Requested by
VMG Technics, UAB
Zita Andriušienė
Liepu street 68
LT-92100 Klaipeda, Lithuania
zita.andriusiene@vmg.eu

Order ref.
Mantas Leknius, order 5.6.2025 related to offer V8JNPT250027-02

Contact person
Eurofins Expert Services Oy
Ari Kevarinmäki
Tekniikantie 15A, Espoo
P.O. Box 47, FI-02151 Espoo, Finland
Ari.Kevarinmaki@cpt.eurofinseu.com

Task

Initial testing of VMG Technics Angle Brackets

In this report, the mechanical properties of VMG Technics Angle Bracket connections are verified using calculations according to Eurocodes 3 and 5. The initial testing by calculations is performed according to the requirements descripted in EAD 130186-00-0603 “Three Dimensional Nailing Plates”. The geometry and dimensions of two (2) Angle Bracket connectors are ensured from sample connectors and material certificates delivered to Eurofins Expert Services Oy (Eurofins) by the client. The design rules of the Angle Bracket connections are derived in this research report.

Scope

The analysis is limited to relate connections where the force act on the plane of flange A of the connector in the middle of flange and the connector is fixed by anchor nails or screws to sawn timber, glued laminated timber (glulam), LVL (Laminated Veneer Lumber) or to CLT (Cross laminated Timber). For non-symmetric connectors, flange A means the bigger flange, when B is the smaller flange (for unclear cases see Appendix 1). This analysis does not relate the fixing of the connector to the end grain of timber member or to the edgeface of LVL.

The flange B of the Angle Bracket may be connected also to other applicable rigid material such as concrete or steel (support side material). In this case, the Angle Bracket shall be fixed with CE-marked bolts, threaded bars, anchor bolts or concrete screws with diameter 8 or 10 mm through the 8,5 or 11 mm holes to the rigid material. The concrete screws shall have been ETA assessed in accordance with EAD 330232-00-0601 or EAD 330499-01-0601.

Steel material

According to the clarification of the client, the VMG Technics Angle Brackets are manufactured from pre-galvanised steel plate of grade DX51D+Z275 according to the standard EN 10346:2015 with minimum yield strength R_{eL} or R_{p02} of 250 N/mm^2 and minimum tensile strength R_m of 330 N/mm^2 with tolerances according to EN 10143:2006. The connectors may be manufactured also from pre-galvanised steel strips of the grade S250GD+Z275 according to EN 10346.

The client delivered material certificates for steel thicknesses of 2,0 mm and 2,5 mm from steel grades DX51D+Z275. The required yield and tensile strengths are confirmed from material certificates for both steel thicknesses. The comparison of the mechanical properties presented in the manufacture’s inspection certificates with the requirements of corresponding steel grade S250GD+Z275 (EN 10346) are presented in Table 1. The tested values presented in the material certificates fulfil the strength and elongation requirements of the corresponding steel grade S250GD+Z275 (EN 10346). The material certificates are presented in Appendix 2.

The yield strength of grade S250GD, R_{eH} or R_{p02}, is at least 250 N/mm^2, the tension strength, R_m, at least 330 N/mm^2 and the elongation A_{80} is at least 19 %. These values are used in calculations of VMG Technics Angle Bracket connectors. The material thicknesses with allowed tolerances (EN 10143) are 2,00 ± 0,15 mm and 2,50 ± 0,17 mm.

Table 1. Tested steel properties DX51D+Z275 and the requirements given in standard EN 10346:2015.

Manufacture's inspection certificates Steel grade DX51D+Z275		R_{p02} / R_{eH} N/mm^2	R_m N/mm^2	A_{80mm} %	zinc g/m^2
	thickness = 2,0 mm	295	387	33	
	thickness = 2,5 mm	311,0	382,1	31,8	
Requirements for minimum values					
	Steel grade DX51D+Z275	-	270	22	275*
	Steel grade S250GD+Z275	250	330	19	275*

* for mean value

Angle Brackets

The article numbers and nominal dimensions of the Angle Brackets are presented in Table 2. The geometry and dimensions of the Angle Brackets are presented in Appendix 1. The tolerance of the length of the flange is ± 2,0 mm. For the other main dimensions of the connectors, the tolerance is ± 1,0 mm. The tolerance of the diameter of fastener holes is ± 0,4 mm and the tolerance for spacings and placements of holes is ± 1,0 mm.

The client delivered to Eurofins three samples from each type and size of the Angle Brackets. Eurofins checked with measurements all the connectors and stated that the samples corresponded with the drawings presented in Appendix 1 within the allowed tolerances.

Fasteners

The angle brackets are fixed by anchor nails or screws according to EN 14592 (see Figure 1). The diameter of the anchor nails d = 4,0 mm and the profiled length is at least 24 mm. The diameter of the smooth part of the anchor screws d = 4,5…5,0 mm and the inner diameter of the threaded part $d_s \geq$ 3,0 mm. The length of the threaded part of the screws shall be at least 6d. Timber parts are not pre-bored for the nails or screws that shall be perpendicular to the grain of the timber.

Figure 1. Fasteners: a) anchor nail and b) anchor screw.

Lateral load-carrying capacity of fastener

According to the Eurocode 5 /1/, the characteristic load-carrying capacity for nails and screws in single shear connections per fastener should be taken as the minimum value found from the following expressions:

- for a thin steel ($t \leq d$):

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

- for a thick steel plate ($t \geq d$):

$$F_{v,Rk} = \min \begin{cases} f_{h,k} t_1 d & \text{(a)} \\ f_{h,k} t_1 d \left[\sqrt{2 + \dfrac{4M_{y,Rk}}{f_{h,k} d\, t_1^2}} - 1 \right] + \dfrac{F_{ax,Rk}}{4} & \text{(b)} \\ 2{,}3\sqrt{M_{y,Rk} f_{h,k} d} + \dfrac{F_{ax,Rk}}{4} & \text{(c)} \end{cases} \tag{2}$$

In equations (1) and (2), the penetration length of fastener in timber $t_1 = L - t$, where L is the length of fastener and t is the thickness of steel plate, d is the nominal diameter of nail or the effective diameter of screw = 1,1d_i, when d_i is the inner diameter of threaded part of screw, $M_{y,k}$ is the characteristic yield moment of the fastener determined according to standards EN 14952 and EN 409 and $F_{ax,k}$ is the characteristic withdrawal capacity of the fastener calculated by equation (5) or (6) and limited at maximum to 1/3 with nails and to 1/2 with screws from the load-carrying capacity $F_{v,Rk}$. The characteristic embedding strength $f_{h,k}$ is calculated as follows:

$$f_{h,k} = 0{,}082 \rho_k d^{-0,3} \qquad \text{N/mm}^2 \tag{3}$$

where ρ_k is the characteristic density of timber.

For connectors of thickness 0,5d < t < d, a linear interpolation is used between equations (1) and (2):

$$F_{v,Rk} = F_{v,Rk}(1) + \frac{t - 0{,}5d}{0{,}5d}\left(F_{v,Rk}(2) - F_{v,Rk}(1)\right) \tag{4}$$

where t is the nominal steel thickness of the connector and $F_{v,Rk}$(1) is the load-carrying capacity according to equation (1) and $F_{v,Rk}$(2) is the capacity according to equation (2).

According to tests results published by Ehlbeck and Görlacher /2/ the equation (2) may be used also for thinner steel plates provided, that the thickness of steel plate is at least 2 mm and the anchor nail of diameter 4,0 mm has a cone head with minimum conical part length of 4 mm and the minimum cone diameter of 5,2 mm at the head of nail (see also the STEP lecture C13 presented by Gehri in /3/).

Axial withdrawal capacity of the fastener

According to Eurocode 5 /1/ the axial withdrawal capacity of an anchor nail is calculated from expression:

$$F_{ax,Rk} = f_{ax,k}\, d\, t_{pen} \leq f_{tens,k} \tag{5}$$

where $f_{ax,k}$ is the withdrawal parameter determined according to standards EN 14592 and EN 1382 for the actual timber material, $f_{tens,k}$ is the experimentally determined tensile resistance of the fastener together with a steel plate and t_{pen} is the penetration depth of the profiled part of the nail in timber (> 6d). If the penetration depth for an anchor nail is less than $t_{pen} \leq 8d$ = 32 mm, the resistance according to Eq. (5) is reduced by (t_{pen}/8mm – 3).

