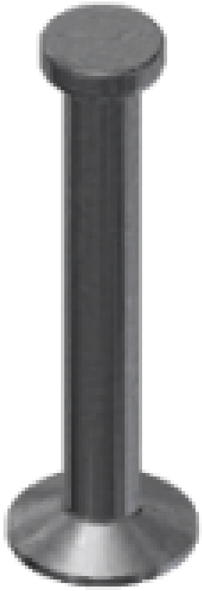
TECHNICAL DOCUMENTATION

3D - LIFTING SYSTEMS | T-SLOT ANCHOR



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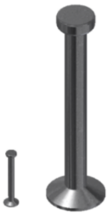
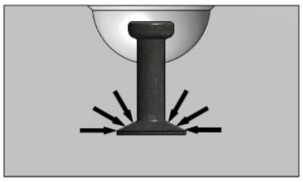
T–SLOT ANCHOR

BASIC PRINCIPLES FOR ANCHOR SELECTION

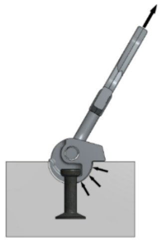
The T-slot anchors are forged from round steel and have a design load capacity in the range of 13kN to 320kN. Suitable for large precast elements, such as slabs, beams, panels and pipes. Anchors from 13 kN to 320 kN are made of S355J2 steel and the 450 kN anchors are made of alloyed steel 42CrMo4 (w1.7225-EN-10083-1). Anchors in the same load group are available in various lengths. Longer anchors are installed for reduced edge spacing or for low concrete strengths. The load on the anchor is transferred to the concrete through the anchor foot.



13 kN to 450 kN

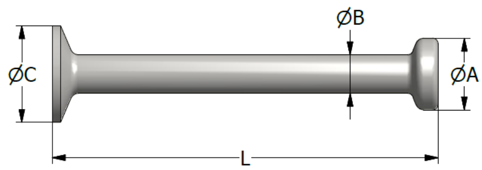


Load transfer to the anchor foot



Angled lifting

The anchors must be fixed in the mould using recess formers. The recess former holds the anchor securely in position when pouring the concrete. The recess former creates a void around the anchor head which corresponds to the lifting system head (shackle). Incorrect coupling of parts of different load groups is not possible. Another advantage is that the shackle rests against the concrete during angled pull. The horizontal load is therefore transferred directly to the concrete. For this reason, additional reinforcement is not required in large units. In thin walls, additional reinforcement is necessary for angled lift, to absorb the transverse pulling forces.



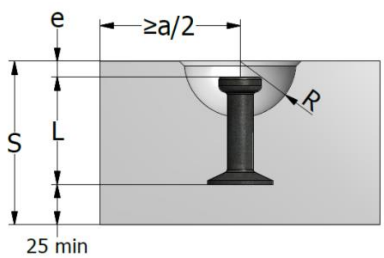
T-slot black		T-slot - hot dip galvanised		T-slot stainless steel 1.4301 (AISI 304)		Load group	L	ØA	ØB	ØC
Description	Prod. No.	Description	Prod. No.	Description	Prod. No.	kN	mm	mm	mm	mm
Lifting clutch load group 13 kN										
T-013-0040	43177	T-013-0040-TV	43178	T-013-0040-SS2	44405	13	40	19	10	25
T-013-0050	43180	T-013-0050-TV	43181	T-013-0050-SS2	43179	13	50	19	10	25
T-013-0055	43182	T-013-0055-TV	43183	T-013-0055-SS2	44406	13	55	19	10	25
T-013-0065	43184	T-013-0065-TV	43185	T-013-0065-SS2	43186	13	65	19	10	25
T-013-0085	43187	T-013-0085-TV	43188	T-013-0085-SS2	43189	13	85	19	10	25
T-013-0120	43190	T-013-0120-TV	43191	T-013-0120-SS2	43192	13	120	19	10	25
T-013-0240	43193	T-013-0240-TV	43194	T-013-0240-SS2	44407	13	240	19	10	25
Lifting clutch load group 25 kN										
T-025-0045	43808	T-025-0045-TV	43809	T-025-0045-SS2	44408	25	45	26	14	35
T-025-0055	43195	T-025-0055-TV	43196	T-025-0055-SS2	44409	25	55	26	14	35
T-025-0065	43197	T-025-0065-TV	43198	T-025-0065-SS2	61850	25	65	26	14	35
T-025-0070	43199	T-025-0070-TV	43200	T-025-0070-SS2	61851	25	70	26	14	35
T-025-0085	43201	T-025-0085-TV	43202	T-025-0085-SS2	43203	25	85	26	14	35
T-025-0100	43204	T-025-0100-TV	43205	T-025-0100-SS2	61852	25	100	26	14	35
T-025-0120	43206	T-025-0120-TV	43207	T-025-0120-SS2	43208	25	120	26	14	35
T-025-0140	43209	T-025-0140-TV	43817	T-025-0140-SS2	61853	25	140	26	14	35
T-025-0170	43210	T-025-0170-TV	43211	T-025-0170-SS2	43212	25	170	26	14	35
T-025-0210	43820	T-025-0210-TV	44960	T-025-0210-SS2	61854	25	210	26	14	35
T-025-0240	44961	T-025-0240-TV	44962	T-025-0240-SS2	61855	25	240	26	14	35
T-025-0280	43213	T-025-0280-TV	43214	T-025-0280-SS2	61856	25	280	26	14	35

T-slot black		T-slot - hot dip galvanised		T-slot stainless steel 1.4301 (AISI 304)		Load group	L	ØA	ØB	ØC
Description	Prod. No.	Description	Prod. No.	Description	Prod. No.	kN	mm	mm	mm	mm
Lifting clutch load group 50 kN										
T-040-0055	43821	T-040-0055-TV	43822	T-040-0055-SS2	63308	40	55	36	18	45
T-040-0065	43823	T-040-0065-TV	43824	T-040-0065-SS2	63309	40	65	36	18	45
T-040-0070	43825	T-040-0070-TV	43826	T-040-0070-SS2	63310	40	70	36	18	45
T-040-0075	43771	T-040-0075-TV	43772	T-040-0075-SS2	43773	40	75	36	18	45
T-040-0080	43774	T-040-0080-TV	43775	T-040-0080-SS2	43776	40	80	36	18	45
T-040-0095	43777	T-040-0095-TV	43778	T-040-0095-SS2	43779	40	95	36	18	45
T-040-0110	43827	T-040-0110-TV	43828	T-040-0110-SS2	63311	40	110	36	18	45
T-040-0120	43780	T-040-0120-TV	43781	T-040-0120-SS2	43782	40	120	36	18	45
T-040-0140	43829	T-040-0140-TV	43830	T-040-0140-SS2	63312	40	140	36	18	45
T-040-0160	43831	T-040-0160-TV	43832	T-040-0160-SS2	63313	40	160	36	18	45
T-040-0170	43833	T-040-0170-TV	43972	T-040-0170-SS2	63314	40	170	36	18	45
T-040-0180	43783	T-040-0180-TV	43784	T-040-0180-SS2	43785	40	180	36	18	45
T-040-0210	43786	T-040-0210-TV	43787	T-040-0210-SS2	43788	40	210	36	18	45
T-040-0240	43789	T-040-0240-TV	43790	T-040-0240-SS2	43791	40	240	36	18	45
T-040-0340	43792	T-040-0340-TV	43793	T-040-0340-SS2	43794	40	340	36	18	45
Lifting clutch load group 50 kN										
T-050-0055	43536	T-050-0055-TV	63299	T-050-0055-SS2	61857	50	55	36	20	50
T-050-0065	43215	T-050-0065-TV	43216	T-050-0065-SS2	61858	50	65	36	20	50
T-050-0075	43217	T-050-0075-TV	43218	T-050-0075-SS2	61859	50	75	36	20	50
T-050-0080	43219	T-050-0080-TV	43220	T-050-0080-SS2	61860	50	80	36	20	50
T-050-0085	43834	T-050-0085-TV	43221	T-050-0085-SS2	60235	50	85	36	20	50
T-050-0095	43222	T-050-0095-TV	43223	T-050-0095-SS2	61861	50	95	36	20	50
T-050-0110	43224	T-050-0110-TV	43835	T-050-0110-SS2	61862	50	110	36	20	50
T-050-0120	43225	T-050-0120-TV	43226	T-050-0120-SS2	43227	50	120	36	20	50
T-050-0140	43228	T-050-0140-TV	43836	T-050-0140-SS2	61863	50	140	36	20	50
T-050-0150	43837	T-050-0150-TV	43838	T-050-0150-SS2	61864	50	150	36	20	50
T-050-0160	43229	T-050-0160-TV	43230	T-050-0160-SS2	61865	50	160	36	20	50
T-050-0170	46267	T-050-0170-TV	48684	T-050-0170-SS2	61866	50	170	36	20	50
T-050-0180	43231	T-050-0180-TV	43232	T-050-0180-SS2	43233	50	180	36	20	50
T-050-0210	43234	T-050-0210-TV	43235	T-050-0210-SS2	61867	50	210	36	20	50
T-050-0240	43236	T-050-0240-TV	43237	T-050-0240-SS2	43238	50	240	36	20	50
T-050-0340	43239	T-050-0340-TV	43240	T-050-0340-SS2	61868	50	340	36	20	50
T-050-0480	43839	T-050-0480-TV	43840	T-050-0480-SS2	61869	50	480	36	20	50
T-050-0680	43604	T-050-0680-TV	46342	T-050-0680-SS2	61870	50	680	36	20	50
Lifting clutch load group 100 kN										
T-075-0100	47482	T-075-0100-TV	43626	T-075-0100-SS2	61873	75	100	46	24	60
T-075-0120	43244	T-075-0120-TV	43245	T-075-0120-SS2	43246	75	120	46	24	60
T-075-0140	43842	T-075-0140-TV	43973	T-075-0140-SS2	61874	75	140	46	24	60
T-075-0150	43247	T-075-0150-TV	43248	T-075-0150-SS2	61875	75	150	46	24	60
T-075-0160	43249	T-075-0160-TV	43250	T-075-0160-SS2	61876	75	160	46	24	60
T-075-0165	43251	T-075-0165-TV	43252	T-075-0165-SS2	60537	75	165	46	24	60
T-075-0170	43253	T-075-0170-TV	43974	T-075-0170-SS2	61877	75	170	46	24	60
T-075-0200	43254	T-075-0200-TV	43255	T-075-0200-SS2	61878	75	200	46	24	60
T-075-0240	44963	T-075-0240-TV	44964	T-075-0240-SS2	61879	75	240	46	24	60
T-075-0280	48043	T-075-0280-TV	48044	T-075-0280-SS2	61880	75	280	46	24	60
T-075-0300	43256	T-075-0300-TV	43257	T-075-0300-SS2	43258	75	300	46	24	60
T-075-0540	43259	T-075-0540-TV	43260	T-075-0540-SS2	61881	75	540	46	24	60
T-075-0680	43843	T-075-0680-TV	43844	T-075-0680-SS2	61882	75	680	46	24	60
Lifting clutch load group 100 kN										
T-100-0115	43266	T-100-0115-TV	43267	T-100-0115-SS2	43268	100	115	46	28	70
T-100-0120	43269	T-100-0120-TV	43270	T-100-0120-SS2	61888	100	120	46	28	70
T-100-0135	43271	T-100-0135-TV	43272	T-100-0135-SS2	60134	100	135	46	28	70
T-100-0140	43847	T-100-0140-TV	61890	T-100-0140-SS2	61889	100	140	46	28	70
T-100-0150	43273	T-100-0150-TV	43274	T-100-0150-SS2	61891	100	150	46	28	70
T-100-0170	43275	T-100-0170-TV	43276	T-100-0170-SS2	43277	100	170	46	28	70
T-100-0200	43848	T-100-0200-TV	44965	T-100-0200-SS2	61892	100	200	46	28	70

