Verification example – T-stub – prying forces

Type of connection: Simple T-stub with 4 bolts

Unit system: Metric

Designed acc. to: Kulak, Fisher, Struik: Guide to Design Criteria for Bolted and Riveted Joints, ed. 2, AISC, Chicago, 2001 – Chapter 17.5 and 17.6 as recommended by CISC Handbook of Steel Construction

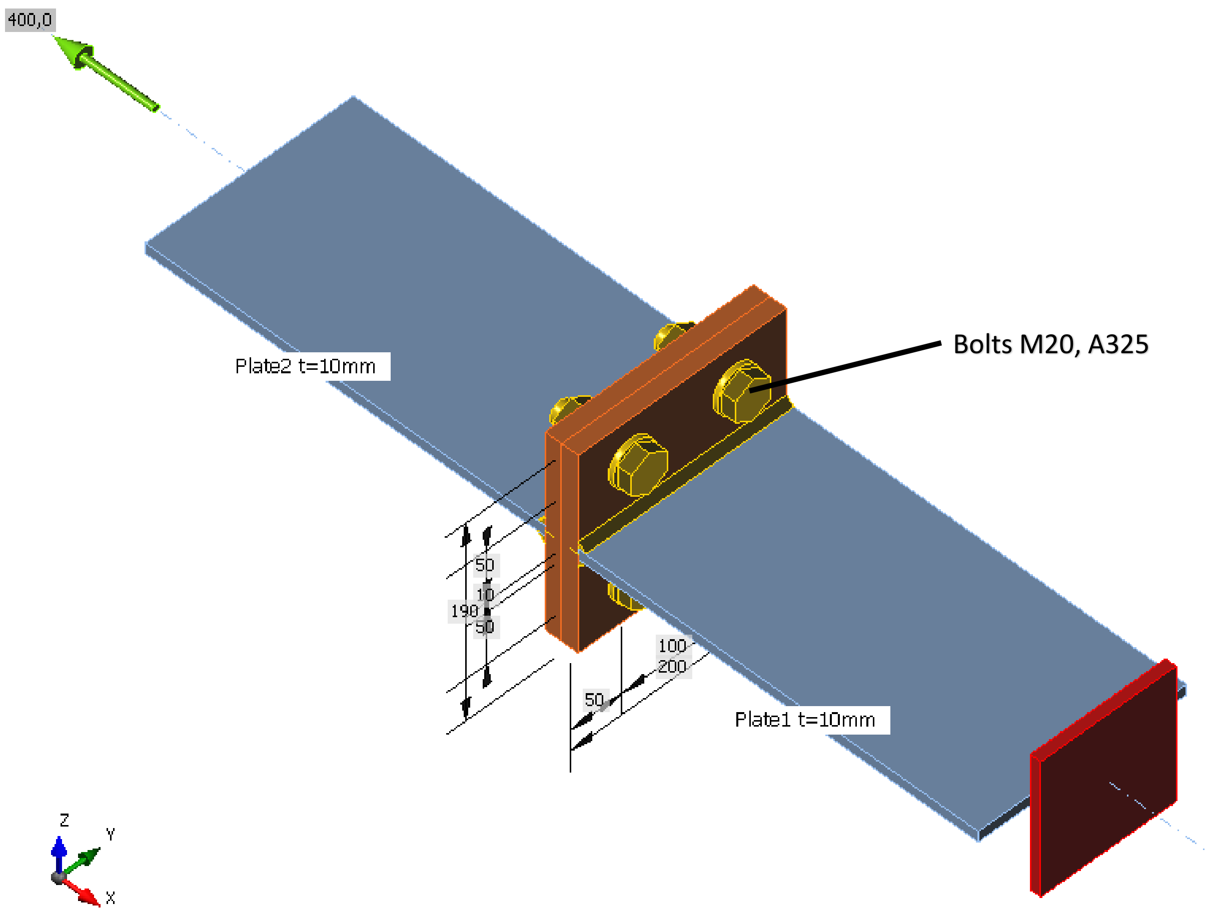
Investigated: Bolts

Plate Materials: Steel grade 350W,

Bolts: M20, grade A325

Welds: Fillet welds, electrodes E70XX, leg size 7 mm

Geometry:



a = 40 mm; *b* = 50 mm; *a'* = 51 mm; *b'* = 39 mm; *w* = 100 mm; d_0 = 22 mm

Applied forces:

N = 400 kN

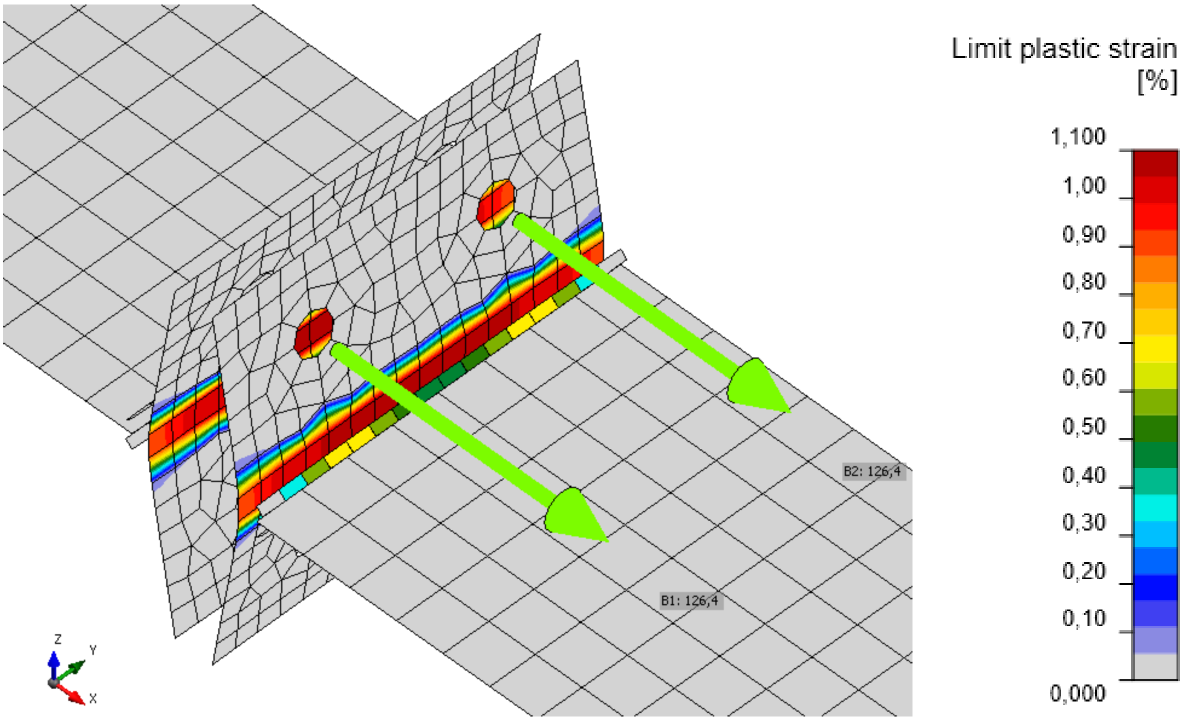
V = 0 kN

M = 0 kNm

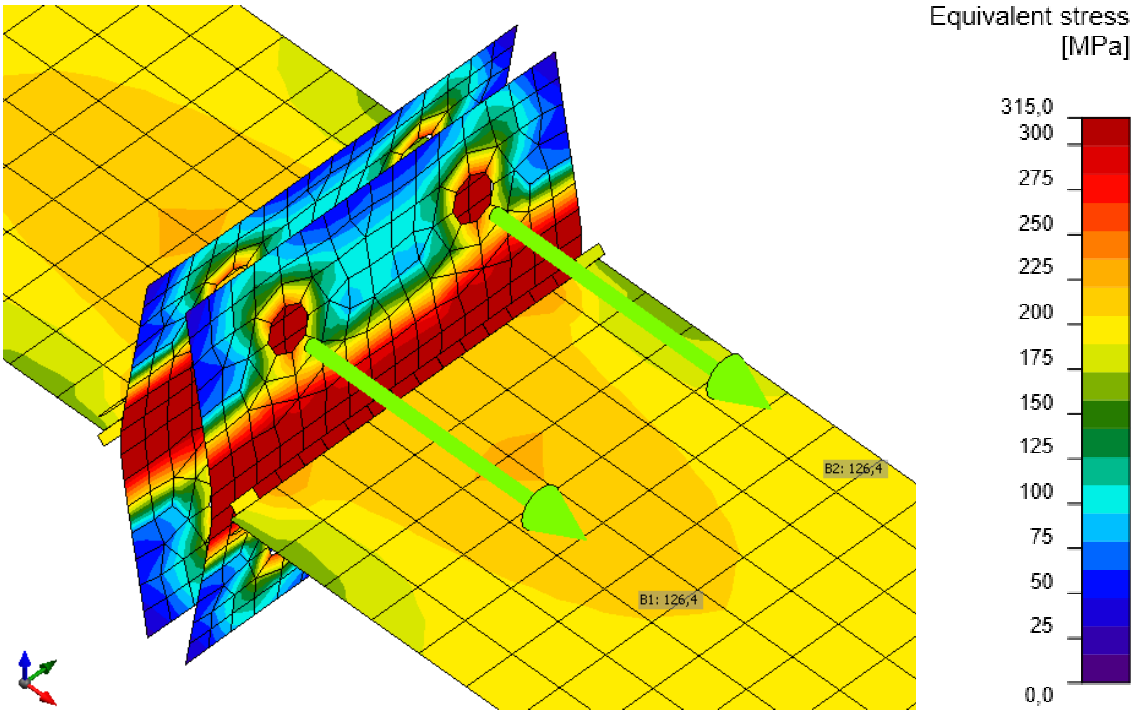
Procedure:

Regular bolts M20, steel grade A325 (shear force transfer by bearing) are used, threads are excluded. A simple T-stub with 4 bolts was modelled and was loaded with normal force. The thickness of “flange” was varied from 16 mm to 30 mm in IDEA, the normal force was held constant.

IDEA StatiCa Connection



