# TECHNICAL DOCUMENTATION

# 3D - LIFTING SYSTEMS | TH2 LIFTING CLUTCH

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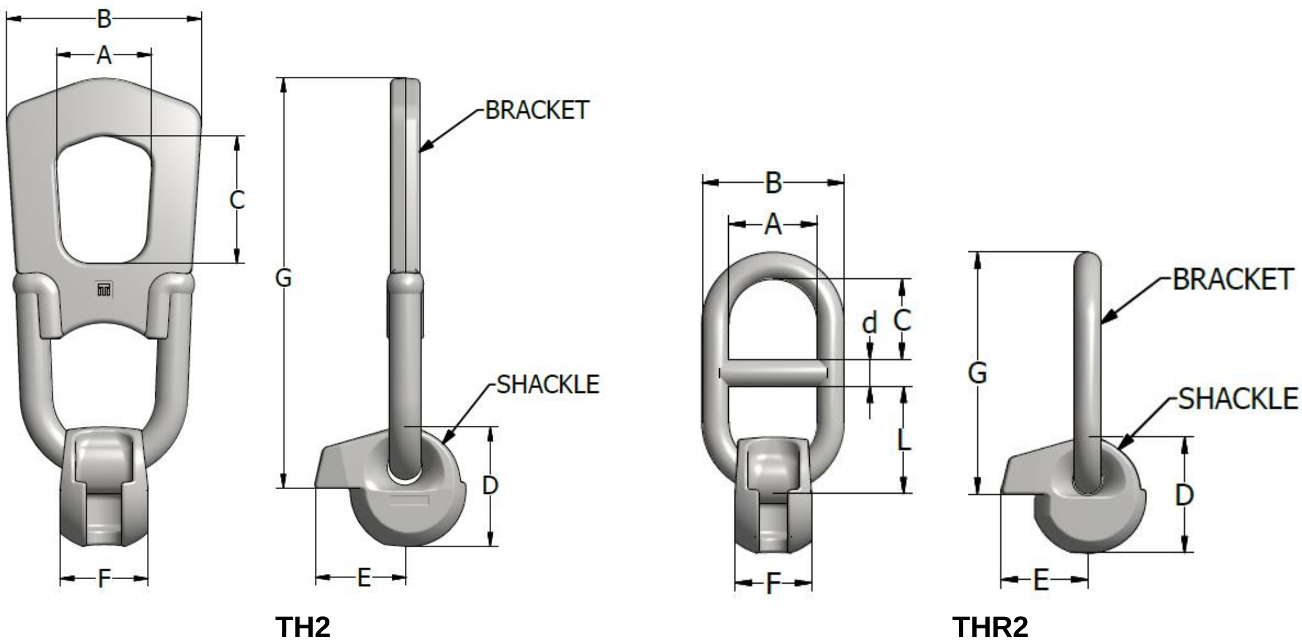
## LIFTING CLUTCHES TH2 AND THR2

The 3D lifting systems TH2 and THR2 are made of high-quality steel and are designed with a safety factor of 5. Every system is individually tested for a safety factor 3 times the working load and comes with a unique certificate.
The special design of the clutch ensures a tight, safe connection to the anchor. Of course, the shackle fits the hemispherical cavity created by the recess former perfectly.
The lifting clutch, recess former and anchor are only compatible when they are from the same load group, which is clearly marked on the lifting clutch.




### TH2 specifications

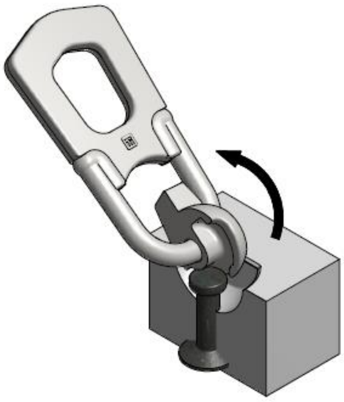
| TH2 lifting system | | Load group | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Product no.** | **[kN]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** |
| TH2 13 | 43143 | 13 | 48 | 77 | 60 | 55 | 40 | 33 | 165 |
| TH2 25 | 43144 | 25 | 50 | 92 | 75 | 68 | 55 | 42 | 205 |
| TH2 40/50 | 43145 | 50 | 68 | 121 | 86 | 88 | 64 | 57 | 240 |
| TH2 75/100 | 43146 | 100 | 84 | 170 | 110 | 108 | 90 | 77 | 346 |
| TH2 150/200 | 43147 | 200 | 124 | 230 | 140 | 146 | 118 | 115 | 520 |
| TH2 320 | 43148 | 320 | 155 | 303 | 175 | 195 | 160 | 155 | 590 |
| TH2 450 | 44500 | 450 | 155 | 303 | 175 | 195 | 160 | 155 | 590 |

### Specifications of the THR2

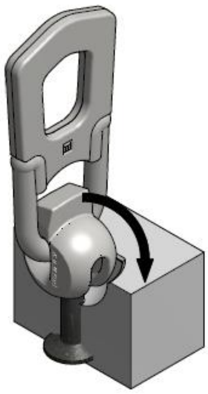
| TH2 lifting system | | Load group | A | B | C | d | L | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Product no.** | **[kN]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** | **[mm]** |
| THR2 40/50 | 45281 | 50 | 66 | 106 | 60 | 20 | 80 | 88 | 64 | 57 | 180 |
| THR2 75/100 | 45279 | 100 | 90 | 146 | 58 | 28 | 68 | 108 | 90 | 77 | 210 |

**OPERATING INSTRUCTIONS**

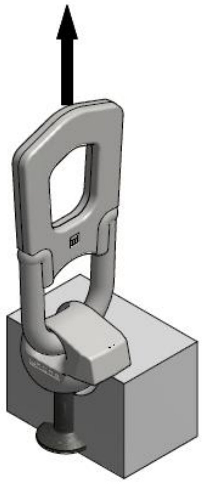
**1**
The clutch is placed in the right position.



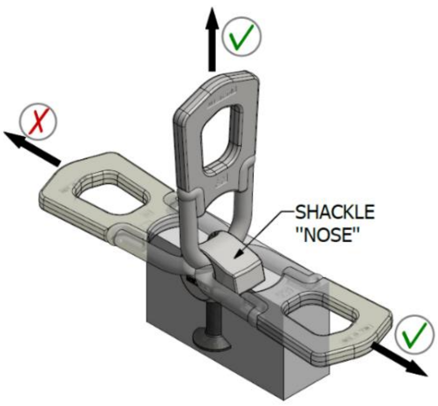
**2**
Rotate the shackle, until the opening corresponds with the anchor head.



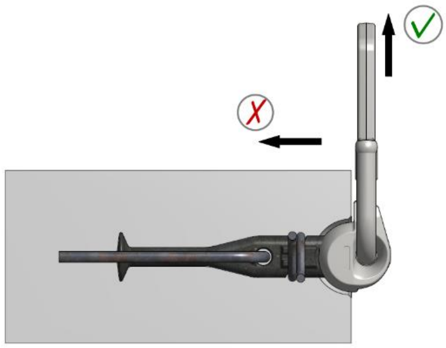
**3**
The shackle rotates to its locking position.



**4**
The nose of the shackle is pushed against the concrete element.

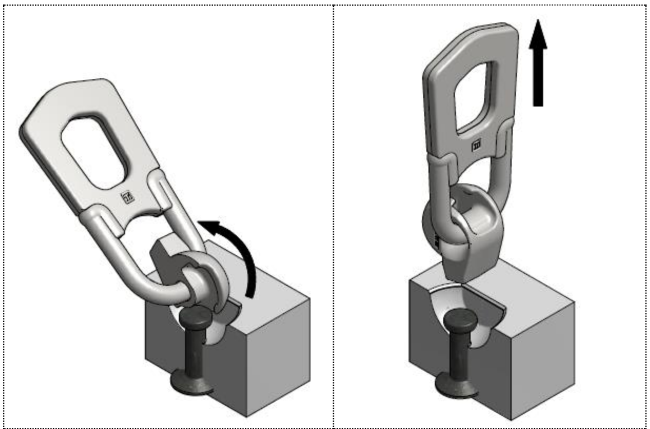



**Angled lifting**

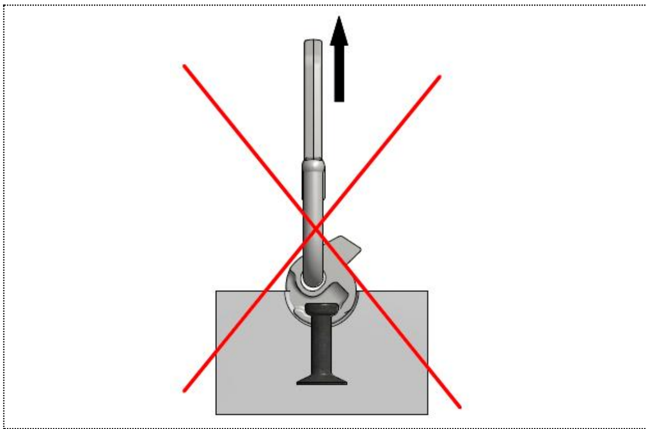


**Tilt-up lifting**

When tilting the concrete unit with the 3D lifting system, the nose must face the same direction as the load (see illustration above). Due to the counterweight of the nose, the shackle remains connected, even in an unloaded state. To release the 3D lifting system, the load hook is lowered and the shackle is turned up and out. The crane can only be withdrawn after the lifting system is completely detached from the recess and anchor. The 3D lifting system can remain attached to the crane hook until the next use.



***Release operation after lifting***



***If the shackle remains in the position showed above, the lifting of the concrete unit is not allowed***

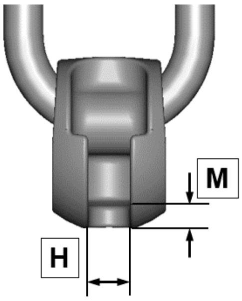
## LIFTING CLUTCHES - SYSTEM MAINTENANCE

As with all lifting devices, the lifting systems TH1, TH2 and THR2 must be checked at least twice a year by trained personnel. Any defects found should be corrected before use. It is important to determine the amount of wear. The lettering and identification of the lifting system must be visible. If the shackle is deformed or the mouth opening is enlarged, the 3D lifting system must be taken out of use and cannot be repaired. If the limiting dimensions for H given in the tables below are exceeded or fall short for “M”, the lifting system is not safe for further use. Repairs, especially welding operations on the lifting system are strictly forbidden. Do not combine our products with accessories from other manufacturers.

