bolts M16, the other to the bogie with 4 bolts M24.

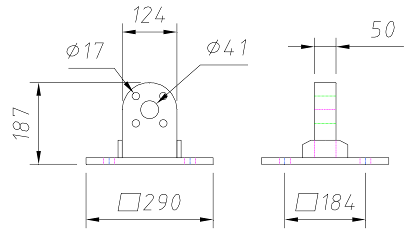


The End Joint MK is used to form vertical structures or towers modules, that is, what the previous head joint makes at 74º, the Head Joint MK makes at 90º.

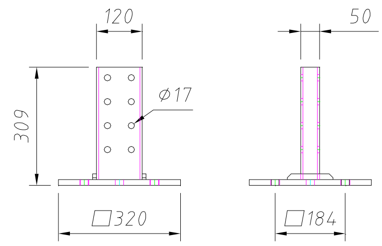


2.2.28. NODE END-PLATE JOINT MK and WALER END-PLATE JOINT MK

The Node End-Plate Joint MK enables an end joint of structures whenever a hinged support on the same is required. It is connected directly onto the MK Shoring Towers or to the bogie.



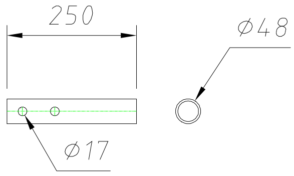
Likewise, the Waler End-Plate Joint MK enables an end joint of structures on the walers of the structure. It is connected directly onto the MK Shoring Towers or to the bogie.



One end is fastened to the structure with pin D40 in the case of the node end-plate and with 6 bolts M16 in the case of the waler end-plate. The other end is fastened to the shoring towers with 4 bolts M24 or to the main beams with Clamps 16/70.

2.2.29. HANDRAIL HEAD MK

The handrail head serves to place tubes D48 to create a handrail system at any height of the waler. It is fastened with 2 bolts M16.



3. ASSEMBLY, USE AND DISMANTLING

3.1. TECHNICHAL ASSEMBLY INSTRUCTIONS. GENERAL ASSEMBLY

For further information on this section, it is advisable to read and follow the respective technical assembly instructions for the different products offered by the MK System with regard to their erection, dismantling and handling.

ITM_MK01-01 "ERECTION OF THE MK TRUSS SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN HORIZONTAL POSITION"

ITM_MK02-01 "DISMANTLING OF THE MK TRUSS SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN HORIZONTAL POSITION"

ITM_MK03-01 "ERECTION OF THE MK TRUSS SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN VERTICAL POSITION"

ITM_MK04-01 "DISMANTLING OF THE MK TRUSS SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN VERTICAL POSITION"

ITM_MK05-01 "ERECTION OF THE MK FORM CARRIER SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN HORIZONTAL POSITION"

ITM_MK06-01 "DISMANTLING OF THE MK FORM CARRIER SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN HORIZONTAL POSITION"

ITM_MK07-01 "ERECTION OF THE MK FORM CARRIER SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN VERTICAL POSITION"

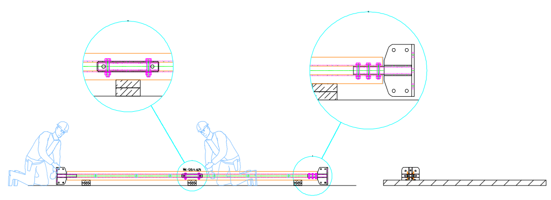
ITM_MK08-01 "DISMANTLING OF THE MK FORM CARRIER SYSTEM WITH AND WITHOUT BOTTOM PLATFORMS IN VERTICAL POSITION"

ITM_MK09-01 "ERECTION OF THE MK CUT-AND-COVER FORM CARRIER WITH BOTTOM PLATFORMS IN VERTICAL POSITION"

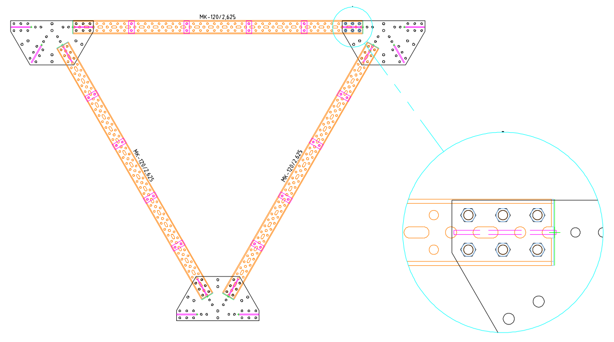
ITM_MK10-01 "DISMANTLING OF THE MK CUT-AND-COVER FORM CARRIER WITH BOTTOM PLATFORMS IN VERTICAL POSITION"

3.1.1. Main structure erection. Node assembly

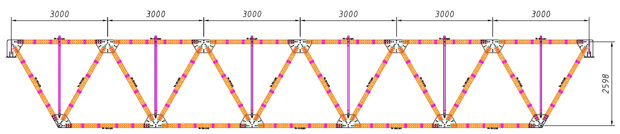
- Start with the assembly of the booms and diagonals. Place the nodes on the waler according to the indications in the assembly drawings.



All waler-node joints are fastened with bolts M16x90. 6 bolts are required for a joint with high load-bearing capacity at compression, 4 bolts for a medium load-bearing capacity and 2 for a low load-bearing capacity. For capacity calculations, all waler-node joints are assumed to be hinged.



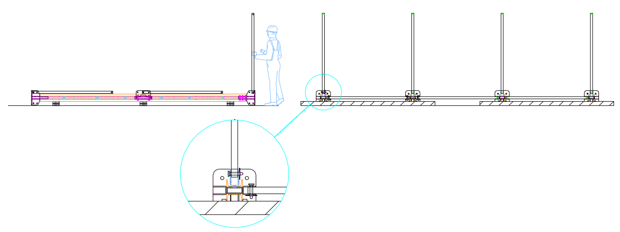
- If indicated in the assembly drawings, the V Bracing Truss MK is assembled next. Connect it to the node using the bolt M20x90 and to the waler using 2 bolts M16x90. Insert the V Bracing Truss MK into the gap between the waler UPN profiles and connect it to the node of the opposite boom.



3.1.2. Joints and braces assembly. Diagonals and horizontal braces on main axis.

- Place the U secondary axis joints on nodes and walers of the main axis in direction of the secondary axis and fasten with bolts M20x90.

- Connect the horizontal braces to the U secondary axis joints with pins E20x70.

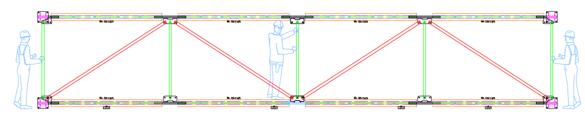


3.1.3. Bracing assembly. Diagonals and horizontal braces assembly between structures.

- Assemble another structure equal to the first by following the steps described in 3.1.1.

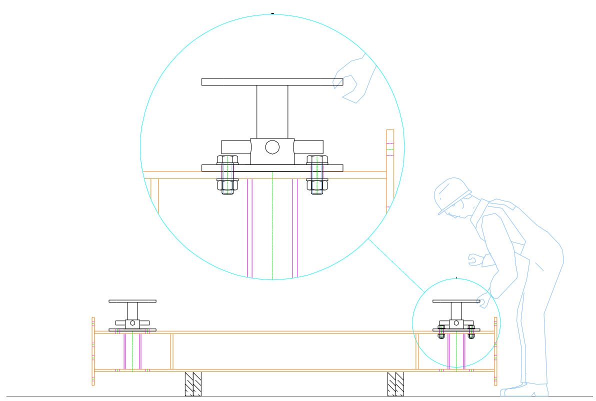
- Lift the whole or part of the structure and place it parallel to the first with the horizontal braces already in place. Fasten the braces to the lifted structure with pins E20x70.

- Assemble the diagonals to finish the bracing of the module.

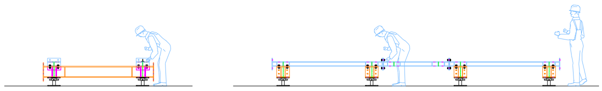


3.1.4. Bogie assembly

- By following the indications in the assembly drawings, place the jack waler with jacks and wheels fastened with bolts M24. Likewise, the jack walers are connected to each other with bolts M24.

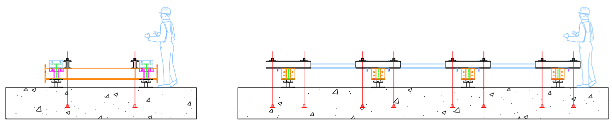


- Put the already assembled set on the wheels, and if indicated in the assembly drawings, place more jack walers perpendicular to the previous ones, and fasten with bolts M24.



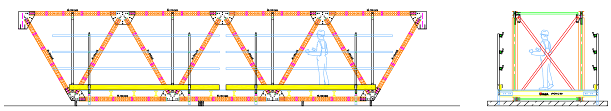
- Likewise proceed if it is required to assemble the Triangular Base MK.

- Adjust the entity in height and direction with the jacks aided by topography techniques if necessary. If working with triangular bases, use props to plumb the structure at the base.



3.1.5. Platforms and handrail system assembly

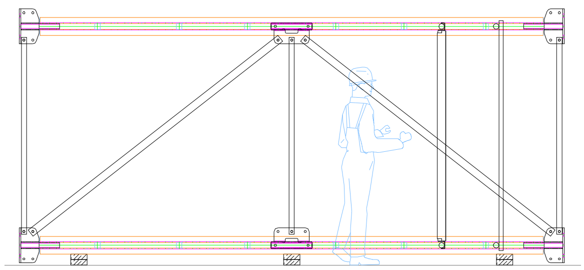
If the assembly drawings indicate the installation of working platforms and handrail system, those must be installed before the lifting of the structure.



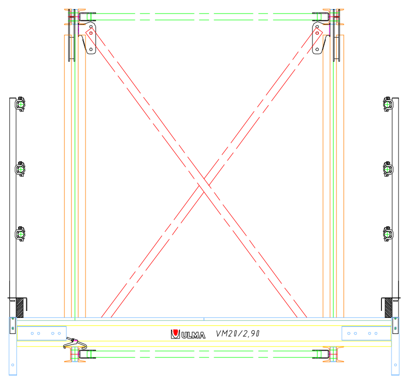
Platforms can be created in the following ways:

- With BRIO platforms placed onto the horizontal braces: no need of extra components.
- With BRIO platforms placed on tubes D48: fix the tube onto the Handrail Head MK and fasten with couplers 48. Insert the head into the gap between the waler UPN profiles at the height indicated in the assembly drawings and fasten with bolts M16.
- With Beams VM20 and board: place another waler with the Axial Node M D20 MK fastened with bolt M16 additionally to the pin E20x70 at the height indicated in the assembly drawings.

To form the handrail, use tubes D48 connected with the Handrail Head MK and couplers 48. The head is fastened to the waler with bolt M16.

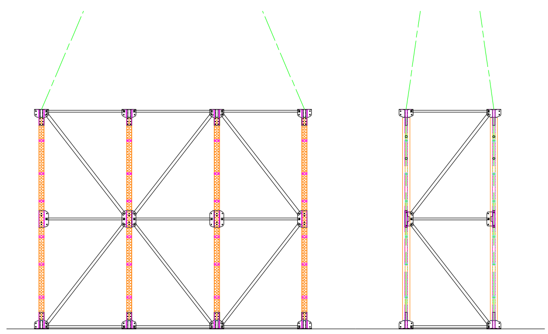


An alternative is to use 2 Tie Rods 15 with Plate Nuts 15 at both sides, as also common for other solutions.

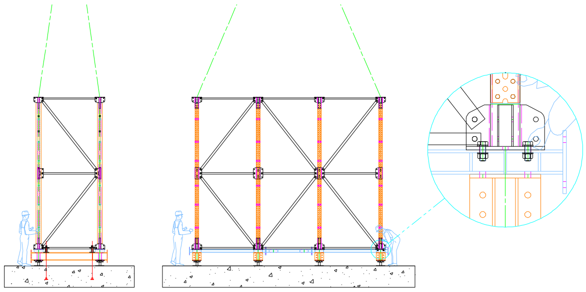


3.1.6. Lifting and positioning of standard structures

- Attach auxiliary load lifting means to the modules assembled in section 3.1.3 and position the module vertically by means of a mechanical load lifting device.

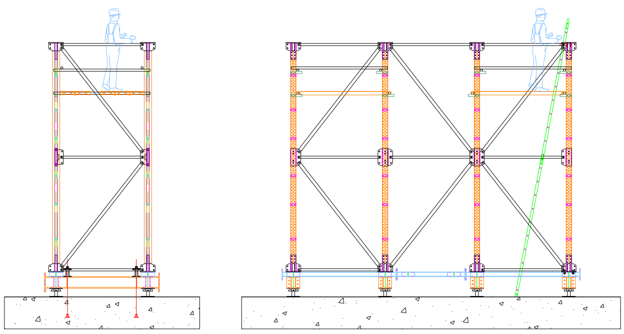


- Move the lifted modules to support them on the jack walers and fasten with bolts M24. Check the levelling of the structure.

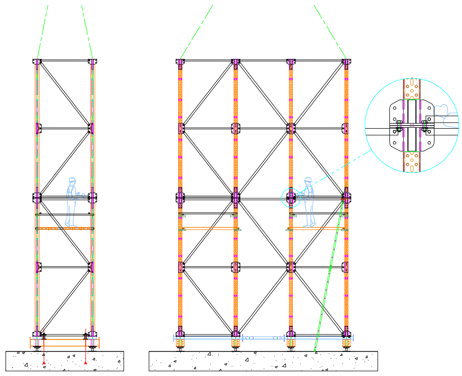


- Likewise proceed with as many structures as indicated in the assembly drawings. Usually two structures are lifted together. The bracing with horizontal braces and diagonals between the structures is made after having placed them in their final position.

