7.3 Uniplanar T-joint between longitudinal gusset plate and RHS chord

7.3.1 Description

The object of this chapter is verification of component based finite element method (CBFEM) of the uniplanar welded T-joint of gusset plate to rectangular hollow sections with method of failure modes (FM). The gusset plate is welded directly onto the face of rectangular hollow sections in the lattice truss.

7.3.2 Method of failure modes

In these joints usually occurs only failure mode the chord face failure, see Fig. 7.3.1. Welds are designed according to EN 1993-1-8 not to be the weakest component in the joint. In the parts of lattice truss design continues load causes design internal forces in the form of normal forces and bending moments. Action of internal forces in location of T-joint is described as follows:

Axially-loaded RHS chord

The normal forces in the chord right and left of T-joint location act in location of chord longitudinal axis.

Diffraction-loaded RHS chord

For calculation only bending moments right and left of T-joint location in plane of T-joint are considered in the chord and these bending moments rotate around one of the axes in plane of chord cross-section for rotation in plane of T-joint.

Axially loaded gusset plate

The normal force in the brace of T-joint location acts in location of brace longitudinal axis.

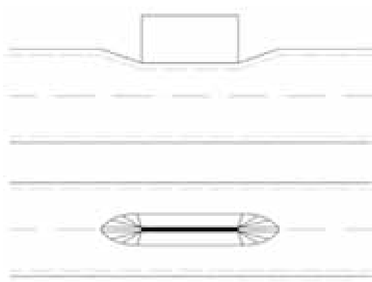

Fig. 7.3.1: Chord face failure

The design resistance of the chord web is determined using the method given in section 7.6 EN1993-1-8:2006, which background is described in (Wardenier et al, 2010). The load from the gusset plate has to be transferred through the face of the chord. The design resistance of the joint is predicted as

$$N_{i,Rd} = k_m \cdot f_{y0} \cdot t_0{}^2 \cdot \left(2 \cdot h_1/b_0 + 4 \cdot \sqrt{1 - t_1/b_0}\right)/\gamma_{M5} \qquad (7.3.1)$$

where

$$\text{For } n > 0\ (compression) \rightarrow\ k_m = 1{,}3 \cdot (1 - n) \leq 1{,}0 \qquad (7.3.2)$$

$$\text{For } n < 0\ (tensile) \rightarrow\ k_m = 1{,}0 \qquad (7.3.3)$$

Plates loaded by axial forces

Overview of the considered examples and the material are given in the Tab. 7.3.1. Geometries of joints with dimensions are shown in Fig. 7.3.2.

Tab. 7.3.1: Cases of plates loaded by axial forces

Example	Chord	Brace	Weld	Material		
	Section	Section	*a*	f_y	f_u	*E*
			[mm]	[MPa]	[MPa]	[GPa]
a1	SHS 100x5	P 8x100	12	355	490	210
a2	SHS 100x5	P 8x120	12	355	490	210
a3	SHS 100x5	P 10x150	15	355	490	210
a4	SHS 100x8	P 8x100	12	355	490	210
a5	SHS 100x8	P 8x120	12	355	490	210
a6	SHS 100x8	P 10x150	15	355	490	210
a7	SHS 150x6,3	P 8x100	12	355	490	210
a8	SHS 150x6,3	P 8x120	12	355	490	210
a9	SHS 150x6,3	P 10x150	15	355	490	210
a10	SHS 150x12,5	P 10x100	15	355	490	210
a11	SHS 150x12,5	P 12x120	18	355	490	210
a12	SHS 150x12,5	P 15x150	23	355	490	210
a13	SHS 200x12,5	P 15x150	23	355	490	210
a14	SHS 200x12,5	P 20x200	30	355	490	210
a15	SHS 300x10	P 15x200	23	355	490	210
a16	SHS 300x10	P 20x300	30	355	490	210
a17	SHS 300x16	P 15x200	23	355	490	210
a18	SHS 300x16	P 20x300	30	355	490	210

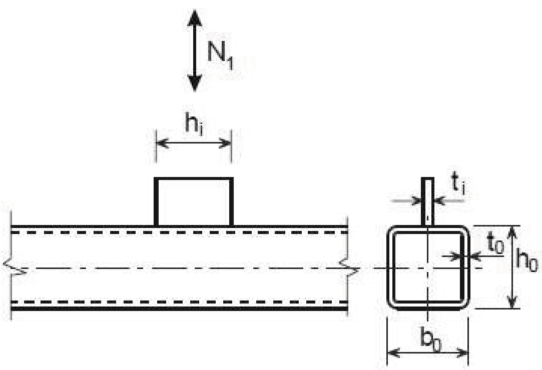

Fig. 7.3.2 Joint’s geometry with dimensions

7.3.3 Verification of resistance

Results of the method based on failure modes (FM) are compared with the results of CBF. The comparison was focused on resistance and the critical component of the joint, see in Tab. 7.3.2.

