TERWA

TECHNICAL DOCUMENTATION

2D - LIFTING SYSTEMS | SA-B SPREAD ANCHOR
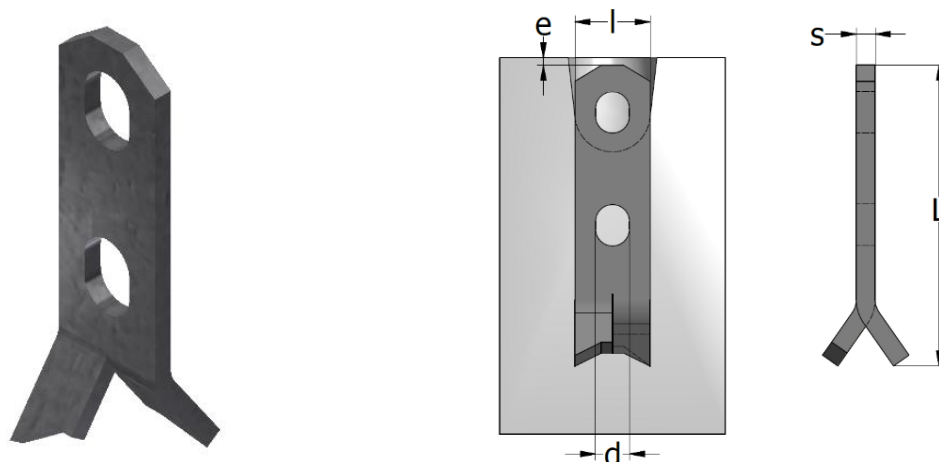
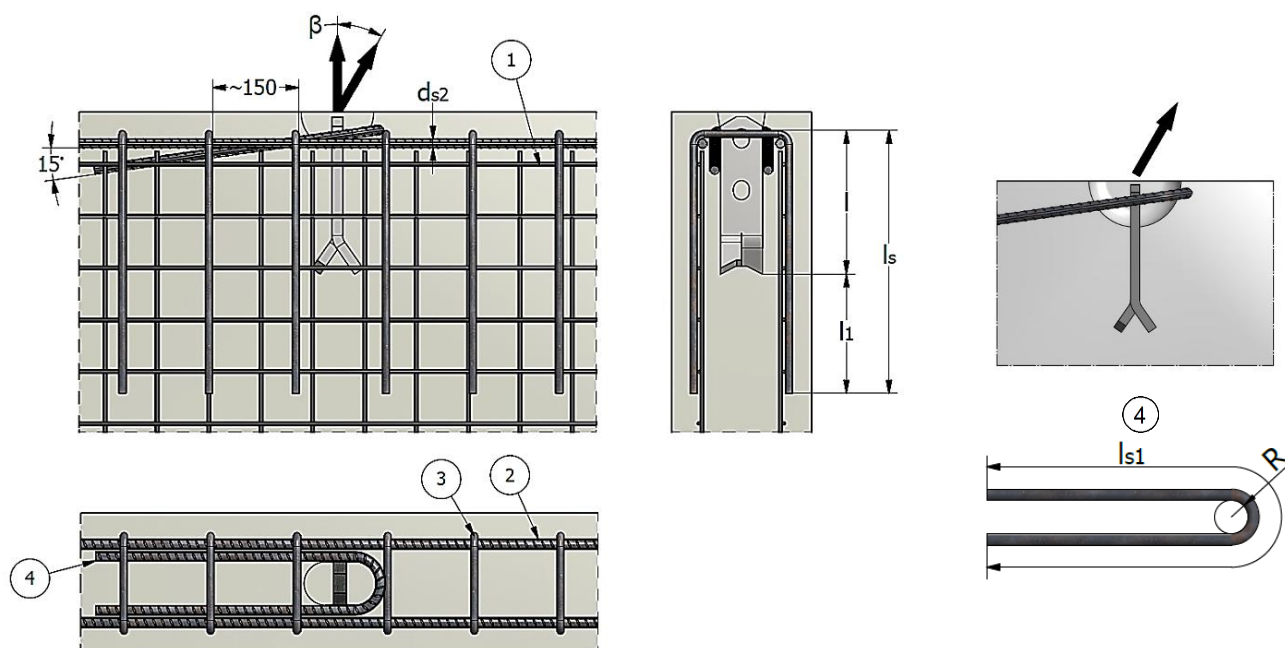**TABLE OF CONTENTS:**

![TERWA]

SPREAD ANCHOR SA-B

The **"spread anchor" SA-B anchors** are designed for load range 14 kN to 220 kN. They are easily adaptable and provide an efficient anchorage for thin panels as well as for large slabs or other precast elements. The anchor is designed with a hole for extra reinforcement steel.

SPREAD ANCHOR SA -B, DIMENSIONS AND LOAD CAPACITY								
Anchor type	**Product number**		**L**	**l**	**s**	**d**	**Load range**	**e**
	Black	**Hot-dip galvanised**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[kN]**	**[mm]**
Lifting clutch load group 25 kN								
SA -B 7 kN – 110	44991	45022	110	30	5	14	7	
SA -B 14 kN – 110	44992	45023	110	30	6	14	14	
SA -B 14 kN – 160	44993	45024	160	30	6	14	14	
SA -B 20 kN – 130	44994	45025	130	30	8	14	20	
SA -B 20 kN – 160	44995	45026	160	30	8	14	20	
SA -B 20 kN – 210	44996	45027	210	30	8	14	20	10
SA -B 25 kN – 150	44997	45028	150	30	10	14	25	
SA -B 25 kN – 200	44998	45029	200	30	10	14	25	
SA -B 25 kN – 250	44999	45030	250	30	10	14	25	
Lifting clutch load group 50 kN								
SA -B 30 kN – 160	45000	45031	160	40	10	18	30	
SA -B 30 kN – 220	45001	45032	220	40	10	18	30	
SA -B 30 kN – 280	45002	45033	280	40	10	18	30	
SA -B 40 kN – 180	45003	45034	180	40	12	18	40	
SA -B 40 kN – 240	45004	45035	240	40	12	18	40	
SA -B 40 kN – 320	45005	45036	320	40	12	18	40	10
SA -B 50 kN – 180	45006	45037	180	40	15	18	50	
SA -B 50 kN – 240	45007	45038	240	40	15	18	50	
SA -B 50 kN – 400	45008	45039	400	40	15	18	50	
Lifting clutch load group 100 kN								
SA -B 53 kN – 220	45009	45040	220	60	12	26	53	
SA -B 53 kN – 260	45010	45041	260	60	12	26	53	
SA -B 53 kN – 340	45011	45042	340	60	12	26	53	
SA -B 75 kN – 260	45012	45043	260	60	15	26	75	
SA -B 75 kN – 300	45013	45044	300	60	15	26	75	15
SA -B 75 kN – 420	45014	45045	420	60	15	26	75	
SA -B 100 kN – 300	45015	45046	300	60	20	27	100	
SA -B 100 kN – 370	45016	45047	370	60	20	27	100	
SA -B 100 kN – 520	45017	45048	520	60	20	27	100	
Lifting clutch load group 260 kN								
SA -B 140 kN – 370	45018	45049	370	80	20	35	140	
SA -B 140 kN – 460	45019	45050	460	80	20	35	140	15
SA -B 220 kN – 500	45020	45051	500	80	25	35	220	
SA -B 220 kN – 620	45021	45052	620	80	25	35	220	

