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The providing of protection requirements of residential buildings from the progressive destruction

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Abstract

The article examines and analyzes the requirements for protection multistory residential buildings of 2nd level of responsibility from the progressive destruction. Such buildings form the basis of urban mass building. As an example, the article describes the results of a technical survey of the emergency destruction of panel residential building type series 1-115 after a gas explosion in the kitchen of one of the apartments. Provided the constructive solution implemented in the process of restoration of the destroyed floors of the building.

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Keywords: protection from the progressive destruction, multistory residential buildings of 2nd level of responsibility, a technical survey of the building, emergency destruction of a panel residential building, the restoration of panel building constructions.

Multistory residential buildings of mass urban development made of monolithic and precast concrete must be protected from the progressive destruction in case of loss of separate bearing structures due to accident impacts [1].

According to the classification, proposed in [2], residential buildings of mass urban development of 2nd level of responsibility have any constructive system, height - no more than 25 floors or 75 meters.

On the basins constructed, exploited and reconstructed residential buildings of 2nd level of responsibility spread the requirements for protection them from the progressive destruction, which are understood as preventing the destruction of the other structures of the building after the hypothetical destruction of the vertical structure of one of the floors of the building.

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The calculations of progressive destruction are made only for strength and stability of the constructive elements. The width of the cracks and deformation are not limited.

Figure 1 shows a picture of an emergency destruction of a 9-storey residential building from the gas explosion [3].

The building was built in 1977 on a standard project 1-115-04. The destruction of the buildings took place in November 2012 as a result of domestic gas explosion in the kitchen of the eighth-floor apartment. The external ceramsite concrete panel walls of the eighth, ninth floor and attic were collapsed, causing the destruction of floor decks of the building and floor slabs of covering. Fragments of the destroyed panel walls, hollow-core slabs and ribbed building floor slabs of covering panels covering part fell to the ground.

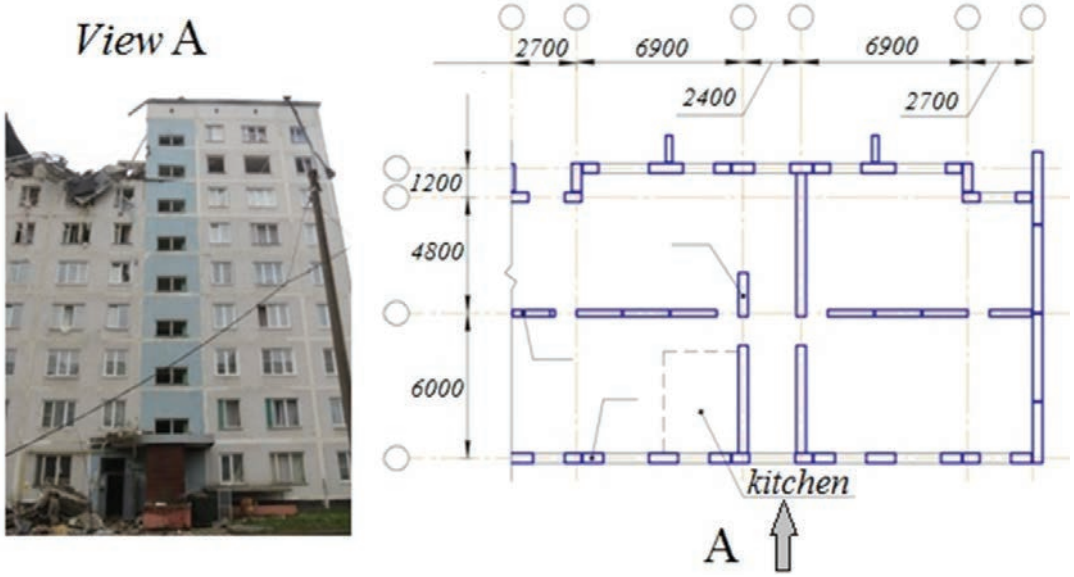

Fig.1. The destruction of the constructions of a residential building after gas explosion in the kitchen of apartment of the eighth floor (1-outer longitudinal panel walls of ceramsite concrete, 2 internal longitudinal concrete panel wall, 3 - internal transverse wall of concrete blocks)

The technical survey carried out after an emergency destruction of the building, showed the possibility and feasibility of its restoration.

Precast concrete panels of bearing longitudinal walls destroyed by explosion (Pos. 1 and 2 in Figure 1) were restored as a monolithic reinforced concrete walls with transverse protrusions at places of partitions contiguity to them.