Tab. 7.3.2 Comparison of CBFEM and FM for tensile force in plate

Tension in plate					
Example	Design resistance				
	FM [kN]	Mode of failure	CBFEM [kN]	Mode of failure	Diff. [%]
a1	52	Chord face failure	54	Chord face failure	3
a2	55	Chord face failure	60	Chord face failure	8
a3	60	Chord face failure	67	Chord face failure	10
a4	132	Chord face failure	139	Chord face failure	5
a5	141	Chord face failure	156	Chord face failure	10
a6	154	Chord face failure	180	Chord face failure	14
a7	74	Chord face failure	68	Plate failure	7
a8	77	Chord face failure	75	Chord face failure	2
a9	83	Chord face failure	83	Chord face failure	1
a10	288	Chord face failure	267	Chord face failure	7
a11	301	Chord face failure	305	Chord face failure	1
a12	321	Chord face failure	348	Chord face failure	8
a13	296	Chord face failure	298	Chord face failure	1
a14	321	Chord face failure	347	Chord face failure	7
a15	185	Chord face failure	171	Chord face failure	8
a16	208	Chord face failure	195	Chord face failure	6
a17	475	Chord face failure	431	Plate failure	9
a18	532	Chord face failure	551	Chord face failure	3

The parametric studies show good agreement for the applied load cases. To illustrate the accuracy of the CBFEM model, results of the parametric studies are summarized in a diagram comparing CBFEM's and FM's design resistance, see Fig. 7.3.3. The results show that the difference of the two calculation methods is in most of cases less than 14%.

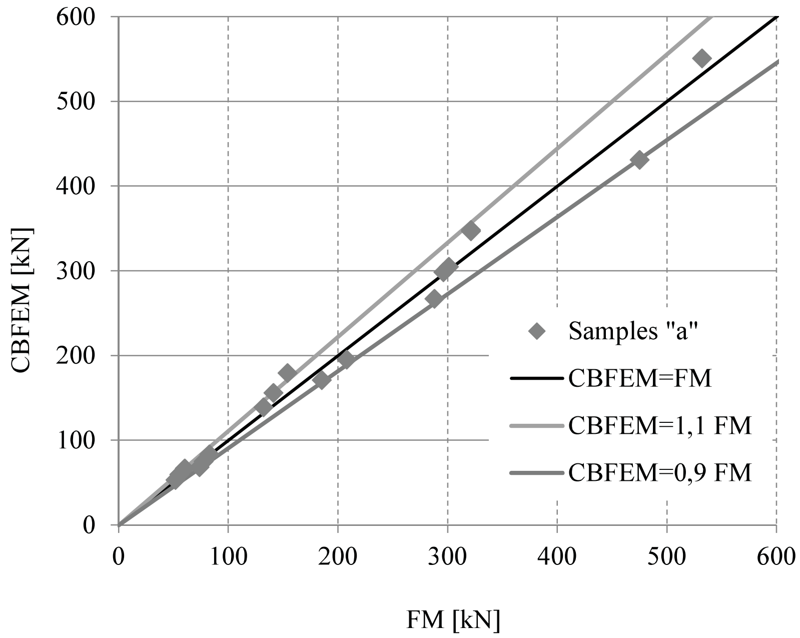

Fig. 7.3.3 Verification of CBFEM to CM for axial force in the brace of the uniplanar T-joint between longitudinal gusset plate and RHS chord

7.3.4 Range of validity

CBFEM is verified for T-joints between rectangular hollow section and open section. Range of validity is defined in Tab. 9 in ISO/FDIS 14346, see Tab. 7.3.3. The validation to experiments or verification to validated research model should be prepared in case of application of the CBFEM model outside the range of validity of FM.

Tab. 7.3.3 Range of validity of joints between longitudinal gusset plate and RHS chord (Table 9 in ISO/FDIS 14346)

Chord	Compression	class 1 or 2; $b_0/t_0 \leq 40$ and $h_0/t_0 \leq 40$
	Tensile	$b_0/t_0 \leq 40$ and $h_0/t_0 \leq 40$
	Aspect ratio	$0{,}5 \leq h_0/b_0 \leq 2$
Longitudinal plate	Compression	$1 \leq h_1/b_0 \leq 4$
Angle between chord and plate		$\theta_i = 90°$

7.3.5 Benchmark case

Inputs

Chord

- Steel S355
- SHS 200x12,5

Gusset plate

- Steel S355
- Plate P15x150

Weld

- Throat thickness a_w = 23 mm
- Fillet weld around the plate

Outputs

- Design resistance in tensile is $F_{c,Rd}$ = 298,4 kN
- Collapse mode is chord face failure