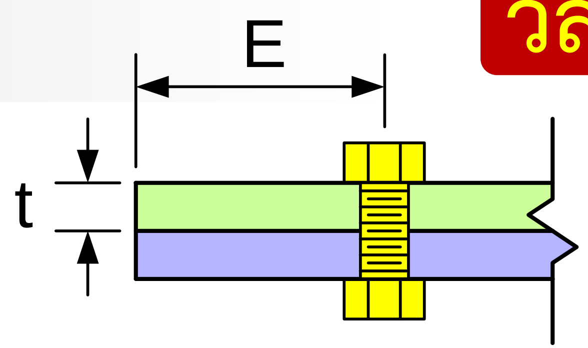
องค์อาคารประกอบ

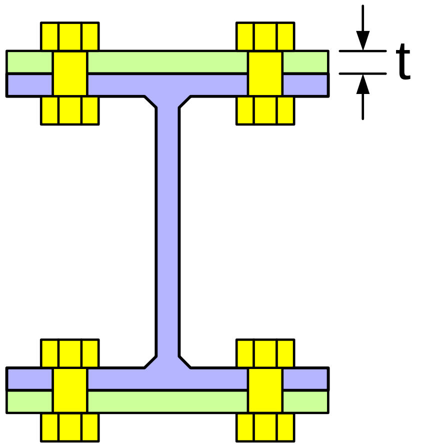
วสท.

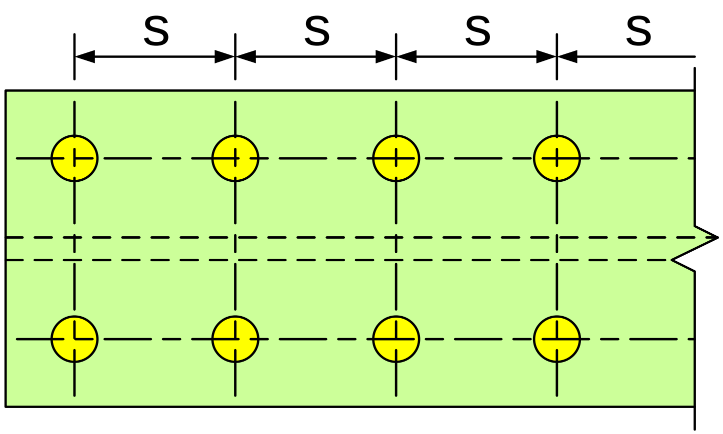


ระยะห่างสูงสุดจากจุดศูนย์กลางสลักเกลียวถึงขอบชิ้นส่วน E เท่ากับ $12t \leq 15$ cm

การเว้นระยะของตัวยึดตามแนวยาวระหว่างชิ้นส่วนที่ประกอบด้วย แผ่นโลหะและรูปทรง หรือแผ่นโลหะ 2 แผ่น ที่ต้องเนื่องกัน จะต้องมีคุณสมบัติดังนี้

(1) สำหรับชิ้นส่วนที่มีการทาสีหรือไม่ทาสีไม่อยู่ภายใต้การกัดกร่อน ระยะห่าง s จะต้องไม่เกิน $24t \leq 30$ cm





องค์อาคารประกอบ

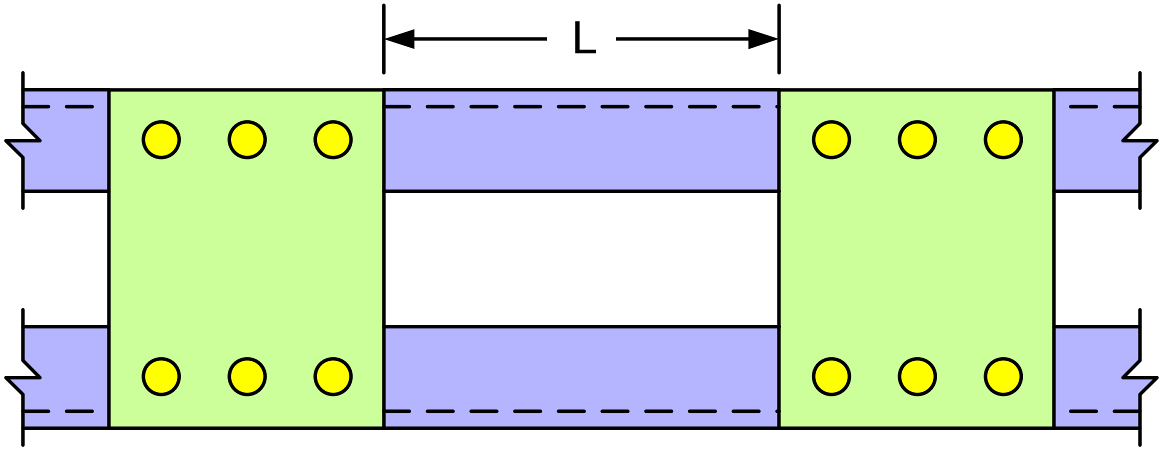
วสท.

(2) สำหรับชิ้นส่วนที่ไม่มีการทาสีของโลหะที่ทนต่อสภาพดินฟ้าอากาศภายใต้การกัดกร่อนตามบรรยากาศ การเว้นระยะห่าง s จะต้องไม่เกิน $14t \leq 18$ cm

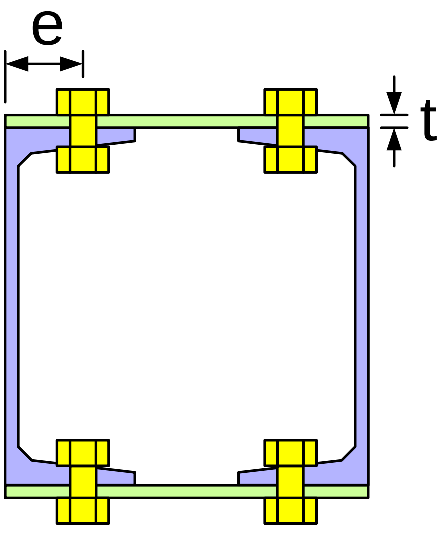
หมายเหตุ : ขนาดใน **(1)** และ **(2)** ไม่สามารถใช้ได้กับชิ้นส่วนที่ประกอบไปด้วย 2 รูปทรงที่ติดกันอย่างต่อเนื่อง

Built-up Tension Members

3) For built-up member from two or more shapes separated, the spacing between the connector should limit the slenderness ratio in any component to 300.



4) The e distance from the center of any bolt to the nearest edge shall not exceed 12 times the thickness nor 15 cm.