T-slot black		T-slot - hot dip galvanised		T-slot stainless steel 1.4301 (AISI 304)		Load group	L	ØA	ØB	ØC
Description	**Prod. No.**	**Description**	**Prod. No.**	**Description**	**Prod. No.**	**kN**	**mm**	**mm**	**mm**	**mm**
T-100-0220	43278	T-100-0220-TV	43849	T-100-0220-SS2	61893	100	220	46	28	70
T-100-0250	43279	T-100-0250-TV	43280	T-100-0250-SS2	60087	100	250	46	28	70
T-100-0340	43281	T-100-0340-TV	43282	T-100-0340-SS2	43283	100	340	46	28	70
T-100-0500	43514	T-100-0500-TV	61895	T-100-0500-SS2	61894	100	500	46	28	70
T-100-0540	47481	T-100-0540-TV	61897	T-100-0540-SS2	61896	100	540	46	28	70
T-100-0650	43284	T-100-0650-TV	43850	T-100-0650-SS2	61898	100	650	46	28	70
T-100-0680	43285	T-100-0680-TV	43286	T-100-0680-SS2	61899	100	680	46	28	70
T-100-1300	45168	T-100-1300-TV	61901	T-100-1300-SS2	61900	100	1300	46	28	70
Lifting clutch load group 200 kN										
T-150-0140	43851	T-150-0140-TV	43852	T-150-0140-SS2	61902	150	140	70	38	80
T-150-0150	43853	T-150-0150-TV	43854	T-150-0150-SS2	61903	150	150	70	38	80
T-150-0165	43287	T-150-0165-TV	43288	T-150-0165-SS2	61904	150	165	70	38	80
T-150-0170	43855	T-150-0170-TV	61906	T-150-0170-SS2	61905	150	170	70	38	80
T-150-0200	43856	T-150-0200-TV	43857	T-150-0200-SS2	60133	150	200	70	38	80
T-150-0210	43289	T-150-0210-TV	43290	T-150-0210-SS2	61907	150	210	70	38	80
T-150-0300	43291	T-150-0300-TV	43292	T-150-0300-SS2	61908	150	300	70	38	80
T-150-0400	43293	T-150-0400-TV	43294	T-150-0400-SS2	62536	150	400	70	38	80
T-150-0840	43295	T-150-0840-TV	43296	T-150-0840-SS2	61909	150	840	70	38	80
Lifting clutch load group 200 kN										
T-200-0200	43298	T-200-0200-TV	44966	T-200-0200-SS2	61916	200	200	70	40	98
T-200-0240	43859	T-200-0240-TV	61918	T-200-0240-SS2	61917	200	240	70	40	98
T-200-0250	43299	T-200-0250-TV	43300	T-200-0250-SS2	61919	200	250	70	40	98
T-200-0340	43301	T-200-0340-TV	43302	T-200-0340-SS2	61920	200	340	70	40	98
T-200-0500	43303	T-200-0500-TV	43304	T-200-0500-SS2	61921	200	500	70	40	98
T-200-1000	43305	T-200-1000-TV	43515	T-200-1000-SS2	61922	200	1000	70	40	98
Lifting clutch load group 320 kN										
T-320-0280	43516	T-320-0280-TV	43306	T-320-0280-SS2	61925	320	280	88	50	135
T-320-0320	46086	T-320-0320-TV	46087	T-320-0320-SS2	61926	320	320	88	50	135
T-320-0500	43517	T-320-0500-TV	43307	T-320-0500-SS2	61927	320	500	88	50	135
T-320-0700	43518	T-320-0700-TV	43308	T-320-0700-SS2	61928	320	700	88	50	135
T-320-1200	43519	T-320-1200-TV	43309	T-320-1200-SS2	61929	320	1200	88	50	135
Lifting clutch load group 450 kN										
T-450-0280	44567	T-450-0280-TV	44571	T-450-0280-SS2	/	450	280	88	50	135
T-450-0500	44568	T-450-0500-TV	44572	T-450-0500-SS2	/	450	500	88	50	135
T-450-0700	44569	T-450-0700-TV	44573	T-450-0700-SS2	/	450	700	88	50	135
T-450-1200	44570	T-450-1200-TV	44574	T-450-1200-SS2	/	450	1200	88	50	135

T-anchors are available in three versions: shot blasting, hot dip galvanised (TV) or stainless steel (SS2) on request.

Type T Anchor	Load group	"R"	"e"
Description	**[kN]**	**[mm]**	**[mm]**
T-013-XXXX	13	30	10
T-025-XXXX	25	37	11
T-040-XXXX	40	47	15
T-050-XXXX	50	47	15
T-075-XXXX	75	59	15
T-100-XXXX	100	59	15
T-150-XXXX	150	80	15
T-200-XXXX	200	80	15
T-320-XXXX	320	102	23
T-450-XXXX	450	102	23

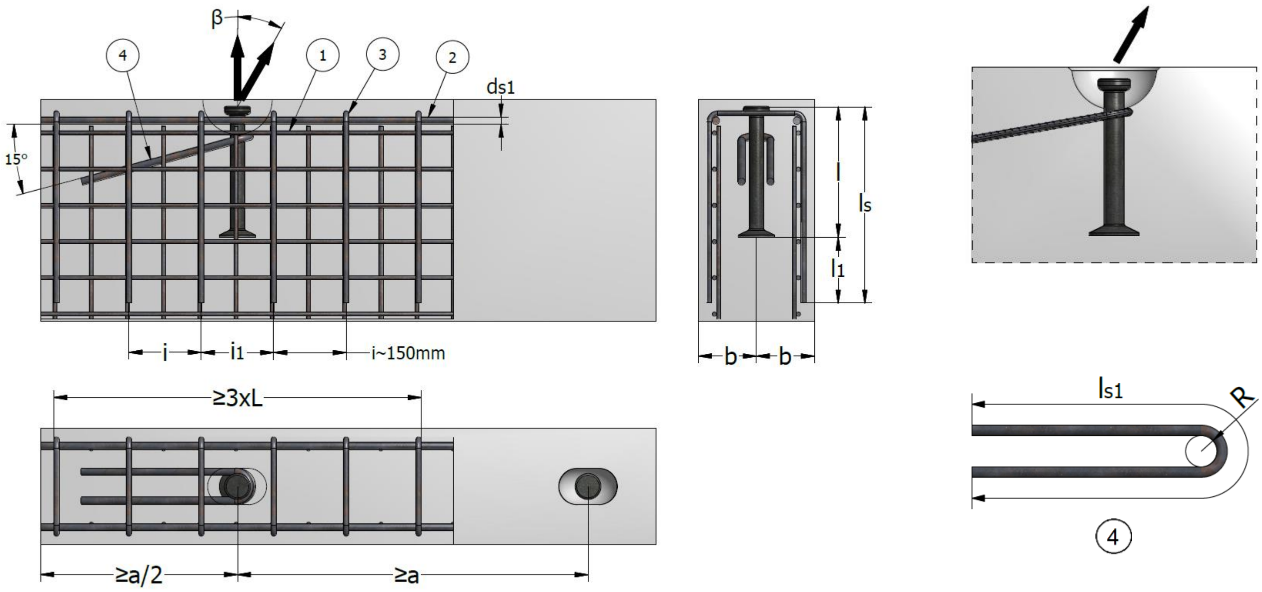


- *L = anchor length*
- *a/2 = edge distance*
- *e = cover to anchor head*
- *R = recess radius*

T-ANCHOR – INSTALLATION AND REINFORCEMENT

REINFORCEMENT USED IN ANCHOR ZONE FOR ANGLED LIFT IN PANELS OR BEAMS

For angled pull, additional reinforcement installed in the direction opposite of the load is required. We recommend installing this angled pull reinforcement as close as possible under the recess former and in full contact with the anchor..
The additional reinforcements necessary in the anchor zone for lifting the panels and beams at angles ß ≤ 45° are shown in the figures below and in next table. The concrete strength must be at least 15 MPa. We recommend that angle ß should not exceed 30°.



Note:

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

The diagonal reinforcement must be placed as close as possible under the recess former and installed so it is in contact with the lifting anchor.

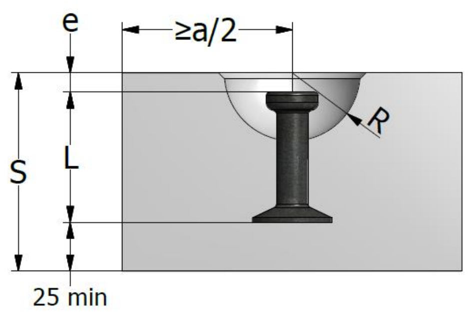
The reinforced zone must be ≥ 3 × anchor lenght "L". *The two stirrups near the anchor should be installed as close as possible to the recess former.*

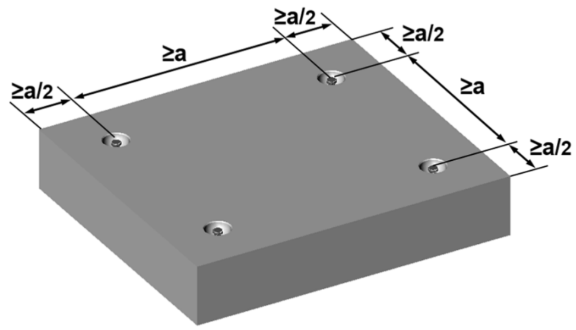
Length $l_s = l_1$ +Anchor length

The dimensions in the illustrations are in [mm]

