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DETERMINATIONOFCHANGESINTHERMALSTRESSSTATEOF STEEL BEAMS IN LIRA-SAPR SOFTWARE

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Abstract. A study of the stress-strain and temperature state of the steel frame of the building is provided.Based on the results of the analysis of the dynamic thermal conductivity problem, the temperature fields of the beam at certain time intervals are determined. Reducing coefficients of physical properties of steel section were determined. The algorithm of analysis of steel structures for fire resistance taking into account heat engineering analysis results is given.

Keywords: stress-strainstate, fireresistance, thermal conductivity, finite element method, LIRA-SAPR.

Topicality. The analysis of steel structures for fire resistance is one of the most important design stages. The building codes provide several options for analysing structures for fire resistance: simplified, refined analysis methods, and analysis based on tabular data.

Analysis based on tabular data is the simplest option that allows you to calculate the parameters of structural elements for standard time intervals while exposed to fire.The method of analysing according to tabular data and simple calculation models are usually used to analyze individual structural elements, under simple boundary conditions.

But the analysis options shown above have a number of limitations. For example, the analysis by tabular data can be used only for a certain level of load, the amount of eccentricity and flexibility of the elements. And the simplified technique does not allow to take into account the change in the strength of materials with increasing temperature. While refined calculation models are universal for any design and allow to take into account changes in the properties of steel during a fire.

According to the specified method of analysis, it is necessary to perform thermal analysis on the basis of which it is necessary to change mechanical characteristics of materials.

In order to perform thermal analysis- it is necessary to solve the problem of thermal conductivity. The equation of the boundary value problem of nonstationary thermal conductivity is given in formula (1):

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$$K_{xx}\frac{\delta^2 T}{\delta x^2}+K_{yy}\frac{\delta^2 T}{\delta y^2}+K_{zz}\frac{\delta^2 T}{\delta z^2}+w=\rho c\frac{\delta T}{\delta t}, \qquad (1)$$

where$T = T(x,y,z,t)$ – temperature field in the area Ω; K_{xx}, K_{yy}, K_{zz} – thermal conductivity coefficients in the x, y, z direction, respectively; $w = w(x,y,z,t)$ – power of heat sources inside the body; ρ - material density; c - specific heat capacity of the material.

This equation can be solved by using the finite element method or the finite difference method. When using the first method, the structure is modeled with special finite elements with one degree of freedom - the temperature, which is a scalar quantity.

In general, refined calculation models are mainly used to determine the behavior of the whole structure in determining the interaction of its elements.Although the refined design calculation method can be performed using a standard temperature-time dependence, this method is usually part of the design based on real parameters using natural fire models.

Analysis of research. A huge contribution to the development of methods for designing steel structures for fire resistance made Bilyk A.S. [3, 4, 5], Calafat K.V. [13], Savitsky M.V.

Information about mathematical basics and interaction of the finite element method with the methods of structural mechanics (in solving linear and nonlinear problems) are given in [6, 7] Gorodetsky A.S. Methods of numerical modeling of structures and their strength analysis on the influence of various factors, as well as the creation of mathematical and computer models used in solving problems of thermal conductivity, are considered in the works of Barabash MS [1, 2], Zenkevich [9], Klovanich [8].

Among foreign scientists, the following works have become very popular in the field of analysing steel structures for fire resistance: [16], [17], [18].

The unsolved part of the problem. The design standards describe in detail only the simplified methods of analysing steel structures for fire resistance.The specified calculation methods are not considered in detail in building codes.The Eurocode and DSTU norms describe only the design principles that underlie the refined methods. A brief overview of using of refined calculation methods is contained in the publication of the British Institute of Civil Engineers [14]. However, taking into account the absence of a universal algorithm for analysing steel structures for fire resistance according to the specified method - the question of creating such an algorithm is an urgent design problem.

There is a need to clarify the characteristics of the boundary conditions in fires from the standpoint of preventing the possibility of loss of life for steel frame structures [1,4,20] and prevent caloptic destruction and collapse of structures [1,2,5,6, 21].

Research objectives. The purpose of this article is to study the strength and deformation characteristics of steel frame structures under the influence of fire.

To achieve this goal it is necessary to solve the following tasks:

- the problem of thermal conductivity by the finite element method to detect temperature changes in the cross section of the structural element over time with refinement of the analytic model using different forms of steel profiles in combination with reinforced concrete slabs;

- strength analysis of metal structures in a linear setting, taking into account changes in strength and deformation characteristics of materials with increasing temperature.

