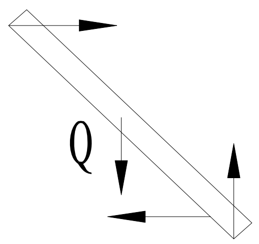
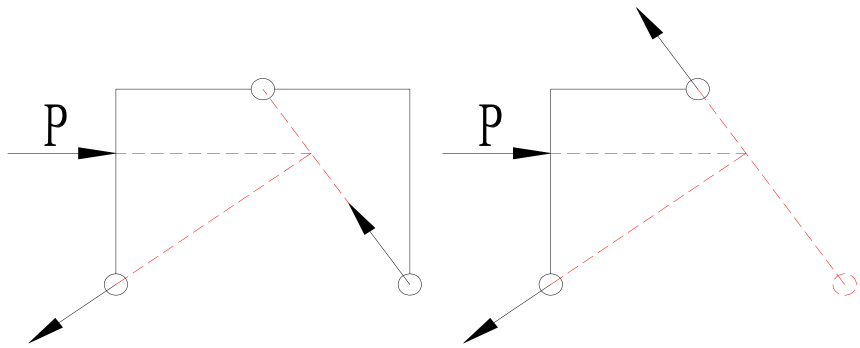
1-1 解



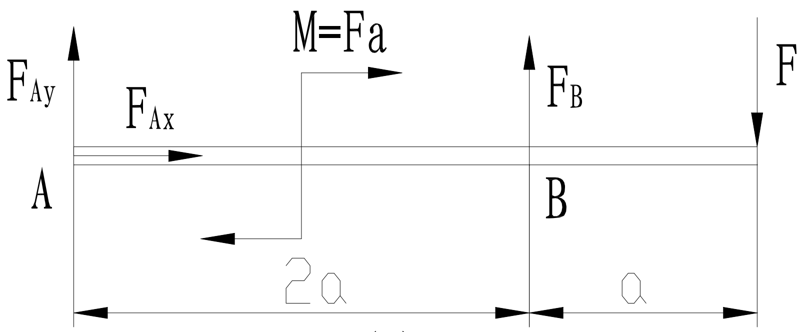
(c)



(d)

1-9 解

（a） 设约束反力 F_{AX}、F_{AY}、F_B 方向如图所示



(a)

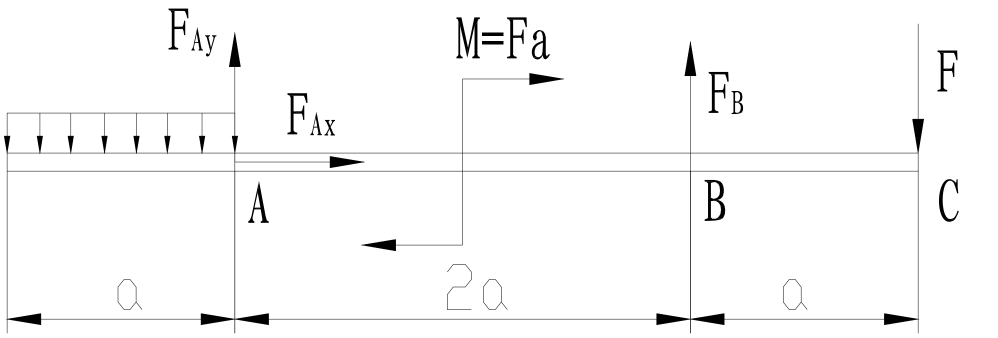
由平衡条件：

$\sum M_A = 0: F_B \cdot 2a - F \cdot 3a - Fa = 0 \Rightarrow F_B = 2F$ (与所设方向相同)

$\sum M_B = 0: -F_{AY} \cdot 2a - F \cdot a - Fa = 0 \Rightarrow F_{AY} = -F$ (与所设方向相反)

$\boxed{\sum X = 0: F_{AX} = 0}$

（b） 设约束反力 F_{AX}、F_{AY}、F_B 方向如图所示



(b)

由平衡条件：

$$\sum M_A = 0: qa \cdot \frac{a}{2} - F \cdot a - F \cdot 3a + F_B 2a = 0 \Rightarrow F_B = 1.75F \quad (\text{与所设方向相同})$$

