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CALCULATION OF I-SECTION ROD REINFORCEMENTS LEANED STIFFENING RIBS

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In the article the method of construction of the algorithm for finding the free terms of the canonical equations of the force method for adjusted calculating the single-span hinged-cantilever and simply supported I-beams with asymmetrical cross-section with the t-number of "anti-torsional connections" is enclosed. At the same time the given system is divided into a range of bands composing it (the basic system) and operation of each band is considered separately. It is shown that for appropriateness of separate consideration of each of these bands it is necessary to apply unknown efforts of interaction to their adjoining edges, which substitute for the influence of discarded parts.

From the standpoint of functional analysis, search for free members $\Delta_{i,K(x)}$ of the canonical system of equations by iteration is the definition of a fixed point $\Delta_{0,K(x)}$ Euclidean space Δ (space motion) when it is displayed in yourself. Determination of successive approximations $\Delta_{i,K(x)}$, educing to a fixed point $\Delta_{0,K(x)}$, can be made on the basis of any element.

Selecting an item will affect only the rate of convergence to its limit $\Delta_{0,K(x)}$.

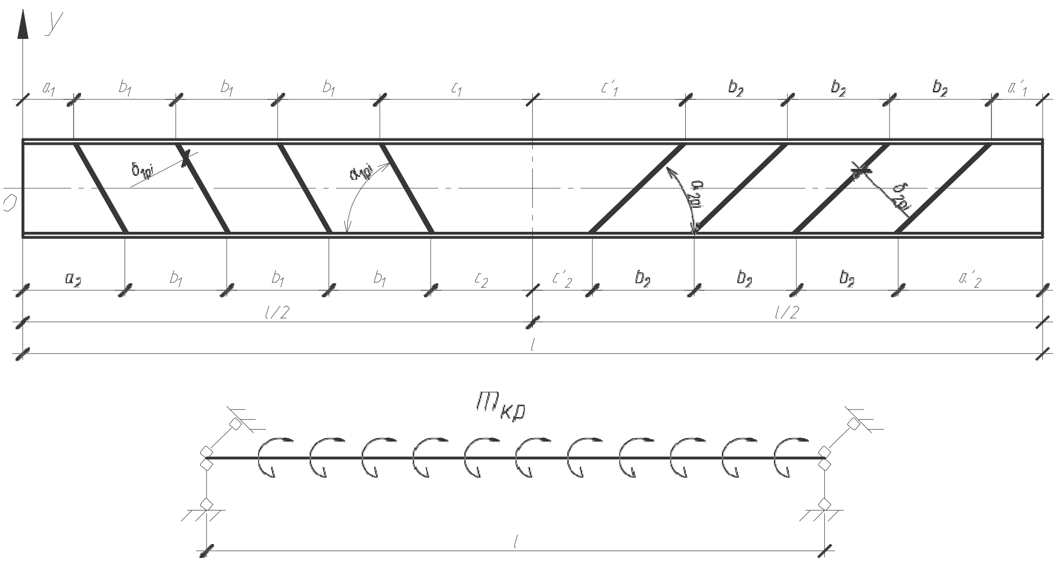
Moreover, it is known that «*n*» – the solution of the canonical equations of the forces method $A \cdot X = G^1$ by the initial approximation $X^{(0)}$ is expressed as:

$$X^{(n)} = B^{(n)} \cdot X^{(n)} + (E^1 + B ... + B^{(n-1)}) \cdot G^1 , \tag{1}$$

E^1 – the identity matrix; A – the coefficient matrix of the system; G^1 – column of free members; $B = E^1 - A$; X – column with unknown values of members.

The question of the compressibility of the arithmetic n-dimensional space, which is the system of canonical equations, is not considered here, but many numerical solutions of this type of tasks show that the iterative process converges very quickly.