The main content. The analysis of mathematical models was carried out on the basis of the "LIRA-SAPR" software, in which the problem of thermal conductivity was solved and the strength analysis was performed.The heat transfer problem was modeled using finite elements of thermal conductivity.Heat transfer between the floor beam and the airspace was modeled by special finite elements of convective heat transfer.The mathematical model for strength analysis was created using bar finite elements.

If we enter the boundary conditions for solving the quasiharmonic equation (1), this equation will look like:

$$K_{xx}\frac{\delta^2 T}{\delta x^2}I_x + K_{yy}\frac{\delta^2 T}{\delta y^2}I_y + K_{zz}\frac{\delta^2 T}{\delta z^2}I_z + q + h(T_s - T_b) = 0, \qquad (2)$$

where I_x, I_y, I_z - directing cosines of the outer normal to the boundary surface, q – heat flow, $h(T_s - T_b)$ – heat loss through convection (h – convective heat transfer coefficient).

To solve equation (2), the solid under consideration is divided into finite elements in which the degrees of freedom are the temperature in the nodes.The temperature inside each element is approximated by linear polynomials.

Here is an example of some approximating polynomials of finite elements of thermal conductivity:

- three-node flat FE:

$$T(x,y) = \alpha_1 + \alpha_2 x + \alpha_3 y; \qquad (3.1)$$

- four-node isoparametric flat FE:

$$T(x,y) = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 xy; \qquad (3.2)$$

- spatial tetrahedral FE:

$$T(x,y,z) = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 z. \qquad (3.3)$$

Since linear polynomials are used to approximate the temperature function of a discrete model, finite elements of thermal conductivity are also called simplex elements [9].

Substituting the values of nodal temperatures and coordinates of nodes into the corresponding polynomials, we can obtain expressions for the coefficients α_1, α_2, α_3, α_4. If we return these coefficients to equations 3.1 - 3.3, it is possible to obtain the expression:

$$[T(x,y,z)] = [N(x,y,z]_e\{T\}_e, \qquad (4)$$

where $[N(x,y,z]_e$ – matrix of functions of forms.

Let us consider the matrix of thermal conductivity coefficients:

$$K\begin{pmatrix} K_{xx} & 0 & 0 \\ 0 & K_{yy} & 0 \\ 0 & 0 & K_{zz} \end{pmatrix}, \tag{5}$$

and a matrix-column of temperature gradients, which is analogous to the stress matrix:

$$gradT = \begin{bmatrix} \frac{\delta T}{\delta x} \\ \frac{\delta T}{\delta y} \\ \frac{\delta T}{\delta z} \end{bmatrix} = DT\,. \tag{6}$$

Then the contribution of each individual finite element in solving problems of nonstationary thermal conductivity can be written in the form of a matrix differential relation:

$$\{Q\}_e = [C]_e \frac{\delta}{\delta t}\{T\}_e + [K]_e\{T\}_e - \{Q\}_e^q - \{Q\}_e^g - \{Q\}_e^h, \tag{7}$$

where $[K]_e$ – element thermal conductivity matrix (analog of stiffness matrix),

$$[K]_e = \int [B]^T[D][B]dV + \int h[N]^T[N]dS, \tag{8}$$

$[C]_e$ – heat absorption matrix (analog of damping matrix),

$$[C]_e = \int \rho c[N]^T[N]dV, \tag{9}$$

$\{Q\}_e^q, \{Q\}_e^g, \{Q\}_e^h$ - vectors of nodal heat flows.

A test problem was solved to verify the results of theoretical research. The dimensions of the studied structure are: length - 12 m, width - 8 m, height of columns – 3 m, thickness of reinforced concrete slab – 120 mm. In the calculation scheme, the floor slab is taken into account by the applied external load.

The analytical scheme is shown in Figure 1.

Fig. 1. Analytical scheme of structure

To perform the thermal calculation and determine the temperature fields, the cross-sectional analysis of the floor beam was performed. For the experimental design was taken beam with a cross section I-section №35B1 according to GOST 26020-83 on which reinforced concrete slab 120 mm thick rests (see Fig. 2).

Since the change in temperature along the length of the beam is uniform, it allows us to consider the temperature distribution along the cross section of one height.