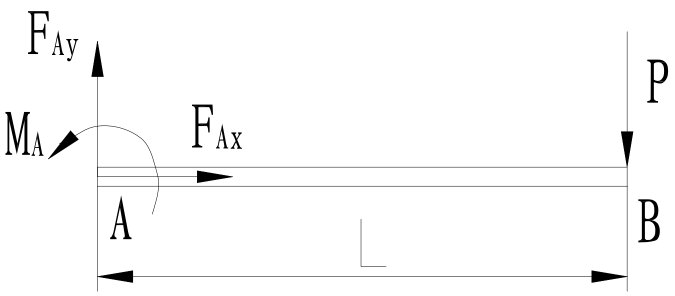
$$\boxed{\sum Y = 0: -qa + F_{AY} - F + F_B = 0 \Rightarrow F_{AY} = 0.25F \quad (\text{与所设方向相反})}$$

$$\sum X = 0: F_{AX} = 0$$

注意此时不再按照Mb为零进行列式计算

1-11 解

设约束反力和力偶方向如图所示



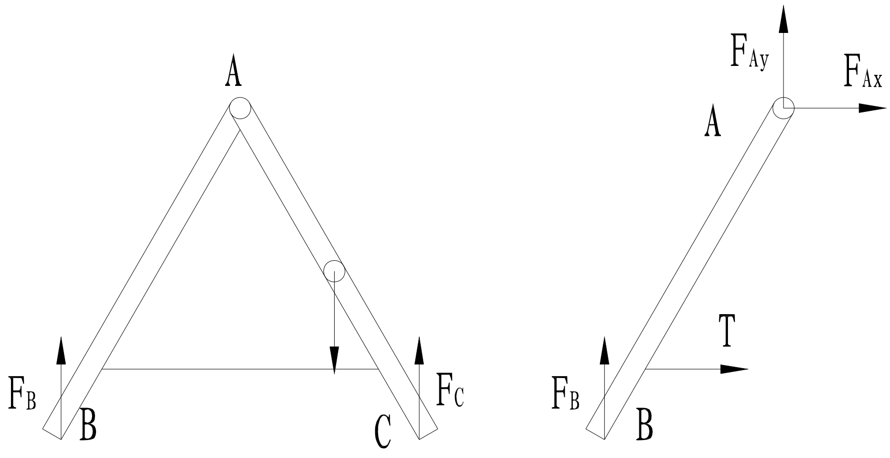
由平衡条件：

$$\sum Y = 0: F_{AY} = P \quad (\text{正号表示与所设方向相同})$$

$$\sum X = 0: F_{AX} = 0$$

$$\sum M_A = 0: M_A = PL \quad (\text{正号表示与所设方向相同})$$

1-15 解



（1）先求地面对梯子的支撑反力，如图所示分别设为 FB、FC。

由平衡条件:

$$\sum M_C = 0: -F_B \bullet 2l\cos\alpha + Pa \bullet \cos\alpha = 0 \Rightarrow F_B = \frac{a}{2l}P$$ (与所设方向相同)

$$\sum Y = 0: F_B - P + F_C = 0 \Rightarrow F_C = (1 - \frac{a}{2l})P$$ (与所设方向相同)

或 $\sum M_B = 0: F_C \bullet 2l\cos\alpha - P(2l-a)\cos\alpha = 0 \Rightarrow F_C = (1-\frac{a}{2l})P$ (与所设方向相同)

$$\sum Y = 0: F_B - P + F_C = 0 \Rightarrow F_B = \frac{a}{2l}P$$ (与所设方向相同)

