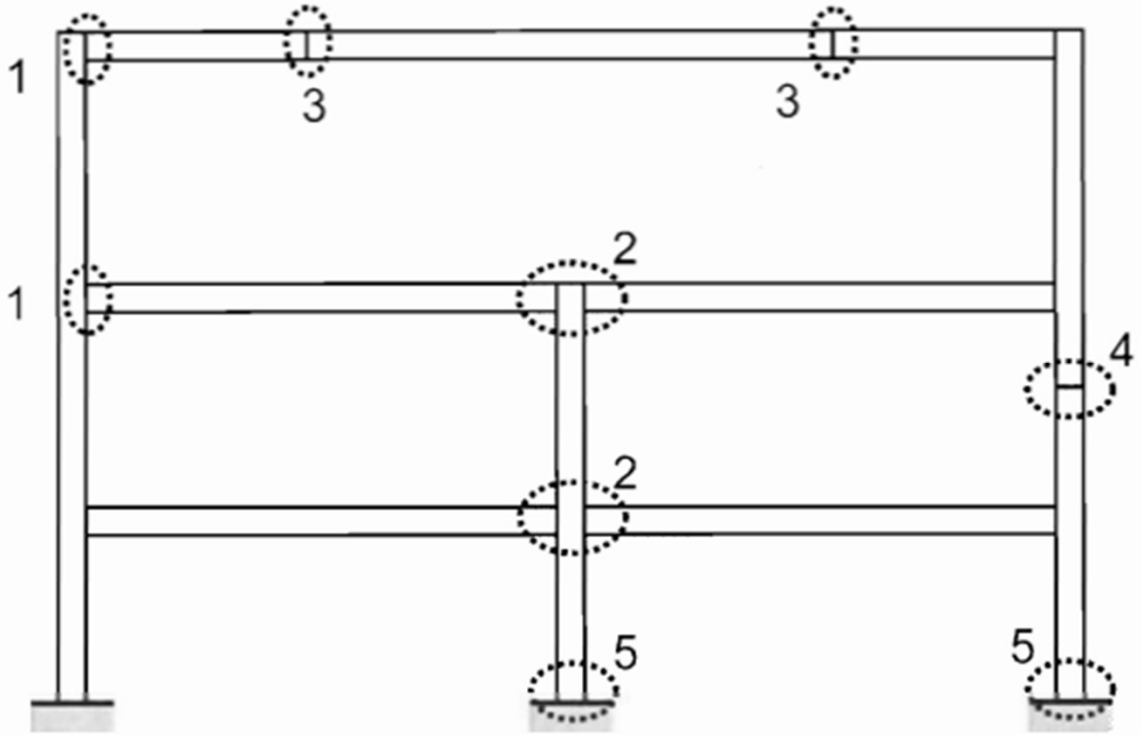
Introduction



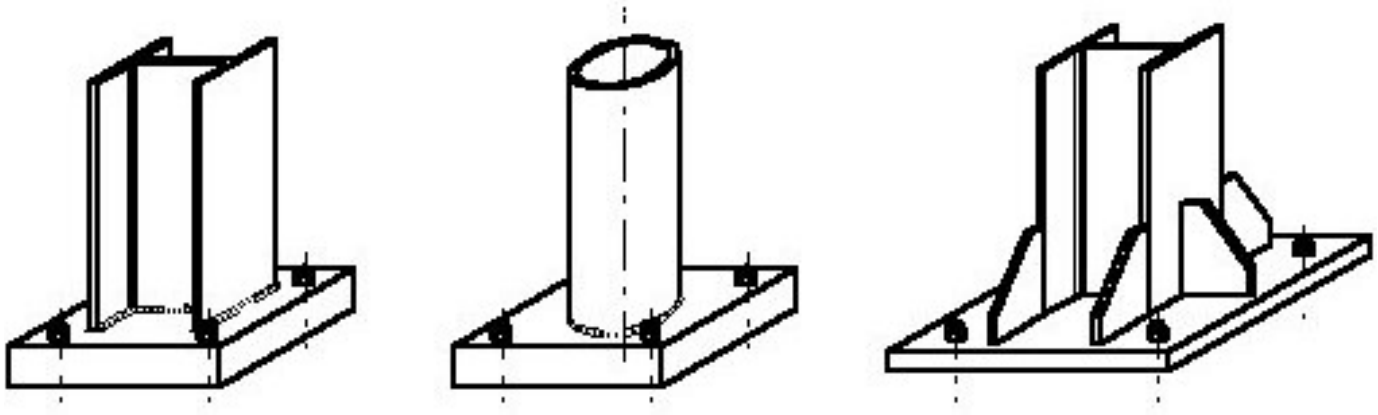
1 *Single-sided beam-to-column joint configuration;*