Type of anchor	Load Group	Mesh reinforcement (1)	Edge reinforcement B500B (both sides) (2)	Stirrups - B500B (3) Axial pull $\beta < 30°$			Stirrups - B500B (3) Angled pull $\beta > 30°$ max. 45°			Angled pull reinforcement B500B (4)
			ds1	Number of stirrups	"d"	"l_1"	Number of stirrups	"d"	"l_1"	Ø x l_{s1}
Symbol	[kN]	[mm2/m]	[mm]	[pcs]	[mm]	[mm]	[pcs]	[mm]	[mm]	[mm]
T-013-0xxx	13	2 x 60	Ø 10	≥ 2	Ø6	300	≥ 2	Ø6	450	Ø8 x 800
T-025-0xxx	25	2 x 100	Ø 10	≥ 2	Ø8	600	≥ 4	Ø8	600	Ø10 x 1500
T-040-0xxx	40	2 x 125	Ø 10	≥ 2	Ø8	600	≥ 4	Ø8	600	Ø12 x 1600
T-050-0xxx	50	2 x 140	Ø 12	≥ 2	Ø10	750	≥ 4	Ø10	750	Ø16 x 2000
T-075-0xxx	75	2 x 160	Ø 12	≥ 4	Ø10	750	≥ 6	Ø10	750	Ø16 x 2300
T-100-0xxx	100	2 x 180	Ø 12	≥ 4	Ø10	750	≥ 8	Ø10	750	Ø20 x 2600
T-150-0xxx	150	2 x 240	Ø 16	≥ 4	Ø12	800	≥ 6	Ø12	1000	Ø25 x 3000
T-200-0xxx	200	2 x 350	Ø 16	≥ 6	Ø12	1000	≥ 10	Ø12	1000	2 x Ø25 x 3400
T-320-0xxx	320	2 x 400	Ø 16	≥ 8	Ø12	1000	≥ 10	Ø14	1100	2 x Ø25 x 3400
T-450-0xxx	450	2 x 500	Ø 20	≥ 10	Ø14	1400	≥ 12	Ø14	1450	2 x Ø25 x 3400

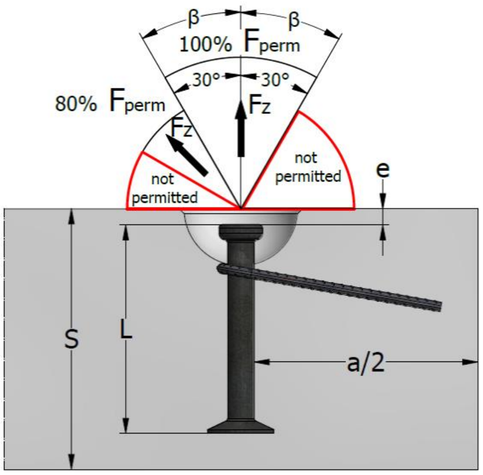
INSTALLATION OF T-ANCHOR IN SLABS





L = anchor length
a/2 = edge distance
e = cover to anchor head
R = recess radius

For slab units or demoulding panels, the edge distance of the "T" anchor (a) is: ***a/2 = 3 x (L + e)***



- ***Angled pull of 30° ≤ β ≤ 45° with no angled pull reinforcement is only permitted for:***

- *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
- *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
- *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*

- ***Angled pull with cable/chain spread of β > 45° is not permitted***

Required reinforcement

- **Mesh reinforcement -** ①
- **Angled pull reinforcement -** ④

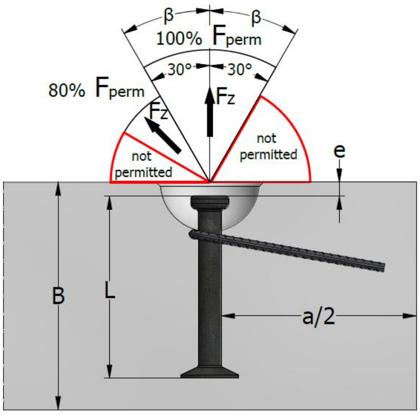
T-ANCHOR – LOAD CAPACITY IN SLABS FOR ANY DIRECTION OF PULL							
Type of anchor	Load group	Minimum thickness	Load capacity for minimum thickness				Minimum spacing between anchors
			Axial pull F_Z $\beta < 30°$	Angled pull F_Z $\beta < 45°$	Axial pull and angled pull F_Z $\beta < 45°$		
		s	f_{cu}≥ 15 MPa	f_{cu}≥ 15 MPa	f_{cu}≥ 25 MPa	f_{cu}≥ 35 MPa	a
	[kN]	[mm]	[kN]	[kN]	[kN]	[kN]	[mm]
T-013-0040	13	75	3.0	2.4	3.9	4.6	180
T-013-0050		85	10.1	10.1	13.0	13.0	220
T-013-0065		100	13.0	11.1			260
T-013-0085		120		13.0			315
T-013-0120		155					375
T-025-0055	25	90	4.7	3.8	6.1	7.2	240
T-025-0065		100	13.8	13.8	7.2	21.1	285
T-025-0085		120	19.5	19.5	17.8	25.0	325
T-025-0120		155	25.0	22.8	25.0		410
T-025-0170		205		25.0			520

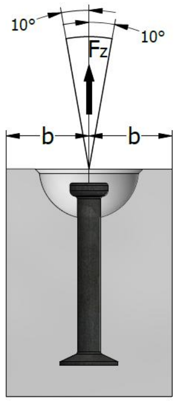
T-ANCHOR – LOAD CAPACITY IN SLABS FOR ANY DIRECTION OF PULL

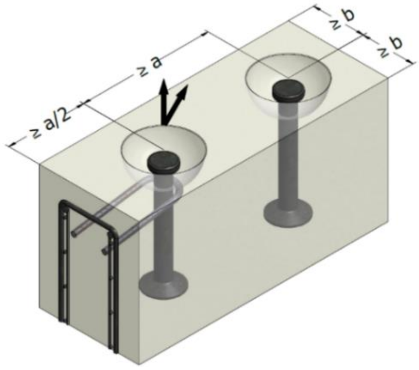
Type of anchor	Load group	Minimum thickness	Load capacity for minimum thickness				Minimum spacing between anchors
			Axial pull F_Z $\beta < 30°$	Angled pull F_Z $\beta < 45°$	Axial pull and angled pull F_Z $\beta < 45°$		
		s	$f_{cu} \geq$ 15 MPa	$f_{cu} \geq$ 15 MPa	$f_{cu} \geq$ 25 MPa	$f_{cu} \geq$ 35 MPa	a
	[kN]	[mm]	[kN]	[kN]	[kN]	[kN]	[mm]
T-040-0075	40	115	17.5	17.5	22.6	26.8	325
T-040-0100		140	25.3	25.3	32.7	38.6	350
T-040-0170		210	40.0	40.0	40.0	40.0	565
T-040-0210		250					650
T-050-0085	50	125	20.1	20.1	26.0	30.8	360
T-050-0095		135	23.3	23.3	30.0	35.5	400
T-050-0120		160	31.7	31.7	41.0	48.5	475
T-050-0180		220	50.0	44.4	50.0	50.0	630
T-050-0240		280		50.0			735
T-075-0100	75	140	24.5	24.5	31.6	37.4	415
T-075-0120		160	31.3	31.3	40.4	47.8	490
T-075-0140		180	38.6	38.6	49.9	59.0	550
T-075-0165		205	48.6	48.6	62.7	74.2	620
T-075-0200		240	63.8	60.0	75.0	75.0	710
T-075-0300		340	75.0	75.0			910
T-100-0115	100	155	29.1	29.2	37.5	44.4	470
T-100-0135		175	36.3	36.3	46.8	55.4	550
T-100-0150		190	42.0	42.0	54.3	64.2	590
T-100-0170		210	50.2	50.2	64.8	76.6	655
T-100-0200		240	63.2	63.2	81.7	96.6	730
T-100-0250		290	87.3	80.0	100.0	100.0	890
T-100-0340		380	100.0	100.0	100.0	100.0	1025
T-150-0140	150	180	37.5	37.5	48.6	57.2	560
T-150-0165		205	47.3	47.3	61.1	72.3	640
T-150-0200		240	62.4	62.4	80.6	95.3	730
T-150-0300		340	113.0	113.0	145.8	150.0	1020
T-150-0400		440	150.0	138.6	150.0	150.0	1195
T-200-0200	200	240	61.6	61.6	79.5	94.1	780
T-200-0240		280	80.5	80.5	103.9	122.9	900
T-200-0340		380	134.9	134.9	174.2	200.0	1175
T-200-0500		540	200.0	192.6	200.0	200.0	1485
T-320-0200	320	248	62.4	62.4	80.5	95.3	800
T-320-0250		298	86.4	86.4	111.5	132.0	1000
T-320-0280		328	102.1	102.1	131.8	155.9	1065
T-320-0320		368	124.4	124.4	160.6	190.0	1120

INSTALLATION OF T-ANCHOR IN BEAMS AND WALLS

LOAD CAPACITY IN BEAMS AND WALLS WITH ADDITIONAL REINFORCEMENTS







The angled pull reinforcement must be mounted opposite the direction of the load
The diagonal reinforcement must be placed as close as possible under the recess former and installed so it makes contact with the lifting anchor.

NOTES:

Required reinforcement (*see page 26*)

- **Mesh reinforcement -** ①
- **Angled pull reinforcement -** ④

- ***Angled pull of 30° ≤ β ≤ 45° with no angled pull reinforcement is only permitted for:***
  - *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
  - *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
  - *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
- ***Angled pull with cable/chain spread of β > 45° is not permitted***

