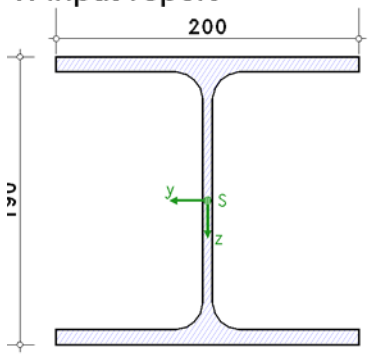
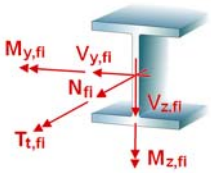
POS. 12: FIRE DESIGN EX. 5.13

fire design EC 3-1-2 (12.10), NA: Deutschland

1. input report



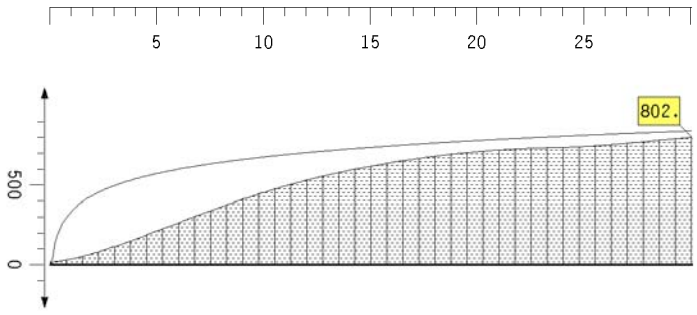
steel
steel grade S355
material safety factor
resistance of cross-sections γ_{M0} = 1.00
resistance of components in the event of fire $\gamma_{M,fi}$ = 1.00
geometry
section HE200A
cross-section temperature
thermal action due to the standard curve, fire resistance time t = 30 min
section all sides flamed
resistance
elastic verification incl. c/t-verification
fire design at load level
adjustment factors for uneven temperature distribution
across the cross section κ_1 = 1.00, along the beam κ_2 = 1.00
internal forces and moments (event of fire)
σ-generating forces (N, M) work at centroid, τ-generating forces (V, T_t) work at shear center
Lk 1: N_{fi} = 100.00 kN, $M_{y,fi}$ = 20.00 kNm



notes
stability is not investigated.

2. cross-section temperature

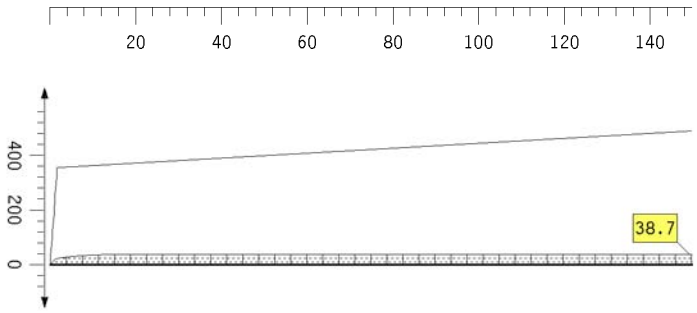
surface of the section exposed to fire A_m = 1136.1 mm²/mm
section factor of the unprotected component A_m/V = 1136.1 / 5383.1 ·10³ = 211.0 1/m
fire-stressed inner surface of the enclosing box A_b = 780.0 mm²/mm
section factor for the enclosing box A_b/V = 780.0 / 5383.1 ·10³ = 144.9 1/m
correction factor k_{sh} = (A_b/V) / (A_m/V) = 144.9 / 211.0 = 0.687, I-section: 0.9·k_{sh} = 0.618
temperature development:



temperature in °C
fire time in min
max T_a = 801.9°C
max t = 30 min

cross-section temperature acc. to t = 30 min: T_a = 801.9 °C
reduction factors: $k_{y,fi}$ = 0.109, $k_{p,fi}$ = 0.050, $k_{E,fi}$ = 0.090
material parameters: $f_{p,fi}$ = 17.7 N/mm², $f_{y,fi}$ = 38.7 N/mm², E_{fi} = 18809.1 N/mm², $\alpha_{T,fi}$ = 1.41·10⁻⁵ 1/K
limit of strains: $\varepsilon_{p,fi}$ = 0.939‰, $\varepsilon_{y,fi}$ = 20‰, $\varepsilon_{t,fi}$ = 150‰

stress-strain line:



stress in N/mm²
elongation in ‰
max $f_{y,fi}$ = 38.7 N/mm²
max ε_{fi} = 150.0‰

fire design with the simple design method s. EC 3-1-2, 4.2

3. Lk 1

3.1. fire design

internal forces and moments (event of fire): N_{fi} = 100.00 kN, $M_{y,fi}$ = 20.00 kNm

3.1.1. elastic verification

3.1.1.1. verification at load level

elastic verification for N = 100.00 kN, M_y = 20.00 kNm
elastic stresses: max $|\sigma_x|$ = 70.08 N/mm², max τ = 0.00 N/mm², max σ_v = 70.08 N/mm²
max σ_x bei y = 100.0 mm, z = 95.0 mm: σ_x = 70.08 N/mm², τ = 0.00 N/mm², σ_v = 70.08 N/mm²
min σ_x bei y = 100.0 mm, z = -95.0 mm: σ_x = -32.90 N/mm², τ = 0.00 N/mm², σ_v = 32.90 N/mm²
max σ_v bei y = 100.0 mm, z = 95.0 mm: σ_x = 70.08 N/mm², τ = 0.00 N/mm², σ_v = 70.08 N/mm²
valid equivalent stress: $\sigma_{v,Rd}$ = 38.7 N/mm²
verification: σ_v = 70.08 N/mm² > $\sigma_{v,Rd}$ = 38.71 N/mm² ⇒ U_σ = 1.810 > 1 **fault !!**

cross-section in class 3, material coefficient $\varepsilon = 0.85 \cdot (235/355.0)^{0.5}$ = 0.692
c/t-verification: outstand flange: utilization $U_{c/t}$ = 0.827 < 1 **ok**
internal compression parts: utilization $U_{c/t}$ = 0.241 < 1 **ok**
total: utilization $U_{c/t}$ = 0.827 < 1 **ok** (reg. section class 3)

4. final result

maximum utilization:	stress	max U_σ = 1.810 > 1 **fault !!**
	c/t-ratio	max $U_{c/t}$ = 0.827 < 1 **ok**
	resistance	max U = 1.810 > 1 **fault !!**

resistance not ensured !!

5. Regulations

DIN EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
DIN EN 1990/NA, Nationaler Anhang zur DIN EN 1990, Ausgabe Dezember 2010

DIN EN 1991-1-2, Eurocode 1: Einwirkungen auf Tragwerke - Teil 1-2: Allgemeine Einwirkungen - Brandeinwirkungen auf Tragwerke; Deutsche Fassung EN 1991-1-2, Ausgabe Dezember 2010
DIN EN 1991-1-2/NA, Nationaler Anhang zur DIN EN 1991-1-2, Ausgabe September 2015

DIN EN 1993-1-2, Eurocode 3: Bemessung und Konstruktion von Stahlbauten - Teil 1-2: Allgemeine Regeln - Tragwerksbemessung für den Brandfall; Deutsche Fassung EN 1993-1-2, Ausgabe Dezember 2010
DIN EN 1993-1-2/NA, Nationaler Anhang zur DIN EN 1993-1-2, Ausgabe Dezember 2010