2 *Double-sided beam-to-column joint configuration;*

3 *Beam splice;*

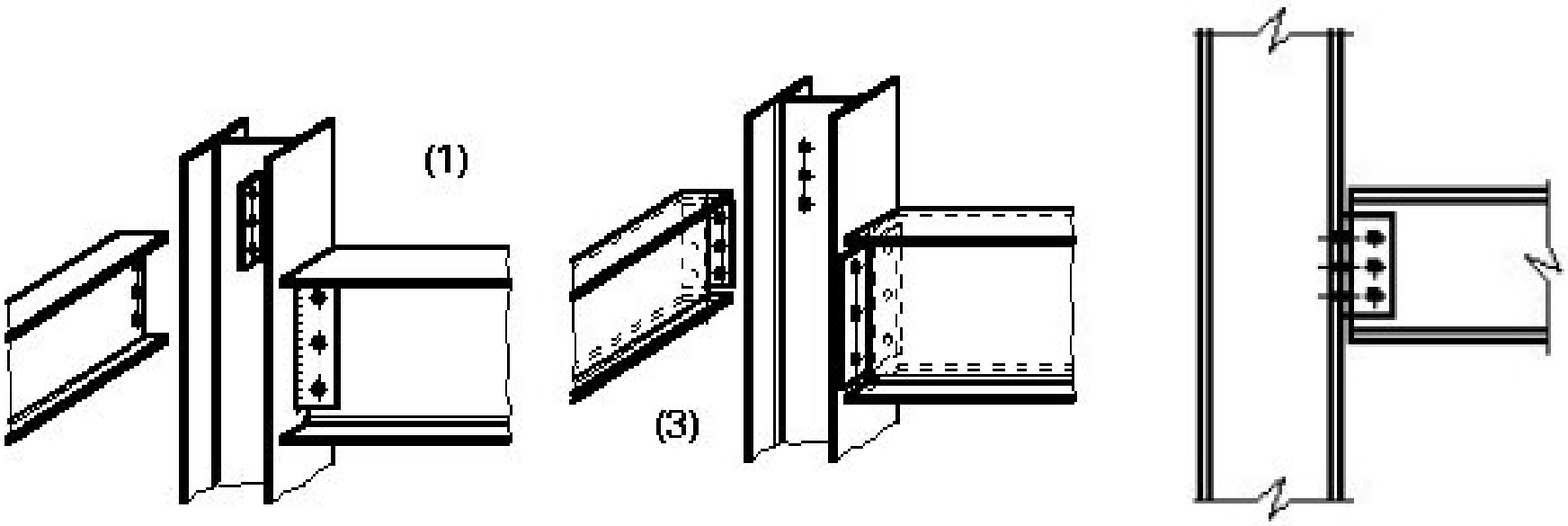
4 *Column splice;*

5 *Column base.*

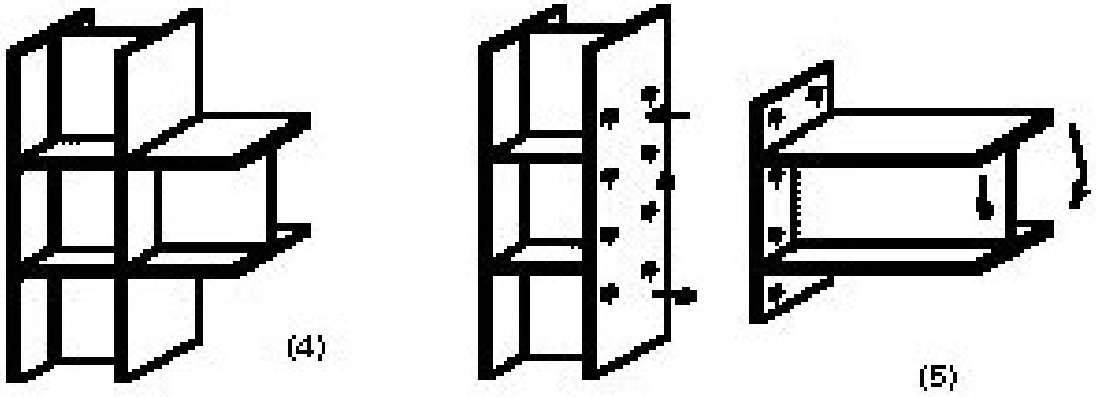


Column bases

