Timber Construction Application Sheet No. 2

Tensile Reinforcement of Beams

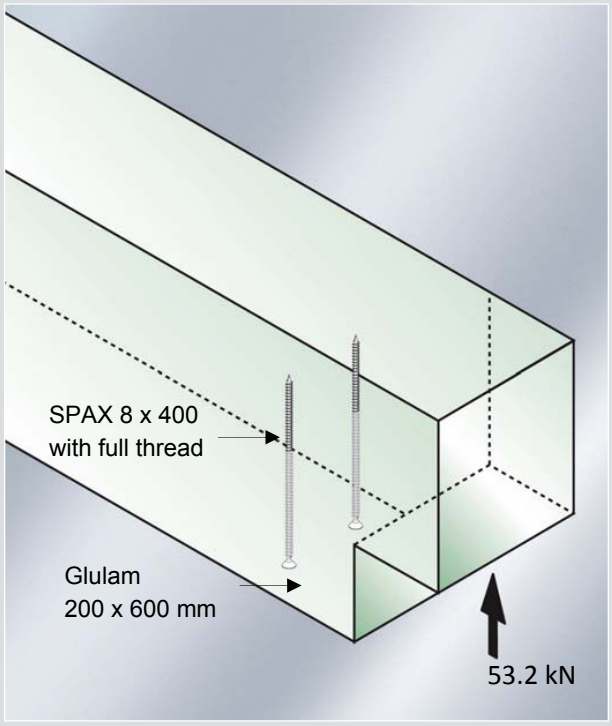
Failure in tension perpendicular to the grain in timber beams can occur in notched beams and around penetrations due to the reduction of the lateral force bearing capacity, resulting in crack initiation at the corner of the notch or penetration, rapid crack propagation and then sudden brittle failure of the beam.

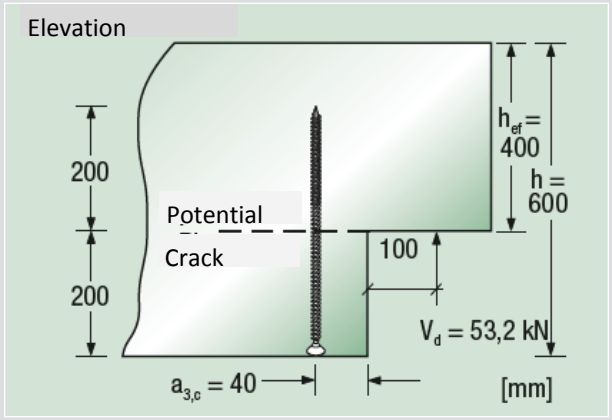
Reinforcement of the beam can be achieved using SPAX fully threaded screws applied perpendicular to the grain of the timber, thereby restoring the lateral force capacity of the timber.

The design of the reinforcement is derived from the Eurocode EC5 in combination with the European Technical Assessment (ETA-12/0114) for SPAX.

The requirements for minimum edge distances and spacing must be satisfied while keeping the reinforcement as close to the notch or penetration corner as possible.

The design approach is to assume that the tensile force perpendicular to the grain is carried entirely by the reinforcement.





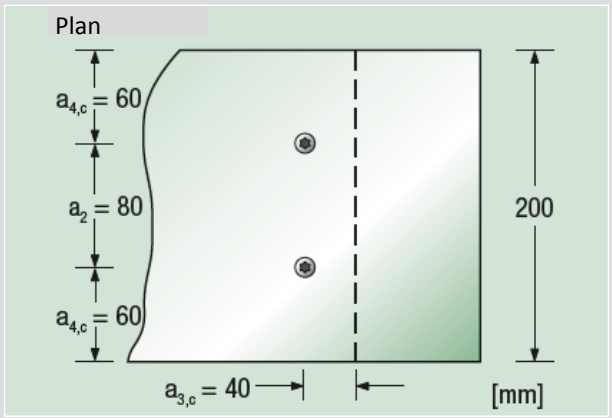
Notched Beams

The tensile capacity of reinforcement of a notched beam support shall fulfil the following condition:

$F_{t,90,d}/F_{ax,Rd} \leq 1$ where

$F_{t,90,d} = 1.3\ V_d\ [3(1-\alpha)^2-2(1-\alpha)^3]$ (ETA-12/0114 Annex D)

Where
V_d = Design value of the shear force,
$\alpha = h_{ef}/h$
h_{ef} = reduced beam height at notch
h = total beam height
$F_{ax,Rd}$ = Minimum of the design values of the withdrawal capacity and the tensile capacity of the reinforcing screws or threaded rods where ℓ_{ef} is the smaller value of the penetration depth below or above the potential crack.



