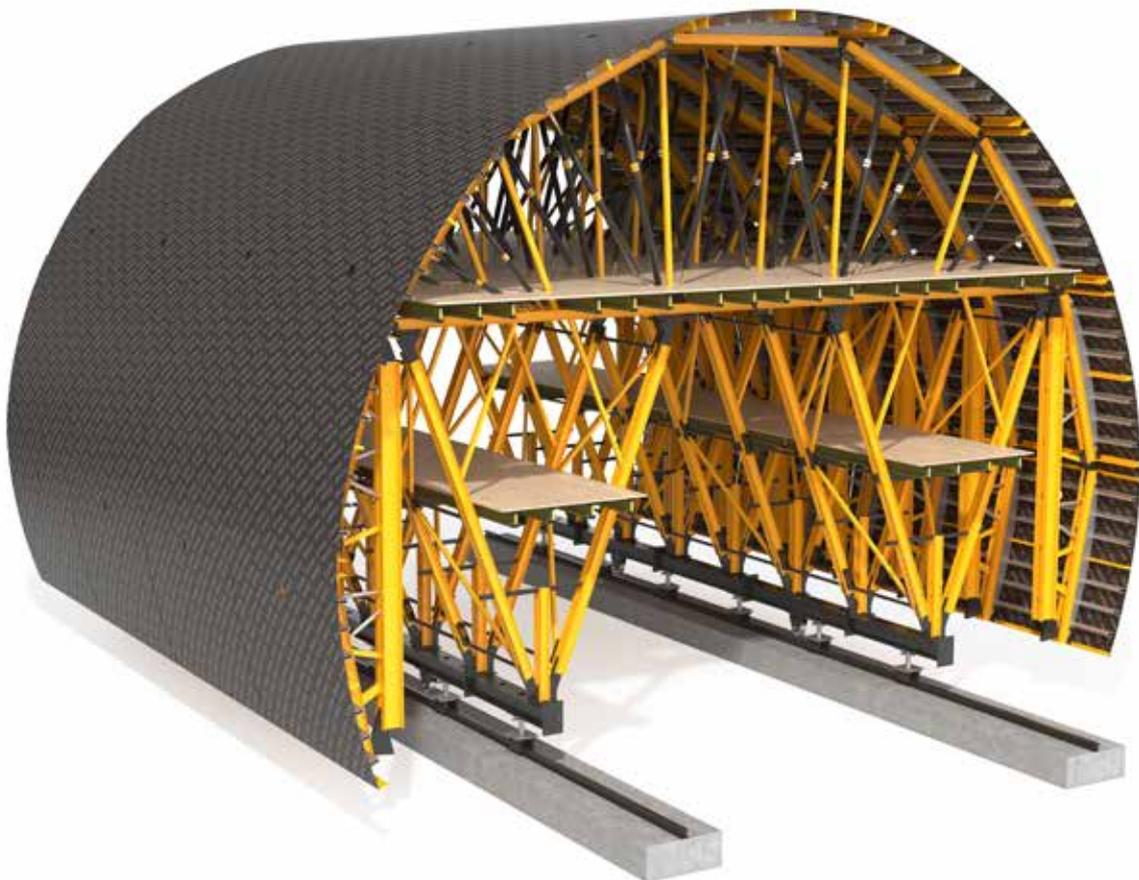


USER GUIDE

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# MK CARRIAGES FOR TUNNELS



## **IMPORTANT:**

All health and safety regulations established by the relevant professional or governmental authorities in each country must be followed when using ULMA products.

The images in this document are depictions of site-specific situations or stages of assembly and therefore for safety purposes are not to be considered comprehensive, nor shall they be used as a guide.

All instructions regarding safety and operation contained in this guide, including the data on stress and loads, must be followed. Any change or unique assembly necessitates a special calculation or solution.

The weights of the basic constituent components included in this document are approximate.

ULMA equipment is designed to work only with ULMA accessories and components. Combining our equipment with other manufacturers' products without first making all necessary inspections can be extremely dangerous.

The company reserves the right to make any changes deemed necessary for the technical development of the product.

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# 1. PRODUCT DESCRIPTION

The MK carriage for tunnels provides a base structure and formwork civil engineering solution for activities where it may be necessary to clad or form a construction in tunnel or box section concrete.

The shoe of the structure is the MK system; a product designed for carrying out assemblies of great versatility and load-bearing capacity to support different types of formwork, also allowing appropriate mobility of the structural assembly for construction of the successive phases required by the construction procedure.

The basic component used in all these solutions is the beam known as the MK WALER. Its versatile design and the specific accessories for each application make it possible for the MK system to provide the aforementioned different configurations.

Within the structures of the tunnels that can be configured using this product, two types are worth highlighting:

- Open air structures.
- Structures for mined tunnels.



CUT-AND-COVER TUNNEL FOR A DAM TRANSIT GALLERY



MINED TUNNEL FOR THE CONSTRUCTION OF AN INTERIOR STRUCTURE

The MK solution for tunnel structures can be considered another solution for the load bearing carriage, adapted to the special features of these tunnel structures where the structure

carriages that enable the construction of walls and slabs at the same time, such as those seen in cut-and-cover tunnels, can also be included in this field.

In **open air construction tunnels**, due to the space available on the outer side of the sections (tunnel side wall area) this can be solved with formwork on both sides. Normally the exterior part is projected until the concrete reaches the internal friction angle of approximately 30°.

The skin of the formwork is usually made of plywood panels, depending on the number of uses, requiring the tying of the exterior and interior panels with ties in order to withstand the concreting pressure of.

The interior carriage is usually a set of parts that must not be dismantled each time it changes position. The outside panels of the exterior formwork can be independent and they are normally moved to the next phase by means of a crane.



INTERIOR CARRIAGE AND EXTERIOR FORMWORK FOR CUT-AND-COVER TUNNEL

Based on the required number of use, they can be manufactured with manual movement for a few meter long tunnels or hydraulics for longer stretches.

**Mined tunnels**, on the other hand, are equipments for the final cladding of tunnels drilled through rock, addressing not only the mechanical part but also the aesthetic part, so that the final appearance after stripping is impeccable.

The formwork is only used in the interior area. Concrete is poured in the exterior side against the rocky area by means of concrete pouring nozzles. Using pneumatic external vibrators allows the wall to be given the desired finished look.

The TMK formwork panel, provided by ULMA as standard, has a metal sheet that adapts to the different radii of the tunnel. This allows the shuttering face to be used for another tunnel by just changing the curvatures of the shaping timber or walers.



TMK ADJUSTABLE SHEET METAL FORMWORK PANEL  
WITH CURVED WALER

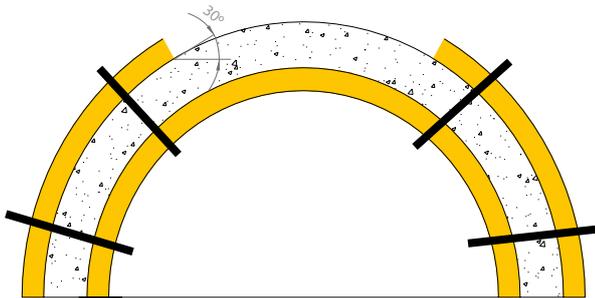
## 2. SOLUTIONS

### 2.1. DIFFERENCES BETWEEN CUT-AND-COVER TUNNELS AND MINED TUNNELS

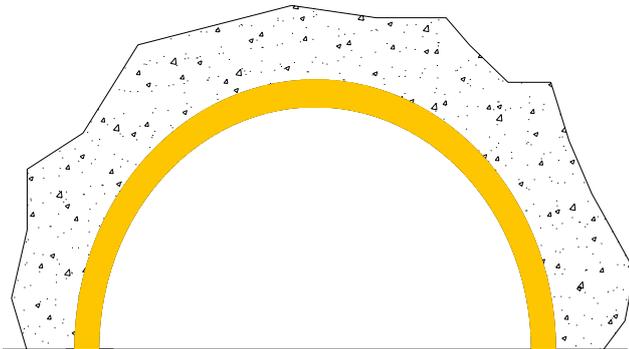
Tunnels that can be constructed using the MK carriage system can be divided into those that are made in the open air (**cut-and-cover tunnels**) and those constructed in a cavity inside rock (**mined tunnels**).

The main differences between the two systems can be:

- The calculation of pressures and weights of concrete pouring in the back-filling phase.
- The way the concrete is inserted into the mould.
- The way the concrete is vibrated after being inserted into the mould.

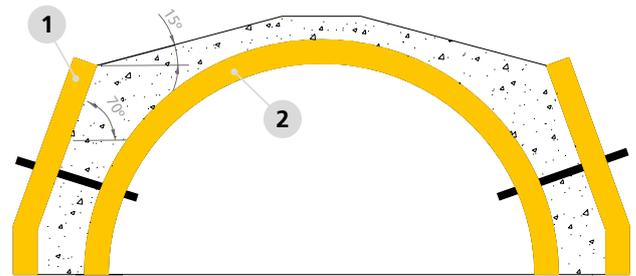
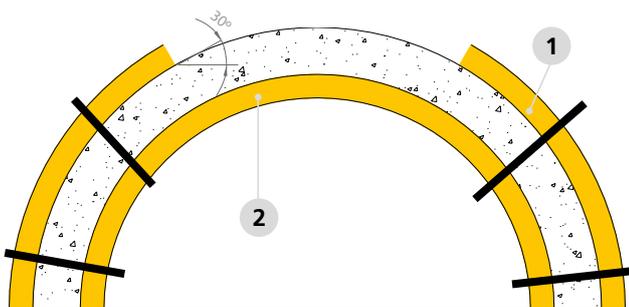


CUT-AND-COVER TUNNEL FORMWORK



MINED TUNNEL FORMWORK

In a **cut-and-cover tunnel**, the concrete pouring causes two types of loads on the structure. The pressure of the concrete on the formwork for the vault and side walls and the pressure in the areas where there is formwork on both sides of the poured concrete.



- 1 Exterior Formwork
- 2 Interior Formwork

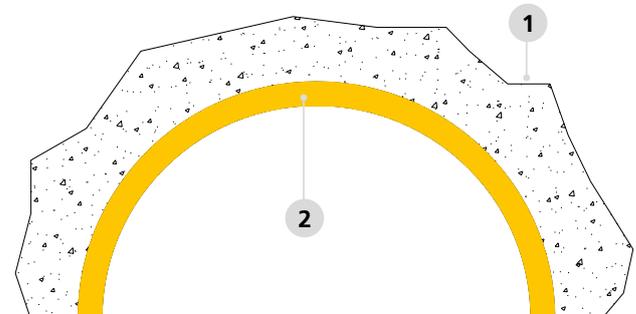
FORMWORK OPERATION DRAWING FOR CUT-AND-COVER TUNNEL

For slab angles of greater than  $30^\circ$  (guide value for internal concrete friction), a filler shape or cover is necessary to avoid the concrete spilling. An exterior formwork should be tied to the interior formwork with tie rods, in order to make sure the pressures between them are balanced and the structure does not overload.

For slab angles less than  $30^\circ$ , the only acting load on the carriage will be the weight of the concrete and there will not be any additional weights on the mould in this area without filler shape.

By way of example, in a cut-and-cover tunnel for a slab with a thickness of 0.5 m with main sections separated every 2.00 m (quite a frequent the case) the load to be considered over each section would be 25 kN/ml.

In a **Mined Tunnel** a practically constant pressure is considered in the whole section (\*), and of a perpendicular direction to the same at all points. It is also important to emphasise that for mined tunnels, the formwork is always used on "one face", in other words there is no possibility of placing an exterior formwork that would balance the pressure of the concrete pouring with the help of tie rods. This means that the demands on the structure are much more exacting than for cut-and-cover tunnels.



- 1 Opening in the rock
- 2 Interior Formwork

FORMWORK DRAWING OPERATION FOR CUT-AND-COVER TUNNEL

By way of example, in a mined tunnel with a pressure of  $50\text{kN/m}^2$  and sections separated every 1.00 m, the load to be considered over every section is about 50 kN/ml.

(\*) In the vault keystone area, this pressure usually depends on the thickness of the slab to concrete.

## 2.2. SOLUTIONS ACCORDING TO TYPES OF CONCRETE STRUCTURES

Within the variety of tunnel sections, those with vault shapes at the keystone can be differentiated from those with box type sections. While the first ones have curved stretches on their perimeter, the second ones have vertical walls and flat slabs, which has significant repercussions on the forces upon the structure.

On occasions, the tunnel is not made as a whole at the same time, but one part is constructed first instead, known as the side wall or vault springing, then the central part of the vault is finished with the structure of the Carriage itself. These are also complemented with swivel parts to facilitate working with formwork and moving the structures.

### 2.2.1 Cut-and-cover tunnels

There are many different types of cut-and-cover tunnels. Generally, they are structures that are constructed then covered with earth or other materials.

- **Cut-and-cover tunnels**

These are typically constructed in two phases, side walls and vault, although it is also possible to undertake both phases at the same time.



CONSTRUCTION OF THE SIDE WALL IN THE FIRST PHASE



CONSTRUCTION OF THE VAULT IN PHASE TWO

The construction of the side wall during the first phase is followed by the carriage with the formwork for constructing the vault. Usually, the movement of the side wall formwork is done with a crane.



GENERAL VIEW OF THE CUT-AND-COVER TUNNEL CONSTRUCTION PROCESS

- **Transit tunnels**

These have geometrically variable sections along the length of the tunnel, which usually require ad-hoc solutions. The distinguishing feature of structures constructed using the MK system is that the formwork can be configured and modified according to the geometry solutions needed for each stretch.

Examples of this type of structures with variable geometry are the dam turbine output nozzle area, or the entrance of a road tunnel.





CONSTRUCTION OF A DAM TURBINE NOZZLE WITH VARIABLE SECTION

- **Box sections and underpasses**

Unlike the previous examples, the sections of these are normally rectangular. The way they are constructed can also be "by complete section" including side walls and roof or by constructing the roof of the structure in a second phase.



BOX SECTION UNDERTAKEN IN TWO PHASES



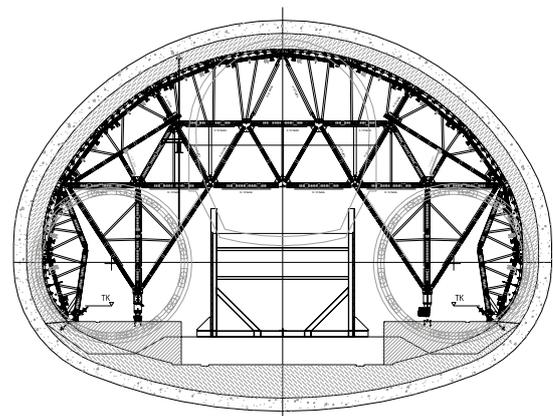
BOX SECTION UNDERTAKEN IN ONE PHASE

### 2.2.2 Mined tunnel

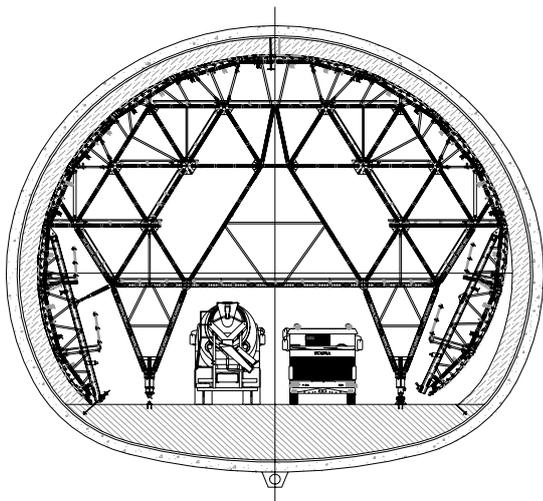
The type of mined tunnel used varies according to the different ways of supporting the rock and the use the tunnel is going to have, which is generally for the transit of vehicles, trains or water.

- **Metro stations or underground stations**

Sections with large diameter or width, normally straight and not excessively long (300 m). The MK tunnel carriage system allows for adapting to any size and shape using standard or common items, within the large variety of sections and shapes of stations.



These are sections that need uniform and polished finishes with a maximum of about 50 uses. The use of metal surfaces such as the TMK formwork panel enhances this feature remarkably.



- **Mined tunnels for roads or trains**

The way of constructing a mined tunnel is to construct the vault and side walls together, although it is also possible to construct the side wall independently during the first stage. For long tunnel lengths, it is essential to use the TMK steel panel with a radius that can be adjusted to different curvatures.

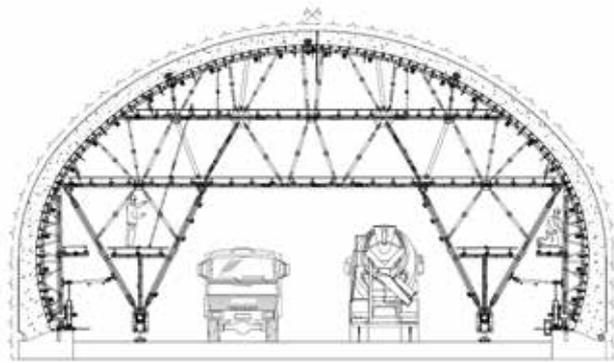


TUNNEL SECTION UNDERTAKEN IN ONE PHASE

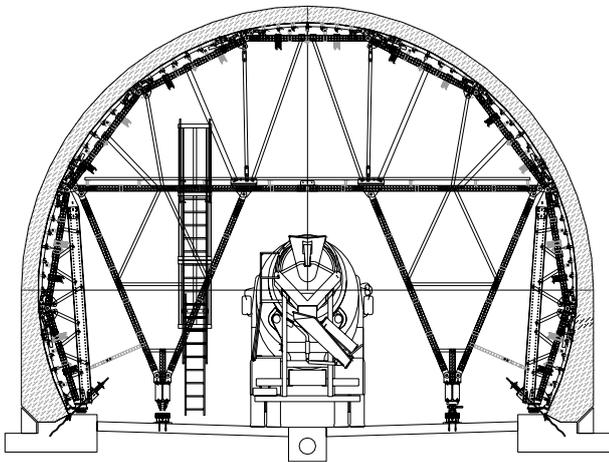


TUNNEL SECTION UNDERTAKEN IN TWO PHASES

Anchorage to the sill allows the structure to be lightened for the transit of vehicles during the concrete pouring stage.

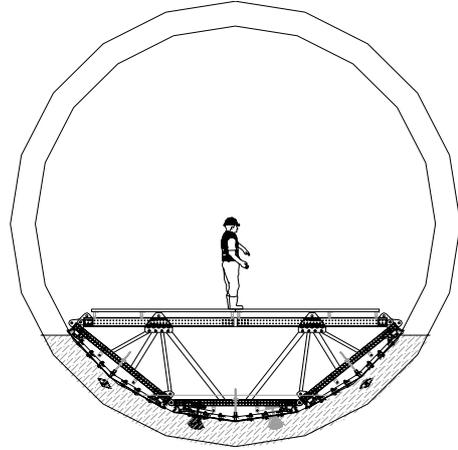


The longitudinal modulation of the panels allows a great variety of carriage lengths while the section view curvature needed is achieved by changing the waler of the tunnel's transverse radius.



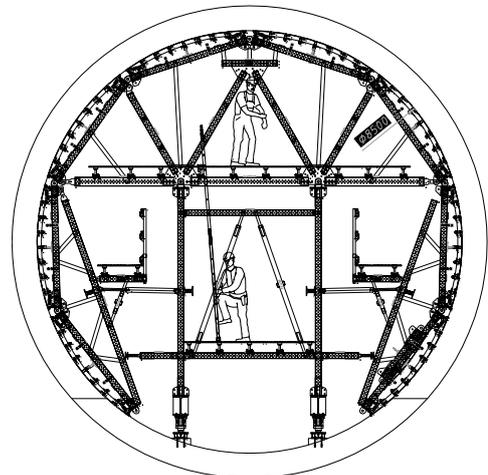
### • Hydraulic galleries

Solutions associated with dams, waterworks or connecting tunnels, which require two concrete pouring phases; the first corresponding to the construction of the sill and the second to the tunnel area (side walls and vault) itself.



FIRST PHASE CORRESPONDING TO THE SILL

The two-phase implementation is ideally suited to using standard material for repetitive tunnels on one site and where the length is not excessive. The reduced weight of the items allows them to be easily handled in small spaces providing faster transport and finishing of jobs.





SECOND PHASE: SIDE WALLS AND VAULT

### 2.2.3 Mobile carriage for the placement of steel rebar and sealing

In some Mined Tunnel solutions, it is necessary to have a carriage that will allow the placement of the seal over the tunnel's rocky substrate and that will also facilitate the placing of the steel rebar.

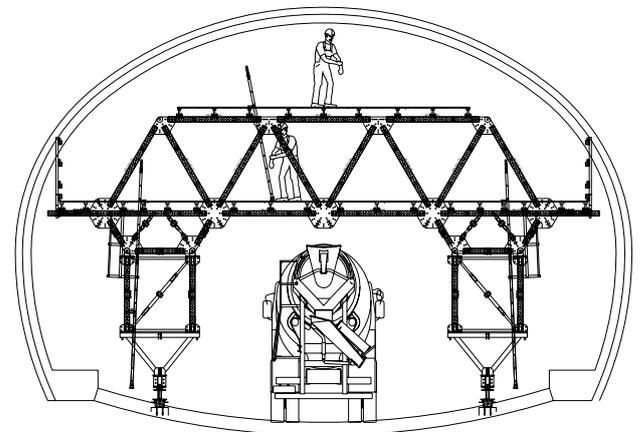
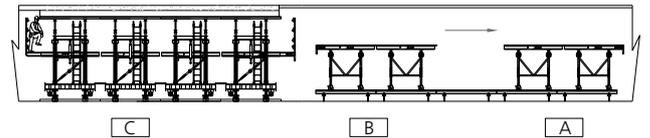


These and other similar applications are described in "BRIO-MK Solutions Guide".



The sequence for the use of the different assemblies can be scheduled as can be seen in the attached diagram which shows the entire process for the entire construction of a mined tunnel:

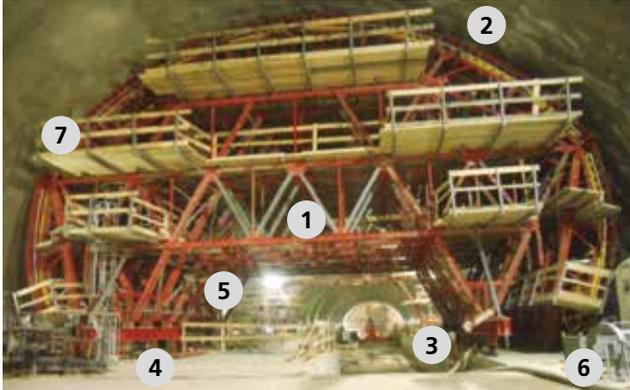
- A. MK Carriage for Sealing Tunnels.
- B. MK Carriage for Steel Rebaring.
- C. MK Carriage for Tunnel Concrete Pouring.



AUXILIARY STRUCTURE USED FOR SEALING AND STEEL REBARRING

## 2.3. CONFIGURATION OF STRUCTURES FOR MK TUNNELS

The structure with MK material is the basis for all the solutions proposed for both cut-and-cover as well as mined tunnels. We find common items in all of them that only vary on the basis of the forces to be supported and the concrete pouring technology that can be used in each case.

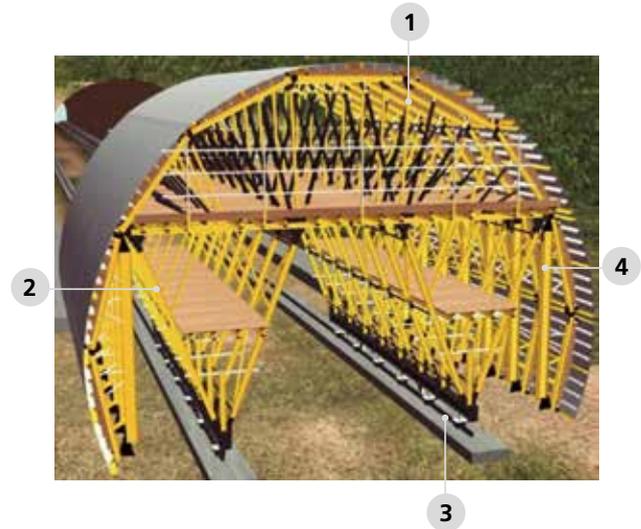


- 1 Main structure. Structure constructed with the MK system which supports both vertical and horizontal loads during the concrete pouring and the advance of the assembly.
- 2 Formwork. Structural part that is in contact with the concrete and gives shape to it, permitting the correct adjustment of the geometry thus setting it up for the correct stripping for movement to a new phase.
- 3 Movement structure. Structure for advancing the assembly. It supports forces during the movement and concrete pouring of the structure.
- 4 Rolling and levelling system. Set of items that permits the movement of the entire structural assembly, its proper levelling and resetting as well as correct stripping.
- 5 Bracing. Items that counteract the effects due to transverse and longitudinal movements.
- 6 Anchorages, vibration accessories and concrete pouring accessories. Accessories needed based on the needs of the site.
- 7 Safety and accessories. Working platforms, safety handrails and accessories needed depending on the requirements of each project.

### 2.3.1 Main structure Vertical supports and vault

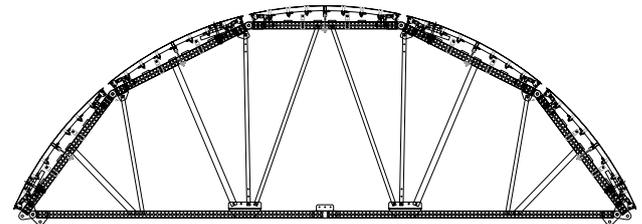
Composed of the elements that bear the main loads that are put on the structure mainly during the concrete pouring phase.

Within the variety of structures that could be used, they are always differentiated: one structure to form the **side wall** or **gable**, the other to form the central part of the tunnel. The solution for this part combines a **vertical support** structure or MK falsework, and another MK structure adapted to the shape of the vault as well as the **bogie** configuration.

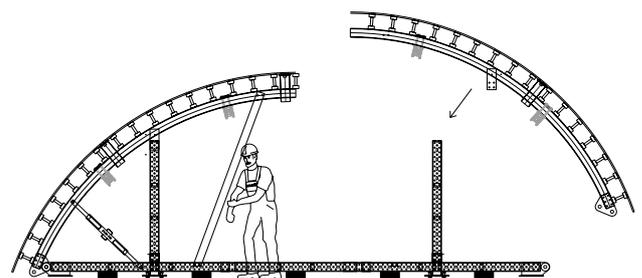


- 1 Vault structure
- 2 Vertical support
- 3 Bogie
- 4 Side wall or gable

Although it can be composed of different types of formwork, the configuration of the **vault** is similar in all cases concerning tunnels. It is constructed with a horizontal waler over which the modular structure that defines the vault is fitted.



EXAMPLE OF MINED TUNNEL VAULT

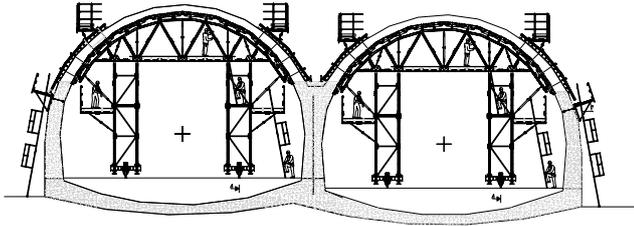


EXAMPLE OF CUT-AND-COVER TUNNEL VAULT

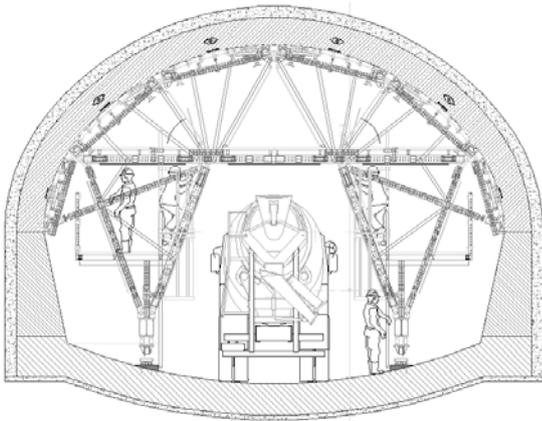
Generally, the Tunnel carriages can have small variations depending on aspects such as those indicated ones, which mainly determine the shape of the vertical supports:

- The load to be supported during the concrete pouring. Cut-and-cover tunnel or mined tunnel.
- The possibility of allowing vehicular transit and the dimensions of the vehicles.
- The support area for the movement system at its base.

There are two types of support area: Those where, due to necessity, the support area is quite small, and those where it is not.



CUT-AND-COVER TUNNEL CARRIAGE WITH AREA FREE OF SUPPORT



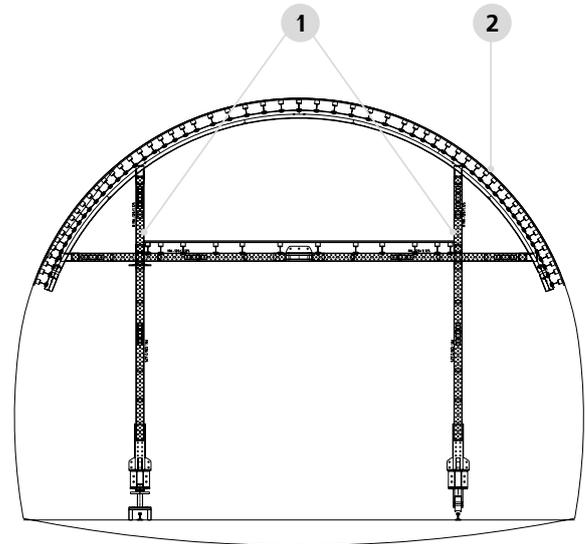
MINED TUNNEL CARRIAGE WITH RESTRICTED SUPPORT

The carriage rolling and levelling system, explained in section 2.3.4 is integrated in the configuration of the **bogie**. The system includes the necessary accessories to join the different parts of the structure to it.

- **Curved walers in vault**

In the case of cut-and-cover tunnels, most of the main structure of the carriage is composed of standard MK system items (walers, joints and push-pull props). However, it is recommended that the last waler which gives the final shape to the tunnel vault should be made to be adapted to each solution, since it guarantees a solution which is clean, financially attractive and facilitates assembly.