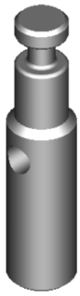
- ***Any deformation to the wire rope (see the type of damages mentioned on page 60), shackle, or metal structural elements causes a weakening of the lifting device with the risk of the precast element falling. Do not perform any repair work. The lifting device must be discarded. Lifting loops with broken strands or other signs of damage, kinking, bird caging, corrosion that require discarding according EN 13414-1 must not be used for further lifting.***

- ***Damage, distortions, cracks and extensive corrosion can reduce the load-carrying capacity and lead to failure. This causes a hazard to life and limb. If necessary, any affected parts must be taken out of service immediately.***

Cables must not come into contact with acids, caustic solutions or other aggressive substances.




**Shackle dimensions**



**Checking TH calibre**

A checking calibre for each type is available on request.

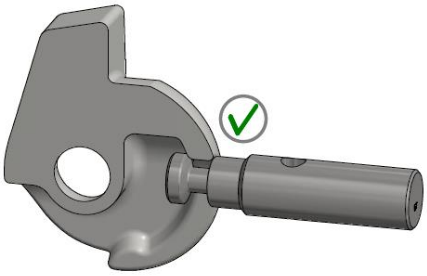
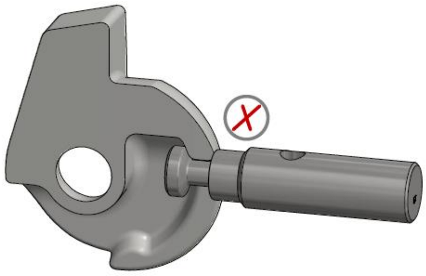
| TYPE | TH2 NUMBER | H MAXIMUM [mm] | M MINIMUM [mm] | CALIBRE “GO/NO-GO” NUMBER |
|---|---|---|---|---|
| TH2 13 | 43143 | 13 | 5.5 | 46193 |
| TH2 25 | 43144 | 18 | 7 | 46194 |
| TH2 50 | 43145 | 24 | 9 | 46195 |
| TH2 100 | 43146 | 33 | 12 | 46196 |
| TH2 200 | 43147 | 45 | 18 | 46197 |
| TH2 320 | 43148 | 56 | 25 | 46198 |
| TH2 450 | 44500 | 56 | 25 | 46199 |

| TYPE | THR2 NUMBER | H MAXIMUM [mm] | M MINIMUM [mm] | CALIBRE “GO/NO-GO” NUMBER |
|---|---|---|---|---|
| THR2 40/50 | 45281 | 24 | 9 | 46195 |
| THR2 75/100 | 45279 | 33 | 12 | 46196 |

## CHECKING THE LIFTING SYSTEM

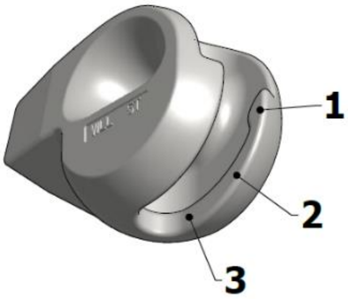
### CHECKING DIMENSION “M”

The dimension “M” must be checked in this zone for the risk of fracturing during use.

| **ACCEPTABLE**<br>Dimension “M” is greater than the minimum permitted. | **NOT ACCEPTABLE**<br>In this case, dimension “M” is less than permitted. |
|---|---|
|  |  |

### CHECKING DIMENSION “H”

The “H” dimension must be checked in at least 3 zones for the risk of wearing out during use.



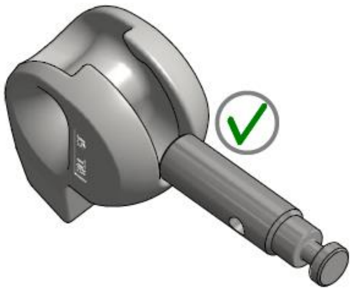

**PRIMARY ZONE**

| **ACCEPTABLE**<br>Dimension “H” is less than the maximum permitted. | **NOT ACCEPTABLE**<br>In this case, dimension “H” is greater than permitted. |
|---|---|
|  |  |

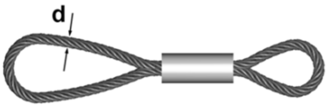
**SECONDARY ZONE**

| **ACCEPTABLE**<br>Dimension “H” is less than the maximum permitted. | **NOT ACCEPTABLE**<br>In this case, dimension “H” is greater than permitted. |
|---|---|
|  |  |

## THE THIRD ZONE

| **ACCEPTABLE**<br>Dimension “H” is less than the maximum permitted. | **NOT ACCEPTABLE**<br>In this case, dimension “H” is greater than permitted. |
|---|---|
|  |  |

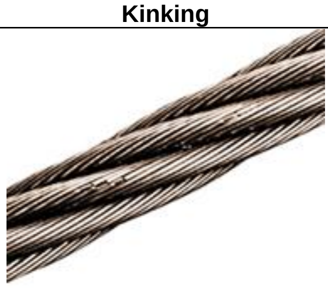
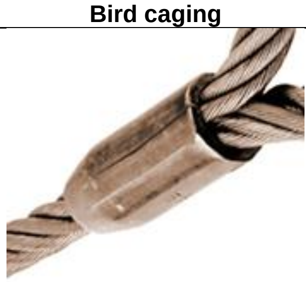
## CHECKING WIRE CABLE

| | Cable type | Number of visible broken wires over a length of | | |
|---|---|---|---|---|
|   | | 3d | 6d | 30d |
| | Stranded rope | 4 | 6 | 16 |

d = cable diameter

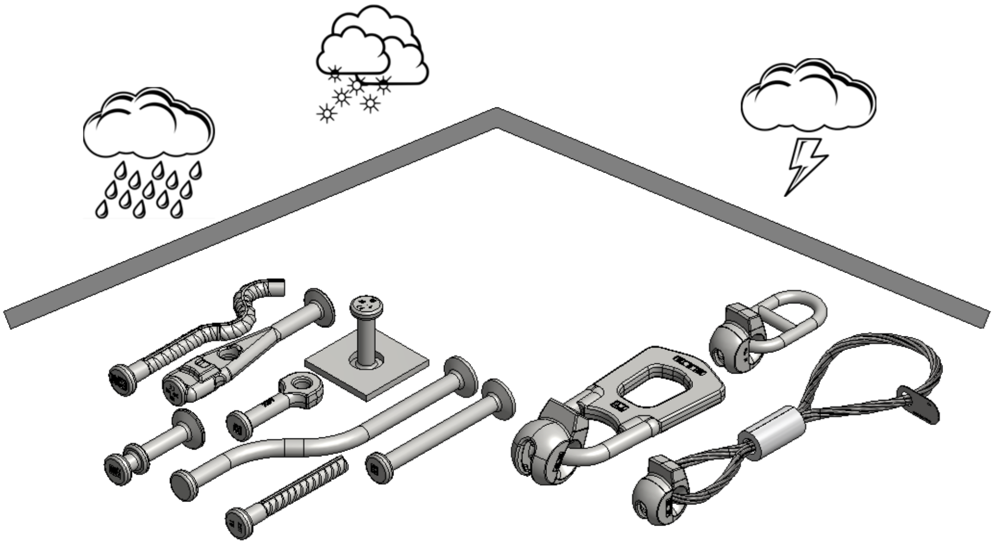
Wire cables should be inspected and discarded according EN 13414-1 when the following flaws occur:

- Kinking
- One strand is broken
- Separation of the outer layer of braids
- Crushed strands
- Crushing at the shackle contact point with more than 4 ruptured wires on braided cables or more than 10 ruptured wires on cable-laid rope
- Signs of corrosion
- Damage to or severe wear of the closing bush.
- Signs of slipping between the cable and the closing bush
- A cable with several broken wires mentioned in the table above must be taken out of use

| **Wire rope dimensions** | | |
|---|---|---|
|  |  |  |
| **Kinking** | **Severe wear** | **Bird caging** |
|  |  |  |
| **Broken wire** | **Corrosion** | **Closing bush damage** |

**STORAGE REQUIREMENTS**

Lifting systems and anchors must be stored and protected in dry conditions, under a roof. Large temperature variations, snow, ice, humidity, or salt and salt water impact may cause damage to anchors and shorten the service life.



**SAFETY INSTRUCTIONS**

***Warning:*** Use only trained personnel. Use the anchor and the lifting device by untrained personnel poses the risk of incorrect use or falling, which may cause injury or death. The lifting systems must be used only for lifting and moving precast concrete elements.

Obligatory instructions for safe working:
- All lifting anchors and lifting devices must be operated manually
- Visually inspect lifting anchors before use; check and clean all lifting anchor prior to use
- Hook in all lifting systems separately, without using force. Never use a hammer to close the lifting device.

Respect local regulations for safe lifting and hoisting at all times.

Incorrect use may result in safety hazards and reduced load-carrying capacity. This may cause the lifted object to fall and pose a hazard to life and limb. Lifting anchor systems must be used only by suitable trained personnel.

## GENERAL INFORMATION

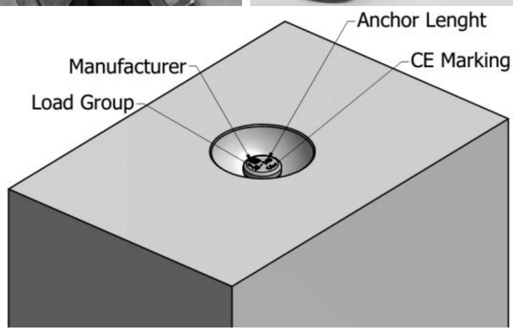
Using the 3D T-slot Anchor System is fast, and the utilisation of a cheap T-Slot-anchor makes application of this lifting system the most economical solution.
The T-Slot anchor is built into the concrete element with the aid of a rubber recess former. After pouring the shuttering and after the concrete has hardened, the rubber ball can be removed. The TH2 lifting clutch fits perfectly in the hole created, facilitating pulling the prefab element up out of the shuttering.
Some of the important advantages of these systems include:

- Safe, simple and fast connection and disconnection between lifting anchors and lifting clutches.
- Anchors and links are designed for load capacities between **1.3 – 45 t**.
- High quality alloy material for lifting anchors can be used in any environment.
- Available in hot-dip galvanised and stainless steel for protection against corrosion.
- Perfect lifting and transport solution for most applications and precast elements.
- CE-certified system. All Terwa lifting systems have the CE marking which guarantees conformance with the European regulations.
- The design for Terwa 3D lifting anchors and technical instructions comply with the national German guideline VDI/BV-BS 6205:2012 “Lifting inserts and lifting insert for precast concrete elements”. Based on this guideline, the manufacturer must also ensure that the lifting systems have sufficient strength to prevent concrete failure.
- The anchors are designed to resist at a minimum safety factor = 3.

