TECHNICAL DOCUMENTATION

1D - LIFTING SYSTEMS | HBB – LIFTING BOLT ANCHOR

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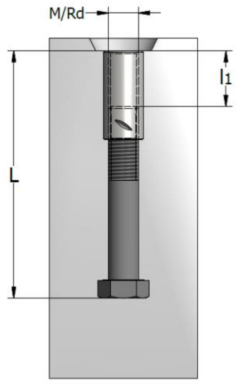
LIFTING BOLT ANCHOR – HBB



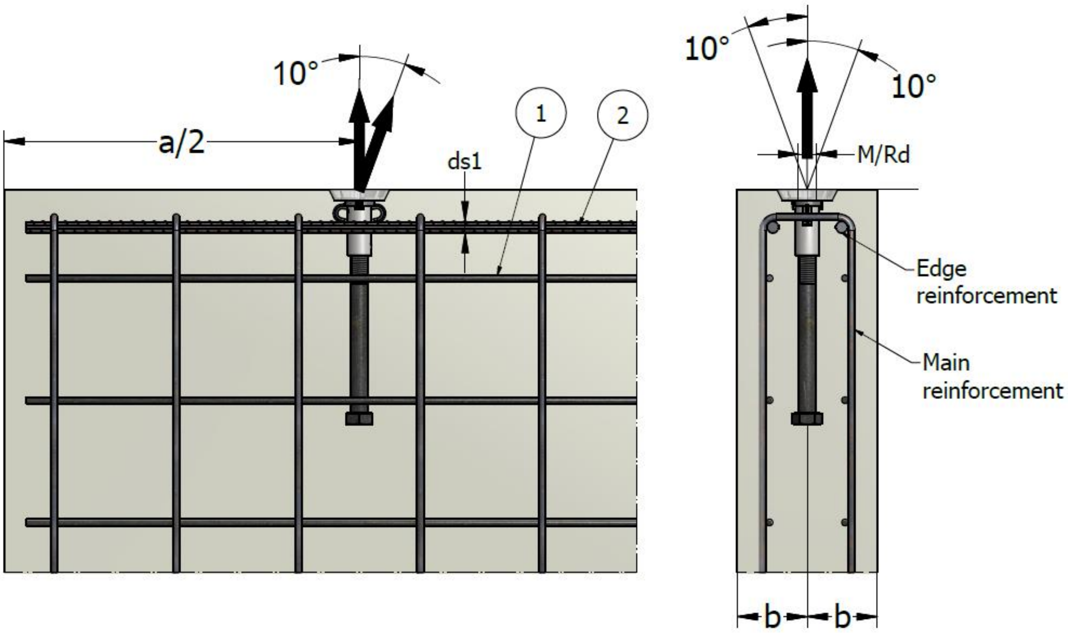
The lifting bolt anchors are suitable for shallow embedded elements with no need for a reinforcement tail. The force transfer into the concrete is provided by the bolt heat of the screw. Additional reinforcement is necessary for angled lifts. The lift angle must not exceed 30°. Special tilting reinforcement must be used for turning/tilting. In all cases, standard mesh reinforcement must be present in the concrete element.
These fixing and lifting systems consist of a threaded bush locked on a standard bolt. The threaded bush is made of steel S355J0 (yield strength min 355 MPa) galvanic protected (EV) or hot-dipped galvanised (TV); the bolt is made of steel group 8.8. The threaded bush can also be made of stainless-steel W 1.4571 –AISI 316Ti (SS4).

HBB	Product number			Load group f_{cu}> 15N/mm²	Thread	Overall length L	l_1	Bolt
	Zinc galvanizing	Stainless steel SS4	Hot dipped galvanized	[t]	M	[mm]	[mm]	
HBB M12x150	43703	43704	45753	0.5	12	150	22	M12x120
HBB M16x220	43711	43712	45754	1.2	16	220	30	M16x180
HBB M20x180	43921	43922	45291	2.0	20	180	35	M20x130
HBB M20x270	44534	44535	45756	2.0	20	270	35	M20x220
HBB M24x320	44623	44624	45758	2.5	24	320	45	M24x260
HBB M30x380	44631	44632	45640	4.0	30	380	60	M30x300
HBB M36x300	44753	44754	45641	6.3	36	300	74	M36x200
HBB M36x420	44757	44758	45642	6.3	36	420	74	M36x320
HBB M42x300	44761	44762	45643	8.0	42	300	70	M42x200
HBB M42x460	44765	44780	45644	8.0	42	460	70	M42x360

HBB	Product number			Load group f_{cu}> 15N/mm²	Thread	Overall length L	l_1	Bolt
	Zinc galvanizing	Stainless steel SS4	Hot dipped galvanized	[t]	Rd	[mm]	[mm]	
HBB Rd12x150	62927	62931	62935	0.5	12	150	22	M12x120
HBB Rd16x220	62937	62940	62943	1.2	16	220	30	M16x180
HBB Rd20x180	62946	62949	62953	2.0	20	180	35	M20x130
HBB Rd20x270	49480	62950	62954	2.0	20	270	35	M20x220
HBB Rd24x320	62955	62957	62959	2.5	24	320	45	M24x260
HBB Rd30x380	62962	62965	62968	4.0	30	380	60	M30x300
HBB Rd36x300	62969	62971	62973	6.3	36	300	74	M36x200
HBB Rd36x420	62970	62972	62974	6.3	36	420	74	M36x320
HBB Rd42x300	62975	62977	62979	8.0	42	300	70	M42x200
HBB Rd42x460	62976	62978	62980	8.0	42	460	70	M42x360