This curved waler should be designed in such a way that will allow secondary beams be joined to form the formwork and at the same time makes a connection to the rest of the structure possible, with rigid elements that will guarantee the geometry of the vault.



- 1 Main structure with rigid elements
- 2 Curved waler adapted to the vault shape



When the sealing of the exterior formwork is required, other adapted curved walers are used, which are joined to the interior curved walers by means of ties, balancing the pressure in order to avoid overloading the structure.



### 2.3.2 Formwork

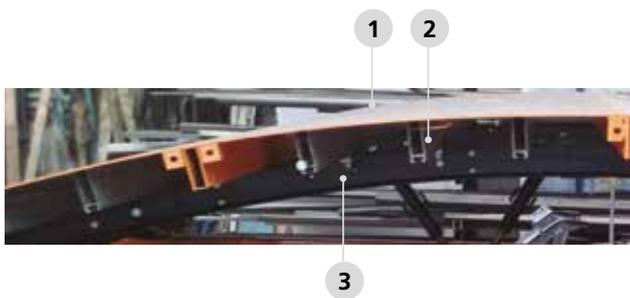
Different types of formwork from the ULMA range can be used, combining the different types of products and materials according to the needs of each site. The next ones are available:

- A / TMK Formwork Panel with curved waler.
- B / Formwork with curved waler and secondary beam + plywood panel.
- C / Formwork with standard straight waler and secondary beam + shaping timber and plywood panel.
- D / Made to measure metal Formwork Panel.

#### • TMK Formwork Panel with curved waler

This is the most common formwork in Mined Tunnel applications, and it consists of a primary curved Waler and TMK adjustable panel.

All the materials are reusable apart from the curved waler which gives the sheet the necessary shape so that it can be adapted to the geometry of the structure to concrete.



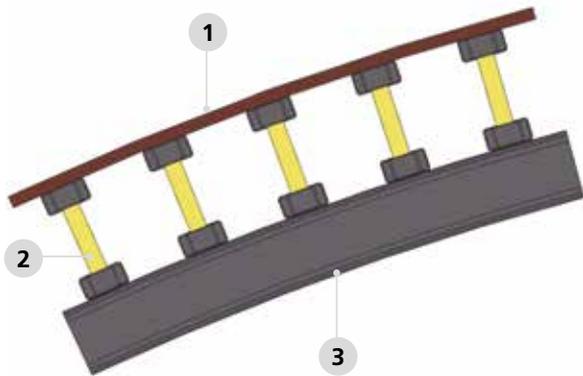
- 1 Sheet panel 6.00 mm
- 2 Omega secondary beam Primary
- 3 Curved waler

Main features and applications of this model:

- Main application as formwork for mined tunnels.
- Adjustable panel for radii greater than 3 m.
- Panel formed by few items. Possibility to optimize material in each section.
- Panel comprising mostly reusable elements. In successive applications, both the secondary beams and the sheet metal are reusable as they are standard materials.
- The TMK Sheet is suitable for the technology employed in the construction of mined tunnels, since they permit the incorporation of specific concrete pouring accessories in the most efficient way.
- Simple and quick pre-assembly of panels on site.
- Allows variation of different radii within the same panel.
- The formwork can only be adapted to a different geometry by changing the curved waler.

- **Formwork with curved waler and beams**

Consists of an adapted primary curved waler which is joined to a standard secondary beam and, to finish, a plywood board which is adjusted properly to the curve and serves as a mould for correct concrete pouring.



- 1 Plywood board
- 2 Standard secondary beam
- 3 Primary curved waler

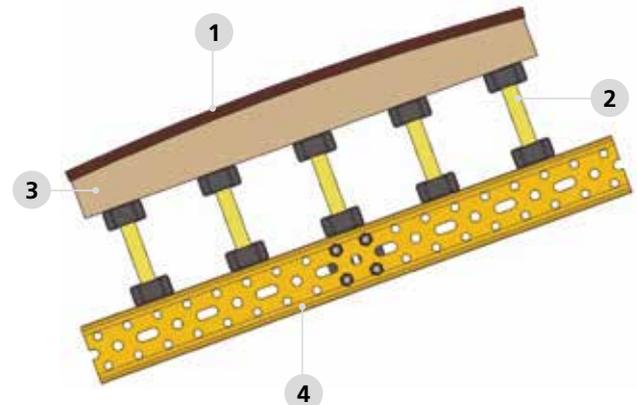
Main features and applications of this model:

- Main application as formwork for cut-and-cover tunnels with sections of constant geometry.
- The curved waler permits simple adaptation of the rest of the formwork to the planned geometry.
- Simple and quick pre-assembly of sections on site.
- Possibility to optimize material in each section.
- Specific details can be included in the curved waler that will improve the product's on-site behaviour and performance.
- Using the standard secondary beams allows these to be used in subsequent applications.
- The solution obliges the sale of the plywood board and the curved waler.
- Curved walers of a different diameter are needed to adapt the solution to different radius.
- The number of times it can be used will be extended by the proper care of the plywood panel. (To increase its lifetime, a thin metal sheet is usually placed on it).



- **Formwork with straight waler and beams**

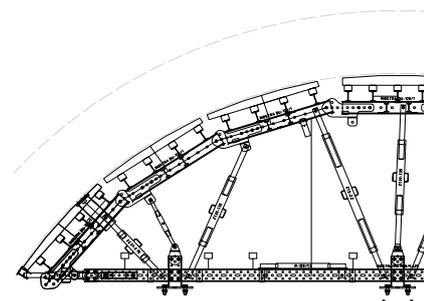
The primary is a standard MK waler over which the secondary beams are placed. Adjacent to it there is a shaping timber in the shape of a geometric curve on which the plywood board serves as a mould.



- 1 Plywood board
- 2 Standard secondary beam
- 3 Shaping timber
- 4 Primary MK waler

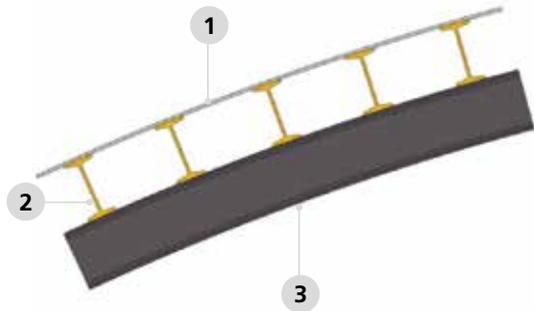
Main features and applications of this model:

- Main application as formwork for cut-and-cover tunnels with sections of variable geometry.
- The shaping timber allows the formwork to be adapted to the geometry of the structure.
- The formwork can only be adapted to a different geometry by changing the shaping timber and plywood.
- In successive applications, both the secondary and primary beams are reusable as they are standard materials.
- Pre-assembly of sections on site is laborious due to the number of shaping timbers needed.
- The number of times it can be used will be extended by the proper care of the plywood panel. (To increase its lifetime, a thin metal sheet is usually placed on it).



- **Made to measure metal formwork panel.**

This is composed of a main beam generally cold curved to adapt it to the required geometry, a secondary beam which is usually welded to the first one and a shuttering face of variable thickness according to the load to support.



- 1 Shuttering face
- 2 Secondary beam
- 3 Curved main beam

Main features and applications of this model:

- Main application as formwork for cut-and-cover tunnels or mined tunnels with small Gallery or Radius sections.
- Adapted in each case to the shape required by the section to concrete.
- The thickness of the sheet can be varied, as well as the distance between profiles and the type of profile for the concrete pressure required.
- Specific details that will improve the product's on-site behaviour and performance can be included in the formwork.
- The metal sheet increases the lifetime of the formwork as it permits a larger number of uses than the plywood panel.
- Special solution for sale. Significant cost in Euro/m<sup>2</sup>.
- Can not be reused in the different applications.



### 2.3.3 Exterior lateral structure and interior gable

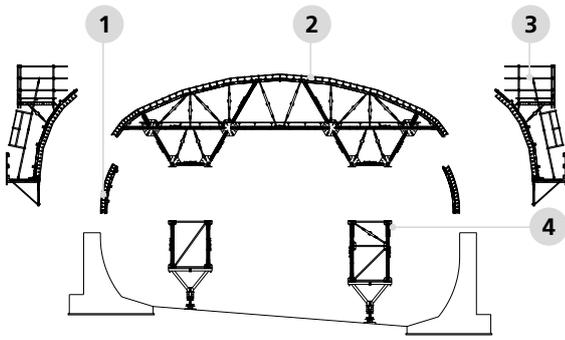
The **interior gable** is the panel which is articulated in the structure of the vault and which turns on the joint pin to the main structure in order to allow the advance of the assembly known as the interior gable. This is an interior formwork and its length will depend on both the design of the carriage and the different concrete pouring phases in which the definitive structure is constructed.



INTERIOR GABLE FOR ADJUSTMENT WITH SIDE WALL, FIRST PHASE



The **short interior gable** is used to ensure water tightness and avoid, as far as possible, very marked seals between the different concrete pouring phases of the tunnel, gables are normally placed at the side edges of the carriage. These gables, usually have a turning point in the main structure and usually have an adjustment pipe brace that adjusts and approaches the lower part of the formwork until the previously constructed phases, it approaches and touches the side wall with a minimum overlap which guarantees water-tightness.



- 1 Interior gable
- 2 Vault formwork
- 3 Exterior side structure (cut-and-cover tunnel)
- 4 Shoring



CUT-AND-COVER TUNNEL UNDERTAKEN IN TWO PHASES.

The **long interior gable** is used in small tunnels which are constructed in a single phase or in sections where the concrete pouring is carried out in two phases but the vault section is quite high.

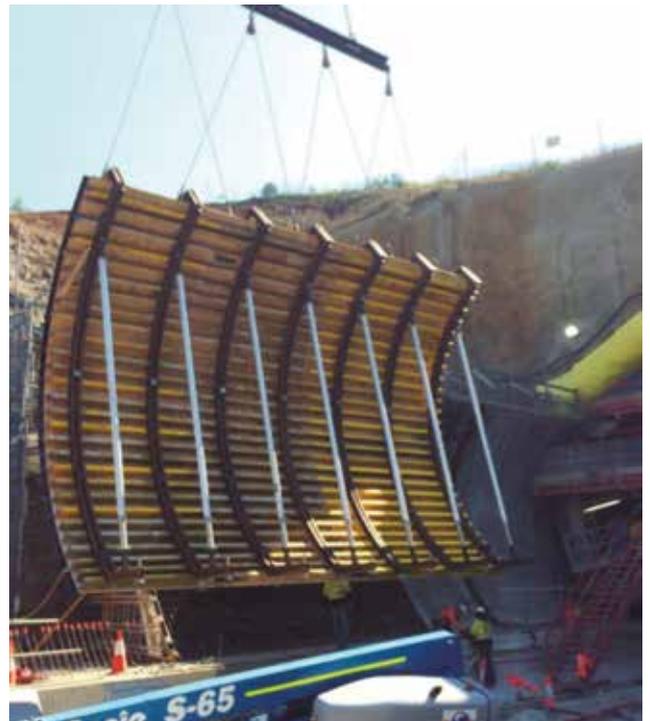


INTERIOR GABLE OF A COMPLETE SECTION CUT-AND-COVER TUNNEL

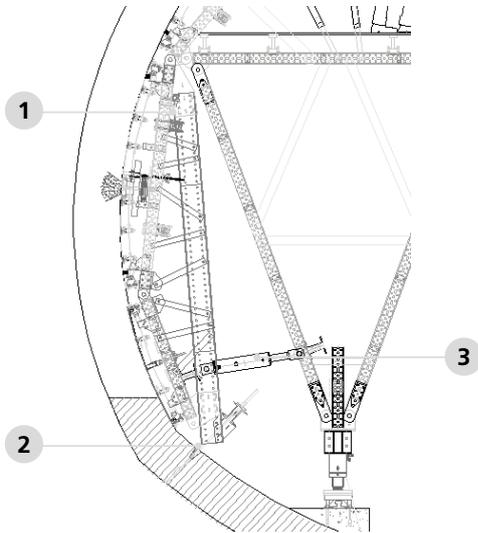
For cut-and-cover tunnels, the exterior side formwork must be taken into account. This will be tied to the interior in order to balance out the concrete pressure. This formwork can be used in formwork for the first or the second phases for cut-and-cover tunnels.



The shoring for the exterior structure can be carried out directly on the base shoe or over support brackets in the concrete structure itself.

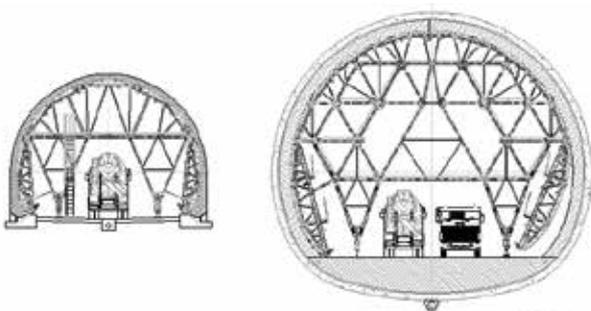


For mined tunnels, it is the interior gable what transmits the concrete pressure to the main structure through the pipe brace to the gable aperture system push-pull prop. If the pressure in this area is too high for the main structure or the requirements of the connection are very demanding, this point should be anchored to the side wall.



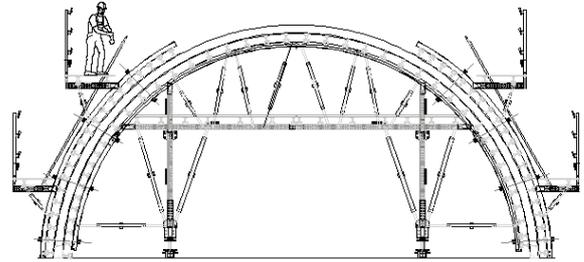
- 1 Gable in concrete pouring position
- 2 Anchorage
- 3 System for opening and closing the gable

The shape of the interior gable in mined tunnels can be different depending on how the structure has been designed, on the pressure the gable supports and the capacity of the anchorage to the sill or lower slab.



• **Two-sided side wall**

In cut-and-cover tunnels, the side wall area that corresponds with the gable area is made with a filler shape or formwork that is joined to the side wall with tie bars to compensate for the pressures due to the concrete. Normally this filler shape has to be made up to a sufficient height where the concrete stops exerting pressure on the assembly and only weight needs to be considered.

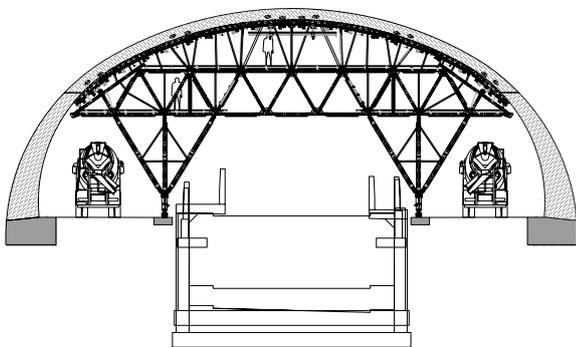
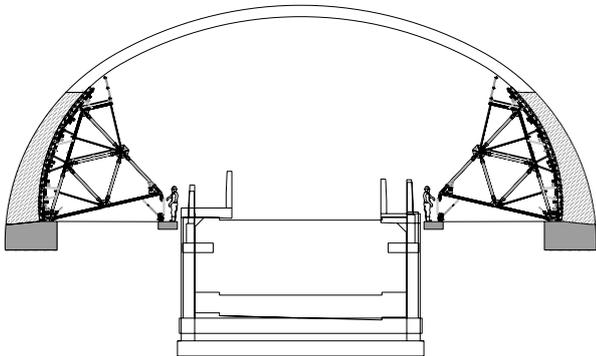


Due to its accessibility, the use of internal vibrators is more common in these cases. However, attention must be paid to sloped areas and to their correct vibration for correcting the blockwork shaping, thus giving the concrete the correct finish. There should be window accesses in the formwork when the shape of the section requires them.



- **Single-sided wall**

When it comes to mined tunnels and the side wall area is to be made in the first phase, it is carried out with single-sided wall formwork. Pressures are not withstood by the tie bars but by the structure itself.



This solution is useful for sections of large height, where the work is divided into various jobs it allows us to increase site performance.



### 2.3.4 Support and movement system. Bogie system

The support of the structure is made over a series of profiles, also called bogies which have a double purpose:

- They serve as a component for the transmission of loads to the ground through the support screw jacks.
- As a system movement component when the wheels that are going to be used for the advance are brought to the profile.

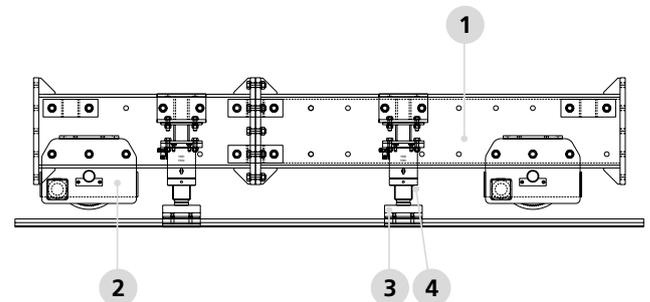
Depending on the type of structure, mainly more or less heavy, there are two Bogie systems.

- **DUPN500 BOGIE System**

Mainly used for Mined Tunnel structures, its most important features are as follows:

- Main use in carriages for large Mined tunnels.
- The system can accommodate different lengths between sections, the most standard being 1 m.
- Option to integrate automatic moving systems. Hydraulic Drive.
- Heavy carriages up to 80 t together.
- Carriage lengths up to 12-15 m.
- Rolling on Burback A65 type Rails or similar. Great crushing capacity.

The support from the load cylinders is distributed over support benches (rail shoe) which prevent interference with the cantilever rail.



- 1 Double UPN 500 profile
- 2 DUPN500 20 T Wheel system
- 3 Rail Shoe
- 4 Cylinder CRI-GS-TA

**i** For more information on drive systems, see the "omplementary guides".

## • **BOGIE system screw jack profiles**

Mainly used for Cut-and-cover Tunnel structures, its most important features are as follows:

- Main use in carriages for Cut-and-cover Tunnels or small Mined tunnels.
- The system can accommodate different lengths between sections, the most standard being 1.5 m in Mined Tunnels and 2 m in Cut-and-cover Tunnels.
- Option to integrate automatic moving systems. Electric Drive The **electronic drive system** is mainly used when there are no longitudinal slopes (maximum 4%).
- Carriages of up to 40 t all together as maximum.
- Carriage lengths up to 12-15 m.
- Rolling on S20 type rails or similar.



The wheeled screw jack step can be carried out by means of **manual hydraulic jacks** which allow the formwork to easily be reset and stripped.

The load cylinders are supported over support benches (rail shoe) to prevent interference with the cantilever rails.



For more information on drive systems, see the "complementary guides".

### 2.3.5 Anchoring System

When the gable or side wall is very high, the concrete pressure cannot be transferred to the support structure. It is necessary to anchor it to the bottom part of concrete structure so that the gable can withstand the loads. These anchorages are mostly needed in mined tunnels, especially when an area for vehicular transit is needed.

There are different types of anchoring systems, those that don't need to leave parts permanently in the concrete and those that do.

- NP (Recoverable) Anchoring System.
- BP (Non-recoverable) Anchoring System.

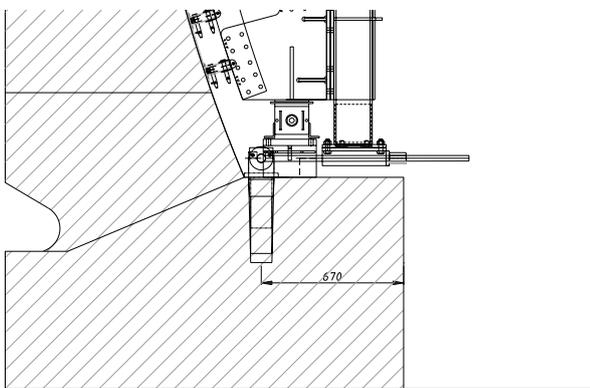
## • NP Anchoring System

These are based on the effect of transmitting the force to a solid block inserted into the concrete shoe, which then holds the pull through the shear force on this.

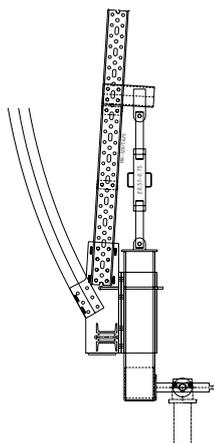
Main features:

- They can transmit up to 210 kN of horizontal load over the concrete. Depending on the Concrete.
- They transmit hardly any vertical loads. They are not recommended in tunnels with slopes against the base.
- No items are left behind. This makes it a recoverable anchoring system.
- More suitable for very long tunnels, where the cost of lost items accumulates.

There are different types, depending on the nature of the resulting on the fastening tie: Tension or Compression. The first is used when there is a small footing shoe. The second is better for other cases, since it provides better accessibility to items.



TENSION NP TIE ANCHORING SYSTEM



COMPRESSION NP SCREW JACK ANCHORING SYSTEM

## • BP Anchoring System

These are based on the effect of transmitting the force to a tilted tie rod inserted into the concrete, which then holds the pull through the resulting traction on this.

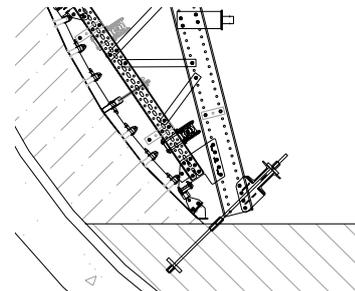
Main features:

- They can transmit up to 300 kN of pressure in the direction of the tie rod over the concrete. The traction of the tie rods depends on whether the type of tie rod used is DW15 or DW20.
- They transmit vertical loads. More suitable for tunnels with pronounced curves at the base. This force causes an increase in forces over the structure.
- They are simple and economical.
- They do leave items behind in the concrete.
- More suitable for short tunnels, where the cost of lost items is lower.

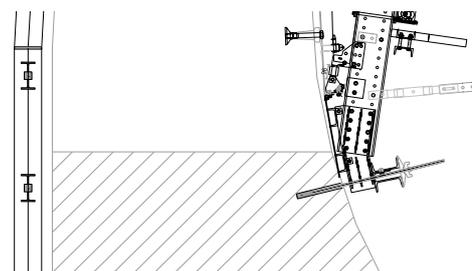


DETAIL OF THE ANCHORING SYSTEM ON SITE

There are different types of anchorage according to the needs of a particular site. The **Lost Tie and Post** system is the most widely used and allows the anchorage from a previous phase to be incorporated into the concrete pouring of the tunnel section. The **Expansion Block** system is used for cases where the lost Post cannot be placed mainly because the footing has already been made.



LOST TIE AND POST



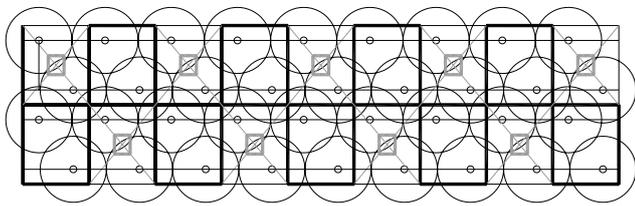
EXPANSION BLOCK

### 2.3.6 Vibration system

Unlike mined tunnels, with cut-and-cover tunnels the concrete can be accessed from outside, which means that internal vibrators can be used in even the most complicated areas.

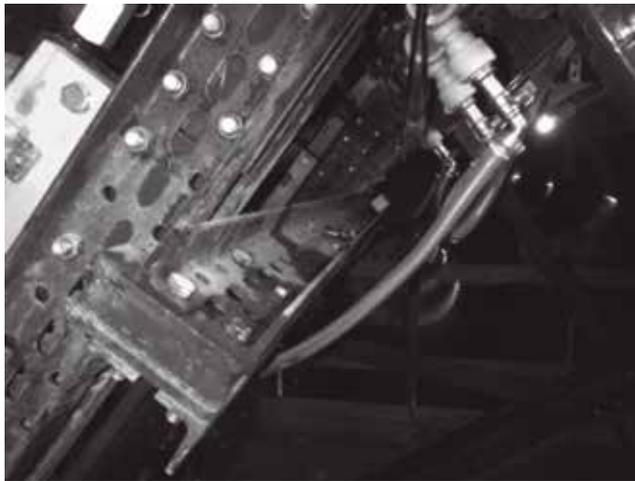
External vibration allows the concreting work to be carried out in the most efficient way when there is no access to the inside part of the mould (e.g., in mined tunnels) or when there are areas that are difficult to access or when the steel rebar means that the concrete cannot be easily compacted.

The vibration system is pneumatic and ULMA supplies all the necessary equipment for its operation, with the exception of the air compressor. The external vibration is done with vibration equipments fixed to the mould without changing of position. There is a hose system which supplies all the equipment with compressed air.



ACTION OF VIBRATORS ON THE ENTIRE FORMWORK SURFACE

Only 3 or 4 vibrators can be used simultaneously and the way they are designed and placed in the mould, with their radius of action they cover the entire surface of the mould in a way that is suitable for the concrete.



PLACEMENT OF THE VIBRATOR ON THE FORMWORK WITH ITS PNEUMATIC CONNECTIONS

### 2.3.7 Concrete pouring system

The formwork system for mined tunnels facilitates, through its devices in metal formwork, the introduction of the concrete pouring and control of the pouring process.

- **Concrete pouring nozzles** that allow rapid adjustment of the concrete pouring hoses supplied by the site through standard couplers.
- **Inspection windows** during the pouring process.
- **Detection tube** placed in the vault to see when the concrete has reached the fill level in the mould. This level coincides with the slab thickness to be concreted.

The different types of sheet panels are there as much for using nozzles to pour the concrete as for windows and the filling control system.



DETAIL OF THE DETECTION TUBE



DETAIL OF THE COUPLER AND CONCRETE POURING NOZZLE



DETAIL OF THE CONCRETE POURING NOZZLE AND INSPECTION WINDOW

### 2.3.8 Front cover

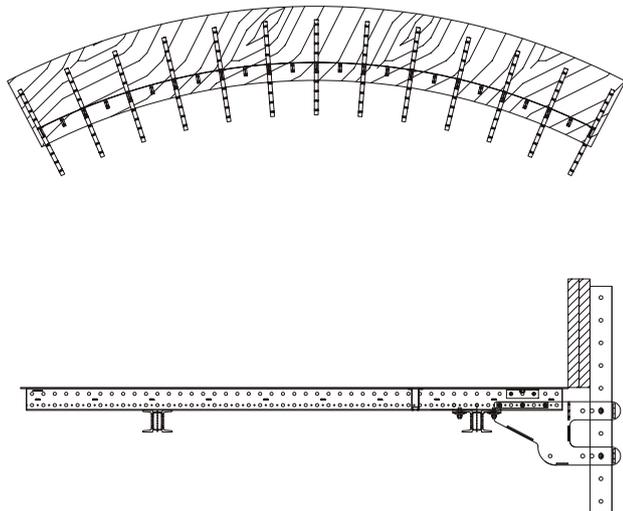
The concrete pouring front seal is made by means of a cover that avoids the concrete escaping and resists the push caused by the fresh concrete.

This cover comprises the Front Cover Protector, TF Tube, Plywood and Wedges.

The Front Cover Protector is joined to the Omega Beam of the TMK Panel using 3 Pins D16.

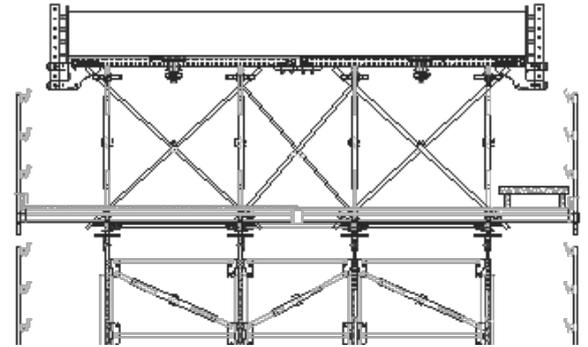
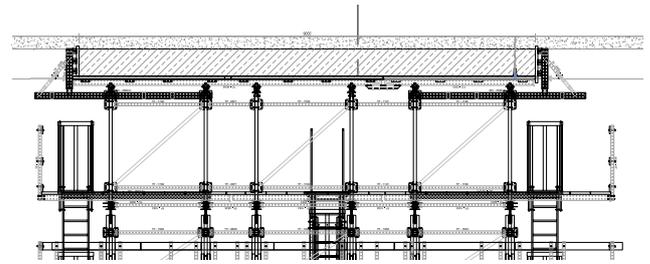
The TF Tube is mounted to the Front Cover Protector with 2 Pins E20x70.

The Front Cover Plywood is screwed to the Front Cover Protector, and is supported on the TF Tubes.



The cover set is calculated for concrete thicknesses of 0.65 m, placing elements every 31.5 cm in the transverse direction, and for thicknesses of 0.44 m, placing the elements every 63 cm.

Depending on how the structure is, covers can be arranged on both sides of the formwork to start the first voussoir.

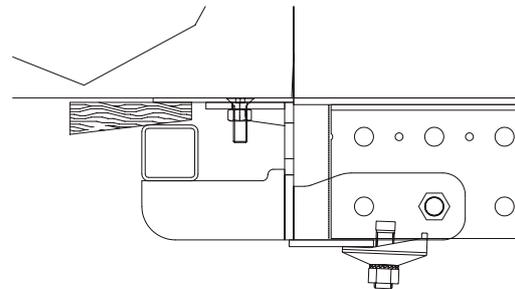


INITIAL CONCRETE WITH TWO COVERS

### 2.3.9 Rear overlap

Once the first pouring is done, the overlap is mounted on the back of the carriage.

First, the Back Compensation Connectors are mounted on the Omega Beams and TMK Panels tube.



In the joints and corners of the panels, are mounted the Edge bc Connectors.

Once all the connectors have been placed, the Back Closure Plates are placed on top of them, screwing them.

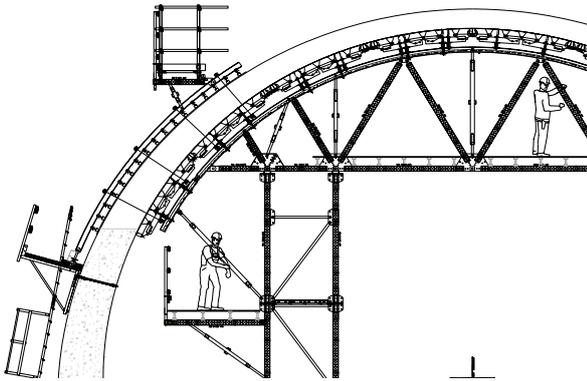
To improve the position, wooden wedges are inserted between the Rear Overlap Connectors and the Back Closure Plate.

