E14 - STATICS XIII

Wed 05/11/11

STRUCTURES WEEK

WHAT'S a FRAME? (CHAPTER 6.6)

6.4 METHOD OF SECTIONS

alternative to 6.2 method of joints

read @ home

6.5 SPACE TRUSSES

Similar to 6.2 method of joints but 3d

read @ home

6.6 FRAMES & MACHINES

STRUCTURES composed of pin-connected MULTIFORCE members, e.g. weight, load, ...

definition: "frame" → support loads

"machine" → moving parts to transmit & alter forces

FREE BODY DIAGRAM

1 ▷ for structure as a whole

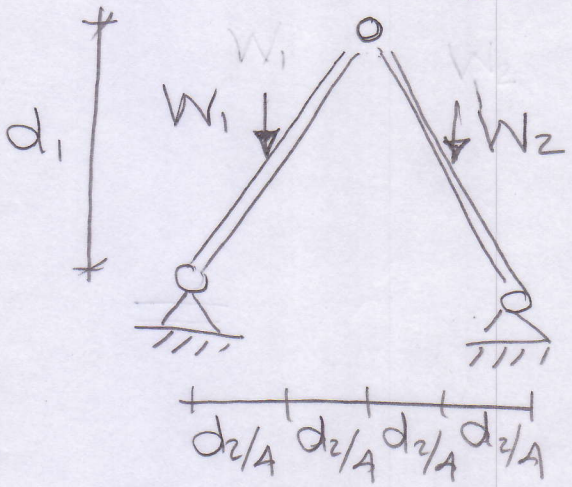
1 ▷ for each member

(1 ▷ for each joint)

EXAMPLE 6.9 - assume pin-connected!

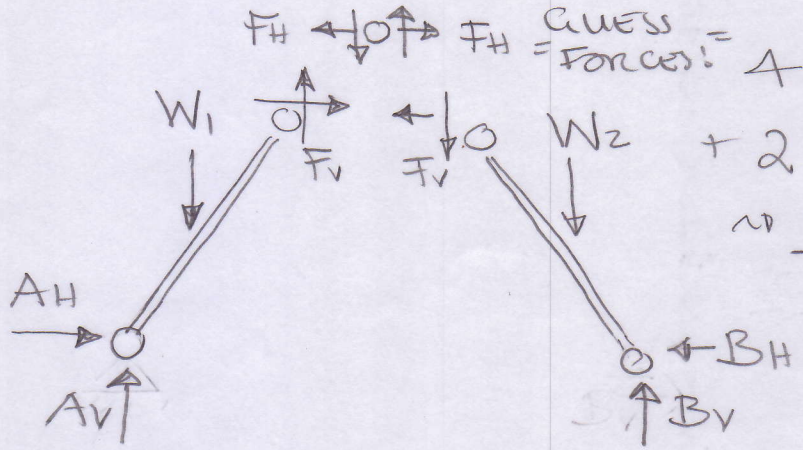
FREE BODY DIAGRAM

= GUESS FORCES! =



⇝ very common design
4 reactions ⇝ constrained
but: joint! ⇝ statically determinate

⇝ count: 2 subsystems à 3 equations
⇝ 6 equations



= GUESS FORCES! =
4 reactions (external)
+ 2 reactions (internal)
⇝ 6 unknowns ✓ ;-)

TS total system $\circlearrowleft^{+} \sum M_A \overset{!}{=} 0$: $W_1 \cdot \frac{d_2}{4} + W_2 \cdot \frac{3d_2}{4} - B_V \cdot \frac{4d_2}{4} \overset{!}{=} 0$

⇝ $B_V = [1 \cdot W_1 + 3W_2]/4$

TS total system $\circlearrowleft^{+} \sum M_B \overset{!}{=} 0$: $A_V \cdot \frac{4d_2}{4} - W_1 \frac{3d_2}{4} - W_2 \frac{1d_2}{4} \overset{!}{=} 0$

⇝ $A_V = [3 \cdot W_1 + 1W_2]/4$

CONTROL:

TS total system: $+\uparrow \sum F_y \overset{!}{=} 0$: $A_V + B_V - W_1 - W_2$

$= \frac{3}{4} W_1 + \frac{1}{4} W_2 + \frac{1}{4} W_1 + \frac{3}{4} W_2 - W_1 - W_2 = 0$ ✓

LS left system $\overset{+}{\circlearrowleft}\sum M_{joint} \overset{!}{=} 0$: $A_Y \cdot \frac{2d_2}{4} - W_1\frac{d_2}{4} - A_H \cdot d_1 \overset{!}{=} 0$

$$A_H = \left[-W_1 \underbrace{\frac{d_2}{4}}_{2/8} + \left[\underbrace{\frac{3}{4}}_{3/8} W_1 \underbrace{\frac{1}{4}}_{1/8} W_2\right] \frac{2d_2}{4}\right] / d_1$$

$$A_H = \left[+\frac{1}{8} W_1 + \frac{1}{8} W_2\right]\left[d_2/d_1\right]$$

$$\underline{\underline{A_H = +\frac{1}{8}\left[W_1 + W_2\right] d_2/d_1}}$$

LS left system $\overset{+}{\rightarrow}\sum F_H \overset{!}{=} 0$: $\underline{\underline{F_H}} = -A_H = \underline{\underline{-\frac{1}{8}\left[W_1 + W_2\right] d_2/d_1}}$

RS right system $\overset{+}{\rightarrow}\sum F_H \overset{!}{=} 0$: $\underline{\underline{B_H}} = -F_H = \underline{\underline{+\frac{1}{8}\left[W_1 + W_2\right] d_2/d_1}}$

RS right system $\overset{+}{\uparrow}\sum F_V \overset{!}{=} 0$: $B_Y - F_V - W_2 = 0$

$$F_V = B_Y - W_2 = \frac{1}{4} W_1 + \frac{3}{4} W_2 - W_2$$

$$\underline{\underline{F_V = \frac{1}{4} W_1 - \frac{1}{4} W_2}}$$

CONTROL

LS left system $\overset{+}{\uparrow}\sum F_V \overset{!}{=} 0$: $A_V + F_V - W_1 \overset{!}{=} 0$

$$\rightsquigarrow \frac{3}{4}\cancel{W_1} + \frac{1}{4} W_2 + \cancel{\frac{1}{4} W_1} - \cancel{\frac{1}{4} W_2} - \cancel{W_1} = 0 \checkmark$$

CONTROL

Left system $\overset{+}{\circlearrowleft}\sum M_A \overset{!}{=} 0$ $\quad W_1 \frac{d_2}{4} + F_H d_1 - F_Y \cdot \frac{2d_2}{4} \overset{!}{=} 0$

$$\rightsquigarrow W_1 \underbrace{\frac{d_2}{4}}_{+1/4} - \underbrace{\frac{1}{8}}_{-1/8} W_1 d_2 - \underbrace{\frac{1}{8}}_{+1/8} W_2 d_2 - \underbrace{\frac{1}{4}}_{-1/8} W_1 \frac{2}{4} d_2 + \underbrace{\frac{1}{4}}_{+1/8} W_2 \frac{2}{4} d_2 = 0 \checkmark$$

remark: although there are no external horizontal forces, there are horizontal reactions in A_H & B_H and in F_H !

1▷ for first example

$W_1 = 600N \quad W_2 = 500N$

$d_1 = 1.50m \quad d_2 = 2.0m$

then...

$A_V = [3W_1 + 1W_2]/4 = 575N$

$B_V = [W_1 + 3W_2]/4 = 525N$

$A_H = B_H = \frac{1}{8}[W_1 + W_2]\, d_2/d_1 = 183.3 = -F_H$

$F_V = \frac{1}{4}W_1 - \frac{1}{4}W_2 = 25kN$

1▷ for the second example

$W_1 = 700N \quad W_2 = 700N$

$d_1 = 1.50m \quad d_2 = 2.25m$

then

$A_V = 700N$

$B_V = 700N$

$A_H = B_H = 291.7N = -F_H$ for $d_1 = \frac{1}{2} d_2$

$F_V = 0N$ 350N