STEEL DESIGN TO EUROCODE 3

GENERAL PRINCIPLES

THE LIMIT STATE DESIGN METHOD CAN BE SUMMARISED AS FOLLOWS:

- **IDENTIFYING RELEVANT LIMIT STATES AT WHICH STRUCTURAL BEHAVIOUR IS TO BE CHECKED**
- **FOR EACH OF THESE STATES DETERMINING RELEVANT LOADS/ACTIONS AND RESULTING DESIGN EFFECTS**
- **CHECKING THAT NONE OF THE LIMIT STATES ARE EXCEEDED**

LIMIT STATE DESIGN

THIS CAN BE EXPRESSED MATHEMATICALLY AS

$$R_d \geq S_d$$

WHERE

S_d IS THE DESIGN EFFECT OF THE LOADS I.E. INTERNAL FORCES AND MOMENTS, AND IS GIVEN BY

$$S_d = f_n \{\gamma_{f1} F_{k,1}, \gamma_{f2} F_{k,2}, \gamma_{f3} F_{k,3} \ldots\ldots\}$$

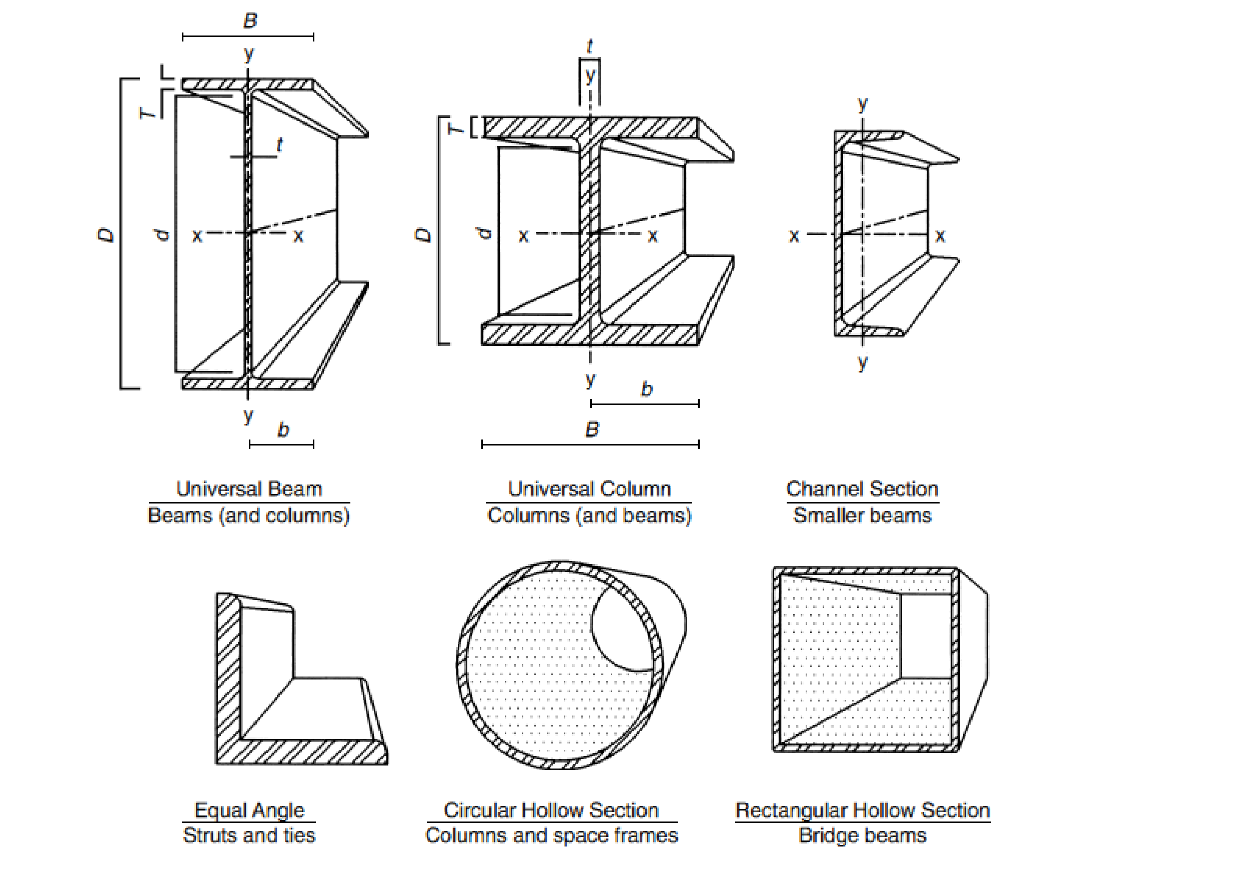
R_d IS THE DESIGN STRENGTH OF ELEMENT OR STRUCTURE AND IS GIVEN BY

$$R_d = f_n \{f_1/\gamma_{m1}\ f_2/\gamma_{m2}, f_3/\gamma_{m3} \ldots\ldots\}$$

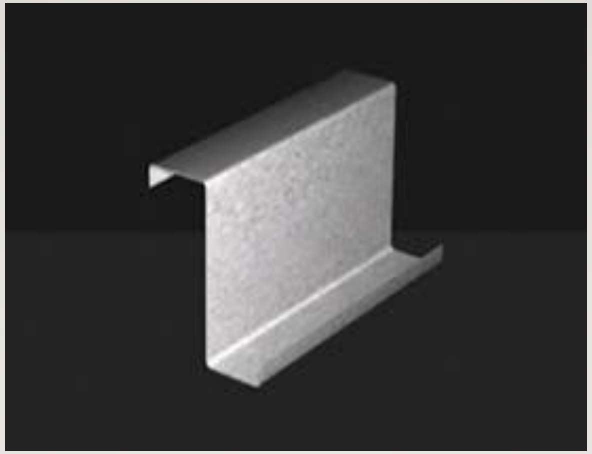
LIMIT STATES RELEVANT TO THE DESIGN OF STEEL STRUCTURES

ULTIMATE	SERVICEABILITY
• STRENGTH (INCLUDING GENERAL YIELDING, RUPTURE, BUCKLING AND FORMING A MECHANISM) • STABILITY AGAINST OVERTURNING AND SWAY STABILITY • FRACTURE DUE TO FATIGUE • BRITTLE FRACTURE	• DEFLECTION • VIBRATION • WIND INDUCED OSCILLATION • DURABILITY

