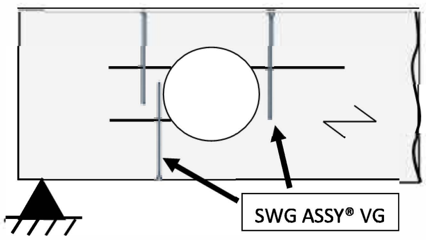
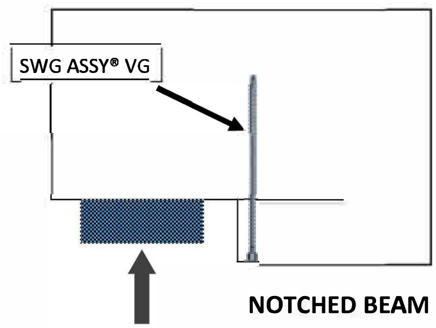
MTC Solutions White Paper

Fully threaded SWG ASSY® Screws as Reinforcement

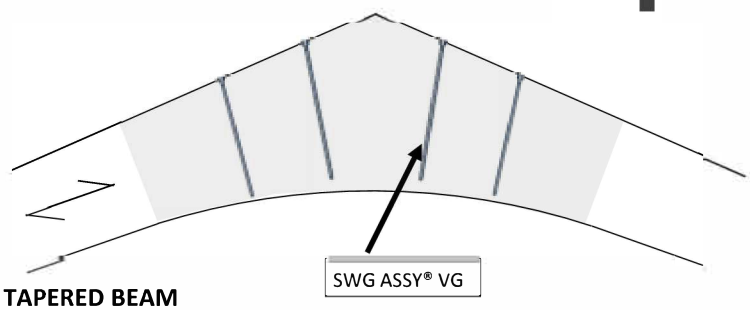
By Max Closen Dipl.-Ing (FH), M.A.Sc.



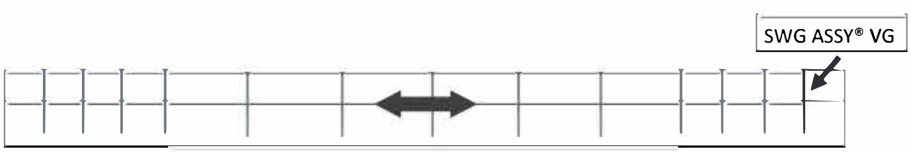
BEAM WITH OPENINGS



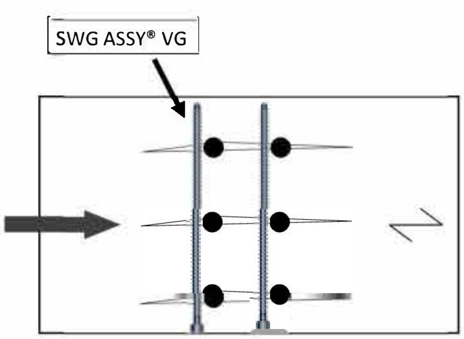
NOTCHED BEAM



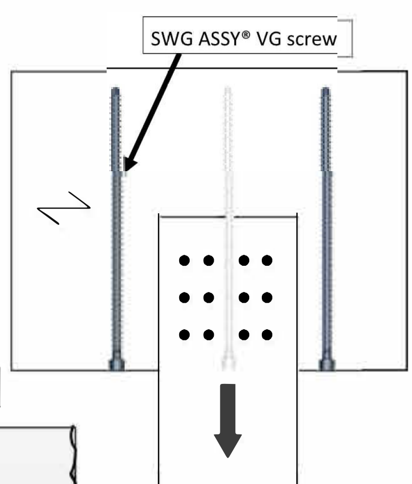
PITCHED TAPERED BEAM



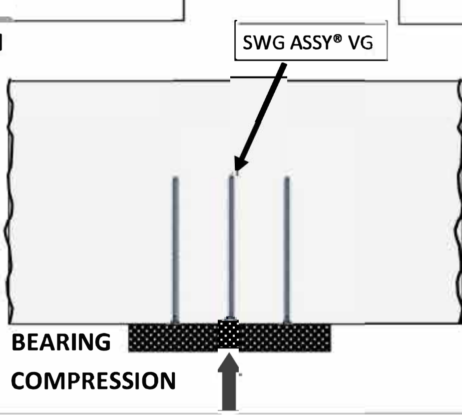
MECHANICALLY JOINTED BEAM



BOLTED CONNECTION



PERPENDICULAR CONNECTION



BEARING COMPRESSION

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Introduction

Originally published in 2014, this Timber Reinforcement Guide serves as a comprehensive resource that showcases a wide spectrum of design techniques employed in the timber industry. A central emphasis is placed on the application of fully threaded screws as a primary method of reinforcement. The Guide's main objective is to foster a deeper understanding of design methodologies, particularly those presented in European standards.

In the realm of timber design, challenges often arise in addressing inherent weaknesses in wood, most notably the issue of perpendicular-to-grain splitting. This challenge manifests prominently in structural elements such as perpendicular-to-grain connections, notched beams, beams with openings for heating, ventilation, and air conditioning (HVAC) access, and those with unique geometric configurations like curved or pitched beams. In situations where the perpendicular-to-grain stress is anticipated to exceed the wood's resistance, reinforcement becomes imperative. This Guide imparts insights into reinforcing wood using fully threaded screws, covering a diverse array of structural scenarios, including compression reinforcement, pitched and tapered beams, and bolted connections.

Perpendicular-to-grain tensile reinforcement requires exclusive use of SWG ASSY® VG fully threaded screws. The screws should be driven into the member perpendicular to the contact surface, that is, at an angle of 90° between the screw axis and wood grain.

The design proposals in this Guide are only applicable to the following timber products:

- Solid timber made of softwood or specific hardwood (beech or oak)
- Glue-laminated timber (glulam)
- Glued solid timber made of softwood or specific hardwood (beech or oak)
- Laminated veneer lumber (LVL)

Importantly, while the document offers valuable information, it is not intended as a prescriptive design manual. Given its 2014 origin, it is advisable for design professionals to diligently cross-reference their designs against the latest standards and best practices to ensure safety, durability, and optimal performance under various load situations.