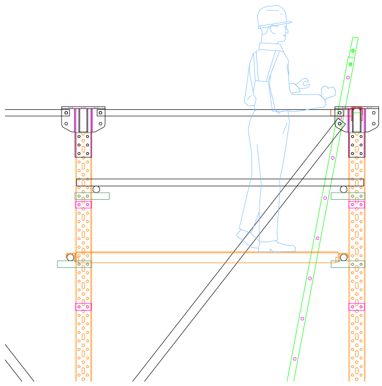
- In the case of combinations between MK Shoring Towers and MK Structure (Cut-and-cover tunnel form carrier), the lifting is carried out in several steps. To place the structure on towers, use walkway platforms.



- Lift the structure and connect it to the towers with bolts M24. Use a pointed pin to help inserting the bolts into the holes.



- Remove the statutory auxiliary lifting means, and platforms and auxiliary ladders (if applies).



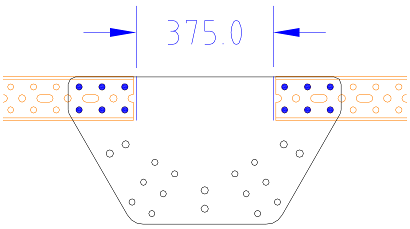
- Proceed with covering the parts of the structure with plywood which are indicated in the assembly drawings.

4. Solutions

High load-bearing capacity structures up to 360 kN are obtained with triangular structures. These structures are mainly used for solutions such as gantry shoring systems, trusses, deck flange and cut-and-cover tunnel form carriers.

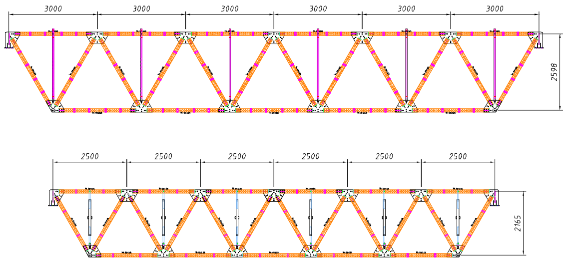
These structures are characterised by using walers for all diagonal and horizontal connections in direction of the main axis, and by using such nodes that allow of connecting one, two, three or more walers at 60º. Those can be alternated at determined points of the structure with nodes allowing of waler connections at 90º and 45º.

All high load-bearing capacity joints are fastened with 6 bolts M16 quality 8.8 and their corresponding nuts providing a maximum tensile or compression load of 360 kN to the node.

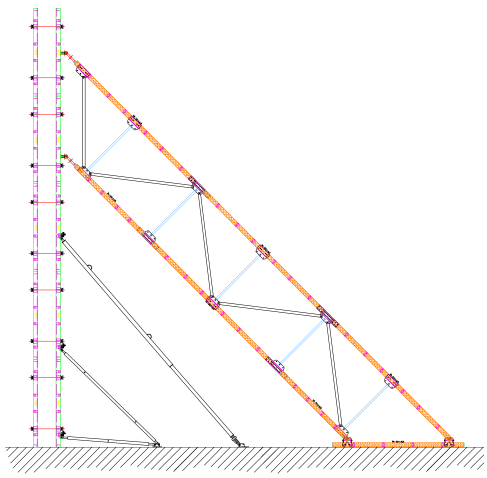


The triangular structures are formed with the same waler size, the load-bearing capacity increasing proportionally to the waler length. However, there is another limitation to the structure at buckling in the direction of the weak or secondary axis.

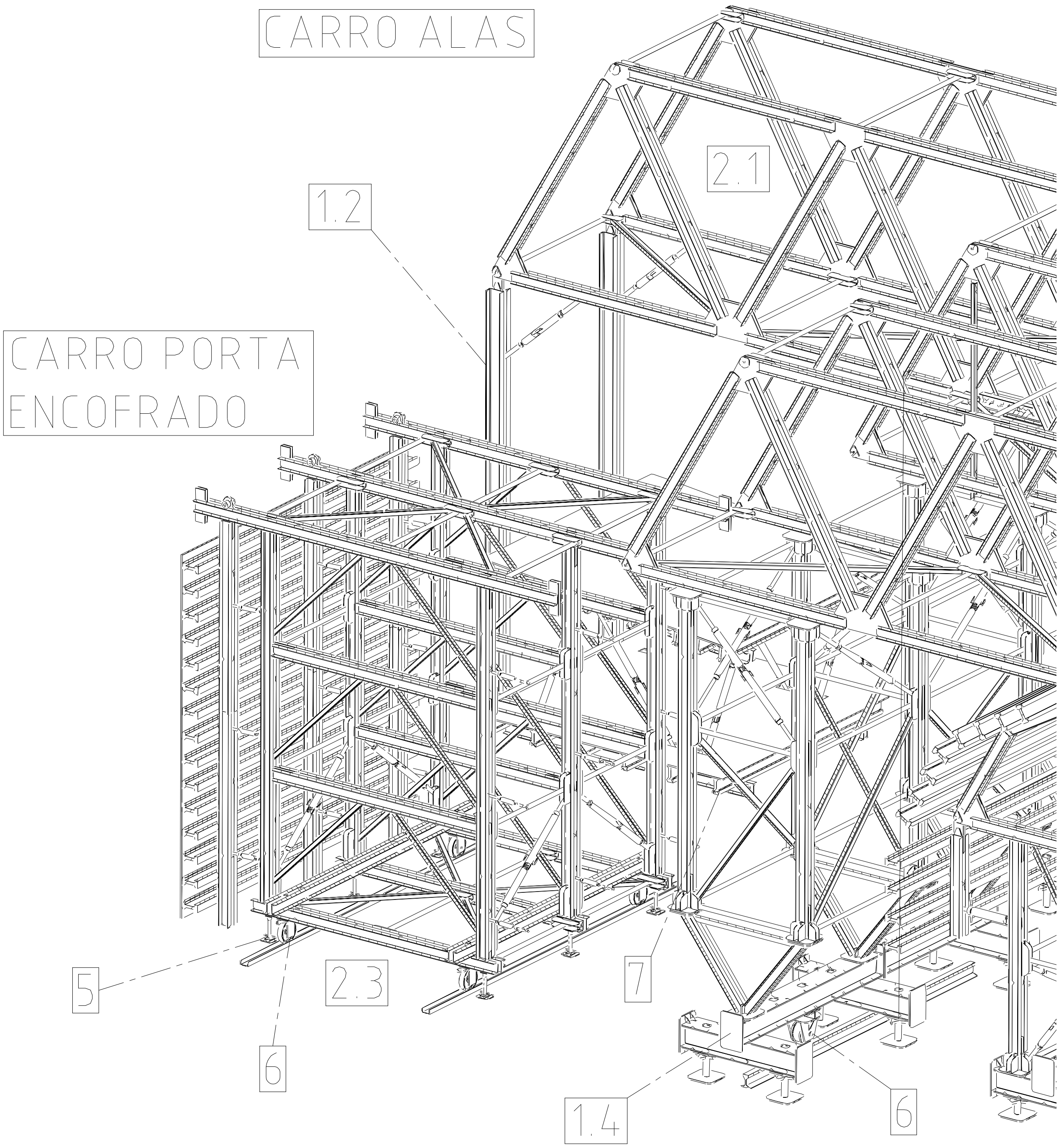
The waler providing the best structure weight–working load ratio is the Waler MK-120 / 2.625 enabling a distance between nodes of 3 m.
Usually the structure is assembled at once, although it might be useful to divide the assembly in modules in order to ease future operations such as the placing of the structure into its final position.



Medium load-bearing capacity structures up to 150 kN are characterised by using more frequently tubular elements for the diagonal and horizontal connections, reserving the walers for the most demanding parts of the structure. These structures are mainly used for solutions such as vertical formwork carriers or parapet form carriers.



Medium load-bearing capacity joints are fastened with pins D20 providing a maximum tensile or compression load of 75 kN to the diagonals and 360 kN to the walers. Moreover, there is the load limitation of the tube used for the diagonals and horizontal braces.



4.1 STRUCTURE TYPES

4.1.1 Truss structure

4.1.2 Hanging structure

4.1.3 Structure of form carriers

4.1.4 Forward-moving structure

4.2 STRUCTURE LAYOUTS

4.2.1 High load-bearing capacity structure

4.2.2 Reinforced main axis structure

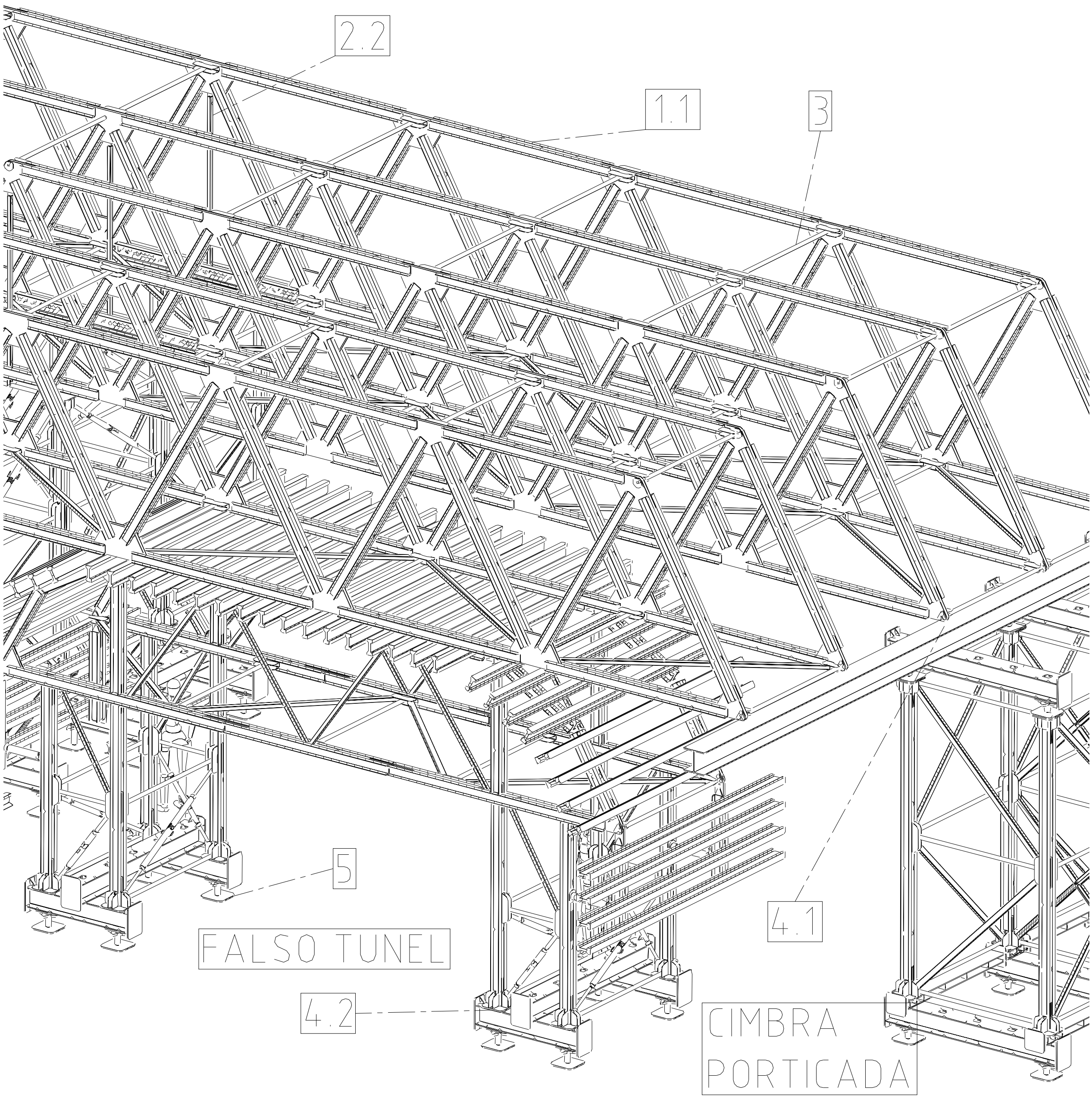
4.2.3 Medium load-bearing capacity structure

4.2.4 Secondary axis structure

4.3 BRACING BETWEEN STRUCTURES

4.3.1 Bracing on waler axis

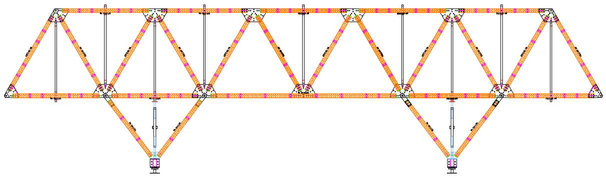
4.3.2 Bracing off waler axis


2.2
1.1
3
5
FALSO TUNEL
4.2
4.1
CIMBRA
PORTICADA

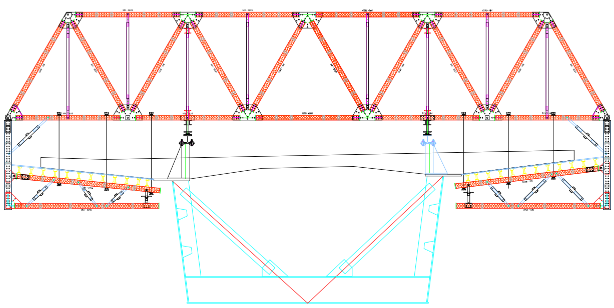
4.1. STRUCTURE TYPES

4.1.1. Bi- or multi-supported truss structure

This refers to truss structures resting on at least two supports. These are mainly used for high load-bearing capacity structures up to 360 kN on horizontal braces and diagonals.



