CALCULATION REPORT

CALCULATION OF LOAD BEARING CAPACITY OF ANCHORAGE FOR TIMBER ELEMENT TRANSPORT (cod. ATRE0315)

Cortaccia - BZ - ITALY 22/08/2011

STRUCTURAL CALCULATION EDITED BY:

Ing. Albino Angeli

-STANDARD REGULATIONS REFERENCES-

EN 1995 1-1:2009 Eurocode 5
ETA – 11/0030
NTC 2008 D.M. 14/01/2008

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INDEX

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1 INTRODUCTION

1.1 PREAMBLE

The following calculation report concerns calculation of load bearing capacity of anchorage for timber elements transport (cod. ATRE0315) dealt by *Rotho Blaas Srl*.

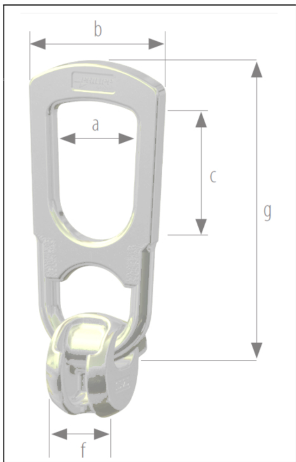
Calculation of load bearing capacity is issued in function of different types of installation of the anchorage.

1.2 STANDARD REGULATIONS REFERENCES

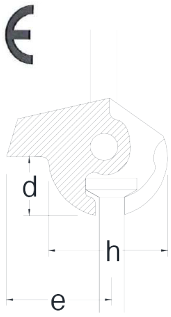
EN 1995-1-1:2009 Eurocode 5. “Design of timber structures”

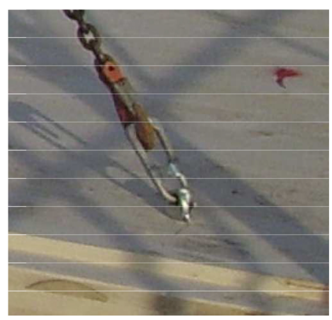
NTC 2008. “Italian Technical Code”

1.3 LIFTING SYSTEM DESCRIPTION



Code	Load group [kg]	a [mm]	b [mm]	c [mm]	d [mm]	e [mm]	f [mm]	g [mm]	h [mm]
ATRE0315	1000 - 1300	47,5	75,0	71,0	30,0	45,0	33,0	164,5	55,0

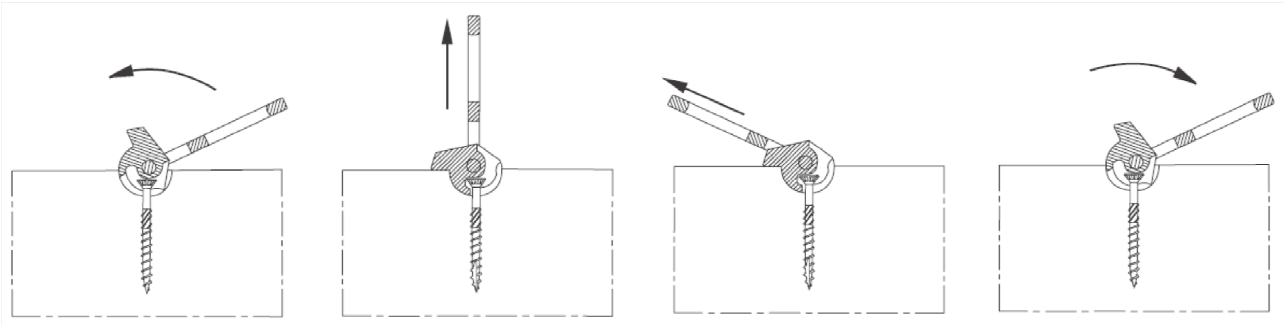




The anchorage is suitable for lifting and transport of timber elements (beams, panels, precast elements, etc..). The hook of the anchorage has a spherical head and it is provided with a blocking-system in order to ensure the stability during transportation. The anchorage is made with galvanized cast steel and belongs to the loading group class 1000-1300 kg. The **maximal admissible load capacity is 13kN**. In the following chapters fixing system information, intended use and calculation hypothesis are given; according to these features the load capacity has been calculated in chapter 2. The load bearing capacity of the transporting system depends in fact on the *system of fixation*, on the *typology of installation* and on the characteristics of the lifted members.

1.4 FIXING SYSTEM AND INSTRUCTION OF USE

The anchorage must be fixed to the ligneous member by a screw; after insertion of the screw, the anchorage is fixed by hand by moving its jaws in the way that anchorage is hooked to the head of the screw. It's important that during lifting operation of all the members, the bearing point of the hook maintains the same direction of the lifting force device; to unhook the anchorage it's sufficient to rotate the hook in the opposite way (as shown in the picture). The German Standards for safety at work BGR 500 “Berufsgenossenschaftliche Regeln für Sicherheit und Gesundheit bei der Arbeit” at chapter 2.8 deals with lifting systems; at point 3.5.2 it prescribes that during lifting operations, the angle α between slinging inclination and carried element plane can't be less than 30°. In the calculations an angle between 30° and 90° is considered.

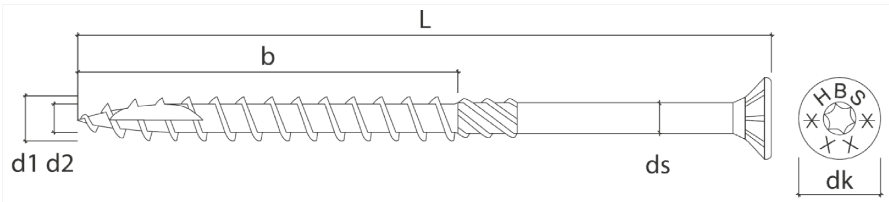


Insertion of the screw and hooking | Position of the hook with perpendicular lifting force | Position of the hook with inclined lifting force | Unhooking

As regards fixing systems, it is prescribed the use of self-tapping screws HBS Ø10 or VGS Ø11, both issued with a CE certification according to ETA-11/0030, produced and distributed by *Rotho Blaas srl*:

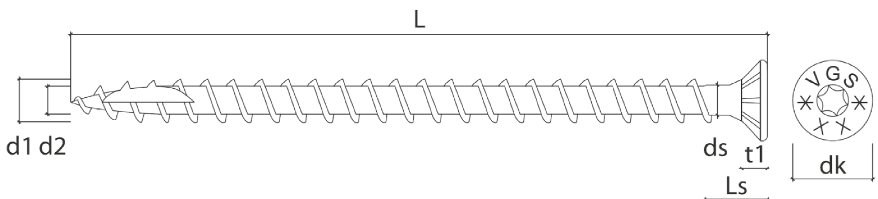
- *Self-tapping screw with partial thread HBS Ø 10*

d_1 (mm)	10,00
TX	40
d_2 (mm)	6,40
d_k (mm)	18,25
d_s (mm)	7,00

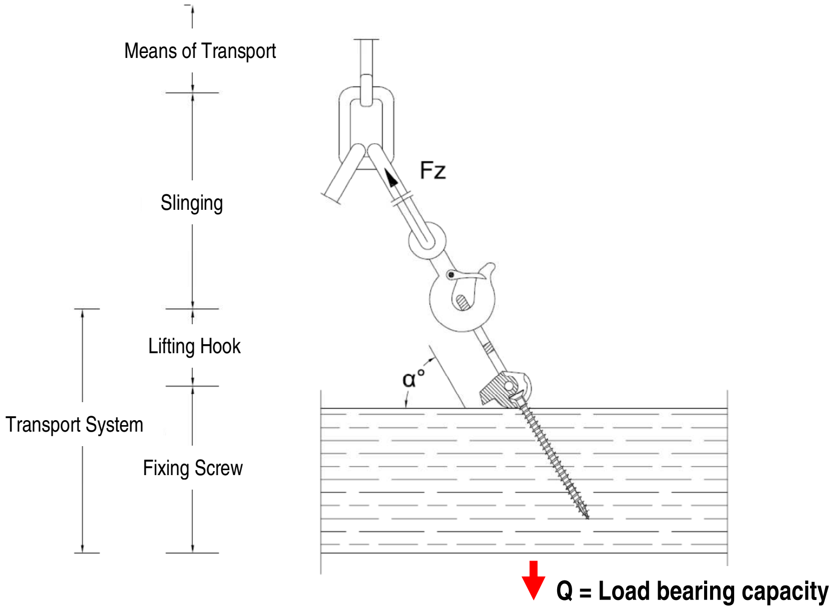


- *Self-tapping screw with full thread VGS Ø 11*

d_1 (mm)	11,00
TX	50
d_2 (mm)	6,60
d_k (mm)	19,30
d_s (mm)	7,7
L-Ls	L-35
t1	8,20

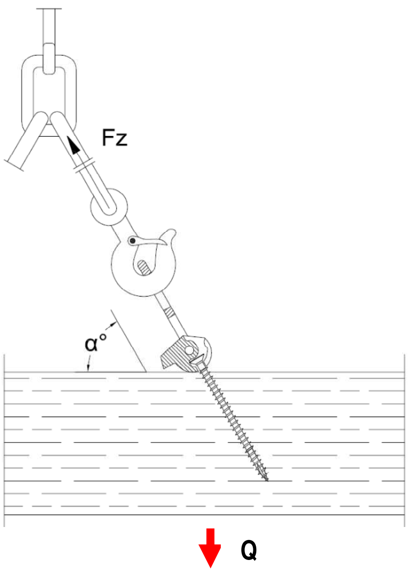


The following image shows a standard application and gives lifting system components:



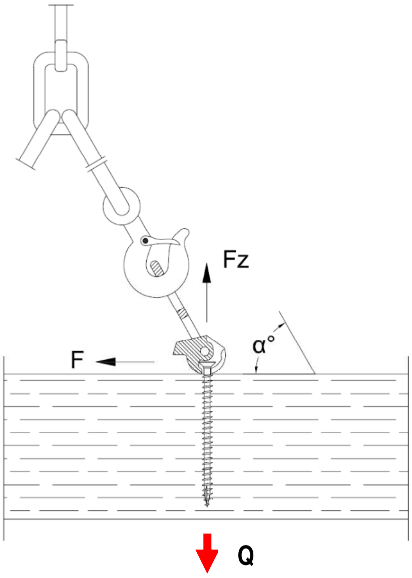
As regard typology of installation, three possibilities are considered:

- *Installation with inclined screw*



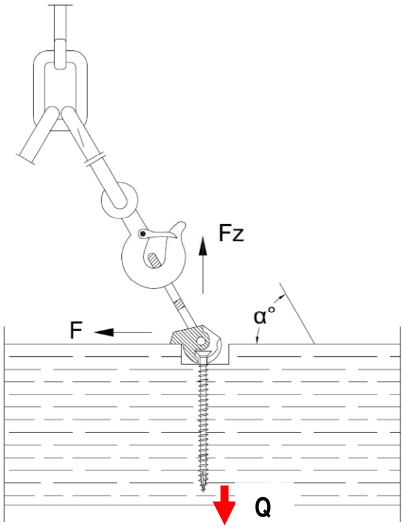
With this type of installation screws are inserted with the same inclination angle of force F_z; α is the inclination angle between screw and horizontal plane of element to be transported. Distance between under-head of the screw and surface of timber element must be the minimum to allow hook clasp; it's important to minimize space between timber element and the anchorage avoiding any gap. In this configuration the screw is axially loaded and mechanism of resistance is characterized by the withdrawal capacity of the thread of the screw. ETA of screws enhances an inclination angle between the timber grain and screw axis in a range between 30° and 90°.

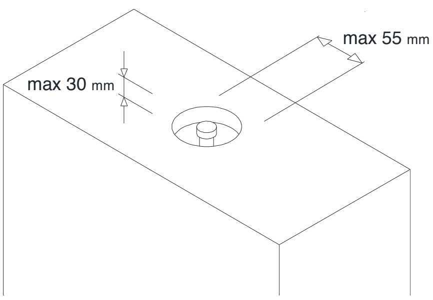
- *Perpendicular Installation*



With this type of installation screws are inserted perpendicular to the timber grain; inclination α between slinging direction and horizontal plane of the element can't be inferior to 30°. Distance between under-head of the screw and surface of timber element must be the minimum to allow hook clasp; it's important to minimize space between timber element and the anchorage avoiding any gap. In this configuration screws are stressed by a combination of lateral and axial force; mechanism of resistance is function of the combination between shear resistance capacity and withdrawal capacity of the screw.

- *Perpendicular installation with milling cut*

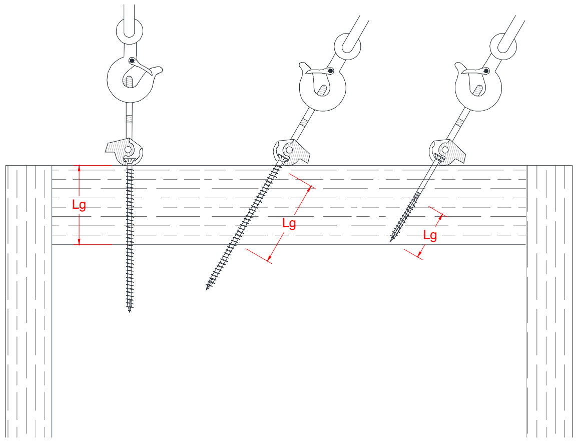




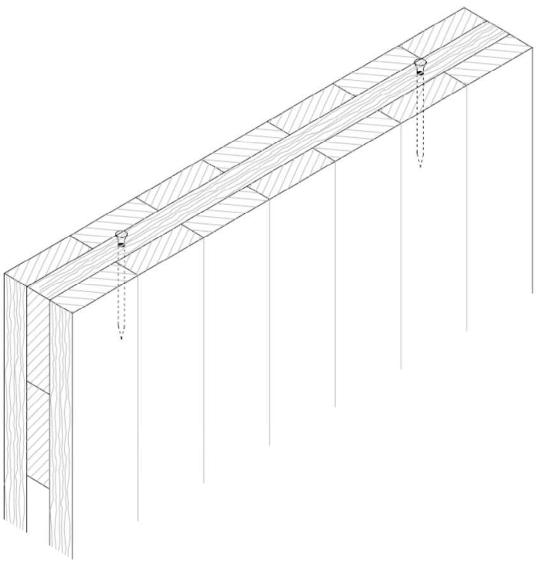
With this type of installation screws are inserted perpendicular to the timber grain; additionally a milling cut on the surface of timber element is realized in order to place the anchorage in tight contact with the timber element surface. Inclination α between slinging direction and horizontal plane of the element can't be inferior to 30°. Distance between under-head of the screw and surface of timber element must be the minimum to allow hook clasp; it's important to minimize space between timber element and the anchorage avoiding any gap. In this configuration screws are stressed by a combination of lateral and axial force. Lateral component is modeled to be transferred by tight local contacts between the anchorage and the timber milling cut; for this reason the mechanism of resistance can be considered the withdrawal capacity of the thread of the screw stressed by axial component of force Fz. In the contact point between anchorage and timber, a compression resistance verification will be issued. This type of configuration has to be realized through a milling cut with the dimension showed in the figure above: maximum 30mm depth and 55mm wide diameter; in this geometrical condition, a minimum lateral contact surface of 480 mm^2 between anchorage and timber element is created.

Instructions of use

- In order to guarantee the load bearing capacity given in chapter 2 it is important to ensure the *thread penetration length* (L_g) used for the calculation and an inclination in the range 30° - 90° between timber grain and the screw. In the case screws are fixed in timber elements with a thickness smaller than the length of the screw , the actual penetration length of the screws in the timber element (L_g) must be considered in the calculation of load bearing capacity.
- Transport of *plywood panels with structural layers* must be executed carefully; in this case screws must be inserted in the layer with the boards laid horizontally (as shown in the lower image); this is required in order to guarantee the correct inclination between timber grain and screw.
- Screws used during a lifting operation can't be reused for the next lifting operations; screws must be substituted with new screws in order to guarantee the load bearing capacity here calculated.
- The anchorage must be subjected to annual checking carried by the technical responsible of safety in the construction site through inspections.
- The anchorage is marked on its surface where information as type of model, load group, producer, year of production and CE marking are given.



Lg = length of the thread actually inserted in the timber element to be transported.



Insertion of the screw in the layer with horizontals boards in the case of transport of plywood panels with structural layers (screws are inserted perpendicular to the timber grain)

1.5 CALCULATION METHOD

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Load bearing capacity is calculated in function of anchorage resistance, timber element and fixing screws. The load acting on the system is considered the design action and it is classified as a static accidental action.

The following table shows the load increaser coefficients which take into account the increment of static load due to dynamic forces acting during lifting operation:

Class of the lifting mode	Dynamic load coefficient ***f*** (V_H= speed of lifting)	
	V_H < 90 m/min	V_H > 90 m/min
H1	1,1 + 0,0022 V_H	1,3
H2	1,2 + 0,0044 V_H	1,6
H3	1,3 + 0,0066 V_H	1,9
H4	1,4 + 0,0088 V_H	2,2

If the speed of lifting is less than 90 m/min and if the maximum caution in the lifting operation is carried out, it is possible to use a factor ***f*** =1 .

The calculation of load bearing capacity is developed in order to obtain both characteristic values and admissible values; in the case of the admissible values, the admissible capacity is compared to the admissible resistance calculated according to DIN 1052:1988; in the case of the characteristic values, the design action and the design capacity are obtained through the characteristic values calculated according to the Standard Regulations EN 1995:2009; the characteristic values must be reduced by the partial safety factors according to the specified code used in the verification (for National Italian Code the values are given in NTC 2008 Norms).

Design Action

During transporting operation carried load is classified as live load; partial safety factor γ_G to be applied to the design action according to the load combination, depends on the Standard Regulations used as reference; after calculation of design resistance ($R_{,d}$), the design capacity value ($F_{,d}$) is calculated through the expression $R_{,d} = \gamma_G \times F_{,d}$, and so $F_{,d} = R_{,d} / \gamma_G$.

In Italy, according to point 2.5.1.3 of NTC 2008 Norm, the design action is classified as permanent load; consequently safety partial factor is assumed as γ_G **= 1,3** . The design capacity value is therefore calculated as $F_{,d} = R_{,d} / 1,3$.