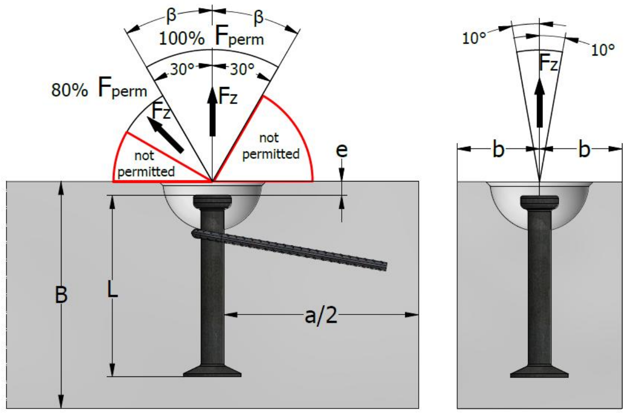
T-ANCHOR – LOAD CAPACITY IN BEAMS AND WALLS WITH NO SPECIAL REINFORCEMENTS

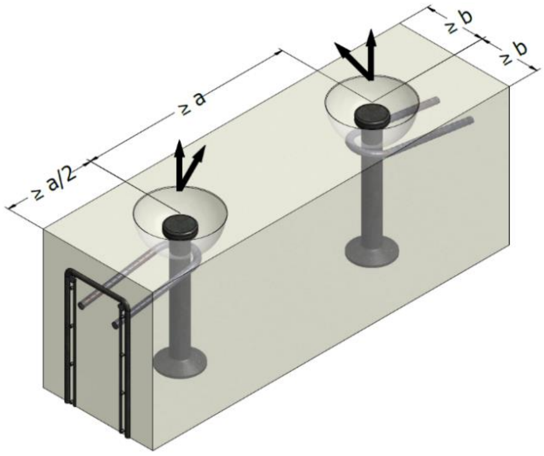
Type of anchor	Load group	Minimum height of beams	Wall thickness	Load capacity				Spacing between anchors
				Axial pull F_Z $\beta < 30°$	Angled pull F_Z $\beta < 45°$	Axial pull and angled pull F_Z $\beta < 45°$		
		B	2 x b	f_{cu}≥ 15 MPa	f_{cu}≥ 15 MPa	f_{cu}≥ 25 MPa	f_{cu}≥ 35 MPa	a
	[kN]	[mm]	[mm]	[kN]	[kN]	[kN]	[kN]	[mm]
T-013-0085		180	100	12.2	9.8			
			120	13.0	11.2	13.0	13.0	270
			140	13.0	12.5			
T-013-0120		250	80	13.0	10.7			
	13		100	13.0	12.7	13.0	13.0	375
			120	13.0	13.0			
T-013-0240		490	60	9.9	9.9	12.7		
			80	13.0	13.0	13.0	13.0	735
			100	13.0	13.0	13.0		
T-025-0120		250	120	18.1	14.5	23.3		
			140	20.3	16.2	25.0	25.0	375
			160	22.4	17.9	25.0		
T-025-0170		350	100	20.7	16.5	25.0		
	25		120	23.7	19.0	25.0	25.0	525
			140	25.0	21.3	25.0		
T-025-0280		570	80	18.4	18.4	23.8		
			100	23.0	23.0	25.0	25.0	855
			120	25.0	25.0	25.0		
T-040-0170		347	160	29.8	23.8	38.5		
			180	32.5	26.0	40.0	40.0	535
			200	35.2	28.2			
T-040-0240		487	120	31.3	25.1			
	40		140	35.2	28.1	40.0	40.0	745
			160	38.9	31.1			
T-040-0340		687	100	29.6	28.7	38.2		
			120	35.6	32.9	40.0	40.0	1045
			140	40.0	36.9			

T-ANCHOR – LOAD CAPACITY IN BEAMS AND WALLS WITH NO SPECIAL REINFORCEMENTS

Type of anchor	Load group	Minimum height of beams	Wall thickness	Load capacity: Axial pull F_Z $\beta < 30°$	Load capacity: Angled pull F_Z $\beta < 45°$	Load capacity: Axial pull and angled pull F_Z $\beta < 45°$		Spacing between anchors
		B	2 x b	$f_{cu} \geq$ 15 MPa	$f_{cu} \geq$ 15 MPa	$f_{cu} \geq$ 25 MPa	$f_{cu} \geq$ 35 MPa	a
	[kN]	[mm]	[mm]	[kN]	[kN]	[kN]	[kN]	[mm]
			200	45.7	36.5			
T-050-0240		490	220	49.1	39.2	50.0	50.0	735
			240	50.0	41.9			
			160	50.0	40.6			
T-050-0340	50	690	180	50.0	44.4	50.0	50.0	1035
			200	50.0	48.0			
			140	46.1	46.1			
T-050-0480		970	160	50.0	50.0	50.0	50.0	1455
			180	50.0	50.0			
			240	45.1	36.0	58.2	68.8	
T-075-0200		410	260	47.8	38.3	61.8	73.1	610
			280	50.6	40.5	65.3	75.0	
			200	54.1	43.3	69.9		
T-075-0300	75	610	220	58.1	46.5	75.0	75.0	910
			240	62.2	49.7	75.0		
			160	63.2	58.4			
T-075-0540		1090	180	71.1	63.8	75.0	75.0	1630
			200	75.0	69.1			
			300	46.4	37.2	60.0	70.9	
T-100-0170		340	350	52.1	41.7	67.3	79.6	520
			400	57.6	46.1	74.4	88.0	
			280	76.6	61.3	98.9		
T-100-0340	100	680	300	80.7	64.5	100.0	100.0	1030
			320	84.7	67.7	100.0		
			160	73.7	70.0	95.2		
T-100-0680		1360	180	83.0	76.5	100.0	100.0	2050
			200	92.2	82.8	100.0		
			350	81.3	65.0	104.9	124.2	
T-150-0300		600	400	89.5	71.9	116.0	137.2	900
			500	106.2	85.0	137.1	150.0	
			350	102.5	82.0	132.3		
T-150-0400	150	800	400	113.2	90.6	146.2	150.0	1200
			450	123.7	99.0	150.0		
			300	150.0	132.5			
T-150-0840		1680	340	150.0	145.5	150.0	150.0	2520
			380	150.0	150.0			
			500	116.6	93.3	150.6	178.2	
T-200-0340		670	750	158.1	126.5	200.0	200.0	1010
			1000	196.2	156.9	200.0	200.0	
			400	134.8	107.9	174.1		
T-200-0500	200	990	500	159.4	127.5	200.0	200.0	1490
			600	182.8	146.2	200.0		
			240	154.9	128.6	200.0		
T-200-1000		1990	300	190.0	152.0	200.0	200.0	3000
			330	200.0	163.2	200.0		
			600	126.7	101.3	163.5	193.5	
T-320-0320		630	800	157.2	125.7	2029	240.1	940
			1200	177.2	141.8	228.8	270.1	
			500	208.6	166.9	269.4	318.7	
T-320-0700	320	1390	600	239.2	191.4	308.8	320.0	2080
			750	282.8	226.2	320.0	320.0	
			400	272.5	218.0			
T-320-1200		2390	450	297.7	238.2	320.0	320.0	3580
			500	320.0	257.8			
			800	226.0	180.8	291.8	345.3	
T-450-0500		990	1000	267.2	213.8	345.0	408.2	1480
	450		1500	358.4	286.7	450.0	450.0	
			500	322.2	257.8	416.0		
T-450-1200		2400	600	369.4	295.5	450.0	450	3580
			750	436.7	349.4	450.0		

LOAD CAPACITY IN WALLS WITH ADDITIONAL REINFORCEMENTS





The angled pull reinforcement must be mounted opposite the direction of the load
The diagonal reinforcement must be placed as close as possible under the recess former and installed so it makes contact with the lifting anchor.

NOTES:

Required reinforcement (*see page 26*)

- **Mesh reinforcement -** ①
- **Edge reinforcement -** ②
- **Stirrups -** ③
- **Angled pull reinforcement -** ④

- ***Angled pull of 30° ≤ β ≤ 45° with no angled pull reinforcement is only permitted for:***
  - *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
  - *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
  - *f_{cu} ≥ 15 MPa + 3 times min. edge distance a/2*
- ***Angled pull with cable/chain spread of β > 45° is not permitted***

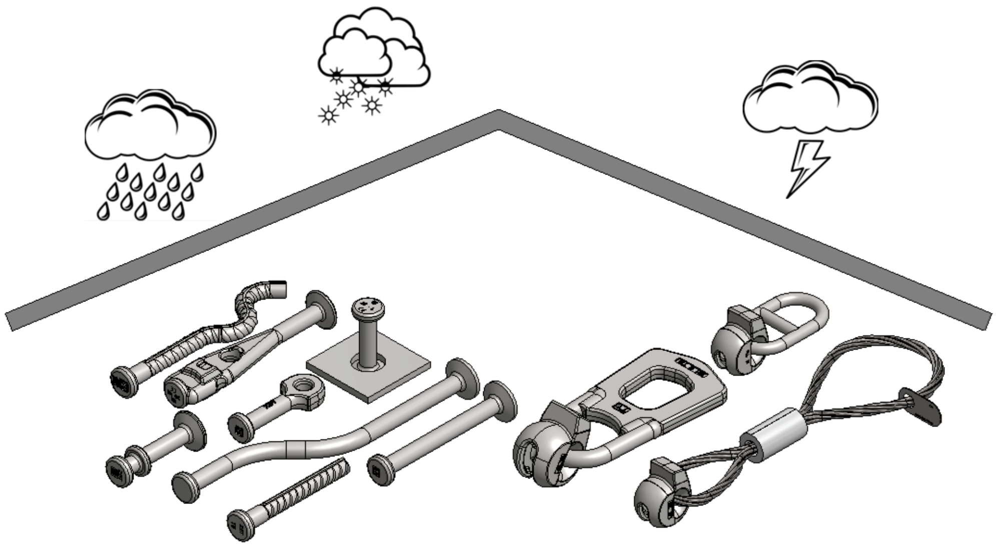
T-ANCHOR – LOAD CAPACITY IN WALLS WITH ADDITIONAL REINFORCEMENTS

Type of anchor	Load group	Wall thickness 2 x b	Load capacity: Axial pull F_Z $\beta < 30°$	Angled pull F_Z $\beta < 45°$	Axial pull and angled pull F_Z $\beta < 45°$		Spacing between anchors
			f_{cu}≥ 15 MPa	f_{cu}≥ 15 MPa	f_{cu}≥ 25 MPa	f_{cu}≥ 35 MPa	a
	[kN]	[mm]	[kN]	[kN]	[kN]	[kN]	[mm]
T-013-0120	13	60	9.9	9.9	12.8	13.0	375
		80	13.0	13.0	13.0		
		100	13.0	13.0	13.0		
T-013-0240		60	9.9	9.9	12.8	13.0	735
		80	13.0	13.0	13.0		
		100	13.0	13.0	13.0		
T-025-0170	25	80	18.4	18.4	23.8	25.0	525
		100	23.0	23.0	25.0		
		120	25.0	25.0	25.0		
T-025-0280		80	18.4	18.4	23.8	25.0	855
		100	23.0	23.0	25.0		
		120	25.0	25.0	25.0		
T-040-0240	40	120	35.6	35.6	40.0	40.0	745
		140	40.0	36.0			
		160	40.0	38.5			
T-040-0340		100	29.6	29.6	38.2	40.0	1045
		120	35.6	35.6	40.0		
		140	40.0	40.0	40.0		
T-050-0240	50	160	50.0	45.2	50.0	50.0	735
		180	50.0	48.0			
		200	50.0	50.0			
T-050-0340		120	39.5	39.5	50.0	50.0	1035
		140	46.1	46.1			
		160	50.0	50.0			

