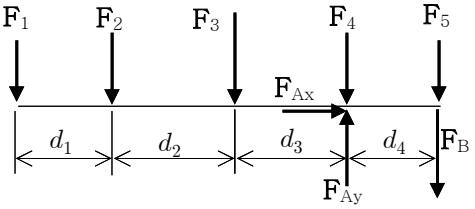
<4.1~4.5절>

4.4 [반력(핀, 링크), 평형(모멘트, 힘)]

$F_1 = F_5 = 60$ N, $F_2 = F_4 = 80$ N,

$F_3 = 140$ N

$d_1 = d_4 = 0.15$ m, $d_2 = d_3 = 0.2$ m



(a) $\rightarrow \Sigma F_x = 0$; $F_{Ax} = 0$

$+\circlearrowleft \Sigma M_B = 0$; $(d_1+d_2+d_3+d_4)F_1 + (d_2+d_3+d_4)F_2 + (d_3+d_4)F_3 + d_4(F_4-F_{Ay}) = 0$

$\Rightarrow F_{Ay} = \frac{1}{d_4}[(d_1+d_2+d_3+d_4)F_1 + (d_2+d_3+d_4)F_2 + (d_3+d_4)F_3 + d_4F_4]$

$= \frac{1}{0.15\text{ m}}$ [(0.7m)(60N) + (0.55m)(80N) + (0.35m)(140N) + (0.15m)(80N)]

$= \frac{147\text{ N}\cdot\text{m}}{0.15\text{ m}} = 980$ N $\Rightarrow$ $\mathbf{F}_A = 980$ N ↑

(b) $\uparrow \Sigma F_y = 0$; $-F_1 - F_2 - F_3 - F_4 - F_5 + F_{Ay} - F_B = 0$

$\Rightarrow F_B = -F_1 - F_2 - F_3 - F_4 - F_5 + F_{Ay}$

$= -(60\text{ N}) - (80\text{ N}) - (140\text{ N}) - (80\text{ N}) - (60\text{ N}) + (980\text{ N}) = 560$ N

다른 방법 (또는 검산) :

$+\circlearrowleft \Sigma M_A = 0$; $(d_1+d_2+d_3)F_1 + (d_2+d_3)F_2 + d_3F_3 - d_4(F_5+F_B) = 0$

$\Rightarrow F_B = \frac{1}{d_4}[(d_1+d_2+d_3)F_1 + (d_2+d_3)F_2 + (d_3)F_3 - d_4F_5]$

$= \frac{1}{0.15\text{ m}}$ [(0.55m)(60N) + (0.4m)(80N) + (0.2m)(140N) - (0.15m)(60N)]

$= \frac{84\text{ N}\cdot\text{m}}{0.15\text{ m}} = 560$ N

4.5 [반력(롤러), 평형(힘, 모멘트)]

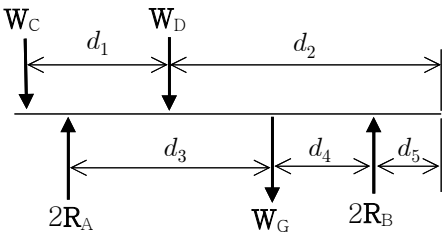
$d_1 = 1.7$ m, $d_2 = 2.8$ m, $d_3 = 1.8$ m

$d_4 = 1.2$ m, $d_5 = 0.75$ m

$m_C = m_D = 350$ kg, $m_G = 1400$ kg

$W_C = W_D = (350\text{ kg})(9.81\text{ m/s}^2) = 3434$ N

$W_G = (1400\text{ kg})(9.81\text{ m/s}^2) = 13734$ N



(a) $+\circlearrowleft \Sigma M_B = 0$; $(d_1+d_2-d_5)W_C + (d_2-d_5)W_D + d_4W_G - (d_3+d_4)\,2R_A = 0$

$\Rightarrow R_A = \frac{1}{2(d_3+d_4)}$ $[(d_1+d_2-d_5)W_C + (d_2-d_5)W_D + d_4W_G]$

$= \frac{1}{2(3.0\text{ m})}$ [(3.75 m)(3434 N) + (2.05 m)(3434 N) + (1.2 m)(13734 N)]

$= \frac{36398\text{ N}\cdot\text{m}}{6.0\text{ m}} = 6066.3$ N $\Rightarrow$ $\mathbf{R}_A = 6070$ N ↑ $= 6.07$ kN ↑

