CALCULATION OF STATIC EXACT FARMS BY MOMENT POINT METHOD

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https://doi.org/10.5281/zenodo.10636435

Abstract. *In order to calculate trusses, that is, to determine the stresses created by external loads in their struts, their base reactions are usually determined using balance equations.*
Keywords: *truss, stern, external force, moment point, balance equation, base reaction.*

Truss systems, which retain their geometric invariance when single nodes are replaced by hinges, are called trusses.

In order to calculate trusses, that is, to determine the stresses created by external loads in their struts, their base reactions are usually determined using balance equations.

We used the moment point method to calculate the truss below. For this, the following conditions must be met:

1. Checking the static accuracy and geometric stability of the farm;
2. Analytical determination of the stresses of the trusses in the given panel of the farm;
3. Construction of the action lines of the base reaction forces and tension forces calculated above;
4. Determining the tension of the beams in the given panel using the constructed influence lines;
5. Comparing the results of the analytical calculation with the results of the influence line.

Given values:

1) $l = 27m$; $R = 1,2kN$; 2) $Panel$ №2; 3) $h = 4,5m$;

Solve: 1. We check the static accuracy and geometric invariance of the given farm: *D-21* sturgeon (disk);

$$SH = 2 \cdot 1 + 3 \cdot 2 + 6 \cdot 3 + 1 \cdot 4 = 30 \text{ simple hinges}$$

St=3 because the base is sturgeon

$W = 3 \cdot D - 2 \cdot SH - S_t = 3 \cdot 21 - 2 \cdot 30 - 3 = 63 - 63 = 0$

So, the considered farm is statically precise and geometrically invariant.

2. First of all, we calculate the support reaction forces of the truss: $\sum M_A = -P \cdot l/[6(1+2+3+4+5)] + R_B \cdot l = 0$ $R_B = \dfrac{+P \cdot l/[6 \cdot (1+2+3+4+5)]}{l} = \dfrac{15Pl}{6l} = 2,5 \cdot 1,2 = 3$

Since the truss is symmetrical and the external forces are equal $R_A = R_B = 3$;

Checking: $\sum Y = R_A + R_B - 5 \cdot P = 0$

$3 + 3 - 5 \cdot 1,2$

$6 - 6 = 0$

$0 = 0$

So, we have correctly calculated the reaction forces of the truss support.

We pass the I-I section from the node #2 of the given panel of the truss and calculate the tension forces on the struts of this panel. We use the moment point method.

1) $U_{2'3'}$ we calculate the tensile strength. The moment point of this tension is the second node. We construct the equilibrium equation of the left side of the farm with respect to this node:

$$\sum M_2 = U_{2'3'} \cdot h/2 - R_A \cdot l/6 = 0 \quad U_{2'3'} = \frac{R_A \cdot l \cdot 2}{6 \cdot h} = \frac{3 \cdot 27 \cdot 2}{6 \cdot 4{,}5} = \frac{162}{27} = 6;$$

2) $V_{2'3'}$ we calculate the tensile strength. The moment point of this tension force is the first node point. We construct the equilibrium equation of the left side of the farm with respect to this node:

$$\sum M_1 = -V_{23'} \cos\alpha \cdot l/6 - V_{23'} \cdot \sin\alpha \cdot h/2 - P \cdot l/6 = 0$$

$$tg\alpha = \frac{l/6}{h/2} = \frac{l}{6} \cdot \frac{2}{h} = \frac{l}{3h} = \frac{27}{13{,}5} = 2; \quad \alpha = arctg2 = 63^0 26'; \quad \sin 63^0 26' = 0{,}8944; \quad \cos 63^0 26' = 0{,}4503;$$

$$-V_{23'}(\cos\alpha \cdot l/6 + \sin\alpha \cdot h/2) = P \cdot l/6;$$

$$V_{23'} = -\frac{P \cdot l/6}{\cos\alpha \cdot l/6 + \sin\alpha \cdot h/2} = -\frac{1{,}2 \cdot 27/6}{0{,}4503 \cdot 27/6 + 0{,}8944 \cdot 4{,}5/2} = -\frac{5{,}4}{2{,}0263 + 2{,}0124} =$$

$$= -\frac{5{,}4}{4{,}0377} = -1{,}337;$$

2) O_{23} we calculate the tensile strength. This is the moment point of the tension force $3'$ - a node is a point. We write the equilibrium equation of the left side of the truss with respect to this node.