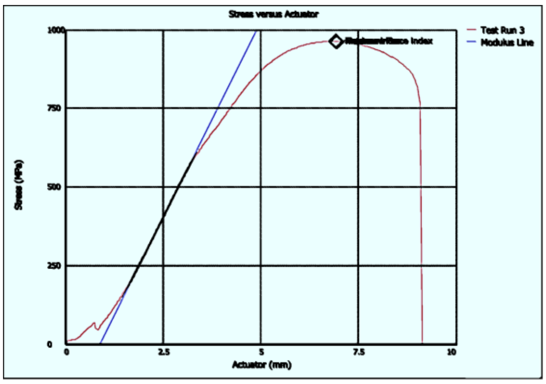
A failure of lifting anchors and lifting anchor devices can endanger human lives as well as can lead to significant damage. Therefore, lifting anchors and lifting devices must be produced with high quality, carefully selected and which are designed for the respective application and used by skilled personnel according to lifting and handling instructions.
**Welding on the anchor is not permitted.**

**Quality**
Terwa continuously controls the anchor production process in terms of strength, dimensional and material quality, and performs all of the required inspections for a superior quality system. All of the products are tracked from material acquisition to the final, ready to use product.

**Marking and traceability**
All anchors and lifting clutches are CE marked and have all the necessary data for traceability and the load group.




**Anchor testing**
Terwa lifting anchors are designed to resist at a minimum safety factor of **3x load group**



## Application of lifting anchor system

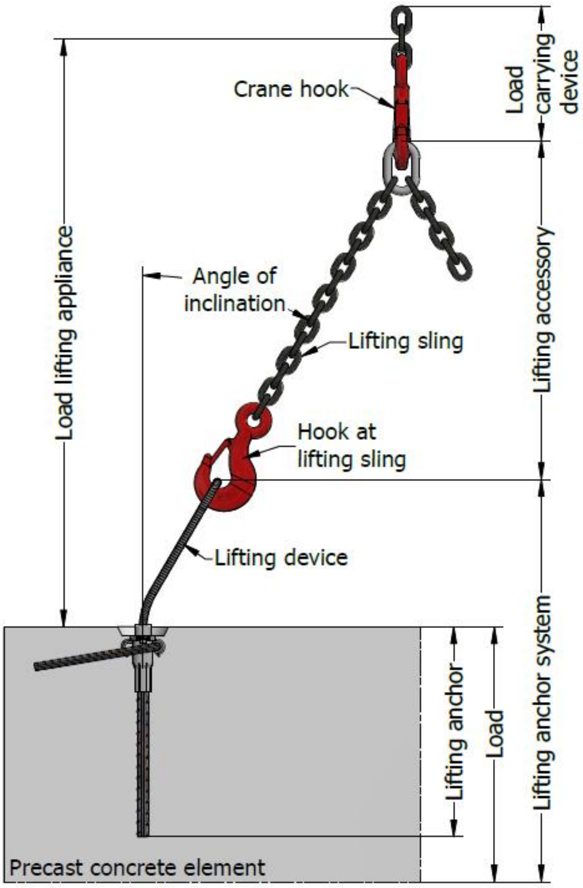
**Load carrying devices** - are equipment that is permanently connected to the hoist for attaching lifting devices, lifting accessory or loads.

**Lifting accessory** – equipment that creates a link between the load carrying device and the lifting device.

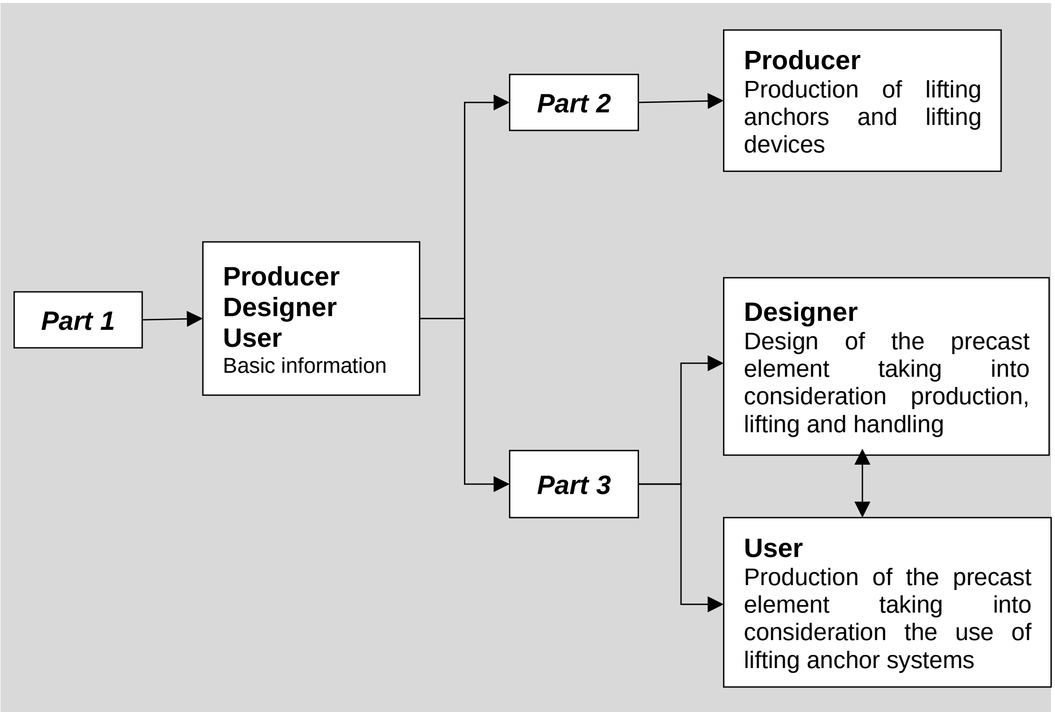
**Lifting device (lifting key)** – equipment that connects the loads to the load carrying device by means of lifting accessories.

**Lifting anchor** – steel part embedded in the concrete element, which is intended as an attachment point for the lifting device.

**Lifting anchor system** - consists of a lifting anchor (insert), which is permanently anchored in the precast concrete element and the corresponding lifting device, which is temporarily fixed to the embedded lifting anchor.




## Interaction between the parts of the series of guidelines VDI/BV-BS 6205



## CE MARKING

CE marking means that a product is manufactured and inspected in accordance with a harmonised European standard (hEN) or a European Technical Approval (ETA). ETA can be used as the basis for CE marking for cases in which there is no harmonised EN standard. However, ETA is voluntary and not required by EU directives or legislation .Manufacturers may use the CE marking to declare that their construction products meet harmonised European standards or have been granted ETA Approvals. These documents define properties the products must have to be granted the right to use the CE marking and describe how the manufacture of these products is supervised and tested.
EU Construction Products Regulation takes full effect on 1 July 2013. There are no harmonised EN standards for detailed building parts, such as connections used in concrete constructions, excluding lifting items and devices, which are covered by the EU Machinery Directive. For steel constructions, CE marking will become mandatory as of 1 July 2014, as covered by the EU Construction Products Directive.

## LIFTING SYSTEM

- **LIFTING CLUTCHES**

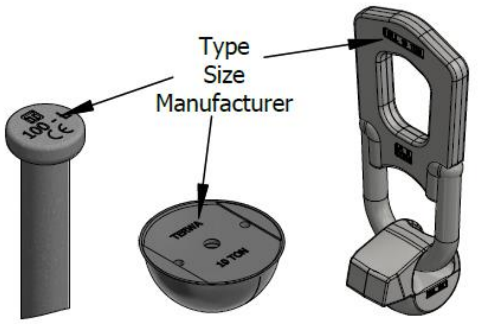
"Terwa" offers various lifting clutches and a wide range of different recess formers. The difference between all of the systems is actually defined by the type of anchors.

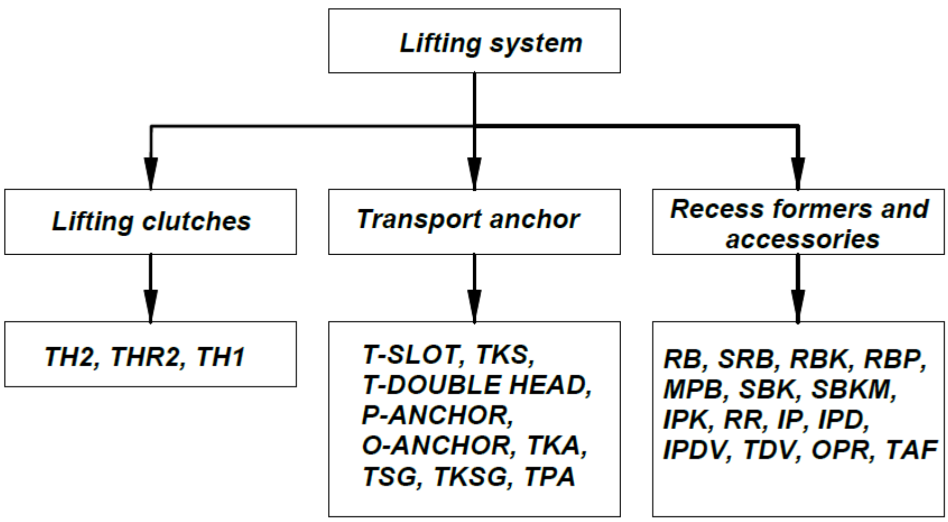
- **TRANSPORT ANCHORS**

The anchors are forged from round carbon steel. Available in black (with no surface treatment other than being slightly oiled) or hot dip galvanised, Terwa abbreviation **''TV''**. A small range of stainless steel anchors (A**2**-1.4301; AISI 304, Terwa abbreviation SS**2**) is available as well. All anchors are designed to meet a minimum safety factor of c=3.

- **RECESS FORMERS AND ACCESSORIES**

The anchors are fitted in the mould with a recess former. The recess formers are available in the same range as the lifting clutches and the anchors. This is indicated by a load group, marked on the top.
The formers are mounted on the mould using fixing plates.



## TECHNICAL INFORMATION – CHOOSING THE TYPE OF ANCHOR

Terwa offers a total of 3 types of lifting systems:

- 1D threaded lifting system
- 2D strip anchor lifting system
- 3D T-slot anchor lifting system

The method for choosing the anchor is identical for all these types and depends on the lifting method and/or experience.
The 1D threaded lifting system is mainly used when the hoisting angles are limited, while the 2D strip anchor lifting system and the 3D T-slot anchor lifting system can be used for all hoisting angles, with minor limitations for the 2D strip anchor lifting system.
The difference between the 2D strip anchor lifting system and the 3D T-slot anchor lifting system lies principally in the experience one has in using one or the other system.
Terwa also has software for making the anchor calculations.

