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праця на правах рукопису

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ДИСЕРТАЦІЯ

КОМБІНОВАНІ ЗГИНАЛЬНІ КОНСТРУКЦІЇ З НЕСУЧИМИ БІЧНИМИ
ЗАЛІЗОБЕТОННИМИ ПЛАСТИНАМИ І КАМ'ЯНИМ ЗАПОВНЕННЯМ

05.23.01 – Будівельні конструкції, будівлі та споруди

Подається на здобуття наукового ступеня кандидата технічних наук

Дисертація містить результати власних досліджень. Використання ідей,
результатів і текстів інших авторів мають посилання на відповідне

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ABSTRACT

Miza O.S. Combined bending structures with load-bearing side lateral reinforced concrete plates and stone filling - *qualifying scientific work on the rights of the manuscript.*

Dissertation for the Candidate Degree in Engineering in the specialty 05.23.01 "Construction Structures, Buildings and Structures" (192 - Civil Engineering and Building). - Odessa State Academy of Civil Engineering and Architecture, Odessa, 2019.

Contents of the dissertation. **The introduction** substantiates the relevance of the dissertation topic, the scientific novelty of the results obtained, the practical value, information about the implementation of the results of the work, the personal contribution of the applicant, information about the approbation of the results; the publications of the applicant on the topic of the dissertation are outlined; General characteristics of the work, structure and scope of the dissertation are presented.

Section 1 provides an overview of the literature on the methods of calculating stone and reinforced concrete structures, methods of reinforcing stone structures and their calculation. Attention is paid to the consideration of existing regulatory and authoritative methods of calculating the reinforcement of stone and reinforced concrete structures by the action of bending moments.

It is concluded that bending stone structures are reinforced in different ways, but each has its disadvantages. It has been found that the calculation of composite structures consisting of stone and reinforced concrete elements can be carried out by methods of calculating bending reinforced concrete elements. There are various methods of calculating the strength and deformability of reinforced concrete elements, have both advantages and disadvantages. The application of these methods directly to the calculation of combined structures consisting of stone and reinforced concrete elements can only be carried out if materials with different characteristics are cross-sectioned.

On the basis of the literature review, the research objectives were set.

Section 2 deals with the stress-strain state and strength of combined bending structures with lateral reinforced concrete plates and stone filling. A technique for

determining the forces in the joints that connect the stone and reinforced concrete parts of the combined beam is developed, which allows to calculate the named structures without changing software complexes, and to vary the parameters of the combined structure quickly and effectively. It is shown that in order to calculate the combined construction should be divided into two separate layers (two beams). In places of the opening of the elm in the first and second cut off layers (beams) will operate unknown vertical and horizontal forces. These unknowns are determined by the addition of deformation (displacement) compatibility equations for the first and second layers of the combined structure. A calculation algorithm for the proposed method and a program written in Pascal have been developed. After determining the forces in the anchors, each element of the combined structure is considered as a separate beam with external loads and forces in the anchors applied to it. The developed technique allows to carry out a detailed analysis of the efficiency of amplification when varying various factors without the use of software complexes.

The section also shows the calculation of combined beams with a lateral reinforced concrete plate, taking into account the formation of cracks. Given that such elements have a small span, the calculation of such a system considered the calculation of a two-block model with a crack, the blocks of which are connected by an elastic link (reinforcement, reinforced concrete plate), and in the upper zone have a hinge.

It is shown that at a certain step and a certain diameter of elms (anchors) between reinforced concrete and stone beams they can be considered as a monolithic construction. In this case, such construction can be calculated by the method of calculation of reinforced concrete structures using diagrammatic methods, including the method of DSTU B B.2.6-156: 2010, but with the adjustment to the fact of the presence of different materials in cross section of the element. However, given the symmetry of the arrangement of reinforced concrete plates and the stone beam, the structure can be considered as a straight bendable element, ie two layers on two sides of the stone element can be conditionally brought to one located on the side of the stone element. Then you can conditionally consider a two-layer element. The method of calculation of combined bending structures allows to calculate elements in which the

reinforced concrete plates are located symmetrically on both sides and on one side face, including taking into account nonlinear properties of materials.

The section also develops a method for calculating combined torsion beams. The cross-section of the beam is then divided by the finite number of longitudinal rod elements of the rectangular cross-section that are connected by the cross bars. The rigidity of each longitudinal rod is taken as the rigidity of the respective rectangles. The rigidity of the transverse rods is chosen so that their axial displacement is equal to the displacement from the local deformation of the longitudinal rods. Local deformation values are taken from a series of preliminary calculations by means of volumetric finite elements in Lyra and by obtaining local displacement dependences on the cross-sectional dimensions of the longitudinal rod and the location of the transverse rods along the longitudinal length. Thus, the calculation of the torsion of the bulk element is carried out by the method of rod approximation. That is, a solid body is replaced by a rod system with longitudinal and transverse rods. In the locations of the side plate and the stone part of the rigidity of the rods differ.

Section 3 presents the results of experimental studies of the strength and deformability of composite beams with lateral reinforced concrete one-sided and double-sided plates and brick and lightweight concrete filling. The characteristics of the experimental samples, the design of the test facility, the test methods and devices are given. Tested beams consisted of aerated concrete blocks with lateral one-sided and double-sided reinforced concrete plates, as well as beams consisting of brickwork with lateral one-sided reinforced concrete plates.

Experimental data are analyzed. As a result of the experiments it is established that the combined bending elements, consisting of a stone part and bilateral or unilateral reinforced concrete plates, are quite viable and can be recommended in the practice of construction. The stone part of the combined structure plays the role of an element that prevents the loss of stability of the flat form of bending of reinforced concrete plates. It is established that when reinforcing aerated concrete bending elements with lateral reinforced concrete plates, the condition of having anchors connecting the stone and reinforced concrete parts is mandatory. The work of brick beams with one-sided reinforced concrete plates also showed the reliability of such structures.

It is shown that the use of one-sided reinforced concrete plates is as effective as two-sided in the combined elements, in which the span to section height and width are small. In the experiments, no noticeable difference in deformation of the opposite faces of the beams was observed, indicating that there was no significant torsion.

Section 4 discusses the algorithm for the design of combined bending structures with load-bearing reinforced concrete plates and stone filling, taking into account the influence of ties, nonlinear material properties.

The method of calculating the considered structures using the Prandl diagram is developed. It is assumed that n layers of longitudinal reinforcement are located in the reinforced concrete beam (side plate). Since the materials of the layers of the beam have different characteristics, the stresses for different layers are different when deforming the extreme compressed fiber b .

The calculation is performed by the method of selection of deformations b in the compressed zone and satisfaction of the equilibrium conditions, as well as by observing the hypothesis of flat sections. With a given deformation b , there are two cases of a stress plot in the compressed zone of each element layer: when the deformation b is less than or greater than the maximum deformations of the considered layer (reinforced concrete plate or stone part). Depending on this, the efforts in cross section of the combined beam are determined.

The section also discusses the engineering method of calculation, which significantly reduced the number of iterations. It is taken into account that there are two different materials in the section. Different methods of calculation are compared. The limits of application of different calculation methods and cases when it is profitable to apply one or another method are considered.

The experimental data are compared with the calculated data. The theoretical data are in good agreement with the experimental data. The average error is from -2% to +21%. The coefficients of variation are from 3.4% to 12%. This gives the right to recommend the developed methods of calculation in the practice of design.

The section provides recommendations for the use of lateral reinforced concrete plates for reinforcing stone walls, the foundations of which are exposed to uneven draft. The advantages of this method of reinforcement of stone walls are shown. It is

proposed to use jumpers made of lightweight concrete blocks with double or double sided reinforced concrete plates. It is shown that the economic feasibility of using the proposed jumpers with lateral reinforced concrete plates is that the window or door opening is overlapped with the same material as the wall. The need to use reinforced concrete jumpers is eliminated. The jumper does not require any additional equipment, additional materials or additional mounting accessories. The jumper can be mounted manually because its weight is small. In addition, the jumper is made directly at the construction site.

The general conclusions show what an important problem is solved in the dissertation, the main results of the research conducted in the dissertation.

The annexes provide programs for computers by developed calculation methods. Applications are written in Pascal.

The results of the research were implemented in the design of real objects for various purposes, for which the appendices have relevant references.

Keywords: combined bending structures, combined beam, reinforced concrete plate, ties, reinforcement, non-linear work, teamwork.

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$$M_E \leq M_R Z \tag{1.1}$$

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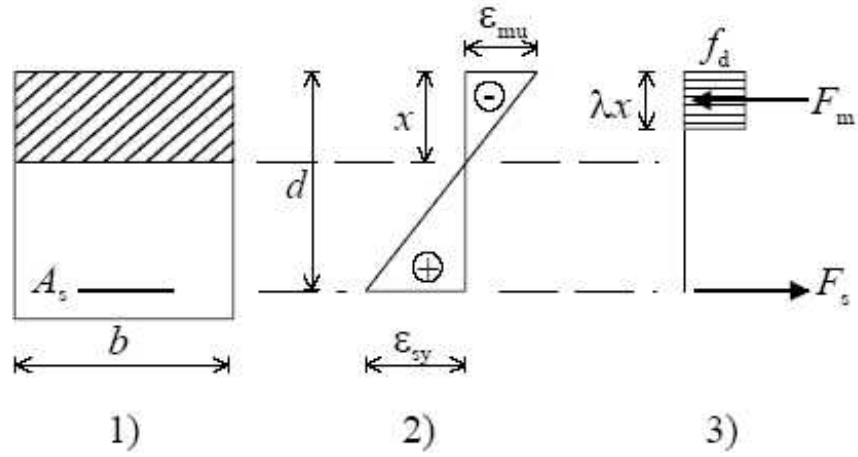
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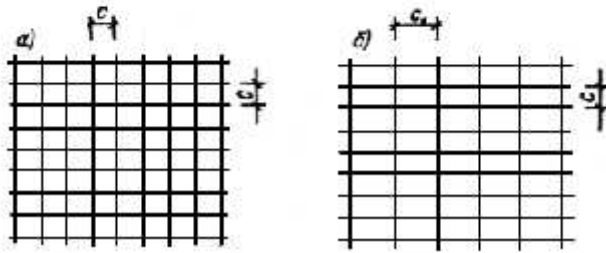
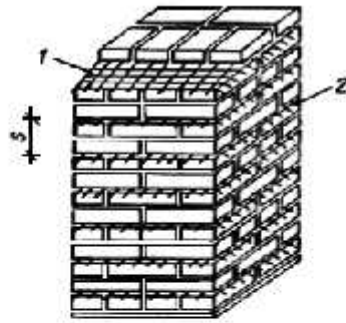
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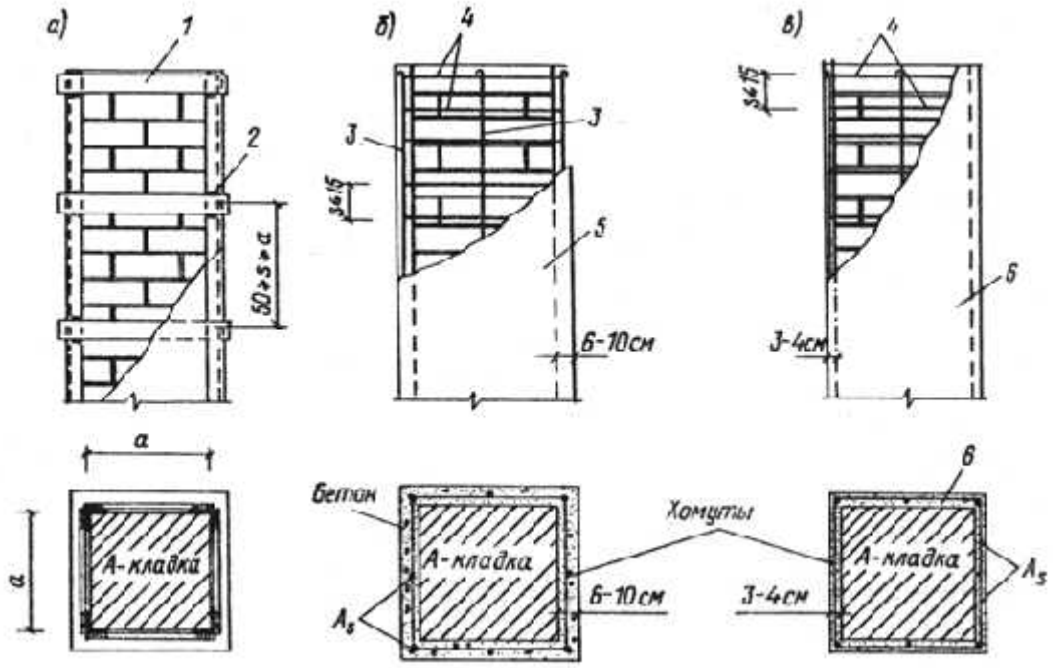
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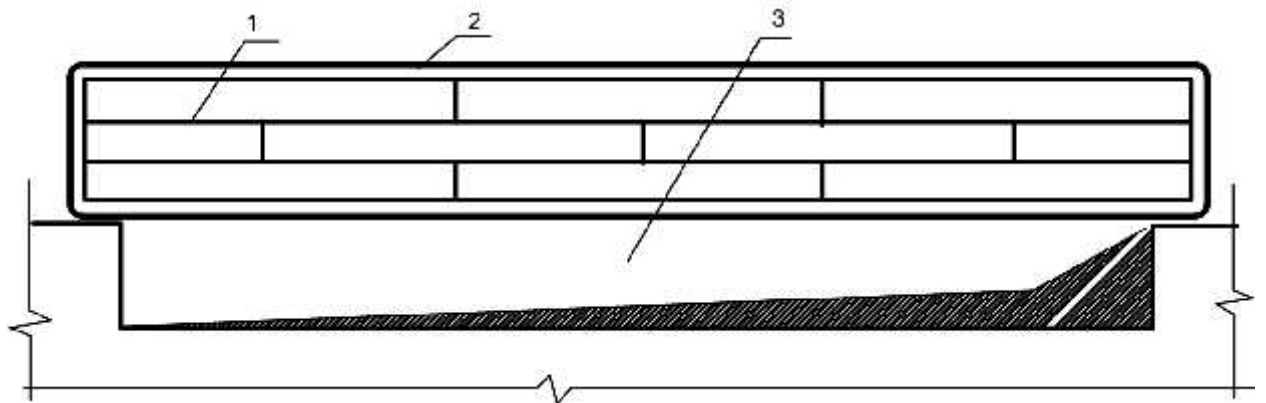
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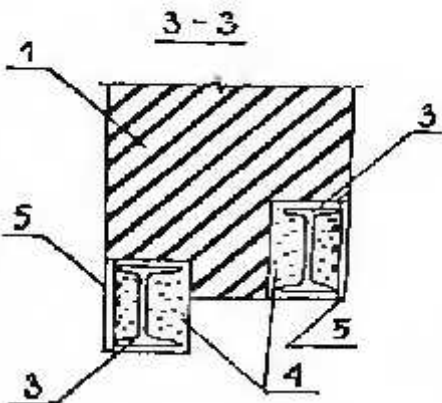
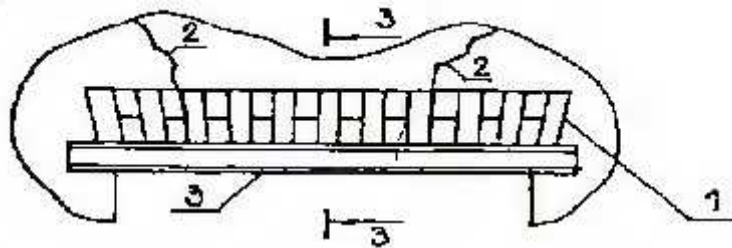
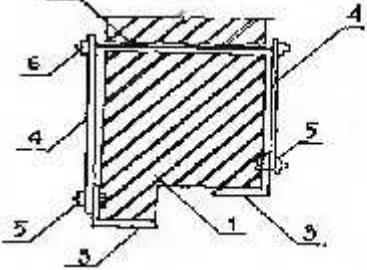
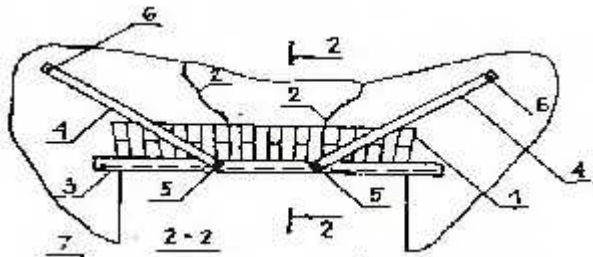
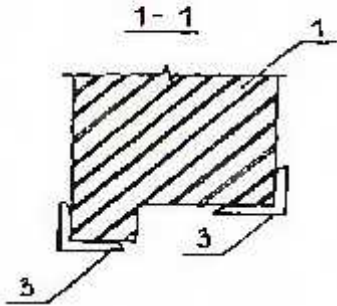
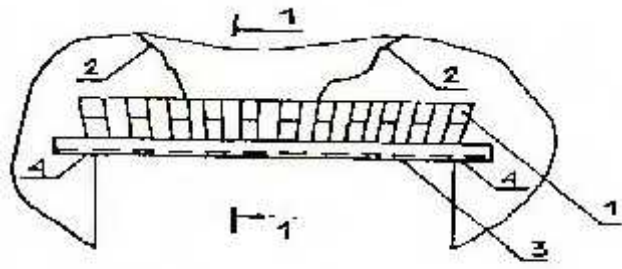


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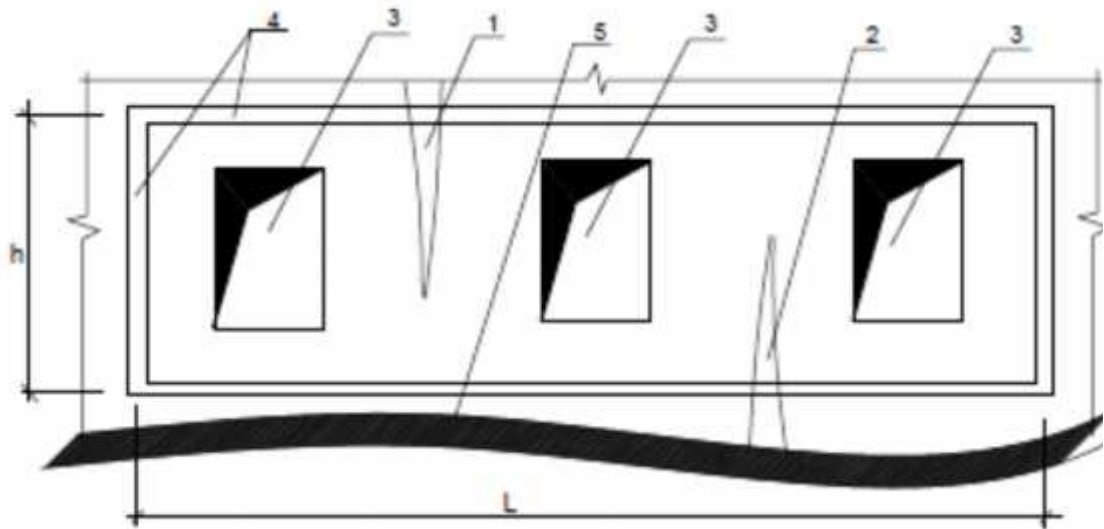
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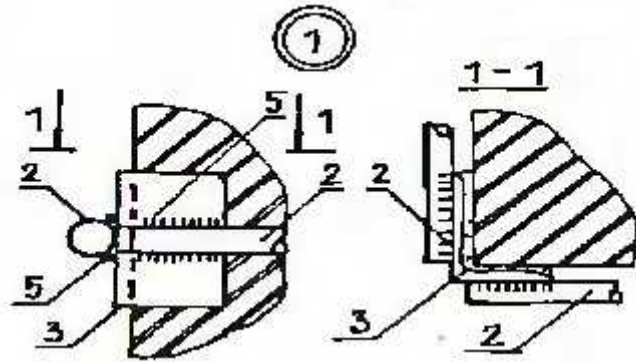
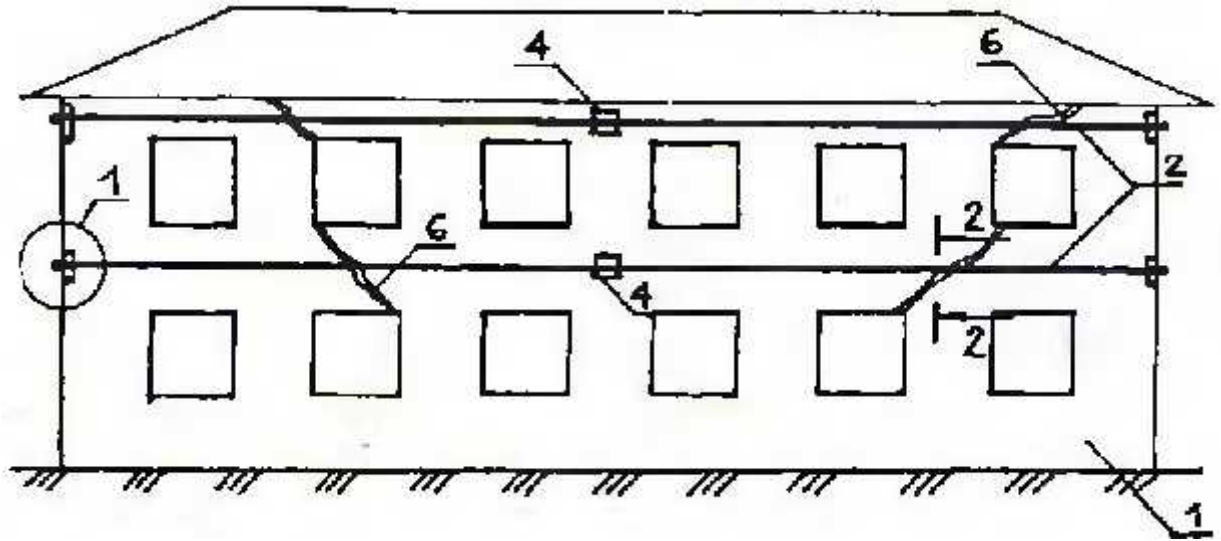
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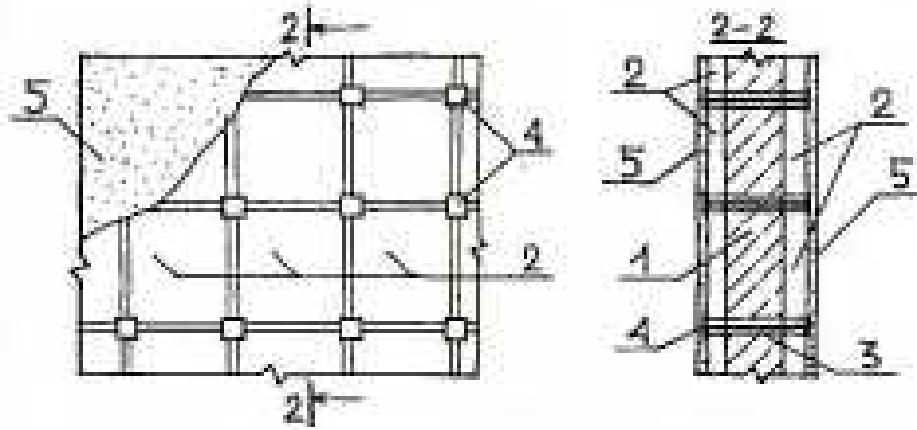
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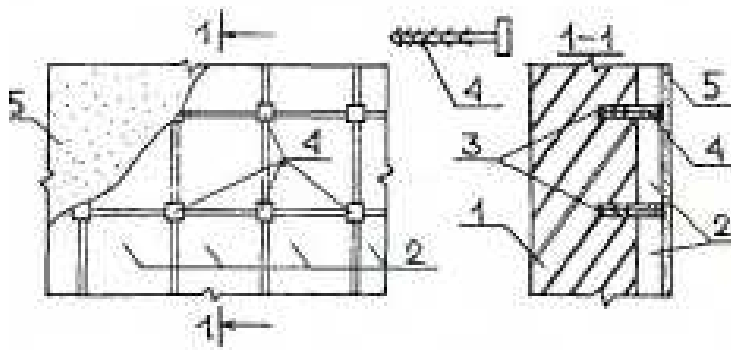
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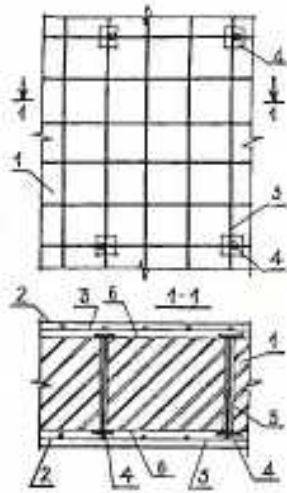
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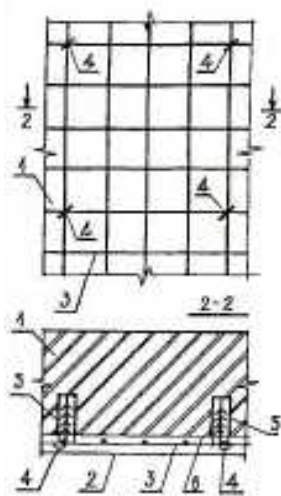
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[29,34,53,76-78,191,192,195-200]



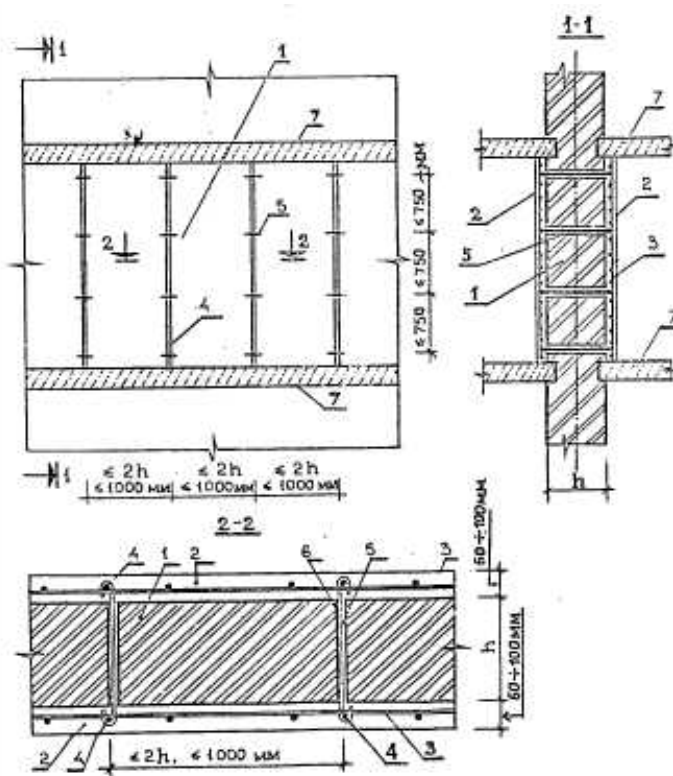
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[19, 21-27, 31, 39, 40,60,72, 73,118-120,133, 134, 136, 137, 157,178,188,190].