（2）以 AB 杆为研究对象（或以 BC 杆为研究对象）

由平衡条件：

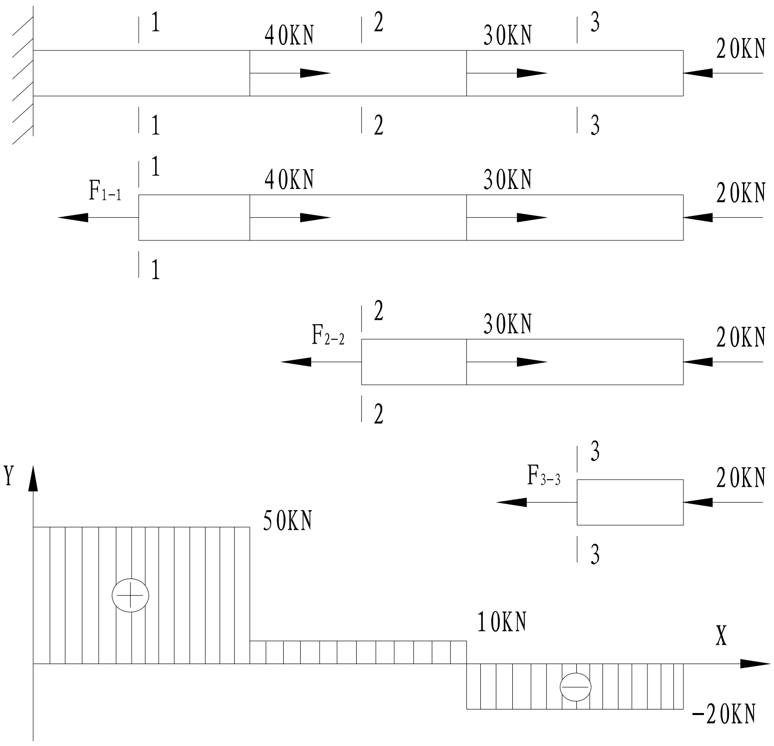
$$\sum M_A = 0$$

则： $-F_B l\cos\alpha + Th = 0 \Rightarrow T = \frac{l}{h}\cos\alpha \bullet F_B = \frac{a\cos\alpha}{2h}P$

代入数据，则：

$$T = \frac{a\cos\alpha}{2h}P = \frac{2\cos 75^\circ}{2\times 3}\times 600 = 51.76(N)$$ 拉力

1-17 解：（a）



(a)

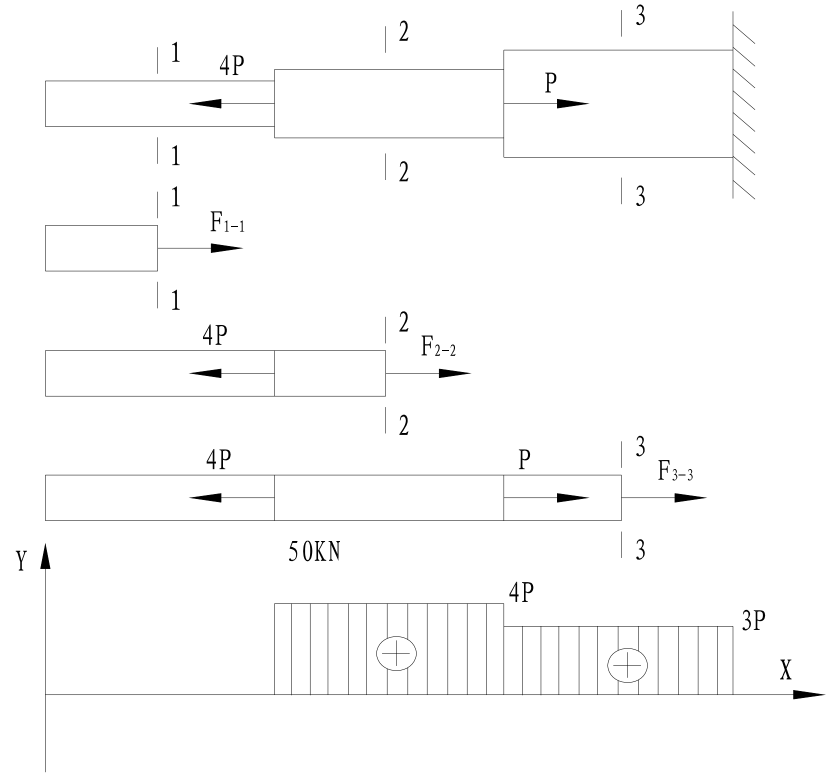
由$\sum F=0$得：

$$F_{1-1}=50KN$$

$$F_{2-2}=10KN$$

$$F_{3-3}=-20KN$$

（b）



(b)

由$\sum F=0$得：

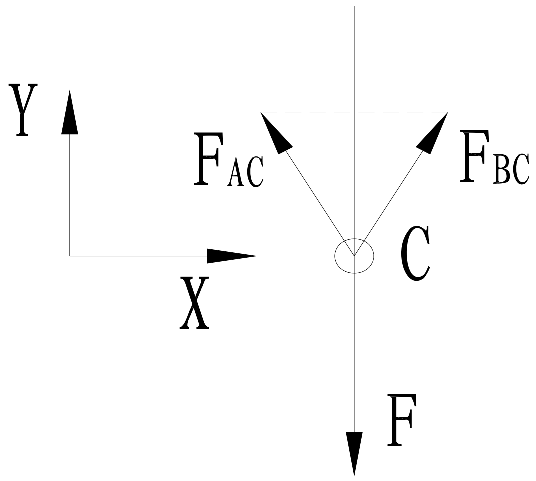
$$F_{1-1}=0$$

$$F_{2-2}=4P$$

$$F_{3-3}=3P$$

1-18 解

（1）求 AC、BC 杆的受力(忽略变形对角度的影响)