SA-B ANCHOR - INSTALLATION AND REINFORCEMENT

Note: *The bend radius will be determined according to EN 1992.*
The diagonal reinforcement must be placed as close as possible to the recess former and installed in contact with the lifting anchor.
The reinforced zone must be $\geq 3 \times$ anchor lenght "L".
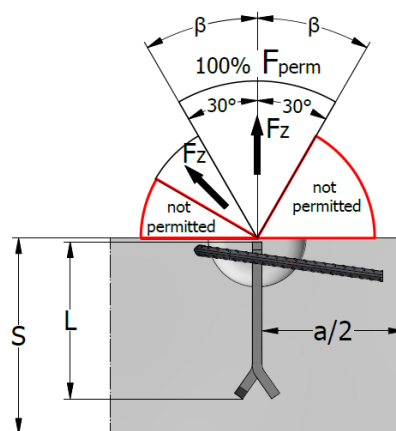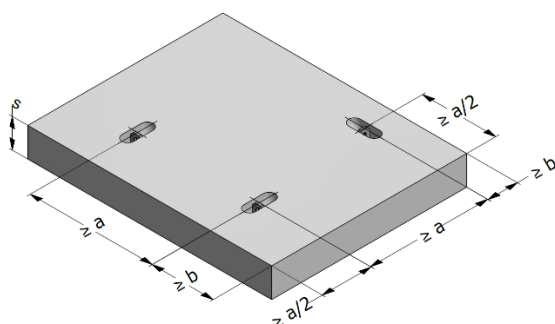*Length* $l_s = l_1 +$*Anchor length*
The dimensions in the illustrations are in [mm]

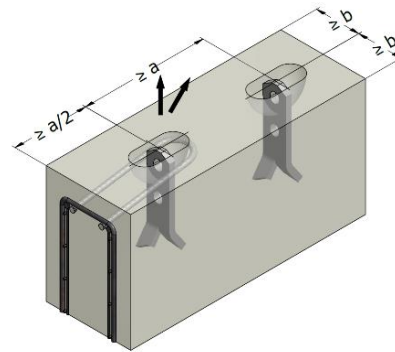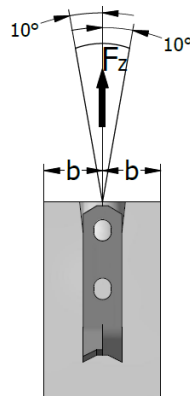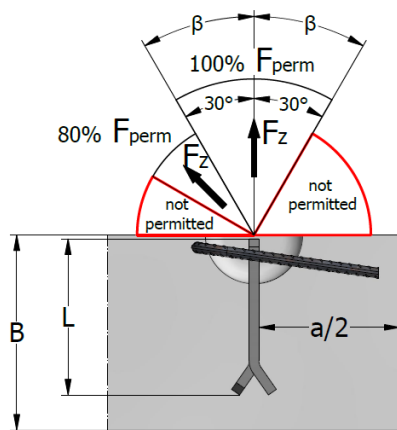| SA-B ANCHOR, INSTALLATION AND REINFORCEMENT						
Anchor type	**Load group**	**Pull** $\beta < 30°$ **Mesh reinforcement (both sides)** ①	**Edge reinforcement** ②	**Angled pull** $\beta > 30°$ max. 45° **Stirrups** ③		**Angled pull reinforcement** $\emptyset \times l_{s1}$ ④
				$\emptyset \times l_1$	**Number of stirrups**	
	[kN]	[mm2/m]	ds1 [mm]	[mm]	[pcs.]	[mm]
Lifting clutch load group 25 kN						
SA -B 7 kN	7	2x131	Ø 8	Ø 6 x 400	4	Ø 6 x 900
SA -B 14 kN	14		Ø 8	Ø 6 x 400	4	Ø 6 x 900
SA -B 20 kN	20		Ø 8	Ø 6 x 500	4	Ø 8 x 1000
SA -B 25 kN	25		Ø 10	Ø 8 x 600	4	Ø 8 x 1200
Lifting clutch load group 50 kN						
SA -B 30 kN	30	2x131	Ø 10	Ø 8 x 700	4	Ø10 x 1150
SA -B 40 kN	40		Ø 12	Ø 8 x 800	4	Ø10 x 1500
SA -B 50 kN	50		Ø12	Ø10 x 800	4	Ø12 x 1550
Lifting clutch load group 100 kN						
SA -B 53 kN	53	2x188	Ø12	Ø10 x 800	4	Ø14 x 1800
SA -B 75 kN	75		Ø12	Ø10 x 800	4	Ø14 x 2000
SA -B 100 kN	100		Ø14	Ø10 x1000	6	Ø16 x 2300
Lifting clutch load group 260 kN						
SA -B 140 kN	140	2x257	Ø14	Ø10 x1000	8	Ø20 x 2600
SA -B 220 kN	220		Ø16	Ø10 x1200	8	Ø28 x 3450

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INSTALLATION OF SA-B IN SLABS

For the lifting procedure, the position of the anchor in the concrete element is very important. The axial spacing for SA-B anchors in slabs can be seen in the table below.

Note: *The minimum accepted concrete cover is 25 mm. A thinner slab can only be permitted if there is special corrosion protection.*
For angled lifting reinforcement steel, please see page 23.

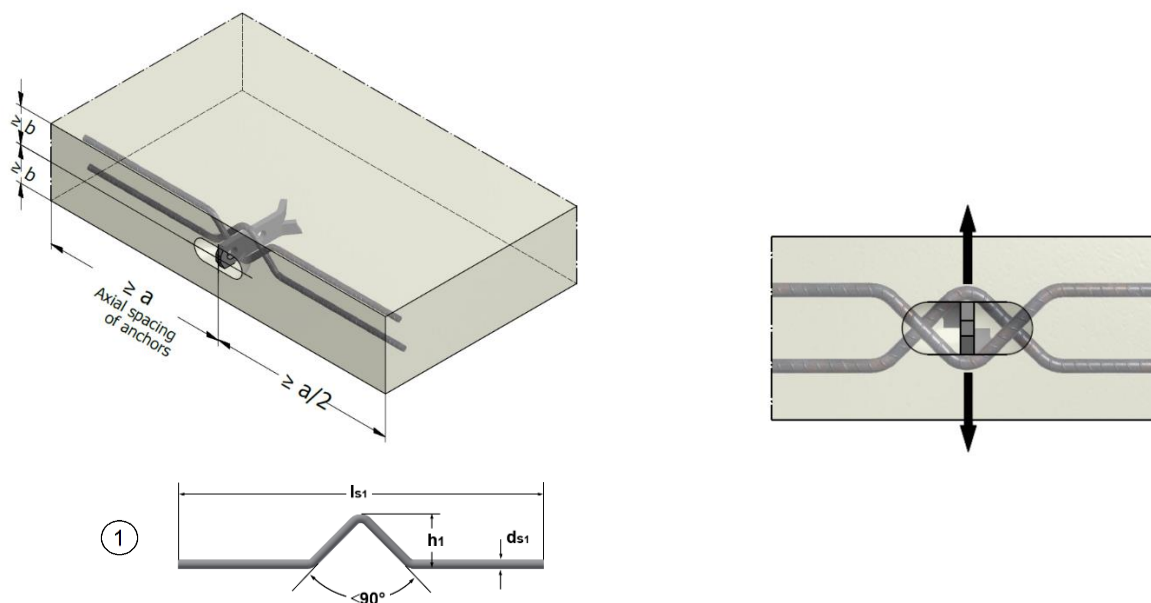| INSTALLATION OF SA-B IN SLABS – LOAD CAPACITY, INSTALLATION DIMENSIONS									
Anchor type	**Anchor length "L"**	**Load group**	**Minimum thickness of precast unit "S"**	**Minimum edge distance "b"**			**Load capacity** $f_{cu} \geq$ 15 MPa		**Minimum spacing between anchors "a"**
				$f_{cu} \geq$ 15 MPa	$f_{cu} \geq$ 15 MPa	$f_{cu} \geq$ 15 MPa	**Axial pull**	**Angled pull** $\beta > 30°$ max. $45°$	
	[mm]	[kN]	[mm]	[mm]	[mm]	[mm]	[kN]	[kN]	[mm]
Lifting clutch load group 25 kN									
SA -B 7 kN – 110	110	7	145	45	40	35	7	5.6	280
SA -B 14 kN – 110	110	14	145	70	50	40	14	11.2	380
SA -B 14 kN – 160	160	20	195	50	35	35	14	11.2	540
SA -B 20 kN – 130	130	20	165	100	70	55	20	16.0	440
SA -B 20 kN – 160	160	20	195	85	65	45	20	16.0	520
SA -B 20 kN – 210	210	20	195	70	50	40	20	16.0	770
SA -B 25 kN – 150	150	25	185	120	85	70	25	20.0	530
SA -B 25 kN – 200	200	25	235	90	64	50	25	20.0	720
SA -B 25 kN – 250	250	25	285	80	55	40	25	20.0	920
Lifting clutch load group 50 kN									
SA -B 30 kN – 160	160	30	195	145	102	80	30	24.0	550
SA -B 30 kN – 220	220	30	255	110	78	61	30	24.0	750
SA -B 30 kN – 280	280	30	315	105	75	58	30	24.0	950
SA -B 40 kN – 180	180	40	215	190	135	105	40	32.0	610
SA -B 40 kN – 240	240	40	275	145	100	80	40	32.0	850
SA -B 40 kN – 320	320	40	355	110	75	60	40	32.0	1170
SA -B 50 kN – 180	180	50	215	260	180	145	50	40.0	600
SA -B 50 kN – 240	240	50	275	195	140	110	50	40.0	840
SA -B 50 kN – 400	400	50	435	115	85	65	50	40.0	1480
Lifting clutch load group 100 kN									
SA -B 53 kN – 220	220	53	260	240	175	155	53	42.4	660
SA -B 53 kN – 260	260	53	300	200	145	135	53	42.4	780
SA -B 53 kN – 340	340	53	380	170	120	110	53	42.4	1020
SA -B 75 kN – 260	260	75	300	300	215	175	75	60.0	900
SA -B 75 kN – 300	300	75	340	265	190	150	75	60.0	1060
SA -B 75 kN – 420	420	75	460	190	135	110	75	60.0	1540
SA -B 100 kN – 300	300	100	340	390	275	220	100	80.0	1030
SA -B 100 kN – 370	370	100	410	315	225	180	100	80.0	1310
SA -B 100 kN – 520	520	100	560	225	160	130	100	80.0	1910
Lifting clutch load group 260 kN									
SA -B 140 kN – 370	370	140	410	500	355	285	140	112.0	1230
SA -B 140 kN – 460	460	140	500	400	285	230	140	112.0	1590
SA -B 220 kN – 500	500	220	540	675	480	385	220	176.0	1700
SA -B 220 kN – 620	620	220	660	540	385	310	220	176.0	2180