Figures from: ESDEP course



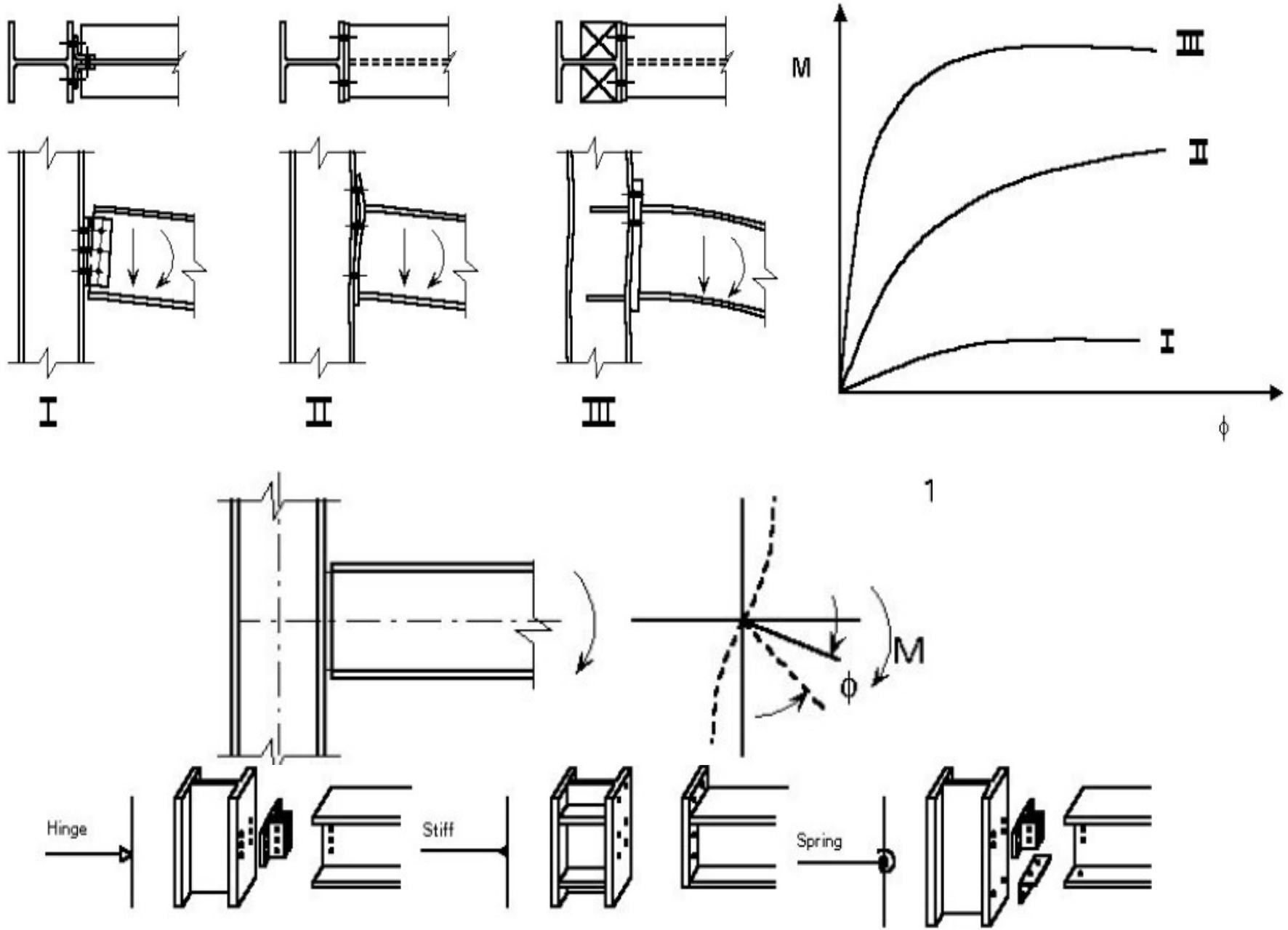
simple or pinned beam-to-column connections (transfer only shear force)



rigid beam-to-column connections (transfer moment and shear)