According to Eurocode 5 /1/ the axial withdrawal capacity of a group of anchor screws is calculated from expression:

$$F_{ax,Rk} = n^{-0,1} f_{ax,k} d\, l_{ef} \left(\frac{\rho_k}{\rho_a}\right)^{0,8} \leq n^{-0,1} f_{tens,k} \tag{6}$$

where n is the number of screws in tension in the connection, d is the outer diameter of the screw, l_{ef} on the length of the threaded part of the screw, $f_{ax,k}$ is the withdrawal parameter determined according to standards EN 14592 and EN 1382 perpendicular to the grain with timber density of ρ_a, ρ_k is the characteristic density of the timber in the actual connection and $f_{tens,k}$ is the tension capacity of the screw determined according to EN 14592.

Combined laterally and axially loaded fasteners

When an anchor nail or screw is subjected to a combination of axial load $F_{a,d}$ and lateral load $F_{v,d}$, the following design criteria of Eurocode 5 /1/ should be satisfied:

$$\left(\frac{F_{a,d}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{v,d}}{F_{v,Rd}}\right)^2 \leq 1 \tag{7}$$

where $F_{ax,Rd}$ is the axial design capacity of the fastener and $F_{v,Rd}$ is the design value for the lateral load-carrying capacity of the fastener.

Shear capacity of Angle Bracket connection

In this report, the shear capacity of Angle Bracket connection means connection resistance against a force acting parallel to the direction of the bent edge of the Angle Bracket. Respectively, in this report the tension and compression capacity mean the connection resistance against force acting perpendicular to the flange B of the connector.

In following, the distribution of fastener forces are analysed in flange B when the shear force of the connector F_x acting at the bent edge of the Angle Bracket (see Figure 2). Then the eccentricity moment for the fastener group of flange B: $M = F_x e$, where e is the distance from the bent edge to the centroid of the fastener group.

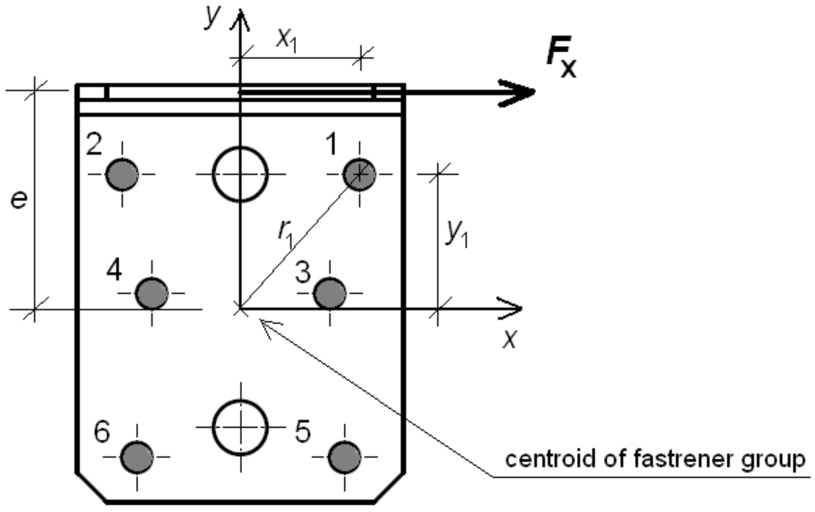


Figure 2. Symbols used in analysis of shear force loaded flange B; in this example number of fasteners n_B = 6.

When the yield capacity of fasteners is taken into account, the fasteners forces of flange B may be solved from the equations (8) - (10):

- for fastener *i*, the shear force component parallel to the connection force F_x

$$q_{ix} = \frac{F_x}{n_B} + \frac{M}{\sum r_i} \cdot \frac{y_i}{r_i} \tag{8}$$

- for fastener *i*, the shear force component perpendicular to the connection force F_x

$$q_{iy} = \frac{M}{\sum r_i} \cdot \frac{x_i}{r_i} \tag{9}$$

- and the resultant force for fastener *i*

$$q_i = \sqrt{q_{ix}^2 + q_{iy}^2} \tag{10}$$

where n_B is the number of fasteners in flange B, r_i is the distance of fastener *i* from the centroid of the fastener group, x_i is the distance of fastener *i* from the centroid of the fastener group parallel to the width direction of the connector and y_i is the distance of fastener *i* from the centroid of the fastener group parallel to the length direction of the connector (see Figure 2).

By substitution of equations (8) and (9) and $M = F_x e$ to the equation (10), it may be derived the following solution for the resultant force q_i

$$q_i = F_x \cdot \sqrt{\frac{1}{n_B^2} + \frac{e}{\sum r_i \cdot r_i} \cdot \left(\frac{2y_i}{n_B} + \frac{e \cdot y_i^2}{\sum r_i \cdot r_i} + \frac{e \cdot x_i^2}{\sum r_i \cdot r_i} \right)} \tag{11}$$

The dependence between the shear force of the connector and fastener force may be presented as follows

$$F_x = k_i \, q_i \tag{12}$$

where $$k_i = \frac{1}{\sqrt{\frac{1}{n_B^2} + \frac{e}{\sum r_i \cdot r_i} \cdot \left(\frac{2y_i}{n_B} + \frac{e \cdot y_i^2}{\sum r_i \cdot r_i} + \frac{e \cdot x_i^2}{\sum r_i \cdot r_i} \right)}} \quad (13)$$

The shear force capacity of the fastener group is reached, when the fastener force of the most loaded fastener corresponds the lateral load-carrying capacity of the fastener:

$$\max(q_1, q_2, \ldots, q_{nB}) = q_m = F_{v,Rk} \quad (14)$$

Then by substitution to the equation (12) the characteristic shear force capacity for the fasteners of flange B may be solved from

$$R_{B,x,k} = k_m F_{v,Rk} \quad (15)$$

where $k_m = \min(k_1, k_2, \ldots, k_{nB})$ (16)

when the value of factor k_i is calculated for each fastener by equation (13).

The values of k_m factors calculated by equations (13) and (16) are presented in Table 2, when the fasteners are placed in the flange B to all holes of 5 mm diameter.

Table 2. Article numbers of the VMG Technics Angle Bracket connectors, nominal dimensions, number of fasteners in flange B, eccentricity of fastener group e, the sum of moment arms of the fastener group Σr_i and values for factor k_m.

Art. No.	Size (mm)	Grade	n_B	e (mm)	Σr_i (mm)	k_m
VMGT-7055AB	70x70x55x2,0	DX51D	6	35,8	150,9	2,612
VMGT-9065RAB	90x90x65x2,5	DX51D	10	47,6	295,2	3,970

Tension capacity of Angle Bracket connection

In following the load-carrying capacity of an Angle Bracket connection is analysed, when the connection force $F_{z,t}$ is tension and acting perpendicular the plane of flange B. Then the tension capacity of the connection is as minimum from the lateral load-carrying capacity of fasteners of flange A or from the combination of bending capacity and fasteners axial withdrawal capacity at the flange B.

<u>Unreinforced Angle Brackets</u>

In following, the tension capacity of flange B is analysed for connectors where the bent edge has not been reinforced by any additional folds. In tension, the unreinforced Angle Bracket yields first from the bent edge and otherwise the connector may be assumed to be almost rigid. A situation corresponding this assumption is presented in Figure 3.

In the situation of Figure 3 the equilibrium of forces may be presented as

$$F_{z,t} = F_{n,1} + F_{n,2} - F_c \quad (17)$$

where $F_{n,1}$ is the withdrawal capacity of fasteners in row 1,
$F_{n,2}$ is the withdrawal capacity of fasteners in row 2 and
F_c is contact force between timber member and the flange B of connector.

The bending moments acting on the bent edge may be solved from the forces acting on the flange B as follows

$$M_0 = F_{n,1} d_1 + F_{n,2} d_2 - F_c(L_B - c/3) \tag{18}$$

where the distances d_1, d_2, L_B and c are according to Figure 3.