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INSTALLATION OF SA-B IN BEAMS AND WALLS

The angled pull reinforcement must be mounted opposite the direction of the load

| Product name	Anchor length "L"	Load group	Minimum beam height "B"	Minimum thickness of precast unit "2 × b"			100 % F_{perm} pull $\beta < 30°$	80 % F_{perm} pull $\beta > 30°$ max. $45°$	Minimum spacing between anchors "a"
				$f_{cu} \geq 15$ MPa	$f_{cu} \geq 15$ MPa	$f_{cu} \geq 15$ MPa			
	[mm]	[kN]	[mm]	[mm]	[mm]	[mm]			[mm]
Lifting clutch load group 25 kN									
SA -B 7 kN – 110	110	7	240	70	60	60	7	5.6	375
SA -B 14 kN – 110	110	14	240	80	64	65	14	11	375
SA -B 14 kN – 160	160	20	340	80	64	65	14	11	540
SA -B 20 kN – 130	130	20	280	100	80	72	20	16	440
SA -B 20 kN – 160	160	20	350	100	80	72	20	16	520
SA -B 20 kN – 210	210	20	385	100	80	72	20	16	770
SA -B 25 kN – 150	150	25	320	120	95	85	25	20	530
SA -B 25 kN – 200	200	25	420	120	95	85	25	20	720
SA -B 25 kN – 250	250	25	520	120	95	85	25	20	920
Lifting clutch load group 50 kN									
SA -B 30 kN – 160	160	30	340	160	110	100	30	24	550
SA -B 30 kN – 220	220	30	450	130	100	90	30	24	750
SA -B 30 kN – 280	280	30	580	120	95	85	30	24	950
SA -B 40 kN – 180	180	40	380	210	150	130	40	32	610
SA -B 40 kN – 240	240	40	500	200	140	120	40	32	850
SA -B 40 kN – 320	320	40	660	180	130	115	40	32	1170
SA -B 50 kN – 180	180	50	380	350	245	190	50	40	600
SA -B 50 kN – 240	240	50	500	220	155	140	50	40	840
SA -B 50 kN – 400	400	50	820	200	140	130	50	40	1480
Lifting clutch load group 100 kN									
SA -B 53 kN – 220	220	53	460	350	210	150	53	42.4	710
SA -B 53 kN – 260	260	53	545	180	150	120	53	42.4	835
SA -B 53 kN – 340	340	53	700	180	150	120	53	42.4	1080
SA -B 75 kN – 260	260	75	550	340	240	190	75	60	900
SA -B 75 kN – 300	300	75	630	240	170	135	75	60	1060
SA -B 75 kN – 420	420	75	870	200	160	150	75	60	1540
SA -B 100 kN – 300	300	100	630	450	300	200	100	80	1030
SA -B 100 kN – 370	370	100	770	270	216	170	100	80	1310
SA -B 100 kN – 520	520	100	1070	250	200	160	100	80	1910
Lifting clutch load group 260 kN									
SA -B 140 kN – 370	370	140	770	610	420	320	140	112	1230
SA -B 140 kN – 460	460	140	950	350	250	200	140	112	1590
SA -B 220 kN – 500	500	220	1030	760	500	360	220	176	1700
SA -B 220 kN – 620	620	220	1270	450	315	260	220	176	2180

Note: *For required reinforcement and angled pull, please see the table and illustrations on page 23.*
*Angled pull using cable or chain with $\beta > 45°$ is **not permitted**.*

![TERWA logo]

SA-B ANCHOR - INSTALLATION AND REINFORCEMENT FOR TURNING AND TILTING

Note: *The bend radius and length l_s will be determined according to EN 1992.*
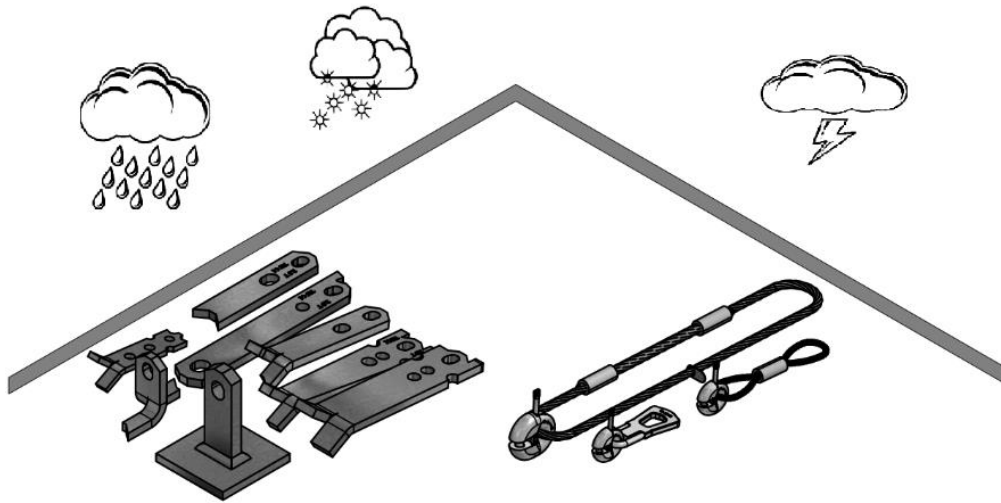*The additional reinforcement and the anchor position will be positioned as in the illustration above.*
The h1 dimension will be determined in function of the thickness of the element.