Plastic strain for flange with the thickness of 20 mm



Von Mises stress for flange with the thickness of 20 mm

Check of bolts for extreme load effect

		Item	Loads	Tf [kN]	Vf [kN]	Utt [%]	Uts [%]	Utts [%]	Status
>	⊞	B1	LE1	126,4	0,0	80,8	0,0	65,3	✓
	⊞	B2	LE1	126,4	0,0	80,8	0,0	65,3	✓
	⊞	B3	LE1	126,4	0,0	80,8	0,0	65,3	✓
	⊞	B4	LE1	126,4	0,0	80,8	0,0	65,3	✓

Design data

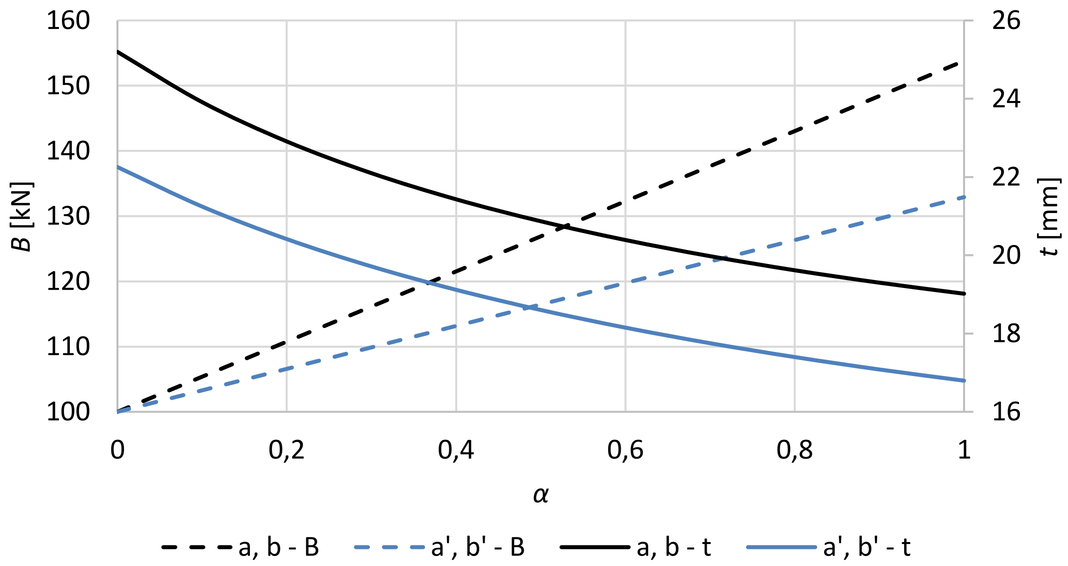
	Item	Tr [kN]	Vr [kN]	Br [kN]
>	20 A325M - 1	156,4	125,1	432,0