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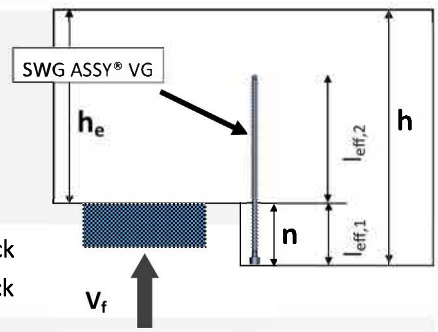
Notched beam reinforcement

Notched beams experience stress concentrations which may exceed specified capacities of the beam. In these areas a combination of stresses may require beam reinforcement.

Reinforcement can be applied using self-tapping full thread SWG ASSY® VG screws. It is assumed that a check or split has already occurred in the corner of the notch and the entire transverse shear force occurring in the lower portion of the beam is to be transmitted through an axial force component in the screw. In longitudinal direction of the beam only one screw row shall be taken into account.

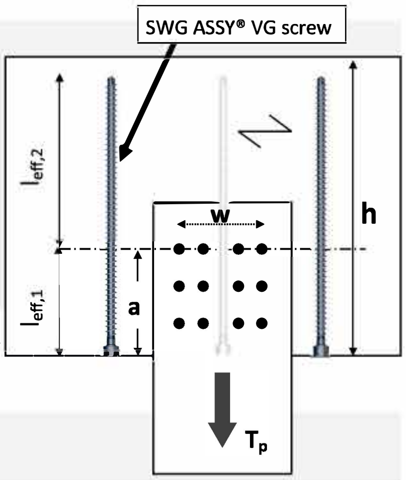


DESIGN NOTCHED BEAM REINFORCEMENT	
Conditions of use	rectangular glue-laminated timber member with notch at the tension side at supports
Geometry	**b** = beam width **h** = beam depth **n** = notch depth $\mathbf{h_e}$ = distance from potential crack to the edge
Effective thread length	$l_{eff,1}$ = threaded length below potential crack $l_{eff,2}$ = threaded length above potential crack
Longitudinal shear resistance [1]	$F_v = f_v\,(K_D K_H K_{Sv} K_T)$ [N/mm²]
Maximum shear resistance [1]	$V_{r,max}$
Existing bearing reaction shear force	V_f
CONDITION	**IF** $V_f \geq V_{r,\,max}$ **REINFORCEMENT IS REQUIRED**
Factors [2] *(k_α values for standard α ratios are calculated in table 2)*	$\alpha = (h_e / h)$ $k_\alpha = 1.3 * [3 * (1-\alpha)^2 - 2 * (1-\alpha)^3]$
Tensile design force [2] to be transmitted by the reinforcing SWG ASSY® VG screws	$V_{r,t,90} = k_\alpha * V_f$
boundary conditions for screw design withdrawal resistance [12]	effective screw length: $l_{eff} = \min\{l_{eff,1}\,;\,l_{eff,2}\}$ minimum penetration depth: $p_{min} = 4 * D$ (outside thread diameter) $\leq l_{eff}$ (smaller penetration can not be taken into account for beam reinforcement)
Withdrawal resistance of one SWG ASSY® VG screw (refer to table 1)	$P'_{rw,\alpha} = \min \begin{cases} \text{withdrawal resistance [kN/20 mm]} * l_{eff} \\ \text{tensile resistance} \end{cases}$
Required number of reinforcing screws [1]	$n_{screws} = \sqrt[0.9]{(V_{r,t,90} / P'_{rw,\alpha})}$

Note: [1] considering an effective number of screws $n_{eff} = n^{0.9}$ as per [13]
A minimum of 2 screws shall be used whereas only one may be used when minimum penetration depth below and above potential crack is 20*D (=outer thread screw diameter). Required spacing, end and edge distances as per *table 6* to be followed

Perpendicular connection members with reinforcement

Perpendicular to grain reinforcement may be required to reduce the potential of perpendicular to grain splitting. The zone at risk is in the outer row of fasteners to the edge of the beam.
Reinforcement can be applied using self-tapping full thread SWG ASSY® VG screws.
Outside of the connection only one screw row in longitudinal direction of the beam shall be taken into account.



DESIGN PERPENDICULAR CONNECTION WITH REINFORCEMENT	
Conditions of use	Perpendicular to grain loaded beam
Geometry	**b** = beam width [mm] **h** = beam depth [mm] **a** = distance measured from the center of the upper row of fasteners (potential crack) to the loaded edge **w** = width of connection less the included fastener diameters
Effective thread length	$l_{eff,1}$ = threaded length below potential crack $l_{eff,2}$ = threaded length above potential crack
Tensile strength perpendicular to grain [1]	$F_{tp} = f_{tp} (K_D K_H K_{Sf} K_T)$ [N/mm²]
Net tension resistance	$T_{r,tp,max} = \phi\ (=0.7) * F_{tp} * A_n$ **with** $A_n = b * w$ [mm²]
Existing vertical connection shear force	T_p
CONDITION	**IF** $T_P \geq T_{r,tp,max}$ **REINFORCEMENT IS REQUIRED**
factors [3] *(k_{tp} values for standard α ratios are calculated in table 3)*	$\alpha = (a/h)$ $k_{tp} = [1 - 3 * \alpha^2 + 2 * \alpha^3]$
Tensile design force [3] to be transmitted by the reinforcing SWG ASSY® VG screws	$T_{r,tp,90} = k_{tp} * T_p$
boundary conditions for screw design withdrawal resistance [12]	effective screw length: $l_{eff} = \min \{l_{eff,1} ; l_{eff,2}\}$ minimum penetration depth: $p_{min} = 4 * D$ (outside thread diameter) $\leq l_{eff}$ (smaller penetration can not be taken into account for beam reinforcement)
Withdrawal resistance of one SWG ASSY® VG screw (refer to table 1)	$P'_{rw,\alpha} = \min \begin{cases} \text{withdrawal resistance [kN/20 mm]} * l_{eff} \\ \text{tensile resistance} \end{cases}$
Required number of reinforcing screws [1]	$n_{screws} = \sqrt[0.9]{(T_{r,tp,90} / P'_{rw,\alpha})}$

Note: [1] considering an effective number of screws $n_{eff} = n^{0.9}$ as per [13]
A minimum of 2 screws shall be used whereas only one may be used when minimum penetration depth below and above potential crack is 20*D (=outer thread screw diameter). Required spacing, end and edge distances as per *table 6* to be followed