SA-B ANCHOR – INSTALLATION DIMENSIONS AND REINFORCEMENT FOR TILTING AND TURNING								
		$f_{cu} \geq 15$ MPa			Tilting and turning reinforcement (1)		$f_{cu} \geq 15$ MPa	
Anchor type	**Load group**	**100 % F_{perm} LIFTING $\beta < 30°$**	**80 % F_{perm} LIFTING $\beta > 30°$ max. 45°**	**50 % F_{perm} TILTING**	**ds1**	**ls1**	**Minimum spacing between anchors "a"**	**Minimum edge distance "b"**
	[kN]	[kN]	[kN]	[kN]	[mm]	[mm]	[mm]	
Lifting clutch load group 25 kN								
SA -B 7 kN – 110	7	7	5.6	3.5	Ø 8	600	700	100
SA -B 14 kN – 160	14	14	11.2	7	Ø 10	700	700	100
SA -B 20 kN – 210	20	20	16	10	Ø 10	750	800	100
SA -B 25 kN – 250	25	25	20	12.5	Ø 12	800	875	100
Lifting clutch load group 50 KN								
SA -B 30 kN – 280	30	30	24	15	Ø 12	850	950	150
SA -B 40 kN – 320	40	40	32	20	Ø 14	950	1050	150
SA -B 50 kN – 400	50	50	40	25	Ø 16	1000	1435	150
Lifting clutch load group 100 KN								
SA -B 53 kN – 340	53	53	42.4	26.5	Ø16	1000	1200	150
SA -B 75 kN – 420	75	75	60	37.5	Ø 20	1200	1470	250
SA -B 100 kN – 520	100	100	80	50	Ø 20	1500	1820	300
Lifting clutch load group 260 KN								
SA -B 140 kN – 460	140	140	112	70	Ø 25	1800	1800	525
SA -B 220 kN – 620	220	220	176	110	Ø 28	1800	2200	710

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.
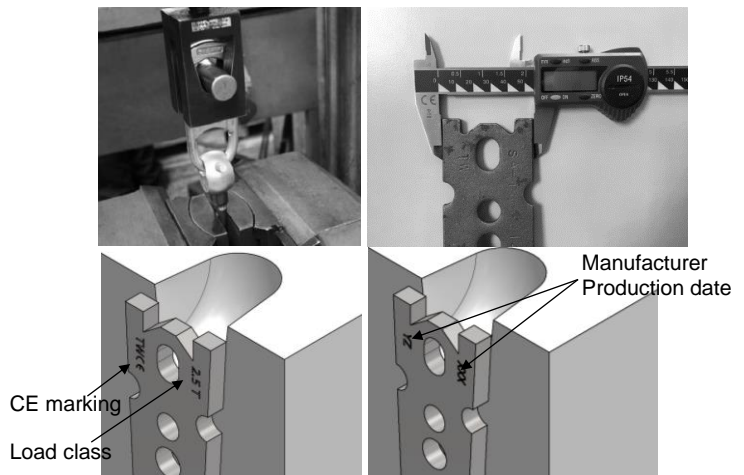
Welding on the anchor is not permitted.

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.
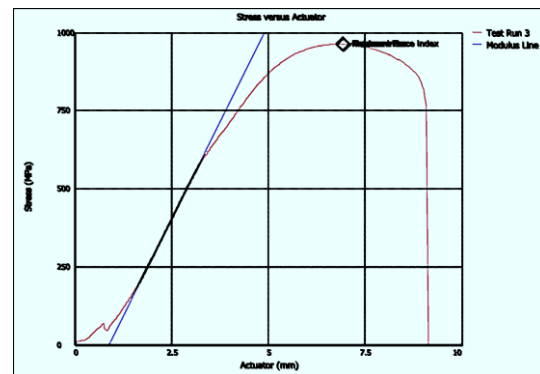

Marking and traceability

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

Manufacturer
Production date

CE marking

Load class

Anchor testing

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

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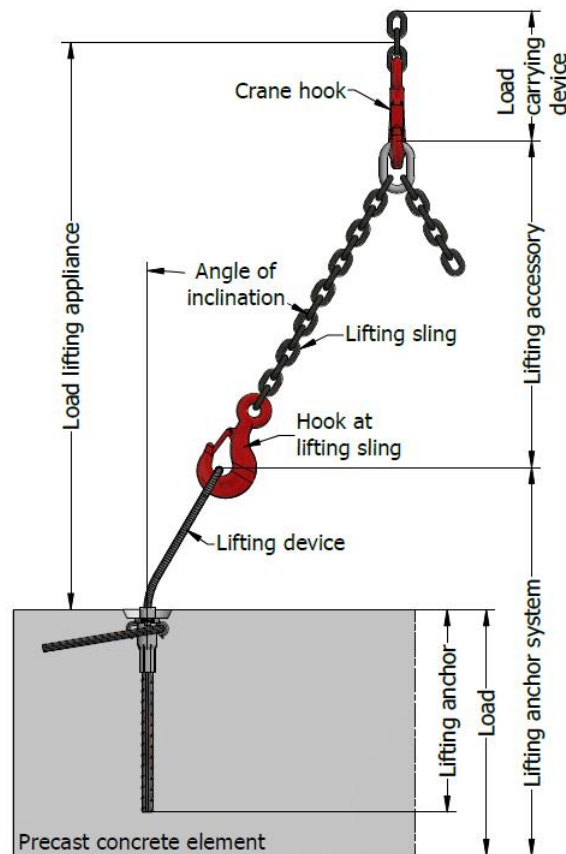
Application of lifting anchor system

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

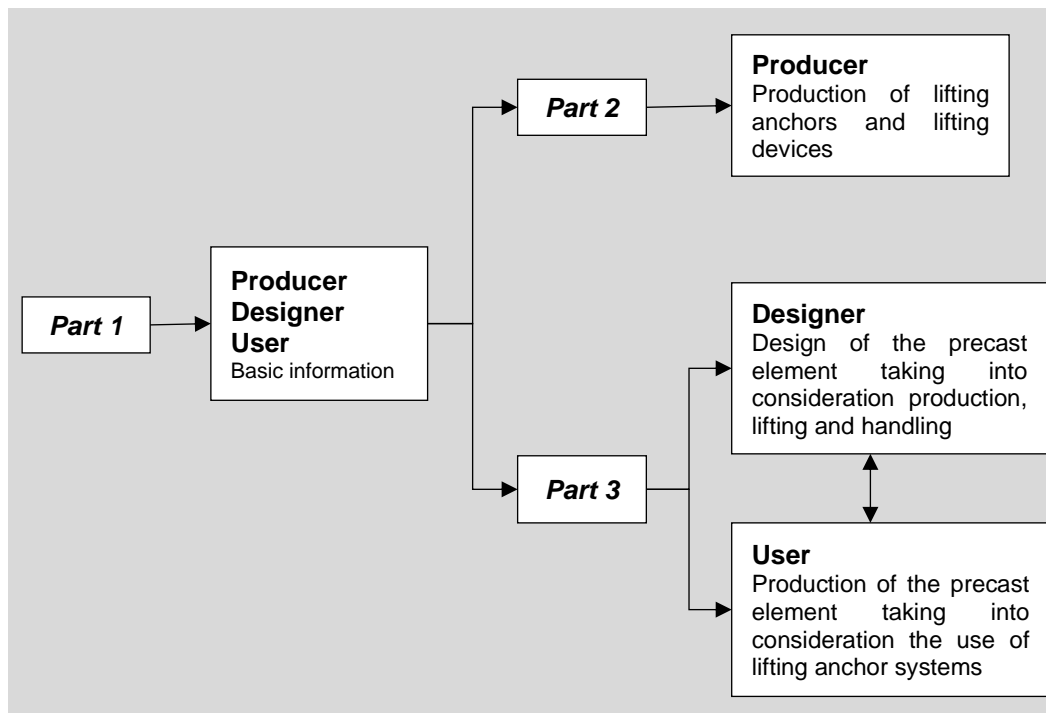**Lifting accessory** – equipment that creates a link between the load carrying device and the lifting device.