设 AC、BC 杆所受的拉力分别 F_{AC}、F_{BC}，如图所示

由平衡条件：

$$\sum X = 0: F_{AC} = F_{BC}$$

$$\sum Y = 0: F_{AC}\cos 30° + F_{BC}\cos 30° - F = 0$$

$$\therefore F_{AC} = F_{BC} = \frac{1}{\sqrt{3}}F = \frac{1}{\sqrt{3}} \times 130KN = 75.06KN$$

（2）校核构件强度

$$\sigma_{AC拉} = \frac{F_{AC}}{A_{AC}} = \frac{75.06\times10^{3}}{0.015^{2}\times\pi}Pa = 106.18MPa < \left[\sigma_{钢}\right] = 160MPa$$

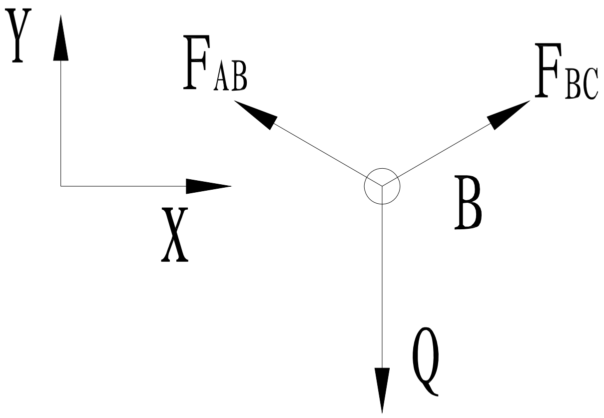
AC 杆强度满足。

$$\sigma_{BC拉} = \frac{F_{BC}}{A_{BC}} = \frac{75.06\times10^{3}}{0.02^{2}\times\pi}Pa = 59.73MPa < \left[\sigma_{铝}\right] = 60MPa$$

BC 杆强度满足。

1-19 解

（1）先分别求出 AB、BC 杆的受力（分析 B 点受力平衡）



设 AB 杆受拉力 F_{AB}，BC 杆受压力 F_{BC}

$$\sum X = 0 : F_{AB} = F_{BC}$$

$$\sum Y = 0 : F_{AB} \sin 30° + F_{BC} \sin 30° - F = 0$$

则： $F_{AB} = F_{BC} = F = 60KN$

正号表示受力方向与假设相同。

（2）两杆所需最小横截面面积

由已知：

$$\frac{F_{AB}}{A_{AB}} \le [\sigma_{钢}] = 160MPa \Rightarrow A_{AB} \ge \frac{F_{AB}}{160MPa} = \frac{60\times10^3}{160\times10^6} = 0.375\times10^{-3} m^2$$

AB 杆最小横截面面积：$A_{AB(min)}$=0.375×$10^{-3}$$m^2$

$$\frac{F_{BC}}{A_{BC}} \le [\sigma] = 4MPa \Rightarrow A_{BC} \ge \frac{60\times10^3}{4\times10^6} = 0.015m^2$$

BC 杆最小横截面面积：$A_{BC(min)}$=0.015m^2

1-22 解

由强度条件得：

（1）剪切 $\dfrac{P}{\pi dh} \le [\tau] = 0.6[\sigma] \Rightarrow \dfrac{P}{0.6\pi dh} \le [\sigma]$

（2）拉伸 $\dfrac{P}{\pi d^2/4} \le [\sigma]$

显然当 $\dfrac{P}{0.6\pi dh} = \dfrac{P}{\pi d^2/4} = [\sigma]$ 剪切与拉伸同时满足强度条件,

此时 d 与 h 的较为合理,即 d/h=2.4。

1-26 解

力矩平衡，以轴心为支点： $P \times 600 = Q \times \dfrac{d}{2} = Q \times 10 \Rightarrow Q = 60P$

剪应力 $\tau = \dfrac{Q}{6 \times 35 \times 10^{-6}} = \dfrac{Q}{2.1 \times 10^{-4}} \le [\tau] = 100 \times 10^6 Pa \quad \Rightarrow Q \le 21000N$

