Steel Design to Eurocode 3

Brittle Fracture

Steel sub-grade selection

Brittle failure is most likely to occur at very low temperatures. It should be considered where there are tensile stresses. It can be avoided by choosing a steel with sufficient fracture toughness

Failure mainly dependent on:

- Steel strength grade
- Thickness
- Lowest service temperature
- Material toughness
- Tensile Stress
- Notches or defects in the element

Steel toughness

Steel toughness is measured by Charpy V-notch value. The Charpy test measures how much energy is absorbed by a steel sample, at a given temperature.

- S275 JR - Charpy value of 27 J can be obtained at +20°C
- S275 J0 - Charpy value of 27J can be obtained at 0°C
- S275 J2 - Charpy value of 27J can be obtained at -20°C

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The method given in the Eurocodes can be quite complex to use, it is recommended that you use Published Document PD 6695 instead.

The service temperature is lowered i.e. it becomes a reference temperature. Refer to table 2.1 of the Eurocodes so determine the steel sub grade, below is an extract from that table.

$f_y(t)$

$f_y(t) = f_{y,nom} - 0.25\ (t/t_0)$

but t_0 = 1mm, so $f_y(t) = f_{y,nom} - 0.25\ (t)$.

PD 6695-1-10

- Published Document is much Simpler to use
  - Internal T_{md} is -5°C (Table 2)
  - External is T_{md} -15°C (Table 3)

NOTE: Can only use this document for design in the UK

Steel grade	Sub-grade	Charpy Energy CVN		Reference temperature T_{Ed} [°C]													
		At T [°C]	J_{min}	10	0	-10	-20	-30	-40	-50	10	0	-10	-20	-30	-40	-50
				$\sigma_{Ed} = 0.75\ f_y(t)$							$\sigma_{Ed} = 0.50\ f_y(t)$						
S275	JR	20	27	55	45	35	30	25	20	15	80	70	55	50	40	35	30
	J0	0	27	75	65	55	45	35	30	25	115	95	80	70	55	50	40
	J2	-20	27	110	95	75	65	55	45	35	155	130	115	95	80	70	55
S355	JR	20	27	40	35	25	20	15	15	10	65	55	45	40	30	25	25
	J0	0	27	60	50	40	35	25	20	15	95	80	65	55	45	40	30
	J2	-20	27	90	75	60	50	40	35	25	135	110	95	80	65	55	45

EN 1993-1-10: Table 2.1: Maximum permissible values of element thickness t in mm

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Table 2 Maximum thicknesses for internal steelwork in buildings for T_{md} = -5°C

Detail type		**Tensile stress level, $\sigma_{Ed}/f_y(t)$**							
Description	**ΔT_{RD}**								
'Plain material'	+30°C	≤0	0.15	0.3	≥0.5				
'Bolted'	+20°C		≤0	0.15	0.3	≥0.5			
'Welded – moderate'	0°C				≤0	0.15	0.3	≥0.5	
'Welded – severe'	-20°C						≤0	0.15	0.3
'Welded – very severe'	-30°C							≤0	0.15
Steel grade	**Subgrade**	**Maximum thickness, mm**							
S275	JR	122.5	102.5	85	70	60	50	40	32.5
	J0	142.5	120	100	82.5	67.5	55	45	37.5
	J2	200	200	192.5	172.5	147.5	122.5	102.5	85
S355	JR	82.5	67.5	55	45	37.5	30	22.5	17.5
	J0	142.5	120	100	82.5	67.5	55	45	37.5
	J2	190	167.5	142.5	120	100	82.5	67.5	55

Table 3 Maximum thicknesses for external steelwork in buildings for T_{md} = -15°C

Detail type		**Tensile stress level, $\sigma_{Ed}/f_y(t)$**							
Description	**ΔT_{RD}**								
'Plain material'	+30°C	≤0	0.15	0.3	≥0.5				
'Bolted'	+20°C		≤0	0.15	0.3	≥0.5			
'Welded – moderate'	0°C				≤0	0.15	0.3	≥0.5	
'Welded – severe'	-20°C						≤0	0.15	0.3
'Welded – very severe'	-30°C							≤0	0.15
Steel grade	**Subgrade**	**Maximum thickness, mm**							
S275	JR	70	60	50	40	32.5	27.5	22.5	17.5
	J0	172.5	147.5	122.5	102.5	85	70	60	50
	J2	200	192.5	172.5	147.5	102.5	102.5	85	70
S355	JR	45	37.5	30	22.5	15	15	12.5	10
	J0	120	100	82.5	67.5	45	45	37.5	30
	J2	167.5	142.5	120	100	67.5	67.5	55	45