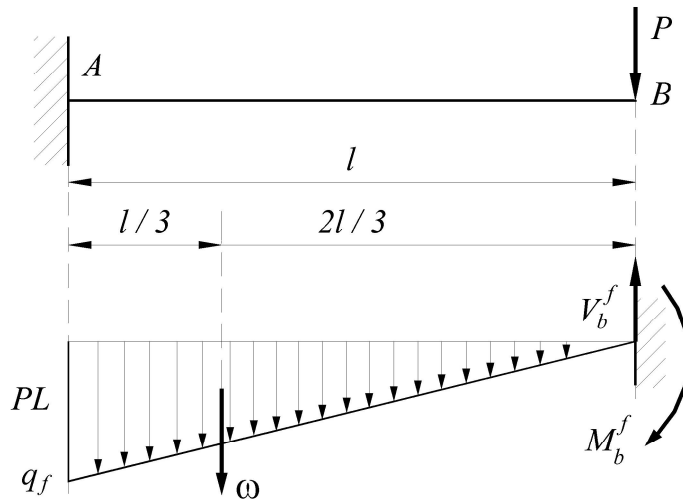


Íðeì áðú ðañ÷áðà

Íðeì áð 1. Äëý eîíñîëüííé áàëëè, ñ îðëèíæáíííé è íáé ñîðááîðîí÷áíííé ñëèíé Ð, îíðáááëèòú óáíé îíáíðîíðà è îðíæá ñá÷áíëý, îðíîíäýùááí ÷áðaç òí÷éó Â (Ðèñ. 27).



Ðèñ. 27

1. Áú÷áð÷èáááì ðañ÷áðíóþ ñóàì ó áàëëè.
2. Ñòðíèì ýíþðó èçæèáþùèò îííáíòíá.
3. Òàè èàè îííáíð óóááð îððèòàðèüíùì, ñòðáëè òèèðèáííé ðañíðáááëáííé íáððóçèè íáíðáäëýáì áíèç.
4. Íðeìè ààì òèèðèáííé áàëëó.
5. Ííðáááëýáì áàëè÷éíó îííðíúò ðáàèòèè òèèðèáííé áàëëè:

$$\mathbf{S} \bar{I}_A = 0 = -M_B^f + w(2/3)l = -M_A^f + (1/2)Pl \times (2/3)l; \bar{I}_A^f = Pl^3/3;$$

$$\mathbf{S} Y = 0 = V_A^f - w = V_A^f - Pl^2/2; V_A^f = Pl^2/2.$$

6. Ííðáááëýáì áàëè÷éíú èçæèáþùááì îííáíðà è îííáðáííé ñëèù á ñá÷áíëè, îðíîíäýùááì ÷áðaç òí÷éó Â:

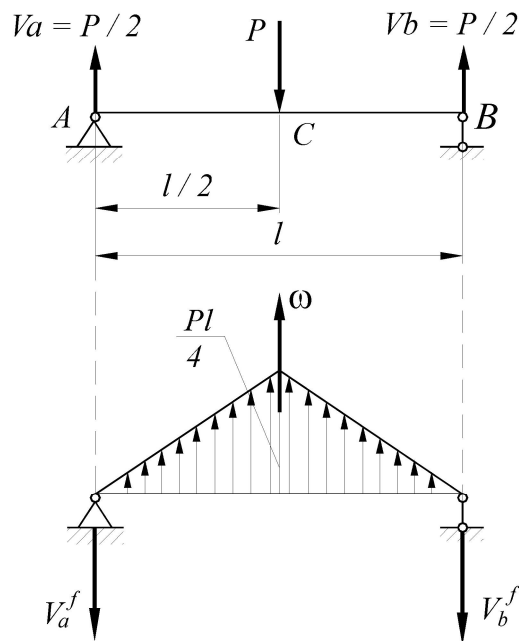
$$\bar{I}_A^f = -Pl^3/3; Q_A^f = -Pl^2/2.$$

7. Ííðáááëýáì íáððáì áùáíëý îí òíðíóèàì (7.8) è (7.9).

$$y_B = M_B^f/EI = -3Pl^3/3EI; Q_B = Q_B^f/EI = -3Pl^2/2EI.$$

Äèáíí, ÷òí ýðè îðááòú èááíðè÷íú ðáðáíèþ ìáðíáì ìáííðáááðááííáì èíðááðèðíááíëý àèòáðáíòèäèüííáì óðááíáíëý èçíáíóðíé îñè áàëëè.

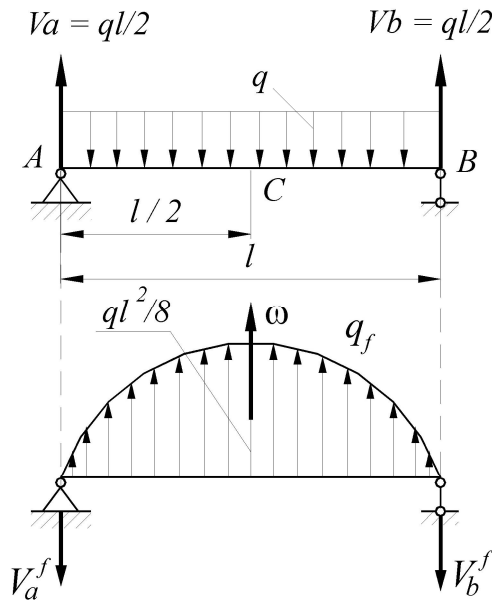
Íðeì áð 2. Äëý áàèèè, íàãðóæáííé á ñàðáàéíá ìðíéàðà ñíñðááí òí÷áííé ñèèíé Ð, ìíðáááèèðü óáíé ìíáíðíðà ñá÷áíèý, ìðíðíäýüááí ÷áðáç òí÷éó Â, è ìðíáéá ñá÷áíèý, ìðíðíäýüááí ÷áðáç òí÷éó Ñ (Ðèñ. 28).



Ðèñ. 28

1. Âú÷áð÷éáááì ðàñ÷áðíðð ñóáì ó áàèèè.
2. Ñððíèì ýíððó èçæéáàðüèð ìííáíðíá.
3. Òàè èàè ìííáíð ñóááð ìíèíæèðáèüíüì, íàìðààèýáì ñððáèèè òèèðèáííé ðàñíðáááèáííé íàãðóçèè áááðð.
4. Íðèíèì ááì òèèðèáíðð áàèèó (Ðèñ. 28).
5. Ííðáááèýáì áàèè÷éíó ðáàèðèé òèèðèáííé áàèèè:
Òàè èàè íàãðóçèà ñèììáððè÷íà $V_A^f = V_B^f = w/2 = (1/2) (PI/4)(1/2) = PI^2/16$.
6. Ííðáááèýáì áàèè÷éíó ìííáðá÷ííé ñèèü á ñá÷áíèè, ìðíðíäýüáì ÷áðáç òí÷éó Â: $Q_B^B = V_B^f = PI^2/16$;
7. Ííðáááèýáì áàèè÷éíó èçæéáàðüááí ìííáíðà á ñá÷áíèè, ìðíðíäýüáì ÷áðáç òí÷éó Ñ: $l_f^C = -V_A^f(1/2) + (1/2)(PI/4)(1/2)(1/3)(1/2) = - (PI^3/32) + (PI^3/96) = - PI^3/48$.
8. Ííðáááèýáì ìáðáì áüáíèý Q_B è óÑ: $Q_B = Q_B^B/EI = PI^2/16EI$; $óÑ = M_f^C/EI = -PI^3/48EI$

Íðeì áð 3. Äëý îáíííðíëáðííé ááëëè, íááðóæáííé ðàííðáááëáííé íááðóçéíé, ííðáááëèðü íðíáëá ò_N á ñáðááëíá íðíëáðà è óáíé ííáíðíðà ñááíëý Q_A , íðíðíäýüááí ÷áðáç èááóþ íííðó (Ðeñ. 29).



Ðeñ. 29

1. Áú÷áð÷éáááì ðàñ÷áðíóþ ñóáì ó ááëëè.
2. Ñòðíèì ýíþðó èçáëáþùèð íííáíðíá.
3. Ðaè èàè íííáíð ýäëýáðñý ííèíæèðáëüíüì, íáíðááëýáì ñòðáëëè òèèðèáííé ðàííðáááëáííé íááðóçéè áááðó.
4. Íðeíèìááì òèèðèáííé ááëëó ñì ðeñ.
5. Ííðáááëýáì ááëè÷eíó íííðíúð ðááèðèè òèèðèáííé ááëëè:

$$V_A^f = V_A^f = w / 2.$$

Ííðáááëýáì ííèíüàü w eíðááðèðíááíeáì óðááíáíëý èçáëáþùèð íííáíðíá: $M = (ql / 2)x - qx^2/2$;

$$w = \int_0^l [(dl / 2)x - qx^2/2] dx = ql^3/4 - ql^3/6 = ql^3/12, \text{ òíááà } V_A^f = V_A^f = ql^3/24.$$

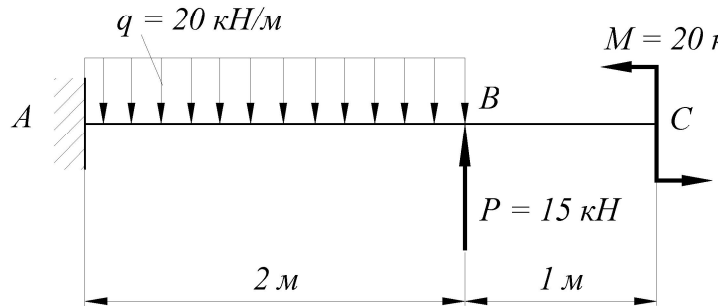
6. Ííðáááëýáì íííáðá÷íóþ ñèéð á ñááíëè, íðíðíäýüááí ÷áðáç òí÷eó Á.

$$Q_f^A = -V_A^f = -ql^3/24.$$

7. Ííðáááëýáì ááëè÷eíó èçáëáþùááí íííáíðà á ñááíëè, íðíðíäýüááí ÷áðáç òí÷eó Ñ òèèðèáííé ááëëè (Ðeñ. 7.30): $M_f^C = - (1/2)V_A^f \times (w/2)(1/2 - x_c)$; íáéááì eííðáëíàðó óáíððà òýæáñðè $x_c = S_Y/F$ [ñì . Óíðì óeó (2.4)].

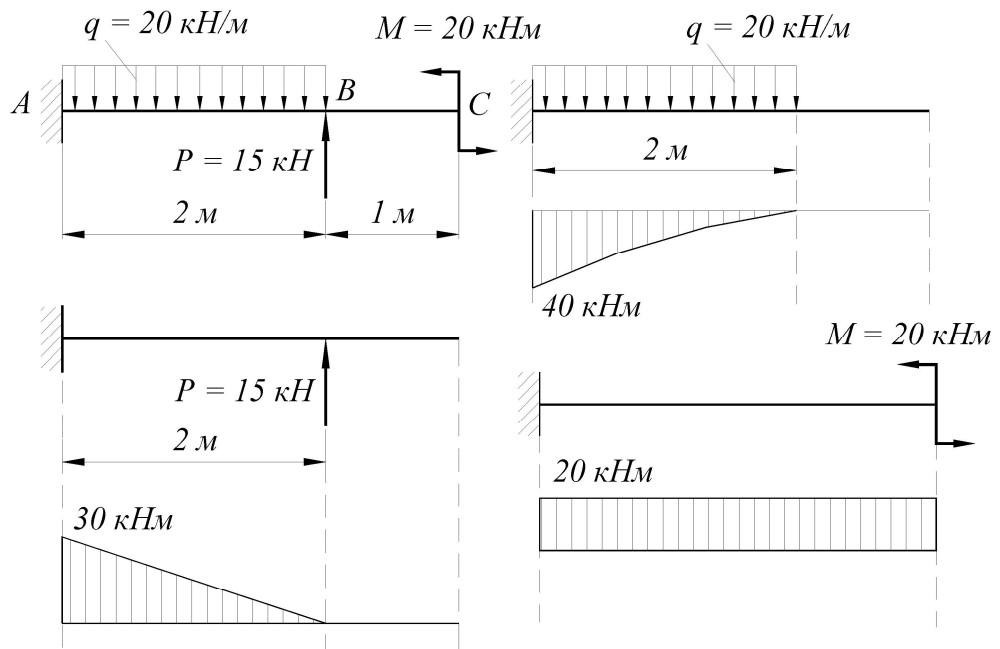
Á íáøáì ñeó÷áá $F = w / 2 = ql^3 / 24$, à

Ήδεη άδ 4. Άέü εήήήέüήήή έ άέέέή ήήάάέέέüü όάήέ ήήήήήήήά ήά-άήέü, ήήήήήήήήήήή ήάάά όή-έό Ñ, έ ήήήήήή ήά-άήέü, ήήήήήήήήήήή ήάάά όή-έό Ä (Ήέñ.31).