Built-up Tension Members

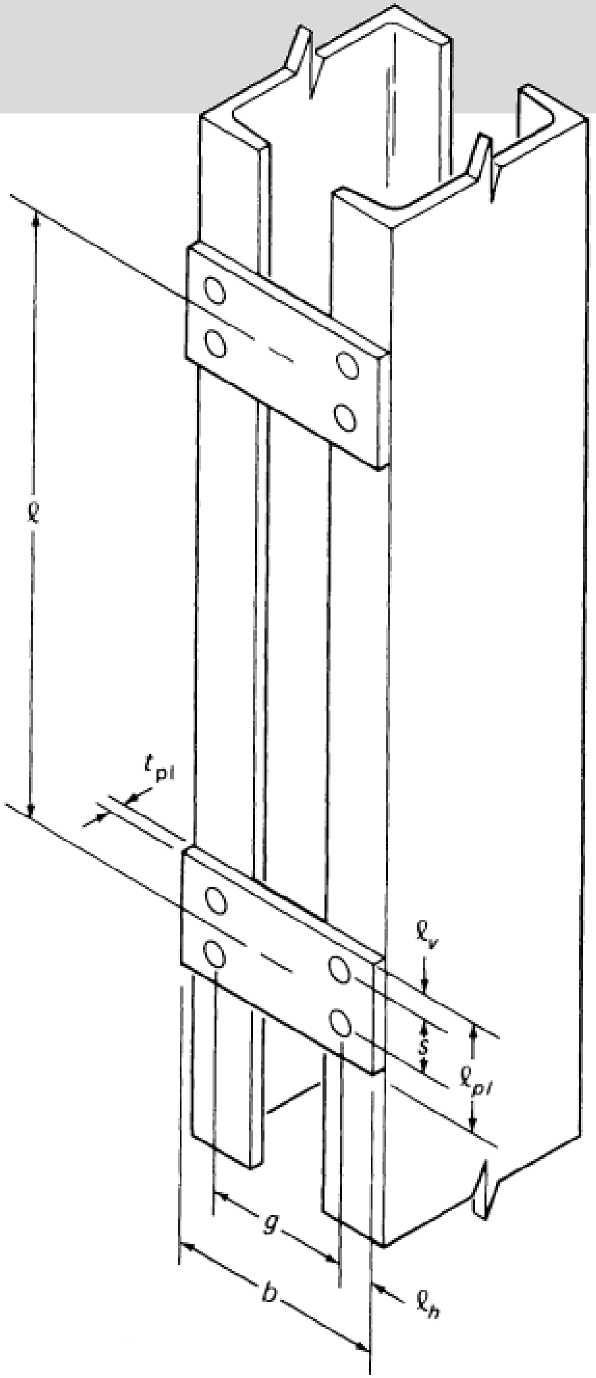
5) For built-up seperate member using the interval tied plate without the diagonal lacing:

- Plate length $\ell_{pl} \geq \frac{2}{3} g$

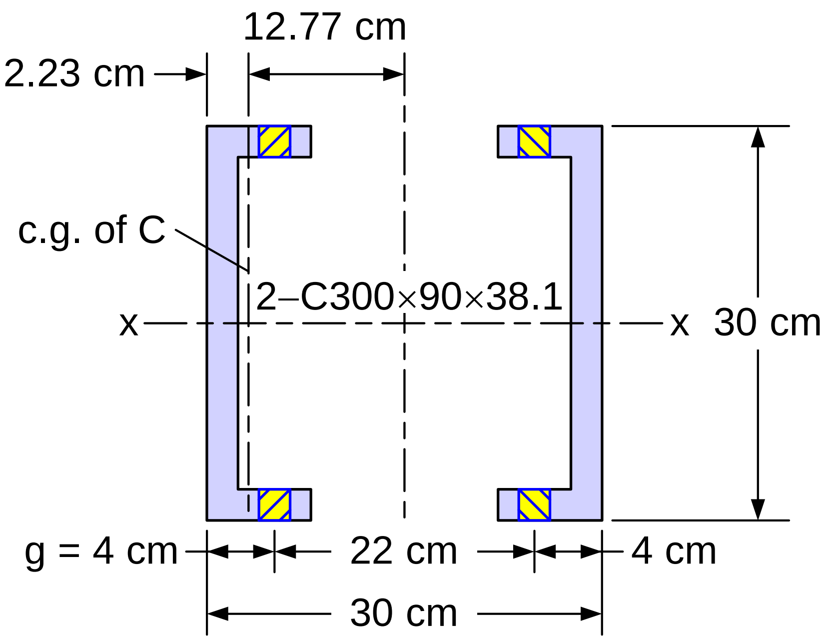
- Plate thickness $t_{pl} \geq \frac{1}{50} g$

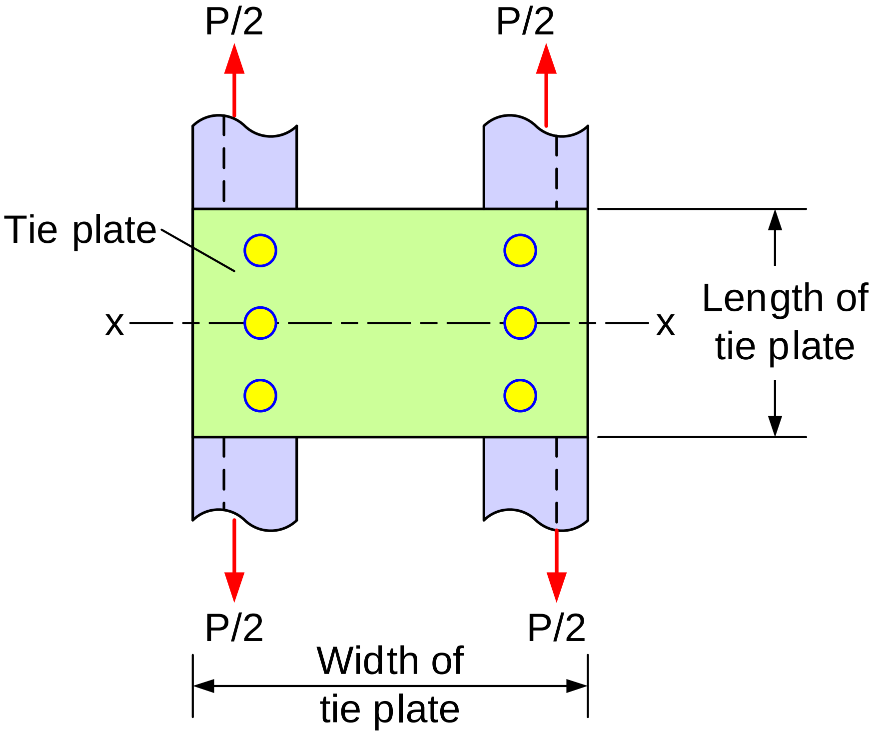
- Plate width $b \geq g + 2(1.5\varnothing)$

$\varnothing$ = hole diameter



Example 4-3: The two C300×90×38.1 are selected to support a dead tensile working load of 50 tons and a live tensile working load of 80 tons. The member is 9 m long, consists of A36 steel, and has one line of three 22-mm bolts in each flange 7.5 cm on center). Determine whether the member is satisfactory and design the tie plates. Assume centers of bolt holes are 4-cm from the backs of the channels.





Solution Using C300×90×38.1 ($A_g = 48.57$ cm^2, $t_f = 13$ mm, $I_x = 6{,}440$ cm^4, $I_y = 325$ cm^4, $c_y = 2.23$ cm and $r_y = 2.59$ cm)

(a) Load Combinations

LRFD	ASD
$P_u = 1.4D + 1.7L$ $= 1.4(50) + 1.7(80)$ $= 206$ tons	$P = D + L$ $= 50 + 80$ $= 130$ tons

(b) Gross section yielding

$$P_n = F_y A_g = (2.5)(2 \times 48.57) = 243 \text{ tons}$$

LRFD	ASD
$\phi_t = 0.9$ $\phi_t P_n = 0.9(243)$ $= 219$ tons $>$ 206 tons **OK**	$\Omega_t = 1.67$ $\dfrac{P_n}{\Omega_t} = \dfrac{243}{1.67}$ $= 146$ tons $>$ 130 tons **OK**