STANDARD ROLLED STEEL SECTION



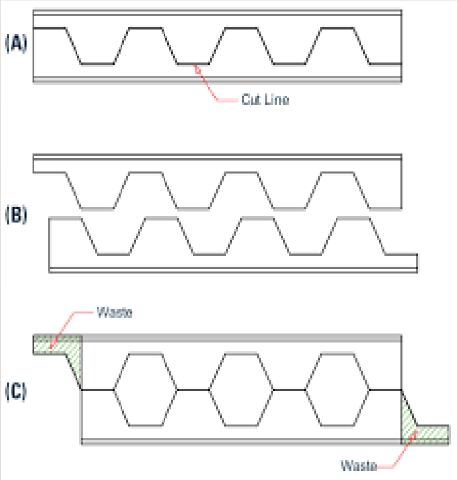
SIGMA BEAM



ZED BEAM

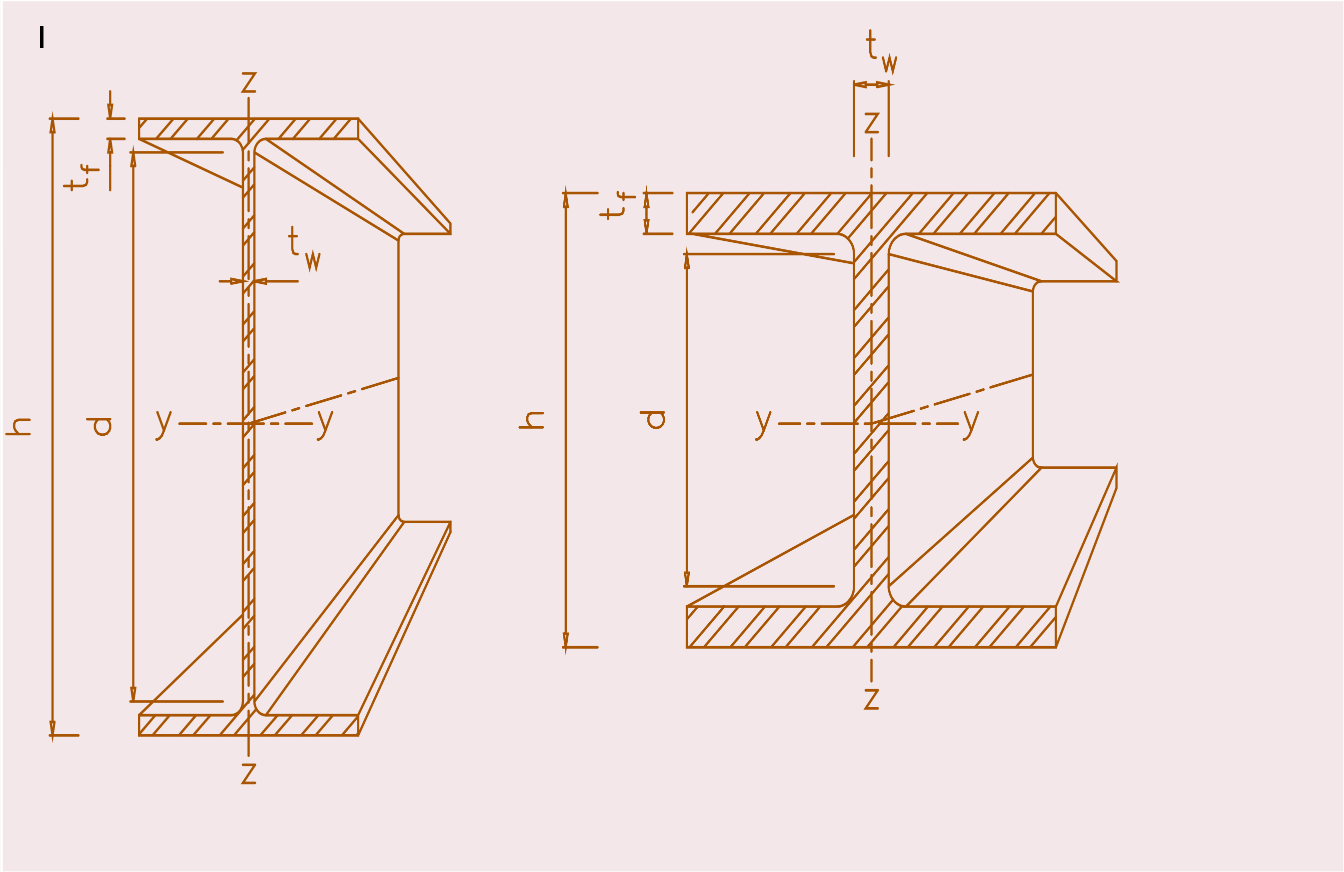
SIGMA AND ZED SHEETING RAILS

CASTELLATED BEAM



MANUFACTURING PROCESS

MEMBER DEFINITIONS AND AXES USED IN EC3



CHARACTERISTIC LOADS/ACTIONS

CHARACTERISTIC PERMANENT (g_k, G_k), VARIABLE (q_k, Q_k) AND WIND ACTIONS (W_k) ARE OBTAINED FROM:

- EN 1991: ACTIONS ON STRUCTURES (EC1)
- MANUFACTURER'S LITERATURE

OTHER DOCUMENTS

- BS 6399: PART 1 – DEAD AND IMPOSED LOADS
- BS648 – WEIGHT OF BUILDING MATERIALS
- CP3: CHAPTER V: PART 2 / BS 6399: PART 2 – WIND LOADS