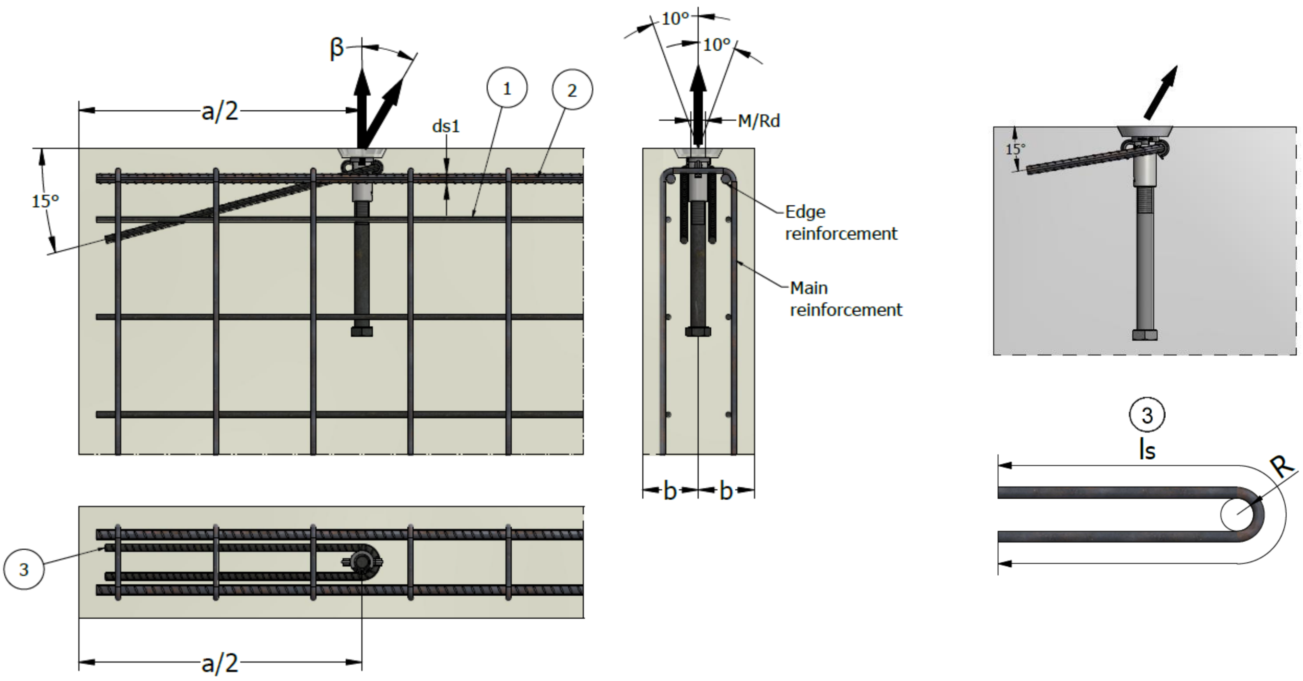
LIFTING BOLT ANCHOR – INSTALLATION AND REINFORCEMENTS

REINFORCEMENT AND LOAD CAPACITY – AXIAL LOAD UP TO 10°

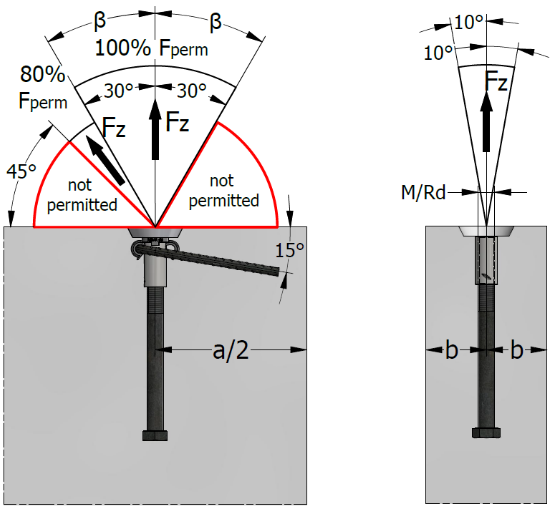


HBB-M(Rd)	Load group	Minimum unit thickness	Axial spacing	Mesh reinforcement ①	Edge reinforcement ②	Load capacity	
		2 x b	a		d_{s1}	f_{cu}> 15 MPa	f_{cu}> 25 MPa
	[t]	[mm]	[mm]	[mm²/m]	[mm]	[kN]	[kN]
M(Rd)12-100	0.5	60	300	1 x 188	Ø8	5.0	5.0
M(Rd)16-140	1.2	70	400	2 x 131	2 x Ø8	12.0	12.0
M(Rd)20-180	2.0	80	540	2 x 188	2 x Ø10	16.9	20.0
M(Rd)24-200	2.5	100	600	2 x 188	2 x Ø12	25.0	25.0
M(Rd)30-240	4.0	120	720	2 x 188	2 x Ø12	40.0	40.0
M(Rd)36-300	6.3	140	900	2 x 188	2 x Ø12	55.7	63.0
M(Rd)42-460	8.0	180	1380	2 x 188	2 x Ø14	77.0	80.0

REINFORCEMENT AND LOAD CAPACITY – DIAGONAL LOAD UP TO 45°



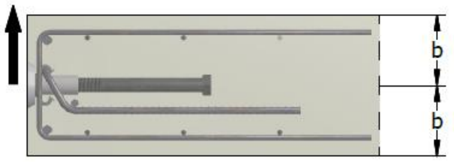
HBB-M(Rd)	Load group	Minimum unit thickness	Axial spacing	Mesh reinforcement ①	Edge reinforcement ②	Diagonal reinforcement $\beta > 30°$ max. 45° ③		Load capacity for lifting loop application		Load capacity for lifting THS application
		2 x b	a		d_{s1}	d_s	L_s	f_{cu}> 15 MPa	f_{cu}> 25 MPa	f_{cu}> 25 MPa
	[t]	[mm]	[mm]	[mm²/m]	[mm]	[mm]	[mm]	[kN]	[kN]	[kN]
M(Rd)12-100	0.5	60	300	1 x 188	Ø8	Ø6	320	4.0	5.0	5.0
M(Rd)16-140	1.2	80	400	2 x 131	2 x Ø8	Ø8	640	9.6	12.0	12.0
M(Rd)20-180	2.0	100	540	2 x 188	2 x Ø10	Ø10	840	16.0	20.0	20.0
M(Rd)24-200	2.5	100	600	2 x 188	2 x Ø10	Ø10	1050	20.0	25.0	25.0
M(Rd)30-240	4.0	120	720	2 x 188	2 x Ø12	Ø12	1260	32.0	40.0	40.0
M(Rd)36-300	6.3	160	900	2 x 188	2 x Ø12	Ø16	1600	44.6	63.0	63.0
M(Rd)42-460	8.0	200	1380	2 x 188	2 x Ø14	Ø20	2000	64.0	80.0	80.0

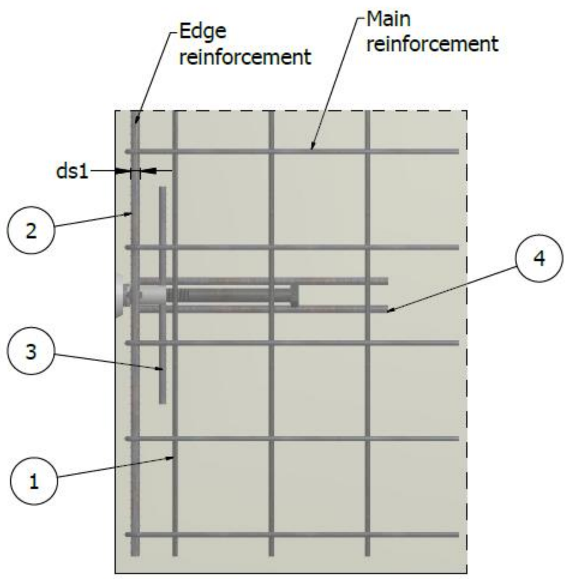


Note: *The bend radius R will be determined according to EN 1992.*

Diagonal reinforcement must be placed in direct contact with the socket anchor.
Always install diagonal reinforcement opposite the load direction.
The dimensions in the illustrations are in [mm].

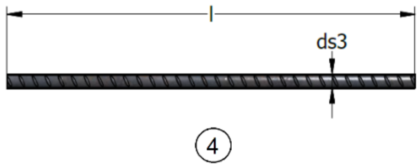
REINFORCEMENT AND LOAD CAPACITY – TILTING UP TO 90°

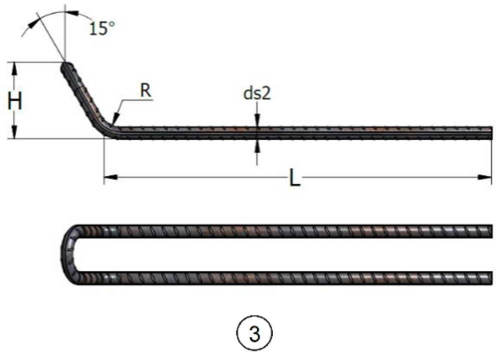




Note: *The bend radius will be determined according to EN 1992.*

Only a long socket anchor may be used for tilting operations.
The turning reinforcement must be placed in direct contact with the socket anchor.
The dimensions in the illustrations are in [mm].
Do not use lifting loop for tilting.



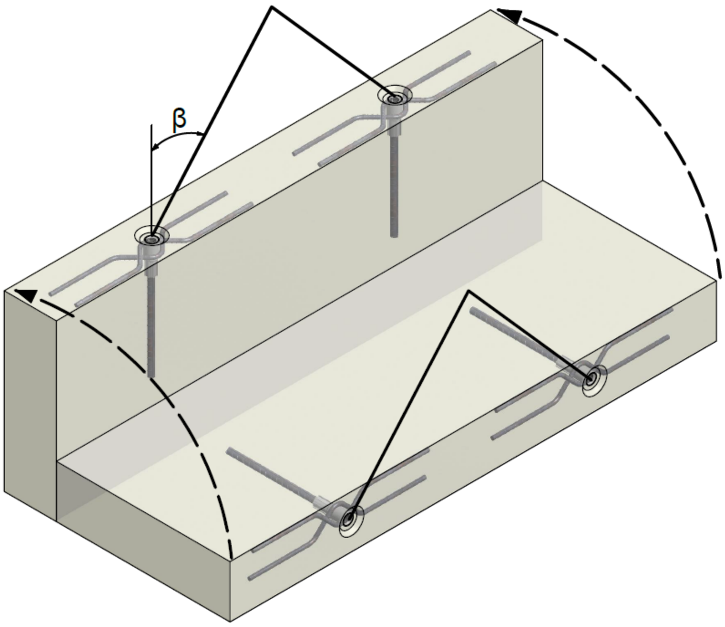


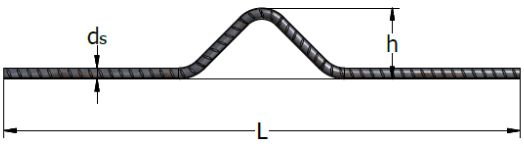
HBB-M(Rd)	Load group	Minimum unit thickness 2 x b	Mesh reinforcement (1)	Edge reinforcement (2)	Turning reinforcement (3)				Lateral reinforcement (4)		Load capacity	
				d_{s1}	d_{s2}	L	H	R	d_{s3}	l	f_{cu}> 15 MPa	f_{cu}> 25 MPa
	[t]	[mm]	[mm²/m]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[kN]	[kN]
M(Rd)12-100	0.5	80	2 x 131	2 x Ø8	6	270	35	12	8	500	2.5	2.5
M(Rd)16-140	1.2	120	2 x 131	2 x Ø8	8	420	50	16	12	500	6.0	6.0
M(Rd)20-180	2.0	140	2 x 188	2 x Ø10	10	490	65	20	14	500	10.0	10.0
M(Rd)24-200	2.5	160	2 x 188	2 x Ø12	12	520	75	24	14	550	12.5	12.5
M(Rd)30-240	4.0	160	2 x 188	2 x Ø12	12	570	95	24	16	600	20.0	20.0
M(Rd)36-300	6.3	210	2 x 188	2 x Ø12	14	690	120	30	16	700	31.5	31.5
M(Rd)42-460	8.0	240	2 x 188	2 x Ø14	16	830	145	32	20	850	40.0	40.0

REINFORCEMENT AND LOAD CAPACITY – DIAGONAL LOAD AND TILTING UP TO 90°

For tilting and diagonal pull, additional reinforcements must be installed in the anchor zone. Make certain that the placement of the anchors ensures load transfer. When turning and lifting at an angle, tilt reinforcement is sufficient and there is no need for angle lift reinforcement.
We recommend not exceeding an angle of ß 30°, if possible.

