طراحی اجزاء یک - تمرین سری ۲

سؤال 1

$\frac{r}{d} = 0.15$

$\frac{D}{d} = 1.10$

Table A-15-7: محوری $K_t = 1.45$

Table A-15-8: $K_{ts} = 1.15$ پیچشی

Table A-15-9: خمشی $K_t = 1.45$

Steel 1050-CD

Table A-20 → $S_{ut} = 100$ kpsi, $S_{yt} = 84$ kpsi

$$\sigma_a = \overset{\text{خمش}}{K_f} \frac{32 M_a}{\pi d^3}, \quad \tau_a = K_{fs} \frac{16 T_a}{\pi d^3}, \quad \sigma_m = \overset{\text{محوری}}{K_f} \frac{4F}{\pi d^2}, \quad \tau_m = 0$$

$S'_e = 0.5 S_{ut}$ $\quad S_{ut} \leqslant 200$ kpsi

$\rightarrow S'_e = 0.5 \times 100 = 50$ kpsi

$k_a = a S_{ut}^b$

Table 6-2 → CD → $a = 2.70$, $b = -0.265$

$\rightarrow k_a = 2.70 (100)^{-0.265} = 0.797$

ضریب محوره (خمشی لحاظ می‌شود!)

$$k_b = \begin{cases} 0.879\, d_e^{-0.107} & 0.11 \leqslant d \leqslant 2 \text{ in} \\ 0.910\, d_e^{-0.157} & 2 < d \leqslant 10 \text{ in} \end{cases}$$

Non-rotational

$d_e = 0.370 d$

$k_c = 1$ ضریب محوره (خمشی لحاظ می‌شود!)

$k_d = 1$ کار در دمای محیط

$k_e = 0.868$ for $R = 95\%$

Figure 6-20 → $S_{ut} = 100$ kpsi → $q = 0.85$ (Assume $d = 1$ in, $r = 0.15$)

Figure 6-21 → $S_{ut} = 100$ kpsi → $q_s = 0.90$ 〃

$K_f = 1 + q(K_t - 1) = 1 + 0.85(1.45 - 1) = 1.383$ محوری/خمشی

$K_{fs} = 1 + q(K_{ts} - 1) = 1 + 0.90(1.15 - 1) = 1.135$ پیچشی

فرض: $d = 1$ in → $k_b = 0.879(0.370 \times 1)^{-0.107} = 0.978$

$$S_e = k_a k_b k_c k_d k_e \underset{\substack{\downarrow \\ \text{اینجا یک لحاظ می‌شود}}}{k_f} S'_e = 0.797 \times 0.978 \times 1 \times 1 \times 0.868 \times 1 \times 50 = 33.8 \text{ kpsi}$$

②

فرض $d = 1$ in

$$\sigma_a = 1.383 \times \frac{32 \times 1500}{\pi (1)^3} = 21.1 \quad \text{kpsi}$$

$$\tau_a = 1.135 \times \frac{16 \times 1000}{\pi (1)^3} = 5.8 \quad \text{kpsi}$$

$$\sigma_m = 1.383 \times \frac{4 \times 100}{\pi (1)^2} = 0.2 \quad \text{kpsi}$$

$$\tau_m = 0$$

$$\sigma_a' = \sqrt{\sigma_a^2 + 3\tau_a^2} = \sqrt{(21.1)^2 + 3(5.8)^2} = 23.4 \quad \text{kpsi}$$

$$\sigma_m' = \sqrt{\sigma_m^2 + 3\tau_m^2} = \sqrt{(0.2)^2 + 3(0)^2} = 0.2 \quad \text{kpsi}$$

گودمن ✓

$$\frac{1}{n} = \frac{\sigma_a'}{S_e} + \frac{\sigma_m'}{S_{ut}}$$

$$\rightarrow \frac{1}{n} = \frac{23.4}{33.8} + \frac{0.2}{100}$$

$$\rightarrow n = 1.4$$

سودربرگ ✓

$$\frac{1}{n} = \frac{\sigma_a'}{S_e} + \frac{\sigma_m'}{S_{yt}}$$

$$\rightarrow \frac{1}{n} = \frac{23.4}{33.8} + \frac{0.2}{84}$$

$$\rightarrow n = 1.4$$

پس مطابق با گودمن کنترل گردد همانطور که در صورت سوال عدد ضریب اطمینان 1.2 لحاظ شده است!