## SAFETY RULES

The anchors are embedded in the concrete elements. The lifting system is connected to the anchor only when required for lifting.
**Ensure that the concrete has reached MPA strength of at least 15 MP before beginning lifting.**

These lifting systems are not suitable for intensive re-use.
In designing the lifting system, the safety factors for the failure mode steel rupture derived from the Machinery Directive 2006/42/EC are:

- **for steel component (solid sections)** $\gamma = 3$
- **for steel wires** $\gamma = 4$

For this, the load-side dynamic working coefficient $\psi_{dyn}$ **= 1.3**
For the determination of the characteristic resistances based on method A in accordance with DIN EN 1990 - Annex D for the concrete break-out, splitting, blow-out and pull-out failure modes, the safety factor is $\gamma$ **= 2.5**
The safety concept requires that the action E does not exceed the admissible value for the resistance $R_{adm}$:

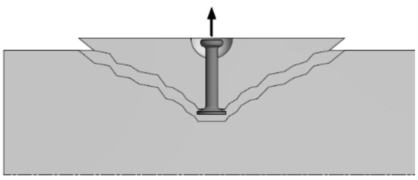
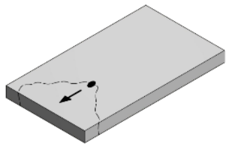
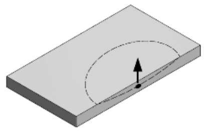
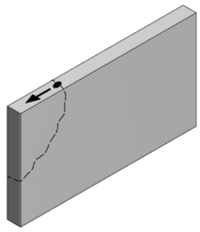
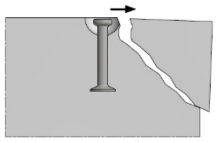
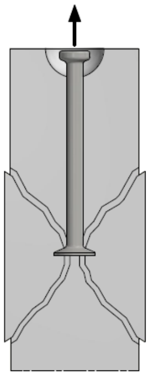
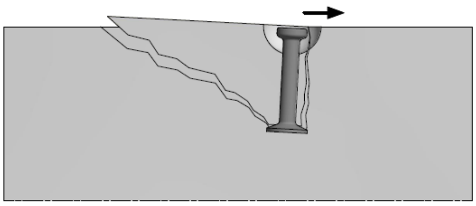
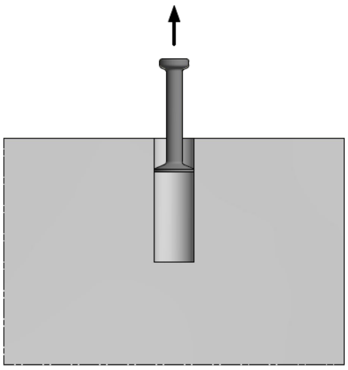
$E \leq R_{adm}$ Where: E - action, $R_{adm}$ - admissible load (resistance)

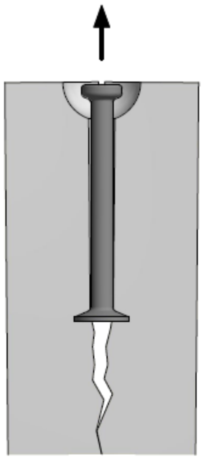
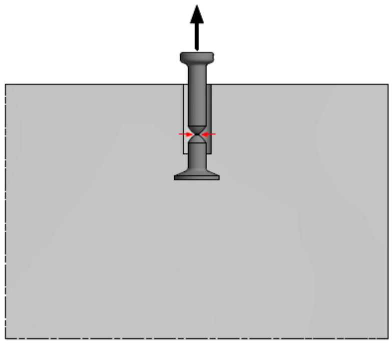
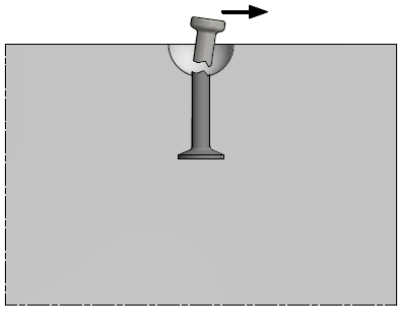
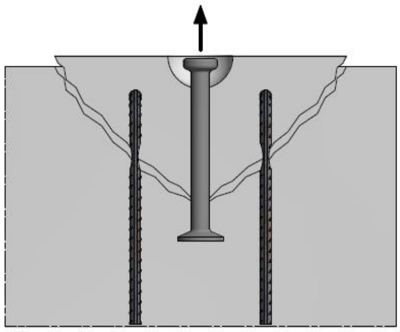
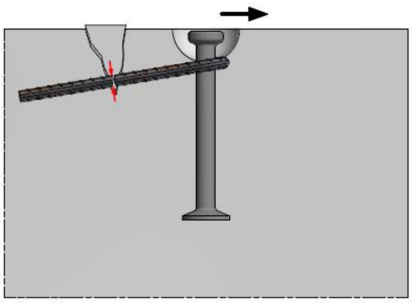
The admissible load (resistance) of lifting anchor and lifting device is obtained as follows:

$R_{adm} = \frac{Rk}{\gamma}$ Where: $R_k$ - characteristic resistance of the anchoring of a lifting anchor or lifting device, $\gamma$ - global safety factor

***Notice:*** The lifting anchors must always be installed above the centre of gravity.Otherwise, the element can tip over during transport.
The maximum permitted load on the components quoted in the tables has been obtained by applying a safety factor on test data.

**POSSIBLE TYPES OF FAILURE OF A LIFTING ANCHOR**

| Failure type | Fracture pattern: tensile force | Fracture pattern: transverse shear force |
|---|---|---|
| **Concrete break-out**<br>Failure mode, characterised by a wedge or cone shaped concrete break-out body, which was separated from the anchor ground and is initiated by the lifting anchor |  |  <br>  |
| **Local concrete break-out (blow-out)**<br>Concrete spalling at the side of the component that contains the anchor, at the level of the form-fitting load application by the lifting anchor into the concrete break-out at the concrete surface. |  | |
| **Pry-out (rear breakout of concrete)**<br>Failure mode characterised by the concrete breaking out opposite the direction of load, on lifting anchors with shear load. | |  |
| **Pull-out**<br>Failure mode, where the lifting anchor under tension load is pulled out of the concrete with large displacements and a small concrete break-out. |  | |

| Failure type | Fracture pattern: tensile force | Fracture pattern: transverse shear force |
|---|---|---|
| **Splitting of the component**<br>A concrete failure in which the concrete fractures along a plane passing through the axis of the lifting anchor. |  | |
| **Steel failure**<br>Failure mode characterised by fracture of the steel lifting anchor parts. |  |  |
| **Steel failure of additional reinforcement**<br>Steel failure of the supplementary reinforcement loaded directly or indirectly by the lifting anchor |  |  |

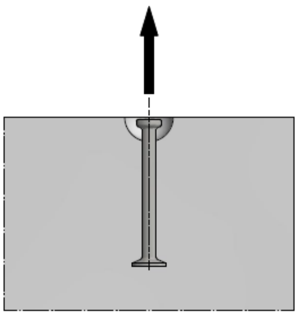
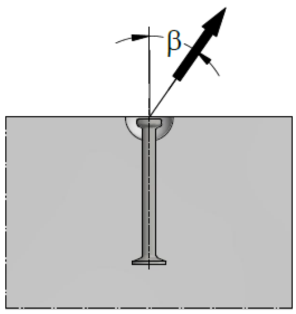
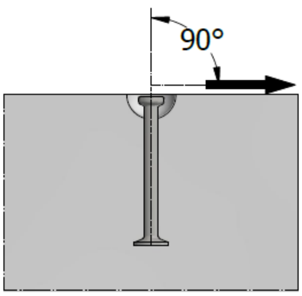
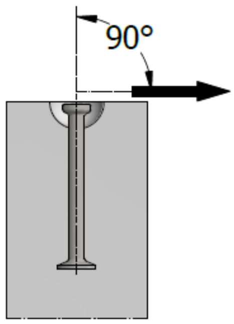
**DIMENSIONING OF LIFTING ANCHOR SYSTEM**

For the safe dimensioning of lifting anchor systems for precast concrete elements, the following points must be made clear at the start:

- The type of the structural element and the geometry
- Weight and location of centre of gravity of the structural element
- Directions of the loads on the anchor during the entire transport process, with all loading cases that occur.
- The static system of taking on the loads.

To determine the correct size of lifting anchor, the stresses in the direction of the wire rope sling must be determined for all load classes. These stresses must then be compared with the applicable resistance values for the type of loading case.

**Stress ≤ Resistance** always applies

| ***Direction of stress*** | | | |
|---|---|---|---|
| ***Axial tension*** | | ***Parallel shear pull*** | |
| Load or load component action in the direction of the longitudinal axis of the lifting anchor. |  | Load or load component action at an angle β to the longitudinal axis of the lifting anchor in the plane of the precast component. |   |
| | | | |
| ***Transverse shear pull parallel to the structural element plane*** | | ***Transverse shear pull perpendicular to the structural element plane*** | |
| Load or load component parallel to the surface of structural element and to the plane of the element, acting at an angle β perpendicular to the longitudinal axis of the lifting anchor. |   | Load or load component parallel to the building component surface and perpendicular to the surface of the component. |   |

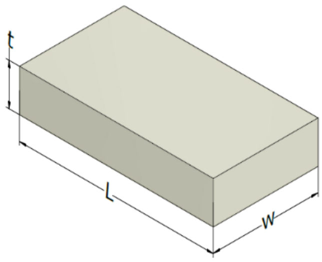
## LOAD CAPACITY

The load capacity of the anchor depends on multiple factors, such as:

- The deadweight of the precast concrete element "$F_G$"
- Adhesion to the formwork
- The load direction, angle of pull
- Number of load bearing anchors
- The edge distance and spacing of the anchors
- The strength of the concrete when operating, lifting or transporting
- The embedded depth of the anchor
- Dynamic forces
- The reinforcement arrangement

## WEIGHT OF PRECAST UNIT

The total self-weight "$F_G$" of the precast reinforced concrete element is determined using a specific weight of: **ρ = 25kN/m³.** For prefabricated elements composed of reinforcing elements with a higher concentration, this will be taken into consideration when calculating the weight.




$$F_G = \rho \times V$$

$$V = L \times w \times h$$

Where:
$V$ - volume of precast unit in [m³]
$L$ – length in [m]
$w$ – width in [m]
$h$ – thickness in [m]

## ADHESION TO FORMWORK COEFFICIENT

When a precast element is lifted from the formwork, adhesion force between element and formwork develops. This force must be taken into consideration for the calculation of the anchor load and depends on the total area in contact with the formwork, the shape of the precast element and the material of the formwork. The value "$F_{adh}$" of adhesion to the formwork is calculated using the following equation:

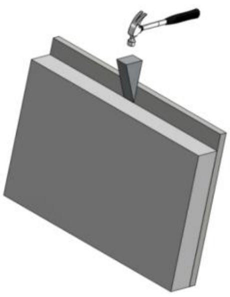
$$F_{adh} = q_{adh} \times A_f \ [kN]$$

Where: $F_{adh}$ – action due to adhesion and form friction, in kN
$q_{adh}$ - the adhesion to formwork and form friction factor corresponding to the material of the formwork
$A_f$ - the area of contact between the formwork and the concrete element when starting the lift

| Adhesion to the formwork | $q_{adh}$ in kN/m² |
|---|---|
| Oiled steel formwork, oiled plastic-coated plywood | $\geq 1$ |
| Varnished timber formwork with panel boards | $\geq 2$ |
| Rough timber formwork | $\geq 3$ |

In some cases, such as $\pi$ - panel or other specially shaped elements, an increased adhesion coefficient must be taken into consideration.

| Adhesion to the formwork | |
|---|---|
| Double-T beams | $F_{adh} = 2 \times F_G \ [kN]$ |
| Ribbed elements | $F_{adh} = 3 \times F_G \ [kN]$ |
| Waffled panel | $F_{adh} = 4 \times F_G \ [kN]$ |



Adhesion to the formwork should be minimised before lifting the concrete element out of the formwork by removing as many parts of the formwork as possible.