This type of reinforcement is recommended for tilting concrete elements with TGL, TRL or HBB anchors.

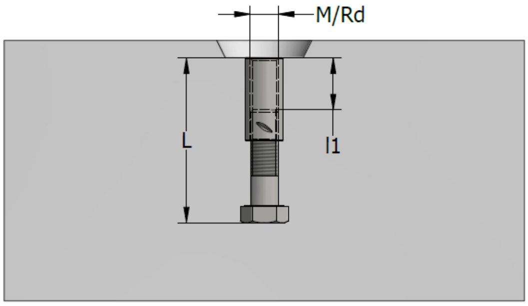




Tilt reinforcement

TGL/ TRL/ HBB - M(Rd)	Tilt reinforcement		
	Ød₃	L	h
	[mm]	[mm]	[mm]
M(Rd)12	6	270	35
M(Rd)16	8	420	50
M(Rd)20	10	500	65
M(Rd)24	12	520	75
M(Rd)30	12	570	92
M(Rd)36	14	700	120
M(Rd)42	16	830	145

LIFTING BOLT ANCHOR – HBB-SHORT



The lifting bolt anchors HBB-SHORT are suitable for lifting and transporting slabs precast concrete elements. The force transfer into the concrete is provided by the bolt heat of the screw. Additional reinforcement is necessary for angled lifts. The lift angle must not exceed 30°. In all cases, standard mesh reinforcement must be present in the concrete element.
These fixing and lifting systems consist of a threaded bush locked on a standard bolt. The threaded bush is made of steel S355J0 (yield strength min 355 MPa) galvanic protected (EV) or hot-dipped galvanised (TV); the bolt is made of steel group 8.8. The threaded bush can also be made of stainless-steel W 1.4571 –AISI 316Ti (SS4).

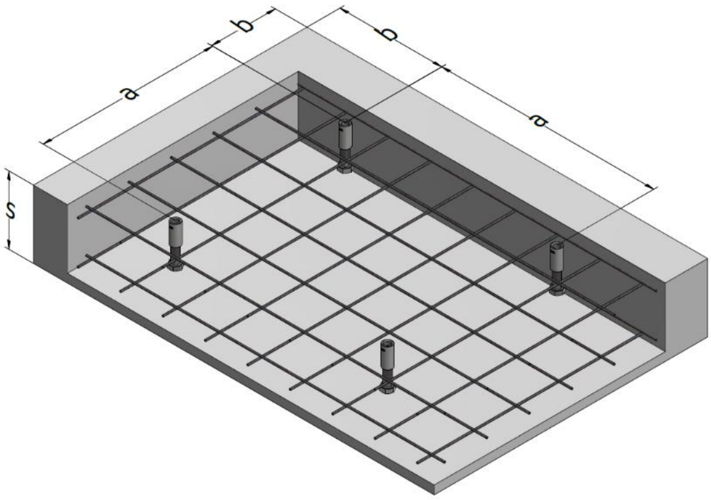
HBB-SHORT	Product number			Load group f_{cu}> 15 MPa	Thread	Overall length L	l_1	Bolt
	Zinc galvanizing	Stainless steel SS4	Hot dipped galvanized	[t]	M	[mm]	[mm]	
HBB M12x90	45627	45629	45286	0.5	12	90	22	M12x60
HBB M12x100	43699	43700	45287	0.5	12	100	22	M12x70
HBB M16x140	43707	43708	45288	1.2	16	140	30	M16x100
HBB M20x140	45628	45631	45289	2.0	20	140	35	M20x90
HBB M20x150	43715	43716	45290	2.0	20	150	35	M20x100
HBB M24x200	44619	45757	45292	2.5	24	200	45	M24x140
HBB M30x240	44627	44628	45639	4.0	30	240	60	M30x160

HBB-SHORT	Product number			Load group f_{cu}> 15 MPa	Thread	Overall length L	l_1	Bolt
	Zinc galvanizing	Stainless steel SS4	Hot dipped galvanized	[t]	Rd	[mm]	[mm]	
HBB Rd12x90	62925	62929	62933	0.5	12	90	22	M12x60
HBB Rd12x100	62926	62930	62934	0.5	12	100	22	M12x70
HBB Rd16x140	49479	62939	62942	1.2	16	140	30	M16x100
HBB Rd20x140	62945	62948	62952	2.0	20	140	35	M20x90
HBB Rd24x200	49481	62956	62958	2.5	24	200	45	M24x140
HBB Rd30x240	62961	62964	62967	4.0	30	240	60	M30x160

LIFTING AND TRANSPORT – HBB SHORT ANCHORS

Edge distance and spacing for lifting sockets.

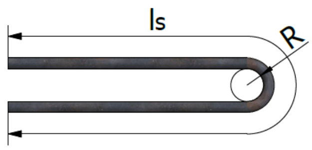
HBB-M(Rd)	s minimum	a minimum	b minimum
	[mm]	[mm]	[mm]
M(Rd)12-90	120	340	170
M(Rd)12-100	130	380	190
M(Rd)16-140	170	520	260
M(Rd)20-140	170	520	260
M(Rd)20-150	180	560	280
M(Rd)24-200	230	740	370
M(Rd)30-240	270	880	440



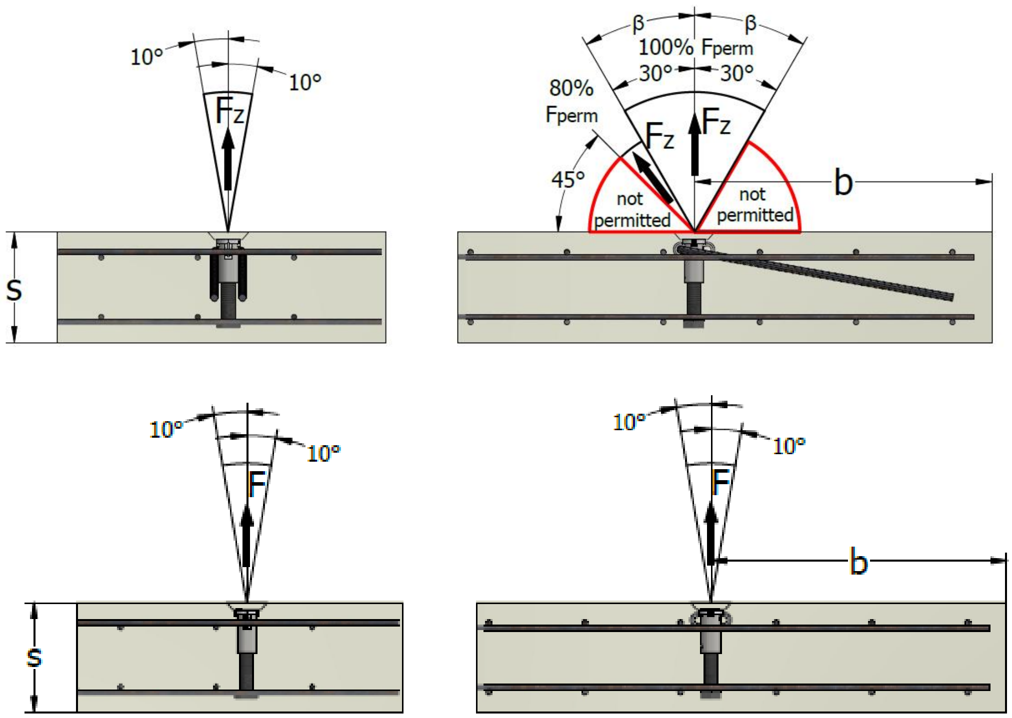
The HBB anchors are used for lifting flat elements such as floor slabs. The lifting angle must be ≤ 45°. For a lifting angle between 10° and 45°, additional reinforcement is required.

HBB-M(Rd)	Load group	Thread	Overall length	Element thickness	Axial load and diagonal load ≤ 45°
	f_{cu}> 15 MPa				f_{cu}> 25 MPa
	[t]	M(Rd)	[mm]	[mm]	[kN]
HBB-M(Rd)12-090	0.5	12	90	115	5
HBB-M(Rd)12-100	0.5	12	100	125	5
HBB-M(Rd)16-140	1.2	16	140	165	12
HBB-M(Rd)20-140	2.0	20	140	165	20
HBB-M(Rd)20-150	2.0	20	150	175	20
HBB -M(Rd)24-200	2.5	24	200	225	25
HBB -M(Rd)30-240	4.0	30	240	265	40

HBB-M(Rd) short	Thread	Two layers of mesh	Diagonal reinforcement Diameter d	Diagonal reinforcement Length before bending Ls
				f_{cu}> 15 MPa
	M(Rd)	mm²/m	[mm]	[mm]
HBB-M(Rd)12-090	12	2 x 188	Ø 6	320
HBB-M(Rd)12-100	12	2 x 188	Ø 6	320
HBB-M(Rd)16-140	16	2 x 188	Ø 8	500
HBB-M(Rd)20-140	20	2 x 188	Ø 8	650
HBB-M(Rd)20-150	20	2 x 188	Ø 8	650
HBB -M(Rd)24-200	24	2 x 188	Ø 10	650
HBB -M(Rd)30-240	30	2 x 188	Ø 12	850



Note: *The bend radius R will be determined according to EN 1992.*
There must be two layers of mesh reinforcement.
Diagonal reinforcement must be placed in direct contact with the socket anchor.
Always install diagonal reinforcement opposite the load direction.