Suppose there is a rod asymmetrical I-beam cross-section (Fig., *a*) with a «*t*» the number of inclined ribs in the form of sheet thickness diaphragms δ_{pi} and δ_{2pi}, installed on both sides of the wall of the beam angle and α_{pi} and α_{2pi}, providing communication bimoment opposing warping cross section and loaded evenly distributed torque $m_{кр}$ intensity (Fig., *b*).



a

b

I-section rod

Solving the differential equation of equilibrium $EJ_{\omega} \cdot \theta^{IV}(x) - EJ_d \cdot \theta^{II}(x) - m_{кр}(x) = 0$ the method of initial parameters and using the principle of superposition, we define the functions twist angles $\theta j(x)$ and sectional warping measure $\theta'(x)$.

It should be noted that the solution of a given location inclined rigid ribs bone will depend on the last step, the angle of inclination of the geometric dimensions of the ribs.

For example shown in Figure 1, and we will have

$$\frac{h_0}{tg\alpha_{pi}} < b_1 < \frac{\frac{l}{2} - (a_1 + c_1)}{\frac{t}{2} - 1},$$

$$\frac{h_0}{tg\alpha_{2pi}} < b_2 < \frac{\frac{l}{2} - (a_1^1 + c_1^1)}{\frac{t}{2} - 1},$$

$$b_1 = b_2 = b;$$

If $j = 1; 0 < x < a_1$, than:

$j = 3, 5, 7, ..., (t-1); a_2 + \frac{j-3}{2} b < x < a_1 + \frac{j-1}{2} b$,

$$\theta_j(x) = \frac{1}{kGJ_\alpha} \left\{ \sum_{i=1}^{j-1} \left\{ \begin{aligned} & M_{i,(n-1)}^0 \left[k(1-\alpha_{1,i})(l-x) - \nu_{1,i} shk(l-x) \right] + M_{i,(n-1)} kr_1 \left[\frac{l-x}{l} - \xi_{1,i} shk(l-x) \right] + \\ & + M_{i,(n-1)}^1 \left[k(1-\alpha_{2,i})(l-x) - \nu_{2,i} shk(l-x) \right] + M_{i,(n-1)} kr_2 \left[\frac{l-x}{l} - \xi_{2,i} shk(l-x) \right] + \\ & + \sum_{i=\frac{j+1}{2}}^{\frac{t}{2}} M_{i,(n-1)}^0 \left[k\alpha_{1,i} x - \beta_{1,i} shkx \right] + M_{i,(n-1)} kr_1 \left[\frac{x}{l} - \eta_1 shkx \right] + \\ & + \left[\begin{aligned} & M_{i,(n-1)}^1 \left[k\alpha_{2,i} x - \beta_{2,i} shkx \right] + \overline{M}_{i,(n-1)} kr_2 \left[\frac{x}{l} - \eta_2 shkx \right] + \\ & + \sum_{i=\frac{t}{2}+1}^{t} \left[\begin{aligned} & M_{i,(n-1)}^0 \left[k\gamma_{1,i} x - \varepsilon_{1,i} shkx \right] + M^1{}_{i,(n-1)} \left[k\gamma_{2,i} x - \varepsilon_{2,i} shkx \right] - \\ & - M_{i,(n-1)} kr_1 \left[\frac{x}{l} - \lambda_{1,i} shkx \right] - \overline{M}_{i,(n-1)} kr_2 \left[\frac{x}{l} - \lambda_2 shkx \right] \end{aligned} \right] \end{aligned} \right] \end{aligned} \right\} + \theta_0(x) \right\} \quad (2)$$

