TC FUSION TIMBER-CONCRETE FUSION

CE
ETA 22/0806

TIMBER-TO-CONCRETE JOINT SYSTEM

HYBRID STRUCTURES

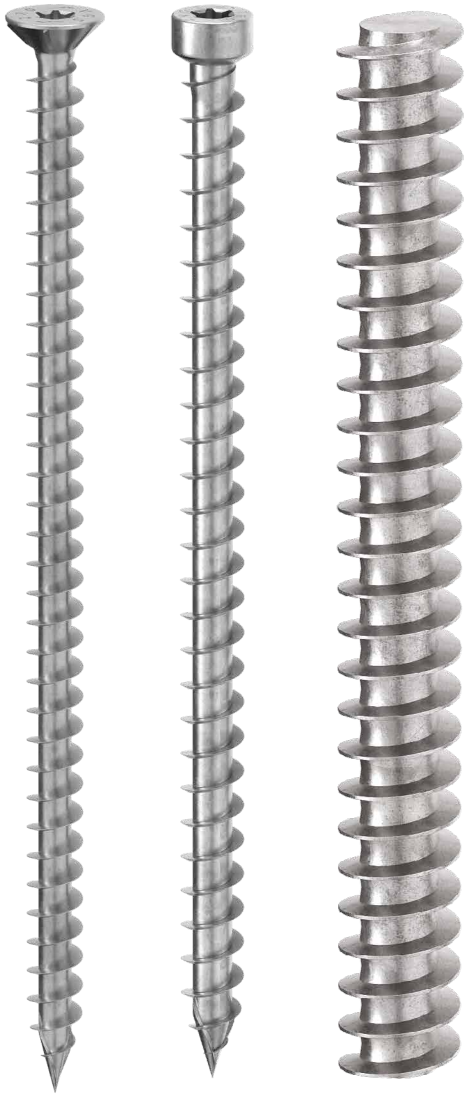
The VGS, VGZ and RTR full-thread connectors are now certified for any type of application where a timber element (wall, ceiling, etc.) must transmit stresses to a concrete element (bracing core, foundation, etc.).

PREFABRICATION

The concrete prefabrication combines with timber prefabrication: the reinforcing bars inserted into the concrete casting accommodate the full thread timber connectors; the supplementary casting carried out after installing the timber components completes the connection.

POST AND SLAB SYSTEMS

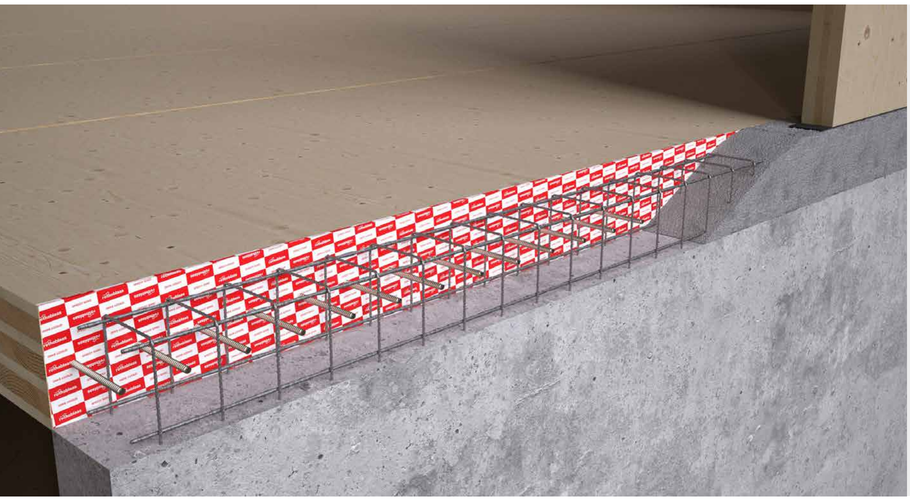
It allows connections between CLT panels with exceptional strength and stiffness for shear, bending moment and axial stress. It is the natural complement to the SPIDER and PILLAR systems.



VGS VGZ RTR

CHARACTERISTICS

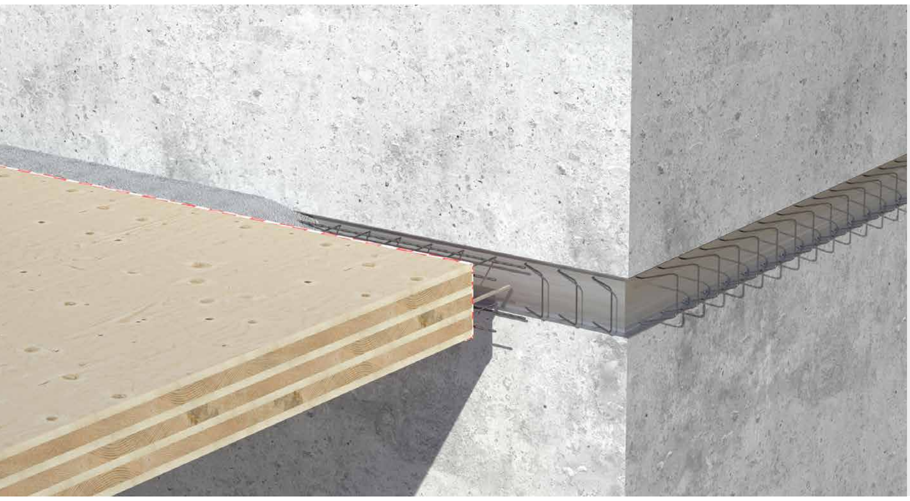
FOCUS	timber-to-concrete joints with strength in all directions
DIAMETER	screws Ø9 mm, Ø11 mm, Ø13 mm, Ø16 mm
FASTENERS	VGS, VGZ and RTR
CERTIFICATION	CE marking in accordance with ETA-22/0806



FIELDS OF USE

Timber-to-concrete joints:

- CLT, LVL
- Glulam and solid timber



SPIDER AND PILLAR

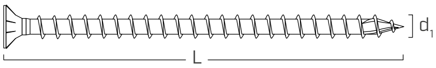
TC FUSION complements the SPIDER and PILLAR systems, allowing the implementation of moment connections between panels. Rothoblaas waterproofing systems make it possible to separate timber and concrete.