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Design Resistance

Calculation of fixing system design resistance is issued according to point 2.4.1 of Standard Regulations Eurocode EN 1995-1-1:2009:

$$X_d = \frac{k_{mod} X_k}{\gamma_M}$$

- K_{mod}

K_{mod} value is a modification factor taking into account the effect of the duration of load, the service class and the structural material typology.

In Italy, transport and lifting operation of timber elements can be classified within a load duration class "instantaneous" and within a service class 3 according to point 4.4.4. of NTC2008.

Classe di durata del carico	Durata del carico
Permanente	più di 10 anni
Lunga durata	6 mesi -10 anni
Media durata	1 settimana – 6 mesi
Breve durata	meno di 1 settimana
Istantaneo	--

Tabella 4.4.IV -*Valori di* k_{mod} *per legno e prodotti strutturali a base di legno*

Materiale	Riferimento	Classe di servizio	Classe di durata del carico				
			Permanente	Lunga	Media	Breve	Istantanea
Legno massiccio Legno lamellare incollato	EN 14081-1 EN 14080	1	0,60	0,70	0,80	0,90	1,00
		2	0,60	0,70	0,80	0,90	1,00
		3	0,50	0,55	0,65	0,70	0,90

According to Italian code $\mathbf{k_{mod}}$ factor can be assumed with a value of **0,9**.

- γ_M

Coefficient $\boldsymbol{\gamma_M}$ is the partial factor for a material property.

Standard Regulations EN 1995-1-1:2009 gives the following $\boldsymbol{\gamma_M}$ values

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Fundamental combinations:	
Solid timber	1,3
Glued laminated timber	1,25
LVL, plywood, OSB,	1,2
Particleboards	1,3
Fibreboards, hard	1,3
Fibreboards, medium	1,3
Fibreboards, MDF	1,3
Fibreboards, soft	1,3
Connections	1,3
Punched metal plate fasteners	1,25
Accidental combinations	1,0

In Italy the coefficient is provided with the value **1,5**; fixing between timber element and anchoring system is defined as *union* in accordance with table 4.4.III of NTC 2008. this coefficient is more restrictive compared with other countries which can assume values according to Eurocode.

Tabella 4.4.III -*Coefficienti parziali γ_M per le proprietà dei materiali*

Stati limite ultimi	γ_M
- combinazioni fondamentali	
legno massiccio	1,50
legno lamellare incollato	1,45
pannelli di particelle o di fibre	1,50
compensato, pannelli di scaglie orientate	1,40
unioni	1,50
- combinazioni eccezionali	1,00

1.6 MATERIALS

- HBS screw :

self-tapping screw for timber structures in conformity with ZA Annex of Standard Regulation EN 14592:2008;

		HBS Ø10,0
$f_{head,k}$	[Mpa]	10,50
$\rho_{a,head}$	[kg/mc]	350
$f_{ax,k}$	[Mpa]	11,70
$\rho_{a,ax}$	[kg/mc]	350
$M_{y,k}$	[Nm]	35829,6
$f_{tens,k} = R_{t,u,k}$	[kN]	31,40
Coeff $_{thread}$	[ZUL]	5

- **VGS screw** :

self-tapping screw for timber structures in conformity with ZA Annex of Standard Regulation EN 14592:2008;

		VGS Ø11,0
$f_{head,k}$	[Mpa]	10,50
$\rho_{a,head}$	[kg/mc]	350
$f_{ax,k}$	[Mpa]	11,70
$\rho_{a,ax}$	[kg/mc]	350
$M_{y,k}$	[Nm]	45905,4
$f_{tens,k} = R_{t,u,k}$	[kN]	38,0
Coeff $_{thread}$	[ZUL]	5

- **Timber**:

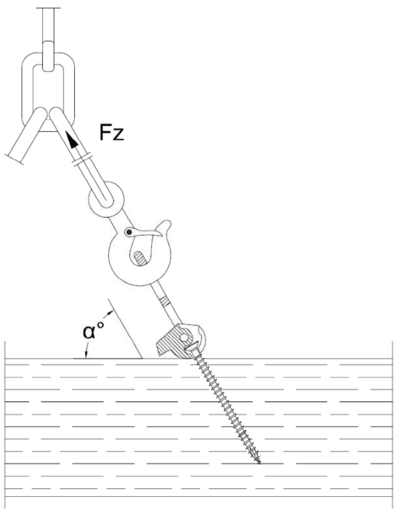
In order to ensure higher safety standards, in the calculation it is assumed a timber resistance class C20:

Modulus of elasticity (E)			C20	C24
Mean Char. Mod. El. parallel	$E_{0,mean}$	MPa	9500	11000
5-perc. Char. Mod. El. parallel	$E_{0,05}$	MPa	6400	7400
Mean Char. Mod. El. perpend.	$E_{90,mean}$	MPa	320	370
Mean Char. Shear Mod.	G_{mean}	MPa	590	690

Characteristic resistance strength			C20	C24
Bending strength	$f_{m,k}$	MPa	20,00	24,00
Tensile strength parallel	$f_{t,0,k}$	MPa	12,00	14,00
Tensile strength perpend.	$f_{t,90,k}$	MPa	0,50	0,50
Compression strength parallel	$f_{c,0,k}$	MPa	19,00	21,00
Compression strength perpend.	$f_{c,90,k}$	MPa	2,30	2,50
Shear strength	$f_{v,k}$	MPa	2,20	2,50

Characteristic density	ρ_k	kg/m³	320	350

2 CALCULATION OF LOAD BEARING CAPACITY



In the following part the load bearing capacity of transport system is calculated in function of type of installation, type of screw, insertion depth length of the screw and inclination with horizontal plane of the lifting force.

2.1 INCLINED INSTALLATION

In the case of inclined installation, the maximum load bearing capacity in the slinging direction (axial resistance capacity of the screw F_z) is calculated as the minimum value between the withdrawal capacity of the screw (according to the inclination angle) and the load bearing capacity of the anchorage. Load bearing capacity Q is calculated as the projection of Q value on the vertical plan:

$$Q = F_z \cdot \sin\alpha$$

α = angle of inclination between horizontal plane and lifting force direction

- ***Admissible values of resistance*** (Standard Regulations DIN 1052:1988)

The admissible value of resistance of **withdrawal capacity of the thread** is calculated as follows:

$$N_{ax,zul} = d_1 \cdot L_g \cdot coef_{thread} \; [N]$$

where:

$\mathrm{d_1}$ = outer diameter of the thread
$\mathrm{L_g}$ = thread length
$\mathrm{coef_{thread}}$ = coefficient of the thread

Admissible value does not take into account variation of inclination between screw and timber grain

$$F_z = min\begin{cases} N_{ax,zul} \\ 13000\;[N] \end{cases}$$ maximum admissible capacity value in the slinging direction

and:

$$Q_{zul} = F_z \cdot \sin\alpha \;\; [N]$$ **maximum admissible capacity value**

- ***Characteristic values of resistance*** (according to ETA-11/0030)

The characteristic withdrawal resistance value of **thread extraction** of the screw for an angle in the range 30° and 90° between screw and timber grain is calculated in accordance with ETA-11/0030 expression according to EN 1995:2009 Standard Regulations:

$$R_{ax,k} = \frac{n_{ef} \cdot f_{ax,k} \cdot d_1 \cdot l_{ef}}{1{,}2 \cdot \cos^2\alpha + \sin^2\alpha} \cdot \left(\frac{\rho_k}{350}\right)^{0{,}8} \; [N]$$

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where:

d_1 = outer diameter of the thread

n_{ef} = effective number

$f_{ax,k}$ = characteristic withdrawal resistance of the thread

l_{ef} = length of penetration of the thread

ρ_k = timber characteristic density

Coefficients K_{mod} and γ_M are applied in order to obtain design values from characteristic values as explained in point 1.5 of current technical report and in accordance with Italian Standard Regulation NTC2008; additionally the partial safety factor γ_Q has to be taken into account and capacity value is calculated as:

$F_{z,k} = min\begin{cases} R_{ax,k} \\ f_{tens,k} \end{cases}$ maximum characteristic capacity value in the slinging direction

where: $f_{tens,k}$ = 31,4 kN (HBS Ø 10)

= 38,0 kN (VGS Ø 11)

$F_{z,k,Q} = F_{z,k} \cdot \sin\alpha$ **maximum characteristic capacity value**

and:

$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$ maximum design capacity value

where according to NTC 2008:

$K_{mod} = 0{,}9$
$\gamma_M = 1{,}5$
$\gamma_G = 1{,}3$

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HBS screws – C20

α	HBS SCREW Ø 10		$Q_{,zul}$ (1) [kN]	$Q_{,k}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L [mm]	Lg [mm]			
30°	80-100	52	**1,30**	2,46	**1.26**
	120-140	60	**1,50**	2,84	**1,46**
	160-280	80	**2,00**	3,79	**1,94**
	300-400	100	**2,50**	4,74	**2,43**
45°	80-100	52	**1,84**	3,64	**1,87**
	120-140	60	**2,12**	4,20	**2,15**
	160-280	80	**2,83**	5,60	**2,87**
	300-400	100	**3,54**	7,00	**3,59**
60°	80-100	52	**2,25**	4,67	**2,40**
	120-140	60	**2,60**	5,39	**2,76**
	160-280	80	**3,46**	7,19	**3,69**
	300-400	100	**4,33**	8,98	**4,61**
75°	80-100	52	**2,51**	5,40	**2,77**
	120-140	60	**2,90**	6,23	**3,19**
	160-280	80	**3,86**	8,30	**4,26**
	300-400	100	**4,83**	10,38	**5,32**
90°	80-100	52	**2,60**	5,66	**2,90**
	120-140	60	**3,00**	6,53	**3,35**
	160-280	80	**4,00**	8,71	**4.,47**
	300-400	100	**5,00**	10,89	**5,58**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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HBS screws – C24

