

## TECHNICAL DOCUMENTATION



### 2D - LIFTING SYSTEMS | **TF2 LIFTING CLUTCHES**



**TABLE OF CONTENTS:**

|  |           |
|--|-----------|
| <b>2D LIFTING CLUTCHES.....</b>  | <b>3</b>  |
| <b>2D LIFTING CLUTCHES – DIMENSIONS AND COMPONENTS.....</b>                        | <b>4</b>  |
| <b>2D LIFTING CLUTCHES – APPLICATION INSTRUCTIONS.....</b>                         | <b>5</b>  |
| <b>MISUSE OF THE LIFTING SYSTEM .....</b>  | <b>7</b>  |
| <b>CHECKING THE LIFTING SYSTEM.....</b>  | <b>8</b>  |
| <b>STORAGE REQUIREMENTS .....</b>  | <b>10</b> |
| <b>SAFETY INSTRUCTIONS.....</b>  | <b>10</b> |
| <b>GENERAL INFORMATION .....</b>   | <b>11</b> |
| <b>CE MARKING.....</b>   | <b>13</b> |
| <b>LIFTING SYSTEMS.....</b>  | <b>13</b> |
| <b>TECHNICAL INFORMATION – CHOOSING THE TYPE OF ANCHOR .....</b>                   | <b>14</b> |
| SAFETY RULES .....   | 14        |
| POSSIBLE TYPES OF FAILURE OF A LIFTING ANCHOR .....                                | 15        |
| DIMENSIONING OF LIFTING ANCHOR SYSTEM .....  | 16        |
| LOAD CAPACITY .....  | 17        |
| WEIGHT OF PRECAST UNIT .....   | 17        |
| ADHESION TO FORMWORK COEFFICIENT .....   | 17        |
| DYNAMIC LOADS COEFFICIENT .....  | 18        |
| LIFTING OF PRECAST CONCRETE ELEMENT UNDER COMBINED TENSION AND SHEAR LOADING ..... | 18        |
| ASYMMETRIC DISTRIBUTION OF THE LOAD .....  | 19        |
| ANCHORS LIFTING CONDITIONS .....   | 20        |
| LOAD DIRECTIONS .....  | 22        |
| POSITIONING THE ANCHORS IN WALLS.....  | 23        |
| DETERMINATION OF ANCHOR LOAD.....  | 24        |
| <b>BASIC PRINCIPLES FOR THE ANCHOR SELECTION .....</b>                             | <b>25</b> |
| <b>CALCULATION EXAMPLES .....</b>  | <b>26</b> |
| EXAMPLE 1: SLAB UNIT .....   | 26        |
| EXAMPLE 1: WALL PANEL .....  | 27        |
| EXAMPLE 1: DOUBLE-T BEAM .....   | 28        |
| <b>CONTACT .....</b>   | <b>29</b> |
| <b>DISCLAIMER .....</b>  | <b>29</b> |

## 2D LIFTING CLUTCHES

| Load group [kN]       | Lifting system         | Anchor group [kN] | Load range anchor [kN]   |
|-----------------------|------------------------|-------------------|--------------------------|
| 15 (12.5 kN – 15 kN)  | TF1 - 012              | 12.5 – 15         | 12.5<br>15               |
| 25 (7 kN – 25 kN)     | TF1 - 025<br>TF2 - 025 | 14 – 25           | 7<br>14<br>20<br>25      |
| 50 (30 kN – 50 kN)    | TF1 - 050<br>TF2 - 050 | 30 – 50           | 30<br>40<br>50           |
| 100 (53 kN – 100 kN)  | TF1 - 100<br>TF2 - 100 | 53 – 100          | 53<br>75<br>100          |
| 260 (125 kN – 260 kN) | TF1 - 260<br>TF2 - 260 | 125 – 260         | 125<br>140<br>220<br>260 |

*Only components in the same load group can be combined.*



TF2 - 25 kN  
 TF2 - 50 kN  
 TF2 - 100 kN  
 TF2 - 260 kN

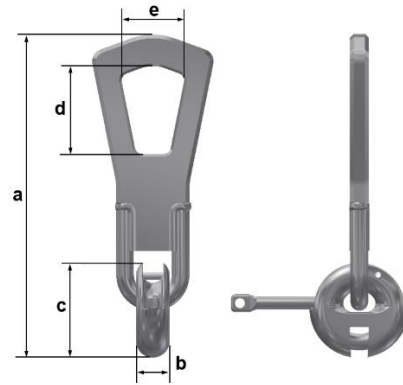
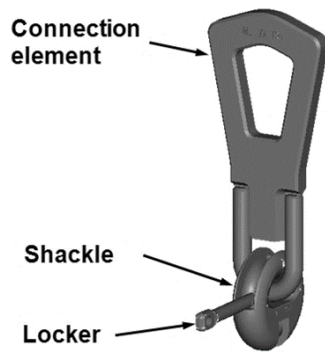
The lifting systems TF1 are made of high-grade steel wire rope according EN 12385-4, swaged in a ferrule made of AlMg1.8, and a shackle produced from high-strength steel. TF2 are made of high-quality steel and are designed with a safety factor  $c=5$ . When TF1 and TF2 systems are assembled with the corresponding anchor, together they have the anchor minimum safety factor of  $c=3$ .

Before delivery, the working load of each system is tested three times, and individual testing certificates are attached.

TF2s are different from TF1s due to the connection element (bracket) to the crane hook: the TF1 system's connection element is made with heavy-duty wire cable according EN12385-4.

The clutch head (shackle) in each load group matches the shape of the recess former RBF and incorporates a locker, which is inserted in the appropriate head anchor hole.

## 2D LIFTING CLUTCHES – DIMENSIONS AND COMPONENTS



**Note:** Each lifting clutch TF2 is marked with the anchor load group, the CE marking, the manufacturer and identification numbers.

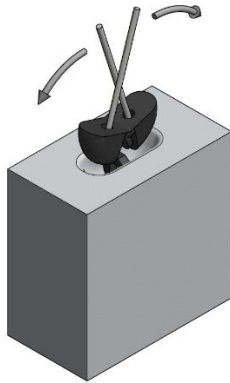
| TF2<br>(Zinc plated) | Load class | Load Range | Dimensions |      |      |       |      |     |
|----------------------|------------|------------|------------|------|------|-------|------|-----|
|                      |            |            | a          | b    | c    | d     | e    |     |
|                      |            |            | [mm]       | [mm] | [mm] | [mm]  | [mm] |     |
| TF2 -025             | 44843      | 25         | 7 – 25     | 259  | 27   | 78,5  | 70   | 50  |
| TF2 -050             | 44844      | 50         | 30 – 50    | 325  | 36   | 105   | 86   | 58  |
| TF2 -100             | 44845      | 100        | 53 – 100   | 431  | 50   | 146,7 | 107  | 75  |
| TF2 -260             | 44846      | 260        | 125 – 260  | 620  | 72   | 216   | 154  | 110 |

## 2D LIFTING CLUTCHES – APPLICATION INSTRUCTIONS

### 1) De-mould

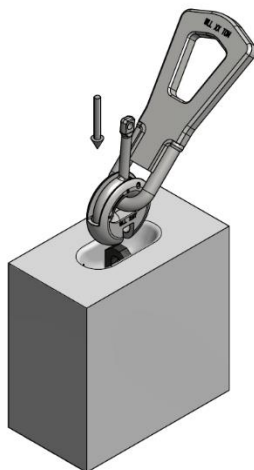
Before lifting the precast concrete element, removing as many parts of the formwork as possible to minimise adhesion to the mould is recommended. In the de-mould process, the forces acting on the lift system are considerably greater than the actual weight of the precast element. In the opposite case, the precast concrete unit may flake.

### 2) Removing the recess former



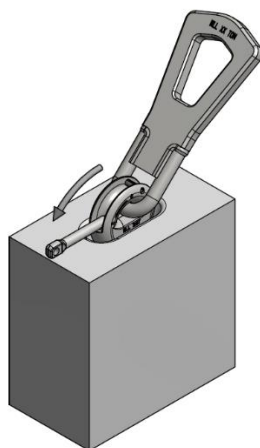
To remove the recess former, two rods are inserted in the holes in the recess former, after which they are levered out by scissoring action. Do not use a hammer to remove the recess former as that may destroy the former.

### 3) Attaching the lifting system



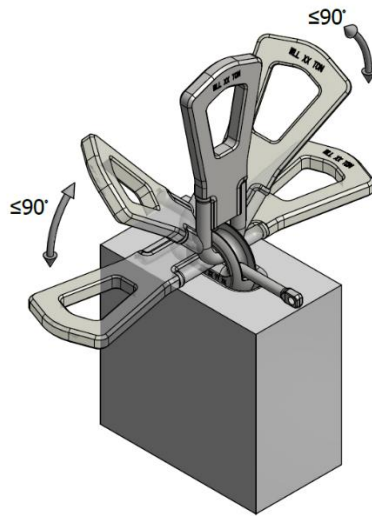
To transport the concrete units, the appropriate lifting system for the load group is inserted above the anchor head. Only matching components will fit together.