$\therefore P \le \dfrac{21000}{60} = 350N$

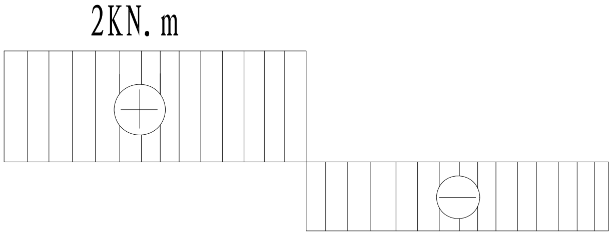
挤压应力 $\sigma = \dfrac{Q}{\frac{1}{2} \times 6 \times 35 \times 10^{-6}} = \dfrac{Q}{1.05 \times 10^{-4}} \le [\sigma_{iy}] = 220 \times 10^6 Pa \quad \Rightarrow Q \le 23100N$

$\therefore P \le \dfrac{23100}{60} = 385N$

所以许可作用力 $P \le 350N$

1-28 解

(1)解

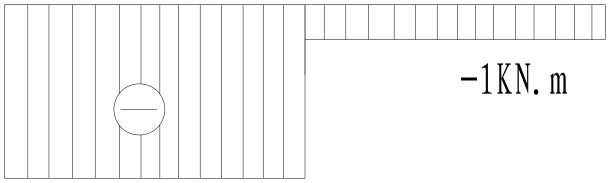


(a)

对 1-1 截面：$T_1 = 2KN.m$

对 2-2 截面：$T_2 = -1KN.m$

(2)解



(b)

对 1-1 截面：$T_1 = -1KN.m$

对 2-2 截面：$T_2 = -4KN.m$

1-29 解

$$\boxed{m = 9550\frac{N}{n}} = 9550 \times \frac{5.5}{40} = 1313.1N.m$$

$$\boxed{W_P = \frac{\pi D^3}{16}\left(1-\alpha^4\right)} = \frac{3.14 \times 0.089^3}{16}\left[1-\left(\frac{69}{89}\right)^4\right] = 8.84 \times 10^{-5} m^3$$

$$\boxed{\tau = \frac{m}{W_p}} = \frac{1313.1}{8.84 \times 10^{-5}} \approx 14.86MPa < [\tau]$$

故强度足够，安全。

1-30 解

计算外力偶矩：$m = 9550\frac{P}{n} = 9550 \times \frac{7.35}{100} = 701.925(N.m)$

轴上的扭矩：$T = m = 701.925(N.m)$

由 $\tau_{\max} = \frac{T}{W_P} \leq [\tau]$

实心轴：$W_P = \frac{\pi d_1^3}{16}$

则： $d_1 \geq \sqrt[3]{\dfrac{16T}{\pi[\tau]}} = \sqrt[3]{\dfrac{16 \times 701.925}{\pi \times 20 \times 10^6}} = 5.633 \times 10^{-2}(m)$

空心轴： $W_P = \dfrac{\pi D_2^{\ 3}}{16}\left(1-\alpha^4\right)$

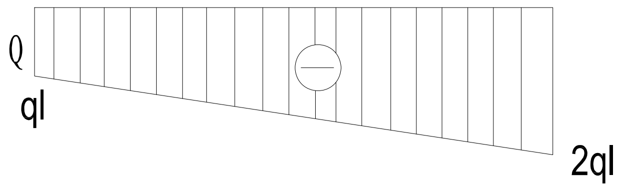
则： $D_2 \geq \sqrt[3]{\dfrac{16T}{\pi\left(1-\alpha^4\right)[\tau]}} = 6.71 \times 10^{-2}(m)$

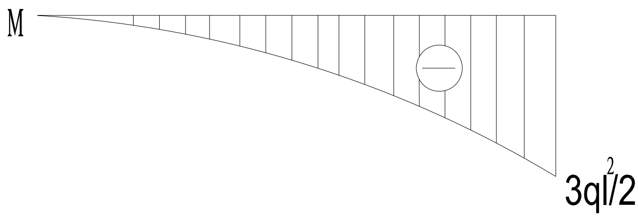
1-33 解

(a)

$Q(x) = -q(x+l) \quad 0 \leq x \leq l$（坐标系从左到右，以下题目均如此）

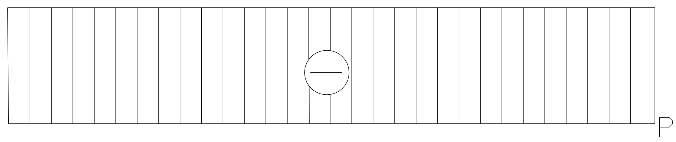
$M(x) = -qlx - \dfrac{q}{2}x^2 \quad 0 \leq x \leq l$