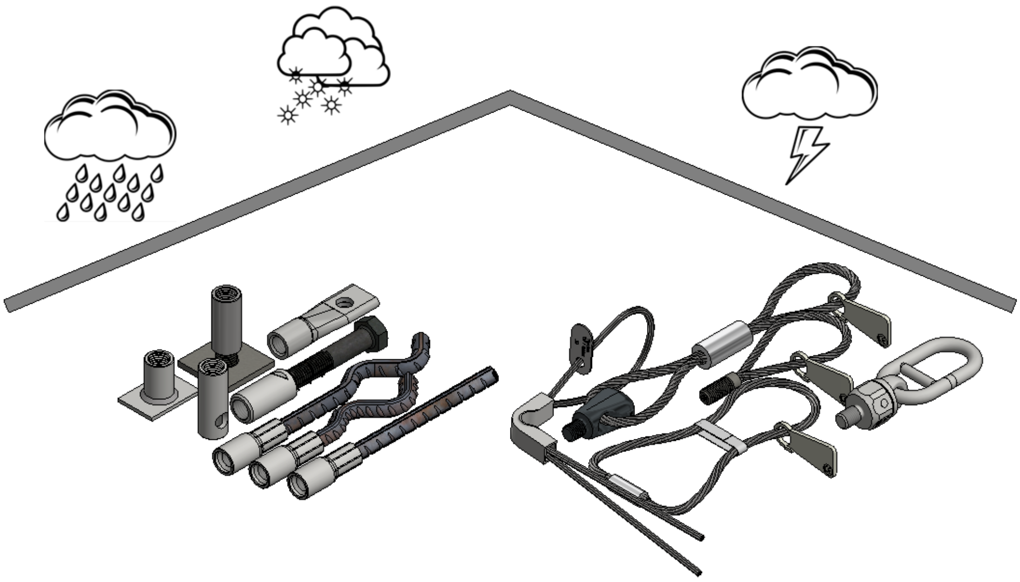


Note: *The bend R radius will be determined according to EN 1992.*

Diagonal reinforcement must be placed in direct contact with the socket anchor.
Always install diagonal reinforcement opposite the load direction.
The dimensions in the illustrations are in [mm].

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 must be operated manually
- Visually inspect lifting anchors before use; check and clean all lifting inserts prior to use
- Hook in all lifting systems separately, without using force
- 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

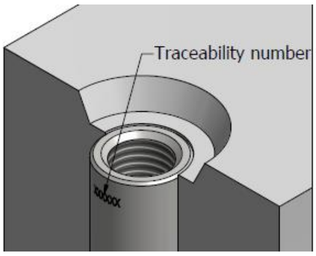
Thread-lifting systems are used in the precast industry and are suitable for lifting, transport and installation of precast concrete elements on site.
Some of the advantages of this system include:

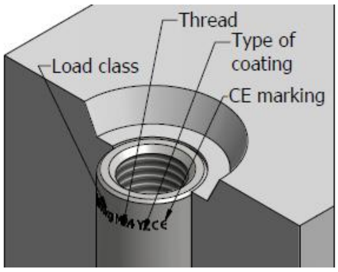
- a wide range of lifting sockets
- threaded lifting loops and cast-in lifting loops,
- capability of establishing a connection in a safe, simple manner
- most of the lifting systems can be re-used
- CE-certified system. All Terwa lifting systems have the CE marking which guarantees conformance with the European regulations.

The threaded lifting system combines a lifting anchor embedded in a concrete unit and a lifting device.
The design for Terwa threaded lifting anchors and technical instructions comply with the national German guideline VDI/BV-BS6205 “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.

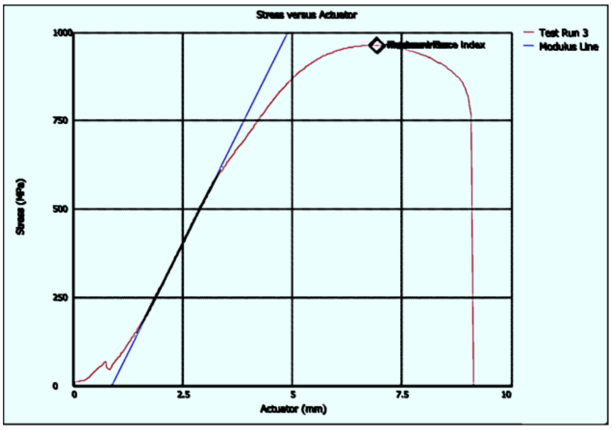
Quality
Terwa continuously controls the anchor production process in terms of strength, dimensional and material quality, and performs all of the required inspections for a superior quality system. All of the products are tracked from material acquisition to the final, ready to use product.

Marking and traceability
All anchors and lifting clutches have the CE marking and all data necessary for traceability, thread type 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

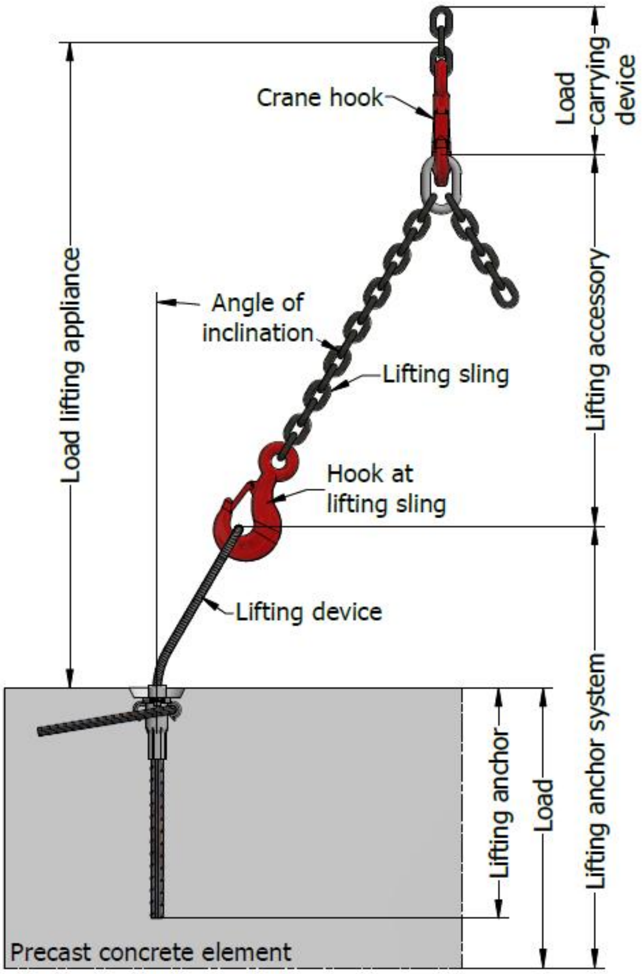
Load carrying devices - are equipment that is permanently connected to the hoist for attaching lifting devices, lifting accessory or loads.

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

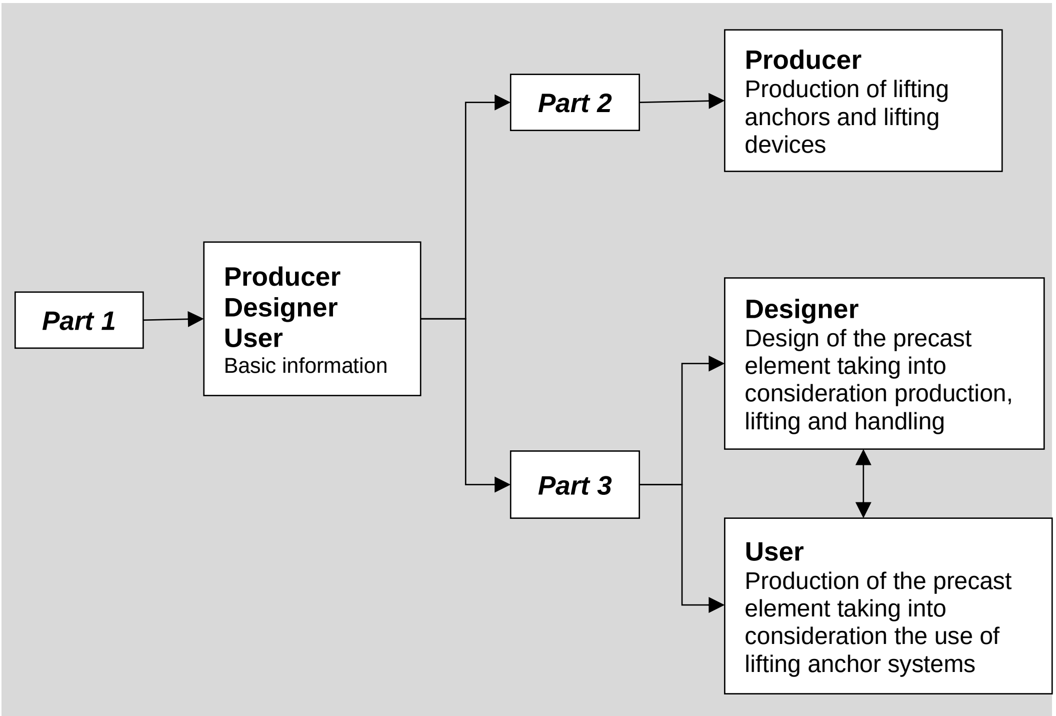
Lifting device (lifting key) – equipment that connects the loads to the load carrying device by means of lifting accessories.