Figures from: ESDEP course

• Connection response characteristics: strength, stiffness, ductility

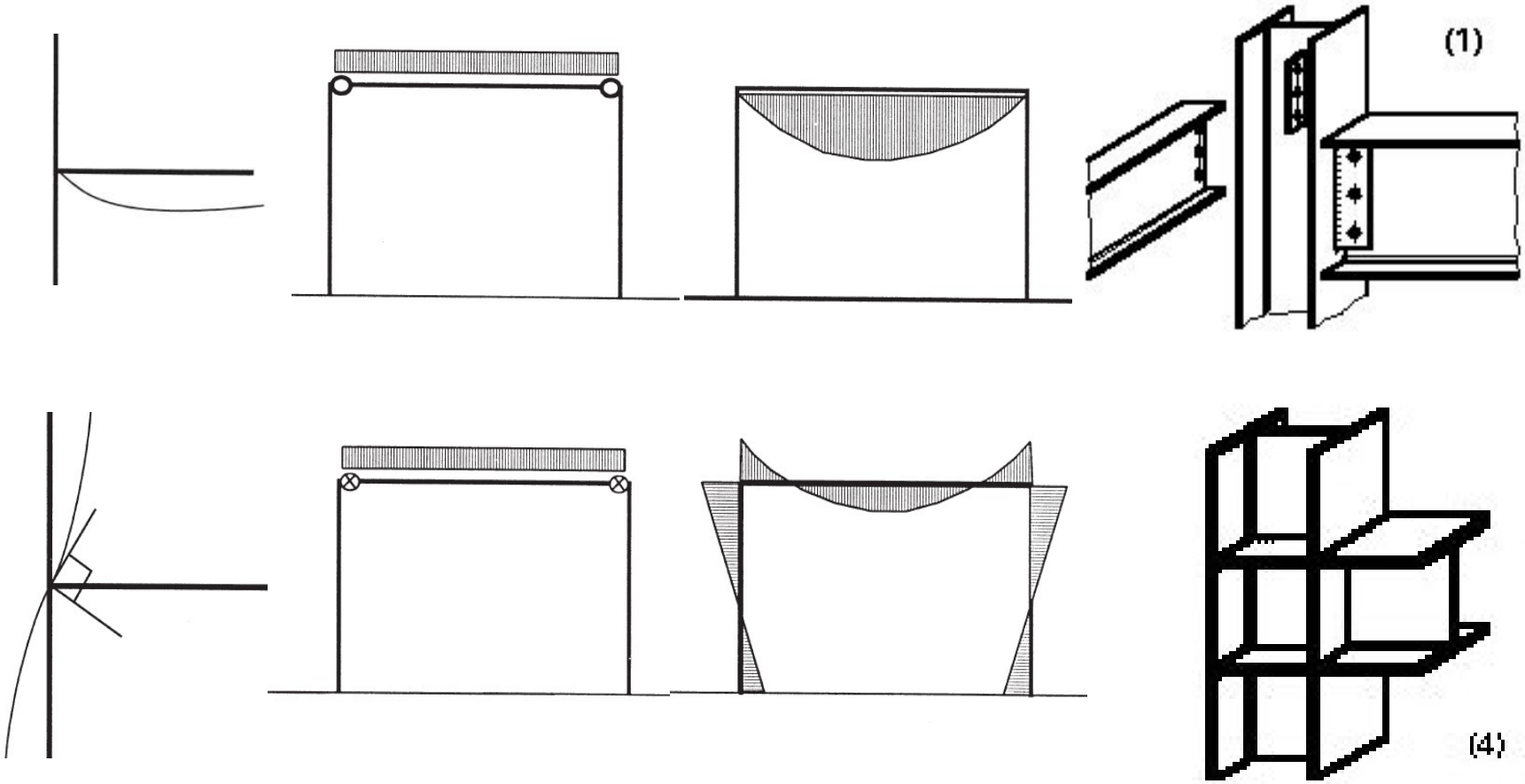


Figures from: ESDEP course

- Strength relates to the connection's ability to safely transfer the design ***shear force*** (and/or ***bending moment***) assumed in analysis.

- Stiffness affects the beam deflections and the horizontal displacements of moment resisting frames.

- Connection details have to be ***compatible with design assumptions***.



Effect of connections on cost

- Overall cost includes cost of material and labour
- For a steel building 20-40% of the overall cost is the material cost, with the remaining being spent on design and drawings, fabrication, erection, protection (e.g. anti-corrosion painting, fire protection) etc.
- The choice of connection type significantly affects the fabrication and material cost

Some old figures:

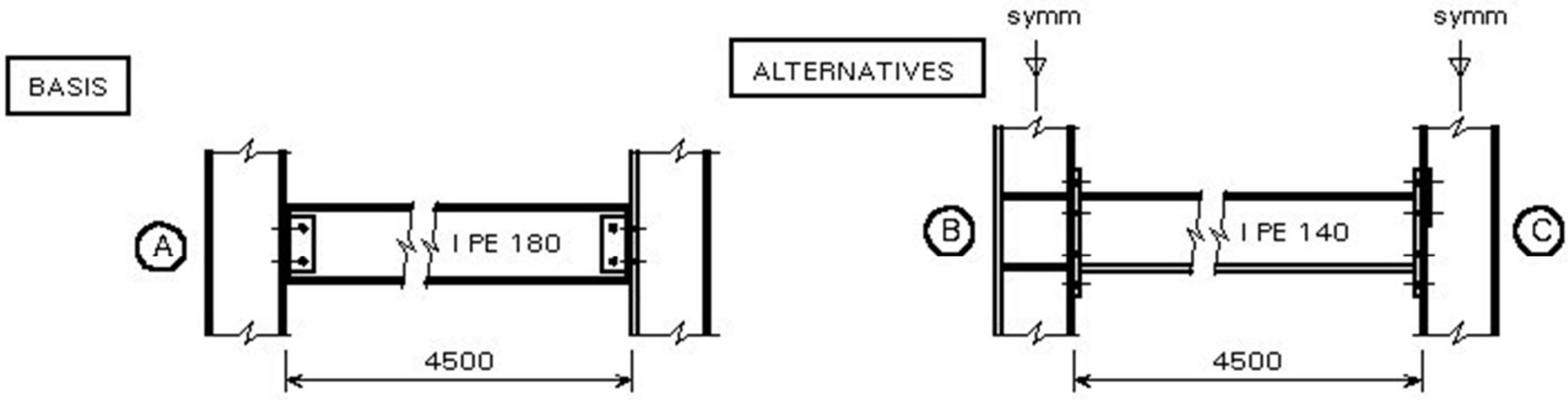
$1cm^3$ of weld=0.7 kg of steel

Drilling of 1 hole= 2kg of steel

Cost of welding of stiffening plates=material cost of stiffening plates

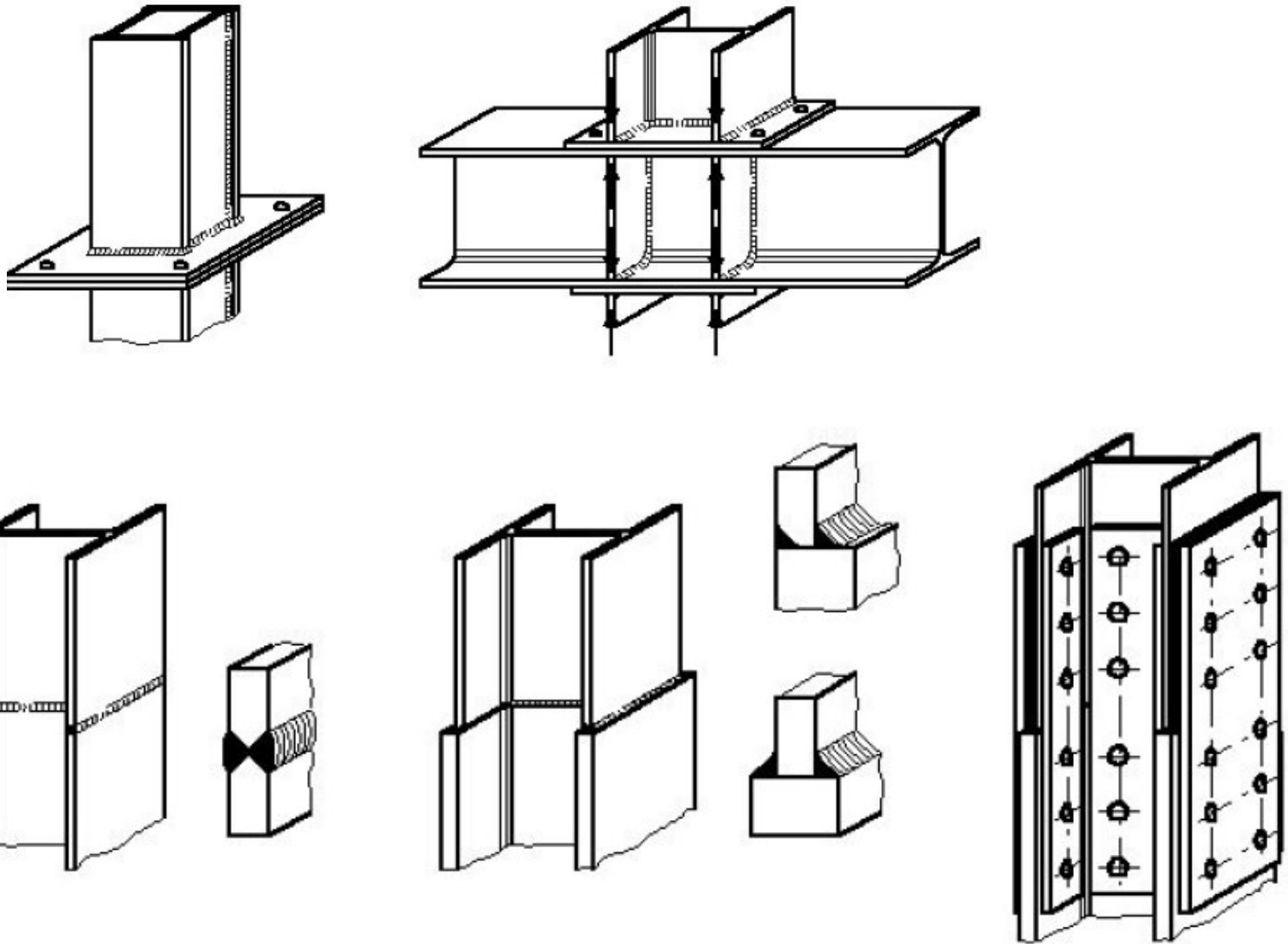
Figures from: ESDEP course

Effect of connections on cost