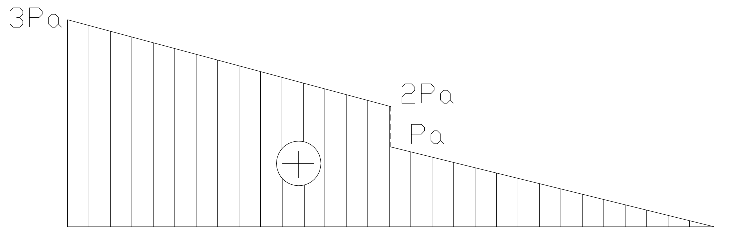




(e) $Q(x) = -P \qquad 0 \leq x \leq 2a$

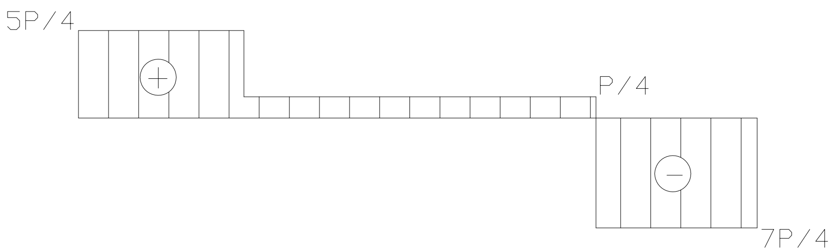
$$M(x) = \begin{cases} P(3a - x) & 0 \leq x < a \\ P(2a - x) & a < x \leq 2a \end{cases}$$

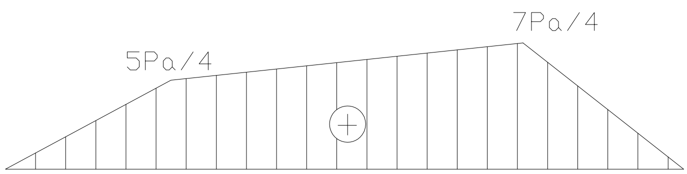




（f） $R_A=\dfrac{5}{4}P \quad R_B=\dfrac{7}{4}P$ （均向上）

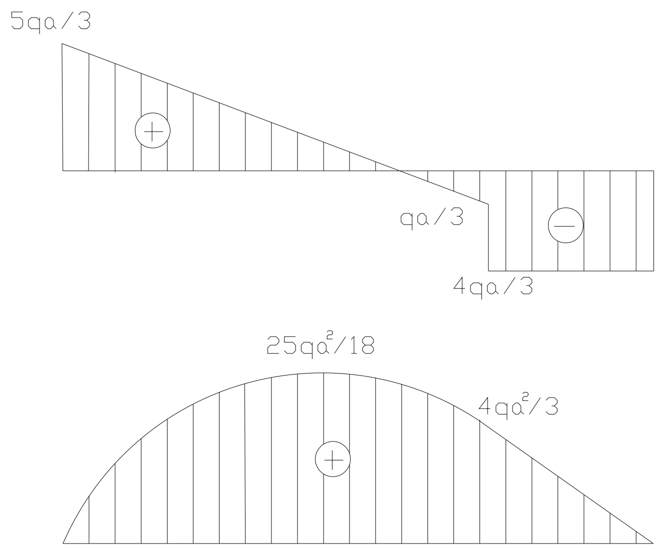
$$Q(x)=\begin{cases}\dfrac{5}{4}P & 0\le x<a\\ \dfrac{P}{4} & a<x<3a\\ -\dfrac{7}{4}P & 3a<x\le 4a\end{cases}\qquad M(x)=\begin{cases}\dfrac{5}{4}Px & 0\le x\le a\\ \dfrac{P}{4}x+Pa & a\le x\le 3a\\ -\dfrac{7}{4}Px+7Pa & 3a\le x\le 4a\end{cases}$$





(j) $R_A=\dfrac{5}{3}qa \quad R_B=\dfrac{4}{3}qa$ （均向上）

$$Q(x)=\begin{cases}\dfrac{5}{3}qa-qx & 0\le x<2a\\ -\dfrac{4}{3}qa & 2a<x\le 3a\end{cases}\qquad M(x)=\begin{cases}\dfrac{5}{3}qax-\dfrac{1}{2}qx^2 & 0\le x\le 2a\\ \dfrac{4}{3}qa(3a-x) & 2a\le x\le 3a\end{cases}$$



