IJCRSSSL
International Journal of Current Researches in Sciences, Social Sciences and Languages

Volume: 01 | Issue: 04 | 2021 | Open Access | Impact Factor: 4.625

Improving Methods To Increase The Fire Resistance of Reinforced Concrete Structures

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Abstract: This research paper presents the results of the development of new compositions for convex paint materials and the measurement of their convexity levels. The ability of each binder to form a thin layer on the surface of a metal plate and how the resulting thin layer swells at temperatures of 300 C – 600 C and changes their adhesion to the metal surface after swelling were examined and analyzed. The analysis of the scientific literature on liquid glass, vallastonite, calcium carbonate-containing minerals, and vermiculite, and the prohibitions it has carried out, are scientifically based on the properties of these materials that prevent them from obtaining effective fire and heat-protective coatings. Studies have shown that by eliminating some of the shortcomings in the properties of these liquid glass and vermiculites, it is possible to use them effectively and develop effective coating materials with a new composition based on them. By performing these inspections, the most important components used for convex paint materials have been selected, flammability tests have been performed, and the results of thermal methods of inspection have been described. In addition, it was suggested that all theoretical research in the design of coatings to select the required chemical composition for the coating should be carried out in several stages.

Keywords: building structures, binders, flammability, paint materials, convexity, thermal effects.

INTRODUCTION

Research to increase the fire resistance of reinforced concrete structures shows the need to conduct research using thin film inflatable coatings, as well as studies aimed at improving the resistance of fire-resistant explosion-proof concrete with thin-layer inflatable coatings. Based on these assumptions, the purpose of the work was to study the possibility of increasing the fire resistance of reinforced concrete structures using thin-layer fire-resistant embossed coatings.There are a number of methods and tools available to increase the flammability limit of concrete structures and prevent explosive concrete damage. In construction practice, several weak methods of fire protection are used, namely, concreting, application of plaster coatings, screen and surface coatings, thin-layer inflatable coatings.Each of the fire protection means of the given reinforced concrete structures has its own pros and cons.

METHODS OF RESEARCH

The use of the method of increasing the flammability of reinforced concrete structures by increasing the thickness of the protective layer in them allows to increase the flammability limit of reinforced concrete structures to the desired performance (from 180 to 240 minutes).However, there are a number of shortcomings in the method of increasing the fire resistance of the structure, such as the possibility of explosive destruction of concrete. The high degree of durability of the contact relationship between the surface of the protective structure of the concrete coating plays a negative role in this case, because such strength does not prevent the development of internal cracks from this surface to the reinforced concrete, despite the tightness of the boundaries of the layers. The fact that this method of fire protection not only expands the geometric dimensions of the load-bearing parts of the structure, but also greatly aggravates their weight, in some cases this situation is not true for multi-storey buildings.This type of fire protection also requires the strengthening of the concrete surface, and the installation of formwork for various types of structures greatly prolongs the time of removal of solid concrete from the formwork, and in these cases more time is spent on the restoration of technological holes.

The use of this method in increasing the fire resistance of reinforced concrete structures, as well as the use of slab surfaces and screens, as well as leaf surfaces, allows to increase the fire resistance of reinforced concrete structures to 180-240 minutes. It is better to use these materials for fire protection of less complex structures (mainly in increasing the fire resistance of curtains).

The advantage of this method is the technological suitability of mechanical fastening to structures, and it is not subject to the condition of the previously given layers, as well as the fact that it has a non-dense connection to the surface of the structure does not impede the flow of water.But there are a few drawbacks, and they limit the application of leaf and plate surfaces and screens, primarily layers with a large layer of fire protection, the complexity of the tightness of the seams, high levels of vapor permeability (which can lead to changes in flammability properties).).It should be noted that the fire protection leaves consist of metal fastening elements, which also need to be protected from the effects of high temperatures. It should be noted that the main disadvantage of fibrous flammable layers is their oleophilicity, ie they have the ability to absorb flammable liquids, vapors from oils. In the air of some manufacturing plants we encounter vapors of highly flammable liquids, highly flammable dusts, which have the ability to be adsorbed on the fibers of flammable coatings, the accumulation of such substances takes place during a certain period. In the event of a fire, these flammable coatings serve as a source of flame spread, as well as reducing their flammability efficiency.

