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Fire Resistance of Metal Compressed Structures

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Abstract: The article discusses the method to determine the fire resistance of the compressed metal columns.
Keywords: fire resistance, metal structures, flexibility, strength, temperature creep of steel, centrally compressed rods.

Introduction

Advantages and disadvantages of metals as building materials, metals have high reliability and durability, which is a consequence of their homogeneity and isotropy. These properties underlie the development of the theory of calculation. Therefore, the hypothesis of the continuity and isotropy of materials in a resisting material most accurately describes the behavior of metals under load.

Metals have high strength, as a result of which, with small cross-sections, metal elements can perceive large forces Steel has the highest modulus of elasticity among building materials E_{ct} = 2.06 * 105 MPa (2100000 kg / cm2), therefore, the displacements and deformations of steel elements are small. For aluminum alloys, the modulus of elasticity E_{al} = 0.7 * 105 MPa, i.e. aluminum is 3 times more deformable than steel. Therefore, other things being equal, aluminum beams, for example, have 3 times greater deflections than steel ones.

The fire resistance of load-bearing metal structures is lost due to a decrease in the strength and elasticity of the metal when heated, as well as due to the development of its plastic and temperature deformations.

The Main Findings and Results

The concept of the fire resistance limit of a structure means the time after which the structure loses its bearing and enclosing capacity.

The temperature at which deformations from loading in load-bearing structures go beyond the elastic limits and the strength sharply decreases is considered critical.

The limits of fire resistance of metal structures are established empirically or determined by calculation. When calculating, the critical heating temperature is determined, the static calculation and the heating time of the structure to the critical temperature, the heat engineering calculation.

When heated to high temperatures, centrally compressed rods (columns, frames, racks and truss braces) lose their bearing capacity or stability (as a result, a loss of strength).

Loss of strength occurs due to a decrease in the resistance of the metal of the heated rod to stresses from operating loads in its cross section. This is usually the case for rods with low to medium flexibility.

Bars with great flexibility during heating, due to the presence of small eccentricities caused by axial curvature, eccentric load application, etc., can lose their bearing capacity due to loss of stability due to a decrease in the elastic modulus and an increase in deformations of thermal creep of the metal at high temperatures.

In both cases, the critical temperature of the bar is determined from the critical creep deformations of the metal п $\varepsilon_п$ (in total with the deformations from a decrease in the elastic modulus).

The critical deformation (elastic or elastoplastic) of a metal for the case of loss of stability of a centrally compressed bar is found

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$$\varepsilon_{кр} = \frac{\sigma_{кр}}{E} \quad (1)$$

Where $\sigma_{кр}$ – the critical stress is found by the Euler formula

$$\sigma_{кр} = \frac{N_{кр}}{A} = \frac{\pi^2 \cdot I_x E}{l_{ef}^2 A} = \frac{\pi^2 \cdot E}{\lambda^2} \quad (2)$$

$\lambda = \frac{l_{cfx}}{i_x}$ - rod flexibility;

$i_x = \sqrt{\frac{I_x}{A}}$ Section radius of gyration

l_{cfx} - Calculated bar length.

E - modulus of elasticity of the metal.

Substituting (2) into (1) we obtain

$$\varepsilon_{кр} = \frac{\pi^2 E}{E \lambda^2} = \frac{\pi^2}{\lambda^2} \quad (3)$$

Formula (3) shows that critical deformations of the metal depend only on the flexibility of the rod.

Under the action of fire, when the rod is under a constant working load, it loses its stability due to the development of creep deformations of the heated metal. In this case, the loss of stability of the rod is characterized by a sharp increase in deformations at small temperature increments.

By the magnitude of the critical deformation ε_n and the degree of loading of the rod $\gamma_a = \frac{\sigma_o}{\sigma_T}$ determine the critical temperature of the compressed rod.

The calculated critical deformation of its steel creep is found by the formula:

$$\varepsilon_{кр} = \frac{\sigma_{cз}}{\sigma_o \left[\frac{\Delta\sigma_e}{\Delta\sigma} \cdot (1-K) + K\right]} \left(\frac{\pi^2}{\lambda^2} - \frac{\sigma_o}{E}\right)$$

Where

$\sigma_{cp} = \frac{(\sigma_1 + \sigma_2)}{2}$ - medium voltage;

$\sigma_o = \frac{N}{A}$ - operating voltage at the center of the section,

$\Delta\sigma_e = \frac{(2N \cdot e)}{W} - \frac{(2\sigma_0 A \cdot e)}{W}$ - stress difference from the presence of the initial eccentricity

$$l = \frac{M}{N}$$

K - coefficient of the level of stresses arising due to deflection f_t.

The coefficient k takes into account the effect of a change in temperature deflection from 0 to a final value on the deformation of the temperature creep of steel. Based on this consideration, the coefficient k should vary from 0 to 1.

For calculations, it can be taken equal to:

K=0,5 in $\lambda \leq$ 125; K=0,75 in 125 < $\lambda \leq$150; K=1,0 in λ >150

Thus, formula (4) is a generalized expression for calculating the critical deformation

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ε_m at loss of bearing capacity of a compressed bar.

Heating of metal structures in a fire depends on many factors, among which the main ones are the intensity of the fire and the methods of protecting the metal structures.

