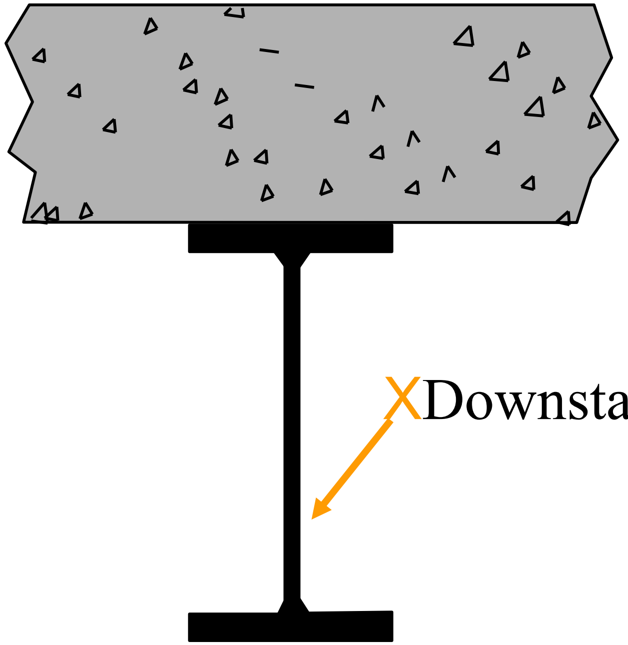
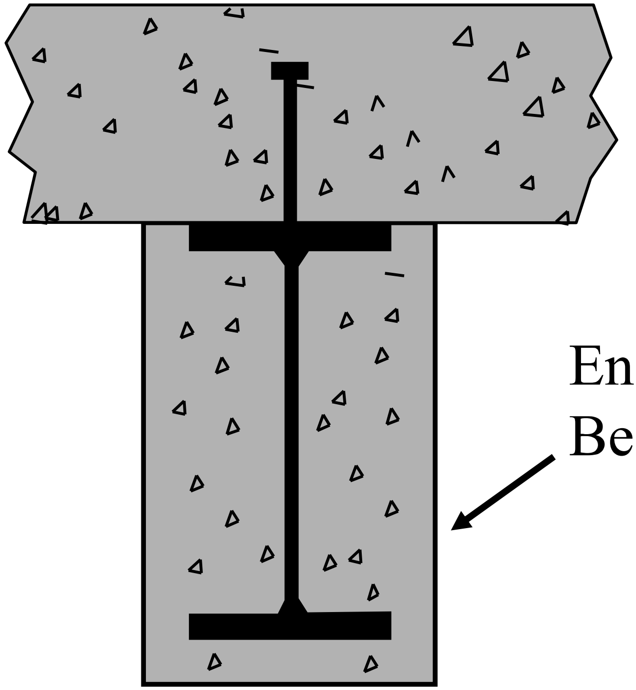
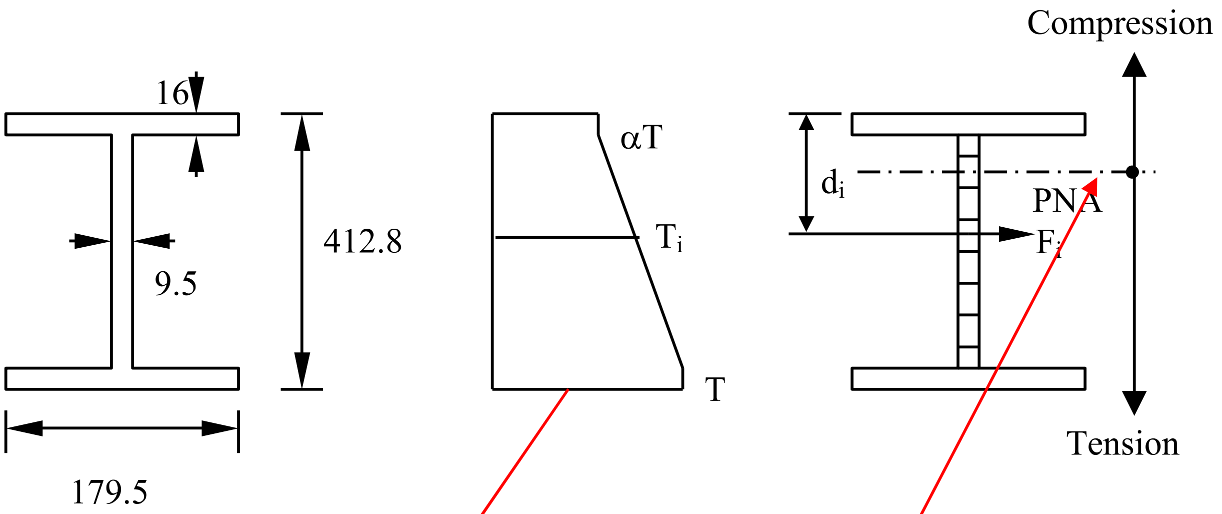
Steel and Composite Beams



Downstand Beam



Encased Beam



In general, because the temperature distribution in the steel section is non-uniform, the steel section is divided into layers of approximately the same temperatures.

