Rescue system for people evacuation for high-rise buildings

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Abstract. The article deals with the issues of ensuring fire safety of multifunctional high-rise buildings and structures. Measures are given to ensure fire safety of multifunctional high-rise buildings and structures. Effective modern methods of improving the safety of using constructive solutions that prevent the spread of fire and the evacuation of people from places covered in flames and smoke by combustion products and blocking access to stairwells are reflected. Since in some cases it is not possible to save people from a burning building in traditional ways, structural solutions are additionally presented that contribute to the safe evacuation of residents of the house. When reviewing existing designs, their shortcomings were identified. The authors proposed a new design of an effective, non-traumatic and safe device for saving people, especially those with low physical fitness and limited physical abilities. It allows you to simplify the design, provide the necessary speed, ensure the availability of evacuation of people with physical disabilities, avoid the presence of auxiliary equipment on a stationary ground object, ensure manufacturability in use, which does not allow, if necessary, to save people from windows and balconies, increase productivity in the “descent-ascent” mode.

1 Introduction

Due to the high density of development, the construction of residential complexes, buildings and multifunctional facilities, whose height exceeds 100 m, is actively underway in cities. All of them are objects with a massive stay of people and the concentration of huge material values in them. In this regard, one of the key problems arises - human safety and the preservation of material values associated with fires [1].

Every year, the residential sector accounts for about 70% of the total number of fires in the Russian Federation [2, 3].

To this end, to ensure the fire safety of multifunctional high-rise buildings and structures, the following activities are carried out [4]:
1. constructive solutions are provided to prevent the spread of fire between floors, sections, fire compartments and adjacent buildings.
2. the use of building materials with a high fire hazard class is limited;

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3. organization of a fire safety system (availability of primary fire extinguishing equipment, as well as alarms);
4. creation of safety zones and emergency and evacuation exits.

In addition, the most effective modern methods of improving safety is the use of constructive solutions that prevent the spread of fire and the evacuation of people from places covered in flames and smoke by combustion products and blocking access to stairwells [5]. Persons with physical disabilities present a particular problem.

These include:
1. fire barriers - include partitions, floor slabs, valves, zones, etc. Barriers ensure the safety of load-bearing structures, prevent the spread of fire. Contribute to the spontaneous extinction of the flame;
2. fire walls. The disadvantages of high-rise buildings are that, starting from 30 meters from the ground, fire extinguishing with the help of mechanical devices becomes extremely difficult. To prevent fire, vertical partitions are installed, starting from the base of the building. A fire barrier in a high-rise building makes it possible to prevent the spread of fire even in the event of a collapse from the source of fire;
3. fire breaks - the distance between high-rise buildings is designed to ensure free passage of vehicles, including fire engines, as well as to prevent the spread of fire to a neighboring house.
4. life-saving equipment: mechanical ladders, hydrants, etc., but they are mainly designed for heights up to 30 meters.

In some cases, saving people from a burning building by traditional means is not possible. For this, structural solutions are additionally designed that contribute to the safe evacuation of residents of the house [5].

The design of additional structural solutions that contribute to the safe evacuation of the residents of the house must be considered at the stages of drafting the project and the method of arranging the roof [6, 7].

According to the design and shape of the roof (roof) are divided into [8]:
- single-pitched (with a different inclined angle);
- gable;
- multi-slope;
- slopeless (standard flat roofs);
- complex (more typical for modern buildings than for old houses).

The aim of the research is to develop an effective, non-traumatic and safe device for rescuing people, especially those with low physical fitness and physical disabilities from a building in flames, which has speed, improved manufacturability in use and increased productivity in the "descent-rise" mode in relation to rampless, standard flat roofs.

2 Results

At the Volga State University of Technology proposed a new technical solution for a rescue system for high-rise buildings during the evacuation of people and valuables during a fire from roofs in relation to pitchless (standard flat roofs), windows and balconies of buildings [9]. Moreover, this device is effective, non-traumatic and safe, has a high speed, improved manufacturability in use (the ability to evacuate people from the roof, balconies, windows) and increase productivity in the "descent-ascent" mode.