$$\theta_j^{/}(x) = \frac{1}{GJ_\alpha} \left\{ \sum_{i=1}^{\frac{j-1}{2}} \left\{ \begin{aligned} & M_{i,(n-1)}^0 \left[\alpha_{1,i} - \nu_{1,i} chk(l-x) - 1 \right] + M_{i,(n-1)} r_1 \left[k\xi_{1,i} chk(l-x) - \frac{1}{l} \right] + \\ & + M_{i,(n-1)}^1 \left[\alpha_{2,i} - \nu_{2,i} chk(l-x) - 1 \right] + \overline{M}_{i,(n-1)} r_2 \left[k\xi_{2,i} chk(l-x) - \frac{1}{l} \right] + \\ & + \sum_{i=\frac{i+1}{2}}^{\frac{t}{2}} \left[M_{i,(n-1)}^0 \left[\alpha_{1,i} - \beta_{1,i} chkx \right] + M^1{}_{i,(n-1)} \left[\alpha_{2,i} - \beta_{2,i} chkx \right] \right] + \\ & + M_{i,(n-1)} r_1 \left[\frac{1}{l} - k\eta_{1,i} chkx \right] + \overline{M}_{i,(n-1)} r_2 \left[\frac{1}{l} - k\eta_{2,i} chkx \right] + \\ & + \sum_{i=\frac{j}{2}+1}^{\frac{t}{2}} \left[\begin{aligned} & M_{i,(n-1)}^0 \left[\gamma_{1,i} - \varepsilon_{1,i} chkx \right] + M^1{}_{i,(n-1)} \left[\gamma_{2,i} - \varepsilon_{2,i} chkx \right] - \\ & + M_{i,(n-1)} r_1 \left[\frac{1}{l} - k\lambda_{1,i} chkx \right] + \overline{M}_{i,(n-1)} r_2 \left[\frac{1}{l} - k\lambda_{2,i} chkx \right] \end{aligned} \right] \end{aligned} \right\} + \theta_0^{/}(x) \right\} \quad (3)$$

The values of the above statements describe the following equation

$$\theta_j\ (x)=\frac{m_{кр}}{k^2GJ_\alpha}\left[\frac{k^2x(l-x)}{2}+\frac{chk(0.5l-x)}{ch0.5kl}-1\right],$$

$$\theta_0^{/}(x)=\frac{m_{кр}}{k\ GJ_\alpha}\left[\frac{k^2x(l-x2)}{2}+\frac{shk(0.5l-x)}{ch0.5kl}-1\right],$$

$$M^0_{i,(n-1)}=x^0_{i,(n-1)}\cdot r_1, M^1_{i,(n-1)}=x^1_{i,(n-1)}\cdot r_2,$$

where the value of the elements $x^0_{i,(n-1)}, x^1_{i,(n-1)} -(n-1)$ is the decision system for the upper and lower zones of the beam [1; 2].

Hyperbole trigonometric functions in expressions (2) – (3), are displayed as a:

$$\alpha_{f,i}=\frac{l-(a_f+(i-1)b)}{l}, \gamma_{f,i}=\frac{l-(a_f+(i-2)b+c_1+c_1^{/})}{l},$$

$$\beta_{f,i}=\frac{shkl-(a_f+(i-1)b)}{shkl}, \eta_{f,i}=\frac{chkl-(i-2)b}{shkl},$$

$$\nu_{f,i}=\frac{shk(a_f+(i-1)b)}{shkl}, \xi_{f,i}=\frac{chk(a_f+(i-1)b)}{shkl}, \varepsilon_{f,i}=\frac{shkl-(a_f+(i-2)b+c_1+c_1^{/})}{shkl}$$

$$\lambda_{f,i}=\frac{chkl-(a_f+(i-2)b+c_1+c_1^{/})}{shkl}, \zeta=\frac{chk(a_f+(i-2)b+c_1+c_1^{/})}{shkl},$$

where

$$\alpha_f=a_0\pm\frac{r_f}{tg\alpha_{pi}}; c_f=\frac{l}{2}-\left[a_0+\left(\frac{t}{2}-1\right)b\right]\pm\frac{r_f}{tg\alpha_{pi}}; c_f^{/}=\frac{l}{2}\left[a_0^{/}+\left(\frac{t}{2}-1\right)b\right]\pm\frac{r_f}{tg\alpha_{2pi}}; \quad (4)$$

f – takes consecutively values 1 и 2; a_0, (a_0) – consideration of the left (right) end of the test rod to the first "anti-rotation link", measured by the neutral axis; r_f – coordinates of the center of the bend.

ω x Moreover, the upper sign in front of coefficients $\frac{r_f}{tg\alpha_{pi}}$ and $\frac{r_f}{tg\alpha_{2pi}}$ in the expressions (6) have a sense when *f* = 1, lower sign – when *f* = 2.

In practice, to determine the coordinates r_1 we take the center of gravity of the upper horizontal plate in the pole frame.

After that we create diagrams sectorial origin ω with selected pole and line coordinates *x*.