Part i	Temperature T_i (°C)	Resultant force $F_i = p_y(T_i) * A_i$ (kN)	Lever arm from top d_i (mm)	Bending moment $= F_i * d_i$ (kN.m)
Upper flange	650*0.8=520	-565.81	8	-4.53
Web 1	528.13	-86.08	39.8	-3.43
Web 2	544.38	-24.10	70.76	-1.71
		55.96	94.56	5.29
Web 3	560.63	73.93	135.0	9.98
Web 4	576.88	67.74	182.6	12.37
Web 5	593.13	61.56	230.2	14.17
Web 6	609.38	55.75	277.8	15.49
Web 7	625.63	50.21	325.4	16.34
Web 8	641.88	44.68	373.0	16.66
Lower flange	650.0	266.16	404.8	107.74
Total	NA	0	NA	**188.39**

Simple Method in Eurocode 3 Part 1.2

The full plastic bending moment method involves lengthy calculations. For steel temperature distribution based on a steel section supporting a concrete slab, the approximate calculation method is:

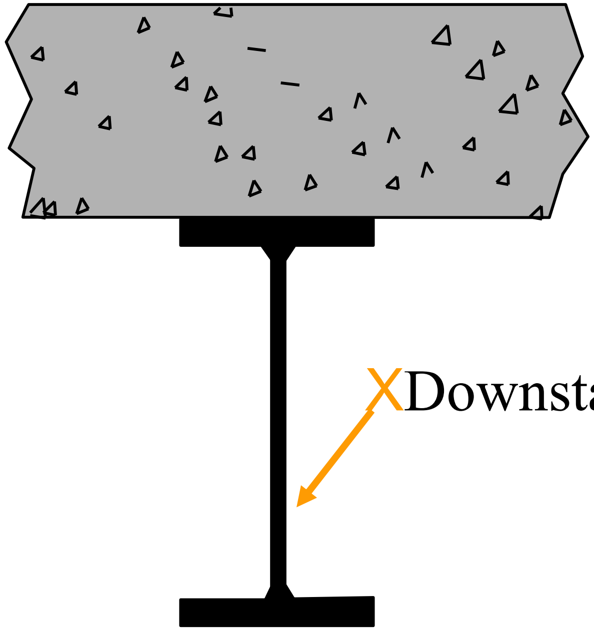
$$M_{P,fi} = k_{y,T} M_p / (\kappa_1 \kappa_2)$$

k_1=1.0 for uniform heating across section/for composite beam, k_1=0.7 for steel beam with three sided heating

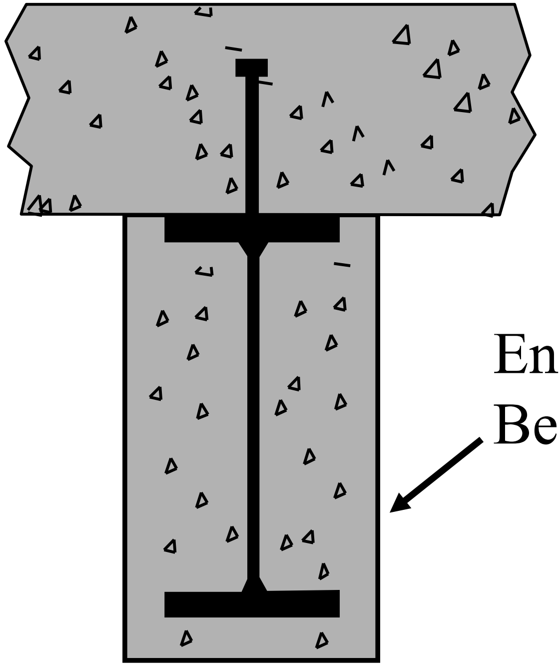
k_2=1.0 for uniform heating along length, k_2=0.85 for hogging bending moment near supports

Previous example: Section UB406x178x74, steel grade S275, W_{pl}=1501cm^3, steel retention factor =0.337 at 650^{o}C, $M_{p,fi}$=1501* 0.337*0.275/0.7=198.7 kN.m. Compare this to 188.39 kN.m from previous calculations.