It is expedient to introduce lightweight plastered layers to more advanced refractory types today, as their composition is based on a hydraulic-type alloy. The composition of such coatings can protect the fire resistance of reinforced concrete structures from the effects of fire for 4 hours.

This also requires that the processing of transport tunnels, the use of nitrogen and carbon monoxide in the environment and the construction of facilities with high humidity, take into account the fact that they operate under conditions of extremely large temperature changes. The advantages over the previously considered types of fire protection are: sufficient mechanical strength and contact strength, longevity, ability to apply on complex shaped surfaces, ability to paint with hydrophobic, decorative and other compositions, resistance to atmospheric, water, anti-icing reagents and cleaning solutions , can serve as a substrate for additional equipment (lighting, surveillance, etc.).

Disadvantages of high-rise buildings, such as the laying of protective compounds on their surface and, consequently, their fire-retardant properties, excessive consumption of coatings applied to the surfaces to correct rough surfaces, additional load on the load-bearing bodies in the building, the use of these coatings increasing the amount of work to be done. The density of such coatings reaches 500-1000 kg / m2).

Inflatable fire-resistant coatings are typically designed to increase the fire resistance of metal structures. In the 90s of the twentieth century, such coatings began to be used as fire protection of wood and materials based on it.

Inflatable fire-resistant coatings increase the thickness of the initial layer by 10-50 March when heated. The effectiveness of such coatings is determined by the fact that the application of a thin layer, for example, 1-2 mm, is sufficient to protect the surface. When exposed to fire temperature, the coating forms a porous layer several centimeters thick. Similar research has not been sufficiently conducted for reinforced concrete structures, which requires the development of research in this area.

This porous layer covers the protected surface, fills holes and cracks, insulates the flame and makes it difficult to heat the building surface. The coefficient of expansion of the coating depends not only on the natural properties of the material, but also on its heating conditions (maximum temperature and rate of rise).

The cause of swelling and porosity is the release of water vapor or gas at high temperatures. When a porous layer is formed, the binder softens, and when the foaming substance breaks down, non-combustible vapors and gases are released. The coating begins to swell, the temperature range being 160-350 ° C.

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Today, the development of the construction complex with high and unique buildings has led to the need to increase the fire resistance limits of buildings made not only of metal, but also of reinforced concrete. Much work is known to evaluate the fire-resistance effectiveness of various inflatable coatings in relation to metal structures. There is a need to analyze the situation in the field of methods and tools to increase the fire resistance of concrete structures, to improve the selection, development and implementation of methods and tools to assess the durability of reinforced concrete structures, taking into account the use of thin-layer, fire-resistant, glazed coatings.Considering the use of thin-layer fire-retardant coatings, it is also necessary to study the heating properties of reinforced concrete structures during fire and to improve and fully localize the properties of the formation of thin-layer coatings of reinforced concrete structures swollen under fire.There is also a need to develop a method to increase the fire resistance of thin-layer fire-resistant coatings of concrete structures and to reform the work on assessing the fire-resistance efficiency and optimal thickness of thin-layer fire-resistant coatings applied to reinforced concrete structures.It is difficult to imagine the construction of modern buildings and structures today without metal and reinforced concrete structures. This is due to the fact that this type of construction has a high strength and durability, as well as resistance to high impact forces (weight and pressure). Also, the possibility of large-scale industrial production of this type of construction and its ease of use in construction allows any construction project to be completed in a relatively short time.But metal and reinforced concrete structures have many advantages as well as some disadvantages. Examples are the corrosion of metal structures and the non-flammability of reinforced concrete structures. Metal structures do not burn under the influence of fire, but lose their strength in the short term under the influence of heat during a fire. It is known that the flammability limit of unprotected metal structural elements is a value of up to 15 minutes. This is very rare. Therefore, increasing the fire resistance of metal structures is a topical issue, and various methods and coating materials are used to solve this problem.The use of convex fire-retardant composite compositions to increase the fire resistance of building structures is one of the most common modern methods today. Researchers are paying special attention to the application of pre-known flame retardants, the development of new effective convex compounds and the widespread and effective use of modern nanotechnologies in solving this topical problem.