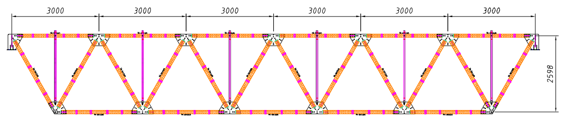
The structures can be supported on the ends or on the central part thus working as a beam at bending with point load or distributed load.



Truss structures are adapted to the spans between supports and to the load-bearing capacity required for the structure.

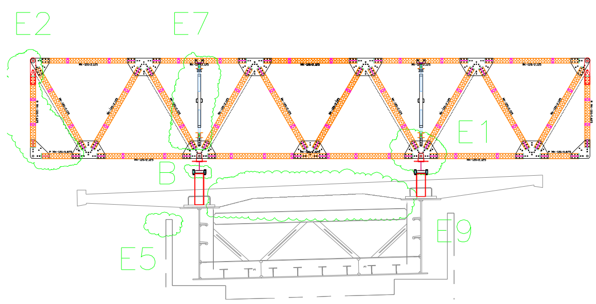
Solutions with constant and metric distances between nodes are preferred hence the most commonly used waler lengths for this structure type are:

Theoretical length	Nodes distance
1.625 m	2 m
2.125 m	2.5 m
2.625 m	3 m



Truss structures are frequently combined with the MK Shoring system. The levelling and adjustment elements applied are usually of high load-bearing capacity (360kN).

The forward-moving of those heavy structures is carried out with the Wheel 100 MK.

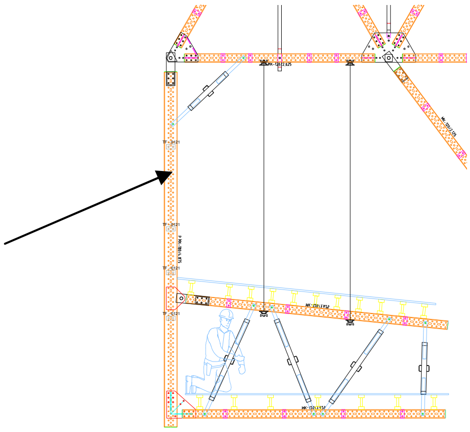


4.1.2. Hanging structures

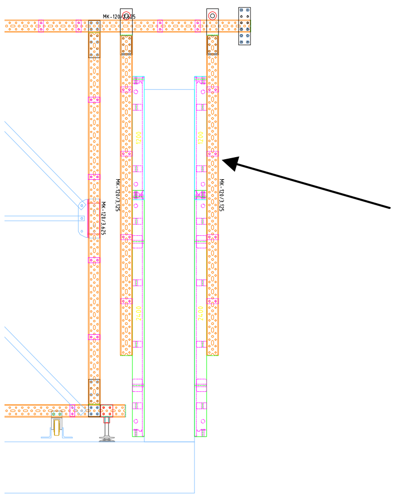
This refers to structures which are not directly supported on the ground or floor but are hanging from others which are supported though.

Hanging structures usually hold the formwork and must only be able to bear loads in order to transmit them to the structures being supported on the ground.

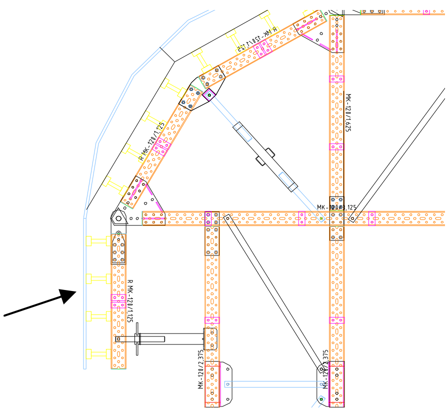
In general, they are tied directly to the main structures with pins D40 allowing of a fast and safe on-site assembly.



Hanging structure in a MK deck flange form carrier



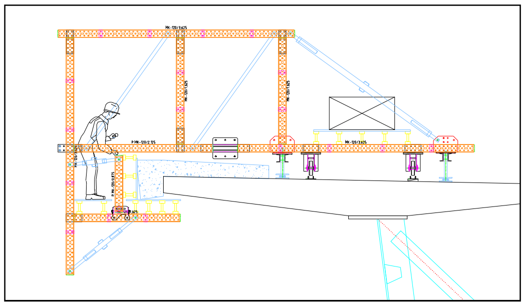
Hanging structure in a MK vertical formwork carrier



Hanging structure in a MK cut-and-cover tunnel form carrier

4.1.3. Structure of form carriers

Such structures must only bear their self-weight plus the formwork they hold. They are medium load-bearing capacity structures and light, in general.

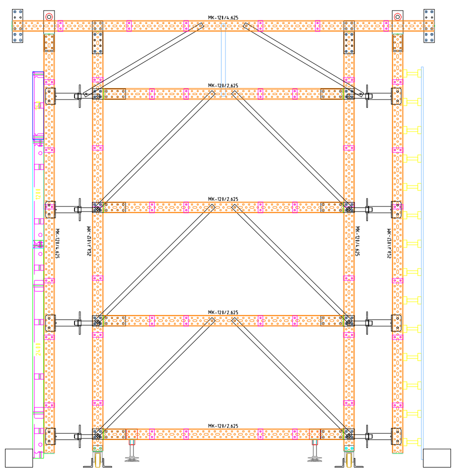


MK parapet form carrier structure

The horizontal braces and diagonals are tubes in all directions, reserving the walers for the most demanding areas of the structure, in this case, to connect levelling and rolling elements.

The rolling and levelling parts have lower load-bearing capacity: 150 kN and 60 kN for the jacks and 25 kN for the wheels.

Occasionally, when these structures are submitted to concrete loads caused by lateral forces or they support single-sided wall formwork, walers are used to reinforce the horizontal axis.



MK vertical formwork carrier structure

4.1.4. Forward-moving structures

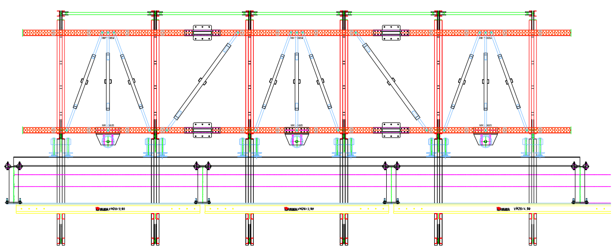
For the forward-moving of heavy structures, an auxiliary structure is required.

Such complementary or secondary structure (bogie) is placed perpendicular to the main structure easing the forward-moving of the overall structure consisting of several main structures.

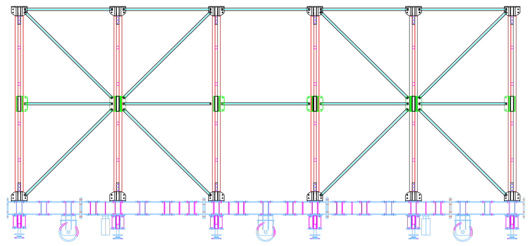
The bogie must bear the loads during the forward-moving of the overall structure but does not necessarily have to bear the loads during concrete placement or working stage.

It can be rather simple consisting of jack walers joined together, and supporting the structure and jacks on one side and the rolling elements on the other.

The bogie can be reinforced with elements of the MK system. This might apply when the jack walers alone are not able to bear the weight of the overall structure or to provide extra stability to it, as in the case of very tall structures.



Forward-moving structure in a MK deck flange form carrier



Forward-moving structure in a MK cut-and-cover tunnel form carrier

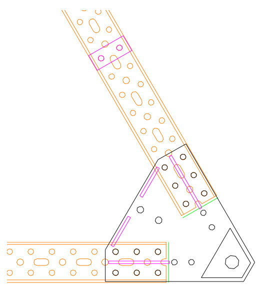
4.2. STRUCTURE LAYOUTS

4.2.1. High load-bearing capacity structure

There are various structures of this kind in all sorts of applications, and inside them, there are different node connection types depending on the area required to be solved.

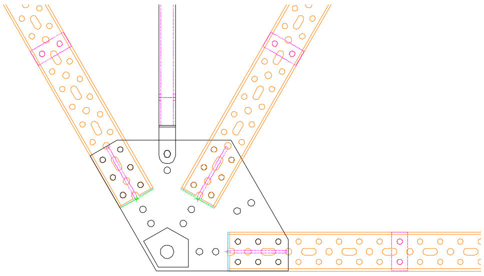
➢ <u>60º joint</u>

Used at the ends which require a termination of the structure at 60º. Moreover useful when a pre-assembled structure (or tower) shall be quickly joined to an already existing one.



➢ <u>120º joint</u>

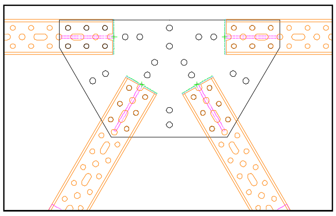
Used at the ends which require a termination of the structure at 120º. Moreover useful when a pre-assembled structure (or tower) shall be quickly joined to an already existing one.

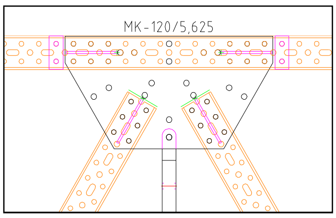


➢ <u>180º joint</u>

Used for the intermediate nodes of the structure.

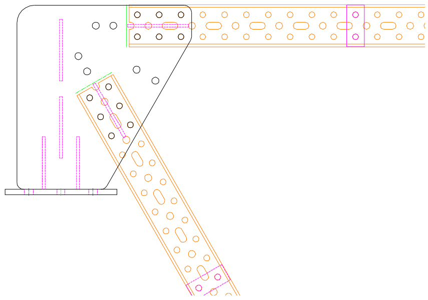
There are two options depending on the requirement to quickly join a pre-assembled structure (or tower) to the intermediate joints or not. In the latter case, the waler could pass through the node and 4 bolts on each side of the joint would be sufficient.





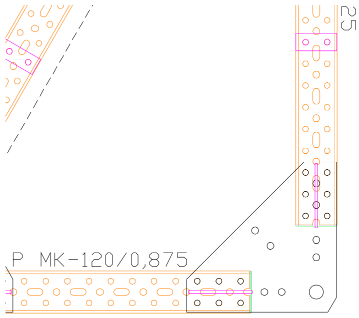
➢ <u>60º joint with support</u>

Used at the ends which require a termination of the structure at 60º and at the same time a support located on the top part of the truss.



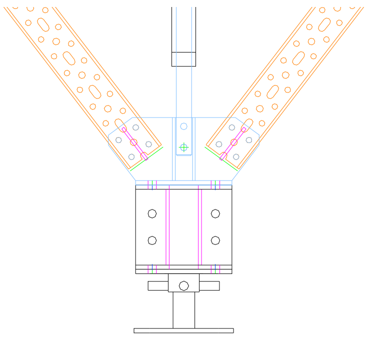
➢ <u>90º joint</u>

Used at the ends which require a termination of the structure at 90º. Moreover useful when a pre-assembled structure (or tower) shall be quickly joined to an already existing one.



➢ <u>74º joint</u>

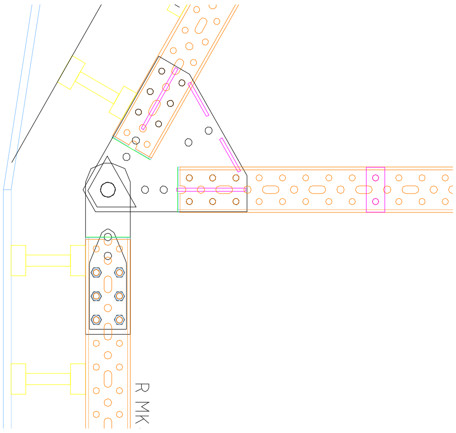
Used at the ends which require an end joint at 74º. This joint provides a single support in direction of the main axis, as it is the case on bogies.



➢ <u>Joint with pins</u>

It is used to join two structures quickly and effectively. These are usually end joints which require a male end element on one structure and a female on the other. There are several parts fulfilling this function.

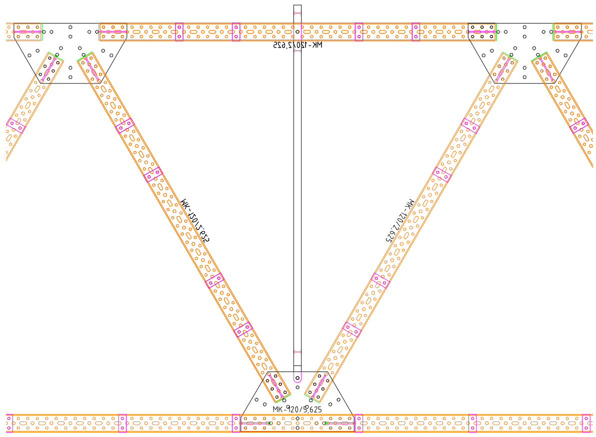
The joint is fastened with a conical tip pin D40.



4.2.2. Reinforced main axis structure

For the reinforcement of the waler centre or a specific part of the structure of high load-bearing capacity structures, the V Bracing Truss MK is used.

This part only serves to reinforce the most common triangular structure layout of 3 m between nodes. If the distance between nodes is bigger or smaller, push-pull props E and heads are used.



The joints are fastened with pins E20x70.