[84, 85]

[21-24]:

$$\sigma_c = f_c \sum_{k=1}^5 a_k \eta^k, \tag{1.6}$$

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[63]:

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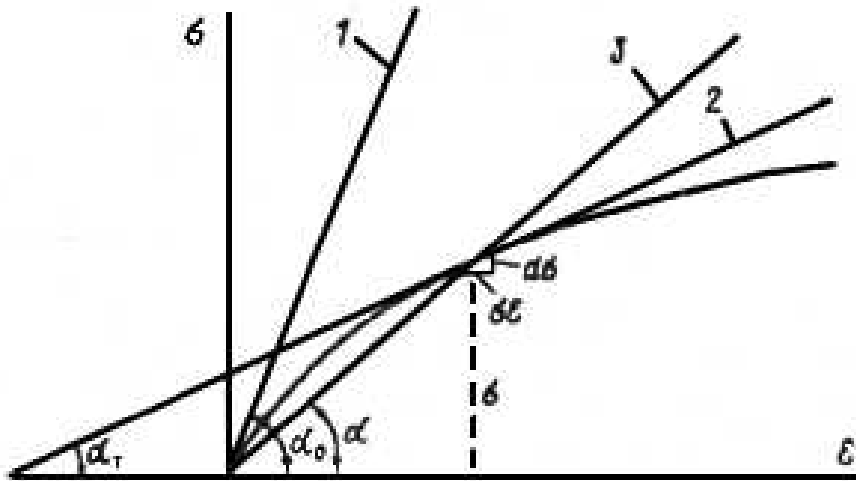
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[128, 139]

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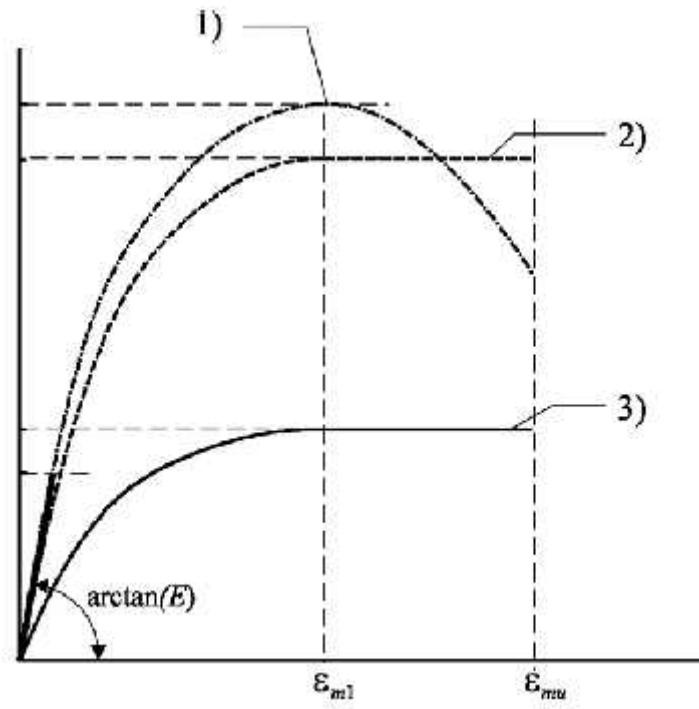
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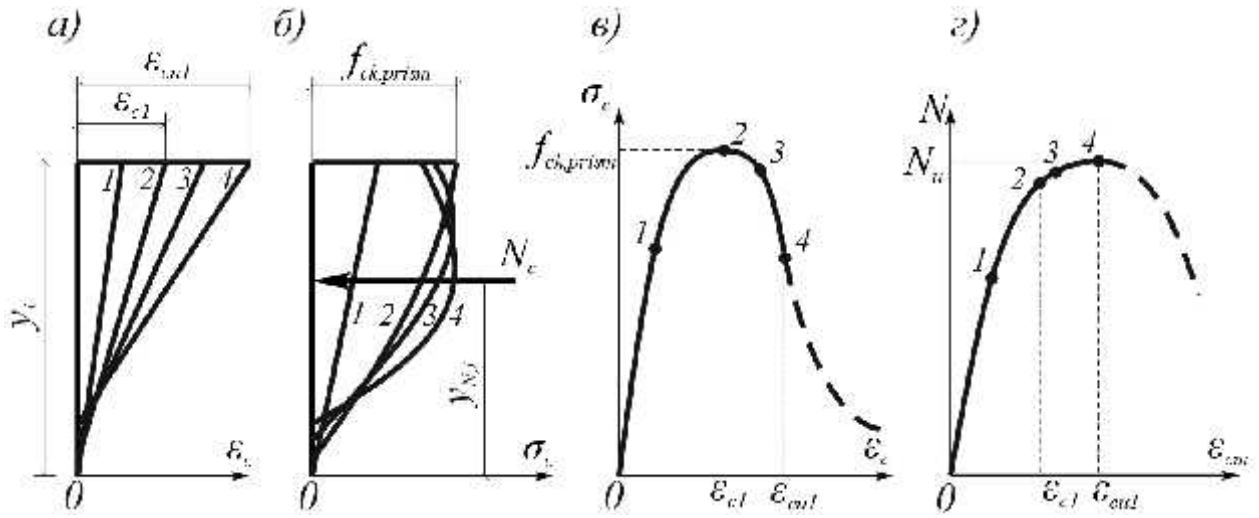
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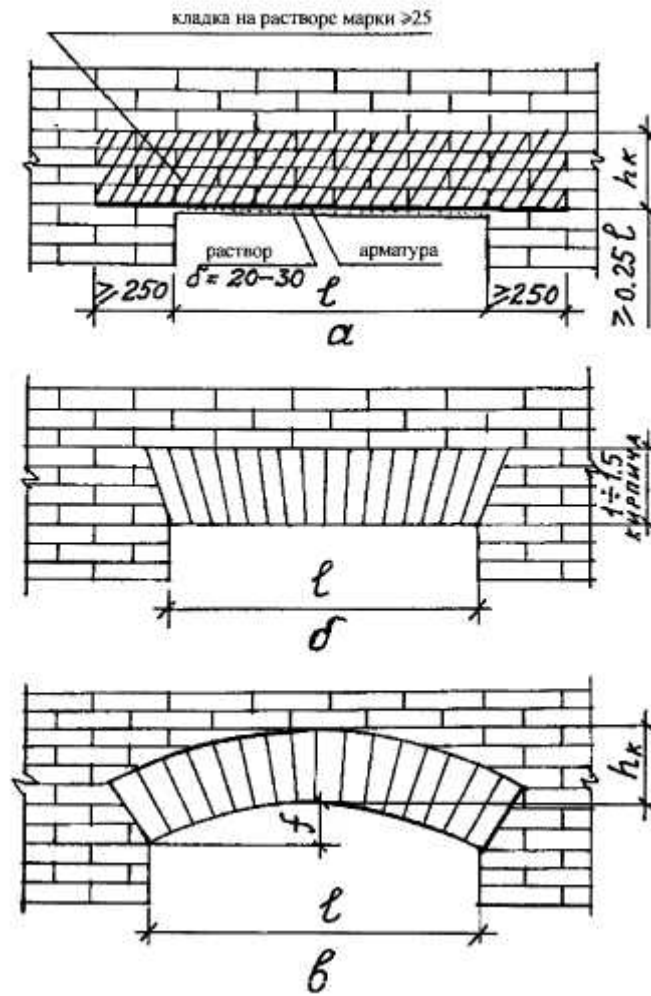
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[2, 4, 5, 6, 10, 14, 68].



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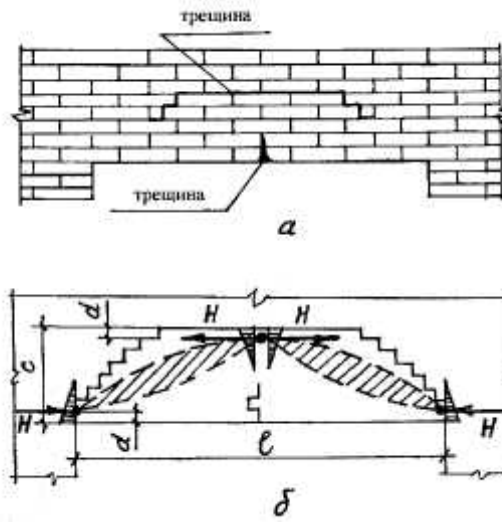
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f=1/5...1/6

[2, 4,

68].

. 1.20 [30, 43].



. 1.20.

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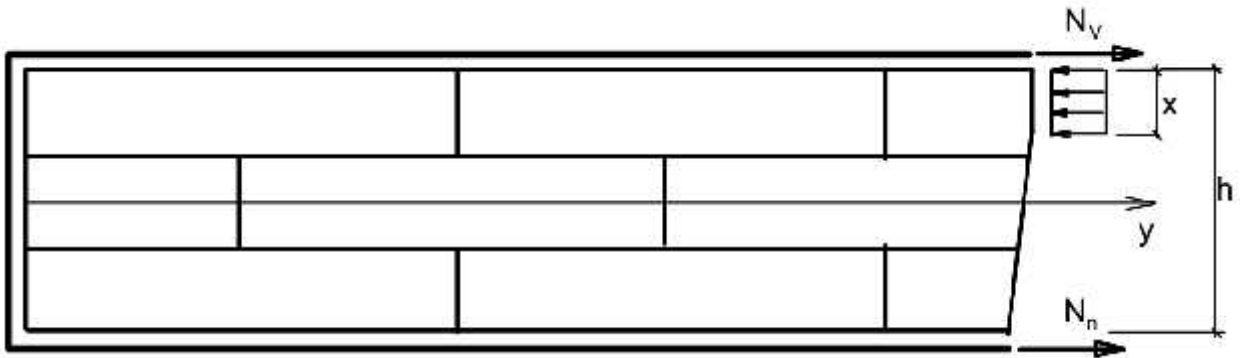
(. 1.20,).

[2, 4, 10, 68]

. 1.21

[68].

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. 1.21.

[68]

[68]

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(. 1.22).

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[125].

[56-57, 127, 129, 164, 166, 168].

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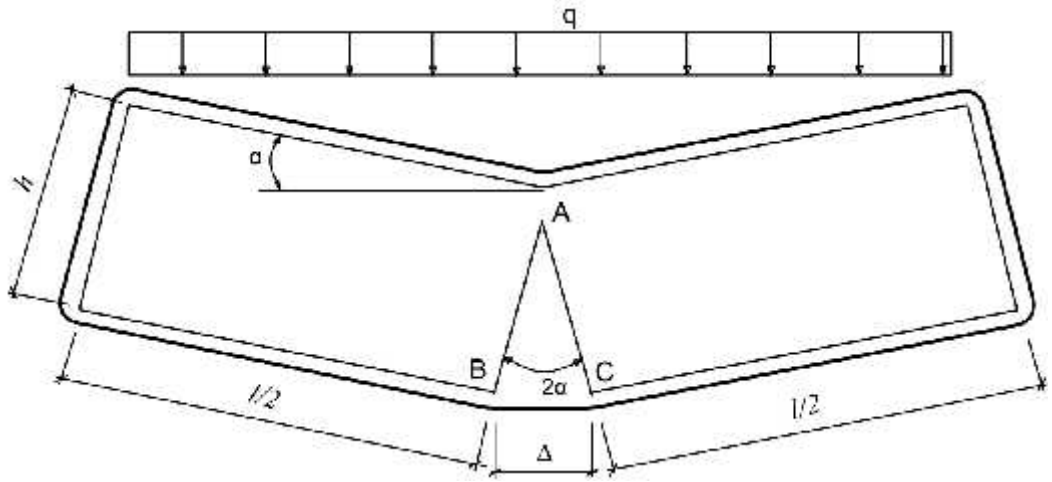
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. 1.22.

[20,25,33,55,62,66,82,112,126].

[24, 26,44, 48, 60, 72, 73, 96, 109, 118, 151, 152, 155]

[1].

[84, 85]

Eurocod-2 [15, 168, 169]

[111,160,165,167,169, 171,176, 183,189]

[87-98]

[91].

(1.123):

$$f_y A_s - f_c b = 0 \tag{1.11}$$

$$f_y A_s(d - x) + f_c \frac{bx^2}{2} = M_e \tag{1.12}$$

(1.12)

(1.12) 6:

$$6D_1 = \frac{\epsilon M_e}{bd^2} \quad 6D_1 = \frac{M_e}{W_c} \tag{1.13}$$

W_c -

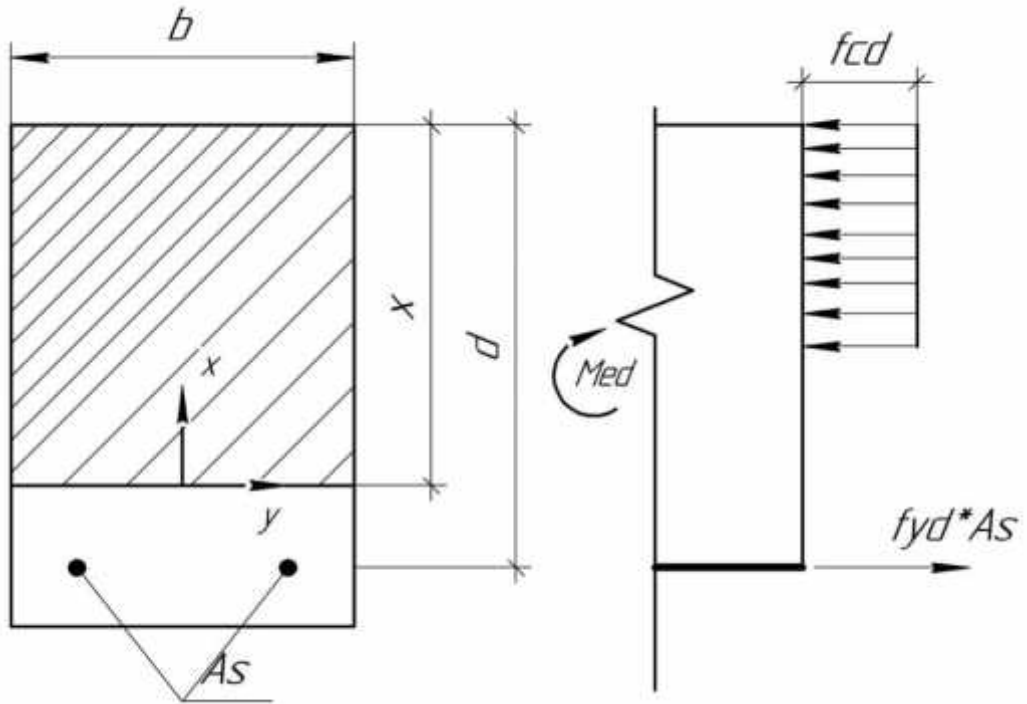
; $6D_1$ -

.1.23

[33,55,62,82,112,126],

A

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. 1.23.

[28,32,41,42,45,46,47,50,58,61,65,67,75,80,81,102,105,110,113,114,131,135,140,141,144,147,148,153,158,159,164,193,194,199].

1.4.

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[36, 53, 69, 71, 103]

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. 2.1.

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[128].

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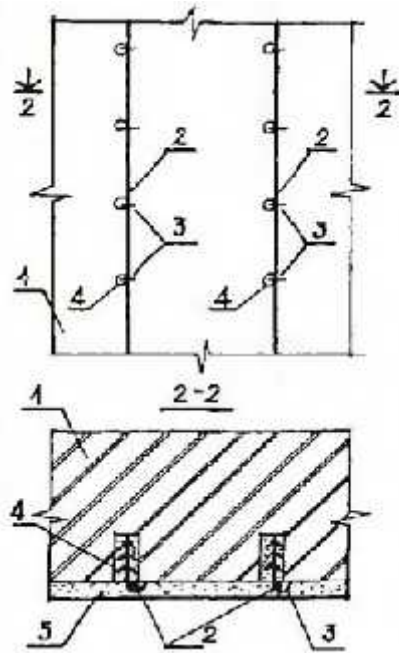
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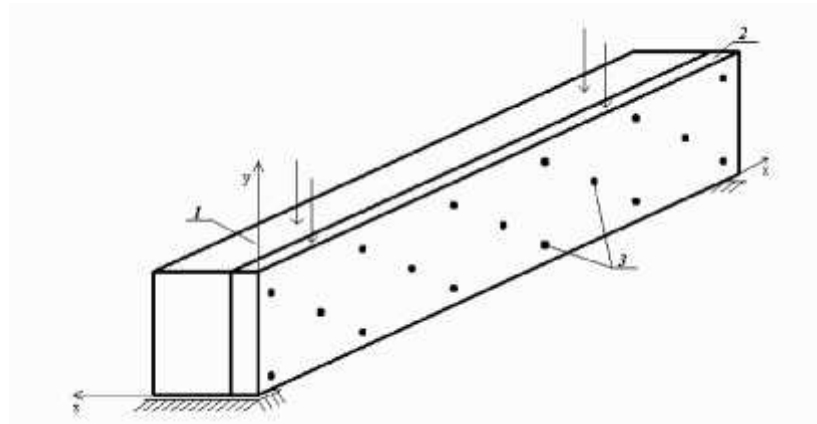
. 2.1.

[103]

1 – , ; 2 - ; 3 -
; 4 - ; 5 -

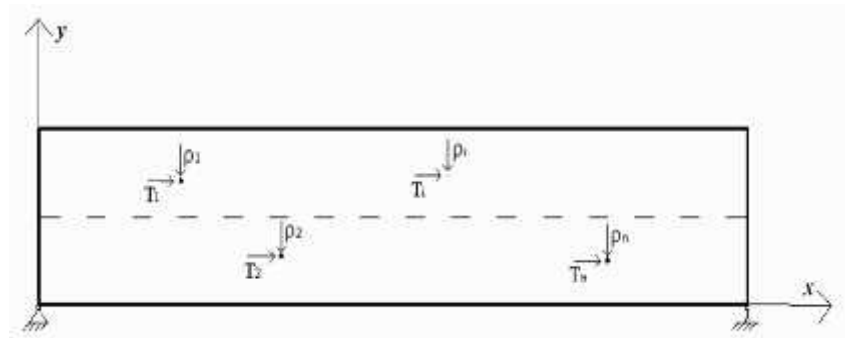
2.2).

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() S_i
 T_i , i - (. 2.3).



. 2.2.

1 - ; 2 - ; 3 -



. 2.3.

i-

1. ;
2. S_i (. 2.3);
3. , T_i .
4. , S_i (1, 2);
5. S_i (,).

i-

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- 6. ;
- 7. S_i ;
- 8. , T_i
XOY (. . 2.3);
- 9. , T_i
YOZ (. . 2.2);
- 10. () T_i ;
- 11. T_i

i- ' :

$$v_i = T_1 a_{i,1}^t + T_2 a_{i,2}^t + \dots + T_n a_{i,n}^t + S_1 a_{i,1}^s + S_2 a_{i,2}^s + \dots + S_n a_{i,n}^s + q a_i^q \quad (2.1)$$

$$a_{i,j}^t - T_k,$$

6-11

$$a_{i,j}^s - S_k;$$

$$a_i^q -$$

i-

, :

$$y_i = T_1 c_{i,1}^t + T_2 c_{i,2}^t + \dots + T_n c_{i,n}^t + S_1 c_{i,1}^s + S_2 c_{i,2}^s + \dots + S_n c_{i,n}^s + q c_i^q \quad (2.2)$$

$$\frac{t}{i,j} \frac{s}{i,j} - , \quad (\quad 1-5$$

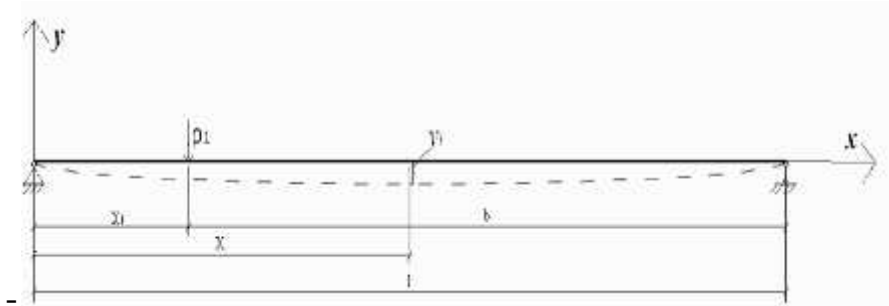
$$).$$

$$, , c_{i,1}^s S_1 (. . 2.2)$$

$$S_1 \quad (2.3)$$

1 X₁ (. 2.4) [124]:

$$y = S_1 * \frac{x_1^2 b^2}{6E} \left[2 \frac{l-x_1}{b} + \frac{l-x_1}{x_1} - \frac{(l-x_1)^3}{x_1 b^2} \right] \quad (2.3)$$



. 2.4.

() (2.2) (2.3).

X_i Y_i

i-

2 * n

c 2 * n

n

T₁ ... T_n, S₁ ... S_n.

T₁ ... T_n, S₁ ... S_n.

(. 5 11

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2.2.

- 1. ;
 - 2. S_i (. 2.3);
 - 3. , T_i .
- (. 2.3);

4. (, ') .

i- (, ') :

5. ;

6. S_i;

7. , T_i

XOY (. . 2.3);

8. () T_i;

9. T_i

i- ' (. . 2.1) 2.1 2.2.

() (2.2) (2.3).

x_i y_i

, i- , n , 2 * n c 2 * n T₁ ... T_n, S₁ ... S_n. (.)

1.

q₁ - (')

q₂ - ()

b₁, b₂, h₁, h₂ -

l - ;

n - ' ;

x (i) - ' (. 2.4)

h (i) - i- ' (. 2.3) (

) , h (i)

- , - .

2.