### 2.3.10 Safety platforms and access

Safety platforms are mounted directly over the MK structure configured by the carriage. They can be made in two ways:

- **Directly over two adjacent structures.** On the available walers, supported by the secondary beams and the deck. The suitable tying system depends on which beam is being used.
- **Directly over the bracing tubes between structures.** To do this, steel scaffolding platforms are used supported on either round or square tubes.

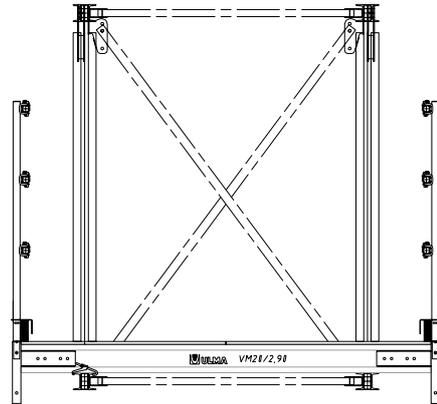
The platforms can be placed on any point of the structure, thus forming work areas at different levels, to help during the assembly phase and platforms to allow access to higher parts if required.



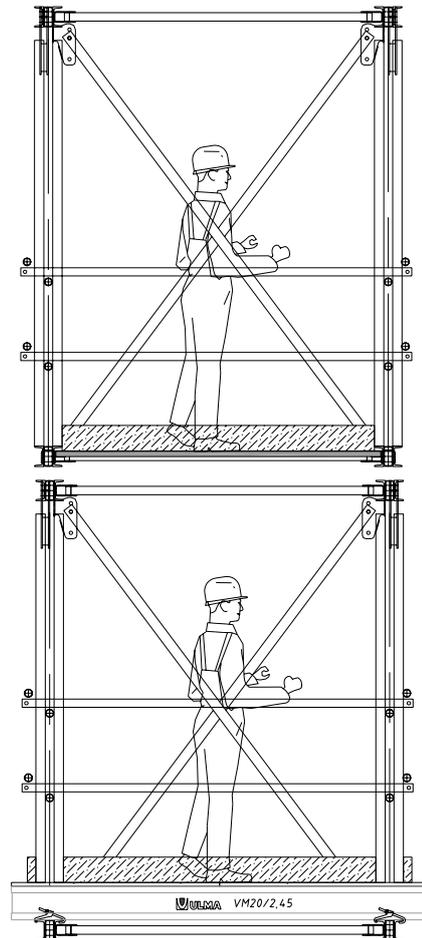
The first method allows the assembly of suspended platforms so it is more suitable for making platforms outside from the plan view projection of the structure. On the contrary, either one of the two is suitable for assembling platforms within the structure.

There are also two possible ways to place the safety handrails:

- **By means of handrail heads on secondary beams,** suitable for all cases, whether on secondary beams or other systems.



- **By means of MK handrail heads** on the waler of the structures and tube and coupler tied to the head. This method is always used with scaffolding platforms.



## 3. ASSEMBLY, USE AND DISMANTLING

### 3.1 TECHNICAL ASSEMBLY INSTRUCTIONS

For further information in this section, it is advisable to read and follow the technical instructions on assembling, dismantling or handling different parts of MK carriages:

- Assembly instructions **TMK01-00** "Assembly of carriage for cut-and-cover tunnels"
- Assembly instructions **TMK02-00** "Assembly of MK V support"
- Assembly instructions **TMK03-00** "Assembly of cut-and-cover tunnels vaults"
- Assembly instructions **TMK04-00** "Assembly of cut-and-cover tunnel formwork"
- Assembly instructions **TMK05-00** "Assembly of carriage for mined tunnels"
- Assembly instructions **TMK06-00** "Assembly of mined tunnel vault"
- Assembly instructions **TMK07-00** "Assembly of mined tunnel formwork"
- Disassembly instructions **TMK08-00** "Disassembly of carriage for mined tunnels"
- Assembly instructions **MK07-01** "Assembly of MK roller Bogie"
- Assembly instructions **MK 12-00** "Assembly of module type for MK shoring"

### 3.2 ANIMATIONS

Animations available on the ULMA Construction website.



## 4. SYSTEM PROPERTIES

It is difficult to establish limits for the different structures that can be constructed with the MK system, given that each individual case has always to be calculated. However, here are shown parameters that may be more significant.

### 4.1 CUT-AND-COVER TUNNELS

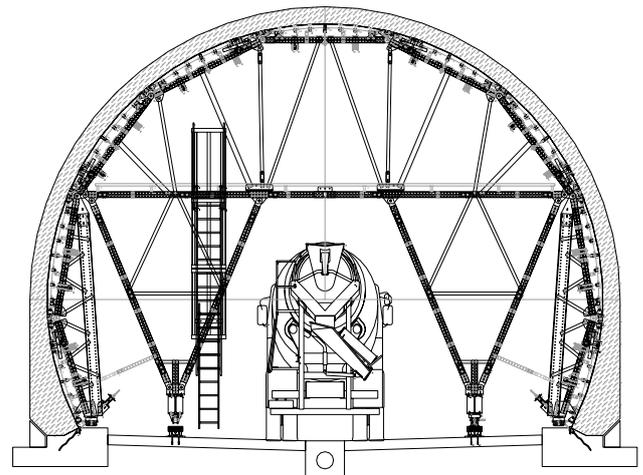
The outdoor formwork can consist of a varied set of items (plywood board, beams and walers), which can be used to achieve different values depending on distance and type.

- **CONCRETE PRESSURE.** The value type is 50 kN/m<sup>2</sup> although higher values can be obtained depending on the constitution of the panel (Formwork type panel, distance between secondary beams and distance between walers or points of support).
- **Construction generally in two clearly differentiated phases.** First phase corresponding to the side walls or vertical walls and second pier cap phase in the case of an open air tunnel, or a vault if it is a cut-and-cover tunnel.
- **TRANSVERSE RADIUS FOR CUT-AND-COVER TUNNELS.** For circular sections between 4.00 and 9.00 m. For small radii, the curvature of the plywood board can require two layers of plywood board.
- **LENGTH OF CARRIAGE.** The limitation defines the construction system (length of steel rebar, plan view curve, concrete poured in each stretch, etc.). The usual length of the carriages varies between 6.00 and 15.00 m.
- **MINIMUM PLAN VIEW RADIUS.** R = 300 m.
- **LONGITUDINAL SLOPE.** P = 14% ascending.
- **SITE CYCLE:** 2-3 days.
- **CONCRETE PARAMETERS IN POURING PHASE**

MECHANICAL PARAMETER	SYMBOL	INTERVAL	REF. VALUE.
Internal friction angle (°)	$\varphi$	2 - 40	30
Cohesion (kPa)	c	2 - 10	5
Angle of dilatancy (°)	$\psi$	2 - 40	30
Modulus of Elasticity (kPa)	E	$2 \cdot 10^3 - 2 \cdot 10^6$	$2 \cdot 10^4$
Poisson Coefficient	$\nu$	0.30 - 0.40	0.30
Concrete - Formwork Friction Coefficient	$\mu$	0.01 - 0.20	0.05

### 4.2 TUNNELS THROUGH ROCK

- **CONCRETE PRESSURE.** The value type over the panel is 75 kN/m<sup>2</sup>. In the upper area of the vault, this value is reduced in relation to slab thickness.
- **TRANSVERSAL RADIUS FOR MINED TUNNEL.** For circular sections with a minimum of 3.00 m, which is the capacity of the 6.00 mm sheet.
- **LENGTH OF CARRIAGE.** The limitation defines the construction system (length of steel rebar, plan view curve, concrete poured in each stretch, etc.). The usual length of the carriages varies between 6.00 and 15.00 m.
- **MINIMUM PLAN VIEW RADIUS.**  
For a carriage length of 6.00 m R = 260 m.  
For a carriage length of 12.00 m R = 750 m.
- **LONGITUDINAL SLOPE.** P = 14 % ascending.
- **SITE CYCLE:**
  - 2-3 uses in one week with 8 - 10 hours of work for circular tunnels with a radius of 4 - 5 m. Concrete pouring volume 250-275 m<sup>3</sup> approx. This means 2 days per cycle.
  - 1-2 uses in one week with 8 - 10 hours of work for tunnels with a longer vault. Concrete pouring volume approx. 300-325 m<sup>3</sup>. This means 3 days per cycle.



### 4.3 FORMWORK PERFORMANCE

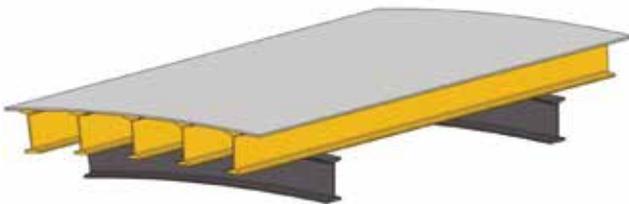
The most common types of formwork used with cut-and-cover tunnel and mined tunnel structures and which we have defined as:

#### 4.3.1 Mainly for mined tunnel:

- **A** / TMK steel Formwork Panel with Curved Waler

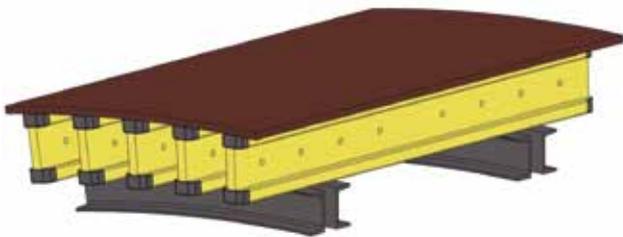


- **B** / Made to measure steel formwork panel.

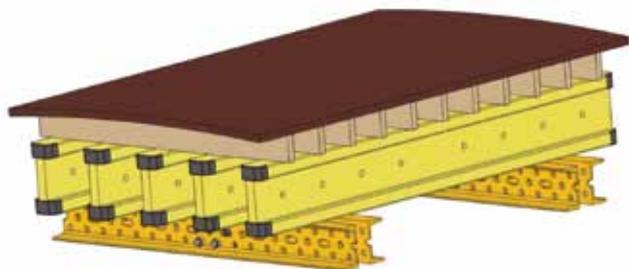


#### 4.3.2 Mainly for cut-and-cover tunnels:

- **C** / Formwork with curved waler and secondary beam + plywood panel.



- **D** / Formwork with standard straight waler and secondary beam + shaping timber and plywood panel.



The most common applications of each system are shown in this table.

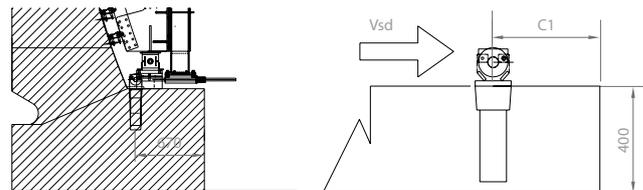
	RADIUS IN CROSS			LONGITUDINAL SECTION		PRESSURE	
	R < 3m	3 < R < 10	R > 10	Constant	Variable	< 50 kN / m <sup>2</sup>	> 50 kN / m <sup>2</sup>
<b>A</b>	•	•	•	•	•	•	•
<b>B</b>		•	•	•			•
<b>C</b>	•	•		•		•	
<b>D</b>		•	•	•	•	•	

### 4.4 ANCHORAGE PERFORMANCE

The performances of the types of anchorage available are shown in the following table:

#### 4.4.1 NP Anchorage

According to calculations based on the theory of anchorages, the actual strength of the anchorage will depend on the type of concrete used for the shoe (footing), and on the distance to its edge. The values shown here are indicative and should be checked by the client.



Concrete type	c1 (cm)	Slab edge	Pry out
		Vsd (kN)	VRK, cp (kN)
<b>C30/37</b>	40	133	300
<b>C30/37</b>	50	173	351
<b>C30/37</b>	60	216	407
<b>C30/37</b>	70	261	467
<b>C30/37</b>	80	308	530
<b>C30/37</b>	90	358	597
<b>C30/37</b>	100	409	668

Slab depth 400 mm (Load on SLS)

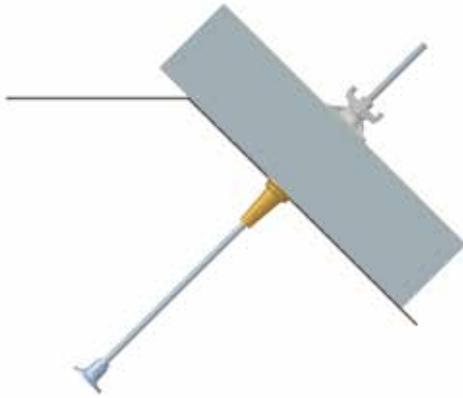
$\gamma_f$  1,5 Enlargement loads

$\gamma_c$  1,5 Load decrease

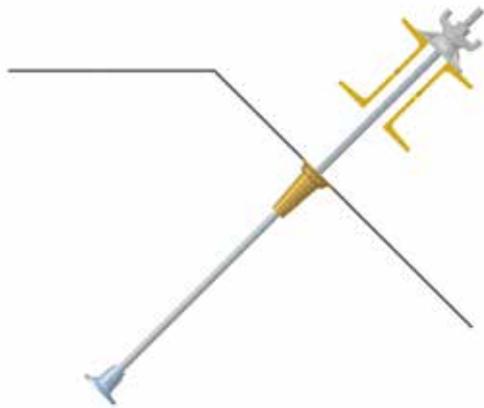
**Note:** Values estimated without considering footing reinforcement.

#### 4.4.2 BP Anchorage

- Cone type anchorage



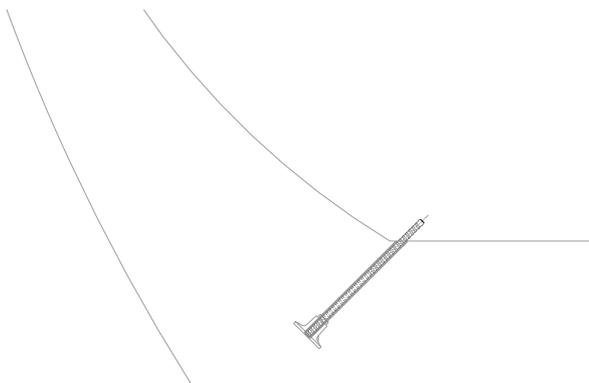
POSITION IN THE FORMWORK



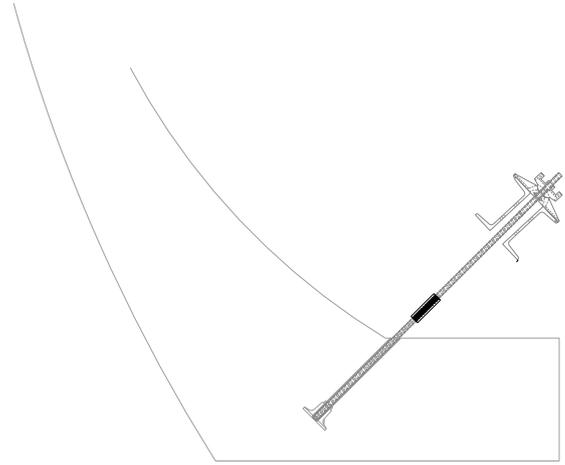
CONCRETE POURING POSITION

Type of Anchorage	Anchorage use load (kN)	$f_y$ (N/mm <sup>2</sup> )	$f_{ub}$ (N/mm <sup>2</sup> )
D15 ELS F	90	900	1100
D20 ELS F	160	900	1100

- Coneless type anchorage



POSITION IN THE FORMWORK



CONCRETE POURING POSITION

Type of Anchorage	Anchorage use load (kN)	$f_y$ (N/mm <sup>2</sup> )	$f_{ub}$ (N/mm <sup>2</sup> )
D15 ELS F	90	900	1100
D20 ELS F	160	900	1100

- "Expansion Shell" type anchorage



Type of Anchorage	Anchorage use load (kN)
D15 ELS F	72
D20 ELS F	88

- \* Consult with Technical Area to determine the depth and diameter required in each case.

# 5. COMPONENTS AND ACCESSORIES

## 5.1. CUT-AND-COVER TUNNEL AND MINED TUNNEL SHARED ITEMS

ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
-------------	------------	------	-------------	---------

### MK-120 WALERS AND PROFILES AND MK-180

1990103	4.6	PROFILE MK-120 / 0.375
1990104	6	PROFILE MK-120 / 0.5
1990105	7.6	PROFILE MK-120 / 0.625
1990106	9.1	PROFILE MK-120 / 0.75
1990107	10.7	PROFILE MK-120 / 0.875

This is a common item for all applications.

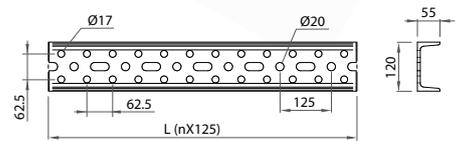
The MK-120 **waler** is formed by two UPN-120 profiles facing each other.



The main feature of the profile is its double row of holes that are used for the different connections required.

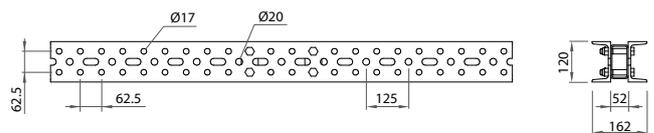
1990209	29.3	WALER MK-120 / 1.125
1990211	35	WALER MK-120 / 1.375
1990213	41.7	WALER MK-120 / 1.625
1990215	47.9	WALER MK-120 / 1.875
1990217	54	WALER MK-120 / 2.125
1990219	60	WALER MK-120 / 2.375
1990221	68	WALER MK-120 / 2.625
1990223	75	WALER MK-120 / 2.875
1990225	81	WALER MK-120 / 3.125
1990227	87	WALER MK-120 / 3.375
1990229	93	WALER MK-120 / 3.625
1990231	101	WALER MK-120 / 3.875
1990233	107	WALER MK-120 / 4.125
1990235	113	WALER MK-120 / 4.375
1990237	120	WALER MK-120 / 4.625
1990239	126	WALER MK-120 / 4.875
1990241	132	WALER MK-120 / 5.125
1990243	140	WALER MK-120 / 5.375
1990245	146	WALER MK-120 / 5.625
1990247	152	WALER MK-120 / 5.875

The outer row of holes is  $\varnothing 17$ , 62.5 mm apart in both directions. In the central row, there are alternate holes of  $\varnothing 20$  and slots of 45.5 mm in width.



The gap between the holes in the waler is 62.5 mm for the outer row and 125 mm for the central.

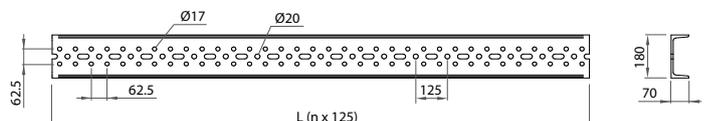
All the **walers and profiles** start with a hole of  $\varnothing 20$  in both ends of the centre row.



1990013	33.6	PROFILE MK-180 / 1.625
1990017	44.1	PROFILE MK-180 / 2.125
1990019	49.3	PROFILE MK-180 / 2.325
1990021	55	PROFILE MK-180 / 2.625
1990025	65	PROFILE MK-180 / 3.125
1990029	75	PROFILE MK-180 / 3.625
1990033	86	PROFILE MK-180 / 4.125
1990037	96	PROFILE MK-180 / 4.625
1990045	117	PROFILE MK-180 / 5.625
1990053	138	PROFILE MK-180 / 6.625
1990061	159	PROFILE MK-180 / 7.625
1990069	180	PROFILE MK-180 / 8.625
1990085	222	PROFILE MK-180 / 10.625

Profile with similar characteristics to UPN-120, formed of a UNP-180.

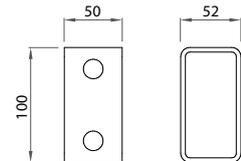
Used in areas where the **MK-120** waler does not have sufficient load-bearing capacity.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**MK-120 WALERS AND PROFILES AND MK-180**

1990200 0.46 SPACER TUBE MK-120 / 52 This is the item that separates the profiles formed by the **MK walers**.  
  
With walers, it is used as a spare part, as they already have this item built-in.



0241690 0.17 HEXAG BOLT M16x90  
DIN931 8.8C Used to fix the MK spacer tube to profiles and so define the walers.  
0241600 0.03 HEXAG NUT M16 DIN934 8C Also used for connections between walers and connectors.



**NODES AND STRUCTURE ITEMS**

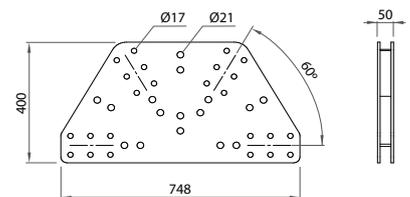
1990485 30.7 NODE 180 MK Joins up to 4 walers at 60° to one another. Two of them are thus aligned longitudinally.



The joints are made using 6 M16 bolts.

They cover a theoretical hole of up to 387 mm in the waler.

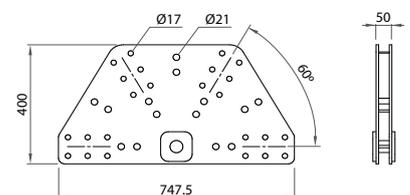
The **node 180 MK** allows a waler to pass in the longitudinal direction.



1990480 32 NODE 180 D40 MK The **node 180 D40 MK** can also join another male item, with an articulated joint, in the centre and downwards. This joint is made using a **D40 pin**.



The Ø 21 holes are mainly used to join secondary elements for the bracing of the set in general.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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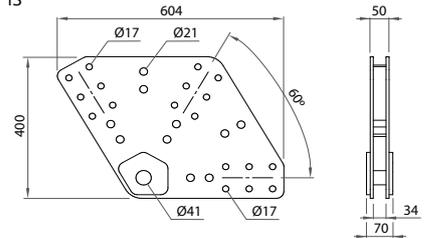
**NODES AND STRUCTURE ITEMS**

1990420    24.0    NODE 120 MK

Joins up to 3 **walers** at 60° to one another. The joints are made using 6 M16 bolts.

The Ø 21 holes are mainly used to join secondary elements for the bracing of the set in general.

It can also be joined with an articulated joint, by means of another male item. This joint is made using a **D40 pin**.

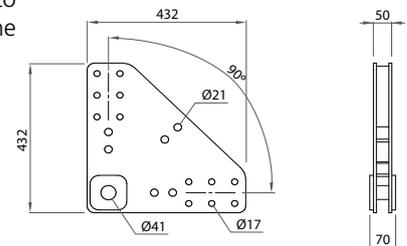


1990390    18.9    NODE 90 MK

Joins up to 2 **walers** at 90° to one another. The joints are made using 6 M16 bolts.

It can also be joined with an articulated joint, by means of another male item. This joint is made using a **D40 pin**.

The Ø 21 holes are mainly used to join secondary elements for the bracing of the set in general.

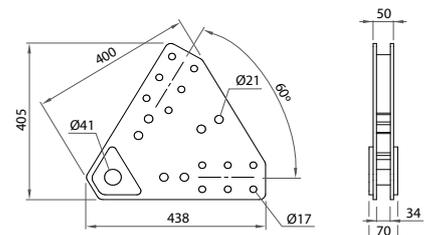


1990360    16.0    NODE 60 F MK

Joins up to 2 **walers** at 60° to one another. The joints are made using 6 M16 bolts.

There are two models, one female and one male. Each one allows another element (male or female) to be joined with an articulated joint by means of a **D40 pin**.

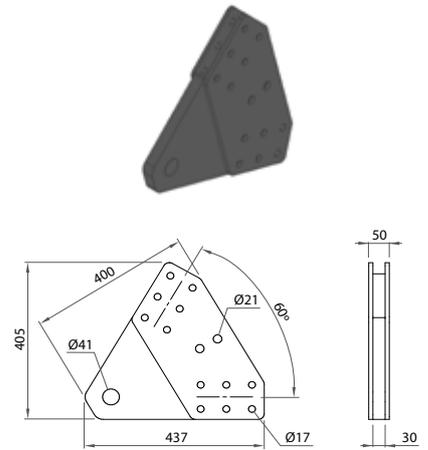
The Ø 21 holes are mainly used to join secondary elements for the bracing of the set in general.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**NODES AND STRUCTURE ITEMS**

1990361 21.3 NODE 60 M MK



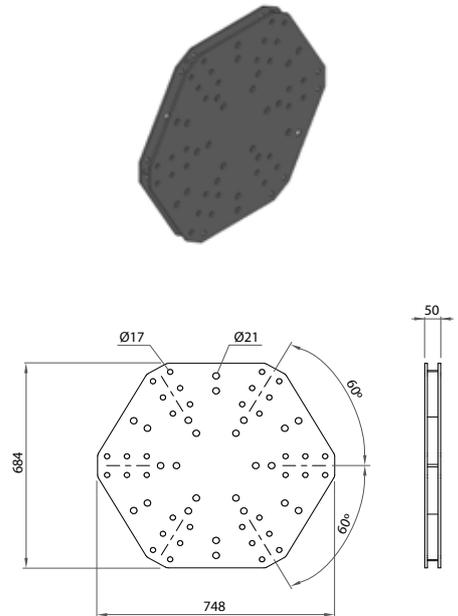
1990665 50 NODE 360 MK

Joins up to 6 **walers** at 60° to one another. This aligns the walers longitudinally, two by two.

The joints are made using 6 M16 bolts.

They cover a theoretical hole of up to 387 mm in the waler.

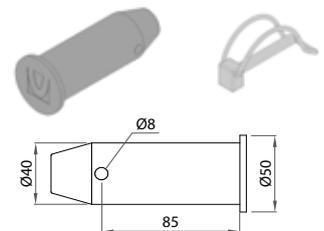
The Ø 21 holes are mainly used to join secondary elements for the bracing of the set in general.



1980120 1.1 PIN D40x85  
9023102 0.04 SAFETY PIN D 7x50

This is the joining element between **male nodes** and **female nodes**. These are joints with a high load-bearing capacity and where it is best to articulate the joint for their application.

Each **D40 x85 pin** has a **D7 x 50 safety pin**.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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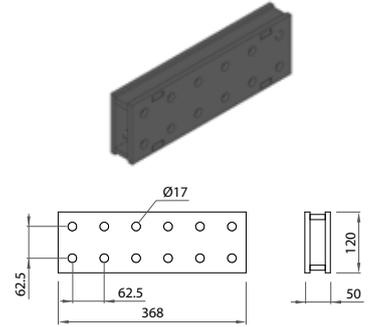
**NODES AND STRUCTURE ITEMS**

1990395    8.2    ORTHOGONAL JOINT MK

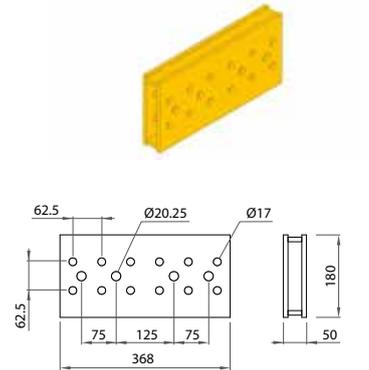
These are joined longitudinally and to the abutment, in the first load drawing, 2 **walers** to one another.

The joint is made using 6 M16 bolts.

They are also used for joining up to 3 **walers** to one another perpendicularly. In this case, each waler is joined with 4 M16 bolts



1991200    11.5    ORTHOGONAL JOINT MK-180

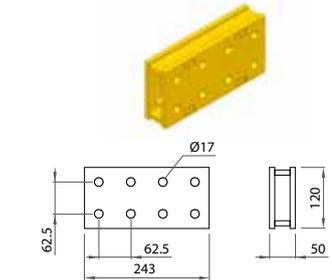


1990412    5.4    ORTHOGONAL JOINT 8 MK

These are joined longitudinally and in the first load drawing, 2 walers to one another.

The joint is made using 4 M16 bolts.

This model is used for joints with less traction load.

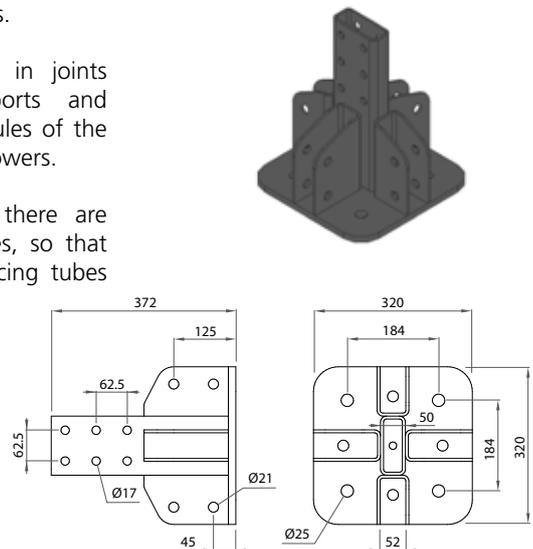


1990504    24.4    HEAD JOINT MK

Allows for an end joint at 90° between structures. The end joint is made by using M24 Bolts.

These are mainly used in joints between vertical supports and bogie, forming the modules of the vertical supports or MK towers.

In the secondary axis, there are heads with 21 mm holes, so that push-pull props and bracing tubes can be inserted.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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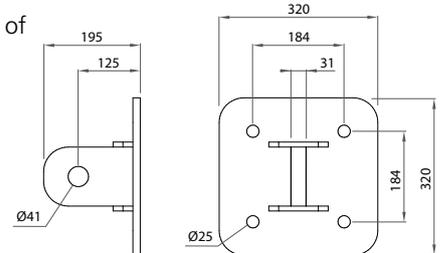
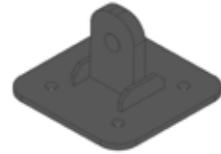
**NODES AND STRUCTURE ITEMS**

1990400 16.7 PLATE NODE HEAD MK

This allows for a 90° end joint between vault and vertical support when an articulated support in the vault is needed at the same time.

This joint is made using a **D40 pin**.

The end joint is made by means of M24 bolts.