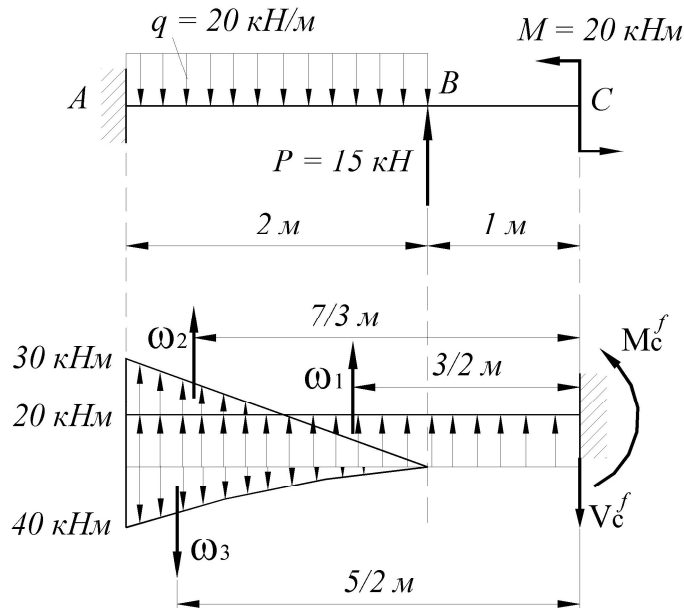
Ήέñ.31

1. Äü-ää-έάάάή ήάñ-άόήόρ ήόάή ό άέέέή (Ήέñ. 31).
2. Ñόόήέή üήρδü έçääέάρüέό ήήήήήήή ήό έάääήέ έç ήέέ, ήέέήääήήüü έ άέέέή (Ήέñ. 32, à), ά ήόääέüήήήέ (Ήέñ. 32, á, â, ã).



Ήέñ. 32

3. Ñάήέή άñά όδè üήρδü ήά ήñü άέέέή (Ήέñ. 33). ήά üήρδäü ήήήήέόääéüήüήέ çήά-άήέüήέ ήήήήήήή ήόääέέέ όέέέέήήέ ήάñήääääέήήέ ήääόçέέ ήάήääéüήή άääδö, à ήά üήρδäü ή ήόδèöääéüήüήέ çήά-άήέüήέ ήήήήήήήή - άήέç.



Δεñ. 33

4. $\hat{\Gamma}\hat{\delta}\hat{\epsilon}\hat{\iota}\hat{\epsilon}\hat{\iota}\hat{\alpha}\hat{\alpha}\hat{\iota}\hat{\omega}\hat{\epsilon}\hat{\epsilon}\hat{\delta}\hat{\epsilon}\hat{\alpha}\hat{\iota}\hat{\sigma}\hat{\rho}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\omicron}$.

5. $\hat{\Gamma}\hat{\iota}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\gamma}\hat{\alpha}\hat{\iota}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\epsilon}\hat{\epsilon}\hat{\iota}\hat{\omicron}\hat{\iota}\hat{\iota}\hat{\delta}\hat{\iota}\hat{\upsilon}\hat{\omicron}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\omicron}\hat{\epsilon}\hat{\epsilon}\hat{\omega}\hat{\epsilon}\hat{\epsilon}\hat{\delta}\hat{\epsilon}\hat{\alpha}\hat{\iota}\hat{\tau}\hat{\epsilon}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\epsilon}$:

$$S\hat{\iota}\hat{N} = 0 = M_N^f + w_3(5/2) - w_2(7/3) - w_1(3/2), \hat{\epsilon}\hat{\epsilon}\hat{\epsilon}$$

$$M_C^f = + (1/2) \cdot 30 \cdot 2 \cdot (7/3) - (1/3) \cdot 40 \cdot 2 \cdot (5/2) + 20 \cdot 3 \cdot (3/2) \gg 93,33 \hat{\epsilon}\hat{\iota}\hat{\iota}^3;$$

$$S\hat{Y} = 0 = -V_C^f + w_1 + w_2 - w_3, \hat{\epsilon}\hat{\epsilon}\hat{\epsilon} V_N^f = 20 \cdot 3 + (1/2) \cdot 30 \cdot 2 - (1/3) \cdot 40 \cdot 2 \gg 63,3 \hat{\epsilon}\hat{\iota}\hat{\iota}^2.$$

6. $\hat{\Gamma}\hat{\iota}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\gamma}\hat{\alpha}\hat{\iota}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\epsilon}\hat{\epsilon}\hat{\iota}\hat{\omicron}\hat{\iota}\hat{\iota}\hat{\iota}\hat{\alpha}\hat{\delta}\hat{\alpha}\hat{\iota}\hat{\tau}\hat{\epsilon}\hat{\eta}\hat{\epsilon}\hat{\upsilon}\hat{\alpha}\hat{\eta}\hat{\alpha}\hat{\iota}\hat{\epsilon}\hat{\epsilon}\hat{\omega}\hat{\epsilon}\hat{\delta}\hat{\epsilon}\hat{\alpha}\hat{\iota}\hat{\tau}\hat{\epsilon}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\epsilon}$, $\hat{\iota}\hat{\delta}\hat{\iota}\hat{\omicron}\hat{\iota}\hat{\alpha}\hat{\gamma}\hat{\upsilon}\hat{\alpha}\hat{\iota}\hat{\alpha}\hat{\delta}\hat{\alpha}\hat{\zeta}\hat{\omicron}\hat{\iota}\hat{\alpha}\hat{\epsilon}\hat{\omicron}\hat{N}$, $\hat{\epsilon}\hat{\zeta}\hat{\alpha}\hat{\epsilon}\hat{\alpha}\hat{\rho}\hat{\upsilon}\hat{\epsilon}\hat{\epsilon}\hat{\iota}\hat{\iota}\hat{\iota}\hat{\alpha}\hat{\iota}\hat{\delta} M_f^B$.

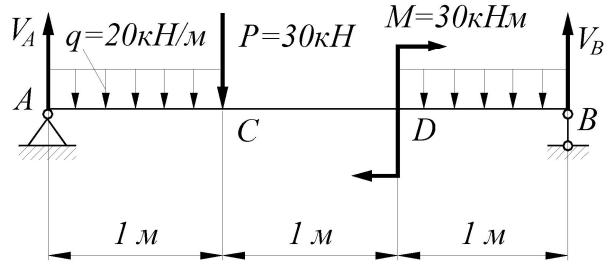
$$Q_f^C = V_C^f = 63,3 \hat{\epsilon}\hat{\iota}\hat{\iota}^2; M_f^B = M_C^f + 20 \cdot 1 \cdot 0,5 - V_C^f \cdot 1 = 93,3 + 10 - 63,3 = 40,0 \hat{\epsilon}\hat{\iota}\hat{\iota}^3.$$

7. $\hat{\Gamma}\hat{\iota}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\gamma}\hat{\alpha}\hat{\iota}\hat{Q}_N$ $\hat{\epsilon}\hat{\omicron}\hat{A}$, $\hat{\alpha}\hat{\eta}\hat{\epsilon}\hat{\epsilon}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\alpha}\hat{\zeta}\hat{\alpha}\hat{\iota}\hat{\omicron}\hat{\iota}\hat{\alpha}\hat{\epsilon}\hat{\alpha}\hat{\iota}\hat{\alpha}\hat{\zeta}\hat{\alpha}\hat{\omicron}\hat{\delta}\hat{\alpha}\hat{\delta}\hat{\alpha}^1 30$, $\hat{\omicron}\hat{\epsilon}\hat{\iota}\hat{\delta}\hat{\iota}\hat{\delta}\hat{\iota}\hat{\alpha}\hat{\iota}\hat{\iota}\hat{\eta}\hat{\alpha}\hat{\alpha}\hat{\iota}\hat{\epsilon}\hat{\iota}\hat{\iota}\hat{\iota}\hat{\alpha}\hat{\iota}\hat{\delta}\hat{\epsilon}\hat{\iota}\hat{\alpha}\hat{\delta}\hat{\omicron}\hat{\epsilon}\hat{\epsilon}\hat{\iota}\hat{\delta}\hat{\iota}\hat{\iota}\hat{\eta}\hat{\epsilon}\hat{\delta}\hat{\alpha}\hat{\epsilon}\hat{\upsilon}\hat{\iota}\hat{\iota}\hat{\iota}\hat{\alpha}\hat{\epsilon}\hat{\delta}\hat{\alpha}\hat{\epsilon}\hat{\upsilon}\hat{\iota}\hat{\tau}\hat{\epsilon}\hat{\iota}\hat{\eta}\hat{\epsilon} l = 7080 \hat{\eta}\hat{\iota}^4$.

$$Q_N = Q_f^C / EI = 63,3 / (2 \cdot 10^8 \cdot 7080 \cdot 10^{-8}) = 0,0044 \hat{\delta}\hat{\alpha}\hat{\alpha} = 0,25^\circ;$$

$$y_C = M_f^B / EI = 40 / (2 \cdot 10^8 \cdot 7080 \cdot 10^{-8}) = 0,0028 \hat{\iota} = 2,8 \hat{\iota}\hat{\iota}.$$

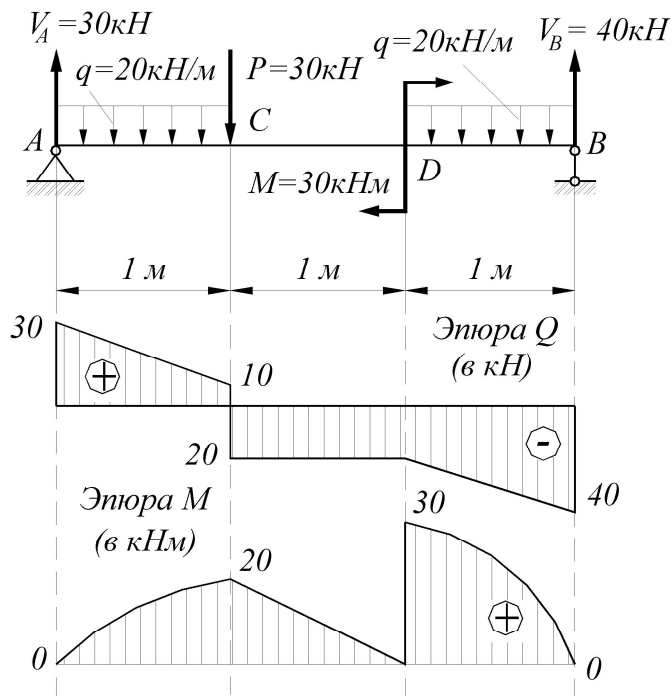
Íðeì áð 5. Äëý çàààíííé áàèèè (Ðèñ. 34) ïííððíèòü ýíððü ïííáðä÷íüò ñèè è èçãèáàðüèò ïííáíðíá.



Ðèñ. 34

Íííáðäòü èáàáðàðííá ïííáðä÷íá ñá÷áíèá èç áàðäáá, ïíèóçóÿíü òíèíáèàì ïðí÷ííðè ïí ïíðíàèüíüì íáíðÿæáíèÿì è ($R = 9$ Ííà) è ïííððíèòü èçíáíóðòð ïíü áàèèè ñ ïíííüòüð ìáðíáá ìá÷àèüíüò ìáðàì áððíá. Ííðááèèòü äëý ÿðíáí óáèü ïíáíðíðà ñá÷áíèé, ïðíðíáÿüèò ÷áðáç ïííðü, è ïðíáèáü ñá÷áíèé, ïðíðíáÿüèò ÷áðáç òí÷èè Ñ è D.

Ð á ø á í è á. 1. Ñ÷èðáÿ ïííðííá ðáàèèè ïíðááèáííüì, ñððíè "ýíððü èçãèáàðüèò ïííáíðíá (Ðèñ. 35).



Ðèñ. 35

$Ely_B = 0 = Elq_0x + 55$, ἰὸνπρὰ $Elq_0x = -55$, α $Elq_0 = -18,33 \text{ \acute{e}\acute{l}\acute{i}^2$, οἱᾶᾶ $q_0 = q_A = -18,33 / EI = -18,33 / 4429 = 0,0041 \text{ \delta\acute{a}\acute{a}} = 0,2373^\circ$.