A1, A2, J1, J2 -

EJ1, EJ2, EA1, EA2 -

3.

anker1

anker2

[7]:

$$a_1 = \frac{1}{a_s^3 E_1^2} + \frac{1}{a_s E_1}; \quad a_2 = \frac{1}{a_s^3 E_2^2} + \frac{1}{a_s E_2}$$

4. (for i = 1 to n) (for j = 1 to n).

i - , ; j - ,

M

T(j) = 1,

h (j), M = h (j); a = x (j); x = x (i); EJ = EJ1; EA = EA1.

4.1.

$$\theta_0 = -\frac{M}{6E} \left(2 - \frac{6a}{l} + \frac{3a^2}{l^2} \right)$$

4.2.

$$4.2.1. \quad x > a, \quad \varphi(x) = \theta_0 + \frac{\frac{M}{2l} * x^2 + M(x-a)}{E}$$

$$w(x) = \theta_0 x - \frac{Mx^3}{6E} + \frac{M(x-a)^2}{2E}$$

$$4.2.1. \quad x < a, \quad \varphi(x) = \theta_0 + \frac{\frac{M}{2l} * x^2}{E}$$

$$w(x) = \theta_0 x - \frac{Mx^3}{6E}$$

4.3.

$$a_1(i, j) = -\varphi(x) * h(i) + x(i)/E$$

$$c_1(i, j) = w(x)$$

5.

. 4

. 4.1-4.3

$$a_2(i, j) \quad c_2(i, j)$$

6. (for $i = 1$ to n) (for $j = 1$ to n).
 i - , ; j - ,

$$P = 1; a = x(j); b = lx(j); x = x(i); EJ = EJ1; EA = EA1.$$

6.1.

$$\theta_0 = -\frac{Pl^2}{6E} \left(-\frac{b^3}{l^3} + \frac{b}{l} \right)$$

6.2.

$$6.2.1. \quad x > a, \quad \varphi(x) = \theta_0 + \frac{\frac{P}{l} \cdot \frac{x^2}{2} - \frac{P(x-a)^2}{2}}{E}$$

$$w(x) = \theta_0 x + \frac{P * b * \frac{x^3}{6l} - \frac{P(x-a)^3}{6}}{E}$$

$$6.2.2. \quad x < a, \quad \varphi(x) = \theta_0 + \frac{\frac{P}{l} \cdot \frac{x^2}{2}}{E}$$

$$w(x) = \theta_0 x + \frac{P * b * \frac{x^3}{6l}}{E}$$

6.3.

$$a_1(i, j) = -\varphi(x) * h(i)$$

$$c_1(i, j) = w(x)$$

7. . 6

$$6.1-6.3 \quad a_2(i, j) \quad c_2(i, j)$$

8. (for $i = 1$ to n). x
 $= x(i); EJ = EJ1; q = ql.$

:

8.1.

$$\theta_0 = -\frac{ql^3}{24E}$$

$$\varphi(x) = \theta_0 + \frac{\frac{qx^2}{4} - \frac{qx^3}{6}}{E}$$

$$w(x) = \theta_0 x + \frac{-\frac{qx^4}{2} + \frac{qx^3}{1}}{E}$$

8.2. $b_1(i) = w(x)$

9. $b_2(i) = w(x)$

10. $b_2(i) = w(x)$

10.1. (for $i = 1$ to n) (for $j = 1$ to n) :

$$i = j, \quad a(i, j) = a_1(i, j) - a_2(i, j) + a_1 + a_2$$

$$i \neq j, \quad a(i, j) = a_1(i, j) - a_2(i, j)$$

10.2. (for $i = 1$ to n) (for $j = n + 1$ to $n * 2$)

$$a(i, j) = a_1(i, j - n) - a_2(i, j - n)$$

10.3. (for $i = n + 1$ to $n * 2$) (for $j = 1$ to n)

$$a(i, j) = c_1(i - n, j) - c_2(i - n, j)$$

10.4. (for $i = n + 1$ to $n * 2$) (for $j = n + 1$ to $n * 2$)

$$i = j,$$

$$a(i, j) = c_1(i - n, j - n) - c_2(i - n, j - n) - a_1 - a_2$$

$$i \neq j, \quad a(i, j) = c_1(i - n, j - n) - c_2(i - n, j - n)$$

11.

11.1. (for $i = 1$ to n)

$$b(i) = -b_1(i) + b_2(i)$$

11.2. (for $i = n + 1$ to $n * 2$)

$$b(i) = -b_1(i - n) + b_2(i - n)$$

12.

:

$$T(i); \quad \begin{matrix} i-1 & n \\ i & n+1 & 2n \end{matrix} \quad x(i) \quad x(i) \\ S(i-n).$$

$$T_1 \dots T_n, S_1 \dots S_n.$$

2.1

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 200 300 ,
 b2 () n ().

2.1

	b2	n	k ds				kmax / k
			3	6.5	10	14	
1	10	2	1,5	1,61	1,64	1,65	1,1
2	10	3	1,8	1,93	1,96	1,97	1,09
3	10	5	1,79	1,87	1,88	1,88	1,05
4	20	2	1,75	2,04	2,11	2,15	1,23
5	20	3	2,4	2,9	3,01	3,06	1,27
6	20	5	2,44	2,73	2,78	2,8	1,15
7	40	2	2,0	2,59	2,79	2,89	1,44
8	40	3	3,24	4,93	5,47	5,74	1,77
9	40	5	3,45	4,45	4,68	4,77	1,38

ds (),

h = 50 .

q = 10 / .

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[103].

2.1,

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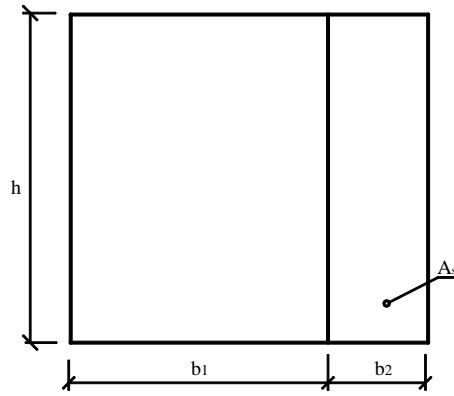
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b₂

E₂.

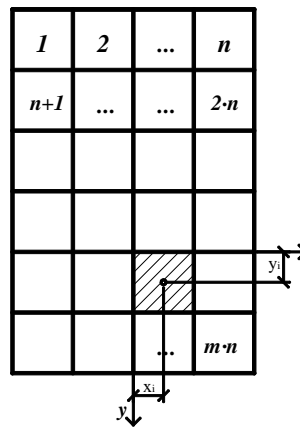
[55, 62]



. 2.5.

[154],

(. 2.6).



. 2.6.

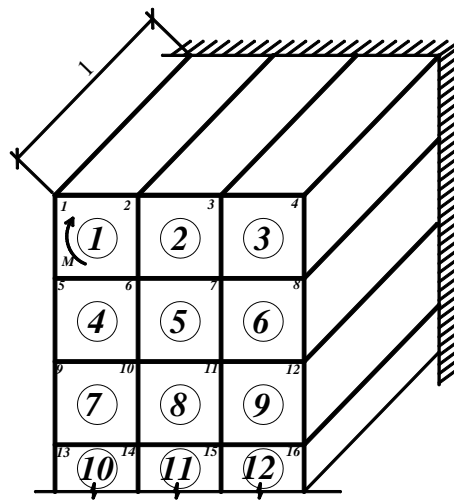
, X n , Y - m .
 $m \cdot n$ (. 2.6).

i- $x_i y_i$.

[154]

[154]

Mi (. 2.7).



. 2.7.

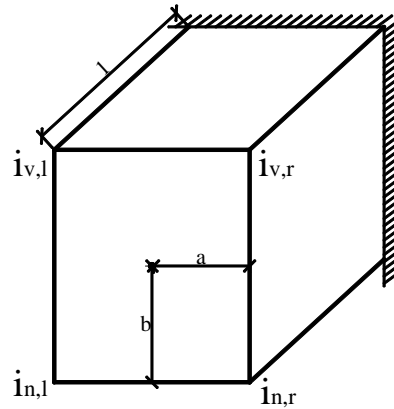
() i-

5

1, 2, 3, 4, 6, 7, 8 9.

i- (. 2.8).

(. . 2.8)



. 2.8. i-

M_i (. 2.9). , ,

$$\Delta_x \quad \Delta_y$$

. 2.9

(

. 2.9):

$$\Delta_x = [M_i + a(s_i^{u,l} - s_i^{v,l} + s_i^{u,r} - s_i^{v,r}) + b(H_i^{u,l} - H_i^{u,r} + H_i^{v,l} - H_i^{v,r})] \frac{a}{G_i} \quad (2.4)$$

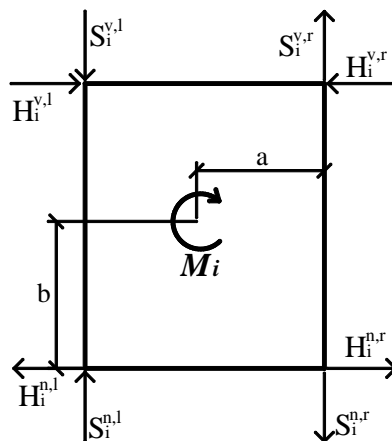
$$\Delta_y = [M_i + a(s_i^{u,l} - s_i^{v,l} + s_i^{u,r} - s_i^{v,r}) - b(H_i^{u,l} - H_i^{u,r} + H_i^{v,l} - H_i^{v,r})] \frac{b}{G_i} \quad (2.5)$$

GJi -

i-

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. 2.9.

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. 2.10

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b h .

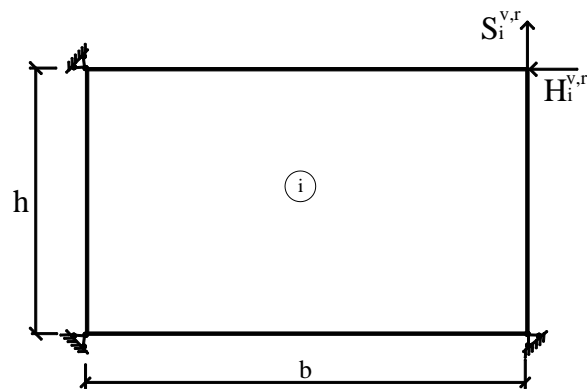
(, Mathcad)

$$\delta_x = f_1(b, h); \quad \delta_y = f_2(b, h) \quad ; \quad (2.6)$$

x, y

x, y

i-



. 2.10.

k k , $k = 2 \cdot n \cdot m$ -

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X, Y,

H S (. . 2.9).

$a_{i,j}$,

.2.8),

i (. . 2.7 2.8),

Mathcad:

1.

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$$i = a_c n + k \tag{2.7}$$

$a_c -$

; $n -$

(. . 2.7); $k -$

2.

$$i_{v,l} = a_c(n + 1) + k; i_{v,r} = a_c(n + 1) + k + 1;$$

$$i_{vl} = (a_c + 1)(n + 1) + k; i_{vr} = (a_c + 1)(n + 1) + k + 1 \tag{2.8}$$

[55, 62].

[119]

[154],

[203]

[154].

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[142],

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. 2.11

O₅.

dxh (XOY)
 axb , , O₁ ...
 1 ... 4,

(. 2.11),
axb 1 ...

5.

(. 2.11)

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(XOY . 2.11).

M_t,

cx d.

c < h, h -

. 2.11

cx d,

[1].

cx d,

$$y_z=f_1(c,d); \quad x_z=f_2(c,d)$$

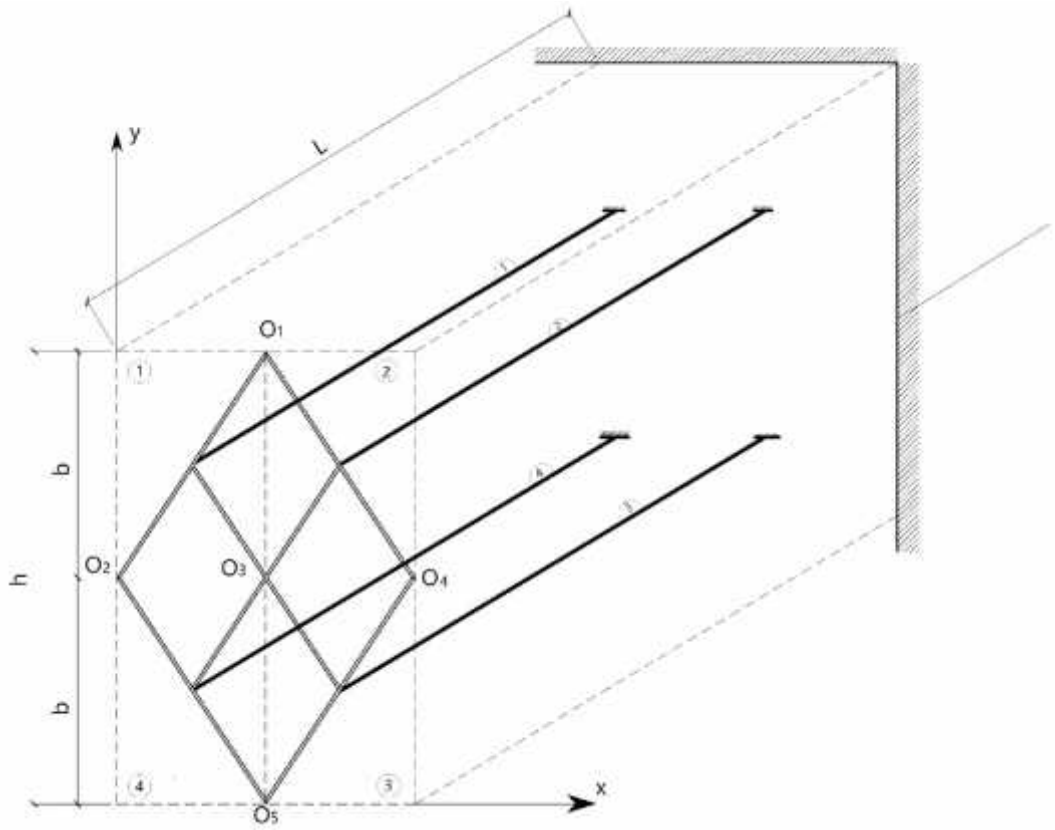
(2.9)

2ax2b

nxm

cx2a (. 2.12),

1, 2, ..., 3n.



. 2.11.

$$cx2a$$

$$T_x \quad T_y$$

$$(2.9)$$

$$T_y$$

$$i$$

$$. 2.12,$$

$$T_y = \int_0^s \int_{2t}^{3t} \tau_y \, d \quad ,$$

$$(2.10)$$

yz

$$(2.9).$$

$$T_x:$$

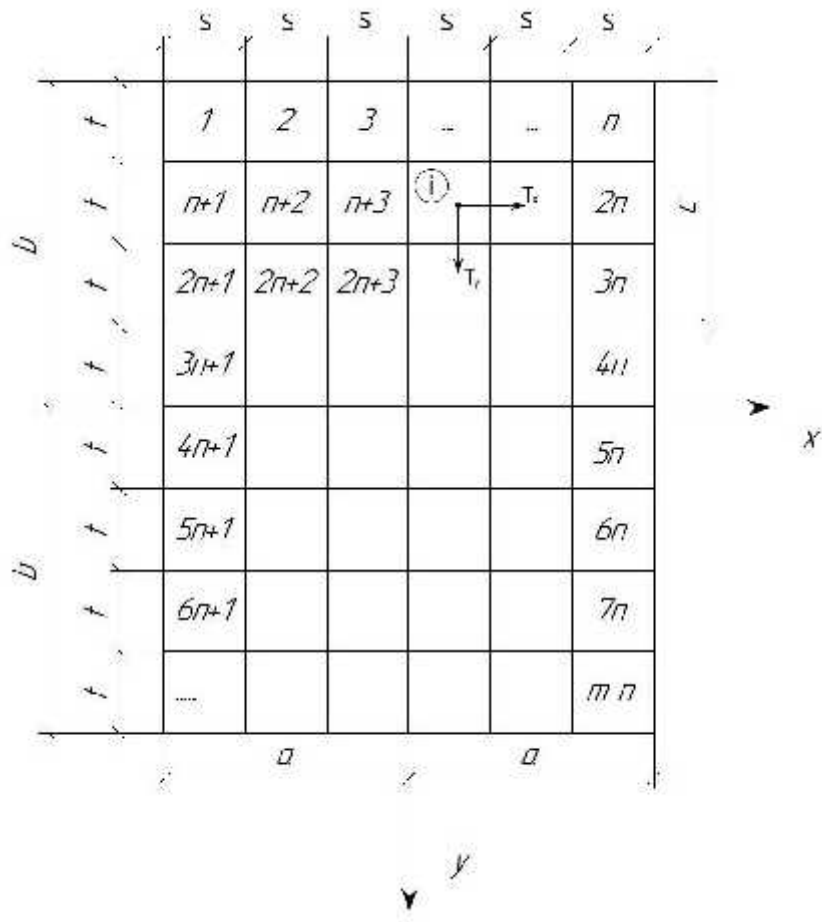
$$T_x = \int_0^s \int_{2t}^{3t} \tau_x \, d \quad ,$$

$$(2.11)$$

$$(2.10) \quad (2.11)$$

$$(2.9),$$

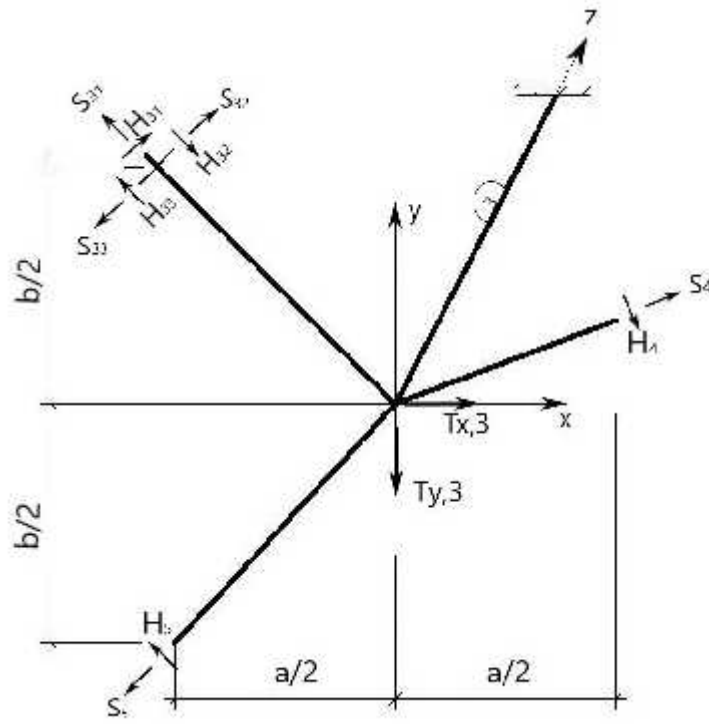
$$T_x \quad T_y$$



.2.12.

3 .2.11.

3 .2.13.



. 2.13.

3 (. 2.11)

3 ()

(. . 2.13) $S_{31}, H_{31}, S_{32}, H_{32}, S_{33}, H_{33}, S_4, H_4, S_5,$

$H_5, T_{x3}, T_{y3}.$ ()

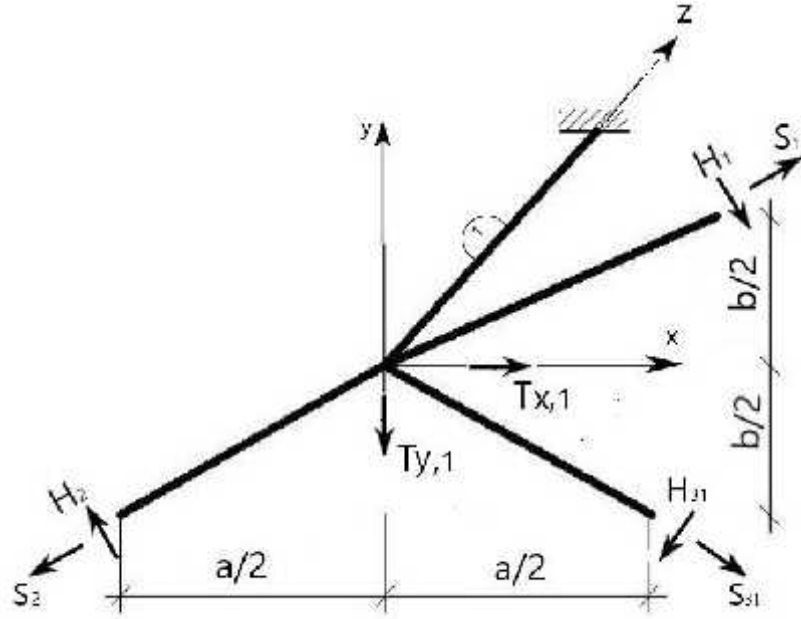
3 $H_1, S_1, H_2, S_2, H_{31}, S_{31},$

$T_{x1}, T_{y1}(\ . 2.14).$

$i- T_{x,i} T_{y,i}$ (2.10).

()

$T_{x,i} T_{y,i}$



. 2.14.

3 (. 2.11)

$a, b,$

$T_x, T_y.$

a, b
(2.9)

(1 ... 4 . 2.11).

2.15,

. 2.15,

T_x

xz

e
 $M_{t,i} =$
 T_x, T_y

$T_x \cdot e.$

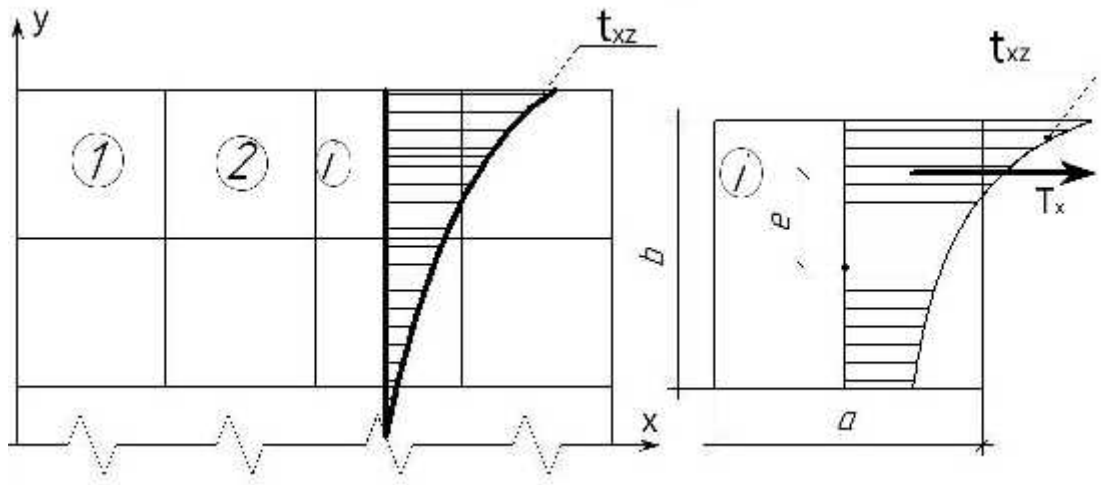
$M_{t,i}$

(. 2.13, 2.14).

(Z)

$axb,$

$kg_i,$



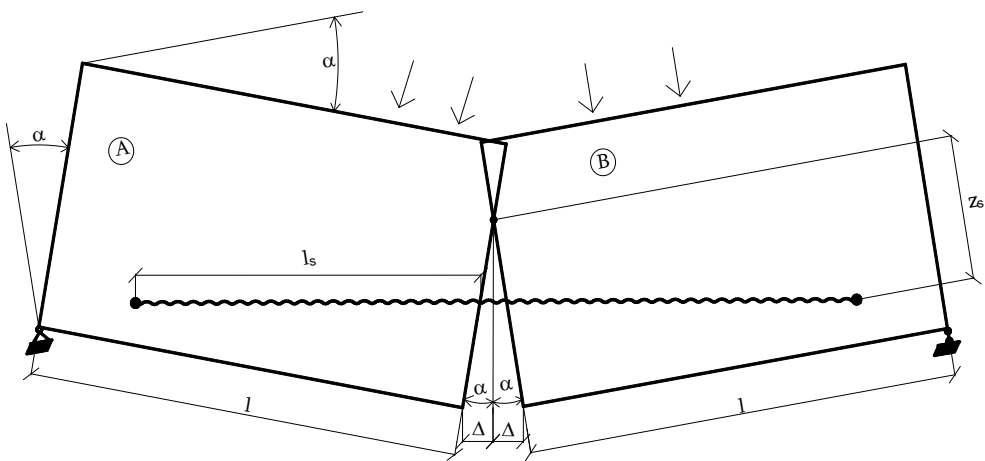
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(. 2.16).