(b) $\uparrow \Sigma F_y = 0$; $\quad -W_C - W_D - W_G + 2R_A + 2R_B = 0$

$$\Rightarrow \quad R_B = \frac{1}{2}\,[\,W_C + W_D + W_G - 2R_A\,]$$

$$= \frac{1}{2}\,[(3434\ \text{N}) + (3434\ \text{N}) + (13734\ \text{N}) - 2\,(6066.3\ \text{N})]$$

$$= 4234\ \text{N} \qquad \Rightarrow \qquad \mathbf{R}_\text{B} = 4230\ \text{N} \uparrow = 4.23\ \text{kN} \uparrow$$

다른 방법 (또는 검산) :

$+\circlearrowleft \Sigma M_A = 0$; $\quad (d_1 + d_2 - d_3 - d_4 - d_5)\,W_C - (d_3 + d_4 + d_5 - d_2)\,W_D - d_3\,W_G + (d_3 + d_4)2R_B = 0$

$$\Rightarrow \quad R_B = \frac{1}{2(d_3 + d_4)}\,[-(d_1 + d_2 - d_3 - d_4 - d_5)\,W_C + (d_3 + d_4 + d_5 - d_2)\,W_D + d_3\,W_G]$$

$$= \frac{1}{2\,(3.0\ \text{m})}\,[-(0.75\ \text{m})(3434\ \text{N}) + (0.95\ \text{m})(3434\ \text{N}) + (1.8\ \text{m})(13734\ \text{N})]$$

$$= \frac{25408\ \text{N}\cdot\text{m}}{6.0\ \text{m}} = 4234\ \text{N} \qquad \Rightarrow \qquad \mathbf{R}_\text{B} = 4230\ \text{N} \uparrow = 4.23\ \text{kN} \uparrow$$

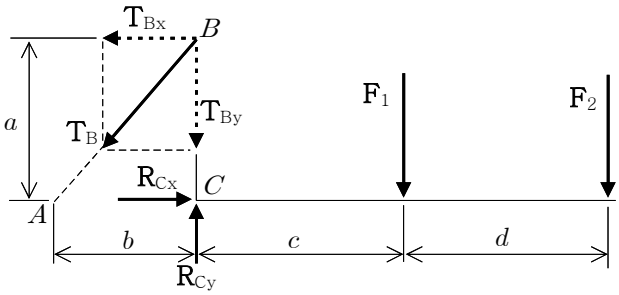
4.19 [반력(케이블, 힌지), 평형(힘, 모멘트)]

$a = 0.18$ m, $\quad b = 0.24$ m

$c = 0.4$ m, $\quad d = 0.4$ m

$F_1 = F_2 = 240$ N

$T_{Bx} = \frac{4}{5}\,T_B, \quad T_{By} = \frac{3}{5}\,T_B$



(a) $+\circlearrowleft \Sigma M_C = 0$; $\quad a\ T_{Bx} - c\ F_1 - (c + d)\ F_2 = 0$

$$\Rightarrow \quad T_{Bx} = \frac{1}{a}\,[c\ F_1 + (c + d)\ F_2] = \frac{1}{0.18\ \text{m}}\,[(0.4\ \text{m})(240\ \text{N}) + (0.8\ \text{m})(240\ \text{N})]$$

$$= \frac{288\ \text{N}\cdot\text{m}}{0.18\ \text{m}} = 1600\ \text{N}$$

$$T_B = \frac{5}{4}\,T_{Bx} = \frac{5}{4}\,(1600\ \text{N}) = 2000\ \text{N} = 2.00\ \text{kN}$$

(b) $\rightarrow \Sigma F_x = 0$; $\quad R_{Cx} - T_{Bx} = 0$

$$\Rightarrow \qquad R_{Cx} = T_{Bx} = 1600\ \text{N}$$

$\uparrow \Sigma F_y = 0$; $\quad R_{Cy} - T_{By} - F_1 - F_2 = 0$

$$\Rightarrow \qquad R_{Cy} = T_{By} + F_1 + F_2 = \frac{3}{5}\,(2000\ \text{N}) + (240\ \text{N}) + (240\ \text{N}) = 1680\ \text{N}$$

$$R_C = \sqrt{R_{Cx}^2 + R_{Cy}^2} = \sqrt{(1600\ \text{N})^2 + (1680\ \text{N})^2} = 2320\ \text{N} = 2.32\ \text{kN}$$