When convex paint materials are applied to structures, they become layers of a protective coating on the surface of the structure. Under the influence of heat during a fire, this coating layer bulges 10 to 40 times its thickness to form a thick protective layer. This protective layer reduces the thermal impact on building structures during a fire and prolongs the fire resistance of structures. Modern cladding materials have the ability to protect building structures not only from fire, but also from other types of adverse effects, such as corrosion, sudden increase in air temperature or cooling, that is, they also act as a heat shielding material.

Experiments GOST R 12.3.047-98 “Fire safety of technological processes. General requirements. Control methods ”, appendix - F:“ Requirements for fire protection of technological equipment barriers ”4.4. in accordance with paragraph "Device for determining the coefficient of convexity." The device is designed to determine the degree of convexity of flammable coatings.

Preparation of samples: 3 metal plates with dimensions 100x100 mm and thickness 1 mm are prepared for testing, the layer thickness is pushed in the form of a coating around 1 mm. Samples are placed in a drying chamber at 60 ° C for 24 h. The thickness of the coatings formed on the surface of the samples taken from the drying chamber is then measured in 3 places - h0. The samples are then placed in a thermos at 600 ° C for 5 minutes. After five minutes, the samples are removed from the thermos and cooled to room temperature in a desiccator. The thickness of the cooled specimens is measured again from 3 places measured before the test - h. The coefficient of convexity - Kqv is determined by relating the thickness of the layer of convexity formed after the test - h to the initial thickness of the coating - h0: Kit= h/ h0 During the experiments, the thickness of the coatings was measured with a micrometer. The coefficient of convexity is defined as the arithmetic mean of the three measurements. Description of measuring instruments: GOST R 12.3.047-98. F.4.4. 3 metal plates of size 100x100x1 mm in the "Device for determining the coefficient of convexity" in accordance with the application. Micrometer for measuring thickness. Temperature meter XA thermocouple, PT 200 digital temperature control device and SNOL 1.6 laboratory oven.From the analysis of scientific sources on modern paint materials that increase the fire resistance of building structures, it is known that these materials are based on inorganic and organic-based binders and special fillers. Standard liquid glass, urea-formaldehyde resins, acrylic emulsion, and Na-KMTs were tested as binders in the development of the final compositions of the convex effective flame-retardant paint materials. Vallastonite, vermiculite, dolomite were used as fillers.

Preliminary research examined the ability of each of the above-mentioned binders to form a thin layer on the surface of a metal plate and how the resulting thin layer swells at temperatures of 3000 C – 6000 C and changes their adhesion to the metal surface after swelling.The highest level of convexity (20-25 times) was observed in the coating formed by the sodium liquid glass. Acrylic emulsion had the least swelling, up to 1-1.5 times. The best performance among the tested binders was obtained from the liquid bottle. Liquid glass has a good degree of convexity as mentioned above, but does not lose its adhesion to the metal surface after convection, and the strength of the convex layer formed is high. Therefore, in subsequent studies, liquid glass was selected as the main binder and the effects of other binders and fillers on its viscosity, convexity and other properties as an additional component to the liquid glass were studied. Vermiculite and vallastonite minerals were also selected as filler components. The reason for the choice of these minerals is that they have unique properties that are useful in obtaining flammable materials.

CONCLUSION

Consequently, it should be noted that the construction of modern buildings requires up to 10% of the total cost of building structures and up to 30% of structures to protect their structures from fire. In order to increase the fire resistance of concrete and reinforced concrete structures, fire research has been conducted in many studies, researches and constructions. According to the test results, the use of thin-layer, inflatable coatings for fire protection of concrete and reinforced concrete structures is considered effective.

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