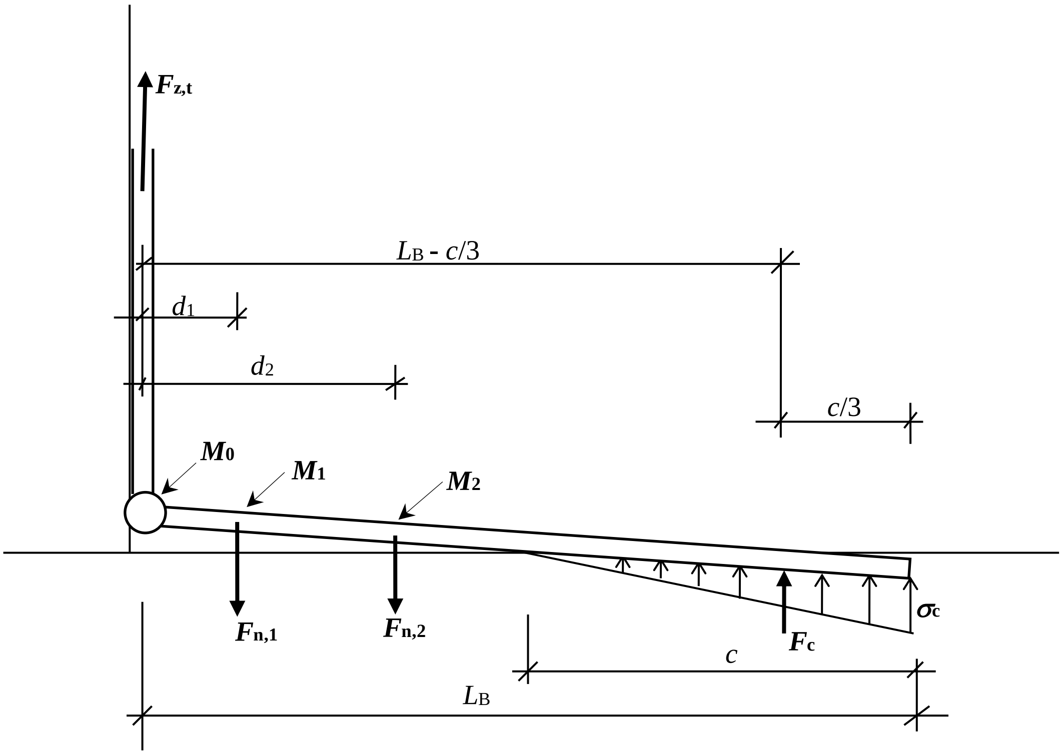


Figure 3. Behaviour of a tension loaded flange of Angle Bracket when the connector yields at the place of the bent edge and two of first fastener rows are tensioned.

The contact between the flange B and the timber member can start after the tension loaded fasteners. Then the length of compression area $c < L_B - d_2$. By substation $c = L_B - d_2$ to the equation (18) it may be solved the theoretical maximum value for the contact force:

$$F_c = 3 \cdot \frac{F_{n,1} \cdot d_1 + F_{n,2} \cdot d_2 - M_0}{2L_B + d_2} \tag{19}$$

The characteristic value for the fully plastic yield moment capacity of the bent edge may be calculated from

$$M_0 = \frac{B \cdot t_d^{\ 2}}{4} \cdot f_y \tag{20}$$

where B is the width of the Angle Bracket, t_d is the design thickness for the steel plate and f_y is the yield strength of the steel plate. For the VMG Technics Angle Brackets, the following values are used: f_y = 250 N/mm^2 and t_d = 1,81 mm for nominal thickness of 2,0 mm and t_d = 2,29 mm for nominal thickness of 2,5 mm.

When the expression (20) is substituted to the equation (19) and furthermore to equation (17), the solution for the tension capacity may be derived to form

$$R_{\mathrm{B,z,t,k}} = F_{\mathrm{n,1}} + F_{\mathrm{n,2}} - 3 \cdot \frac{F_{\mathrm{n,1}} \cdot d_1 + F_{\mathrm{n,2}} \cdot d_2 - \frac{B \cdot t_{\mathrm{d}}^{2}}{4} \cdot f_{\mathrm{y}}}{2L_{\mathrm{B}} + d_2} \tag{21}$$

where the withdrawal capacities $F_{n,1} = n_1 F_{ax,Rk}$ and $F_{n,2} = n_2 F_{ax,Rk}$, when n_1 is the number of fasteners in the nearest row from the bent edge, n_2 respectively the number of fasteners in the following row and $F_{ax,Rk}$ is the withdrawal capacity of a single fastener (see equations 5 and 6).

The capacity calculated by equation (21) is valid, when the flange B yields from the bent edge and the plastic yield moment is not reached in any other place of the connector. In addition of the calculation of the tension capacity according to the equation (21), also the situations where another yield point is reached or no yielding is occurring shall be checked.

The possible other yield point placements are the locations of fasteners rows 1 and 2, where the flange is weakened by the holes. The bending moment acting at the location of the first fastener row may be calculated from expression

$$M_1 = F_{z,t}\, d_1 - M_0 \tag{22}$$

when M_0 is the bending moment acting on the bent edge and $F_{z,t}$ and d_1 are corresponding the notations presented in Figure 3.

At the location of the first fastener row, the fully plastic moment capacity

$$M_{1,p} = \frac{B_{\mathrm{net,1}} \cdot t_d^{2}}{4} \cdot f_{\mathrm{y}} \tag{23}$$

where $B_{net,1}$ is the net width of the flange decreased by the holes at the location of the first fastener row.

When the flange yields both at the bent edge and at the location of the first fastener row, the tension capacity of the Angle Bracket may be solved from equation (22) with the substitutions of the moment capacities according to expressions (20) and (23):

$$R_{\mathrm{B,z,t,k}} = \frac{M_0 + M_{1,\mathrm{p}}}{d_1} = \frac{t_{\mathrm{d}}^{2} f_{\mathrm{y}}}{4d_1}\left(B + B_{\mathrm{net,1}}\right) \tag{24}$$

When the fasteners of the first row are in tension, the bending moment acting at the location of the second fastener row may be calculated from the expression

$$M_2 = F_{z,t}\, d_2 - M_0 - F_{n,1}(d_2 - d_1) \tag{25}$$

where the symbols are according to the Figure 3.

At the location of the second fastener row, the fully plastic moment capacity

$$M_{2,\mathrm{p}} = \frac{B_{\mathrm{net,2}} \cdot t_{\mathrm{d}}^{2}}{4} \cdot f_{\mathrm{y}} \tag{26}$$

where $B_{net,2}$ is the net width of the flange decreased by the holes at the location of the second fastener row.

When the flange yields both from the bent edge and from the location of the second fastener row, the tension capacity of the Angle Bracket may be solved from equation (25) with the substitutions of the moment capacities according to expressions (20) and (26):

$$R_{B,z,t,k} = \frac{M_0 + M_{2,p} + F_{n,1}(d_2 - d_1)}{d_2} = \frac{t_d^{\,2} f_y}{4d_2}\left(B + B_{net,2}\right) + \frac{F_{n,1}(d_2 - d_1)}{d_2} \tag{27}$$

where the withdrawal capacity of the first fastener row $F_{n,1} = n_1 F_{ax,Rk}$.

If more than two fastener rows should be tension loaded before the yielding of the bent edge is possible, the solution according to equation (21) is not valid. If the situation is not analysed more exactly, this possibility may be taken into account by limiting the tension capacity of the Angle Bracket to at maximum to correspond the withdrawal capacity of the fastener rows 1 and 2:

$$R_{B,z,t,k} = F_{n,1} + F_{n,2} \tag{28}$$

The tension capacity of the Angle Bracket is then as the minimum of the expressions (21), (24), (27) and (28). If all the fasteners of flange B are only in two rows, it is possible that the distance between the second row and the end of the flange is so small, that the compression strength of timber is reached in the situation presented in Figure 3. Then the compression stress of timber shall fulfil the following condition:

$$\sigma_c = \frac{2(F_{n,1} + F_{n,2} - F_{z,t})}{B(L_B - d_2)} \le k_{c,90} f_{c,90,k} \tag{29}$$

where $k_{c,90}$ is the increasing factor of compression strength perpendicular to the grain, for local compression value $k_{c,90}$ = 3,0 may be used (see eq. 40);
$f_{c,90,k}$ is the compression strength of timber perpendicular to the grain.

If this condition is not valid or it is not checked, values $F_{n,2} = 0$ and $d_2 = d_1$ are substituted to the equation (21) and equation (27) is not needed to check (it is assumed that in the bending of the flange only the fasteners of the first row are loaded by tension).