α	VITE HBS Ø 10		$Q_{,zul}$ (1) [kN]	$R_{ax,k}$ [kN]	$f_{tens,k}$ [kN]	$F_{z,k}$ [kN]	$F_{z,d}$ [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L [mm]	Lg [mm]							
30°	80-100	52	**1,30**	5,29	**31,40**	5,29	3,66	2,65	**1,36**
	120-140	60	**1,50**	6,10	**31,40**	6,10	4,23	3,05	**1,57**
	160-280	80	**2,00**	8,14	**31,40**	8,14	5,63	4,07	**2,09**
	300-400	100	**2,50**	10,17	**31,40**	10,17	7,04	5,09	**2,61**
45°	80-100	52	**1,84**	5,53	**31,40**	5,53	3,83	3,91	**2,01**
	120-140	60	**2,12**	6,38	**31,40**	6,38	4,42	4,51	**2,31**
	160-280	80	**2,83**	8,51	**31,40**	8,51	5,89	6,02	**3,09**
	300-400	100	**3,54**	10,64	**31,40**	10,64	7,36	7,52	**3,86**
60°	80-100	52	**2,25**	5,79	**31,40**	5,79	4,01	5,02	**2,57**
	120-140	60	**2,60**	6,69	**31,40**	6,69	4,63	5,79	**2,97**
	160-280	80	**3,46**	8,91	**31,40**	8,91	6,17	7,72	**3,96**
	300-400	100	**4,33**	11,14	**31,40**	11,14	7,71	9,65	**4,95**
75°	80-100	52	**2,51**	6,00	**31,40**	6,00	4,16	5,80	**2,97**
	120-140	60	**2,90**	6,93	**31,40**	6,93	4,80	6,69	**3,43**
	160-280	80	**3,86**	9,24	**31,40**	9,24	6,39	8,92	**4,58**
	300-400	100	**4,83**	11,55	**31,40**	11,55	7,99	11,15	**5,72**
90°	80-100	52	**2,60**	6,08	**31,40**	6,08	4,21	6,08	**3,12**
	120-140	60	**3,00**	7,02	**31,40**	7,02	4,86	7,02	**3,60**
	160-280	80	**4,00**	9,36	**31,40**	9,36	6,48	9,36	**4,80**
	300-400	100	**5,00**	11,70	**31,40**	11,70	8,10	11,70	**6,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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VGS screws – C20

(α = 30° - 45°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L [mm]	Lg [mm]			
30°	100	75	**2,06**	3,91	**2,00**
	150	125	**3,44**	6,50	**3,34**
	200	175	**4,81**	6,50	**4,67**
	250	225	**6,19**	6,50	**6,01**
	300	275	**6,50**	6,50	**6,50**
	350	325	**6,50**	6,50	**6,50**
	400	375	**6,50**	6,50	**6,50**
	450	425	**6,50**	6,50	**6,50**
	500	475	**6,50**	6,50	**6,50**
	550	525	**6,50**	6,50	**6,50**
	600	575	**6,50**	6,50	**6,50**
45°	100	75	**2,92**	5,78	**2,96**
	150	125	**4,86**	9,63	**4,94**
	200	175	**6,81**	13,48	**6,91**
	250	225	**8,75**	17,33	**8,89**
	300	275	**9,19**	21,18	**9,19**
	350	325	**9,19**	25,03	**9,19**
	400	375	**9,19**	26,87	**9,19**
	450	425	**9,19**	26,87	**9,19**
	500	475	**9,19**	26,87	**9,19**
	550	525	**9,19**	26,87	**9,19**
	600	575	**9,19**	26,87	**9,19**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases}\frac{F_{z,k}\cdot K_{mod}}{\gamma_M\cdot\gamma_G}\\ 13000\cdot\sin\alpha\ [N]\end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

viti VGS – C20

(α = 60° - 75° -90°)

α	VITE VGS Ø 11		$Q_{,zul}$ [(1)] [kN]	$F_{z,k,Q}$ [(2)] [kN]	$Q_{,k}$ [(3)] [kN]
	L [mm]	Lg [mm]			
60°	100	75	**3,57**	7,41	**3,80**
	150	125	**5,95**	12,35	**6,33**
	200	175	**8,34**	17,29	**8,87**
	250	225	**10,72**	22,23	**11,26**
	300	275	**11,26**	27,17	**11,26**
	350	325	**11,26**	32,11	**11,26**
	400	375	**11,26**	32,91	**11,26**
	450	425	**11,26**	32,91	**11,26**
	500	475	**11,26**	32,91	**11,26**
	550	525	**11,26**	32,91	**11,26**
	600	575	**11,26**	32,91	**11,26**
75°	100	75	**3,98**	8,56	**4,39**
	150	125	**6,64**	14,27	**7,32**
	200	175	**9,30**	19,98	**10,25**
	250	225	**11,95**	25,69	**12,56**
	300	275	**12,56**	31,40	**12,56**
	350	325	**12,56**	36,71	**12,56**
	400	375	**12,56**	36,71	**12,56**
	450	425	**12,56**	36,71	**12,56**
	500	475	**12,56**	36,71	**12,56**
	550	525	**12,56**	36,71	**12,56**
	600	575	**12,56**	36,71	**12,56**
90°	100	75	**4,13**	8,98	**4,61**
	150	125	**6,88**	14,97	**7,68**
	200	175	**9,63**	20,96	**10,75**
	250	225	**12,38**	26,95	**13,00**
	300	275	**13,00**	32,94	**13,00**
	350	325	**13,00**	38,00	**13,00**
	400	375	**13,00**	38,00	**13,00**
	450	425	**13,00**	38,00	**13,00**
	500	475	**13,00**	38,00	**13,00**
	550	525	**13,00**	38,00	**13,00**
	600	575	**13,00**	38,00	**13,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$

where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

viti VGS – C24
(α = 30° - 45°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$R_{ax,k}$ [kN]	$f_{tens,k}$ [kN]	$F_{z,k}$ [kN]	$F_{z,d}$ [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L [mm]	Lg [mm]							
30°	100	75	**2,06**	8,39	38,00	8,39	5,81	4,20	**2,15**
	150	125	**3,44**	13,99	38,00	13,99	9,68	6,99	**3,59**
	200	175	**4,81**	19,58	38,00	19,58	13,56	9,79	**5,02**
	250	225	**6,19**	25,18	38,00	25,18	17,43	12,59	**6,46**
	300	275	**6,50**	30,78	38,00	30,78	21,31	15,39	**6,50**
	350	325	**6,50**	36,37	38,00	36,37	25,18	18,19	**6,50**
	400	375	**6,50**	41,97	38,00	38,00	26,31	19,00	**6,50**
	450	425	**6,50**	47,56	38,00	38,00	26,31	19,00	**6,50**
	500	475	**6,50**	53,16	38,00	38,00	26,31	19,00	**6,50**
	550	525	**6,50**	58,75	38,00	38,00	26,31	19,00	**6,50**
	600	575	**6,50**	64,35	38,00	38,00	26,31	19,00	**6,50**
45°	100	75	**2,92**	8,78	38,00	8,78	6,08	6,20	**3,18**
	150	125	**4,86**	14,63	38,00	14,63	10,13	10,34	**5,30**
	200	175	**6,81**	20,48	38,00	20,48	14,18	14,48	**7,42**
	250	225	**8,75**	26,33	38,00	26,33	18,23	18,61	**9,19**
	300	275	**9,19**	32,18	38,00	32,18	22,28	22,75	**9,19**
	350	325	**9,19**	38,03	38,00	38,00	26,31	26,87	**9,19**
	400	375	**9,19**	43,88	38,00	38,00	26,31	26,87	**9,19**
	450	425	**9,19**	49,73	38,00	38,00	26,31	26,87	**9,19**
	500	475	**9,19**	55,58	38,00	38,00	26,31	26,87	**9,19**
	550	525	**9,19**	61,43	38,00	38,00	26,31	26,87	**9,19**
	600	575	**9,19**	67,28	38,00	38,00	26,31	26,87	**9,19**

α = angle of inclination between slinging direction and plane of the element to be transported
(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998
(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.
(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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viti VGS – C24

(α = 60° - 75° - 90°)