T-ANCHOR – LOAD CAPACITY IN WALLS WITH ADDITIONAL REINFORCEMENTS							
Type of anchor	Load group	Wall thickness	Load capacity				Spacing between anchors
			Axial pull F_Z $\beta < 30°$	Angled pull F_Z $\beta < 45°$	Axial pull and angled pull F_Z $\beta < 45°$		
		2 x b	$f_{cu} \geq 15$ MPa	$f_{cu} \geq 15$ MPa	$f_{cu} \geq 25$ MPa	$f_{cu} \geq 35$ MPa	a
	[kN]	[mm]	[kN]	[kN]	[kN]	[kN]	[mm]
T-050-0480		100	32.9	32.9	42.5	50.0	1455
		120	39.5	39.5	50.0		
		140	46.1	46.1	50.0		
T-075-0300	75	160	63.2	56.6	75.0	75.0	910
		180	71.1	60.0			
		200	75.0	63.2			
T-075-0540		140	55.3	55.3	71.4	75.0	1630
		160	63.2	63.2	75.0		
		180	71.1	71.1	75.0		
T-100-0340	100	200	89.5	71.6	100.0	100.0	1030
		240	98.0	78.4			
		280	100.0	84.7			
T-100-0680		160	73.7	73.7	95.2	100.0	2050
		180	83.0	83.0	100.0		
		200	92.2	92.2	100.0		
T-150-0400	150	300	128.9	103.1	150.0	150.0	1200
		400	148.9	119.1			
		500	150.0	133.1			
T-150-0840		200	111.9	111.9	144.5	150.0	2520
		220	123.1	123.1	150.0		
		240	134.2	134.2	150.0		
T-200-0500	200	400	175.1	140.1	200.0	200.0	200.0
		500	187.2	149.7			
		600	200.0	183.4			
T-200-1000		240	154.9	154.9	200.0	200.0	200.0
		260	167.8	167.8			
		280	180.7	180.7			
T-320-0700	320	450	282.6	226.1	320.0	320.0	2080
		550	312.5	250.0			
		650	320.0	271.8			
T-320-1200		300	266.7	266.7	320.0	320.0	3580
		350	311.1	311.1			
		400	320.0	320.0			
T-450-1200	450	400	355.5	355.5	450	450	3580
		500	444.4	421.6			
		600	450.0	450.0			

STORAGE REQUIREMENTS

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



SAFETY INSTRUCTIONS

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

Obligatory instructions for safe working:

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

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

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

GENERAL INFORMATION

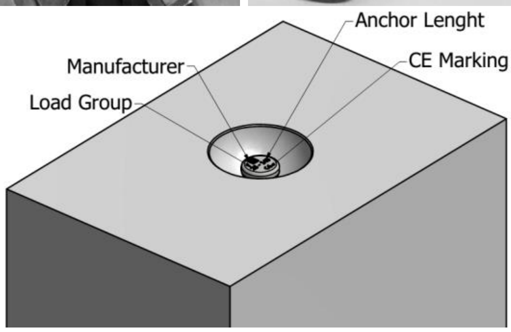
Using the 3D T-slot Anchor System is fast, and the utilisation of a cheap T-Slot-anchor makes application of this lifting system the most economical solution.
The T-Slot anchor is built into the concrete element with the aid of a rubber recess former. After pouring the shuttering and after the concrete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

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

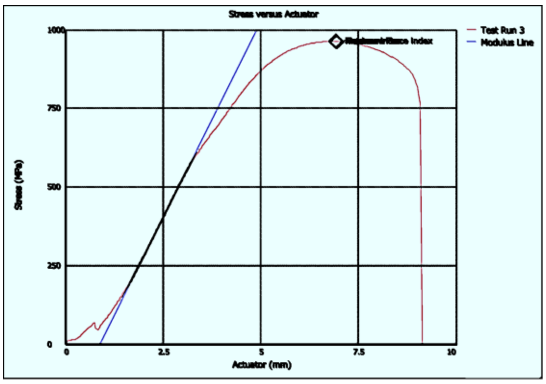
A failure of lifting anchors and lifting anchor devices can endanger human lives as well as can lead to significant damage. Therefore, lifting anchors and lifting devices must be produced with high quality, carefully selected and which are designed for the respective application and used by skilled personnel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

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

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



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



Application of lifting anchor system

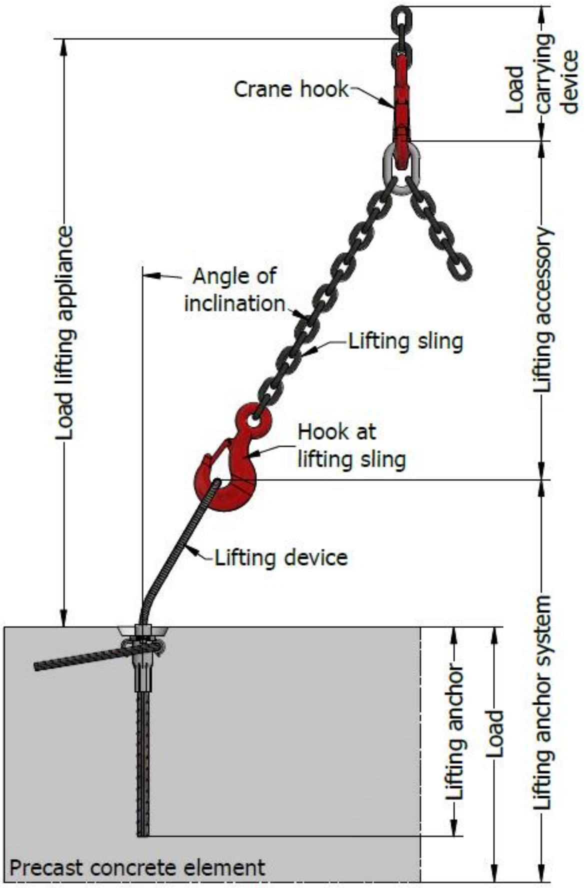
Load carrying devices - are equipment that is permanently connected to the hoist for attaching lifting devices, lifting accessory or loads.

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

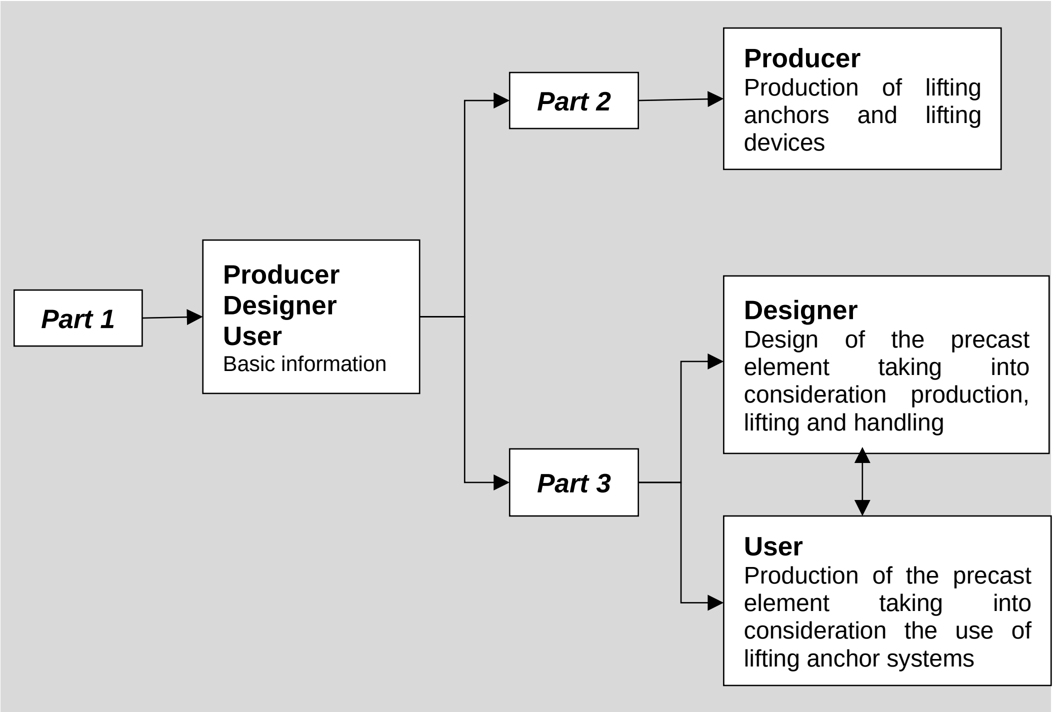
Lifting device (lifting key) – equipment that connects the loads to the load carrying device by means of lifting accessories.

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

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



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



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

LIFTING SYSTEM

- **LIFTING CLUTCHES**

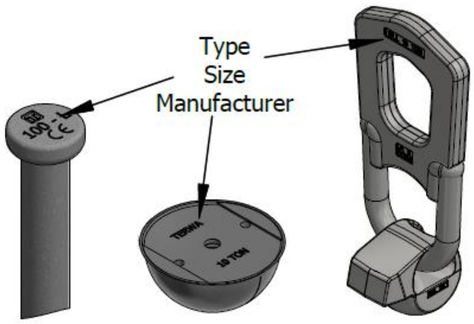
"Terwa" offers various lifting clutches and a wide range of different recess formers. The difference between all of the systems is actually defined by the type of anchors.

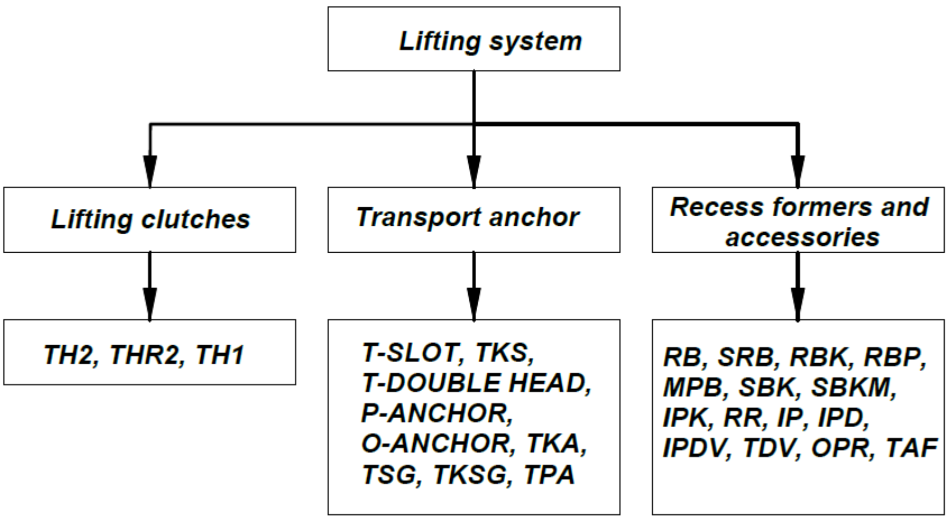
- **TRANSPORT ANCHORS**

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

- **RECESS FORMERS AND ACCESSORIES**

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





TECHNICAL INFORMATION – CHOOSING THE TYPE OF ANCHOR

Terwa offers a total of 3 types of lifting systems:

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

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

SAFETY RULES

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

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

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

For this, the load-side dynamic working coefficient ψ_{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 γ **= 2.5**
The safety concept requires that the action E does not exceed the admissible value for the resistance R_{adm}:

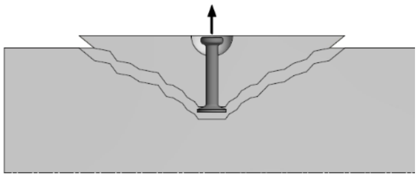
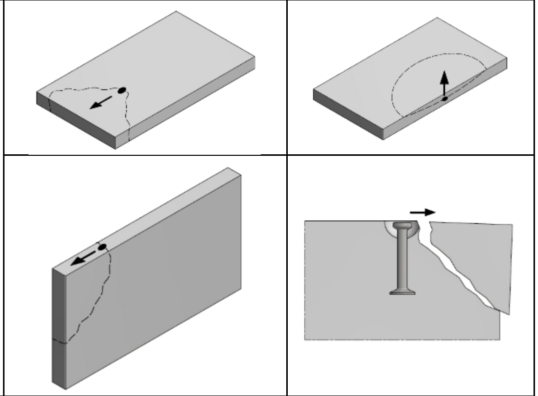
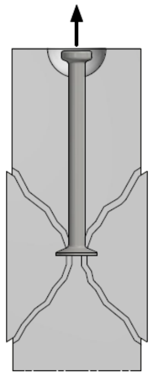
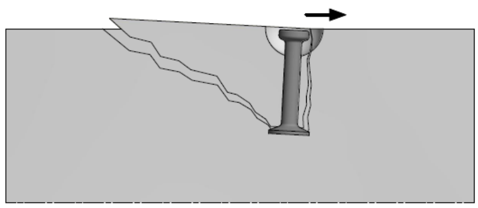
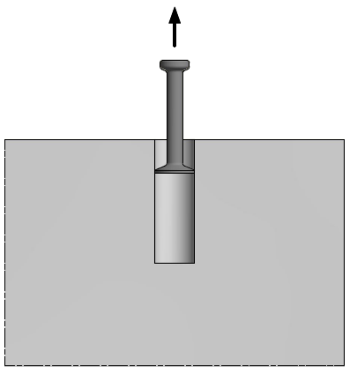
$\boldsymbol{E} \leq R_{adm}$ Where: E - action, R_{adm} - admissible load (resistance)

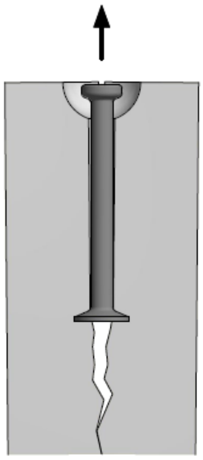
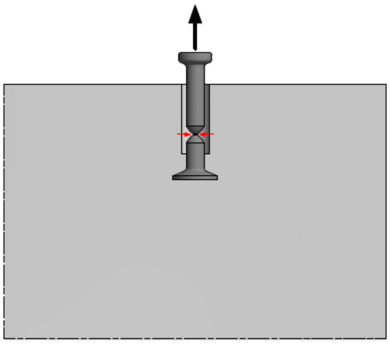
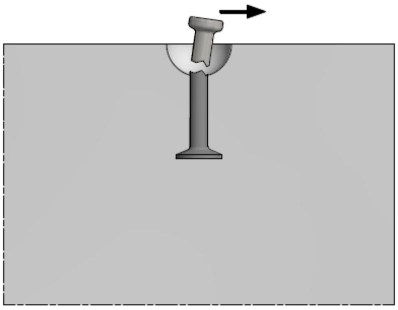
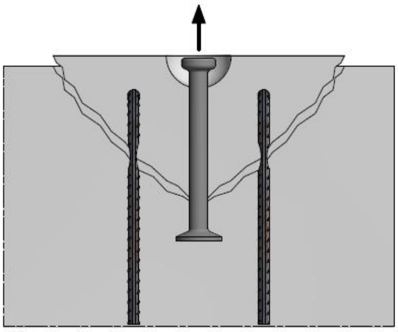
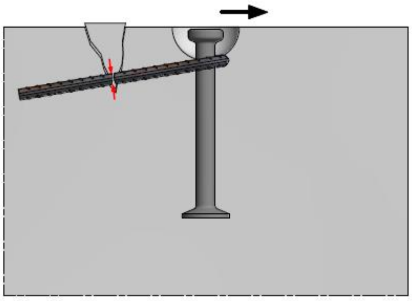
The admissible load (resistance) of lifting anchor and lifting device is obtained as follows:

$R_{adm} = \frac{\boldsymbol{Rk}}{\boldsymbol{\gamma}}$ 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.		

Failure type	Fracture pattern: tensile force	Fracture pattern: transverse shear force
Splitting of the component A concrete failure in which the concrete fractures along a plane passing through the axis of the lifting anchor.		
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		

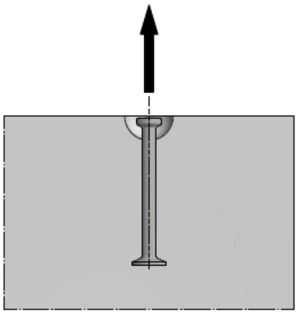
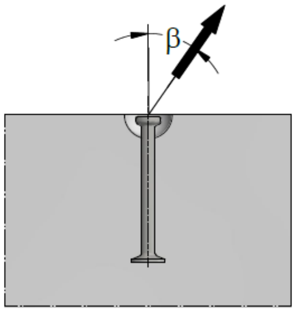
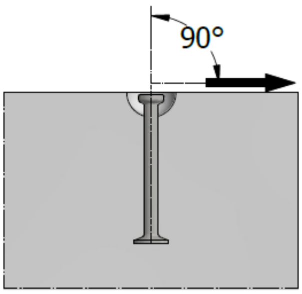
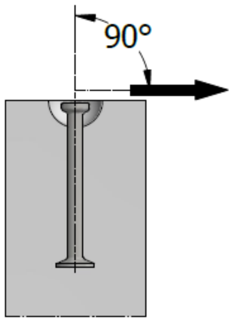
DIMENSIONING OF LIFTING ANCHOR SYSTEM

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.	

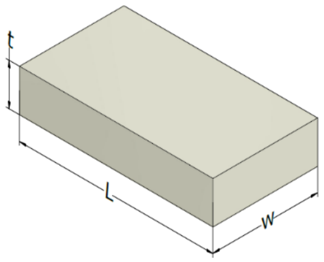
LOAD CAPACITY

The 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

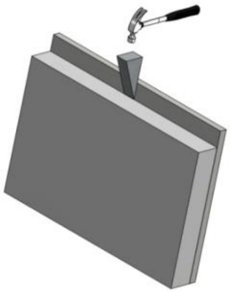
q_{adh} - the adhesion to formwork and form friction factor corresponding to the material of the formwork

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.

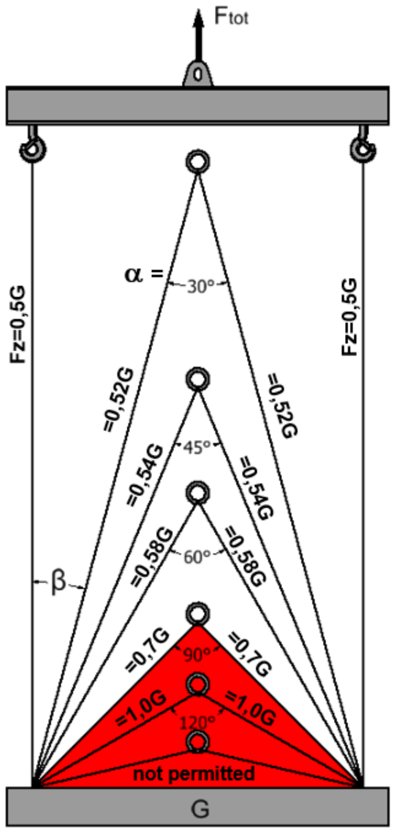
LIFTING OF PRECAST CONCRETE ELEMENT UNDER COMBINED TENSION AND SHEAR LOADING

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

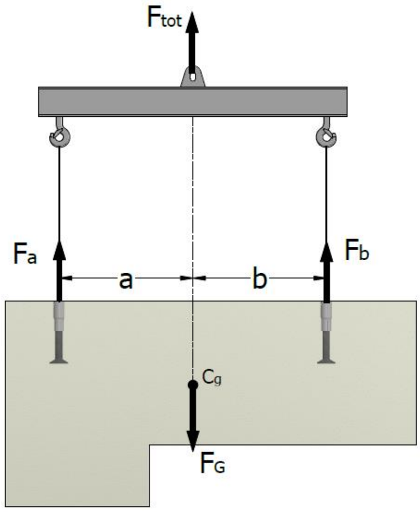
For asymmetrical elements, calculate the loads based on the centre of gravity before installing the anchors.
The load of each anchor depends on the embedded position of the anchor in the precast unit and on the transport mode:

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:

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

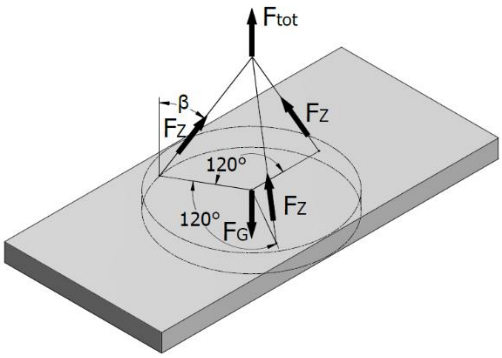
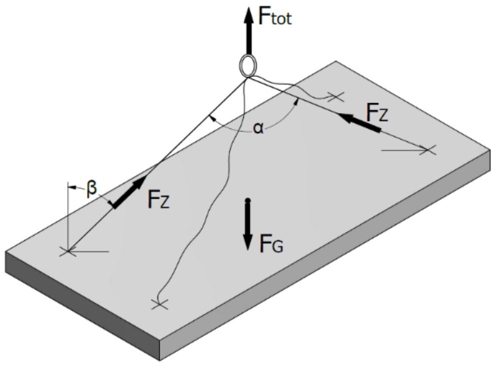
$$F_b = F_{tot} \times \mathbf{a}/(\mathbf{a}+\mathbf{b})$$