(c) Tensile rupture strength

$$A_n = 2\left[48.57 - (2)(2.2+0.3)(1.3)\right] = 84.14 \text{ cm}^2$$

$$L = (2)(7.5) = 15 \text{ cm}$$

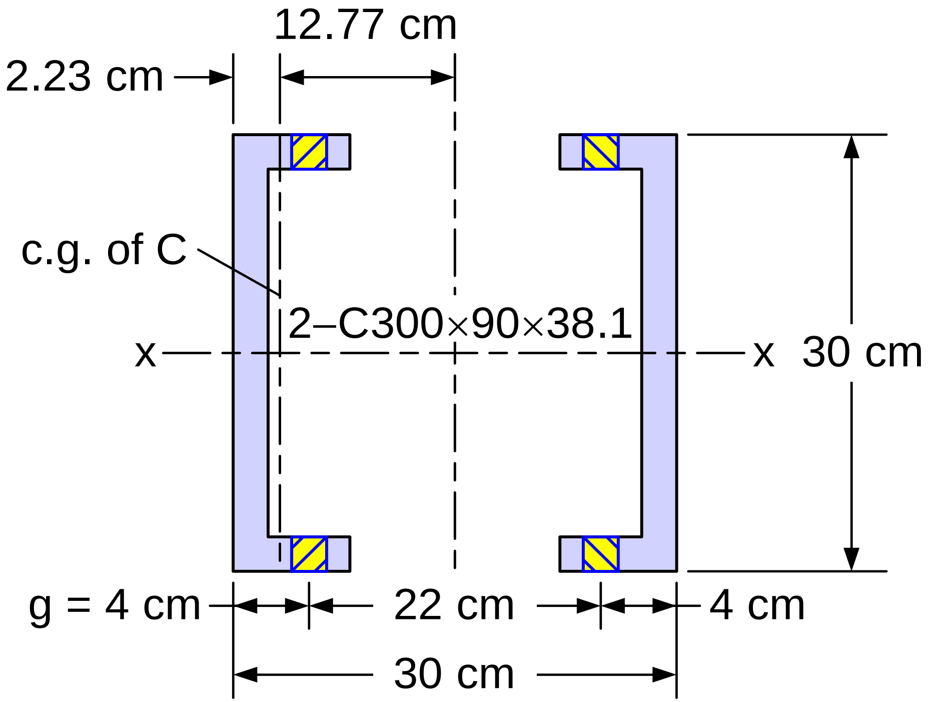
$$U = \left(1-\frac{\bar{x}}{L}\right) = \left(1-\frac{2.23}{15}\right) = 0.85$$

$$A_e = U A_n = 0.85 \times 84.14 = 71.52 \text{ cm}^2$$

$$P_n = F_u A_e = (4.0)(71.52) = 286 \text{ tons}$$

LRFD	ASD
$\phi_t = 0.75$	$\Omega_t = 2.00$
$\phi_t P_n = 0.75(286)$	$\frac{P_n}{\Omega_t} = \frac{286}{2.00}$
$= 215 \text{ tons} > 206 \text{ tons}$ **OK**	$= 143 \text{ tons} > 130 \text{ tons}$ **OK**

(d) Slenderness ratio



$$I_x = 2 \times 6,440 = 12,880 \text{ cm}^4$$

$$I_y = 2 \times 325 + 2 \times 48.57 \times 12.77^2$$

$$= 16,491 \text{ cm}^4$$

$$r_{min} = r_x = \sqrt{\frac{12,880}{2 \times 48.57}} = 11.5 \text{ cm}$$

$$\frac{L_x}{r_x} = \frac{900}{11.5} = 78.3 < 300$$ **OK**

(e) Design of tie plate

Distance between lines of bolts $=$ 30 – 2(4) $=$ 22 cm

Minimum length of tie plate $=$ (2/3)(22) $=$ 14.7 cm (say 15 cm)

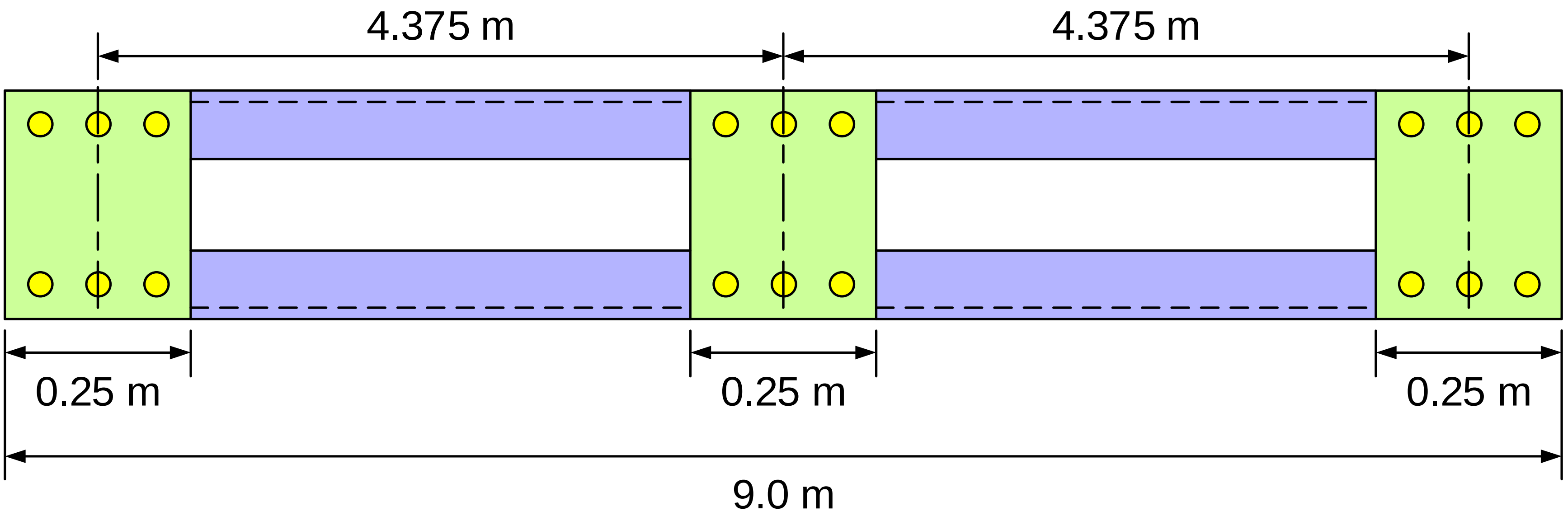
Minimum thickness of tie plate $=$ (1/50)(22) $=$ 0.44 cm (say 0.5 cm)

Minimum width of tie plate $=$ 22 + 2(1.5)(2.5) $=$ 29.5 cm (say 30 cm)

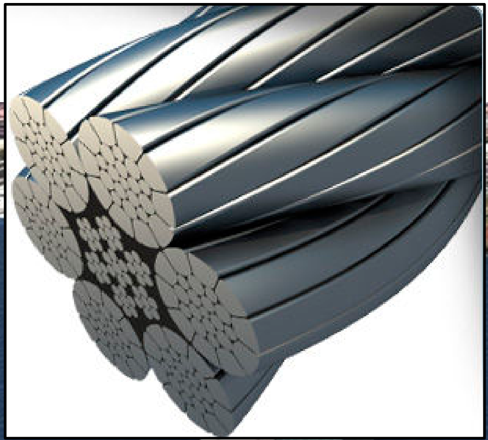
Maximum preferable spacing of tie plates:

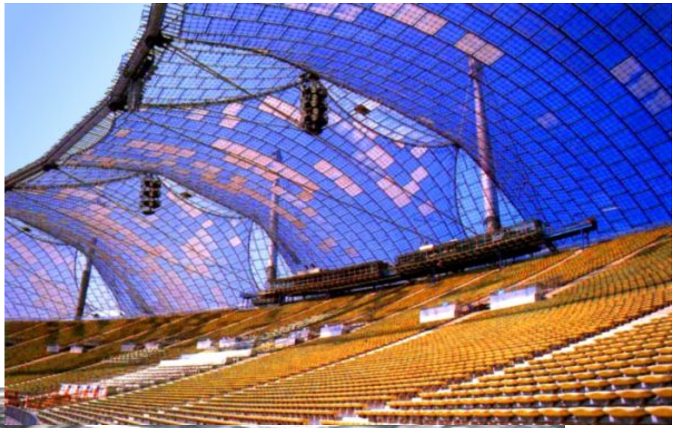
$$\frac{L}{r} = \frac{L(100)}{2.59} = 300 \longrightarrow L = 7.77\text{ m (say 4.375 m)}$$

