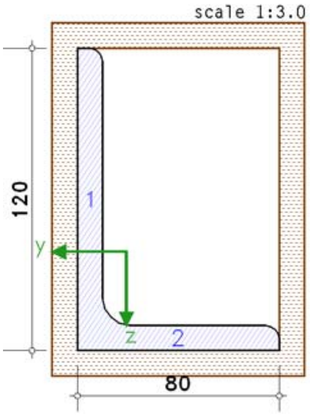
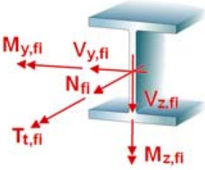
POS. 180: L-SECTION

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

1. input report



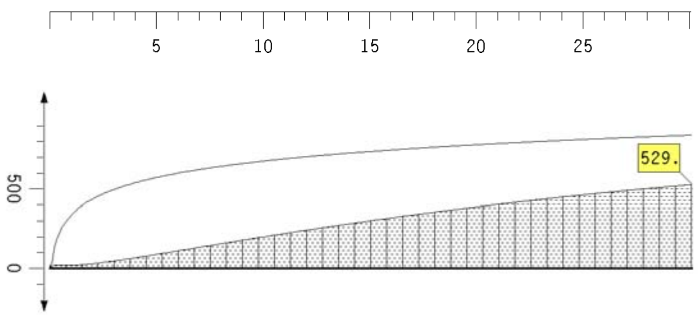
steel
steel grade S235
material safety factor
resistance of cross-sections γ_{M0} = 1.00
resistance of components in the event of fire $\gamma_{M,fi}$ = 1.00
geometry
section L 120 X 80 X 10
cross-section temperature
thermal action due to the standard curve, fire resistance time t = 30 min
section all sides flamed
thermal insulation protection by plate cladding s. EC 3-1-2, appendix AA:
thermal conductivity λ_p = 0.20 W/(m·K), specific heat capacity c_p = 1700 J/(kg·K), maximum density ρ_p = 945 kg/m³
thickness of insulating material d_p = 10.0 mm
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
plus verification at normal temperature, load factor $\eta_{fi} = E_{d,fi}/E_d$ = 0.700
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: $M_{y,fi}$ = 3.00 kNm, $M_{z,fi}$ = 2.00 kNm



notes
stability is not investigated.

2. cross-section temperature

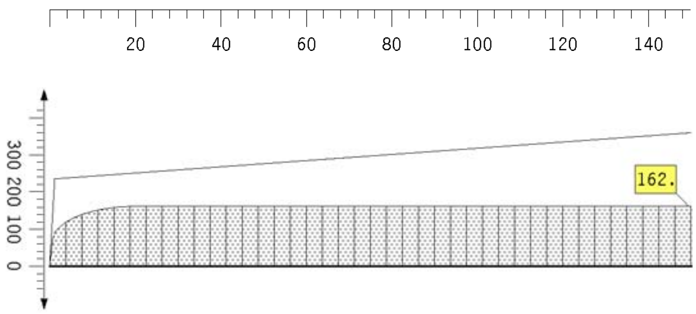
internal development of the fire-stressed box A_p = 400.0 mm²/mm
section factor of the protected component A_p/V = 400.0 / 1913.0 ·10³ = 209.1 1/m
temperature development:



temperature in °C
fire time in min
max T_a = 528.9°C
max t = 30 min

cross-section temperature acc. to t = 30 min: T_a = 528.9 °C
reduction factors: $k_{y,fi}$ = 0.690, $k_{p,fi}$ = 0.308, $k_{E,fi}$ = 0.516
material parameters: $f_{p,fi}$ = 72.4 N/mm², $f_{y,fi}$ = 162.2 N/mm², E_{fi} = 108397.1 N/mm², $\alpha_{T,fi} = 1.42 \cdot 10^{-5}$ 1/K
limit of strains: $\varepsilon_{p,fi}$ = 0.668‰, $\varepsilon_{y,fi}$ = 20‰, $\varepsilon_{t,fi}$ = 150‰