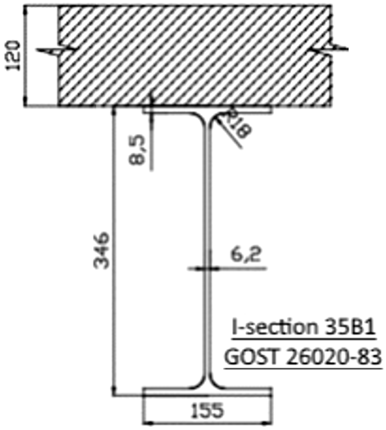


Fig. 2. Scheme of experimental structure

The following heat-conducting properties of steel are accepted for thermal engineering analysis: density – 76490 N/m^3, thermal conductivity coefficient – 53 W/(m*s), heat absorption coefficient - 440 W. The coefficient of convective heat transfer was assumed to be equal to 25 W/(m^2*s).The temperature load was set according to the standard temperature of the fire. The ambient temperature at the initial time is taken as 20 °C.

Figure 3 shows that the upper shelf of the I-beam heats up much longer than the lower. This is due to the fact that the experimental section of the beam supports a reinforced concrete floor slab therefore the top shelf gives energy to this slab.

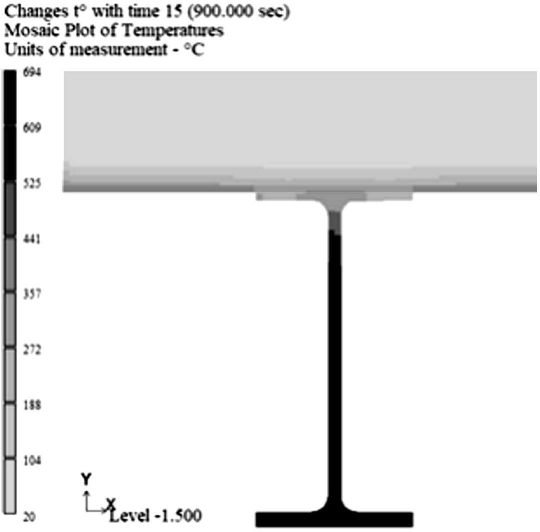
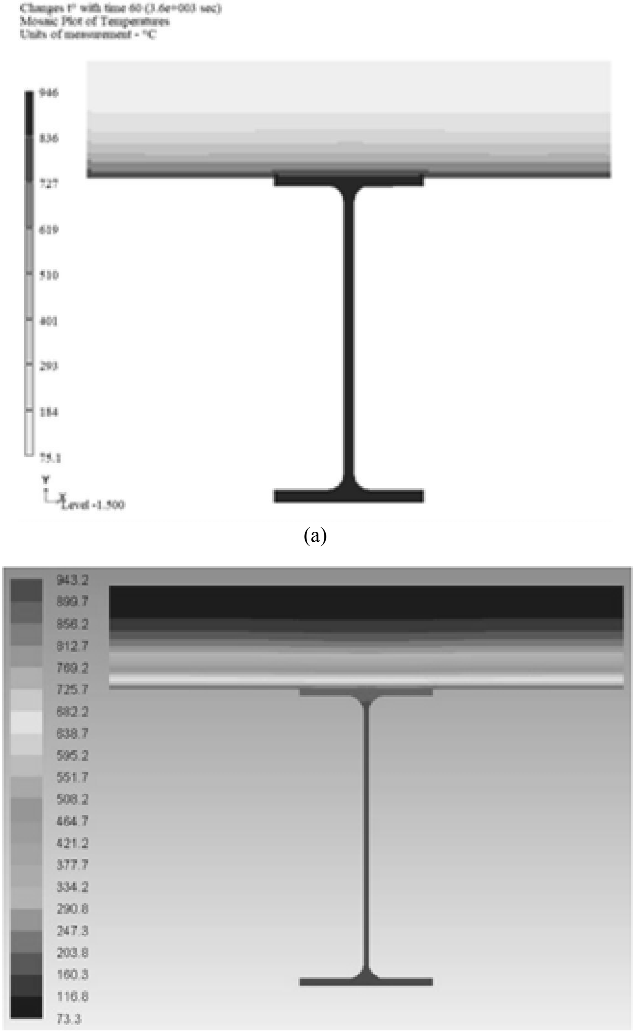


Fig. 3. The distribution of the temperature field in the cross section of the floor beam at the time - 15 minutes

The results of thermal analysis at the time 60 minutes, shown in Figure 4.The obtained results of the analysis of the steel beam for fire resistance in LIRA-SAPR software (see Fig. 4 (a)) are different from the results of the analysis in the ANSYS software (see Fig. 4 (b)), given in Annex P.3 [18] less than 1%.

Figure 4 shows a graph of the temperature change in the cross section of the beam in time, and

Figure 5 shows a graph of the modulus of elasticity change in the cross section of the beam in the temperature rising.



