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ANALYSIS OF THE STATE OF FIRE RESISTANCE PROBLEMS OF REINFORCED CONCRETE STRUCTURES, TAKING INTO ACCOUNT THE TIME AND CONDITIONS OF THEIR OPERATION

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Abstract:
This article examines the use of in-kind technical fire resistance surveys of reinforced concrete structures. Its practical significance will allow for the formulation of design proposals that can improve residual strength, reduce residual deformation, and ensure the safety of reinforced concrete elements in industrial facilities.

Keywords
design, fire resistance limit, fire, fire safety, load-bearing capacity.

Introduction

Losses from building destruction during fires account for approximately 15–20% of total losses. Therefore, studying issues aimed at reducing material losses from fires, ensuring the fire safety of building structures, and determining their post-fire operability is relevant [1]. And, of course, we must not forget that any construction projects and proposals must address the primary objective—the safety of human life and health.

The growth of construction projects and the increasing complexity of building design require increasing attention to the issue of fire resistance.

Reinforced concrete structures, widely used in construction, offer relatively good resistance to high-temperature fires compared to metal and wood structures. Load-bearing reinforced concrete structures, while having a high fire resistance rating, still experience changes in their performance properties during and after a fire [1].

The essence of fire resistance lies in the rapid loss of required properties by building materials and structures when exposed to fire. The most serious fires occur in industrial and warehouse buildings, where the fire load consists of combustible and flammable materials, as well as liquefied gases, and fire temperatures can reach 1200–1600°C.

The technical regulations on fire safety requirements set forth fire resistance requirements and the functional fire hazard class of load-bearing structures [4]. Concrete is a non-combustible material and corresponds to the highest structural fire hazard class K0.

As for the fire resistance of reinforced concrete structures, they better retain their stability in the event of a fire.

The fire resistance of reinforced concrete structures depends on many factors: the design, geometry, level of operational loads, thickness of the protective layers of concrete, type of reinforcement, type of concrete, its moisture content, etc.

Under fire conditions, the fire resistance limit of reinforced concrete structures is reached, as a rule, due to a decrease in the strength of concrete during heating, thermal expansion and thermal creep of the reinforcement, the appearance of through holes or cracks in the sections of structures, and also as a result of the loss of thermal insulation capacity [5].

This leads to a rapid reduction in the load-bearing capacity of the structure during a fire. At the point in time of fire exposure, when the load-bearing capacity of the structure drops to the working load level, its fire resistance limit, according to the R-rating, is reached [5].
In modern methodology, there are experimental and theoretical methods for assessing the fire resistance of reinforced concrete structures.
However, the experimental method has significant drawbacks. Testing using this method requires cumbersome and expensive experiments, which, in some cases, makes it difficult to promptly assess the fire resistance of various types of new building structures.
The theoretical approach is more promising and cost-effective. Therefore, computational methods for assessing fire resistance are being developed in our country. The essence of the calculation generally boils down to assessing the temperature distribution across a structural cross-section under fire conditions (thermal engineering) and calculating the load-bearing capacity of the heated structure (static engineering). However, the theory of fire resistance for building structures is still insufficiently developed, so even an experienced designer finds it difficult to design the required fire protection for structural load-bearing elements. The first challenge faced by practicing engineers in this approach is determining the nature of the temperature distribution across structural material cross-sections at certain time intervals. In other words, they must solve the problem of transient heating of the load-bearing element material under fire conditions.
An approximate solution with the required accuracy can almost always be found using numerical methods, especially when using computers.
The essence of calculating the fire resistance of structures lies in determining the point in time after which, under fire conditions, structures lose their load-bearing or thermal insulation capacity.
Fire resistance of a structure based on the loss of load-bearing capacity is defined as the moment in time of exposure to fire at which the load-bearing capacity of the structure, under the influence of the fire temperature, decreases to the value of the working loads acting on it.
The type dependencies were obtained as a result of many years of specialized experimental studies [3] for all major building materials. These studies demonstrate that the resistance of common building materials to fire conditions begins to decrease rapidly after a certain temperature. These dependencies are currently used as reference data in fire resistance calculations for building structures [2].
The critical heating temperature of a structural material during a fire is the temperature at which the material loses its ability to resist the effects of fire.
The concept of critical heating temperature of structural materials is one of the basic indicators used in the theory of calculating building structures for fire resistance [2].
When using this indicator, the calculation of building structures for fire resistance also includes solving two problems:
1) the strength problem of fire resistance: determination of the standard working load on the structure under consideration, then the corresponding value of the coefficient of the working conditions of the materials of the structure during a fire and, further, the value of their critical heating temperature at a given level of working load;
2) thermophysical problem of fire resistance: determining the moment in time of fire impact on a building structure at which key elements of the structure heat up to a critical temperature.

In this regard, there is a need to develop more general methods for assessing the resistance time of objects during a fire, which would make it possible to take into account the specifics of a combined special impact involving a fire.
The issue of ensuring the safety of buildings and structures during fires is highly relevant in our country, as the construction industry is one of the most vulnerable types of facilities to such impacts.

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