The device of the rescue system for high-rise buildings (Figure 1) consists of a trolley 1 installed on rail tracks 2, on which a lifting boom is mounted in the form of an articulated four-bar 3, in the upper part of which there is a platform 4, with a mechanism for raising and lowering 5 of the rescue cabin 6 with a ladder (not shown), and the lifting boom is connected...
to the drive station 8 by means of a cable suspension 7, while a counterweight 9 is installed in the rear part of the cart 1 behind the lifting boom 3.

**Fig. 1.** Device for performing fire and rescue operations in the initial position (a - side view, b - top view).

The device works as follows (Figure 2).

**Fig. 2.** Possible operating positions of the rescue cabin.

In the event of a fire from the command console, a signal is given to turn on the rescue system, while each lifting mechanism is transferred to the working position: the drive station.
8 releases the cable with the output of the boom 3 and the rescue cabin 6 beyond the contour of the building. The drive station 5 lowers the rescue cabin 6 to the ground to accommodate the necessary rescue equipment and a rescuer inside. With the help of remote control, the rescue cabin rises to the desired window or balcony while simultaneously moving the trolley 1, moving the lifting boom 3 and winding the cables using drive stations 5 and 8. Having reached the specified window or balcony, the rescuer folds the ladder onto the window opening or onto the balcony railing and rescued people move to the rescue cabin 6. The rescuer returns the ladder to its original position and the rescue cabin 6 is transported either to loading to another window, or to unloading to a safe lower floor or ground. After unloading, the cycle repeats.

Upon completion of the rescue operation, the device is returned to its original position.

In order to test the performance of the proposed design of the rescue system for high-rise buildings during the evacuation of people and valuables during a fire, an animation model of the operation of this system was developed, fragments of which are shown in the Figure 3.

Fig. 3. Fragments of the operation of the rescue system for high-rise buildings during the evacuation of people and valuables during a fire.
3 Discussion

According to many researchers in the field of creating rescue systems during fire and rescue operations, when the evacuation of people and valuables in traditional ways is not possible, it is an urgent task [10, 11, 12, 13].

Despite the fact that many well-known researchers have worked on this topic, the patent and literature search made it possible to conclude that a similar development in the field of fire and rescue operations is effective, namely, the evacuation of people and valuables from the roofs, windows and balconies of buildings in case of fire. The closest examples of such constructive solutions can be considered the designs proposed in the patents of the Russian Federation [11, 12, 13].

During the morphological analysis and synthesis of elements of devices for fire and rescue operations [11, 12], the shortcomings of these structures were revealed:

1. design complexity;
2. lack of speed;
3. the difficulty of evacuating people with physical disabilities;
4. the presence of auxiliary means on a ground immovable object, for example, on a vehicle;
5. insufficient manufacturability in use, which does not allow, if necessary, to save people from windows and balconies, from roofs with a building height of more than 75 m.;
6. low productivity in the “descent-ascent” mode.

And the device for fire and rescue operations [13] has the following disadvantages in the morphological analysis and synthesis of its elements:

1. design complexity;
2. lack of speed;
3. low productivity in the “descent-ascent” mode.

4 Conclusion

The proposed design of the rescue system for high-rise buildings during the evacuation of people and valuables during a fire allows:

1. simplify the design;
2. provide the necessary performance;
3. availability of evacuation of people with physical limitations;
4. to avoid the presence of auxiliary means on a stationary ground object, for example, on a vehicle;
5. ensure manufacturability in use, which does not allow, if necessary, to save people from windows and balconies, from the roofs of buildings over 75 m.;
6. to increase productivity in the "descent-rise" mode.

The research was supported by the Ministry of Science and Higher Education of the Russian Federation (Grant № 075-15-2021-674) and Core Facility Centre «Ecology, biotechnologies and processes for obtaining environmentally friendly energy carriers» of Volga State University of Technology, Yoshkar-Ola).

References


10. V.V. Kopytkov, A.V. Shnyparkov, A.Z. Skorokhod, A.N Salenko, Bulletin of GSTU named after P.O. Sukhoi, Mashinostroyeniye i Mashinovededenie 2, 3-69 (2014)