(a)

(b)

Fig. 4. The distribution of the temperature field in the cross section of the floor beam at the time - 60 minutes: (a) in the LIRA-SAPR software; (b) in ANSYS software

From the results shown in Figure 5, we conclude that with time of the fire, modulus of elasticity, and therefore the load-bearing capacity of the beams decreases.To take into account the effect of temperature on the stress-strain state of the structure under consideration, the corresponding elements (floor beams exposed to fire) must be assigned stiffnesses with reduced values of modulus of elasticity and yield strength corresponding to the work of the structure at certain intervals.

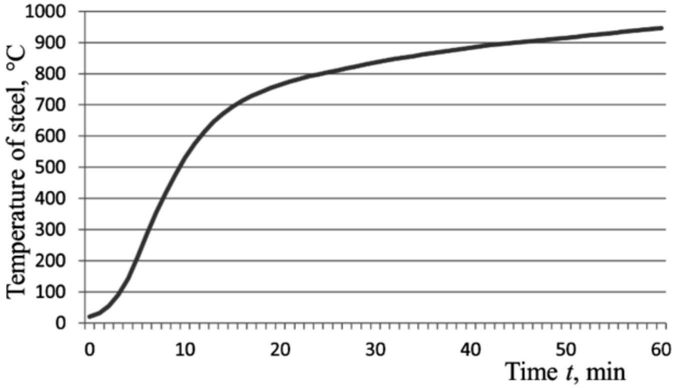


Fig. 5. Temperature change in the cross section of the beam in time

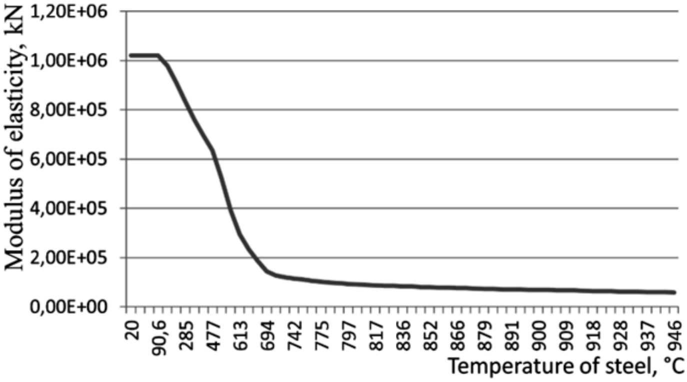


Fig. 6. Modulus of elasticity change in the cross section of the beam in the temperature rising

The maximum cross-sectional temperature of the cross section of the beam at 60 minutes is 946°C (see Fig. 3). Using table 1 and the method of linear interpolation, we calculate the coefficients of reduction for a given temperature:

$$k_{f_y,\theta} = 0.060 + \frac{0.040 - 0.060}{1000 - 900} \cdot (946 - 900) = 0.0508, \qquad (10.1)$$

$$k_{E_a,\theta} = 0.0675 + \frac{0.0450 - 0.0675}{1000 - 900} \cdot (946 - 900) = 0.05715. \qquad (10.2)$$

The results of the static analysis and steel design of the structure in the LIRA-SAPR software before the fire and after 60 minutes of combustion are shown in Figures 7, 8 and 9.

Table 1

Reduction factors for carbon steel at rised temperatures

Temperature of steel θ_a, °C	Reduction factors at temperature θ_a relative to the value of f_y or E_a for 20°C		
	Reduction factor (relative to the f_y) for designyield strength $k_{y,\theta} = f_{y,\theta} / f_y$	Reduction factor (relative to the f_y) for the limit of proportionality $k_{p,\theta} = f_{p,\theta} / f_y$	Reduction factor (relative to the E_a) for the slope of the linear elastic section $k_{E,\theta} = E_{a,\theta} / E_a$
20	1,000	1,000	1,000
100	1,000	1,000	1,000
200	1,000	0,807	0,900
300	1,000	0,613	0,800
400	1,000	0,420	0,700
500	0,780	0,360	0,600
600	0,470	0,180	0,310
700	0,230	0,075	0,130
800	0,110	0,050	0,090
900	0,060	0,0375	0,0675
1000	0,040	0,0250	0,0450
1100	0,020	0,0125	0,0225
1200	0,000	0,0000	0,0000
Note. Linear interpolation can be used for intermediate values of steel temperature			

