Lecture 20
THE CONSTRUCTION METHOD OF THE DIAGRAMS OF SHEAR-FORCE AND BENDING-MOMENT FOR THE SIMPLE FRAME

Plan

1. Determine the reactions of supports.
2. The building the diagram of normal force.
3. The building the diagram of shear force.
4. The building the diagram of bend moment.

20.1. Determine the reactions of supports.

Earlier we considered the diagrams of internal efforts for beams. However, in addition to beams, the frames are expected to bend also.

The frame is a plane structure, which is consisting of vertical and horizontal bars.

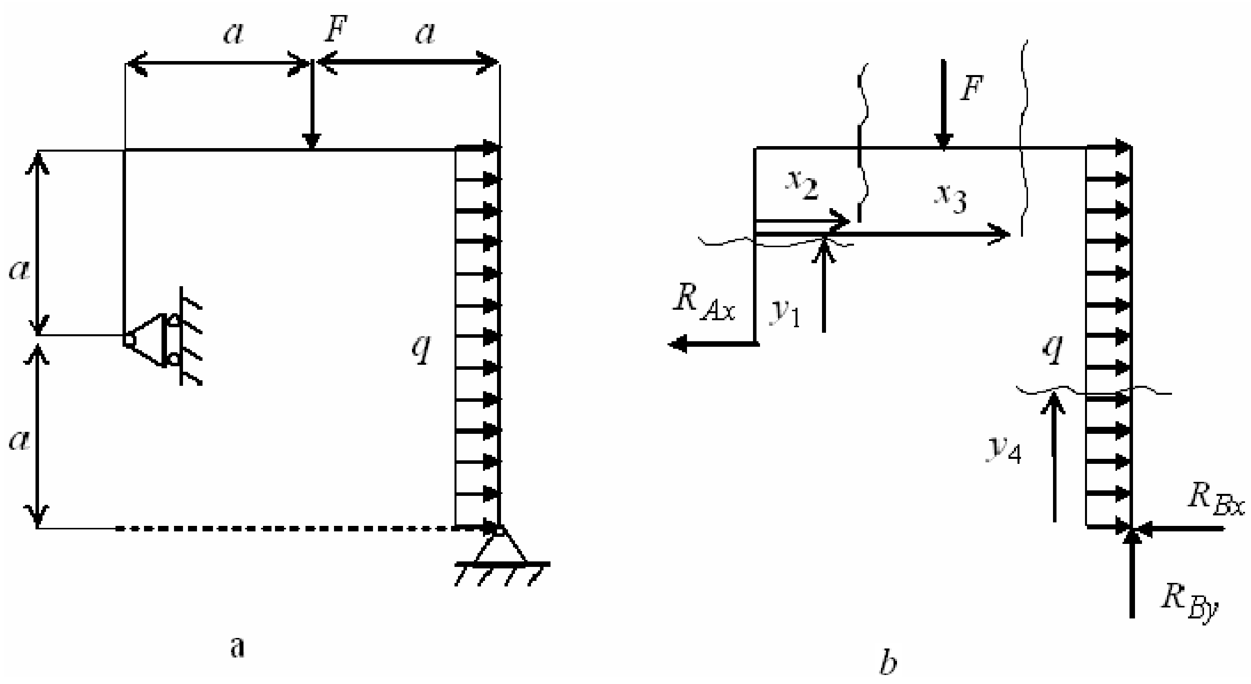


Fig. 20.1

Today we will consider the principals of construction the diagrams of internal efforts for frame.

Let a given plane frame represented on Fig. 20.1, a, has the followings geometrical and force parameters: $a = 2$ m, $q = 2{,}5$ N/m, $F = 2$ N.

Determine the reactions of supports of frame.

From statics let us determine the reactions of supports of frame (Fig. 20.1, b):

$$\sum F_{yi} = 0, \qquad R_{By} - F = 0, \quad R_{By} = F = 2 \text{ N};$$

$$\sum M_{B_i} = 0, \qquad F \cdot a - 0{,}5q(2a)^2 + R_{Ax} \cdot a = 0,$$

$$R_{Ax} = 2qa - P = 2 \cdot 2{,}5 \cdot 2 - 2 = 8 \text{ N};$$

$$\sum M_{A_i} = 0, \qquad R_{By} \cdot 2a - R_{Bx} \cdot a - F \cdot a = 0,$$

$$R_{Bx} = R_{By} \cdot 2 - F = 2 \cdot 2 - 2 = 2 \text{ N}.$$

Let us execute verification of obtained reactions: $\sum F_{xi} = 0$:
or

$$-R_{Ax} - R_{Bx} + 2qa = -8 - 2 + 2 \cdot 2{,}5 \cdot 2 = -10 + 10 = 0.$$

Thus, reactions are correctly determined.