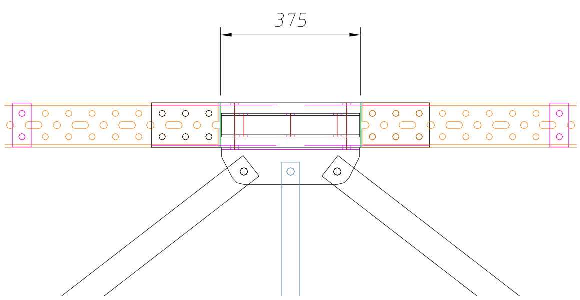
4.2.3. Medium load-bearing capacity structure

As mentioned beforehand, there are various structures of this kind in all sorts of applications, and inside them, there are different node connection types depending on the area required to be solved.

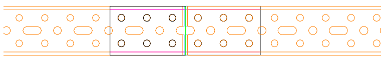
➢ <u>Longitudinal joints between walers</u>

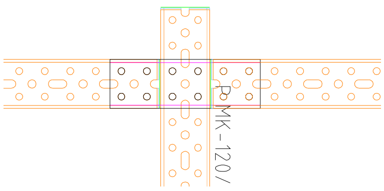
There are two types of longitudinal joints for walers offering different additional features:

- The first waler joint can be stiffened with diagonals and braced in the secondary axis. It moreover allows of a 375 mm gap between the walers.



- The second waler joint is a joint only between walers. The bracing of the secondary axis is made at another point. It enables either a butt joint fastened with 6 bolts each or a joint with a 125 mm gap between walers fastened with 4 bolts. In the latter case, walers can be crossed.





4.2.4. Secondary axis structure. Waler joints at different level

This refers to joints between walers perpendicular between the main axis and the secondary axis. There are various possible solutions depending on the specific application.

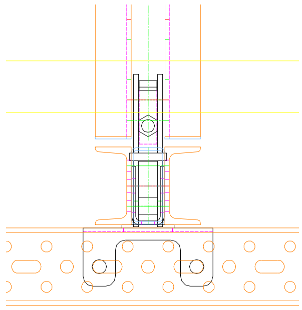
The walers can be independent (formwork) or part of other structures to be installed in this direction.

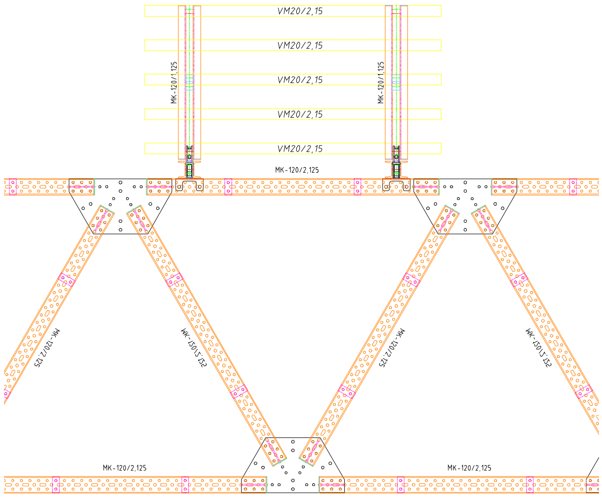
These joints can only work at compression, never at tension. Therefore the joints must be assembled to support the secondary walers on the main ones and never the other way around.

➢ <u>Waler on waler joint</u>

The Waler-Waler 90º Joint MK is used to join walers of the secondary axis on top of the walers of the main axis.

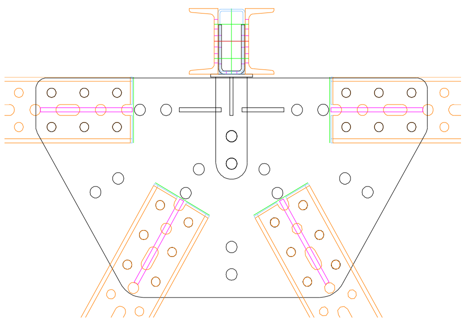
The joint can be fixed at any point of the waler, aligned with a hole or slot every 62.5 mm, in both directions.





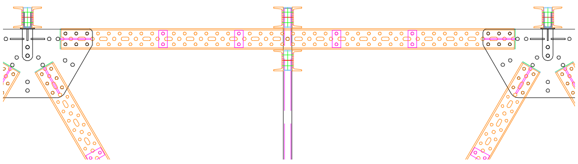
➢ <u>Waler on node joint</u>

In accordance with the previous joint, the Node-Waler 90º Joint MK is used to join the secondary axis waler on top of a node of the main axis. This joint can only be connected to the centre of the node.



➢ Waler on V Bracing Truss MK joint

There is still another way to join two walers. That is with the V Bracing Truss MK and without any additional part. The V bracing can only be fixed to the centre of a main truss waler, and only if tubes are used in the application.

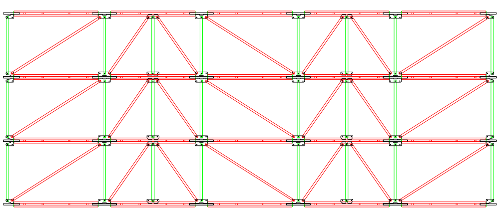


4.3. BRACING BETWEEN STRUCTURES

Bracing between structures is understood as all tubes and joints used to connect two or more equal structures parallel to each other and thus also reinforcing them in the secondary plane.

This tubes and joints framework structure must mainly be able to absorb secondary actions such as lateral wind, forces during the process of forward-moving of the structures and forces due to inclinations or slopes of the application.

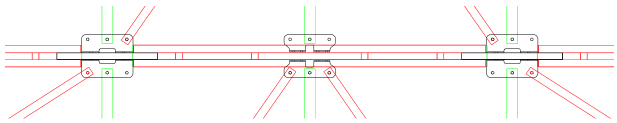
In some cases, these loads might happen to be important, therefore the requirement to use bracing which transmits the actions to the structure axis.



There is another possibility to externally brace the structures. However, this bracing does not offer the same qualities of the previous one and may only be used when actions in the secondary plane are certainly not important.

4.3.1. Bracing on waler axis

For this type of bracing, diagonals and horizontal braces are used, joined to the walers with U secondary axis joints fastened and with pins D20. Hence these connections are all hinged which requires them to be also braced diagonally at some points to achieve an appropriate bracing for all the structures.



The bracing system transmits the forces to the waler axis, and the horizontal braces join and determine the distance between two adjacent structures. More structures can be braced parallel to the other, always in the secondary plane.

4.3.2. Bracing off waler axis

Tubes and couplers are directly fixed to the Handrail Head MK joined to the walers and fastened with 2 bolts M16.

This type of bracing does not offer the same qualities of the previous one and is not advisable to be used with high load-bearing capacity structures.

Its main advantage is its simplicity (few elements) and ease of assembly hence it is very useful for the bracing of light structures. It may also be used to join two independent, that is, self-standing sets or form carriers which are not supposed to be moved.

4.4. STRUCTURE CONNECTION WITH SHORING SYSTEM

There are two types of connections between standard truss structures and support structures.

4.4.1. Support on shoring towers or props

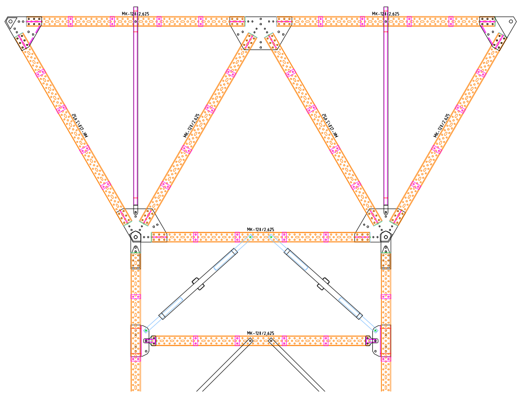
The support of the structure on the shoring can as well be secured in two different ways:

- Directly on the shoring: The structure rests directly on top of one shoring leg.

  The joint can be pinned or simply resting on the shoring and being fastened subsequently with bolts.

  (1) The first case requires male-female joints as the ones described before. Their implementation is easier for structures of small height and or for such being assembled on the ground.

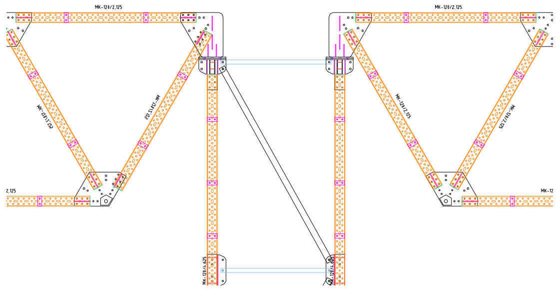
  This type is frequently used for connections with the MK Prop system.



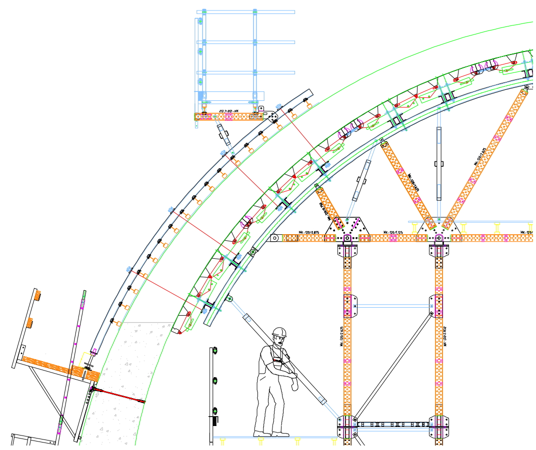
  (2) For the second case, head joints are used as end elements as well for the structure as for the shoring or towers.

These joints allow of the pre-assembly of towers. Only subsequently, the structure is supported on and fastened to them.

This joint type suits best the requirements of heavy and large structures.



MK truss structure supported on MK tower

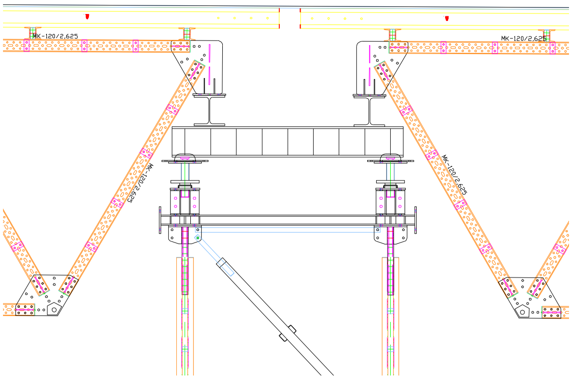


MK cut-and-cover tunnel form carrier

Both cases require high assembly accuracy as well as the same number of structures and lines of supports.

- With load distributing beam: This is the classical support for gantry solutions. Its main advantage lies in the better load and force distribution on the supports.

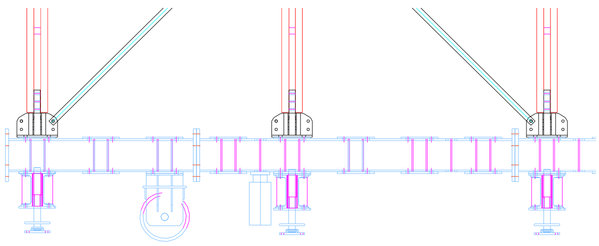
This connection type does not require an equal number of lines of supports and structures with the correspondent savings which this supposes.



4.4.2. Support on bogie

This is the case of cut-and-cover tunnel and deck flange form carriers where the main structure rests on the jack walers (or a similar profile acting as bogie) and where the end joints fixed to the jack walers form the end of the structures, tied on the fastening points of the profiles.

In case the structure does not have end joints, a joint with similar features shall be found for the connection.



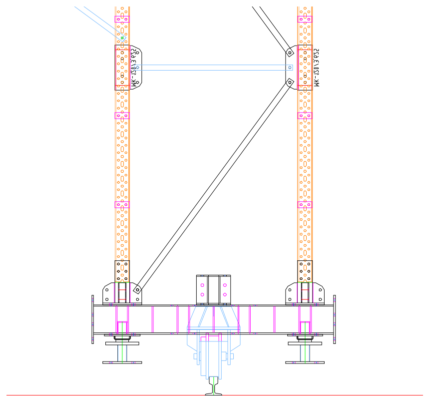
4.5. STRUCTURE LEVELLING

4.5.1. High load-bearing capacity structure

These structures commonly have a bogie. The levelling of these structures is done with the Jacks MK 360 below the jack walers that form the bogie. If the acting loads allow it, Jacks MK 150 might also be used.

The number of jacks necessary to level the structure depends on the application. As general rule, one levelling line per each main structure support is required to avoid loading the bogie when the structure is not in the process of forward-moving.

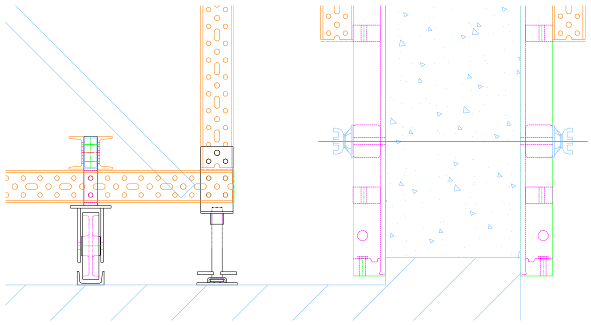
For ordinary form carrier solutions such as cut-and-cover tunnel or deck flange and always if a stable support area of sufficient size is available, two pairs of jacks at both sides of the bogie are placed to free the guide rail used for the forward-moving of the form carrier.



If only a reduced support area for the form carrier is available, the same is reduced to only one row of supports. In such case, the jacks should rest directly on the guide rail. The levelling of this type of structures supposes rather complicated solutions.