$$\sum M_{3'} = -O_{23} \cdot \cos\beta \cdot h/2 - O_{23} \cdot \sin\beta \cdot l/6 + P \cdot \ell/6 - R_A \cdot l/3 = 0$$

$$tg\beta = \frac{h/2}{l/6} = \frac{h}{2} \cdot \frac{6}{l} = \frac{3h}{l} = \frac{3 \cdot 4{,}5}{27} = \frac{13{,}5}{27} = 0{,}5; \quad \beta = arctg0{,}5 = 26^0 34'; \quad \sin 26^0 34' = 0{,}4472; \quad \cos 26^0 34' = 0{,}8954;$$

$$-O_{23}(\cos\beta \cdot h/2 + \sin\beta \cdot l/2) + P \cdot l/6 = R_A \cdot l/3;$$

$$O_{23} = -\frac{R_A \cdot l/3 - P \cdot l/6}{\cos\beta \cdot h/2 + \sin\beta \cdot l/6} = -\frac{3 \cdot 27/3 - 1{,}2 \cdot 27/6}{0{,}8954 \cdot 4{,}5/2 + 0{,}4472 \cdot 27/6} = -\frac{27 - 5{,}4}{2{,}0146 + 2{,}0124} =$$

$$= -\frac{21{,}6}{4{,}027} = -5{,}3637;$$

3) We calculate the on the right mast $V_{3'3}$ tensile strength. For this $3'$ - we cut the node and check its balance:

$$\sum Y = V_{3'3} + V_{23'} \cdot \cos\alpha = 0$$

$$V_{3'3} = -V_{23'} \cdot \cos\alpha = 1{,}3370 \cdot 0{,}4503 = 0{,}602;$$

3. We will construct the line of action of the tension forces calculated above. For this, a given truss is a unit moving force without external forces $P = 1$ of I–I We can redraw the farm by combining the 2 states of moving to the left and right of the section in one drawing. This is illustrated in (Fig. 44, b). of the farm $P=1$ the base reaction forces generated from the unit force are the same as a simple balkan, and its action lines are shown in (Fig. 44, c).

1) $U_{2'3'}$ we will construct the line of action of tension force. The moment point of this tension force is node 2.

1-moment: $P=1$ on the left. We construct the balance equation on the right side:

$$\sum M_2 = -U_{2'3'}^{o'ng} \cdot \frac{h}{2} + R_B^{P=1} \cdot \frac{5l}{6} = 0; \qquad U_{2'3'}^{o'ng} = \frac{5l \cdot 2}{6 \cdot h} \cdot R_B^{P=1} = \frac{5l}{3h} \cdot R_B^{P=1} = 10 \cdot R_B^{P=1};$$

2-moment: $P=1$ on the right. We construct the balance equation on the left side:

$$\sum M_2 = U_{2'3'}^{chap} \cdot \frac{h}{2} - R_A^{P=1} \cdot \frac{l}{6} = 0; \qquad U_{2'3'}^{chap} = \frac{l \cdot 2}{6 \cdot h} \cdot R_A^{P=1} = \frac{l}{3h} \cdot R_A^{P=1} = 2 \cdot R_A^{P=1};$$

So, $U_{2'3'}$ The left line of the tension force line can be formed by multiplying the base reaction force line V by 10 times, and the right line by increasing the line of base reaction force A by 2 times. it is. It is built on what has been said $U_{2'3'}$ the line of action of tension force (Fig. 44, g) is presented in the figure. The ordinates were found using the similarity of triangles.