The floor decks of 7 ... 9 floors and floor slabs of covering over the attic rooms of the building were restored from the precast hollow core reinforced concrete slabs with monolithic sections. The presence of monolithic sections allowed to organize reliable conjugation of restored floor decks and slabs of covering with the monolithic longitudinal walls and transverse wall of the staircase which been preserved after the explosion. The walls of the staircase adjacent to the kitchen of destroyed apartments were made of large blocks (Pos. 3 in Fig. 1).

The providing of the necessary protection of multistory residential buildings from the progressive destruction must be confirmed by the assessment of resistance to progressive destruction of the building structural system. Recommendations on calculation and design of residential buildings structural system, that can resist the progressive destruction, are given in [4, 5, 6].

The calculation of the structural system of multistory residential building is made with the construction of volumetric computer model of a ground, underground parts of the building and the soil base of the building in the complex software Lira, STARK-ES and other calculation complexes. The model takes into account the kind of conjugation of design scheme elements. The design load combination, including the dynamic, is prepared for it, the physical and geometric nonlinearity of the stiffness characteristics of the elements of the calculation scheme is taken into account, too.

Calculations on the progressive destruction of the structural system of the building carried out after the static calculation and the selection of reinforcement of building constructions and envisage selective multiple removal of the vertical elements of the calculation scheme.

This changes the geometry of the calculation scheme and the nature of the work of structural elements of the calculation scheme, which are contiguous with the place of destruction. Due to the changing nature of work of elements of the calculation scheme for them it is necessary to change the stiffness characteristics of these elements and to describe the nature of the relationship between them differently.

This represents the certain complexity due to the uncertainty of the quantitative assessment of these parameters of the calculation scheme. The calculation is made on a special combination of loads, which includes permanent and longtime temporary loads with coefficients of load combination and coefficients of reliability for loads be equal to one [7]. When performing calculations the normative values of strength and deformation characteristics of the concrete and reinforcement are accepted. [8]

The constructive requirements for elements of the bearing system of multistory residential buildings relate to the choice of reinforcement, the plastic properties of which in the limiting state permit the redistribution of efforts between the workable constructions with blocking of the process of progressive destruction after the occurrence of local destruction in the building.

Since the thermomechanical hardening of reinforcement is associated with the loss of its plastic properties, the increasing of the strength properties of reinforcement while maintaining its plasticity is one of the promising areas of production of steel reinforcement for reinforced concrete structures.

The inclusion in the spatial work of the structural system of the building not load-bearing structural elements, such as outer wall panels, can improve the protection of the building against progressive destruction

At the same time, the horizontal tie-roads of mounted concrete or reinforced concrete the exterior panels with to the bearing elements of the building should be perceive: if the height of floor is 3.0 m - tensile force is of at least 10 kN per meter length of the panel, and if the height of floor is 3.5 m floor – tensile force is of at least 12 kN per meter length of the panel.

The volumetric computer model of the structural system of the building can also include other non-structural elements. Figure 2 shows a constructive solution of ties of panel residential building series 1-115 and the technical condition of the cargo sling loop in a damaged lightweight aggregate wall panel.

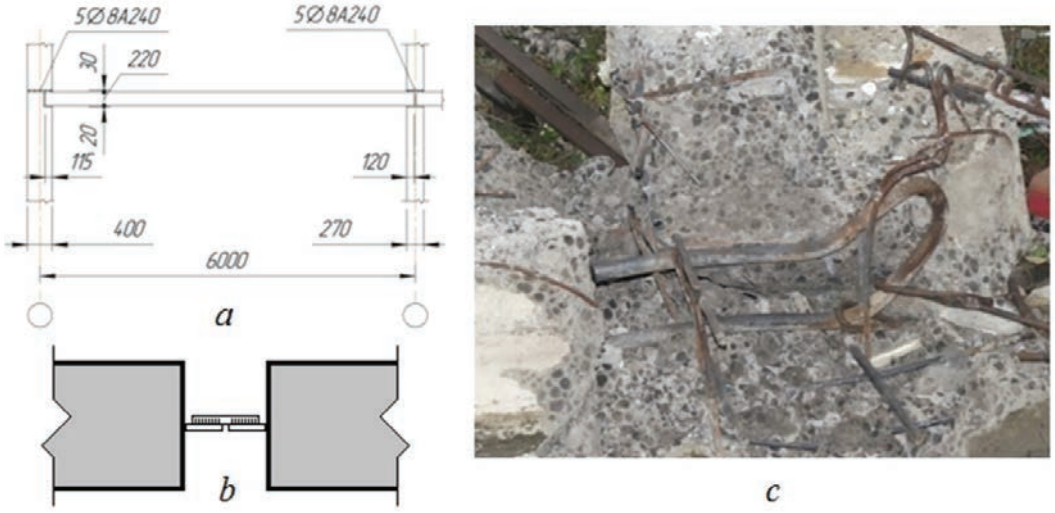

Fig.2. The constructive solution of ties of panel building series 1-115, where has been a an emergency destruction: a) - the scheme of leaning of bearing hollow-core floor slab on the load-bearing walls of the building; b) – the scheme of welded steel cargo sling loop between the panels of bearing walls; c) - cargo sling loop in a damaged lightweight aggregate wall panel