4.5.2. Medium load-bearing capacity structure

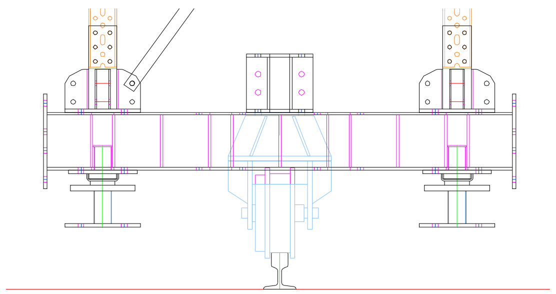
For lighter form carriers, the levelling is done using the Jack MK 60. These solutions do not require a secondary structure for the forward-moving, and are usually made up of 2 or 3 main structures. Common applications are vertical formwork carriers or such applications where load requirements of the structure are not significant.



4.6. FORWARD-MOVING OF STRUCTURES: ROLLING SYSTEM

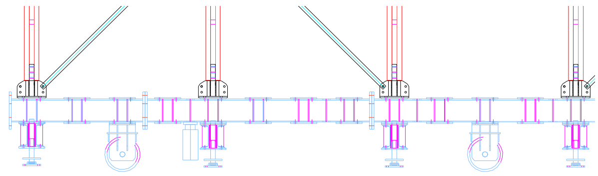
4.6.1. High load-bearing capacity structure

The forward-moving of this type of structures is done with Wheels MK 100 attached directly onto the jack walers which form the bogie. During the process of forward-moving, the wheels run on a guide rail. The guide rail rests directly on the ground and is anchored to it.



The guide rail is quite heavy (HEB-200 type) due to the loads it must bear. The pulling of the structure to the next pouring stage is done with the aid of load arrester devices (e.g. Tractels).

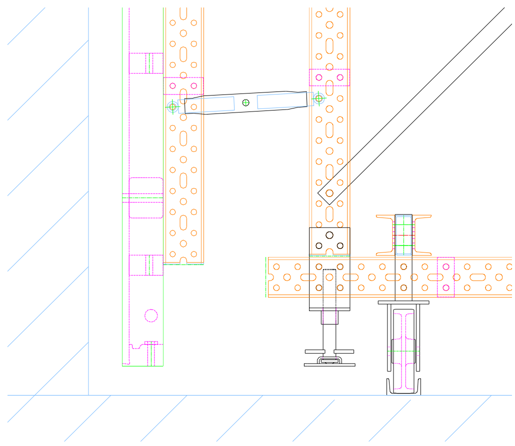
Each form carrier or structure usually has 4 wheels which allows of moving up to 40 tons. The wheels are also the support points for the secondary structure (bogie). In this case, the bogie bears the total weight of the form carrier. Once the forward-moving has finished, the form carrier gets blocked by means of the jacks and the bogie gets not loaded any more.



4.6.2. Medium load-bearing capacity structure

Lighter form carriers are moved forward with the Wheel MK 15 up to 60 kN. These are made up of several main structures, and the wheels are attached directly to the jack walers.

A lighter guide rail is used (UPN type) and the forward-moving of the structure is done manually.



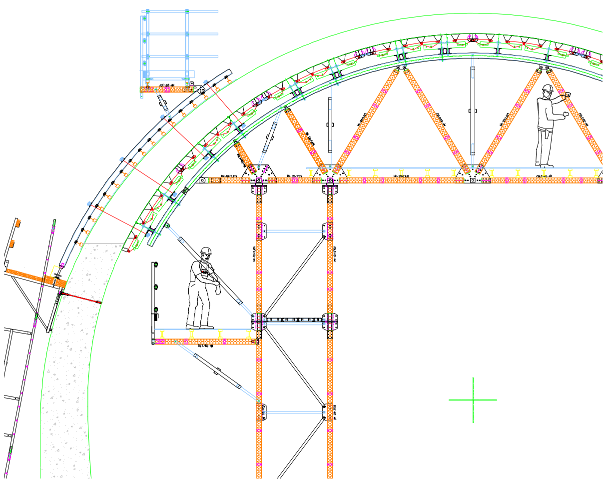
4.7. SAFETY AND ACCESS PLATFORMS

Safety platforms are assembled directly on the structures. This can be done in two ways:

- Directly on two adjoining structures with the available walers. Secondary beams and board rest on the walers. Depending on the beam used, the corresponding fixing system is employed.

- Directly on the bracing tubes between structures with metal scaffolding platforms on round or square tubes.

Platforms can be installed at any point of the structure to provide working areas at different levels and thus assisting the assembly. Moreover, access platforms provide access to higher areas if required.



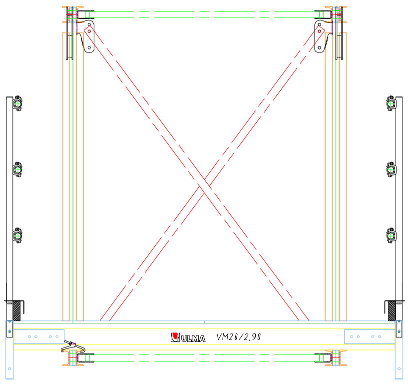
The first option allows of installing cantilever platforms, that is, platforms outside the structure.

5.

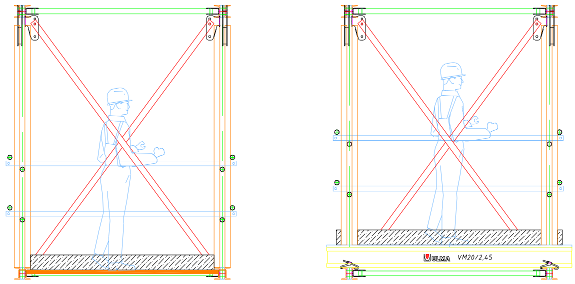
Both options similarly serve to assemble platforms inside the structure.

The safety handrail system can also be assembled in two different ways:

- With Handrail Heads MK on secondary beamsusing the appropriate handrails for each case as in any other system.



- With Handrail Heads MK on walersassembling the handrail heads directly onto the walers of the structure. Tubes and couplers get fastened to the head. Typically used with metal (scaffolding) platforms, this option suits well any kind of platform.



SYSTEM PROPERTIES

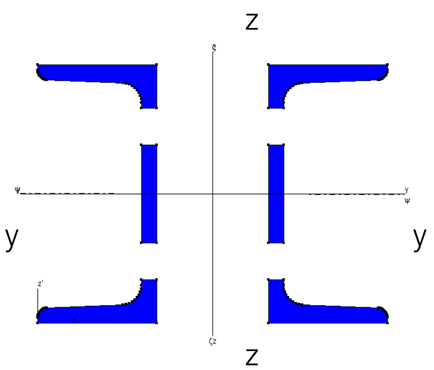
It is rather difficult to define limits for the manifold possible structure options which can be formed with the MK system. As for their variety, each structure must be calculated on an individual basis. Nevertheless, this chapter gives the necessary data to perform these calculations, and presents some limits for the most critical elements.

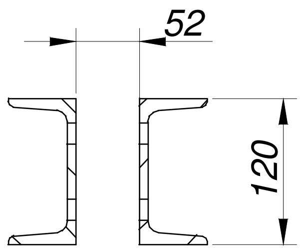
Some working load tables for particular applications are given below which may serve as orientation on the obtainable load-bearing capacity of these structures.

5.1. MAIN ITEM PROPERTIES

5.1.1. WALER MK-120

The technical material properties of the WALER MK-120 are:





m = 27.5	[kg/m]	weight/m
A = 27.5 10^{-4}	[m^2]	net section area (without holes)
f_y = 275	[MPa]	yield strength

Main axis (strong axis):

Av_{zz} =12,32 10-^{4}	[m^2]	shear area
I_{yy} = 680 10^{-8}	[m^4]	moment of inertia
W_{elyy} = 113 10^{-6}	[m^3]	Young's modulus
W_{plyy} = 128 10^{-6}	[m^3]	plastic section modulus?

Secondary axis (weak axis):

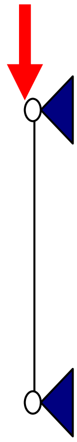
Av_{yy} =17,2 10-^{4}	[m^2]	shear area
I_{zz} = 311 10^{-8}	[m^4]	moment of inertia
W_{elzz} = 38 10^{-6}	[m^3]	Young's modulus

The technical properties of the WALER MK-120 are (for SLS loads):

M_{Rdyy} = 21.33	**(kN m)**	Maximum permissible bending moment on axis y-y
V_{Rdzz} = 118,2	**(kN)**	Maximum permissible shear force on axis y-y?
M_{Rdzz} = 6.3	**(kN m)**	Maximum permissible bending moment on axis z-z

Compression load of WALER MK-120

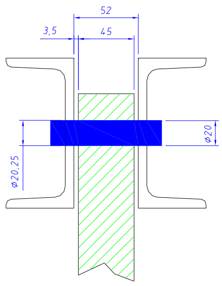
Free length	Compression load N_{crd} (SLS)
1.5 m	360 kN **
2 m	336 kN
2.5 m	287 kN
3 m	240 kN



** Limited by the joint with 6 bolts

Values of pure buckling, not considering bending moment effects on any axis

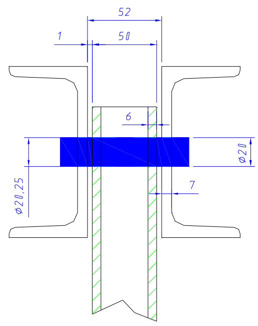
5.1.2. PIN E20X70 AND PUSH-PULL PROP E JOINTS



The working load of the pin E20x70 in the WALER MK-120

Designation	Working load (SLS)
PIN E20x70	77 kN

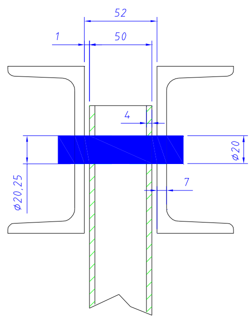
5.1.3. PIN E20X70 AND TUBE 50X6 JOINT (V BRACING TRUSS MK TUBE)



The working load of the pin E20x70 in the WALER MK-120

Designation	Working load (SLS)
PIN E20x70	77 kN

5.1.4. PIN E20X70 AND TUBE 50X4 JOINT



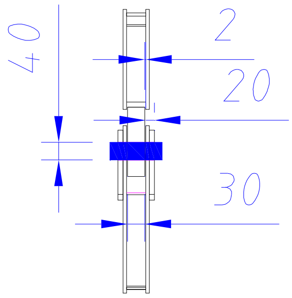
The working load of the pin E20x70 in the WALER MK-120

Designation	Working load (SLS)
PIN E20X70	30 kN **

** The strength limit of the diagonals is given by the tearing of the hole

5.1.5. PINNED JOINTS: PIN D40 AND MK CONNECTOR / NODES / JOINTS

The working load of the pin D40 used in a joint of the structure:

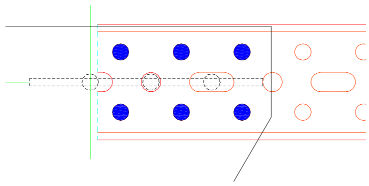


Designation	Working load (SLS)
PIN E40X70	426 kN

5.1.6. BOLTED JOINTS: WALERS AND NODES

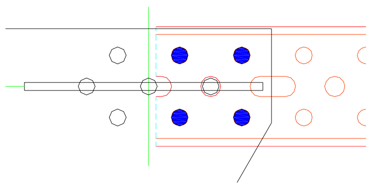
The working load of a joint fixed with 6 bolts between Walers MK-120 and different nodes is:

Designation	Axile $_{Max}$ (SLS)	M $_{Max}$ (SLS)
6-bolt joint at tension	360 kN	0 kNm
6-bolt joint at bending moment	0 kN	16.4 kNm



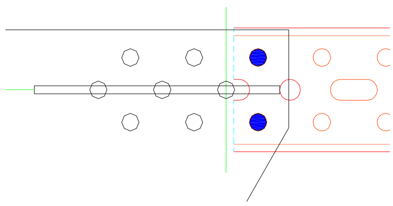
The working load of a joint fixed with 4 bolts between Walers MK-120 and different nodes is:

Designation	Axile $_{Max}$ (SLS)	M $_{Max}$ (SLS)
4-bolt joint at tension	240 kN	0 kNm
4-bolt joint at bending moment	0 kN	10.6 kNm



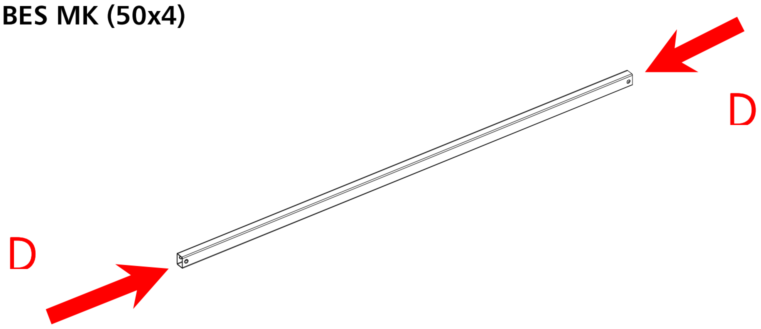
The working load of a joint fixed with 2 bolts between Walers MK-120 and different nodes is:

Designation	Axile $_{Max}$ (SLS)	M $_{Max}$ (SLS)
2-bolt joint at tension	120 kN	0 kNm
2-bolt joint at bending moment	0 kN	3.7 kNm



These values refer to the maximum working load of the joint at pure tension and bending moment. They do not refer to the load combination of both.

