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RESEARCH OF A STATIC CABLE ROPE WITH A BREAK OF A CABLE

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Abstract. Establishing the influence of changes in the temporary properties of rubber on the stress state of the rubber traction body with a damaged cable. The method of research consists in the analytical solution of the model of the humorous traction body taking into account the rupture of the cable continuity and the change in the properties of the rubber. The dependences of the change of the stress state of the traction body of the humotross with the broken structure due to the rheology of the rubber shell are established. An algorithm for determining the stress state of a rubber traction body in case of its failure is formulated. It is shown that the loads on the ropes caused by the rupture of one of them lead to a local redistribution of forces almost only between two cables - damaged and adjacent; when damaged, non-extreme cable forces change in almost only three cables - damaged and two related. There are no extreme values of the internal load forces of the cables, which depend on the change of the shear modulus of the rubber material over time.

Construction of a method for determining the influence of impulses of individual cables of a cable rubber rope on its stress state.

Development and solution of the model of stress-strain state of the cable rubber rope with breaks in the continuity of the cables.

Methods of determining the stress state of a cable rope with a damaged cable.

The mechanism and nature of the influence of the impulses of the continuity of the cable of the cable rubber rope on its stress-strain state.

The developed method allows to take into account the influence of cable bursts on the stress state of the humorous cable rope of arbitrary design. Its application will allow to reasonably determine the minimum reserves of strength under the condition of safe use of the rubber rope, including in case of rupture of individual cables.

The mechanism of influence of change of properties of rubber on pressure is established by a condition of a traction body taking into account a rupture of continuity of a cable and change of properties of rubber. Taking into account the dependence of the stress-strain state of the rope with local violations of the cable base on changes in mechanical properties of rubber provides the ability to predict the stress state of the rope to improve safety and reliability of rubber traction with a long service life.

Key words: rubber, cable rupture, stress state, cable rope.

1. Introduction

One of the directions of construction development is to reduce the cost of construction and timing of construction, such as cable-stayed bridges. Less noticeable technical solutions such as reinforced concrete structures are being introduced. They, with a large size in the plan, have a small mass [1]. In such constructions reinforced concrete slabs are connected by cables. One of the problems of implementation of such structures is to ensure their reliability throughout the life of the structure.

Cable rubber rope consists of parallel cables located in parallel layers and connected into a single product by an elastic shell. It protects the rope ropes from the aggressive effects of the environment. Cables, as elements of the system with parallel connection of elements and incomplete redundancy, significantly increase the reliability of the system - cable rope.

A factor affecting the reliability of the rope is the rupture of the integrity of one of the ropes. Reduction of rope reliability in case of cable rupture should be taken into account in the rope design process provided that the specified level of incomplete redundancy is ensured. The rupture of the cable locally changes the stress-strain state (VAT) of the rope. Locally, the internal load forces of the cables increase. The method of determining the stress state of the rope with a comprehensive account of its mechanical characteristics, design, rupture of an arbitrary cable is absent. The development of a method for determining the stress-strain state of a cable rope will allow to solve the current scientific and technical problem of improving the safety of operation of capital facilities in which cables are used.

The rubber cable rope is composite in its construction. The influence of ruptures of reinforcement elements of composite flat rubber ropes (tapes) is considered in a number of works [2-7]. Issues of restoring the traction capacity of humorous traction bodies with damaged ones are considered in [8, 9]. The ends of the conveyor belts are connected. In [10] the stress state of the joints was investigated.

The rope, according to the operating conditions, consists of an arbitrary pair of ropes. Cables, in order to minimize the weight of the rope, are laid regularly, with a technically determined step. The distribution of loads between the cables depends on the design of the rope and the properties of the elastic shell, the nature of the load.

2. Calculation of effective perforated welded beams

Based on the peculiarities of the design of the cable rope, the conditions of its operation, we take a number of simplifications. The cable rope is loaded only by tensile forces. We will consider only such forces. The tensile stiffness of the ropes exceeds the stiffness of the elastic shell located between the ropes. Assume that the elastic shell between the cables transmits only the shear stress. Rope ropes are loaded with forces within their linear deformation. We will solve the problem of force distribution between the cables as a linear one.