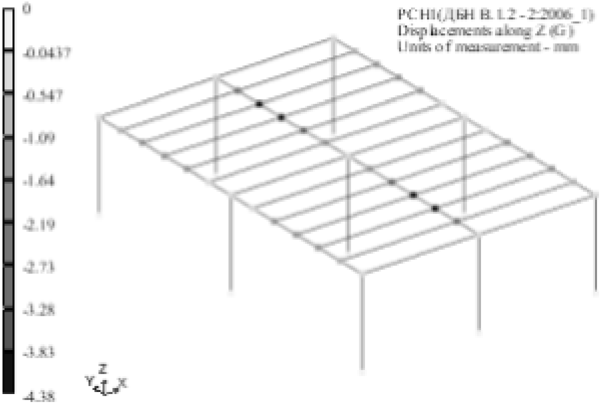


Fig. 7(a). The results of the static analysis of the building (displacements by Z) before the fire

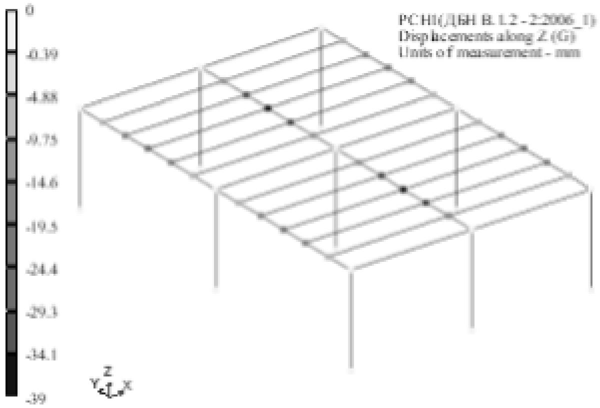
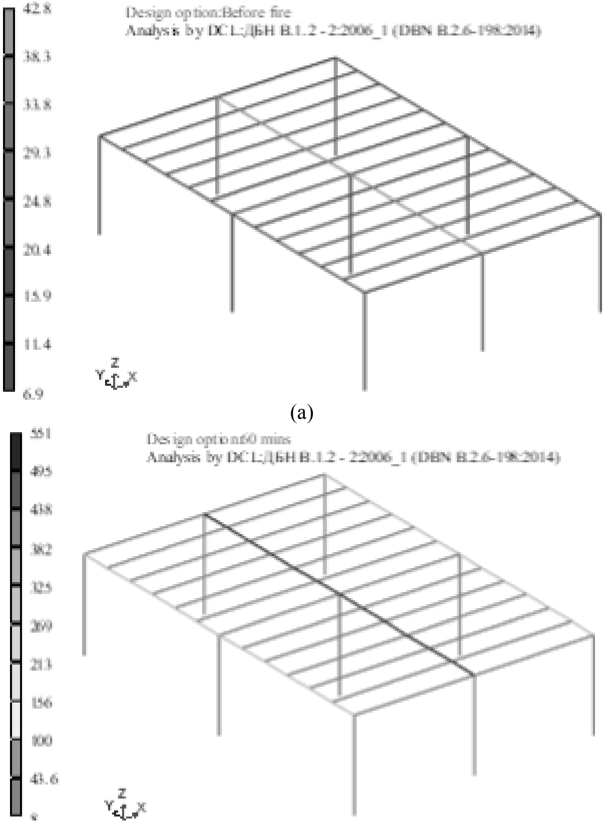


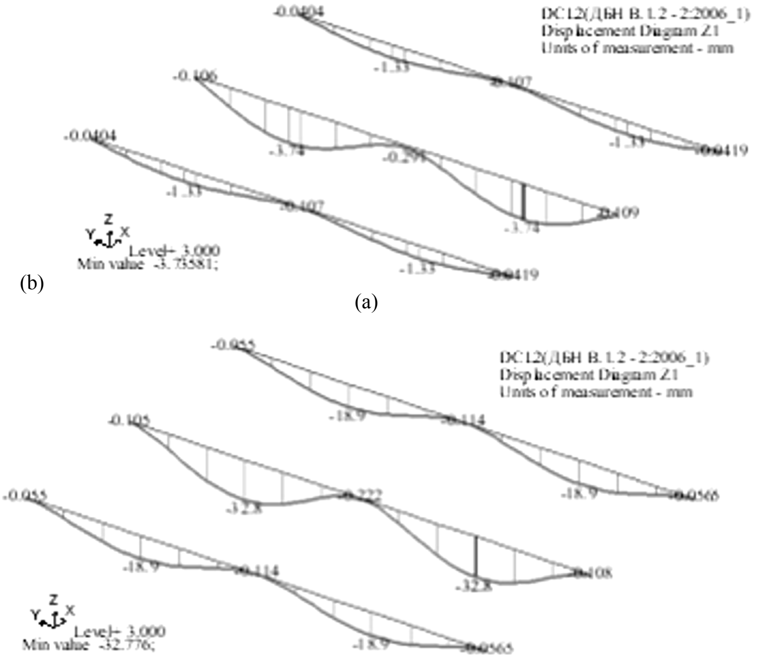
Fig. 7(b). The results of the static analysis of the building (displacements by *Z*)
at the mark of 60 minutes