5.1.7. DIAGONAL TUBES MK (50x4)



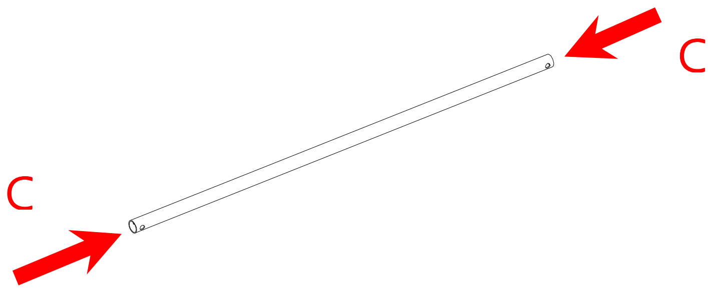
For any length of diagonals

DIAGONAL LENGTH	TENSION (SLS)	COMPRESSION (SLS)
Any	30 kN	30 kN

⚠ It is **NOT** enough to verify the diagonals at buckling because diagonals submitted only to tension must be verified with respect to the working load value ***NEVER*** exceeding 30 kN due to the tear of the ∅20 hole of the diagonal. The maximum working load of the diagonals is given by the tearing of the hole.

5.1.8. HORIZONTAL BRACES MK

Two limit values are given below for the horizontal braces. The first value does not consider any working platform installed on the braces hence they are only submitted to compression loads. The second value considers apart from compression, the generation of bending moments along the brace due to working platforms.

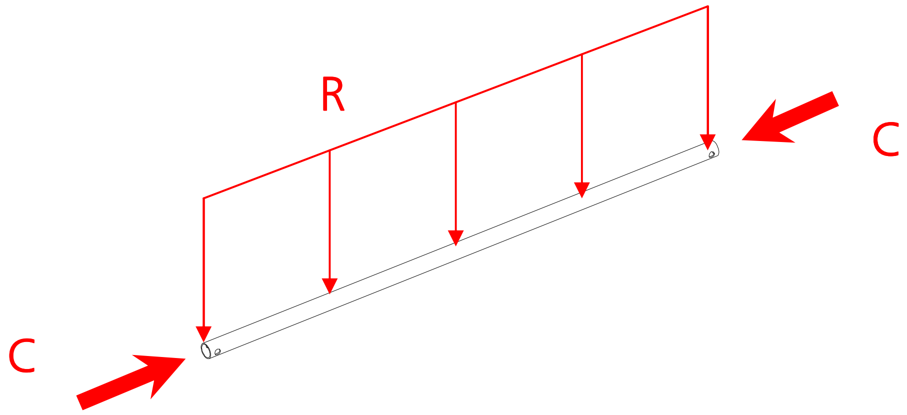


For the first case and for any length of horizontal braces:

BRACE LENGTH	TENSION (SLS)	COMPRESSION (SLS)
Any	20 kN	20 kN

⚠ It is **NOT** enough to verify the horizontal braces at buckling because braces submitted only to tension must be verified with respect to the working load value ***NEVER*** exceeding 20kN due to the tear of the ∅20 hole of the diagonal. The maximum working load of the braces is given by the tearing of the hole.

For the second case:



BRACE LENGTH	DISTRIBUTED LOAD (SLS) R	COMPRESSION (SLS)
0.75 m	- kN/m	10 kN
1 m	17 kN/m	10 kN
1.5 m	5.8 kN/m	10 kN
2 m	2.6 kN/m	10 kN
2.5 m **	1.1 kN/m	10 kN
3 m **	1.9 kN/m	10 kN

** Due to the permissible load distribution, it is advisable not to install platforms on the horizontal braces of 2.5 m and 3 m. In any case, these braces require a previous verification.

5.1.9. BEAM VM20

Technical properties of the Beam VM20:

$M_{ad} = 5$ (kNm) Maximum permissible bending moment

$Q_{ad} = 11$ (kN) Maximum permissible shear force

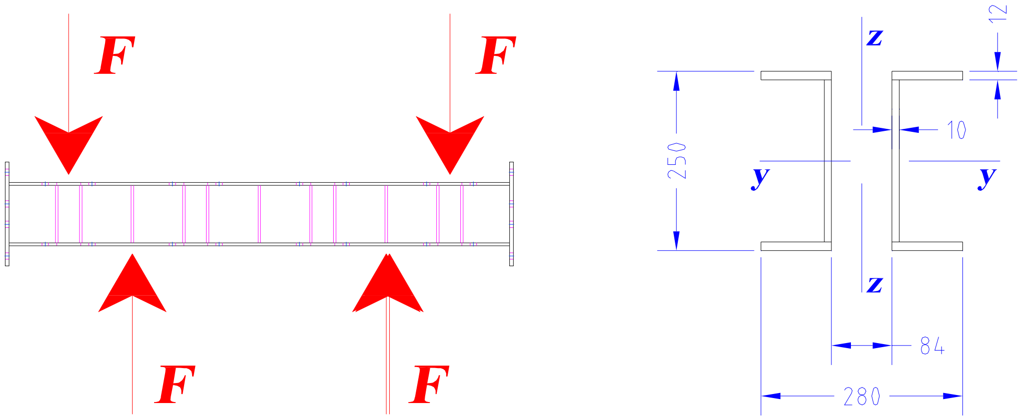
$EI = 450$ (kN m^2) Stiffness (EI)

5.1.10. PLYWOOD BOARDS (SHUTTERING FACE)

Regarding the high variety of different board types on the market, a separate document collects all mechanical properties of formwork boards. For more information, please refer to that document.

5.1.11. JACK WALER MK

The jack waler is studied for the stripping at a 250 mm distance from the supporting areas of the posts. These areas have to be properly stiffened.



F = 360 kN (SLS)

Technical properties of the Jack Waler MK:

m = 72.4 (kg/m) weight/m

A = $92.24\ 10^{-4}$ (m^2) net section area (without holes)

Av_{zz} =42.16 10-4 (m^2) shear area — Av_{yy} =62.90 10-4 (m^2) shear area

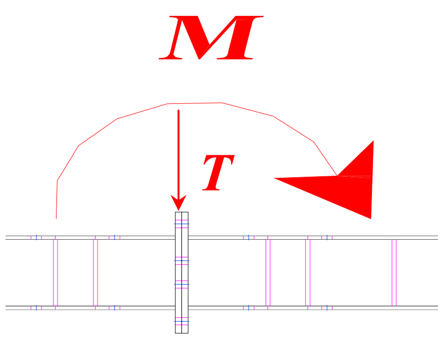
I_{yy} = $8590\ 10^{-8}$ (m^4) moment of inertia — I_{zz} = $5274\ 10^{-8}$ (m^4) moment of inertia

W_{elyy} = $687\ 10^{-6}$ (m^3) Young's modulus — W_{elzz} = $376\ 10^{-6}$ (m^3) Young's modulus

f_y = 355 (MPa) yield strength

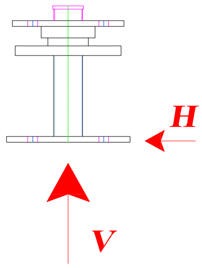
The maximum permissible bending moment and shear force of the connection is:

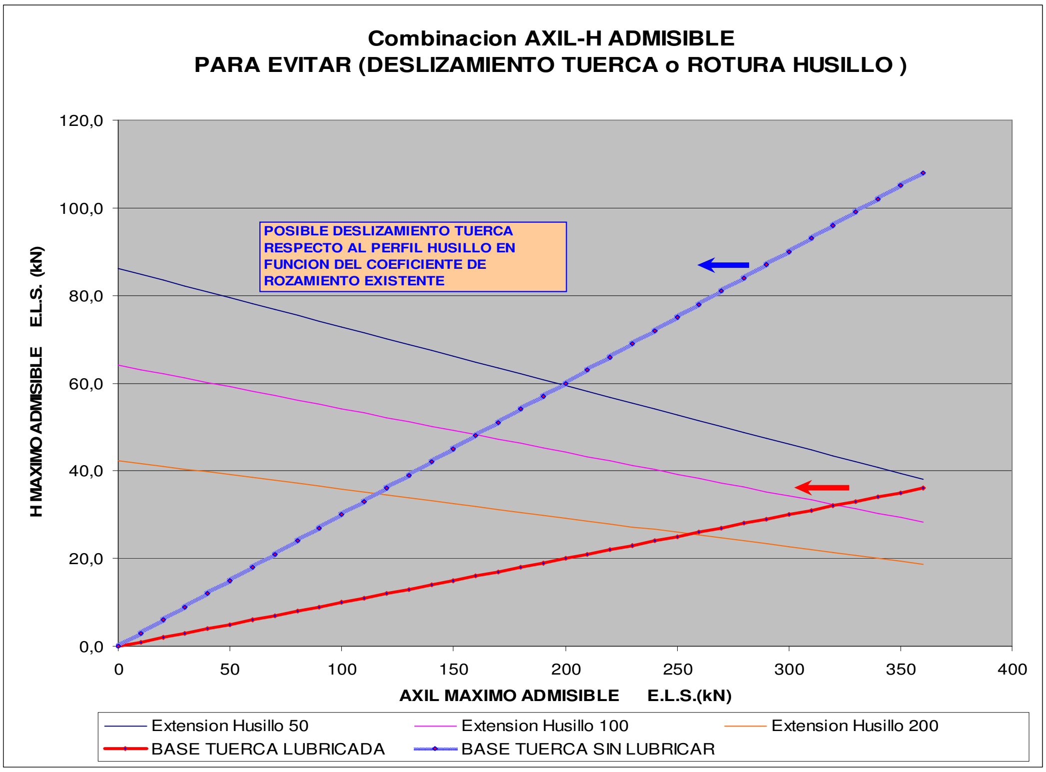
8 bolts M24x60 8.8	Mmax $_{yy}$ (SLS) = 75 kNm ~ 45 % waler strength	Tmax $_{yy}$ (SLS) = 300 kN
8 bolts M24x60 10.9	Mmax $_{yy}$ (SLS) = 100 kNm ~ 60 % waler strength	Tmax $_{yy}$ (SLS) = 375 kN



5.1.12. JACK MK 360

The working loads of the Jack MK 360 are indicated in the table below. The table shows the possible combinations of axial (V) and horizontal (H) forces for the different jack extensions. In the same figure, two straight lines delimit the values for which there might be a sliding of the nut with respect to the fixed base depending on some estimated friction coefficients for a nut lubricated or non-lubricated on its base.

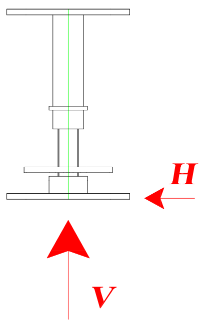




5.1.13. JACK MK 150

The working loads for the JACK MK 150:

V max (SLS)	H max (SLS)
150 kN	8 kN



5.2. LIMITS FOR STANDARD STRUCTURES

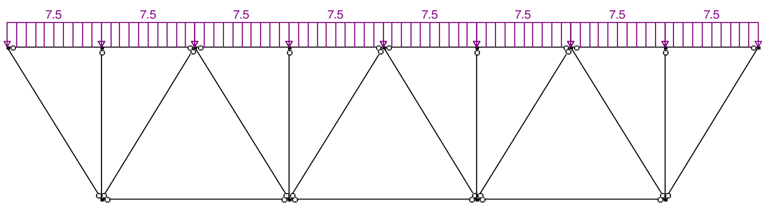
The following information and data may merely act as reference. Formulas included in different calculation bases for truss beams are used. They are valid as a first approximation but it is advisable to always verify individually any truss application.

There are no whatsoever limits for possible truss deformations included herein. Those must be verified with the help of calculation software for structures.

5.2.1. Bi-supported truss structure

This refers to a truss with supports at both ends as shown in the following figure. The spans possible to achieve with this truss vary depending on the applied modulation. Three load application cases are analysed subsequently:

- As distributed load along the truss
- As point load applied on the centre of the upper boom
- As point loads applied on all nodes of the upper boom

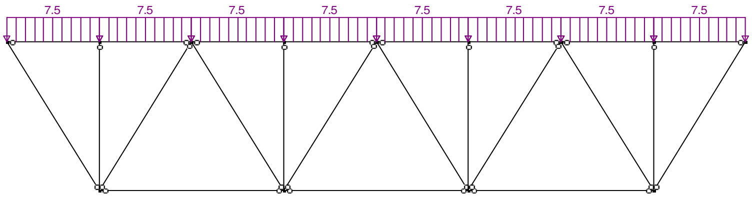


The tables show the maximum permissible load in SLS for each truss (qmax) (Pmax): maximum reaction on prop-boom joint?, maximum bending moment the truss is able to absorb (M truss max), maximum bending moment in the waler, maximum axial force in the waler and reactions on the supports depending on the distance between nodes of the truss.