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.

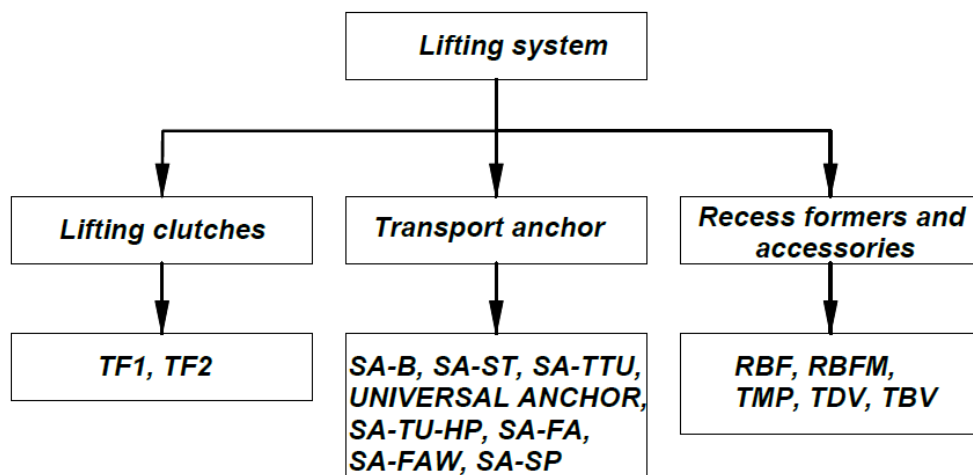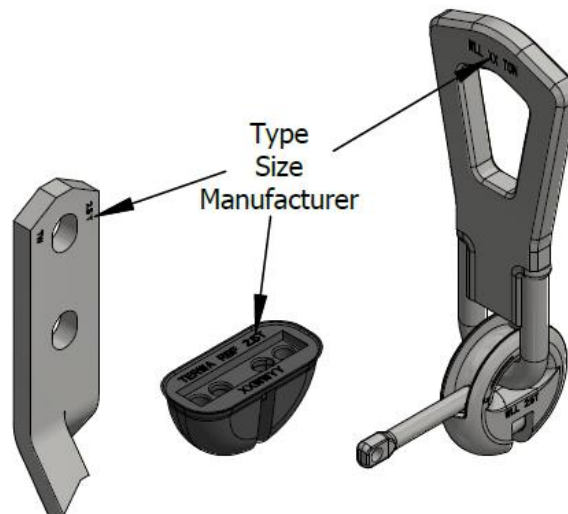**LIFTING SYSTEMS**

- **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.

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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.
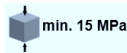
The 1D threaded lifting system is mainly used when the hoisting angles are limited, while the 2D strip anchor lifting system and the 3D T-slot anchor lifting system can be used for all hoisting angles, with minor limitations for the 2D strip anchor lifting system. The difference between the 2D strip 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)
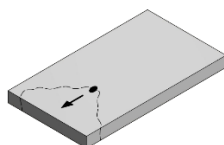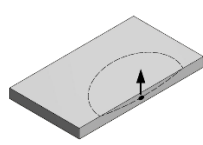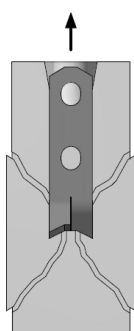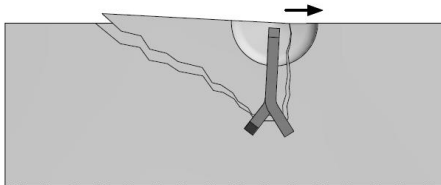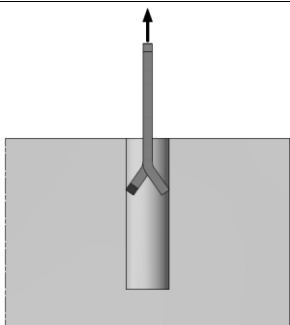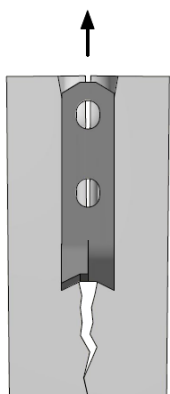
The admissible load (resistance) of lifting anchor and lifting device is obtained as follows:
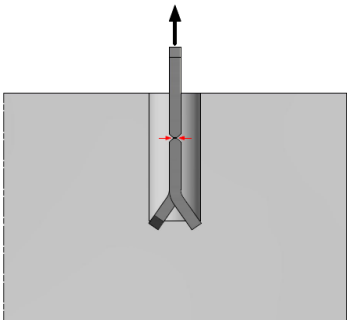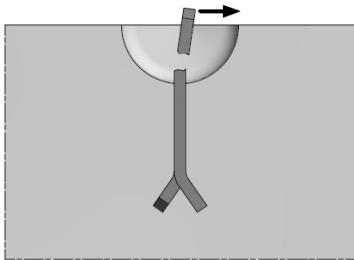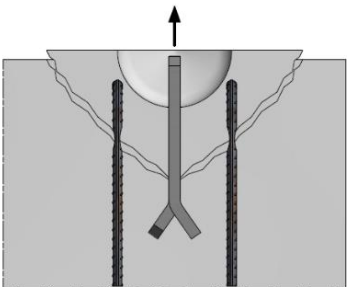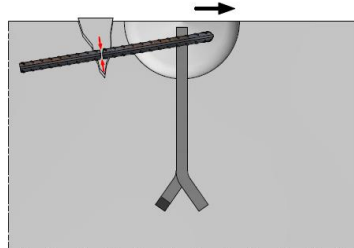
$$R_{adm} = \frac{Rk}{\gamma}$$ Where: R_k - characteristic resistance of the anchoring of a lifting anchor or lifting device, γ - global safety factor

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.

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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.			

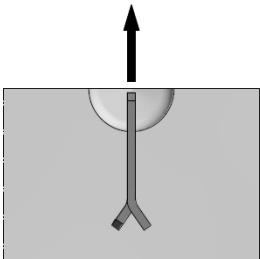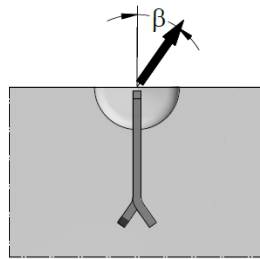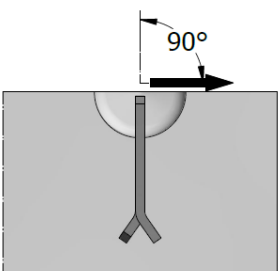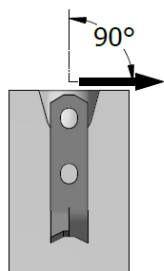| Failure type	Fracture pattern: tensile force	Fracture pattern: transverse shear force
Steel failure Failure mode characterised by fracture of the steel lifting anchor parts.		
Steel failure of additional reinforcement Steel failure of the supplementary reinforcement loaded directly or indirectly by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

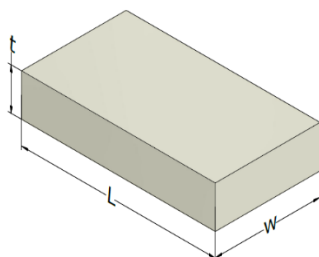| *Direction of stress*			
Axial tension		*Parallel shear pull*	
Load or load component action in the direction of the longitudinal axis of the lifting anchor.		Load or load component action at an angle β to the longitudinal axis of the lifting anchor in the plane of the precast component.	
Transverse 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.	