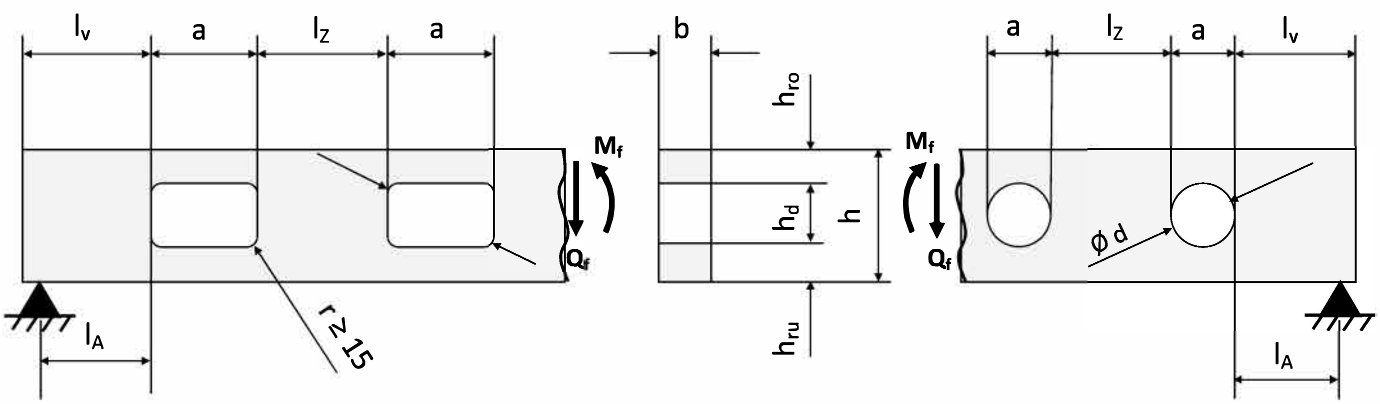
Reinforcing openings and penetrations

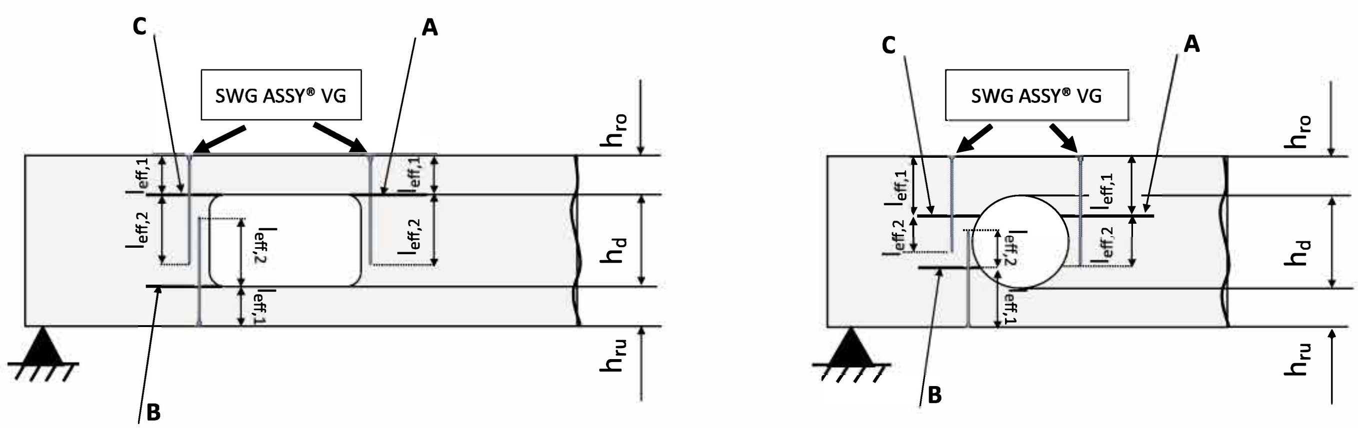
Holes greater d = 50 mm (2") may weaken the effective cross section so that shear and normal stress travel at the hole are impacted. Resulting forces perpendicular to grain may require reinforcement.

Self-tapping full thread SWG ASSY® VG screws inserted on each side of the hole are a suitable reinforcement method.

Conditions of use [1] for reinforced beam						
$l_v \ge h$	$l_z \ge \max\{h ; 300\ mm\}$	$l_A \ge h/2$	$h_{ro\ (ru)} \ge 0.25 *h$	$a \le h$	$a \le 2.5 *h_d$	$h_d \le 0.3 *h$

Note: [1] according to [4]





Note:

A potential crack on the **right side** of opening

B potential crack on the **left side** of opening, if $F_{t,M,r} \le F_{t,v,r}$

C **additional** potential crack to B on the **left side** of opening, if $F_{t,M,r} > F_{t,v,r}$

right side: side of opening or penetration away from bearing area

left side: side of opening or penetration close to bearing area

DESIGN REINFORCEMENT FOR BEAMS WITH OPENINGS AND PENETRATIONS	
Conditions of use	beam with penetration in the high shear zone
Geometry	**b** = beam width **h** = beam depth **a** = length resp. diameter of the hole
Effective thread length	Rectangular hole: $l_{eff,1}$ = min {h_{ro} ; h_{ru}} less unthread head part $l_{eff,2}$ = remaining threaded length less tip length (tip length = outer thread diameter) Circular hole: $l_{eff,1}$ = min {h_{ro} + 0.15 *h_d ; h_{ru}+ 0.15 *h_d} less unthread part $l_{eff,2}$ = remaining threaded length less tip length
Tensile strength perpendicular to grain [1]	F_{tp} = f_{tp} ($K_D K_H K_{Sf} K_T$) [N/mm²]
Design and reduction factors [5]	Rectangular hole: $l_{t,90}$ = 0.5 *(h_d + h) Circular hole: $l_{t,90}$ = 0.353 *h_d + 0.5 *h $k_{t,90}$ = min{ $(450/h)^{0.5}$; 1}
Net tension resistance [5]	$T_{r,tp,max}$ = 0.5 *$l_{t,90}$ *b *$k_{t,90}$ * ϕ (=0.7) *F_{tp}
External load at section	Q_f , M_f
Reduced height [5]	Rectangular hole: h_r = min {h_{ro} ; h_{ru}} Circular hole: h_r = min {h_{ro} + 0.15 *h_d ; h_{ru}+ 0.15 *h_d}
Design stress [5] at opening perpendicular-to-grain from shear	$F_{t,V,r}$ = (Q_f *h_d) / (4 *h) *[3—(h_d^2 /h^2)]
Design stress [5] at opening perpendicular-to-grain from bending	$F_{t,M,r}$ = 0.008 *M_f / h_r
Resulting design stress [5] at opening perpendicular-to-grain	$F_{t,r}$ = $F_{t,V,r}$ + $F_{t,M,r}$
CONDITION	**IF** $F_{t,r} \geq T_{r,tp,max}$ **REINFORCEMENT IS REQUIRED**
Tensile design force [5] to be transmitted by the reinforcing SWG ASSY® VG screws [1]	$F_{t,r}$ = $F_{t,V,r}$ + $F_{t,M,r}$
boundary conditions for screw design with-drawal resistance [12]	effective screw length: l_{eff} = min {$l_{eff,1}$; $l_{eff,2}$} minimum penetration depth: p_{min} = 4 * D (outside thread diameter) ≤ l_{eff} (smaller penetration can not be taken into account for beam reinforcement)
*Withdrawal resistance of **one** SWG ASSY® VG screw (refer to table 1)*	$P'_{rw,\alpha}$ = min { **withdrawal resistance** [kN/20 mm] * l_{eff} ; **tensile resistance** }
Required number of reinforcing screws on one side of the hole [2]	n_{screws} = $\sqrt[0.9]{(F_{t,r} / P'_{rw,\alpha})}$