### 4) Locking the lifting system



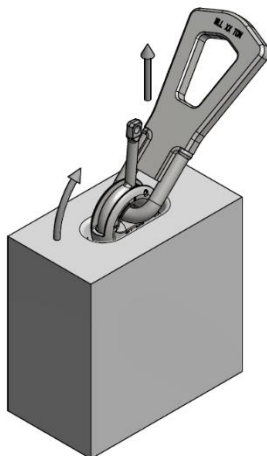
The lifting system is locked using a simple handle on the locker. The lifting system is now free to move in any direction. From this moment, the precast concrete unit can be lifted out of the formwork and transported to the storage site. As a rule, the lifting angle should be 30°, but it can be up to 45°.

### 5) Handling the system



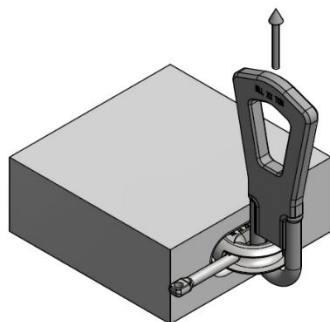
The clutch's 2D lifting bracket can be moved in any direction. Overloading the lifting anchor is not permitted (see the 2D lifting anchors conditions).

### 6) Releasing the lifting system



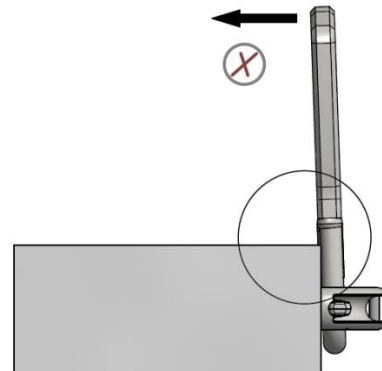
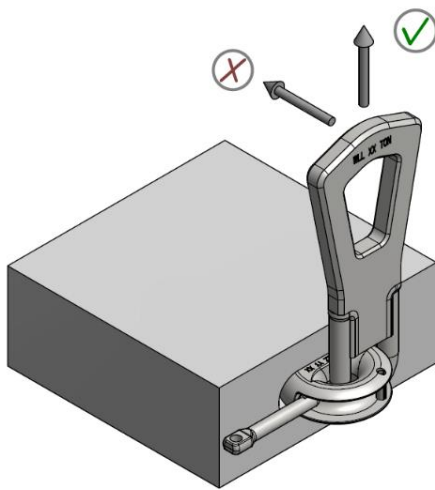
After the lifting/transport of the precast element, the lifting system can be easily released by pushing back the locker after the system is off load. The lifting clutch can remain attached to the crane hook until further use.

### 7) Moving slabs from the horizontal to vertical position

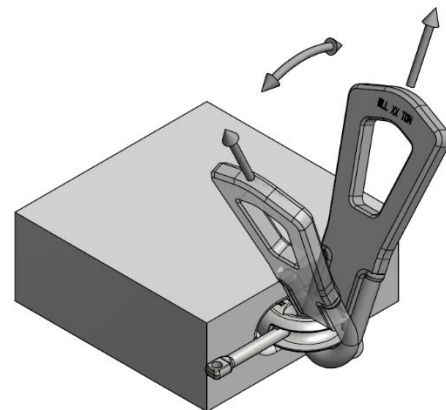
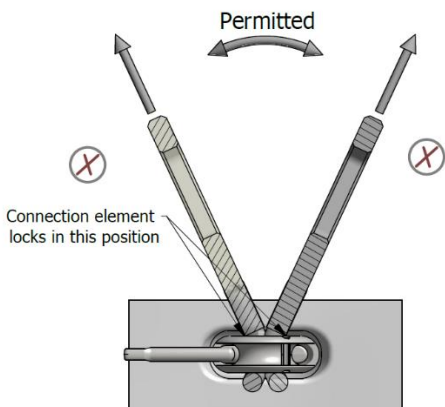


The flat precast concrete units can be moved from the horizontal to vertical position by using TILT UP anchor SA -TU or SA -TTU with additional reinforcement embedded in concrete. The direction of pull is at right angles to the cast-in anchor. Using a crossbeam for lifting to avoid angular and torsion forces is recommended.

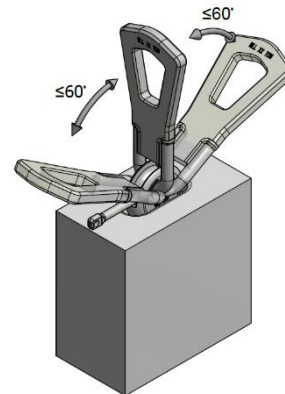
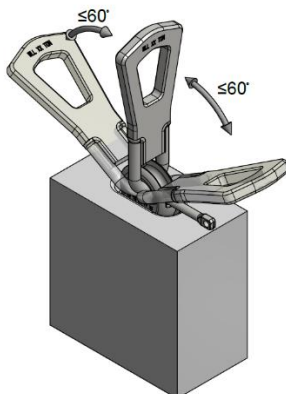
### MISUSE OF THE LIFTING SYSTEM



If the lifting direction is not headed, the precast element or the lifting clutch can suffer major damage. Proper use can prevent damage and extend the service life of the lifting system.



In this position, the connection element may lock inside the shackle. A small angle of the lifting cable angle will determine the bracket to bend. The problem can be overcome by turning the connection element. In this position, the connection element cannot lock.



*Angled pull using cable or chain with  $\beta > 45^\circ$  is **not allowed**.*

## CHECKING THE LIFTING SYSTEM

Just as with all lifting devices, trained personnel must inspect the TF1, TF2 lifting system at least twice a year. Any deformation of a locker indicates that the permitted load has been exceeded at least three times. A damaged locker can be replaced. No other repairs are permitted.


- **Any deformation to the wire rope (see the type of damages mentioned on page 50), shackle, or metal structural elements weakens 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.

**Combining products from different companies is not recommended.**


### • The locker

A lifting system with a worn or bent locker must be taken out of use. The wear on the locker must be less than the limits shown in the following table.

|  | Load group | Nominal dimension d | Minimum dimension d |
|---|------------|---------------------|---------------------|
|   | [kN]       | [mm]                | [mm]                |
|   | 12.5– 15   | Ø 8 +0.3/0          | 7.5                 |
|   | 25         | Ø 13 +0.5/0         | 12                  |
|   | 50         | Ø 17 +0.5/0         | 16                  |
|   | 100        | Ø 22 +0.5/0         | 21                  |
|   | 260        | Ø 32 +0.5/0         | 31                  |

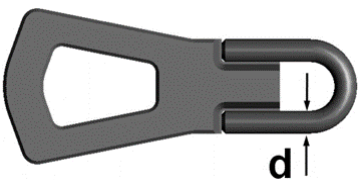
### • The shackle

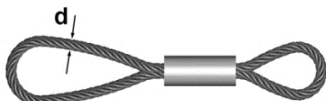
If the shackle is deformed or the opening “e” is enlarged, the lifting system must be taken out of use and cannot be repaired. The wear on the locker must be less than the limits shown in the following table.

|  | Load group | Nominal dimension e | Maximum dimension e |
|---|------------|---------------------|---------------------|
|   | [kN]       | [mm]                | [mm]                |
|   | 12.5– 15   | 7 +0.5/0            | 8                   |
|   | 25         | 13 +0.5/0           | 14                  |
|   | 50         | 20 +0.5/0           | 21                  |
|   | 100        | 22 +0.5/0           | 23                  |
|   | 260        | 33 +1.0/0           | 35                  |

### • The connection element

Connection elements (bracket) to the crane hook which have visible signs of damage or excessive wear must be immediately taken out of use. The wear on the bracket must be less than the limits shown in the following tables.

|  | Load group | Nominal dimension d | Minimum dimension d |
|---|------------|---------------------|---------------------|
|   | [kN]       | [mm]                | [mm]                |
|   | 25         | 14                  | 13                  |
|   | 50         | 20                  | 19                  |
|   | 100        | 26                  | 25                  |
|   | 260        | 40                  | 38,5                |







|  | 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:

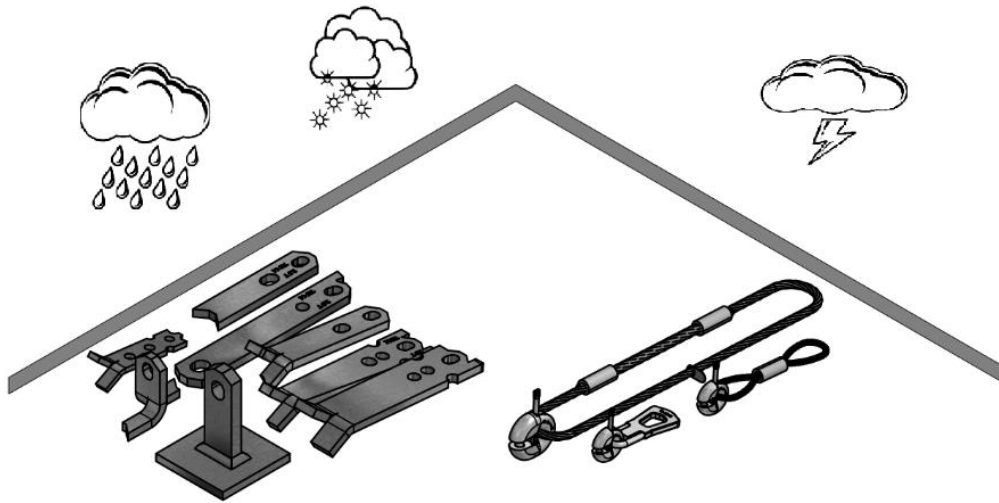


- Kinking
- One strand is broken
- Separation of the outer layer of braids
- Crushed strands
- Crushing at the shackle contact point with more than 4 ruptured wires on braided cables or more than 10 ruptured wires on cable-laid rope
- Signs of corrosion
- Damage to or severe wear of the closing bush.
- 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

| <b>Wire rope dimensions</b>  |  |  |
|--|--|--|
|   |   |   |
| <b>Kinking</b>   | <b>Severe wear</b>   | <b>Bird caging</b>   |
|  |  |  |
| <b>Broken wire</b>   | <b>Corrosion</b>   | <b>Closing bush damage</b>   |

## 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

The strip anchor lifting system manufactured by TERWA is a high quality, safe, easy to handle, cost-effective system. It used for transporting all types of concrete elements.