CONSTRUCTION JOINTS

TC FUSION can be used in conjunction with construction joint systems to connect panel floors and the bracing core with a small addition to the casting.

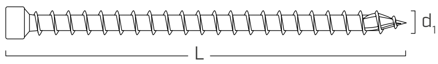
CODES AND DIMENSIONS

VGS - full thread screw with countersunk or hexagonal head



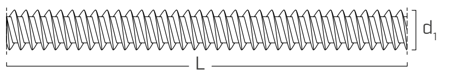
d_1 [mm]	CODE	L [mm]	b [mm]	pcs
9 TX 40	VGS9200	200	190	25
	VGS9220	220	210	25
	VGS9240	240	230	25
	VGS9260	260	250	25
	VGS9280	280	270	25
	VGS9300	300	290	25
	VGS9320	320	310	25
	VGS9340	340	330	25
	VGS9360	360	350	25
	VGS9380	380	370	25
	VGS9400	400	390	25
	VGS9440	440	430	25
	VGS9480	480	470	25
	VGS9520	520	510	25
	VGS9560	560	550	25
	VGS9600	600	590	25
11 TX 50	VGS11200	200	190	25
	VGS11225	225	215	25
	VGS11250	250	240	25
	VGS11275	275	265	25
	VGS11300	300	290	25
	VGS11325	325	315	25
	VGS11350	350	340	25
	VGS11375	375	365	25
	VGS11400	400	390	25
	VGS11425	425	415	25
	VGS11450	450	440	25
	VGS11475	475	465	25
	VGS11500	500	490	25
	VGS11525	525	515	25
	VGS11550	550	540	25
	VGS11575	575	565	25
	VGS11600	600	590	25
11 SW 17 TX 50	VGS11650	650	630	25
	VGS11700	700	680	25
	VGS11750	750	680	25
	VGS11800	800	780	25
	VGS11850	850	830	25
	VGS11900	900	880	25
	VGS11950	950	930	25
	VGS111000	1000	980	25
13 TX 50	VGS13200	200	190	25
	VGS13250	250	240	25
	VGS13300	300	280	25
	VGS13350	350	330	25
	VGS13400	400	380	25
	VGS13450	450	430	25
	VGS13500	500	480	25
	VGS13550	550	530	25
	VGS13600	600	580	25
13 SW 19 TX 50	VGS13650	650	630	25
	VGS13700	700	680	25
	VGS13750	750	730	25
	VGS13800	800	780	25
	VGS13850	850	830	25
	VGS13900	900	880	25
	VGS13950	950	930	25
	VGS131000	1000	980	25
	VGS131100	1100	1080	25
	VGS131200	1200	1180	25
	VGS131300	1300	1280	25
	VGS131400	1400	1380	25
	VGS131500	1500	1480	25

VGZ - mini full threaded screw with cylindrical head



d_1 [mm]	CODE	L [mm]	b [mm]	pcs
9 TX 40	VGZ9200	200	190	25
	VGZ9220	220	210	25
	VGZ9240	240	230	25
	VGZ9260	260	250	25
	VGZ9280	280	270	25
	VGZ9300	300	290	25
	VGZ9320	320	310	25
	VGZ9340	340	330	25
	VGZ9360	360	350	25
	VGZ9380	380	370	25
	VGZ9400	400	390	25
	VGZ9440	440	430	25
	VGZ9480	480	470	25
	VGZ9520	520	510	25
	VGZ9560	560	550	25
	VGZ9600	600	590	25
11 TX 50	VGZ11200	200	190	25
	VGZ11250	250	240	25
	VGZ11275	275	265	25
	VGZ11300	300	290	25
	VGZ11325	325	315	25
	VGZ11350	350	340	25
	VGZ11375	375	365	25
	VGZ11400	400	390	25
	VGZ11425	425	415	25
	VGZ11450	450	440	25
	VGZ11475	475	465	25
	VGZ11500	500	490	25
	VGZ11525	525	515	25
	VGZ11550	550	540	25
	VGZ11575	575	565	25
	VGZ11600	600	590	25
	VGZ11650	650	640	25
	VGZ11700	700	690	25
	VGZ11750	750	740	25
	VGZ11800	800	790	25
	VGZ11850	850	840	25
	VGZ11900	900	890	25
	VGZ11950	950	940	25
	VGZ111000	1000	990	25

RTR - structural reinforcement system



d_1 [mm]	CODE	L [mm]	pcs
16	RTR162200	2200	10

GEOMETRY AND MECHANICAL CHARACTERISTICS

VGS - VGZ

			VGS					VGZ	
Nominal diameter	d_1	**[mm]**	**9**	**11**	**11**	**13**	**13**	**9**	**11**
Length	L	[mm]	-	≤ 600 mm	> 600 mm	≤ 600 mm	> 600 mm	-	-
Countersunk head diameter	d_K	[mm]	16,00	19,30	-	22,00	-	11,50	13,50
Countersunk head thickness	t_1	[mm]	6,50	8,20	-	9,40	-	-	-
Wrench size	SW	-	-	-	SW 17	-	SW 19	-	-
Hexagonal head thickness	t_s	[mm]	-	-	6,40	-	7,50	-	-
Thread diameter	d_2	[mm]	5,90	6,60	6,60	8,00	8,00	5,90	6,60
Pre-drilling hole diameter[1]	$d_{V,S}$	[mm]	5,0	6,0	6,0	8,0	8,0	5,0	6,0
Pre-drilling hole diameter[2]	$d_{V,H}$	[mm]	6,0	7,0	7,0	9,0	9,0	6,0	7,0
Characteristic tensile strength	$f_{tens,k}$	[kN]	25,4	38,0	38,0	53,0	53,0	-	-
Characteristic yield moment	$M_{y,k}$	[Nm]	27,2	45,9	45,9	70,9	70,9	-	-
Characteristic yield strength	$f_{y,k}$	[N/mm²]	1000	1000	1000	1000	1000	-	-

[1] Pre-drilling valid for softwood.
[2] Pre-drilling valid for hardwood and beech LVL.