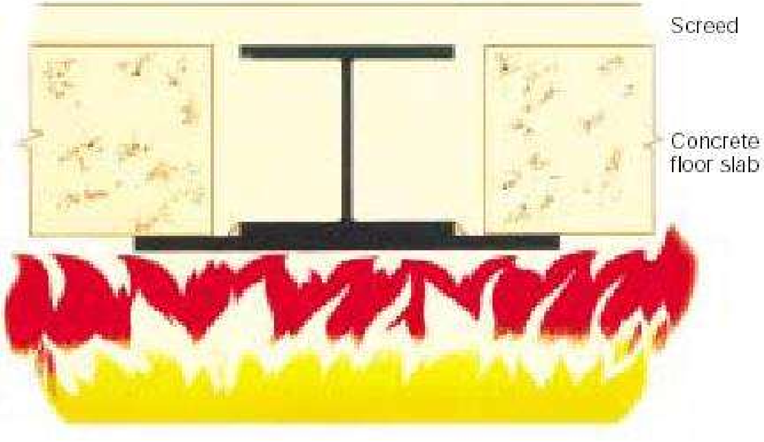
Limit of simple method



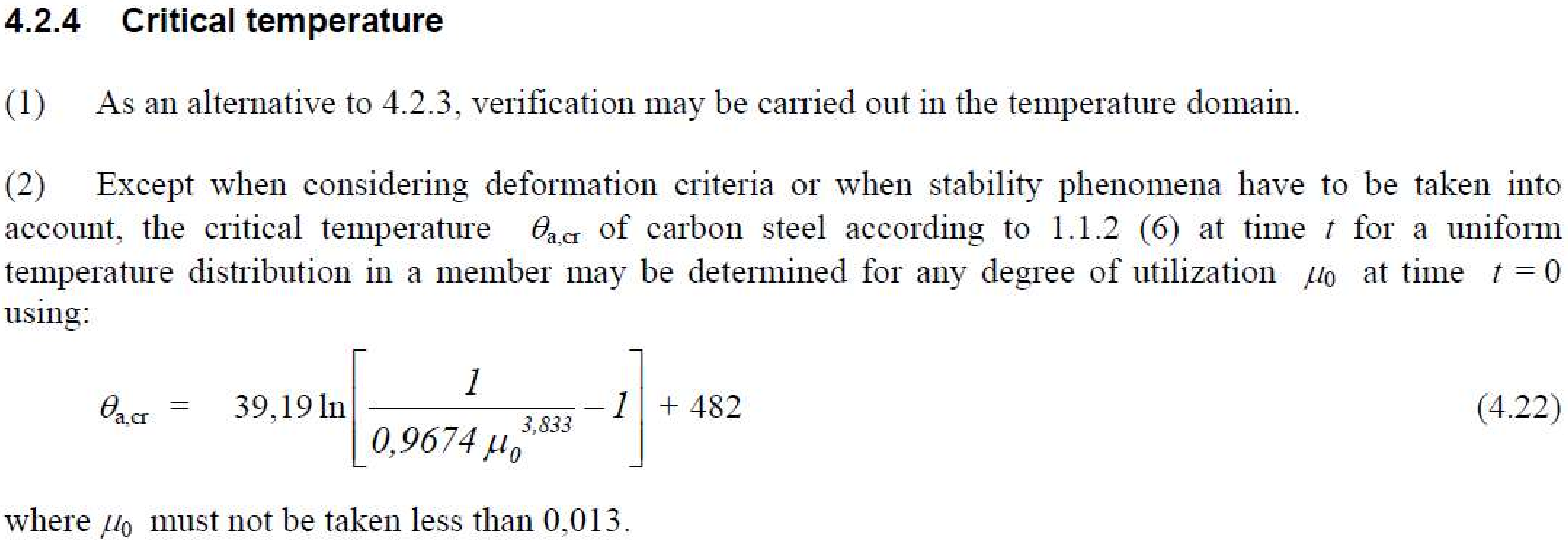
XDownstand Beam



Encased Beam



Critical temperature



4.2.4 Critical temperature

(1) As an alternative to 4.2.3, verification may be carried out in the temperature domain.

(2) Except when considering deformation criteria or when stability phenomena have to be taken into account, the critical temperature $\theta_{a,cr}$ of carbon steel according to 1.1.2 (6) at time t for a uniform temperature distribution in a member may be determined for any degree of utilization μ_0 at time $t = 0$ using:

$$\theta_{a,cr} = 39{,}19 \ln\left[\frac{1}{0{,}9674\,\mu_0^{3{,}833}} - 1\right] + 482 \qquad (4.22)$$

where μ_0 must not be taken less than 0,013.

Calculating Load Ratio: Beam Example

Ambient temperature design data:

9m, Dead load = 10.5 kN/m, Imposed Load = 15 kN/m,

UKB 457x152x52, f_y=355N/mm^2, M_{pl}=389 kN.m

Calculating load ratio (assuming φ_{fi}=0.5):

UDL=1.0*10.5+0.5*15=18kN/m

$M_{fire}=1/8 * 18 * 9^2 = 182$ kN.m

Load ratio = 182/389 = 0.47