α	VITE VGS Ø 11 L [mm]	Lg [mm]	$Q_{,zul}$ (1) [kN]	$R_{ax,k}$ [kN]	$f_{tens,k}$ [kN]	$F_{z,k}$ [kN]	$F_{z,d}$ [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
60°	100	75	**3,57**	9,19	38,00	9,19	6,36	7,96	**4,08**
	150	125	**5,95**	15,32	38,00	15,32	10,61	13,27	**6,80**
	200	175	**8,34**	21,45	38,00	21,45	14,85	18,58	**9,53**
	250	225	**10,72**	27,58	38,00	27,58	19,09	23,88	**11,26**
	300	275	**11,26**	33,71	38,00	33,71	23,34	29,19	**11,26**
	350	325	**11,26**	39,84	38,00	38,00	26,31	32,91	**11,26**
	400	375	**11,26**	45,96	38,00	38,00	26,31	32,91	**11,26**
	450	425	**11,26**	52,09	38,00	38,00	26,31	32,91	**11,26**
	500	475	**11,26**	58,22	38,00	38,00	26,31	32,91	**11,26**
	550	525	**11,26**	64,35	38,00	38,00	26,31	32,91	**11,26**
	600	575	**11,26**	70,48	38,00	38,00	26,31	32,91	**11,26**
75°	100	75	**3,98**	9,52	38,00	9,52	6,59	9,20	**4,72**
	150	125	**6,64**	15,87	38,00	15,87	10,99	15,33	**7,86**
	200	175	**9,30**	22,22	38,00	22,22	15,39	21,47	**11,01**
	250	225	**11,95**	28,57	38,00	28,57	19,78	27,60	**12,56**
	300	275	**12,56**	34,92	38,00	34,92	24,18	33,73	**12,56**
	350	325	**12,56**	41,27	38,00	38,00	26,31	36,71	**12,56**
	400	375	**12,56**	47,62	38,00	38,00	26,31	36,71	**12,56**
	450	425	**12,56**	53,97	38,00	38,00	26,31	36,71	**12,56**
	500	475	**12,56**	60,32	38,00	38,00	26,31	36,71	**12,56**
	550	525	**12,56**	66,67	38,00	38,00	26,31	36,71	**12,56**
	600	575	**12,56**	73,02	38,00	38,00	26,31	36,71	**12,56**
90°	100	75	**4,13**	9,65	38,00	9,65	6,68	9,65	**4,95**
	150	125	**6,88**	16,09	38,00	16,09	11,14	16,09	**8,25**
	200	175	**9,63**	22,52	38,00	22,52	15,59	22,52	**11,55**
	250	225	**12,38**	28,96	38,00	28,96	20,05	28,96	**13,00**
	300	275	**13,00**	35,39	38,00	35,39	24,50	35,39	**13,00**
	350	325	**13,00**	41,83	38,00	38,00	26,31	38,00	**13,00**
	400	375	**13,00**	48,26	38,00	38,00	26,31	38,00	**13,00**
	450	425	**13,00**	54,70	38,00	38,00	26,31	38,00	**13,00**
	500	475	**13,00**	61,13	38,00	38,00	26,31	38,00	**13,00**
	550	525	**13,00**	67,57	38,00	38,00	26,31	38,00	**13,00**
	600	575	**13,00**	74,00	38,00	38,00	26,31	38,00	**13,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ \ [N] \end{cases}$$ where: K_{mod}= modification factor , γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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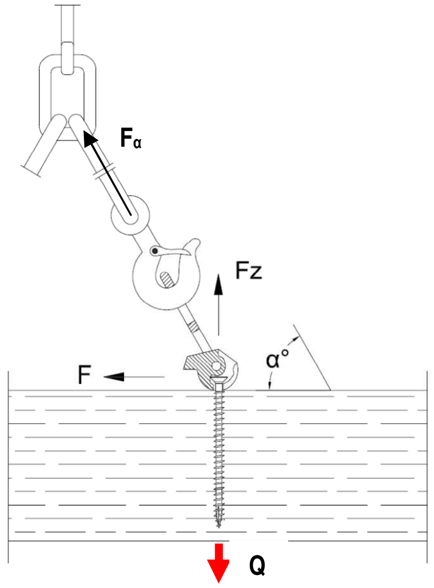
2.2 PERPENDICULAR INSTALLATION



In the case of installation of the screw perpendicular to the timber grain and with the lifting force inclined, screw is stressed by a combination of lateral and axial force. Maximum load bearing capacity in the slinging direction is calculated in function of bi-axial resistance combination (shear and extraction) of the screw. Load bearing capacity Q is given by the projection of Q value on the vertical plan:

$$Q = F_z$$

α = angle of inclination between horizontal plane and lifting force direction

Combined laterally and axially loaded screws (point 8.3.3 of Standard Regulations EN 1995-1-1:2009)

With this configuration the fixing screw is required to satisfy the following condition:

$$\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{v,Ed}}{F_{v,Rd}}\right)^2 \leq 1$$

where:

$F_{ax,Ed}$ = axial load (F_z)

$F_{v,Ed}$ = lateral load (F)

$F_{ax,Rd}$ = axial design capacity

$F_{v,Rd}$ = lateral design capacity

- ***Admissible values of resistance*** (Standard Regulations DIN 1052:1988)

The admissible value of resistance of **withdrawal capacity of the thread** is calculated as follows:

$$N_{ax,zul} = d_1 \cdot L_g \cdot coef_{thread} \; [N]$$

where:

d_1 = outer diameter of the thread

L_g = thread length

$coef_{thread}$ = coefficient of the thread

Admissible value does not take into account variation of inclination between screw and timber grain

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The admissible value of **shear** resistance of the screw is calculated considering a steel-to-timber connection with a single shear according to the following expression:

$$N_{v,zul} = 1{,}25 \cdot 17 \cdot {d_1}^2 \;\; [N]$$

In order to obtain the maximum load bearing capacity in the slinging direction, the bi-axial combination expression $\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{v,Ed}}{F_{v,Rd}}\right)^2 \leq 1$ is optimized by attempts determining the two components $\mathbf{F_{ax,Rd}}$ ($\mathbf{F_z}$) and $\mathbf{F_{v,Rd}}$ (**F**) which give the greater value of $\mathbf{F_\alpha}$.

And so:

$$Q_{zul} = min\begin{cases} F_z \\ 13000 \cdot \sin\alpha \;\; [N] \end{cases}$$ **maximum admissible capacity value**

- ***Characteristic values of resistance*** (according to ETA-11/0030)

The characteristic withdrawal resistance value of **thread extraction** of the screw for an angle in the range 30° and 90° between screw and timber grain is calculated in accordance with ETA-11/0030 expression according to EN 1995:2009 Standard Regulations:

$$R_{ax,k} = \frac{n_{ef} \cdot f_{ax,k} \cdot d_1 \cdot l_{ef}}{1{,}2 \cdot \cos^2\alpha + \sin^2\alpha} \cdot \left(\frac{\rho_k}{350}\right)^{0{,}8} \;\; [N]$$

where:

$d_1 =$ outer diameter of the thread

$n_{ef} =$ effective number

$f_{ax,k} =$ characteristic withdrawal resistance of the thread

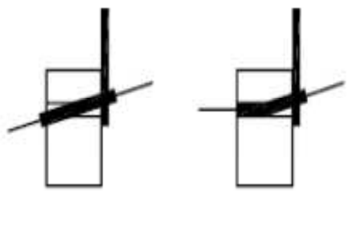
$l_{ef} =$ length of penetration of the thread

$\rho_k =$ timber characteristic density

In order to calculate characteristic **laterally load carrying capacity** of the screw, a timber-to-steel failure mode with single shear is considered. Thickness of anchorage acting as plate is about 5,5mm; for higher safety standards it is assumed that thickness is not sufficient to generate a plastic hinge in the contact point between anchorage and timber; consequently failure modes of steel-to-timber connections with a thin steel plate are considered in accordance with Standard Regulations EN 1995-1-1:2009:

For a thin steel plate in single shear:

$$F_{v,Rk} = \min\begin{cases} 0{,}4\, f_{h,k}\, t_1\, d & \text{(a)} \\ 1{,}15\sqrt{2\, M_{y,Rk}\, f_{h,k}\, d} + \dfrac{F_{ax,Rk}}{4} & \text{(b)} \end{cases}$$



a b

where:

$f_{h,k}$ = characteristic embedment strength

In the case of screws HBS Ø 10 or VGS Ø 11, characteristic embedment strength is calculated as:

$f_{h,\alpha,k} = \frac{f_{h,0,k}}{(k_{90} \cdot \sin^2 \alpha + \cos^2 \alpha)}$ where:

$f_{h,0,k} = 0{,}082 \cdot (1 - 0{,}01 \cdot \emptyset_c) \cdot \rho_k$ = characteristic embedment strength parallel to the grain

$k_{90} = 1{,}35 + 0{,}015 \cdot \emptyset_c$ = angle parameter

$\emptyset_c$ = calculation diameter (7 mm for HBS Ø 10; 7,26 mm for VGS Ø 11)

α = angle between stress and grain in the timber element; for higher safety standards α = 90° is assumed

$M_{y,k}$ = characteristic yield moment of the screw

$F_{ax,Rk}$ = characteristic withdrawal capacity of the screw

Also in this case, in order to obtain the maximum load bearing capacity in the slinging direction, the bi-axial combination expression $\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{v,Ed}}{F_{v,Rd}}\right)^2 \leq 1$ is optimized by attempts determining the two components **$F_{ax,Ed}$** (**F_z**) and **$F_{v,Ed}$** (**F**) which give the greater value of **F_α** .

Characteristic resistance values and not design resistance values are assumed in the expression in order to obtain a characteristic load bearing value.