RTR

Nominal diameter	d_1	**[mm]**	**16**
Thread diameter	d_2	[mm]	12,00
Pre-drilling hole diameter[1]	$d_{V,S}$	[mm]	13,0
Characteristic tensile strength	$f_{tens,k}$	[kN]	100,0
Characteristic yield moment	$M_{y,k}$	[Nm]	200,0
Characteristic yield strength	$f_{y,k}$	[N/mm²]	640

[1] Pre-drilling valid for softwood.

MECHANICAL CHARACTERISTICS OF TC FUSION SYSTEM

				VGS/VGZ		RTR
Nominal diameter	d_1	**[mm]**	**9**	**11**	**13**	**16**
Tangential strength of adhesion in concrete C25/30	$f_{b,k}$	[N/mm²]	12,5	12,5	12,5	9,0

For applications with different materials please see ETA-22/0806

RELATED PRODUCTS

D 38 RLE
4-SPEED DRILL DRIVER

SPEEDY BAND
UNIVERSAL SINGLE-SIDED TAPE WITHOUT RELEASE LINER

FLUID MEMBRANE
SYNTHETIC SEALING MEMBRANE FOR BRUSH AND SPRAY APPLICATION

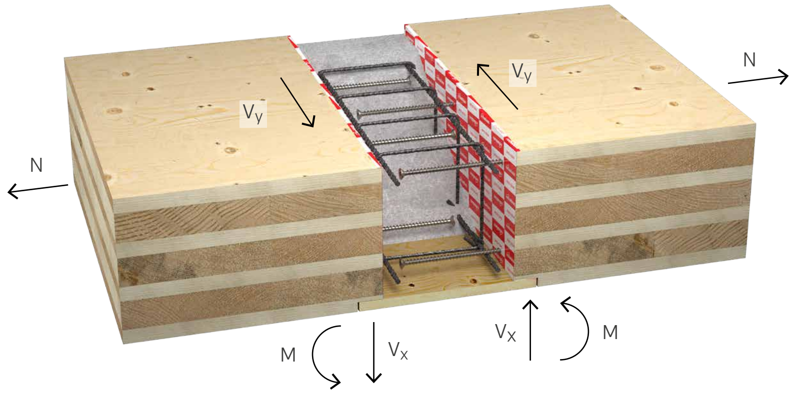
INVISI BAND
TRANSPARENT SINGLE-SIDED ADHESIVE TAPE WITHOUT LINER, RESISTANT TO UV AND HIGH TEMPERATURES

Find out more at **www.rothoblaas.com**

FIELD OF USE

ETA 22/0806 is specifically for timber-concrete applications with VGS, VGZ and RTR all-thread connectors.
The calculation method for evaluating both joint strength and stiffness is made explicit.
The connection allows the transfer of shear, tensile and bending moment stresses between timber elements (CLT, LVL, GL, glulam) and concrete, both at floor and wall level.
The TC FUSION system was tested and validated at the Arbeitsbereich für Holzbau of the University of Innsbruck as part of a research project co-funded by the Österreichische Forschungsförderungsgesellschaft (FFG).

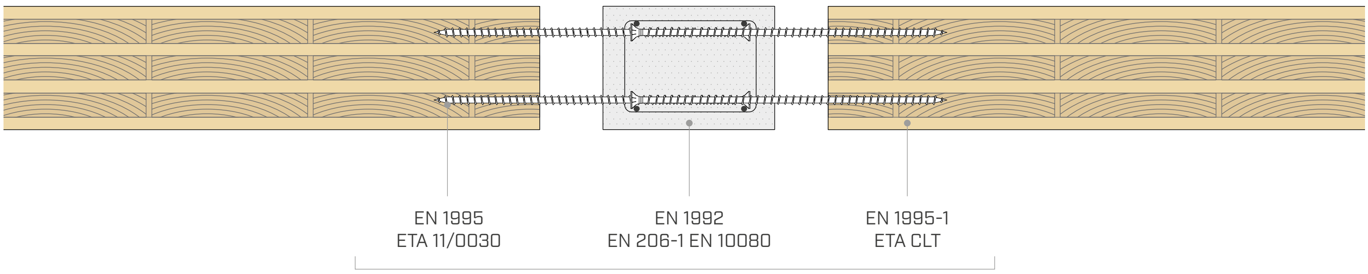
EXTERNAL LOADS



Rigid joint:
- cut in the panel plane (V_y)
- out-of-plane cutting (V_x)
- tension (N)
- bending moment (M)

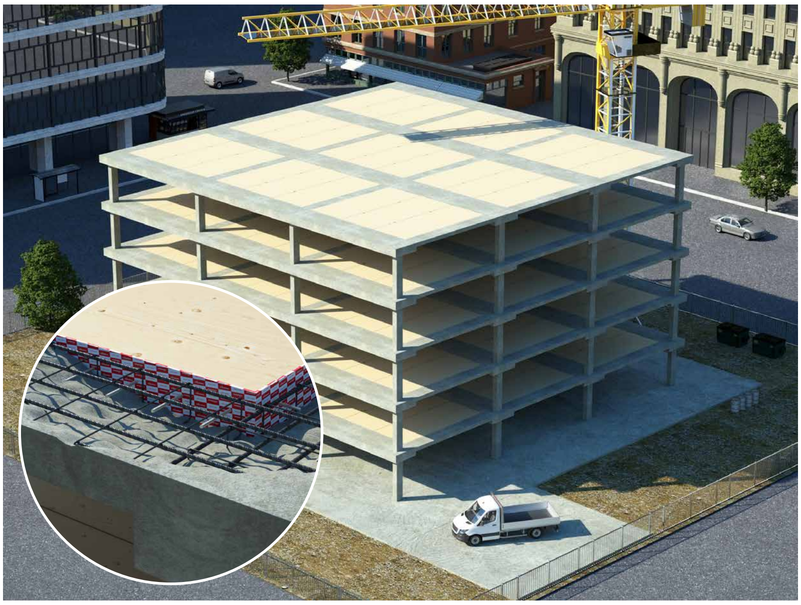
Hinge joint:
- cut in the panel plane (V_y)
- out-of-plane cutting (V_x)
- tension (N)