∴ Use tie plate PL0.5×30×15 cm with spacing 4.375 m ■

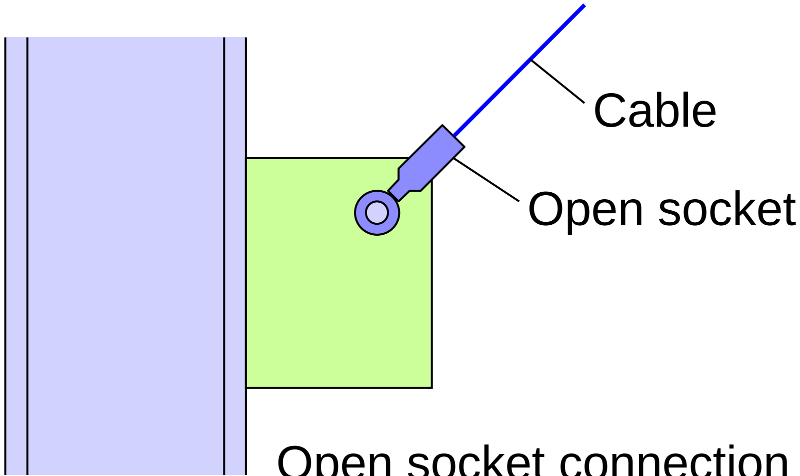


Rods and Cables
เหล็กเส้นและเคเบิ้ล

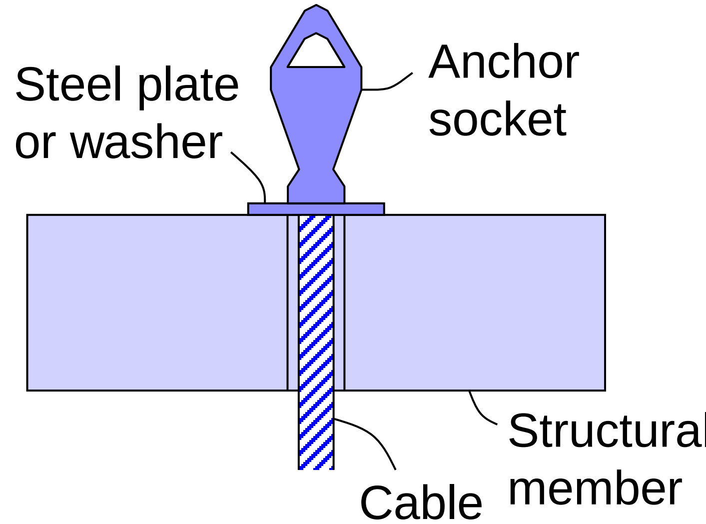


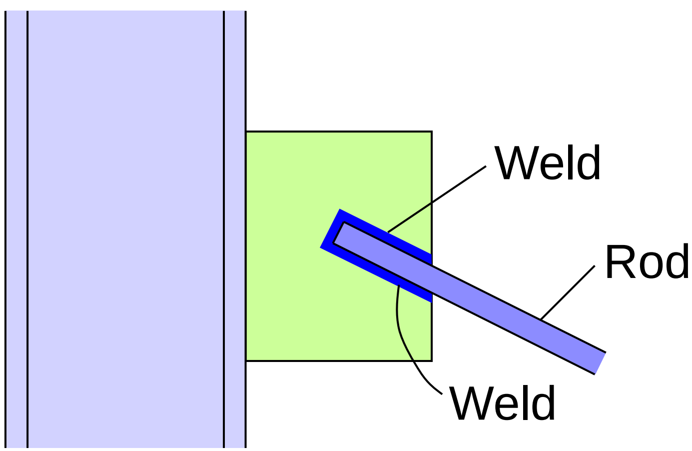


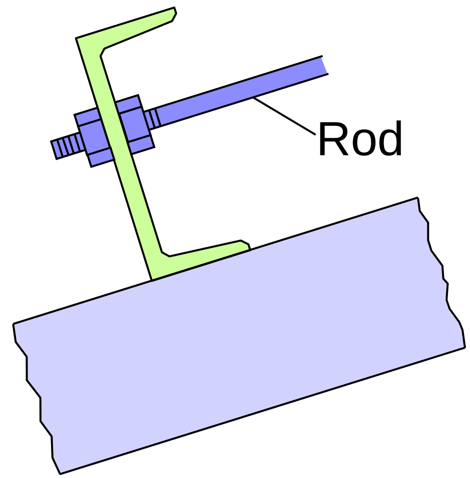
Rod and Cable Connections



Open socket connection







Rods Strength

Rods may be welded or treaded and held in place with nuts at their ends

$$R_n = F_{nt} A_D = 0.75 F_u A_D$$

Required rod area:

LRFD	ASD
$\phi = 0.75$	$\Omega = 2.00$
$A_D \geq \dfrac{P_u}{\phi 0.75 F_u}$	$A_D \geq \dfrac{\Omega P_u}{0.75 F_u}$

where A_D = Gross area of the rod

Example 4-4: Using AISC Specification, select a standard threaded rod of A36 steel to support a tensile working dead load of 5 tons and a tensile working live load of 8 tons.

Solution

LRFD	ASD
$P_u = 1.4D + 1.7L$ $= 1.4(5) + 1.7(8) = 20.6$ tons	$P = D + L$ $= 5 + 8 = 13$ tons

$$A_D \geq \frac{P_u}{\phi 0.75 F_u} = \frac{20.6}{0.75(0.75)(4.0)} = 9.16\ cm^2$$

Try 3.6-cm diameter rod ($A_D = 10.18\ cm^2$)

$$R_n = 0.75 F_u A_D = 0.75(4.0)(10.18) = 30.5 \text{ tons}$$

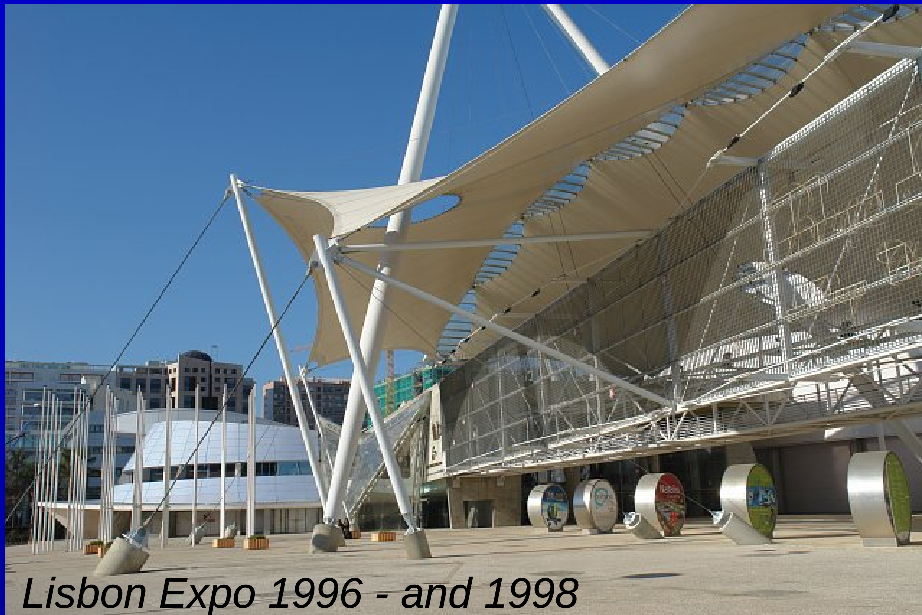
LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = 0.75(30.5)$ $= 22.9$ tons $>$ 20.6 tons **OK**	$R_n / \Omega = 30.5 / 2.00$ $= 15.3$ tons $>$ 13 tons **OK**