فرض $d = 0.8$ in

$$k_b = 0.879\,(0.370 \times 0.8)^{-0.107} = 1.001$$

$$\frac{r}{d} = 0.15 \longrightarrow r = 0.15 \times 0.8 = 0.120 \longrightarrow$$ تغییرات زیادی در q و q_s ایجاد نمی‌شود

$$\Rightarrow K_f = 1.383 , \quad K_{fs} = 1.135$$

$$\rightarrow S_e = 34.6 \quad \text{kpsi}$$

$$\rightarrow \sigma_a = 41.3 \text{ kpsi} , \quad \tau_a = 11.3 \text{ kpsi} , \quad \sigma_m = 0.3 \text{ kpsi}$$

$$\rightarrow \sigma_a' = 45.7 \text{ kpsi} , \quad \sigma_m' = 0.3 \text{ kpsi}$$

$$\rightarrow n_{Goodman} = 0.8 , \quad n_{Soderberg} = 0.8$$

X غیرقابل قبول است !!!

③

نوبت سوم $d = 0.9$ in

$k_b = 0.879(0.370 \times 0.9)^{-0.107} = 0.989$

$\frac{r}{d} = 0.15 \rightarrow r = 0.15 \times 0.9 = 0.135$ → تغییرات زیادی در q و qs نداریم!
Kf و Kfs همان است!

→ $S_e = 34.2$ kpsi

→ $\sigma_a = 29.0$ kpsi, $\tau_a = 7.9$ kpsi, $\sigma_m = 0.2$ kpsi

→ $\sigma_a' = 32.1$ kpsi, $\sigma_m' = 0.2$ kpsi

→ $n_{Goodman} = 1.1$, $n_{Soderberg} = 1.1$

X کمتر از مقدار صورت مسئله است !

نوبت چهارم $d = 0.95$ in

$k_b = 0.983$

→ $S_e = 34.0$ kpsi

→ $\sigma_a = 24.6$ kpsi, $\tau_a = 6.7$ kpsi, $\sigma_m = 0.2$ kpsi

→ $\sigma_a' = 27.3$ kpsi, $\sigma_m' = 0.2$ kpsi

→ $n_{Goodman} = 1.2$, $n_{Soderberg} = 1.2$

④

سؤال ۱)

M20 : Heavy Hexagonal

Table A-29 → $W = 34$ mm , $H = 13.40$ mm   پیچ (bolt)

Table A-30 → $W = 34$ mm , $H = 12.88$ mm   پیچ (screw)

Table 8-1 → $d = 20$ mm , $p = 2.5$ mm
$A_t = 245 \text{ mm}^2$, $A_r = 225 \text{ mm}^2$ } Coarse-pitch series

$d = 20$ mm , $p = 1.5$ mm
$A_t = 272 \text{ mm}^2$, $A_r = 259 \text{ mm}^2$ } Fine-pitch series

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Table A-31 → $W = 30$ mm , $H = 18$ mm   مهره (nut)

Table 8-7 (a)

$$l = t_1 + t_2 = 20 + 25 = 45 \text{ mm}$$

$$L > l + H = 45 + 18 = 63 \text{ mm}$$

$$L_T = 2d + 6 \text{ mm} \qquad L \leq 125 \text{ mm}, \; d \leq 48 \text{ mm}$$