Note: [1] Additional reinforcement shall be designed if $F_{t,M,r} > F_{t,V,r}$

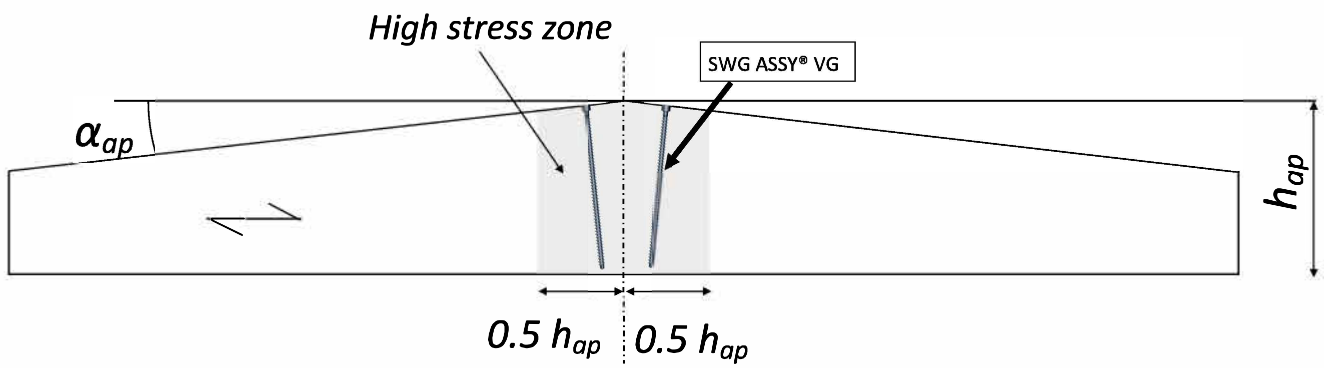
[2] considering an effective number of screws $n_{eff} = n^{0.9}$ as per [13]

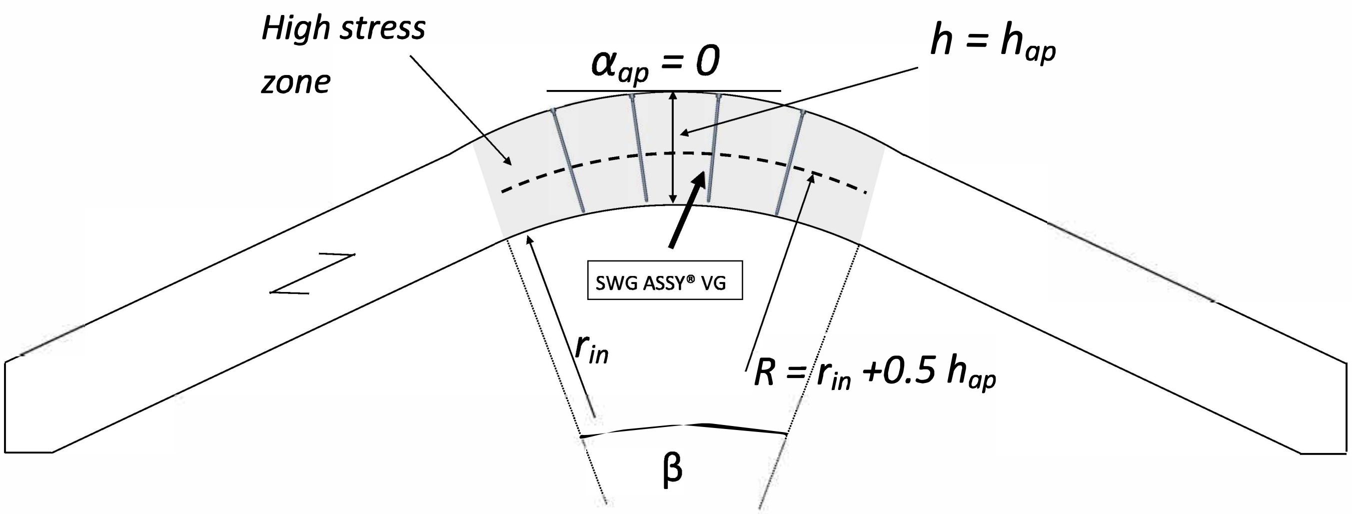
Screws to be driven in on each side of opening **sufficiently extending into the timber below and above opening.**