It is recommended to select options for design solutions based on a comparison of technology - economic indicators. To ensure the comparability of the design options, they must have the same purpose, be designed for the same loads designed in accordance with the current standards and for the same climatic, seismic, soil and operating conditions.

The emergence and constant improvement of computing technology made it possible to put forward the idea of an automated search for a design that is minimal in terms of costs. These kinds of problems are called optimal design problems or optimization problems. Using the methods of mathematical programming, it is possible to solve the problems of a targeted search for a structure, the costs of creating which are minimized by some quality criterion, for example, by the minimum cost of material or by cost, and finally by reduced costs. The selected quality criterion is called the objective function, the minimum of which must be found. The minimum of the objective function is often found when a number of constraints on the conditions of rigidity, strength, stability, and some design constraints are satisfied. The objective function and restrictions to it are written in a certain mathematical form. After drawing up such a mathematical model, they begin to solve it by one or another method of mathematical programming. The result is optimal, i.e. the most profitable technical solution.

The existing structure of the cost of building structures, the practice of construction and operation revealed that with large spans 80 ... 100 m, heights, loads and difficult soil conditions, where the dead weight of structures makes up the majority of all existing loads - steel and wooden structures are beneficial, and for small and medium spans, where massiveness, high protective qualities are required, reinforced concrete structures are more profitable.

For construction in the North, steel load-bearing and lightweight enclosing structures are more effective. For the northern regions of the country, the cost of transport costs is very high and reaches 40 ... 50% of the total cost of construction.

Thus, the task of increasing the efficiency of construction in the North should be solved by reducing the mass, increasing the degree of factory readiness, and assembly. Delivery of structures should be carried out by the most efficient means of transport, including aviation.

An increase in the seismicity of the construction area from 6 to 9 points increases (other things being equal) the efficiency of using steel frames and profiled steel decking. This is due to the fact that with a decrease in mass, the load from seismic action also decreases.

The correct choice of structures and materials is influenced by the temperature and humidity conditions, the presence of chemically aggressive influences in the production process. In conditions of high humidity without chemical aggression, the advantages of reinforced concrete structures over steel or wood in terms of service life and repair costs are undeniable.

The fire resistance limit of load-bearing metal structures depends on the given metal thickness t_{red}, which is determined by the formula: (1)

$$t_{red} = \frac{A}{U}$$

Where: A – cross-sectional area, cm^2; U - heated part of the section perimeter, see.

The heated perimeter of metal structures is determined without taking into account the surfaces adjacent to slabs, floorings and walls, provided that the fire resistance of these structures is not lower than the fire resistance of the heated structure.

For trusses and other statically definable structures consisting of elements of different

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sections, the reduced metal thickness is determined by the smallest value for all loaded elements.

In fire-fighting design, actual and required fire resistance limits of structures are determined and compiled. Calculation of the limits of fire resistance of structures consists of determining the non-standard field of structures at a given temperature regime of thermal exposure; determination of the bearing capacity of structures, taking into account its properties in the process of thermal and power effects; setting the time from the beginning of the thermal effect to the onset of the limiting state (I, II, III).

Features of fire protection of structures

Methods of fire protection of structures are diverse and include constructive methods, methods of creating various types of heat shields on the surface of elements, physicochemical and technological methods aimed at reducing the fire hazard of materials.

Table 1 Examples of some methods of fire protection

Fire protection method	Fire retardant layer thickness, mm, at fire resistance limit, h		Average density, kg / m3
	0,75	2,5	
Constructive methods			
Concreting	35	60	2250
Brick lining	65	125	1800
Large-sized claddings (gypsum plasterboards)	16	32	850
Plastering			
Cement - sand plaster	25	40	1800
Perlite plaster	20	40	450
Lightweight heat shields			
Coating (phosphate grade OFP - MV)	15	45	300
Intumescent paint	4	-	1450

The use of one or another method of fire protection is determined by the specific features of various types of structures, their areas of application, the values of the required fire resistance and fire propagation limits, as well as the temperature - humidity conditions of fire protection work, operating conditions, etc.

Conclusion

This article provides a methodology for determining the fire resistance of compressed metal columns.

In short, columns are one of the most important structures in construction and metal structures. Because columns are structural elements that transfer loads from structures above them to foundations. Therefore, it is important to correctly check their compressive strength and correctly identify the cutting surfaces.

Therefore, it is necessary to increase the fire resistance of metal structures.

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References

1. Saydullaev Q.A., Shukurova K.Q. “Metal structures”. Textbook. Tashkent: “Science and technology”. 2010.
2. A.I. Yakovlev Calculation of fire resistance of building structures. - Moscow: Build from dates,1988 –p. 143.
3. QMQ 2.03.05 - 97. Standards for the design of steel structures. Tashkent:, 1997.
4. Saydullaev Q.A. Shukurova K.Q. “Steel structures”. Study guide. Tashkent: 2004.
5. Romanenkov I.G., Levites F.A., Fire protection of building structures Moscow:, Build from dates, 1991. – p. 320.
6. SHNK 2.01.02 - 04. Fire safety of buildings and structures. Tashkent: 2005.
7. Shukurova K.Q. “Metal structures”. Textbook. Tashkent: 2019.