And so:

$F_{z,k} = min \begin{cases} R_{ax,k} \\ f_{tens,k} \end{cases}$ **maximum characteristic capacity value**

where: $f_{tens,k}$ = 31,4 kN (HBS Ø 10)

= 38,0 kN (VGS Ø 11)

And:

$Q_k = min \begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin \alpha \ [N] \end{cases}$ maximum design capacity value

where according to NTC 2008:

$K_{mod} = 0{,}9$

$\gamma_M = 1{,}5$

$\gamma_G = 1{,}3$

HBS screws – C20

α	VITE HBS Ø 10		$Q_{,zul}$ (1) [kN]	$F_{z,k}$ (2) [kN]	Q_k (3) [kN]
	L [mm]	Lg [mm]			
30°	80	52	**1,03**	1,90	**0,97**
	100	52	**1,10**	2,33	**1,19**
	120-140	60	**1,13**	2,63	**1,35**
	160-280	80	**1,15**	2,98	**1,53**
	300-400	100	**1,18**	3,33	**1,71**
45°	80	52	**1,56**	2,97	**1,52**
	100	52	**1,63**	3,46	**1,78**
	120-140	60	**1,73**	3,92	**2,01**
	160-280	80	**1,87**	4,63	**2,38**
	300-400	100	**1,94**	5,27	**2,70**
60°	80	52	**2,04**	4,11	**2,11**
	100	52	**2,12**	4,55	**2,33**
	120-140	60	**2,29**	5,20	**2,66**
	160-280	80	**2,68**	6,41	**3,29**
	300-400	100	**2,94**	7,53	**3,86**
75°	80	52	**2,41**	5,17	**2,65**
	100	52	**2,46**	5,17	**2,65**
	120-140	60	**2,80**	6,13	**3,15**
	160-280	80	**3,53**	8,02	**4,11**
	300-400	100	**4,20**	9,80	**5,03**
90°	80	52	**2,60**	5,66	**2,90**
	100	52	**2,60**	5,66	**2,90**
	120-140	60	**3,00**	6,53	**3,35**
	160-280	80	**4,00**	8,71	**4,47**
	300-400	100	**5,00**	10,89	**5,58**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases}\frac{F_{z,k}\cdot K_{mod}}{\gamma_M\cdot\gamma_G}\\ 13000\cdot\sin\alpha\ \ [N]\end{cases}$$

where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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HBS screws – C24

α	VITE HBS Ø 10		$Q_{,zul}$ (1) [kN]	$F_{z,k}$ (2) [kN]	Q_k (3) [kN]
	L [mm]	Lg [mm]			
30°	80	52	**1,03**	2,08	**1,06**
	100	52	**1,10**	2,53	**1,29**
	120-140	60	**1,13**	2,78	**1,42**
	160-280	80	**1,15**	3,15	**1,62**
	300-400	100	**1,18**	3,53	**1,81**
45°	80	52	**1,56**	3,22	**1,65**
	100	52	**1,63**	3,78	**1,94**
	120-140	60	**1,73**	4,17	**2,14**
	160-280	80	**1,87**	4,91	**2,52**
	300-400	100	**1,94**	5,62	**2,88**
60°	80	52	**2,04**	4,46	**2,29**
	100	52	**2,12**	4,89	**2,51**
	120-140	60	**2,29**	5,54	**2,84**
	160-280	80	**2,68**	6,84	**3,51**
	300-400	100	**2,94**	8,05	**4,13**
75°	80	52	**2,41**	5,55	**2,85**
	100	52	**2,46**	5,75	**2,95**
	120-140	60	**2,80**	6,57	**3,37**
	160-280	80	**3,53**	8,60	**4,41**
	300-400	100	**4,20**	10,48	**5,37**
90°	80	52	**2,60**	6,08	**3,12**
	100	52	**2,60**	6,08	**3,12**
	120-140	60	**3,00**	7,02	**3,60**
	160-280	80	**4,00**	9,36	**4,80**
	300-400	100	**5,00**	11,70	**6,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min \begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

VGS screws – C20

(α= 30° - 45°)

α	VITE VGS Ø 11 L [mm]	VITE VGS Ø 11 Lg [mm]	$Q_{,zul}$ (1) [kN]	$F_{z,k}$ (2) [kN]	Q_k (3) [kN]
30°	100	75	**1,38**	2,53	**1,29**
	150	125	**1,44**	3,90	**2,00**
	200	175	**1,46**	4,33	**2,22**
	250	225	**1,47**	4,35	**2,23**
	300	275	**1,48**	4,38	**2,24**
	350	325	**1,48**	4,38	**2,24**
	400	375	**1,48**	4,40	**2,26**
	450	425	**1,48**	4,40	**2,26**
	500	475	**1,48**	4,40	**2,26**
	550	525	**1,48**	4,40	**2,26**
	600	575	**1,48**	4,40	**2,26**
45°	100	75	**2,09**	4,07	**2,09**
	150	125	**2,37**	6,33	**3,25**
	200	175	**2,44**	7,18	**3,68**
	250	225	**2,47**	7,35	**3,77**
	300	275	**2,51**	7,46	**3,83**
	350	325	**2,51**	7,50	**3,84**
	400	375	**2,55**	7,53	**3,86**
	450	425	**2,55**	7,57	**3,88**
	500	475	**2,55**	7,57	**3,88**
	550	525	**2,55**	7,60	**3,90**
	600	575	**2,56**	7,60	**3,90**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

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(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases}\frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G}\\ 13000 \cdot \sin\alpha \ [N]\end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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VGS screws – C20
(α= 60° - 75° - 90°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k}$ (2) [kN]	Q_k (3) [kN]
	L [mm]	Lg [mm]			
60°	100	75	**2,81**	5,93	**3,04**
	150	125	**3,59**	9,40	**4,82**
	200	175	**3,94**	11,22	**5,75**
	250	225	**4,11**	11,86	**6,08**
	300	275	**4,20**	12,30	**6,31**
	350	325	**4,29**	12,56	**6,44**
	400	375	**4,33**	12,73	**6,53**
	450	425	**4,33**	12,82	**6,57**
	500	475	**4,37**	12,90	**6,62**
	550	525	**4,38**	12,99	**6,66**
	600	575	**4,40**	13,03	**6,68**
75°	100	75	**3,77**	8,16	**4,19**
	150	125	**5,55**	13,67	**7,01**
	200	175	**6,76**	19,13	**9,81**
	250	225	**7,58**	24,58	**12,56**
	300	275	**8,07**	30,04	**12,56**
	350	325	**8,45**	35,40	**12,56**
	400	375	**8,69**	35,40	**12,56**
	450	425	**8,84**	35,40	**12,56**
	500	475	**8,98**	35,40	**12,56**
	550	525	**9,08**	35,40	**12,56**
	600	575	**9,18**	35,40	**12,56**
90°	100	75	**4,13**	8,98	**4,61**
	150	125	**6,88**	14,97	**7,68**
	200	175	**9,63**	20,96	**10,75**
	250	225	**12,38**	26,95	**13,00**
	300	275	**13,00**	32,94	**13,00**
	350	325	**13,00**	38,00	**13,00**
	400	375	**13,00**	38,00	**13,00**
	450	425	**13,00**	38,00	**13,00**
	500	475	**13,00**	38,00	**13,00**
	550	525	**13,00**	38,00	**13,00**
	600	575	**13,00**	38,00	**13,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

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$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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VGS screws – C24
(α= 30° - 45°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k}$ (2) [kN]	Q_k (3) [kN]
	L [mm]	Lg [mm]			
30°	100	75	**1,38**	2,75	**1,41**
	150	125	**1,44**	4,25	**2,18**
	200	175	**1,46**	4,53	**2,32**
	250	225	**1,47**	4,55	**2,33**
	300	275	**1,48**	4,58	**2,35**
	350	325	**1,48**	4,58	**2,35**
	400	375	**1,48**	4,58	**2,35**
	450	425	**1,48**	4,58	**2,35**
	500	475	**1,48**	4,58	**2,35**
	550	525	**1,48**	4,58	**2,35**
	600	575	**1,48**	4,58	**2,35**
45°	100	75	**2,09**	4,81	**2,47**
	150	125	**2,37**	7,46	**3,83**
	200	175	**2,44**	7,88	**4,04**
	250	225	**2,47**	8,06	**4,13**
	300	275	**2,51**	8,13	**4,17**
	350	325	**2,51**	8,13	**4,17**
	400	375	**2,55**	8,13	**4,17**
	450	425	**2,55**	8,13	**4,17**
	500	475	**2,55**	8,13	**4,17**
	550	525	**2,55**	8,13	**4,17**
	600	575	**2,56**	8,13	**4,17**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

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$$Q_k = min\begin{cases}\frac{F_{z,k}\cdot K_{mod}}{\gamma_M\cdot\gamma_G}\\ 13000\cdot\sin\alpha\ [N]\end{cases}$$

where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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VGS screws – C24