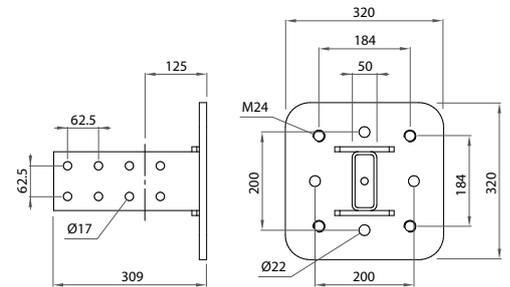


1990405 15.7 PLATE WALER HEAD MK

This allows for a 90° end joint between vault and vertical support at the same time as having a projection from the **waler** within the vault.

The waler joint is made using 6 M16 Bolts.

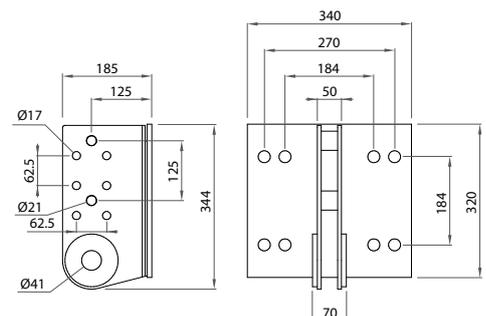
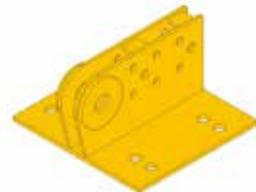
The end joint is made by means of M24 bolts.



1992950 16.4 END-NODE JOINT MK-D40-F

This is a female node used in the ends of the vault's **lower waler**. It acts as a connection between the **TMK panels** of the curved part and this waler.

This joint is made using a **D40 pin**.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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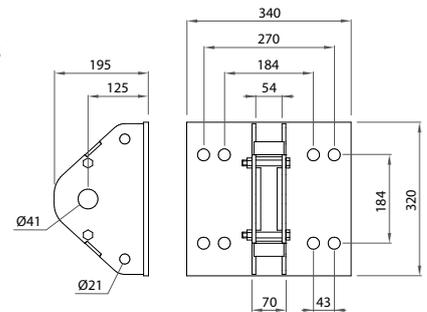
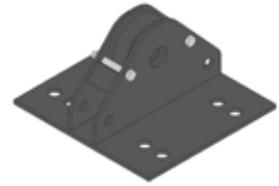
**NODES AND STRUCTURE ITEMS**

1991970 15.2 VAULT END-NODE JOINT

Allows vertical supports or the legs of the structure to be joined to the vault at any degree of slope.

M24 bolts are used for the end joint, whereas the 41 mm hole serves as an articulated joint using the **D40 pin**.

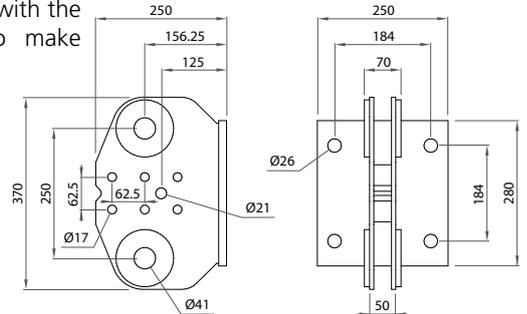
It also allows the insertion of tubes and push-pull props in the 21 mm hole.



1991877 19.7 BASE PLATE TMK

Shoe item which allows a waler to be vertically joined between the Ø 17 holes. The two Ø 41 holes are used to articulate the vertical supports or legs of the tunnel with an angle other than 90°.

In reality, this is a node for connecting to the bogie, which is used with the **vault end-node joint** to make vertical V-shaped supports.

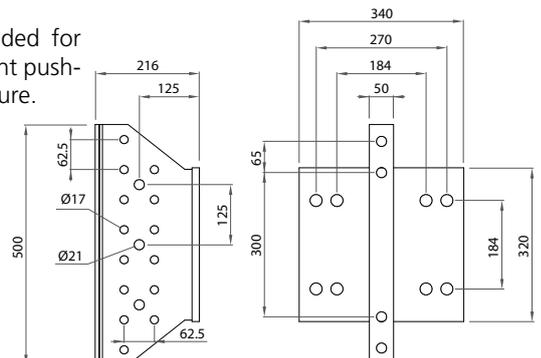
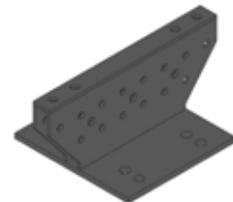


1991975 23.3 DIAGONALS END-NODE JOINT

This is used in the centre of the vault's **lower waler**, allowing the end joint between the end joint and the vertical supports or legs.

Designed for inserting M16 or M20 bolts (according to casuistry) for joining to the waler.

A **U main axis** can be added for tube heads and reinforcement push-pull props in the vault structure.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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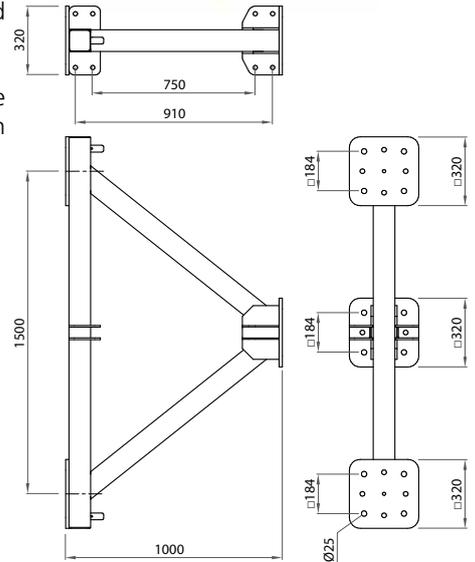
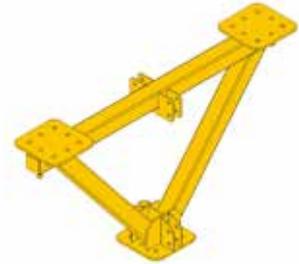
**NODES AND STRUCTURE ITEMS**

1990645 141 TRIANGULAR BASE MK 1500

Used in vertical support shoes when there is not enough space for carriage supports. Their main application is in tunnel structures of great height.

On one side they are joined to the **head plates** of the structure's vertical supports and to the bogie on the other side. M24 bolts are used for the joint in both cases.

A pair of alignment pins in the ends stabilise and vertically align structures in their assembly phase.



0242460 0.30 HEXAG BOLT M24x60  
DIN933 8.8C  
0242400 0.11 HEXAG NUT M24 DIN-934-8  
0242401 0.03 FLAT WASHER A24 DIN125

Bolts M24 for tying the different items together.



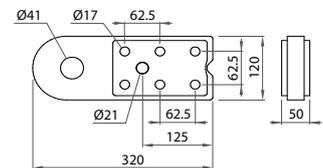
1991950 10.4 AXIAL NODE M / 62.5

Used to make an articulated joint between any **waler** and a vault assembly.

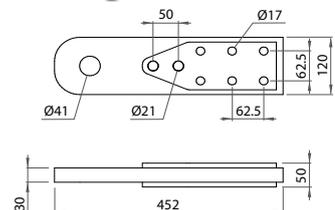
This joint is made using 6 M16 bolts.

These are male nodes and the joint to the assembly should always be made with another female node.

This joint is made using a **D40 pin**.



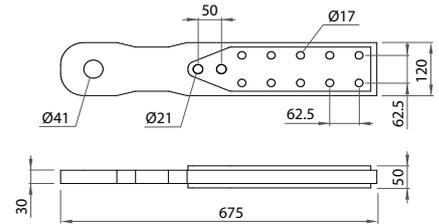
1990300 15.0 AXIAL NODE M / 187.5



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**NODES AND STRUCTURE ITEMS**

1990301    22.4    AXIAL NODE 90° M



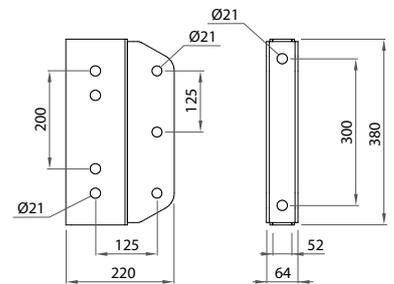
1990501    8.5    HALF-WAY CONNECTOR MK-120

They are placed on the main axis of the waler. They are used to join **horiz. braces, diagonals and push-pull props** to the structures, reinforcing them at these points.

They are most commonly used in vertical supports of great height.

The **waler** joint is made using M20 Bolts.

Joints with **horiz. braces, diagonals and push-pull props** are made using **E20x70 pins**.



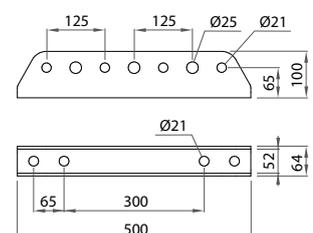
1991976    5.1    U MAIN AXIS MK/4

These prolong the bracing or reinforcement of structures at the main axis, linking the **horiz. braces, diagonals and push-pull props**.

They cannot be directly joined to the waler MK, so they are used with other items: **diagonals end-node joints** or **half-way connectors MK-120**.

The node joint is made using M20 Bolts.

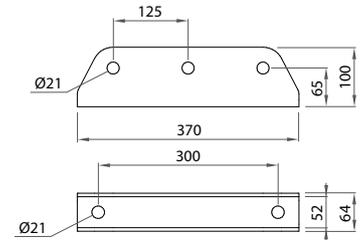
Joints with **horiz. braces, diagonals and push-pull props**, are made using **E20x70 pins**.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**NODES AND STRUCTURE ITEMS**

1990513 3.8 U MAIN AXIS MK/3



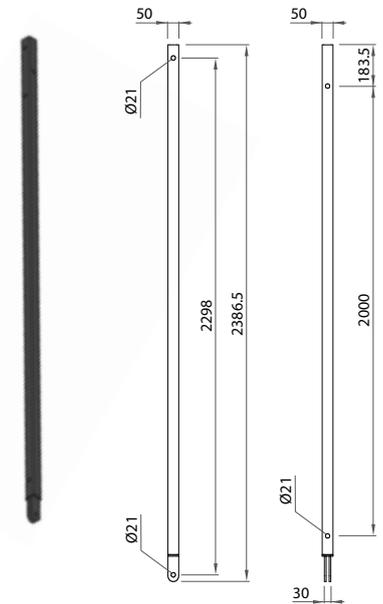
1990404 18.6 V BRACING TRUSS MK

Used in areas where, because of the loads on the structure, the structure's **waler** needs to be reinforced.

This model can only be adjusted to the 3x3 triangular structure.

This piece is joined to the assembly by means of the Ø 21 holes with **E20x70 pins**. It is joined to a **node** on one side and to the **waler** on the other.

In their profile view, the Ø 21 holes allow **walers** to be joined to the main structure in a transversal direction.



0242050 0.18 HEXAG BOLT M20x50  
DIN933 8.8C

M20 bolts for tying bracing items.

M20x100 ties the **secondary U axis to the waler**. M20x150 would be used for the MK/2 model.



0242010 0.30 HEXAG BOLT M20x100  
DIN931 8.8C



0242015 0.50 HEXAG BOLT M20x150  
DIN931 8.8C



0242000 0.06 HEXAG NUT M20 DIN934 8C



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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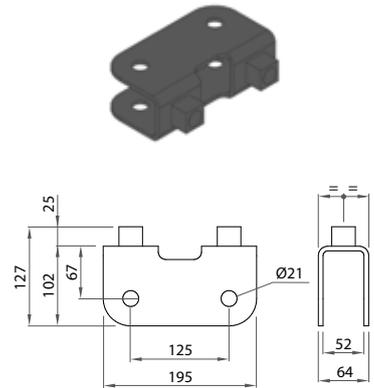
**JOINTS AND BRACING ITEMS**

1990522    2.2    U SECONDARY AXIS MK/2

These join the **horiz. braces, diagonals and push-pull props** to the structures' secondary axis. They allow bracing to be formed on this axis.  
An important feature of these joints is that they allow the bracing to be centred on the waler axis.

In the **MK/3** model, **walers or nodes** can be placed interchangeably.

The **MK/2** model can only be placed in the **walers**. It is mainly used in the ends and side wall of the vault structures. It serves as a bracing start and end item.

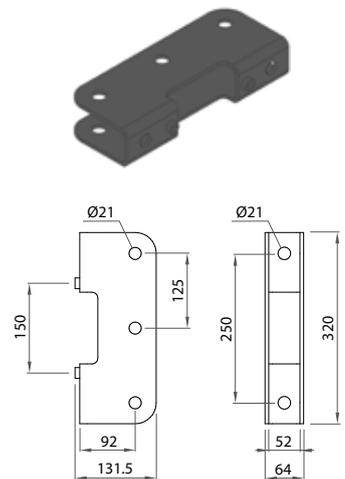


1990521    3.7    U SECONDARY AXIS MK/3

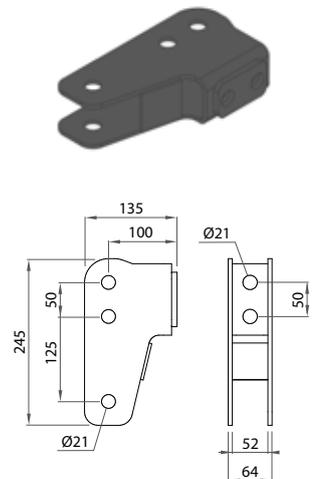
The **MK end** serves a similar purpose: it serves as a start and end item for bracing, but it can only be placed on **nodes**.

The **waler or node** joint is made using an M20 bolt.

Joints with **horiz. braces, diagonals and push-pull props**, are made using **E20x70 pins**.



2.7    U SECONDARY AXIS END MK



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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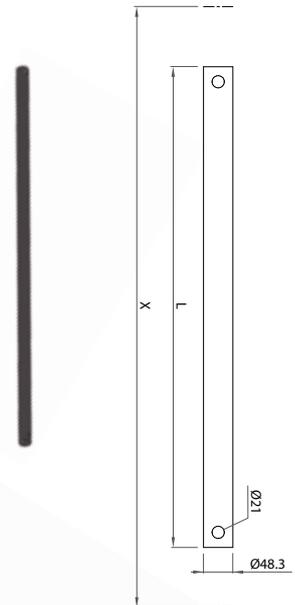
### JOINTS AND BRACING ITEMS

1990605	1.9	HORIZ. BRACE MK 0.75/ 550
1990608	2.7	HORIZ. BRACE MK 1/ 800
1990613	4.5	HORIZ. BRACE MK 1.5/1300
1990610	5.3	HORIZ. BRACE MK 1.75/1550
1990618	6.2	HORIZ. BRACE MK 2/1800
1990623	7.9	HORIZ. BRACE MK 2.5/ 2300

These brace tunnel structures in the secondary drawing mainly.

The **horiz. braces** are perpendicular to the plan of the structure, and maintain distance between 2 adjacent structures.

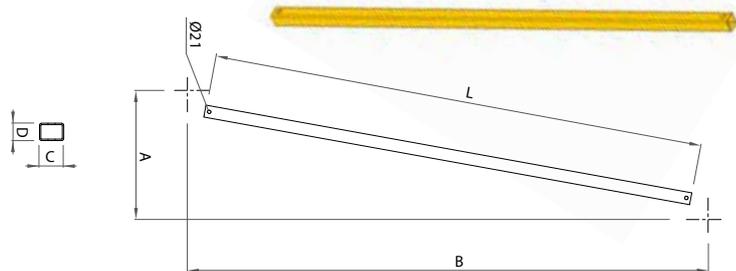
The length L refers to the length of the tube. The name contains the distance between the structures that are joined.



1990614	7.7	DIAGONAL MK 0.75x1.5 / 1396
1990628	19.4	DIAGONAL MK 0.75x3 / 2845
1990611	6.1	DIAGONAL MK 1x1 / 1110
1990612	7.2	DIAGONAL MK 1x1.25 / 1300
1990615	8.3	DIAGONAL MK 1x1.5 / 1508
1992917	9.6	DIAGONAL MK 1x1.75 / 1727
1990620	10.8	DIAGONAL MK 1x2 / 1954
1990619	10.1	DIAGONAL MK 1.5x1.5 / 1818
1990622	12.2	DIAGONAL MK 1.5x2 / 2201
1990626	17.9	DIAGONAL MK 1.5x2.5 / 2624
1990630	20.9	DIAGONAL MK 1.5x3 / 3071
1992920	11.1	DIAGONAL MK 1.75x1.5 / 2003
1992923	16	DIAGONAL MK 1.75x2 / 2355
1992927	18.7	DIAGONAL MK 1.75x2.5 / 2754
1990625	17.2	DIAGONAL MK 2x2 / 2525
1990629	19.7	DIAGONAL MK 2x2.5 / 1x3 / 2900
1990633	22.5	DIAGONAL MK 2x3 / 3310

The **diagonals** complement the bracing, providing the diagonal bracing required for the plan in each application.

The length L refers to the length of the tube. The name also contains, in metres, the distance A x B between the structures and the **horiz. braces**.



### PUSH-PULL PROPS

1960210	11	PUSH-PULL PROP E 0.51-0.75
1960100	14.4	PUSH-PULL PROP E 0.75-1.05
1960110	19.2	PUSH-PULL PROP E 1-1.55
1960115	24.4	PUSH-PULL PROP E 1.51-2.2
1960130	33.6	PUSH-PULL PROP E 2.15-2.75
1960125	38.2	PUSH-PULL PROP E 2.7-3.3
1960410	45.3	PUSH-PULL PROP E 3.25-4

Load bearing and provides the vaults with the necessary shape. They complete the system forming horiz. braces and diagonals for the vertical supports, in non-standard lengths of these.

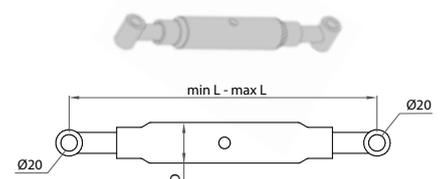
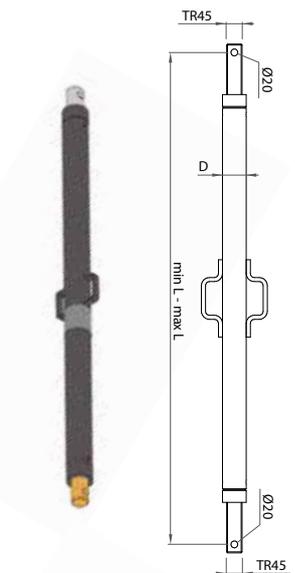
The joint is made by means of 2 **E20x70 pins** (1 to each side). The range of **E push-pull props** available is the same as other systems have, and their features depend on which push-pull prop is used in each case.

Code	min L	max L	D
1960210	510	750	70
1960100	750	1050	70
1960110	1000	1550	70
1960115	1510	2200	70
1960130	2150	2750	90
1960125	2700	3300	90
1960410	3250	4000	90

0212100	2.5	PUSH-PULL PROP 1" 0.36-0.52 (D20)
0212125	6.2	PUSH-PULL PROP 1.5" 0.44-0.66 (D20)

**Inch push-pull props** are used for applications where, due to their geometry, smaller push-pull props are needed.

Código	min L	max L	D
0212100	360	530	40
0212125	410	630	55



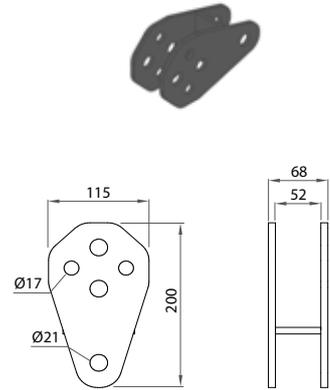
ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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### PUSH-PULL PROPS

1990403    2.2    JOINT PUSH-PULL PROP E-NODE MK    This part serves to join **E push-pull props** to any node.

Two **E20x70 pins** are used for the connection to the **node**, whereas only one is used for the **push-pull prop**, allowing an articulated joint to be made.

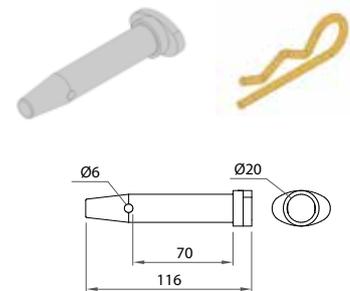
Two M16 bolts can also be used to connect it to the **node**.



0252070    0.29    PIN E20x70  
0250000    0.03    COTTER PIN R/5

Allows joints to be made with **waler, node, joint, push-pull prop, horiz. braces or diagonal**, which require articulated connections by means of a Pin E20 x 70.

Each pin has an **R/5mm cotter pin**.



0241690    0.17    BOLT M16x90 DIN931 8.8C  
0241600    0.03    NUT M16 DIN934 8C

Used for fixing the push-pull prop joint to the node MK.

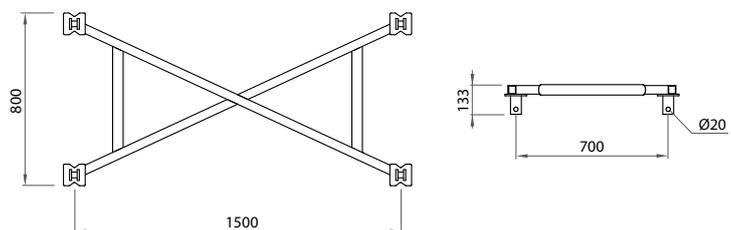


### Ø 48 TUBE BRACING

1960390    20.1    R-120/1.5 BRACING

This part has two functions. On one hand it is used as an assembly frame for the vault, and after assembly it allows the 3 m assembly to be braced, in transversal sections, between the **bottom waler** and the **vault waler**.

It is mainly placed in the vault's **bottom waler**.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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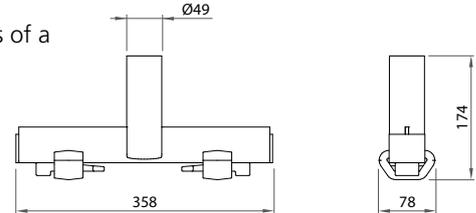
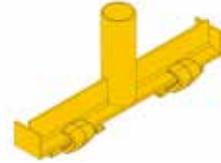
### Ø 48 TUBE BRACING

0260505 3.4 SIMPLE BRACING

Combined with other bracing items, this allows **Ø 48 tubes** to be placed in a cross shape, for bracing assemblies.

This part is mainly placed on the **vault's walers**.

It is tied to the **waler** by means of a wedge and collar.



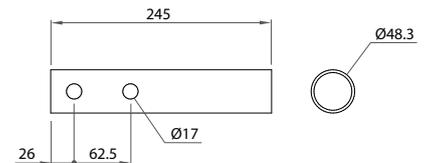
1990570 0.82 HANDRAIL HEAD MK

Combined with other bracing items, this allows **Ø 48 tubes** to be placed in a cross shape for bracing assemblies.

This part is mainly placed on the **vault's walers**.

It can also be used for placing **Ø 48 tubes** as a guardrail at any height of the **waler** in the vertical supports.

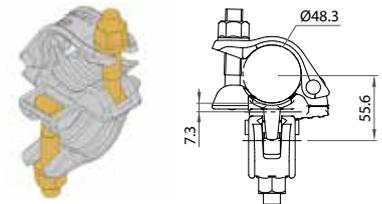
It is tied by 2 M16 bolts.



2125148 1.2 RIGHT ANGLE COUPLER 48/48

Allows two **Ø 48 tubes** to be joined perpendicularly.

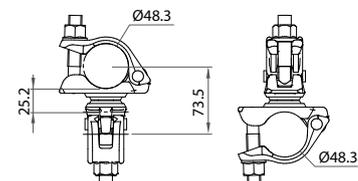
Tied directly to the **Ø 48 tubes**.



2125147 1.3 SWIVEL COUPLER 48/48

Allows two join **Ø48 tubes** at an angle other than 90 degrees, allowing cross bracing, for example.

Tied directly to the **Ø 48 tubes**.

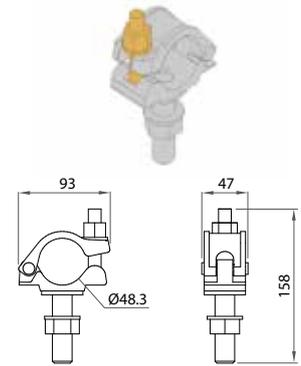


ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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### Ø 48 TUBE BRACING

0200004 0.88 HALF-COUPLER 48/M20X70 Combined with other bracing items, this allows **Ø 48 tubes** to be placed in a cross shape for bracing assemblies.

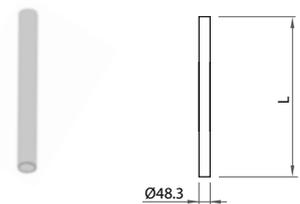
This part is mainly placed in the **TMK panel's L profile** and is tied directly to it.



2125288 1.8 TUBE 48/0.5  
 2125289 3.7 TUBE 48/1.1  
 2125290 5.5 TUBE 48/1.6  
 2125291 7 TUBE 48/2.1  
 2125647 8.7 TUBE 48/2.6  
 2125249 11.4 TUBE 48/3.1  
 2125648 12.1 TUBO 48/3.6  
 2125250 14.6 TUBE 48/4.1  
 2125251 18 TUBE 48/5  
 0200600 20 TUBE 48/6

**Ø 48 tubes** used for many applications.

Can be used for bracing the vault structures in a transversal direction, bracing the wall carriages or to the ground; forms handrails.

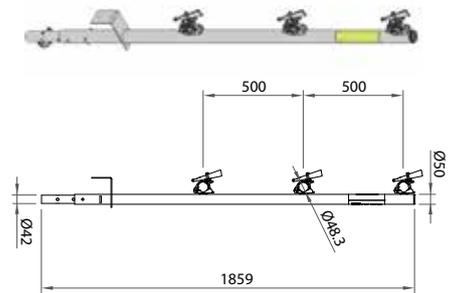


### SAFETY AND ACCESS PLATFORMS

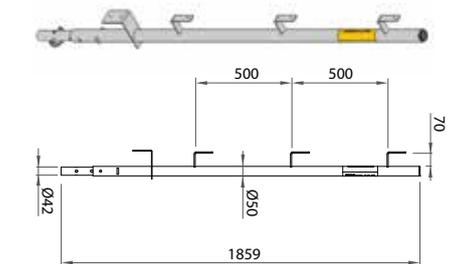
2211156 9.6 HANDRAIL POST 1.5 These are site safety items. They are placed vertically and spaced at a specific distance.

There are different models; in some bracing tubes are used to assemble the handrail and in others planks.

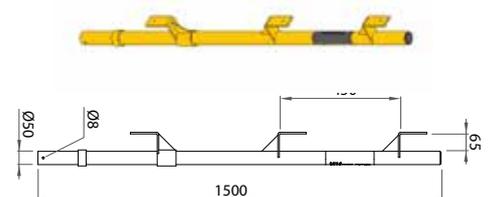
The 1.5 m high models allow 3 rows of handrails to be placed. In the 1.2 m model, only 2.



2211185 8 HANDRAIL POST 1.5 WOOD



0121000 7.2 HANDRAIL POST 1.2 WOOD



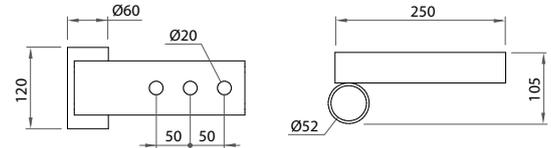
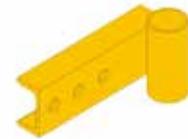
ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**SAFETY AND ACCESS PLATFORMS**

0121004 2.9 HANDRAIL SOCKET D50

Allows placement of a **1.50 m handrail post** at the end of the platform waler, so that lateral handrails can be assembled.

The joints are made with M20 bolts and nuts.



0242085 0.27 HEXAG BOLT M20x85  
DIN931 8.8C  
0242000 0.06 HEXAG NUT M20 DIN934 8C

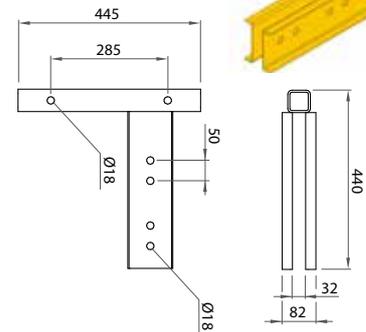
Used to the fix the handrail socket to the end of the waler.



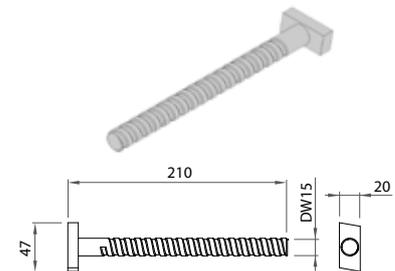
2211165 6.9 HANDRAIL SUPPORT VM

It is used as support for the **1.5 m handrail post** in front handrails.

It is tied to the **VM 20 beam** using a pair of **waler hooks** and joined by means of **plate nuts 15**.



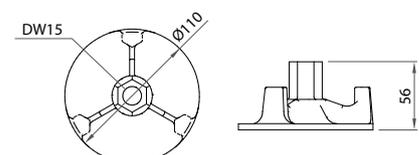
1861122 0.39 PANEL BOLT



7238000 0.73 PLATE NUT 15

Used for tying the **DW 15 tie** against the **0.45 waler**.

Also used for tying the **window TMK** to the tube of **TMK panel**.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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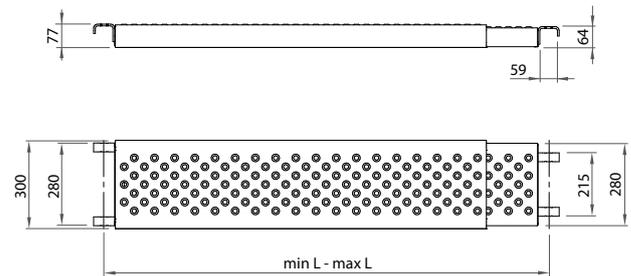
**SAFETY AND ACCESS PLATFORMS**

2067035	12.6	EXTENDING PLATFORM 1-1.6	Platforms for forming floors in working areas. Being extendible allows them to be adjusted to various dimensions or distances between parallel sections.
2067048	17.3	EXTENDING PLATAFORM 1.5-2.35	
2067043	20.6	EXTENDING PLATFORM 2-2.7	

They are tied directly to **Ø 48 tubes, horiz. braces and MK-120 profiles.**

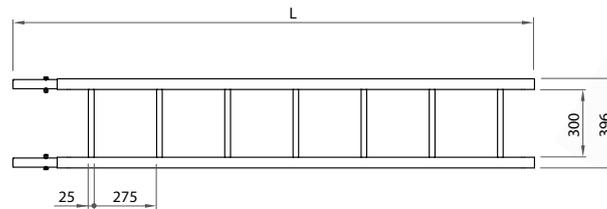


Code	min. L	max. L
2067035	1000	1500
2067048	1500	2350
2067043	2000	2700

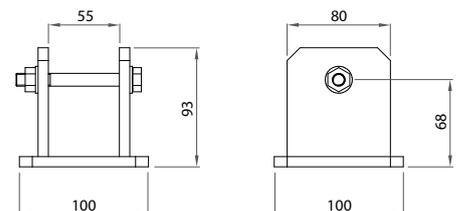


0333008	14.1	LADDER C2.1	Ladders providing access between different platform levels.
0333009	19.4	LADDER C3	

There are sockets to allow them to be joined together where different ladder lengths are required.