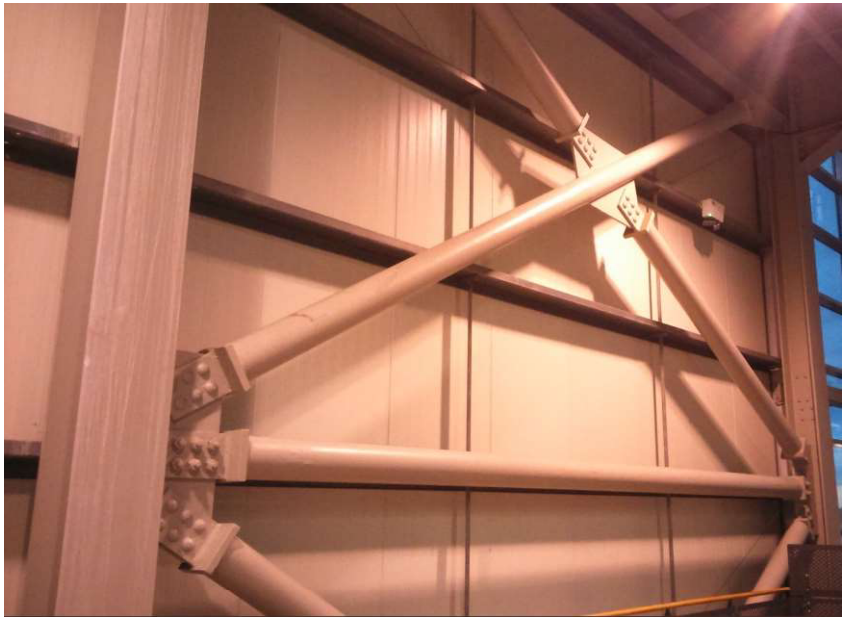


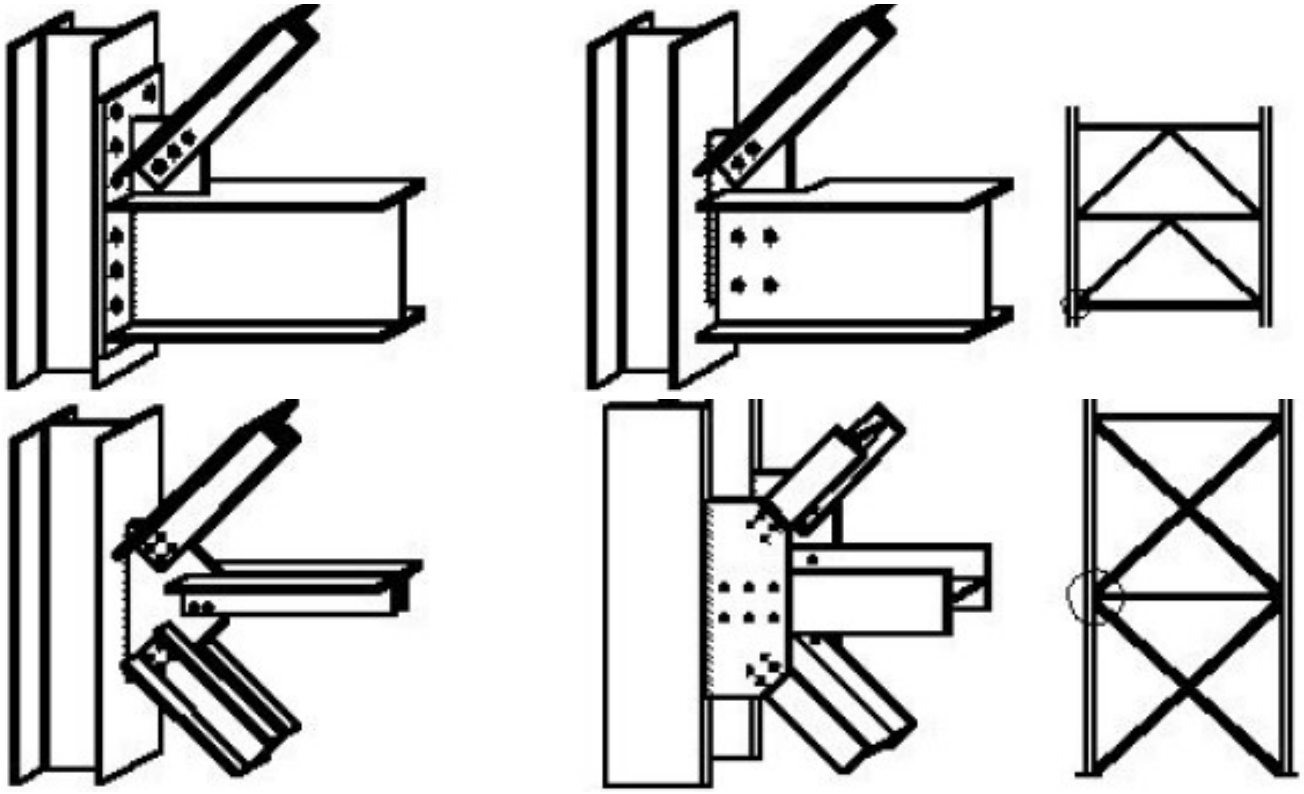
• Less steel	-16 kg	-22 kg
• More welding:		
4,5m 5 ≈	+ 79 kg	
1,1m 5 ≈		+ 20 kg
• Fabrication		
of plates etc	+ 79 kg	+ 20 kg
• Extra holes		
+ 2 holes ≈	+ 4 kg	
+ 6 holes ≈		+ 12 kg
Difference	+ 146 kg	+ 30 kg