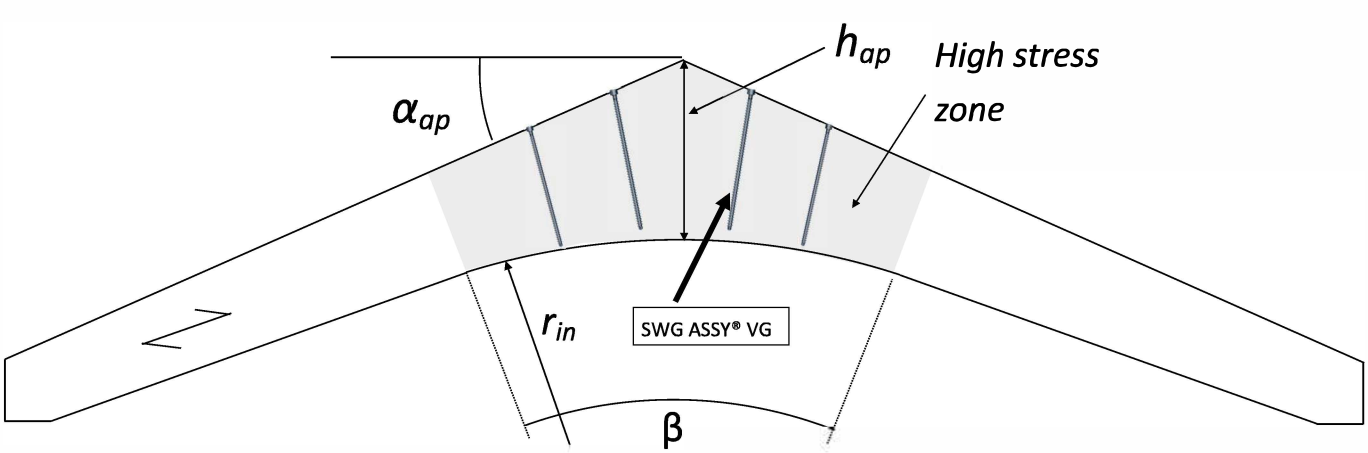
Reinforcing pitched tapered beams

In pitched tapered beams radial tension stresses often limit the beam slope to 15° or less. Increased bending stress and tensile stress perpendicular-to-grain may occur at the apex cross section.
Reinforcement in the apex area may be applied using self-tapping full thread SWG ASSY® VG screws inserted over the beam depth in the high stressed zone.

Applicable to glue-laminated timber only.







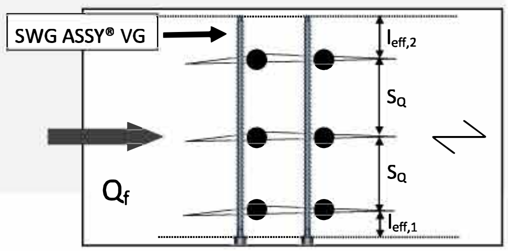
DESIGN PITCHED TAPERED BEAM REINFORCEMENT	
Conditions of use	Pitched tapered beam with rectangular cross section
Geometry	**b** = beam width **h** = beam depth h_{ap} = beam depth at the apex r_{in} = inner radius at the apex **r** = r_{in} + 0.5 h_{ap} (radius of curvature at centreline) α_{ap} = angle of the taper in the centre of the apex **β** = enclosed angle in radians
Effective thread length [7]	**Screws must penetrate the entire beam depth —> $l_{screw} \approx h$** $l_{eff,1}$ = half of the screw length less the unthreaded head part [mm] $l_{eff,2}$ = half of the screw length less 1*D (outer thread diameter) for the tip length [mm]
Tensile strength perpendicular to grain [1]	F_{tp} = f_{tp} $(K_D K_H K_{Sf} K_T)$ [N/mm^2]
Factored bending moment resistance [1] based on radial tension strength	M_{rt}
Design moment causing tensile stress	$M_{r,ap}$
CONDITION	**IF** $M_{r,ap} \geq M_{rt}$ **REINFORCEMENT IS REQUIRED**
Factors [6]	$k_6 = 0.25 - 1.5 \tan\alpha_{ap} + 2.6 \tan^2\alpha_{ap}$ $k_7 = 2.1 \tan\alpha_{ap} - 4 \tan^2\alpha_{ap}$ $k_p = 0.2 \tan\alpha_{ap} + k_6 (h_{ap}/r) + k_7 (h_{ap}/r)^2$
Greatest tensile stress [6] perpendicular-to-grain at the apex due to bending moment	$\sigma_{r,t,90} = k_p * (6 * M_{r,ap}) / (b * h_{ap}^2)$ [N/mm^2]
Spacing of fasteners [7]	**250 mm** $\leq a_1 \leq 0.75 * h_{ap}$
Tensile design force [7] to be transmitted by the reinforcing ASSY® VG screws	$F_{t,r} = \sigma_{r,t,90} * b * a_1$
boundary conditions for screw design with-drawal resistance [12]	effective screw length: $l_{eff} = \min\{l_{eff,1}; l_{eff,2}\}$ minimum penetration depth: $p_{min} = 4 * D$ (outside thread diameter) $\leq l_{eff}$ (smaller penetration can not be taken into account for beam reinforcement)
Withdrawal resistance of one SWG ASSY® VG screw (refer to table 1)	$P'_{rw,\alpha}$ = min { **withdrawal resistance** [kN/20 mm] * l_{eff} ; **tensile resistance** }
Required number of reinforcing screws [1]	$n_{screws} = \sqrt[0.9]{(F_{t,r} / P'_{rw,\alpha})}$

Note: [1] considering an effective number of screws $n_{eff} = n^{0.9}$ as per [13]
A minimum of 2 reinforcing screws evenly distributed in the highly stressed apex zone shall be applied.
Required spacing, end and edge distances as per *table 6* to be followed.

Perpendicular-to-grain splitting reinforcement in bolted connections

Bolted connections with multiple bolts per row may fail brittle due to splitting. Design codes reduce the effective number of bolts by at least 2/3 to reduce brittle failure through splitting.