2) $V_{23'}$ we construct the tension force action line:

1-moment: $P=1$ on the left. We construct the balance equation on the right side:

$$\sum M_1 = V_{23'}^{o'ng} \cos\alpha \cdot \frac{l}{3} + R_B^{P=1} \cdot l = 0;$$

$$V_{23'}^{o'ng} = \frac{-l \cdot 3}{l \cdot \sin\alpha} \cdot R_B^{P=1} = \frac{-3}{0{,}4503} \cdot R_B^{P=1} = -6{,}6622 \cdot R_B^{P=1};$$

2-moment: $P=1$ on the right. We construct the balance equation on the left side:

$$\sum M_1 = -V_{23'}^{chap} \cos\alpha \cdot \frac{l}{6} - V_{23'}^{chap} \sin\alpha \cdot \frac{h}{2} = 0; \qquad \text{From this we take } V_{23'}^{chap} = 0.$$

So, $V_{23'}$ the left line of the tension force action line can be formed by multiplying the base reaction force action line by -6.6622 times. The right line overlaps with the number line. It is built on what has been said $V_{23'}$ tension force is presented in the line of action (Fig. 44, d). $2'$ *âà* $3'$ under the knots $V_{23'}$ the line of influence changes according to the law of the line of transmission.

4) O_{23} we see the line of action of tension force:

1-moment: $P=1$ on the right. We construct the balance equation on the left side:

5) $$\sum M_{3'} = -O_{23'}^{chap} \cos\beta \cdot \frac{h}{6} - O_{23}^{chap} \sin\beta \cdot \frac{l}{6} - R_A^{P=1} \cdot \frac{l}{3} = 0;$$

$$-O_{23}^{chap}(\cos\beta \cdot \frac{h}{2} + \sin\beta \cdot \frac{l}{6}) = R_A^{P=1} \cdot \frac{l}{3}$$

$$O_{23}^{chap} = \frac{-l}{3(\cos\beta \cdot h/2 + \sin\beta \cdot l/6} \cdot R_A^{P=1} = \frac{-27}{3(0{,}8954 \cdot 4{,}5/2 + 0{,}7772 \cdot 27/6)} \cdot R_A^{P=1} =$$

$$= \frac{-27}{3(2{,}0146 + 2{,}0124)} \cdot R_A^{P=1} = \frac{-27}{12{,}081} \cdot R_A^{P=1} = -2{,}2349 \cdot R_A^{P=1}$$

2-moment: $P=1$ On the left. We construct the balance equation on the right side:

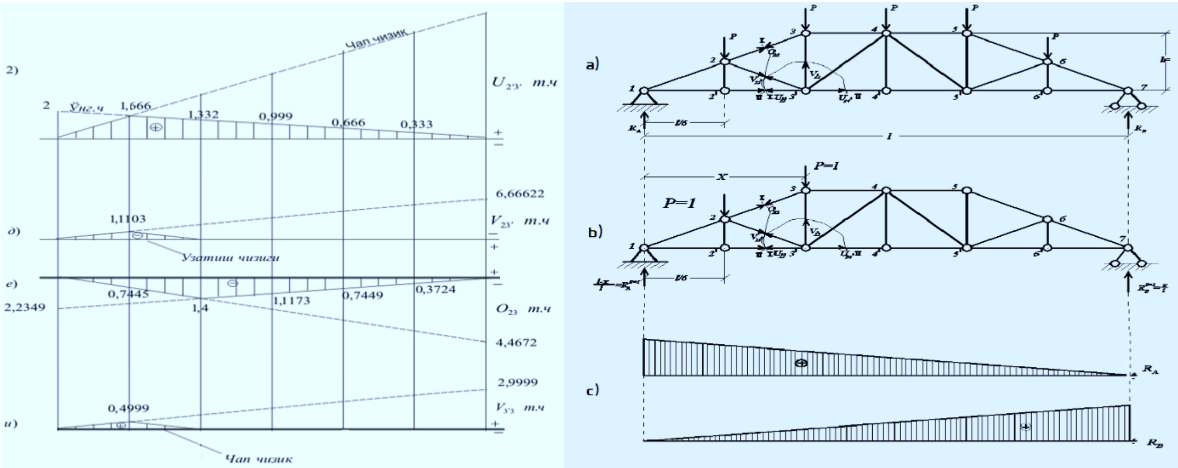
$$\sum M_{3'} = O_{23}^{o'ng} \cos\beta \cdot h + R_B^{P=1} \cdot \frac{2l}{3} = 0;$$