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.

PRODUCT RANGE

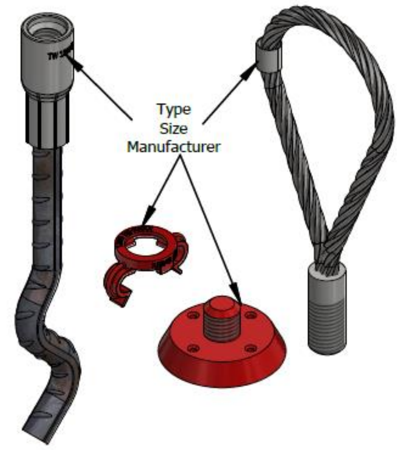
LIFTING SYSTEMS

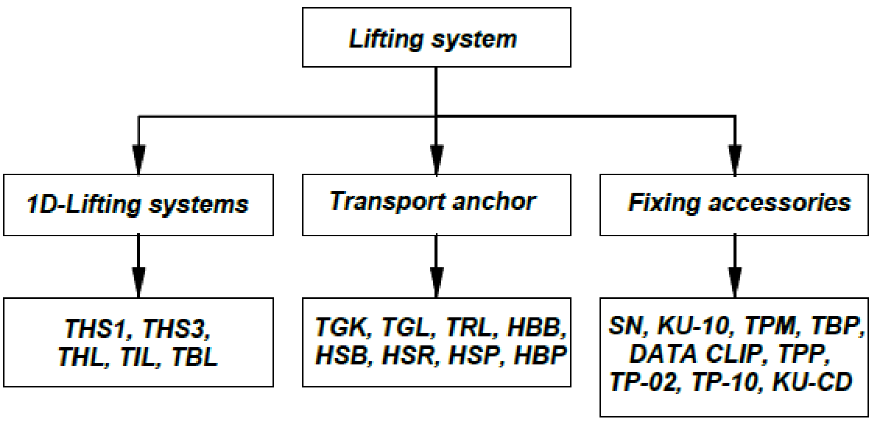
- **REUSABLE THREADED LIFTING SYSTEM**
  Terwa offers various types of reusable threaded lifting keys suitable for lifting, transport and installation of precast concrete elements.

- **CAST-IN LIFTING SYSTEM**
  Steel wire loops swaged into a ferrule without an additional tail which can be used in combination with a standard crane hook. Can be cut off after use.

- **TRANSPORT ANCHORS**
  Various anchors made from a socket swaged onto wavy reinforcement steel, plain socket lifting inserts, sockets welded to a plate and anchors made from a socket swaged to a standard bolt for thin units.

- **RECESS FORMERS AND MOUNTING ACCESSORIES**
  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:

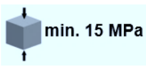
- 1D threaded lifting system
- 2D strip anchor lifting system
- 3D T-slot anchor lifting system

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}:

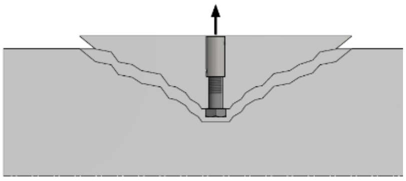
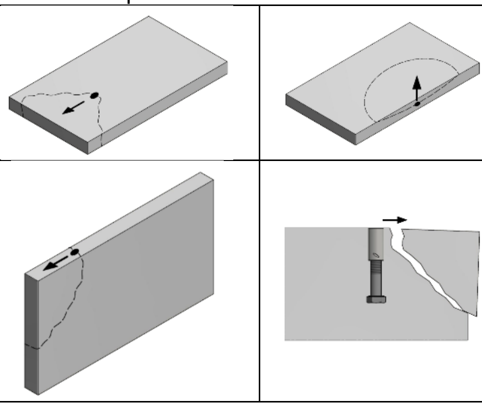
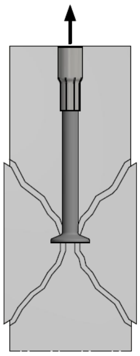
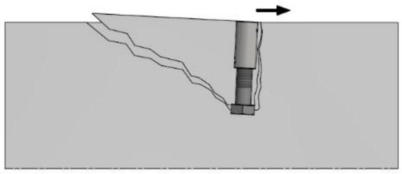
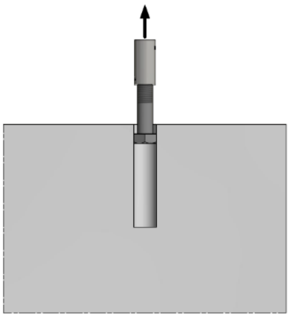
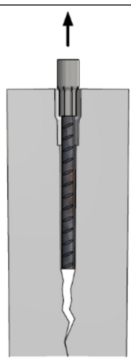
$E \leq R_{adm}$ Where: E - action, R_{adm} - admissible load (resistance)

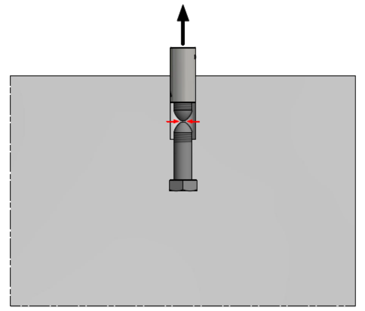
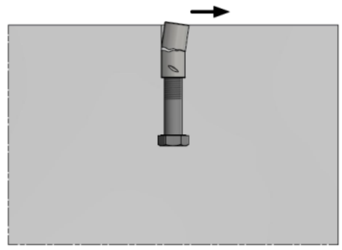
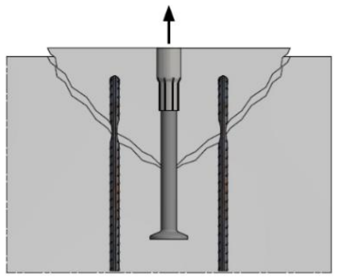
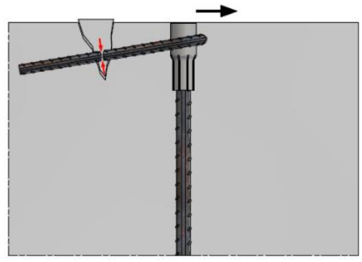
The admissible load (resistance) of lifting anchor and lifting device is obtained as follows:

$R_{adm} = \frac{Rk}{\gamma}$ Where: R_k - characteristic resistance of the anchoring of a lifting anchor or lifting device, γ - 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 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		
Local concrete break-out (blow-out) 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) Failure mode characterised by the concrete breaking out opposite the direction of load, on lifting anchors with shear load.		
Pull-out Failure mode, where the lifting anchor under tension load is pulled out of the concrete with large displacements and a small concrete break-out.		
Splitting of the component A concrete failure in which the concrete fractures along a plane passing through the axis of the lifting anchor.		

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

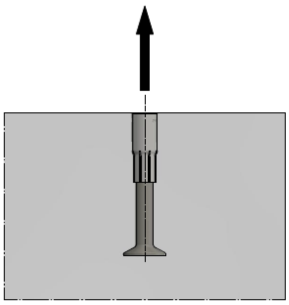
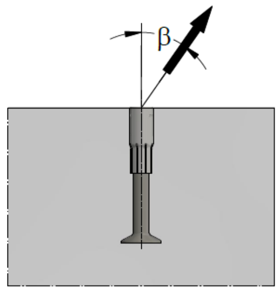
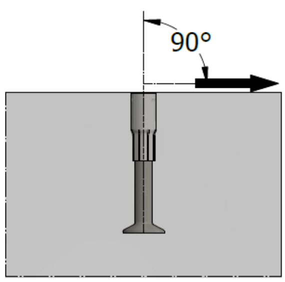
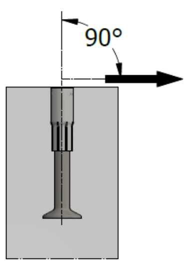
DIMENSIONING OF LIFTING ANCHOR SYSTEM

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.	

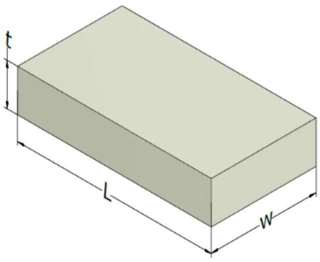
LOAD CAPACITY

The loading and capacity of the anchors depend on multiple factors such as:

- The total weight 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

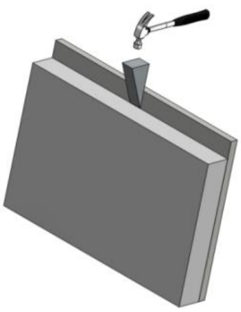
q_{adh} - the adhesion to formwork and form friction factor corresponding to the material of the formwork

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	≥ 1
Varnished timber formwork with panel boards	≥ 2
Rough timber formwork	≥ 3

In some cases, such as π - 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 ψ_{dyn}.