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$$N = M_{ext} / Z_s, \tag{2.12}$$

M_{ext} -

, Z_s -

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$$\Delta = \frac{N \cdot l_s}{E \cdot A_s} \tag{2.13}$$

$l_s, E \cdot A_s$ -

(. 2.16).

(

Z_s):

$$\Delta \approx 2Z_s \sin \frac{r}{2} \tag{2.14}$$

(2.14) :

$$r = 2 \arcsin \left(\frac{\Delta}{2Z_s} \right) \tag{2.15}$$

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(. 2.16):

$$f = l \cdot \sin r \tag{2.16}$$

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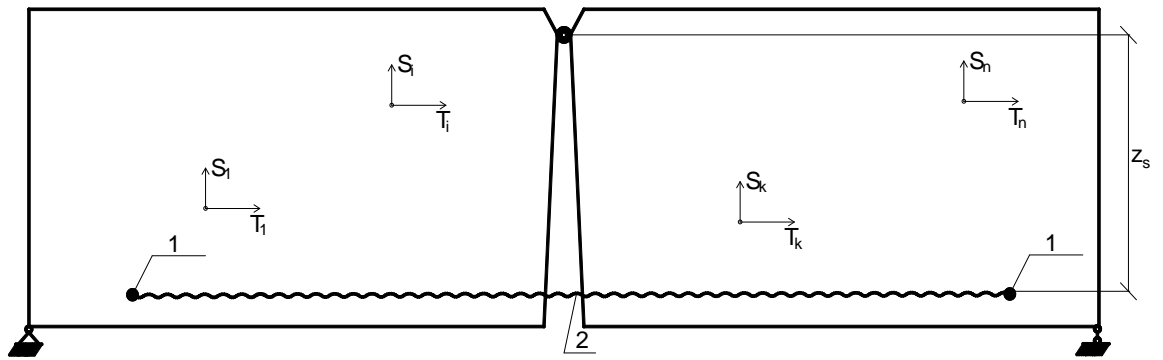
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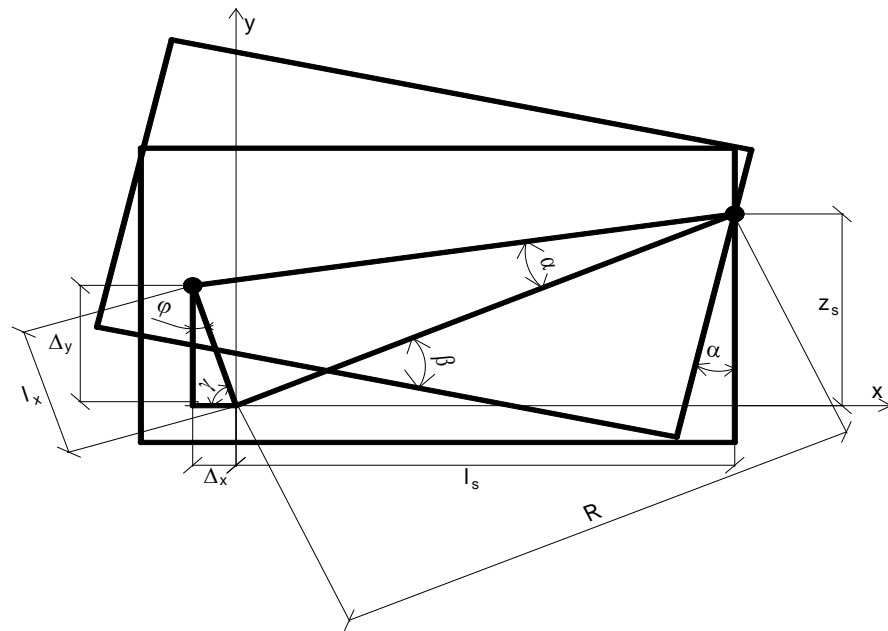
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. 2.18 (

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. 2.17.



. 2.18.

и O R (. . 2.18). l_x

:

$$l_x = 2 \cdot R \cdot \sin \frac{\gamma}{2} \quad (2.17)$$

R - i- O (. . 2.18).
R :

$$R = \sqrt{l_s^2 + z_s^2} \quad (2.18)$$

R :

$$s = \text{Arctg} \left(\frac{z_s}{l_s} \right) \quad (2.19)$$

. 2.18 :

$$\chi = 180^\circ - s - \frac{180^\circ - \gamma}{2} = 90^\circ - s + \frac{\gamma}{2} \quad (2.20)$$

$$\{ = 180^\circ - 90^\circ - \chi = 90^\circ - \chi \quad (2.21)$$

i Δ_x Δ_y :

$$\Delta_x = l_x \cdot \sin \{ ; \Delta_y = l_x \cdot \cos \{ . \quad (2.22)$$

Δ_x (), Δ_y -
(). Δ_x - , Δ_y - .

(2.12) - (2.22)

S_i T_i .

(. 2.18).

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T_i S_i.

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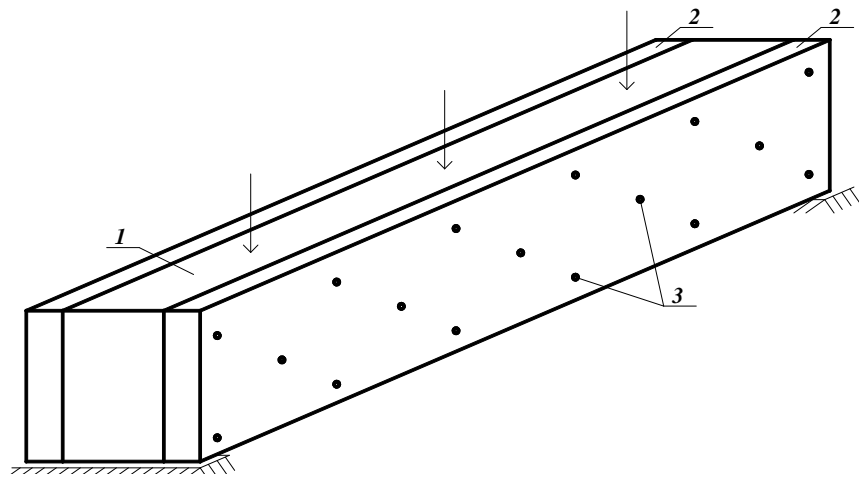
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(. 2.19).



. 2.19.

1 - ; 2 - ; 3 -

2.2-2.3

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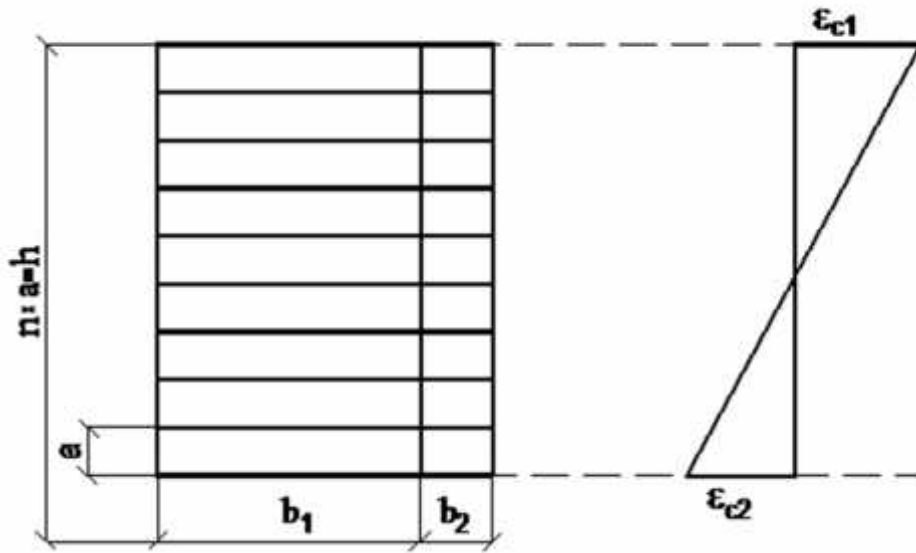
[24, 84, 85],

(2.20)

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2.20.

$$\dagger = f_{ck} \frac{ky - y^2}{1 + (k-2)y}, \tag{2.23}$$

f_{ck} (,); k - [69]; $y = v_c / v_{cl}$ ((, , , k

(2.23)

[69],

[129].

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[138]:

$$E = E_0 \left(1 - \frac{\dagger}{1.1R_u} \right), \tag{2.24}$$

\dagger - ; R_u - () [71].

[85]

2 .

() V_n V_1 .
:
 $\frac{1}{...} = \frac{V_1 - V_n}{h}$, e_{xc} , Z_s [85] ().

$$\tag{2.25}$$

i- :

$$Z_i = X_1 - (i-1) \cdot a + a/2 \tag{2.26}$$

i-

$$v_i = Z_i \cdot \frac{1}{\dots} \tag{2.27}$$

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(2.24):

$$E_i = \frac{E_0}{1 + \frac{E_0}{1.1 \cdot R_{U}} \cdot \dots} \tag{2.28}$$

i-

$$\dagger_i = E_i \dagger_i \tag{2.29}$$

(2.23)

$$\dagger_i > 1.5R_{bt},$$

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$$M_{sech} = \sum_{i=1}^n \dagger_i Z_i \cdot a \cdot b \tag{2.30}$$

$$N_{sech} = \sum_{i=1}^n \dagger_i \cdot a \cdot b \tag{2.31}$$

$$M_{tot} = M_{sech} + \dagger_s A_s Z_s \tag{2.32}$$

$$N_{tot} = N_{sech} + \dagger_s A_s \tag{2.33}$$

$$M_{tot} - N_{tot} \cdot e_{xc} \geq 0 \tag{2.34}$$

(2.34)

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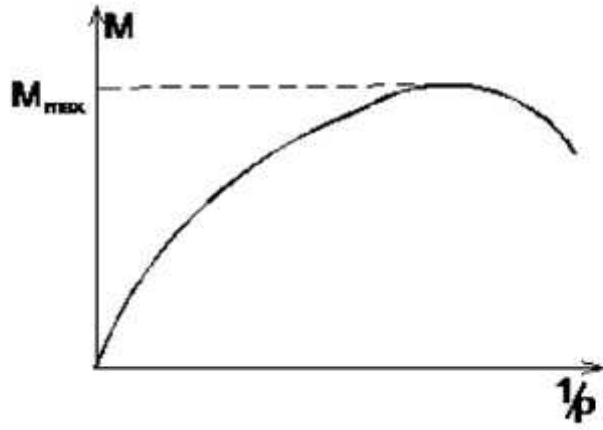
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$$B_{sech} = \frac{M_{tot}}{1 / \dots}, \tag{2.35}$$

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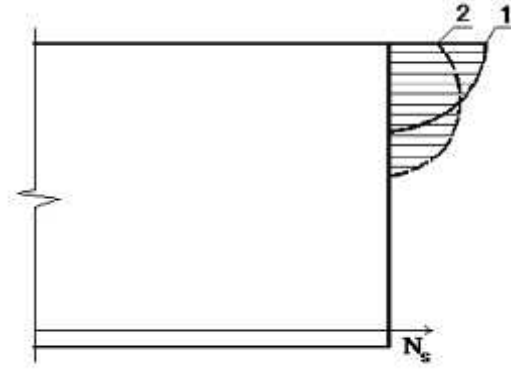
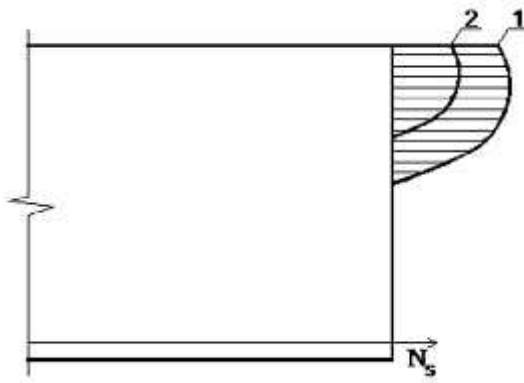
$M-t$ (.2.21).



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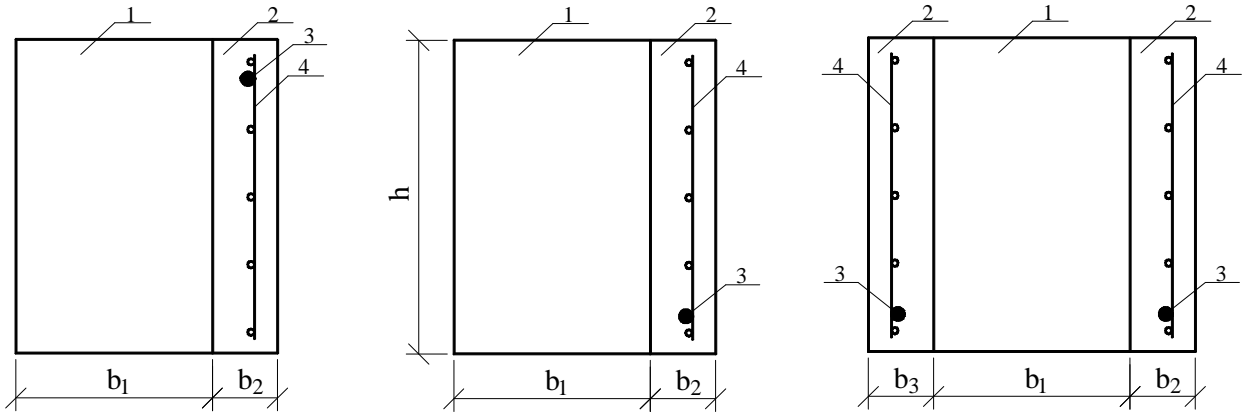
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3	1-3- (1)	300	200	30	-	.3,	10	+
4	1-3- (2)	300	200	30	-	.3,	10	+
5	1-5- (1)	300	200	50	-	.3,	10	+
6	1-5- (2)	300	200	50	-	.3,	10	+
7	2-2 (1)	300	200	20	20	.3,	8	+
8	2-2 (2)	300	200	20	20	.3,	8	+
9	2-3 (1)	300	200	30	30	.3,	8	+
10	2-3 (2)	300	200	30	30	.3,	8	+
11	2-4 (1)	300	200	40	40	.3,	8	+
12	2-4 (2)	300	200	40	40	.3,	8	+
13	-4 (1)	...	2503,	10	+
14	-4 (2)	...	2503,	10	+
15	1-3- (1)	300	200	30	-	.3,	10	
16	1-3- (2)	300	200	30	-	.3,	10	

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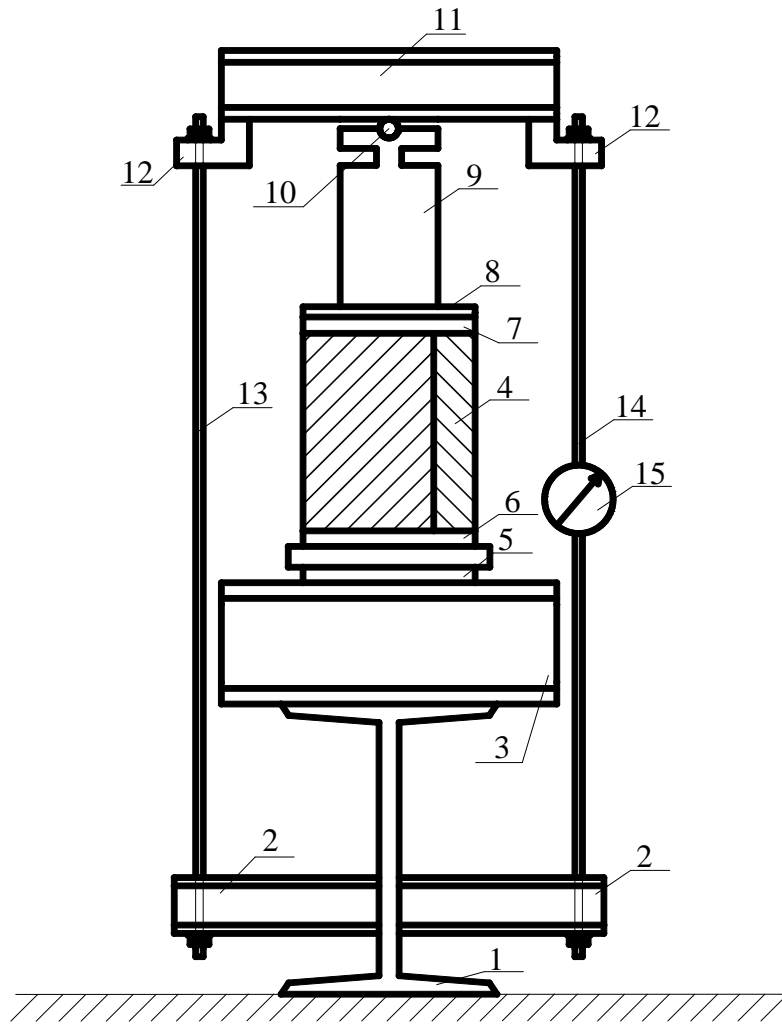
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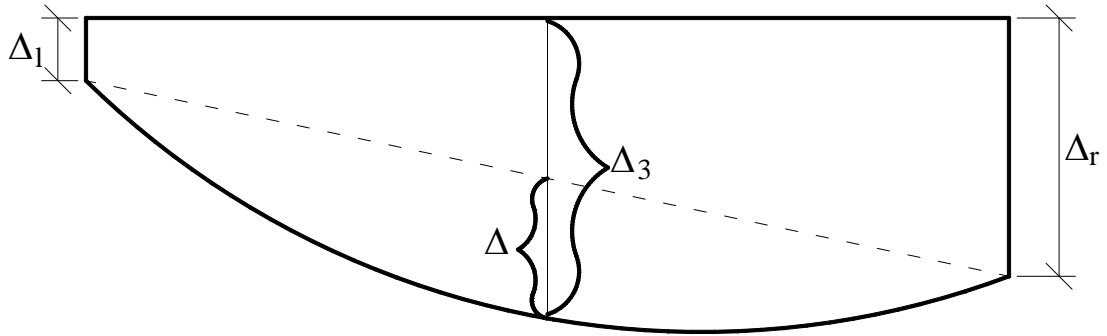
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$$\Delta = \Delta_3 - \frac{\Delta_l + \Delta_r}{2} \tag{3.1}$$



