Overview of Technical Solutions for Ensuring Fire Security of High-rise Buildings

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***Abstract*— This article faces the problems of ensuring fire safety in high-rise buildings. The objectives of the study are to identify the relevance of the problem, to find out the factors of increased risk of high-rise buildings, to collect the statistical data about fires occurred in Moscow, to discuss some technical solutions for fire safety of high-rise building and to propose measures for fire safety improvement.**

***Index Terms*— high-rise buildings, fire, fire hazard, fire safety.**

I. Introduction

At present, one of the most important activities developing in Russia is erection of multi-floor buildings.

In the environment of modern megalopolis, there is a significant demand for residential houses and offices, regularly lots of projects are implemented in this direction. As a consequence of this trend, high-rise buildings and constructions are a central topic, allowing to solve the problem of free ground area lacking for buildings construction and give the investors the opportunity to obtain the maximum profit from the minimum area.

According to Russian Federation regulations, a building is classified as "high-rise building" as its height overcomes 75 metres (25 floors). Being such height significant for the structural resistance, this kind of buildings is characterized by complex structural solutions and differ by a number of features that need to be considered in the planning phase. These features include increased wind loads, a particular strength of the foundation, providing the functioning of the building by appropriate engineering devices. One of the most important issues in tall buildings is fire hazard, owing to the complex flames propagation paths during a fire and to the particular difficulty of evacuating a large number of people.

Due to the cost-cutting, the elements of building construction do not correspond to requirements of effective saving operations, as the result there are problems regarding the fire-prevention space between buildings and the ability for fire trucks to reach the building in case of emergency.

Moreover, technical equipment for extinguishing fires for high-rise buildings and rescue equipment lag behind in technical improvement. During the period from 2011 to 2015, in the Russian Federation 90 fires were registered in skyscrapers, 44 of them took place in residential high-rise buildings [1].

Fig.1 Fire in Tower East (The Federation Towers), 02.04.2012 (from supercoolpics.com).

Brief information about the most famous fires in Moscow is presented in table 1.

II. Buildings fire safety

Ensuring fire safety of high-rise buildings, in accordance with the life cycle of the building (complex of buildings), should start at the stages of its design and continue during construction. Increased fire hazard of skyscrapers is characterized by rapid spread of fire in the vertical direction, owing to convective motion of hot combustion gases: the vertical extension of the object and the natural upwards air flow contribute to the rapid development of the fire in the higher floors and to the rapid temperature increase that could lead to loss of strength and stability of load-bearing structures.

Also, the presence of large internal volumes not separated by fire barriers, strong wind flows that contribute to increase the chimney effect and flame spread, contribute to the low fire safety of these building structures.

Moreover, the difficulties with evacuation due to the

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obstruction of escape routes by the products of combustion and fire, hard conditions for the action of fire and rescue units, in addition to the deficit or lack of equipment to access the floors above 100 meters, entail increased probability of adverse consequences.

Obviously, the standard norms for high-rise buildings are unacceptable, and therefore an individual approach is required. Unfortunately, today there is not a single approach to ensuring the safety of buildings higher than 100 meters in Russia.

In Table 1 are listed some of the most harmful fires that developed in Moscow since 2000; the table indicates the interested building main features and the fire consequences.

TABLE I
THE MOST FAMOUS FIRES IN MOSCOW

Date	Place of incident	Height, m	Time of extinguishing	Fire area	Victims
27.08. 2000	Ostankino Tower	540.1	26 h 36 min	200 sq.m	10 (3 death)
02.04. 2012	Tower East (The Federation Towers)	374	4 h	300 sq.m	-
25.01. 2013	OKO Tower (Moscow City)	354	2 h	60 sq.m	1
18.08. 2016	Kotelnicheskaya Embankment Building	176	1 h	5 sq.m	-
18.11. 2005	Apartment building, 2nd Setunsky proezd, 11	75	5 h	250 sq.m	9 (4 death)
21.04. 2006	Domitory of MSU	80	1h 53 min	250 sq.m	9 (2 death)
25.01. 2013	Apartment building 'Triumph Palace'	264,1	48 min	30 sq.m	1 (1 death)
06.05. 2017	Apartment building 'Dirizhabl'	120	2 h 30 min	54 sq.m	9

The main objective of fire safety is to reduce fire risks to acceptable levels. In order to get certain technical decisions on this issue, it is necessary to wholly explore the issue of security of the high-rise buildings of a metropolis in which have already built high-rise complexes and others will be constructed in the nearest future. In the field of fire safety it is important to highlight three main topics: preventive action to prevent fires; fire extinguishing, in case of its occurrence and the immediate evacuation of people. Fire prevention measures include the elimination of potential sources of fire, limitation of fire spread, the creation of safe evacuation conditions, ensuring of necessary conditions for fire fighting. Special attention should be paid to process of fighting fires and methods of people evacuation because even buildings constructed in accordance with all requirements cannot provide absolute security.

However, not all buildings are equipped by the necessary water supply for firefighting, serviceable exterior stairs, but because of the increase of parked vehicles around the houses there is no free space for approaching rescue equipment and fire trucks to the burning environment. Moreover, there are no sufficiently reliable and universal rescue facilities, which could be used in a short time to carry out the rescue operation.

III. TECHNICAL SOLUTIONS

Fortunately, nowadays in Russia there are actual inventions and useful models that should be used for the evacuation of people from a great height. One of them is the device for rope feed to high-rise danger area [2].