The number of layers of cables in the rope is denoted by N. The number of cables in layers M. We determine the location of cables by their numbers j ($1 \leq j \leq N$) and i ($1 \leq i \leq M$). Take the rope to the x-axis parallel to it.

We formulate the equilibrium condition of a rope of short length dx cut from a rope

$$dP_{i,j} + \left(\tau_{1,i,j-1} - \tau_{1,i.j} + \tau_{2,i-1,j} - \tau_{2,i.j}\right) bdx = 0\,, \tag{1}$$

where τ – the average values of the shear stress in the material of the elastic shell located between the cables; b – step of arrangement of layers of cables and cables in layers

$$\tau_{1,i,j} = \frac{Gk_G}{b-d}\left(u_{i,j} - u_{i,j-1}\right), \tag{2}$$

$$\tau_{2,i,j} = \frac{Gk_G}{b-d}\left(u_{i,j} - u_{i-1,j}\right), \tag{3}$$

where G – the shear modulus of the elastic sheath material of the cable rope; k_G – coefficient taking into account the influence of the shape of the elastic shell located between the cables on its stiffness shear; d is the diameter of the rope ropes.

Substitute (2), (3) into (1). We will receive

$$\frac{dP_{i,j}}{dx} + \frac{Gk_G}{h} b\left(u_{i,j-1} - 4u_{i,j} + u_{i,j+1} + u_{i-1,j} + u_{i+1,j}\right) = 0. \tag{4}$$

Hooke's law for longitudinal deformation of a cable

$$P_{i,j} = EF\frac{du_{i,j}}{dx}, \tag{5}$$

where E is the modulus of elasticity and the cross-sectional area of the cable.

Consider (5). We write (4) in the following form

$$\frac{d^2u_{i,j}}{dx^2} + \frac{Gbk_G}{EF(b-d)}\left(u_{i,j-1} - 4u_{i,j} + u_{i,j+1} + u_{i-1,j} + u_{i+1,j}\right) = 0\,. \tag{6}$$

A system of homogeneous equations is compiled for an arbitrary cable. The equilibrium condition of the extreme cables is excellent

$$\frac{d^2u_{1,j}}{dx^2} + \frac{Gbk_G}{EF(b-d)}\left(u_{1,j-1} - 3u_{1,j} + u_{1,j+1} + u_{2,j}\right) = 0\,, \tag{7}$$

$$\frac{d^2u_{M,j}}{dx^2} + \frac{Gbk_G}{EF(b-d)}\left(u_{M,j-1} - 3u_{M,j} + u_{M,j+1} + u_{M-1,j}\right) = 0, \tag{8}$$

$$\frac{d^2u_{i,1}}{dx^2} + \frac{Gbk_G}{EF(b-d)}\left(-3u_{i,1} + u_{i,2} + u_{i-1,1} + u_{i+1,1}\right) = 0, \tag{9}$$

$$\frac{d^2u_{i,N}}{dx^2} + \frac{Gbk_G}{EF(b-d)}\left(u_{i,N-1} - 3u_{i,N} + u_{i-1,N} + u_{i+1,N}\right) = 0. \tag{10}$$

Expressions (6) - (10) are $N \cdot M$ of homogeneous systems of equations. We will look for their solution with respect to displacements in the form of products of functions depending on the location of the cables in the rope crossing and the functions of the x coordinate

$$u_{i,j} = e^{\beta x + \sqrt{-1}\mu i + \sqrt{-1}\chi j}. \tag{11}$$

The values of the characteristic indicators with an imaginary factor are taken from the condition of satisfying the systems of homogeneous equations (7) - (10)

$$\mu_m = \frac{\pi m}{M}, \ \chi_n = \frac{\pi n}{N}. \tag{12}$$

Substitute the values of the accepted components of the characteristic indicators in (6). Let's define other characteristic indicators

$$\beta_{m,n} = \pm\sqrt{2\frac{Gb}{hEF}(2-\cos(\mu_m)-\cos(\chi_n))},$$

$$\beta m_m = \pm\sqrt{2\frac{Gb}{hEF}(1-\cos(\mu_m))},$$

$$\beta n_n = \pm\sqrt{2\frac{Gb}{hEF}(1-\cos(\chi_n))}, \ 1 \le m \le M, \ 1 \le n \le N. \tag{13}$$