3.6. Ἰἰḃᾶᾶᾶᾶᾶᾶ ἰḃἱᾶᾶ ὀ_η. Ἰἱᾶḃᾶᾶᾶᾶᾶ ᾶᾶᾶ ᾶḃἱᾶᾶ ᾶ ὀḃᾶᾶᾶᾶᾶ (α) $x_1 = 1 \text{ ἱ}$:

$$Ely_c = -18,33 \cdot 1 + 30(1/6) - 20(1/24) = -14,17 \text{ \acute{e}\acute{l}\acute{i}^3};$$

$$\sigma_N = -14,47/4429 = -0,003198 \text{ ἱ} = -0,32 \text{ ḃἱ}.$$

3.7. Ἰἰḃᾶᾶᾶᾶᾶ ἰḃἱᾶᾶ ὀ_δ. Ḃᾶἱᾶḃᾶᾶᾶ ἱᾶᾶᾶᾶᾶᾶ ὀḃᾶᾶᾶᾶᾶ ᾶᾶᾶᾶᾶᾶ ᾶᾶᾶᾶᾶᾶ ᾶ ἱᾶᾶᾶ ὀ₂ = 2ἱ:

$$Ely_2 = Elq_0x_2 + V_A(x_2^3/6) - q(x_2^4/24) + q(x_2 - 1)^4/24 - P(x_2 - 1)^3/6;$$

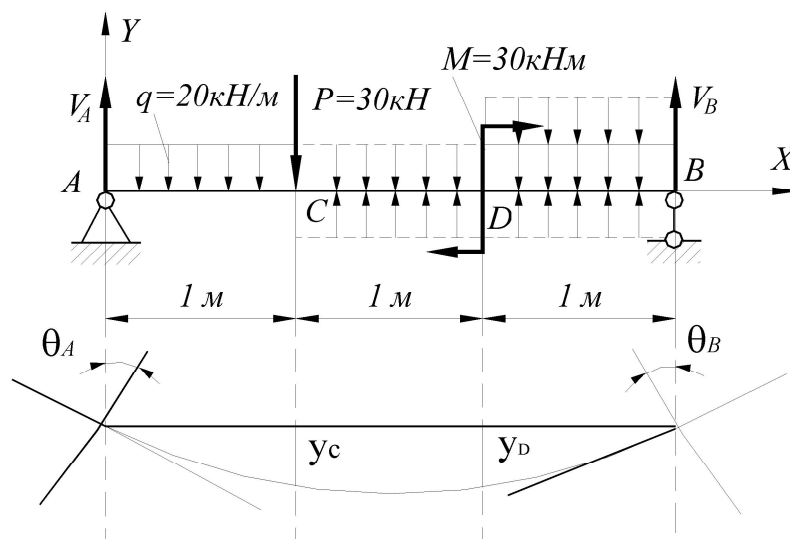
$$Ely_D \text{ (ἰḃᾶ } x_2=2 \text{ ἱ)} = -14,17 \text{ \acute{e}\acute{l}\acute{i}^3; } \sigma_D = -14,17/4429 = -0,003198 \text{ ἱ} = 0,32 \text{ ḃἱ}.$$

3.8. Ἰἰḃᾶᾶᾶᾶᾶ ὀᾶᾶᾶ ἱᾶᾶᾶᾶ ὀ_ᾶ. Ḃᾶἱᾶḃᾶᾶᾶ ᾶᾶᾶ ᾶḃἱᾶᾶ ἱᾶᾶᾶᾶᾶᾶ ὀḃᾶᾶᾶᾶᾶ ᾶᾶᾶᾶᾶᾶ ᾶ ἱᾶᾶᾶ ὀ₃ = 3ἱ:

$$Elq_3 = Elq_0 + V_A(x_3^2/6) - q(x_3^3/6) + q(x_3 - 1)^3/6 - P(x_3 - 1)^2/2 + M(x_3 - 2) - q(x_3 - 2)^3/6;$$

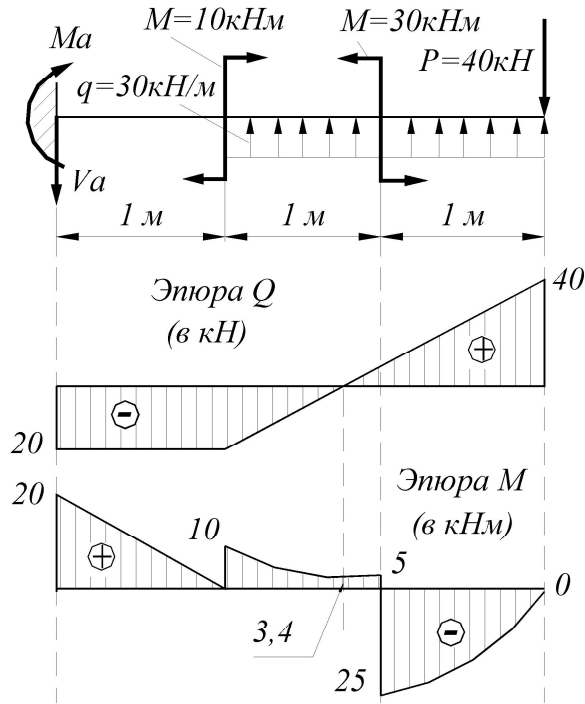
$$\Delta q_A \text{ (ἰḃᾶ } \sigma_3 = 3 \text{ ἱ)} = 20 \text{ \acute{e}\acute{l}\acute{i}^2; } q_A = 20/4429 = 0,0045 \text{ \delta\acute{a}\acute{a}} = 0,258^\circ.$$

3.9. Ἰἱ ἱἱᾶᾶᾶᾶᾶ ᾶᾶᾶᾶ ḃᾶᾶᾶᾶ ᾶᾶᾶᾶᾶ ᾶᾶᾶᾶᾶ (Ḃᾶḃ. 37).



Ḃᾶḃ. 37

Ήθελο 6. Άεϋ ϋαααίίτε ααεεε (Θεñ. 38) ίίñòðíεòü γίρðü ίίίáðá÷íüò ñεε ε εϋαεάαρùεò ίίίáíòíá, ίίáíáðáòü εðóáεíá ίίίáðá÷ίίá ñá÷áίεá εϋ αáðáαα, ίίεüçóγñü óñεíáεáí ίðí÷ίίñòε ίί ίίðíáεüíüí ίáíðÿæáíεÿí (R = 9 ίίá) ε ίίñòðíεòü εϋίáίóòòρ ίñü ααεεε ñ ίίίίüüρ ίáðíáá ίá÷áεüíüò ίáðáí áððíá. Ííðáááεεòü áεÿ γòíáí q_A ε q_D , á ðáεæá ίðíáεáü ó_B, ó_C ε ó_Γ.



Θεñ. 38

Θ á ø á í ε á. 1. Ñòðíεí γίρðü ίίίáðá÷íüò ñεε ε εϋαεάαρùεò ίίίáíòíá (Θεñ. 38).

2. Ííááεðááí ίίίáðá÷ίίá ñá÷áίεá ααεεε, ίίεüçóγñü óñεíáεáí ίðí÷ίίñòε ίί ίίðíáεüíüí ίáíðÿæáíεÿí [ñí. óíðí óεó (6.5)]:

$$s = M_{\max} / W \leq R, \text{ ίòñρáá } W = M_{\max} / R = 25 \times 10^{-3} / 9 = 0,0028 \text{ } \grave{\text{m}}^3 = 2800 \text{ } \grave{\text{m}}^3.$$

$$\text{Òáε εáε áεÿ εðóáεíáí ñá÷áίεÿ } W = 0,1d^3, \text{ òí}$$

$$d = \sqrt[3]{\overset{\circ}{W} / 0,1} = \sqrt[3]{\overset{\circ}{28000}} = 30,4 \text{ } \grave{\text{m}} \gg 30 \text{ } \grave{\text{m}}.$$

3. Ííðáááεÿáí ίáðáí áüáίεÿ ααεεε.

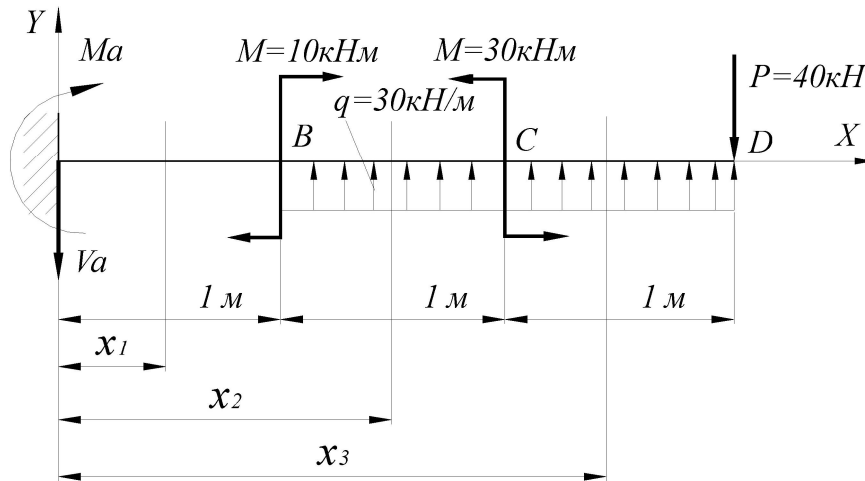
3.1. Ííðáááεÿáí ááεε÷είό ίñááíáí ίίίáíòá είáðòεε ααεεε ίðíίñεòáεüíί ίáεòðáεüíίε ίñε:

$$I = \rho d^4 / 64 = 3,14 \times 30^4 / 64 = 39740,63 \text{ } \grave{\text{m}}^4 \gg 39741 \times 10^{-8} \text{ } \grave{\text{m}}^4.$$

3.2. Ííðáááεÿáí æáñòείñòü ααεεε [$A_{\text{ááð}} = 10^4 \text{ } \grave{\text{m}}^2$]:

$$EI = 10^4 \times 10^3 \times 39741 \times 10^{-8} \gg 3974 \text{ } \acute{\text{e}} \acute{\text{m}}^2.$$

3.3. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí.



Đèñ. 39

3.4. Çàìèñóàààì $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí.

$$Ely_1 = M_A(x_1^2/2) - V_A(x_1^3/6); \quad Elq_1 = \dot{M}_A x_1 - V_A(x_1^2/2);$$

$$Ei\acute{o}_A \text{ (íðè } \acute{o} = 1 \text{)} = 6,67 \text{ èí } \acute{i}^3, \text{ òíããà } \acute{o}_A = 6,67/3974 = 0,0017 \text{ ì} = 0,17 \text{ ñì};$$

$$\dot{A}lq_A \text{ (íðè } x_1 = 1 \text{)} = 10 \text{ èí } \acute{i}^2, \text{ òíããà } q_A = 10/3974 = 0,0025 \text{ ðàà} = 0,14^\circ.$$

3.5. Çàìèñóàààì $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí.

$$Ely_2 = M_A x_2^2 / 2 - V_A x_2^3 / 6 + \dot{M}_1 (x_2 - 1)^2 / 2 + q(x_2 - 1)^4 / 24;$$

$$Ely_{\dot{N}} \text{ (íðè } x_2 = 2 \text{)} = 19,58 \text{ èí } \acute{i}^3, \text{ òíããà } \acute{o}_C = 19,58/3974 = 0,0049 \text{ ì} = 0,49 \text{ ñì}.$$

3.6. Çàìèñóàààì $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí.

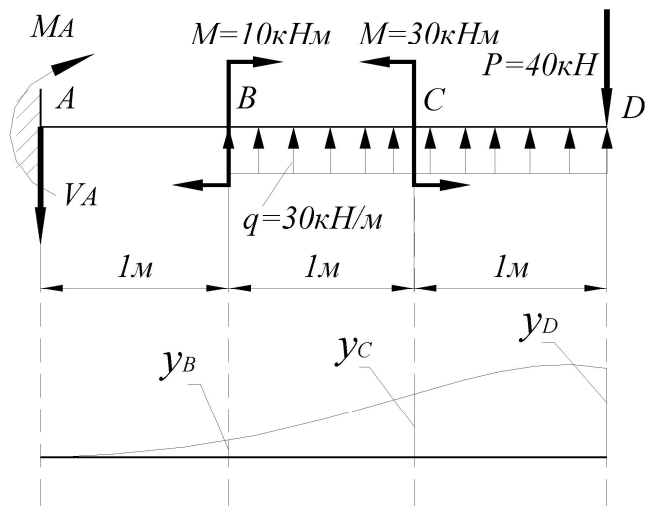
$$Ely_3 = M_A x_3^2 / 2 - V_A x_3^3 / 6 + \dot{M}_1 (x_3 - 1)^2 / 2 + q(x_3 - 1)^4 / 24 - M_2 (x_3 - 2)^2 / 2;$$

$$Elq_3 = \dot{M}_A x_3 - V_A x_3^2 / 2 + \dot{M}_1 (x_3 - 1) + q(x_3 - 1)^3 / 6 - M_2 (x_3 - 2);$$

$$Ely_D \text{ (íðè } \acute{o}_3 = 3 \text{)} = 25 \text{ èí } \acute{i}^3, \text{ òíããà } \acute{o}_D = 25/3974 = 0,0063 \text{ ì} = 0,63 \text{ ñì};$$

$$Elq_D \text{ (íðè } x_3 = 3 \text{)} = 0 \text{ èí } \acute{i}^2, \text{ òíããà } q_D = 0 \text{ ðàà} = 0^\circ.$$

3.7. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí. $\dot{q}_A = \dot{q}_0 = 0$ è $\acute{o}_A = \acute{o}_0 = 0$ è, \grave{n} èààíààòàèúíí, \grave{i} íðàààèÿòù èò íà íààí.