Some of the important advantages of these systems include:

- Safe, simple and fast connection and disconnection between lifting links and correspondent anchors.
- Anchors and lifting keys are designed for load capacities between **0.7 – 26.0 t**.
- High-quality alloy material for lifting keys and anchors can be used in any environment.
- Available in a hot-dip galvanised version for corrosion protection.
- 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 strip 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.

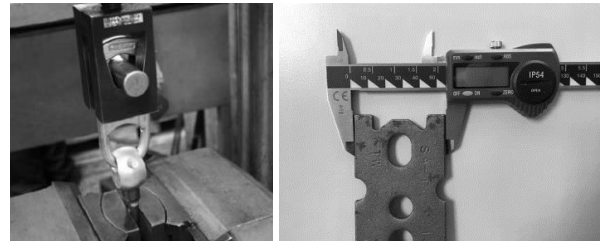
A failure of lifting anchors and lifting anchor devices can endanger human lives as well as can lead to significant damage. Therefore, lifting anchors and lifting devices must be produced with high quality, carefully selected and which are designed for the respective application and used by skilled personnel according to lifting and handling instructions.

The anchors are designed to resist at a minimum safety factor = 3.

**Welding on the anchor is not permitted.**

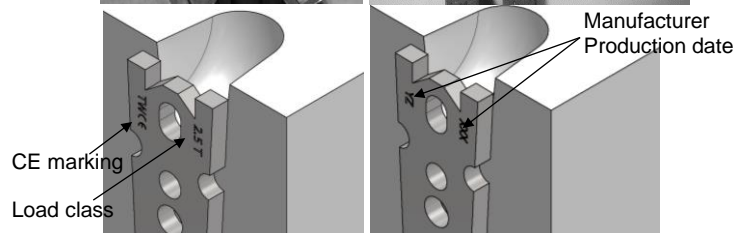
### Quality

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.



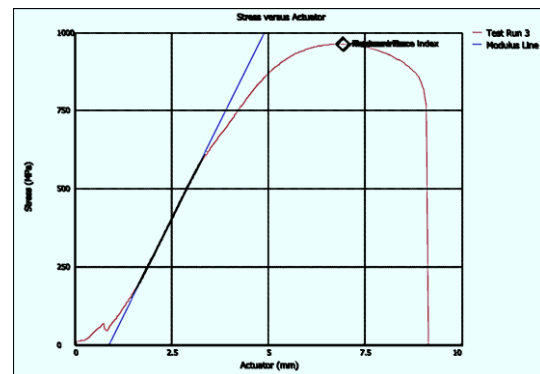
### Marking and traceability

All anchors and lifting clutches have the CE marking and all data necessary for traceability and load class.



### Anchor testing

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



### Application of lifting anchor system

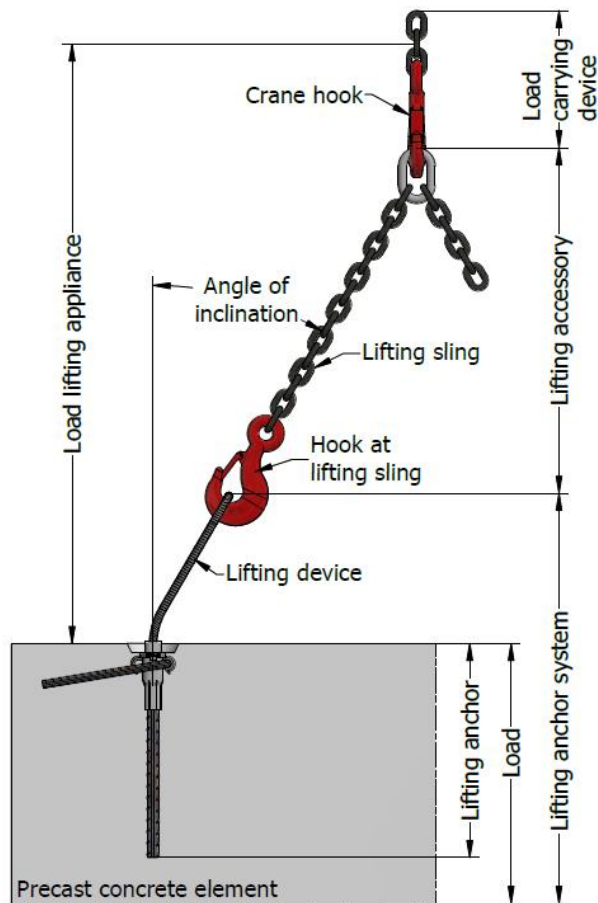
**Load carrying devices** - are equipment that is permanently connected to the hoist for attaching lifting devices, lifting accessory or loads.

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

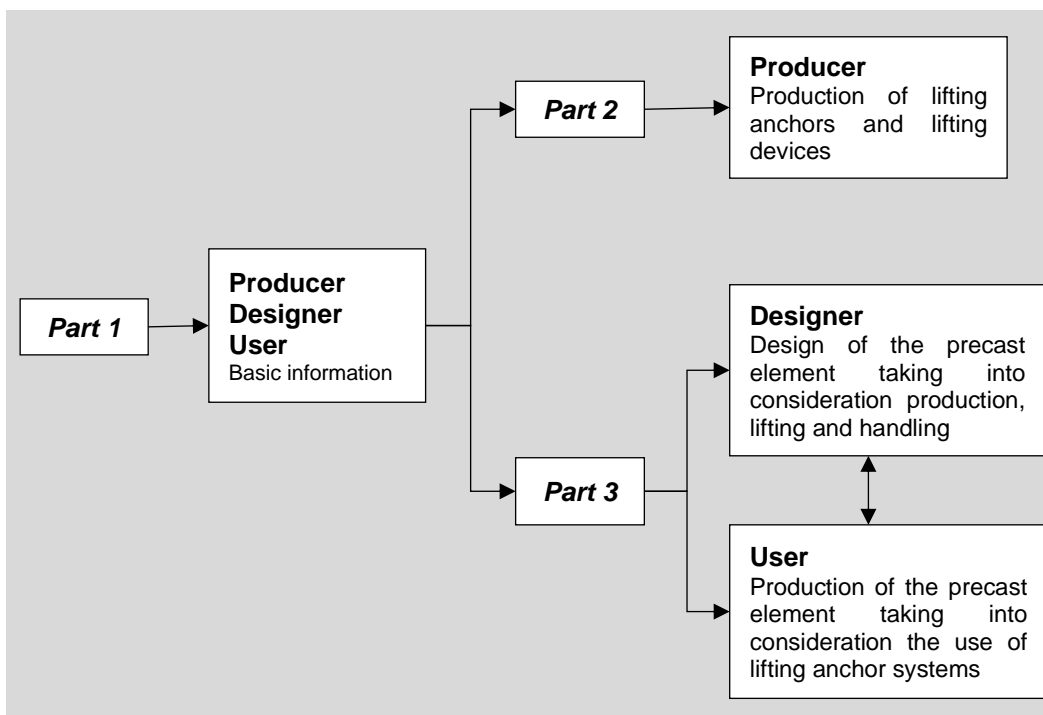
**Lifting device (lifting key)** – equipment that connects the loads to the load carrying device by means of lifting accessories.