On beginning

20.2. The building the diagram of normal force.

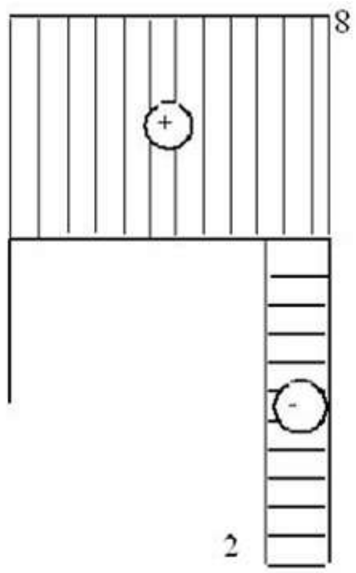
Let us draw the diagram of normal force N_x (Fig. 20.2). To do this, we should project all forces applied to the bar on its longitudinal axis:

I portion. $0 \le y_1 \le 2$ m. $\qquad N_{y_1} = 0.$

II portion. $0 \text{ m} \le x_2 \le 2$ m. $\quad N_{x_2} = R_{Ax} = 8$ N.

III portion. $2 \text{ m} \le x_3 \le 4$ m. $\quad N_{x_3} = R_{Ax} = 8$ N.

IV portion. $0 \text{ m} \le y_4 \le 4$ m. $\qquad N_{y_4} = -R_{By} = -2$ N.



N_x, N
Fig. 20.2

20.3. The building the diagram of shear force.

Let us draw the diagram of shearing force Q_x (Fig. 20.3). To do this, we should project all forces applied to the bar on axis, which is perpendicular located to its longitudinal axis:

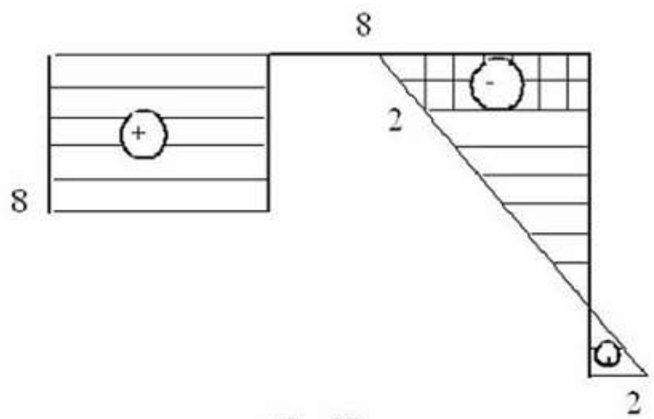
I portion. $0 \le y_1 \le 2$ m. $Q_{y_1} = R_{Ax} = 8$ N,

II portion. 0 m $\le x_2 \le 2$ m. $Q_{x_2} = 0$.

III portion. 2 m $\le x_3 \le 4$ m. $Q_{x_3} = -F = -2$ N,

IV portion. 0 m $\le y_4 \le 4$ m. $Q_{y_4} = R_{Bx} - qy_4$,

$Q(0) = 2$ N, $Q(4) = -8$ N,



Q_x, N

Fig. 20.3**On beginning**

20.4. The building the diagram of bend moment (Fig. 20.4):

I portion. $0 \le y_1 \le 2$ m. $M_{y_1} = R_{Ax} \cdot y_1,$

$$M(0) = 0\ , \qquad M(2) = 16\ \text{N·m};$$

II portion. $0\ \text{m} \le x_2 \le 2$ m. $M_{x_2} = 16$ N·m;

III portion. $2\ \text{m} \le x_3 \le 4$ m. $M_{x_3} = 16 - F \cdot (x_3 - a),$

$$M(4) = 12\ \text{N·m}.$$

IV portion. $0\ \text{m} \le y_4 \le 4$ m. $M_{y_4} = -R_{Bx} \cdot y_4 + \dfrac{qy_4^2}{2},$

$$M(0) = 0\ \text{N·m}, \qquad M(4) = -0{,}74\ \text{N·m},$$

$$\frac{\partial M_{y_4}}{\partial y_4} = -R_B^x + qy_4 = 0, \quad \Rightarrow\ y_4 = \frac{R_B^x}{q} = \frac{2}{2{,}5} = 0{,}8\ \text{m},$$

$$M(0{,}8) = -0{,}8\ \text{N·m}.$$

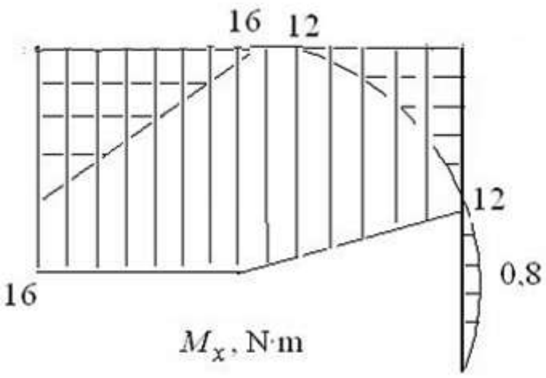


Fig. 20.4

On beginning