4.4 Fillet weld in beam to column joint

4.4.1 Description

The object of this chapter is verification of component based finite element method (CBFEM) for a fillet weld in a stiffened beam-to-column joint with component method (CM). An open section beam IPE is connected to open section column HEB400. The stiffeners are inside column opposite to beam flanges. The beam section is the changing parameter. Three load cases are considered, i.e. the beam is loaded in tension, shear and bending.

4.4.2 Analytical model

The fillet weld is the only component examined in the study. The welds are designed according to Chapter 4 in EN1993-1-8:2006 to be the weakest component in the joint. The design resistance of the fillet weld is described in section 4.1. Overview of the considered examples and the material are given in the Tab. 4.4.1. A geometry of the joint with dimensions is shown in Fig. 4.4.1.

Tab. 4.4.1 Examples overview

Example	Material					Weld	Beam		Column
	f_y	f_u	E	γ_{M0}	γ_{M2}	a_w	Section	e	Section
	[MPa]	[MPa]	[GPa]	[-]	[-]	[mm]		[mm]	
IPE160	235	360	210	1	1,25	3	IPE160	200	HEB400
IPE180	235	360	210	1	1,25	3	IPE180	200	HEB400
IPE200	235	360	210	1	1,25	3	IPE200	200	HEB400
IPE220	235	360	210	1	1,25	3	IPE220	200	HEB400
IPE240	235	360	210	1	1,25	3	IPE240	200	HEB400
IPE270	235	360	210	1	1,25	3	IPE270	200	HEB400
IPE300	235	360	210	1	1,25	3	IPE300	200	HEB400
IPE330	235	360	210	1	1,25	3	IPE330	200	HEB400
IPE360	235	360	210	1	1,25	3	IPE360	200	HEB400
IPE400	235	360	210	1	1,25	3	IPE400	200	HEB400

4.4.3 Numerical model

The weld in CBFEM model is described in section 3.4.

Nonlinear elastic-plastic material is used for welds in this study. The limit plastic strain is reached in longer part of the weld and stress peaks are redistributed.

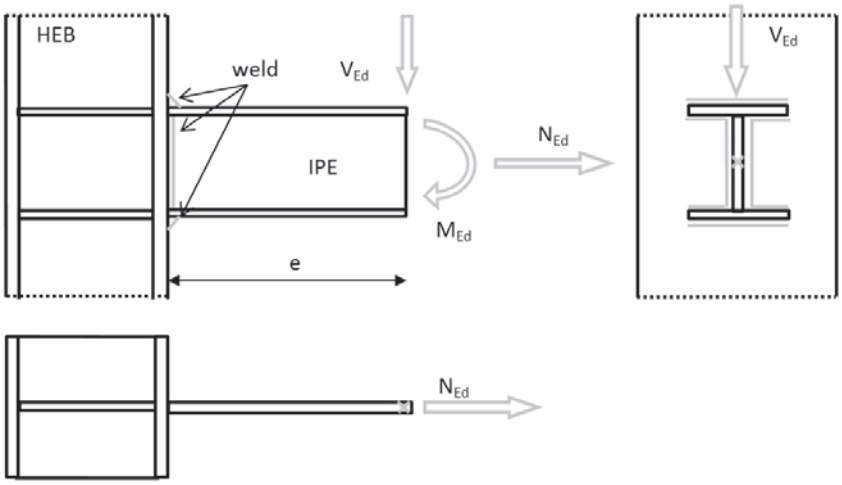

Fig. 4.4.1 Joint's geometry with dimensions

4.4.4 Verification of resistance

Design resistance calculated by CBFEM Idea RS software is compared with the results of CM. The weld's design resistances are compared, see Tab. 4.4.2. The study is performed for one parameter beam section and three load cases: normal force N_{Ed}, shear force V_{Ed} and bending moment M_{Ed}.