After the integration of these diagrams, we have

$$r_1=\frac{h\cdot b^3_{нп}\cdot\delta_{нп}}{12y}, \text{ or } r_2=-\frac{J_{yнп}}{J_y}\cdot h.$$

Negative meaning indicates that the desired coordinate should be deferred from the pole B with negative direction OY. Substituting the values of twist angles in the well-known formula [1; 2]

$$K_j(x)=\frac{M_x-GJ_d\dfrac{d\theta(x)}{dx}}{h_0}.$$

After some transformations, we obtain the resultant shear stresses sectorial τ_ω – cross load $K_j(x)$ as a

$$K_j(x)=\frac{1}{h_0}\left(\frac{m_{кр}\cdot l}{2}-A_jchkx-B_jch(l-x)+\frac{m_{кр}}{kch0.5kl}\cdot shk\left(\frac{l}{2}-x\right)+F_j-C_j\right). \quad (5)$$

As a result we obtain the bending moment and shear force in the upper and lower zones of the studied beams

$$Q_j(x)=K_j(x),$$

$$M_j(x)=\frac{1}{h_0}\left\{m_{кр}\left[\frac{l\cdot x}{2}-\frac{1}{k^2ch0.5kl}\cdot chk\left(\frac{l}{2}-x\right)\right]-\frac{1}{k}\left[A_jshx-B_jshk(l-x)\right]+F_j-C_jx+D_j\right\}, \quad (6)$$

Dj – constant of integration provided by $j = 2,4,6,...,t$:

$$D_j=\frac{1}{h_0}\sum_{i=1}^{\frac{j}{2}}\left\{\left[C_{2i}-F_{2i}-C_{2i-1}-F_{2i-1}\right](1-\alpha_{1,i})l+\frac{shkl}{k}\left[A_{2t}-A_{2t-1}\cdot\nu_{1,i}-B_{2,i}-B_{2,i-1}\cdot\beta_{1,i}\right]\right\}+$$

$$+\frac{1}{h_0}\sum_{i=1}^{\frac{j}{2}-1}\left\{\left[C_{2i+1}-F_{2i+1}-C_{2i}-F_{2i}\right](1-\alpha_{2,i})l+\frac{shkl}{k}\left[A_{2i+1}-A_{2i}\cdot\nu_{2,i}-B_{2i+1}-B_{2,i}\cdot\beta_{2,i}\right]\right\}+\frac{1}{k^2\cdot h}\cdot m_{кр}-B_1k\cdot shkl. \quad (7)$$

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Specific bending moments and shear forces in the belts beams from individual efforts taking as defined below

$$\bar{x}_i=1,\bar{x}_{i/2+1}=1,\bar{x}_{t+i}=1,\bar{x}_{3t/2+1}=1.$$

In the given boundary conditions and acceptance of the rights of characters get a result:

$$\left.\begin{aligned}\overline{M_{1,f,i}}&=-\alpha_{f,i}x\\ \overline{M_{2,f,i}}&=-(1-\alpha_{f,i})(l-x)\\ \overline{Q_{1,f,i}}&=-\alpha_{f,i}\\ \overline{Q_{2,f,i}}&=1-\alpha_{f,i}\end{aligned}\right\}i=1,2,3,...,\frac{t}{2},\quad \left.\begin{aligned}\overline{M_{2,f,i}}&=-(1-\delta_{f,i})(l-x)\\ \overline{Q_{1,f,i}}&=-\delta_{f,i}\\ \overline{Q_{2,f,i}}&=1-\delta_{f,i}\end{aligned}\right\}i=\left(\frac{t}{2}+1\right),\left(\frac{t}{2}+1\right),...,t$$

$$\left.\begin{aligned}\overline{M_{1,f,i}}&=\pm\frac{1}{l}x\\ \overline{M_{2,f,i}}&=\pm\frac{(l-x)}{l}\\ \overline{Q_{f,i}}&=\pm\frac{1}{l}\end{aligned}\right\}i=(t+1),(t+2),...,2t \quad (8)$$

The values used depend on the internal efforts indicate the number of area moment diagrams M_i and diagrams of lateral forces Q_i. Thus, if f = 1, the upper, and if f = 2 is the lower.