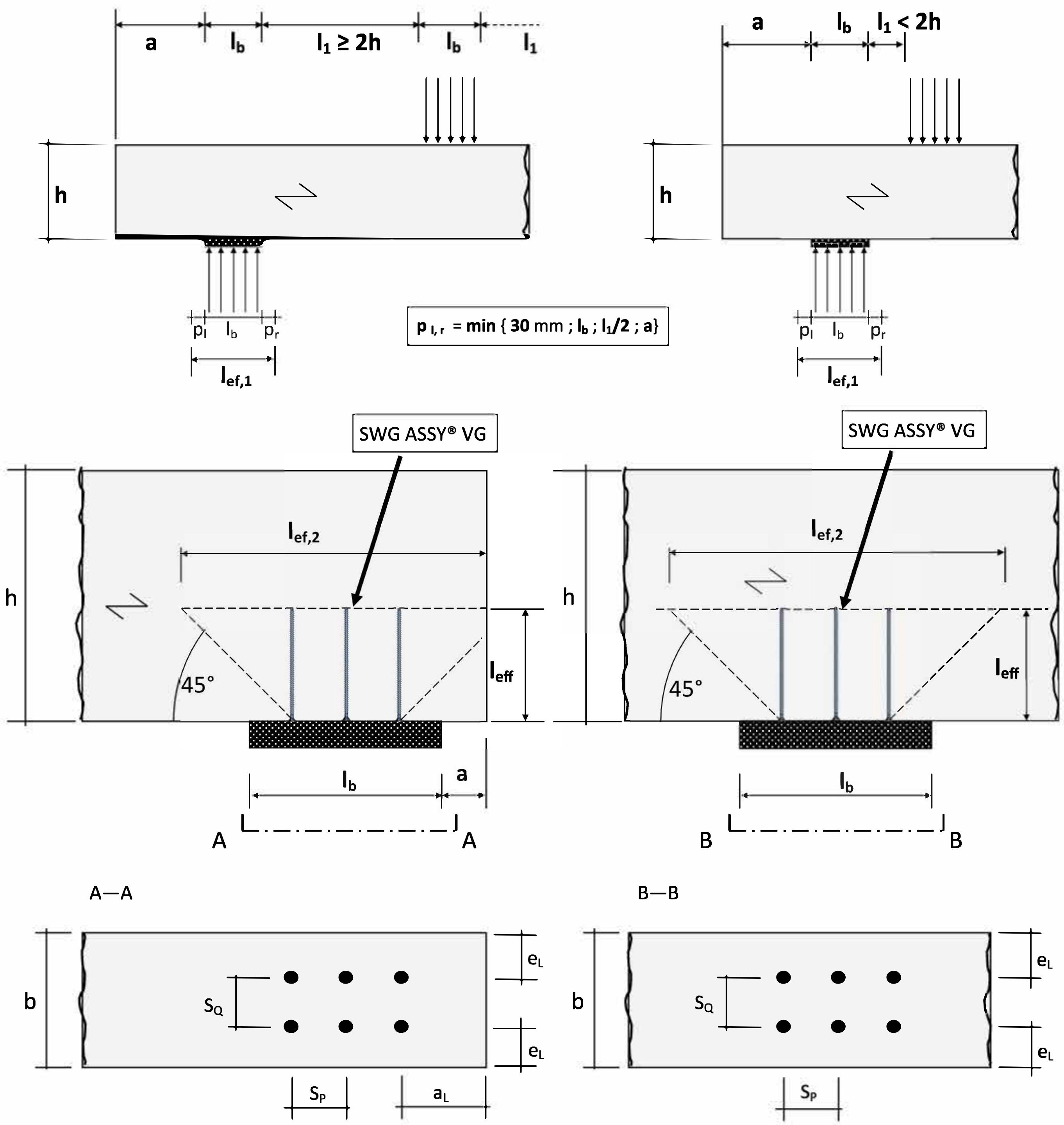
Splitting perpendicular to grain can efficiently be reinforced using self-tapping full thread SWG ASSY® VG screws driven in perpendicular to the bolt axis.
The reinforcing screws with full thread shall be inserted behind the bolt (compression side) as close as possible. The reinforced connection allows to assume all bolts as active and higher connection capacities are achieved.

DESIGN REINFORCEMENT IN BOLTED CONNECTIONS	
Conditions of use	Bolted connection loaded parallel to grain with reinforcement
Geometry	**b** = beam width **d** = beam depth $\mathbf{S_Q}$ = spacing between bolts perpendicular to grain $\mathbf{e_L}$ = minimum bolt edge distance 
Effective thread length	$\mathbf{l_{eff,1}}$ = threaded length below lower potential crack $\mathbf{l_{eff,2}}$ = threaded length above upper potential crack less 1*D (=outer thread diameter) for the tip length
Connection parameters	$\mathbf{P_r}$ = factored shear resistance of one bolt $\mathbf{n_{sp}}$ = number of shear planes per bolt
Tensile design force [8] perpendicular-to-grain to be transmitted by the reinforcing ASSY® VG screws	$\mathbf{F_{r,t,90} = n_{sp} * 0.3 * P_r}$
boundary conditions for screw design withdrawal resistance [12]	<u>effective screw length</u>: $\mathbf{l_{eff} = \min\{l_{eff,1} ; l_{eff,2}\}}$ <u>minimum penetration depth:</u> $\mathbf{p_{min} = 4 * D}$ (outside thread diameter) $\leq \mathbf{l_{eff}}$ (smaller penetration can not be taken into account for beam reinforcement)
Withdrawal resistance of one SWG ASSY® VG screw (refer to table 1)	$P'_{rw,\alpha} = \min \begin{cases} \textbf{withdrawal resistance } [kN/20\ mm] * l_{eff} \\ \textbf{tensile resistance} \end{cases}$
Required number of reinforcing screws [1]	$\mathbf{n_{screws} = {}^{0.9}\sqrt{(F_{r,t,90} / P'_{rw,\alpha})}}$

<u>*Note:*</u> [1] considering an effective number of screws $n_{eff} = n^{0.9}$ as per [13]
Reinforcing screws **arranged adjacent to bolts**.
Required spacing, end and edge distances as per *table 6* to be followed.

Compression reinforcement perpendicular to grain

When bearing loads exceed the compression strength of wood perpendicular to grain compression reinforcement may be applied using full thread SWG ASSY® VG screws. The screws are to be driven into the timber member perpendicular to grain top flush with the timber surface and with contact to the bearing plate to distribute the bearing force evenly.