5.2.1.1. Node distance 3 m

L_{Truss} **3** m

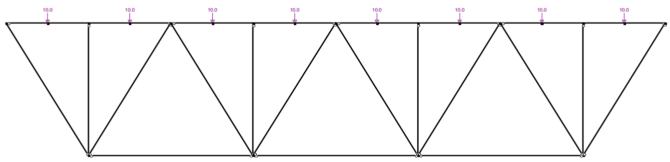
h_{Truss} 2,60 m



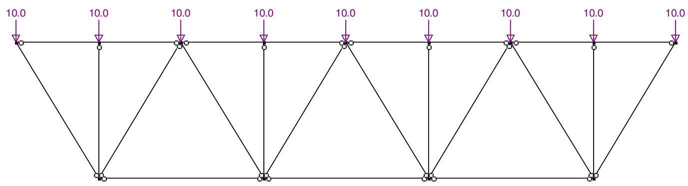
Longitud Total Truss (m)	qmax kN/m (ELS)	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
12	31,93	59,86	Tubo 50x50x6	574,67	8,98	221,19	191,56
15	24,08	45,15	Tubo 50x50x6	677,32	6,77	260,70	180,62
18	18,52	34,73	Tubo 50x50x6	750,10	5,21	288,71	166,69
21	14,55	27,28	Tubo 50x50x6	802,06	4,09	308,71	152,77
24	11,66	21,87	Tubo 50x50x6	839,82	3,28	323,25	139,97
27	9,52	17,86	Tubo 50x50x6	867,84	2,68	334,03	128,57
30	7,90	14,82	Tubo 50x50x6	889,05	2,22	342,19	118,54

L_{Truss} **3** m

h_{Truss} 2,60 m



Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
12	26,34	39,51	49,38	Tubo 50x50x6	474,08	11,14	182,48	158,03
15	20,76	31,14	38,92	Tubo 50x50x6	583,87	8,78	224,73	155,70
18	16,49	24,74	30,92	Tubo 50x50x6	667,89	6,98	257,07	148,42
21	13,27	19,90	24,88	Tubo 50x50x6	731,35	5,61	281,50	139,30
24	10,83	16,24	20,30	Tubo 50x50x6	779,41	4,58	299,99	129,90
27	8,96	13,44	16,79	Tubo 50x50x6	816,18	3,79	314,15	120,92
30	7,51	11,26	14,08	Tubo 50x50x6	844,69	3,18	325,12	112,63

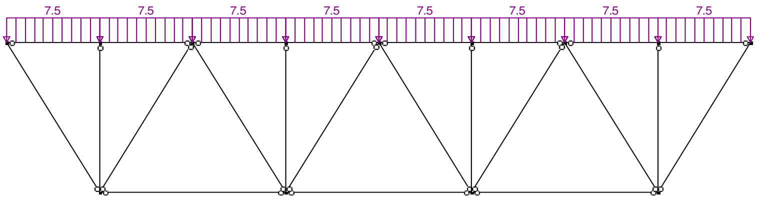


Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
12	44,54	66,81	59,38	Tubo 50x50x6	801,69	0,00	308,57	300,63
15	33,26	49,88	45,35	Tubo 50x50x6	935,31	0,00	360,00	274,36
18	23,09	34,64	31,98	Tubo 50x50x6	935,31	0,00	360,00	225,17
21	16,97	25,45	23,75	Tubo 50x50x6	935,31	0,00	360,00	190,88
24	12,99	19,49	18,34	Tubo 50x50x6	935,31	0,00	360,00	165,63
27	10,26	15,40	14,59	Tubo 50x50x6	935,31	0,00	360,00	146,26
30	8,31	12,47	11,88	Tubo 50x50x6	935,31	0,00	360,00	130,94

* Valores orientativos (referencia para comparar)

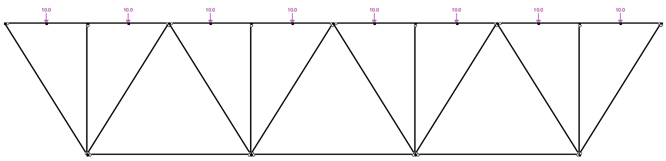
5.2.1.2. Node distance 2.5 m

L_{Truss}	2,5	m
h_{Truss}	2,17	m

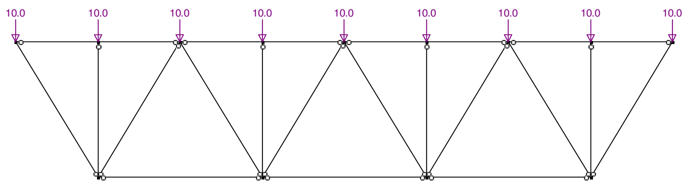


Longitud Total Truss (m)	qmax kN/m (ELS)	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
10	42,65	66,64	Tensor E 1,5-2,2	533,10	8,33	246,23	213,24
12,5	31,76	49,62	Tensor E 1,5-2,2	620,31	6,20	286,51	198,50
15	24,21	37,82	Tensor E 1,5-2,2	680,81	4,73	314,45	181,55
17,5	18,90	29,52	Tensor E 1,5-2,2	723,35	3,69	334,10	165,34
20	15,08	23,56	Tensor E 1,5-2,2	753,92	2,94	348,22	150,78
22,5	12,27	19,17	Tensor E 1,5-2,2	776,42	2,40	358,61	138,03
25	9,98	15,59	Tensor E 1,5-2,2	779,42	1,95	360,00	124,71

L_{Truss}	2,5	m
h_{Truss}	2,17	m



Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
10	35,63	44,54	55,68	Tensor E 1,5-2,2	445,43	10,47	205,74	178,17
12,5	27,70	34,62	43,28	Tensor E 1,5-2,2	541,01	8,14	249,88	173,12
15	21,77	27,22	34,02	Tensor E 1,5-2,2	612,40	6,40	282,85	163,31
17,5	17,38	21,72	27,16	Tensor E 1,5-2,2	665,33	5,11	307,30	152,07
20	14,10	17,62	22,03	Tensor E 1,5-2,2	704,87	4,14	325,57	140,97
22,5	11,61	14,51	18,14	Tensor E 1,5-2,2	734,81	3,41	339,39	130,63
25	9,70	12,13	15,16	Tensor E 1,5-2,2	757,84	2,85	350,03	121,25

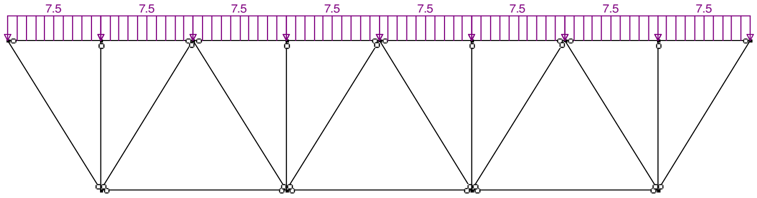


Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
10	62,35	77,94	69,28	Tensor E 1,5-2,2	779,42	0,00	360,00	350,74
12,5	39,91	49,88	45,35	Tensor E 1,5-2,2	779,42	0,00	360,00	274,36
15	27,71	34,64	31,98	Tensor E 1,5-2,2	779,42	0,00	360,00	225,17
17,5	20,36	25,45	23,75	Tensor E 1,5-2,2	779,42	0,00	360,00	190,88
20	15,59	19,49	18,34	Tensor E 1,5-2,2	779,42	0,00	360,00	165,63
22,5	12,32	15,40	14,59	Tensor E 1,5-2,2	779,42	0,00	360,00	146,26
25	9,98	12,47	11,88	Tensor E 1,5-2,2	779,42	0,00	360,00	130,94

* Valores orientativos (referencia para comparar)

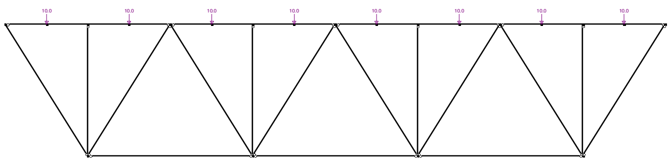
5.2.1.3. Node distance 2m

L_{Truss}	2	m
h_{Truss}	1,73	m

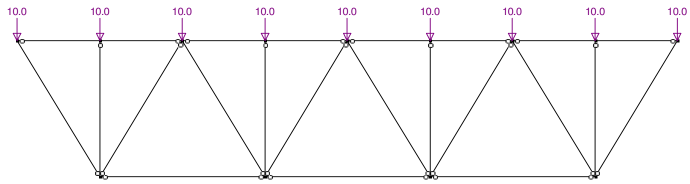


Longitud Total Truss (m)	qmax kN/m (ELS)	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
8	59,78	74,72	Tensor E 1-1,5	478,24	7,47	276,11	239,12
10	43,78	54,73	Tensor E 1-1,5	547,26	5,47	315,96	218,90
12	32,99	41,24	Tensor E 1-1,5	593,81	4,12	342,84	197,94
14	25,45	31,81	Tensor E 1-1,5	623,54	3,18	360,00	178,15
16	19,49	24,36	Tensor E 1-1,5	623,54	2,44	360,00	155,88
18	15,40	19,25	Tensor E 1-1,5	623,54	1,92	360,00	138,56
20	12,47	15,59	Tensor E 1-1,5	623,54	1,56	360,00	124,71

L_{Truss}	2	m
h_{Truss}	1,73	m



Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
8	50,81	50,81	63,51	Tensor E 1-1,5	406,47	9,55	234,68	203,24
10	38,77	38,77	48,46	Tensor E 1-1,5	484,59	7,29	279,78	193,84
12	30,06	30,06	37,58	Tensor E 1-1,5	541,09	5,65	312,40	180,36
14	23,75	23,75	29,69	Tensor E 1-1,5	582,00	4,47	336,02	166,28
16	19,13	19,13	23,91	Tensor E 1-1,5	612,03	3,60	353,36	153,01
18	15,40	15,40	19,25	Tensor E 1-1,5	623,54	2,89	360,00	138,56
20	12,47	12,47	15,59	Tensor E 1-1,5	623,54	2,34	360,00	124,71



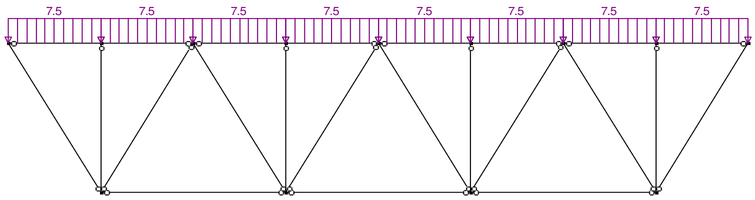
Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
8	77,94	77,94	69,28	Tensor E 1-1,5	623,54	0,00	360,00	350,74
10	49,88	49,88	45,35	Tensor E 1-1,5	623,54	0,00	360,00	274,36
12	34,64	34,64	31,98	Tensor E 1-1,5	623,54	0,00	360,00	225,17
14	25,45	25,45	23,75	Tensor E 1-1,5	623,54	0,00	360,00	190,88
16	19,49	19,49	18,34	Tensor E 1-1,5	623,54	0,00	360,00	165,63
18	15,40	15,40	14,59	Tensor E 1-1,5	623,54	0,00	360,00	146,26
20	12,47	12,47	11,88	Tensor E 1-1,5	623,54	0,00	360,00	130,94

* Valores orientativos (referencia para comparar)

5.2.1.4. Node distance 1.5m

L_{Truss} **1,5** m

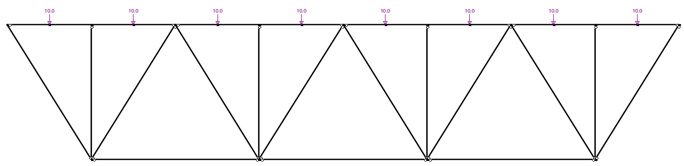
h_{Truss} 1,30 m



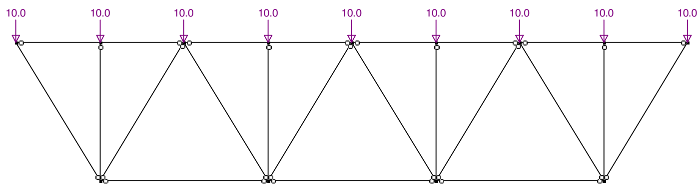
Longitud Total Truss (m)	qmax kN/m (ELS)	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
6	90,25	84,60	OTRA OPCION	406,10	6,35	312,62	270,74
7,5	64,68	60,64	Tensor E 1-1,05	454,81	4,55	350,11	242,57
9	46,19	43,30	Tensor E 1-1,05	467,65	3,25	360,00	207,85
10,5	33,93	31,81	Tensor E 1-1,05	467,65	2,39	360,00	178,15
12	25,98	24,36	Tensor E 1-1,05	467,65	1,83	360,00	155,88
13,5	20,53	19,25	Tensor E 1-1,05	467,65	1,44	360,00	138,56
15	16,63	15,59	Tensor E 1-1,05	467,65	1,17	360,00	124,71

L_{Truss} **1,5** m

h_{Truss} 1,30 m



Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
6	78,48	58,86	73,57	Tensor E 1-1,05	353,15	8,30	271,86	235,44
7,5	58,41	43,81	54,76	Tensor E 1-1,05	410,68	6,18	316,14	219,03
9	44,50	33,37	41,72	Tensor E 1-1,05	450,54	4,71	346,83	200,24
10,5	33,93	25,45	31,81	Tensor E 1-1,05	467,65	3,59	360,00	178,15
12	25,98	19,49	24,36	Tensor E 1-1,05	467,65	2,75	360,00	155,88
13,5	20,53	15,40	19,25	Tensor E 1-1,05	467,65	2,17	360,00	138,56
15	16,63	12,47	15,59	Tensor E 1-1,05	467,65	1,76	360,00	124,71



Longitud Total Truss (m)	qmax * kN/m (ELS)	Pmax kN (ELS	NTensor max kN (ELS)	Tensor a utilizar	MCercha max kNm (ELS)	Mmax Riostra kNm (ELS)	Axil Max kN (ELS)	R Apoyos kN (ELS)
6	103,92	77,94	69,28	Tensor E 1-1,05	467,65	0,00	360,00	350,74
7,5	66,51	49,88	45,35	Tensor E 1-1,05	467,65	0,00	360,00	274,36
9	46,19	34,64	31,98	Tensor E 1-1,05	467,65	0,00	360,00	225,17
10,5	33,93	25,45	23,75	Tensor E 1-1,05	467,65	0,00	360,00	190,88
12	25,98	19,49	18,34	Tensor E 1-1,05	467,65	0,00	360,00	165,63
13,5	20,53	15,40	14,59	Tensor E 1-1,05	467,65	0,00	360,00	146,26
15	16,63	12,47	11,88	Tensor E 1-1,05	467,65	0,00	360,00	130,94