Wanted movement of cables

$$u_{i,j} = \Bigg(\sum_{m-1}^{M-1}\sum_{n=1}^{N-1}\left(A_{m,n}e^{\beta_{m,n}x} + B_{m,n}e^{-\beta_{m,n}x}\right)\beta_{m,n}\cos\left(\mu_m(i-0{,}5)\right)\cos\left(\chi_n(j-0{,}5)\right) +$$
$$+\sum_{m-1}^{M-1}\left(Am_m e^{\beta m_m x} + Bm_{m,k}e^{-\beta m_m x}\right)\beta m_m\cos\left(\mu_m(i-0{,}5)\right) +$$
$$+\sum_{n=1}^{N-1}\left(An_n e^{\beta n_n x} + Bn_{n,k}e^{-\beta n_n x}\right)\beta n_n\cos\left(\chi_n(j-0{,}5)\right)\Bigg) + \frac{Px}{EF} + \delta, \tag{14}$$

where δ are unknown constants.

We use Hooke's law (5). We obtain the expression for determining the internal load forces of the rope ropes

$$p_{i,j} = EF\Bigg(\sum_{m-1}^{M-1}\sum_{n=1}^{N-1}\left(A_{m,n}e^{\beta_{m,n}x} - B_{m,n}e^{-\beta_{m,n}x}\right)\beta_{m,n}\cos\left(\mu_m(i-0{,}5)\right)\cos\left(\chi_n(j-0{,}5)\right) +$$
$$+\sum_{m-1}^{M-1}\left(Am_m e^{\beta m_m x} - Bm_{m,k}e^{-\beta m_m x}\right)\beta m_m\cos\left(\mu_m(i-0{,}5)\right) +$$
$$+\sum_{n=1}^{N-1}\left(An_n e^{\beta n_n x} - Bn_n e^{-\beta n_n x}\right)\beta n_n\cos\left(\chi_n(j-0{,}5)\right)\Bigg) + P. \tag{15}$$

The formulated regularities of distribution of displacements and internal forces of loading of ropes of a rope (14), (15), at known values of unknown constants, sizes allow to define the VAT of a cable-stayed rubber rope. The values of unknown constants should be determined from the condition and load of the rope.

Consider the problem of determining the VAT of a rope with a damaged cable. Let the length of the rope *L*. The rope ends are attached to the structure. The beginning of the coordinate axis is compatible with one end of the rope. In the section x = l the *I*, *J*-th cable is damaged. In cross section, it violates the design of the rope, in our case, the condition of the continuity of its cables. Solutions (14) and (15) are constructed for a rope without cable breaks so they are not acceptable for such a case. In order to solve this problem, we will conditionally cut the rope into two parts with a cross section of the cable break. In each part the cables are solid. Solutions (14) and (15) are acceptable for them. We will give numbers one and two to the parts. We will write down numbers in indexes of the sizes concerning them. In sections (x=0) and (x=L) the rope is rigidly attached to the structure. In accordance

$$A_{1,m,n}=-B_{1,m,n},\ Am_{1,m}=-Bm_{1,m},\ An_{1,n}=-Bn_{1,n},$$

$$A_{2,m,n}=-B_{2,m,n}e^{-2\beta_{m,n}L},\ Am_{2,m}=-Bm_{2,m}e^{-2\beta m_m L},\ An_{2,n}=-Bn_{2,n}e^{-2\beta n_n L}. \quad (16)$$