Дèñ. 40

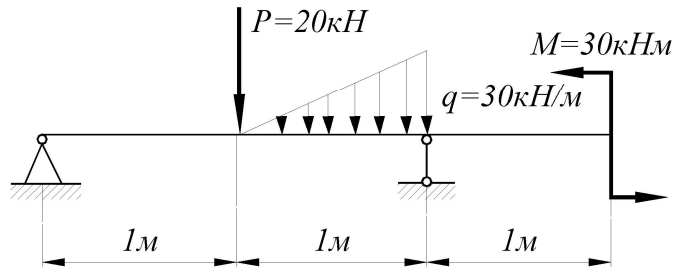
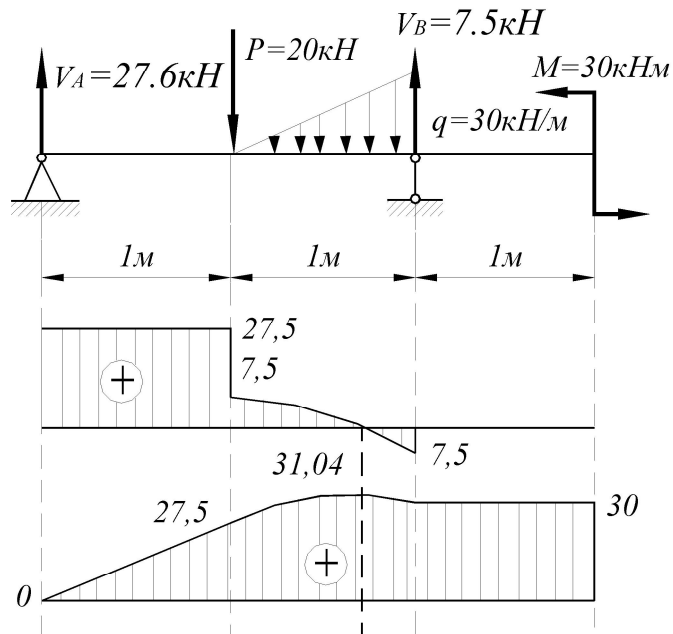


Рис. 41

Ήδεη άδ 7. Άεϑ ϑαααίίτε άαεεε (Ήδñ. 41) ίίñððίεοδϑ ϑίρδϑ ίίίáðá÷ίϑð ñεε ε εϑαεάαρϑεð ίίίáίðίá, ίίáίáðαδϑϑ ááοðααðίáίá ίίίáðá÷ίá ñá÷áίεá, άñεε ðáñ÷áðίίá ñίðίðεáεáίεá $R = 160$ ίίá. ίίñððίεοδϑ εϑίáίóοð ίñϑ áαεεε, ίίεϑϑόϑñϑ ίáðίáί ίá÷αεϑίϑð ίáðáίáððίá. Άεϑ ϑοίáί ίίðáááεεδϑ: óáεϑ ίίáίðίðίá q_A ε q_B ; ίðίáεáϑ o_c ε o_d .

Ή á ø á ί ε á. 1. Ñððίεί ϑίρδϑ ίίίáðá÷ίϑð ñεε ε εϑαεάαρϑεð ίίίáίðίá (Ήδñ. 42).



Ήδñ. 42

2. ίίááεðááί ááοðααðίáίá ίίίáðá÷ίá ñá÷áίεá áαεεε, ίίεϑϑόϑñϑ óñείáεáί ίðί÷ίίñðε ίί ίíðί áεϑίϑί ίáίðϑϑáίεϑί:

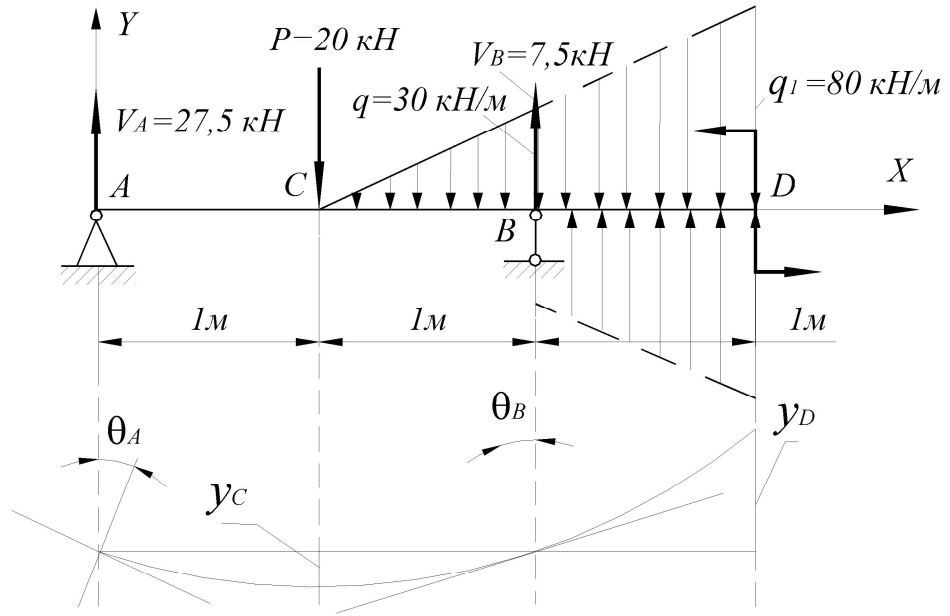
$$s = M_{\max} / W < R, \text{ ίðñρáá } W = M_{\max} / R = 31,04 \times 10^{-3} / 160 = 1940 \times 10^7 \text{ } \grave{\iota}^3 = 194 \text{ } \grave{\iota}^3.$$

$$\text{Έϑ } \text{ΆΪ} \text{ } \text{Ν} \text{ } 8239-89 \text{ áϑáεðááί ááοðααð } \text{ }^1 \text{ } 20\grave{\alpha} \text{ } \grave{\iota} \text{ } W_0 = 203 \text{ } \grave{\iota}^3.$$

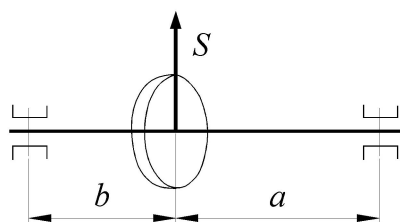
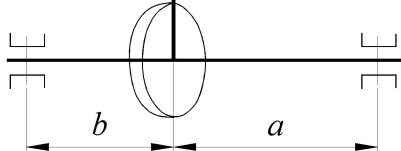
3. ίίðáááεϑáί ίáðáί áϑáίεϑ áαεεε.

3.8. Íî ïîéó÷áññùî äáññùî ñððñèì èçñáñóðð ïñù äáèèè (Ðèñ..44).

Íðèì á÷áñèá: áñ áñáð çááá÷áð, ðáðáññùð ñ ïñññùùð ïáðñáá ïá÷áèùíùð ïáðáìáððñá, ïðè ñññðááèáñèè ïáññùáññùð óðááñáñèè èçñáñóðñè èñè èñññèùçñááèèñù òñðñèèù (6) è (7).



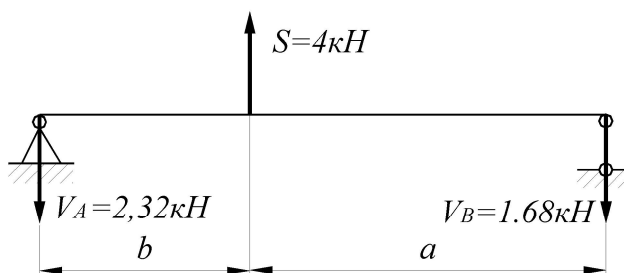
Ðèñ..44



Đèn. 45

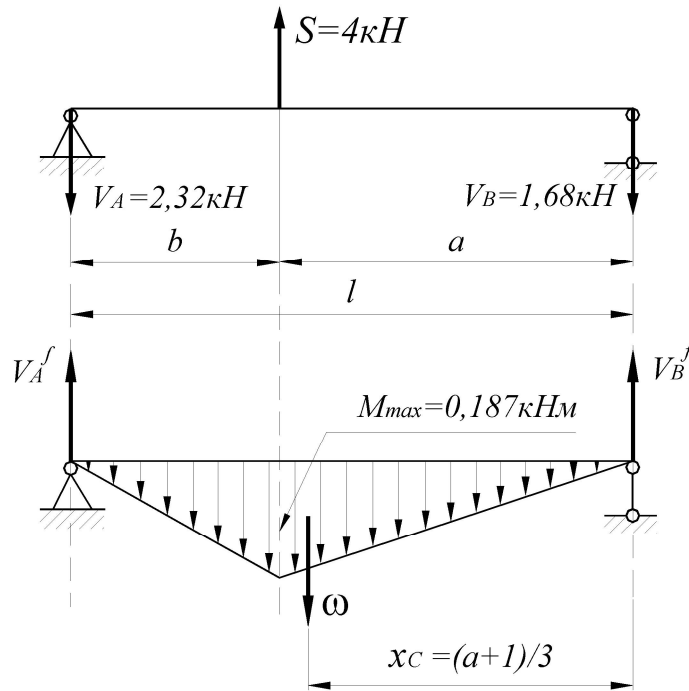
Íðeì áð 8. Íðíááðèòü æáñðéíñòü áàèà ðááóèòíðà), áñèè ìðíáèá á ìéíñéíñòè, ìðíòíäýùáé ÷áðäç íñè áàéíá á ìáñðá óñðáííáèè øáñðáðíè íá áíéæáí ìðááùøàòü [y] = 0,1 ìì. Àèàì áðð áàèà d = 32 ìì, ðáññòíýíèà íò ìðááíáí ìíäøèííèèà áí øáñðáðíè à = 110 ìì, à ìð èááíáí ìíäøèííèèà áí øáñðáðíè-b = 80 ìì. Ðáèèèüííá áàèéáíèá S = 4 éÍ (Đèn. 45).

Ð á ø á í è á. 1. Íðèíèìáì ðáñ÷áðíóð ñòáì ó áàèà (Đèn.46), éíòíðäý áóááð ìðááñðááèýòü ñíáíé ááóòííðíóð áàèèó ñ ìðèéíæáííé è íáé ñíñðááíòí÷áííé ñèéíé S.



Đèn.46

2. Ííðááèýáì áàèè÷éíó ìííðíúð ðáàèòèé, ñòðíèì ýíððó èçáèáðùèð ìííáíòíá è íááðóæáì áé òèèðèáíóð áàèèó (Đèn. 47).

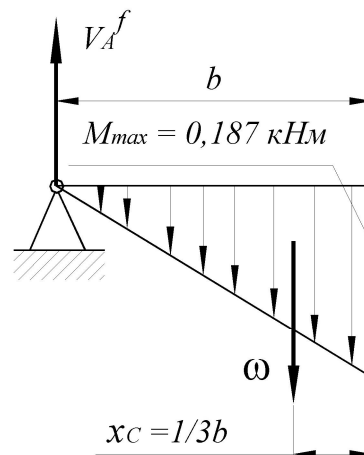


Đèñ. 47

3. Îí ðáááëÿàì ááèè÷éíó ðáàèöèè:

$$\begin{aligned} \mathbf{SM}_B &= -V_A^f(b+a) + \mathbf{w}x_c = 0, \text{ ñèááì áàðáèüíì, } V_A^f = \mathbf{w}(a+1)/3(b+a) = \\ &= 0,5M_{\max}(b+a)(a+1) / 3(b+a) = 0,5 \times 0,187(0,11+0,19) / 3 = 0,009 \text{ éÍ} = 9 \text{ Í.} \end{aligned}$$

4. Îí ðáááëÿàì ááèè÷éíó öèèðèáííáì èçáèáðùááì ìììáíòà á ìáñòà ðáñííèíæáíèÿ ðáñòáðíè (Đèñ. 48).