This invention refers to high-rise life saving equipment and mounting facilities. A device for rope feed to a high-rise danger area is arranged on a high-rise roof and comprises a traversing gear, a vertical feed mechanism and a winch mechanism with a rope. Aiming and feed mechanisms are integrated in one structural assembly. The structural assembly comprises a ball mounted on a flat bearing of a hold-down mechanism. The hold-down mechanism accommodates rotary guides and actuating cylinders and chutes inclined to eaves. In Fig. 2 is presented the force status to which the ball is subjected, while in Fig. 3 is presented the main scheme of the device.

This invention could be really effective because provides higher reliability of rescue operations by the fact that can be used in power cutoff.

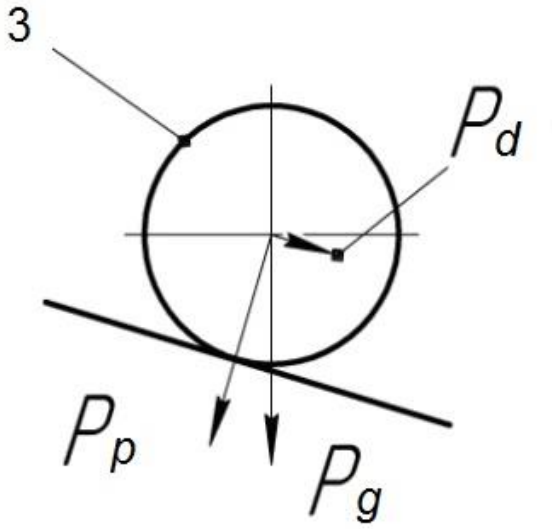

Fig.2 The ball located on the inclined plane. Pg- the force of gravity; Pp – the pressure on the plane; Pd – the force that drives the ball along the plane.

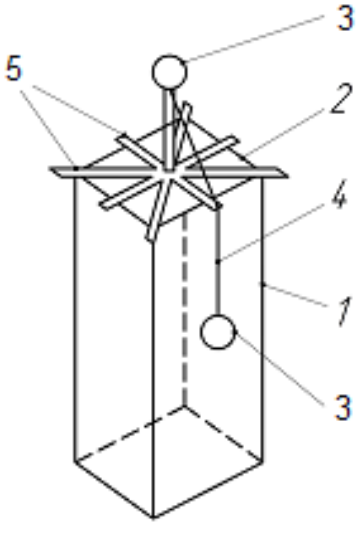

Fig.3 Installation of a ball on the support. 1-high-rise

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building; 2-roof; 3-ball; 4-wire; 5-tray

Another invention is the technology stair [3]. It is suitable for installation on roofs with different slopes of the roof. This stair is a structure adjoin to the roof slope by using swivel joint of stopper ladder and pawl over the ridge. Flexible, rope ladder allow increasing opportunities of the ladder. It can be used in construction, repair works, as well as for firefighting and rescue activities.

In Fig. 4 a scheme of the roof ladder system is provided.

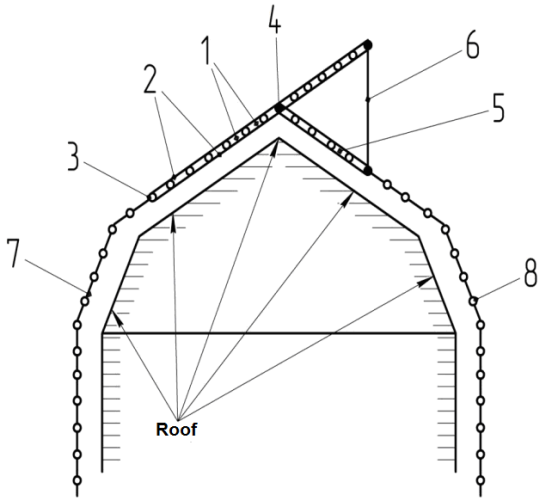

Fig.4 Mounting of a ladder to the roof ridge. 1-ladder; 2-longitudinal beams; 3-cross beam; 4-hinge; 5-capture; 6-unit for retainer; 7,8-flexible ladders.

Another invention is the belt for firefighters [4]. On this belt there is a movable, re-locatable sealing ring where there is a horizontal axis with units of location and fixation of the shaft. This design allows to ease the load on firefighter, redistributing the load from the shoulder to the lumbar.

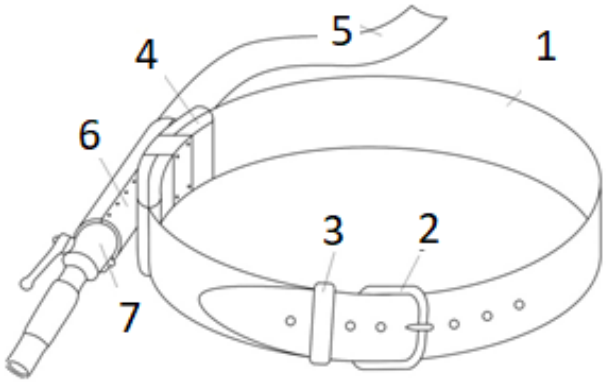

Fig.5 The belt of firefighter. 1 – belt; 2 – buckle; 3 – clamp; 4 – movable sealing ring; 5 – sleeve; 6 – fretanier of shaft; 7-shaft.

IV. Conclusion

After analyzing the problem of fire safety of high-rise buildings, it can be concluded that there is a necessity to review existing ways and means of rescue, to raise the demand of development and introduction of new technologies [7-9], and to propose and prove new technical solutions.

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