stress-strain line:



stress in N/mm²
elongation in ‰
max $f_{y,fi}$ = 162.2 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) refering to local axes of cross-section:
$M_{y,fi}$ = 3.00 kNm, $M_{z,fi}$ = 2.00 kNm
internal forces and moments (normal temperature, load factor η_{fi} = 0.700) refering to local axes of cross-section: $M_{y,Ed}$ = 4.29 kN
internal forces and moments (kalt) refering to main axes: $M_{\eta,Ed}$ = 5.07 kNm, $M_{\zeta,Ed}$ = 0.91 kNm

3.1.1. elastic verification

3.1.1.1. verification at load level

elastic verification for M_y = 3.00 kNm, M_z = 2.00 kNm
elastic stresses: max $|\sigma_x|$ = 111.65 N/mm², max τ = 0.00 N/mm², max σ_v = 111.65 N/mm²

max σ_x	bei y = -60.5 mm, z = 39.2 mm:	σ_x = 111.65 N/mm², τ = 0.00 N/mm², σ_v = 111.65 N/mm²
min σ_x	bei y = 19.5 mm, z = -80.8 mm:	σ_x = -75.06 N/mm², τ = 0.00 N/mm², σ_v = 75.06 N/mm²
max σ_v	bei y = -60.5 mm, z = 39.2 mm:	σ_x = 111.65 N/mm², τ = 0.00 N/mm², σ_v = 111.65 N/mm²

valid equivalent stress: $\sigma_{v,Rd}$ = 162.2 N/mm²
verification: σ_v = 111.65 N/mm² < $\sigma_{v,Rd}$ = 162.24 N/mm² ⇒ U_σ = 0.688 < 1 ok

cross-section in class 3, material coefficient $\varepsilon = 0.85 \cdot (235/235.0)^{0.5} = 0.850$
c/t-verification: outstand flange: utilization $U_{c/t}$ = 0.888 < 1 ok
total: utilization $U_{c/t}$ = 0.888 < 1 ok (reg. section class 3)

3.1.1.2. verification at normal temperature

elastic verification for M_y = 4.29 kNm, M_z = 2.86 kNm
elastic stresses: max $|\sigma_x|$ = 159.49 N/mm², max τ = 0.00 N/mm², max σ_v = 159.49 N/mm²

max σ_x	bei y = -60.5 mm, z = 39.2 mm:	σ_x = 159.49 N/mm², τ = 0.00 N/mm², σ_v = 159.49 N/mm²
min σ_x	bei y = 19.5 mm, z = -80.8 mm:	σ_x = -107.23 N/mm², τ = 0.00 N/mm², σ_v = 107.23 N/mm²
max σ_v	bei y = -60.5 mm, z = 39.2 mm:	σ_x = 159.49 N/mm², τ = 0.00 N/mm², σ_v = 159.49 N/mm²

valid equivalent stress: $\sigma_{v,Rd}$ = 235.0 N/mm²
verification: σ_v = 159.49 N/mm² < $\sigma_{v,Rd}$ = 235.00 N/mm² ⇒ U_σ = 0.679 < 1 ok

cross-section in class 3, material coefficient $\varepsilon = (235/235.0)^{0.5} = 1.000$
c/t-verification: outstand flange: utilization $U_{c/t}$ = 0.484 < 1 ok
total: utilization $U_{c/t}$ = 0.484 < 1 ok (reg. section class 3)

4. final result

maximum utilization:	stress	max U_σ = 0.688 < 1 ok
	c/t-ratio	max $U_{c/t}$ = 0.888 < 1 ok
	resistance	max U = 0.888 < 1 ok

verification succeeded

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 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-1/A1, Ergänzungen zur DIN EN 1993-1-1, Ausgabe Juli 2014
DIN EN 1993-1-1/NA, Nationaler Anhang zur DIN EN 1993-1-1, Ausgabe Dezember 2018

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