0333010	1.6	LADDER FIXER	Used to fix the base of ladders, anchoring them to the ground or platforms.
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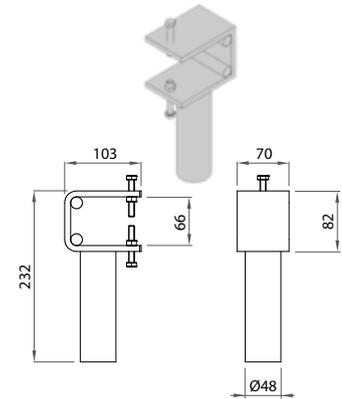
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**SAFETY AND ACCESS PLATFORMS**

0005416 1.8 T-500 LADDER CLAMP

Used to fix the tops of ladders.

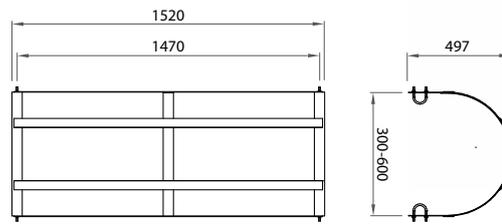
Tied directly to **Ø 48 tubes, horiz. braces and MK-120 profiles.**



0333012 13.1 LADDER PROTECTION

Back protection for **ladders.**

Used for ladders over 4 m in height, always leaving the bottom 2 m free.

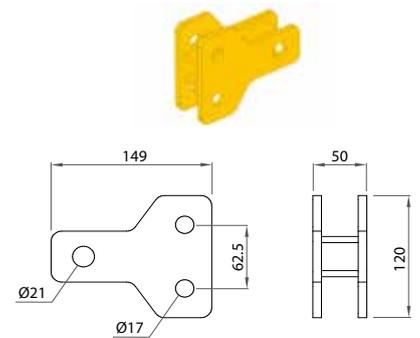


1990590 1.85 AXIAL NODE M D20 MK

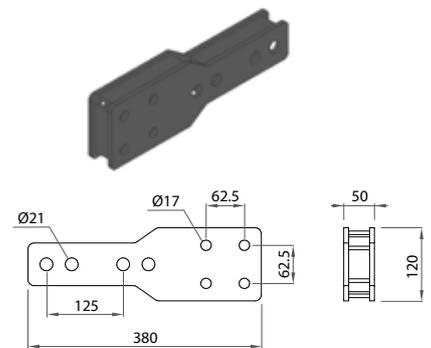
These **nodes** are used during the generation of working platforms. They can be used to make articulated joints between any **waler** and another, always on its main level.

The joint is made using 2 M16 bolts. This is not a **node** with great load bearing capacity.

The articulated joint is made using **E20 x 70 pins.**



1991458 5.3 AXIAL NODE M 2-D20 MK



0241690 0.17 HEXAG BOLT M16x90  
DIN 931-8.8C

Used for fixing **axial nodes** to **MK walers.**

0241600 0.03 HEXAG NUT M16 DIN934 8C

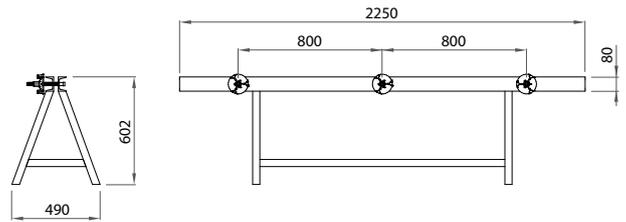


ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**ASSEMBLY ACCESSORIES**

1905141    52    RACK

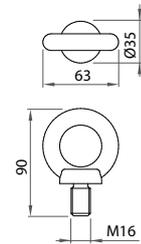
Allows **TMK panels** to be assembled at a more ergonomic height.



9165400    0.3    EYEBOLT SCREW M16  
DIN 580 C

These are used for handling **TMK panels** during assembly phases.

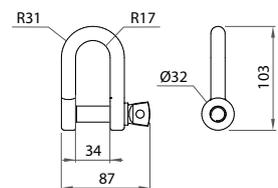
Tied with the M16 bolts to the holes in the L corner panel at the end of the **panels**.



0907614    0.3    SHACKLE 5/8 M16 ZINC

Used for handling **TMK panels** during assembly phases.

Tied directly to the **eyebolts**.



## 5.2. MINED TUNNEL

ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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### SHUTTERING PANEL

1992830	597	PANEL TMK3x2.5	Sheet formwork panel with an opaque surface, intended for areas of smooth formwork.
1992890	326	PANEL TMK 3x1.25	
1992858	260	PANEL TMK 3x0.937	
1992857	192	PANEL TMK 3x0.625	
1992853	124	PANEL TMK 3x0.312	

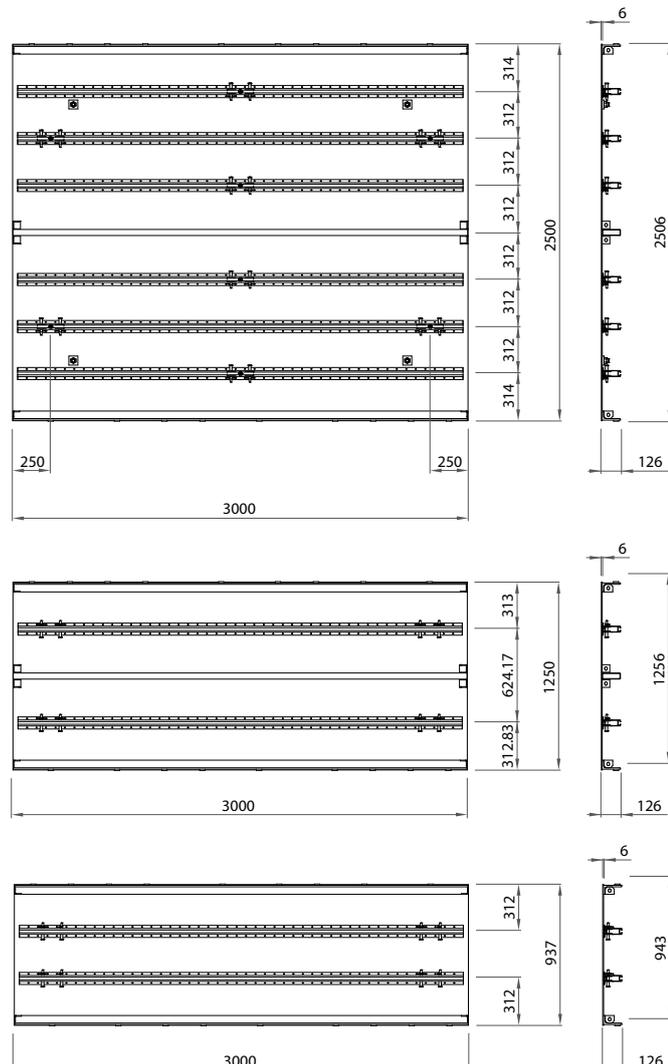
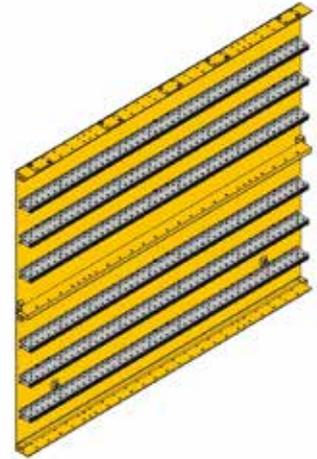
These are arranged along the structure, combined with other panels.

Measuring 3 m, they feature a central tube and two L profiles at their ends, all drilled with Ø 21 holes every 62.5 mm, along with 6 omega beams.

Size 2500, 1250, 937, 625 or 312 mm sheets are curved until they reach the necessary curvature.

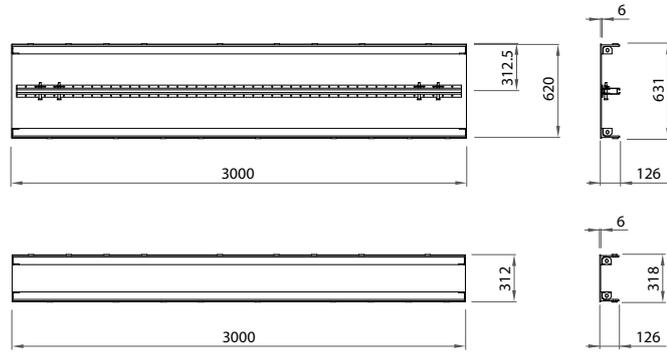
There are 5 models to best suit the needs required along the perimeter of the tunnel:

It includes holes for connection with the **omega beam**.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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## SHUTTERING PANEL



1992895	606	PANEL NOZZLE/RELIEF TMK 3 x 2.5
1992840	333	PANEL NOZZLE/RELIEF TMK 3 x 1.25

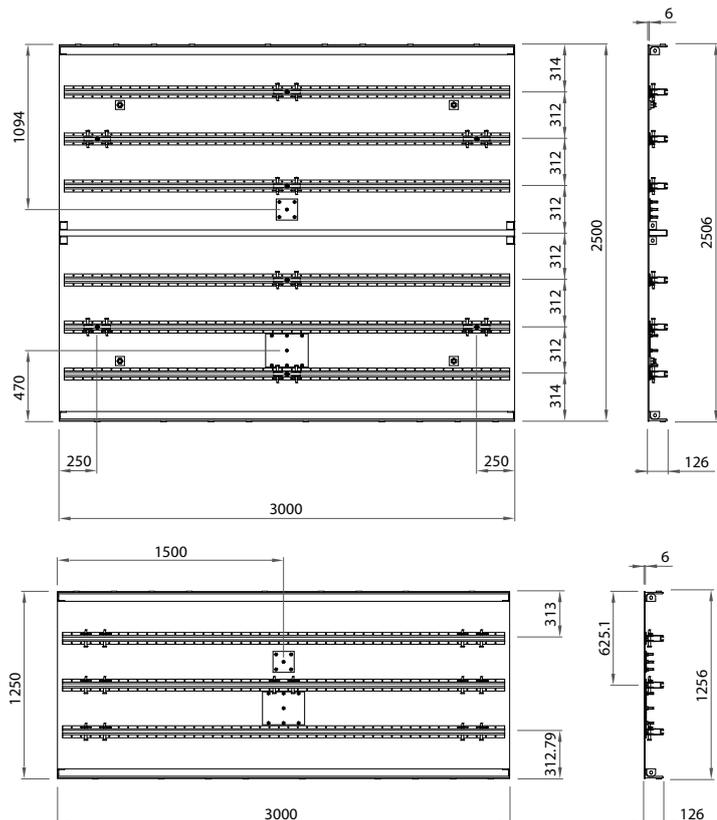
Formwork sheet panel with central window for observing concrete pouring and a hole or nozzle for concrete pouring.

These are arranged along the structure, combined with opaque sheets.

In their 3000 size, they have a central tube and two L profiles at their ends, each perforated with  $\varnothing 20$  holes every 62.5 mm.

The size 2500 sheets are curved until they reach the necessary curvature.

Includes holes for connection with the **omega beam**.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**SHUTTERING PANEL**

1992835    588    PANEL NOZZLE/WINDOW  
TMK 3 x 2.5

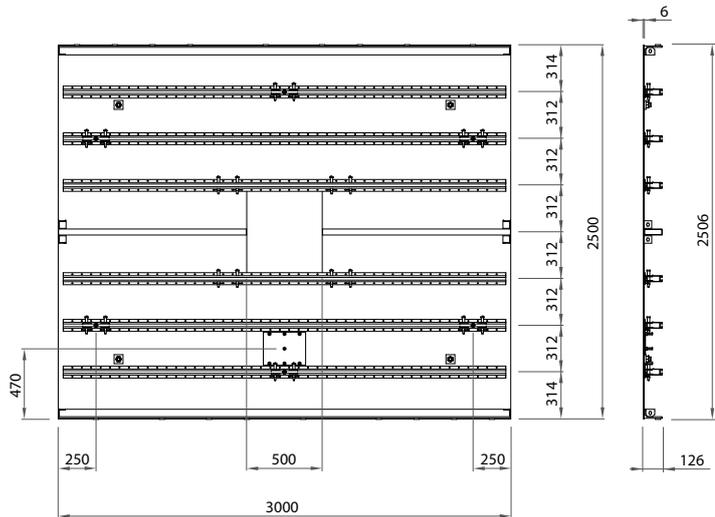
Formwork sheet panel with central window for observing concrete pouring and a hole or nozzle for concrete pouring.

These are arranged along the structure, combined with opaque sheets.

In their 3000 size, they have a central tube and two L profiles at their ends, each perforated with Ø 20 holes every 62.5 mm.

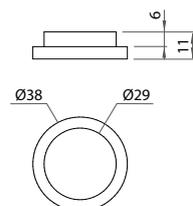
The size 2500 sheets are curved until they reach the necessary curvature.

Includes holes for connection with the **omega beam**.



1991733    0.06    PANEL REPARATION PLUG  
DW20 TMK

Covers the holes made in the shuttering face of the panel to use it as 2-faced formwork, with tie rods. It must be welded to the sheet.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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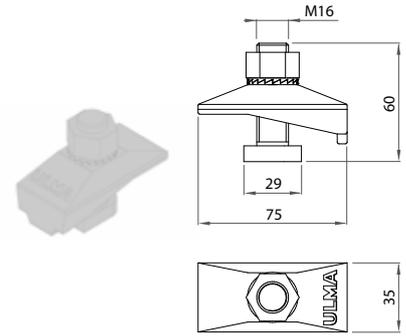
**SHUTTERING PANEL**

0135001 0.41 CLAMP BEAM OMEGA SET

Holds the **omega beam** to the **MK waler**.

The bolt head allows for adjustment along the slot of the **omega beam**, while the clamp tightens the wing of the **MK waler**.

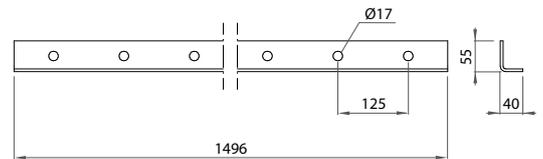
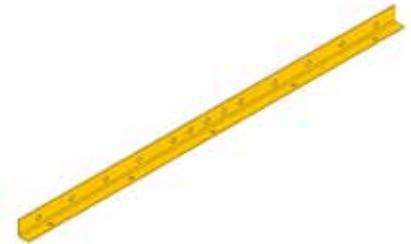
It is tightened using an M16 bolt.



1991853 4.6 SUPPORT COMPENSATION 3000

L-shaped plate included at the end of the **TMK panel** to support the **closure hinge 160 x 3000** for adjustment between panels.

In the curved waler system, the **closure hinge 160 x 3000** solution is only needed in the connection between vault and side wall.



0241635 0.083 HEXAG BOLT M16x35  
DIN933 8.8C

0241600 0.032 HEXAG NUT M16 DIN934 8C

These bolts are used to join the **support compensation 3000** to one of the **TMK panels**.

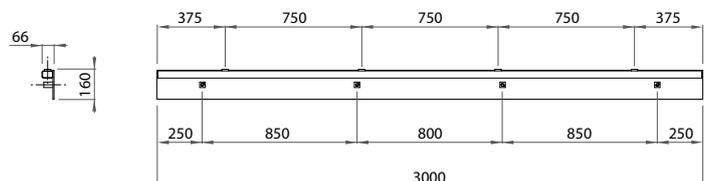


1992816 36 CLOSURE HINGE 160 x 3000

Used as a cover in the hinge joint of 2 curved walers.

Joined to one of the **TMK panels** using 4 **bolts M16 x 80** and 4 **M16 nuts**.

The shuttering face is not treated.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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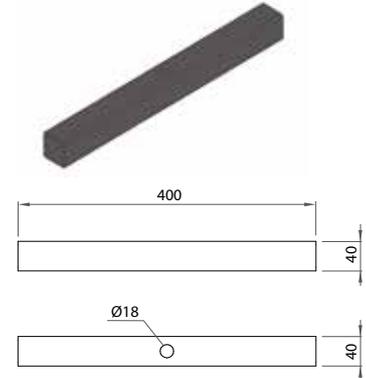
**SHUTTERING PANEL**

0241690	0.16	HEXAG BOLT M16x90 DIN931 8.8C	These bolts are used to join the <b>compensation plate 160 x 3000</b> to one of the <b>TMK panels</b> .
0241600	0.03	HEXAG NUT M16 DIN934 8C	

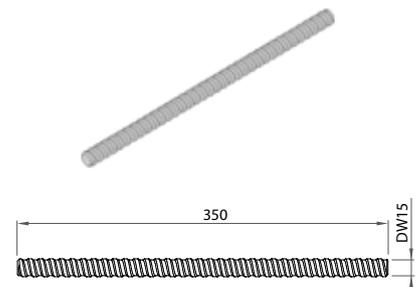


0122002	1.4	TUBE 40x40x3 L=400 (D18)	Used to lock the <b>closure hinge 160 x 3000</b> between the <b>TMK panels</b> located in the vault-side wall joint.
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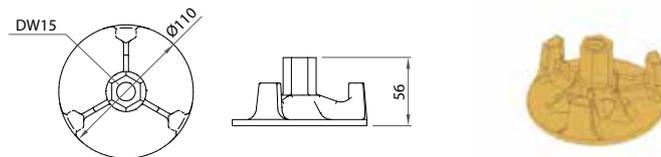
This tube abuts against the **TMK panels**. The short cotter pin passes through this tube, and is tied using the **plate nut 15**.



1861033	0.6	SHORT PIN 0.35	The closure hinge is placed in its location using 4 <b>short pins 0.35</b> and 4 <b>plate nuts 15</b> .
			Also used for tying the <b>window TMK</b> to the tube of <b>TMK panel</b> .



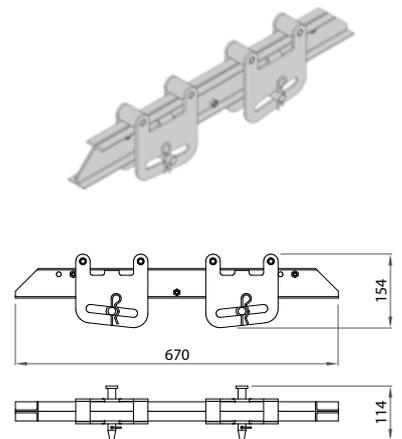
7238000	0.73	PLATE NUT 15
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1991939	6.7	ALIGNMENT DEVICE AD 70	Joins the <b>omega beams</b> of various <b>TMK panels</b> , together longitudinally.
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It consists of 2 hooks that can be moved on a double profile to find the correct positioning.

It is tied to the **omega beam** by means of a **D16 pin**.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**CONCRETE POURING ITEMS**  
(This section brings together all the items that are part of the accessories needed for concrete pouring)

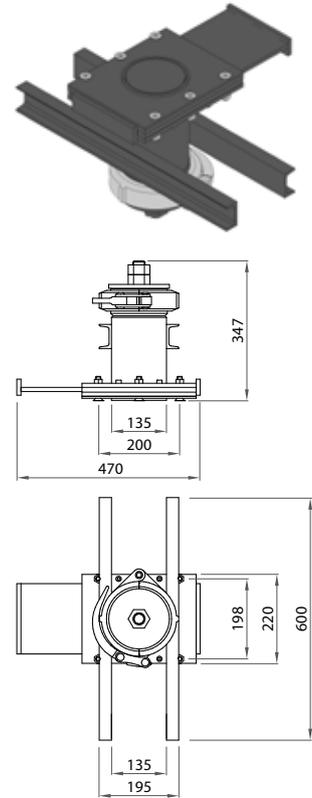
1991900 40.3 POURING NOZZLE GROUP

Used to connect the nozzle of the concrete pouring hose to the **TMK panel**, serving as a hose extension.

It has a tubed hole that is adjusted to the **TMK panel**, from where concrete is poured, and two UPN profiles that allow the set to be connected to the **omega beams** using the **clamp omega beam set**. Also tied to the **TMK panel** using **screws M12x40 DIN7991 10.9**.

It includes the nozzle items with guillotine, the coupler nozzle for connecting to the concrete pouring mouth and the nozzle plug. It also has a 4 mm rubber seal that guarantees a hermetic seal between the **nozzle** and the **TMK panel**.

The guillotine blocks the passage of the concrete once the concrete pouring operation is finished. The plug prevents the concrete from re-emerging through the hole.

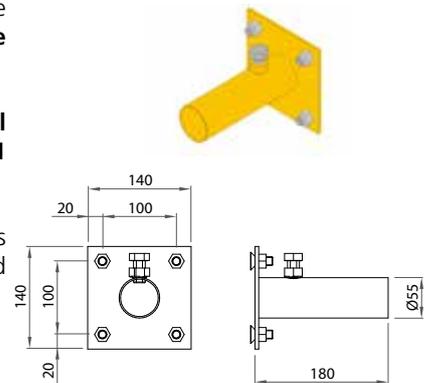


1991903 1.4 NOZZLE TUBE RECOGNITION

Used for the joint between the **TMK panel** sheet and the **pipe recognition**.

They are tied to the **TMK panel** using **screws M12x40 DIN7991 10.9**.

The incorporated M20 bolt allows the **detection tube** to be adjusted to the desired dimensions.

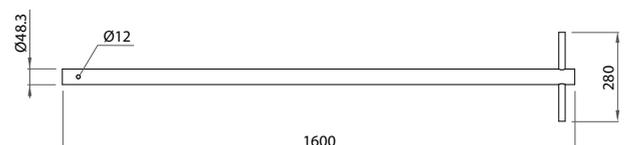


1991898 6.3 CONCRETE PIPE RECOGNITION

This is used to detect the actual concrete pouring level.

It is tied to the **TMK panel** using the **nozzle tube recognition**, and depending on concrete thickness, the distance of the tube is adjusted to the desired dimensions.

It has 4 holes at the end of the **tube**, from where concrete falls through its inner part.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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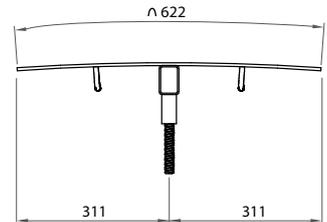
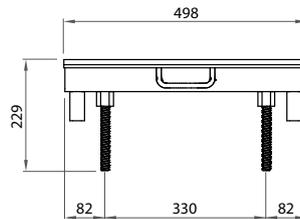
**CONCRETE POURING ITEMS**  
(This section brings together all the items that are part of the accessories needed for concrete pouring)

1991860 18.2 WINDOW TMK

Used to cover the hole of the window in the **TMK panel**.

It has a non-variable curved sheet to counteract the curvature of the panel.

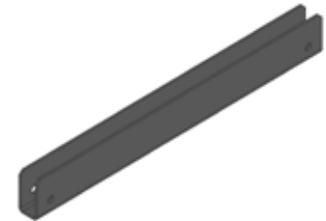
It includes DW 15 ties for tying to the **TMK panel's** tube.



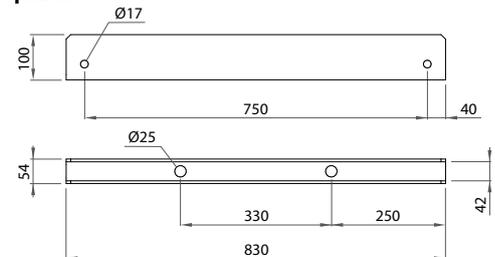
1991804 9.1 WINDOW SUPPORT PROFILE

Supports forces generated by concrete pouring in the window area.

It is tied to the central tube of the **TMK panel** using the D17 side holes. The  $\varnothing 25$  holes serve to free the DW 15 tie from the **window TMK**.



Sealing is possible using the **plate nut**.



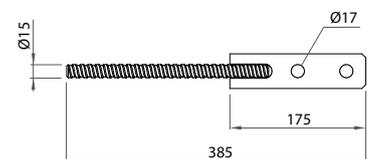
**CURVED WALER SYSTEM PANEL ITEMS**

1991754 0.82 ADJUSTABLE PLATE PANELS  
TMK

Allows zero overlap between adjacent **TMK panels**, always within the length of the curved waler.

Tied to the L at the end of the **TMK panels** using M16 bolts.

The connection to the curved waler is made using the **plate nut**.

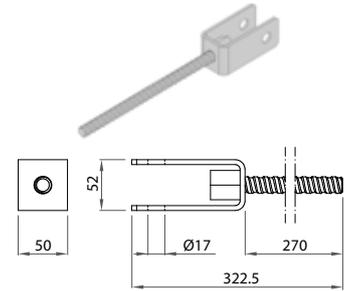


ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**CURVED WALER SYSTEM PANEL ITEMS**

1991800 1.12 PANEL CONNECTOR TMK 270 This is used for adjusting the **TMK panel**, through the central tube, directly to the waler.

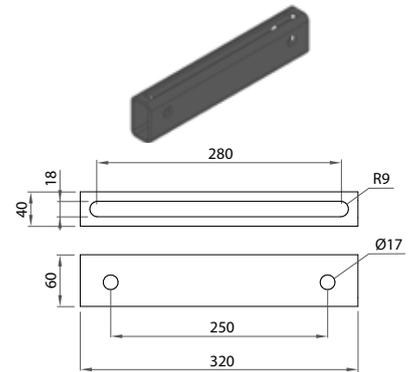
The DW 15 tie has a welded nut at one end, and at the other end it is tied using a **plate nut** which abuts against the **MK waler**.



1991751 2.1 CONNECTOR BENDING EDGE TMK Connects the **TMK panels** to the **curved walers** at the ends of the walers.

Tied to the L at the end of the **TMK panels** using M16 bolts.

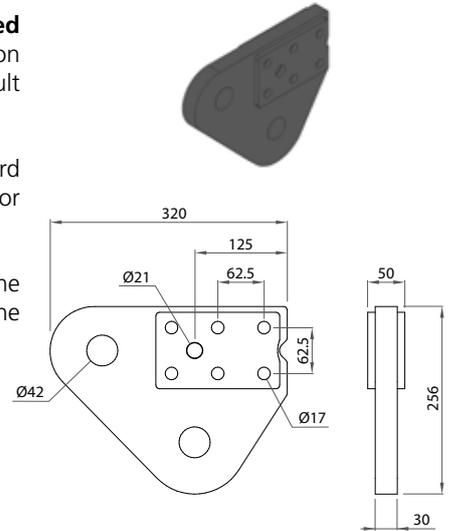
Connection to the **curved waler** is made using the **omega clamp beam set**.



1991965 15.6 NODE MK-2D40-M Used at the end of the **curved walers** and serves as connection to the Lower Waler of the Vault structure.

At the same time, it allows a third axis to be connected if necessary, for example for a side wall structure.

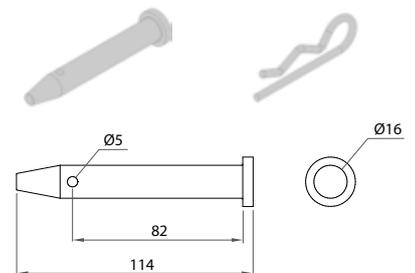
Its main use is, therefore, to join the vertical support, the vault and the gable or side wall of the tunnel.



1980125 0.17 PIN D16X80  
9023100 0.02 COTTER PIN R/4

Allows all joints with walers, nodes, joints requiring articulated joints to be made by means of the Ø 16 pin.

Each pin has an R/4 mm cotter pin.



0241690 0.17 HEXAG BOLT M16x90  
DIN931 8.8C  
0241600 0.03 HEXAG NUT M16 DIN934 8C

Used in screwed connections between **walers** and **nodes**.



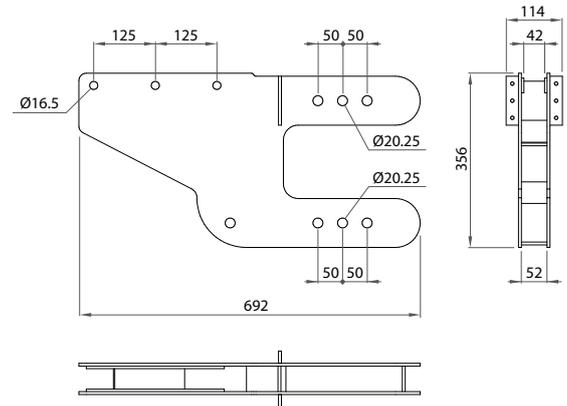
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**FRONT COVER AND REAR OVERLAP**

1992805 16.3 FRONT COMPENSATION CONNECTOR

Used together with **TF tubes** to form the front stopend of the tunnel's formwork.

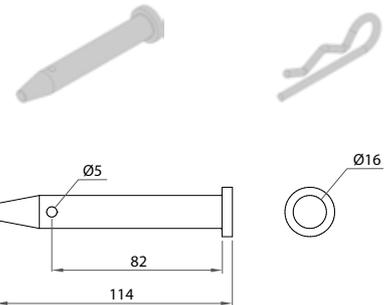
Joined to the omega beams of the **TMK panels** using 3 **pins D16 x 80**.