Lifting equipment	Dynamic factor ψ_{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.

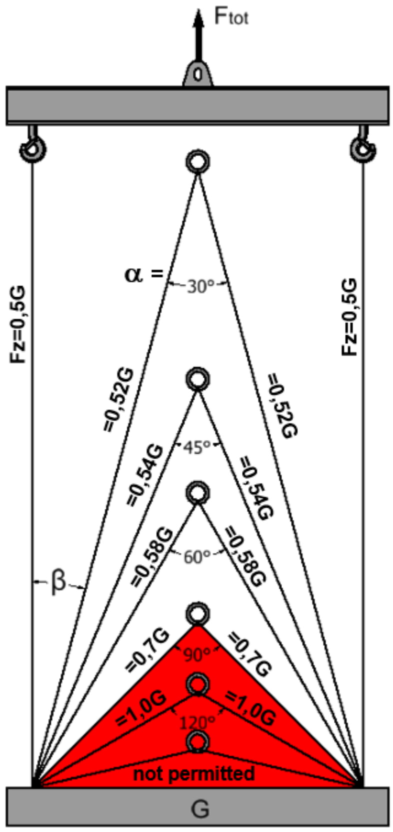
LIFTING OF PRECAST CONCRETE ELEMENT UNDER COMBINED TENSION AND SHEAR LOADING

The load value applied on each anchor depends on the chain inclination, which is defined by the angle β between the normal direction and the lifting chain.
The cable angle β is determined by the length of the suspension chain. We recommend that, if possible, β 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/cosβ

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

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



Cable angle β	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

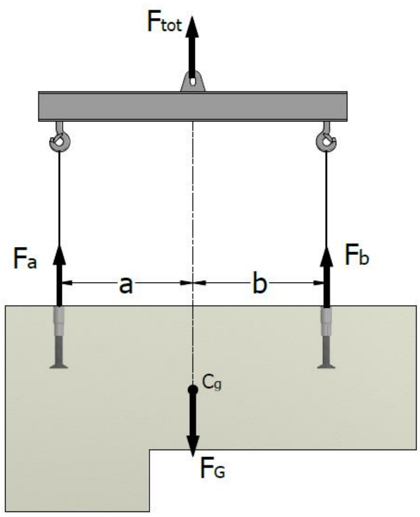
For asymmetrical elements, calculate the loads based on the centre of gravity before installing the anchors.
The load of each anchor depends on the embedded position of the anchor in the precast unit and on the transport mode:

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:

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

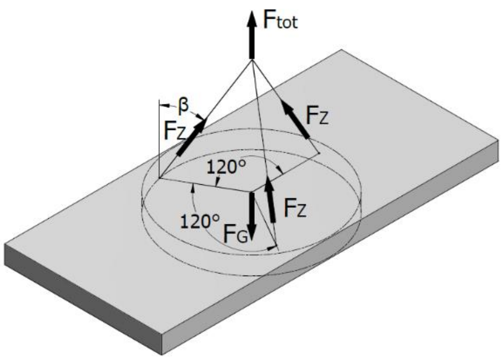
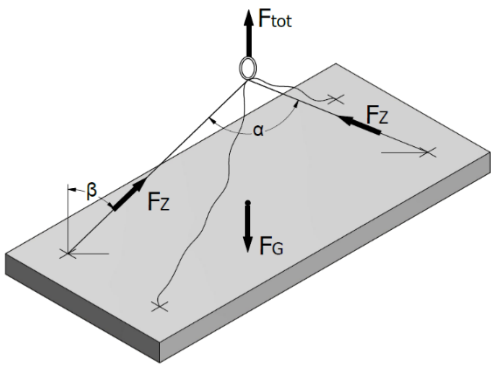
$$F_b = F_{tot} \times \mathrm{a}/(\mathrm{a}+\mathrm{b})$$

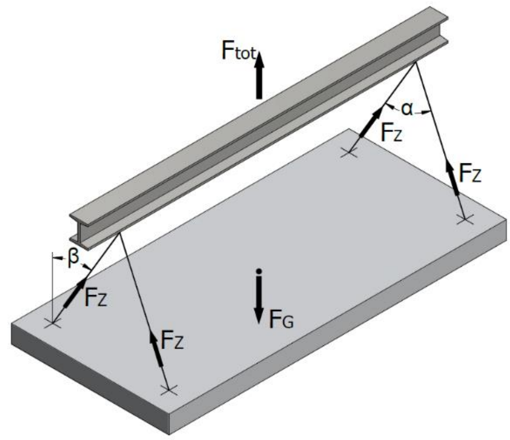
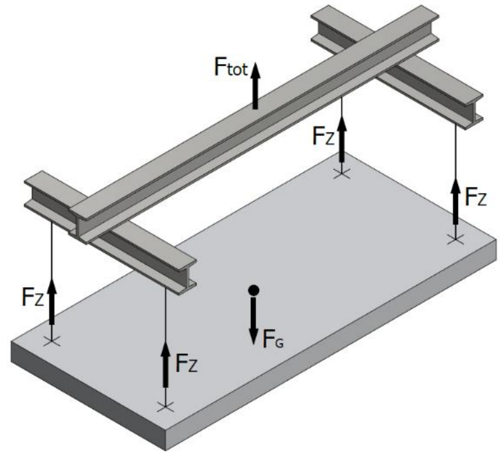
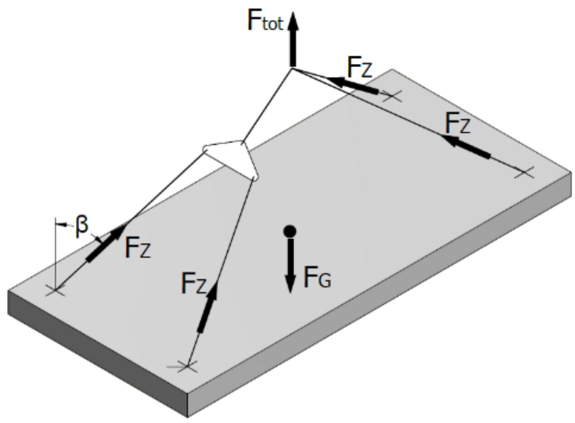
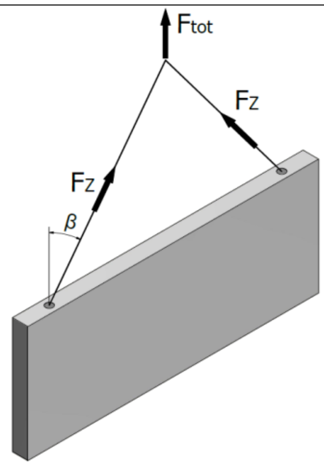
Note: To avoid tilting the element during transport, the load should be suspended from the lifting beam in such a way that its centre of gravity (Cg) is directly under the crane hook.

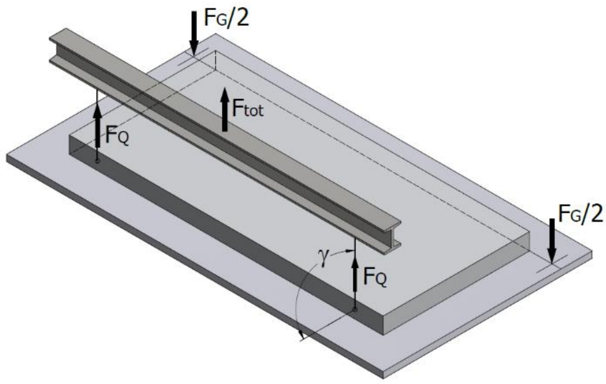
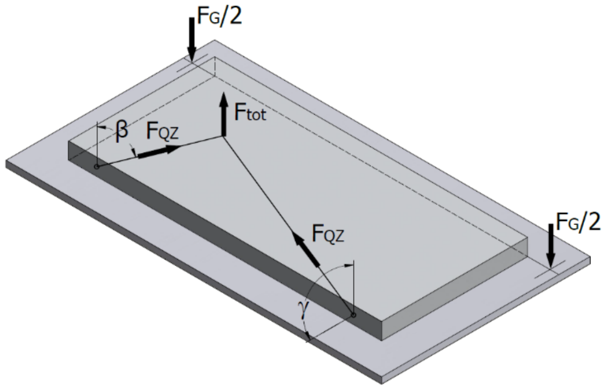


b) For transporting without a lifting beam, the load on the anchor depends on the cable angle (ß).