Cable-Stayed Bridges





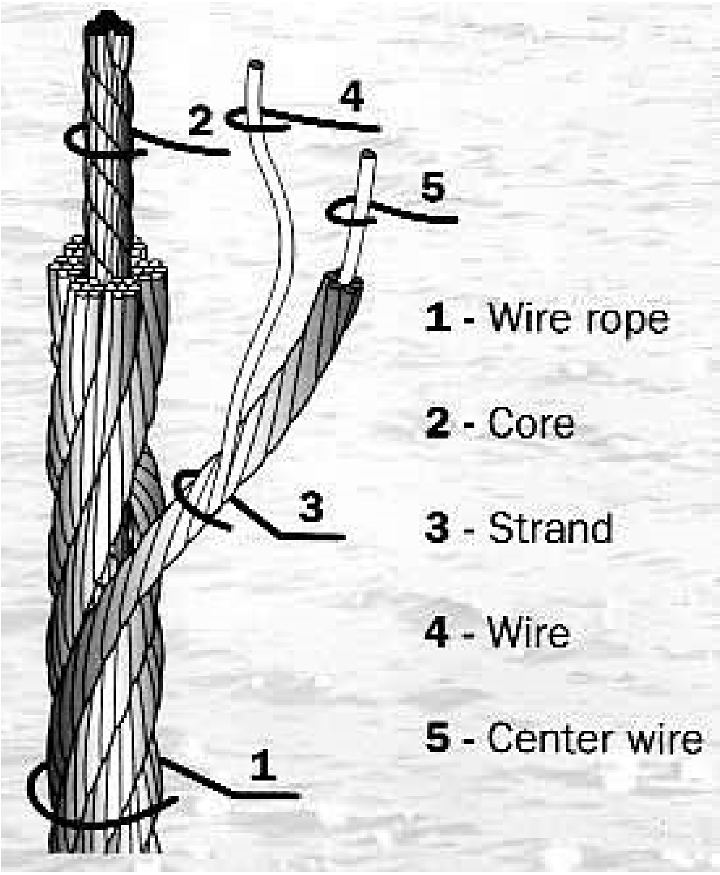
Cable-Stayed Roofs


Lisbon Expo 1996 - and 1998

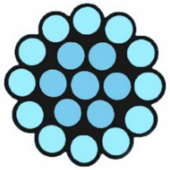

Manchester City Stadium

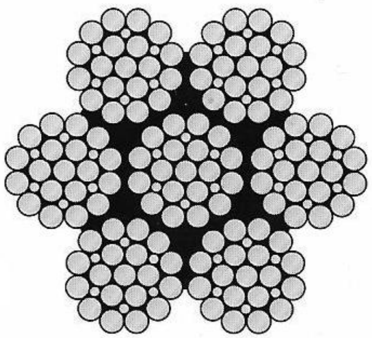

Olympic stadium roof - Munich

Strand & Wire rope



Wire → Strand → Wire rope

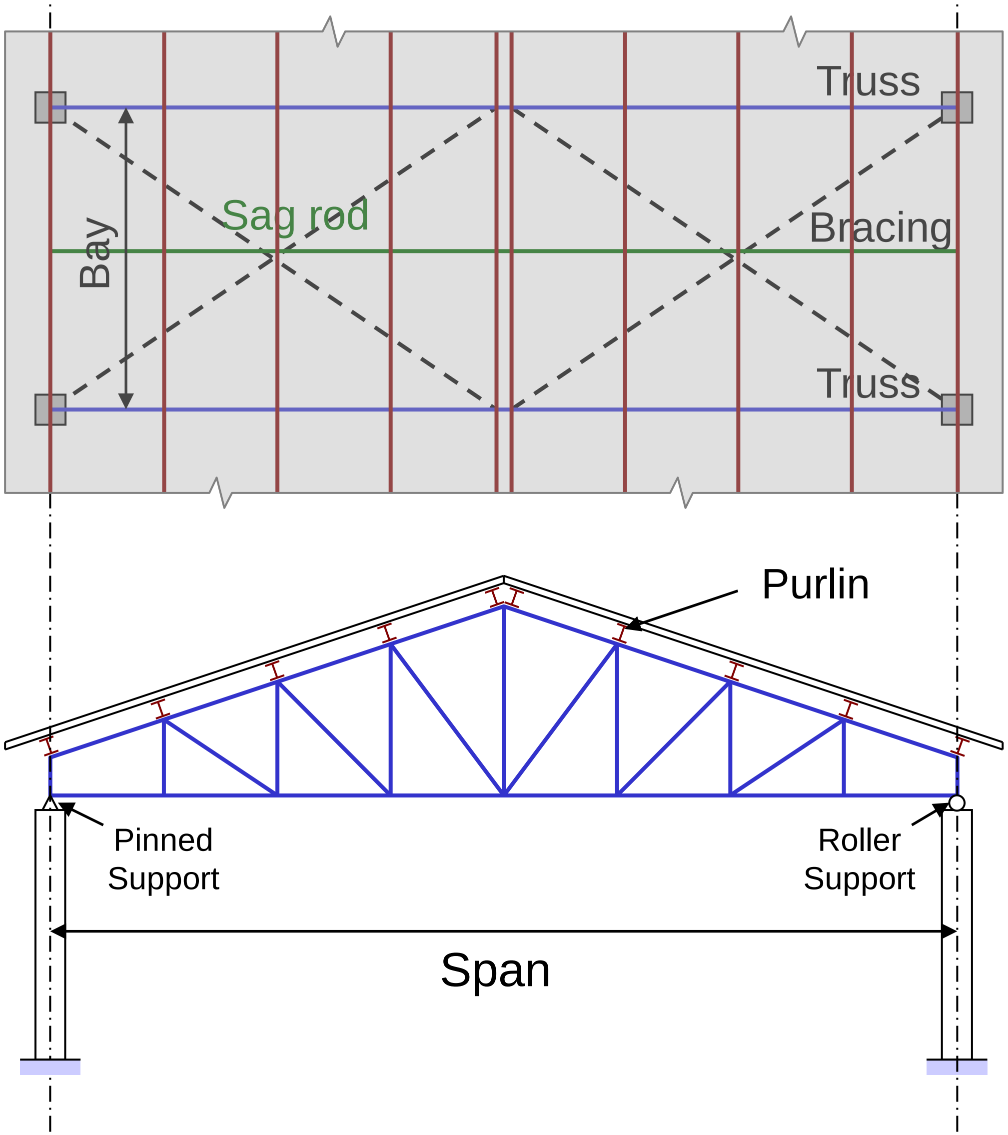




Low Relaxation Prestressed Concrete Steel Strand (PC Strand)