Before lifting from the table, the adhesion to the formwork must be reduced as much as possible by removing the formwork from the concrete element (tilting the formwork table, brief vibration for detachment, using wedges).

**DYNAMIC LOADS COEFFICIENT**

During lifting and handling of the precast elements, the lifting devices are subject to dynamic actions. The value of the dynamic actions depends on the type of lifting machinery. Dynamic effect shall be considered by the dynamic factor $\psi_{dyn}$.

| Lifting equipment | Dynamic factor $\psi_{dyn}$ |
|---|---|
| Tower crane, portal crane and mobile crane | 1.3 *) |
| Lifting and moving on flat terrain | 2.5 |
| Lifting and moving on rough terrain | ≥ 4.0 |
| *) lower values may be appropriate in precast plants if special arrangements are made. | |

For special transport and lifting cases, the dynamic factor is established based on the tests or on proven experience.

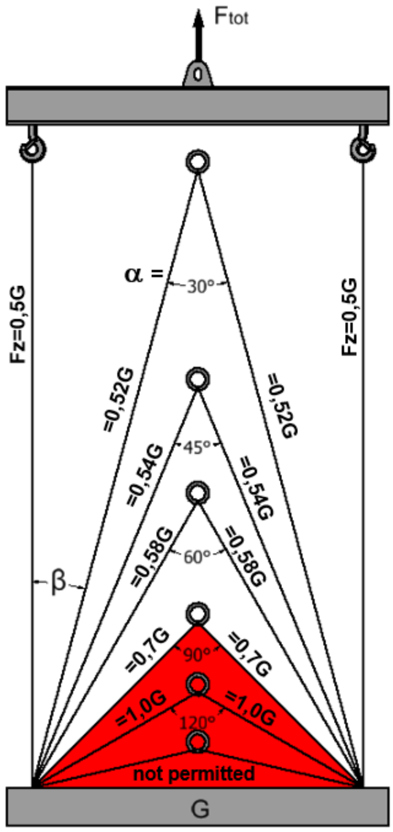
**LIFTING OF PRECAST CONCRETE ELEMENT UNDER COMBINED TENSION AND SHEAR LOADING**

The load value applied on each anchor depends on the chain inclination, which is defined by the angle $\beta$ between the normal direction and the lifting chain.
The cable angle $\beta$ is determined by the length of the suspension chain. We recommend that, if possible, $\beta$ should be kept to $\beta \leq 30^o$. The tensile force on the anchor will be increased by a cable angle coefficient "**z**".

**z = 1/cos**$\beta$

$$F = \frac{F_{tot} \times z}{n}$$

Where:
$z$ - cable angle coefficient
$n$ - number of load bearing anchors




| Cable angle $\beta$ | Spread angle a | Cable angle factor z |
|---|---|---|
| 0 ° | - | 1.00 |
| 7.5 ° | 15 ° | 1.01 |
| 15.0 ° | 30 ° | 1.04 |
| 22.5 ° | 45 ° | 1.08 |
| 30.0 ° | 60 ° | 1.16 |
| *37.5° | 75 ° | 1.26 |
| *45.0° | 90 ° | 1.41 |

*** preferred ß ≤ 30°**

**Note:** If no lifting beam is used during transport, the anchor must be embedded symmetrical to the load.

## ASYMMETRIC DISTRIBUTION OF THE LOAD

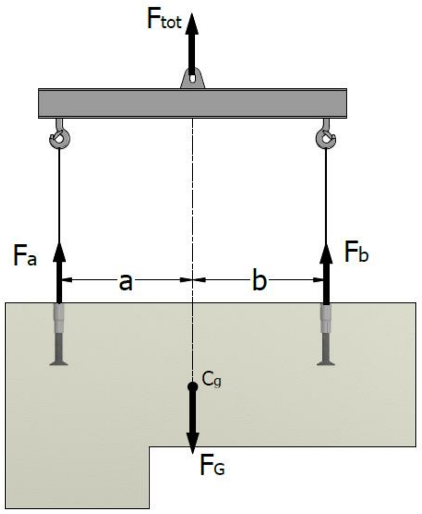
For asymmetrical elements, calculate the loads based on the centre of gravity before installing the anchors.
The load of each anchor depends on the embedded position of the anchor in the precast unit and on the transport mode:

a) If the arrangement of the anchors is asymmetrical in relation to the centre of gravity, the individual anchors support different loads. For the load distribution in asymmetrically installed anchors when a spreader beam is used, the forces on each anchor are calculated using the following equation:

$$F_a = F_{tot} \times \mathbf{b}/(\mathbf{a}+\mathbf{b})$$

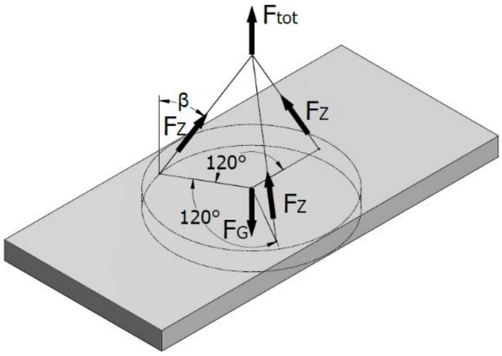
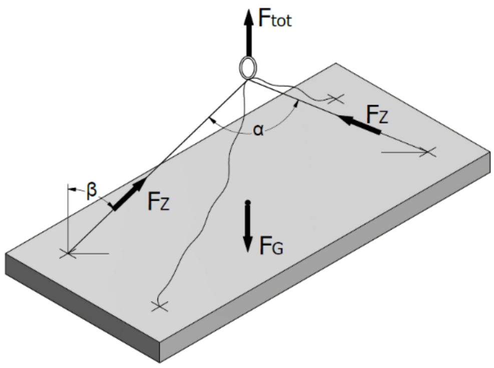
$$F_b = F_{tot} \times \mathbf{a}/(\mathbf{a}+\mathbf{b})$$

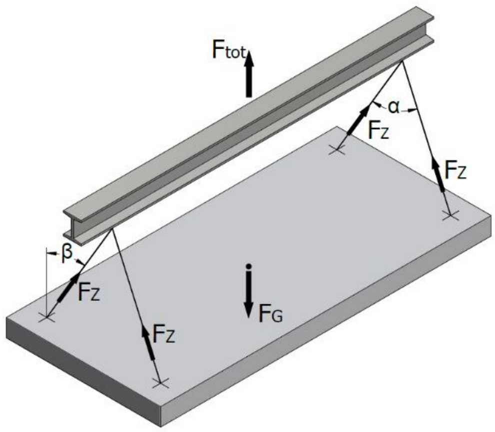
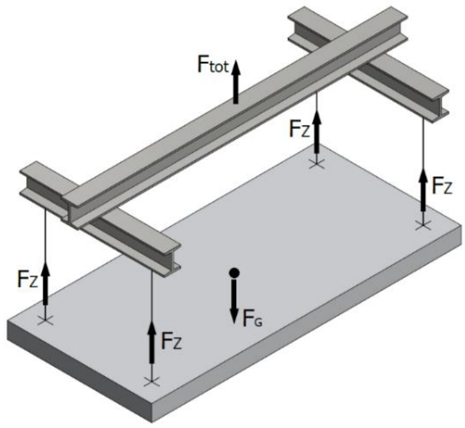
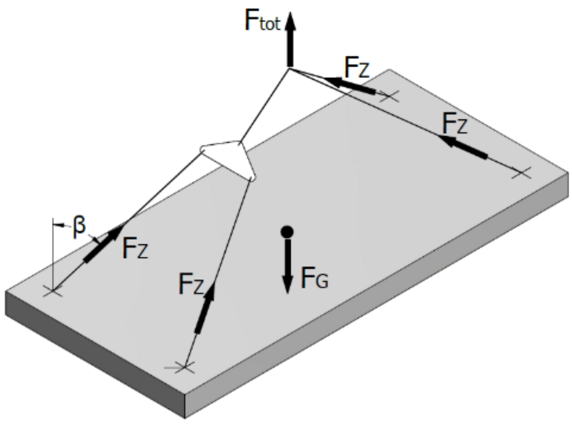
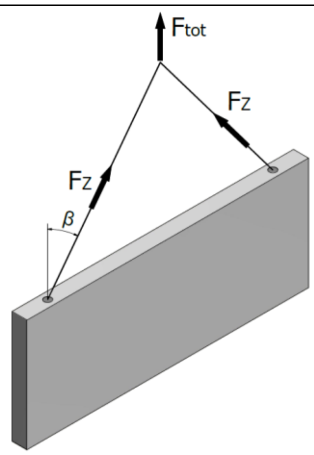
Note: To avoid tilting the element during transport, the load should be suspended from the lifting beam in such a way that its centre of gravity (Cg) is directly under the crane hook.