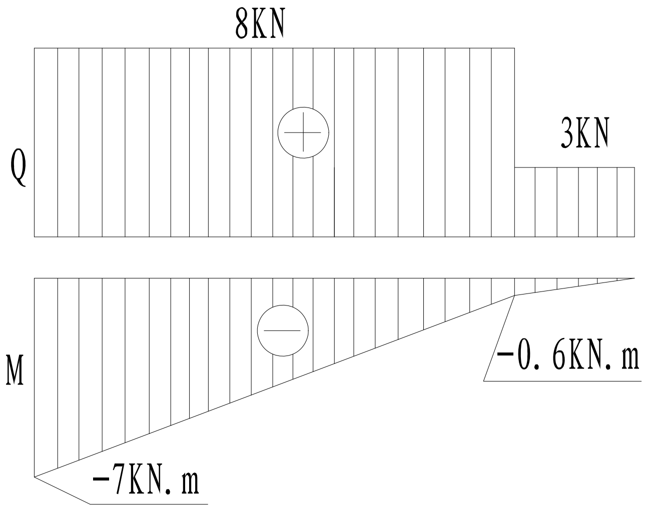
1-36 解

如下图 $M_{\max}=7KN.m$

取许用应力 $[\sigma]=120MPa$

则 $W_z=\dfrac{M_{\max}}{[\sigma]}=\dfrac{7KN.m}{120MPa}=58.3cm^3$

查表可选用 12.6 型号的工字钢。



1-37 解

$$\sum M_0=0\Rightarrow N=2P=16KN$$

$$\boxed{W_Z=\frac{bh^2}{6}=\frac{3}{2}b^3}$$

对 I-I 截面 $M_I=P\times(680-80)=4.8KN.m$

$$\boxed{\sigma=\frac{M_{max}}{I}y_{max}\qquad I=\frac{bh^3}{12}}$$

$$W_Z=\frac{3}{2}b_I{}^3\geq\frac{M_I}{[\sigma]}\Rightarrow b_I\geq40mm$$

对 II-II 截面 $M_{II}=N\times(340-80)=4.16KN.m$

$$W_Z=\frac{3}{2}b_{II}{}^3\geq\frac{M_{II}}{[\sigma]}\Rightarrow b_{II}\geq38.2mm$$

综上所述，在截面 I-I 与 II-II 截面尺寸相同的情况下，应选取 40x120mm。

1-38 解

裙式支座底部的最大弯矩 $M_{\max}=q.\frac{h^2}{2}.(D_{内}+2\delta)=23.77KN.m$

抗弯截面模量 $W_z=\frac{\pi\left[\left(D_{内}+2\delta\right)^4-D_{内}{}^4\right]}{32\left(D_{内}+2\delta\right)}=6.33\times10^{-3}m^3$

$$[\sigma]_{\max}=\frac{M_{\max}}{W_Z}=3.76MPa$$

1-45 解

拉应力：$\sigma_{拉}=\frac{P}{A}=\frac{P}{\pi d^2/4}=0.955MPa$

最大弯曲正应力：$\boxed{\sigma_{弯}=\pm\frac{m}{W_Z}=\pm\frac{Ph}{\pi d^3/32}}=\pm30.56MPa$

轴上最大正应力：

$$\sigma_{\max}=\frac{P}{A}+\frac{m}{W_Z}=0.955+30.56=31.6<35MPa=[\sigma]$$

立柱强度满足。

3-6

(a)　A 点：$R_1 = r$；

$$R_2 = r + \frac{D}{2\sin\varphi}$$；

$$r_A = r\sin\varphi + \frac{D}{2}$$

A’点：$R_1 = \infty$；

$$R_2 = \frac{D}{2}$$；

$$r_{A'} = \frac{D}{2}$$。

(b)　A 点：$R_1 = \infty$；

$$R_2 = \frac{x\tan\alpha}{\cos\alpha}$$；

$$r_A = x\tan\alpha$$

A’点：$R_1 = \infty$；

$$R_2 = \frac{D}{2\cos\alpha}$$；

$$r_{A'} = \frac{D}{2}$$。

3-7

(1)
$$\sigma_\varphi = \sigma_\theta = \frac{pD}{4\delta} = \frac{2MPa\times 1000mm}{4\times 20mm} = 25MPa$$