STANDARDS AND CERTIFICATIONS INVOLVED



ETA-22/0806 Rothoblaas
FOR TIMBER-TO-CONCRETE CONNECTIONS

USE FOR HYBRID TIMBER-CONCRETE STRUCTURES



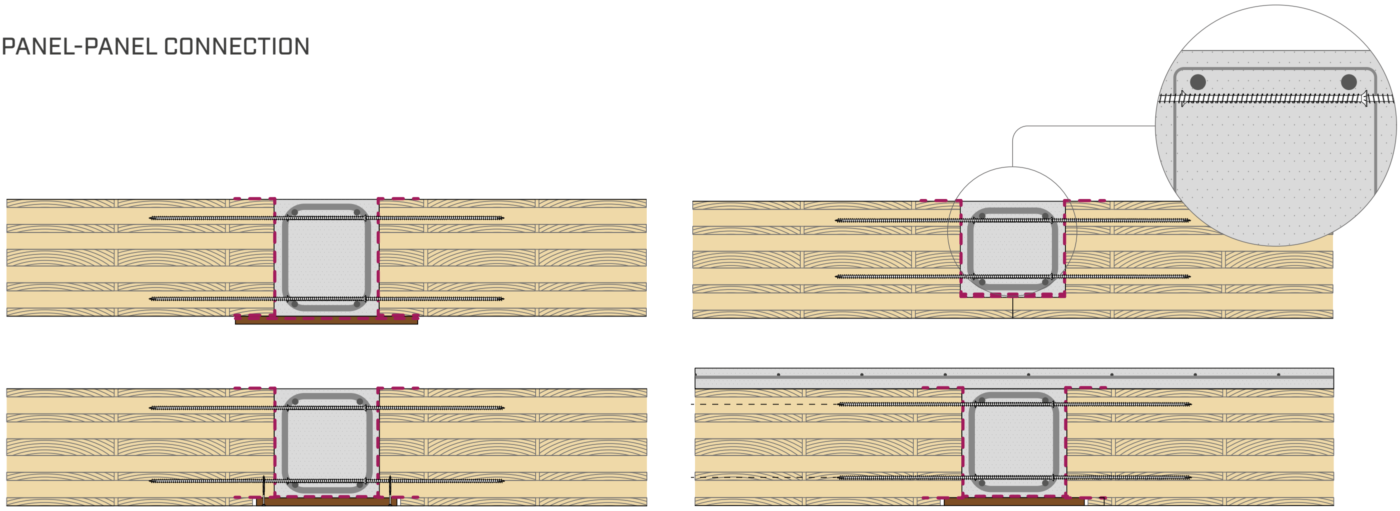
Using the TC FUSION system with screws and threaded rods offers an exceptional level of versatility for the construction of timber-concrete hybrid structures.

The connection is perfectly suited to situations where hinged or semi-rigid constraints are required. Screws and concrete can effectively transfer tension, shear and bending moment. The stiffness and moment of resistance increase progressively with increasing internal torque arm between tensioned flap screws and compressed concrete.

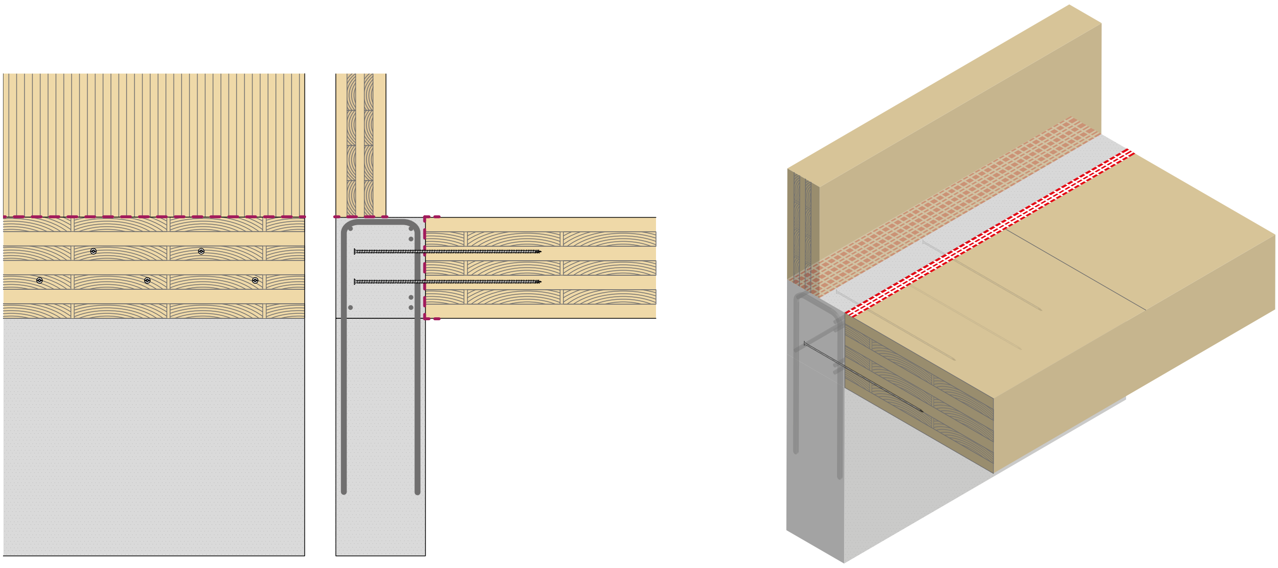
Combining the two materials creates a significant increase in stiffness and reduces structural tolerance issues.