For the thickness of 16 mm, the most heavily loaded component were bolts:

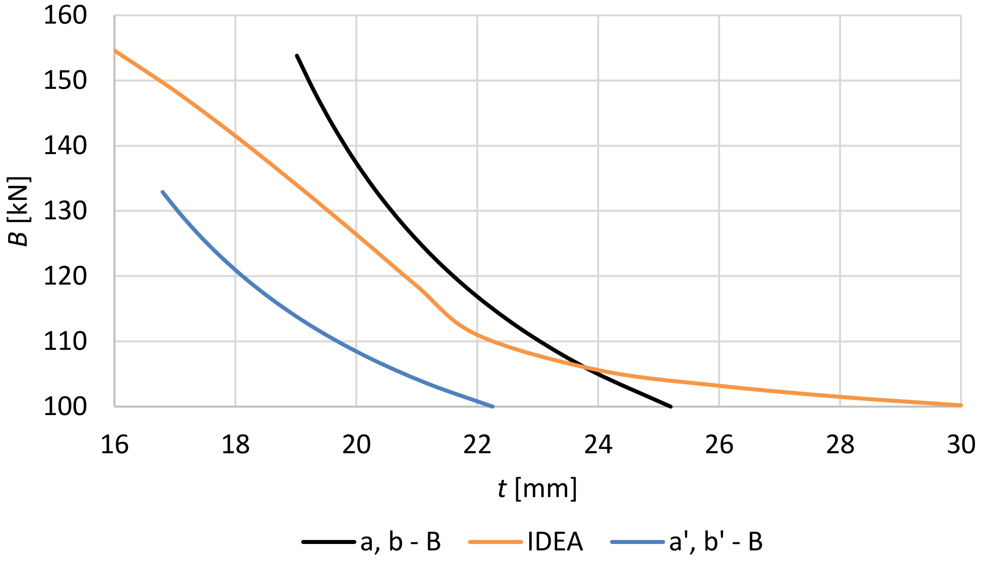
Check item	Value	Status
Analysis	100,0%	✓
Plates	4,9 < 5%	✓
Bolts	98,9 < 100%	✓
Welds	80,2 < 100%	✓
Buckling	Not calculated	

Manual assessment

For values of α (ratio between the moment per unit width at the centreline of the bolt line and the flange moment at the web face) ranging from 0 to 1, the thickness and force including prying forces were determined. The analytical assumption using geometrical values of a and b were compared to the recommended approach using values of a' and b'. The resistance factor for structural steel $\phi = 0.9$ was used for reduction of the yield strength of steel, F_y. Bolt holes with diameter $d_0 = 22$ mm were assumed ($\delta = 0.76$).



Comparison:



The results of the force acting on a bolt including prying force of IDEA StatiCa generally lies between the analytical approach using geometrical values of *a* and *b* and recommended approach using geometrical values of *a’* and *b’* in formulas for bolt forces including prying forces. Therefore, the magnitude of prying forces is slightly overestimated in IDEA (by cca 10 to 15 % compared to recommended approach), which is conservative. IDEA shows the forces in bolts with prying forces included and since the prying forces are a bit higher than according to manual calculation, the forces in bolts are also higher. Note that IDEA automatically determines the yield line and its length using finite element analysis. The analysis is materially nonlinear, thus, the ratio of the prying force *Q* and applied force *T* vary with the applied force *T*. The prying forces diminish with increasing thickness of the end plate.