SCOPE OF EUROCODE 1

Document No	Subject
BS EN 1991-1-1	Densities, self-weight and imposed loads for buildings
BS EN 1991-1-2	Actions on structures exposed to fire
BS EN 1991-1-3	Snow loads
BS EN 1991-1-4	Wind loads
BS EN 1991-1-5	Thermal actions
BS EN 1991-1-6	Actions during execution
BS EN 1991-1-7	Accidental actions due to impact and explosions
BS EN 1991-2	Traffic loads on bridges
BS EN 1991-3	Actions induced by cranes and machinery
BS EN 1991-4	Actions in silos and tanks

DESIGN LOADS/ACTION – ULTIMATE LIMIT STATES

DESIGN LOADS/ACTIONS AT ULTIMATE LIMIT STATE FOR STRENGTH AND STABILITY CALCULATIONS – THE CHARACTERISTIC LOADS/ACTIONS ARE MULTIPLIED BY A PARTIAL SAFETY FACTOR TAKEN FROM EN 1990 (EC0).

SEVERAL LOAD CASES MAY NEED TO BE CONSIDERED TO OBTAIN A "WORST CASE" ENVELOP OF FORCES AND MOMENTS AROUND THE STRUCTURE.

DESIGN VALUE OF ACTIONS (EN 1990)

THE DESIGN VALUE OF ACTION EFFECTS, E_d, ASSUMING THE STRUCTURE IS SUBJECTED TO BOTH A PERMANENT ACTION AND A VARIABLE ACTION CAN BE ASSESSED USING THE FOLLOWING EXPRESSION

$$E_d = \sum_{j\geq 1} \gamma_{G,j} G_{k,j} \text{ " + " } \gamma_{Q,1} Q_{k,1}$$

THE DESIGN VALUE OF AN ACTION EFFECT DUE TO A PERMANENT ACTION AND TWO (OR MORE) VARIABLE ACTIONS E.G. IMPOSED PLUS WIND LOAD, IS OBTAINED USING THE FOLLOWING EXPRESSION:

$$E_d = \sum_{j\geq 1} \gamma_{G,j} G_{k,j} \text{ "+" } \gamma_{Q,1} Q_{k,1} \text{ " + " } \sum_{i\geq 1} \gamma_{Q,i} \psi_{O,\,iQk,1}$$

PARTIAL LOAD FACTORS

PARTIAL LOAD FACTORS FOR COMMON LOAD COMBINATIONS (BASED ON EN 1990)

COMMON LOAD COMBINATIONS AND FACTORS
• $1.35G_k$ "+" $1.5Q_k$ • $1.35G_k$ "+" $1.5W_k$ • $1.00G_k$ "+" $1.5W_k$ (uplift) • $1.35G_k$ "+" $1.5Q_k$ "+" $0.75W_k$ • $1.35G_k$ "+" $1.05Q_k$ "+" $1.5W_k$