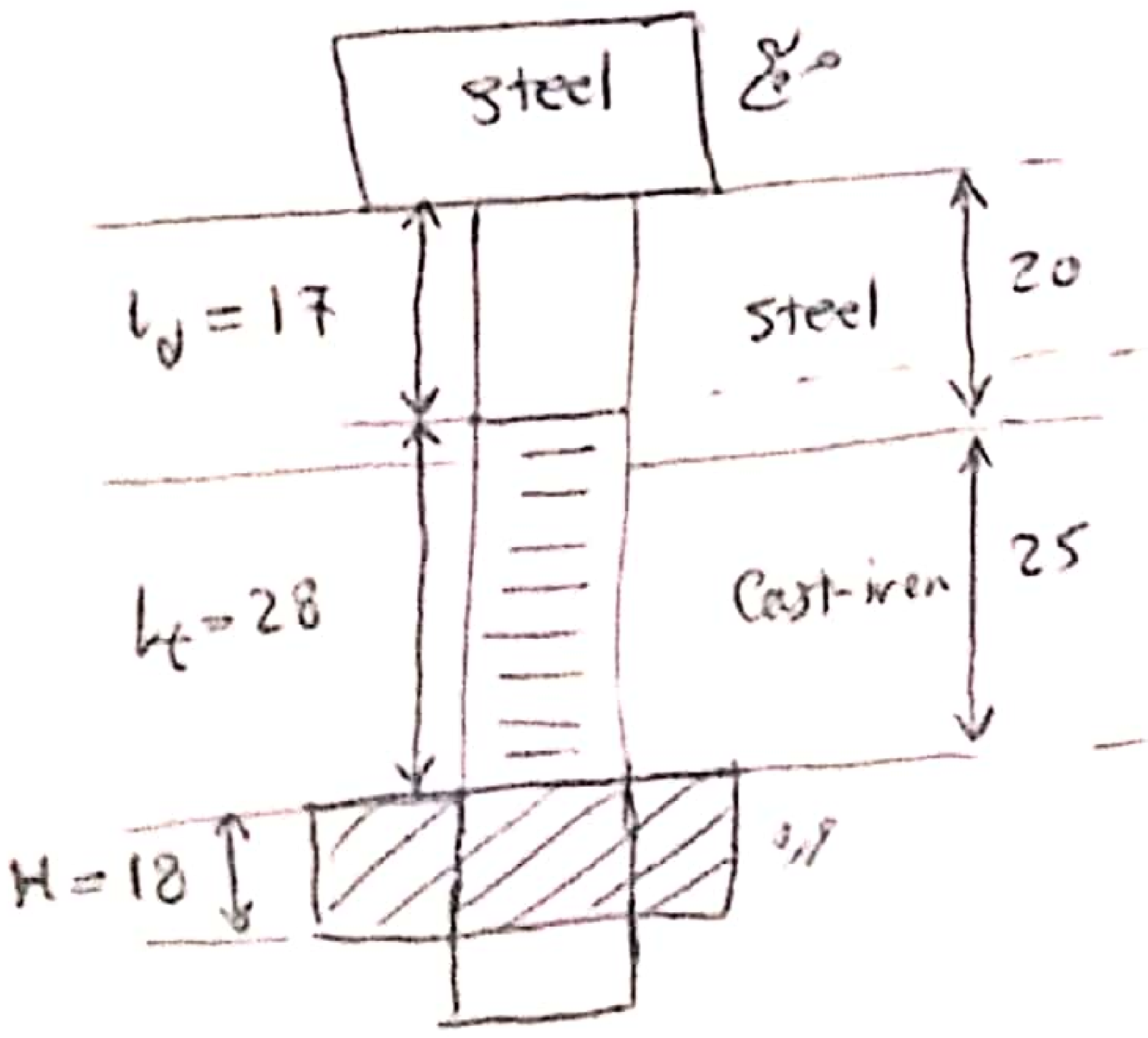
$$\rightarrow L_T = 2 \times 20 + 6 = 46 \text{ mm}$$