INSTALLATION

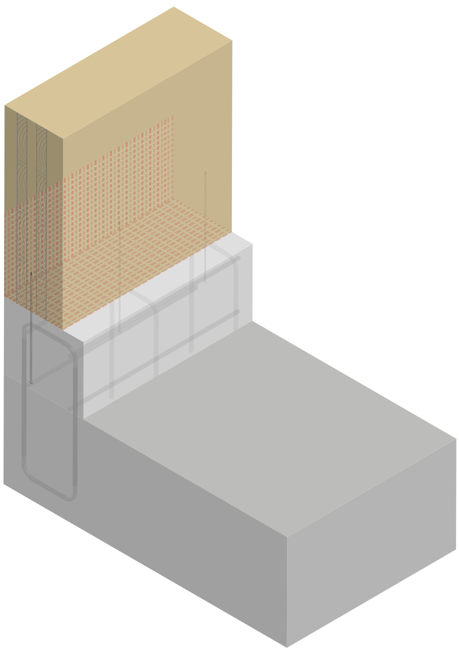
PANEL-PANEL CONNECTION



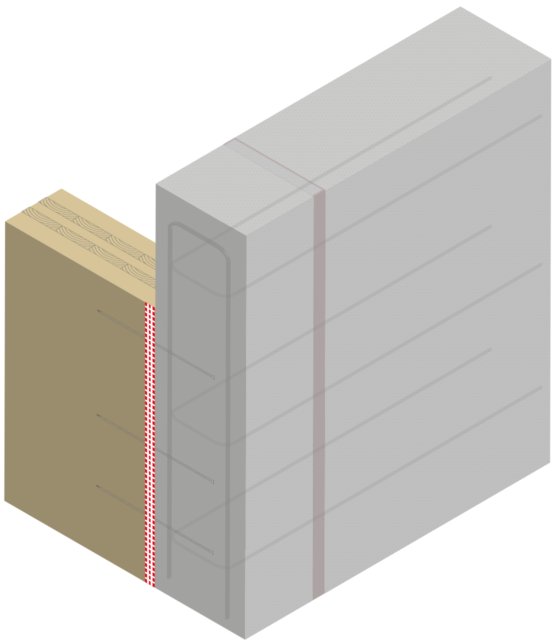
FLOOR-WALL CONNECTION



WALL-FOUNDATION CONNECTION



WALL-WALL CONNECTION

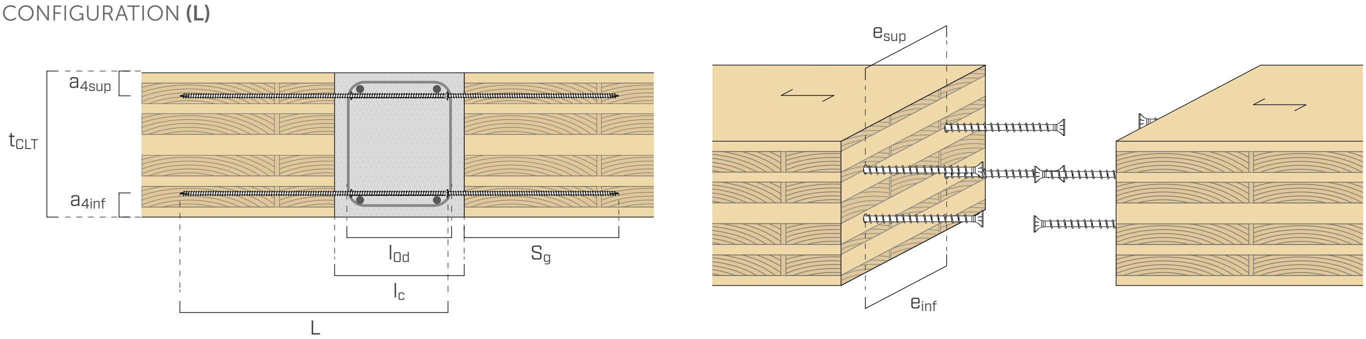


STRUCTURAL VALUES | STRENGTH | TIMBER-CONCRETE-TIMBER

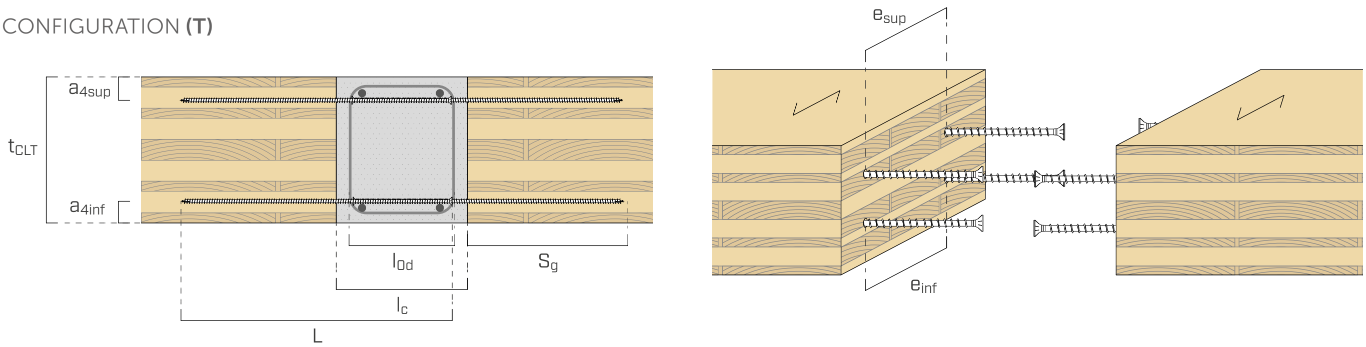
geometry						MOMENT M^*_{Rd}					
						160 (40-20-40-20-40)(1)		180 (40-30-40-30-40)(1)		200 (40-40-40-40-40)(1)	
d_1	L	l_c	l_{0d} (2)	S_g	e_{inf} | e_{sup}	(L)	(T)	(L)	(T)	(L)	(T)
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]
9	300	200	160	120	200	3,5	2,3	4,1	2,9	4,7	3,5
	320	200	160	140	200	4,1	2,6	4,8	3,3	5,5	4,1
	340	200	160	160	200	4,6	3,0	5,4	3,8	6,2	4,6
	360	200	160	180	200	5,1	3,3	6,1	4,2	7,0	5,1
	380	200	160	200	200	5,7	3,7	6,7	4,7	7,7	5,7
	400	200	160	220	200	6,2	4,0	7,3	5,1	8,4	6,2
	440	200	160	260	200	7,2	4,7	8,5	6,0	9,8	7,2
	480	200	160	300	200	8,2	5,3	9,7	6,8	11,2	8,2
	520	200	160	340	200	9,2	5,9	10,9	7,6	12,5	9,2
11	325	200	160	145	200	4,9	3,2	5,8	4,0	6,6	4,9
	350	200	160	170	200	5,7	3,7	6,7	4,7	7,7	5,7
	375	200	160	195	200	6,5	4,2	7,6	5,3	8,8	6,5
	400	200	160	220	200	7,3	4,7	8,6	6,0	9,8	7,3
	450	200	160	270	200	8,8	5,6	10,3	7,2	11,9	8,8
	500	200	160	320	200	10,2	6,6	12,1	8,4	13,9	10,2
	550	200	160	370	200	11,7	7,5	13,7	9,6	15,8	11,7
	600	200	160	420	200	13,0	8,3	15,4	10,7	17,8	13,0
13	400	230	190	190	200	7,2	4,7	8,5	5,9	9,8	7,2
	450	230	190	240	200	9,0	5,8	10,6	7,4	12,2	9,0
	500	230	190	290	200	10,7	6,8	12,6	8,7	14,5	10,7
	600	230	190	390	200	13,9	8,9	16,4	11,4	18,9	13,9
	700	230	190	490	200	17,0	10,8	20,1	13,9	23,2	17,0
	800	230	190	590	200	19,9	12,6	23,6	16,3	27,3	19,9
	900	250	210	670	200	22,2	14,0	26,4	18,1	30,5	22,2
16	545	270	230	295	200	9,6	6,2	11,3	7,9	13,0	9,6
	650	270	230	400	200	12,6	8,1	14,9	10,4	17,2	12,6
	730	270	230	480	200	14,8	9,5	17,5	12,2	20,2	14,8
	900	270	230	650	200	19,3	12,2	22,9	15,8	26,4	19,3
	1095	270	230	845	200	24,2	15,1	28,7	19,7	33,2	24,2