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Example

V_d = 53.2 kN
$\alpha = h_{ef}/h = 400/600 = 0.67$
$F_{t,90,d} = 1.3 \times 53.2[3(1-0.67)^2-2(1-0.67)^3] = 17.93$ kN

Try two 8 x 400 fully threaded screws

1. Thread pull-out
$F_{ax,Rk} = n_{ef} \times f_{ax'k} \times d \times l_{ef} \times (\rho_k/350)^{0.8}$
Where $n_{ef} = n^{0.9} = 2^{0.9} = 1.9$; $f_{ax'k}$ = 12.0 N/mm^2;
d = 8.0
ρ_k = 385 kg/m^3
$F_{ax,Rk} = 1.9 \times 12 \times 8.0 \times 200 \times (385/350)^{0.8} = 39.37$ kN

k_{mod} = 0.8; γ_m = 1.3
$F_{ax,Rd} = 0.8 \times 39.37/1.3 = 24.22$ kN

2. Tensile strength of the steel
$F_{tens,d} = n_{ef} \times F_{tens,k}/\gamma_m$
$= 1.9 \times 17.0/1.3 = 24.84$ kN

Therefore $F_{t,90,d}/F_{ax,Rd} = 17.93/24.22 = 0.74 < 1$ OK

Minimum distances according to ETA -12/0114:
$a_2 \geq 2.5d_1$
$a_{3,c} \geq 5d_1$
$a_{4,c} \geq 3d_1$

Penetrations

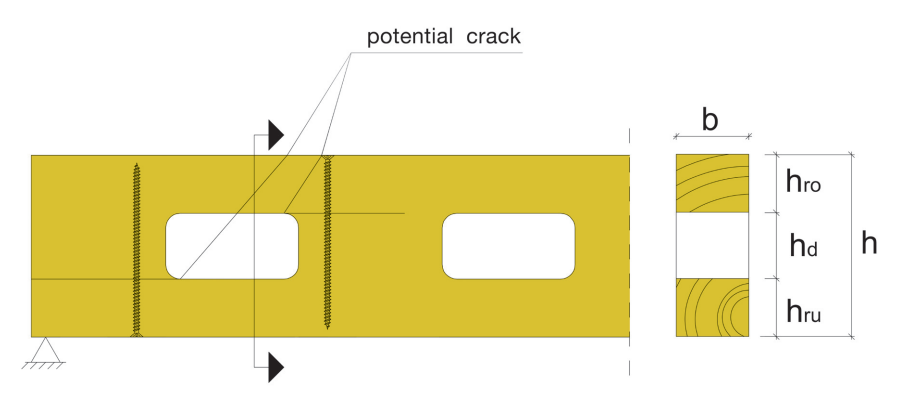
The tensile capacity of reinforcement of a hole in a beam shall fulfil the following condition:

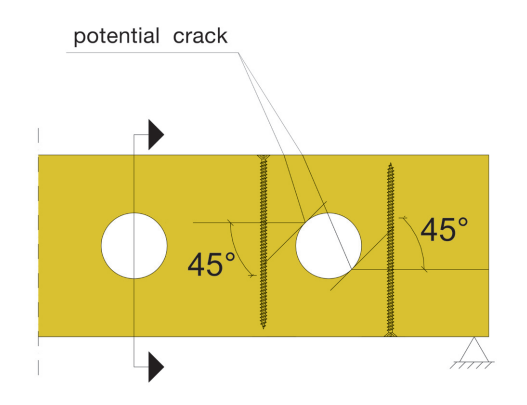
$(F_{t,90,d} + F_{t,M,d})/F_{ax,Rd} \leq 1$ where

$F_{t,90,d} = [(V_d \times h_d)/4h] \times (3 - h_d^2/h^2)$ (ETA-12/0114)

V_d = Design value of the shear force,
h = total beam height
h_d = hole depth for rectangular holes (mm)
h_d = 70% of hole diameter for circular holes (mm)
$F_{t,M,d}$ = design value of the force perpendicular to the grain due to bending moment (N)
$= 0.008 \times M_d/h_r$
M_d = design value of the member bending moment at hole end (Nmm)
h_r = min (h_{ro};h_{ru}) for rectangular holes (mm)
h_r = min (h_{ro};h_{ru}) + 0.15h_d for circular holes (mm)
$F_{ax,Rd}$ = Minimum of the design values of the withdrawal capacity and the tensile capacity of the reinforcing screws or threaded rods where ℓ_{ef} is the smaller value of the penetration depth below or above the potential crack (N).

Apart from the reinforcement with screws, strength verification is required for the shear strength of the timber member in the vicinity of the hole.





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