Đèñ. 48

$$\begin{aligned} \mathbf{\check{I}}_f &= V_A^f b - \mathbf{w}x_c = 9 \times 0,08 - (M_{\max} / 2)(b^2 / 3) = 0,72 - (1/2) \times 0,187 \times 0,08 \times (1/3) \times 0,08 = \\ &= 0,52 \text{ Í}^3. \end{aligned}$$

5. Îí ðáááëÿàì ááèè÷éíó ìðíáèáá á ìáñòà óñòáííáèè ðáñòáðíè ìí òíðì óéá (7.9): $y = \check{I}_f / EI,$

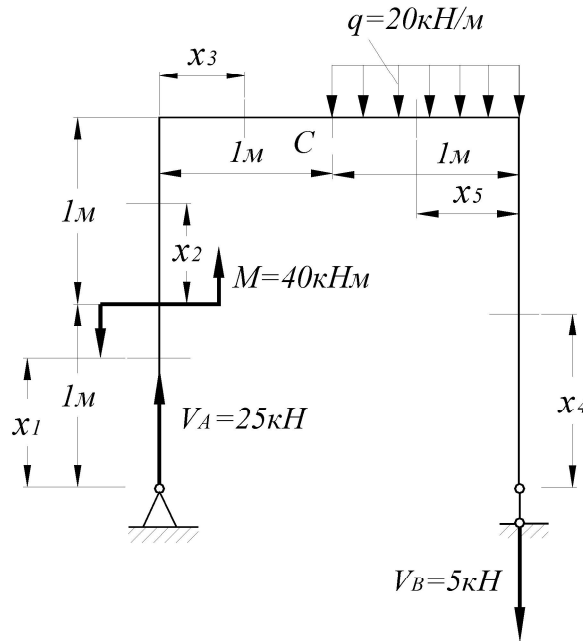
ααα E – ί ί άόέü Π ί ά ά ñ ò à è è , 2×10¹¹ ί ά ;

I – ί ñ á á í é ί ί ί á ò é í á ð ö è è ί ί ί á ð á ÷ ί ί á í ñ á ÷ á í è ý à à è à , 104857×10⁻¹² ί ⁴ .

Ò ί á á á y_{max} = 0,52 / (2×10¹¹×104857×10⁻¹²) = 0,000024 ί = 0,024 ί ί .

Ò à è è à è y_{max} = 0,024 ί ί < [ó] = 0,1 ί ί , æ å ñ ò é í ñ ò ù á à è à ί á á ñ í á ÷ á í á .

Ί δει άδ 9. Άέü ç á á á í í é ð á ì ú (Ð è ñ . 50) ñ ί ί ί í ú ü þ ί á ð í á á Ì à è ñ á á è è á – Ì í ð á í í ð á á á á á è è ò ù ó á í é ί ί á í ð í ð á q_A è í ð í á è á ó ñ . Æ å ñ ò é í ñ ò ù é í é í í í è ð è á á é á é ð á ì ú í ð é í ý ò ù ð á á í ú ì è EI .



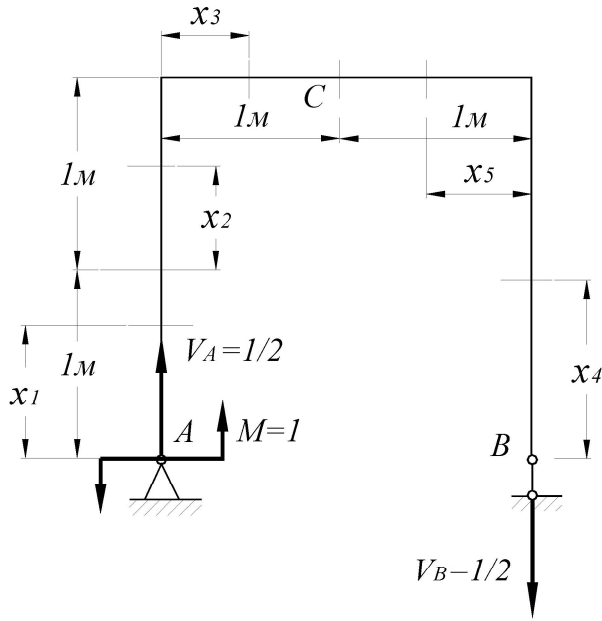
Ð è ñ . 50

Ð á ø á í è á . 1. Ì í ð á á á é ý á ì á á è è ÷ é í ó ί ί í ð í ú ò ð á á è è è , ð á ç á è á á á ì ð á ì ó í à ñ è é í á ú á ó ÷ à ñ ò è è , ί ð í á í á è ì í à è à æ á ì ì ó ÷ à ñ ò è á í í í á ð á ÷ í ú á ñ á ÷ á í è ý (Ð è ñ . 7.51) è á é ý è à æ á í á í è ç í è ò ç à ì è ñ ú á á á ì ó ð á á í á í è ý è ç á è á á þ ú è ò ί ί ί á ð í á .

$$M_1 = 0; 0 \leq x_1 \leq 1 \text{ m}; M_2 = -\bar{M} = -40; 0 \leq \bar{o}_2 \leq 1 \text{ m};$$

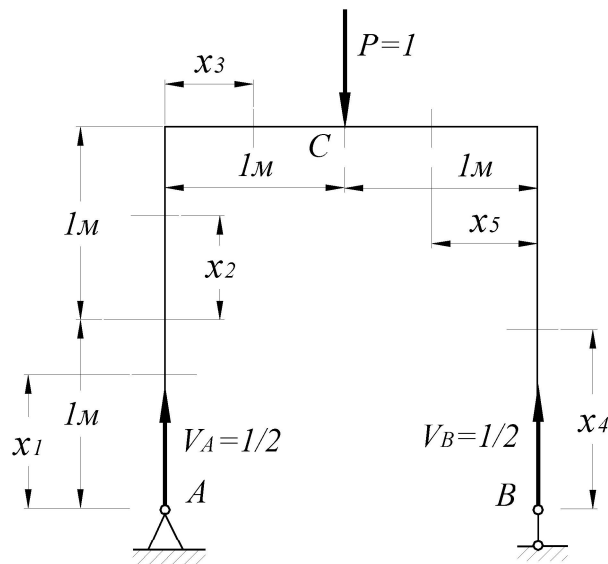
$$\bar{I}_ç = -\bar{M} + V_A x_3 = -40 + 25 \bar{o}_3; 0 \leq \bar{o}_3 \leq 1 \text{ m}; \bar{I}_4 = 0; 0 \leq x_4 \leq 1 \text{ m};$$

$$\bar{I}_5 = -V_B x_5 - q x_5^2 / 2 = -5 \bar{o} - 10 \bar{o}^2; 0 \leq \bar{o}_5 \leq 1 \text{ m} .$$



Đèñ. 51

2. $\hat{\Gamma}$ íðáááëýáì óáíë ííáíðíðà q_A . $\hat{\Gamma}$ ðëëëääúáááì á òí÷éá À ííáíð Ì=1 (Đèñ. 52) è $\hat{\Gamma}$ íðáááëýáì ááëë÷éíó $\hat{\Gamma}$ ííðíúð ðáàëöëé. $\hat{\Gamma}$ òíé áá $\hat{\Gamma}$ íñëááíáàðáëúííñðë, ÷òí íà ááëñðáëðáëúííé ðàì á, $\hat{\Gamma}$ ðíáíáëì $\hat{\Gamma}$ ííáðá÷íúá ñá÷áíëý è çáìññúááì óðááíáíëý èçãëáàðùëò $\hat{\Gamma}$ ííáíðíá.



Đèñ. 52

$$M_1^0 = -1; \hat{\Gamma}_2^0 = -1; \hat{\Gamma}_3^0 = -1 + x_3 / 2; \hat{\Gamma}_4^0 = 0; \hat{\Gamma}_6^0 = -x_5 / 2.$$

Èì ááì ñëááòðùëà óðááíáíëý:

$$M_1 = 0; 0 \leq \bar{\Gamma} \leq 1; M_1^0 = -1; M_2 = -40; 0 \leq \bar{\Gamma} \leq 1; \hat{\Gamma}_2^0 = -1;$$

$$\begin{aligned} \bar{I}_3 &= -40 + 25\bar{o}; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_3^{\circ} = -1 + x/2; \bar{I}_4 = 0; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_4^{\circ} = 0; \\ \bar{I}_5 &= -5\bar{o} - 10\bar{o}^2; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_5^{\circ} = -x/2. \end{aligned}$$

Àεáíí, ÷òí ìðè ïíðáááεáíεè óáεà ïíáíðíðà q_A ìðíñòí ìεðòðòñý òðè εíðááðáεà Ìíðà, òàε èàε íà ïáðáíì è ðáðáððòíì ó-àñðéáð ìðíεçáááíεý Ìí°=0.

$$\begin{aligned} q_A &= (1/EI) \left[\int_0^1 \bar{M}_2 M_2^{\circ} dx + \int_0^1 \bar{M}_3 M_3^{\circ} dx + \int_0^1 \bar{M}_5 M_5^{\circ} dx \right] = \\ &= (1/EI) \left[\int_0^1 (-40)(-1) dx + \int_0^1 (-40+25x)(-1+x/2) dx + \int_0^1 (-5x-10x^2)(-x/2) dx \right] = \\ &= (1/EI) (40x + 40x - 25x^2/2 - 20x^2/2 + 12,5x^3/3 + 2,5x^3/3 + 5x^4/4) \hat{O} = \\ &= 63,75/EI. \end{aligned}$$

$$q_A = 63.75/EI.$$

3. Ìíðáááεýáì ìðíáεá óñ. Ìðèéááúáááì á òí÷éá Ñ ñèéó Ð = 1 (Ðεñ. 7.52) è ïíðáááεýáì ááεè÷εíó ïíðíúð ðáεèéε. Á òíé æá ïíñéááíáðáεüííñòè, ÷òí íà ááεñðáεèðáεüííé ðàìá, ìðíáíáè ïííáðá÷íúá ñá÷áíεý è çáíεñúáááì óðááíáíεý εçáεáðúεò ìííáíðíá.

$$M_1^{\circ} = 0; \bar{I}_2^{\circ} = 0; \bar{I}_3^{\circ} = x_3/2; \bar{I}_4^{\circ} = 0; M_5^{\circ} = x_5/2.$$

Èí ááì ñéááòðúεá óðááíáíεý:

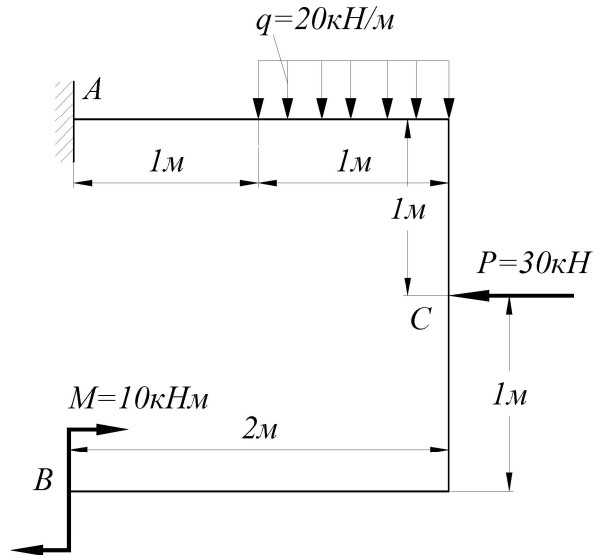
$$\begin{aligned} M_1 &= 0; 0 \leq \bar{o} \leq 1 \text{ m}; M_1^{\circ} = 0; \bar{I}_2 = -40; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_2^{\circ} = 0; \\ \bar{I}_3 &= -40 + 25\bar{o}; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_3^{\circ} = x/2; \bar{I}_4 = 0; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_4^{\circ} = 0; \\ M_5 &= -5\bar{o} - 10\bar{o}^2; 0 \leq \bar{o} \leq 1 \text{ m}; \bar{I}_5^{\circ} = -x/2. \end{aligned}$$

Àεáíí, ÷òí ìðè ïíðáááεáíεè ìðíáεáá óñ ìðíñòí ìεðòðòñý ááá εíðááðáεà Ìíðà, òàε èàε íà ïáðáíì, áðíðíì è ðáðáððòíì ó-àñðéáð ìðíεçáááíεý Ìí° = 0.

$$\begin{aligned} y_c &= (1/EI) \left[\int_0^1 \bar{M}_3 M_3^{\circ} dx + \int_0^1 \bar{M}_5 M_5^{\circ} dx \right] = \\ &= (1/EI) \left[\int_0^1 (-40 + 25x)(x/2) dx + \int_0^1 (-5x - 10x^2)(x/2) dx \right] = \\ &= (1/EI) (-20x^2/2 + 12,5x^3/3 - 2,5x^3/3 - 5x^4/4) \hat{O} = -7,92/EI. \end{aligned}$$

$$y_c = -7,92 /EI.$$

Πρόβλημα 10. Δεδομένη είναι η δοκός (Παράρτημα 53) η οποία υποστηρίζεται από την άρθρωση Α και την αγκύρα Β. Η δοκός είναι κατασκευασμένη από υλικό με μέτρο ελαστικότητας EI . Η δοκός είναι κατασκευασμένη από υλικό με μέτρο ελαστικότητας EI .