(a)

(b)

Fig. 8. The results of the analysis of structural elements for strength:
(a) before the fire; (b) at the mark of 60 minutes



(b)

(a)

(b)

Fig. 9. The results of the analysis of beams for deflections:
(a) before the fire; (b) at the mark of 60 minutes

Conclusions. After conducting a numerical experiment, the following conclusions can be drawn:

1. Already at the 60th minute of fire without a fire-resisting coating, the elements of the steel frame significantly lose their load-bearing capacity. This means that such elements must be protected from fire with special paints, mixtures, etc. The influence of heat extraction from the upper shelf of the I-section to the reinforced concrete slab was confirmed.

2. The proposed method of analysing the structures under the influence of fire is quite universal and it allows quickly and flexibly analyze structures on the impact of fire at different time marks.

3. The homeland software LIRA-SAPR is ideally fit for solving fire resistance problems, the reliability of the obtained results is confirmed. The results obtained almost have no difference from the decision of foreign counterparts.

REFERENCES

1. *Barabash M.S.* Modelirovanie zaproektnyh vozdeystviy pri issledovanii zhyznennoho cykla konstrukciy zdaniy I sooruzheniy (Modeling of beyond design impacts in the study of the life cycle of structures of buildings and structures) // International Journal for Computational Civil and Structural Engineering. – 2016. –Vol. 12. – Issue 3. – P. 15-26.

2. *Barabash M.S.,Kyriazev P.N., Romashkina M.A.* Chislennoe modelirovanie napriazhenno-deformirovannoho sostoyaniya kirpichnoho zhiloho zdaniya pri vzryve bytovoho gaza vnutri pomeshcheniya (Numerical simulation of the stress-strain state of a brick residential building during an indoor gas explosion) // International Journal for Computational Civil and Structural Engineering. – 2016.– Vol. 12. – Issue 1. – P. 73-85.
3. *Bilyk A.S.* Porivniannia metodiv rozrakhunku metalevykh karkasiv vysotnykh budivel` na odynychnu zhyvuchist` (Comparison of methods of analysis of metal frames of high-rise buildings for unit survivability) / A.S. Bilyk, A.I. Kovalenko // Zbirnyknaukovykhprac` Ukrains`kohoinstytutustalevykhkonstrukciyimeniV.M. Shymanovskoho. - 2015. - Vol. 16. - P. 30-39. - Access mode: http://nbuv.gov.ua/UJRN/ZNPISK_2015_16_6.
4. *Bilyk A.S.* Dynamichni zusyllia v kolonakh stalevykh karkasiv bahatopoverkhovykh budivel` pry rozrakhunku na odynychnu zhyvuchist` (Dynamic forces in columns of steel frameworks of high-rise buildings at analysis on unit survivability) / A.S. Bilyk, A.I. Kovalenko // Resursoekonomnimaterialy, konstrukcii, budivlitasporudy. - 2016. - Vol. 32. - P. 304-309. - Access mode: http://nbuv.gov.ua/UJRN/rmkbs_2016_32_43.
5. *Bilyk A.S.* Suchasni metody modeliuvannia progresuyuchoho ruynuvannia budivel` I sporud (Modern methods of modeling the progressive collapse of buildings and structures) / A.S. Bilyk, A.I. Kovalenko // Stroitel`stvo. Materialovedeniye. Mashinostroyeniye. Seriya: Sozdaniye vysokotekhnolohicheskikh ekokompleksov v Ukraine na osnove koncepcii sbalansirovannoho (ustoychivoho) razvitiya. - 2016. - Vol. 87. - C. 35-41. - Access mode: http://nbuv.gov.ua/UJRN/smmcvtek_2016_87_5
6. *Gorodetskiy A.S.* Nekotorye aspekty rascheta zdaniy na ustoychivost` k progressiruyushchemu razrusheniyu (Some aspects of the analysis of buildings for resistance to progressive collapse) / A.S. Gorodetskiy, M.S. Barabash // Stroitel`stvo. Materialovedeniye. Mashinostroyeniye. Seriya:Innovacionnyetekhnolohiizhiznennohociklaobyektovzhilishchno-grazhdanskoho, promyshlennohoItransportnohonaznacheniya. - 2009. - Vol. 50. - P. 157-162. - Режим доступу: http://nbuv.gov.ua/UJRN/smmit_2009_50_27
7. *Gorodetskiy A.S.* Kompyuternyye modeli konstruktsiy (Computer models of structures)/ A.S. Gorodetskiy, i. D.Evzerov. – M. : Izdatel`stvo ASV, 2009. –360 p.
8. *Klovanich S.F.* Metod konechnykh elementov v nelineynykh zadachakh inzhenernoy mekhaniki (Finiteelementmethodinnonlinearproblemsofengineeringmechanics) / S.F. Klovanich. – Zaporozhie: Izdatel`stvozhurnala "Svitgeotekhniky", 2009, – 400 p.
9. *Zenkevich O.S.* Metod konechnykh elementov v tekhnike. Monografiya.(Finite element method in engineering. Monograph) — Perevod s angliyskogo. — M.: Mir, 1975. — 543 p.
10. DBN B.1.2-2:2006. Sistema zabezpechennya nadiynosti ta bezpeki budivelnikh ob'єktiv. Navantazhennya i vplivi. Normi proyektuvannya. (Reliability and safety system for construction projects. Loads and effects. Design standards) – Kyiv: Minbud Ukrainy, 2006. – 77 p. – (Derzhavni budivelni normi Ukrayini).
11. DBN B.2.6-198:2014. Konstruktsiї budivel i sporud. Stalevi konstruktsiї. Normi proyektuvannya (Constructions of buildings and structures. Steel structures. Design standards.) – Kyiv: MinrehionUkrayiny, 2014. – 199 p. – (Derzhavni budivelni normi Ukrayini).
12. *DSTU-NB EN 1993-1-2:2010*. Eurocode 3. Proyektuvannya stalevikh konstruktsiy. Chastina 1-2. Zagalni polozhennya. Rozrakhunok konstruktsiy na vognestiykist(Design of steel structures. Part 1-2. Terms. Analysis of structures for fire resistance) (EN 1993-1-2:2005, IDT). - [Chynni vid 2013-07-01]. – K.: MinrehionbudUkrayini, 2010. – 106 p.
13. Rozrakhunok stalevikh konstruktsiy na vognestiykist vidpovidno do Єvrokodu 3. Praktichniy posibnik doDSTU-N EN 1993-1-2:2010 (Analysis of steel structures for fire resistance in accordance with Eurocode 3. Practical guide toDSTU-N EN 1993-1-2:2010) / Ukrayinskiy Tsentr Stalevogo Budivnitstva. – Kyiv, 2016. 81 p.
14. PD 6688-1-2:2007. Reference document to the British National Annex toBS EN 1991-1-2 (with changes made in June2007). — British Standards Institute, 2007.
15. *Barabash M., Romashkina M., Bashynska O.* Thermal stress state of reinforced concrete floor slab // Strength of Materials and Theory of Structures: Scientific-and-technical collected articles – Kyiv: KNUBA, 2019. – Issue 103 . – P. 43-56.