**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

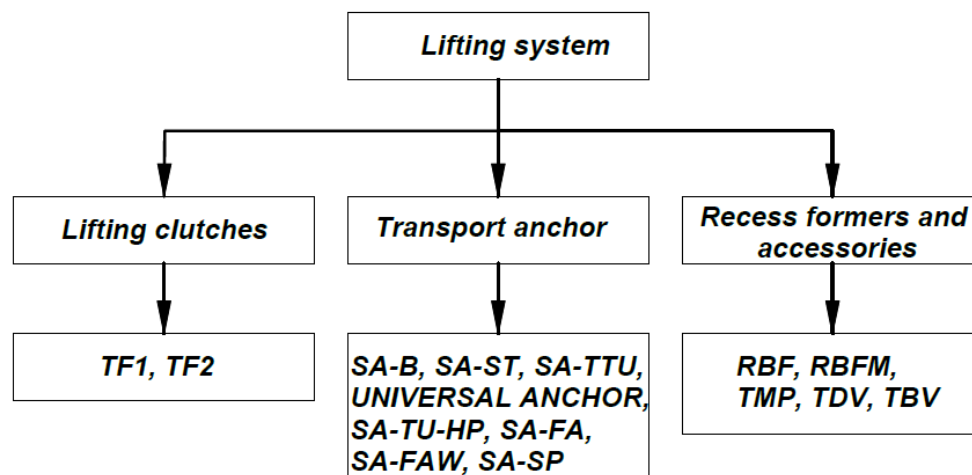
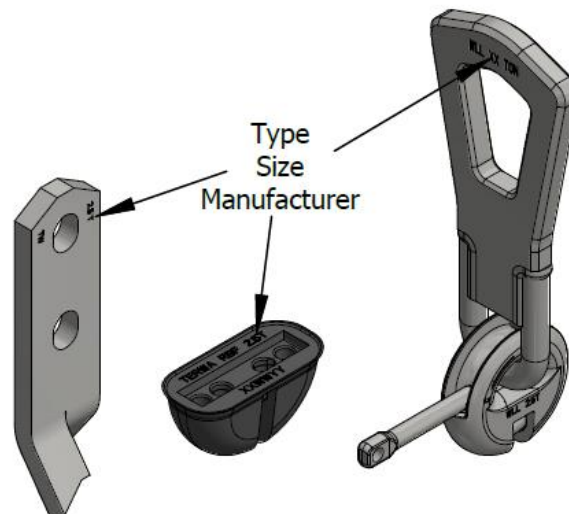
CE marking means that a product is manufactured and inspected in accordance with a harmonised European standard (hEN) or a European Technical Approval (ETA). ETA can be used as the basis for CE marking for cases in which there is no hEN. However, ETA is voluntary and not required by EU directives or 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 SYSTEMS

- **RE-USABLE LIFTING SYSTEM**  
Terwa offers various types of ring clutches suitable for lifting, transport and installation of precast concrete elements.
- **TRANSPORT ANCHORS**  
Strip anchors made from high-quality steel.
- **RECESS FORMERS AND MOUNTING ACCESSORIES**  
Wide range of mounting accessories for fixing the anchors to the formwork during the production of the precast element.



## TECHNICAL INFORMATION – CHOOSING THE TYPE OF ANCHOR

Terwa has 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 lifting system consists of a threaded anchor embedded in concrete and a threaded lifting device. The threaded lifting loop is connected to the anchor only when required for lifting. **Ensure that the concrete has reached MPa strength of at least 15 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)

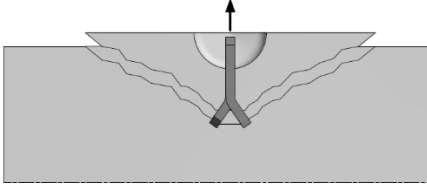
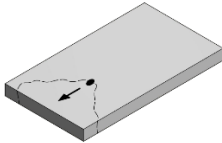
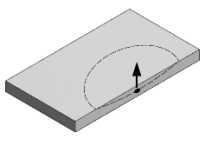
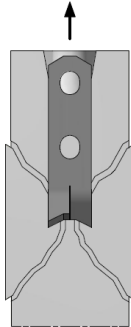
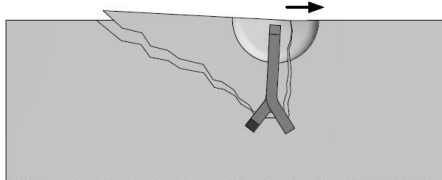
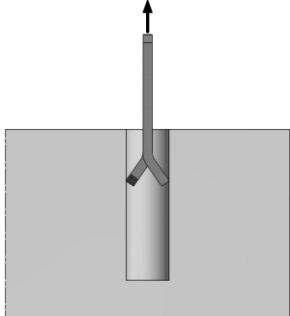
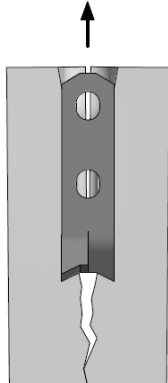
The admissible load (resistance) of lifting anchor and lifting device is obtained as follows:

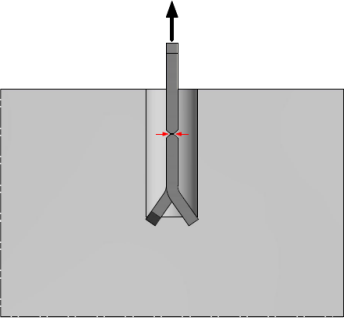
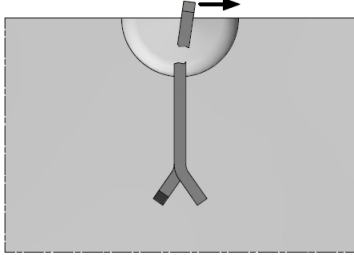
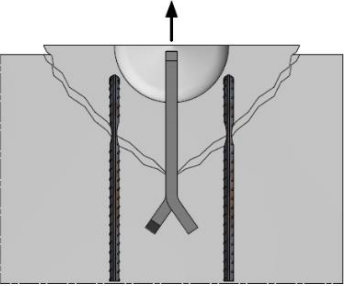
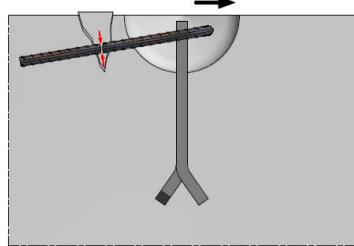
$R_{adm} = \frac{R_k}{\gamma}$  Where:  $R_k$  - characteristic resistance of the anchoring of a lifting anchor or lifting device,  $\gamma$  - global safety factor

**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   |   |
|--|---|--|---|
| <p><b>Concrete break-out</b><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</p>   |    |    |  |
| <p><b>Local concrete break-out (blow-out)</b><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.</p> |   |  |   |
| <p><b>Pry-out (rear breakout of concrete)</b><br/>           Failure mode characterised by the concrete breaking out opposite the direction of load, on lifting anchors with shear load.</p>   |   |  |   |
| <p><b>Pull-out</b><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.</p>   |  |  |   |
| <p><b>Splitting of the component</b><br/>           A concrete failure in which the concrete fractures along a plane passing through the axis of the lifting anchor.</p>   |  |  |   |

| Failure type   | Fracture pattern: tensile force   | Fracture pattern: transverse shear force  |
|--|---|---|
| <b>Steel failure</b><br>Failure mode characterised by fracture of the steel lifting anchor parts.  |  |  |
| <b>Steel failure of additional reinforcement</b><br>Steel failure of the supplementary reinforcement loaded directly or indirectly by the lifting anchor |  |  |

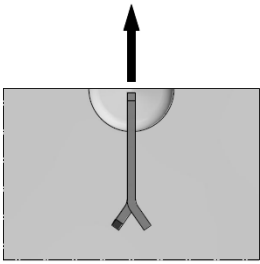
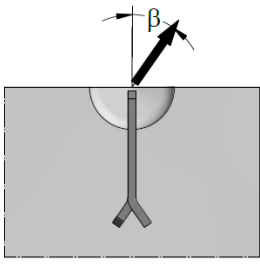
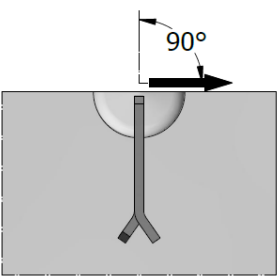
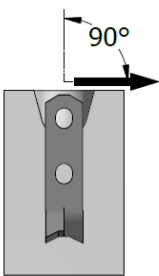
### DIMENSIONING OF LIFTING ANCHOR SYSTEM

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

| <i>Direction of stress</i>   |   |   |   |
|--|---|---|---|
| <i>Axial tension</i>   |   | <i>Parallel shear pull</i>  |   |
| Load or load component action in the direction of the longitudinal axis of the lifting anchor.   |  | Load or load component action at an angle $\beta$ to the longitudinal axis of the lifting anchor in the plane of the precast component. |  |
| <i>Transverse shear pull parallel to the structural element plane</i>  |   | <i>Transverse shear pull perpendicular to the structural element plane</i>  |   |
| Load or load component parallel to the surface of structural element and to the plane of the element, acting at an angle $\beta$ 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.                    |  |



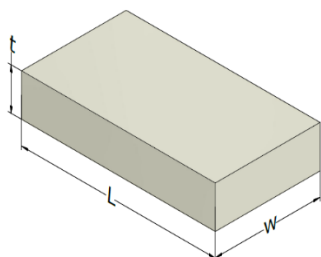
## LOAD CAPACITY

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:  $\rho = 25\text{kN/m}^3$ . 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  $[\text{m}^3]$

$L$  - length in  $[\text{m}]$

$w$  - width in  $[\text{m}]$

$h$  - thickness in  $[\text{m}]$

## 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:

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

Where:  $F_{adh}$  – action due to adhesion and form friction, in kN

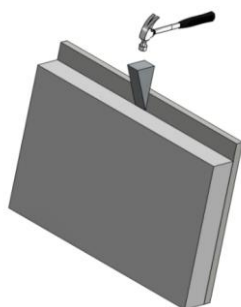
$q_{adh}$  - the adhesion to formwork and form friction factor corresponding to the material of the formwork

$A_f$  - the area of contact between the formwork and the concrete element when starting the lift

| Adhesion to the formwork                           | $q_{adh}$ in $\text{kN/m}^2$ |
|--|------------------------------|
| 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           | $F_{adh} = 2 \times F_G \text{ [kN]}$ |
| Ribbed elements          | $F_{adh} = 3 \times F_G \text{ [kN]}$ |
| Waffled panel            | $F_{adh} = 4 \times F_G \text{ [kN]}$ |



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<br>$\Psi_{dyn}$ |
|--|--------------------------------|
| Tower crane, portal crane and mobile crane | 1.3 *)                         |
| Lifting and moving on flat terrain         | 2.5                            |
| Lifting and moving on rough terrain        | $\geq 4.0$                     |

\*) 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  $\beta \leq 30^\circ$ . The tensile force on the anchor will be increased by a cable angle coefficient "z".