Παράρτημα 53

Παράρτημα 1. Η δοκός είναι κατασκευασμένη από υλικό με μέτρο ελαστικότητας EI . Η δοκός είναι κατασκευασμένη από υλικό με μέτρο ελαστικότητας EI .

$$M_1 = -\bar{I}_A + V_A x_1 = -70 + 20x_1; \quad 0 \leq x_1 \leq 1 \text{ m};$$

$$M_2 = -\bar{I}_A + V_A(x_2 + 1) - qx_2^2/2 = -50 + 20x_2 - 10x_2^2; \quad 0 \leq x_2 \leq 1 \text{ m};$$

$$\bar{I}_3 = -\bar{I} = -10; \quad 0 \leq x_3 \leq 1 \text{ m}; \quad \bar{I}_4 = -\bar{I} = -10; \quad 0 \leq x_4 \leq 1 \text{ m};$$

$$M_5 = -\bar{I} - P\delta_5 = -10 - 30\delta_5; \quad 0 \leq x_5 \leq 1 \text{ m}.$$

$$\bar{I}_1^0 = 1; \bar{I}_2^0 = 1; \bar{I}_3^0 = 0; \bar{I}_4^0 = 0; \bar{I}_5^0 = -x_5;$$

Èì áàì ñèääópùèà óðàáíáíèÿ:

$$M_1 = -70 + 20\bar{o}; 0 \leq x_1 \leq 1 \text{ ì}; M_1^0 = -1; \bar{I}_2 = -50 + 20\bar{o} - 10\bar{o}^2; 0 \leq x_2 \leq 1 \text{ ì}; \bar{I}_2^0 = -1;$$

$$\bar{I}_3 = -10; 0 \leq \bar{o}_3 \leq 1 \text{ ì}; \bar{I}_3^0 = 0; \bar{I}_4 = -10; 0 \leq x_4 \leq 1 \text{ ì}; \bar{I}_4^0 = 0;$$

$$M_5 = -10 - 30\bar{o}; 0 \leq x_5 \leq 1 \text{ ì}; \bar{I}_5^0 = -\bar{o}.$$

Áèáíí, ÷òí ìðè ìíðáääèèáíèè ìáðàìáùáíèÿ \bar{o}_c ìðíñòì ìèðòðòñÿ òíèüèí òðè èíðáððàèà Ìíðà, òàè èàè íà òðàòüáì è ÷àòáððòíì ó÷áñðèàò ìðíèçáääáíèÿ $\bar{I}\bar{X}^0 = 0$.

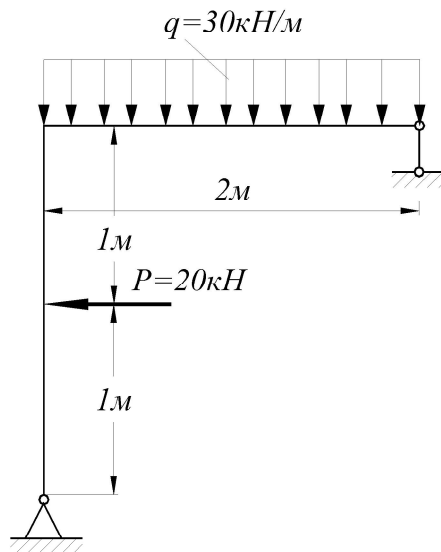
$$x_c = (1/EI) \left(\int_0^1 M_1 M_1^0 dx + \int_0^1 M_2 M_2^0 dx + \int_0^1 M_5 M_5^0 dx \right) =$$

$$= (1/EI) \left[\int_0^1 (-70 + 20x)(-1) dx + \int_0^1 (-50 + 20x - 10x^2)(-1) dx + \int_0^1 (-10 - 30x)(-x) dx \right] =$$

$$= (1/EI) (70x - 20x^2/2 + 50x - 20x^2/2 + 10x^3/3 + 30x^3/3) \Big|_0^1 = 118,33/EI.$$

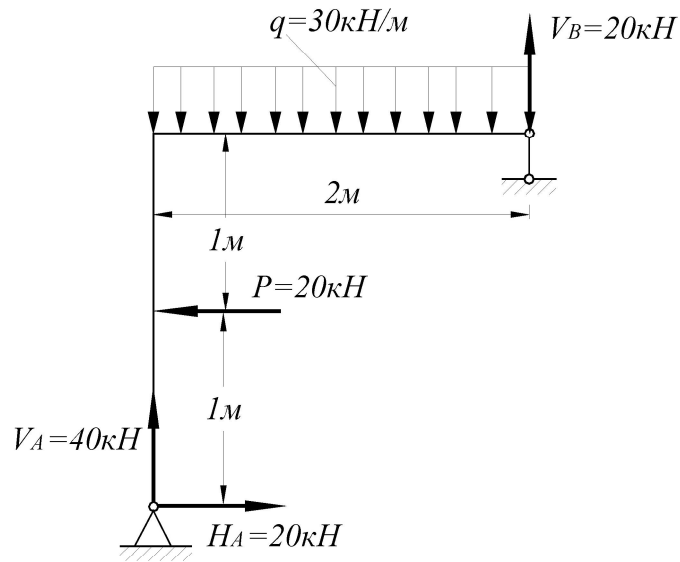
$$x_c = 118,33/EI.$$

Íðèì áð 11. Äèÿ çáääáííé ðàì ù (Ðèñ. 57) ìíðáääèèòü óáíè ìíáíðíòà áá íèæíááí èííòà è áíðèçííðàèüííá ìáðàìáùáíèè ááððíáé ìííòü ìáðíáíì Ááðàùáàèíà. Áèñòèíñòü èíèííü è ðèáàèÿ ðàì ù ìðèíÿòü ðááííé EI.



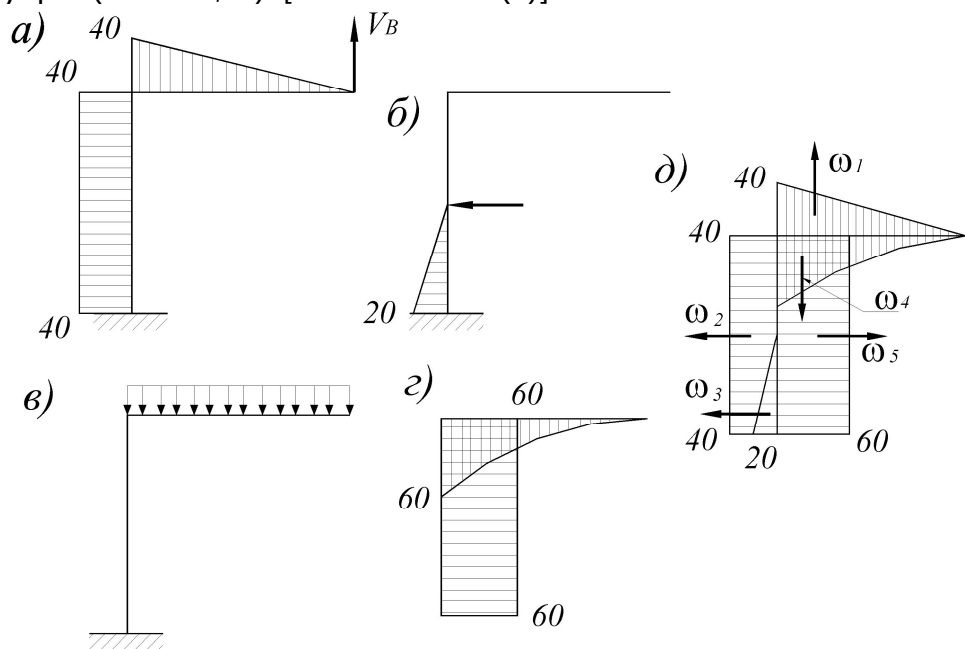
Ðèñ. 57

Ð á ø á í è á. 1. Ìíðáääèÿáì áàèè÷èíü ìííðíóò ðáàèèèè (Ðèñ. 58).



Đèñ. 58

2. Νòðîèì ðàííèîáííóð ýíððó èçæäåàðùèò ìííáíòíâ â îðäåüííòè îð èàæäíé èç ñèè, ìðèèîæáííóò è ðàì á (Đèñ. 59, à, á, â, ã) è ìíðåäåýäì ìèìàèè ìíéò=áííóò ýíððó (Đèñ. 59, ä) [ñì . ðàäèèòó (2)].

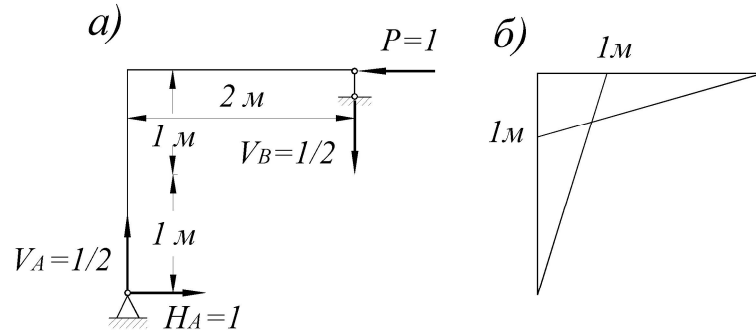


Đèñ. 59

$w_1 = (1/2)40 \times 2 = 40 \text{ éíì}^2$; $w_2 = 40 \times 2 = 80 \text{ éíì}^2$; $w_3 = - (1/3)60 \times 2 = -40 \text{ éíì}^2$;
 $w_4 = -60 \times 2 = -120 \text{ éíì}^2$; $w_5 = (1/2)20 \times 2 = 10 \text{ éíì}^2$.

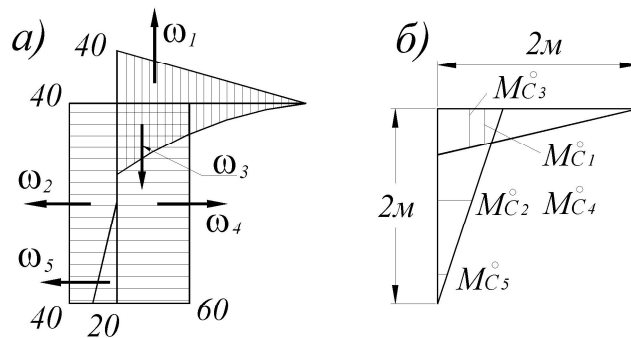
$$= (1/EI)[40(2/3) + 80 \times - 40(3/4) - 120 \times + 10 \times] = - 33,33/EI \text{ ðàà.}$$

5. $\hat{\Gamma}\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{y}\hat{\alpha}\hat{\imath}$ $\hat{\alpha}\hat{\imath}\hat{\delta}\hat{\epsilon}\hat{\Gamma}\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\epsilon}\hat{u}\hat{\imath}\hat{\Gamma}\hat{\alpha}$ $\hat{\imath}\hat{\alpha}\hat{\delta}\hat{\alpha}\hat{\imath}\hat{\alpha}\hat{u}\hat{\alpha}\hat{\imath}\hat{\epsilon}\hat{\alpha}$ \hat{o}_B $\hat{\alpha}\hat{\alpha}\hat{\delta}\hat{o}\hat{\Gamma}\hat{\alpha}\hat{\epsilon}$ $\hat{\imath}\hat{\imath}\hat{\imath}\hat{\delta}\hat{u}$ $\hat{\delta}\hat{\alpha}\hat{\imath}\hat{u}$. $\hat{\Gamma}\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{u}\hat{\alpha}\hat{\alpha}\hat{\alpha}\hat{\imath}$ $\hat{\alpha}\hat{\epsilon}\hat{y}$ $\hat{y}\hat{o}\hat{\Gamma}\hat{\alpha}\hat{\imath}$ $\hat{\alpha}$ $\hat{o}\hat{\imath}\hat{\div}\hat{\epsilon}\hat{\alpha}$ \hat{A} $\hat{n}\hat{\epsilon}\hat{\epsilon}\hat{o}$ $\hat{\delta} = 1$ ($\hat{\delta}\hat{\epsilon}\hat{n}$. 62, $\hat{\alpha}$), $\hat{\Gamma}\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{y}\hat{\alpha}\hat{\imath}$ $\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\epsilon}\hat{\div}\hat{\epsilon}\hat{\imath}\hat{o}$ $\hat{\imath}\hat{\imath}\hat{\imath}\hat{\delta}\hat{\imath}\hat{u}\hat{o}$ $\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{o}\hat{\epsilon}\hat{\epsilon}$ $\hat{\epsilon}$ $\hat{n}\hat{o}\hat{\delta}\hat{\imath}\hat{\epsilon}\hat{\imath}$ $\hat{y}\hat{\imath}\hat{\rho}\hat{\delta}\hat{o}$ $\hat{\epsilon}\hat{\Gamma}\hat{\alpha}\hat{\epsilon}\hat{\alpha}\hat{\rho}\hat{u}\hat{\epsilon}\hat{o}$ $\hat{\imath}\hat{\imath}\hat{\alpha}\hat{\Gamma}\hat{o}\hat{\Gamma}\hat{\alpha}$ ($\hat{\delta}\hat{\epsilon}\hat{n}$.62, $\hat{\alpha}$).