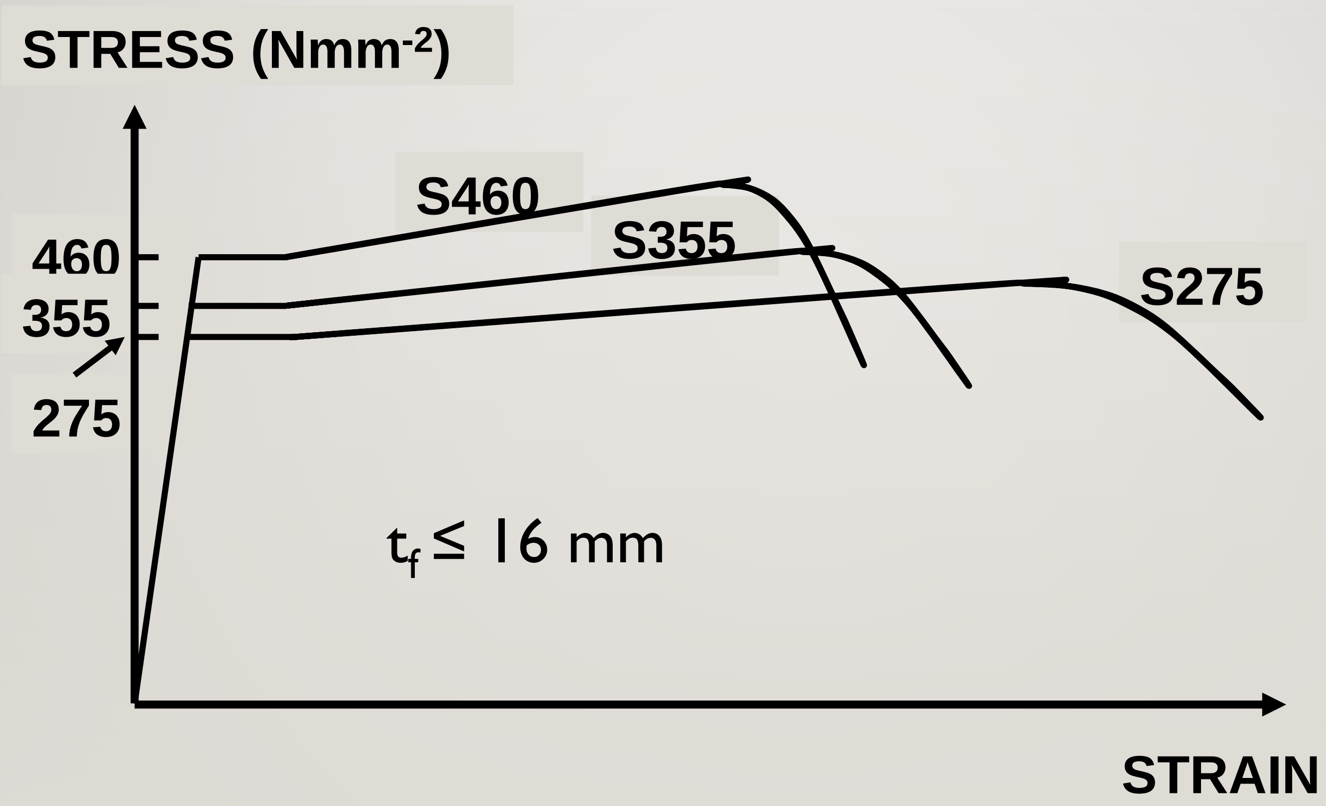
DESIGN LOADS/ACTION – SERVICEABILITY LIMIT STATES

TO OBTAIN DESIGN LOADING AT SERVICEABILITY LIMIT STATE FOR CALCULATION OF DEFLECTIONS USE THE MOST ADVERSE REALISTIC COMBINATION OF <u>UNFACTORED</u> IMPOSED LOADS/VARIABLE ACTIONS.