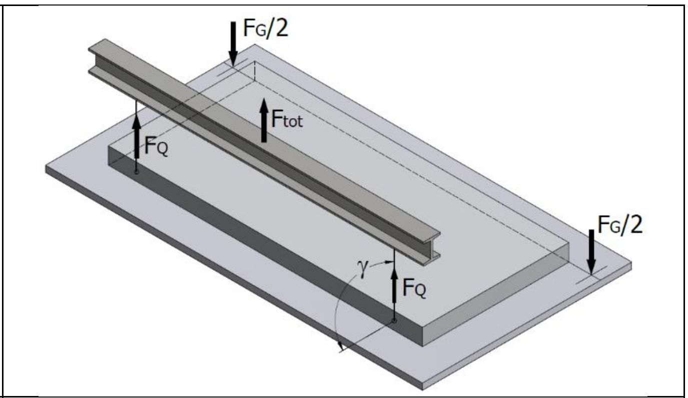
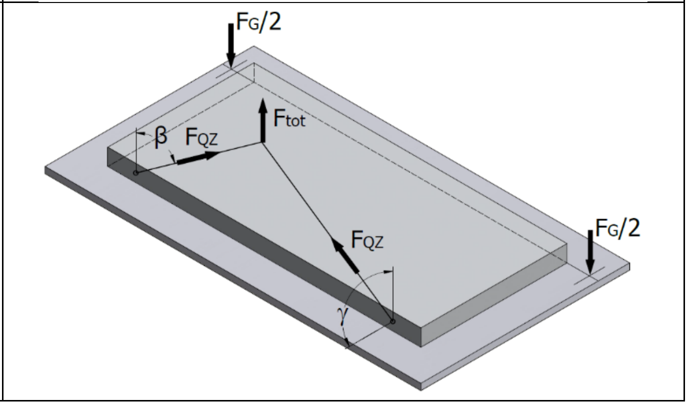



b) For transporting without a lifting beam, the load on the anchor depends on the cable angle (ß).

## ANCHORS LIFTING CONDITIONS

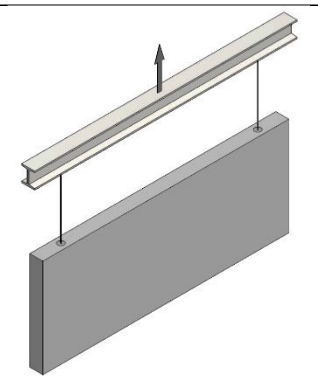
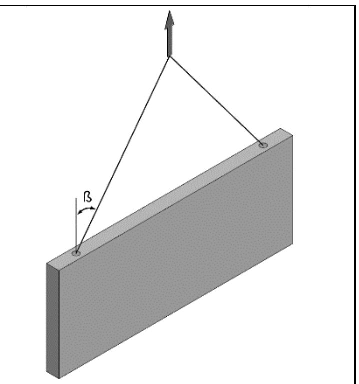
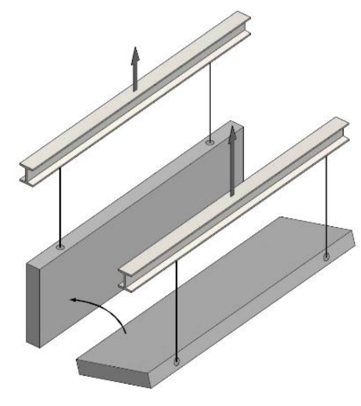
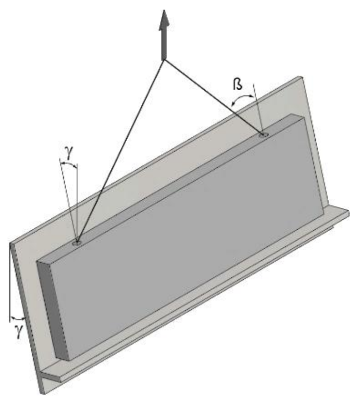
| | |
|---|---|
| Using three anchors spaced the same distance apart from each other as in the figure, three load bearing anchors can be assumed.<br>Load bearing anchors: **n=3**<br>**Load type – lifting of formwork**<br>-shear pull factor $z \geq 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |  |
| Using four anchors lifted without a spreader beam, only two load bearing anchors can be assumed. The load distribution is randomly based<br>Load bearing anchors: **n=3**<br>**Load type – lifting of formwork**<br>-shear pull factor $z \geq 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |  |

| | |
|---|---|
| Perfect force distribution is assumed using a spreader beam<br>Load bearing anchors: **n=3**<br>**Load type – lifting of formwork**<br>-shear pull factor $z \geq 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |   |
| Perfect static weight distribution can be obtained using a lifting beam and two pairs of anchors symmetrically placed.<br>Load bearing anchors: **n=3**<br>**Load type – lifting of formwork**<br>-shear pull factor $z \geq 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |   |
| The compensating lifting slings ensure equal force distribution.<br>Load bearing anchors: **n=4**<br>**Load type – lifting of formwork**<br>-shear pull factor $z \geq 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |   |
| Lifting of wall elements parallel to the axis of concrete element<br>Load bearing anchors: **n=2**<br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |   |

| | |
|---|---|
| When the element is lifted without a lifting table at a straight angle and contact with the ground is maintained. Additional shear reinforcement is required.<br>Load bearing anchors: **n=2**<br>**Load type – lifting of formwork**<br>-shear pull factor $z = 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z = 1$<br>-no formwork adhesion<br>-dynamic factor |  |
| When the element is lifted without a lifting table at a straight angle and contact with the ground is maintained. Additional shear reinforcement is required. ***ß ≤ 30 º***<br>Load bearing anchors: **n=2**<br>**Load type – lifting of formwork**<br>-shear pull factor $z \geq 1$<br>-formwork adhesion<br>-no dynamic factor<br><br>**Load type – transport**<br>-shear pull factor $z \geq 1$<br>-no formwork adhesion<br>-dynamic factor |  |

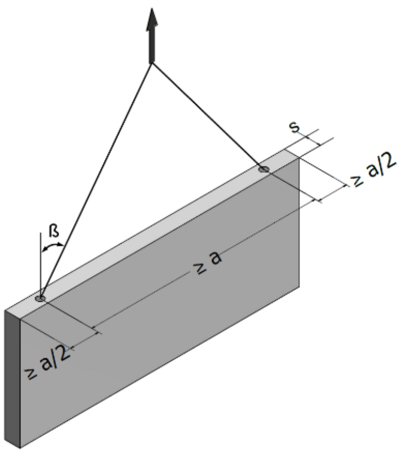
**LOAD DIRECTIONS**

Various scenarios may occur during transport and lifting, such as tilt-up, rotation, hoisting and, of course, installation. The lifting anchors and clutches must have the capacity for all these cases and combinations of them. Therefore, the load direction is a very important factor for proper anchor selection.

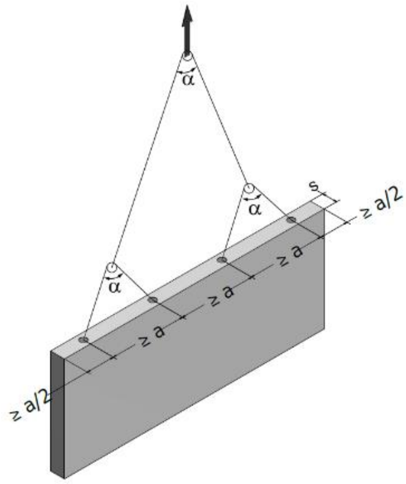
| | | | |
|---|---|---|---|
| Axial load **ß = 0º to 10º** |  | Diagonal load **ß = 10º to 45º**<br><br>*Note:* ***ß ≤ 30 º*** *is recommended* |  |
| Tilting **g = 90 º**<br><br>***Additional shear reinforcement steel must be used.*** |  | When a tilting table is used, the anchors can be used without additional shear reinforcement steel, not to angle g < 15 o |  |

**POSITIONING THE ANCHORS IN WALLS**

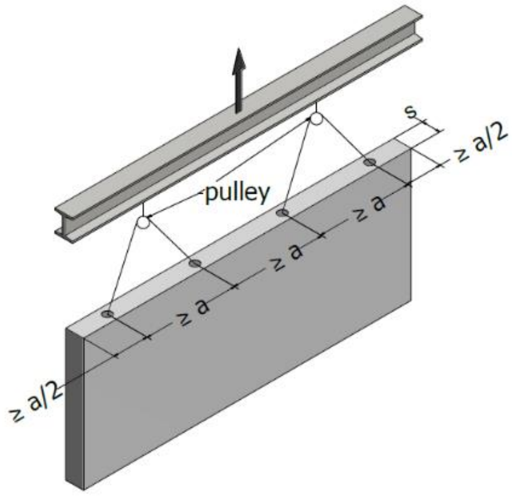
Load bearing anchors:
**n=3**

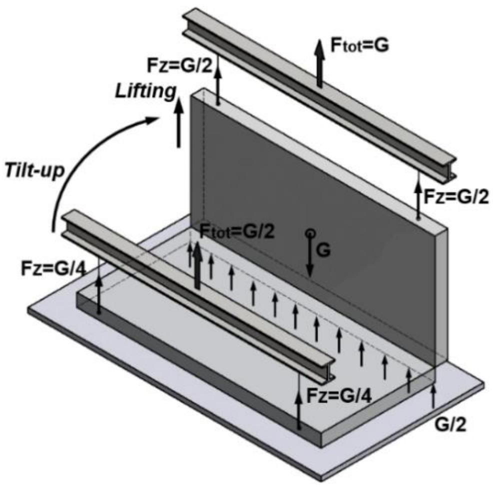



Load bearing anchors:
**n=3**




Load bearing anchors:
**n=4**

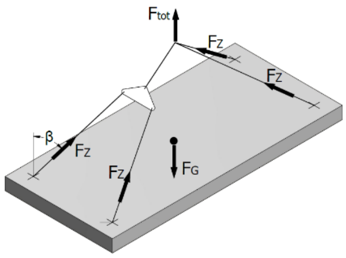
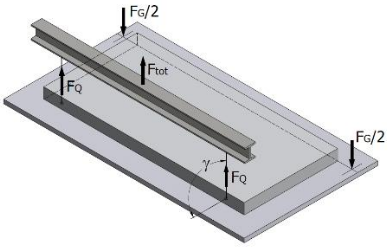
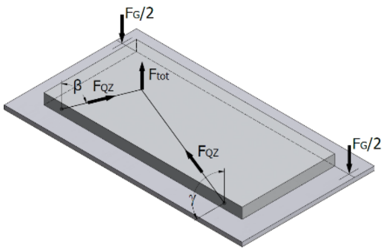
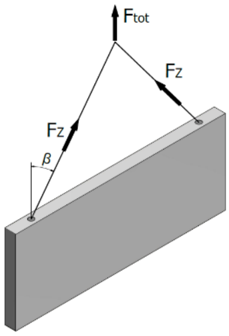


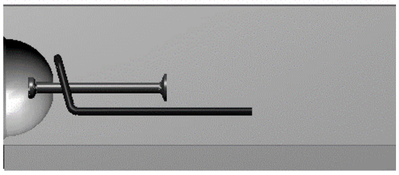

Lifting the walls from horizontal to vertical position without tilt-up table.

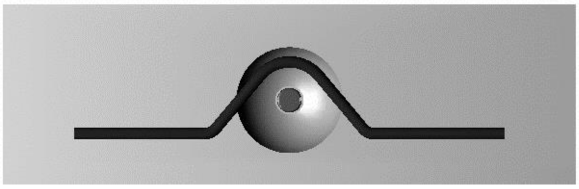
In this case, the anchors are loaded with half of the element weight, since half of the element remains in contact with the casting table.