$\hat{\delta}\hat{\epsilon}\hat{n}$. 62

$\hat{\Gamma}\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{y}\hat{\alpha}\hat{\imath}$ $\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\epsilon}\hat{\imath}\hat{\alpha}\hat{\delta}\hat{u}$ M^0_C $\hat{\imath}\hat{\alpha}$ $\hat{y}\hat{\imath}\hat{\rho}\hat{\delta}\hat{\alpha}$ $\hat{\imath}\hat{o}$ $\hat{\alpha}\hat{\alpha}\hat{\epsilon}\hat{\imath}\hat{\epsilon}\hat{\div}\hat{\imath}\hat{\Gamma}\hat{\epsilon}$ $\hat{n}\hat{\epsilon}\hat{\epsilon}\hat{u}$ ($\hat{\delta}\hat{\epsilon}\hat{n}$. 63, $\hat{\alpha}$), $\hat{\imath}\hat{\imath}\hat{\epsilon}\hat{o}\hat{\div}\hat{\alpha}\hat{\Gamma}\hat{u}\hat{\alpha}$ $\hat{\imath}\hat{\delta}\hat{\epsilon}$ $\hat{\imath}\hat{\delta}\hat{\Gamma}\hat{\alpha}\hat{o}\hat{\epsilon}\hat{\delta}\hat{\Gamma}\hat{\alpha}\hat{\alpha}\hat{\imath}\hat{\epsilon}\hat{\epsilon}$ $\hat{\imath}\hat{\alpha}$ $\hat{\imath}\hat{\alpha}\hat{\alpha}$ $\hat{o}\hat{\alpha}\hat{\Gamma}\hat{o}\hat{\delta}\hat{\Gamma}\hat{\alpha}$ $\hat{o}\hat{y}\hat{\alpha}\hat{\epsilon}\hat{\alpha}\hat{n}\hat{o}\hat{\epsilon}$ $\hat{y}\hat{\imath}\hat{\rho}\hat{\delta}$ $\hat{\epsilon}\hat{\Gamma}\hat{\alpha}\hat{\epsilon}\hat{\alpha}\hat{\rho}\hat{u}\hat{\epsilon}\hat{o}$ $\hat{\imath}\hat{\imath}\hat{\alpha}\hat{\Gamma}\hat{o}\hat{\Gamma}\hat{\alpha}$ $\hat{\imath}\hat{o}$ $\hat{\alpha}\hat{\Gamma}\hat{\alpha}\hat{\rho}\hat{\imath}\hat{\epsilon}\hat{o}$ $\hat{n}\hat{\epsilon}\hat{\epsilon}$ ($\hat{\delta}\hat{\epsilon}\hat{n}$. 63, $\hat{\alpha}$).



$\hat{\delta}\hat{\epsilon}\hat{n}$. 63

$$\hat{\imath}^0_{N1} = - 4/3 \hat{\imath}; \hat{\imath}^0_{N2} = -1 \hat{\imath}; \hat{\imath}^0_{N3} = - 3/2 \hat{\imath}; \hat{\imath}^0_{N4} = -1 \hat{\imath}; \hat{\imath}^0_{N5} = -1/3 \hat{\imath}.$$

$\hat{\epsilon}\hat{\imath}$ $\hat{\alpha}\hat{\alpha}\hat{\imath}$ $\hat{n}\hat{\epsilon}\hat{\alpha}\hat{\alpha}\hat{\rho}\hat{u}\hat{\epsilon}\hat{\alpha}$ $\hat{\imath}\hat{\epsilon}\hat{\imath}$ $\hat{u}\hat{\alpha}\hat{\epsilon}$ $\hat{\epsilon}$ $\hat{\imath}\hat{\delta}\hat{\alpha}\hat{\epsilon}\hat{\imath}\hat{\alpha}\hat{\delta}\hat{u}$:

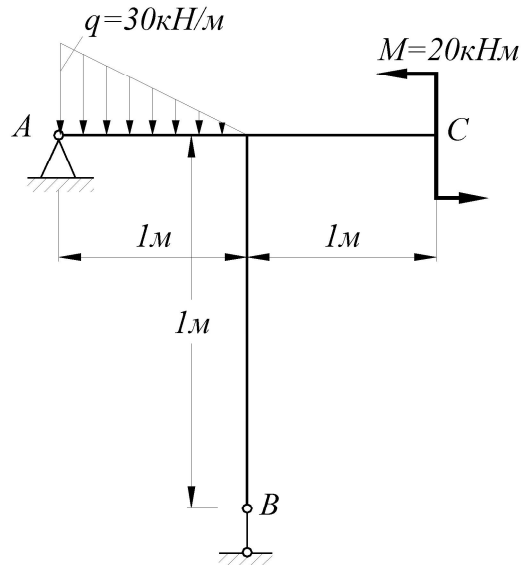
$$\mathbf{w}_1 = 40 \hat{\epsilon}\hat{\Gamma}\hat{\imath}^2; \hat{\imath}^0_{N1} = -4/3 \hat{\imath}; \mathbf{w}_2 = 80 \hat{\epsilon}\hat{\Gamma}\hat{\imath}^2; \hat{\imath}^0_{N2} = -1 \hat{\imath};$$

$$\mathbf{w}_3 = -40 \hat{\epsilon}\hat{\Gamma}\hat{\imath}^2; \hat{\imath}^0_{N3} = -3/2 \hat{\imath}; \mathbf{w}_4 = - 120 \hat{\epsilon}\hat{\Gamma}\hat{\imath}^2; \hat{\imath}^0_{N4} = -1 \hat{\imath};$$

$$\mathbf{w}_5 = 10 \hat{\epsilon}\hat{\Gamma}\hat{\imath}^2; \hat{\imath}^0_{N5} = -1/3 \hat{\imath}.$$

$$\begin{aligned} X_B &= (1/EI)(\mathbf{w}_1 \hat{\imath}^0_{N1} + \mathbf{w}_2 \hat{\imath}^0_{N2} + \mathbf{w}_3 \hat{\imath}^0_{N3} + \mathbf{w}_4 \hat{\imath}^0_{N4} + \mathbf{w}_5 \hat{\imath}^0_{N5}) = \\ &= (1/EI)[-40(4/3) - 80 \times + 40(3/2) + 120 \times - 10(1/3)] = 43,33/EI \text{ ðàà.} \end{aligned}$$

Ίδει αδ 12. Άεϋ çàááííé ðàì ù (Ðèñ. 64) îíðáááèèòù óáíé îíáíðíòà ñà÷áíèϋ, îðíðíáϋùááí ÷áðáç îðááóð îííðó è îðíáèá ñà÷áíèϋ, îðíáááííáí ÷áðáç òí÷éó Ñ. Æáñðèíñòù èíèííú è ðèááèϋ ðàì ù îðèíϋòù ðááíé EI .

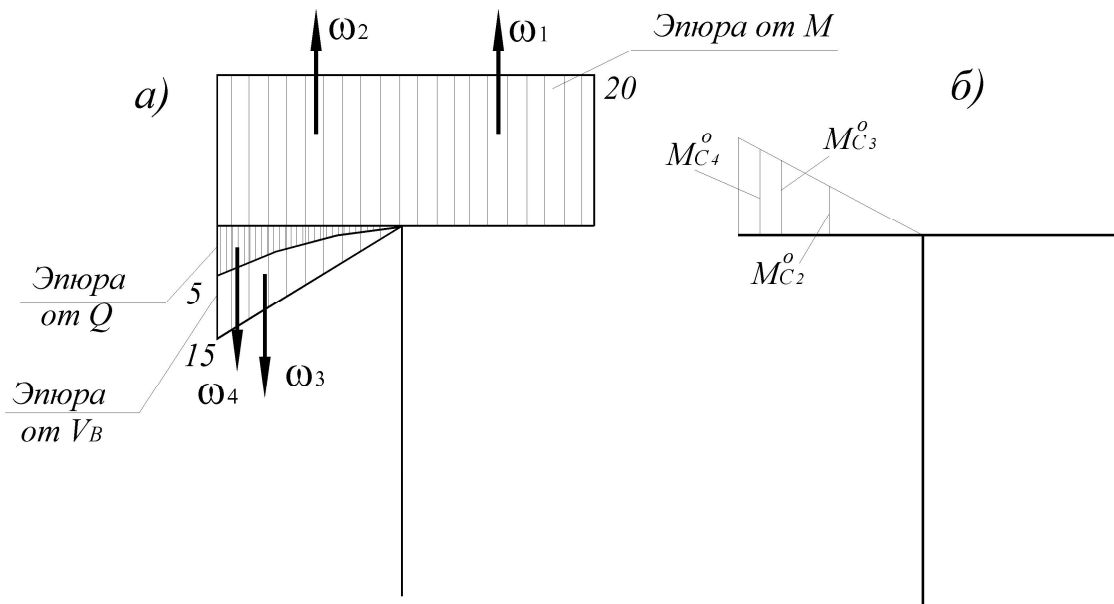


Ðèñ. 64

Ð á ø á í è á. 1. Îíðáááèϋáí ááèè÷èíù îííðíúò ðááèòèé ðàì ù (Ðèñ.65, à), ñððíèì ðáññèíáíóð γíððó èçáèáðùèò îííáíðíá á îðááèϋíñòè îð èáæáíé èç ñèè, îðèèíæáííúò è ðàì á (Ðèñ. 65, á), è îíðáááèϋáí îèíùáèè îíèó÷áííúò γíðð.

$$w_1 = 20\lambda = 20 \kappa Hm^2; w_2 = 20\lambda = 20 \kappa Hm^2; w_3 = -(1/2)15\lambda = -7,5 \kappa Hm^2; w_4 = -(1/4)5\lambda = -5/4 \kappa Hm^2;$$

Τὴ διαμόρφωσις ἰδοῦμεν ἐν τῷ ἔλαστικῷ φάσματι τῆς ἀπόδοσιν (Ἐν. 67,α), ἡ ἐξίσωσις αὐτῆς δὲ ἰσοῦται μετὰ τὴν ἰσοῦσιν τῆς ἀπόδοσιν ἐξ ἑξῆς ἐξισώσεως ἰσοῦσιν τῆς ἀπόδοσιν ἑξῆς (Ἐν. 67, β).