1980125 0.17 PIN D16x80  
9023100 0.02 COTTER PIN R/4

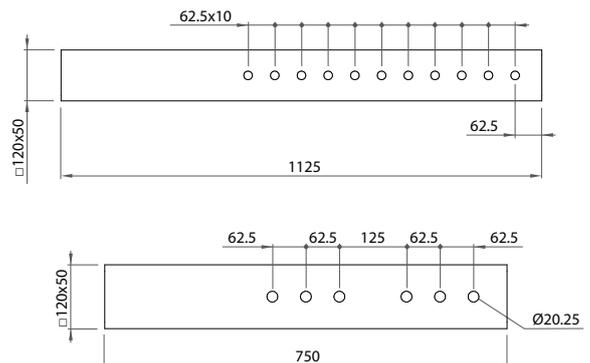
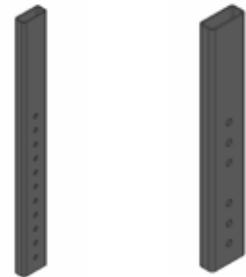
Allows all joints with **walers, nodes, joints** requiring articulated joints to be made by means of the Ø 16 pin.

Each pin has an R/4 mm cotter pin.



1992809 15.7 TUBE FC 1125  
1992810 10.43 TUBE FC 750

Used together with the **front compensation connector** to form the front cover. Joined to the front compensation connector by means of 2 **pins E20 x 70**.



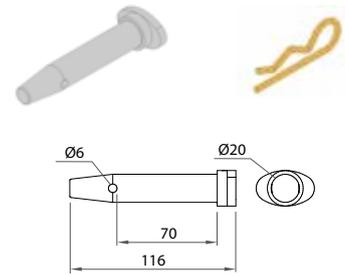
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**FRONT COVER AND REAR OVERLAP**

0252070 0.29 PIN E20 x 70  
0250000 0.03 COTTER PIN R/5

Joining element between **tube FC** and the **front compensation connector**.

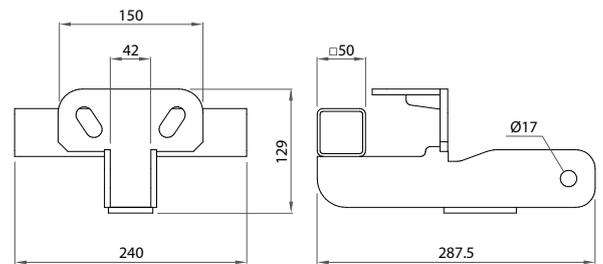
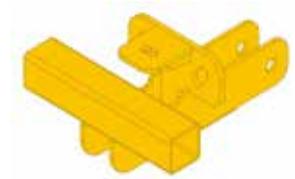
Each **E20 x 70** or **E20 x 190 pin** must include an **R/5 cotter pin** to create an unintentional disengagement system.



1992820 2.45 BACK COMPENSATION CONNECTOR

Placed on the omega beams of the **TMK panels** using 1 **pin D16 x 80**, 1 **cotter pin R/4** and 1 **clamp beam omega set**.

In the tubes of the **TMK panels**, it is placed using 1 **bolt M16 x 90**, 2 **bolts M16x35** and 3 **nuts M16**.

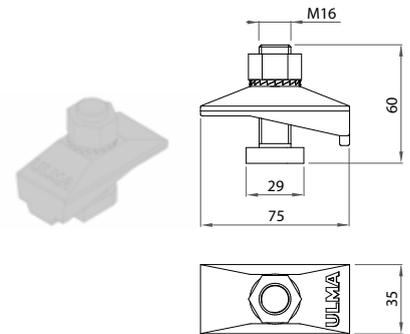


0135001 0.41 CLAMP BEAM OMEGA SET

Holds the **omega beam** to the **MK waler**.

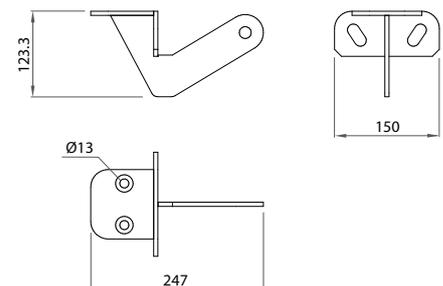
The bolt head allows for adjustment along the slot of the **omega beam**, while the clamp tightens the wing of the **MK waler**.

It is tightened using an M16 nut.



1992814 1.37 EDGE BC CONNECTOR

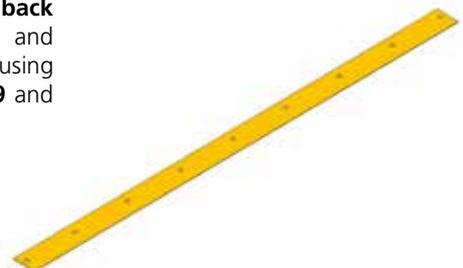
Placed in the end profiles of the **TMK panels** using 1 **bolt M16x90**, 2 **bolts M16x35** and 3 **nuts M16**.



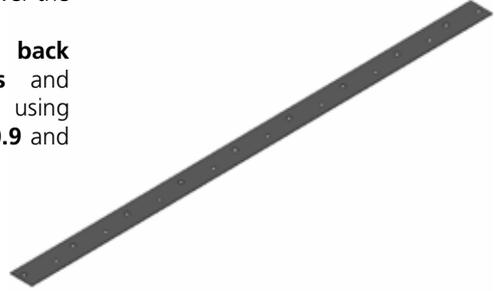
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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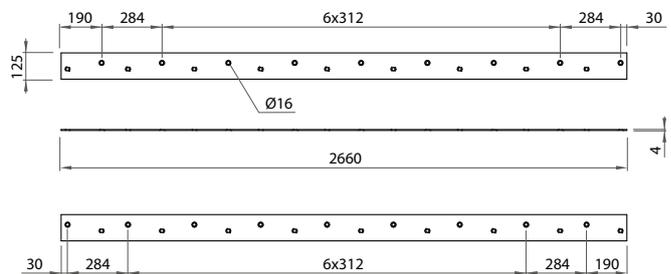
**FRONT COVER AND REAR OVERLAP**

0241690	0.17	HEXAG BOLT M16x90 DIN 931 8.8C	
0241635	0.08	HEXAG BOLT M16x35 DIN 933 8.8C	
0241600	0.032	HEXAG NUT M16 DIN934 8C	

1992827	9.8	BACK CLOSURE PLATE 2500x125	<p>Placed above the <b>back compensation connectors</b> and <b>edge bc connector</b>, tied using <b>screw M12x40 DIN7991 10.9</b> and <b>M12 nuts</b>.</p> 
1992828	4.9	BACK CLOSURE PLATE 1250x125	
1992832	3.6	BACK CLOSURE PLATE 937x125	
1992833	2.42	BACK CLOSURE PLATE 625x125	
1992834	6.1	BACK CLOSURE PLATE 1562x125	



1992829	10.3	BACK CLOSURE PLATE 2660x125	<p>This overlapping is used to cover the cover opening. Placed above the <b>back compensation connectors</b> and <b>edge bc connector</b>, tied using <b>screw M12x40 DIN7991 10.9</b> and <b>M12 nuts</b>.</p> 
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9521929	0.34	SCREW M12 X 40 DIN 7991 10.9	
0241200	0.02	HEXAG NUT M12 DIN 934 8C	

ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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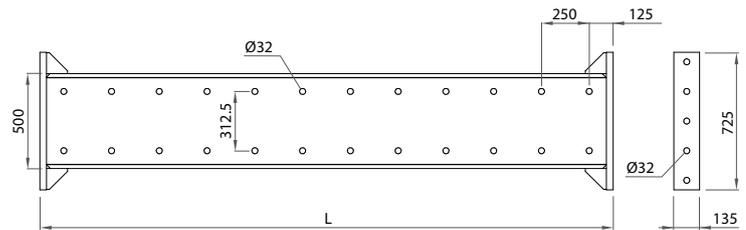
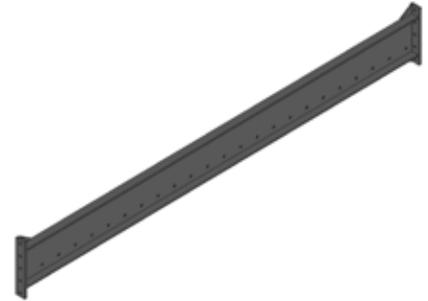
**DUPN500 BOGIE SYSTEM**  
(The items needed to form the bogies for structures up to 80 kN are gathered together here)

3200685	221	PROFILE UPN 500 / 2000
3200640	263	PROFILE UPN 500 / 2500
3200673	310	PROFILE UPN 500 / 3000
3200676	570	PROFILE UPN 500 / 6000
3200679	830	PROFILE UPN 500 / 9000
3200680	1047	PROFILE UPN 500 / 11500

Used for forming the bogie or profile for bracing in tunnel carriages up to 80 t.

Modulation allows for total profile configurations at the desired length, every 0.5 m.

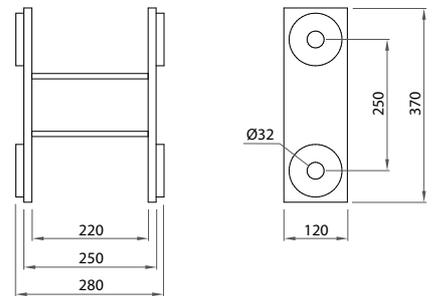
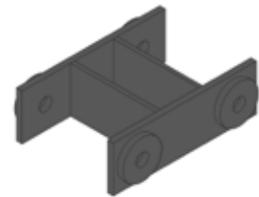
They are joined together with M30 bolts, in the holes in its end-plate joint, shaping a continuous profile.



1991758	17.5	SPACER DUPN500/280
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This is the spacer between **UPN500 profiles**.

They are joined to the **profile** using 4 M30 Bolts.



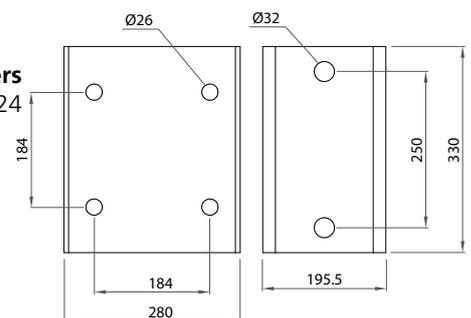
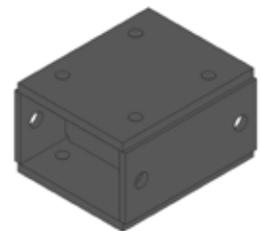
1991760	45.8	BEARING SUPPORT DUPN500
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MK- Joins two **UPN500 profiles** to form a waler-type set.

They are joined to the **profile** using M30 bolts.

**End-joint** items are supported on this, permitting the configuration of the carriage structure at its base, alongside the support **cylinders** and the carriage driving **wheels**.

These **end-joint** items, **cylinders** and **wheels** are joined using M24 bolts.

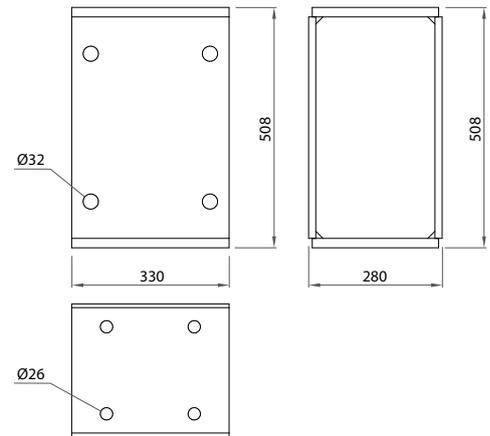
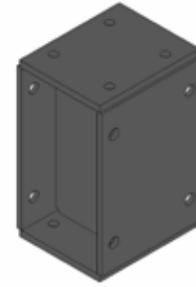


ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**DUPN500 BOGIE SYSTEM**  
(The items needed to form the bogies for structures up to 80 kN are gathered together here)

1992900 84 DUPN500 SUPPORT BEARING CONNECTOR Joined to support MK-DUPN500. Placed between 2 supports.

Joined to each of the supports using 4 bolts M24x70 and 4 M24 nuts.

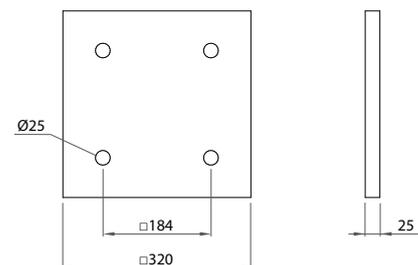
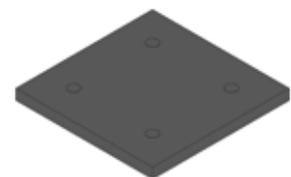


0243021	0.82	HEXAG BOLT M30x110 DN931 10.9C	M30 x 80 bolts for tying the different bogie DUPN500 system components.	
0243080	0.69	HEXAG BOLT M30x80 DIN 931 8.8C		
0243008	0.22	HEXAG NUT M30 DIN 934 10C	M30x110 bolts for end joints between <b>UPN500s</b> .	
0243001	0.05	FLAT WASHER A30 DIN125		
0242470	0.34	HEXAG BOLT M24x70 DIN933 8.8C	M24 bolts for joining <b>end-joint</b> items to <b>support MK-DUPN500</b> and to join <b>support bearing connector</b> to <b>bearing support MK-DUPN500</b> .	
0242400	0.11	HEXAG NUT M24 DIN934 8C		

1991986 19.7 BLOCK 25 Placed between the **20 t wheel** and the **support**, this allows the **wheel** to be moved further or closer to the **roller rail**.

Placed between the **adaptor CRI** of the cylinders and the **support**, this allows the cylinders to be moved further from or closer to the **roller rail**.

Connection is made by means of different lengths of M24 bolts, based on the number of blocks available.

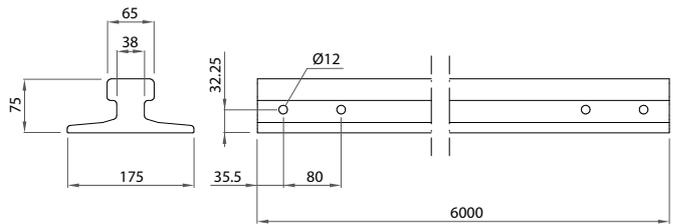


ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**DUPN500 BOGIE SYSTEM**  
(The items needed to form the bogies for structures up to 80 kN are gathered together here)

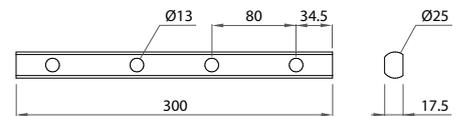
1991988 259 ROLLING BEAM BURBACK 100/6 Item over which the entire carriage rolls.

Anchored to the ground, it supports the **20 t wheels** 270 kN of the DUPN500 system, placed on the bogie.

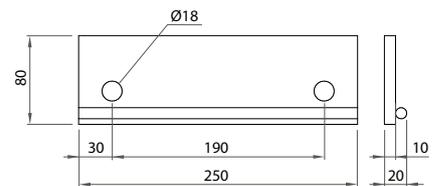


1991796 0.87 JOINT BAR ROLLING BEAM BURBACK Joins the **burback roller rails** longitudinally to one another.

The connection is made using M12 bolts.

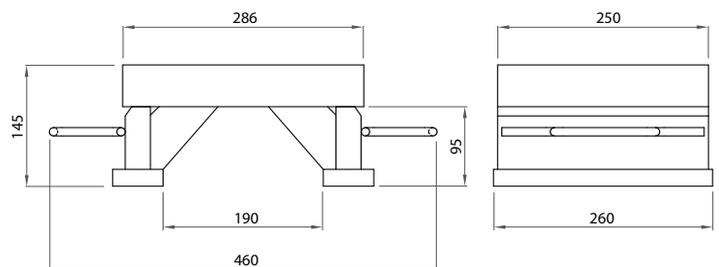
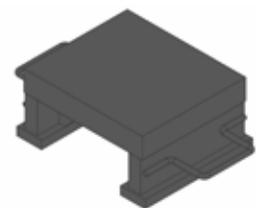


0919259 1.7 PLATE CLAMP DU-DU Used to anchor the **burback roller rails** to the ground during the advance phase of the structure.



1991934 44.9 RAIL SHOE BURBACK 100 The **hydraulic cylinders** of the bogie are supported on this, so that there are no interferences with the **burback roller rail**.

Supports loads of to 75 t in compression.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**DUPN500 BOGIE SYSTEM**  
(The items needed to form the bogies for structures up to 80 kN are gathered together here)

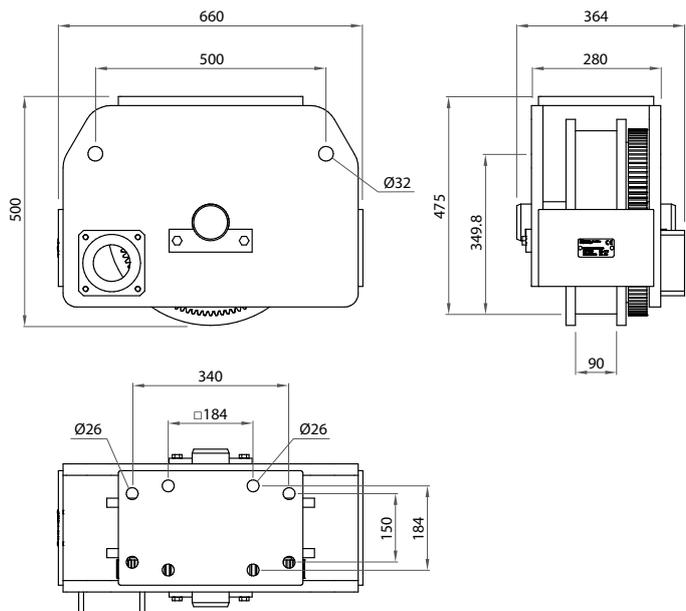
0241290	0.08	HEXAG BOLT M12x90 DIN 933 8.8C	M12 bolts for tying roller rails.	
0241200	0.02	HEXAG NUT M12 DIN934 8C		

1992014	310	WHEEL DUPN500 W/PINION	Used for moving carriages of up to 80 t, both motorised and non-motorised.
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If motorised, a motor is placed in it. It is joined to the UPN500 profile that forms the bogie using 4 M30 bolts in the fixed points for moving.

The load-bearing capacity of the wheel is 270 kN.

When the distance between the wheel and the bogie needs to be increased, blocks can be placed between them.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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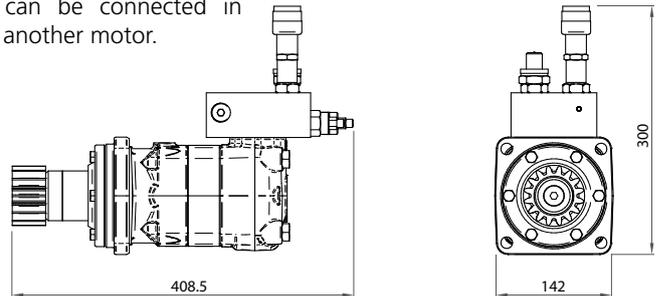
**HYDRAULIC SYSTEM AND ACCESSORIES**

1992012    29    HYD. MOTOR WITH OVERCENTER VALVE

Motor with 891 Nm torque at 210 bar and 25 rpm speed at 10l/min oil flow rate.

Ideal for where steep slopes between 3% and 6% are not required. Braking takes place when the forward or backward movement command is deactivated using the overcenter valve.

If a greater push is needed for the carriage, it can be connected in parallel with another motor.

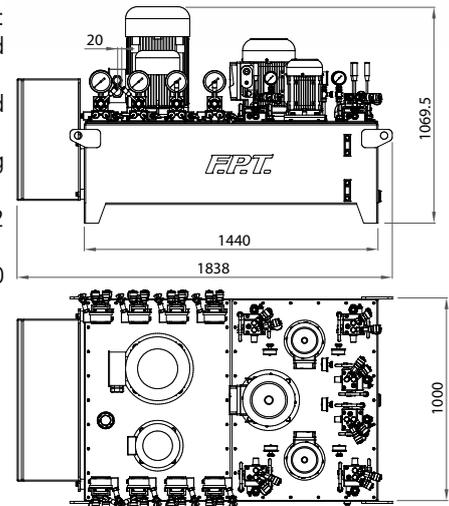


1992135    490    HYD. POWER UNIT  
TMK FPT14-350

Hydraulic unit for the management **of hydraulic cylinders for load, opening and advance.**

Most important features:

- 350 l tank.
- 14 lines or work Valves
  - 4 lines at 2.6 l/min. Pmax 700 bar.
  - 4 lines at 0.9 l/min. Pmax 700 bar.
  - 4 lines at 2.3 l/min. Pmax 210 bar.
  - 2 lines at 10 l/min. Pmax 210 bar.
- Maximum working torque:
  - Load Cylinder = 700 bar
  - Opening Cylinder = 210 bar
  - Advance Cylinder = 210 bar
- Allows for simultaneous working of:
  - Lines 1 and 4: Up to 4 Load Cylinders for levelling.
  - Lines 2 and 3: up to 12 Load Cylinders.
  - Lines 5 and 6: up to 8 Opening and Closing Cylinders.
  - Line 7: up to 4 driving Wheels. (2 per outlet).
- Voltage 400 volts and 50 Hz. / 440 volts and 60Hz / 480 v.

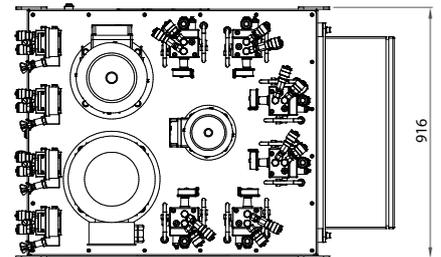
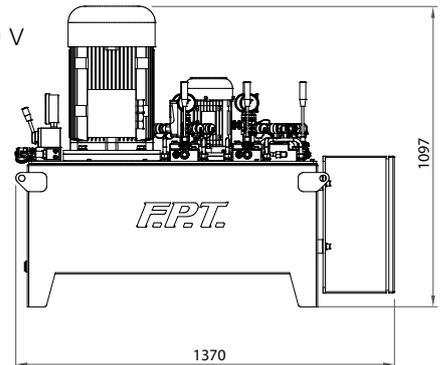
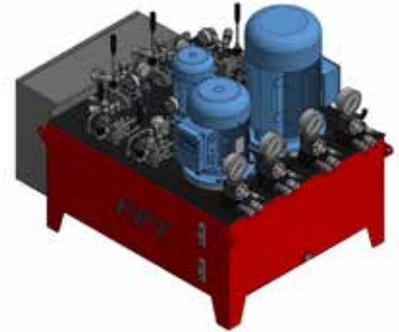


ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**HYDRAULIC SYSTEM AND ACCESSORIES**

1992136    350    HYD. POWER UNIT  
TMK FPT7 -200

- Most important features:
- 200 l tank.
  - 10 lines or work valves
    - 4 independent lines at 1.8 l/min. Pmax 700 bar.
    - 4 lines at 2.3 l/min (only 2 are used each time, or four at mid-flow). Pmax 210 bar.
    - 2 lines at 10 l/min. Pmax 210 bar.
  - Maximum working pressure:
    - Load Cylinder = 700 bar
    - Opening Cylinder = 210 bar
    - Motor drive = 210 bar
  - Voltage 400 V and 50 Hz / 440 V and 60Hz / 480 V and 60hz



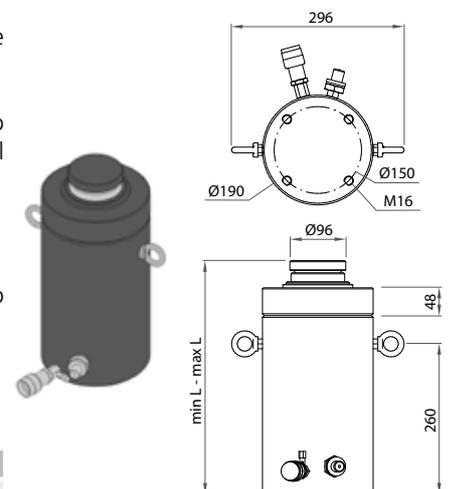
1992029    0.5    FEMALE PLUG 3P+T 400V 125A    Female plug for supplying power to the hydraulic power unit (the unit includes an incorporated male plug).



1991991    65    HYD. CYLINDER CRI-100/200-GS-TA    It has a safety nut that locks the cylinder during the work phase.

It has a tilting head that tilts up to 5° for adjusting to non-horizontal terrain.

- Other features:
- Affective area 144.3 cm<sup>3</sup>
  - Compression load 1000 kN to 700 bar
  - CE marking



Code	min L	max L
1991991	405	605

ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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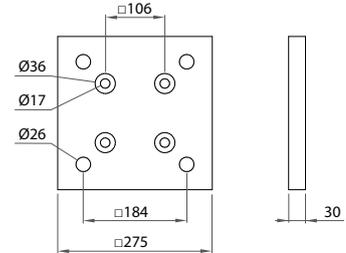
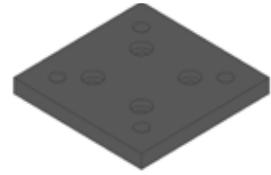
**HYDRAULIC SYSTEM AND ACCESSORIES**

1991982 17.5 CRI-100T JACK WALER ADAPTER

Allows 100t **cylinders** to be connected to the bogie system. M16 bolts are used to make the connection.

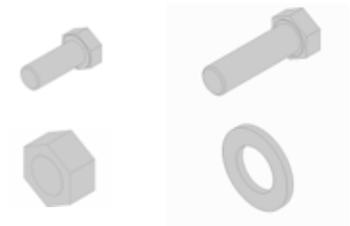
It is tied to the **MK support**, to the DUPN500 bogie system or to the **jack waler** in the bogie system jack waler. The connection is made using M24 bolts.

It can also be used as a 30 block, with the same applications as the **block 25**.



0241640 0.09 HEXAG BOLT M16x40 DIN933 8.8C  
 0242480 0.38 HEXAG BOLT M24x80 DIN931 8.8C  
 0242400 0.11 HEXAG NUT M24 DIN934 8C  
 0242401 0.03 FLAT WASHER A24 DIN125

M16 bolts are used to tie the cylinder to the adapter. M24 bolts are used to tie bogie accessories to the MK structures.



1883606 33 HYD. CYL. CDE-5/450-SP

Double-action hydraulic cylinder for opening the side wall.

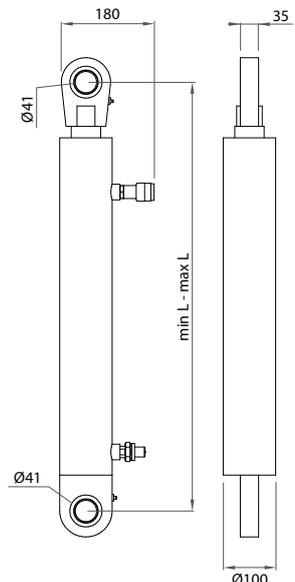
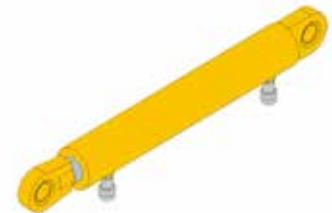
- Compression load capacity, 5 Tn to 100 bar and 10 Tn to 200 bar.
- Compression load capacity, 5 Tn to 200 bar.

The load route is identified with the letter A and has a female connector. The unload route is identified with the letter B and has a male connector.

Available in 450 mm strokes.

It has D40 tilting heads that tilt up to 5° for adjusting the cylinder to small plan view inclinations.

The CT model is used to separate the cylinder and there is a block between them to increase the total length.



Code	min L	max L
1883606	825	1275

ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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### HYDRAULIC SYSTEM AND ACCESSORIES

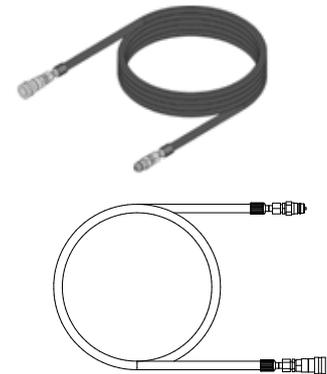
1872564 3 HYD. HOSE  
WP700-DN6-TFGG-10

Hydraulic connection hose between the hydraulic unit and the load and opening cylinders.

It is a hose for working at 700 bar of pressure.

It has a female fitting at one end and male fitting at the other.

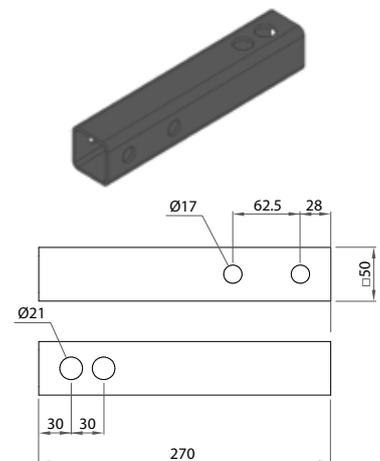
Several hoses can be connected to one another.



1991757 1.4 CONNECTION TUBE MK-120  
MK-180

Allows for 90° connection of MK walers 120 with **MK profiles 180**.

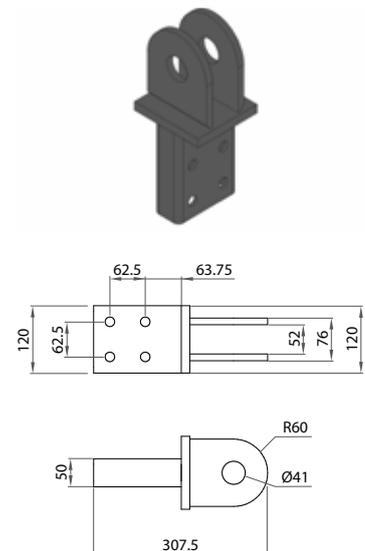
All the connections are made with M16 bolts.



1991981 6.5 CONNECTOR CDE-5T WALER MK

Allows for **opening cylinders** to be connected to a waler formed of **MK-180 profiles**.

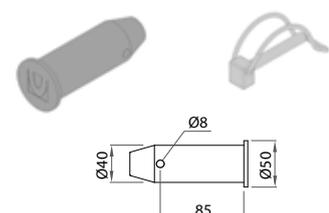
It is tied to the cylinder with a D40 pin and to the waler with M16 bolts.



1980120 1.1 PIN D40x85  
9023102 0.04 SAFETY PIN EN D 7x50

It is the connecting element between the **opening cylinder** and **connector**.