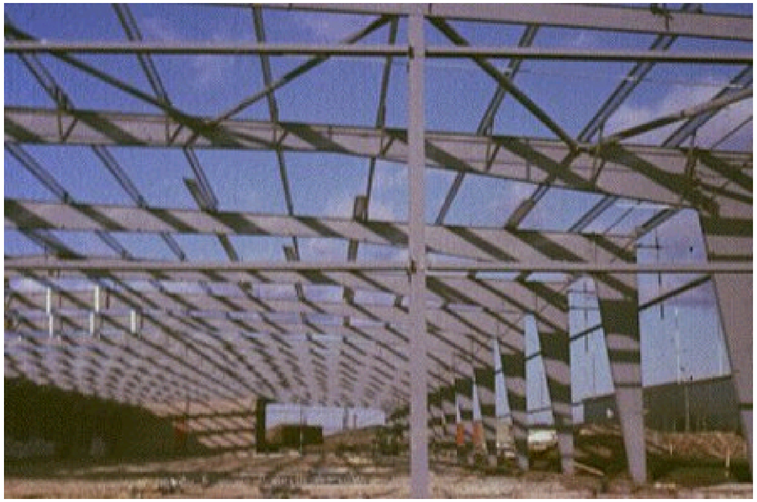
Tension Members

In Roof Trusses

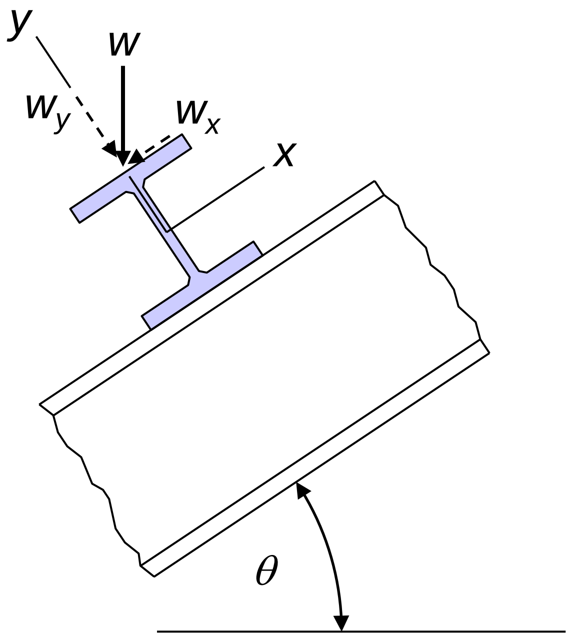


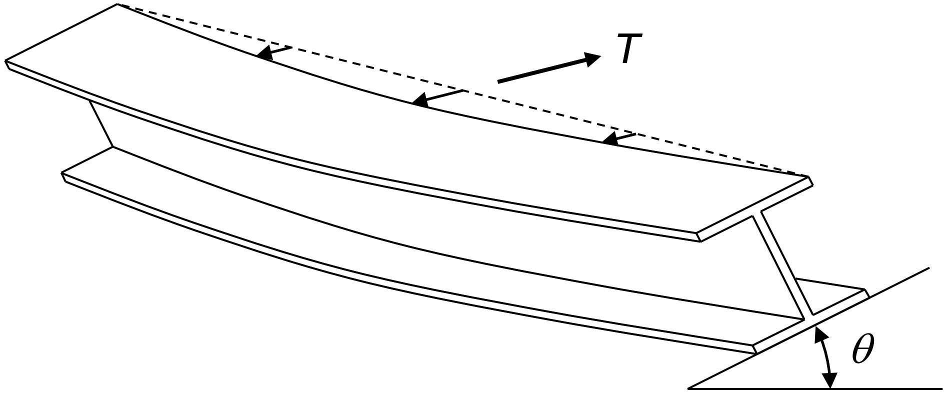
Truss Members :

- Truss
- Purlin
- Sag rod
- Bracing

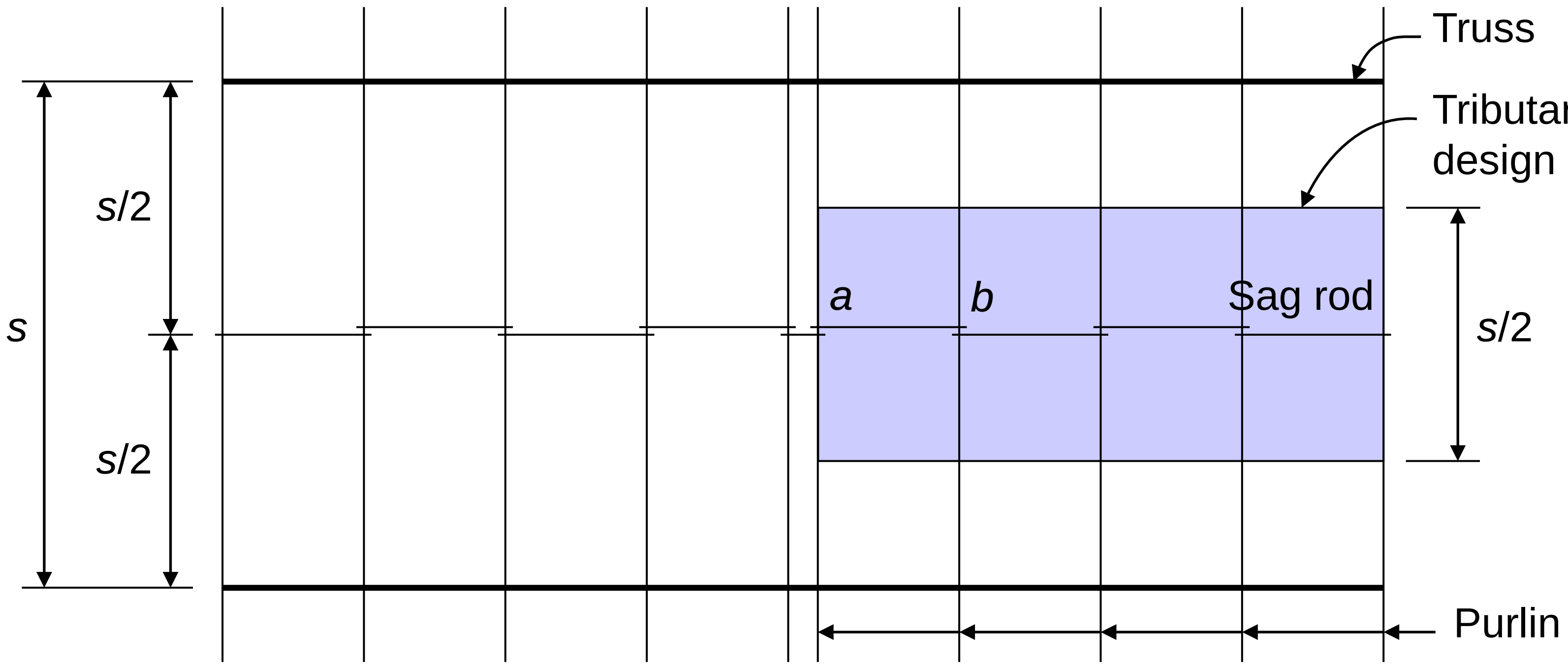


Deflection of Purlin

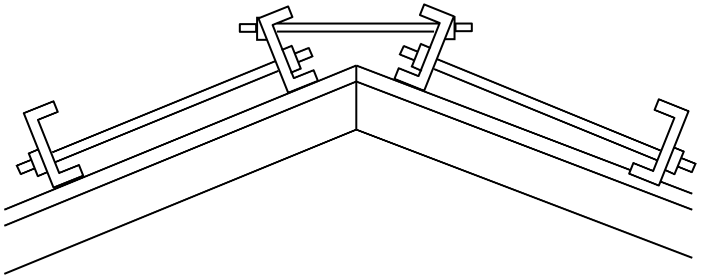


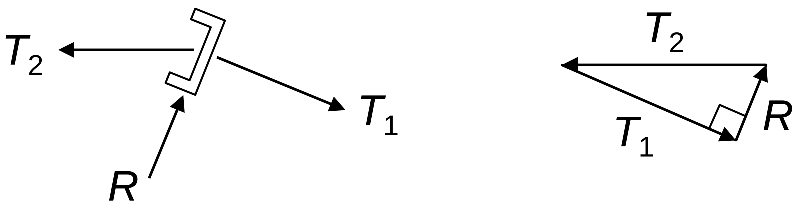


Sag Rod



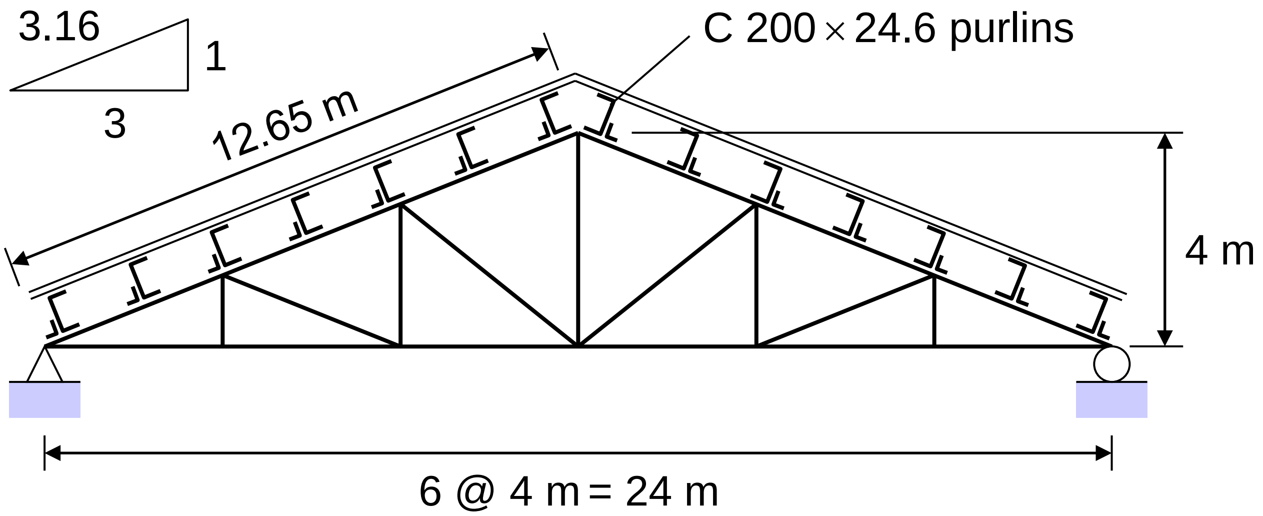
Truss
Tributary area for design of rod *ab*
s
s/2
s/2
a
b
Sag rod
s/2
Purlin