The internal forces of loading the cables and their movement will take the following forms

$$p_{1,i,j}=EF\left(\sum_{m-1}^{M-1}\sum_{n=1}^{N-1}B_{1,m,n}\left(e^{\beta_{m,n}x}+e^{-\beta_{m,n}x}\right)\beta_{m,n}\cos(\mu_m(i-0,5))\cos(\chi_n(j-0,5))+\right.$$
$$+\sum_{m-1}^{M-1}Bm_{1,\eta,m,k}\left(e^{\beta m_m x}+e^{-\beta m_m x}\right)\beta m_m\cos(\mu_m(i-0,5))+$$
$$\left.+\sum_{n=1}^{N-1}Bn_{1,\eta,n,k}\left(e^{\beta n_n x}+e^{-\beta n_n x}\right)\beta n_n\cos(\chi_n(j-0,5))\right)+P, \quad (17)$$

$$u_{1,i,j}=\sum_{m-1}^{M-1}\sum_{n=1}^{N-1}B_{1,m,n}\left(e^{\beta_{m,n}x}-e^{-\beta_{m,n}x}\right)\cos(\mu_m(i-0,5))\cos(\chi_n(j-0,5))+$$
$$+\sum_{m-1}^{M-1}Bm_{1,m,k}\left(e^{\beta m_m x}-e^{-\beta m_m x}\right)\cos(\mu_m(i-0,5))+$$
$$+\sum_{n=1}^{N-1}Bn_{1,n,k}\left(e^{\beta n_n x}-e^{-\beta n_n x}\right)\cos(\chi_n(j-0,5))+\frac{P}{E\ F}x+\delta_1, \quad (18)$$

$$p_{2,i,j}=-EF\left(\sum_{m-1}^{M-1}\sum_{n=1}^{N-1}B_{2,m,n}\left(e^{-\beta_{m,n}x}+e^{\beta_{m,n}(x-2L)}\right)\beta_{m,n}\cos(\mu_m(i-0,5))\cos(\chi_n(j-0,5))+\right.$$
$$+\sum_{m-1}^{M-1}Bm_{2,m,k}\left(e^{-\beta m_m x}+e^{\beta m_m(x-2L)}\right)\beta m_m\cos(\mu_m(i-0,5))+$$
$$\left.+\sum_{n=1}^{N-1}Bn_{2,n,k}\left(e^{-\beta n_n x}+e^{\beta n_n(x-2L)}\right)\beta n_n\cos(\chi_n(j-0,5))\right)+P, \quad (19)$$

$$u_{2,i,j}=\sum_{m-1}^{M-1}\sum_{n=1}^{N-1}B_{2,m,n}\left(e^{-\beta_{m,n}x}-e^{\beta_{m,n}(x-2L)}\right)\cos(\mu_m(i-0,5))\cos(\chi_n(j-0,5))+$$
$$+\sum_{m-1}^{M-1}Bm_{2,m,k}\left(e^{-\beta m_m x}-e^{\beta m_m(x-2L)}\right)\cos(\mu_m(i-0,5))+$$
$$+\sum_{n=1}^{N-1}Bn_{2,n,k}\left(e^{-\beta n_n x}-e^{\beta n_n(x-2L)}\right)\cos(\chi_n(j-0,5))+\frac{P}{EF}x+\delta_2, \quad (20)$$

Consider the compatibility of deformation of parts in the cross section $x = l$. We introduce the condition of equality of forces of loading of cables

$$p_{1,i,j} = p_{2,i,j}. \tag{21}$$

From condition (21) we find the ratio of unknown constants

$$B_{1,m,n,k} = B_{2,m,n,k} \frac{e^{-\beta_{m,n,k}l} + e^{\beta_{m,n,k}(l-2L)}}{e^{-\beta_{m,n,k}l} + e^{\beta_{m,n,k}l}},$$

$$Bm_{1,m,k} = Bm_{2,m,k} \frac{e^{-\beta m_{m,k}l} + e^{\beta m_{m,k}(l-2L)}}{e^{-\beta m_{m,k}l} + e^{\beta m_{m,k}l}}. \tag{22}$$