Each **Ø 40x85 pin** has a safety **safety pin en d Ø 7x50**.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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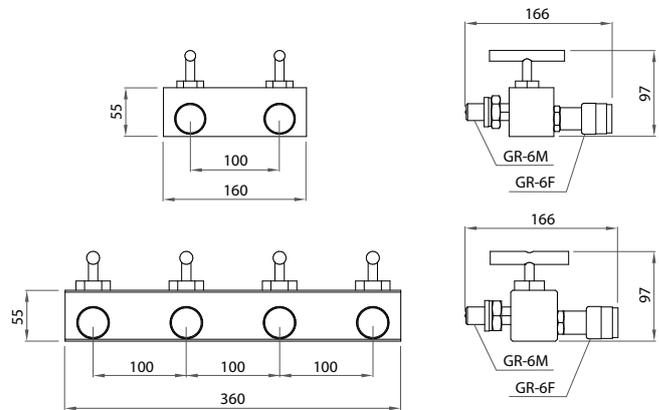
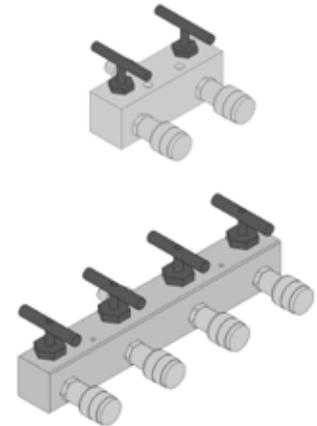
**HYDRAULIC SYSTEM AND ACCESSORIES**

1992037	5	MANIFOLD LIN. "A" VIA 3U-2V	Permits distribution of the oil that reaches the <b>hydraulic unit</b> by route "A" or load route to several <b>cylinders</b> at the same time.
1992038	15	MANIFOLD LIN. "A" VIA 5U-4V	

The **manifold lin. "A" via 3U-2V** has a male input fitting and 2 female output fittings.

The **manifold lin. "A" via 5U-4V** has a male input fitting and 4 female output fittings.

It has shut-off keys at each output.

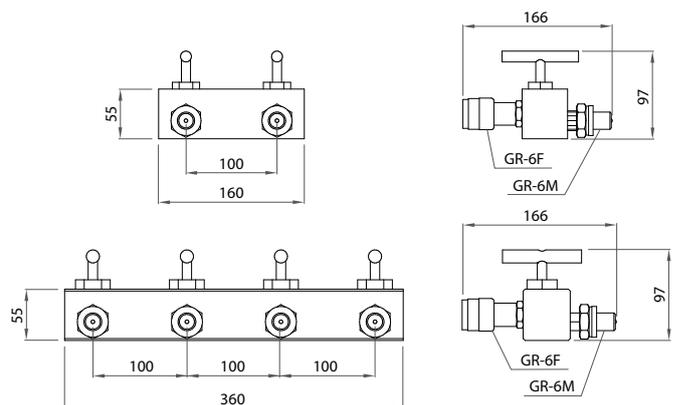
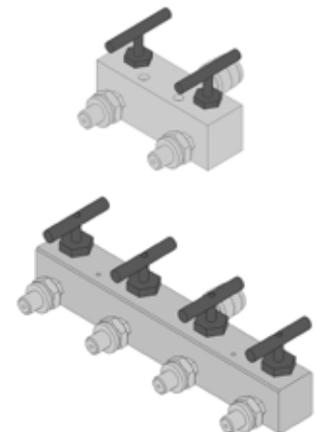


I649150	5	MANIFOLD LIN "B" VIA 3U-2V	Permits distribution of the oil that reaches the <b>hydraulic unit</b> by route "B" or the collection route to several cylinders at the same time.
I877359	15	MANIFOLD LIN "B" VIA 5U-4V	

The **manifold lin. "B" via 3U-2V** has a female input fitting and 2 male output fittings.

The **manifold lin. "B" via 5U-4V** has a female input fitting and 4 male output fittings.

It has shut-off keys at each output.

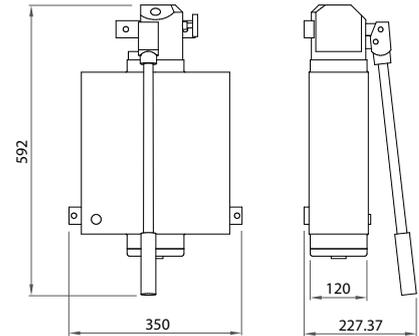


ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**HYDRAULIC SYSTEM AND ACCESSORIES**

1876204    20.5    HYD. MANUAL PUMP PDS-20-L8-DE    Manual pump for driving the double- acting hydraulic cylinders.

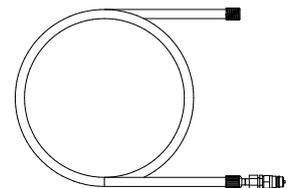
- Most important features:
- 20 l tank.
  - Double limit state pump.
  - Guarantees little force at any pressure.
  - Maximum bar of 700.
  - Pump capacity 20 cm<sup>3</sup>.
  - Tank capacity = 8L.



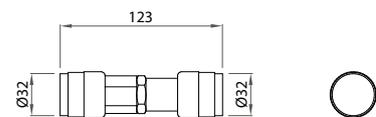
1992125    0.78    HYD. HOSE WP700-DN6-TFG-3    Hydraulic connection hose between the **hyd. anual pump** and the load and opening cylinders.

It is a hose for working at 700 bar of pressure.

It has a male fitting at one end and a 3/8" fitting at the other. The 3/8" end is connected to the pump.



1992124    0.57    QUICK FEMALE CONNECTOR GR6F-GR6FF    By connecting it to hyd. hose WP700-DN6.TFG-3, it allows a female output to be obtained at the end, for connection to the cylinder.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**EXTERNAL VIBRATION SYSTEM**

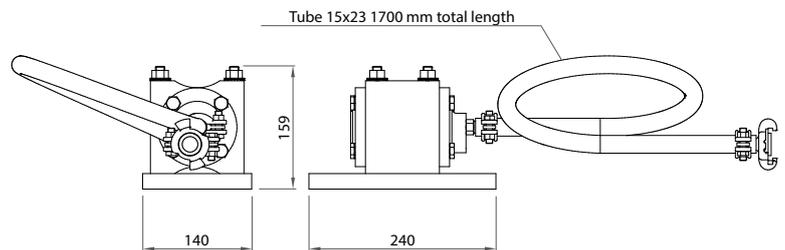
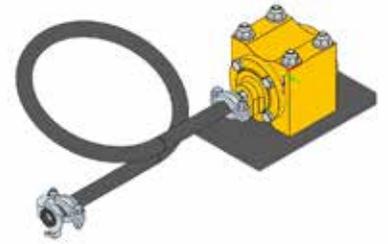
1992170 14.1 VIBRATOR SET VMP 1400

This is the item that vibrates the concrete during pouring, with an influence area of 2.5 m in diameter.

Depth of concrete vibration: 40 cm.

Length of hose: 1.7 m.

CE Marked.



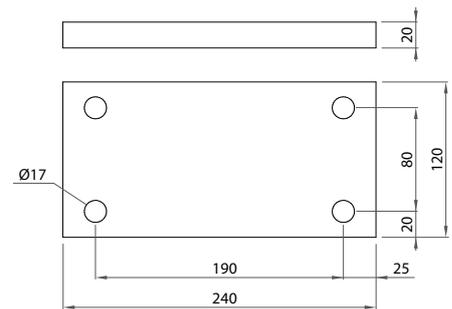
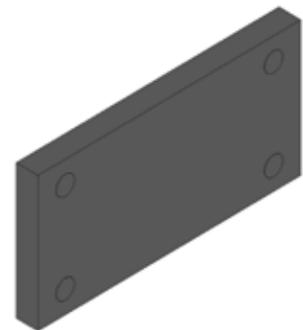
1991851

4.4

VIBRATOR-WALER CONNECTION PLATE

This serves to tie the vibrator set to the MK waler.

Tied with 4 bolts M16 x 180.



0241618

0.31

HEXAG BOLT M16x180  
931 8.8C

Bolts for tying the **vibrator set** to the plate.

2211224

0.01

WASHER NORD-LOCK NL.16

0241600

0.03

HEXAG NUT M16 DIN934 8.8C



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**EXTERNAL VIBRATION SYSTEM**

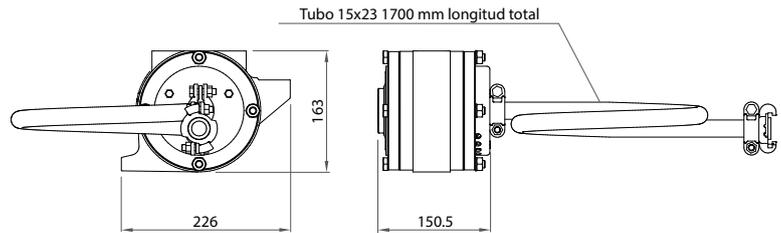
1992160    16    VIBRATOR SET VSP 4423-10

This is the item that vibrates the concrete during pouring, with an influence area of 2.5 m in diameter.

Depth of concrete vibration: 50 cm.

Length of hose: 1.7 m.

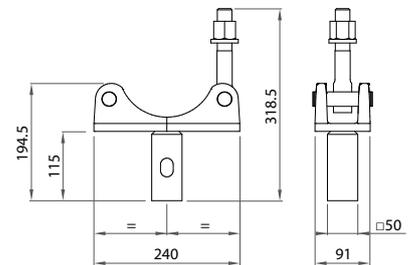
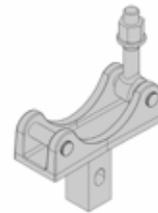
CE Marked.



1992157    8    VIBRATOR FIXER M23

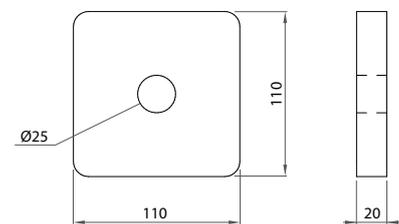
This part allows for joining of the **vibrator set VSP 4423-10** to the waler.

The **vibrator fixer M23** joins to the waler using a **bolt M24x50**, **nord-lock washer NL24** and the **vibrator plate**.



1992158    1.8    VIBRATOR PLATE

This plate is used alongside the **nord-lock washer NL24** and the **bolt M24x50** to tie the **vibrator fixer M23** to the waler.



2211229    0.008    NORD-LOCK WASHER NL24

This part is placed between the **bolt M24x50** and the **vibrator plate**.



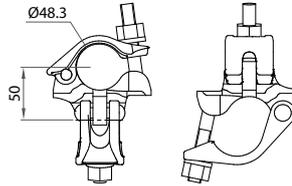
0242450    0.27    HEXAG BOLT M24x50  
DIN933 8.8C



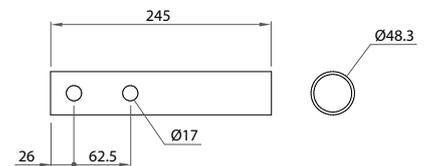
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**EXTERNAL VIBRATION SYSTEM**

6630300    1.2    RIGHT ANGLE COUPLER 42/48    Used to tie the **D42 vibration tubes** to the **MK handrail head**.



1990570    0.82    HANDRAIL HEAD MK    Used to tie the **D42 vibration tubes** to the **walers** using the coupler.  
  
Two M16 bolts are used for tying.

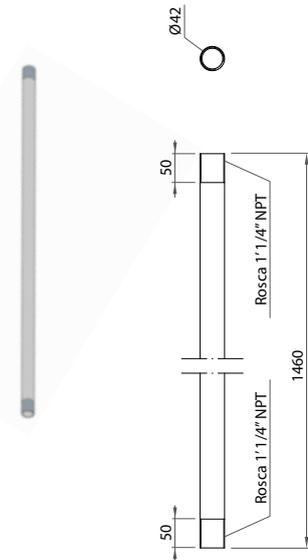


1992151    4.4    VIBRATION TUBE D42 / 1460    Allows for a hollow longitudinal tube to be generated, arranged along the tunnel carriage, along which the air runs.

The longitudinal connection of the tubes is made by means of **splices** of 4 or 2 outputs.

The **tubes** have a 1 1/4" NPT thread at both ends.

In outputs with an axis perpendicular to the **plugs**, a **flexible tube** is connected up to the **vibrators**. The output to the **vibrators** has a 1/2" NPT thread.



1878267    1    JOINT WITH 4 SHUNTS



1878268    0.6    JOINT WITH 2 SHUNTS



1878269    0.1    MALE PLUG 1/2"    This is a 1/2" NPT plug.  
Used to plug the output of the **joints** when there is no need to incorporate **flexible tubes** into them.



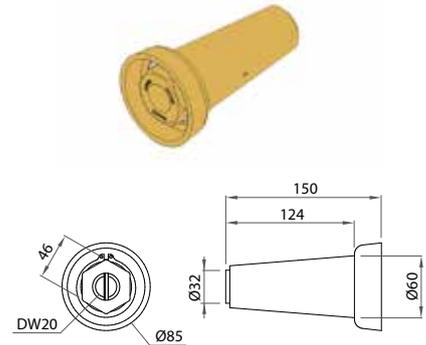
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
<b>EXTERNAL VIBRATION SYSTEM</b>				
1992712	0.32	THREADED BALL COCK ½" + QUICK JUNCTION	<p>This group brings together the items used to take air from the <b>4 or 2 output splice</b> to the <b>vibrator</b>.</p> <p>The threads of the items in this group are ½" NPT.</p>	
1992180	3.48	HOSE 18 BAR 32x44/3.5	<p>P.U. hose support collar 29 mm with coupler SL49 and hose quick plug 1 ¼".</p> <p>Used to connect two parallel stretches of rigid tubes together. Used to give continuity to an entire circuit formed by several lines of rigid tubes.</p> <p>Length of hose: 3.5 m.</p>	
1878280	0.4	CAST IRON QUICK JUNCTION MALE RRM 1" ¼"	Connects the end of a rigid tube with the <b>18 bar hose 32x44/3.5</b> .	
1878281	0.3	CAST-IRON THREADED GALVANIZED TEE FFF 1" ¼	The <b>cast-iron threaded galvanised TEE FFF 1" ¼</b> is used to connect rigid and flexible tubes together at 90°. It has a ¼" NPT thread.	
1878290	0.3	MALE CAST IRON GALVANIZED PLUG 1¼"	It is used to close the passage of one of the outputs of the <b>cast-iron threaded galvanised TEE FFF</b> .	
1992190	10	FRL SET 1" ¼"	<p>This FRL group has three functions:</p> <ul style="list-style-type: none"> <li>- Regulating pressure to that established for the functioning of vibrators, normally, and unless otherwise indicated, 6 bar.</li> <li>- Filtering excessive moisture content in the air, with the aim of preventing rusting and incorrect functioning of pneumatic items.</li> <li>- Lubricating the pneumatic circuit, so that moving items do so more fluidly.</li> </ul> <p>A shut-off valve has been added to the FRL group to close off air to the circuit, alongside a quick plug for connecting it to the rest of the pneumatic circuit.</p>	

ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**VAULT ANCHORAGES**

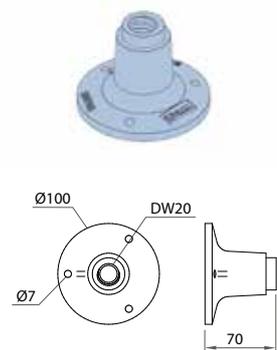
0238050 2 CONE DW20/M30

Allows for the generation of a non-recoverable anchor in the concrete so that the cone can be recovered. It is used with a **DW 20 tie** and **DW 20 fix anchor**.



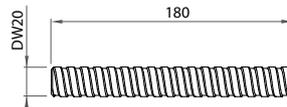
0238025 1 FIX ANCHOR DW20

This is the non-recoverable item that remains in the concrete in DW 20 anchorages.



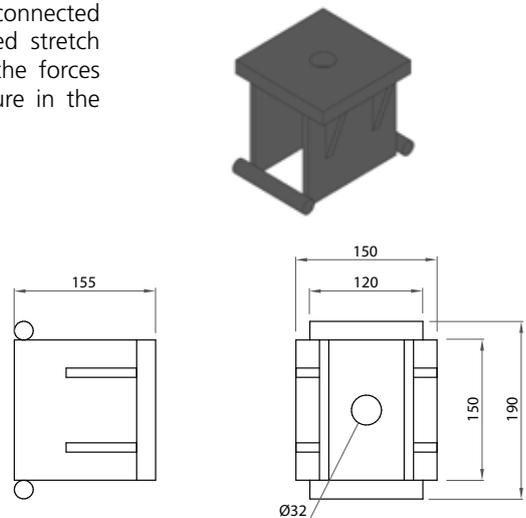
0234018 0.51 TIE ROD 20/0.18

Connects the **fix anchor DW 20** with the **cone DW 20**. It can be recovered if a plastic tube is used.



1991921 7.5 CONE CONNECTOR BARS

Allows for a DW bar to be connected to a previously-constructed stretch of tunnel to counteract the forces of the pull of the structure in the longitudinal direction.



0243080 0.69 HEXAG BOLT M30x80  
DIN931 8.8C

It is used to tie the connector for ties to the **cone DW 20/M30**.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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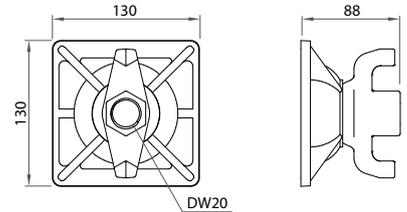
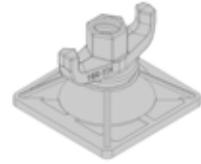
### VAULT ANCHORAGES

1905160 2.1 PLATE WASHER NUT 20

These are placed on the ends of the **DW 20 ties** to hold the force that is exerted on these.

It has wings which allow the nut to be tied using a hammer.

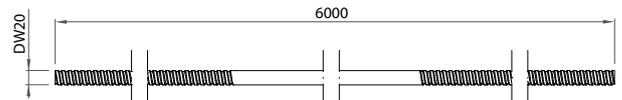
Its ball and socket action allows an angle of 20° between the tie and the support.



0234600 15.4 TIE ROD 20/6

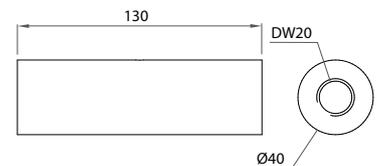
This tie connects the end of the carriage, where there is a front cover, with the tie connector at the other end of the tunnel carriage.

It is used to hold the pull exerted by the front cover on a previously-constructed rigid point.



0239015 1 ROUND COUPLER DW20 D40x130

Connects two **DW 20 ties** together to form a longer tie.



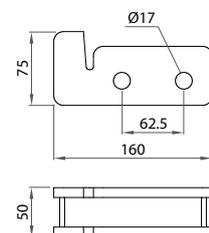
1991862 1.7 CLAMP COVER

Serves to connect one waler to another at 90°.

It is used for the waler shoe that forms the support formwork in the front cover area.

The wing of the vault waler is introduced through its slot and another perpendicular to it through the Ø 17 holes.

The waler tie is made using M16 bolts.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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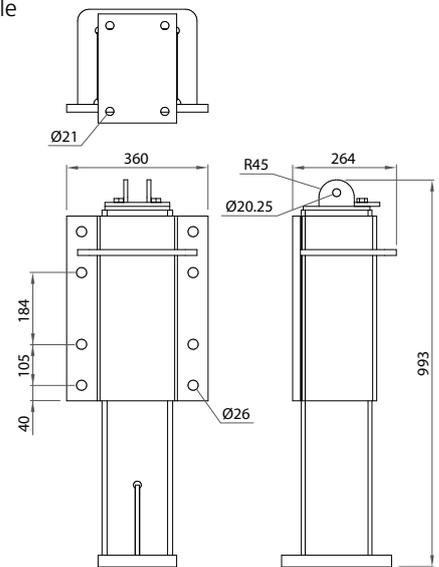
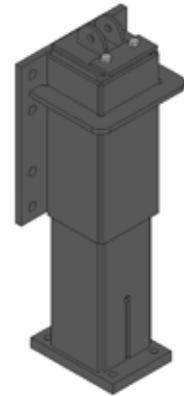
**SIDE WALL ANCHORAGES**

1991756    139    ANCHOR POST NP

Holds the pull from the bottom of the side wall formwork. It is tied directly to the base of the side wall structure using M20 bolts.

The pull can be made in two ways:  
 -By means of the **NP anchorage jack system**, placed behind the Post.  
 -By means of the **NP anchorage tie system**, placed in front of the post.

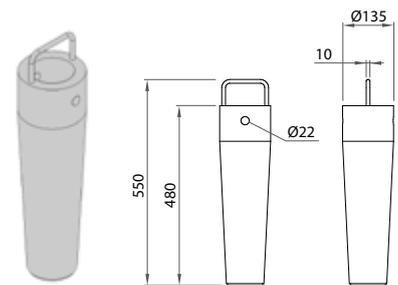
Both methods are used as alternatives to the non-recoverable tie system.



1991671    8.5    ANCHORING FILLER SHAPE

An item which, when inserted in the concrete foundation before its construction, serves to leave a mark on it for subsequently inserting **anchoring NP180**.

This is recoverable anchorage which leaves no items behind in the concrete.

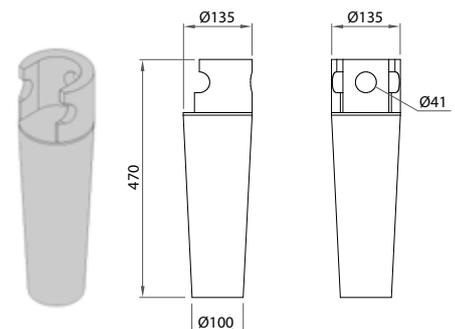


1991670    35.2    ANCHOR NP180

An item which, when inserted into the concrete foundation, holds the pull of the bottom part of the side wall formwork by means of shear force against the concrete.

This is recoverable anchorage which leaves no items behind in the concrete.

It is used in both NP anchorage systems.



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**SIDE WALL ANCHORAGES**

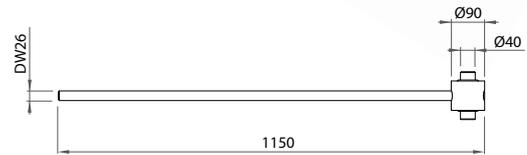
0242060 0.21 HEXAG BOLT M20X60  
DIN 933-8.8



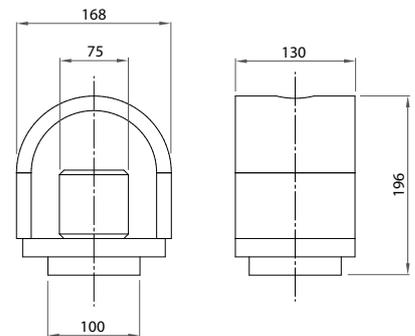
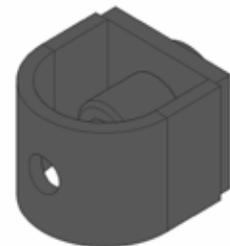
1991675 9.1 CARDAN TENSION DW26

Holds the pull or shear force in the NP anchorage tie system, by means of tension on the tie.

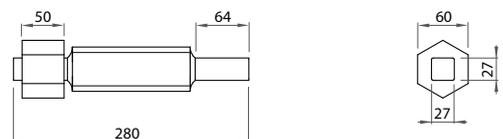
The force is transmitted via the **NP anchorage** to concrete.



1992995 11.5 COMPRESSION ROUND THRUST



1992985 4.2 COMPRESSION JACK TR52x12

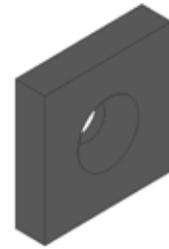
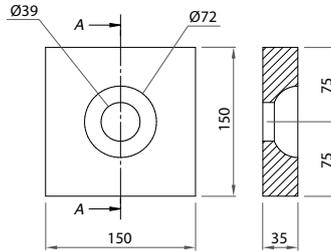


ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**SIDE WALL ANCHORAGES**

0231003    4.5    DOMED PLATE DW26.5

Holds the **tension cardan DW 26** against the **tension head** and the **NP anchorage**.



0231002    1.1    DOMED NUT DW26.5

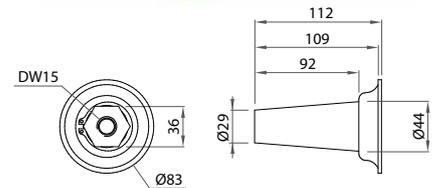
Holds the tie of the **tension cardan DW 26** against the **domed plate DW 26**.



0230010    0.87    CONE DW15/DW15

Allows for the generation of a non-recoverable anchor in the concrete, so that the cone can be recovered.

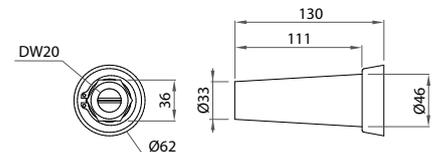
It is used with a **DW 15 tie** and **DW 15 fix anchor**.



0238044    0.95    CONE DW20/DW20

Allows for the generation of a non-recoverable anchor in the concrete so that the cone can be recovered.

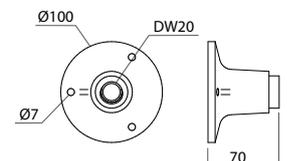
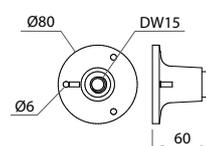
It is used with a **DW 20 tie** and **DW 20 fix anchor**.



0230005    0.56    FIX ANCHOR DW15

0238025    0.97    FIX ANCHOR DW20

This is a non-recoverable item that remains in the concrete in tension anchorages.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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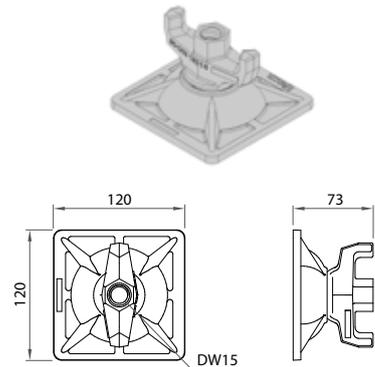
### SIDE WALL ANCHORAGES

1900256    1.4    PLATE WASHER NUT 15

These are placed on the ends of the **DW 15 ties** to hold the force that is exerted on these.

It has wings which allow the nut to be tied using a hammer.

Its ball and socket action allows an angle of 20° between the tie and the support.

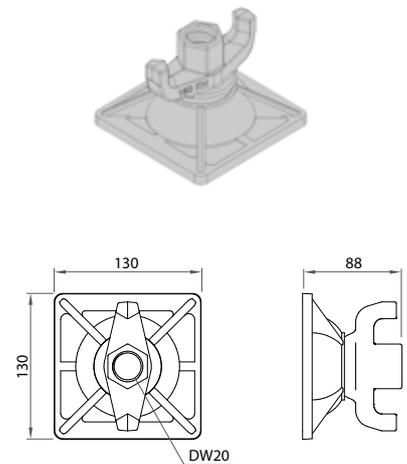


1905160    2.1    PLATE WASHER NUT 20

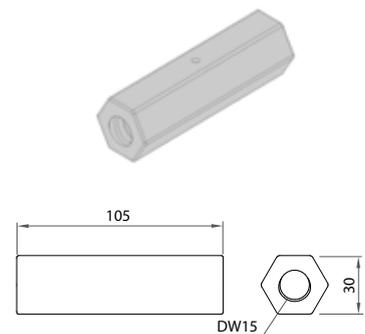
These are placed on the ends of the **DW 20 ties** to hold the force that is exerted on these.

It has wings which allow the nut to be tied using a hammer.

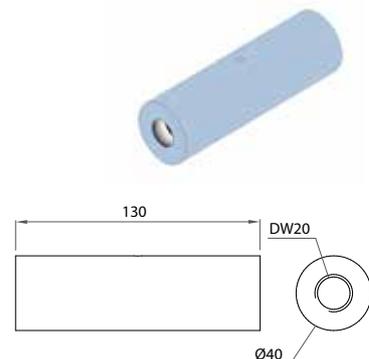
Its ball and socket action allows an angle of 20° between the tie and the support.



7238003    0.3    HEXAGONAL COUPLER DW15- 30x105    These are placed at the ends of the DW15 and DW 20 ties, to join them longitudinally.



0239015    1    ROUND COUPLER DW20 D40x130



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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### SIDE WALL ANCHORAGES

0239022	0.2	EXPANSION SHELL 15/32-34
0239023	0.4	EXPANSION SHELL 20/51-53

These are used in place of the **fix anchor** when these have not been planned in side wall footing.

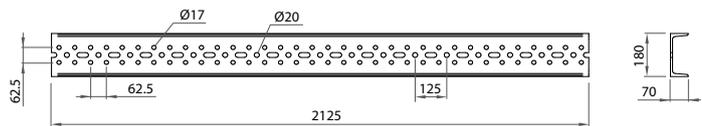
It is a non-recoverable item that remains in the concrete, to which the **tie rod** is directly tied.



1990017	44.1	PROFILE MK-180 / 2.125
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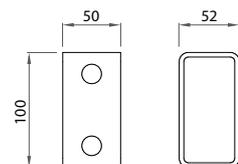
Used to form the **waler** which holds the pull of the structure on its lower part.

It is tied to the base of the side wall structure, and the ties that hold the tension are positioned on it.



1990200	0.46	SPACER TUBE MK-120 / 52
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This is the spacer between **MK-180 profiles**.



0241690	0.17	HEXAG BOLT M16x90 DIN931 8.8C
0241600	0.03	HEXAG NUT M16 DIN934 8C

Used to fix the MK spacer tube to the profiles and so define the walers. They are also used for connections between walers and connectors.



0242050	0.18	HEXAG BOLT M20x50 DIN933 8.8C
0242010	0.30	HEXAG BOLT M20x100 DIN931 8.8C
0242000	0.06	HEXAG NUT M20 DIN 934 8C

M20 bolts for tying the anchorage items. M20x50 ties the **NP anchor post** to the structures via their base nodes.