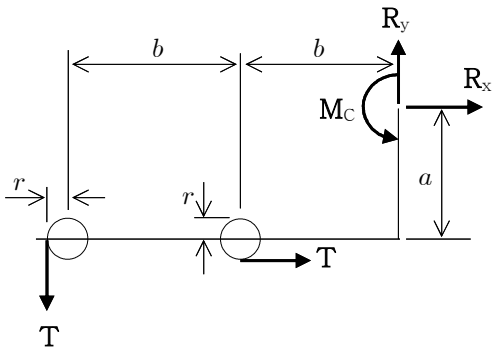
$$\tan\theta = \frac{R_{Cy}}{R_{Cx}} = \frac{1680\ \text{N}}{1600\ \text{N}} = 1.050 \qquad \Rightarrow \qquad \theta = \tan^{-1}(1.050) = 46.40^\circ$$

$\mathbf{R}_\text{C} = 2.32\ \text{kN} \nearrow 46.4^\circ$

4.44 [반력(고정 지지), 평형(힘, 모멘트)]

T = 20 N, r = 8 mm

a = 36 mm, b = 60 mm



$\rightarrow \Sigma F_x = 0$; $R_x + T = 0$

$\Rightarrow$ $R_x = -T = -20$ N

$\Rightarrow$ $\mathbf{R_x}$ = 20.0 N ←

$\uparrow \Sigma F_y = 0$; $R_y - T = 0$

$\Rightarrow$ $R_y = T$ = 20 N $\Rightarrow$ $\mathbf{R_y}$ = 20.0 N ↑

$+\circlearrowleft \Sigma M_C = 0$; $M_C + T(a+r) + T(2b+r) = 0$

$\Rightarrow$ $M_C = -T(a+r) - T(2b+r) = -(20\text{ N})(36+8\text{ mm}) - (20\text{ N})[2(60)+8\text{ mm}]$

$= -3440$ N·mm $= -3.44$ N·m

$\Rightarrow$ $\mathbf{M_C}$ = 3.44 N·m ↺

반력의 다른 표현

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(-20\text{ N})^2 + (20\text{ N})^2} = 28.28$ N

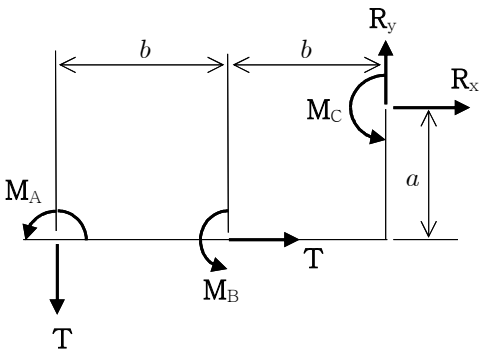
$\tan\theta = \dfrac{R_y}{R_x} = \dfrac{20\text{ N}}{-20\text{ N}} = -1.000$ $\Rightarrow$ $\theta = \tan^{-1}(-1.000) = -45.0°$

$\Rightarrow$ R = 28.3 N ⦤45.0°

<다른 방법>

$M_A = Tr = (20\text{ N})(8\text{ mm}) = 160$ N·mm

$M_B = Tr = (20\text{ N})(8\text{ mm}) = 160$ N·mm



$\rightarrow \Sigma F_x = 0$; $R_x + T = 0$

$\Rightarrow$ $R_x = -T = -20$ N

$\Rightarrow$ $\mathbf{R_x}$ = 20.0 N ←

$\uparrow \Sigma F_y = 0$; $R_y - T = 0$

$\Rightarrow$ $R_y = T$ = 20 N $\Rightarrow$ $\mathbf{R_y}$ = 20.0 N ↑

$+\circlearrowleft \Sigma M_C = 0$; $M_C + M_A + M_B + Ta + T(2b) = 0$

$\Rightarrow$ $M_C = -M_A - M_B - Ta - T(2b)$

$= -(160\text{ N·mm}) - (160\text{ N·mm}) - (20\text{ N})(36\text{ mm}) - (20\text{ N})[2(60\text{ mm})]$

$= -3440$ N·mm $= -3.44$ N·m

$\Rightarrow$ $\mathbf{M_C}$ = 3.44 N·m ↺