Displacement taking into account the relations (22)

$$u_{1,i,j} = \sum_{m-1}^{M-1}\sum_{n=1}^{N-1} B_{2,m,n} \frac{e^{-\beta_{m,n}l} + e^{\beta_{m,n}(l-2L)}}{e^{-\beta_{m,n}l} + e^{\beta_{m,n}l}} \left(e^{\beta_{m,n}x} - e^{-\beta_{m,n}x}\right)\cos\left(\mu_m(i-0,5)\right)\times$$

$$\times\cos\left(\chi_n(j-0,5)\right) + \sum_{m-1}^{M-1} Bm_{2,m} \frac{e^{-\beta m_m l} + e^{\beta m_m(l-2L)}}{e^{-\beta m_m l} + e^{\beta m_m l}} \left(e^{\beta m_m x} - e^{-\beta m_m x}\right)\times$$

$$\times\cos\left(\mu_m(i-0,5)\right) + \sum_{n=1}^{N-1} Bn_{2,n} \frac{e^{-\beta n_n l} + e^{\beta n_n(l-2L)}}{e^{-\beta n_n l} + e^{\beta m_n l}} \left(e^{\beta n_n x} - e^{-\beta n_n x}\right)\times$$

$$\times\cos\left(\chi_n(j-0,5)\right) + \frac{Pl}{EF} + \delta_1, \tag{23}$$

$$u_{2,i,j} = \sum_{k=0}^{K} C_k\cos(\alpha_k t)\left[\sum_{m-1}^{M-1}\sum_{n=1}^{N-1} B_{2,m,n,k}\left(e^{\beta_{m,n,k}x} - e^{-\beta_{m,n,k}x}\right)\cos\left(\mu_m(i-0,5)\right)\times\right.$$

$$\times\cos\left(\chi_n(j-0,5)\right) + \sum_{m-1}^{M-1} Bm_{2,m,k}\left(e^{\beta m_{m,k}x} - e^{-\beta m_{m,k}x}\right)\cos\left(\mu_m(i-0,5)\right) +$$

$$\left. + \sum_{n=1}^{N-1} Bn_{2,n,k}\left(e^{\beta n_{n,k}x} - e^{-\beta n_{n,k}x}\right)\cos\left(\chi_n(j-0,5)\right)\right] + \frac{P + bc\rho l}{EF} + \delta_2. \tag{24}$$

As a result of the rupture of the cable, a gap of unknown size is formed between its ends. We formulate the condition of the difference in the movements of the cables in the cross section x = l, taking into account the formation of a gap between the ends of the damaged cable

$$u_{1,i,j} - u_{2,i,j} = U_0 \sum_{k=0}^{K} C_k\cos\left(\alpha_k t\right)\begin{cases}1, & i = I \wedge j = J\\ 0, & i \neq I \vee j \neq J\end{cases}. \tag{25}$$

The difference of displacements in expression (25) is decomposed into a Fourier series. Determine the values of constants with an unknown gap between the ends of the damaged cable

$$B_{2,m,n} = U_0 \frac{4e^{\beta_{m,n}l}\cos\left(\mu_m(I-0,5)\right)\cos\left(\chi_n(J-0,5)\right)}{MN\left(-\dfrac{1 + e^{2\beta_{m,n}(l-L)}}{th(\beta_{m,n}l)} + e^{2\beta_{m,n}(l-L)} - 1\right)}, \tag{26}$$

$$Bm_{2,m} = U_0 \frac{2\cos\left(\mu_m (I-0,5)\right)}{MN\left(-\dfrac{1+e^{2\beta m_m (l-L)}}{th(\beta m_m l)} + e^{2\beta m_m (l-L)} - 1\right)}, \tag{27}$$

$$Bn_{2,n} = U_0 \frac{2\cos\left(\mu_m (I-0,5)\right)}{MN\left(-\dfrac{1+e^{2\beta n_n (l-L)}}{th(\beta n_n l)} + e^{2\beta n_n (l-L)} - 1\right)}, \tag{28}$$

$$\delta_2 = \delta_1 - \frac{U_0}{MN}. \tag{29}$$

The first parts of the rope, under the accepted conditions, are fixed. Therefore $\delta_1 = 0$. The ends of the damaged cable in the cross section $x = l$ are not loaded. From this condition, taking into account the unknown constants found and their ratio, the magnitude of the gap in the cross section of the cable rupture