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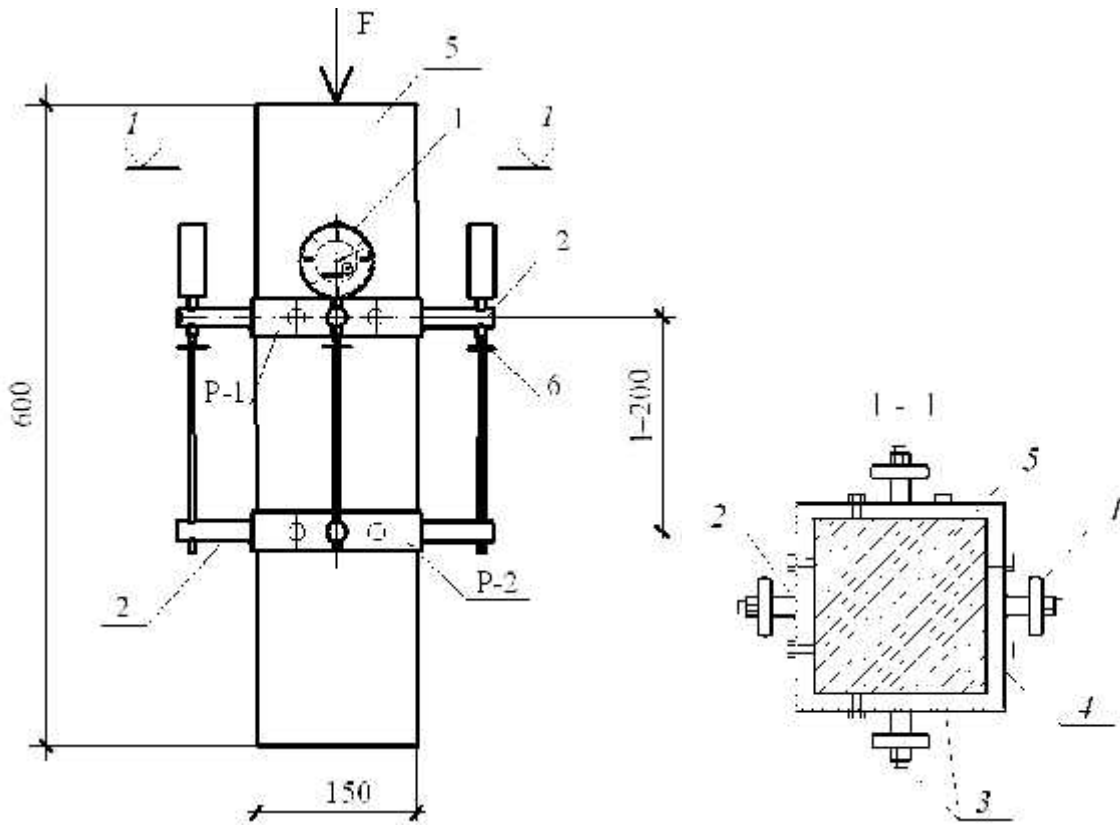
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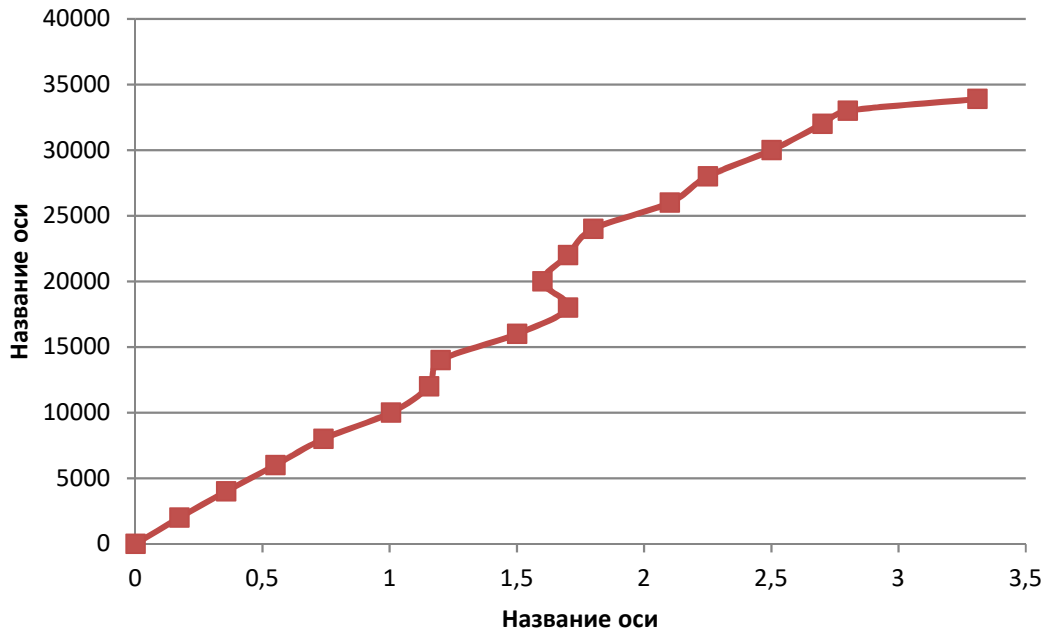
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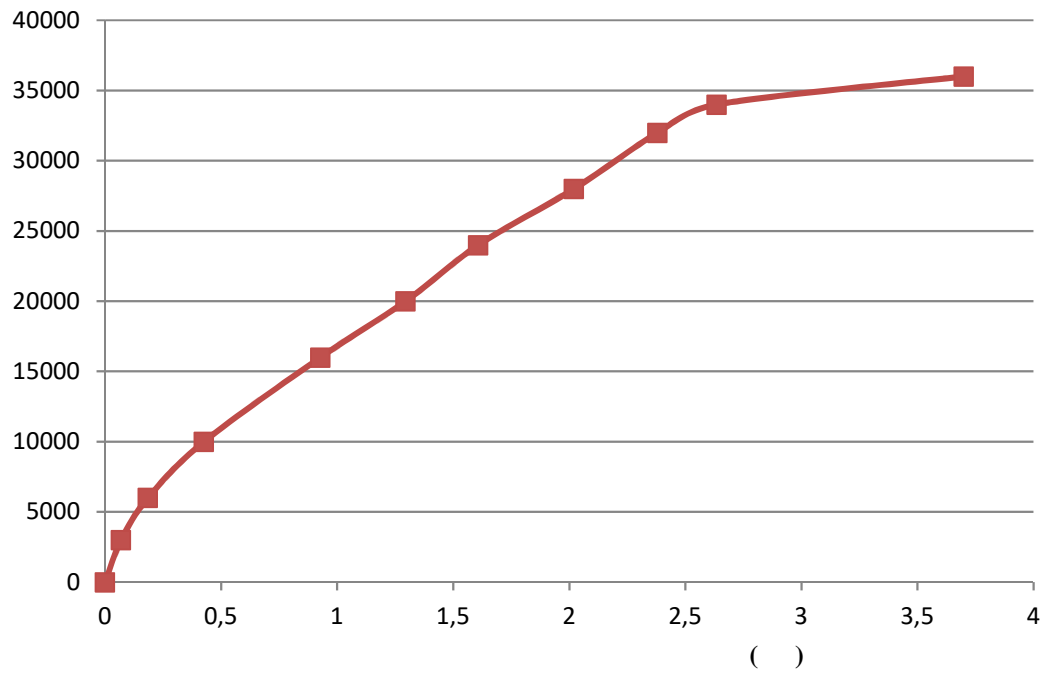
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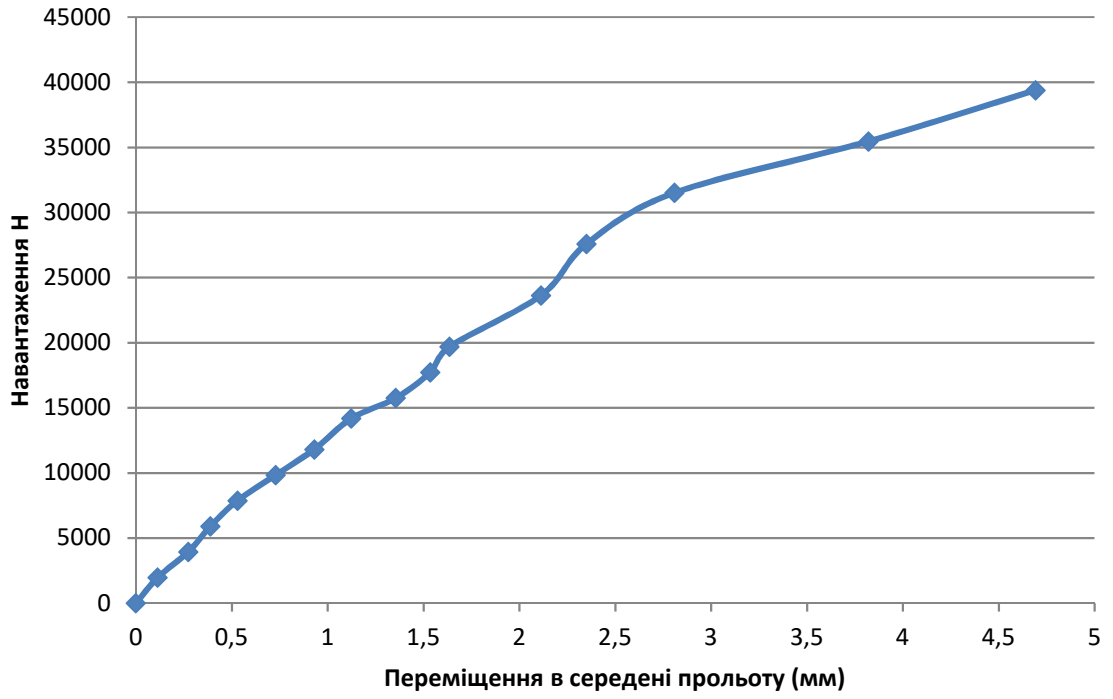
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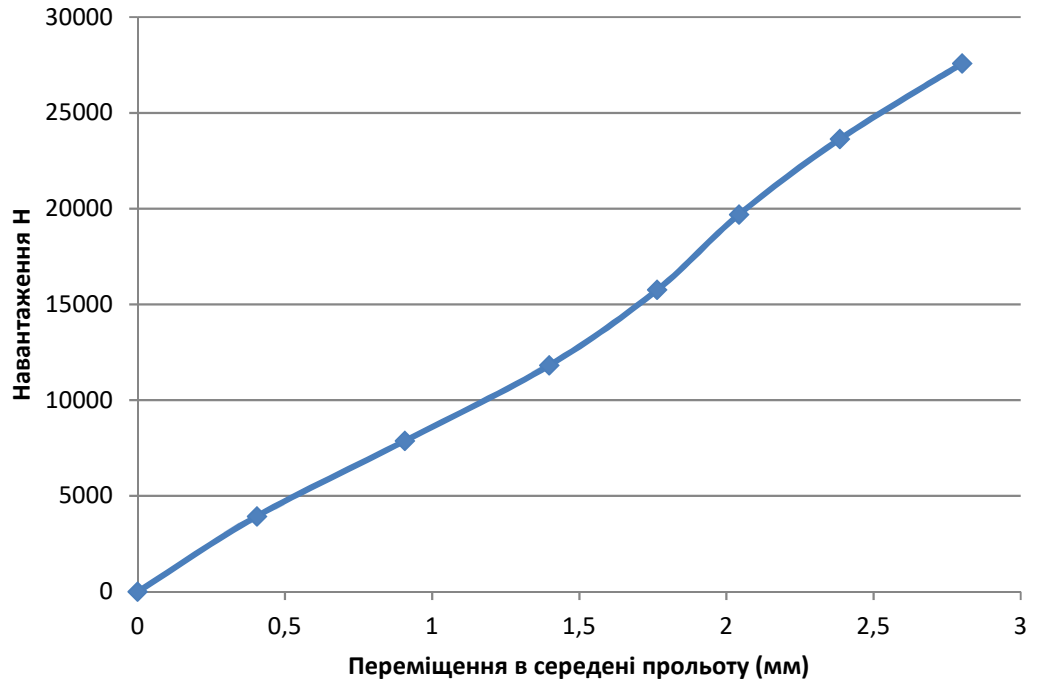
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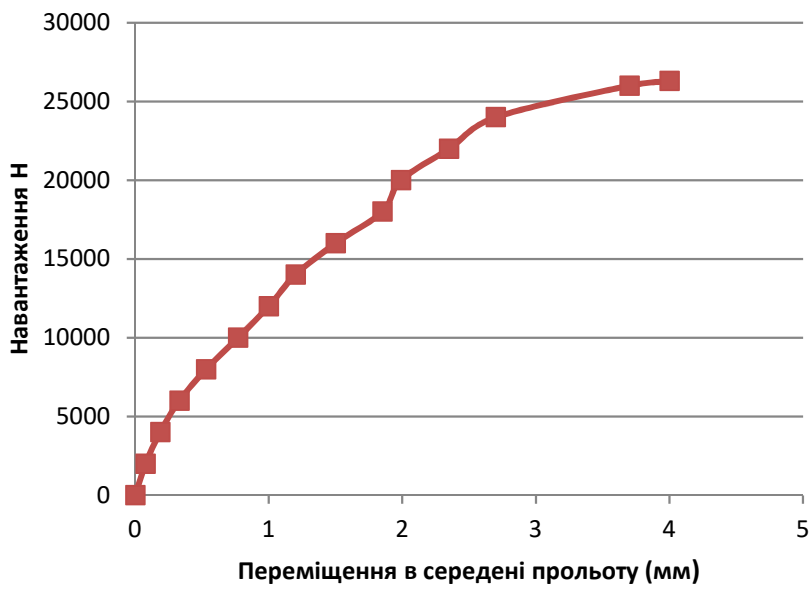
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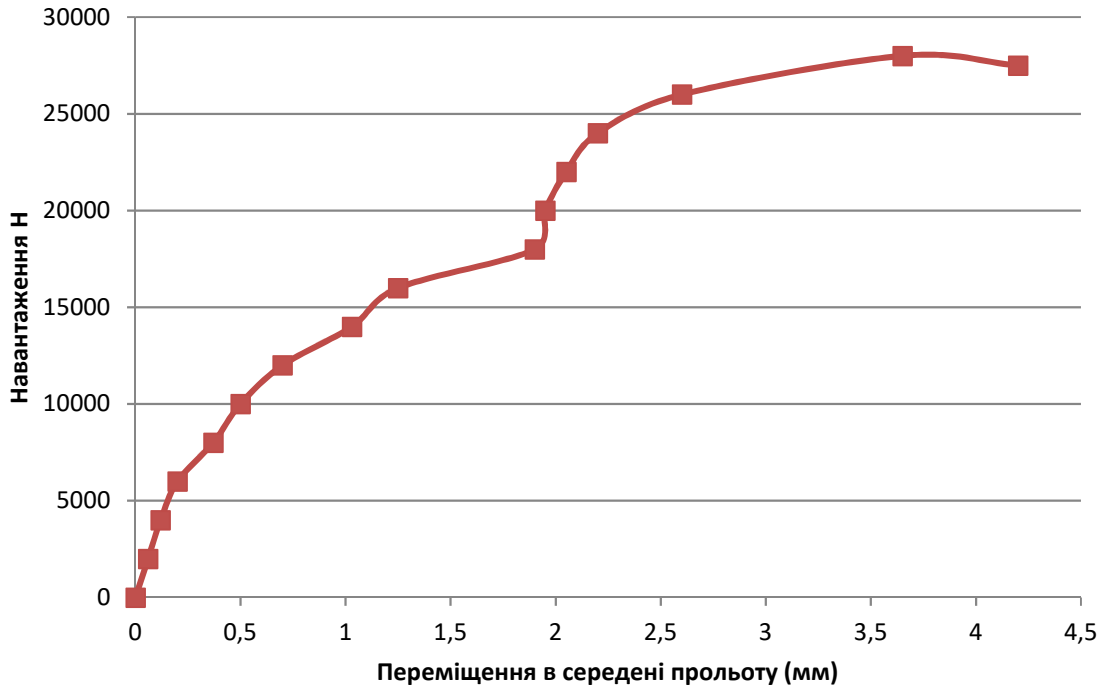
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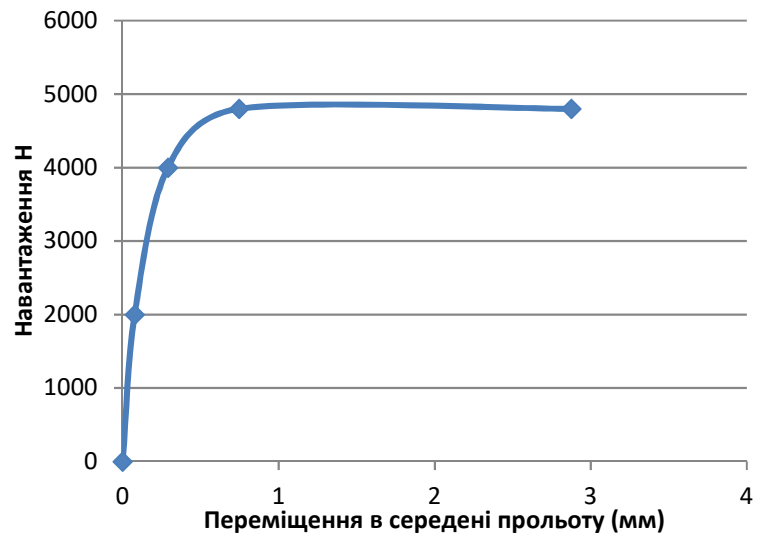
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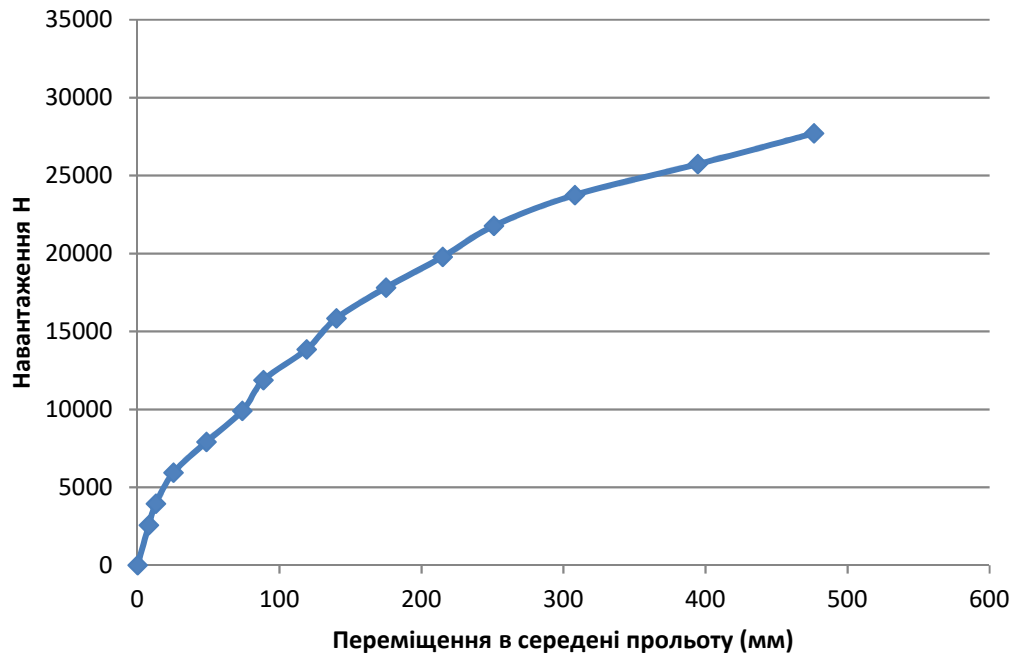
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EJ1 + EJ2.

: EJ2 = (k-1)*EJ1.

k=1.4.

40%.

$$J_e = \frac{(k-1) \cdot E_1}{E_2}, \quad (4.1)$$

EJ1 -

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:

$$b_{el} = 12 * J_e \sqrt[3]{h} \quad (4.2)$$

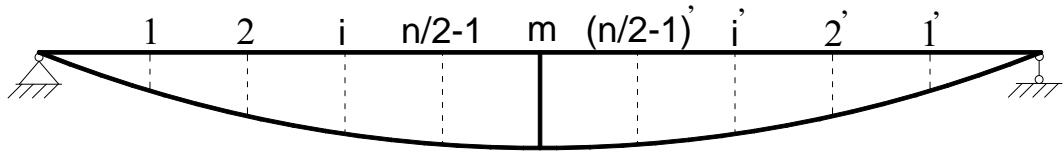
EJ=EJ2+E2*Jekv.

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[114]:

$$f_m = \frac{l^2}{1 n^2} \left\{ 6 \sum_{l=1}^{\frac{n}{2}-1} \left[\left(\frac{1}{\rho} \right)_{l,i} + \left(\frac{1}{\rho} \right)_{r,i} \right] + (3n - 2) \left(\frac{1}{\rho} \right)_m \right\} \quad (4.3)$$

$(1/\rho)_{l,i}, (1/\rho)_{r,i} \quad (1/\rho)_m$ i,

i^l (.4.1).

.2.5.

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[126]:

$$f_q = \int_0^l \overline{Q}_x * \gamma_x * d \quad (4.4)$$

\overline{Q}_x

, , ;

[114] $\chi_x = \dots$;

$$Y_x = \frac{1.5 Q_x \varphi_{D2}}{G_1 b_1 h + G_2 b_2 h} \varphi_c \quad (4.5)$$

$Q_x = \dots$;

$\{b_2 = \dots\}$ [126]; $\{b_2 = 1, 0; G_1, G_2, b_1, b_2 - \dots\}$

;

$\{c_{rc} = \dots\}$;

$\dots - 1, 0.$;

$\{c_{rc} = \dots\}$ [126],

:

$$\varphi_c = \frac{3(E_{D1} J_{r,1} + E_{D2} J_{r,2})}{M_x} \left(\frac{1}{\rho}\right)_x \quad (4.6)$$

$\chi_x \quad (4.4)$

$1.5 \cdot b_2 / (G_1 b_1 h + G_2 b_2 h)$;

;

;

$$\int_0^l \overline{Q_x} * Q_x * dx \quad (4.7)$$

P (

) $P * 1 / 4.$

$$f_q = \beta \cdot P \cdot L / 4 \quad (4.8)$$

(4.5), (4.6) (4.7):

$$\beta = \frac{4.5(E_{D1} J_{r,1} + E_{D2} J_{r,2}) \varphi_{D2}}{M_x (G_1 b_1 h + G_2 b_2 h)} \left(\frac{1}{\rho}\right)_x \quad (4.9)$$

$M_x = \dots$ x.

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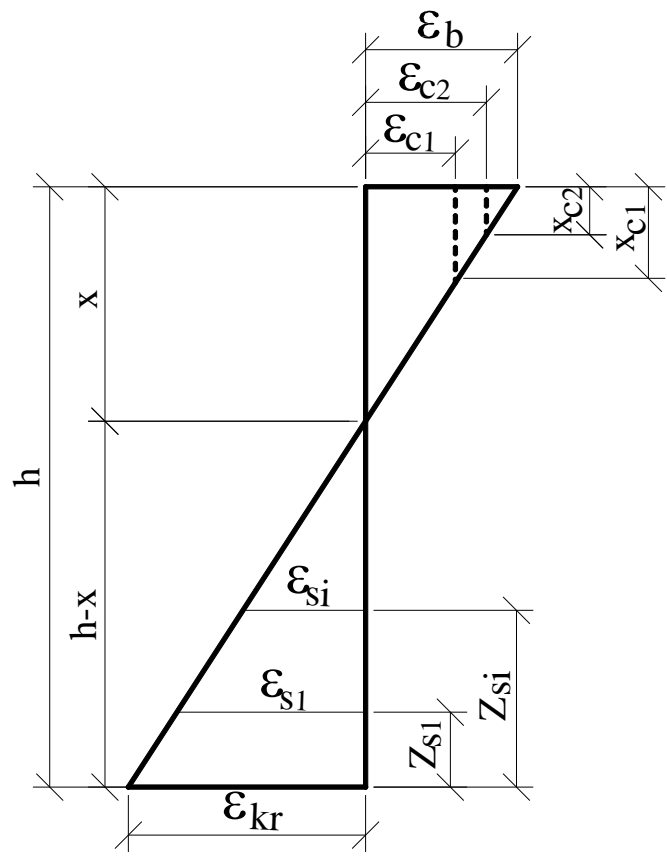
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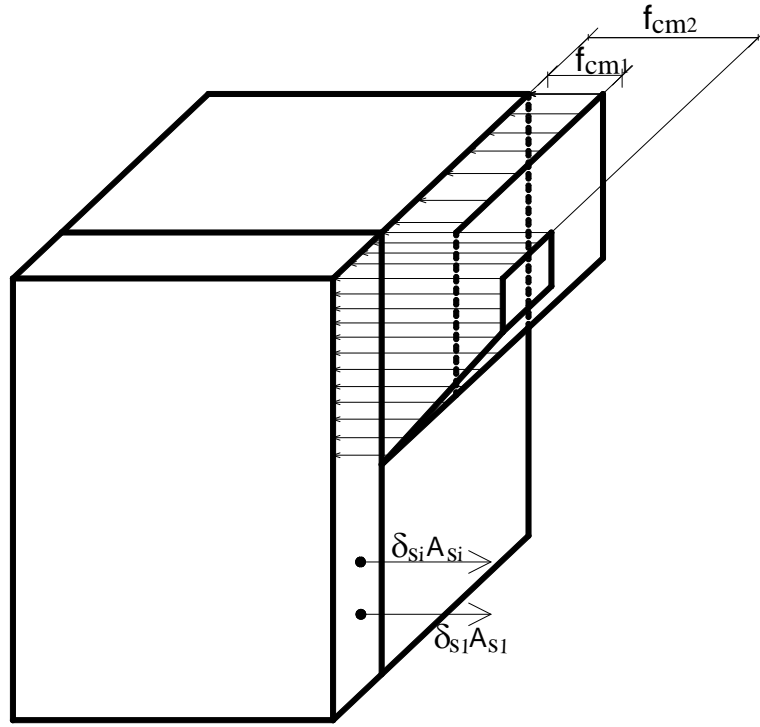
ϵ_{c1} ϵ_{c2}
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 Z_{si} (.4.2).



.4.2.

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.4.3



. 4.3.

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, $b < c_i, i = 1, 2$ -

(. 4.4).

:

$$x = \frac{\epsilon_D (h-x)}{\epsilon_K}; \tag{4.10}$$

$$N_{D,i} = b_i E_{D,i} \epsilon_D x / 2 \tag{4.11}$$

$N_{b,i}$ -

i -

; b_i -

i -

2-

, $b > c_i$,

(. 4.5).

(, ,) :

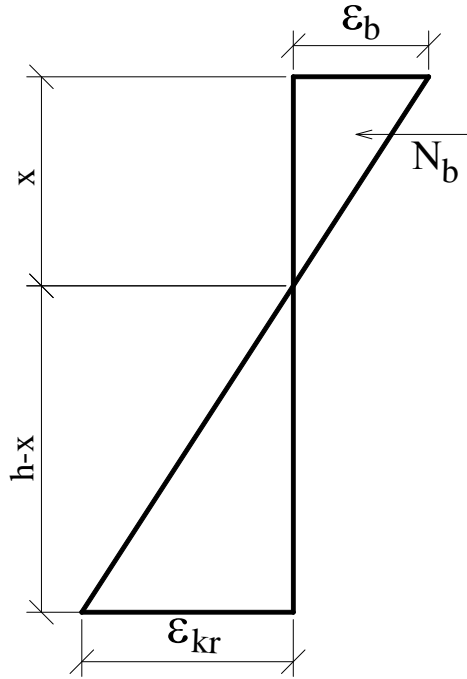
$$x_c = x \frac{\varepsilon_D - \varepsilon_c}{\varepsilon_D} \tag{4.12}$$

:

$$N_D = \frac{E_D D \varepsilon_c}{2} (x_c + x) \tag{4.13}$$

x_c (4.12), :

$$N_D = x \frac{E_D D \varepsilon_c}{2} \left(1 + \frac{\varepsilon_D - \varepsilon_c}{\varepsilon_D} \right) \tag{4.14}$$



. 4.4. , b c,i

N_s :

$$N_s = \sum_{i=1}^n \varepsilon_{s,i} A_{s,i} E_{s,i} \tag{4.15}$$

$A_{s,i}, E_{s,i}$ - i-

. 4.2

:

$$\varepsilon_k = \frac{\varepsilon_D (h-x)}{x} \tag{4.16}$$

4.2 :

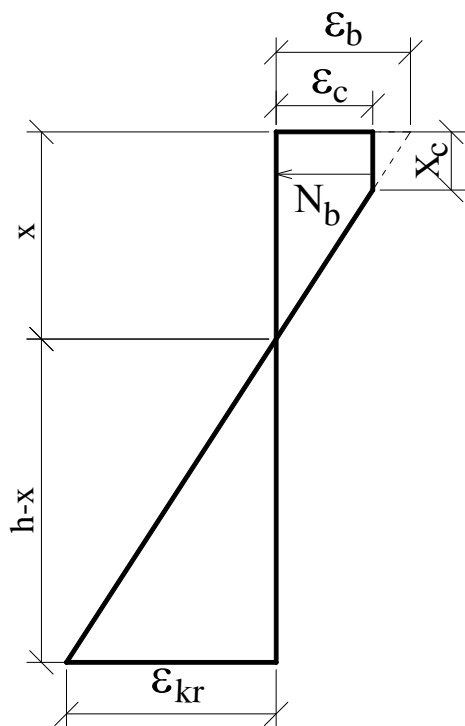
$$\epsilon_{s,i} = \epsilon_k - \epsilon_k \frac{Z_{s,i}}{h-x} \tag{4.17}$$

(4.16), :

$$\epsilon_{s,i} = \frac{1}{x} (\epsilon_D h - \epsilon_D Z_{s,i}) - \epsilon_D \tag{4.18}$$

:

$$N_s = \frac{1}{x} \sum_{i=1}^n E_{s,i} A_{s,i} (\epsilon_D h - \epsilon_D Z_{s,i}) - \sum_{i=1}^n E_{s,i} A_{s,i} \epsilon_D \tag{4.19}$$



4.5. , b > c,i

$$(4.11) \quad (4.14), \quad N_s = \frac{B}{x} - C \tag{4.19}$$

$$N_s = \frac{B}{x} - C$$

:

$$N_s = \frac{B}{x} - C \tag{4.20}$$

(4.19):

$$B = \sum_{i=1}^n E_{s,i} A_{s,i} (\epsilon_D h - \epsilon_D Z_{s,i}) \quad C = \sum_{i=1}^n E_{s,i} A_{s,i} \epsilon_D; \tag{4.21}$$

b

c,1 c,2

1- \cdot b c,1 b c,2 \cdot (4.11) :

$$N_D = \frac{E_{D,1}D_1\varepsilon_D + E_{D,2}D_2\varepsilon_D}{2}x = D_1x \quad (4.22)$$

($N_b = N_s$):

$$D_1x = \frac{B}{x} - C \quad (4.23)$$

(4.23),

2- \cdot b > c,1 b > c,2 \cdot (4.13) :

$$N_D = \left[\frac{E_{D,1}D_1\varepsilon_{c,1}}{2} \left(1 + \frac{\varepsilon_D - \varepsilon_{c,1}}{\varepsilon_D} \right) + \frac{E_{D,2}D_2\varepsilon_{c,2}}{2} \left(1 + \frac{\varepsilon_D - \varepsilon_{c,2}}{\varepsilon_D} \right) \right] x = D_2x \quad (4.24)$$

$$D_2x = \frac{B}{x} - C \quad (4.25)$$

(4.25),

3- \cdot b c,1 , b > c,2 \cdot (4.11), - (4.14):

$$N_D = x * \left[\frac{D_1E_{D,1}\varepsilon_D}{2} + \frac{E_{D,2}D_2\varepsilon_{c,2}}{2} \left(1 + \frac{\varepsilon_D - \varepsilon_{c,2}}{\varepsilon_D} \right) \right] = D_3x \quad (4.26)$$

$$D_3x = \frac{B}{x} - C \quad (4.27)$$

(4.27),

4- \cdot b > c,1 , b c,2 \cdot (4.14), - (4.11):

$$N_D = x * \left[\frac{D_2E_{D,2}\varepsilon_D}{2} + \frac{E_{D,1}D_1\varepsilon_{c,1}}{2} \left(1 + \frac{\varepsilon_D - \varepsilon_{c,1}}{\varepsilon_D} \right) \right] = D_4x \quad (4.28)$$

$$D_4x = \frac{B}{x} - C \quad (4.29)$$

(4.29),

[12],

[85],

4.3.