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LOAD CAPACITY
The load capacity of the anchor depends on multiple factors such as:
- The deadweight of the precast concrete element "F_G"
- Adhesion to the formwork
- The load direction, angle of pull
- Number of load bearing anchors
- The edge distance and spacing of the anchors
- The strength of the concrete when operating, lifting or transporting
- The embedded depth of the anchor
- Dynamic forces
- The reinforcement arrangement

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

$$F_G = \rho \times V$$

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

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

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

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

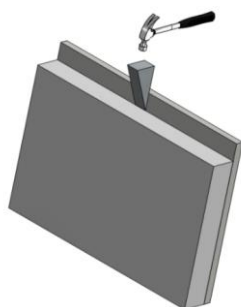Where: F_{adh} – action due to adhesion and form friction, in kN

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

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

Adhesion to the formwork	q_{adh} in kN/m²
Oiled steel formwork, oiled plastic-coated plywood	≥ 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**".
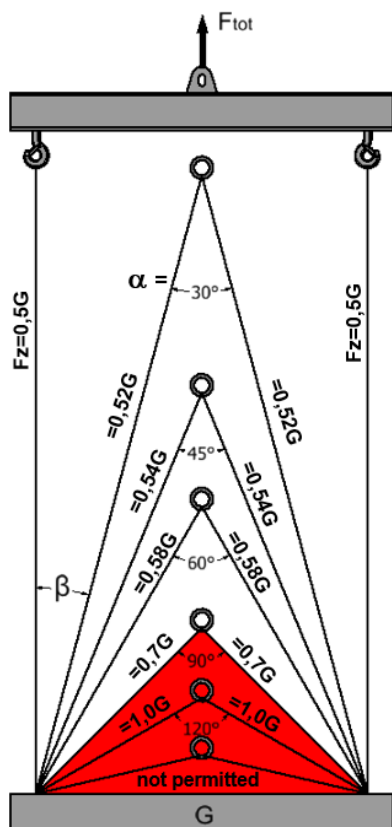
z = 1/cosβ

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

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.
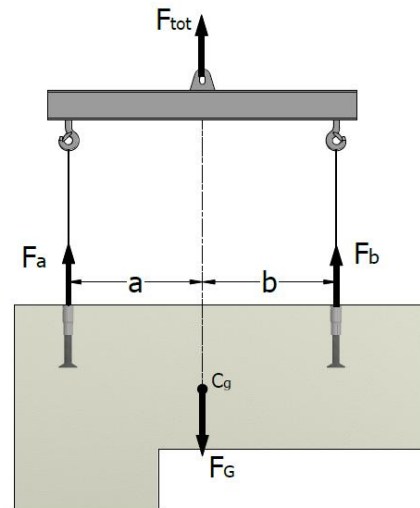
ASYMMETRIC DISTRIBUTION OF THE LOAD

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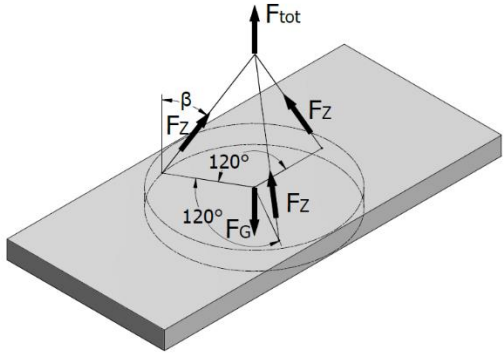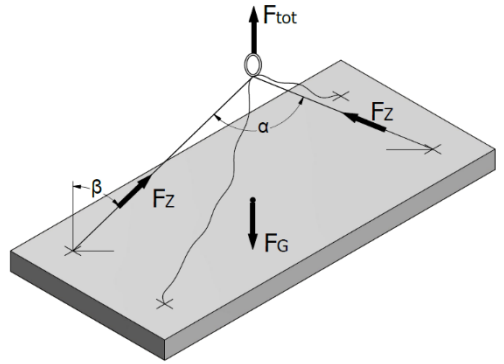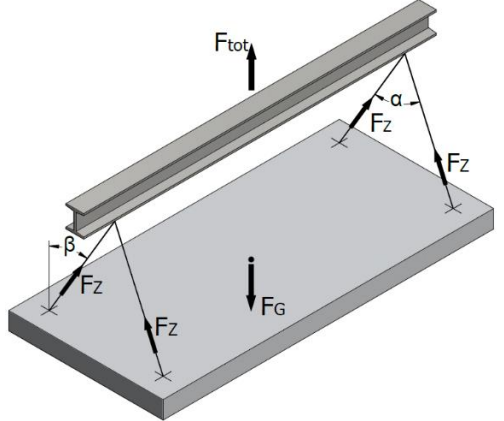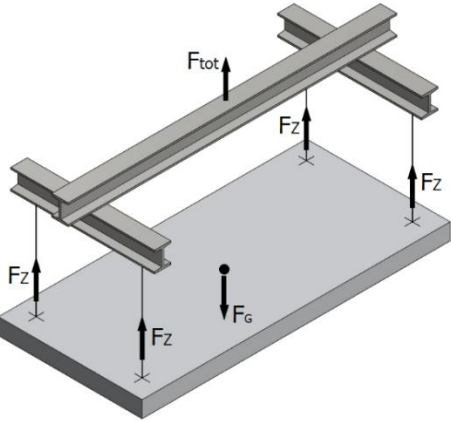
$$F_a = F_{tot} \times b/(a+b)$$
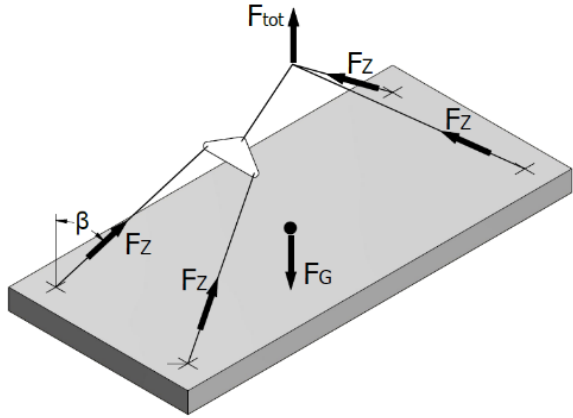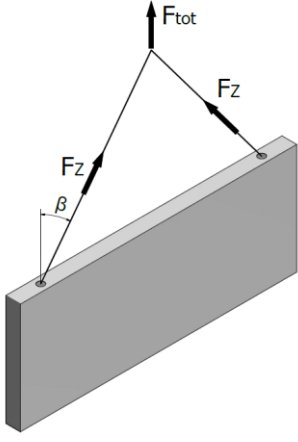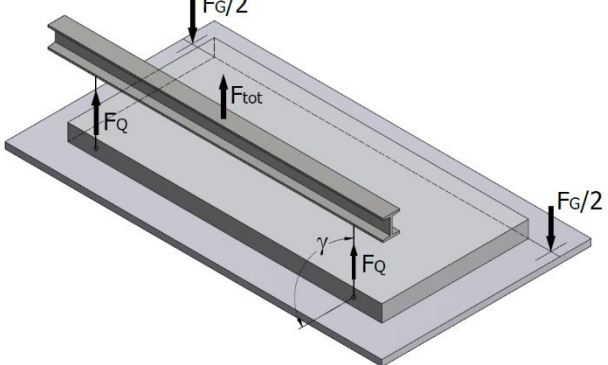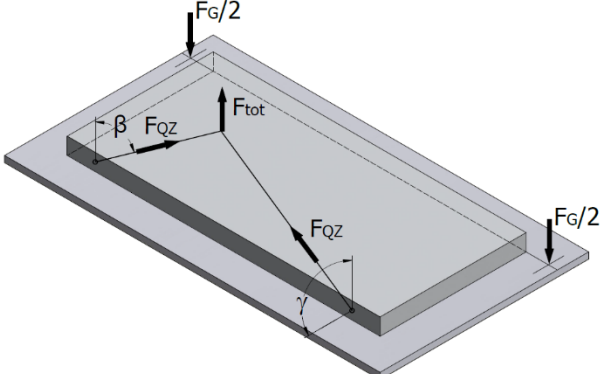
$$F_b = F_{tot} \times a/(a+b)$$