Figure 2a shows a hinged conjugation of floor slabs with bearing panel walls of the building series 1-115,

subjected to emergency destruction. In the operational phase floor slab operates as single-span statically determinate beam, loaded uniformly distributed static load.

The prestressing working reinforcement of floor slab is installed at the lower edge of the constructive element. Volumetric dynamic stresses, resulting from the explosion of household gas in the kitchen space, by the nature, intensity and direction of the load action is fundamentally different from the static floor slab loading in the operational phase and requires a top working reinforcement, which was not provided in the floor slabs of the building.

In addition, in the conditions of small vertical compressive load from the overlying wall panels to the outer wall of the kitchen at the epicenter of the explosion, there was a knocking out by blast wave exterior wall panels throughout the apartment, provoking a progressive destruction of the structural elements of the overlying floor and the attic.

Multistory panel buildings of longitudinal-wall structural system in the conditions of explosive effects are more vulnerable than the buildings of a cross-wall structural system with floor slabs resting on three interior walls or even additionally on the outer wall of the building.

Figure 2a shows that in the process of destruction of the building the link between floor slabs and exterior walls can weaken or even lost. This leads to a change in the calculation scheme of the exterior wall panels. Wall panels in the epicentre of the explosion of domestic gas were destroyed as a result of the explosive impact of considerable intensity.

A monolithic floor slabs are even more reliable in the buildings of the wall structural system. The lower and upper longitudinal working reinforcement, located along both directions of the coordinate axes of the building, must be continuous, and the minimum total cross-sectional area of the lower and upper longitudinal reinforcement should not be less than 0.25.

Figure 3 shows a variant of constructive solution of the monolithic floor slab in the building of the wall structural system. The interruption of bottom reinforcement in the support zone of overlap, as well as the location of the upper grids of reinforcement only over the walls, in case of loss of supports will lead to the destruction of floor slabs and can cause progressive destruction of the bearing system of the building.

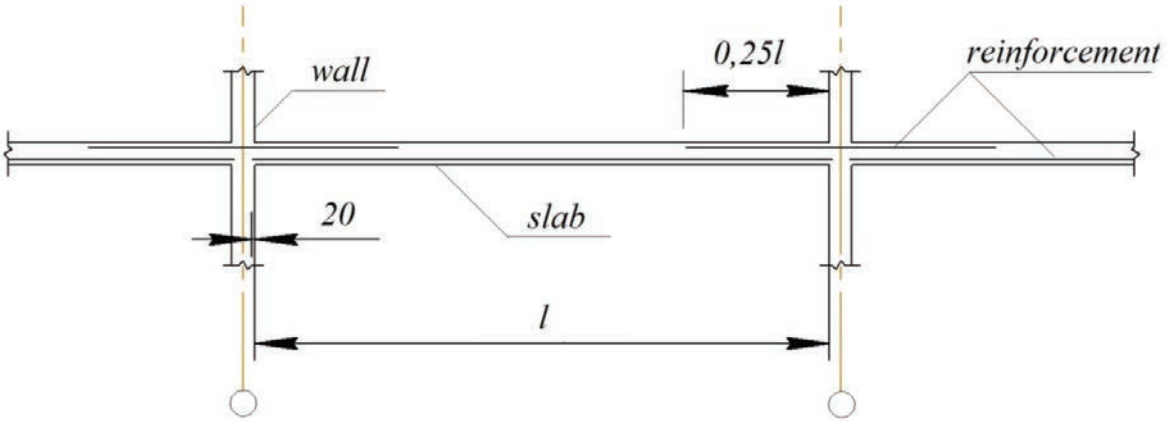

Figure 3. Variant of constructive solution of monolithic overlap in the building of the wall structural system

The observance of regulatory requirements for the protection of multistory residential buildings from the progressive destruction will reduce the risk of their destruction in the case of explosion of domestic gas, carrying out an unauthorized reconstruction and in other cases.

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