In Appendix 3 calculated tension capacities of the unreinforced Angle Brackets are presented for anchor nails 4x50, when the withdrawal parameter of nail $f_{ax,k}$ = 6,0 N/mm^2 and the length of profiled part of nail is 34 mm.

Reinforced Angle Brackets

For the angle brackets reinforced by a fold from the bent edge, the most critical bending moment of the flange B appears at location of the end of the reinforcing fold. When the flange is rigid on the area of the reinforcing fold, all fasteners of this area are tension loaded. After the end of the reinforcing fold, the flange acts like the flange of an unreinforced Angle Bracket.

In the situation of Figure 4, the Angle Brackets yields in the end point of the reinforcing fold and the first fastener row after the reinforcing fold is also tension loaded.

From the force equilibrium of the Figure 4, the following expression may be presented

$$F_{z,t} = \Sigma F_{a,i} + F_{n,1} - F_c \tag{30}$$

where $\Sigma F_{a,i}$ is the sum of the axial withdrawal capacities of fasteners located on the reinforced area,
$F_{n,1}$ is the axial withdrawal capacity of fasteners located at the first row after the end of reinforcing fold and
F_c is the resultant force of the compression stresses of timber affecting on the end of the flange.

The following expression may be presented to the moment affecting in the point of the end of the reinforcing fold

$$M_0 = F_{n,1}d_1 - F_c(L_B - a - c/3) \quad (31)$$

where the dimensions and distances d_1, L_B, a and c are according to Figure 4.

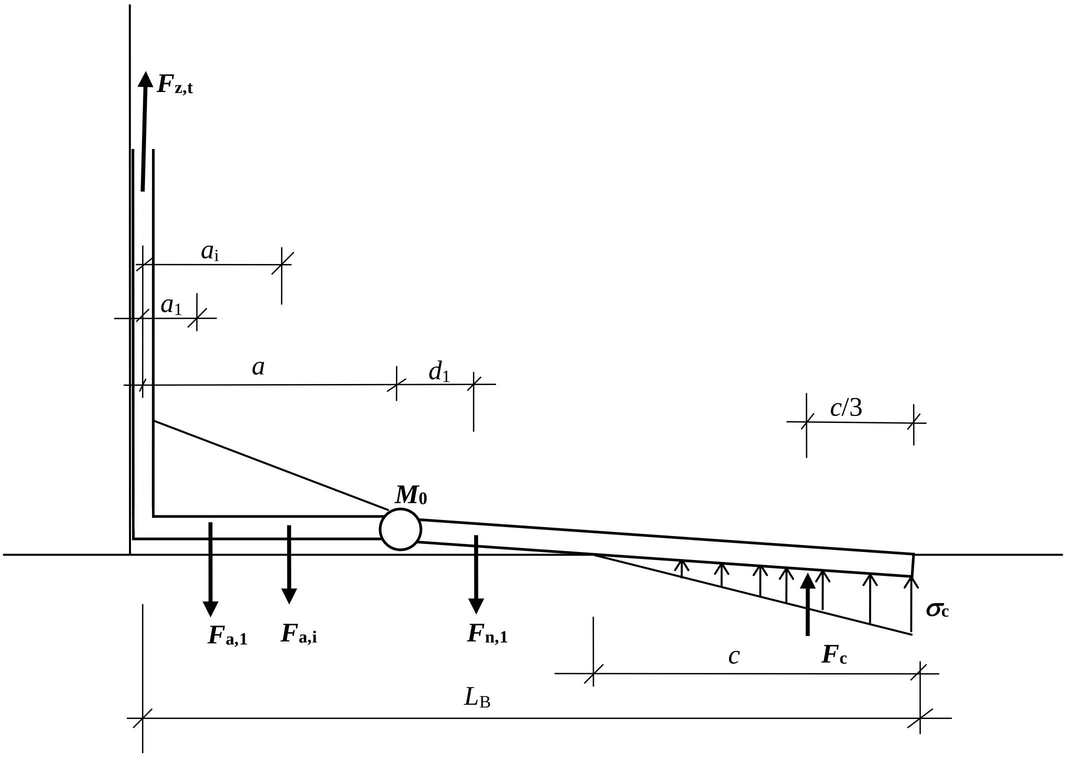


Figure 4. Behaviour of a reinforced flange of tension loaded Angle Bracket when the connector yields at the point of the end of reinforcing fold and after that one row of fastener is loaded by tension.

In the situation of Figure 4, the compression contact between the flange B and the timber member can start only after the tension loaded fasteners. The length of the compressed area $c < L_B - a - d_1$. By substitution of $c = L_B - a - d_1$ to the equation (31), the solution for the upper limit of the contact force may be presented as

$$F_c = 3 \cdot \frac{F_{n,1} \cdot d_1 - M_0}{2L_B - 2a + d_1} \quad (32)$$

By the substitution of yield moment capacity according to equation (20) to the expression (30), the tension capacity of the Angle Bracket may be presented as

$$R_{B,z,t,k} = \sum F_{a,i} + F_{n,1} - 3 \cdot \frac{F_{n,1} \cdot d_1 - \frac{B \cdot t_d^{\,2}}{4} \cdot f_y}{2L_B - 2a + d_1} \quad (33)$$

where the axial withdrawal capacities of fasteners $\Sigma F_{a,i} = n_a F_{ax,Rk}$ and $F_{n,1} = n_1 F_{ax,Rk}$, when n_a is the number of fasteners at the reinforced area of the flange and n_1 is the number of the fasters in the first row after the end of the reinforced area and $F_{ax,Rk}$ is the axial withdrawal capacity of the fastener (see equations 5 and 6).

The tension capacity of equation (33) is valid when the flange B yields only at the location of the end of reinforcing fold. In addition of the equation (33), it shall be checked also a situation, where also another yield point develops or where no yield point develops when only one fastener row is in tension after the end on reinforcing fold.

The possible other yield point locates at the placement of the first fastener row after the reinforcement, where the fastener holes weaken the flange. At that point the bending moment of the flange may be calculated as

$$M_1 = F_{z,t}\,(a + d_1) - M_0 - \Sigma(F_{a,i}\,(a + d_1 - a_i)) \tag{34}$$

when M_0 is the bending moment affecting at the bent edge of the flange, $F_{a,i}$ is the axial withdrawal capacity of the fastener row *i* located on the reinforced area and $F_{z,t}$, *a*, a_i and d_1 are according to the notations used in Figure 4.

When there are yielding points both in the end of the reinforcement and in the location of the first hole row after that, the tension capacity of the Angle Bracket connection may be solved from the equation (34) by substitution of the bending moments presented according to equations (20) and (22):

$$R_{B,z,t,k} = \frac{t_d^{\,2} f_y}{4(a + d_1)}\left(B + B_{net,1}\right) + \frac{\Sigma\left(F_{a,i}(a + d_1 - a_i)\right)}{a + d_1} \tag{35}$$

where $B_{net,1}$ is the net width of the flange at the point of the first hole row after reinforcement.

The solution of the equation (33) is not valid, if the tension force needed for the developing of the full plastic yield moment causes tension for more than one fastener row. If this situation is not analysed more exactly, this possibility may be taken into account by limiting the tension capacity of the Angle Bracket to at maximum to correspond the sum of withdrawal capacities of the fastener located on the reinforced area and in the first row after that:

$$R_{B,z,t,k} = \Sigma F_{a,i} + F_{n,1} \tag{36}$$

The tension capacity of the Angle Bracket is then as the minimum of the expressions (33) and combination of (35) and (36), where the combination is taken as maximum of the expressions (35) and (36). If all the fasteners of the unreinforced area of flange B are situated only in one row, it is possible that the distance between this fastener row and the end of the flange is so small, that the compression strength of timber is reached in the situation presented in Figure 4. If this situation is not analysed more exactly, this possibility may be taken into account by using value $n_1 = 0$ in the equations of the tension capacity (it is assumed that the fasteners of the unreinforced area are not taken any tension).

In Appendix 3, calculated tension capacities of the reinforced Angle Brackets are presented for anchor nails 4x50, when the withdrawal parameter of nail $f_{ax,k} = 6{,}0$ N/mm^2 and the length of profiled part of nail is 34 mm.

Compression capacity of Angle Bracket connection

In following, the load-carrying capacity of an Angle Bracket is analysed when the connection force $F_{z,c}$ is compression and acting perpendicular the plane of flange B, see Figure 5. Then the compression capacity of the connection is as minimum from the lateral load-carrying capacity of fasteners of flange A or from the combination of bending capacity of flange B and compression capacity of the timber member.