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 (ß).
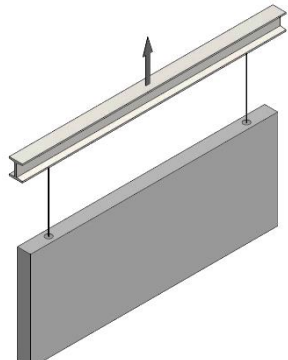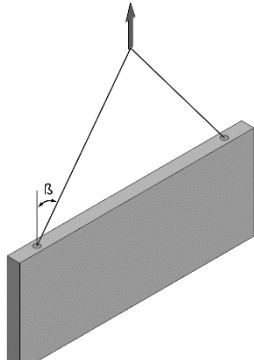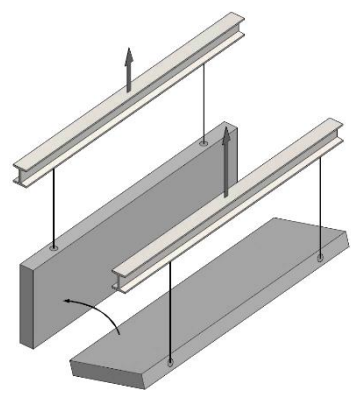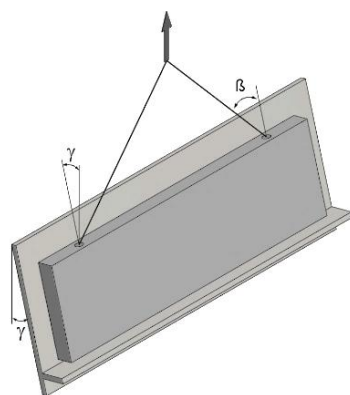
ANCHORS LIFTING CONDITIONS

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=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	
Perfect force distribution is assumed using a spreader beam 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	
Perfect static weight distribution can be obtained using a lifting beam and two pairs of anchors symmetrically placed. 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	

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 ≤ 30°*
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 $z \geq 1$
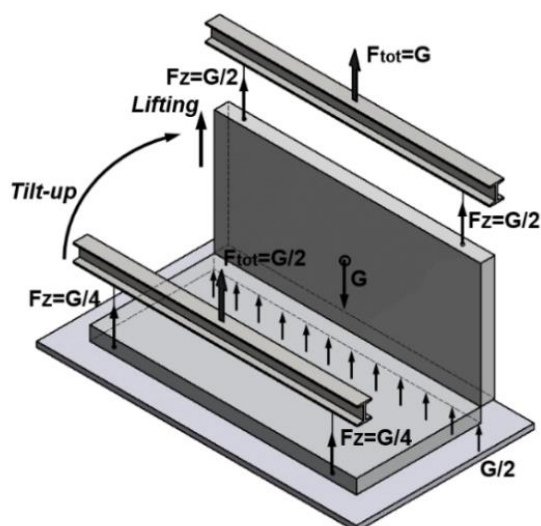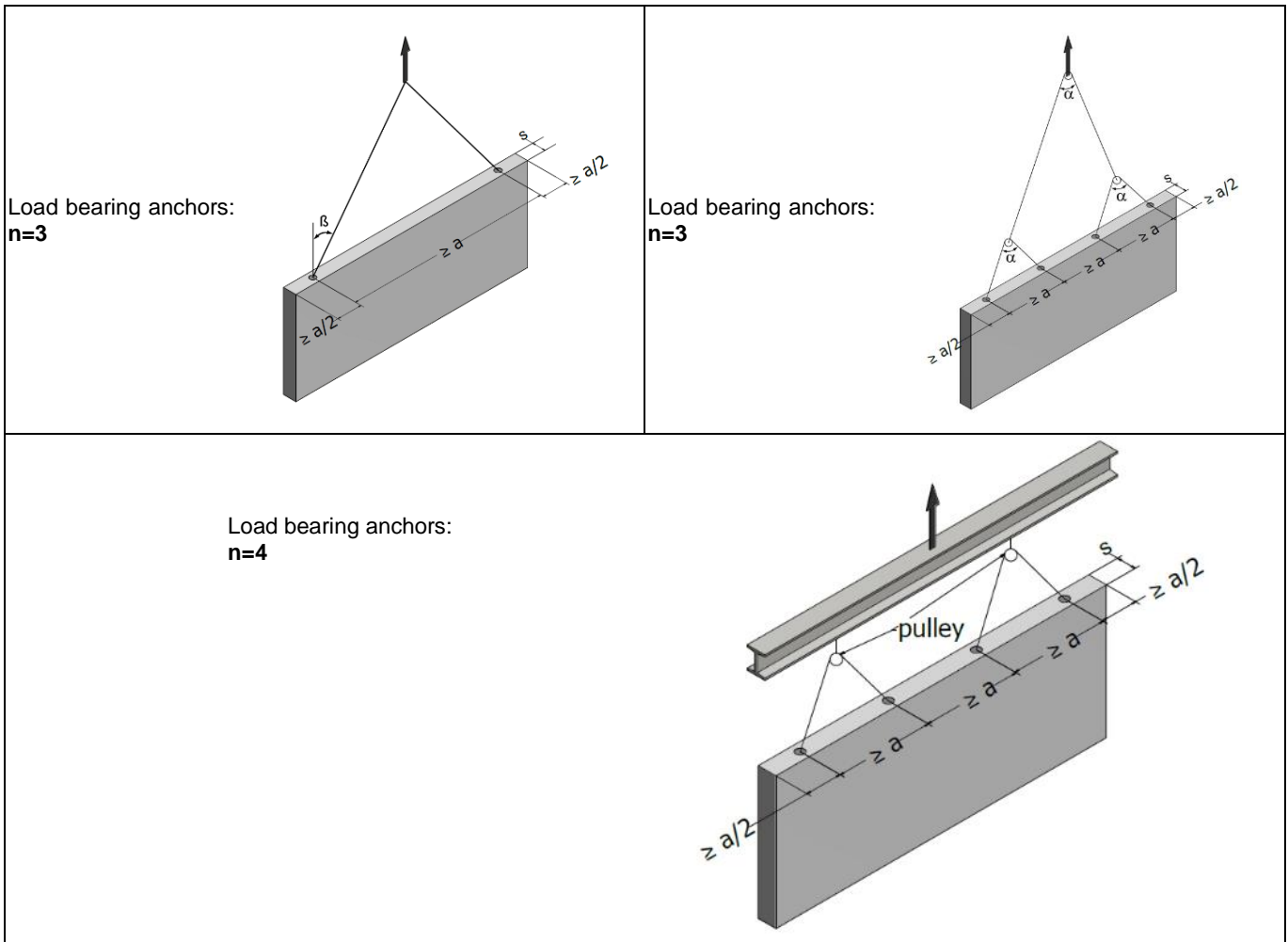-no formwork adhesion
-dynamic factor

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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 ≤ 30 º 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

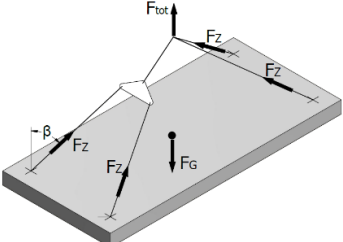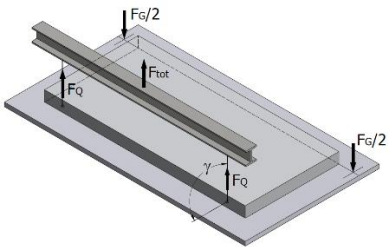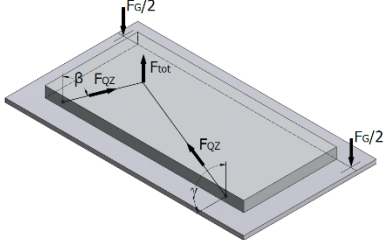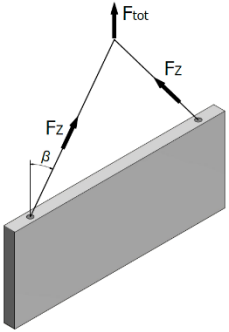Load bearing anchors:
n=3

Load bearing anchors:
n=3

Load bearing anchors:
n=4

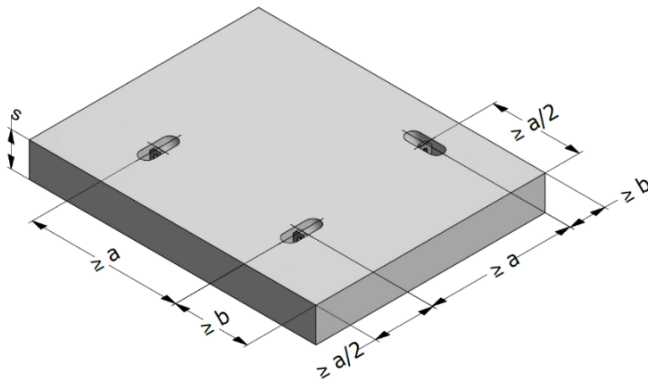Lifting the walls from horizontal to vertical position without tilt-up table.