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.4.6

s,1.

s,i

$$\varepsilon_{s,i} = \varepsilon_{s,1} \frac{n-x-a_i^I}{n-x-a_1^I} \tag{4.30}$$

N_b

$$N_b = (f_{c,prism,1} b_1 + f_{c,prism,2} b_2) \omega \tag{4.31}$$

f_{ck,prism,1}, f_{ck,prism,2}

; b₁, b₂ -

0.8

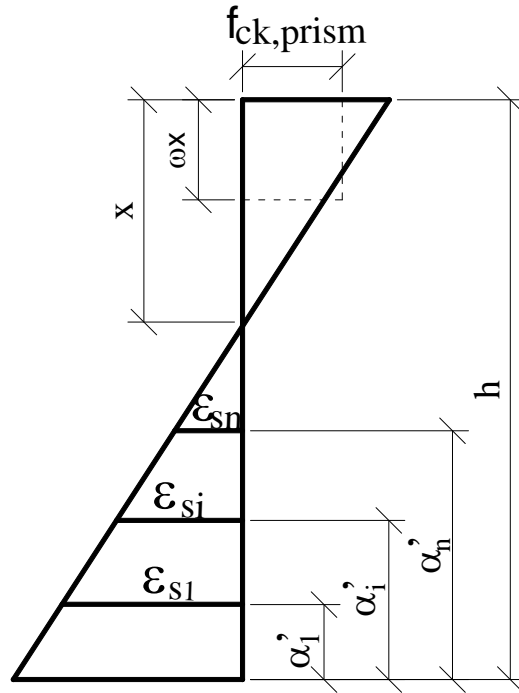
[85].

$$N_s = \sum_{i=1}^n \sigma_{s,i} A_{s,i} \tag{4.32}$$

$\sigma_{s,i} A_{s,i}$ - i- ; $\sigma_{s,i} = \epsilon_{s,i} E_{s,i}$; $E_{s,i}$ -
 i- . $N_b = N_s$

$$x = \frac{N_s}{\omega(f_{c,1} b_1 + f_{c,2} b_2)} \tag{4.33}$$

- $f_{c,1}$, $f_{c,2}$.



. 4.6.

N_s (4.30) (4.32):

$$N_s = \sum_{i=1}^n A_{s,i} E_{s,i} \epsilon_{s,i} \frac{n-x-a_i^t}{n-x-a_1^t} \tag{4.34}$$

2-7

1. s, l .

2. (4.33) ,

$$N_s = f_{y,1} A_{s,1} (f_{y,1} A_{s,1} - ()) .$$

3. (4.30) ;

4. i- $\sigma_{s,t} = \varepsilon_{s,t} E_{s,t};$
 5. N_s (4.34);

6. x (4.33);

7. x

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[84] (.4.7).

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$\sigma_s,$

.4.7

$$\frac{\Delta\sigma_s}{\varepsilon_s - \varepsilon_e} = \frac{f_t - f_y}{\varepsilon_u - \varepsilon_e}, (4.35)$$

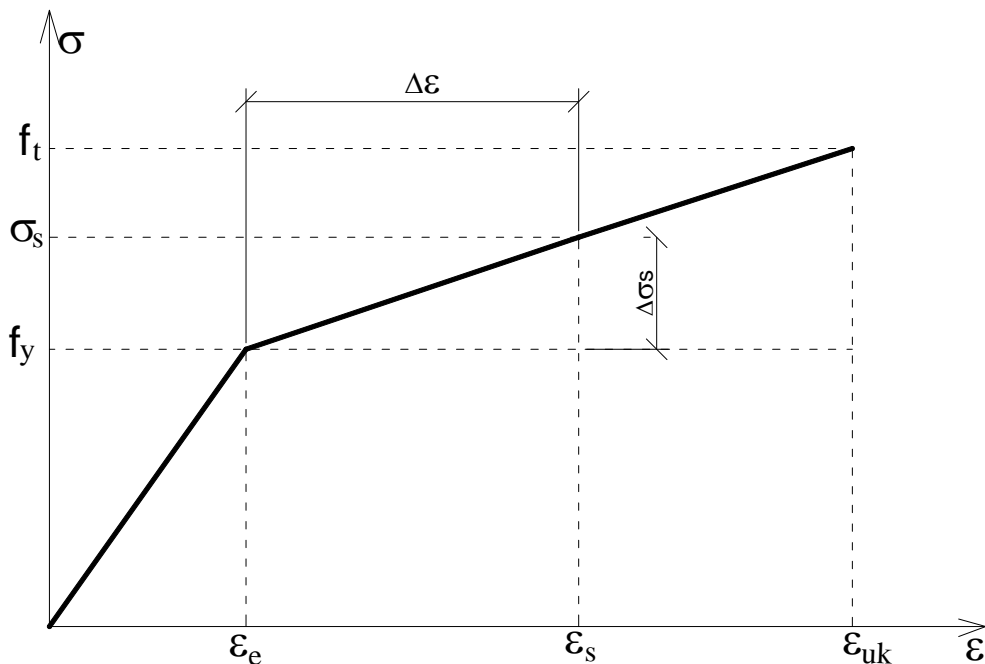
s,1:

$$\varepsilon_{s,1} = \frac{\Delta\sigma_s \varepsilon_u - \varepsilon_e [\Delta\sigma_s + (f_t - f_y)]}{f_t - f_y} (4.36)$$

$$\varepsilon_{s,1} (4.35).$$

4.4.

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 300 , 1500 . $f_{ck,prism1}=2.22$
 ; $f_{ck,prism2}=11$; $E_{b1}=1250$; $E_{b2}=20000$;
 $f_{ct1}=0.31$; $f_{ct2}=1.1$; $b_{u,1}=0.00317$; $b_{u,2}=0.00317$ $c_{,1}=0.00317$; $c_{,2}=0.001776$;
 $c_{,2}=0.00055$.



. 4.7.

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“nelin_raschet.pas” (2)

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“Prandtl7.pas” (3)

. 4.2

“ingener7.pas” (4)

. 4.3.

M_{int} () ;

l / (*10⁻⁵);

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j_{max} .

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	n	(.2.5)				.			(.4.3)		
		M_{int}	$1/$	σ_s	j_{max}	M_{int}	$1/$	σ_s	M_{int}	$1/$	σ_s
1	2	15.15	43.27	530.8	190				14.40	48.8	530.8
2	2.89	14.22	20.14	506.8	79				13.87	20.53	506.8
3	3	14.14	18.82	505.5	98				13.83	19.01	505.5
4	3.3	13.91	15.2	501.8	150				13.68	14.69	501.8
5	3.4	13.83	14.52	501.2	55				13.65	13.99	501.2
6	3.5 ÷ 3.7	n $j_{max} > 30000$									
7	3.8	12.65	12.2	455.5	135	10.74	11.33	411.2			
8	4	12.13	11.61	434.0	116	10.42	10.86	395.5			
9	5	9.88	9.28	346.6	94	9.06	8.94	329.3			
10	6	8.14	7.54	279,0	128	7.88	7.5	276.8			
11	7	6.86	6.26	228.7	95	6.76	6.43	237,3			
12	8	6.00	5.48	200.2	81	5.91	5.62	207.6			

) . 4.3

	σ_s	$M_{int} ()$			$I/ (*10^{-5})$		
		(Nln)	(Ing)	nln / ing	(Nln)	(Ing)	nln / ing
1	530.8	15.15	14.40	1.05	43.27	48.8	0.886
2	506.8	14.23	13.87	1.02	20.14	20.53	0.981
3	505.5	14.14	13.83	1.02	18.82	19.01	0.990
4	501.8	13.91	13.68	1.016	15.20	14.69	1.034
5	501.2	13.83	13.65	1.013	14.52	13.99	1.037

) . 4.2

	n	σ_s	$M_{int} ()$			$I/ (*10^{-5})$		
			(Nln)	4.2 (Pradtl)	nln / pradtl	(Nln)	4.2 (Pradtl)	nln / pradtl
7	3.8	455.5	12.65	10.74	1.17	12.2	11.33	1.076
8	4	434	12.13	10.42	1.16	11.61	10.86	1.069
9	5	346.6	9.88	9.06	1.09	9.28	8.94	1.038
10	6	279,0	8.14	7.88	1.03	7.54	7.5	1.005
11	7	228.7	6.86	6.76	1.01	6.26	6.43	0.973
12	8	200.2	6.00	5.91	1.01	5.48	5.62	0.975

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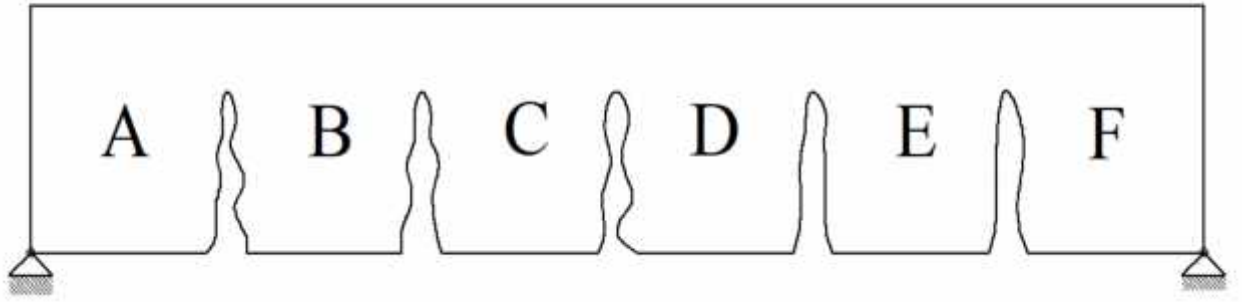
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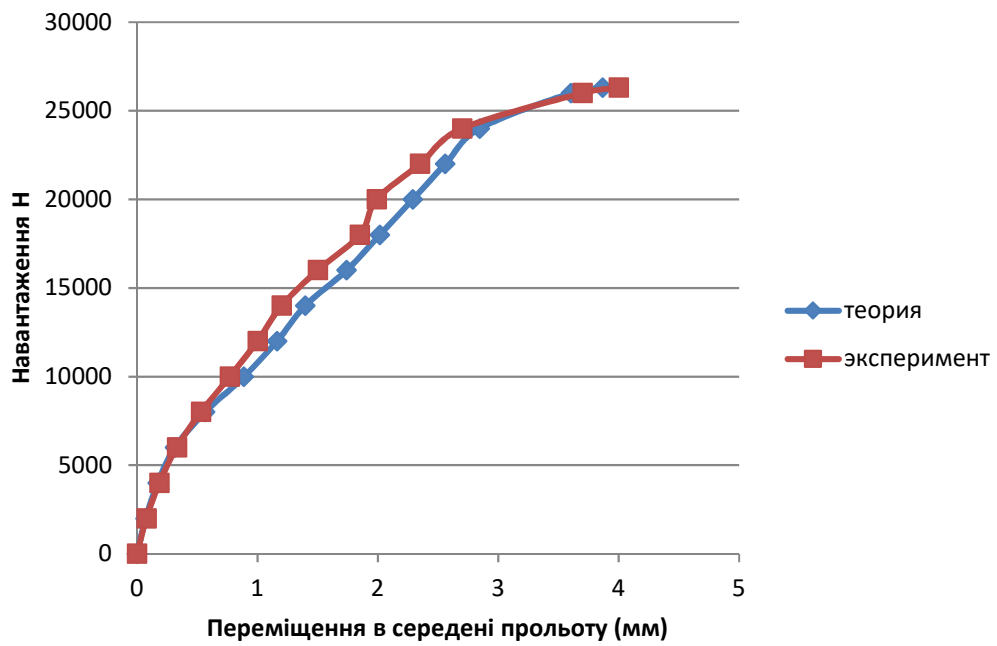
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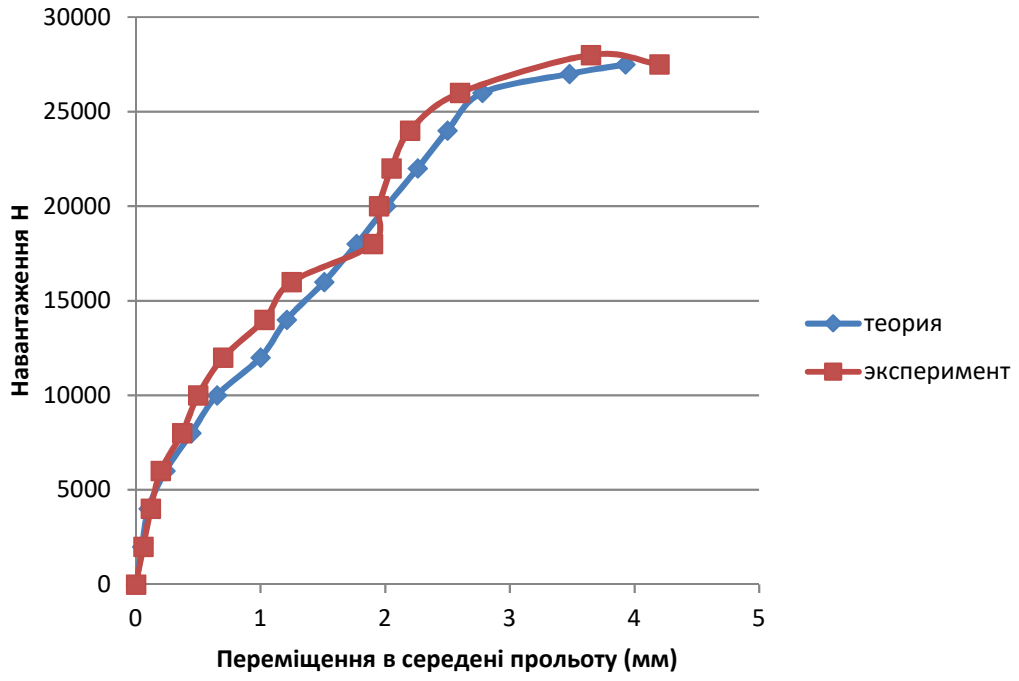
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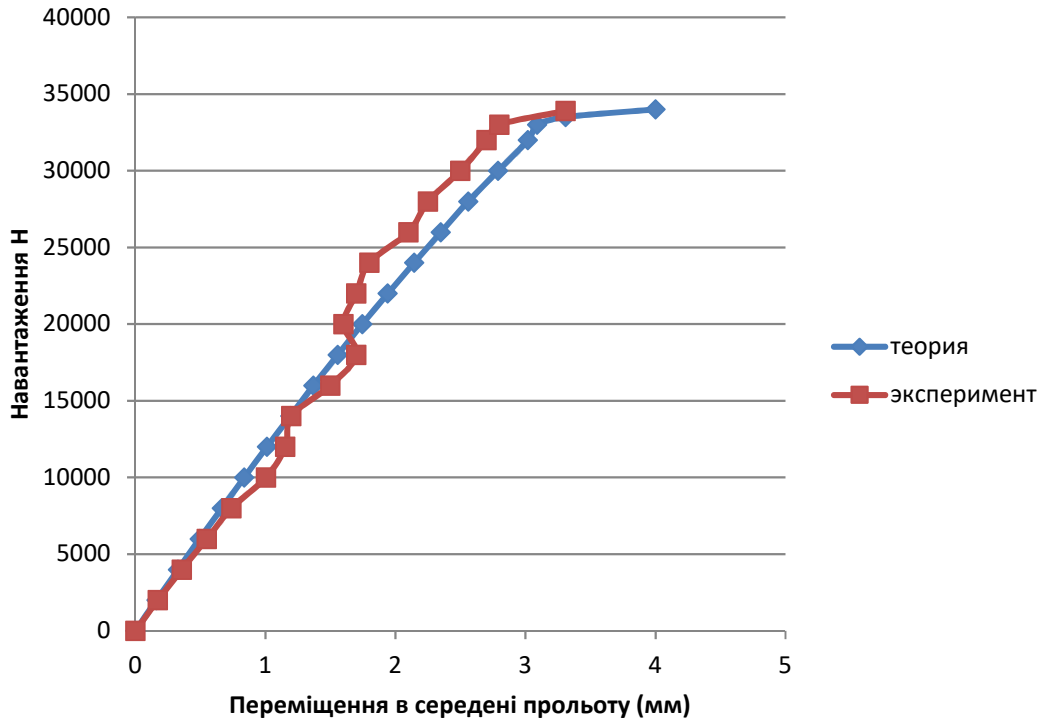
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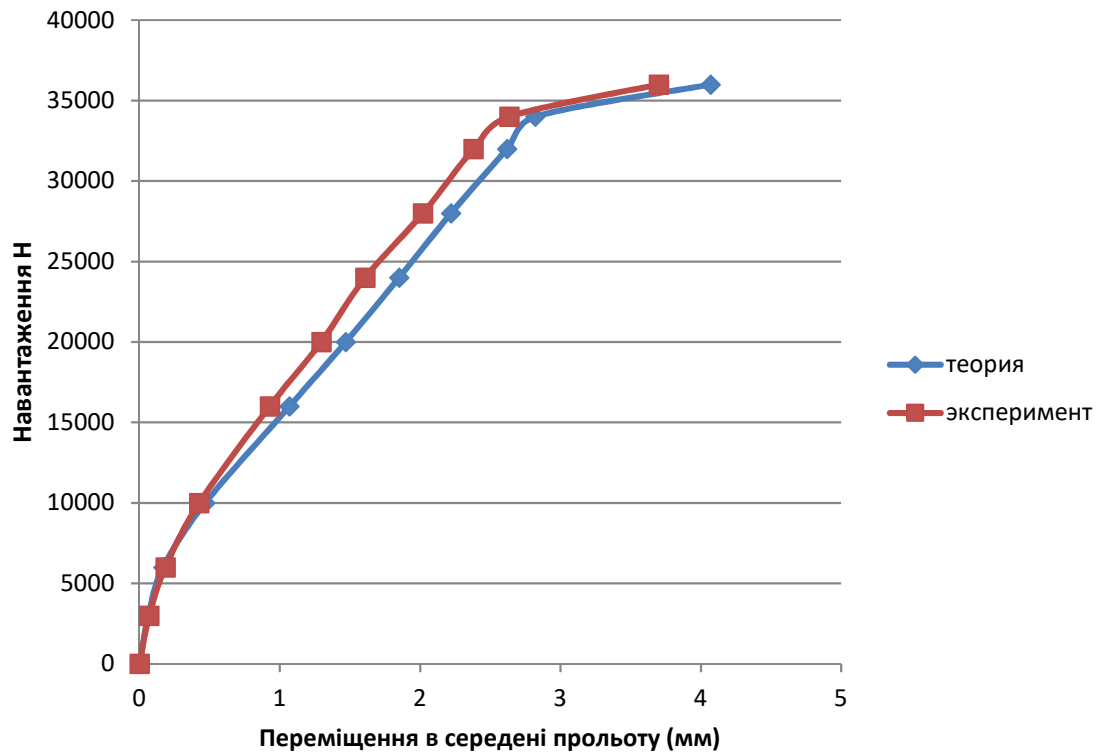
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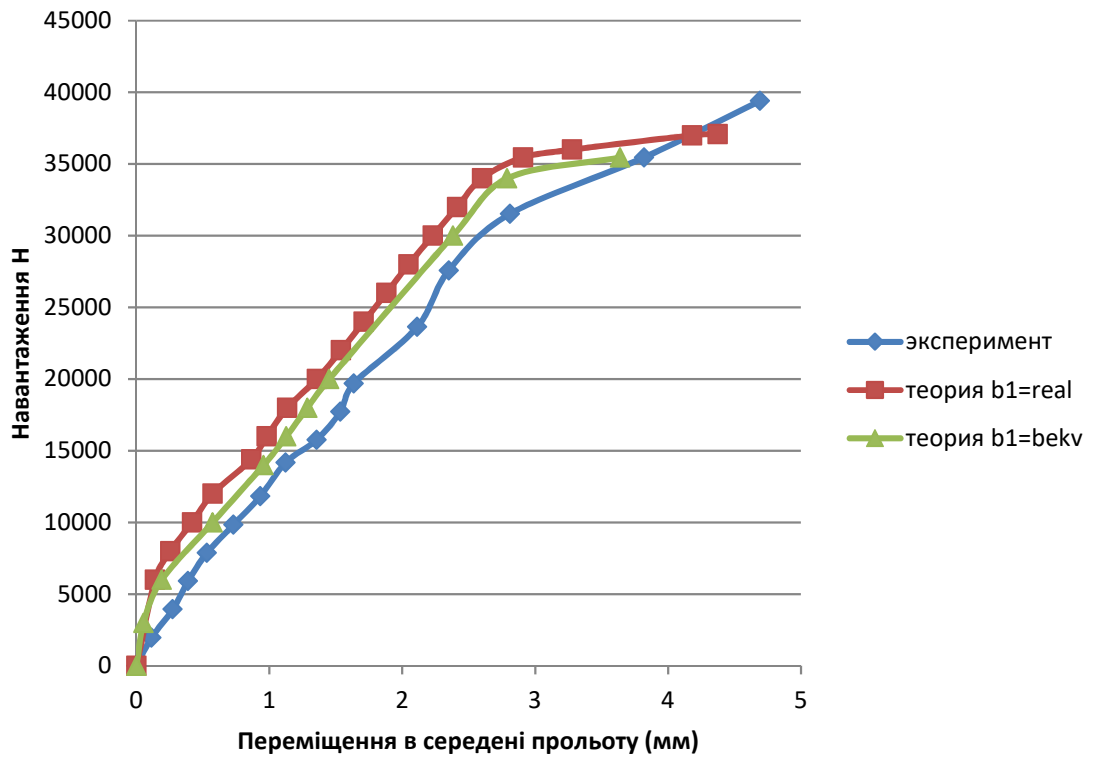
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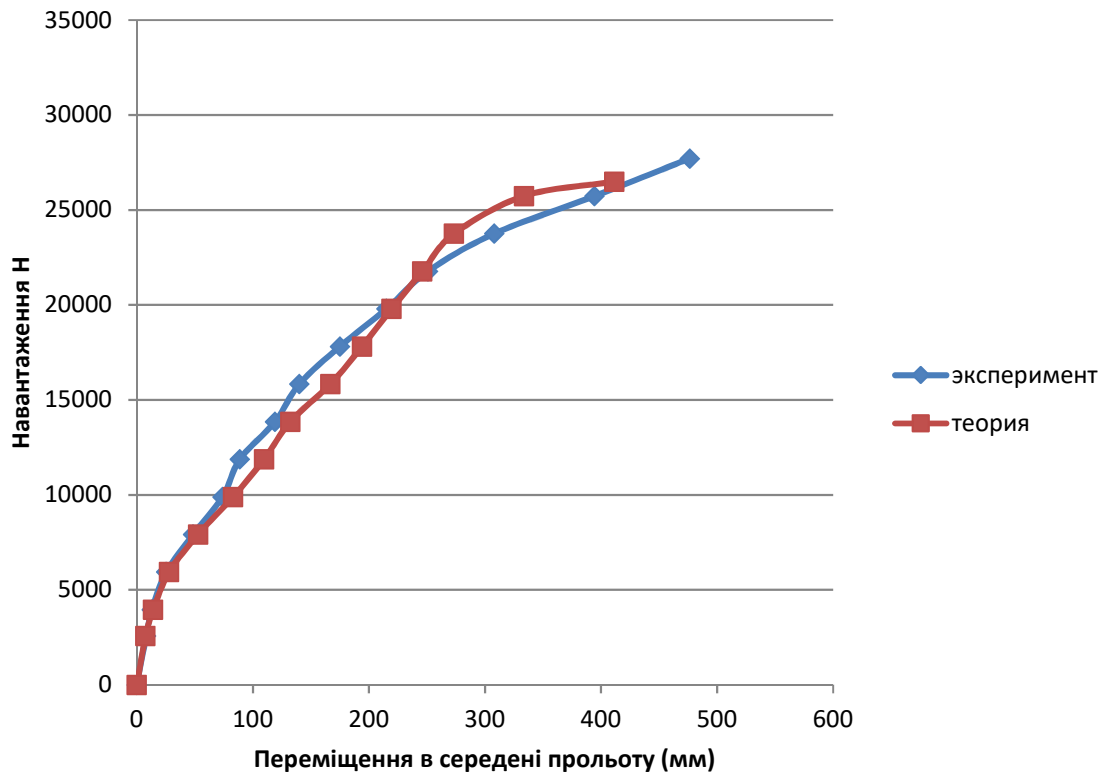
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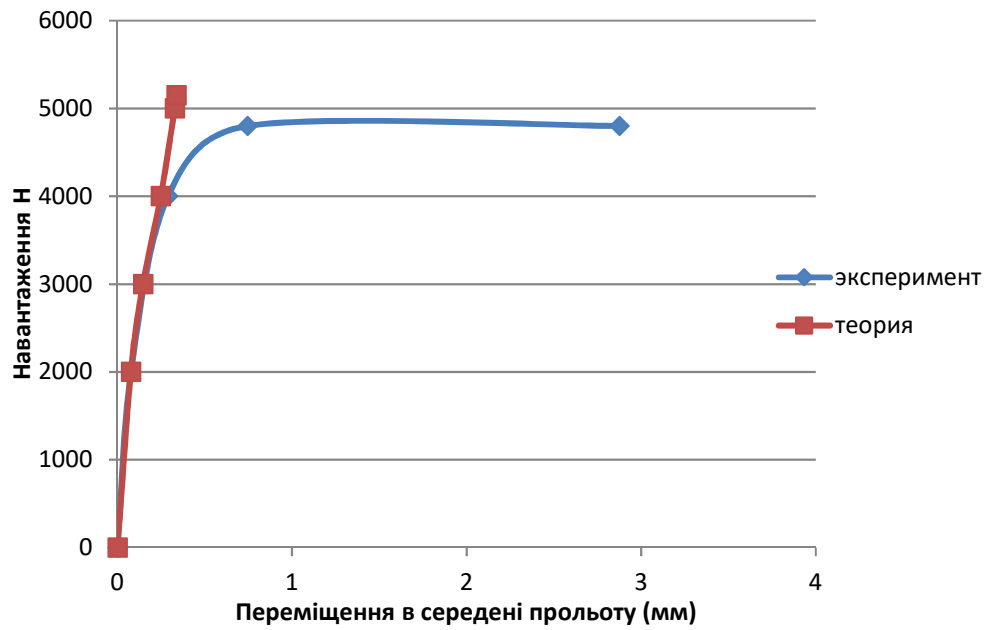
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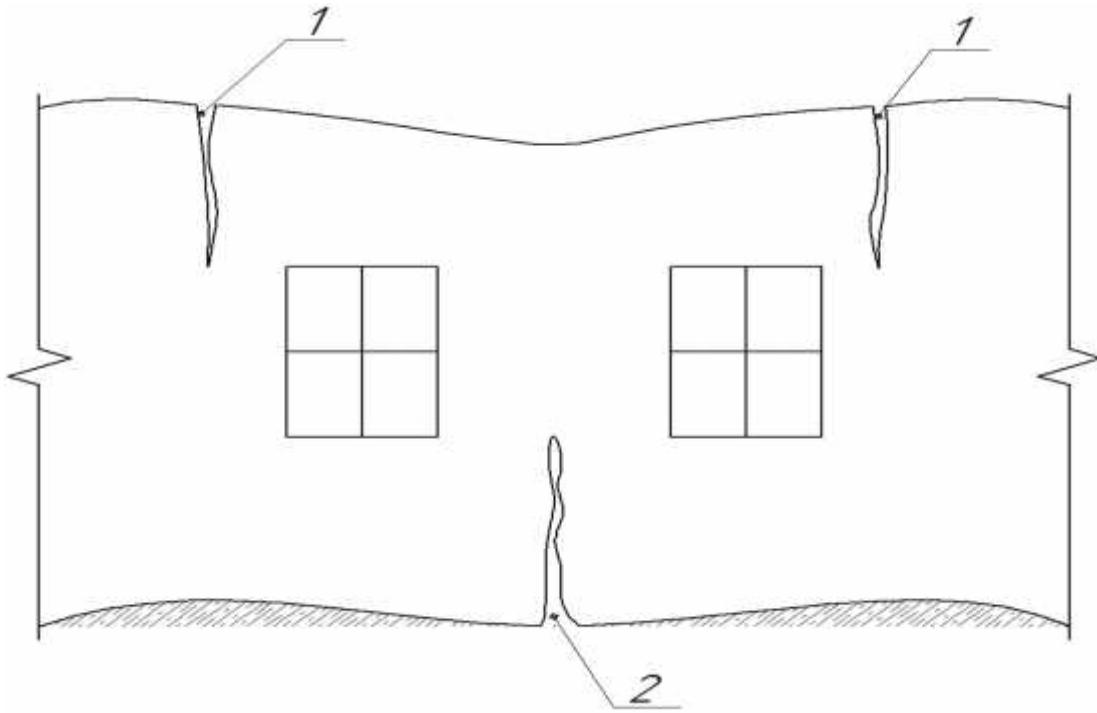
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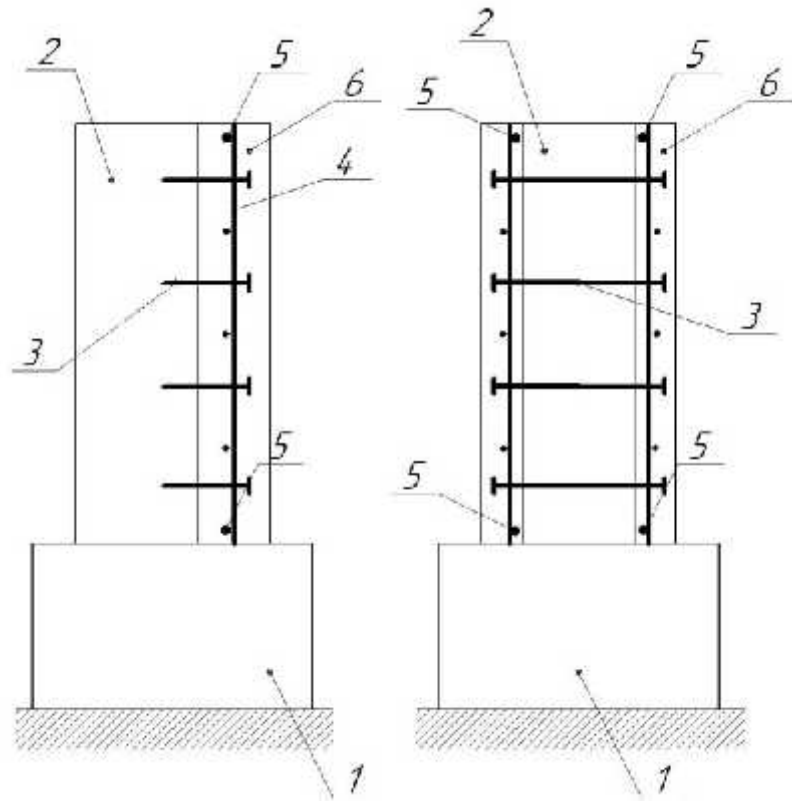
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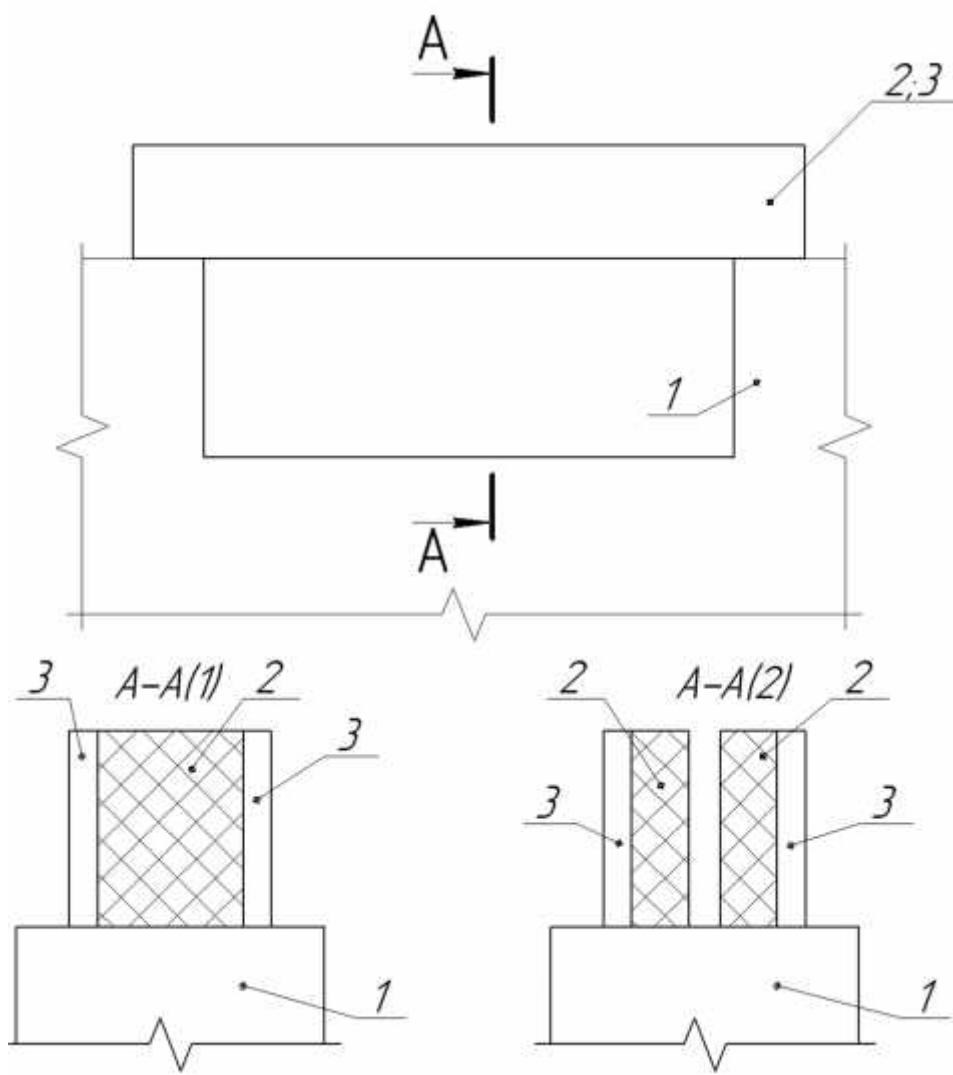
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“sviazi.pas”

```

program sviazi_1; //          Miza_11
uses ugolpovorota_1;
label 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25;
label 26,27,28,29;
const q1=0; q2=0; kanker=1; deltal=50;
n=9; ds=0.25;
    PP1=500; PP2=0;
    AAP=75; //          .
//const bb1=20; hh1=30; bb2=6; hh2=30; //

//      (          )
//const EE1=12500; EE2=200000; //
//      (          )
const bb1=6; hh1=30; bb2=20; hh2=30; //

//      (          )
const EE1=200000; EE2=12500; //

//      (          )
var
    J2ekv,EJekv,EJtot,EJmonolitfikt,bekv:real;
    i, j, n2,kpodpr: integer;
    q,l, AA1, AA2, J1, J2, EJ1, EJ2, EA1, EA2: real;
anker1, anker2: real;
    M, P, aaa, bbb, xxx, EJ, EA: real;
    teta0, fiix, wx, vkube,cct: real;
    Mtott,Mtots,Mser,Mbal,Ssred,kusil: real;