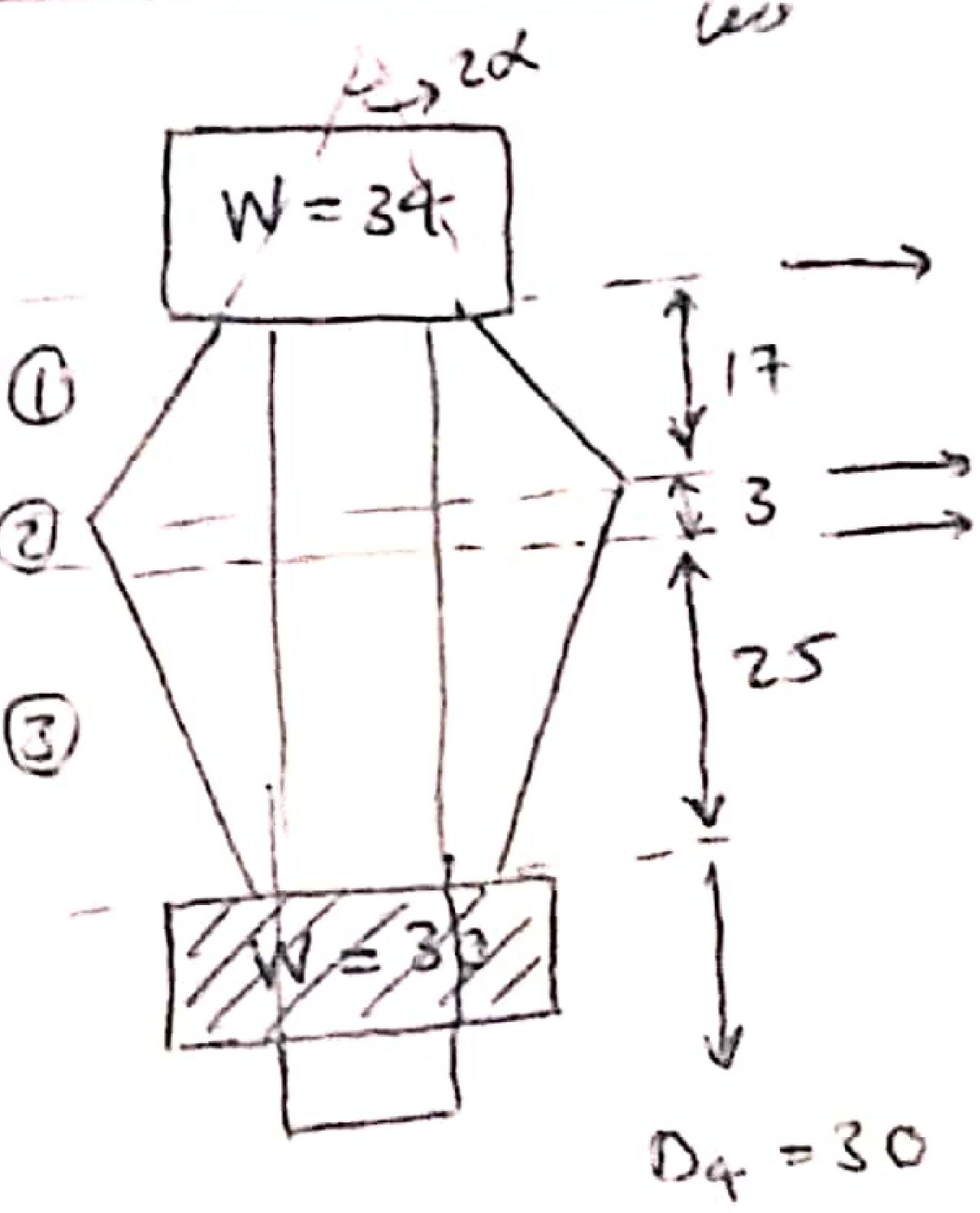
$$l_d = L - L_T = 63 - 46 = 17 \text{ mm}$$

$$l_t = l - l_d = 45 - 17 = 28 \text{ mm}$$

$$A_d = \frac{\pi d^2}{4} = \frac{\pi (20)^2}{4} = 314 \text{ mm}^2$$

Table 8-8 → $E_{steel} = \underset{\text{پیچ و واشر}}{\underset{\downarrow}{207 \text{ GPa}}}$, $E_{cast\text{-}iron} = \underset{\text{بدنه}}{\underset{\downarrow}{100 \text{ GPa}}}$





$\longrightarrow D_1 = 34$ mm

$\longrightarrow D_2 = 34 + 2(17)\tan 30$

$\longrightarrow D_3 = 30 + 2(25)\tan 30$

$\downarrow$

$D_2 = 53.6$

$D_3 = 58.9$

$$k_{i,m} = \frac{0.5774\pi E d}{2\ln\left(5\,\frac{0.5774l + 0.5d}{0.5774l + 2.5d}\right)}$$ X باواشر

$$k_{i,m} = \frac{0.5774\pi E d}{\ln\frac{(1.155t + D - d)(D + d)}{(1.155t + D + d)(D - d)}}$$ ✓ بدون واشر