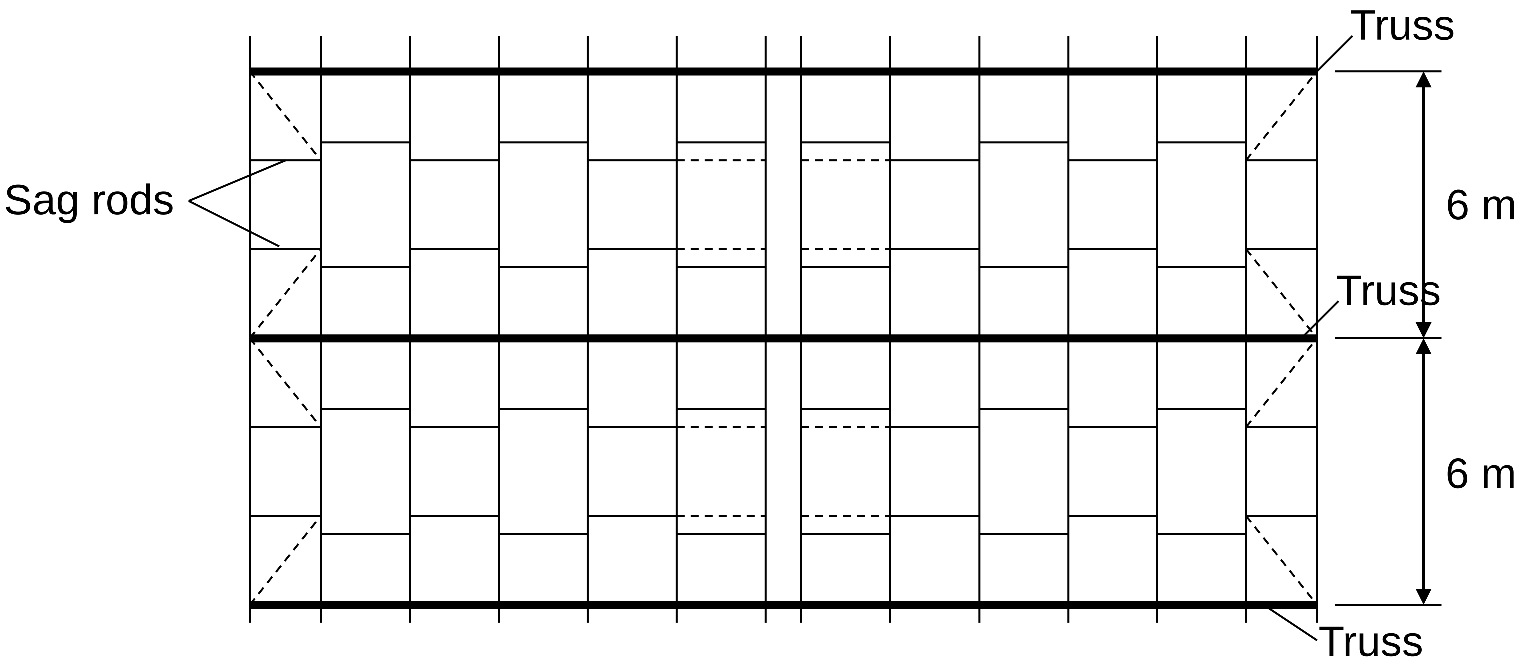




T_2
T_1
R
T_2
T_1
R

Design of Sag Rod





Example 4-5: Design the sag rods for the purlins of the truss. Purlins are to be supported at their one-third points between the trusses, which are spaced 6 m. Use A36 steel and assume that a minimum-size rod of 16 mm is permitted. A roofing material weighing of 50 kg/m^2 of roof surface is used and supports a live load of 50 kg/m^2.

Solution There are 7 purlins on each side of the truss

Gravity loads in kg/m^2 of roof surface are as follows:

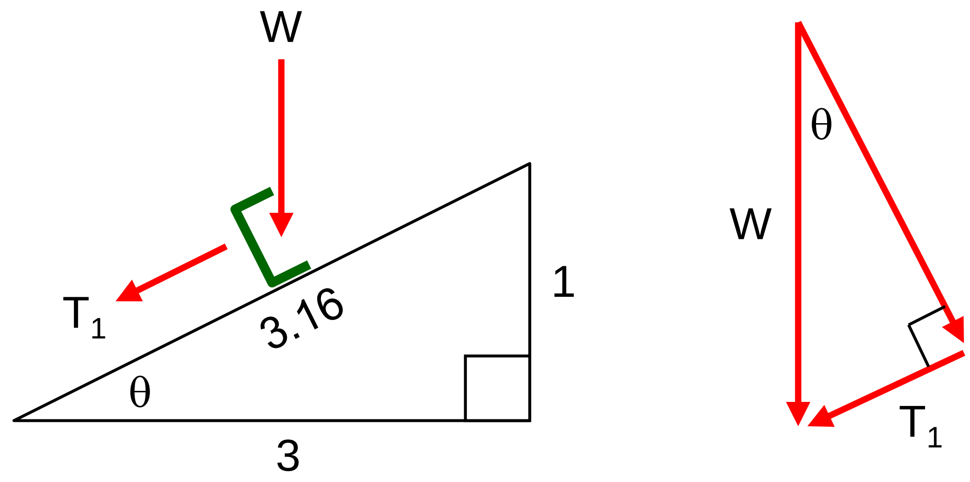
Roofing material	=	50 kg/m^2
Purlin = 7(24.6)/12.0	=	14 kg/m^2
Dead load (w_D)	=	64 kg/m^2