16. *Behnam, B. and Rezvani, F.H.* Structural evaluation of tall steel moment-resisting structures in simulated horizontally travelling postearthquake fire.– Journal of Performance of Constructed Facilities, DOI:10.1061/(ASCE) CF.1943-5509.0000696. – 2015.
17. *B.A. Izzuddin, A.G. Vlassis, A.Y. Elghazouli, D.A.* Nethercot. Progressive collapse of multi-storey buildings due to sudden column loss — Part I: Simplified assessment framework // Engineering Structures. - London: Elsevier, 2008.– Volume 30. – p. 1308-1318.
18. *A.G. Vlassis, B.A. Izzuddin, A.Y. Elghazouli, D.A.* Nethercot. Progressive collapse of multi-storey buildings due to sudden column loss—Part II: Application// Engineering Structures. - London: Elsevier, 2008.– Volume 34. – p. 1424-1438.
19. *DSTU-NB B.2.6-211:2016*Proyektuvannya stalevikh konstruktsiy. Rozrakhunok konstruktsiy na vognestiykist. (Design of steel structures. Analysis of structures for fire resistance) – Kyiv : MinrehionUkrayini, 2016. – 136 с.
20. *Bilyk S.I., Bilyk A.S., Nilova T.O., Shpynda V.Z., Tsyupyn E.I.* Buckling of the steel frames with the I-shaped cross-section columns of variable web height // Strength of Materials and Theory of Structures: Scientific-and-technical collected articles – Kyiv: KNUBA, 2018. – Issue 100. – P. 140-154. http: library.knuba.edu.ua/books/zbirniki/12/201604.pdf.
21. *Bilyk Sergiy, Tonkacheiev Vitaliy* Determining sloped-load limits inside von Mises truss with elastic support. Materiali in tehnologije., Ljubljana, Slovenija 52 (2018), 105-109, doi:10.17222/mit.2016.083 http://mit.imt.si/Revija/izvodi/mit182/bilyk.pdf .