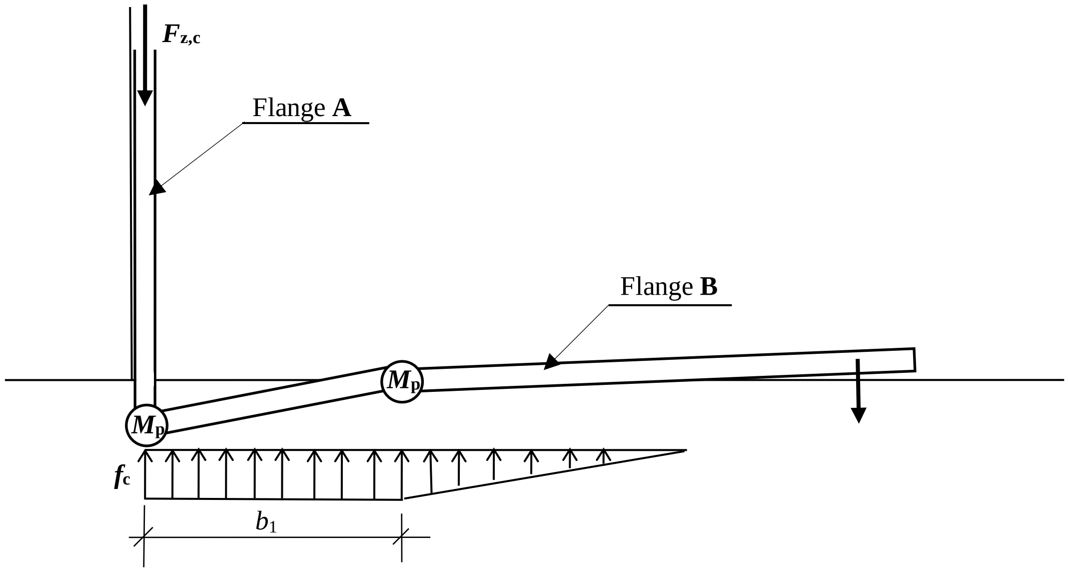


Figure 5. Behaviour of compression loaded Angle Bracket connection.

Unreinforced Angle Brackets

When the fasteners are placed to the hole row nearest by the end of the flange B, the flange acts like a slender dowel type fastener in shear connection between a thick steel plate and a timber member. Then the ultimate capacity of the connection is reached, when the flange have two plastic yielding points and the compression strength of the timber member is achieved between the yielding points as presented in Figure 5. According to the Johansen's yield theory, the solution for the connection capacity $R_{B,z,c,k} = F_{z,c}$ and for the distance between the yielding points b_1 (see e.g. STEP1 lecture C3 /3/):

$$R_{B,z,c,k} = 2\sqrt{M_p \cdot f_c \cdot B} \qquad (37)$$

$$b_1 = 2\sqrt{\frac{M_p}{f_c \cdot B}} \qquad (38)$$

where M_p is the plastic yield moment capacity of the flange, f_c is the local compression capacity of timber and B is the width of the flange.

Due to the holes of the Angle Bracket, the plastic yield moment resistance, M_p, is calculated for the net width of the flange

$$M_p = \frac{B_{net} \cdot t_d^{\,2}}{4} \cdot f_y \qquad (39)$$

where B_{net} is the minimum of the net width of the flange (determined for the placement where the sum of hole dimensions is greatest, see Table 3).

The local compression capacity perpendicular to the grain

$$f_c = k_{c,90}\, f_{c,90,k} \qquad (40)$$

where $f_{c,90,k}$ is the compression strength of wood perpendicular to the grain and $k_{c,90}$ is the increasing factor for local compression. For the analysed Angle Brackets the value $k_{c,90}$ = 3,0 may be used as it is given in EN 1995-1-1 for the bearing capacity of washers.

By the substitutions according to expressions (39) and (40), the equation (37) may be presented as

$$R_{B,z,c,k} = t_d \cdot \sqrt{3 \cdot B \cdot B_{net} \cdot f_y \cdot f_{c,90,k}} \qquad (41)$$

In Table 3 the calculated characteristic values $R_{B,z,c,k}$ are presented for the compression capacities of the unreinforced Angle Bracket connections, when for the compression strength of wood, the value of strength class C24 has been used $f_{c,90,k}$ = 2,5 N/mm^2.

Table 3. Characteristic compression capacities for unreinforced Angle Brackets used with sawn timber in strength class C24. For compression capacities with other strength classes, the characteristic resistance $R_{B,z,c,k}$ should be multiplied by the factor $\sqrt{f_{c,90,k}/2{,}5}$, where $f_{c,90,k}$ is the characteristic compression strength perpendicular of the actual timber grade [N/mm^2].

Art. No.	Size (mm)	t_d (mm)	B (mm)	B_{net} (mm)	M_p (Nmm)	b_1 (mm)	$R_{B,z,c,k}$ (kN)
VMGT-7055AB	70x70x55x2,0	1,81	55	37	7576	8,6	3,54

Reinforced Angle Brackets

For the Angle Brackets reinforced by a fold from the bent edge, the first plastic yield hinge appears to the location of the end of the reinforcing fold. After the end of the reinforcing fold, the flange acts like the flange of an unreinforced Angle Bracket. The second yielding point appears to the distance of b_1 calculated according to equation (38) from the end of the reinforcing fold (cf. Figure 5). If there are no fasteners at the unreinforced area behind the distance b_1 calculated by equation (38), there are no second yield point and only the compression capacity of reinforced area may be utilized.

For the reinforced Angle Brackets, the compression capacity calculated according to equation (41) is increased by the local compression capacity of timber of the reinforced area of the flange:

$$R_{z,c,B,k} = 3 \cdot a \cdot B_{ef} \cdot f_{c,90} + t_d \cdot \sqrt{3 \cdot B \cdot B_{net} \cdot f_y \cdot f_{c,90,k}} \qquad (42)$$

where a is the length of the reinforcing fold, B_{ef} is the width of the flange reduced by the width of the reinforcing fold (see Table 4) and the other symbols are defined in context of equation (41).

In Table 4, the calculated characteristic values $R_{B,z,c,k}$ are presented for the compression capacities of the reinforced Angle Bracket connections, when for the compression strength of wood, the value of strength class C24 has been used $f_{c,90,k}$ = 2,5 N/mm^2.

Table 4. Characteristic compression capacities for reinforced Angle Brackets used with sawn timber in strength class C24. For compression capacities with lower strength classes, the characteristic resistance $R_{B,z,c,k}$ should be reduced by the factor $\sqrt{f_{c,90,k}/2{,}5}$, where $f_{c,90,k}$ is the characteristic compression strength perpendicular of the actual timber grade [N/mm^2].

Art. No.	Size (mm)	t_d (mm)	B (mm)	a (mm)	B_{ef} (mm)	B_{net} (mm)	M_p (Nmm)	b_1 (mm)	$R_{B,z,c,k}$ (kN)
VMGT-9065RAB	90x90x65x2,5	2,29	65	48	46	45	14749	11,0	21,9

Summary on the load carrying capacity of the Angle Bracket connections

The design capacity R_d of the Angle Bracket connection

$$R_d = k_{mod} \frac{R_k}{\gamma_M} \tag{43}$$

where k_{mod} is the modification factor according to EN 1995-1-1 taking into account the effect of the duration of the load and moisture content for timber, γ_M is the partial factor for the resistance of connections according to the relevant National annex of EN 1995-1-1 and R_k is the characteristic resistance of the Angle Bracket connection.

When the connection made by the Angle Bracket is loaded by force acting at the plane of flange A in the middle of the flange, it shall be checked that the conditions according to equations (44) to (46) are fulfilled

$$F_d \le R_{A,d} \tag{44}$$

$$F_{x,d} \le R_{B,x,d} \tag{45}$$

$$F_{z,d} \le \begin{cases} R_{B,z,t,d} & \text{in tension} \\ R_{B,z,c,d} & \text{in compression} \end{cases} \tag{46}$$

where $F_{x,d}$ is the component in the direction of the bent edge of the Angle Bracket from the connection force F_d and $F_{z,d}$ is the component perpendicular to $F_{x,d}$ from the connection force F_d.