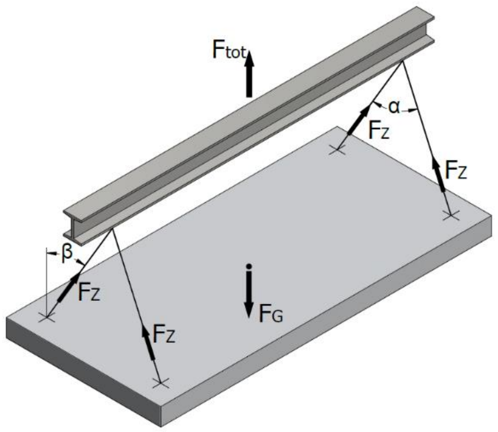
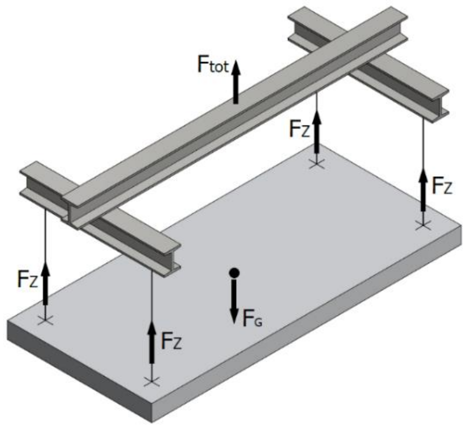
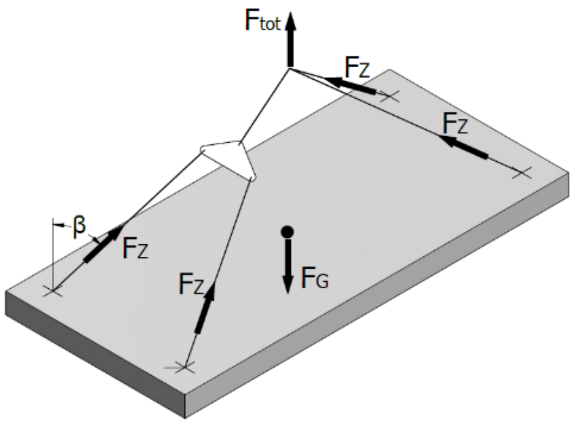
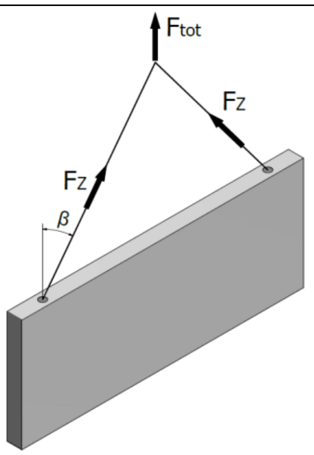
Note: To avoid tilting the element during transport, the load should be suspended from the lifting beam in such a way that its centre of gravity (Cg) is directly under the crane hook.



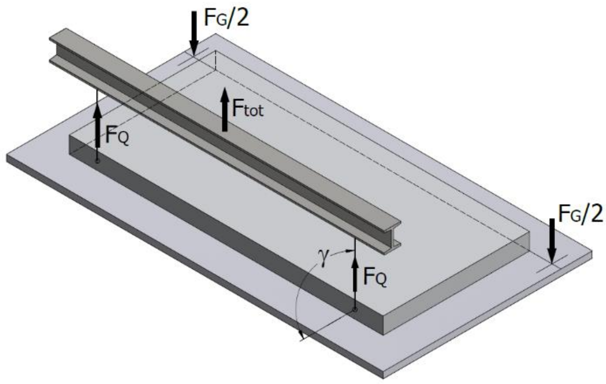
b) For transporting without a lifting beam, the load on the anchor depends on the cable angle (ß).

ANCHORS LIFTING CONDITIONS

Using three anchors spaced the same distance apart from each other as in the figure, three load bearing anchors can be assumed. 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	

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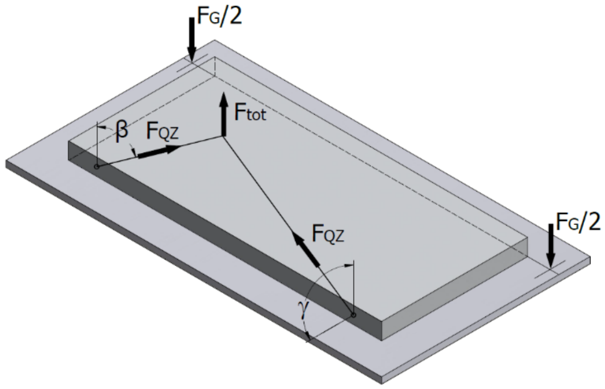
<tr>
<td>When the element is lifted without a lifting table at a straight angle and contact with the ground is maintained. Additional shear reinforcement is required. ß ≤ 30 º
Load bearing anchors: n=2
Load type – lifting of formwork
-shear pull factor $z \geq 1$
-formwork adhesion
-no dynamic factor

Load type – transport
-shear pull factor $z \geq 1$
-no formwork adhesion
-dynamic factor</td>
<td>
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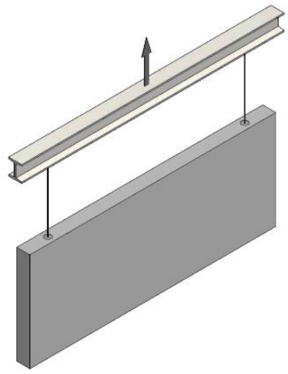
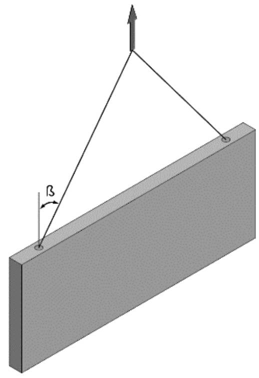
LOAD DIRECTIONS

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.

<table>
<tr>
<td>Axial load ß = 0º to 10º</td>
<td></td>
<td>Diagonal load ß = 10º to 45º

Note: ß ≤ 30 º is recommended</td>
<td>
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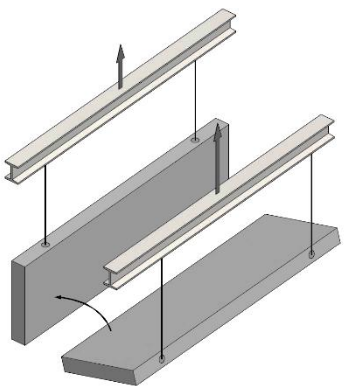
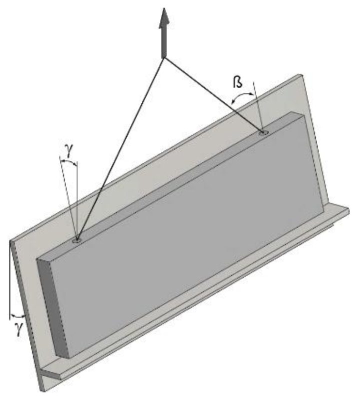
<tr>
<td>Tilting g = 90 º

Additional shear reinforcement steel must be used.</td>
<td></td>
<td>When a tilting table is used, the anchors can be used without additional shear reinforcement steel, not to angle g < 15 o</td>
<td>
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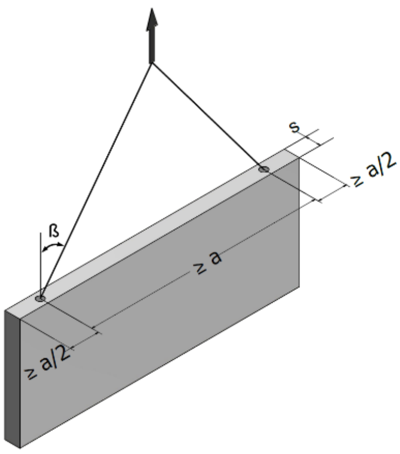
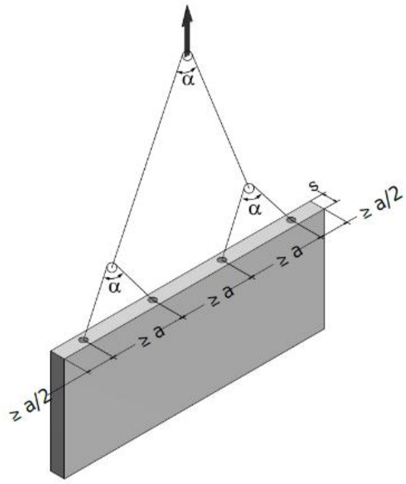
POSITIONING THE ANCHORS IN WALLS

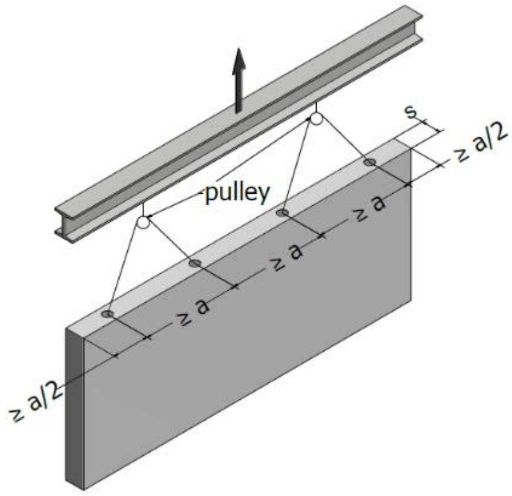
Load bearing anchors:
n=3

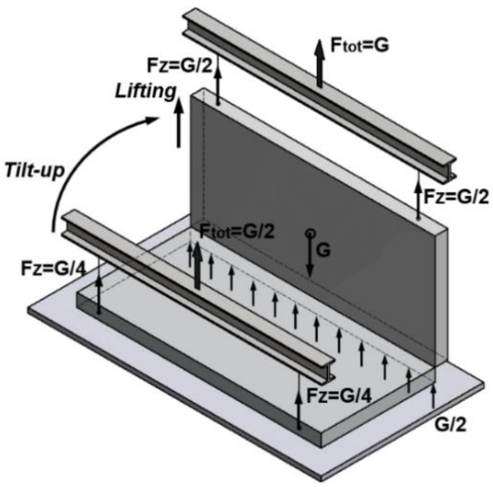


Load bearing anchors:
n=3



Load bearing anchors:
n=4

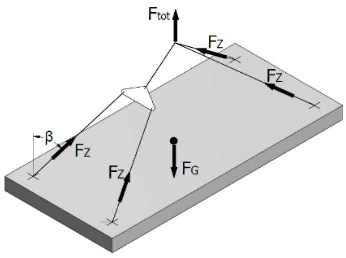
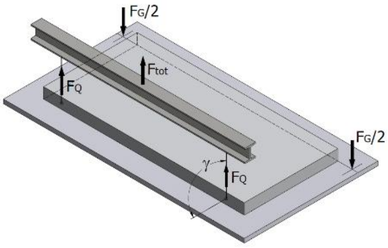
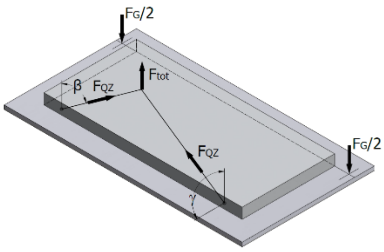
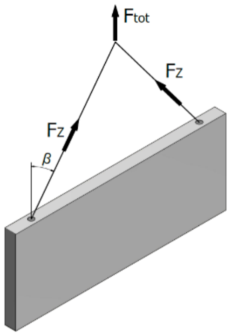




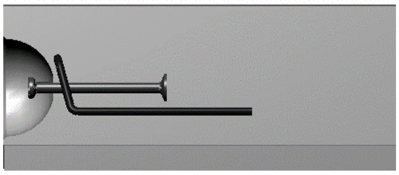
Lifting the walls from horizontal to vertical position without tilt-up table.