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ВИЗНАЧЕННЯ ЗМІНИ ТЕРМОНАПРУЖЕНОГО СТАНУ СТАЛЕВИХ БАЛОК В ПК «ЛІРА-САПР»

Анотація. В даній статі автори провели дослідження напружено-деформованого та температурного стану сталевого каркасу будівлі. Проведено верифікаційний розрахунок сталевого перерізу на вогнестійкість у вітчизняному програмному комплексі. Отримані результати було порівняно з результатами аналогічного розрахунку в закордонному програмному комплексі. Проведено розрахунок динамічної задачі теплопровідності перерізу балки. Наведено основні рівняння для вирішення крайової задачі нестаціонарної теплопровідності. Також, наведено алгоритм реалізації обчислення температурних деформацій по перерізу сталевої балки за допомогою методу скінчених елементів. Розглянуто процес побудови комп’ютерної моделі елементів конструкції та аналіз напружено-деформованого стану при зміні температурного режиму експлуатації. Проведено аналіз кінематичних та статичних характеристик розрахункової моделі, що досліджується.На основі отриманих результатів розрахунку визначено температурні поля балки перекриття у певні проміжки часу. Внаслідок нерівномірного розподілу температури по перерізу елемента, виникають температурні деформації. Також, через обмеження деформацій зовнішніми зв’язками, їх поява супроводжується розвитком температурних напружень. Тому вивчення особливостей температурних деформацій в сталевих конструкціях має значне практичне значення. У зв’язку з актуальністю проблеми визначення температурних напружень та деформацій у конструкціях, є необхідним уточнення та вдосконалення існуючих методів розрахунку, які достатньою мірою не можуть враховувати зміну в часі фізико-механічних характеристик сталі. Тому автори статі порахували коефіцієнти зниження фізичних властивостей перерізу і виконали статичний аналіз конструкції. Показано зміну напружено деформованого стану елементів перекриття при впливі вогню. Наведені результати розрахунку показали важливість урахування впливу температури на зміну міцнісних та деформаційних характеристик при розрахунку конструкцій. Авторами статі було розроблено та наведено алгоритм розрахунку сталевих конструкцій на міцність на гнучкість з урахуванням теплотехнічного розрахунку та розрахунку на вогнестійкість.

Ключові слова: напружено-деформований стан, вогнестійкість, теплопровідність, метод скінченних елементів, ЛІРА-САПР.

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DETERMINATIONOFCHANGESINTHERMALSTRESSSTATEOF STEEL BEAMS IN LIRA-SAPR SOFTWARE

Abstract. In this article, the authors conducted a study of the stress-strain and temperature state of the steel frame of the building.Verification analysis of steel section for fire resistance in the homeland software package is carried out.The obtained results were compared with the results of a similar analysis in a foreign software package.The analysis of the dynamic problem of thermal conductivity of the cross section of the beam is carried out.The basic equations for solving the boundary problem of nonstationary thermal conductivity are given.Also, the algorithm of realization of analysis of temperature deformations on section of a steel beam by finite element method is given.The process of designing analytical model of structural elements and analysis of the stress-strain state when operating temperature is changed is considered.The analysis of kinematic and static characteristics of the calculated model under study is carried out.Based on the obtained analysis results, the temperature fields of the beam at certain time intervals are determined.Due to the uneven distribution of temperature in the cross section of the element, temperature deformations are occured.Also, due to the limitation of deformations by external connections, their appearance is accompanied by the development of temperature stresses.Therefore, the study of the peculiarities of thermal deformations in steel structures has considerable practical importance.Due to the urgency of the problem of determining thermal stresses and strains in structures, it is necessary to clarify and improve existing calculation methods, which can not sufficiently take into account changes in time of physical and mechanical characteristics of steel.Therefore, the authors of the article calculated the coefficients of reduction of the physical properties of the section and performed a static analysis of the structure. The change of the stress-strain state of the floor elements under the influence of fire is shown.The results of the analysis showed the importance of taking into account the influence of temperature on the strength and deformation characteristics in the calculation of structures.The authors of the article developed and presented an algorithm for analysing the strength of steel structures for flexibility, taking into account the thermal conduction analysis and the fire resistance analysis.

Keywords: stress-strainstate, fireresistance, thermal conductivity, finite element method, LIRA-SAPR.

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Визначається вплив пожежі на несучу здатність балок перекриття.

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The effect of fire on the bearing capacity of floor beams is determined.

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