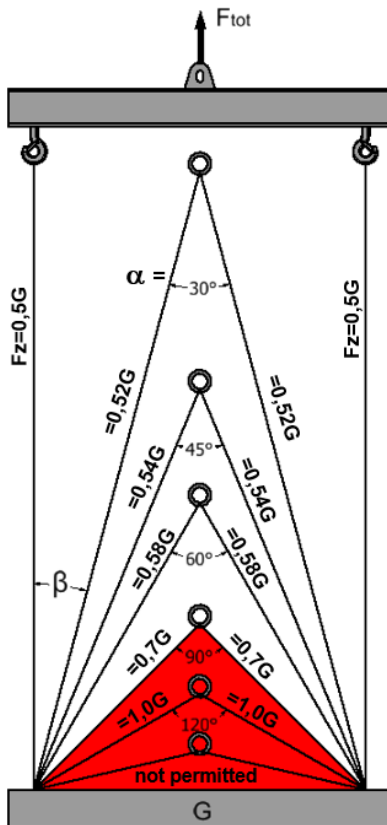
$$z = 1/\cos\beta$$

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

Where:

z - cable angle coefficient

n - number of load bearing anchors



| Cable angle<br>$\beta$ | Spread angle<br>a | Cable angle factor<br>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  $\beta \leq 30^\circ$

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

## ASYMMETRIC DISTRIBUTION OF THE LOAD

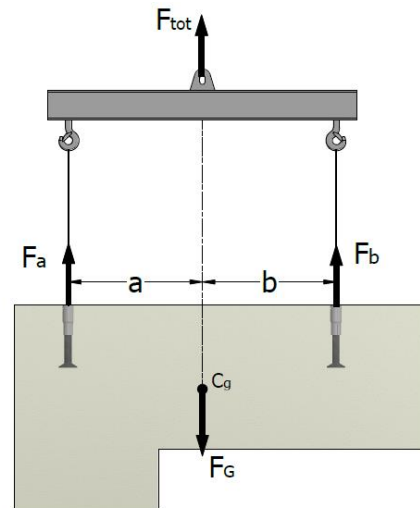
For asymmetrical elements, calculate the loads based on the centre of gravity before installing the anchors.  
 The load of each anchor depends on the embedded position of the anchor in the precast unit and on the transport mode:

- 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 asymmetrical installed anchors when a spreader beam is used, the forces on each anchor are calculated using the following equation:

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

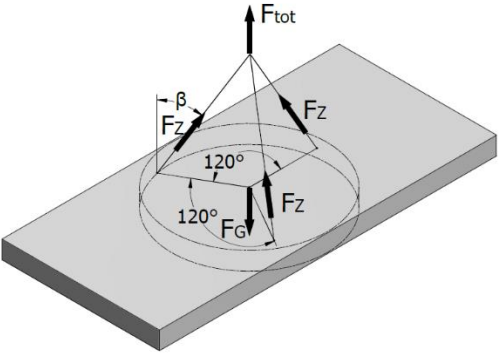
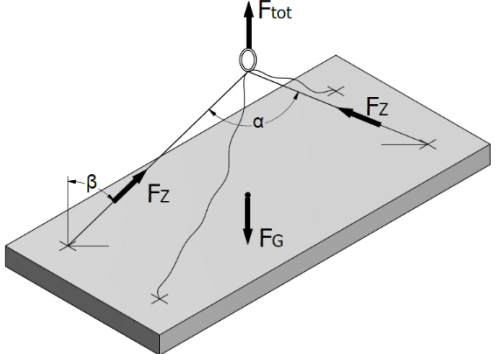
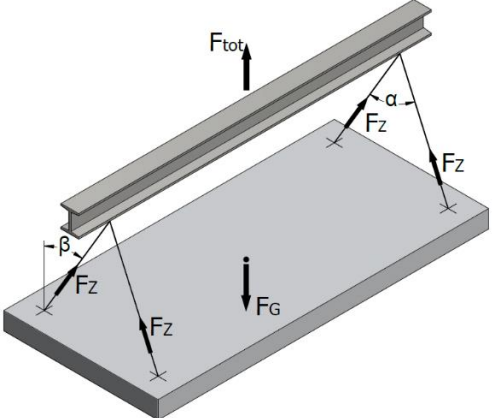
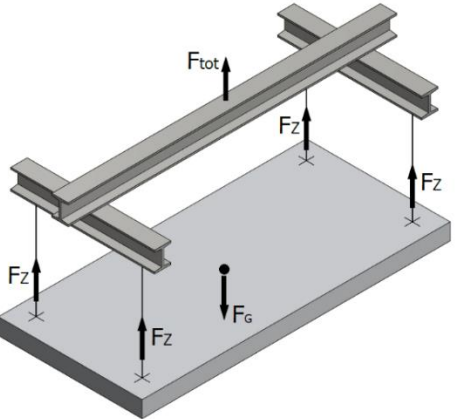
$$F_b = F_{tot} \times a / (a + b)$$

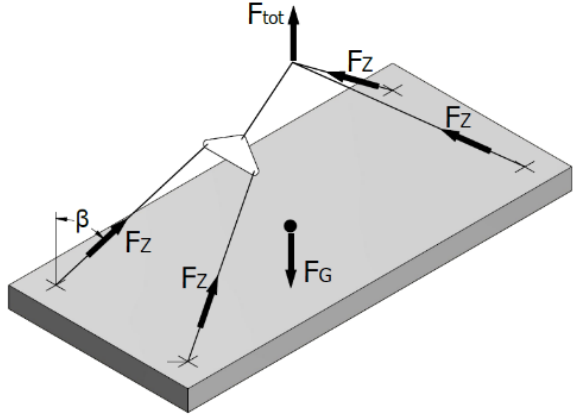
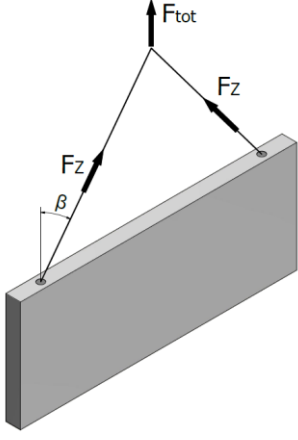
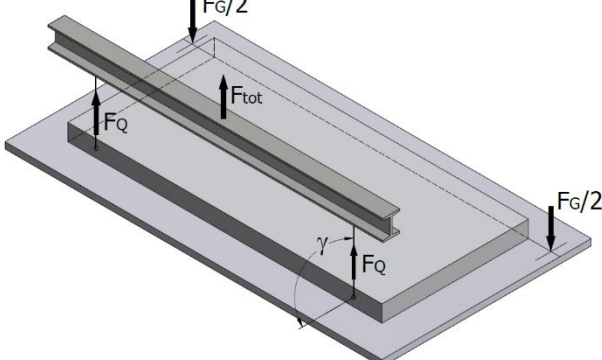
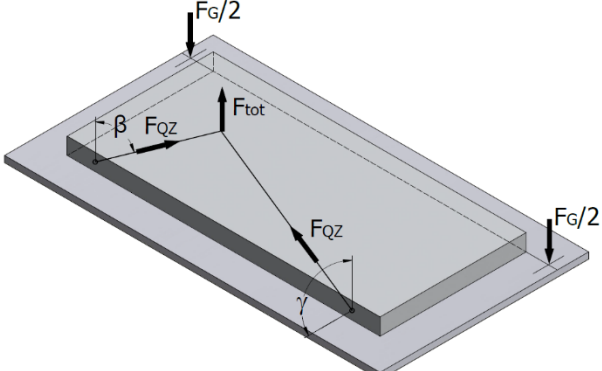
Note: To avoid tilting the element during transport, the load should be suspended from the lifting beam in such a way that its centre of gravity (Cg) is directly under the crane hook.



- b) For transporting without a lifting beam, the load on the anchor depends on the cable angle ( $\beta$ ).