DESIGN COMPRESSION REINFORCEMENT PERPENDICULAR TO GRAIN	
Conditions of use	End or intermediate beam on discrete support
Geometry	**b** = beam width **h** = beam depth **a** = distance from compressed area to beam end $\mathbf{l_b}$ = bearing length of support $\mathbf{l_{eff}}$ = threaded length less one outer thread diameter for the tip length $\mathbf{l_1}$ = length between supports or incoming concentrated load $\mathbf{n_0}$ = number of reinforcing screws arranged in a row parallel to grain $\mathbf{S_p}$ = spacing of reinforcing screws in a plane parallel to grain $\mathbf{a_L}$ = end distance of centre of gravity of threaded part in timber member $\mathbf{e_L}$ = edge distance of centre of gravity of threaded part in timber member
Strength in compression perpendicular to grain [1]	$\mathbf{F_{cp}} = \phi * f_{cp} * (K_D K_{Scp} K_T K_B K_{Zcp})$
Factored compressive resistance perpendicular to grain [1]	$\mathbf{Q_r}$
Compressive design force	$\mathbf{Q_f}$
CONDITION	**IF** $Q_f \geq Q_r$ **REINFORCEMENT IS REQUIRED**
Effective length of distribution $l_{ef,1}$ [9]	Effective bearing length (left, right): $\mathbf{p}_{l,r}$ = **min** { **30** mm ; $\mathbf{l_b}$; $\mathbf{l_1/2}$; **a**} $\mathbf{l_{ef,1}} = \mathbf{l_b + p_l + p_r}$
Compressive reduction factor for discrete supports [9]	$\mathbf{l_1 < 2h}$: $k_{c,90} = 1.00$ $\mathbf{l_1 \geq 2h}$: $k_{c,90} = 1.75$ (glulam with $l_b \leq 400$ mm) $k_{c,90} = 1.50$ (softwood solid sawn) $k_{c,90} = 1.00$ (hardwood)
Design resistance [10] perpendicular-to-grain of a contact area	$\mathbf{R_{cb,90,d}} = k_{c,90} * b * l_{ef,1} * F_{cp}$
boundary conditions for screw design compression resistance [12]	Effective thread penetration length: $\mathbf{l_{eff}}$ minimum penetration depth: $\mathbf{p_{min} = 4 * D}$ (outside thread diameter) (smaller penetration can not be taken into account for beam reinforcement)
Compression resistance of one SWG ASSY® VG screw (refer to table 1 and 4)	$\mathbf{P'_{rw,\alpha}}$ = min { **withdrawal resistance** [kN/20 mm] * $\mathbf{l_{eff}}$ *(refer to table 1)* **tensile resistance** *(refer to table 1)* **buckling resistance of the screw** *(refer to table 4)* }
Required number [1] of reinforcing screws [10]	$\mathbf{n_{screws}} = \sqrt[0.9]{[Q_f - R_{cb,90,d}] / P'_{rw,\alpha}}$
Effective contact length in the plane of the screw tips $l_{ef,2}$ [10]	End supports: $\mathbf{l_{ef,2}} = \{l_{eff} + (n_0 - 1) * S_p + \min(l_{eff} ; a_L)\}$ intermediate supports: $\mathbf{l_{ef,2}} = \{2 * l_{eff} + (n_0 - 1) * S_p\}$
***CONDITION** [10]*	$\mathbf{R_{c,tip,90,d}} = b * l_{ef,2} * F_{cp} \geq \mathbf{Q_f}$ **—>** otherwise screw length or number to be adjusted

Note: [1] considering an effective number of screws $n_{eff} = n^{0.9}$ as per [13]
Required spacing, end and edge distances as per *table 6* to be followed

Design tables for SWG ASSY® VG screws

Table 1: Factored withdrawal resistance of SWG ASSY® VG screws in kN per 20 mm of thread penetration

Factored withdrawal resistance * $P'_{rw,\alpha}$ per 20 mm of thread penetration in kN (only applicable to SWG ASSY® VG screws)							
Screw diameter in mm	Mean oven dry relative density						Factored tensile resistance in kN
	0.35	0.42	0.44	0.46	0.49	0.50 (PSL)	
	*α ** = 90°*						
6	0.63	0.91	0.97	1.06	1.20	0.70	**9.04**
8	0.85	1.22	1.29	1.41	1.60	0.94	**15.12**
10	1.06	1.52	1.61	1.76	2.00	1.17	**19.2**
12	1.27	1.83	1.94	2.12	2.40	1.41	**24**
	*α ** = 45°*						
6	0.54	0.78	0.83	0.91	1.03	0.60	**9.04**
8	0.73	1.04	1.11	1.21	1.37	0.80	**15.12**
10	0.91	1.31	1.38	1.51	1.71	1.00	**19.2**
12	1.09	1.57	1.66	1.81	2.06	1.21	**24**

Note: * resistance as per [12]
** α: angle between wood grain and screw axis

Table 2: values of k_α for standard beam sizes and connections

Values for k_α with respect to the ratio h_e /h										
h_e /h	**0._0**	**0._1**	**0._2**	**0._3**	**0._4**	**0._5**	**0._6**	**0._7**	**0._8**	**0._9**
0.5_	0.650	0.631	0.611	0.592	0.572	0.553	0.534	0.514	0.495	0.476
0.6_	0.458	0.439	0.420	0.402	0.384	0.366	0.349	0.331	0.314	0.297
0.7_	0.281	0.265	0.249	0.233	0.218	0.203	0.189	0.175	0.161	0.148
0.8_	0.135	0.123	0.111	0.100	0.089	0.079	0.069	0.060	0.052	0.044
0.9_	0.036	0.030	0.024	0.018	0.013	0.009	0.006	0.003	0.002	0.000

Table 3: values of k_{tp} for standard beam sizes and connections

Values for k_{tp} with respect to the ratio a /h										
a /h	**0._0**	**0._1**	**0._2**	**0._3**	**0._4**	**0._5**	**0._6**	**0._7**	**0._8**	**0._9**
0.5_	0.500	0.485	0.470	0.455	0.440	0.425	0.410	0.396	0.381	0.366
0.6_	0.352	0.338	0.323	0.309	0.295	0.282	0.268	0.255	0.242	0.229
0.7_	0.216	0.204	0.191	0.179	0.168	0.156	0.145	0.134	0.124	0.114
0.8_	0.104	0.095	0.086	0.077	0.069	0.061	0.053	0.046	0.040	0.034
0.9_	0.028	0.023	0.018	0.014	0.010	0.007	0.005	0.003	0.001	0.000

Design assumptions for SWG ASSY® VG screws as reinforcement

*Table 4: buckling resistance * of one screw considering an angle between screw axis to wood grain of α = 90°*

Contact MTC Solutions for the buckling resistance of ASSY Screws. Support@MTCSolutions.com

Table 5: timber densities

Timber densities		
Visually graded lumber	**Glue-laminated timber**	**Mean oven dry relative density**
Northern Species		**0.35**
Spruce-Pine-Fir		**0.42**
	Spruce-Pine-Fir	**0.44**
Hem-Fir	Hem-Fir	**0.46**
Douglas-Fir-Larch D-Fir-L	Douglas-Fir-Larch D-Fir-L	**0.49**
PSL, LVL, LSL	PSL, LVL, LSL	**0.5**