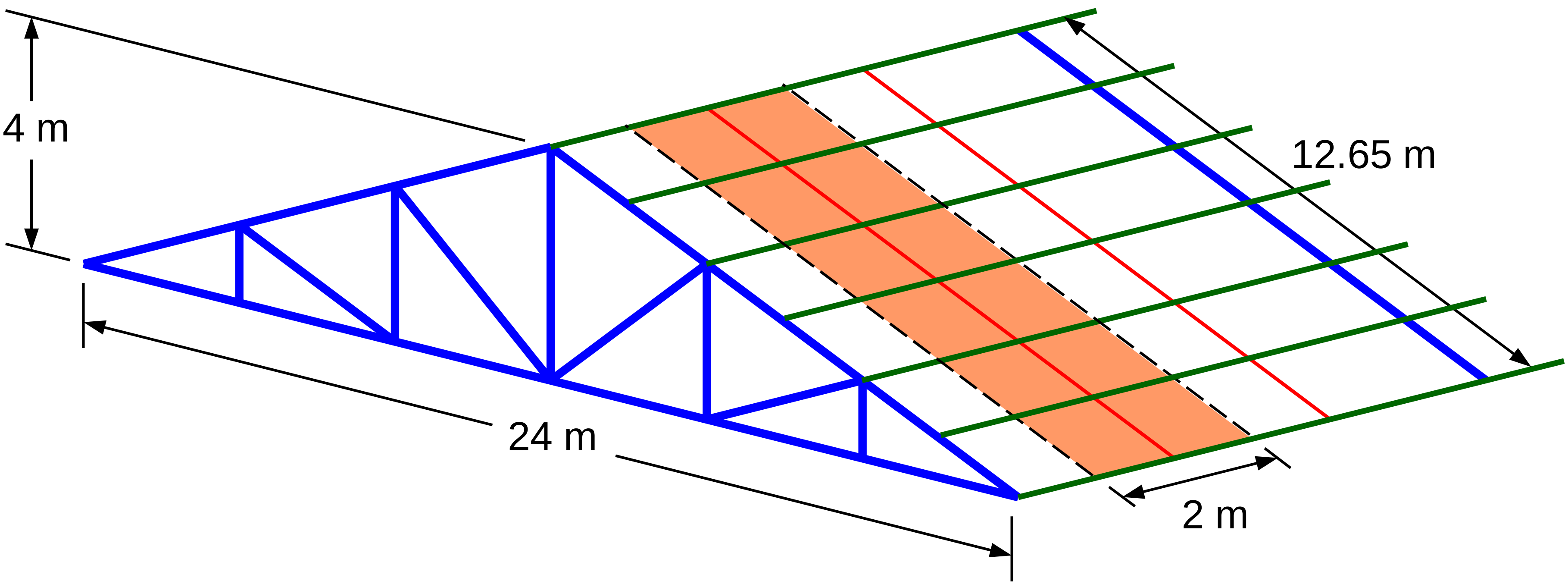
LRFD	ASD
$w_u = 1.4 w_D + 1.7 w_L$ $= 1.4(64) + 1.7(50) = 176\ kg/m^2$	$w = w_D + w_L$ $= 64 + 50 = 114\ kg/m^2$

Component of loads parallel to roof surface:

(1/3.16)(176) = 55.7 kg/m^2	(1/3.16)(114) = 36.1 kg/m^2

Component of loads parallel to roof surface





Tributary load area of one sag rod

Load on top inclined sag rod:

LRFD	ASD
$P_u = 12.65(2.0)(55.7)$ $= 1409\ \text{kg}$	$P_a = 12.65(2.0)(36.1)$ $= 913\ \text{kg}$

Selecting section with LRFD expression

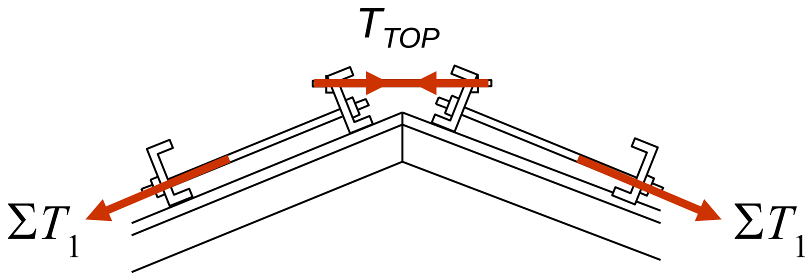
$$A_D \geq \frac{P_u}{\phi 0.75 F_u} = \frac{1.409}{0.75(0.75)(4.0)} = 0.626\ \text{cm}^2$$

Try 16-mm rod $(A_D = 2.01\ \text{cm}^2)$

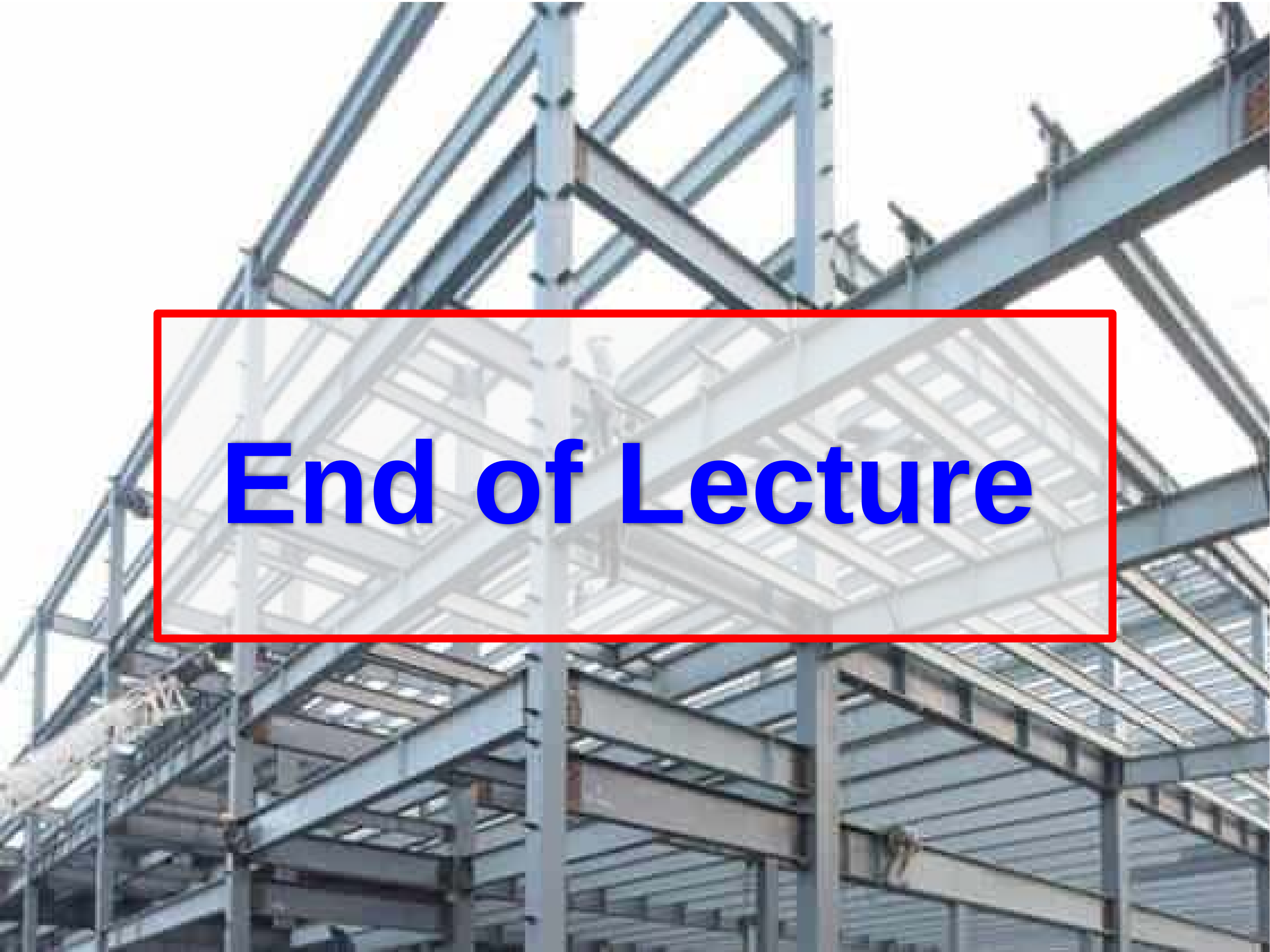
$$P_n = 0.75 F_u A_D = 0.75(4,000)(2.01) = 6,000\ \text{kg}$$

LRFD $\phi = 0.75$	ASD $\Omega = 2.00$
$\phi R_n = 0.75(6,000)$ $= 4,500\ \text{kg} > 1409\ \text{kg}$ **OK**	$R_n / \Omega = 6,000 / 2.00$ $= 3,000\ \text{kg} > 913\ \text{kg}$ **OK**

Checking force in tie rods between ridge purlins:



LRFD	ASD
$T_{TOP,u} = (3.16/3)(1409)$ $= 1{,}484\ kg < 4{,}500\ kg$ **OK**	$T_{TOP} = (3.16/3)(913)$ $= 962\ kg < 3{,}000\ kg$ **OK**


End of Lecture