**DETERMINATION OF ANCHOR LOAD**

| ***Load type*** | | ***Calculation*** | ***Verification*** |
|---|---|---|---|
| *Lifting with formwork adhesion* |   | $$F_Z = \frac{(F_G + F_{adh}) \times z}{n}$$ $F_Z$ – Load acting on the lifting anchor in kN | $F_Z \leq N_{R,adm}$<br>$N_{R,adm}$ – admissible normal load |
| *Erecting* |   | $$F_Q = \frac{(F_G/2) \times \psi_{dyn}}{n}$$ $F_Q$ – Shear load acting on the lifting anchor directed perpendicular to the longitudinal axis of the concrete element when lifting from horizontal position with a beam in kN | $F_Q \leq V_{R,adm}$<br>$V_{R,adm}$– admissible shear load |
| |   | $$F_{QZ} = \frac{(F_G/2) \times \psi_{dyn} \times z}{n}$$ $F_{QZ}$ – Shear load acting on the lifting anchor inclined and perpendicular to the longitudinal axis of the concrete element when lifting from horizontal position with a beam in kN | $F_{QZ}$<br>$\leq V_{R,adm}$<br>$V_{R,adm}$– admissible shear load |
| *Transport* |   | $$F_Z = \frac{F_G \times \psi_{dyn} \times z}{n}$$ $F_Z$ – Load acting on the lifting anchor in kN | $F_Z \leq N_{R,adm}$<br>$N_{R,adm}$ – admissible normal load |

The choice of the lifting anchor type must be made when the force acting on the most heavily loaded lifting has been determined. The T-Slot-anchor type can be determined using the forces acting on the load. Depending on the concrete strength present, the length of the T-slot anchor to be used can be determined using the appended tables.
No reduction of the permissible load is necessary when lifting at an angle using T-slot anchors. It may be necessary to use split reinforcement for the setting small elements vertically, because the applied force from the lifting hook will lead directly to the forces on the concrete. In these cases, we recommend working with the TKA-tilt slot anchors.
Split reinforcement may be adjusted as follows. The lifting clutch results directly in the applied force on the concrete and begins approximately half way along the recess former. That is why split reinforcement must be utilised. See the illustration.





## ANCHORING T-SLOT ANCHORS

If the T-slot anchor loading type has been chosen, the length of must be determined. Depending on the form of the element and the strength of the concrete at the first loading, a T-slot anchor should be selected, which creates a larger anchoring force than is calculated as the force acting on the load. The anchoring force permitted is calculated with a safety factor of 2.5.
The foot of the T-slot anchor ensures the anchoring. When the concrete collapses, a dish-shaped foot emerges from the T-slot anchor. It is a break-out cone with a slope of 1:3. That is why these relatively small anchoring lengths are sufficient..
Tables are appended to this technical documentation, into which most situations that arise can be filled. It is also possible to make an exact calculation of the current situation. Special tables can be made on request which match the practical situations at the prefab factory or at the building site.

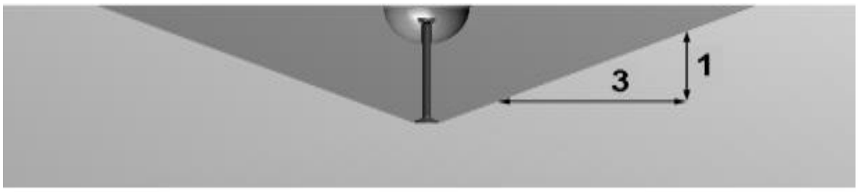
If it is possible to classify elements into the following groups, then the following rule of thumb can be used. In case of there is a lack of experience with the 3D slot anchor system, Terwa can always provide additional information.
Type of element:

- Beams: Standard length T-slot anchors can be used per loading type.
- Horizontal plates T-slot anchors with a length smaller than standard length can be used.
- Vertical plates T-slot anchors with a longer than standard length must be used.

## OVERVIEW OF T-SLOT ANCHORS LENGTHS

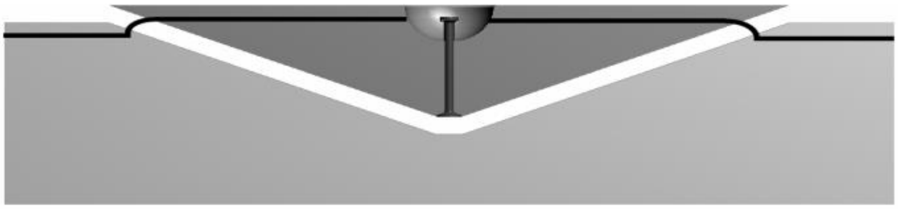
| Loading class [kN] | Standard type T-slot anchor | Shorter frequently used T-slot anchor | Longer frequently used T-slot anchor |
|---:|---:|---:|---:|
| 13 | T 013-0120 | T 013-0065 | T 013-0240 |
| 25 | T 025-0170 | T 025-0085 | T 025-0280 |
| 50 | T 050-0240 | T 050-0120 | T 050-0340 |
| 75 | T 075-0300 | T 075-0150 | T 075-0540 |
| 100 | T 100-0340 | T 100-0170 | T 100-0680 |
| 150 | T 150-0400 | T 150-0210 | T 150-0840 |
| 200 | T 200-0500 | T 200-0340 | T 200-0500 |
| 320 | T 320-0700 | T 320-0500 | T 320-1200 |

All deliverable types of T-slot anchors are mentioned in the product documentation and the price list and can be delivered in untreated, hot dip galvanising or electrolytic galvanising and stainless steel.

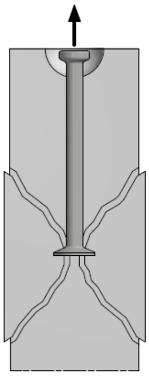



In addition to the length of the T-slot anchor, the concrete strength present is of primary importance when calculating the admissible anchoring force. The lifting force is transferred through the T-slot anchor to the concrete, whose strength at the first loading is primary. If there is any doubt about the admissible concrete force or if it is not possible to realise it, additional measurements have to be taken. For instance, the concrete force can be increased at the location of the T-slot anchor by

adjusting the insulation material. When you use insulation material, higher temperatures in the concrete can be attained, resulting in a faster force development.
The addition of extra reinforcement in the reinforcement nets almost never leads to improvement of the anchoring force. The anchoring force can only increase if the reinforcement is placed around and over the foot of the anchor.



The anchoring force of the T-slot anchor is highest when the T-slot anchor is placed at a distance to the edge 3 times greater than the built-in depth so that a complete break-out cone can be created. If it is not possible to have an edge distance of 3 times the built-in depth in all directions, better anchoring must be obtained with the aid of a longer T-slot anchor.
In the table, a situation is described which meets the edge distances of 3 times larger than the built-in length in all directions as well the situation in which the edge distance is limited to 2 directions. A good impression of what the real admissible force is in situations that are more or less comparable can be obtained with the aid of these tables. In case of doubt, please contact Terwa.

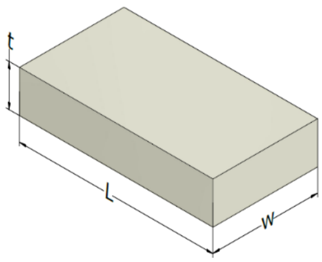


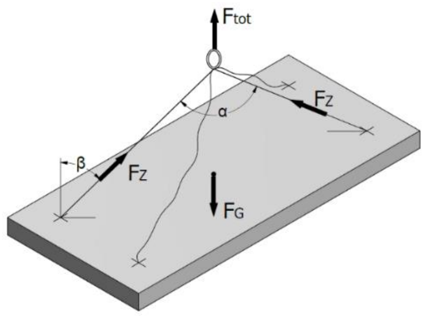
For vertical plates, the possibility that a horizontal break out can occur must be taken into account. The vertical reinforcement present has no effect on the anchoring force here either. The situation in the figure will become very critical if the thickness of the element is less than half the thickness of the T-slot anchor selected. In this situation, additional consultation with Terwa is necessary.

To expand the vertical anchoring, a hairpin can be adjusted which falls around the foot. In this situation, it is also very helpful to use the TKA-tilt slot anchor, an eye anchor or a rod anchor. The anchoring for these lifting anchors is obtained by inserting a reinforcement hairpin or a ribbed rod through the eye of the anchor.

## CALCULATION EXAMPLES

### Example 1: SLAB UNIT




The slab unit has the following dimensions:
$\boldsymbol{L = 5\,m}$
$\boldsymbol{w = 2\,m}$
$\boldsymbol{t = 0.2\,m}$

Weight $\boldsymbol{F_G = \rho \times V = 25 \times (5 \times 2 \times 0.2) = 50kN}$
Formwork area $\boldsymbol{A_f = L \times w = 5 \times 2 = 10\,m^2}$
Anchor number $\boldsymbol{n = 2}$

| General data: | Symbol | De-mould | Transport | Mount |
|---|---|---|---|---|
| Concrete strength at de-mould [MPa] | | 15 | 15 | |
| Concrete strength on site [MPa] | | | | 35 |
| Element weight [kN] | $F_G$ | 50 | | |
| Element area in contact with formwork [m²] | $A_f$ | 10 | | |
| Cable angle factor at de-mould ($\beta$ = 15.0°) | $z$ | 1.04 | 1.04 | |
| Cable angle factor on site ($\beta$ = 30.0°) | $z$ | | | 1.16 |
| Dynamic coefficient at transport | $\psi_{dyn}$ | | 1.3 | |
| Dynamic coefficient on site | $\psi_{dyn}$ | | | 1.3 |
| Adhesion to formwork factor for varnished timber formwork [kN/m²] | $q_{adh}$ | 2 | | |
| Anchor number for de-mould | $n$ | 2 | | |
| Anchor number for transport at the plant | $n$ | | 2 | |
| Anchor number for transport on site | $n$ | | | 2 |

### DE-MOULD AT THE PLANT:

Adhesion to formwork factor: $q_{adh}$ = 2 kN/m²
Cable angle factor: z = 1.04 ($\beta$ = 15.0°)
Concrete strength: 15 MPa

$$F_Z = \frac{[(F_G + q_{adh} \times A_f) \times z]}{n} = \frac{[(50 + 2 \times 10) \times 1.04]}{2} = 36.4\,kN$$

### TRANSPORT AT THE PLANT:

Dynamic coefficient: $\psi_{dyn}$ = 1.3
Cable angle factor: z = 1.04 ($\beta$ = 15.0°)
Concrete strength: 15 MPa

$$F_Z = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{50 \times 1.3 \times 1.04}{2} = 36.4\,kN$$

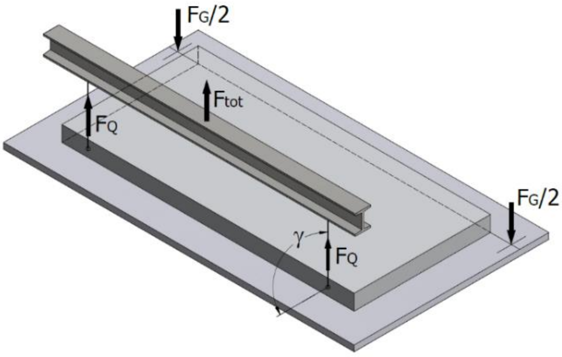
### TRANSPORT ON SITE:

Dynamic coefficient: $\psi_{dyn}$ = 1.3
Cable angle factor: z = 1.04 ($\beta$ = 15.0°)
Concrete strength: 15 MPa

$$F_Z = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{50 \times 1.3 \times 1.04}{2} = 36.4\,kN$$

An anchor in the 4**0 kN** range is required.