In addition, when the joint is loaded in tension, the following interaction equation shall be fulfilled:

$$\left(\frac{F_{z,d}}{R_{B,z,t,d}}\right)^2 + \left(\frac{F_{x,d}}{R_{B,x,d}}\right)^2 \le 1 \tag{47}$$

Characteristic resistance

$$R_{A,k} = n_A F_{A,v,Rk} \tag{48}$$

where n_A is number of fasteners at flange A. $F_{A,v,Rk}$ is the characteristic lateral load-carrying capacity of the fastener in the timber part against flange A according to EN 1995-1-1, see equations (1) and (2).

Characteristic resistance

$$R_{B,x,k} = k_m F_{B,v,Rk} \tag{49}$$

where $F_{B,v,Rk}$ is the characteristic lateral load-carrying capacity of the fastener in the timber part against flange B, according to EN 1995-1-1, and the factor k_m depends on the placement of the fasteners. Values of k_m are given in Table 2 for cases, where fasteners are used in all 5 mm holes of the connector.

Characteristic tension resistance for Angular Brackets without reinforcements

$$R_{B,z,t,k} = \min\begin{cases} F_{n,1} + F_{n,2} - 3 \cdot \dfrac{F_{n,1} \cdot d_1 + F_{n,2} \cdot d_2 - \dfrac{B \cdot t_d^{\,2}}{4} \cdot f_y}{2L_B + d_2} & \text{(a)} \\ \dfrac{t_d^{\,2} f_y}{4 d_1} \cdot \left(B + B_{net,1}\right) & \text{(b)} \\ \dfrac{t_d^{\,2} f_y}{4 d_2} \cdot \left(B + B_{net,2}\right) + \dfrac{F_{n,1}\left(d_2 - d_1\right)}{d_2} & \text{(c)} \\ F_{n,1} + F_{n,2} & \text{(d)} \end{cases} \tag{50}$$

Where d_1 distance between the bent edge and the hole row nearest to it in flange B (i = 1),
d_2 distance between the bent edge and the hole row second nearest to it in flange B (i = 2),
B the width of the Angle Bracket,
t_d is the thickness of the Angle Bracket to be used in calculations (= the minimum thickness minus the thickness of the zinc coating),
f_y yield strength of the steel of the Angle Bracket,
L_B the length of flange B from the middle of the bent edge,
$B_{net,i}$ the net width of the Angle Bracket at hole row i and

$$F_{n,i} = n_i F_{ax,Rk} \tag{51}$$

when n_i is the number of fasteners at row i and $F_{ax,Rk}$ is the characteristic withdrawal resistance of the fastener in the timber member against flange B, see equations (5) and (6).

If there are fasteners only in one or two rows at flange B, in expression (50) equation (a) is inserted by $F_{n,2}$ = 0 and $d_2 = d_1$ and equation (c) needs not to be checked.

Characteristic tension resistance for a reinforced Angle Bracket

$$R_{B,z,t,k} = \min\begin{cases} \Sigma F_{a,j} + F_{n,1} - 3 \cdot \dfrac{F_{n,1} \cdot d_1 - \dfrac{B \cdot t_d^{\,2}}{4} \cdot f_y}{2L_B - 2a + d_2} & \text{(a)} \\ \max\begin{cases} \dfrac{t_d^{\,2} f_y}{4\left(a + d_1\right)} \cdot \left(B + B_{net,1}\right) + \dfrac{\Sigma\left(F_{a,j}\left(a + d_1 - a_j\right)\right)}{a + d_1} & \text{(b)} \\ \sum F_{a,j} + F_{n,1} & \text{(c)} \end{cases} \end{cases} \tag{52}$$

Where d_1 distance between the end of the reinforcement fold and the hole row nearest to it in flange B (i = 1),
a is the length of the reinforcement fold in flange B,
a_j is distance between bent edge and the fastener row j,
B the width of the Angle Bracket at the end of the reinforcement fold,

t_d is the thickness of the Angle Bracket to be used in calculations (= the minimum thickness minus the thickness of the zinc coating),
f_y yield strength of the steel of the Angle Bracket,
L_B the length of flange B from the middle of the bent edge,
$B_{net,i}$ the net width of the Angle Bracket at hole row i,

$$F_{n,1} = n_1 F_{ax,Rk} \quad (53)$$

$$F_{a,j} = n_j F_{ax,Rk} \quad (54)$$

when n_1 is the number of fasteners in the row nearest to the end of the reinforcement fold (i), n_j is the number of fasteners at row j in the part of flange B with the reinforcement and $F_{ax,Rk}$ is the characteristic withdrawal resistance of the fastener in the timber member against flange B, see equations (5) and (6).

If the flange B of the Angle Bracket only has one row of fasteners on the part without reinforcement, $F_{n,1} = 0$ is inserted in equation (52).

For a stiffened connector that have no fasteners on the reinforcement area, the tension capacity may be calculated as maximum of expressions (52) and (50). Then in expression (50), the flange length L_B is taken as distance between the end of the reinforcement and the end of the flange.

Characteristic compression resistance for Angle Brackets without reinforcement

$$R_{B,z,c,k} = t_d \cdot \sqrt{3 \cdot B \cdot B_{net} \cdot f_y \cdot f_{c,90,k}} \quad (55)$$

where t_d, B and f_y are defined as for equation (50) and B_{net} is the smallest net width of the flange B and $f_{c,90,k}$ is the characteristic compression strength perpendicular to the timber member against flange B.

Characteristic compression resistance for Angle Brackets with reinforcements

$$R_{z,c,B,k} = 3 \cdot a \cdot B_{ef} \cdot f_{c,90,k} + t_d \cdot \sqrt{3 \cdot B \cdot B_{net} \cdot f_y \cdot f_{c,90,k}} \quad (56)$$

where a is the length of the reinforcement fold from the bent edge of the Angle Bracket, B_{ef} is the width of the Angle Bracket minus the width of the reinforcement and the other symbols as for equation (55).

For a timber-to-concrete Angle Bracket connection, the resistance of the corresponding timber-to-timber connection may be used, provided that the lateral load carrying capacity and axial tension capacity of the fastener group of flange B in concrete are greater or equal than the capacities of the fastener group of flange B in timber member.

Structural requirements

- The placement of the fasteners used in Angle Brackets shall fulfil the requirements presented in EN 1995-1-1 for nails without pre-drilling: fastener spacings parallel and perpendicular to the grain and the edge and end distances. The minimum spacings given in Table 8.2 of EN 1995-1-1, a_1 and a_2, may be multiply by the factor 0,7 (connections with steel plates).
- If the Angle Brackets are used on both sides of a beam, the fasteners coming from the sides may overlap in the beam, when the point of the fastener is at least 4d from the surface of the opposing side, where d is the nominal diameter of the fastener.
- It is not possible to fill all holes by fasteners in all configurations and loading combinations of the angular brackets. In partial fixing, the fasteners shall always be placed in the row nearest to the end of the flange and as near as possible to

the bent edge of the angular bracket. In addition, the fasteners shall be positioned as symmetrically as possible.

- All fasteners in one flange of the Angle Bracket shall be of equal type and size. The different flanges may be fixed with fasteners of different type or size.
- In service class 2, the nails or screws shall have an electroplated zinc coating according to EN ISO 2081 at least of type and thickness Fe/Zn 12c, or they shall be hot dip zinc coated according to EN ISO 1461, thickness at least 39 µm.
- The VMG Technics Angle Brackets are not suitable for service class 3 applications.
- The VMG Technics Angle Brackets shall not be used without adequate protection for connections where resistance to fire is required.

Espoo, 24th June 2025

Ari Kevarinmäki
Leading Expert, D.Sc. (Tech.)

References

/1/ EN 1995-1-1:2004+A1:2008+A2:2014. Eurocode 5 - Design of timber structures - Part 1-1: General. Common rules and rules for buildings. CEN.

/2/ Ehlbeck, J. & Göerlacher R., 1982, Mindestnagelabstände bei Stahlblech-Holzangelung. Research Report, Verschuchsanstalt für Stahl, Holz, und Steine, Universität Karlsruhe, Germany.

/3/ STEP 1 - Timber Engineering, 1995. Ed. Blass et. al., Centrum Hout, The Netherlands.