ANCHORS LIFTING CONDITIONS

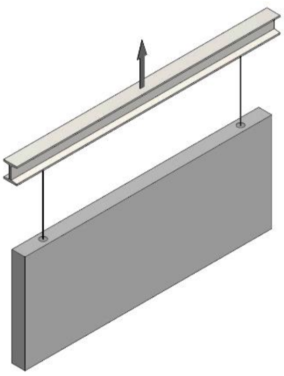
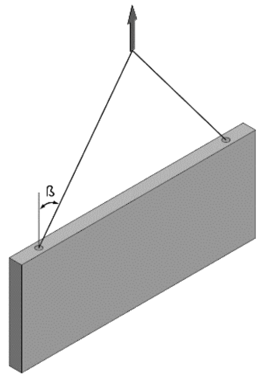
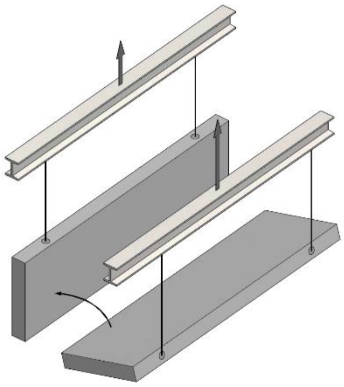
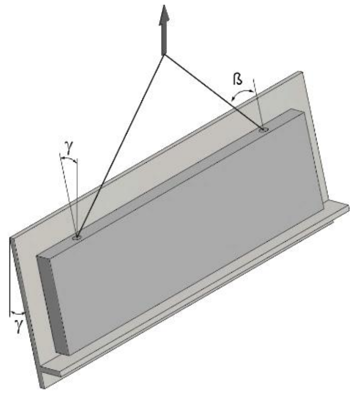
Using three anchors spaced the same distance apart from each other as in the figure, three load bearing anchors can be assumed. Load bearing anchors: **n=3** **Load type – lifting of formwork** -shear pull factor $z \geq 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -dynamic factor	
Using four anchors lifted without a spreader beam, only two load bearing anchors can be assumed. The load distribution is randomly based Load bearing anchors: **n=2** **Load type – lifting of formwork** -shear pull factor $z \geq 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -dynamic factor	

Perfect force distribution is assumed using a spreader beam Load bearing anchors: **n=4** **Load type – lifting of formwork** -shear pull factor $z \geq 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -dynamic factor	
Perfect static weight distribution can be obtained using a lifting beam and two pairs of anchors symmetrically placed. Load bearing anchors: **n=4** **Load type – lifting of formwork** -shear pull factor $z \geq 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -dynamic factor	
The compensating lifting slings ensure equal force distribution. Load bearing anchors: **n=4** **Load type – lifting of formwork** -shear pull factor $z \geq 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -dynamic factor	
Lifting of wall elements parallel to the axis of concrete element Load bearing anchors: **n=2** **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -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. Load bearing anchors: **n=2** **Load type – lifting of formwork** -shear pull factor $z = 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z = 1$ -no formwork adhesion -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 ≤ 30º*** Load bearing anchors: **n=2** **Load type – lifting of formwork** -shear pull factor $z \geq 1$ -formwork adhesion -no dynamic factor **Load type – transport** -shear pull factor $z \geq 1$ -no formwork adhesion -dynamic factor	

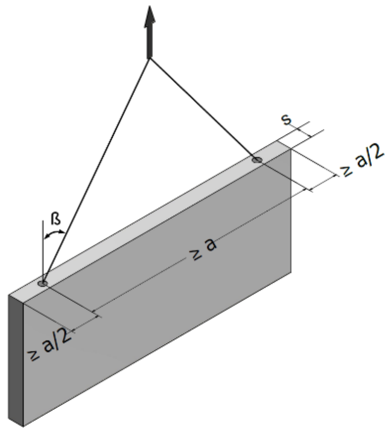
LOAD DIRECTIONS

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.

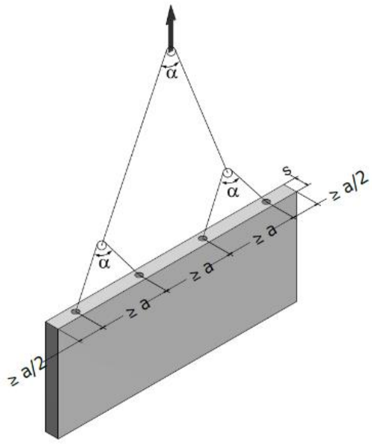
Axial load **ß = 0º to 10º**		Diagonal load **ß = 10º to 45º** *Note:* ***ß ≤ 30º*** *is recommended*	
Tilting **g = 90 º** ***Additional shear reinforcement steel must be used.***		When a tilting table is used, the anchors can be used without additional shear reinforcement steel, not to angle ***g 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

POSITIONING THE ANCHORS IN WALLS

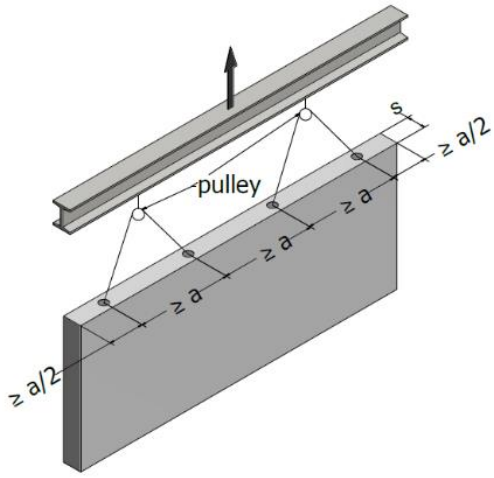
Load bearing anchors:
n=2

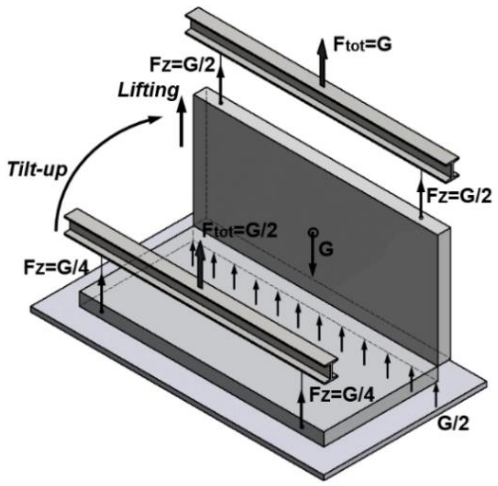


Load bearing anchors:
n=4



Load bearing anchors: **n=4**

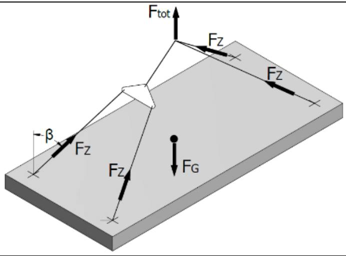
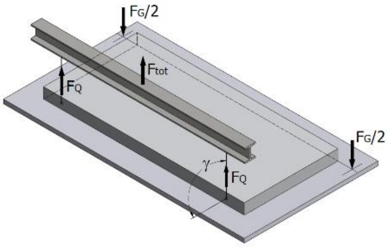
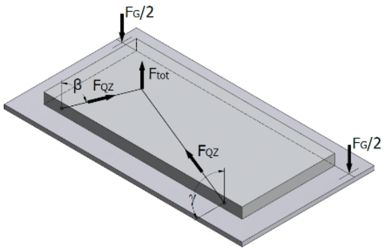
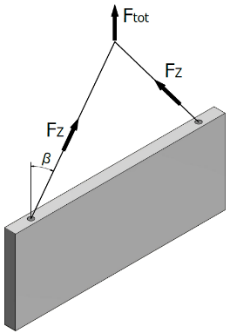




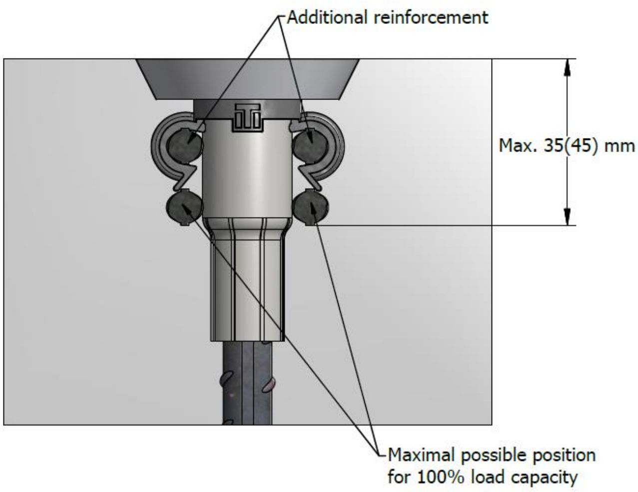
Lifting the walls from horizontal to vertical position without tilt-up table.