Ἐν. 67

$$\delta_{N1}^0 = 0; \delta_{N2}^0 = 0,5 \text{ m}; \delta_{N3}^0 = 2/3 \text{ m}; \delta_{N4}^0 = 4/5 \text{ m}.$$

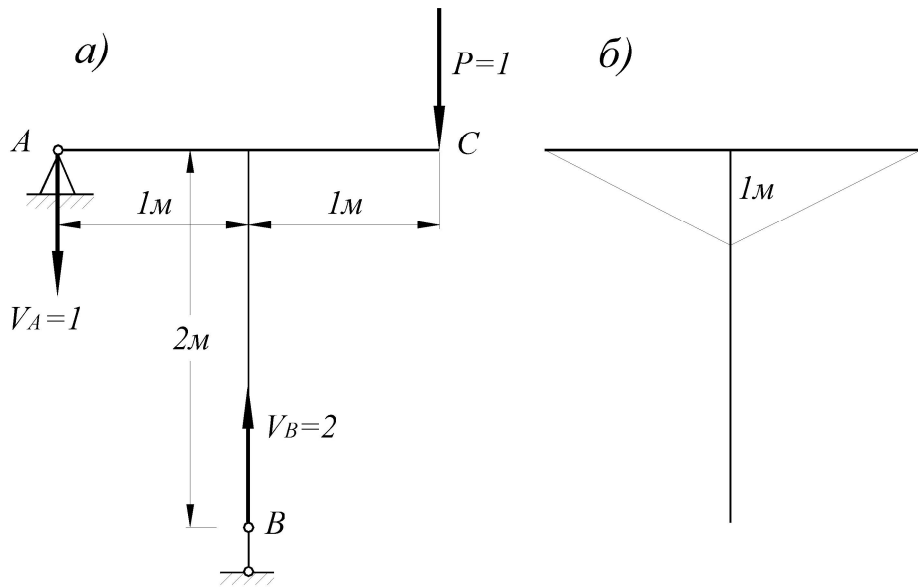
Ἐὰν ἡ ἐξίσωσις αὐτῆς δὲ ἰσοῦται μετὰ τὴν ἰσοῦσιν τῆς ἀπόδοσιν:

$$w_1 = 20 \text{ m}^2; \delta_{N1}^0 = 0; w_2 = 20 \text{ m}^2; \delta_{N2}^0 = 0,5 \text{ m};$$

$$w_3 = -7,5 \text{ m}^2; \delta_{N3}^0 = 2/3 \text{ m}; w_4 = 5/4 \text{ m}^2; \delta_{N4}^0 = 4/5 \text{ m};$$

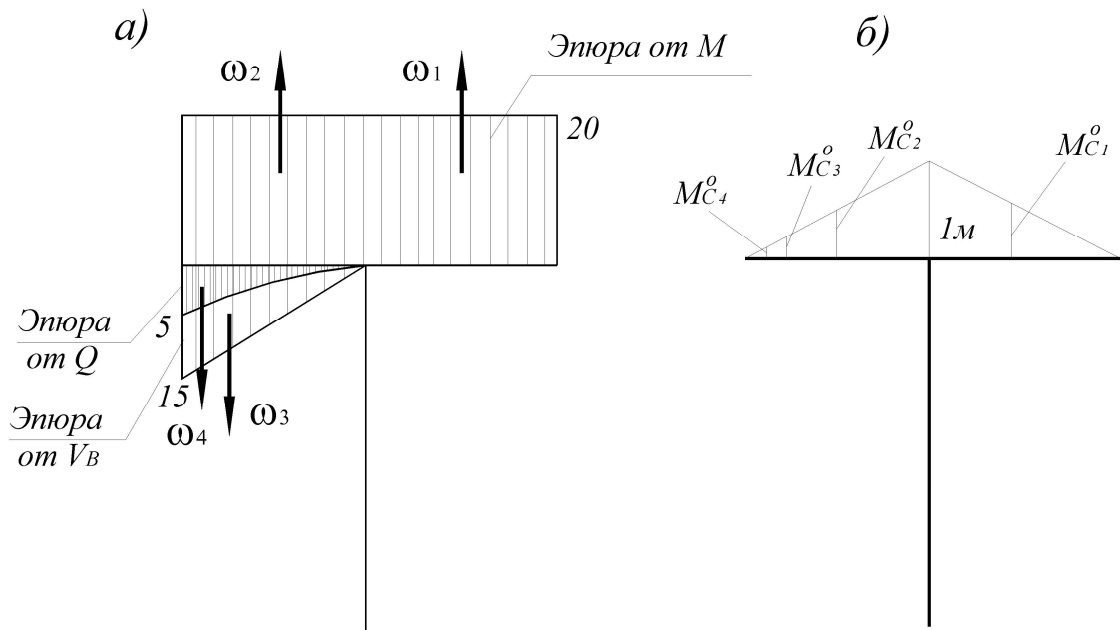
$$\begin{aligned} q_A &= (1/EI)(w_1 \delta_{N1}^0 + w_2 \delta_{N2}^0 + w_3 \delta_{N3}^0 + w_4 \delta_{N4}^0 + w_5 \delta_{N5}^0) = \\ &= (1/EI)(20 \cdot 0,5 - 7,5(2/3) - (5/4)(4/5)) = -4/EI \text{ m}. \end{aligned}$$

3. Τὴ διαμόρφωσις ἰδοῦμεν ἐν τῷ ἔλαστικῷ φάσματι τῆς ἀπόδοσιν ἑξῆς (Ἐν. 68, α), ἡ ἐξίσωσις αὐτῆς δὲ ἰσοῦται μετὰ τὴν ἰσοῦσιν τῆς ἀπόδοσιν ἐξ ἑξῆς ἐξισώσεως ἰσοῦσιν τῆς ἀπόδοσιν ἑξῆς (Ἐν. 68, β).



Đèn. 68

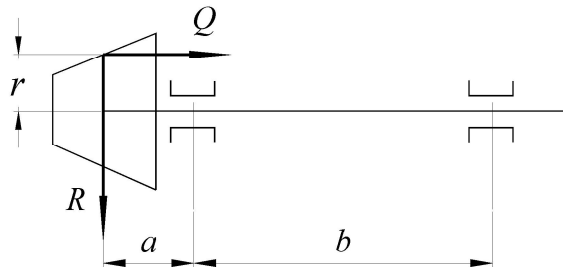
Îĩđäääëÿãĩ îđäëĩàòũ Ì⁰_N íà ÿĩþđã òò ääëĩë=íĩãĩ ìĩĩáíòà (Đèn. 69, á), ìĩëó=áííũã ìđë ìđĩãöëđĩããíëë íà íãã öãíòđĩã òÿæãñòë ÿĩþđ èçãëãþũëò ìĩĩáíòĩã ìò áíãóíëò ñëë (Đèn. 69, à).



Đèn. 69

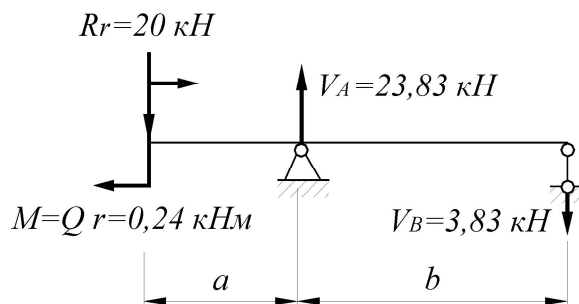
$\bar{I}^0_{N1} = -0,5 \text{ ; } \bar{I}^0_{N2} = -0,5 \text{ ; } \bar{I}^0_{N3} = -1/3 \text{ ; } \bar{I}^0_{N4} = -1/5 \text{ ;}$
 Èĩ äãĩ ñëããóþũëã ìëĩũãë è îđäëĩàòũ:
 $w_1 = 20 \text{ êíĩ}^2 \text{ ; } \bar{I}^0_{N1} = -0,5 \text{ ; } w_2 = 20 \text{ êíĩ}^2 \text{ ; } \bar{I}^0_{N2} = -0,5 \text{ ;}$
 $w_3 = -7,5 \text{ êíĩ}^2 \text{ ; } \bar{I}^0_{N3} = -1/3 \text{ ; } w_4 = 5/4 \text{ êíĩ}^2 \text{ ; } \bar{I}^0_{N4} = -1/5 \text{ ;}$
 $q_A = (1/EI)(w_1\bar{I}^0_{N1} + w_2\bar{I}^0_{N2} + w_3\bar{I}^0_{N3} + w_4\bar{I}^0_{N4} + w_5\bar{I}^0_{N5}) =$
 $= (1/EI)[-20 \times 0,5 + 7,5 \times 0,5 + 7,5(1/3) + (5/4)(1/5)] = -17,25/EI \text{ đãã.}$

Íðeí ãð 13. Í áeðe íðíáeá è óáíe ííáíðíòà eííòà áeà ãeááííe íáðááà÷e ãeàí áòðíí $d = 50$ íí (Ðeñ. 70). Ðaçí áðú: $a = 35$ íí, $b = 120$ íí, ñðááíeé ðááeón eííe÷áñeíe øáñòáðíe $\bar{a} = 120$ íí. Íðe ðaáíòá íáðááà÷e íá áeé íáðááàðoñý ñeááópùeá íáððóçeé: ðáeèeëúíáý $R = 20$ eÍ, íñááý $Q = 8$ eÍ. Íáðáí áúáíeý ííðááeèeòú í áòíáíí íá÷eúíúò íáðáí áòðíá.



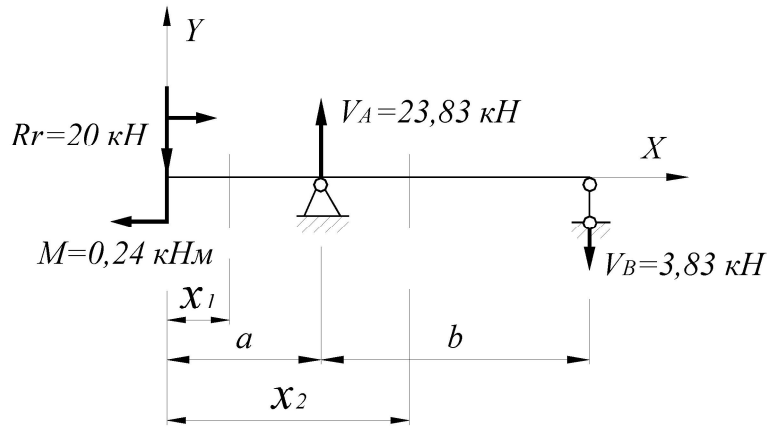
Ðeñ. 70

Ð á ø á í è á. 1.Íðeíeí ááí ðáñ÷áðíóp ñðáí ó áeà (Ðeñ. 71). Í íá áóááð ðááñðááeýòú ñíáíe áeééó íá ááóó ííðáð ñ íðeéíæáííúíe íá eííòá eííñíeè ñíñðááíòí÷áííe ñeéíe R è íííáíòíí $\bar{l} = Q - r = 8 - 0,03 = 0,24$ eÍí.



Ðeñ. 71

2. Ííðáááeýáí áeèe÷eíó íííðíúò ðááeöeé:
3. Íðeíeí ááí íá÷eí eííðáeíáð íá eááíí eííòá áeéè, íðíáíáeí íííáðá÷íúá ñá÷áíeý (Ðeñ. 72) è çáíeñúááí óðááíáíeý íðíáeáíá áeý eáæáíáí eç íeð [ñí. óíðí óeó (6)].



Đèn. 72

$$Ely_1 = Ely_0 + Elq_0x_1 + Mx_1^2/2 - Rx_1^3/6; \quad Ely_A(i \text{ ðè } x_1=0) = Ely_0 + Elq_0 \cdot 0,035 + 0,0000041 = 0;$$

$$Ely_B = Ely_0 + Elq_0x_1 + Mx_2^2/2 - Rx_2^3/6 - V_A(x_2 - 1)^3/6.$$

$$\text{Àèàíî, ÷òî ìðè } x_2=a+b, y_B=0, \text{ òîãàà } Ely_B(i \text{ ðè } x_2=a+b) = Ely_0 + 0,155Elq_0 - 0,0026 = 0.$$

Èì ààì ààà óðàáíáíèý ñ àáóì ý í àèçàñòíóì è:

$$Ely_0 + Elq_0 \cdot 0,035 + 0,0000041 = 0; \quad (\text{à})$$

$$Ely_0 + Elq_0 \cdot 0,155 - 0,0026 = 0. \quad (\text{á})$$

Âú÷èòàý èç óðàáíáíèý (à) óðàáíáíèà (á), ìîéó÷èì:

$$-Elq_0 \cdot 0,12 + 0,00267 = 0, \text{ òîãàà } Elq_0 = 0,022 \text{ éí } \text{ì}^2.$$

Íîñòààèì çíà÷áíèà $Elq_0 = 0,022 \text{ éí } \text{ì}^2$ à óðàáíáíèà (á):

$$Ely_0 + Elq_0 \cdot 0,155 - 0,0026 = 0; \quad Ely_0 = -0,00078 \text{ éí } \text{ì}^3.$$

4. Íîðààèýàì ìáðàì àùáíèý ìðè ìîäóèà Þíàà ñòàèè $\text{Å} = 2 \cdot 10^8 \text{ éí } \text{à} \text{ è } \text{îñàâìì } \text{ìîìáíòà } \text{éíáðöèè } \text{îðíñèòàèüíîí } \text{íáèòðàèüíîíé } \text{îñè } l = \frac{pd^4}{32} = 24,07 \text{ ñì}^4 =$

$$= 61,33 \cdot 10^{-8} \text{ ì}^4.$$

$$q_0 = 0,022 / (2 \cdot 10^8 \cdot 61,33 \cdot 10^{-8}) = 0,00018 \text{ ðàà} = 0,01040^0;$$

$$y_0 = -0,00078 / (2 \cdot 10^8 \cdot 61,33 \cdot 10^{-8}) = -0,0000064 \text{ ì} = 0,0064 \text{ ì}.$$