$$k_1 = \frac{0.5774\pi \times 207\times10^{9} \times 34\times10^{-3}}{\ln\frac{(1.155\times17\times10^{-3} + 53.6\times10^{-3} - 34\times10^{-3})(53.6+34)\times10^{-3}}{(1.155\times17\times10^{-3} + 53.6\times10^{-3} + 34\times10^{-3})(53.6-34)\times10^{-3}}} = 25.959\ \frac{GN}{m}$$

$$k_2 = \frac{0.5774\pi \times 207\times10^{9} \times 53.6\times10^{-3}}{\ln\frac{(1.155\times3\times10^{-3} + 58.9\times10^{-3} - 53.6\times10^{-3})(58.9+53.6)\times10^{-3}}{(1.155\times3\times10^{-3} + 58.9\times10^{-3} + 53.6\times10^{-3})(58.9-53.6)\times10^{-3}}} = 42.575\ \frac{GN}{m}$$

$$k_3 = \frac{0.5774\pi \times 100\times10^{9} \times 30\times10^{-3}}{\ln\frac{(1.155\times25\times10^{-3} + 58.9\times10^{-3} - 30\times10^{-3})(58.9+30)\times10^{-3}}{(1.155\times25\times10^{-3} + 58.9\times10^{-3} + 30\times10^{-3})(58.9-30)\times10^{-3}}} = 13.226\ \frac{GN}{m}$$

$$\frac{1}{k_m} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} = \frac{1}{25.959} + \frac{1}{42.575} + \frac{1}{13.226} \rightarrow k_m = 7.266\ \frac{GN}{m}$$

$$k_b = \frac{A_d A_t E}{A_d l_t + A_t l_d} = \frac{314\times10^{-6} \times A_t \times 207\times10^{9}}{314\times10^{-6}\times28\times10^{-3} + A_t\times17\times10^{-3}}$$

$$\begin{cases} \text{Coarse-pitch series} \rightarrow k_b = 1.229\ \frac{GN}{m} \\ \text{Fine-pitch series} \rightarrow k_b = 1.318\ \frac{GN}{m} \end{cases}$$

$F_i = 0.90 F_p$ for permanent connections

$F_p = A_t S_p$

Table 8-11 → Glass 8.8 → $S_p = 600$ MPa, $S_{ut} = 830$ MPa, $S_{yt} = 660$ MPa

$$F_p = \begin{cases} \rightarrow \text{Coarse-pitch series} = 245\times10^{-6} \times 600\times10^{6} = 147.0\ kN \\ \rightarrow \text{Fine-pitch series} = 272\times10^{-6} \times 600\times10^{6} = 163.2\ kN \end{cases}$$

⑥

$F_i =$ → Coarse-pitch series $= 0.9 \times 147.0 = 132.3$ kN

→ Fine-pitch series $= 0.9 \times 163.2 = 146.9$ kN

Table 8-17 → ISO 8.8 → $S_e = 129$ MPa

$$\sigma_a = \frac{C\,(P_{max} - P_{min})}{2A_t} = \frac{C\,\Delta P}{2A_t}$$

Gerber → $$n_f = \frac{1}{2\sigma_a S_e}\left[S_{ut}\sqrt{S_{ut}^2 + 4S_e(S_e + \sigma_i)} - S_{ut}^2 - 2\sigma_i S_e\right]$$

$C = \dfrac{k_b}{k_b + k_m} =$ → Coarse-pitch Series = [redacted] 0.145

→ Fine-pitch Series = [redacted] 0.154

$\sigma_i = \dfrac{F_i}{A_t} =$ → Coarse-pitch Series = 540 MPa

→ Fine-pitch Series = 540 MPa

⇒ [redacted] - $\sigma_a = \dfrac{C\,\Delta P}{2A_t}$ → Coarse-pitch Series = [redacted] 0.000296 ΔP (MPa)

→ Fine-pitch Serie = [redacted] 0.000283 ΔP (MPa)

Gerber → $\Delta P = \dfrac{1}{2S_e n_f \left(\frac{C}{2A_t}\right)}\left[\cdots\right]$, $n_f = 1.1$

$\Delta P =$ → Coarse-pitch Series = 509.8 kN

→ Fine-pitch Series = 532.9 kN