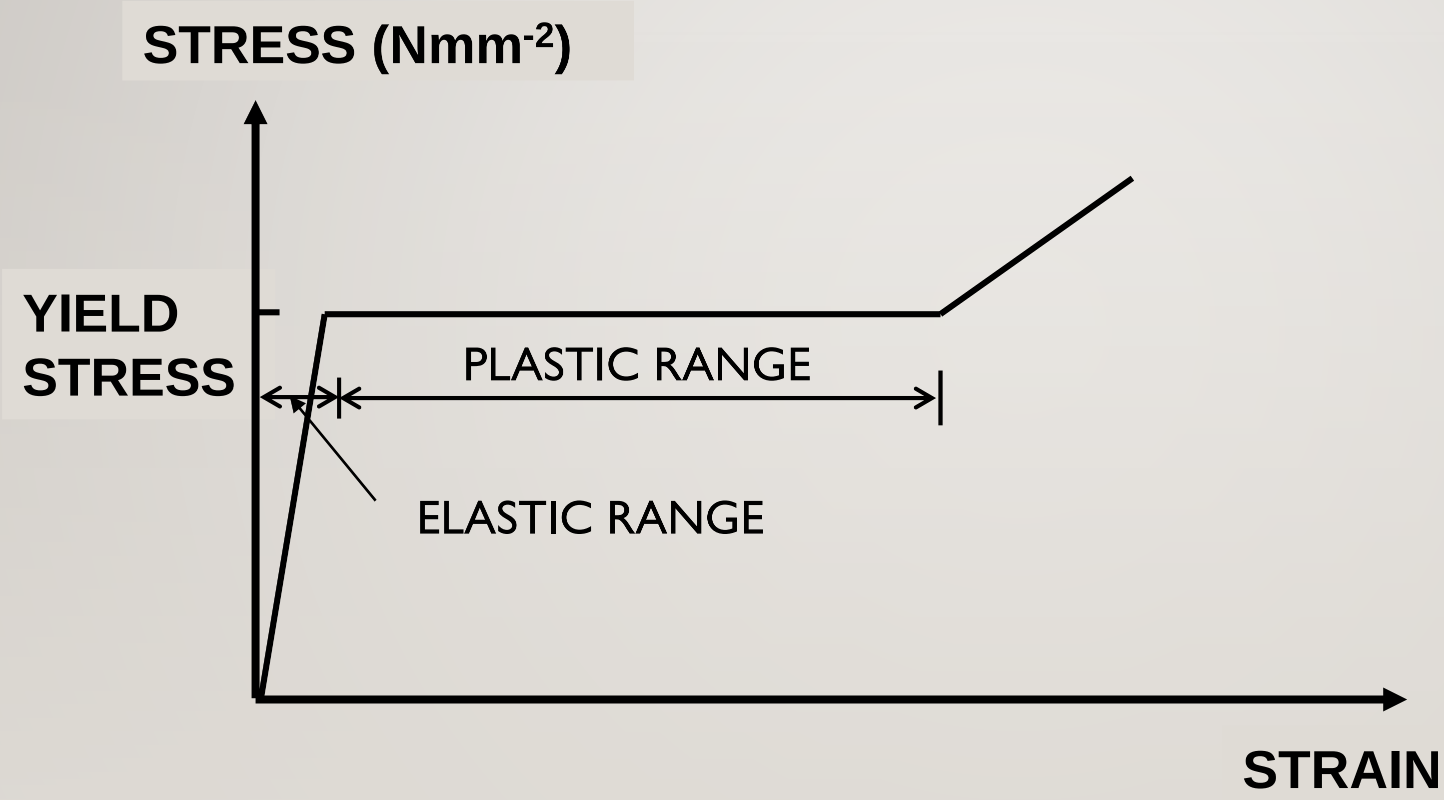
CHARACTERISTIC AND DESIGN STRENGTHS

STRUCTURAL STEEL IS MANFACTURED IN FOUR BASIC GRADES: S235, S275, S355 AND S460, IN WHICH 'S' STANDS FOR STRUCTURAL STEEL AND 235, 275, ETC DENOTE THE YIELD STRENGTH OF THE MATERIAL