(α= 60° - 75° - 90°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k}$ (2) [kN]	Q_k (3) [kN]
	L [mm]	Lg [mm]			
60°	100	75	**2,81**	6,41	**3,29**
	150	125	**3,59**	10,22	**5,24**
	200	175	**3,94**	11,82	**6,06**
	250	225	**4,11**	12,51	**6,42**
	300	275	**4,20**	12,90	**6,62**
	350	325	**4,29**	13,03	**6,68**
	400	375	**4,33**	13,03	**6,68**
	450	425	**4,33**	13,03	**6,68**
	500	475	**4,37**	13,03	**6,68**
	550	525	**4,38**	13,03	**6,68**
	600	575	**4,40**	13,03	**6,68**
75°	100	75	**3,77**	8,98	**4,61**
	150	125	**5,55**	14,97	**7,68**
	200	175	**6,76**	20,96	**10,75**
	250	225	**7,58**	27,00	**12,56**
	300	275	**8,07**	32,99	**12,56**
	350	325	**8,45**	35,40	**12,56**
	400	375	**8,69**	35,40	**12,56**
	450	425	**8,84**	35,40	**12,56**
	500	475	**8,98**	35,40	**12,56**
	550	525	**9,08**	35,40	**12,56**
	600	575	**9,18**	35,40	**12,56**
90°	100	75	**4,13**	9,65	**4,95**
	150	125	**6,88**	16,09	**8,25**
	200	175	**9,63**	22,52	**11,55**
	250	225	**12,38**	28,96	**13,00**
	300	275	**13,00**	35,39	**13,00**
	350	325	**13,00**	38,00	**13,00**
	400	375	**13,00**	38,00	**13,00**
	450	425	**13,00**	38,00	**13,00**
	500	475	**13,00**	38,00	**13,00**
	550	525	**13,00**	38,00	**13,00**
	600	575	**13,00**	38,00	**13,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

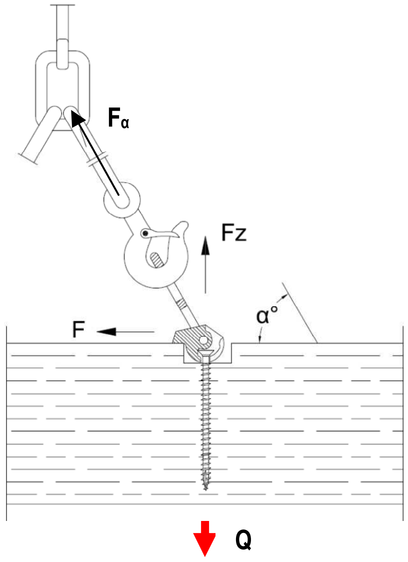
(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

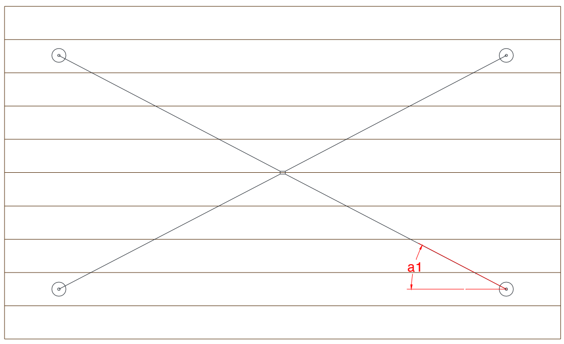
2.3 PERPENDICULAR INSTALLATION WITH MILLING CUT



In the case of screw installation perpendicular to the grain and inclined direction of the lifting force, screw is stressed by a combination of lateral and axial force. The execution of the milling-cut enhances the anchorage to be embedded in the element and to be in tight contact with the timber material. Through a local verification of the compression resistance it is possible to evaluate if inclination between stress and timber grain fulfills the value to guarantee that the horizontal force is transferred by local contacts between anchorage and timber; if this happens screw is not stressed by shear load. If compression resistance of timber is lower than shear resistance of the screw, the configuration coincides with perpendicular installation without milling-cut and values of load bearing capacity can be taken from the previous configuration type. Load bearing capacity Q is calculated as the vertical projection of the maximum capacity in the slinging direction:

$$Q = F_z$$

α = angle of inclination between horizontal plane and lifting force direction



Es. Schema di trasporto del pannello orizzontale

Consequently in the calculation of load bearing capacity it has also been considered the horizontal angle of inclination α_1 between compression stress and direction of timber grain referring to the first 2 cm of thickness of element to be carried. Values have been calculated with an inclination angle $\alpha_1 = 0°$ which means a compression parallel to the timber grain. For angles with values $\alpha_1 > 0°$ a gradual decrement of static benefit occurs up to a limit value of the angle in which static configuration coincides with perpendicular installation without milling cut.

- ***Admissible values of resistance*** (Standard Regulations DIN 1052:1988)

The admissible value of resistance of **withdrawal capacity of the thread** is calculated as follows:

$$N_{ax,zul} = d_1 \cdot L_g \cdot coef_{thread} \ [N]$$

where:

d_1 = outer diameter of the thread
L_g = thread length
$coef_{thread}$ = coefficient of the thread

Admissible value does not take into account variation of inclination between screw and timber grain.

The admissible value of resistance of **timber compression** in the contact between anchorage and timber can be calculated as follows:

$$f_{c,\alpha,adm} = f_{c,/\!/,adm} - (f_{c,/\!/,adm} - f_{c,\perp,adm}) \cdot \sin\alpha_1$$

where:

α_1 = angle of inclination between stress and timber grain
$f_{c,/\!/,\ adm} = 6\ MPa\ (C20 - S7)$
$f_{c,\perp,\ adm} = 2\ MPa\ (C20 - S7)$
$f_{c,//,\ adm} = 8.5\ MPa\ (C24 - S10)$
$f_{c,\perp,\ adm} = 2\ MPa\ (C24 - S10)$

Compression admissible resistance for timber resistance class C20 in the Standard Regulation DIN 1052:1988 corresponds to the softwood solid timber resistance class quality III.

In reference to the minimum lateral contact surface of 480 mm² between anchorage and timber element, it is possible to calculate the admissible horizontal force (F) applicable:

$$F_{adm} = f_{c,\alpha,adm} \cdot contact\ surface$$

And so:

$$Q_{zul} = min\begin{cases} N_{ax,zul} \\ F_{adm} \cdot \tan\alpha \\ 13000 \cdot \sin\alpha\ [N] \end{cases}$$ **maximum admissible capacity value**

- ***Characteristic values of resistance*** (according to ETA-11/0030)

The characteristic withdrawal resistance value of **thread extraction** of the screw for an angle in the range 30° and 90° between screw and timber grain is calculated in accordance with ETA-11/0030 expression according to EN 1995:2009 Standard Regulations:

$$R_{ax,k} = \frac{n_{ef} \cdot f_{ax,k} \cdot d_1 \cdot l_{ef}}{1{,}2 \cdot \cos^2\alpha + \sin^2\alpha} \cdot \left(\frac{\rho_k}{350}\right)^{0{,}8} \; [N]$$

where:

d_1 = outer diameter of the thread

n_{ef} = effective number

$f_{ax,k}$ = characteristic withdrawal resistance of the thread

l_{ef} = length of penetration of the thread

ρ_k = timber characteristic density

The characteristic timber compression resistance in the contact between anchorage and timber is calculated in accordance with Standard Regulations EN 1995-1-1:2009 with the following expression:

$$f_{c,\alpha,k} = \frac{f_{c,0,k}}{\frac{f_{c,0,k}}{k_{c,90} \cdot f_{c,90,k}} \cdot \sin^2\alpha_1 + \cos^2\alpha_1}$$

Where:

$f_{c,0,k}$ = characteristic compression resistance parallel to the timber grain = 19 MPa (C20)
$f_{c,90,k}$ = characteristic compression resistance perpendicular to the timber grain = 2,3 MPa (C20)
$f_{c,0,k}$ = characteristic compression resistance parallel to the timber grain = 21 MPa (C24)
$f_{c,90,k}$ = characteristic compression resistance perpendicular to the timber grain = 2,5 MPa (C24)

$k_{c,90}$ is assumed with value 1
α_1 = inclination angle between stress and timber grain
$F_k = f_{c,\alpha,k} \cdot contact\ surface$

And:

$$Q_k = min \begin{cases} N_{ax,k} \\ F_k \cdot \tan\alpha \\ f_{tens,k} \end{cases}$$ **maximum characteristic capacity value**

where: $f_{tens,k}$ = 31,4 kN (HBS Ø 10)
= 38,0 kN (VGS Ø 11)

and:

$$Q_k = min \begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_Q} \\ 13000 \cdot \sin\alpha \; [N] \end{cases}$$ maximum design capacity value

where according to NTC 2008:

$K_{mod} = 0{,}9$

$\gamma_M = 1{,}5$

$\gamma_G = 1{,}3$

HBS screws – C20

α	VITE HBS Ø 10		$Q_{,zul}$ (1) [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L (mm)	Lg [mm]			
30°	80-100	52	**1,66**	5,27	**2,70**
	120-140	52	**1,66**	5,27	**2,70**
	160-280	60	**1,66**	5,27	**2,70**
	300-400	80	**1,66**	5,27	**2,70**
45°	80-100	100	**2,60**	5,66	**2,90**
	120-140	52	**2,88**	6,53	**3,35**
	160-280	52	**2,88**	8,71	**4,47**
	300-400	60	**2,88**	9,12	**4,68**
60°	80-100	80	**2,60**	5,66	**2,90**
	120-140	100	**3,00**	6,53	**3,35**
	160-280	52	**4,00**	8,71	**4,47**
	300-400	52	**4,99**	10,89	**5,58**
75°	80-100	60	**2,60**	5,66	**2,90**
	120-140	80	**3,00**	6,53	**3,35**
	160-280	100	**4,00**	8,71	**4,47**
	300-400	52	**5,00**	10,89	**5,58**
90°	80-100	52	**2,60**	5,66	**2,90**
	120-140	60	**3,00**	6,53	**3,35**
	160-280	80	**4,00**	8,71	**4,47**
	300-400	100	**5,00**	10,89	**5,58**