```

```

h: array [1..50] of real;
  xx: array [1..50] of real;
  bqgor1: array [1..50] of real;
  bqvert1: array [1..50] of real;
  bqgor2: array [1..50] of real;
  bqvert2: array [1..50] of real;
  Mt1: array [1..50] of real;
  Ms1: array [1..50] of real;

  at1: array [1..50, 1..50] of real;
  ct1: array [1..50, 1..50] of real;
  at2: array [1..50, 1..50] of real;
  ct2: array [1..50, 1..50] of real;
  as1: array [1..50, 1..50] of real;
  cs1: array [1..50, 1..50] of real;
  as2: array [1..50, 1..50] of real;
  cs2: array [1..50, 1..50] of real;
  a: array [1..50, 1..50] of real;
  b: array [1..50] of real;
  T: array [1..50] of real;
  S: array [1..50] of real;

begin
  for i:=1 to n do
    begin
      //h[i]:=5;
      //xx[i]:=i*deltal;
    end;
  l:=150;
  h[1]:=10;h[2]:=10;h[3]:=10;h[4]:=-10;h[5]:=-10;h[6]:=-10;h[7]:=-10;h[8]:=-
10;

```

```

h[9]:=-10; xx[1]:=15;xx[2]:=75;xx[3]:=135;xx[4]:=0;xx[5]:=35;xx[6]:=55;
xx[7]:=95;xx[8]:=115;xx[9]:=150;
AA1:=bb1*hh1;
AA2:=bb2*hh2;
J1:=bb1*Power(hh1,3)/12;
J2:=bb2*Power(hh2,3)/12;
//J1:=J1/10;
EJ1:=EE1*J1;
EJ2:=EE2*J2;
EA1:=EE1*AA1;
EA2:=EE2*AA2;
anker1:=1000/Power(ds,3)/Sqr(EE1)+1/ds/EE1;
anker2:=1000/Power(ds,3)/Sqr(EE2)+1/ds/EE2;
for i:=1 to n do
  begin
    for j:=1 to n do
      begin //    for j
        M:=h[j]; aaa:=xx[j]; xxx:=xx[i]; EJ:=EJ1; EA:=EA1;

ugol1(1,teta0,fiix,wwx,vkube,M,P,aaa,bbb,xxx,EJ,EA,xx,h,at1,ct1,at2,ct2);// -
//
        at1[i,j]:=-fiix*h[i]+xx[i]/EA;
ct1[i,j]:=wwx;

        end; //    for j
      end; //    for i

for i:=1 to n do
  begin //    for i
    for j:=1 to n do

```

```

begin //    for j
    M:=h[j]; aaa:=xx[j]; xxx:=xx[i]; EJ:=EJ2; EA:=EA2;

ugol1(1,teta0,fiix,www,vkube,M,P,aaa,bbb,xxx,EJ,EA,xx,h,at1,ct1,at2,ct2);// -
//
//                ugol1
    at2[i,j]:=fiix*h[i]-xx[i]/EA;
ct2[i,j]:=-www;
    end; //    for j
end; //    for i

for i:=1 to n do
    begin //    for i
        for j:=1 to n do
            begin //    for j
                P:=1; bbb:=1-xx[j]; aaa:=xx[j]; xxx:=xx[i]; EJ:=EJ1; EA:=EA1;

ugol2(1,teta0,fiix,www,vkube,M,P,aaa,bbb,xxx,EJ,EA,xx,h,as1,cs1,as2,cs2,bqgor1,
bqgor2,bqvert1,bqvert2);// .                ugol2
                as1[i,j]:=-fiix*h[i];
cs1[i,j]:=www;
                end; //    for j
            end; //    for i

for i:=1 to n do
    begin //    for i
        for j:=1 to n do
            begin //    for j
                P:=1; bbb:=1-xx[j]; aaa:=xx[j]; xxx:=xx[i]; EJ:=EJ2; EA:=EA2;

```

```

ugol2(1,teta0,fiix,www,vkube,M,P,aaa,bbb,xxx,EJ,EA,xx,h,as1,cs1,as2,cs2,bqgor1,
bqgor2,bqvert1,bqvert2);//      .      ugol2
      as2[i,j]:=fiix*h[i];
cs2[i,j]:=-www;
      end; //      for j
      end; //      for i
//      . Ugol2,      Ugol3
for i:=1 to n do
  begin //      for i
    P:=PP1;bbb:=1-AAP; aaa:=AAP; xxx:=xx[i]; EJ:=EJ1; EA:=EA1;

ugol2(1,teta0,fiix,www,vkube,M,P,aaa,bbb,xxx,EJ,EA,xx,h,as1,cs1,as2,cs2,bqgor1,
bqgor2,bqvert1,bqvert2);//      .      ugol3
      bqgor1[i]:=-fiix*h[i];
bqvert1[i]:=www;
      end; //      for i

for i:=1 to n do
  begin //      for i
    P:=PP2;bbb:=1-AAP; aaa:=AAP; xxx:=xx[i]; EJ:=EJ2; EA:=EA2;

ugol2(1,teta0,fiix,www,vkube,M,P,aaa,bbb,xxx,EJ,EA,xx,h,as1,cs1,as2,cs2,bqgor1,
bqgor2,bqvert1,bqvert2);//      .      ugol3
      bqgor2[i]:=-fiix*h[i];
bqvert2[i]:=www;
      end; //      for i
//for i:=1 to n do
  //writeln ('at1=',at1[2,i],'ct1=',ct1[2,i]);
  //writeln ('at2=',at2[1,i],'ct2=',ct2[1,i]);

```

```

//writeln ('as1=',as1[1,i],'cs1=',cs1[1,i]);
//writeln ('as2=',as2[1,i],'cs2=',cs2[1,i]);
//writeln ('bqgor1=',bqgor1[i],'bqgor2=',bqgor2[i]);
//writeln ('bqvert1=',bqvert1[i],'bqvert2=',bqvert2[i]);

//
-

for i:=1 to n do
begin //    for i
  for j:=1 to n do
    begin //    for j
      if i=j then goto 10;
      a[i,j]:=at1[i,j]-at2[i,j]; goto 11;
    10: a[i,j]:=at1[i,j]-at2[i,j]+kanker*(anker1+anker2);
    11: //writeln;
      end; //    for j
    end; //    for i

  for i:=1 to n do
    begin //    for i
      for j:=n+1 to 2*n do
begin //    for j
      a[i,j]:=as1[i,j-n]-as2[i,j-n];
end; //    for j
      end; //    for i

    for i:=n+1 to 2*n do
begin //    for i
      for j:=1 to n do
        begin //    for j
          a[i,j]:=ct1[i-n,j]-ct2[i-n,j];
        end; //    for j
      end; //    for i
    end; //    for i
  end; //    for i
end; //    for j

```



```

        end; //      for i

    for i:=n+1 to 2*n do
begin //      for i
    for j:=n+1 to 2*n do
begin //      for j
    if i=j then goto 12;
    a[i,j]:=cs1[i-n,j-n]-cs2[i-n,j-n];goto 13;
    12: a[i,j]:=cs1[i-n,j-n]-cs2[i-n,j-n]-kanker*(anker1+anker2);
13: //writeln;
    end; //      for j
    end; //      for i

    for i:=1 to n do
    begin //      for i
        b[i]:=-bqgor1[i]+bqgor2[i];
end; //      for i

    for i:=n+1 to 2*n do
begin //      for i
    b[i]:=-bqvert1[i-n]+bqvert2[i-n];
end; //      for i

    n2:=n*2;
    sistema (n2,a,b);//      .-      "sistema",
        //      -      "sistur2.pas"

for i:=1 to n do begin
T[i]:=x[i]; //
    S[i]:=x[i+n]; //
    end;

    for i:=1 to n do

```

```

begin //      for i
      writeln ('T['i,']=',T[i], '   S['i,']=',S[i]);

end; //      for i
for i:=1 to n do begin
  if xx[i]>1/2 then goto 26;
  Mt1[i]:=-3*x[i]*h[i]/2; goto 27;
26: Mt1[i]:=-x[i]*h[i]/2;
27: if xx[i]>1/2 then goto 28;
  Ms1[i]:=x[i+n]*xx[i]/2; goto 29;
28: Ms1[i]:=x[i+n]*(1/2-xx[i]/2);
29: end; //      next i
for i:=1 to n do begin
Mtott:=Mtott+Mt1[i];
      Mtots:=Mtots+Ms1[i];
end;
Mser:=PP1*(1-AAP)/1*1/2-PP1*(1/2-AAP)-Mtott+Mtots;
Mbal:=PP1*(1-AAP)/1*1/2-PP1*(1/2-AAP);
Ssred:=PP1/n;
kusil:=Mbal/Mser; //      .      , . .      _2
"      "
J2ekv:=(kusil-1)*EJ1/EE2;//
(      )      ,      -
EJekv:=EE2*J2ekv; //
bekv:=12*J2ekv/Power(hh2,3);//      .

//      ,      «      -      »

EJmonolitfikt:=EJ1+EJekv;//      ,
-
//      ,

```

```

EJtot:=EJ1+EJ2; //          (          )

writeln ('Mser=',Mser,' Ssred=',Ssred,' kusil=',kusil);
  writeln ('J2ekv=',J2ekv,' EJtot/EJmonolitfikt=',(EJtot)/EJmonolitfikt);
writeln ('bekv=',bekv);
end.