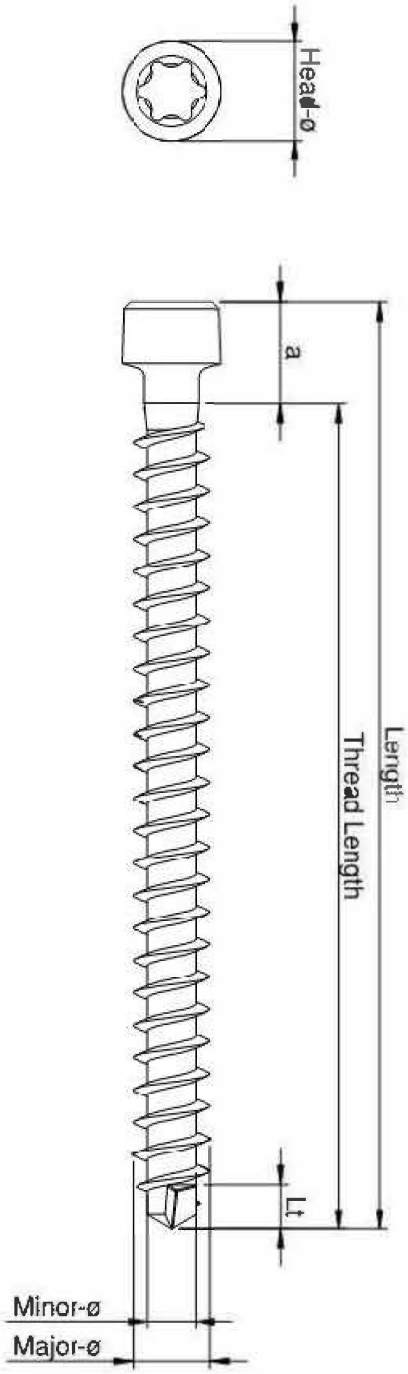
Table 6: Minimum spacing or distance for SWG ASSY® VG screws

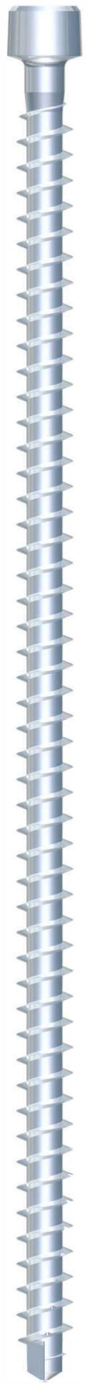
SWG ASSY® VG screws loaded axially	
Minimum spacing or distance *[12]*	(D = outside thread diameter)
S_P **Spacing parallel to grain**	5D (7.5D in D-Fir-L)
S_Q **Spacing perpendicular to grain**	2.5D
a_L **end distance**	5D (7.5D in D-Fir-L)
e_L **edge distance**	3D

SWG ASSY® VG Cyl. (full thread)

Table 7: SWG ASSY® VG Cyl screw specifications

Major ø	Length	Thread Length	L_t	Head ø	Minor ø	Bit
mm						
6	70	63	6	8	3.8	AW 30
	80	73				
	100	93				
	120	113				
	140	133				
	160	153				
	180	173				
	200	193				
8	160 to 300 in 20 mm increments	144 to 284 in 20 mm increments	8	10	5	AW 40
	330	314				
	360	344				
	380	364				
	430	414				
	480	464				
	530	514				
	580	564				
10	140 to 280 in 20 mm increments	125 to 265 in 20 mm increments	10	13.4	6.2	AW 50
	300	280				
	320 to 400 in 20 mm increments	305 to 380 in 20 mm increments				
	430	415				
	480	456				
	530	506				
	580	556				
	and longer	and longer				





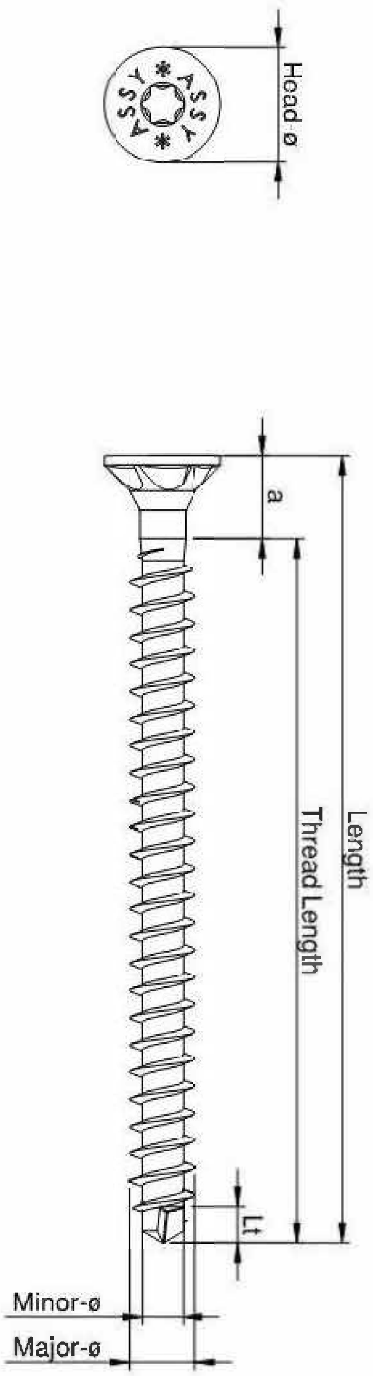
Note: values listed in the table above are average measurements between upper and lower tolerance boundary

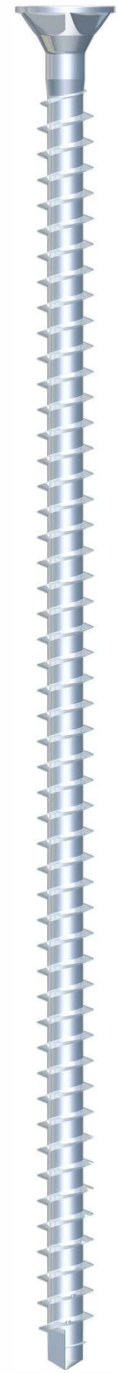
SWG ASSY® VG CSK (full thread)

Table 8: SWG ASSY® VG CSK screw specifications

Major ø	Length	Thread Length	L_t	Head ø	Minor ø	Bit
mm						
8	**120**	103	8	14.8	5	AW 40
	140	123				
	160	143				
	180	163				
	200	183				
	220	203				
	240	223				
	260	243				
	280	263				
	300	283				
10	**140 to 400 in 20 mm increments**	125 to 385 in 20 mm increments	10	19.6	6.2	AW 50
	430	415				
	480	465				
	530	512				
	580	562				
	650 to 800 in 50 mm increments	632 to 782 in 50 mm increments				
12	**220**	205	12	22.1	7.1	AW 50
	380	365				
	480	465				
	600	585				

Note: values listed in the table above are average measurements between upper and lov tolerance boundary





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