**Example 1: WALL PANEL**




The slab unit has the following dimensions:
$L = 6\,m$
$w = 2\,m$
$t = 0.2\,m$

Weight $F_G = \rho \times V = 25 \times (6 \times 2 \times 0.18) = 54\,kN$
Formwork area $A_f = L \times w = 6 \times 2 = 12\,m^2$
Anchor number $n = 2$

| General data: | Symbol | De-mould | Tilting | Mount |
|---|---|---|---|---|
| Concrete strength at de-mould [MPa] | | 15 | 15 | |
| Concrete strength on site [MPa] | | | | 45 |
| Element weight [kN] | $F_G$ | 54 | | |
| Element area in contact with formwork [m²] | $A_f$ | 12 | | |
| Cable angle factor at de-mould ($\beta$ = 0.0°) | $z$ | 1.0 | | |
| Cable angle factor at tilting ($\beta$ = 0.0°) | $z$ | | 1.0 | |
| Cable angle factor on site ($\beta$ = 30°) | $z$ | | | 1.16 |
| Dynamic coefficient at tilting | $\psi_{dyn}$ | | 1.3 | |
| Dynamic coefficient on site | $\psi_{dyn}$ | | | 1.3 |
| Adhesion factor for oiled steel formwork [kN/m²] | $q_{adh}$ | 1.0 | | |
| Anchor number for de-mould | $n$ | 2 | | |
| Anchor number at tilting | $n$ | | 2 | |
| Anchor number for transport on site | $n$ | | | 2 |

**DE-MOULD / TILT-UP AT THE PLANT:**

Adhesion to formwork factor: $q_{adh}$ = 1 kN/m²
Cable angle factor: z = 1.04 ($\beta$ = 15.0°)
Concrete strength: 15 MPa

$$F_Q = \frac{[(F_G/2 + q_{adh} \times A_f) \times z]}{n} = \frac{[(54/2 + 1 \times 12) \times 1.04]}{2} = 19.50\,kN$$

**TRANSPORT AT THE PLANT:**

Dynamic coefficient: $\psi_{dyn}$ = 1.3
Cable angle factor: z = 1.04 ($\beta$ = 15.0°)
Concrete strength: 15 MPa

$$F_Q = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{54 \times 1.3 \times 1}{2} = 35.10\,kN$$

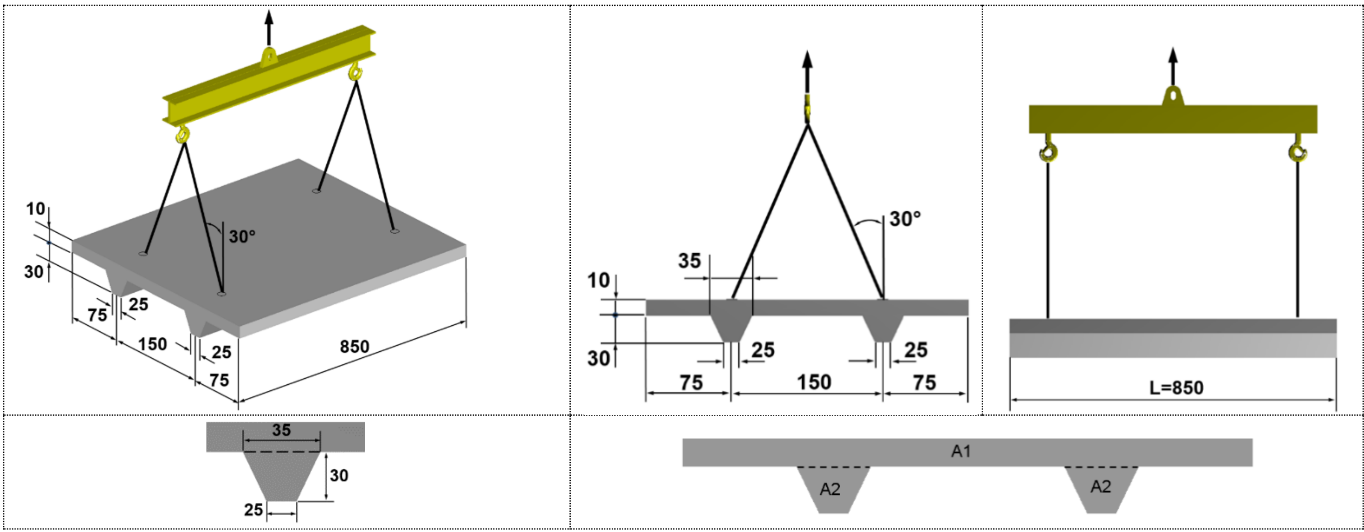
**TRANSPORT ON SITE:**

Dynamic coefficient: $\psi_{dyn}$ = 1.3
Cable angle factor: z = 1.04 ($\beta$ = 15.0°)
Concrete strength: 15 MPa

$$F_Q = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{54 \times 1.3 \times 1.16}{2} = 40.72\,kN = 41\,kN$$

Two anchors embedded on the lateral side, **TKA type in the 50 kN range** are required. For tilting, additional reinforcement will be added (see page 42).

### Example 1: DOUBLE-T BEAM




NOTE: Dimensions are in cm

| General data: | Symbol | De-mould | Transport |
|---|---|---|---|
| Concrete strength at de-mould and transport [MPa] | | 25 | 25 |
| Element weight [kN] | $F_G$ | 102 | |
| Formwork area [m²] | $A_f$ | 35.8 | |
| Cable angle factor at de-mould (ß = 30.0°) | z | 1.16 | |
| Cable angle factor on site (ß = 30.0°) | z | | 1.16 |
| Dynamic coefficient at transport | $\psi_{dyn}$ | | 1.3 |
| Anchor number for de-mould and transport | n | 4 | 4 |

**Load capacity when lifting and transporting at the manufacturing plant.**

| | |
|---|---|
| Concrete strength when de-mould | ≥ 25 MPa |
| Cable angle factor | z = 1.16 (ß = 30.0°) |
| Dynamic coefficient | $\psi_{dyn}$ = 1.3 |
| Anchor number | n = 4 |

$$F_G = V \times \rho = (A \times L) \times \rho = (A1 + A2 \times 2) \times L \times \rho = (0.1 \times 3 + 0.09 \times 2) \times 8.5 \times 25 = 102\ kN$$
$$L = 5\ m$$
$$A1 = 0.1 \times 3\ (m^2)$$
$$A2 = \frac{[(0.35 + 0.25) \times 0.3]}{2} = \frac{(0.6 \times 0.3)}{2} = 0.09\ (m^2)$$

| | |
|---|---|
| Weight: | $F_G = 102\ kN$ |
| Adhesion to mould | $F_{adh} = 2 \times F_G = 102\ kN$ |
| Total load | $F_{tot} = F_G + F_{adh} = 102 + 204 = 306\ kN$ |

**LOAD PER ANCHOR WHEN DE-MOULD:**

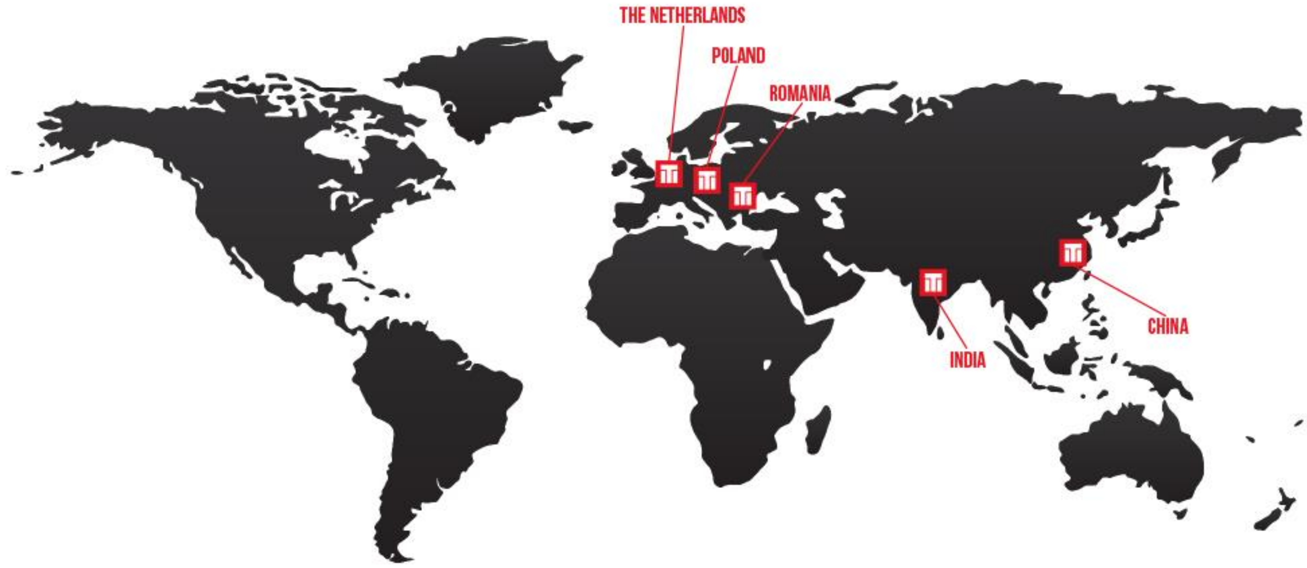
$$F = \frac{F_{tot} \times z}{n} = \frac{[(F_G + F_{adh}) \times z]}{n} = \frac{306 \times 1.16}{4} = 36.4\ kN$$

**LOAD PER ANCHOR WHEN TRANSPORTING:**

$$F = \frac{F_{tot} \times \psi_{dyn} \times z}{n} = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{102 \times 1.3 \times 1.16}{4} = 38.46\ kN$$

**Four anchors in the 100 kN range are required (> 88.74 kN)**

**CONTACT**

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