ACTUAL STRESS-STRAIN CURVES



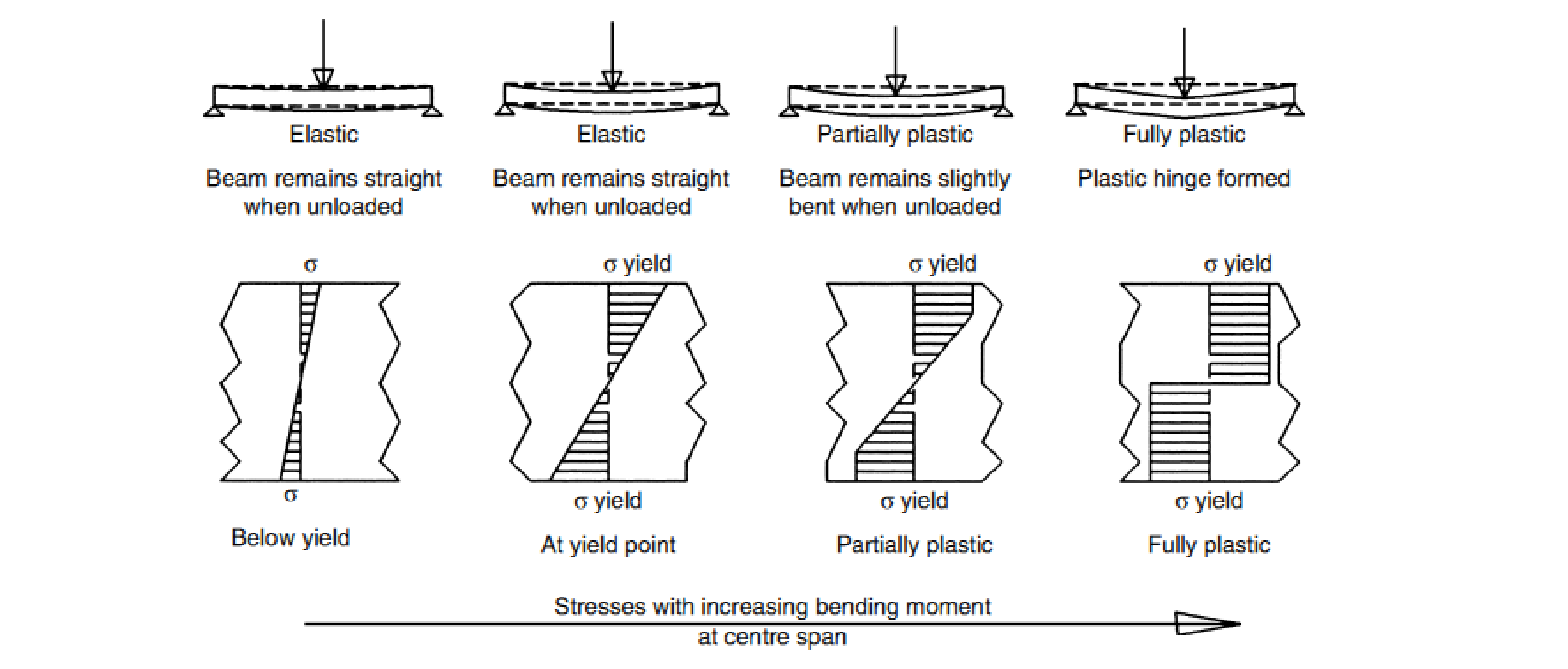
IDEALISED STRESS STRAIN CURVE



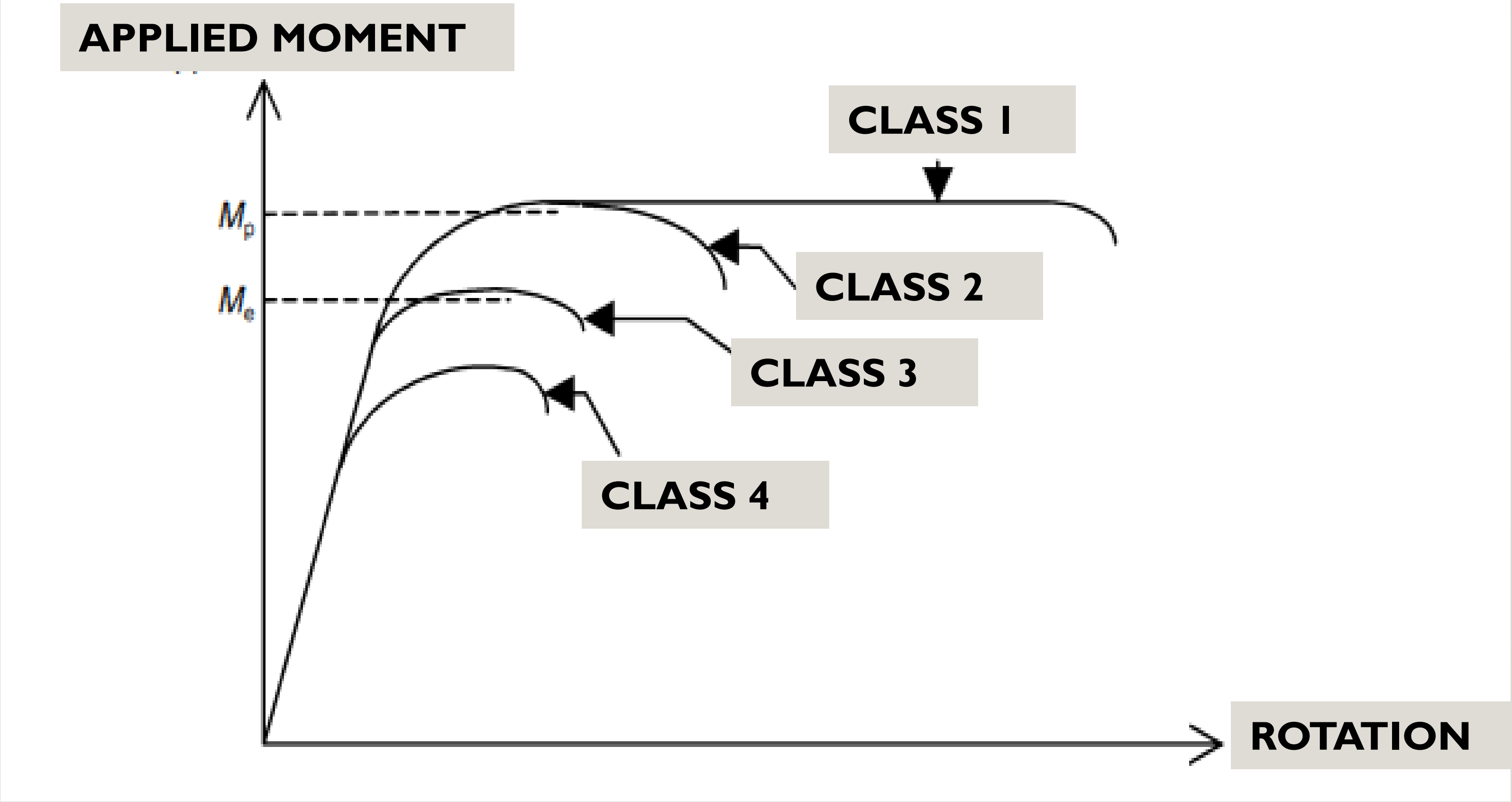
STEEL GRADE, YIELD & ULTIMATE STRENGTHS (EXTRACTED FROM EN10025-2: 2019: TABLE 6)

STEEL GRADE	THICKNESS OF FLANGE t_f (mm)	YIELD STRENGTH, f_y (Nmm^{-2})	ULTIMATE STRENGTH, f_u (Nmm^{-2})
S235	≤ 16 > 16 ≤ 40 > 40 ≤ 100	235 225 215	360 360 360
S275	≤ 16 > 16 ≤ 40 > 40 ≤ 63	275 265 255	430 410 410
S355	≤ 16 > 16 ≤ 40 > 40 ≤ 63	355 345 335	510 470 470

BENDING FAILURE OF A BEAM



BEHAVIOUR IN BENDING OF DIFFERENT CLASSES OF SECTION



LIMITING WIDTH TO THICKNESS RATIOS (BASED ON TABLE 5.2, EC3)

TYPE OF ELEMENT (ALL ROLLED SECTIONS)	Class of section		
	(1)	(2)	(3)
OUTSTAND ELEMENT OF COMPRESSION FLANGE	$c/t \leq 9\varepsilon$	$c/t \leq 10\varepsilon$	$c/t \leq 14\varepsilon$
WEB WITH NEUTRAL AXIS AT MID-DEPTH	$c/t \leq 72\varepsilon$	$c/t \leq 83\varepsilon$	$c/t \leq 124\varepsilon$
WEB WHERE THE WHOLE CROSS-SECTION IS SUBJECT TO AXIAL COMPRESSION ONLY	$c/t \leq 33\varepsilon$	$c/t \leq 38\varepsilon$	$c/t \leq 42\varepsilon$
Note. $\varepsilon = (235/f_y)^{1/2}$			