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

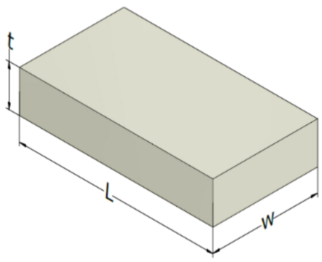
Load type		*Calculation*	*Verification*
Lifting with formwork adhesion		$$F_Z = \frac{(F_G + F_{adh}) \times z}{n}$$ F_Z – Load acting on the lifting anchor in kN	$$F_Z \leq N_{R,adm}$$ $N_{R,adm}$ – admissible normal load
Erecting		$$F_Q = \frac{(F_G/2) \times \psi_{dyn}}{n}$$ F_Q – Shear load acting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

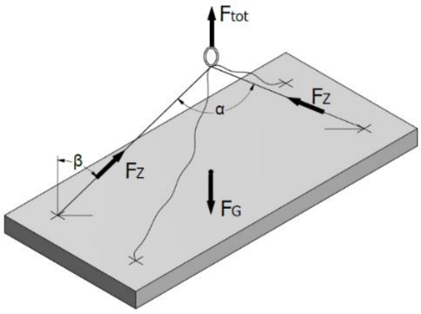
INSTALLATION TOLERANCES FOR ALL TERWA LIFTING SOCKET ANCHORS



CALCULATION EXAMPLE

Example 1: SLAB UNIT





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

Weight $F_G = \rho \times V = 25 \times (5 \times 2 \times 0.2) = 50kN$
Formwork area $A_f = L \times w = 5 \times 2 = 10\ m^2$
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 [m²]	A_f	10		
Cable angle factor at de-mould (β = 15.0°)	z	1.04	1.04	
Cable angle factor on site (β = 30.0°)	z			1.16
Dynamic coefficient at transport	ψ_{dyn}		1.3	
Dynamic coefficient on site	ψ_{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 (β = 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: ψ_{dyn} = 1.3
Cable angle factor: z = 1.04 (β = 15.0°)
Concrete strength: 15 MPa

$$F_Z = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{50 \times 1.3 \times 1.04}{2} = 33.80\ kN$$

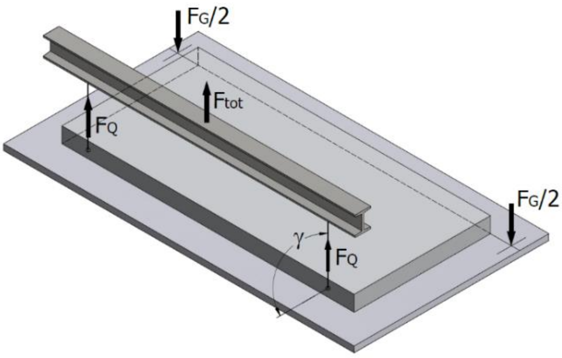
TRANSPORT ON SITE:

Dynamic coefficient: ψ_{dyn} = 1.3
Cable angle factor: z = 1.16 (β = 30.0°)
Concrete strength: 35 MPa

$$F_Z = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{50 \times 1.3 \times 1.16}{2} = 37.70\ kN$$

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

Example 2: WALL PANEL



The slab unit has the following dimensions:
$L = 7.5\ m$
$w = 2\ m$
$t = 0.18\ m$

Weight $F_G = \rho \times V = 25 \times (7.5 \times 2 \times 0.18) = 67.5 kN$
Formwork area $A_f = L \times w = 7.5 \times 2 = 15\ m^2$
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	67.5		
Element area in contact with formwork [m²]	A_f	15		
Cable angle factor at de-mould (β = 0.0°)	z	1.0		
Cable angle factor at tilting (β = 0.0°)	z		1.0	
Cable angle factor on site (β = 30°)	z			1.16
Dynamic coefficient at tilting	ψ_{dyn}		1.3	
Dynamic coefficient on site	ψ_{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 (β = 0°)
Concrete strength: 15 MPa

$$F_Q = \frac{[(F_G/2 + q_{adh} \times A_f) \times z]}{n} = \frac{[(67.5/2 + 1 \times 15) \times 1]}{2} = 24.38\ kN$$

TRANSPORT AT THE PLANT:

Dynamic coefficient: ψ_{dyn} = 1.3
Cable angle factor: z = 1 (β = 0°)
Concrete strength: 15 MPa

$$F_Q = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{67.5 \times 1.3 \times 1}{2} = 43.87\ kN$$

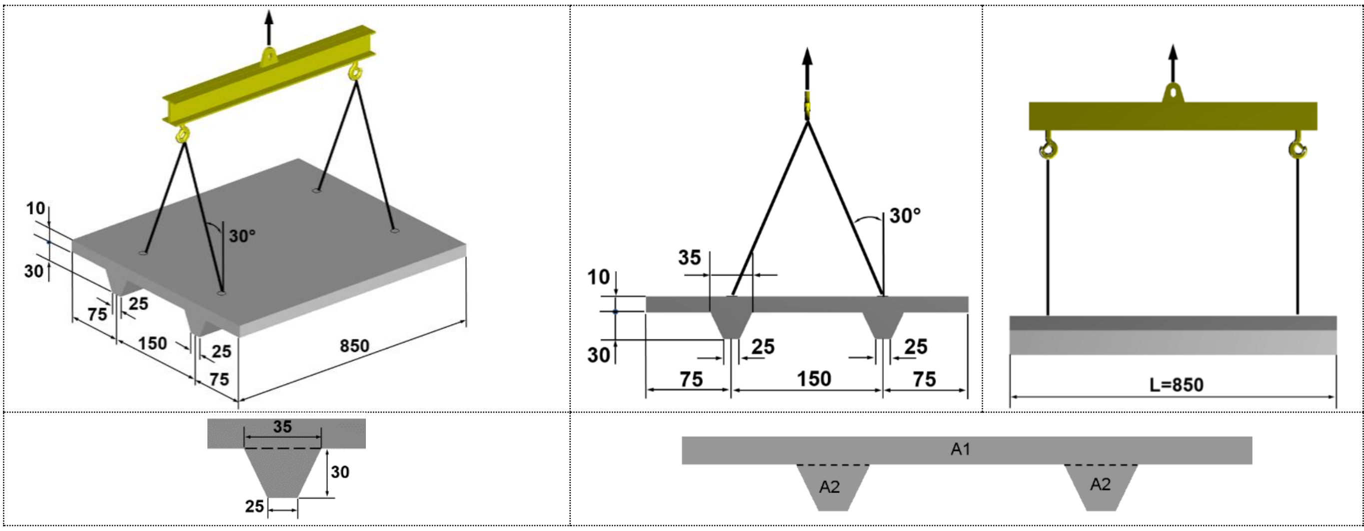
TRANSPORT ON SITE:

Dynamic coefficient: ψ_{dyn} = 1.3
Cable angle factor: z = 1.16 (β = 30.0°)
Concrete strength: 35 MPa

$$F_Q = \frac{F_G \times \psi_{dyn} \times z}{n} = \frac{67.5 \times 1.3 \times 1.16}{2} = 50.89\ kN = 51\ kN$$

For embedding on the lateral side, two anchors in the 75kN range are required.
Tail and tilting reinforcement are usually added for this type of anchor reinforcement.

Example 3: 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	ψ_{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	ψ_{dyn} = 1.3
Anchor number	n = 4

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

$L = 8.5\ m$

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

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

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

LOAD PER ANCHOR WHEN DE-MOULD:

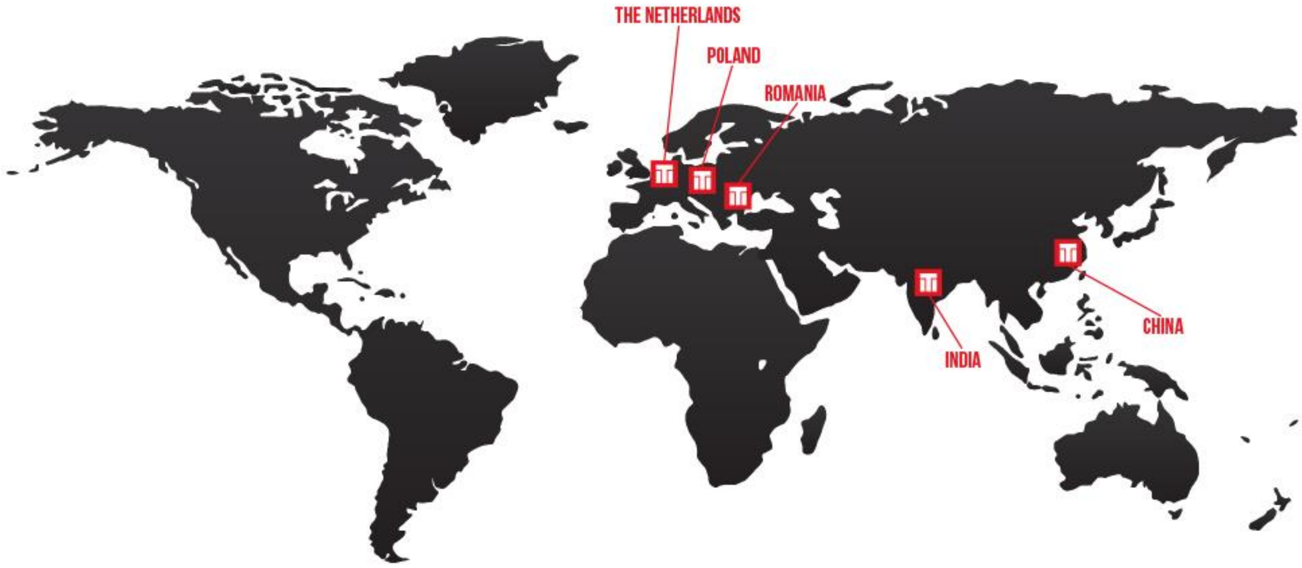
$$F = \frac{F_{tot} \times z}{n} = \frac{[(F_G + F_{adh}) \times z]}{n} = \frac{306 \times 1.16}{4} = 88.74\ kN$$

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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