### 5.3. CUT-AND-COVER TUNNEL

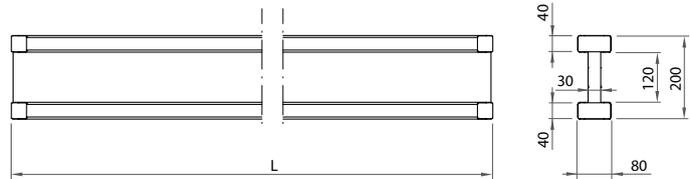
ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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#### WOODEN BEAMS

1940172	9.5	TIMBER BEAM VM20 / 1.9
1940197	10.8	TIMBER BEAM VM20 / 2.15
1950129	12.3	TIMBER BEAM VM20 / 2.45
1940196	13.3	TIMBER BEAM VM20 / 2.65
1940144	14.5	TIMBER BEAM VM20 / 2.9
1950130	16.5	TIMBER BEAM VM20 / 3.3
1940146	18	TIMBER BEAM VM20 / 3.6
1950112	19.5	TIMBER BEAM VM20 / 3.9

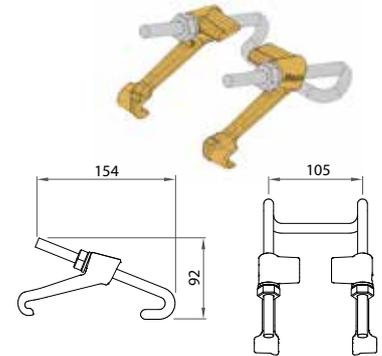
These items, joined perpendicularly to the **walers** (as secondary items), form the surface support which acts as a shuttering face for the system.

They are I-shaped, with a section height of 200 mm and a width of 80 mm. Both ends are protected by plastic edges.



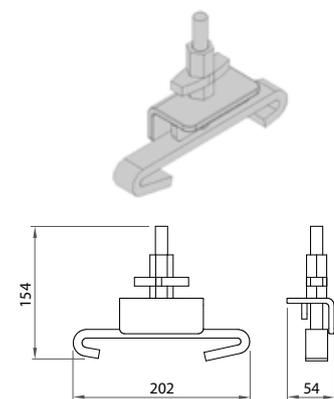
1960375	0.85	WALER-VM20 CLAMP 2T
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This perpendicularly joins the **VM20 beam** to the **MK waler**, quickly and efficiently. The beam must be placed on the flanges of the UPNs forming the **MK waler**.



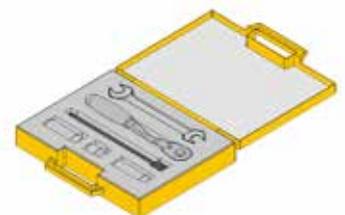
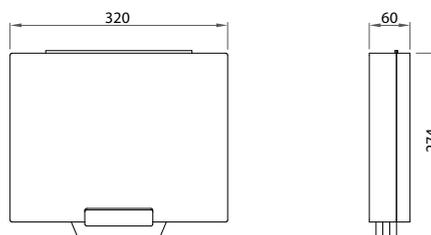
1960345	1.3	WALER VM20 ANGULAR CLAMP	This joint allows the <b>VM20 beam</b> to be tied to the <b>MK waler</b> , forming an plan view angle other than 90°.
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The angle can vary between 74° and 106°.



1960450	2.3	TOOLKIT CASE
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Repair kit for screwing the different nuts and bolts of the MK system.



ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**BOGIE SYSTEM JACK PROFILE**  
(The items needed to form the bogies for structures up to 40 t are gathered together here)

1990530	113	JACK WALER MK 0.5 / 1000
1990551	161	JACK WALER MK 1 / 1500
1990552	207	JACK WALER MK 1.5 / 2000
1990553	253	JACK WALER MK 2 / 2500

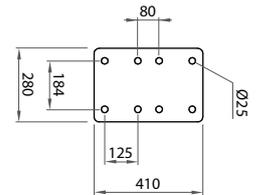
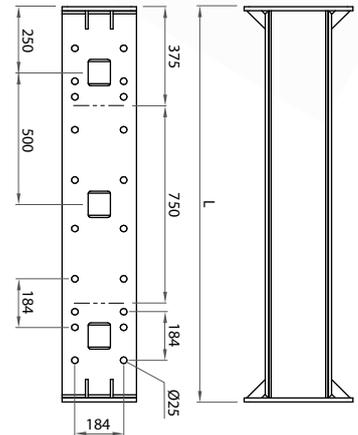
Used to shape the bogie or drag profile in tunnel carriages up to 40 t.

Modulation allows for total profile configurations at the desired length, every 0.5 m.

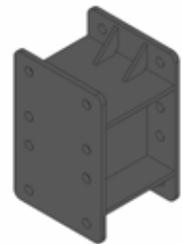
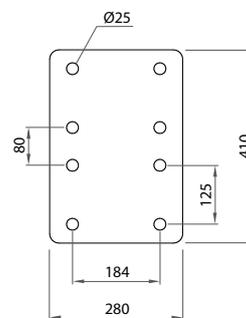
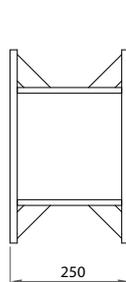
**Profiles** are joined together using 8 M24 bolts, in the holes in its end-joint plates, shaping a continuous profile.

Supported on this part are end-joint components which allow the carriage structure to be configured at its base, alongside the support bolts and **wheels** that permit the carriage to move forwards.

The joint with these components is made by means of 4 M24 bolts.



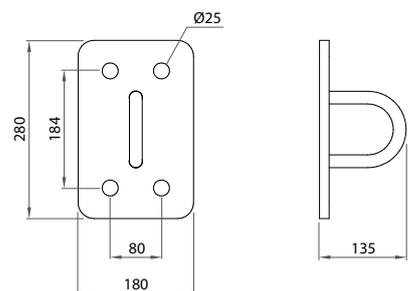
1990532	46	JACK PROFILE SUPPLEMENT
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1990535	6.3	BOGIE PULL PLATE MK
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Holds the pull of the force of the carriage's movement. Joined directly to the **jack profile** by means of 4 M24 bolts.

The capacity supported by this set is no greater than 12.5 kN, so that carriages with a pull plate on each axis can move 25 kN (carriages up to 80 t on horizontal ground).



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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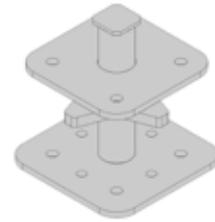
**BOGIE SYSTEM JACK PROFILE**  
(The items needed to form the bogies for structures up to 40 t are gathered together here)

1990550    40.2    JACK MK 360

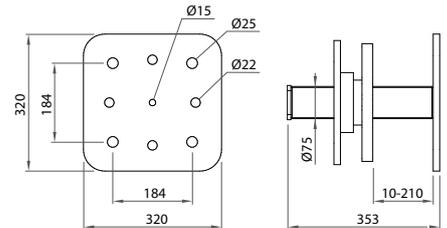
Vertical adjustment component that is placed in the base or bogie of the carriages as a load component.

It has an adjustment of 220 mm and a load-bearing capacity of up to 360 kN.

It is joined directly to the **jack waler** by means of 4 M24 bolts.



The **screw jacks** should be greased before use.



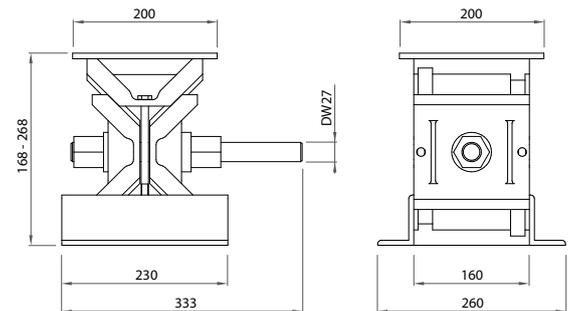
0262050    28    WEDGE JACK 42 TN

Used for supporting forces on the bogie profiles.

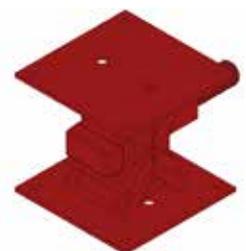
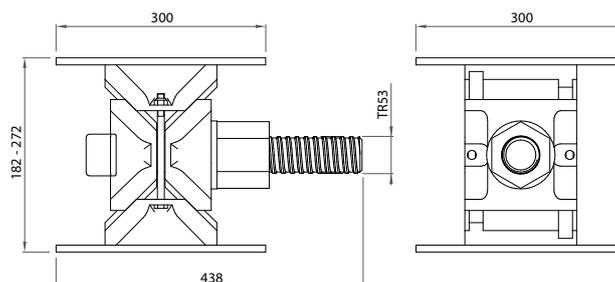
They have an adjustment of 100 mm, and a load-bearing capacity of 42 kN to 100 kN, depending on the model.

They are not joined to the **jack profile**.

The **100 wedge** is available in 2 colours (red and grey). The **50 wedge** is only available in red.



0262051    53    WEDGE JACK 100 TN



ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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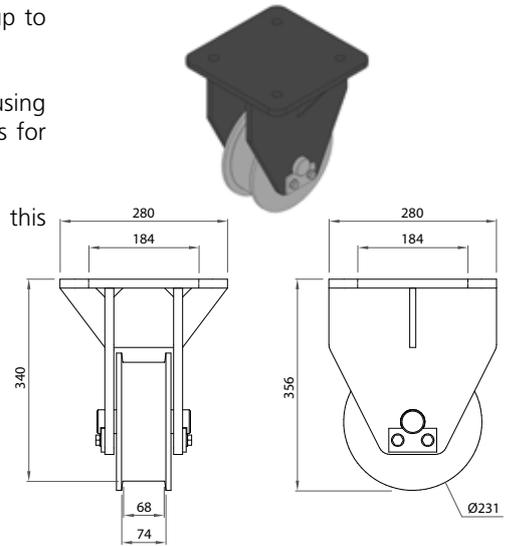
**BOGIE SYSTEM JACK PROFILE**  
(The items needed to form the bogies for structures up to 40 t are gathered together here)

1990655 49.4 WHEEL 100 MK

Used for moving carriages of up to 40 t.

It is joined to the **jack profile** using 4 M24 bolts in the fixed points for movement.

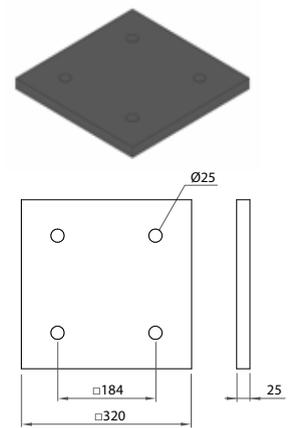
The load-bearing capacity of this wheel is 100 kN.



1991986 19.7 BLOCK 25

Placed between the **wheel 100 MK** and the **jack profile**, it permits the **wheel** to be moved further from or closer to the **roller rail**.

Connection is made by means of different lengths of M24 bolts, based on the number of blocks available.



0242460 0.3 HEXAG BOLT M24x60  
DIN933 8.8C  
0242461 0.3 HEXAG BOLT M24x60  
DIN933 10.9  
0242400 0.11 HEXAG NUT M24 DIN934 8C  
0242401 0.03 FLAT WASHER A24 DIN125

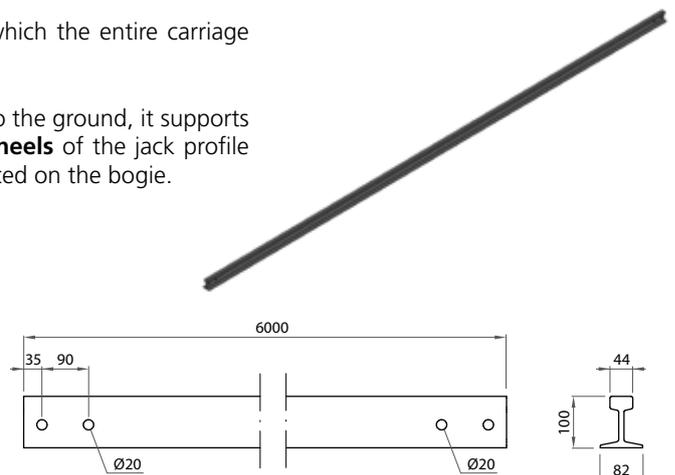
M24 bolts for joining the different elements of the bogie jack waler system.



1990407 119 ROLLING BEAM S-20 / 6

Item over which the entire carriage rolls.

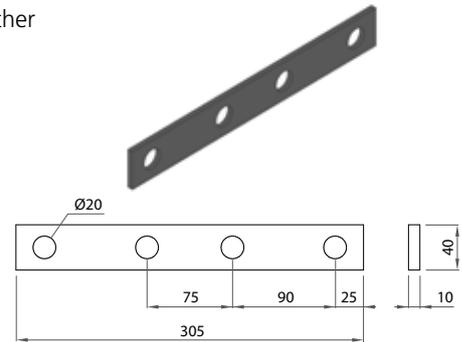
Anchored to the ground, it supports the **10 t wheels** of the jack profile system, placed on the bogie.



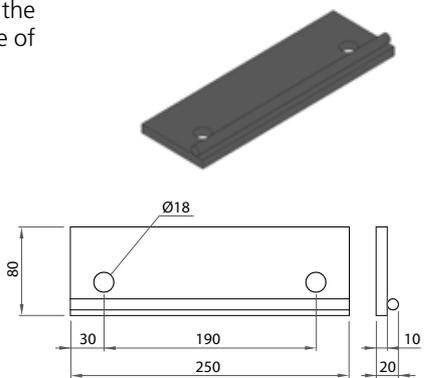
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**BOGIE SYSTEM JACK PROFILE**  
(The items needed to form the bogies for structures up to 40 t are gathered together here)

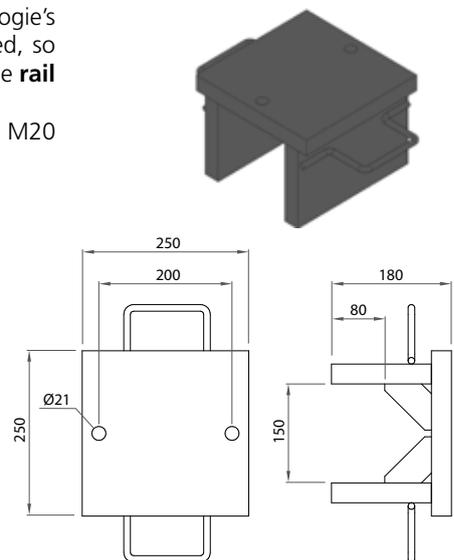
1990408 0.86 JOINT PLATE ROLLING BEAM Joins S-20 Rails together longitudinally.  
M16 bolts are used for tying.



0919259 1.7 PLATE CLAMP DU-DU Used to anchor the **S-20 rails** to the ground during the advance phase of the structure.



1990406 33.4 RAIL SHOE S-20 This is the part where the bogie's cylinders or jacks are supported, so there is no interference with the **rail S-20**.  
In the base plate, it has two M20 holes for joining with the jack.



0242060 0.3 HEXAG BOLT M20x60 M20 bolts for tying the rail shoe to the Jacks 360.  
0242000 0.06 HEXAG NUT M20 DIN934 8C  
0242401 0.03 FLAT WASHER A24 DIN125



0241660 0.123 HEXAG BOLT M16x60 M16 bolts for tying roller rails.  
0241600 0.03 HEXAG NUT M16 DIN934 8C

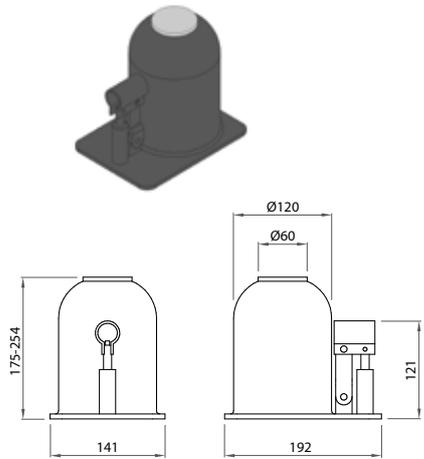


ITEM NUMBER	WEIGHT/ Kg	NAME	DESCRIPTION	DRAWING
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**BOGIE SYSTEM JACK PROFILE**  
(The items needed to form the bogies for structures up to 40 t are gathered together here)

1990654 13.7 HYDRAULIC MANUAL JACK Used for raising and lowering the carriages during their stripping and placing operations. They are used directly on the bogie and have a capacity of 30 t.

They are only used during the stripping phase and in the relocation of the formwork after the carriage advance.



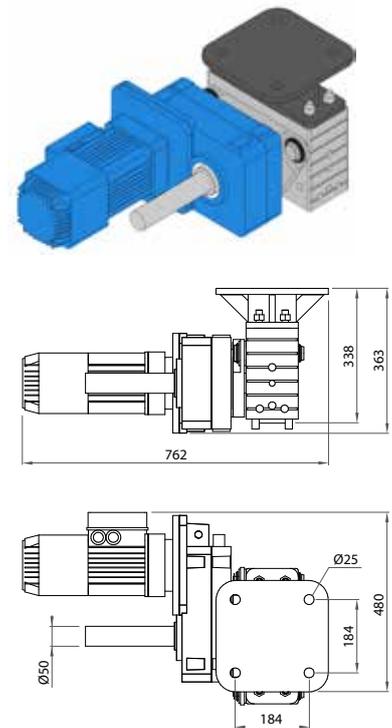
**MOTORISED WHEEL SYSTEM**

1990656 125 DRIVING WHEEL 100 MK Used for automatically moving carriages of up to 40 t.

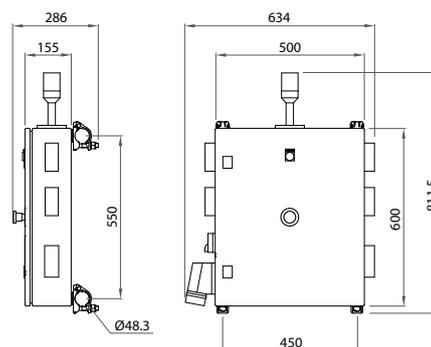
It is joined to the **jack profile** that forms the bogie using 4 M24 bolts in the fixed points for movement.

The load-bearing capacity of this **wheel** is 100 kN.

When the distance between the wheel and the bogie needs to be increased, **blocks** can be placed between them.



1990666 12 ELECTRIC BOX This is the cabinet which drives the **motorised wheel**. Up to 4 motorized wheels can be connected to this cabinet.



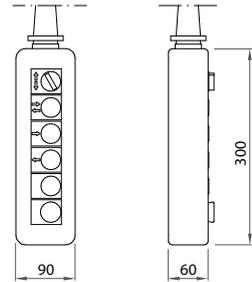
ITEM NUMBER	WEIGHT/Kg	NAME	DESCRIPTION	DRAWING
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**MOTORISED WHEEL SYSTEM**

1990667    6.0    WHEEL CONTROL PAD

Control for handling the **motorised wheels**.

It is connected directly to the cabinet.



1990668    6.0    MOTOR CABLE

Power cable for motor.

Connects the **cabinet** to the motor of the **wheel**.



1990669    6,0    ELECTRIC BOX CABLE

Power cable for cabinet.

Directly connects to the electrical outlet and the **cabinet**.



## 6. CONDITIONS OF USE

### 6.1. CONDITIONS OF USE

#### 6.1.1 General Guidelines

- It is recommended to strictly follow the instructions of the Project plan, the Occupational health and safety plan, as well as any further technical and/or safety rules which might apply to the site.
- The work must be performed by qualified people and under the supervision of a competent person.
- Personnel must comply with the instructions for use of all work equipment used (refer to the manufacturer or supplier manual).
- To perform the work, regulatory ancillary equipment and the appropriate means of protection, preferably collective, shall be used.
- Personal protective equipment to be used includes, as a minimum: hard hat, safety footwear, gloves and tool-holder belt. However, the use of other personal protective equipment can be considered, where appropriate.
- Impacts on platforms or boards should be avoided (it is forbidden to jump, to set down loads abruptly, etc.).
- If works are being carried out in the vicinity of power lines, try to work without power. If this is not possible, the appropriate measures should be taken in accordance with the respective standards.
- Under adverse weather conditions, work with the material should be avoided.
- 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 stripping-dismantling, check that all critical components of the structure are present (ties, etc.), and if not, the structure must be corrected before stripping-dismantling.
- Before stripping-dismantling, check that no loose materials remain on the structure (e.g. on working platforms) which could fall to the ground.
- 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 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 buyer or lessee must periodically inspect the assembled structure to verify the condition of critical components and identify any removal or modification of components of the structure by users or third parties.

#### 6.1.2 Other guidelines for structures

##### • **Assembly of structures (falsework and structure)**

- The intended area for assembly must be clearly lit and marked to prevent people who aren't working on it from entering this area.
- The tightness of the nuts and bolts between the different components must be checked as well as the correct positioning and tightness of the push-pull props.
- The correct tightness of the ties, nuts, round couplers and anchorage plates must be checked as well as any additional items that are tied to the ground.
- Before placing a new gang, make sure the previous gang is properly fastened.
- Do not leave any part partially assembled.
- Ground strength must be ensured for the loads in the conditions of use, to those to which it will be subjected and for weather conditions, adopting the necessary measures (surface cleaning, concrete shoes, etc.).
- In the case of heavy loads, a geotechnical report should be carried out and the contractor should size the foundations accordingly.
- In special foundations cases, a foundation project should be carried out with plans and annexes containing the calculations used.
- The stability of the structure must be ensured, carrying out the ties according to the project and/or configuration type.
- If any product is spilled on the platforms, it should be cleaned up immediately.

- Materials must not be allowed to accumulate on the platforms, only those necessary for the work being carried out are to be there.

##### • **Dismantling structures (falsework and structure)**

- The condition of the falsework must be inspected before dismantling to see if there are any structural and / or tie items missing.
- It must be ensured that there are no loose elements at the top if the procedure is to be performed by crane.
- It must be ensured that there are no workers on the vertical of the dismantling and surrounding area.

- Special care must be taken to ensure the stability of the structure during the dismantling process.
- No material is to be stored on the platforms during dismantling, this will be dropped during dismantling.

### 6.1.3 Other guidelines for formwork

#### • Formwork

- Frames shall be positioned for supporting the formwork panels, to prevent the damage to the panels and to provide order, cleanliness and the distribution of the panels at their appropriate positions.
- The tie plate nuts must be correctly tightened, the push-pull props must be correctly positioned and tightened and the push-pull prop shoe must be correctly fastened to the ground.
- Before placing a new gang, make sure the previous gang is properly fastened.
- Do not leave any part partially assembled.
- Climbing through the formwork panels is prohibited except in exceptional cases that have been duly studied, and only when proper safety equipment is used.
- The cleaning of formwork surfaces prior to the pouring of concrete should be monitored.
- The panels should be cleaned after each use. Wire brushes that can damage the board's phenolic surface must not be used.
- It is important to know that the phenolic film of the panel board barely suffers any damage from the chemical and abrasive action of the concrete, but care must be taken in sealing the holes and damaged areas.
- Any edge of the board which is cut should be sealed as soon as possible because if water penetrates it can cause the layers of the board to swell, making it thicker.
- In general, using nails or bolts is not recommended.
- The panels must be stacked on top of each other, placing a wooden block between them, using some sort of support to separate them from the ground, and under shelter. Prolonged sun and rain exposure may damage the panels.

#### • Release agent

- The use of a release agent is justified due to the importance of preventing adhesion between the concrete and the formwork, as well as increasing the number of uses of the panels.
- The release agent plays an important role in the quality of the concrete surface, ensuring that this surface is free of surface holes and has uniform colour.
- Apply the release agent uniformly and in thin layers, bearing in mind at all times the instructions for correct use.

- Thoroughly clean the panel surfaces before applying the release agent.
- Cleaning of the metal frame of the panel and the application of the release agent is recommended after every 4 to 5 uses.

#### • Concrete placement

- The maximum hydrostatic pressures of the formwork system must be respected (in accordance with the instructions and calculations).
- During the pouring of the concrete the formwork condition must be monitored and pouring stopped if any incident occurs.
- Pour the concrete in uniform layers of between 30 to 45cm.
- Pouring of the concrete from the least possible height, never exceeding 2m, is recommended if this is not done through a duct, channel or another accessory. Pour the concrete as near as possible to the base, centring on one point and without pouring it directly against the formwork.
- If the concrete is poured using a bucket, take special care not to hit the formwork with it and do not exceed the load-bearing limit of the crane.
- Avoid concrete splashes on the panels so that marks are prevented due to these.
- The compaction or vibration system must be suitable to allow the concrete to work correctly.
- The preferred project concrete compaction method is that of needle vibrators. Use external vibration only when the concrete cannot be accessed with needle vibrators and for parts moulded in the workshop. For these cases, a specific analysis of the external vibration method is required.
- The needle vibrator should penetrate the layer by 10 to 15 cm.
- The needle vibrator should never come into contact with the formwork surface to ensure that the calculated loads are not exceeded.
- The penetration of the needle vibrator must be performed quickly, keeping it steady, vertical or slightly inclined.
- The removal of the needle vibrator should be done slowly.

#### • Concrete curing and formwork stripping

- Before starting the stripping process, the concrete must have a minimum resistance to avoid losses of the concrete mass next to the surface, since both the surface appearance as well as the concrete strength and durability could be affected.
- The curing time should be increased if there are low temperatures or air currents which could cause rapid drying of the surface.

- Form stripping of the various construction items should be performed observing the same time interval. This is justified from the point of view of the quality of the concrete surface, given that the surface colour is determined by the time during which it remains isolated from the outside.
- When proceeding to strip the formwork, avoid there being people in the vicinity.
- Once the assembly has been stripped, if it is not going to be used again it is supported on racks for cleaning and dismantling.

## 6.2. TRANSPORT, HANDLING AND STORAGE

### 6.2.1 General Notes

- Be informed about hazards on the building site and preventive measures to avoid those.
- Follow the instructions of the workplace Manager.
- Ensure good communication between the workers involved in the operations.
- Do not use work equipment if you are not authorised and do not have the training and specific information for the job.
- Maintain sufficient safety distance from mobile work equipment (forklifts, lorries, cranes, site machinery, etc.) and from areas with a risk of falling material.
- Under no circumstances must people remain beneath or in the path of elevated loads.
- Parts must not receive blows or be crushed during transport, handling and storage.
- Load material in suitable containers (pallets, wire crates, etc.) or in strapped and properly wedged packages, i.e. secure packets so that the seal is not broken and the package is stable.
- Strap the bundles with sufficient stability to prevent them from moving and getting damaged. If necessary, protect the items with some sort of buffer.
- When cutting the strap of the packages, go to one side and use gloves and goggles (risk of entrapment with the material and of cuts due to the expansion of the strap when released).

### 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.).
- When opening the container or the transport packing, stand away from the path of any parts that may fall out.

### 6.2.3 Handling

#### • Manual handling of loads

The following ergonomic principles, among others, should be observed:

- Do not make sudden movements.
- Before lifting the load, examine it to identify any sharp corners, dirt, etc. and decide on the best place to fasten it according to its shape, weight and volume.
- Lift, separating the feet at shoulder distance, duck, bending the knees, never the back.
- For heavy or difficult to handle loads use mechanical means and/or request the help of other worker(s).

#### • Mechanical handling of loads

- Use lifting equipment that complies with the applicable regulations and which is suitable for the operation.
- Check the good condition of the slings, cables and other fastening items for each use.
- After positioning the lifting accessories and before starting the lifting operations, retreat to a sufficiently safe distance from the load and other materials that may be affected.
- Follow the instructions of the person with special training who manages the work team.
- The load must be lifted smoothly, avoiding sudden movements.
- 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. The load is never guided by hand if there is any item in the vicinity capable of causing entrapment between the load and that item. Swinging and/or unexpected movement of the load could lead to a serious accident.

### 6.2.4 Storage

- Proper storage of the parts is fundamental to keep them in good working condition.
- To prevent damage the parts must be stored in a place protected from the weather and aggressive agents whenever possible.
- It is desirable to place the parts of the same type and dimensions in units designed specifically for them (wire crates, pallets, boxes, etc.).

- Ensure the stability of the stacks, considering, among other matters, the following:
  - Load bearing capacity of the floor.
  - Varying levels of the floor.
  - Levelling of the packages.
  - Support of the package or container.
  - Robustness of the packages.
  - Limit state of the strap.
  - Limit state and capacity of the containers used.
  - Do not stack full containers on top of empty or half-empty containers.
  - External actions (wind, risk of knocks, etc.).

## 6.3. INSPECTION AND MAINTENANCE

### 6.3.1 General Notes

- 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 not in 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 that affect the safety of people.
  - Items made of aluminium, as they are more vulnerable to damage to the welded joints and to deformation (where applicable).

### 6.3.2 Inspection instructions for ULMA construction items with CE marking.

Before each use, check the condition of the item with CE marking. If they do not comply with the specifications, they must be removed.

For more information, consult ULMA Construction.

### 6.3.3 Instructions for the inspection of equipment with CE marking sold by ULMA Construction

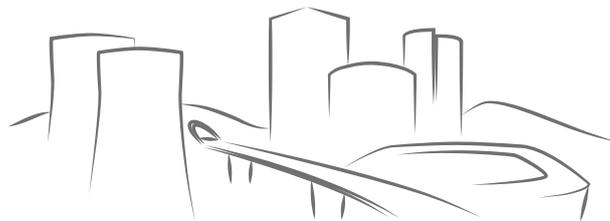
Equipment with CE marking sold by ULMA Construction is checked following the instructions stipulated in the Instruction Manual specific to the equipment.

## 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 on the minimum health and safety requirements for the workplace.
- Council Directive 89/656/EEC of 30 November 1989 on the minimum occupational health and safety requirements for workers' use of personal protective equipment in 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 Directive 92/58/EEC of 24 June 1992.
- Council Directive 92/58/EEC of 24 June 1992 on the minimum requirements for the provision of health and safety signs at work.
- Council Directive 89/655/EEC - Directive 95/63/EC and Directive 2001/45/EC of the European Parliament and of the Council of 27 June 2001 amending Council Directive 89/655/EEC regarding minimum health and safety provisions for workers when working with equipment.
- 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 06 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. Falsework. Performance requirements and general design.
- EN 12811-1 Equipment for temporary site works. Part 1: Scaffolding. Performance requirements and general design.
- EN 12811-2\_Equipment for temporary site works. Part 2: Information on the materials.
- EN 12811-3 Equipment for temporary site works. Part 3: Load testing.
- EN 13374 Temporary edge protection systems. Product specifications, test methods.
- EN 74-1\_Couplers, spigot pins and seat plates for use in scaffolds and falsework. Part 1: Tube joints. Requirements and test procedures.
- EN 74-2\_Couplers, spigot pins and seat plates for use in scaffolds and falsework. Part 2: Special couplings. Requirements and test methods.
- EN 74-3\_Couplings, spigot pins and seat plates for use in scaffolding and works. Part 3: spigot pins and flat standards. Requirements and test methods.



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