$$U_0(t) = PMN \Bigg/ 2EF \left[2\sum_{m-1}^{M-1}\sum_{n=1}^{N-1} \frac{\cos^2\left(\mu_m (I-0,5)\right)\cos^2\left(\chi_n (J-0,5)\right)\beta_{m,n}}{\dfrac{e^{-\beta_{m,n} l} - e^{\beta_{m,n}(l-2L)}}{e^{-\beta_{m,n} l} + e^{\beta_{m,n}(l-2L)}} + \dfrac{e^{\beta_{m,n} l} - e^{-\beta_{m,n} l}}{e^{\beta_{m,n} l} + e^{-\beta_{m,n} l}}} + \right.$$

$$+ \sum_{m-1}^{M-1} \frac{\cos^2\left(\mu_m (I-0,5)\right)\beta m_m}{\dfrac{e^{-\beta m_m l} - e^{\beta m_m (l-2L)}}{e^{-\beta m_m l} + e^{\beta m_m (l-2L)}} - \dfrac{e^{\beta m_m l} - e^{-\beta m_m l}}{e^{\beta m_m l} + e^{-\beta m_m l}}} +$$

$$\left. + \sum_{n=1}^{N-1} \frac{\cos^2\left(\chi_n (J-0,5)\right)\beta n_n}{\dfrac{e^{-\beta n_n l} - e^{\beta n_n (l-2L)}}{e^{-\beta n_n l} + e^{\beta n_n (l-2L)}} - \dfrac{e^{\beta n_n l} - e^{-\beta n_{nm} l}}{e^{\beta n_n l} + e^{-\beta n_n l}}} \right]. \tag{30}$$

The found values allow to determine the VAT of the cable edge with damage to any cable. The sequence of their application is the desired algorithm for calculating the VAT of a rope with a damaged cable.

Consider a cable rope based on cables with a diameter of 8.25 mm. Rope length 5m. The step of laying cables $b = 1{,}2d$. The ropes are arranged in four rows of five ropes. The shear modulus of the elastic shell material $G = 5$MPa. The modulus of elasticity of cables is 105 MPa. The coefficient of shape of the elastic shell material $kG = 1$. The corner cable in section $x = 1$m is damaged. The average load on the rope rope is 5kPA. Here are the results of the calculation.

3. Calculation of effective welded crane girders considering fatigue strength

According to the figure, the difference in displacements of the ends of the cables (the gap between the ends of the cable) in the cross section of the gap reaches 2 mm. The movement of the end of the cable of the second part exceeds the corresponding figure for the first, which is due to the greater distance of the cross section of the rupture from the point of attachment of the second part of the rope. The main factor influencing the impulse on the reliability of the rope is the deviation of the load of individual cables from the average (Fig. 2).

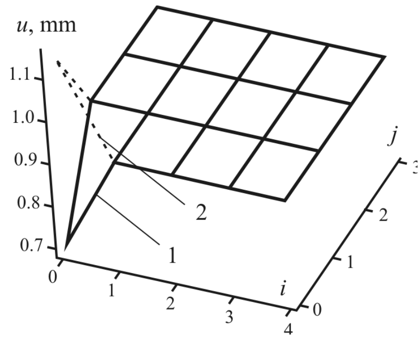

Fig. 1. Movement of cables with numbers i, in layers j in section $x = 1$
(1 - first part, 2- second part)

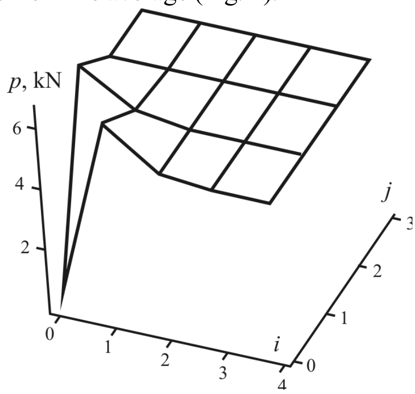

Fig. 2. Distributions of internal forces between cables with numbers i, in layers j in section $x = 1$

According to the obtained distribution of internal forces, the rupture of the cable leads to an increase in the internal tensile forces of only the cables adjacent to the damaged one. Their value, as a result of the surge, increased by 29%, which should be taken into account when determining the level of reservation of cables as part of the system - cable rope. In general, the nature of the stress-strained cable distorted by the gust is local. It is localized in length and width and thickness. The interaction of cables occurs due to tangential stresses arising in the elastic shell in the case of mutual displacement of adjacent cables.