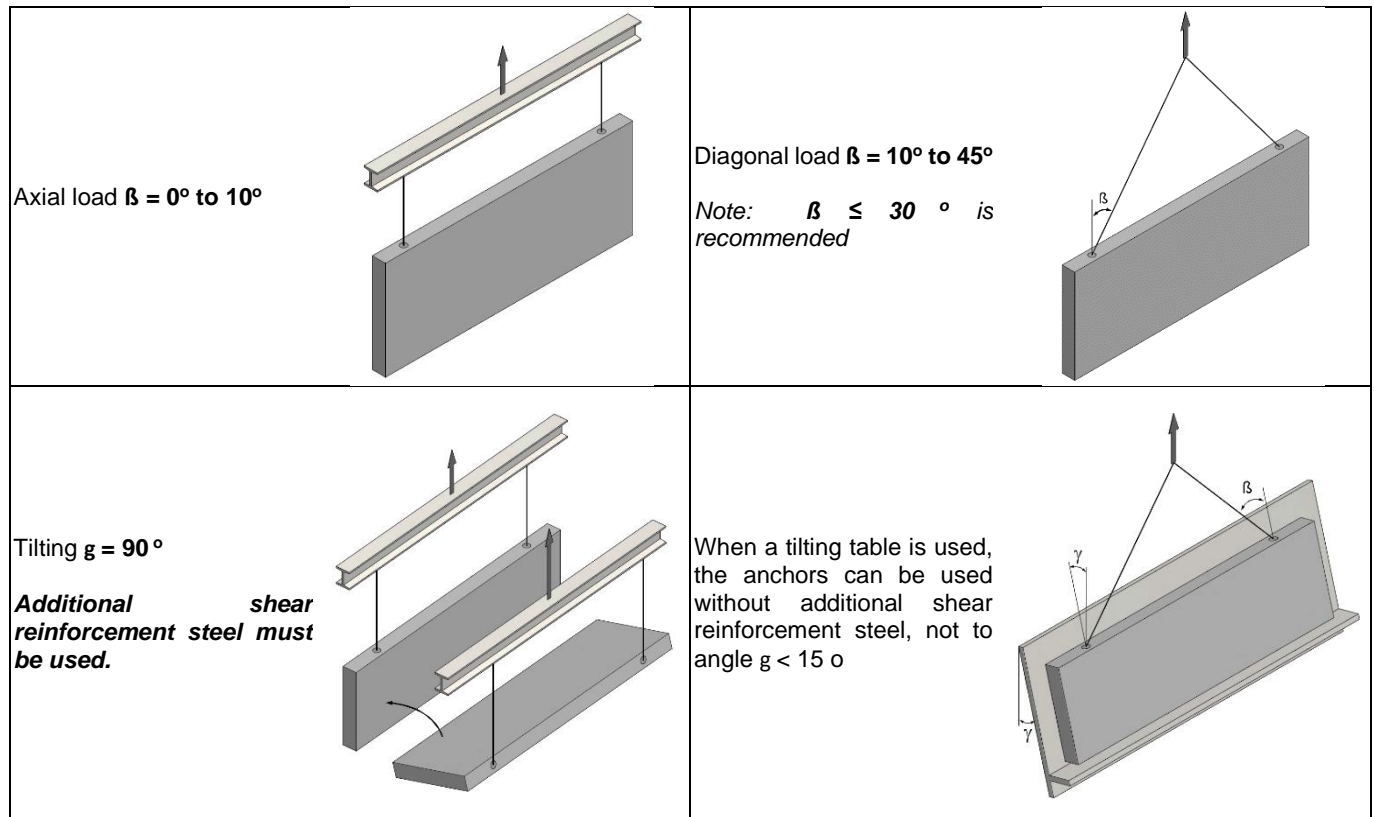
**ANCHORS LIFTING CONDITIONS**

|   |  |
|---|--|
| <p>Using three anchors spaced the same distance apart from each other as in the figure, three load bearing anchors can be assumed.</p> <p>Load bearing anchors: <b>n=3</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p>          |    |
| <p>Using four anchors lifted without a spreader beam, only two load bearing anchors can be assumed. The load distribution is randomly based</p> <p>Load bearing anchors: <b>n=3</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p> |   |
| <p>Perfect force distribution is assumed using a spreader beam</p> <p>Load bearing anchors: <b>n=3</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p>  |  |
| <p>Perfect static weight distribution can be obtained using a lifting beam and two pairs of anchors symmetrically placed.</p> <p>Bearing anchors: <b>n=3</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p>                        |  |

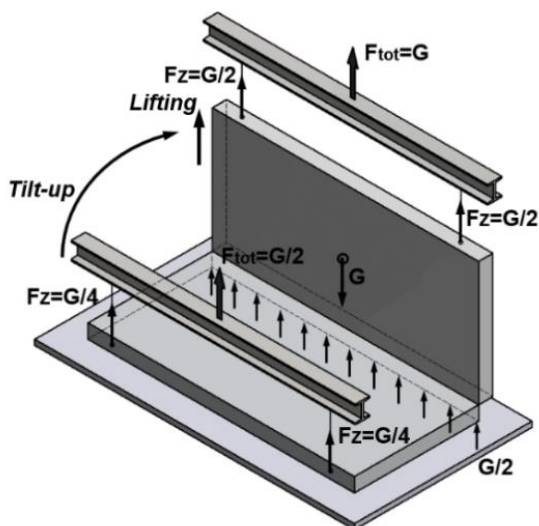
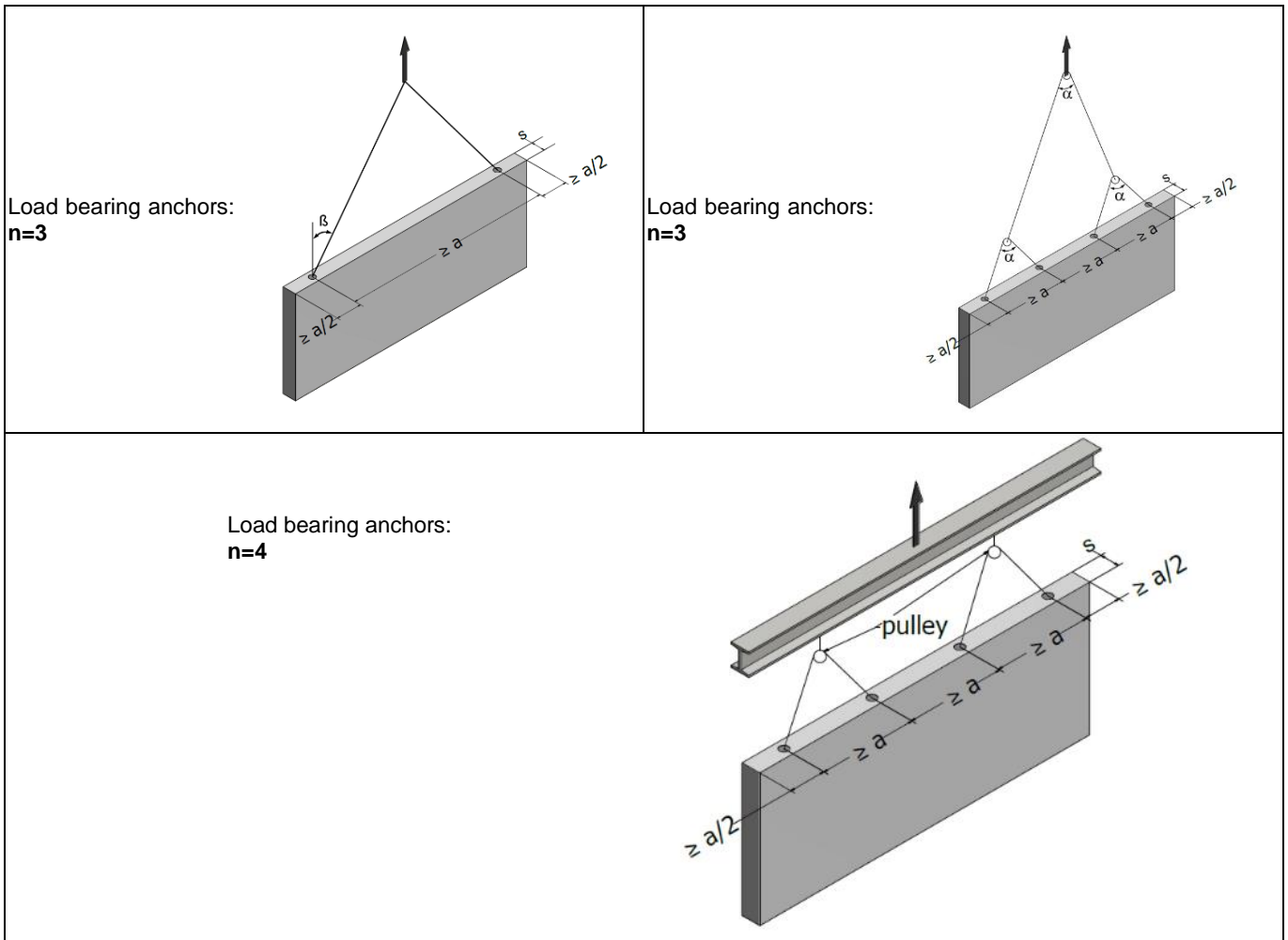
|   |  |
|---|--|
| <p>The compensating lifting slings ensure equal force distribution.<br/>                     Load bearing anchors: <b>n=4</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p>   |    |
| <p>Lifting of wall elements parallel to the axis of concrete element<br/>                     Load bearing anchors: <b>n=2</b><br/> <b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p>  |   |
| <p>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: <b>n=2</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z = 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z = 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p>  |  |
| <p>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. <math>\beta \leq 30^\circ</math><br/>                     Load bearing anchors: <b>n=2</b><br/> <b>Load type – lifting of formwork</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -formwork adhesion<br/>                     -no dynamic factor</p> <p><b>Load type – transport</b><br/>                     -shear pull factor <math>z \geq 1</math><br/>                     -no formwork adhesion<br/>                     -dynamic factor</p> |  |