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

DETERMINATION OF ANCHOR LOAD

Load type		Calculation	Verification
Lifting with formwork adhesion		$$F_Z = \frac{(F_G + F_{adh}) \times z}{n}$$ F_Z – Load acting on the lifting anchor in kN	$$F_Z \leq N_{R,adm}$$ $N_{R,adm}$ – 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

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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:
$$L = 5\,m$$
$$w = 2\,m$$
$$t = 0.2\,m$$

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

Formwork area $A_f = L \times w = 5 \times 2 = 10\,m^2$

Anchor number $n = 2$

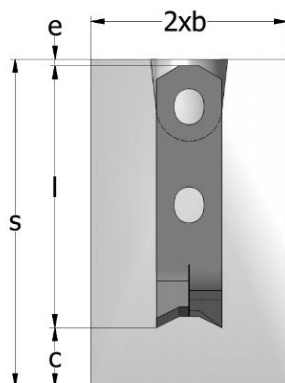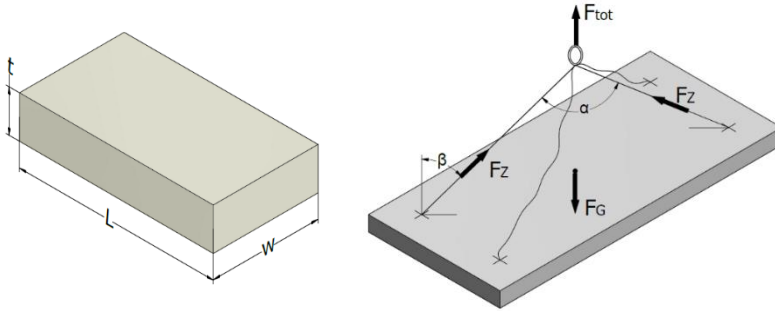| General data:	Symbol	De-mould	Transport	Mount
Concrete strength at de-mould [MPa]		15	15	
Concrete strength on site [MPa]				35
Element weight [kN]	F_G	50		
Element area in contact with formwork [m²]	A_f	10		
Cable angle factor at de-mould ($\beta = 15.0°$)	z	1.04	1.04	
Cable angle factor on site ($\beta = 30.0°$)	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

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

TRANSPORT AT THE PLANT:

Dynamic coefficient: ψ_{dyn} = 1.3
Cable angle factor: z = 1.04 (β = 15.0°)
Concrete strength: 15 MPa

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

TRANSPORT ON SITE:

Dynamic coefficient: ψ_{dyn} = 1.3
Cable angle factor: z = 1.16 (β = 30.0°)
Concrete strength: 15 MPa

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

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

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EXAMPLE 1: WALL PANEL

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

Weight $F_G = \rho \times V = 25 \times (7.5 \times 2 \times 0.18) = 67.5 kN$
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 ($\beta = 0.0°$)	z	1.0		
Cable angle factor at tilting ($\beta = 0.0°$)	z		1.0	
Cable angle factor on site ($\beta = 30°$)	z			1.16
Dynamic coefficient at tilting	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 ($\beta = 0°$)
Concrete strength: 15 MPa

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

TRANSPORT AT THE PLANT:

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

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

TRANSPORT ON SITE:

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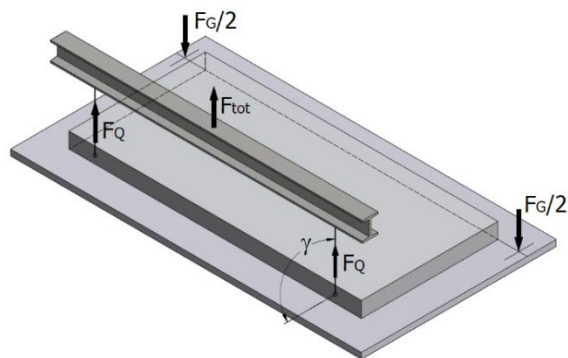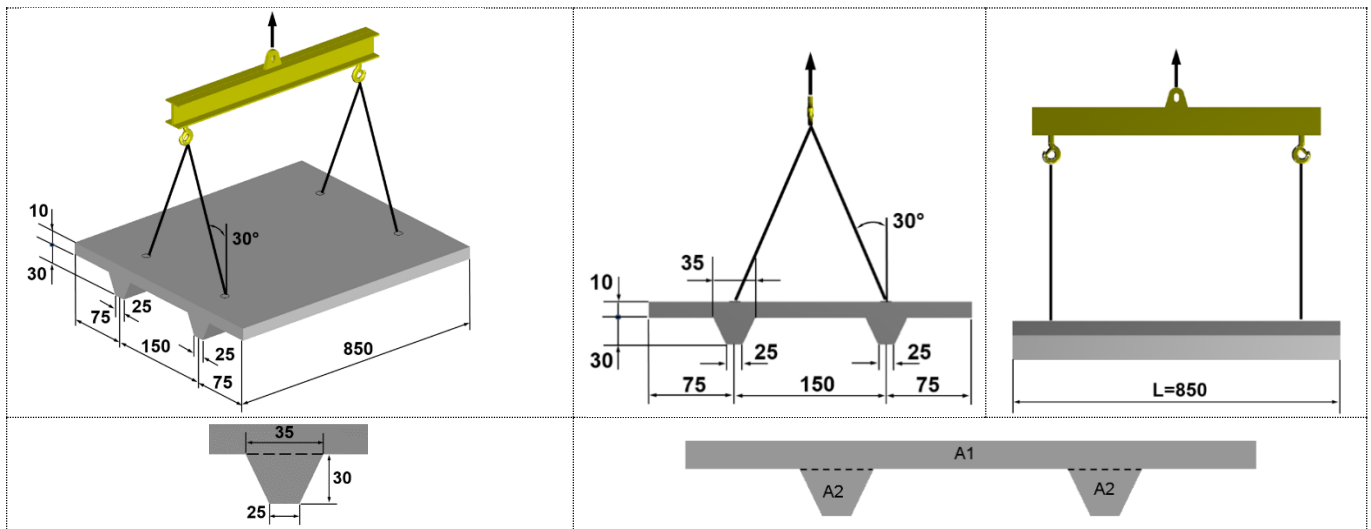Concrete strength: 15 MPa

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

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).

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EXAMPLE 1: DOUBLE-T BEAM

NOTE: Dimensions are in cm

General data:	Symbol	De-mould	Transport
Concrete strength at de-mould and transport [MPa]		25	25
Element weight [kN]	F_G	102	
Formwork area [m²]	A_f	35.8	
Cable angle factor at de-mould (ß = 30.0°)	z	1.16	
Cable angle factor on site (ß = 30.0°)	z		1.16
Dynamic coefficient at transport	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

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

$L = 5\ m$

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

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

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

LOAD PER ANCHOR WHEN DE-MOULD:

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

LOAD PER ANCHOR WHEN TRANSPORTING:

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

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

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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.

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