α = angle of inclination between slinging direction and plane of the element to be transported

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$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ \ [N] \end{cases}$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

HBS screws – C24

α	VITE HBS Ø 10		$Q_{,zul}$ (1) [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L (mm)	Lg [mm]			
30°	80-100	52	**2,36**	5,82	**2,98**
	120-140	52	**2,36**	5,82	**2,98**
	160-280	60	**2,36**	5,82	**2,98**
	300-400	80	**2,36**	5,82	**2,98**
45°	80-100	100	**2,60**	6,08	**3,12**
	120-140	52	**3,00**	7,02	**3,60**
	160-280	52	**4,00**	9,36	**4,80**
	300-400	60	**4,08**	10,08	**5,17**
60°	80-100	80	**2,60**	6,08	**3,12**
	120-140	100	**3,00**	7,02	**3,60**
	160-280	52	**4,00**	9,36	**4,80**
	300-400	52	**5,00**	11,70	**6,00**
75°	80-100	60	**2,60**	6,08	**3,12**
	120-140	80	**3,00**	7,02	**3,60**
	160-280	100	**4,00**	9,36	**4,80**
	300-400	52	**5,00**	11,70	**6,00**
90°	80-100	52	**2,60**	6,08	**3,12**
	120-140	60	**3,00**	7,02	**3,60**
	160-280	80	**4,00**	9,36	**4,80**
	300-400	100	**5,00**	11,70	**6,00**

α = angle of inclination between slinging direction and plane of the element to be transported

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(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

VGS screws – C20

(α=30° - 45° - 60°)

α	VITE VGS Ø 11		**$Q_{,zul}$ (1)** [kN]	$F_{z,k,Q}$ (2) [kN]	**$Q_{,k}$ (3)** [kN]
	L (mm)	Lg [mm]			
30°	100	75	**1,66**	5,27	**2,70**
	150	125	**1,66**	5,27	**2,70**
	200	175	**1,66**	5,27	**2,70**
	250	225	**1,66**	5,27	**2,70**
	300	275	**1,66**	5,27	**2,70**
	350	325	**1,66**	5,27	**2,70**
	400	375	**1,66**	5,27	**2,70**
	450	425	**1,66**	5,27	**2,70**
	500	475	**1,66**	5,27	**2,70**
	550	525	**1,66**	5,27	**2,70**
	600	575	**1,66**	5,27	**2,70**
45°	100	75	**2,88**	8,98	**4,61**
	150	125	**2,88**	9,12	**4,68**
	200	175	**2,88**	9,12	**4,68**
	250	225	**2,88**	9,12	**4,68**
	300	275	**2,88**	9,12	**4,68**
	350	325	**2,88**	9,12	**4,68**
	400	375	**2,88**	9,12	**4,68**
	450	425	**2,88**	9,12	**4,68**
	500	475	**2,88**	9,12	**4,68**
	550	525	**2,88**	9,12	**4,68**
	600	575	**2,88**	9,12	**4,68**
60°	100	75	**4,13**	8,98	**4,61**
	150	125	**4,99**	14,97	**7,68**
	200	175	**4,99**	15,80	**8,10**
	250	225	**4,99**	15,80	**8,10**
	300	275	**4,99**	15,80	**8,10**
	350	325	**4,99**	15,80	**8,10**
	400	375	**4,99**	15,80	**8,10**
	450	425	**4,99**	15,80	**8,10**
	500	475	**4,99**	15,80	**8,10**
	550	525	**4,99**	15,80	**8,10**
	600	575	**4,99**	15,80	**8,10**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases}\frac{F_{z,k}\cdot K_{mod}}{\gamma_M\cdot\gamma_G}\\ 13000\cdot\sin\alpha\ [N]\end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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VGS screws – C20

(α=75° - 90°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L (mm)	Lg [mm]			
75°	100	75	**4,13**	8,98	**4,61**
	150	125	**6,88**	14,97	**7,68**
	200	175	**9,63**	20,96	**10,75**
	250	225	**10,75**	26,95	**12,56**
	300	275	**10,75**	32,94	**12,56**
	350	325	**10,75**	34,04	**12,56**
	400	375	**10,75**	34,04	**12,56**
	450	425	**10,75**	34,04	**12,56**
	500	475	**10,75**	34,04	**12,56**
	550	525	**10,75**	34,04	**12,56**
	600	575	**10,75**	34,04	**12,56**
90°	100	75	**4,13**	8,98	**4,61**
	150	125	**6,88**	14,97	**7,68**
	200	175	**9,63**	20,96	**10,75**
	250	225	**12,38**	26,95	**13,00**
	300	275	**13,00**	32,94	**13,00**
	350	325	**13,00**	38,00	**13,00**
	400	375	**13,00**	38,00	**13,00**
	450	425	**13,00**	38,00	**13,00**
	500	475	**13,00**	38,00	**13,00**
	550	525	**13,00**	38,00	**13,00**
	600	575	**13,00**	38,00	**13,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

(2) Characteristic capacity values are calculated in accordance with ETA-11/0030 according to EN 1995:2009 Standard Regulations.

(3) In order to obtain design values from characteristic values the following safety factors given by the EN 1995:2009 have to be applied

$$Q_k = min\begin{cases} \frac{F_{z,k} \cdot K_{mod}}{\gamma_M \cdot \gamma_G} \\ 13000 \cdot \sin\alpha \ [N] \end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

VGS screws – C24

(α=30° - 45° - 60°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L (mm)	Lg [mm]			
30°	100	75	**2,36**	5,82	**2,98**
	150	125	**2,36**	5,82	**2,98**
	200	175	**2,36**	5,82	**2,98**
	250	225	**2,36**	5,82	**2,98**
	300	275	**2,36**	5,82	**2,98**
	350	325	**2,36**	5,82	**2,98**
	400	375	**2,36**	5,82	**2,98**
	450	425	**2,36**	5,82	**2,98**
	500	475	**2,36**	5,82	**2,98**
	550	525	**2,36**	5,82	**2,98**
	600	575	**2,36**	5,82	**2,98**
45°	100	75	**4,08**	9,65	**4,95**
	150	125	**4,08**	10,08	**5,17**
	200	175	**4,08**	10,08	**5,17**
	250	225	**4,08**	10,08	**5,17**
	300	275	**4,08**	10,08	**5,17**
	350	325	**4,08**	10,08	**5,17**
	400	375	**4,08**	10,08	**5,17**
	450	425	**4,08**	10,08	**5,17**
	500	475	**4,08**	10,08	**5,17**
	550	525	**4,08**	10,08	**5,17**
	600	575	**4,08**	10,08	**5,17**
60°	100	75	**4,13**	9,65	**4,95**
	150	125	**6,88**	16,09	**8,25**
	200	175	**7,07**	17,46	**8,95**
	250	225	**7,07**	17,46	**8,95**
	300	275	**7,07**	17,46	**8,95**
	350	325	**7,07**	17,46	**8,95**
	400	375	**7,07**	17,46	**8,95**
	450	425	**7,07**	17,46	**8,95**
	500	475	**7,07**	17,46	**8,95**
	550	525	**7,07**	17,46	**8,95**
	600	575	**7,07**	17,46	**8,95**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

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In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

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VGS screws – C24

(α = 75° - 90°)

α	VITE VGS Ø 11		$Q_{,zul}$ (1) [kN]	$F_{z,k,Q}$ (2) [kN]	$Q_{,k}$ (3) [kN]
	L (mm)	Lg [mm]			
75°	100	75	**4,13**	9,65	**4,95**
	150	125	**6,88**	16,09	**8,25**
	200	175	**9,63**	22,52	**11,55**
	250	225	**12,38**	28,96	**12,56**
	300	275	**12,56**	35,39	**12,56**
	350	325	**12,56**	37,62	**12,56**
	400	375	**12,56**	37,62	**12,56**
	450	425	**12,56**	37,62	**12,56**
	500	475	**12,56**	37,62	**12,56**
	550	525	**12,56**	37,62	**12,56**
	600	575	**12,56**	37,62	**12,56**
90°	100	75	**4,13**	9,65	**4,95**
	150	125	**6,88**	16,09	**8,25**
	200	175	**9,63**	22,52	**11,55**
	250	225	**12,38**	28,96	**13,00**
	300	275	**13,00**	35,39	**13,00**
	350	325	**13,00**	38,00	**13,00**
	400	375	**13,00**	38,00	**13,00**
	450	425	**13,00**	38,00	**13,00**
	500	475	**13,00**	38,00	**13,00**
	550	525	**13,00**	38,00	**13,00**
	600	575	**13,00**	38,00	**13,00**

α = angle of inclination between slinging direction and plane of the element to be transported

(1) Admissible capacity values are calculated in accordance with Standard Regulation DIN 1052:1998

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$$Q_k = min\begin{cases}\frac{F_{z,k}\cdot K_{mod}}{\gamma_M\cdot\gamma_G}\\ 13000\cdot\sin\alpha\ [N]\end{cases}$$ where: K_{mod}= modification factor, γ_M= partial safety factor, γ_G = load combination parameter.

In this case it has been assumed K_{mod} = 0,9; γ_M = 1,3 and γ_G = 1,35.

Structural calculation

edited by:

Ing. Albino Angeli

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