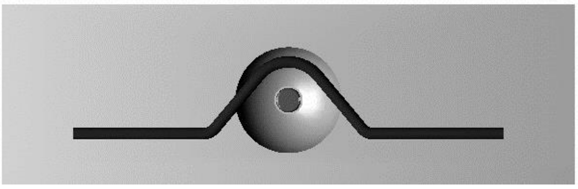
In this case, the anchors are loaded with half of the element weight, since half of the element remains in contact with the casting table.

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

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





ANCHORING T-SLOT ANCHORS

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

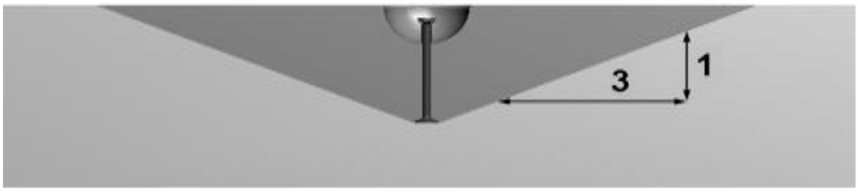
If it is possible to classify elements into the following groups, then the following rule of thumb can be used. In case of there is a lack of experience with the 3D slot anchor system, Terwa can always provide additional information.
Type of element:

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

OVERVIEW OF T-SLOT ANCHORS LENGTHS

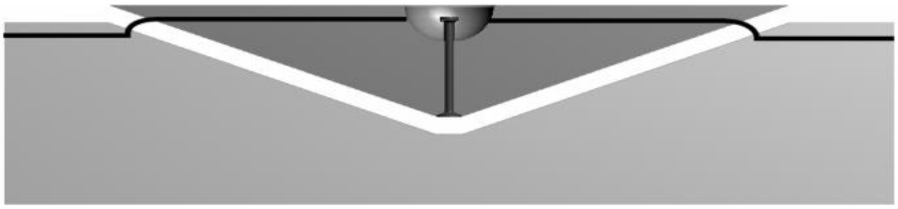
Loading class [kN]	Standard type T-slot anchor	Shorter frequently used T-slot anchor	Longer frequently used T-slot anchor
13	T 013-0120	T 013-0065	T 013-0240
25	T 025-0170	T 025-0085	T 025-0280
50	T 050-0240	T 050-0120	T 050-0340
75	T 075-0300	T 075-0150	T 075-0540
100	T 100-0340	T 100-0170	T 100-0680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

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

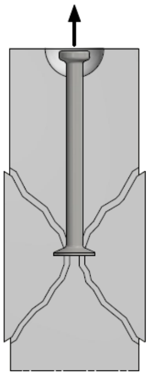


In addition to the length of the T-slot anchor, the concrete strength present is of primary importance when calculating the admissible anchoring force. The lifting force is transferred through the T-slot anchor to the concrete, whose strength at the first loading is primary. If there is any doubt about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

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



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

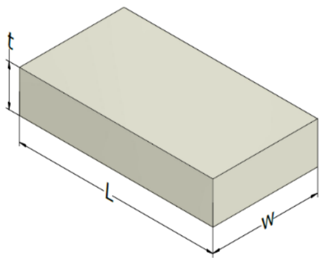


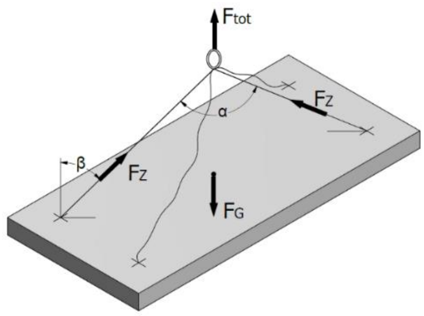
For vertical plates, the possibility that a horizontal break out can occur must be taken into account. The vertical reinforcement present has no effect on the anchoring force here either. The situation in the figure will become very critical if the thickness of the element is less than half the thickness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

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

CALCULATION EXAMPLES

Example 1: SLAB UNIT





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

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

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

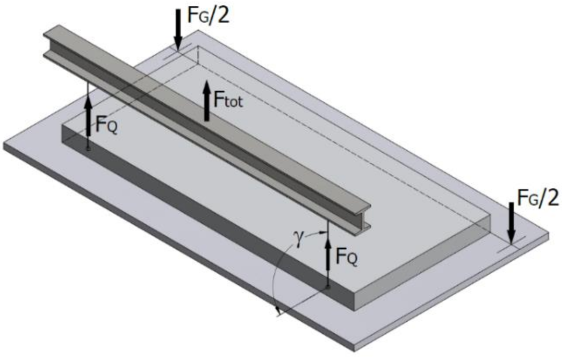
TRANSPORT ON SITE:

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

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

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

Example 1: WALL PANEL



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

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

General data:	Symbol	De-mould	Tilting	Mount
Concrete strength at de-mould [MPa]		15	15	
Concrete strength on site [MPa]				45
Element weight [kN]	F_G	54		
Element area in contact with formwork [m²]	A_f	12		
Cable angle factor at de-mould (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 = 1.04 (β = 15.0°)
Concrete strength: 15 MPa

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

TRANSPORT AT THE PLANT:

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

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

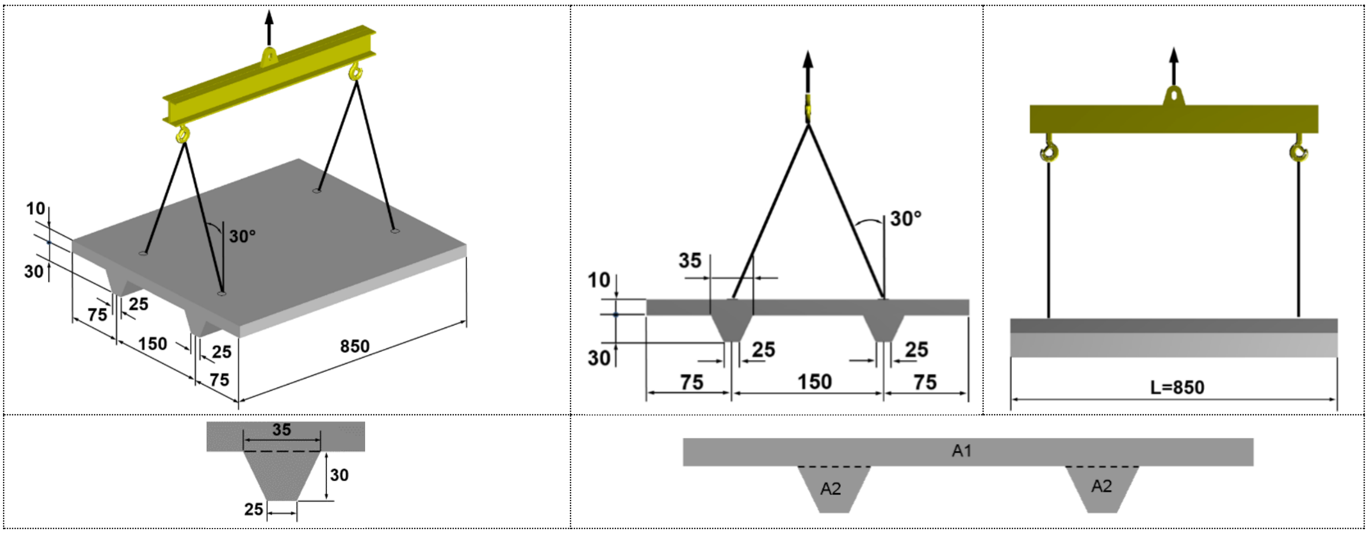
TRANSPORT ON SITE:

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

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

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

Example 1: DOUBLE-T BEAM



NOTE: Dimensions are in cm

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

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

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

LOAD PER ANCHOR WHEN DE-MOULD:

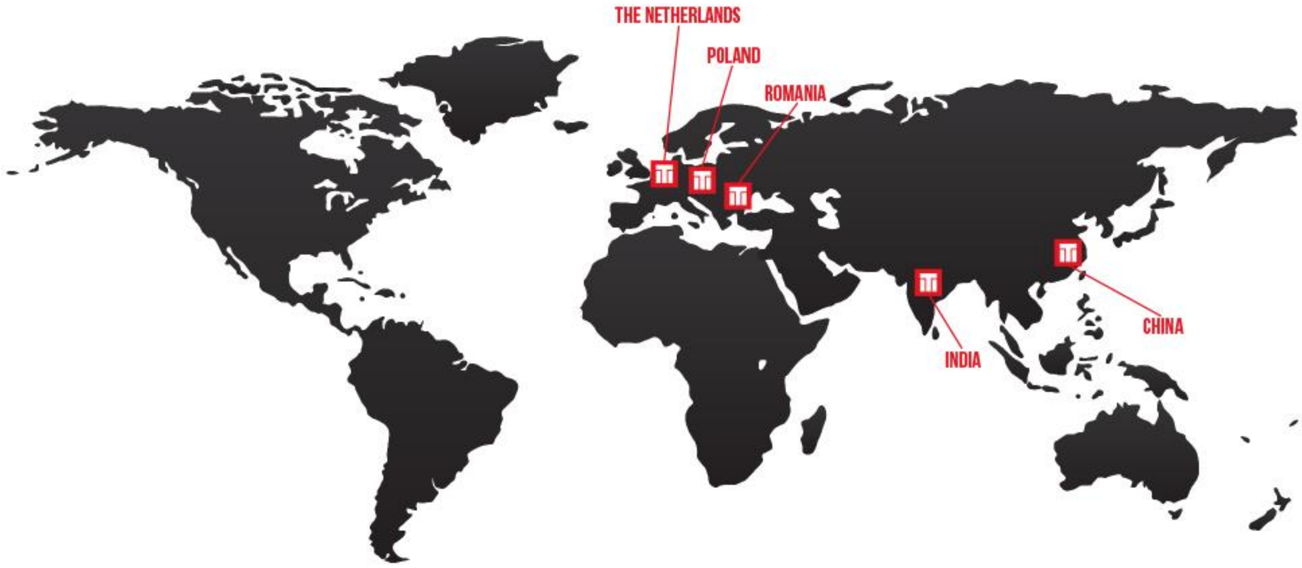
$$F = \frac{F_{tot} \times z}{n} = \frac{[(F_G + F_{adh}) \times z]}{n} = \frac{306 \times 1.16}{4} = 36.4\ kN$$

LOAD PER ANCHOR WHEN TRANSPORTING:

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

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

CONTACT



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