## 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.



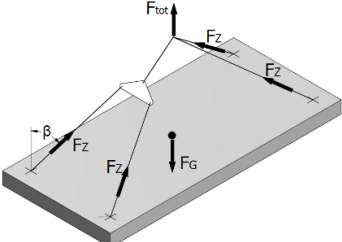
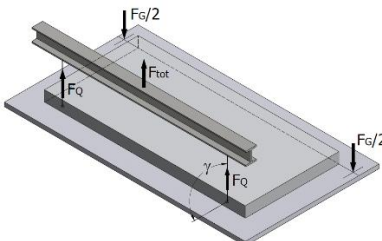
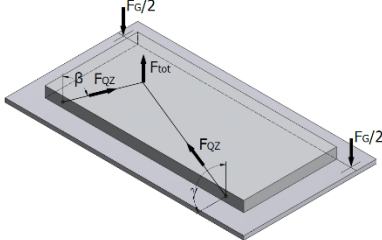
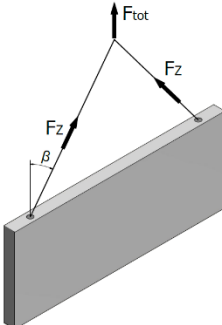
### POSITIONING THE ANCHORS IN WALLS



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.

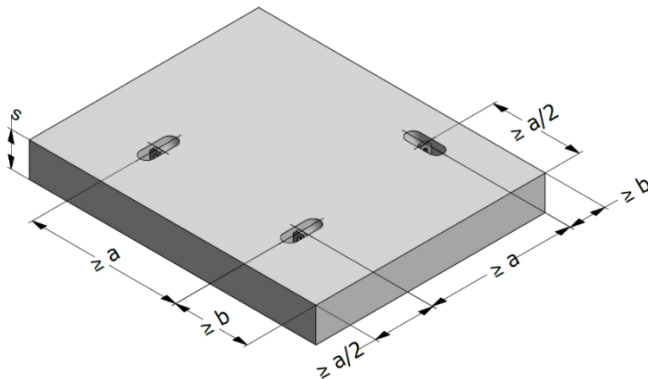
**DETERMINATION OF ANCHOR LOAD**

|                                       | <b>Load type</b>  | <b>Calculation</b>   | <b>Verification</b>   |
|---------------------------------------|---|--|---|
| <i>Lifting with formwork adhesion</i> |    | $F_Z = \frac{(F_G + F_{adh}) \times z}{n}$ <p><math>F_Z</math> – Load acting on the lifting anchor in kN</p>   | $F_Z \leq N_{R,adm}$ <p><math>N_{R,adm}</math> – admissible normal load</p>   |
| <i>Erecting</i>                       |    | $F_Q = \frac{(F_G/2) \times \psi_{dyn}}{n}$ <p><math>F_Q</math> – 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</p>                    | $F_Q \leq V_{R,adm}$ <p><math>V_{R,adm}</math> – admissible shear load</p>    |
|                                       |   | $F_{QZ} = \frac{(F_G/2) \times \psi_{dyn} \times z}{n}$ <p><math>F_{QZ}</math> – 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</p> | $F_{QZ} \leq V_{R,adm}$ <p><math>V_{R,adm}</math> – admissible shear load</p> |
| <i>Transport</i>                      |  | $F_Z = \frac{F_G \times \psi_{dyn} \times z}{n}$ <p><math>F_Z</math> – Load acting on the lifting anchor in kN</p>   | $F_Z \leq N_{R,adm}$ <p><math>N_{R,adm}</math> – admissible normal load</p>   |

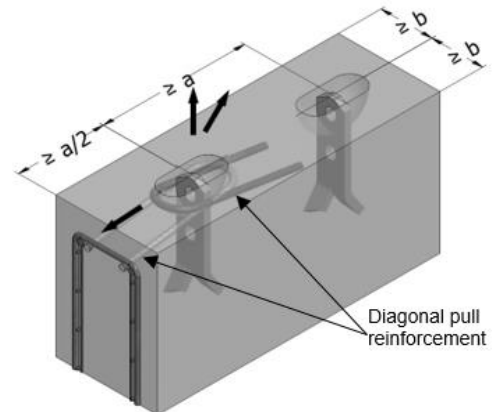


## BASIC PRINCIPLES FOR THE ANCHOR SELECTION

### Anchors for large surface precast unit



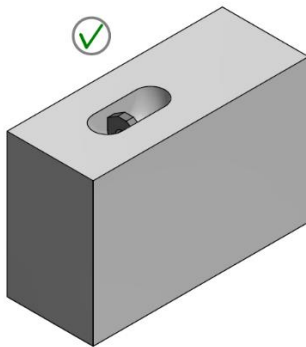
### Anchors for thin-walled precast units



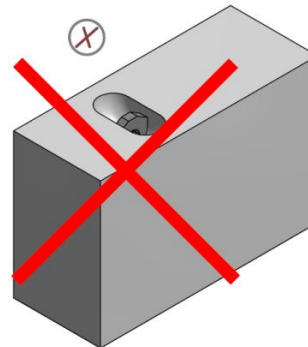
When the load is near the narrow edge, reinforcement for angled pull is necessary. Design and use of the diagonal reinforcement must comply with EN 1992.

### Anchors are for placement in thin-walled elements

In thin-walled units, such as panels, the anchors may only be installed with the flat steel at right angles to the slab.

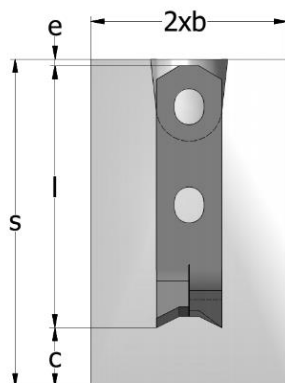


CORRECT INSTALLATION



INCORRECT INSTALLATION

### Minimum thickness of the elements



$$S = c + l + e$$

Where:

$S$  = minimum thickness of precast unit

$l$  = anchor length

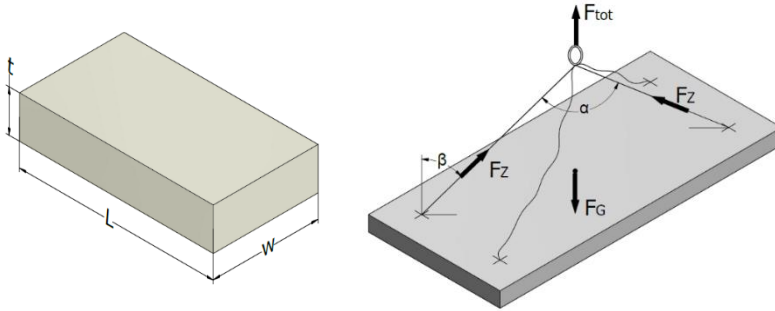
$e$  = cover to anchor head

$c$  = concrete cover according to EN 1992

The length of the anchor depends on the minimum thickness of precast units and must be chosen correctly with respect to the standards.

## CALCULATION EXAMPLES

### EXAMPLE 1: SLAB UNIT



The slab unit has the following dimensions:

$$L = 5 \text{ m}$$

$$w = 2 \text{ m}$$

$$t = 0.2 \text{ m}$$

$$\text{Weight } F_G = \rho \times V = 25 \times (5 \times 2 \times 0.2) = 50 \text{ kN}$$

$$\text{Formwork area } A_f = L \times w = 5 \times 2 = 10 \text{ m}^2$$

$$\text{Anchor number } n = 2$$

| 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 [m <sup>2</sup> ]                        | $A_f$        | 10       |           |       |
| Cable angle factor at de-mould ( $\beta = 15.0^\circ$ )                        | $z$          | 1.04     | 1.04      |       |
| Cable angle factor on site ( $\beta = 30.0^\circ$ )                            | $z$          |          |           | 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/m <sup>2</sup> ] | $q_{adh}$    | 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:

$$q_{adh} = 2 \text{ kN/m}^2$$

Cable angle factor:

$$z = 1.04 (\beta = 15.0^\circ)$$

Concrete strength:

$$15 \text{ MPa}$$

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

#### TRANSPORT AT THE PLANT:

Dynamic coefficient:

$$\Psi_{dyn} = 1.3$$

Cable angle factor:

$$z = 1.04 (\beta = 15.0^\circ)$$

Concrete strength:

$$15 \text{ MPa}$$

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

#### TRANSPORT ON SITE:

Dynamic coefficient:

$$\Psi_{dyn} = 1.3$$

Cable angle factor:

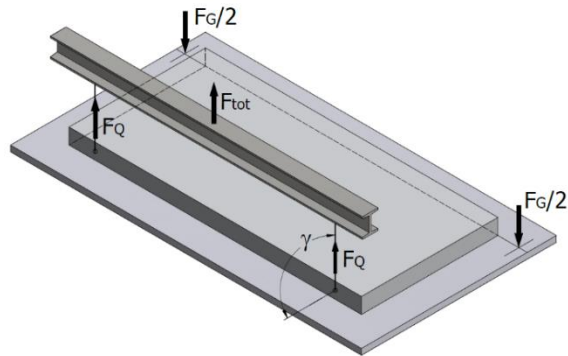
$$z = 1.16 (\beta = 30.0^\circ)$$

Concrete strength:

$$15 \text{ MPa}$$

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

An anchor in the **40 kN** range is required.