Conclusions

The study conducted and found: The change in the shape of the cross section of the ropes of the rubber rope is caused by the rupture of the cable.

The obtained analytical expressions allow to determine the internal load forces of the rope ropes, the maximum values of the stress concentration coefficients in the rope ropes, which is under the influence of external factors.

The model and algorithm of calculation of a condition of a cable rope taking into account a design of a rope and mechanical properties of its components with impulse of an arbitrary cable are created.

It is established that the rupture of the cable leads to an increase in the loads of adjacent cables. The developed algorithm allows to determine the VAT indicators of a rope with a damaged cable.

Analytical regularities are constructed on the basis of classical methods of linear theory of calculation of stress-strain state of composite materials.

Based on the study, the dependences obtained to determine the stress-strain state of the rope in the conditions of operation of the cable rubber rope are obtained.

Thus, the results can be considered reliable, they are obtained by analytical solution of the rope model, built on the basis of linear theory of elasticity, mechanics of composite materials using generally accepted assumptions.

REFERENCES

1. Storozhenko L.I. New steel-reinforced concrete structural-cable structures / L.I. Storozhenko, G.M. Gasiy, S.A. Gapchenko // Collection of Science Works. Ser.: Galuzeve machine-building, business. - Poltava: PoltNTU, 2014. - VIP. 1. - S. 91-96.
2. I.V. Belmas, D.L. Kolosov, T.O. Chechel, O.M. Vorobjova, O.M. Chernish. Infusion of change in the hours of mechanical power of gumi on the stresses of the mill of the gumotrovoy traction body with a cable lug. Collection of Science Practices of the National University of Economics 2020 №61. With. 149-155.Sigarev E. N., Chernyatevich A. G., Chubin K.I., Zarandiya S.A. Desulfurization of hot metal by the injection of disperse magnesium through a submerged rotating. Steel in Translation, 2011. Vol. 41, № 6. P. 487–491.
3. Belmas L., Kolosov D., Kolosov O., Onvshchenko S. Stress-strain state of a conveyor belt with cables of different rigidity and their breakages. Fundamental and applied researches in practice of leading scientific schools Volume 26, Namber 2, 2018 p 231-236.Sigarev E. N., Kochmola D. S., Chubin K. I. Vplivpokrivnogoshlakunaperebigkovshovoi de-sul'furatsiichavunu. Teoriyaipraktikametalurgii. 2018. №1–2. P. 67–75. [in Ukraine].
4. Ropai V.A. Mine balancing ropes: monograph / A.V. Rope. - Dnepropetrovsk: National Mining University, 2016 .-- 263 p.
5. Belmas I., Kolosov D. The stress-strain state of the stepped rubber-rope cable in bobbin of winding. Technical and GeoinformationelSistems in Mining. Taylor & Francis Group, London, UK 2011c. 211-214.
6. Volokhovsky V.Yu., Radin V.P., Rudyak M.B. Concentration of efforts in ropes and bearing capacity of damaged rubber cord conveyor belts. MPEI Bulletin No. 5, 2010, pp. 5-12.
7. Belmas I.V. The stressed state of the rubber cord belt in case of arbitrary damage to the cables. Problems of Strength and Reliability of Machines 1993, N6 p. 45-48.
8. Kolosov D.L., Bilous O.I., Gurov. I.A. The technique of the updated gumotrosovo line. Mathematical Problems of Technical Mechanics and Applied Mathematics - 2019. International Science Conference. Materials of the conference. Dnipro, Kam'yanske -2019 - s. 126-127.
9. Belmas I., Kolosov D., Onyshchenk S., Bobylova I. Partial restoration of tractive ability of rubber-cable tractive element with damaged cable base. Collection of Science Practices of the National University of Economics 2020 №60. With. 196-206.
10. Tantsura G.I. Gnuchki traction organ. Sticks for conveyor lines. - Dniprodzerzhynsk: DDTU, 2010 – 127p.
11. Belmas, I.V., Kolosov, D.L., Tantsura, A.I., &Konokh, Yu.V. (2009). Investigation of the influence of a rupture of a rope base on the strength of a rope of a stepped structure. Irreversible processes in nature and technology: Materials of scientific. conf. Moscow: MSTU im. N.E. Bauman, 2, 255-257.
12. Kolosov, D., Dolgov, O., Bilous, O., & Kolosov, A. (2015). The stress-strain state of the belt in the operating changes of the burdening conveyor parameters. Theoretical and Practical Solutions of Mineral Resources Mining, 585-590.
13. Kokhanenko, Y.V., Yasinsky, V.V., &Tsaripa, I.M. (2001). Pre-accumulation of the length of the edge effect in a sharuvate composite with transversely isotropic similar to mechanical characteristics. Strength Problems, (4), 127-137.