Figures from: ESDEP course



column splices

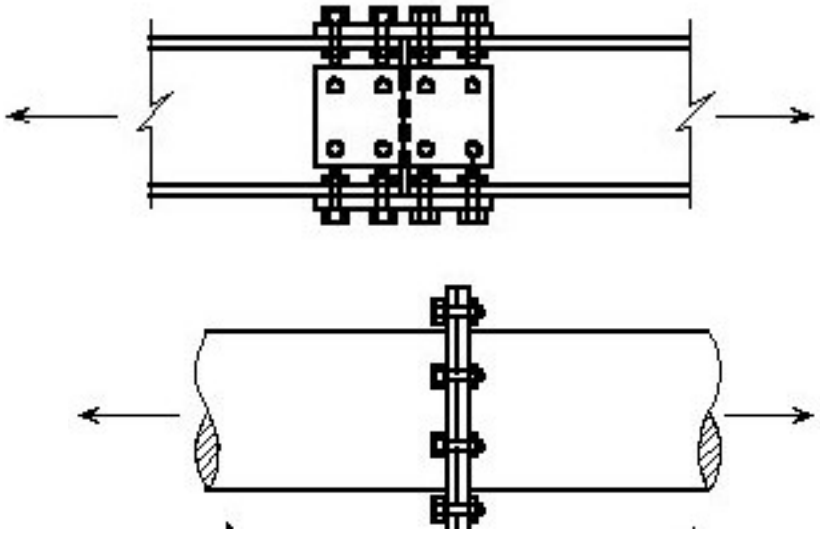




Connections of vertical bracing members

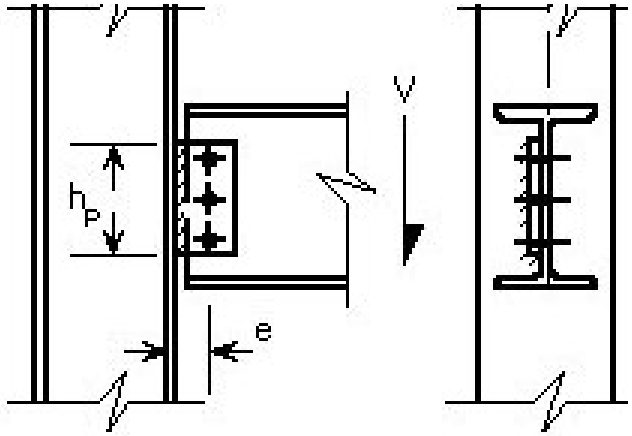
Figures from: ESDEP course

Connections consist of a number of elements. They are required to transmit forces and/or moment between the connected parts. The fasteners may be either bolts or welds.

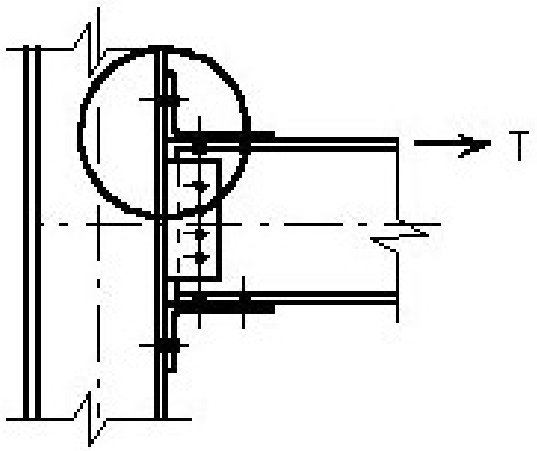


(c) Bolted cover plate

(d) Bolted flange joint for use with tubular construction



(c) Web plate



(e) Angle cleats

Figures from: ESDEP course

Material strength

- steel components to be connected
- angle cleats, fin plates, end plates, cover plates etc
- bolts
- welds

Design codes specify nominal material properties for various material grades. The nominal strengths are further reduced by applying suitable partial safety factors specified in EN 1993-1-8.

Table 2.1: Partial safety factors for joints

Resistance of members and cross-sections	γ_{M0} , γ_{M1} and γ_{M2} see EN 1993-1-1
Resistance of bolts	γ_{M2}
Resistance of rivets	
Resistance of pins	
Resistance of welds	
Resistance of plates in bearing	
Slip resistance - at ultimate limit state (Category C) - at serviceability limit state (Category B)	 γ_{M3} $\gamma_{M3,ser}$
Bearing resistance of an injection bolt	γ_{M4}
Resistance of joints in hollow section lattice girder	γ_{M5}
Resistance of pins at serviceability limit state	$\gamma_{M6,ser}$
Preload of high strength bolts	γ_{M7}
Resistance of concrete	γ_c see EN 1992