**EXAMPLE 1: WALL PANEL**


The slab unit has the following dimensions:

$$L = 5 \text{ m}$$

$$w = 2 \text{ m}$$

$$t = 0.2 \text{ m}$$

$$\text{Weight } F_G = \rho \times V = 25 \times (7.5 \times 2 \times 0.18) = 67.5 \text{ kN}$$

$$\text{Formwork area } A_f = L \times w = 7.5 \times 2 = 15 \text{ m}^2$$

$$\text{Anchor number } n = 2$$

| General data:   | Symbol       | De-mould | Tilting | Mount |
|---|--------------|----------|---------|-------|
| Concrete strength at de-mould [MPa]                           |              | 15       | 15      |       |
| Concrete strength on site [MPa]                               |              |          |         | 45    |
| Element weight [kN]   | $F_G$        | 67.5     |         |       |
| Element area in contact with formwork [m <sup>2</sup> ]       | $A_f$        | 15       |         |       |
| Cable angle factor at de-mould ( $\beta = 0.0^\circ$ )        | $z$          | 1.0      |         |       |
| Cable angle factor at tilting ( $\beta = 0.0^\circ$ )         | $z$          |          | 1.0     |       |
| Cable angle factor on site ( $\beta = 30^\circ$ )             | $z$          |          |         | 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/m <sup>2</sup> ] | $q_{adh}$    | 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:  $q_{adh} = 1 \text{ kN/m}^2$   
 Cable angle factor:  $z = 1 (\beta = 0^\circ)$   
 Concrete strength: 15 MPa

$$F_Q = \frac{[(F_G/2 + q_{adh} \times A_f) \times z]}{n} = \frac{[(67.5/2 + 1 \times 15) \times 1.04]}{2} = 36.4 \text{ kN}$$

**TRANSPORT AT THE PLANT:**

Dynamic coefficient:  $\Psi_{dyn} = 1.3$   
 Cable angle factor:  $z = 1 (\beta = 0^\circ)$   
 Concrete strength: 15 MPa

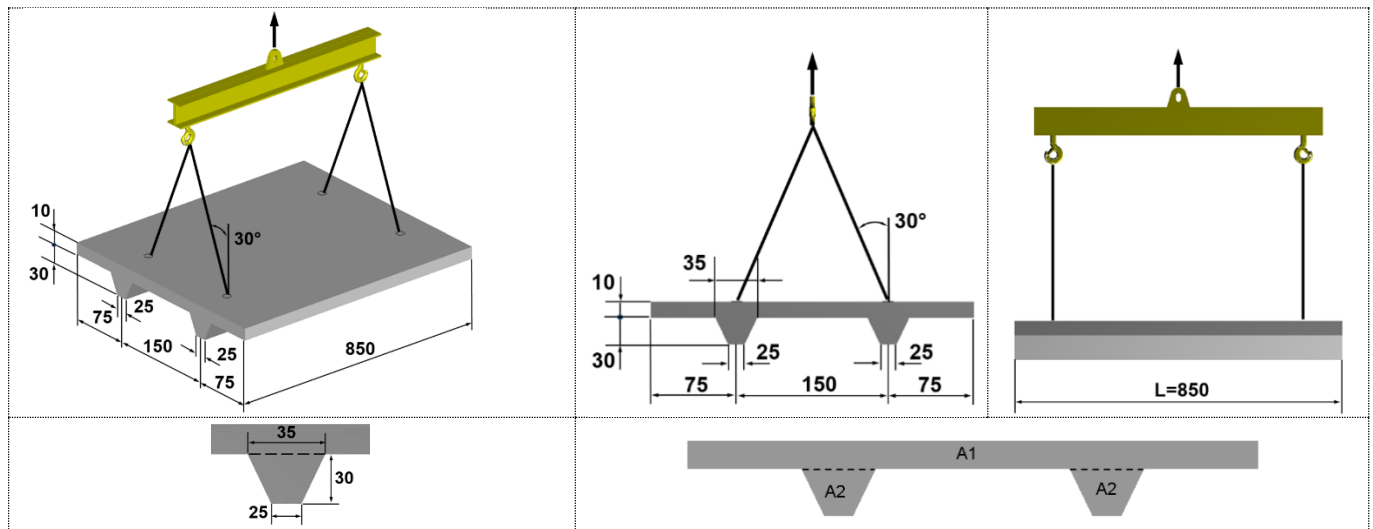
$$F_Q = \frac{F_G \times \Psi_{dyn} \times z}{n} = \frac{50 \times 1.3 \times 1.04}{2} = 36.4 \text{ kN}$$

**TRANSPORT ON SITE:**

Dynamic coefficient:  $\Psi_{dyn} = 1.3$   
 Cable angle factor:  $z = 1.16 (\beta = 30.0^\circ)$   
 Concrete strength: 15 MPa

$$F_Q = \frac{F_G \times \Psi_{dyn} \times z}{n} = \frac{50 \times 1.3 \times 1.04}{2} = 50.89 \text{ kN} = 51 \text{ kN}$$

Two anchors embedded on the lateral side, **SA-TTU type in the 75 kN range** are required. For tilting, additional reinforcement will be added (see page 30).

**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 [m <sup>2</sup> ]                         | $A_f$        | 35.8     |           |
| Cable angle factor at de-mould ( $\beta = 30.0^\circ$ ) | $z$          | 1.16     |           |
| Cable angle factor on site ( $\beta = 30.0^\circ$ )     | $z$          |          | 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 | $\geq 25$ MPa                       |
| Cable angle factor              | $z = 1.16$ ( $\beta = 30.0^\circ$ ) |
| Dynamic coefficient             | $\Psi_{dyn} = 1.3$                  |
| Anchor number                   | $n = 4$                             |

$$F_G = V \times \rho = (A \times L) \times \rho = (A1 + A2 \times 2) \times L \times \rho = (0.1 \times 3 + 0.09 \times 2) \times 8.5 \times 25 = 102 \text{ kN}$$

$$L = 5 \text{ m}$$

$$A1 = 0.1 \times 3 \text{ (m}^2\text{)}$$

$$A2 = \frac{[(0.35 + 0.25) \times 0.3]}{2} = \frac{(0.6 \times 0.3)}{2} = 0.09 \text{ (m}^2\text{)}$$

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

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

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

**LOAD PER ANCHOR WHEN TRANSPORTING:**

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

Four anchors in the 100 kN range are required (&gt; 88.74 kN)

## CONTACT



TERWA is the global supplier for precast and construction solutions with multiple offices around the world. With all our staff, partners and agents, we are happy to provide all construction and precast companies who work in the building industry with full service and 100% support.

### TERWA CONSTRUCTION GROUP

#### Terwa Construction Netherlands (HQ)

**Global Sales & Distribution**  
 Kamerlingh Onneslaan 1-3  
 3401 MZ IJsselstein  
 The Netherlands  
**T** +31-(0)30 699 13 29  
**F** +31-(0)30 220 10 77  
**E** [info@terwa.com](mailto:info@terwa.com)

#### Terwa Construction Central East Europe

**Sales & Distribution**  
 Strada Sânzieni  
 507075 Ghimbav  
 Romania  
**T** +40 372 611 576  
**E** [info@terwa.com](mailto:info@terwa.com)

#### Terwa Construction Poland

**Sales & Distribution**  
 Ul. Cicha 5 lok. 4  
 00-353 Warszawa  
 Poland  
**E** [info@terwa.com](mailto:info@terwa.com)

#### Terwa Construction India & Middle East

**Sales & Distribution**  
 India  
**T** +91 89 687 000 41  
**E** [info@terwa.com](mailto:info@terwa.com)

#### Terwa Construction China

**Sales & distribution**  
 5F 504, No. 101 Chuanchang road  
 PRC, 200032, Shanghai  
 China  
**E** [info@terwa.com](mailto:info@terwa.com)

**ALL SPECIFICATIONS CAN BE CHANGED WITHOUT PREVIOUS NOTICE.**

### DISCLAIMER

Terwa B.V. is not liable for deviations due to wear of the products it has delivered. Neither is Terwa B.V. liable for damage due to inaccurate and/or improper handling and use of the products it has delivered and/or use of same for purposes other than those intended.

Terwa B.V.'s responsibility is furthermore limited in accordance with article 13 of the "Metaalunie" conditions, which are applicable for all Terwa B.V. deliveries. The user is responsible for ensuring compliance with all applicable copyright laws. Without limiting the rights under copyright, no part of this documentation may be reproduced, stored in or introduced into a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), or for any purpose, without the express written permission of Terwa B.V.