TIMBER-CONCRETE-TIMBER INSTALLATION

CONFIGURATION **(L)**



CONFIGURATION **(T)**



LEGEND:

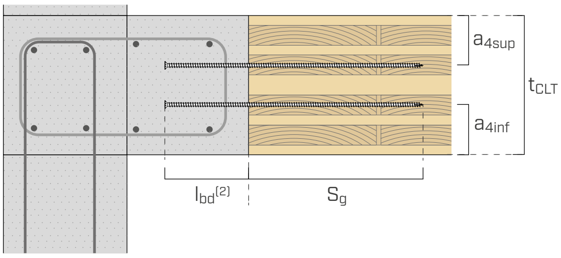
t_{CLT} connected CLT panel thickness
S_g screw pull-through length
l_{0d} overlap length
l_c concrete element width

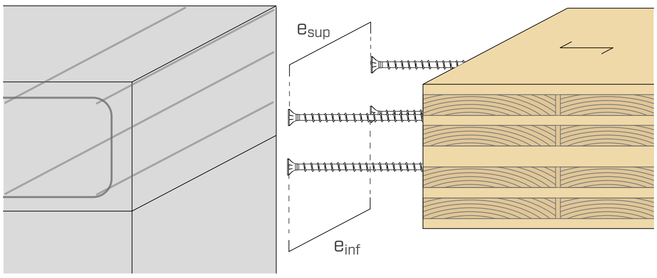
e_{inf} lower screws spacing
e_{sup} upper screws spacing
a_{4inf} distance of the lower screws from the edge
a_{4sup} distance of the upper screws from the edge

MOMENT M^*_{Rd}								SHEAR V^*_{Rd}	TENSION N^*_{Rd}
220 (40-40-20-20-20-40-40)[1]		240 (40-40-20-40-20-40-40)[1]		260 (40-40-30-40-30-40-40)[1]		280 (40-40-40-40-40-40-40)[1]			
(L)	(T)	(L)	(T)	(L)	(T)	(L)	(T)		
[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kNm/m]	[kN/m]	[kN/m]
5,3	4,1	5,9	4,7	6,6	5,3	7,2	5,9	3,8	6,1
6,2	4,8	6,9	5,5	7,6	6,2	8,3	6,9	4,0	7,1
7,0	5,4	7,8	6,2	8,7	7,0	9,5	7,8	4,3	8,1
7,9	6,1	8,8	7,0	9,7	7,9	10,6	8,8	4,5	9,1
8,7	6,7	9,7	7,7	10,7	8,7	11,7	9,7	4,5	10,0
9,5	7,3	10,6	8,4	11,7	9,5	12,8	10,6	4,5	11,0
11,1	8,5	12,4	9,8	13,7	11,1	14,9	12,4	4,5	12,8
12,7	9,7	14,1	11,2	15,6	12,7	17,1	14,1	4,5	14,7
14,2	10,9	15,8	12,5	17,5	14,2	19,1	15,8	4,5	16,5
7,5	5,8	8,4	6,6	9,2	7,5	10,1	8,4	5,3	8,7
8,7	6,7	9,7	7,7	10,8	8,7	11,8	9,7	5,6	10,1
9,9	7,6	11,1	8,8	12,2	9,9	13,4	11,1	6,0	11,5
11,1	8,6	12,4	9,8	13,7	11,1	15,0	12,4	6,2	12,9
13,5	10,3	15,0	11,9	16,6	13,5	18,1	15,0	6,2	15,6
15,7	12,1	17,5	13,9	19,4	15,7	21,2	17,5	6,2	18,3
17,9	13,7	20,0	15,8	22,1	17,9	24,2	20,0	6,2	20,9
20,1	15,4	22,5	17,8	24,8	20,1	27,2	22,5	6,2	23,5
11,1	8,5	12,4	9,8	13,6	11,1	14,9	12,4	7,2	12,8
13,8	10,6	15,4	12,2	17,0	13,8	18,6	15,4	8,0	16,0
16,4	12,6	18,3	14,5	20,2	16,4	22,1	18,3	8,0	19,1
21,4	16,4	23,9	18,9	26,4	21,4	29,0	23,9	8,0	25,1
26,3	20,1	29,4	23,2	32,5	26,3	35,6	29,4	8,0	31,0
31,0	23,6	34,6	27,3	38,3	31,0	42,0	34,6	8,0	36,8
34,6	26,4	38,7	30,5	42,9	34,6	47,0	38,7	8,0	41,3
14,8	11,3	16,5	13,0	18,2	14,8	19,9	16,5	11,4	17,2
19,5	14,9	21,7	17,2	24,0	19,5	26,3	21,7	12,8	22,8
22,9	17,5	25,6	20,2	28,3	22,9	31,0	25,6	13,8	26,9
30,0	22,9	33,6	26,4	37,1	30,0	40,7	33,6	14,2	35,6
37,7	28,7	42,3	33,2	46,8	37,7	51,3	42,3	14,2	45,2