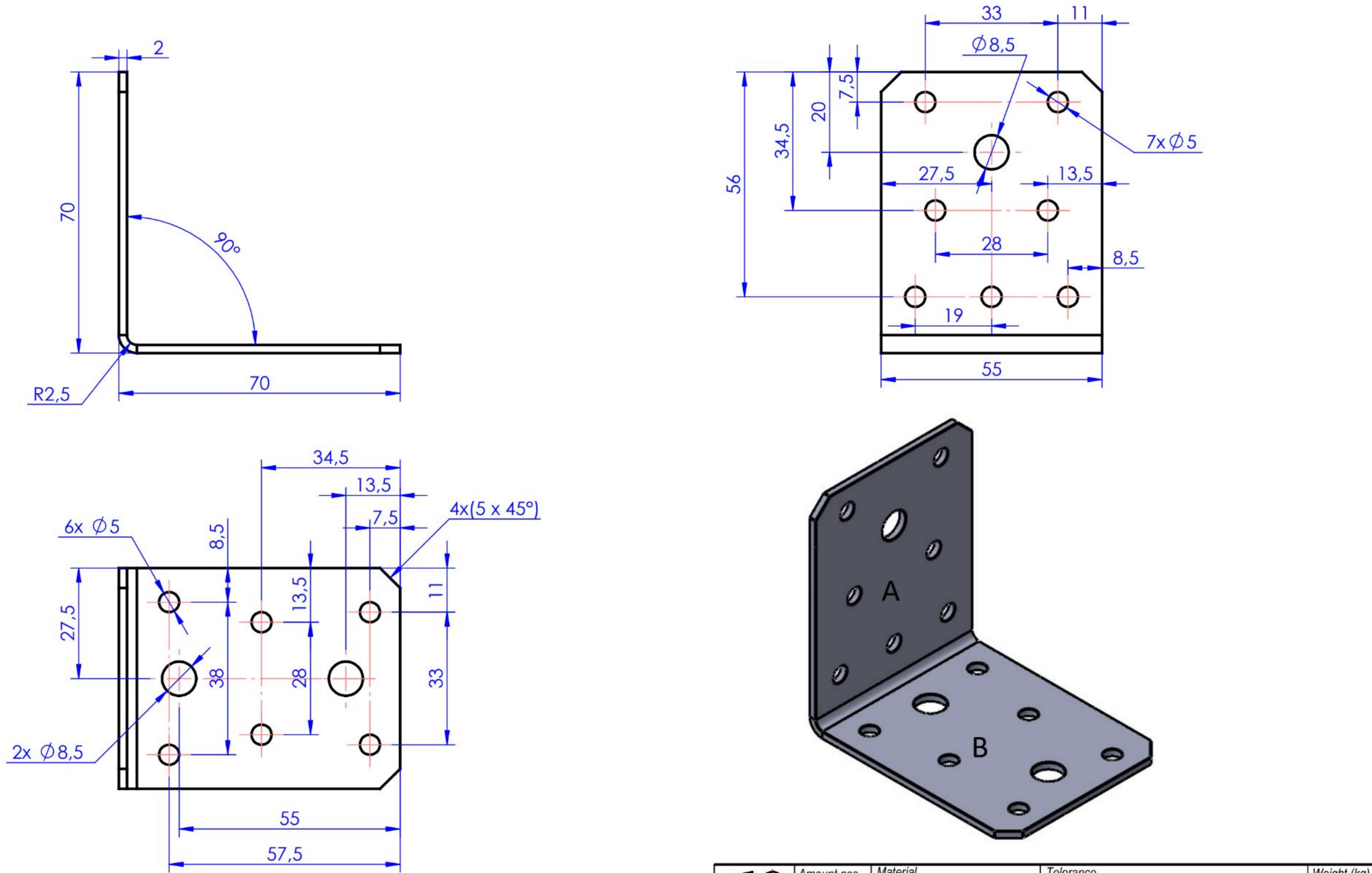
Appendices

Appendix 1: Dimensional drawings of VMG Technics Angle Brackets, 2 p.
Appendix 2: Manufacture’s inspection certificates for steel plate material, 2 p.
Appendix 3: Tension resistances of Angle Bracket connections, 1 p.

Distribution

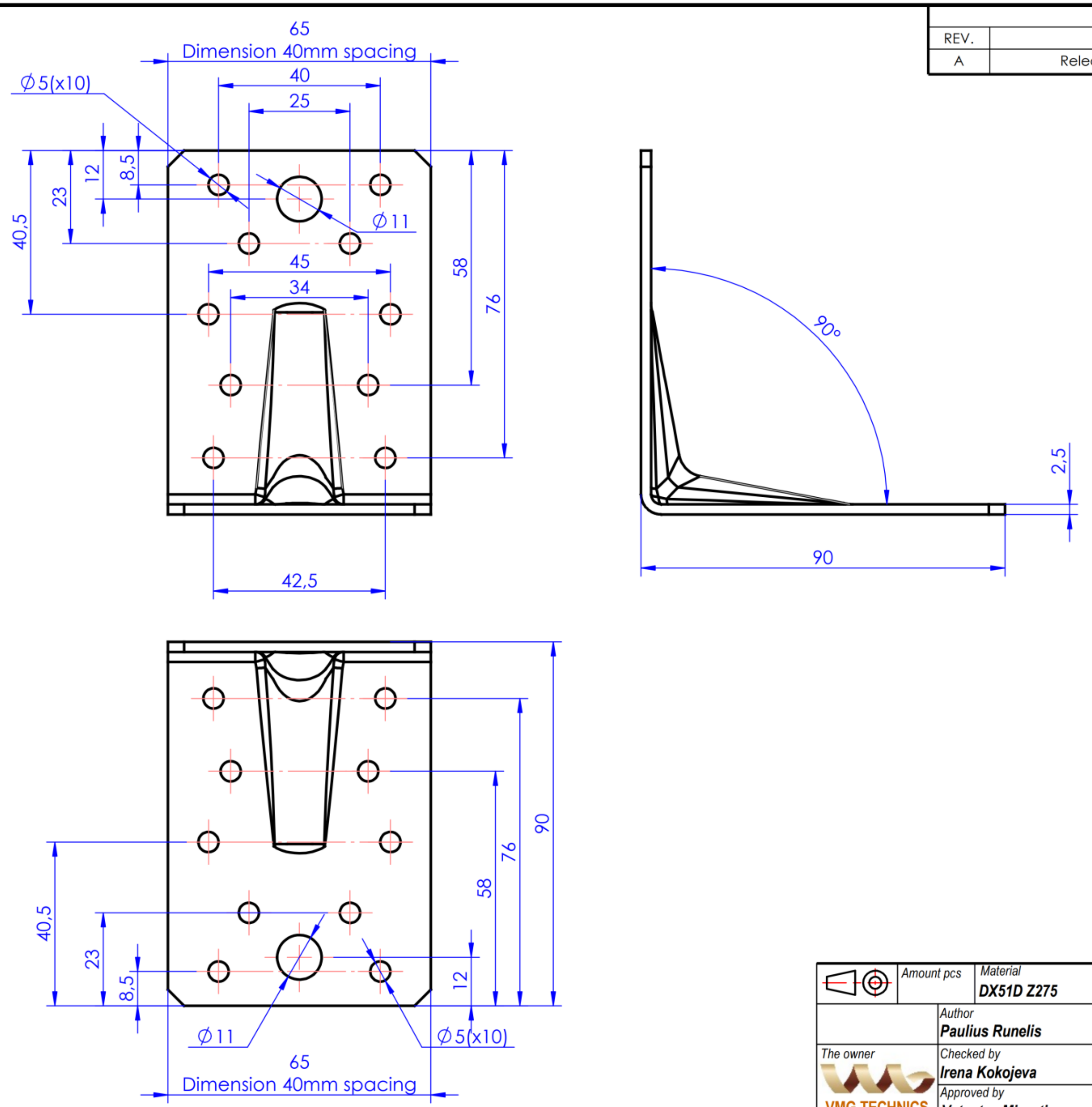
Customer electronically approved

REVISION			
REV.	NOTES	DATE	AUTHOR
A	Released for production	2024-05-03	Paulius Runelis



	Amount pcs	Material DX51D Z275	Tolerance ISO 2768 C	Weight (kg) 0.14	Scale 1:1
	Author Paulius Runelis	Drawing No. VMGT-7055AB			
The owner VMG TECHNICS	Checked by Irena Kokojeva	Title ANGLE BRACKET	Production technology Stamping		
	Approved by Vytautas Miezetis	Project PR23-005	Format A3	Date 2024-05-03	Page 1/1