Tab. 4.4.2 Comparison of CBFEM and CM

Normal force N_{Ed}				Shear force V_{Ed}				Bending moment M_{Ed}			
Example	CM [kN]	CBFEM [kN]	Diff. [%]	Example	CM [kN]	CBFEM [kN]	Diff. [%]	Example	CM [kN]	CBFEM [kN]	Diff. [%]
IPE160	455	440	-3	IPE160	105	103	-2	IPE160	26	26	0
IPE180	511	509	0	IPE180	127	126	0	IPE180	33	33	0
IPE200	567	580	2	IPE200	151	150	-1	IPE200	40	41	2
IPE220	625	648	4	IPE220	175	175	0	IPE220	49	50	3
IPE240	684	703	3	IPE240	200	202	1	IPE240	59	60	2
IPE270	774	797	3	IPE270	239	244	2	IPE270	75	76	1
IPE300	863	886	3	IPE300	278	292	5	IPE300	93	94	1
IPE330	937	956	2	IPE330	315	336	6	IPE330	110	110	0
IPE360	1008	1026	2	IPE360	350	391	10	IPE360	129	128	-1
IPE400	1097	1116	2	IPE400	399	445	10	IPE400	155	153	-1

Results of CBFEM and CM are compared and a sensitivity study is presented. The influence of beam cross-section on the design resistance a welded beam-to-column joint loaded in tension is shown in Fig. 4.4.2, in shear in Fig. 4.4.3 and in bending in Fig. 4.4.4. The study shows good agreement for all applied load cases.

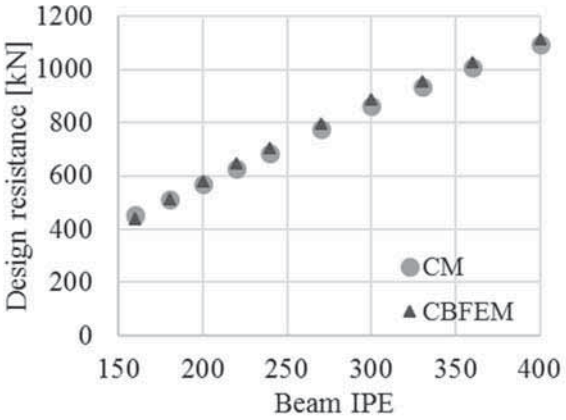

Fig. 4.4.2 Sensitivity study of beam-to-column joint loaded by normal force

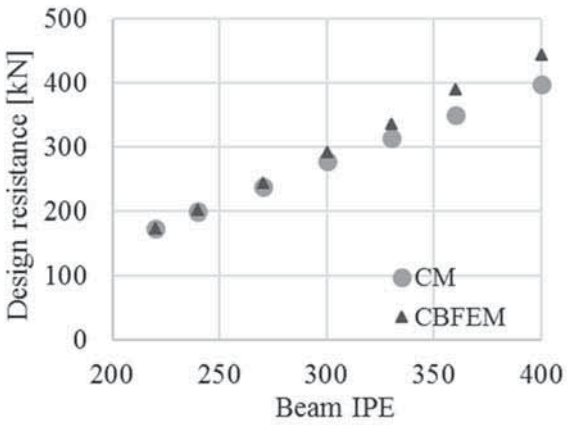

Fig. 4.4.3 Sensitivity study of beam-to-column joint loaded by shear force

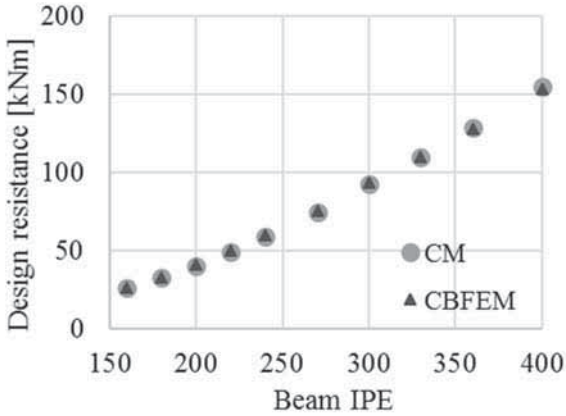

Fig. 4.4.4 Sensitivity study of beam-to-column joint loaded by bending moment

To illustrate the accuracy of the CBFEM model, results of the sensitivity study is summarized in a diagram comparing CBFEM's and CM's design resistances, see Fig. 4.4.5. The results show that the difference of the two calculation methods is in all cases less than 10%.