```

--

```

unit ugolpovor11; //          ugolpovor11.
//          .          ,

uses CRT;
label 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25;
//const q1=10; q2=5;
//const kanker=1; deltal=50; n=5; ds=1;
//const bb1=20; hh1=30; bb2=2; hh2=30;
//const EE1=15000; EE2=25000;
var
  teta0, fiix, wx, vkube: real;
  M, P, aaa, bbb, xxx, EJ, EA,wwx: real;
L1, R:real;
  xx: array [1..50] of real;
  h: array [1..50] of real;
  at1: array [1..50, 1..50] of real;
  ct1: array [1..50, 1..50] of real;
  i, j, k, kpodpr: integer;
  q,l, AA1, AA2, J1, J2, EJ1, EJ2, EA1, EA2: real;
anker1, anker2: real;

```

```

bqgor1: array [1..50] of real;
bqvert1: array [1..50] of real;
bqgor2: array [1..50] of real;
bqvert2: array [1..50] of real;

at2: array [1..50, 1..50] of real;
ct2: array [1..50, 1..50] of real;
as1: array [1..50, 1..50] of real;
cs1: array [1..50, 1..50] of real;
as2: array [1..50, 1..50] of real;
cs2: array [1..50, 1..50] of real;
a: array [1..50, 1..50] of real;
a1: array [1..50, 1..50] of real;
b: array [1..50] of real;
x: array [1..50] of real;
//-----
Procedure ugol1(var
1,teta0,fiix,www,vkube,M,P,aaa,bbb,xxx,EJ,EA:real;xx,h: array [1..50] of
real;at1,ct1,at2,ct2: array [1..50, 1..50] of real);

label 14,15; //          "Ugol1" (
)

begin //          "Ugol1"

//
teta0:=-M*1/6/EJ*(2-6*aaa/1+3*Sqr(aaa)/Sqr(1));
if xxx>aaa then goto 14;
fiix:=teta0+(-M/2/1*Sqr(xxx))/EJ;

```

```

wwx:=teta0*xxx-M*Power(xxx,3)/6/EJ/l; goto 15;
14: fiix:=teta0+(-M/2/l*Sqr(xxx)+M*(xxx-aaa))/EJ;
    wwx:=teta0*xxx-M*Power(xxx,3)/6/EJ/l+M*Sqr(xxx-aaa)/2/EJ;
    //writeln ('wwx=',wwx,'fiix=',fiix);
15:
    end;
    Procedure ugol2 (var
1,teta0,fiix,wwx,vkube,M,P,aaa,bbb,xxx,EJ,EA:real;xx,h: array [1..50] of
real;as1,cs1,as2,cs2: array [1..50, 1..50] of real;bqgor1,bqgor2,bqvert1,bqvert2:
array [1..50] of real);
    label 16,17;

    begin
    teta0:=-P*1/6/EJ*(Power(-bbb,3)/Power(1,3)+bbb/l);
    if xxx>aaa then goto 16;
    fiix:=teta0+(P*bbb/l*xxx*xxx/2)/EJ;
    wwx:=teta0*xxx+(P*bbb/l*Power(xxx,3)/6)/EJ; goto 17;
    16: fiix:=teta0+(P*bbb/l*xxx*xxx/2-P*Sqr(xxx-aaa)/2)/EJ;
vkube:=xxx-aaa;
    wwx:=teta0*xxx+(P*bbb/l*Power(xxx,3)/6-P*Power(vkub,3)/6)/EJ;
17:
    end; //          "Ugol2"

//          "sistema" ( . )
    Procedure sistema(n2:integer;a:array [1..50,1..50] of real;b:array [1..50] of
real);

    label 21,22,23,24,25;

    begin //

```

```

for i:=1 to n2 do begin
for j:=1 to n2 do
  a1[i,j]:=a[i,j];
  x[i]:=b[i];
  end;
  L1:=0;
for i:=1 to n2 do begin
k:=i;
R:=abs(a1[i,i]);
for j:=i+1 to n2 do begin
  if abs(a1[j,i])<=R then goto 21; //3018 if abs(a1(j,i))<=R goto 3020
k:=j; //3019 k=j:r=abs(a1(j,i))
r:=abs(a1[j,i]);
21: end; //3020 next j
if r=0 then goto 23; //3021 if r=0 goto 3038:
  if k=i then goto 22; //3027
r:=x[k]; x[k]:=x[i]; x[i]:=r;//3023 r=x(k):x(k)=x(i):x(i)=r
for j:=1 to n2 do begin //3024 for j=1 to n2
r:=a1[k,j]; a1[k,j]:=a1[i,j]; a1[i,j]:=r; //3025 r=a1(k,j):a1(k,j)=a1(i,j):a1(i,j)=r
end; //3026 next j
22: //3027 '
r:=a1[i,i]; x[i]:=x[i]/r; //3028 r=a1(i,i):x(i)=x(i)/r
for j:=1 to n2 do//3029 for j=1 to n2
a1[i,j]:=a1[i,j]/r; //3030 a1(i,j)=a1(i,j)/r
//3031 next j
for k:=i+1 to n2 do begin //3032 for k=i+1 to n2
r:=a1[k,i]; x[k]:=x[k]-r*x[i]; //3033 r=a1(k,i):x(k)=x(k)-r*x(i)
for j:=i to n2 do//3034 for j=i to n2
a1[k,j]:=a1[k,j]-r*a1[i,j];//3035 a1(k,j)=a1(k,j)-r*a1(i,j)

```

```

// 3036 next j
end;
goto 24;//3037 next k:goto 3040
23: // 3038
L1:=1;
i:=n2+1;//3039 L1=1:i=n2+1
24: end; //3040 next i:if L1=1 goto 3047
if L1=1 then goto 25;
for i:=n2-1 downto 1 do begin//3042 for i=n2-1 to 1 step -1
for j:=i+1 to n2 do//3043 for j=i+1 to n2
x[i]:=x[i]-a1[i,j]*x[j]; //3044 x(i)=x(i)-a1(i,j)*x(j)
//3045 next j
end; //3046 next i
25: //3047 'return
end; // "begin"
end. // "Procedure"

```

“nelin_raschet.pas”

```

program nelin_raschet;

uses nelinej1; // - "nelinej1.pas"
label 239,240,241,242,250,255,260,265,270,275,280,285;
const b=6; h=30;b2=6;h2=30;
const L=150;
const kkk=1; // 1,
      const PP=1640; //
const fckprism=22.2; // . .
(      )
const fckprism2=110; // . .
(      )
const Eb=12500; // (      )
const Eb2=200000; // (      )
const Rbt=3.1; // . . . (      )
const Rbt2=11; // . . . (      )
const Ess=2000000;
const Rss=6000; sigmat=6000;Rrazr=7000; //

const epsisu=0.025; //
const astrich=5.5; //
const Ass=1; //
const As2=0.1; Rs2=3550; // . .

const epsibu1=0.00317; epsibu2=0.0044; // , sigma
      Rb!!!
const epsic1=0.0022;epsic2=0.00161; epsibu=0.0044; epsisud=0.02;

```



```

const koliter=30000; //maximalnoje kol-vo iteracij
const nepsi=350; //
-
//
-
// Nsech, nepsi
( , -
// , )
const nepsibu=250; //
!!!
const n=20; // 'chislo uchastkov po visote sechenija
const delta=2; //
const deltadelta=50;//
const nns=4; //

var jj,hhh,kM:integer;
var Mizg: array [1..550] of real; //
var Nizg: array [1..550] of real; //
var krivizg: array [1..550] of real; //
var Jmaxizg: array [1..550] of real; //
var epsiizg: array [1..550] of real; //
var M: array [1..50] of real; // "moment_osnovn_5"
var krivizna: array [1..50] of real; // "moment_osnovn_5"
var xsgat: array [1..50] of real; // "moment_osnovn_5"
var Mzadan,As1,As3,As4,Zs1,Zs2,Zs3,Zs4,fm:real; //
"moment_osnovn_5"
var alfab,alfas,A1,A2,chisl,znam,yc,G1,G2:real; //
"moment_osnovn_5"
var Jredgb,betagb,fqgb,ftot,EJgb:real; // "moment_osnovn_5"
var Mmax:real;

```

```

begin
  epsise:=sigmat/Ess;
  epsidiagr:=epsisu-epsise;
  deltasigmasmax:=Rrazr-sigmat;
  astr[1]:=1; astr[2]:=8; astr[3]:=15; astr[4]:=22;
  Nsechiter:=0;//
  Eck:=Eb; // ( )
  Eck2:=Eb2;
  k:=1.05*Eck*epsic1/fckprism; //
  ( )
  k2:=1.05*Eck2*epsic2/fckprism2;
  writeln ('k=',k, 'k2=',k2);
  h0:=h-astrich;
  a:=h/n; // ,
  EJ:=Eb*b*(Power(h,3))/12+Eb2*b2*(Power(h2,3))/12;

  M[4]:=PP*1/4; M[1]:=M[4]/4; M[2]:=M[4]/2; M[3]:=3*M[4]/4;
  Mzadan:=M[4]; // M4!!!
  kM:=4;// M4!!!
  239: epsi[1]:=epsibu/nepsibu; // neleinej_osnovn_9 !!!
  //if jj=1 then epsi[1]:=epsibu;
  // - - ,
  // "raschet"
  writeln ('M1sech=',M1sech,' Mzadan=',Mzadan,'N1sech=',N1sech,'
kriv=',kriv);
  N1sech:=0;M1sech:=0;M1sech1:=0;N1sech1:=0;N1stot:=0;M1stot:=0;// -
  // , -
  !!!!!!!
  raschet
(epsi,Ass,b,h,b2,h2,L,fckprism,kkk,Eb,Eb2,Rbt,Rbt2,Ess,Rss,epsisu,
fckprism2,astrich,As2,Rs2,epsibu1,epsibu2,epsic1,epsic2,epsibu,

```

```

    epsisud,koliter,nepsi,n,delta,nns,sigmat,Rrazr,astr);
//          -          !!!
//          -          ,

//          -          .
if Mmax<M1sech then Mmax:=M1sech;
if Mzadan-M1sech>deltadelta then goto 250;
if M1sech-Mzadan>deltadelta then goto 255;
goto 265; //          .          !!!
    epsi[1]:=epsi[1]+epsibu/nepsibu; //
    goto 240;
    //if M1sech-Mzadan>deltadelta then goto 255;
goto 240;
255: epsi[1]:=epsi[1]-epsi[1]/50; //
    goto 240;
    writeln ('          ');

    krivizna[kM]:=kriv;
    xsgat[kM]:=X1;
    writeln ('Mzadan=',Mzadan);
    writeln ('M1sech=',M1sech,' N1sech=',N1sech, ' kriv=',kriv:3:7);
if ABS(epsis)>epsisud then writeln('          !!!');
writeln ('          ! 1-4 -          - ,5
-          ');
    read (kM);
    if kM<=4 then goto 270;
    goto 275;
270: Mzadan:=M[kM]; goto 239;//
//
As1:=Ass;As3:=As2;As4:=As2; //
    Jred

```

```
Zs1:=astrich;Zs2:=astr[1];Zs3:=astr[2];Zs4:=astr[3];
```

```
fm:=1*1/768*(12*krivizna[1]+24*krivizna[2]+36*krivizna[3]+22*krivizna[4]);
```

```
//          "Progib_5_3.pas
```

```
alfab:=Eb2/Eb;
```

```
alfas:=Ess/Eb;
```

```
A1:=b*h; A2:=b2*h;
```

```
chisl:=(A1+A2*alfab)*h/2+alfas*(As1*Zs1+As2*Zs2+As3*Zs3+As4*Zs4);
```

```
znam:=A1+A2*alfab+alfas*(As1+As2+As3+As4);
```

```
yc:=chisl/znam;
```

```
G1:=0.4*Eb;
```

```
G2:=04*Eb2;
```

```
Jredgb:=(b+b2*alfab)*Power(h,3)/12+(b+b2*alfab)*h*SQR(h/2-yc)+alfas*(As1*SQR(Zs1-yc)+As2*SQR(Zs2-yc)+As3*SQR(Zs3-yc)+As4*SQR(Zs4-yc));
```

```
betagb:=4.5*Eb*Jredgb*krivizna[4]/((G1*b*h+G2*b2*h)*M[4]);
```

```
fqgb:=betagb*M[4];
```

```
ftot:=fqgb+fm;
```

```
EJgb:=Eb*(b+b2*alfab)*Power(h,3)/12;
```

```
writeln ('fizgib=',fm,' fqgb=',fqgb,' ftot=',ftot);
```

```
writeln ('yc=',yc);
```

```
writeln (' EJredgb=',Eb*Jredgb,' EJredgb/EJ=',Eb*Jredgb/EJ);
```

```
writeln (' M1=',M[1], ' M2=',M[2], ' M3=',M[3], ' M4=',M[4]);
```

```
writeln;
```

```
writeln ('krivizna1=',krivizna[1]:3:6,' krivizna2=',krivizna[2]:3:6,'
krivizna3=',krivizna[3]:3:6,' krivizna4=',krivizna[4]);
writeln;
writeln ('Xsgat1=',xsgat[1]:3:6,' Xsgat2=',xsgat[2]:3:6,'
Xsgat3=',xsgat[3]:3:6,' Xsgat4=',xsgat[4]:3:6);
writeln ('Mmax=',Mmax);

//

writeln ('!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!');
end.
```

“Prandtl7.pas”

```
program prandtl7;  
    //  
uses CRT;  
  
const Rb1=24; Rb2=110;  
//const epsic1=0.0005; epsic2=0.0015;  
const Eb1=10000; Eb2=200000;  
const Ess=2000000;  
const Essdop=2000000;  
const kk=1; //      kk=1,  
const Rss=5000;  
const Rssdop=0;//3550;  
const Ass=0.7; //  
const Asdop=0.28; //  
const b1=20; b2=4;  
const htot=30; //  
const astrich=0;//4.5;//  
const nss=4; //      -  
const pogresh=0.01;  
  
var h:real; //  
var epsisu,epsib,epsic1,epsic2:real;  
var Ns:real;  
var x,deltax1,deltax2:real;  
var AA0,AA1,AA2,BB1,BB2,CC1,CC2,DD,GG:real;  
var alfa1,alfa2,beta1:real;
```

```

var p0,p1,p2,p3,p4,q0,q1,q2,q3,q4:real;
var Rsdop,Esdop:real;
var i,q10:integer;

var Z: array [1..10] of real; //
-
var AAs: array [1..10] of real;//
var epsis: array [1..10] of real;//
var summaN,SummaM: real;
var j:integer;
var xiter,AAA,pp:real;
label 5,10,20,30,40,50,60;
begin
  h:=htot-astrich;
  epsisu:=Rss/Ess;
  epsic1:=Rb1/Eb1; epsic2:=Rb2/Eb2;
  Z[1]:=1; Z[2]:=8; Z[3]:=15; Z[4]:=22;
  Rsdop:=Rssdop; Esdop:=Essdop;
  if kk=1 then Rsdop:=0;
  if kk=1 then Esdop:=0;

  //BB1:=Eb1*b1*;
  //BB2:=Rb2*b2*epsic2*h/(2*epsisu);
  CC1:=Eb1*b1*epsisu/2;
  CC2:=Eb2*b2*epsisu/2;
  for i:=1 to nss do //
    begin, . .
      AAs[i]:=Asdop;
    for i:=1 to nss do begin
      SummaN:=SummaN+epsisu*Esdop*AAs[i];
      SummaM:=SummaM+epsisu*Esdop*AAs[i]*Z[i];

```

```

end;
// Ns:=Rss*Ass+SummaN; //
-
//
AA0:=epsisu*(Eb1*b1+Eb2*b2)/2;
p0:=Rss*Ass/AA0;
q0:=Rss*Ass*h/AA0;
// X deltax
x:=-p0/2+SQRT(SQR(p0/2)+q0);
epsib:=epsisu*x/(h-x);
writeln (' x=',x, ' epsib=',epsib);
writeln ('epsic1=',epsic1, ' epsic2=',epsic2);
5: j:=j+1; writeln ('j=',j); // . ( )
if j>170 then goto 60;
xiter:=x;
//if j>35 then xiter:=(xiter+x)/2;
//xiter:=(xiter+x)/2;
deltax1:=x*(1-epsic1*(h-x)/(epsisu*x));
deltax2:=x*(1-epsic2*(h-x)/(epsisu*x));
if j<2 then writeln (' deltax1=',deltax1,'deltax2=',deltax2);
AA1:=Eb1*b1*epsic1;
AA2:=Eb2*b2*epsic2;
CC1:=Eb1*b1*epsisu/2;
CC2:=Eb2*b2*epsisu/2;
if (deltax1>0) and (deltax2>0) then goto 10;
if (deltax1<=0) and (deltax2<=0) then goto 20;

```



```

if (deltax1>0) and (deltax2<=0) then goto 30;

if (deltax1<=0) and (deltax2>0) then goto 40;

10: BB1:=Eb1*b1*epsic1*deltax1/2;
   BB2:=Eb2*b2*epsic2*deltax2/2;
   x:=(Rss*Ass-BB1-BB2)/(AA1+AA2);
   writeln ('    dx1>0 and dx2>0,x=',x);
q10:=10;
   goto 50;

20: p1:=Rss*Ass/(CC1+CC2);
   q1:=Rss*Ass*h/(CC1+CC2);
   x:=-p1/2+SQRT(SQR(p1/2)+q1);
   if x>h then x:=-p1/2-SQRT(SQR(p1/2)+q1);
   writeln ('    dx1<0 and dx2<0,x=',x,' p1/2=',p1/2,'
koren20=',SQRT(SQR(p1/2)+q1));
q10:=20;
   goto 50;

30: BB1:=Eb1*b1*epsic1*deltax1/2;
   p2:=(AA1*h-BB1+Rss*Ass)/(CC2-AA1);
   q2:=(Rss*Ass*h-BB1*h)/(CC2-AA1);
   x:=-p2/2+SQRT(SQR(p2/2)+q2);
   if x>h then x:=-p2/2-SQRT(SQR(p2/2)+q2);

   writeln ('    dx1>0 and dx2<0,x=',x,' p2/2=',p2/2,'
koren30=',SQRT(SQR(p2/2)+q2));
q10:=30;
   goto 50;

40: BB2:=Eb2*b2*epsic2*deltax2/2;
   p3:=(AA2*h-BB2+Rss*Ass)/(CC1-AA2);
   q3:=(Rss*Ass*h-BB2*h)/(CC1-AA2);

```

```

x:=-p3/2+SQRT(SQR(p3/2)+q3);
if x>h then x:=-p3/2-SQRT(SQR(p3/2)+q3);
writeln ('    dx1<0 and dx2>0,x=',x,' p3/2=',p3/2,'
koren40=',SQRT(SQR(p3/2)+q3));
q10:=40;
writeln ('x=',x,' xiter=',xiter);
writeln ('deltax1=',deltax1,' deltax2=',deltax2);
writeln ('q10=',q10);
if ABS(xiter-x)/x>pogresh then goto 5;
60: writeln ('otnosh=',ABS(xiter-x)/x);
//Nb:=AA*x-BB;

//for i:=1 to ns do begin
//  epsis[i]:=epsisu*(h-x-Z[i])/(h-x);
//  writeln ('epsis(',i,')=',epsis[i],'AAs=',AAs[i]);
// end;

//for i:=1 to ns do begin
//  Mstot:=Mstot+epsis[i]*AAs[i]*(h-x-Z[i])*Esdop;
//  Nstot:=Nstot+AAs[i]*epsis[i]*Esdop;
//  writeln ('skobka=',h-x-Z[i],'Mstot=',Mstot);
// end;

//Ntot:=Nstot+Rss*Ass;//
//M:=Rb*b*(deltax*(x-deltax/2)+SQR(x-deltax)/3)+Rss*Ass*(h-x)+Mstot;

//xsnip:=Rss*Ass/Rb/b;
//Msnip:=Rss*Ass*(h-xsnip/2);

//writeln ('x=',x,' deltax=',deltax,' xsnip=',xsnip);
//writeln ('Ntot=',Ntot,' Nb=',Nb);
//writeln ('M=',M,' Msnip=',Msnip);
//writeln ('Msnip/M=',Msnip/M);

```

```
//writeln ('epsib=',epsib,' epsic=',epsic, ' epsic/epsib=',epsib/epsic);  
//writeln ('Mstot=',Mstot,' Nstot=',Nstot);  
//writeln ('GG=',GG);  
//writeln ('Rsdop=',Rsdop,' Esdop=',Esdop);  
end.
```

“ingener7.pas”

```

program ingener7;
uses CRT;
const l=150;
const b1=20; b2=8; h=30;
const Rb1=22.2; Rb2=110; epsibu=0.00161;
const Eb1=12500; Eb2=200000;//

const Asosn=1; Rsosn=5000;Rrazr=6000;//

const Ess=2000000; epsiuk=0.025;
const pogresh=0.01;

const sigmazadan=5990;//

const Assdop=0.1; Rssdop=3550; //

const ashtrich=4.5; //
const omega=0.8;//      .      (
    .21 - lamda)
const ns=5; //      (      ,
    )
label 10,15,20,50;
var Ass: array [1..50] of real;
var Rss: array [1..50] of real;
var astr: array [1..50] of real;
var epsis: array [1..50] of real;
var sigmas: array [1..50] of real;

```

```

var i,jj:integer;
var CC: real;
var xsnip,Msnip,Psnip:real;
var epsiss1,MM,PP,x,xiter,NNs:real;
var
deltasigmas,deltaR,epsiupr,kriv,EJuprug,krivuprug,epsibmax:real;
begin
  astr[1]:=4.5; astr[2]:=1; astr[3]:=8; astr[4]:=15; astr[5]:=22;
//
CC:=(Rb1*b1+Rb2*b2)*omega;
Ass[1]:=Asosn; Rss[1]:=Rsosn;
  for i:=2 to ns do begin
Ass[i]:=Assdop;
  Rss[i]:=Rssdop;
  end;
  if sigmazadan>Rsosn then goto 10;//

  epsiss1:=Rss[1]/Ess;// ( )

  sigmas[1]:=Rss[1]; // ( )

  goto 15;
10: // !!!!!
  deltasigmas:=sigmazadan-Rsosn;
  deltaR:=Rrazr-Rsosn;
  epsiupr:=Rsosn/Ess;
  epsiss1:=(deltasigmas*epsiuk-epsiupr*(deltasigmas-
deltaR))/deltaR;
  sigmas[1]:=sigmazadan;
  Rss[1]:=sigmazadan;

```

```

//          !!!!!
15: x:=Rss[1]*Ass[1]/CC; //          .          (
      - )
      xiter:=x;
20: writeln ('          =' ,jj, ' x=' ,x);
      MM:=0; //          !!!
      NNs:=0; //          !!!
for i:=2 to ns do begin
      epsis[i]:=epsiss1*(h-x- astr[i])/(h-x- astr[1]);
      sigmas[i]:=epsis[i]*Ess;
      if sigmas[i]>Rss[i] then sigmas[i]:=Rss[i];
      if sigmas[i]<0 then sigmas[i]:=0;
end;
      for i:=1 to ns do begin;
NNs:=NNs+sigmas[i]*Ass[i]; //
      end;
      x:=NNs/CC;
      if ABS(xiter-x)/ABS(xiter)<=pogresh then goto 50;
xiter:=x; jj:=jj+1;
      goto 20;
50: //          !
      kriv:=epsiss1/(h- astr[1]-x);
      for i:=1 to ns do begin
          MM:=MM+sigmas[i]*Ass[i]*(h- astr[i]-omega*x/2);
end;
      PP:=4*MM/l;
      xsnip:=Rss[1]*Ass[1]/(Rb1*b1+Rb2*b2); //
- -
      Msnip:=Rss[1]*Ass[1]*(h- astr[1]-xsnip/2); //
-

```

```

Psnip:=4*Msnip/l;           //    !!!
EJuprug:=Eb1*(b1*Power(h,3)/12)+Eb2*(b2*Power(h,3)/12);
krivuprug:=MM/EJuprug;//
    !!!
epsibmax:=epsiss1*x/(h-x-ast[1]);
    writeln ('x=',x, ' xsnip=',xsnip);
    writeln ('PP=',PP, ' Psnip=',Psnip);
    writeln ('MM=',MM, ' Msnip=',Msnip);
    for i:=1 to ns do begin
        writeln ('sigmas[',i,']=',sigmas[i]);
    end;
    writeln ('epsiss1=',epsiss1, ' kriv=',kriv);
    writeln ('krivuprug=',krivuprug, ' kriv/krivuprug=',kriv/krivuprug);
    writeln ('epsibmax=',epsibmax,
epsibmax/epsibu=',epsibmax/epsibu);
    end.

```



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№ 3/11 від 11.11.2019 р.

ДОВІДКА
Про впровадження результатів дисертації

Результати дисертаційної роботи Миза Олександра Сергійовича на тему «КОМБІНОВАНІ ЗГІНАЛЬНІ КОНСТРУКЦІЇ З НЕСУЧИМИ ЗАЛІЗОБЕТОННИМИ ПЛАСТИНАМИ І КАМ'ЯНИМ ЗАПОВНЕННЯМ», яка представлена на здобуття наукового ступеня кандидата технічних наук, використані при розробленні проекту підсилення цегляних стін на об'єкті «Капітальний ремонт житлового будинку №10 по пр. Шевченка, м. Суми».

Директор



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вих. № _____
від _____.

ДОВІДКА ПРО ВПРОВАДЖЕННЯ

Матеріали дисертації Миза Олександра Сергійовича «Комбіновані згинальні конструкції з несучими залізобетонними пластинами і кам'яним заповненням» були використані під час реконструкції нежитлової будівлі по вул. Садовій, 15 в м. Умань. При цьому використана методика підсилення цегляних стін підвалу односторонньою залізобетонною пластиною.

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Україна

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Довідка про впровадження

Наше підприємство використовувало матеріали дисертації «Комбіновані згинальні конструкції з несучими залізобетонними пластинами і кам'яним заповненням» Мизи О.С. під час капітального ремонту навчально корпусу № 4 НУ ОМА в м.Одесі.

Директор ТОВ «Ілкомсвіт»



Басенко Д.В.

ТОВАРИСТВО З ОБМЕЖЕНОЮ ВІДПОВІДАЛЬНІСТЮ
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**Довідка про впровадження
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ТОВ «СІГОЛ» взяло до уваги результати дисертаційної роботи Мизи Олександра Сергійовича «Комбіновані згинальні конструкції з несучими залізобетонними пластинами і кам'яним заповненням» та використало їх під час капітального ремонту ОЗОШ №60 1-3 ступенів, розташованої за адресою: м.Одеса, вул.Комітетська, 5

Директор ТОВ «СІГОЛ»



Міцура І.І.