(2)　A 点:
$$\sigma_\theta = \frac{pD}{2\delta\cos\alpha} = \frac{0.5MPa\times 1000mm}{2\times 10mm\cos\alpha} = \frac{25}{\cos\alpha}MPa$$

$$\sigma_\varphi = \frac{pD}{4\delta\cos\alpha} = \frac{0.5MPa\times 1000mm}{4\times 10mm\cos\alpha} = \frac{12.5}{\cos\alpha}MPa$$

B 点: $\sigma_{\varphi}=\sigma_{\theta}=0$

(3) A 点: $\sigma_{\varphi}=\sigma_{\theta}=\dfrac{pa^2}{2b\delta}=10MPa$

B 点: $\sigma_{\varphi}=\dfrac{p}{2\delta}\dfrac{\left[a^4-x^2\left(a^2-b^2\right)\right]^{\frac{1}{2}}}{b}=8.54MPa$

$$\sigma_{\theta}=\frac{p}{2\delta}\frac{\left[a^4-x^2\left(a^2-b^2\right)\right]^{\frac{1}{2}}}{b}\left[2-\frac{a^4}{a^4-x^2\left(a^2-b^2\right)}\right]=5.38MPa$$

C 点: $\sigma_{\varphi}=\dfrac{pa}{2\delta}=5MPa$

$$\sigma_{\theta}=\frac{pa}{2\delta}\left(2-\frac{a^2}{b^2}\right)=-10MPa$$

3-12

(1)确定计算压力 p_c:

$$p_c=p+\rho gh=1.15MPa$$

(2)设计壁厚 δ:

查表得: $\varphi=0.85,[\sigma]^t=148\text{MPa}$

$$\delta=\frac{p_cD_i}{2[\sigma]^t\varphi-p_c}=\frac{1.15\times3000}{2\times148\times0.85-1.15}=13.78mm$$

取 $C_2=1mm$， $C_1=0.3$，则名义厚度 $\delta_n=[\delta+C_1+C_2]=16mm$

(3)试验压力校核

$\delta_e=\delta_n-C=\delta_n-C=16.7mm$ $\delta_e=\delta_n-C_1-C_2=14.7mm$

$$P_T=1.25p\frac{[\sigma]}{[\sigma]^t}=1.25MPa$$

$$\sigma_T = \frac{P_T(D_i + \delta_e)}{2\delta_e} = 128.2 < 0.9\varphi\sigma_S = 0.9 \times 0.85 \times 245 = 187.4$$

满足水压试验要求。

3-14

方法 1：

解： $D_i = 2500mm$ $h = 16000mm$ $\delta = 21.8mm$ $\varphi = 0.85$

$P = 1.6MPa$ $C_1 = 0.3mm$ $C_2 = 0$ 250℃下 $[\sigma]^t = 122MPa$

$P_C = P + \rho gh = 1.6 + 0.176 = 1.776MPa$

$$\delta = \frac{p_c.D_i}{2[\sigma]^t\varphi - p_c} = \frac{1.776 \times 2500}{2 \times 122 \times 0.85 - 1.776} = 21.59mm$$

$\delta_e = 21.8 - C_2 = 21.8 - 0 = 21.8mm$

$\delta_e > \delta$

故该筒体合适

方法 2：

查到 $[\sigma]^t = 122MPa$， $C_1 = 0.3mm$， $C_2 = 0mm$

$\delta_e = 21.8 - C_2 = 21.8mm$

静压力 $\rho gh = 1100 \times 10 \times 16000 \times 10^{-9} = 0.176MPa > 5\%P$

计算压力 $P_c = P + \rho gh = 1.6 + 0.176 = 1.776MPa$

$$\sigma_T = \frac{P_c(D_i + \delta_e)}{2\delta_e} = 102.72MPa < \phi[\sigma]^t = 0.85 \times 122 = 103.7MPa$$

故该筒体合适

3-19

对于 Q345R，取：$E^t = 206GPa$

计算长度：$L = 6000 + 2 \times \frac{1}{3} \times \frac{2800}{4} = 6466.67mm$

外径：$D_0 = D_i + 2\delta_n = 2800 + 2 \times 12 = 2824mm$

有效厚度：$\delta_e = \delta_n - C = 10mm$

$\frac{L}{D_0} = \frac{6466.67}{2824} = 2.2899$，$\frac{D_0}{\delta_e} = \frac{2824}{10} = 282.4$

查图 3-18 得：A=0.00012，

查图 3-20 得：B 落在曲线的左侧，故

$$[P] = \frac{2AE^t}{3\left(D_0 / \delta_e\right)} = \frac{2 \times 0.00012 \times 206 \times 10^9}{3 \times 282.4} = 0.058MPa$$