REVISION			
REV.	NOTES	DATE	AUTHOR
A	Released for production	2024-10-19	Paulius Runelis



Amount pcs	
Material	DX51D Z275
Tolerance	ISO 2768 C
Weight (kg)	0.21
Scale	1:1
Author	Paulius Runelis
Drawing No.	VMGT-9065RAB
The owner	VMG TECHNICS
Checked by	Irena Kokojeva
Title	REINFORCED ANGLE BRACKET
Production technology	Stamping
Approved by	Vytautas Miezetis
Project	PR23-005
Format	A3
Date	2024-10-11
Page	1/1

SSAB

TEST REPORT

Page
1 / 3

FI 13300 HÄMEENLINNA FINLAND
Tel.+358 20 5911

EN 10 204/2.2 | 40705G-01 | 24

Purchaser *	Consignee	Date
VMG TECHNICS UAB	VMG TECHNICS UAB	15.5.2025
LIEPU G. 68	PRAMONES G. 14	
92100 KLAIPEDA LITHUANIA	92498 DIRVUPIAI LITHUANIA	

Customer's Order	Order Confirmation	Type of certificate
PIVEK0084747	40705G	EN 10 204/2.2

Mark

Item	Specification, dimensions	Lift no.	Cast nr	Pcs	Quantity KG	Weight kg
	HOT-DIP ZINC COATED WIDE STEEL STRIP TOLERANCES : EN 10143:2006 BENDING AND PROFILING QUALITY DX51D+Z275-M-A-C EN 10346:2015 EN ISO 6892-1					
001	2,00 X 1420,0 MM	56892001	73689	001	12230	12220
		56892002	73689	001	12170	12160
	POS 001 IN TOTAL	2 *			24400	24380
	DELIVERY IN TOTAL	2 *			24400	24380
	PART DELIVERY					

Hereby we certify that the delivery corresponds to the order confirmation.

We hereby certify, that the material described above has been tested and complies with the terms of the order contract.

SSAB Europe Oy, Raahe Analysis Laboratories T010 and Hämeenlinna Works testing laboratory T057 are accredited by the FINAS accreditation Service (finas.fi) accreditation requirement SFS-EN ISO/IEC 17025.

SSAB EUROPE OY
Testing and inspection, Hämeenlinna
15.5.2025
Mari Koivisto
Mari Koivisto
Authorized inspection representative

TEST REPORT

FI 13300 HÄMEENLINNA FINLAND
Tel.+358 20 5911

EN 10 204/2.2

40705G-01 24

Purchaser *	Consignee	Date
		15.5.2025
VMG TECHNICS UAB	VMG TECHNICS UAB	
LIEPU G. 68	PRAMONES G. 14	
92100 KLAIPEDA LITHUANIA	92498 DIRVUPIAI LITHUANIA	

Item	Lift no.	Chemical composition of cast % C	SI	MN	P	S	TI
001	56892001	,08	,022	,30	,008	,010	,001
001	56892002	,08	,022	,30	,008	,010	,001

Hereby we certify that the delivery corresponds to the order confirmation.

We hereby certify, that the material described above has been tested and complies with the terms of the order contract.

SSAB EUROPE OY
Testing and inspection, Hämeenlinna
15.5.2025

Mari Koivisto
Mari Koivisto
Authorized inspection representative

SSAB

TEST REPORT

FI 13300 HÄMEENLINNA FINLAND
Tel.+358 20 5911

EN 10 204/2.2 | 40705G-01 | 24

Purchaser *

VMG TECHNICS UAB
LIEPU G. 68
92100 KLAIPEDA LITHUANIA

Consignee

VMG TECHNICS UAB
PRAMONES G. 14
92498 DIRVUPIAI LITHUANIA

Date
15.5.2025

Item	Lift no.	Tensile test									Hardness	
		K1	Re N/mm2	Rm N/mm2	L0 mm	A %		BH	AI		HRB	HR30T
001	56892001	10	295	387	80	33						
001	56892002	10	295	387	80	33						

K1 10 = Transverse rectangular test piece   11 = Longitudinal rectangular test piece   13 = The weighted average of n- and r-values

Re = Yield strenght according to the steel standard

Hereby we certify that the delivery corresponds to the order confirmation.

We hereby certify, that the material described above has been tested and complies with the terms of the order contract.

SSAB EUROPE OY
Testing and inspection, Hämeenlinna
15.5.2025
Mari Koivisto
Mari Koivisto
Authorized inspection representative

MARCEGAGLIA CARBON STEEL

Sede Legale e amministrativa:
Via Bresciani, 16
46040 Gazoldo degli Ippoliti
Mantova-Italy
Tel. +39 - 0376 685 1
Fax. +39 - 0376 685 600
www.marcegaglia.com

Type	Test Report 2.2 EN 10204
Number	10425282790
Issued On	30/04/2025

Delivery Nn	8930682454	Quality Control
Of	30/04/2025	Q.M.D. M.Manaresi
Delivery note nr	1004019957	Plant Of Ravenna

Identification Nr	Quantity	Heat	C (%)	Si (%)	Mn (%)	P (%)	S (%)	Ti (%)	Al (%)	Rm [N/mm	Re [N/mm	A (%)
										270		22
			0.18	0.5	1.2	0.12	0.045	0.3		500		

CZ CZ 2.50X1500.00 DX51D Z 275 MABC EN10346 1191878970/100 244/2025/MARCEGAGLIA/HDG ING Date 26/03/2025

25RC016835	11410 KG											
25RC016854	11950 KG											
25RC016858	11820 KG											
25RC016866	11940 KG											

CZ CZ 3.00X1250.00 DX51D Z 275 MABC EN10346 1191878970/110 244/2025/MARCEGAGLIA/HDG ING Date 26/03/2025

25RB040852	11840 KG		.030	.024	.230	.002	.001	.0010	.029	382.1	311.0	31.8
25RB040857	10860 KG											
25RB040870	10800 KG											
25RB040888	10680 KG											
25RB040894	10520 KG											
25RB040904	10360 KG											
25RC016894	10680 KG											
25RC016906	11090 KG											
25RC016913	10410 KG											
25RC016915	11750 KG											
25RC016975	10550 KG											
25RC016988	10600 KG											
25RC017012	10500 KG											
25RC017017	10860 KG											
25RC017018	10680 KG											
25RC017022	10430 KG											
25RC017077	10600 KG											
25RC017092	10400 KG											

Remarks:
We certify that products listed above comply with order requirements
Document validated acc. EN10204 par. 5

Tension resistances $R_{B,z,t,k}$ for unreinforced Angle Brackets with anchor nails 4x50, $f_{ax,k}$ = 6 N/mm^2 and t_{pen} = 34 mm

Art. No.	Size (mm)	L_B (mm)	M_0 (Nmm)	d_1 (mm)	n_1	$B_{net,1}$ (mm)	$F_{n,1}$ (N)	d_2 (mm)	n_2	$B_{net,2}$ (mm)	$F_{n,2}$ (N)	$F_{z,t,k}$ (a) (N)	$F_{z,t,k}$ (b) (N)	$F_{z,t,k}$ (c) (N)	$F_{z,t,k}$ (d) (N)	**$R_{B,z,t,k}$ (kN)**
VMGT-7055AB	70x70x55x2,0	69	11262	13	2	37	1632	34,5	2	45	1632	2112	1449	1611	3264	**1,45**

Tension resistances $R_{B,z,t,k}$ for reinforced Angle Brackets with anchor nails 4x50, $f_{ax,k}$ = 6 N/mm^2 and t_{pen} = 34 mm

Tension resistances according to equation (52):

Art. No.	Size (mm)	L_B (mm)	a (mm)	M_0 (Nmm)	a_1 (mm)	n_{a1}	$F_{a,1}$ (N)	a_2 (mm)	n_{a2}	$F_{a,2}$ (N)	d_1 (mm)	n_1	$B_{net,1}$ (mm)	$F_{n,1}$ (N)	$F_{z,t,k}$ (a) (N)	$F_{z,t,k}$ (b) (N)	$F_{z,t,k}$ (c) (N)	**$R_{B,z,t,k}$ (kN)**
VMGT-9065RAB	90x90x65x2,0	88,75	48	21304	12,75	2	1632	30,75	2	1632	0,25	2	55	1632	5663	2608	4896	**4,90**