$$O_{23}^{o'ng} \frac{-2l}{3h\cos\beta \cdot h} \cdot R_B^{P=1} = \frac{-54}{13{,}5 \cdot 0{,}8954} \cdot R_B^{P=1} = -4{,}4672 R_B^{P=1};$$

This is constructed using the equation of the dashed left and right lines O_{23} the stress force action line (Fig. 1, e) is presented.

4) $V_{23'}$ we construct the tension force action line:

This is when calculating the tensile strength $V_{3'3} = -V_{23'} \cos\alpha$



we got the formula from the equilibrium equation.

So this is $V_{3'3}$ line of action of the tension force (on the main beam). $V_{23'}$ line of action of tension force $-\cos\alpha$ means to generate by multiplying by .

1-figure

So:

$$-1{,}1103(-\cos\alpha) = -1{,}1103 \cdot (-0{,}4503) = 0{,}4999; \text{ 1-rasm.}$$

$$-6{,}6622 \cdot (-\cos\alpha) = -6{,}6622(-0{,}4503) = 2{,}9999$$

It is constructed using ordinates $V_{3'3}$ the line of action of tension force (u in the figure) is presented.

4. We calculate the tension in the struts of the given panel No. 2 using the influence line constructed above:

1) $U_{2'3'} = \sum PiYi = 1{,}2(1{,}666 + 1{,}332 + 0{,}999 + 0{,}666 + 0{,}333) = 1{,}2 \cdot 4{,}9966 = 5{,}9959;$

2) $V_{23'} = \sum PiYi = 1{,}2 \cdot (-1{,}1103) = -1{,}3324;$

3)

$$O_{23} = \sum PiYi = 1{,}2 \cdot (-0{,}7445 - 1{,}4 - 1{,}1173 - 0{,}7449 - 0{,}3724) = 1{,}2 \cdot (-4{,}3791) = -5{,}2549$$

4) $V_{3'3} = \sum PiYi = 1{,}2 \cdot (0{,}4999) = 0{,}5998;$

5. Let's compare the result of the analytical calculation and the result of the influence line:

1) $\frac{U_{2'3'}^{Anal} - U_{2'3'}^{Ta's} \cdot 100\%}{U_{2'3'}^{Ta's}} = \frac{(6 - 5{,}9959) \cdot 100\%}{5{,}9959} = 0{,}0683\%$ error

2) $\frac{(V_{23'}^{Anal} - V_{23'}^{Ta's} \cdot 100\%}{V_{23'}^{Ta's}} = \frac{(-1{,}337 + 1{,}3324) \cdot 100\%}{1{,}3324} = 0{,}3452\%$ error

3) $$\frac{(O_{23}^{Anal}-O_{23}^{Ta's}\cdot 100\%}{O_{23}^{Ta's}}=\frac{(5{,}3637-5{,}2549)\cdot 100\%}{5{,}2549}=2{,}0704\%$$ error

4) $$\frac{(V_{3'3}^{Anal}-V_{3'3}^{Ta's}\cdot 100\%}{V_{3'3}^{Ta's}}=\frac{(0{,}602-0{,}5998)\cdot 100\%}{0{,}5998}=0{,}3667\%$$ error

These errors are very small, which means that the calculations are done with high accuracy. And these errors are the product of approximate calculations.

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