The sign of the (11) has the following laws:

If the $i=(t+1),(t+2),(t+3),...,\frac{3t}{2}$ is in front of the $\frac{1}{l}\cdot x,\frac{l-x}{l},\frac{1}{l}$ you need to put top marks, and if the $i=\left(\frac{3t}{2}+1\right),\left(\frac{3t}{2}+2\right),\left(\frac{3t}{2}+3\right),...2t$ - you need to put lower marks.

Substituting (9), (10) and (11) in formula[2]

$$\left|z_i^{(n)}-z_i^{(n-1)}\right|\le\varepsilon_1$$
$$\left|y_i^{(n)}-y_i^{(n-1)}\right|\le\varepsilon_1$$

and we get the free members of the system, respectively, for the upper and lower belts of the investigated beam.

When programming the iterative process the most convenient features free members to submit a substitution:

$$\Delta_{i,K(x)}=\int_{a_i}^{b_i}f(x)dx=\left|F_i(x)\right|_{a_i}^{b_i}=F_i(b_i)-F_i(a_i). \quad (9)$$

The present study attempts to build the exact method of calculation of thin-walled open section of prismatic bars with different types of inclined ribs and arbitrary location along the length of the bar to the action of torsional loads. This analyzed the rod (target system) is divided into a number of its constituent bands (the main system) and is considered the work of each band independently. For the legitimacy of an independent review of each of these bands to their adjacent edges must be applied by unknown forces of interaction, the effect of replacing the discarded parts.

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ECONOMICALLY EFFICIENT WAYS TO IMPROVE THE RELIABILITY OF WATER SUPPLY SYSTEMS

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Housing services belong to the social sphere connected with everyday life needs of the population . Water supply of cities, settlements and industrial facilities in the required quantities and of the required quality at the required pressure is one of the main tasks of housing services. Improving the reliability of water supply systems is the basis for ensuring safe operation of water utility facilities.

At present considerable attention is paid to ensuring the security of production processes in all spheres of life. The main components in ensuring the safety of production processes are: safety requirements, organization of production, regulation, technical tools, automatization of production as a whole and its processes, control of production, innovative solutions.

In this research the increased reliability to ensure safe production processes, operation, reconstruction and construction of one of the most important aspects of life are analysed. This area covers the water supply systems of cities and towns, settlements, and industrial objects.

Improper operation of water networks for a long time leads to deterioration of their technical condition that has a significant impact on the occurrence of failures and violations in their work. This reflects a reduction in the reliability of water supply systems. To provide the population with high-quality water in the required amount which will meet the existing state standards, it is necessary to take a number of certain measures to improve the reliability of municipal water supplies.

In general the problem of reliability covers a wide range of issues related to providing and maintaining the required level of output of certain types of equipment and structures that are part of the water supply system. Improving the reliability of water networks and their functioning contributes to the growth of labour productivity, saving material resources thus further improving standards of living.

Unfavourable situation with water supply today is under discussion in many countries. Therefore, the problem of improving the stability and reliability of water supply pipelines functioning is now more relevant than ever.

The relevance of this work lies in the consideration of the methods the application of which will make it possible to improve the reliability of water supply systems, namely, methods that are applied to the main element of the system – water supply network. Apart from that the problem of economic efficiency of these methods is considered. Therefore, the method to be chosen should only slightly increase construction costs and subsequent maintenance costs without decreasing quality and working parameters of the system.

Water systems are complex structures designed to supply water in the required quantities and of required quality at the required pressure, at the same time ensuring the reliability of their performance.

The pipelines of the water distribution network are the key elements of urban water supply and, in practice, are its most vulnerable part. Consequently, ensuring reliability of the water supply network functioning correctly is crucial. Water supply network is a system of pipes through which water is transported to consumers.

Systems of water supply and distribution are to meet the following basic requirements:

- to provide consumers with a calculated amount of water;
- to create required pressure in the distribution networks;
- to preserve water quality during its transportation;
- to ensure the reliability and continuity of supply.

Besides the network should be most economical, i.e. to have minimal costs for the construction and operation of the network.