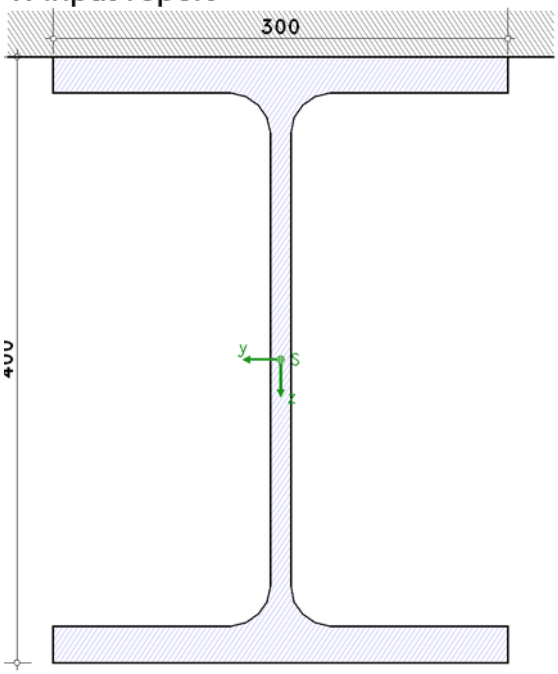
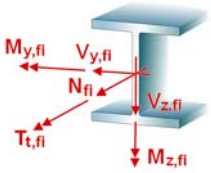
POS. 11: FIRE DESIGN EX. 5.6

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

1. input report



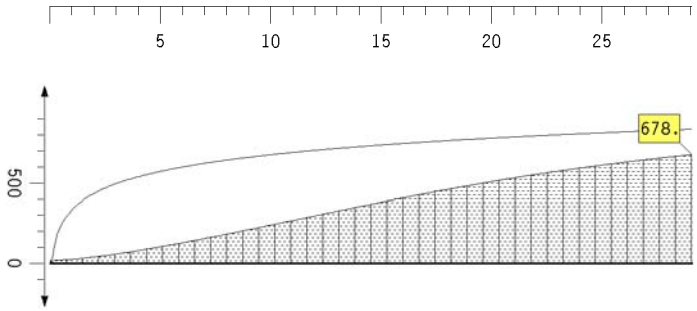
steel
steel grade S235
material safety factor
resistance of cross-sections γ_{M0} = 1.00
resistance of components in the event of fire $\gamma_{M,fi}$ = 1.00
geometry
section HE400B
cross-section temperature
thermal action due to the standard curve, fire resistance time t = 29 min
shadow effect of the section by wall/ceiling top
resistance
plastic verification incl. c/t-verification
fire design at load level
adjustment factors for uneven temperature distribution
across the cross section κ_1 = 0.70, 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: $M_{y,fi}$ = 306.00 kNm



notes
stability is not investigated.

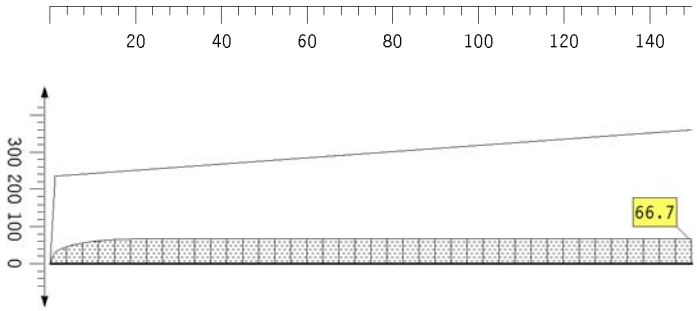
2. cross-section temperature

surface of the section exposed to fire A_m = 1626.6 mm²/mm
section factor of the unprotected component A_m/V = 1626.6 / 19777.8 ·10³ = 82.2 1/m
fire-stressed inner surface of the enclosing box A_b = 1100.0 mm²/mm
section factor for the enclosing box A_b/V = 1100.0 / 19777.8 ·10³ = 55.6 1/m
correction factor k_{sh} = (A_b/V) / (A_m/V) = 55.6 / 82.2 = 0.676, I-section: 0.9·k_{sh} = 0.609
temperature development:



temperature in °C
fire time in min
max T_a = 677.5°C
max t = 29 min

cross-section temperature acc. to t = 29 min: T_a = 677.5 °C
reduction factors: $k_{y,fi}$ = 0.284, $k_{p,fi}$ = 0.099, $k_{E,fi}$ = 0.170
material parameters: $f_{p,fi}$ = 23.2 N/mm², $f_{y,fi}$ = 66.7 N/mm², E_{fi} = 35799.6 N/mm², $\alpha_{T,fi}$ = 1.48·10^{-5} 1/K
limit of strains: $\varepsilon_{p,fi}$ = 0.647‰, $\varepsilon_{y,fi}$ = 20‰, $\varepsilon_{t,fi}$ = 150‰
stress-strain line:



stress in N/mm²
elongation in ‰
max $f_{y,fi}$ = 66.7 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, uneven temperature distribution): $M_{y,fi}$ = 214.20 kNm

3.1.1. plastic verification

3.1.1.1. verification at load level

plastic verification for M_y = 214.20 kNm
valid equivalent stress: $\sigma_{v,Rd}$ = 66.7 N/mm²
zero-line of limit of strains (plastic): y_0 = 0.00 cm, z_0 = -0.00 cm, α = 180.000°
limit of strains of cross-section (plastic): ε_{min} = -150.00 ‰, ε_{max} = 150.00 ‰
limit of normal stresses of cross-section (plastic): σ_{min} = -66.73 N/mm², σ_{max} = 66.73 N/mm²
limit of equivalent stresses of cross-section (plastic): $\sigma_{V,min}$ = 0.00 N/mm², $\sigma_{V,max}$ = 66.73 N/mm²
max. load factor of normal stresses (plastic): $f_{\sigma,pl}$ = 1.007 ⇒ $U_{\sigma,pl}$ = 0.993
verification: U_{pl} = 0.993 < 1 ok

cross-section in class 1, material coefficient $\varepsilon = 0.85 \cdot (235/235.0)^{0.5}$ = 0.850
c/t-verification: outstand flange: utilization $U_{c/t}$ = 0.570 < 1 ok
internal compression parts: utilization $U_{c/t}$ = 0.313 < 1 ok
total: utilization $U_{c/t}$ = 0.570 < 1 ok (reg. section class 2)

4. final result

maximum utilization:	stress	max U_σ = 0.993 < 1 ok
	c/t-ratio	max $U_{c/t}$ = 0.570 < 1 ok
	resistance	max U = 0.993 < 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 1993-1-2, 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