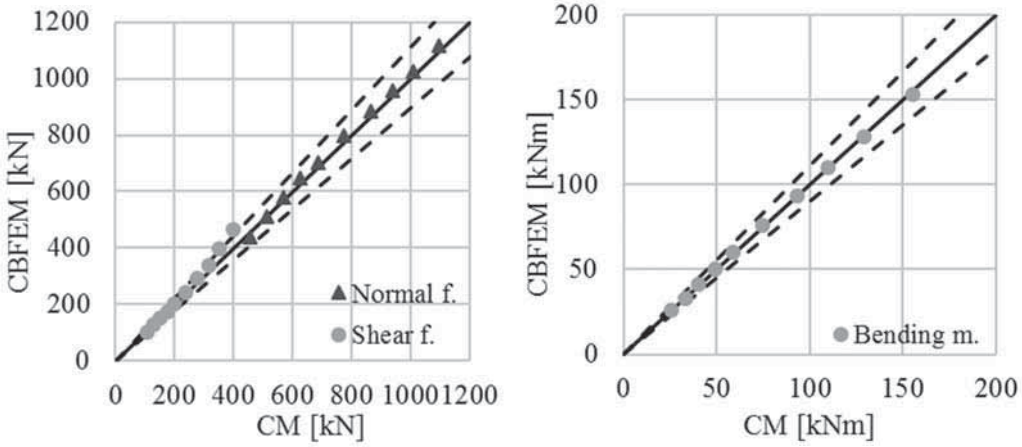

Fig. 4.4.5 Verification of CBFEM to CM

4.4.5 Benchmark example

Inputs

Column

- Steel S235
- HEB400

Beam

- Steel S235
- IPE270
- Length L = 200 mm
- Force eccentricity to weld x = 400 mm, see Fig. 4.4.6

Column stiffeners

- Thickness t_s = 10 mm
- Width b_s = 140 mm
- Related to beam flange, position upper and lower

Weld

- Throat thickness a_w = 3 mm

Outputs:

- Design resistance in shear V_{Rd} = 244 kN

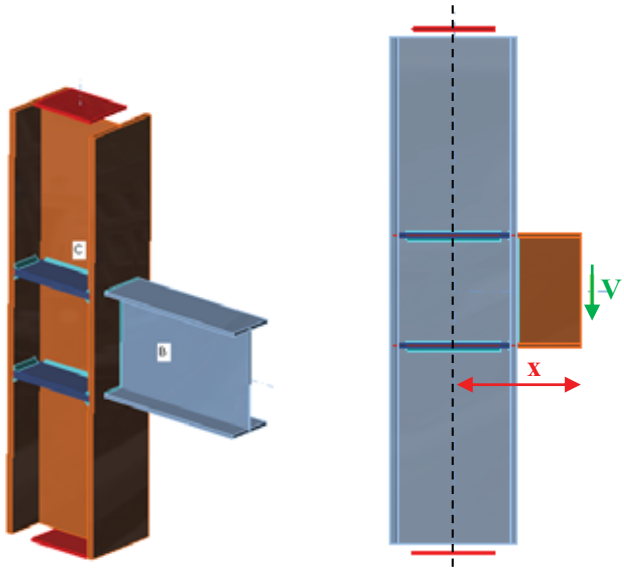

Fig. 4.4.6 Benchmark example of the welded beam to column joint with force eccentricity