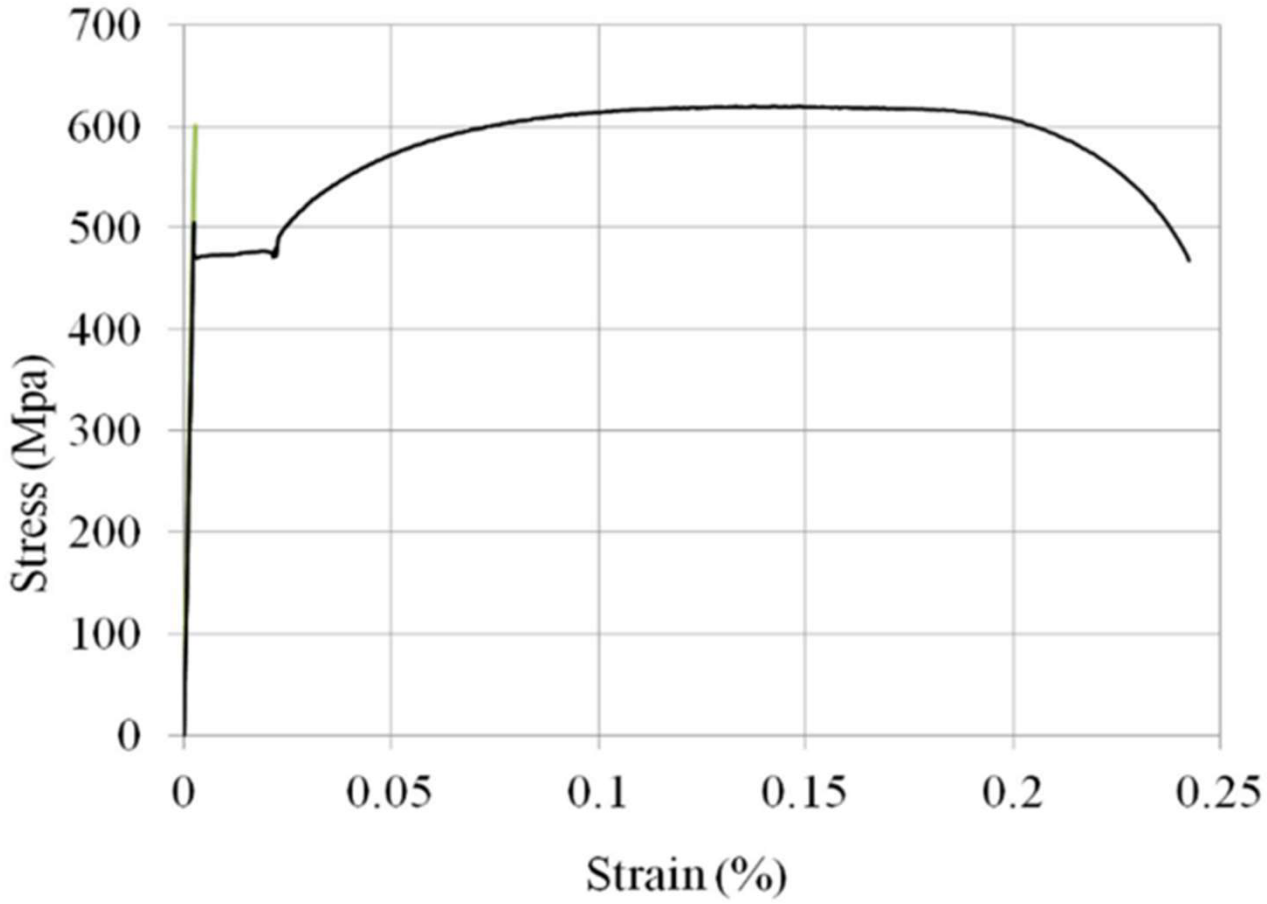
NOTE: Numerical values for γ_M may be defined in the National Annex. Recommended values are as follows: $\gamma_{M2} = 1{,}25$; $\gamma_{M3} = 1{,}25$ and $\gamma_{M3,ser} = 1{,}1$; $\gamma_{M4} = 1{,}0$; $\gamma_{M5} = 1{,}0$; $\gamma_{M6,ser} = 1{,}0$; $\gamma_{M7} = 1{,}1$.

Steel material in tension

Table 5.1 — Nominal values of yield strength f_y and ultimate tensile strength f_u for structural steels conforming to the following standards: EN 10025 (all parts), EN 10210 (all parts), and EN 10219 (all parts)

Steel grade[a]	Nominal thickness of the element t mm			
	$t \leq 40$ mm		40 mm $< t \leq 80$ mm	
	f_y N/mm^2	f_u N/mm^2	f_y N/mm^2	f_u N/mm^2
S235	235	360	215	360
S275	275	390	245	370
S355	355	490	325	470
S420	420	510	390	490
S460	460	540	410	510
S500	500	580	450	580
S550	550	600	500	600
S600	600	650	550	650
S620	620	700	560	660
S650	650	700	-	-
S690	690	770	630	710
S700	700	750	-	-

Steel material in tension



Material data for design:

- Young's modulus (190-220 GPa, assumed 210 GPa)
- Yield strength f_y and UTS f_u depend on material grade

Actual vs nominal material properties

Hot-rolled Steel sections (similar values expected for plates and angle cleats)

	Yield strength (N/mm^2)		Ultimate tensile stress (N/mm^2)	
Steel Grade	nominal	mean	nominal	mean
S235	235	293	360	432
S275	275	343	430	492
S355	355	426	490	540
S460	460	529	540	595

Standardisation of safety assessment procedures across brittle to ductile failure modes (SAFEBRICTILE) RFCS project RFSR-CT-2013-00023.

Actual vs nominal material properties

This is partially reflected in prEN 1993-1-8:2021, where overstrength factors are specified for the design of members or connecitons adjacent to plastic hinges

Table B.4 — Material overstrength factors

Steel grade	γ_{rm}
S235	1,45
S275	1,35
S355	1,25
S460	1,20

prEN 1993-1-8.