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ДОСЛІДЖЕННЯ СТАТИЧНОГО КАНАТА З ОБРИВОМ ТРОСА

Встановлення впливу зміни тимчасових властивостей гуми на напружений стан гумотягового органа з пошкодженим тросом. Спосіб дослідження полягає в аналітичному розв'язанні моделі гумористичного тягового органу з урахуванням розриву суцільності троса та зміни властивостей гуми. Встановлено залежності зміни напруженого стану тягового тіла гумотроса з порушеною структурою за рахунок реології гумової оболонки. Сформульовано алгоритм визначення напруженого стану гумового тягового тіла у разі його поломки. Показано, що навантаження на канати, викликані розривом одного з них, призводять до локального перерозподілу зусиль майже лише між двома кабелями - пошкодженим і сусіднім; при пошкодженні неекстремальні тросові сили змінюються майже лише у трьох тросів - пошкоджених і двох пов'язаних з ним. При цьому відсутні екстремальні значення внутрішніх зусиль навантаження кабелів, що залежать від зміни модуля зсуву гумового матеріалу з часом.

Побудова методу визначення впливу поривів окремих тросів вантового гумотросового канату на його напружений стан.

Розробка та розв'язання моделі напружено-деформованого стану вантового гумотросового канату з розривами неперервності тросів.

Способи визначення напруженого стану вантового гумотросового канату з ушкодженим тросом.

Механізм та характер впливу поривів суцільності троса вантовогогумотросового канату на його напружено-деформований стан.

Розроблений метод дозволяє враховувати вплив поривів тросів на напружений стан гумотросовоговантового канату довільної конструкції. Його застосування дозволить обґрунтовано визначати мінімальні запаси міцності за умови безпечного використання гумотросового канату включно і у разі розриву окремих тросів.

Механізм впливу зміни властивостей гуми на тиск встановлюється стан тягового органу з урахуванням розриву суцільності троса та зміни властивостей гуми. Урахування залежності напружено-деформованого стану каната з локальними порушеннями тросової основи від зміни механічних властивостей гуми забезпечує можливість прогнозування напруженого стану каната для підвищення безпеки та надійності використання гумової тяги кузова, що мають значний термін служби.

Ключові слова: гума, розрив троса, напружений стан, вантовий канат.

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Розглядається один з алгоритмів оцінки і визначення методу поривів окремих тросів вантового канату.
Табл. 0. Іл. 2. Бібліогр. 13назв.

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Belmas I.V., Tantsura A.I., Bilous O.I., Shvachka A.V., Gupalo U.Yu. **Investigation of a static rope with a cable break** // Strength of Materials and Theory of Structures: Scientific-and-technical collected articles. – K.: KNUBA, 2022. – Issue 108. – P. 349-359.
One of the algorithms for estimating and determining the method of gusts of individual cables of a cable-stayed rope is considered.
Tabl. 0. Fig. 2. Ref. 13.

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