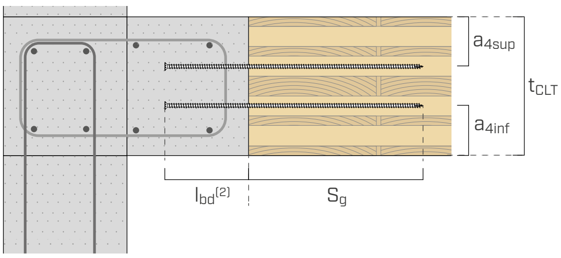
TIMBER-TO-CONCRETE INSTALLATION

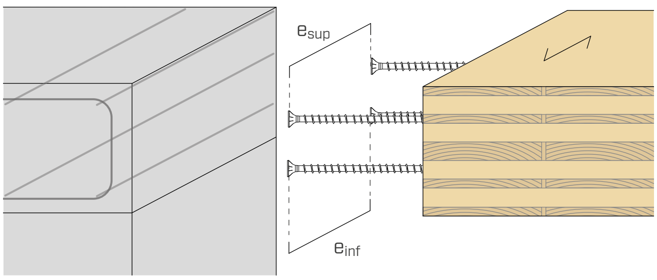
CONFIGURATION **(L)**





CONFIGURATION **(T)**





NOTES:

[1] Panel composition, thickness of overlapping layers with cross fibre orientation.

[2] l_{0d} represents the overlap length of the connectors. In the case of timber-to-concrete joints, this size is to be understood as anchorage length l_{bd}.

STATIC VALUES | STIFFNESS | TIMBER-CONCRETE-TIMBER(*)

geometry						ROTATIONAL STIFFNESS k^*_φ					
						160 (40-20-40-20-40)(1)		180 (40-30-40-30-40)(1)		200 (40-40-40-40-40)(1)	
d_1	L	l_c	l_{0d}(2)	S_g	e_{inf} | e_{sup}	(L)	(T)	(L)	(T)	(L)	(T)
[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]
9	300	200	160	120	200	632	307	913	600	1246	838
	320	200	160	140	200	732	355	1057	695	1443	970
	340	200	160	160	200	830	403	1199	789	1636	1101
	360	200	160	180	200	927	450	1339	881	1828	1229
	380	200	160	200	200	927	450	1339	881	1828	1229
	400	200	160	220	200	927	450	1339	881	1828	1229
	440	200	160	260	200	927	450	1339	881	1828	1229
	480	200	160	300	200	927	450	1339	881	1828	1229
	520	200	160	340	200	927	450	1339	881	1828	1229
11	325	200	160	145	200	841	394	1233	798	1699	1128
	350	200	160	170	200	975	457	1429	925	1970	1308
	375	200	160	195	200	1107	518	1622	1049	2235	1484
	400	200	160	220	200	1235	578	1810	1171	2494	1656
	450	200	160	270	200	1235	578	1810	1171	2494	1656
	500	200	160	320	200	1235	578	1810	1171	2494	1656
	550	200	160	370	200	1235	578	1810	1171	2494	1656
	600	200	160	420	200	1235	578	1810	1171	2494	1656
13	400	230	190	190	200	1258	589	1844	1193	2541	1687
	450	230	190	240	200	1550	725	2271	1469	3129	2078
	500	230	190	290	200	1662	778	2436	1576	3357	2229
	600	230	190	390	200	1662	778	2436	1576	3357	2229
	700	230	190	490	200	1662	778	2436	1576	3357	2229
	800	230	190	590	200	1662	778	2436	1576	3357	2229
	900	250	210	670	200	1662	778	2436	1576	3357	2229
16	545	270	230	295	200	2209	1034	3237	2094	4461	2962
	650	270	230	400	200	2362	1106	3461	2239	4770	3167
	730	270	230	480	200	2362	1106	3461	2239	4770	3167
	900	270	230	650	200	2362	1106	3461	2239	4770	3167
	1095	270	230	845	200	2362	1106	3461	2239	4770	3167

(*) The table refers to the case of timber-concrete-timber connections. In the case of timber-to-concrete, the stiffness of the connection must be doubled.

NOTE

(1) Panel composition, thickness of overlapping layers with cross orientation.

(2) l_{0d} represents the overlap length of the connectors. In the case of timber-to-concrete joints, this size is to be understood as anchorage length l_{bd}.

GENERAL PRINCIPLES

- The case of timber elements made of CLT was considered in the calculation. A compressive strength parallel to the fibres of f_{c0k} = 21 Mpa and an average elastic modulus parallel to the fibres of E_{0m} = 11500 Mpa. In the calculation of strengths and stiffnesses, the contribution of layers with fibres orthogonal to the stress is neglected. A concrete strength class of C25/30 is assumed, preferably with low shrinkage. If higher strength classes (max C50) are used, the adhesion stresses can be increased, according to ETA22/0806.
- For determining the flexural strength, the distance of the screws from the tensioned edge of the a_{4inf} panel was considered to be: 41 mm for Ø9 mm screws and 45 mm for Ø11, Ø13 screws and RTR bars.
- When using the system with other materials, the axial screw strengths must be calculated according to ETA-11/0030.
- Wood and concrete elements must be sized and checked separately. Minimum anchor and overlap lengths, minimum reinforcement arrangement and geometric requirements are indicated in ETA-22/0806.
- In the case of combined stresses, the guidelines in ETA-22/0806 must be followed.
- The safety coefficients γ_M must be taken according to the current regulations used for the calculation. The tables were developed assuming:

  k_{mod} = 1 (short/instantaneous duration)

  γ_M = 1.3 (connections)

  $\gamma_{M,concrete}$ = 1.5 (concrete)

  α_{cc} = 0.85 concrete viscosity coefficient in compression

MOMENT OF RESISTANCE M

- Characteristic values are caluclated in accordance with EN 1995-1-1 and in accordance with ETA-22/0806 and ETA-11/0030. Design resistance values can be obtained from the tabled values as follows:

$$M_{Rd} = M^*_{Rd} \cdot \frac{200}{e} \cdot \frac{k_{mod}}{1,0} \cdot \frac{1,3}{\gamma_M}$$

where:

M_{Rd} moment of resistance referred to design pitch

M^*_{Rd} moment of resistance referred to a standard pitch of 200 mm

e screw pitch at the tensioned flap of the joint (e_{inf} or e_{sup})

SHEAR V_y

- The strength of the system is obtained from the formula:

$$V_{Rd} = V^*_{Rd} \cdot \left(\frac{1000}{e_{inf}} + \frac{1000}{e_{sup}}\right) \cdot \frac{k_{mod}}{1,0} \cdot \frac{1,3}{\gamma_M}$$

where:

V_{Rd} shear strength referred to design pitch

V^*_{Rd} unitary resistant cut (1 screw per metre)

e_{inf} pitch of the screws to the tensioned flap of the joint

e_{sup} screw pitch at the compressed flap of the joint

ROTATIONAL STIFFNESS k^*_{φ}								LATERAL STIFFNESS k^*_{ser}
220 (40-40-20-20-20-40-40)[1]		240 (40-40-20-40-20-40-40)[1]		260 (40-40-30-40-30-40-40)[1]		280 (40-40-40-40-40-40-40)[1]		
(L)	(T)	(L)	(T)	(L)	(T)	(L)	(T)	
[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[kNm/rad/m]	[N/mm/mm]
1630	1115	2066	1431	2553	1787	3092	2183	1371
1887	1291	2392	1658	2957	2070	3581	2528	1371
2141	1465	2714	1880	3354	2348	4062	2868	1371
2391	1636	3031	2100	3746	2622	4537	3202	1371
2391	1636	3031	2100	3746	2622	4537	3202	1371
2391	1636	3031	2100	3746	2622	4537	3202	1371
2391	1636	3031	2100	3746	2622	4537	3202	1371
2391	1636	3031	2100	3746	2622	4537	3202	1371
2391	1636	3031	2100	3746	2622	4537	3202	1371
2240	1515	2855	1960	3545	2462	4309	3020	1928
2597	1757	3310	2273	4110	2854	4996	3502	1928
2946	1993	3755	2578	4663	3238	5668	3973	1928
3288	2225	4191	2877	5204	3614	6326	4434	1928
3288	2225	4191	2877	5204	3614	6326	4434	1928
3288	2225	4191	2877	5204	3614	6326	4434	1928
3288	2225	4191	2877	5204	3614	6326	4434	1928
3288	2225	4191	2877	5204	3614	6326	4434	1928
3349	2266	4269	2931	5301	3681	6444	4517	2562
4125	2791	5259	3610	6529	4534	7937	5563	2562
4425	2994	5641	3872	7004	4864	8514	5968	2562
4425	2994	5641	3872	7004	4864	8514	5968	2562
4425	2994	5641	3872	7004	4864	8514	5968	2562
4425	2994	5641	3872	7004	4864	8514	5968	2562
4425	2994	5641	3872	7004	4864	8514	5968	2562
5881	3979	7496	5146	9307	6463	11314	7931	3646
6288	4255	8016	5503	9952	6911	12099	8480	3646
6288	4255	8016	5503	9952	6911	12099	8480	3646
6288	4255	8016	5503	9952	6911	12099	8480	3646
6288	4255	8016	5503	9952	6911	12099	8480	3646

SHEAR V_x

- The strength of the system is obtained from the formula:

$$V_{Rd} = V^*_{Rd} \cdot \left(\frac{1000}{e_{inf}} + \frac{1000}{e_{sup}}\right) \cdot \beta \cdot \frac{k_{mod}}{1,0} \cdot \frac{1,3}{\gamma_M}$$

$$\beta = min\left\{\frac{a_{4,inf}}{a_{4,inf,min}}\,;\,\frac{a_{4,sup}}{a_{4,sup,min}}\,;\,1\right\}$$

where:

V_{Rd} shear strength referred to design pitch
V^*_{Rd} unitary resistant cut (1 screw per metre), with edge distance greater than the minimum according to ETA-11/0030
e_{inf} pitch of the screws to the tensioned flap of the joint
e_{sup} screw pitch at the compressed flap of the joint
β coefficient for reducing the shear resistance of shear screws in case of deviation from the minimum distance specified in ETA-11/0030
$a_{4inf,min}$ and $a_{4sup,min}$ are the minimum distances according to ETA-11/0030 from the lower and upper edge of the panel
a_{4inf} and a_{4sup} are the design distances from the bottom and top edge of the panel

In the previous formula, the assumption was made to reduce the strength of all screws according to the most penalising distance from the edge.

TENSION N

- The strength of the system is obtained from the formula:

$$N_{Rd} = N^*_{Rd} \cdot \left(\frac{1000}{e_{inf}} + \frac{1000}{e_{sup}}\right) \cdot \frac{k_{mod}}{1,0} \cdot \frac{1,3}{\gamma_M}$$

where:

N_{Rd} tensile strength referred to the design pitch
N^*_{Rd} unit tensile strength (1 screw per metre)
e_{inf} pitch of the screws to the tensioned flap of the joint
e_{sup} screw pitch at the compressed flap of the joint

ROTATIONAL STIFFNESS

- In the calculation of the system rotational stiffness, an effective length limited to a value of 20d was assumed, as stated in ETA 22/0806. In the case of timber-concrete-timber connections, the rotational stiffness must be calculated using the following formula; for timber-to-concrete connections this value must be doubled.

$$k_{\varphi} = k^*_{\varphi} \cdot \frac{200}{e}$$

where:

k_{φ} rotational stiffness referred to the design pitch
k^*_{φ} rotational stiffness based on a standard pitch of 200 mm
e screw pitch at the tensioned flap of the joint

PLANE/OFF-PLANE STIFFNESS

- In the case of timber-concrete-timber connections, the lateral stiffness must be calculated using the following formula; for timber-to-concrete connections this value must be doubled. The stiffness of the system is obtained from the formula.

$$k_{ser} = k^*_{ser} \cdot \left(\frac{1000}{e_{inf}} + \frac{1000}{e_{sup}}\right)$$

where:

k_{ser} = connection stiffness per linear metre
k^*_{ser} = single screw lateral stiffness
e_{inf} pitch of the screws to the tensioned flap of the joint
e_{sup} screw pitch at the compressed flap of the joint

AXIAL STIFFNESS

- For evaluation of axial stiffness, refer to ETA-22/0806