* Valores orientativos (referencia para comparar)

6. TERMS AND CONDITIONS OF USE

6.1. SAFE OPERATING GUIDELINES

6.1.1. General guidelines

- It is recommended to strictly follow the instructions of the project plan, the health and safety plan, as well as any further technical and/or safety rules which might apply to the project.
- Works are carried out by qualified personnel only, and under the supervision of a competent person.
- Instructions of use for the employed equipment must be followed. Consult operating manuals of the manufacturer or distributor.
- Only statutory auxiliary means and the corresponding protection equipment, preferably collective protection equipment are employed.
- Personal protective equipment (PPE) should comprise at least safety helmet, safety footwear, protective gloves and tool holder belt. Whenever necessary use further PPE, such as reflective jackets, anti-fall harness with lifeline, goggles, breathing masks, earmuffs, etc.
- Avoid heavy impacts on working platform or plywood. It is strictly forbidden to jump on platforms or plywood, to abruptly unload material or letting it fall from height onto the platforms.
- If the building site is located nearby high voltage power lines, it is recommended to work without power supply. If this is not possible, the appropriate measures according to the respective reference standard should be taken.
- Under adverse weather conditions, works on the building site should stop.
- Under heavy wind conditions, remove materials and other objects from the platforms, and check the stability of all ties, meshes, platform anchorages, etc. before and afterwards.
- Before starting the stripping/dismantling procedure, check that all structural components (e.g. ties) are in place. If not, revise the assembly before proceeding with stripping/dismantling.
- Furthermore, check that no loose material remains on the structure, e.g. on working platforms, in danger of falling from it, and striking persons below.
- The following measures must be taken to restrict access to the structure during erection and dismantling or whenever the structure is not in correct working conditions (e.g. missing collective protection): signposting, fencing, closing or demarcation with straps, barriers or meshes of the working area and third-party passageways.
- Employees and any third party accessing a structure without collective protection yet in place, must wear all indicated PPE to prevent falls from height or to be protected from falling objects.
- The purchaser or lessee of the structure shall instruct its employees on all necessary guidelines for the safe operating of the structure.
- Any alterations of the structure must be executed under the supervision of a competent person and must comply with instructions in the operating manuals of the manufacturer or distributor.
- The purchaser or lessee shall conduct periodic checks of the assembly to verify the correct installation of critical structural elements and to identify the potential withdrawal of parts or the alteration of the structure as such by employees or a third party.

6.1.2. Guidelines for structures

6.1.2.1. Structure assembly

- Mark and bound an area for the assembly so that anyone outside the assembly will enter the area.
- Ensure the correct fastening of bolts and nuts between different elements, and the correct positioning and tightening of push-pull props.
- Ensure the fastening of ties, nuts, plate nuts, and lots anchors and in general the correct anchorage of those additional items to be tied to the ground.
- Ensure the correct anchorage of the previous set, before placing the next.
- Do not leave any part half-assembled or half-dismantled.
- Ensure ground resistance to withstand the loads, in terms of use, to which it will be subject, and weather conditions, taking the necessary measures (surface cleaning, foundation, …).
- In the event that loads are important, make a geotechnical report and dimension the necessary foundation by the contractor.
- When special foundations are needed, make a foundation project with drawings and calculations.
- Ensure structure stability, making the remarked anchors according to the project or/and standard configurations.
- If any product is spilled on the platforms, it will be cleaned immediately.
- Do not accumulate material on the platforms, only have the necessary equipment at all times.

6.1.2.2. Dismantling of structures

- Inspect the condition of the structure before dismantling, in order to check if any items or anchor is missing.
- Ensure that there are no loose elements on top of the structure if the dismantling is done by means of crane.
- Ensure that there are no workers in the vertical of the removed gang or nearby.
- Take special care to ensure structure stability when dismantling process.
- Do not accumulate material on the platforms while dismantling, it must be lowered while dismantling process is making.

6.1.3. Guidelines for structures

6.1.3.1. Formwork

- Place some sort of support to store or move the formwork panels which prevent their damage and ease the building site order, the panel cleaning and the transport to their area of operation.
- Ensure the fastening of plate nuts, and the correct positioning and anchorage of push-pull props to the ground.
- Ensure the correct anchorage of the previous formwork set, before placing the next.
- Do not leave any part half-assembled or half-dismantled.
- It is forbidden to climb on formwork except in extraordinary cases duly studied and with appropriate protection systems in place.
- Before concrete pouring, make sure the formwork surfaces are clean.
- Clean panels after each use. Wire brushes are not suitable for cleaning as they are damaging the phenolic film of the plywood.
- It is important to state that the phenolic coating rarely suffers from the chemical and abrasive action of the concrete. But where it is already damaged, e.g. at holes and deteriorated areas, it

must be thoroughly sealed to prevent any further damage to the plywood.

- Any cut edge of the plywood should be sealed as soon as possible, because cut edges soak up water from the concrete and swell, thus increasing in thickness.
- In general, it is not recommended to use nails or screws on the plywood.
- For storage, the panels should be stacked one on top of the other, placing wood runners between them. Use some sort of support to separate them from the ground, and provide shelter. Prolonged sun and rain exposure damages the panels.

6.1.3.2. Release agent

- Release agent helps separating the formwork from the concrete, and thus increases the number of uses and the life span of the panel in general.
- It plays an important role for the quality of the concrete finishing because it prevents holes from air bubbles on the concrete surface and provides a uniform colour.
- Apply the release agent uniformly and in thin layers onto the panel, bearing in mind at all times the instructions for correct use.
- Thoroughly clean the panel surface before applying the release agent on it.
- Clean the metal frame and the panel off the release agent after every 4 to 5 uses.

6.1.3.3. Concrete placement and compaction

- Comply with the maximum pressures according to the instructions of the respective formwork system.
- Continuously check the state of the formwork during concrete casting. Stop further casting in case of any incident.
- Place the concrete in uniform layers of 30 to 45 cm.
- For vertical concrete placement, cast the concrete from the least height above the formwork possible. Do never exceed 2 m height unless a pipe or tube or any similar accessory is used to channel the concrete. Deposit the concrete as near as possible to the formwork base, centring on one point without casting directly against the formwork.
- When casting with bucket, take special care of not hitting the formwork, and of complying with the maximum load-bearing capacity of the crane.
- Avoid concrete splashes on the plywood as these will reflect on the finished surface.
- Use the appropriate method for concrete consolidation and compaction depending on the concrete consistency and its workability.
- The preferred consolidation and compaction method for wet cast-in-place concrete are poker vibrators. Use external vibrators only when the concrete cannot be accessed with poker vibrators and for parts moulded already in the workshop. External vibration requires a specific analysis.
- Completely immerse the poker 10 to 15 cm into the concrete, and put it into each area of concrete, only once. When concrete is poured in layers, place the vibrator into the previous layer to meld the two layers together.
- Never allow the vibrator to touch the formwork to prevent exceeding the considered loads.
- Immerse vertically or slightly inclined and quickly, but withdraw slowly.

6.1.3.4. Concrete curing and formwork stripping

- Check that curing is sufficiently advanced for stripping without causing spalling at the concrete surface which destroys the finishing and can affect the strength and durability of the concrete.

- Increase the curing time of the concrete when facing fast drying and shrinkage due to evaporation from wind or low temperatures.
- The time span between casting and stripping shall be the same for all parts of the concrete structure. This is justified when a high finishing quality is aimed for because the tone of the concrete surface depends on how long the concrete surface is isolated from the outside.
- Ensure the absence of unauthorised people in the vicinity where stripping takes place.
- Once stripping is finished, place the formwork on a sort of support and proceed with its cleaning and dismantling, if it is not going to be used for further casts.

6.2. TRANSPORT, HANDLING AND STORAGE

6.2.1. General guidelines

- Get informed about hazards on the building site and preventive measures to avoid those.
- Obey the instructions of the person-in-charge at the workplace.
- Ensure adequate communication between the employees working together.
- Use work equipment only when authorised, trained and provided with all required information to conduct it.
- Maintain minimum distances to mobile work equipment (forklifts, lorries, cranes, other construction machinery) and to areas with the risk of falling objects.
- Do not stand, walk, or work under suspended loads, nor under the trajectory or in the vicinity of these loads.
- Avoid the parts suffering blows and crushing during transport, handling and storage.
- The material is packed for transport in appropriate containers such as wood or steel pallets, boxes, or strapped in bundles with stable base.
- Strap the bundles sufficiently stable to prevent them from moving and getting damaged. If necessary, protect the items with some sort of buffer.
- Cut the metal strap, standing on the side, using gloves and goggles to prevent getting cut by the bouncing strap or caught in the strap.

6.2.2. Transport

- Ensure the stable loading of the material, complying with the instructions of the driver (equilibrated distribution on the lorry bed, fastening of auxiliary items, etc.).
- Keep your distance when opening the containers after transport to prevent injuries from falling objects.

6.2.3. Handling

6.2.3.1. Manual handling of loads

Some ergonomic principles to be followed are listed below:

- Do not make any sudden jerky movements.
- Before lifting the load, examine it to detect any sharp corners, dirt, etc. and decide according to its shape, weight and volume for the best way to get a secure grip of the load.
- Lift, separating the feet at shoulder distance, duck, bending the knees, never the back.
- Do not attempt to lift alone, any load that is too heavy, too large, or awkward. Use a mechanical lifting device or get a helping hand from co-workers.

6.2.3.2. Mechanical handling of loads

- Only statutory mechanical lifting devices, appropriate for the operation are allowed for use.
- Check the condition of the lifting gear such as slings or cables before each use and report any defects.
- Place lifting accessories and step back to a secure distance from the load and other materials which could get affected.
- Comply with all instructions given by the team chef who is specifically trained for this.
- Cause no sudden acceleration or deceleration of the moving load.
- When conducting difficult or dangerous lifting operations, or in the case that the crane operator has no obstruction free visual control of the entire trajectory of the load, the crane operations are directed by a banksman who is in constant communication with the crane operator by means of a previously agreed sign code.
- If necessary, use tag lines to control the load from distance. Keep hands clear of suspended load if hands could get caught between the load and another object. Swinging and/or unforeseen movements with the load can cause serious accidents.

6.2.4. Storage

- Proper storage of the parts is fundamental to keep them in good working condition.
- Wherever possible, store the material in a place protected from atmospheric impact to avoid wear.
- It is recommended to place parts of the same type and dimensions in its respective container (boxes, steel pallets, etc.).
- Ensure the stability of any piles, bearing in mind the following aspects:
  - Load-bearing capacity of the ground
  - Varying ground levels
  - Levelling of the packages
  - Package or container support
  - Package stability
  - State of the strap
  - State and capacity of the containers used
  - Do not stack full containers on top of empty or half-empty containers
  - External conditions (wind, risk of another object hitting the pile, etc.)

6.3. INSPECTION AND MAINTENANCE

6.3.1. General guidelines

- ULMA is responsible for the delivery of the products, for sale or rent, in good working condition.
- From the moment of delivery, the responsibility for correct use, inspection and product maintenance passes on to the purchaser or lessee. All damaged and broken parts, parts with missing components, i.e. all parts in no proper working condition must be removed from service.
- For use, inspection and maintenance of the product, special attention should be paid to the following points:
  - Items aimed to ensure people´s safety
  - Items made of aluminium, as they are more vulnerable to damages of the welded joints and deformation

6.3.2. Inspection instructions of elements appliances with CE marking of ULMA Construcción

Before each use, the condition of element appliances with CE marking must be checked. In case that it does not fulfil all defined requirements, it must be removed from service.

For more information, consult ULMA Construcción.

6.3.3. Inspection instructions with CE marking of equipment marketed by ULMA Construcción

Equipment with CE marking marketed by ULMA Constucción is checked following the instructions stipulated in the User´s Guide of the respective product.

7. LEGAL REFERENCES

- **Council Directive 89/391/EEC** of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work.
- **Council Directive 89/654/EEC** of 30 November 1989 concerning the minimum safety and health requirements for the workplace.
- **Council Directive 89/656/EEC** of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace.
- **Council Directive 90/269/EEC** of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers.
- **Council Directive 92/57/EEC** of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile construction sites.
- **Council Directive 92/58/EEC** of 24 June 1992 on the minimum requirements for the provision of safety and/or health signs at work.
- **Council Directive 89/655/EEC - Council Directive 95/63/EEC - Directive 2001/45/EC** of the European Parliament and of the Council of 27 June 2001 amending Council Directive 89/655/EEC concerning the minimum safety and health requirements for the use of work equipment by workers at work.
- **Directive 2002/44/EC** of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration).
- **Directive 2003/10/EC** of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).
- **Directive 2006/42/EC** of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast).

Standards:

- EN 12812:2008 Falsework. Performance requirements and general design
- EN 12811-1 Temporary works equipment. Part 1: Scaffolds. Performance requirements and general design
- EN 12811-2 Temporary works equipment. Part 2: Information on materials
- EN 12811-3 Temporary works equipment. Part 3: Load testing
- EN 13374 Temporary edge protection systems. Product specifications, test methods
- EN 74-1 Couplers, spigot pins and baseplates for use in falsework and scaffolds. Part 1: Couplers for tubes. Requirements and test procedures
- EN 74-2_Couplers, spigot pins and baseplates for use in falsework and scaffolds. Part 2: Special couplers. Requirements and test procedures
- EN 74-3_Couplers, spigot pins and baseplates for use in falsework and scaffolds. Part 3: Plain base plates and spigot pins. Requirements and test procedures.

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