Analysis of exploitation of residential five-storey buildings, erected on Zaporizhzhia's subsided grounds

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Summary. This article gives an analysis of the housing stock Zaporizhzhia, shows the classification of residential buildings on the number of buildings storey and external walls material, considered types of deformations are given recommendations for improving the reliability of operation of five-storey residential buildings at their possible reconstruction.

A significant part of Zaporizhzhia housing resources (about 25%) is made up of five-storey residential buildings, so-called "Khrushchovki", which were built according to standard design in the 50 − 60 years of the last century. The term of these buildings exploitation is coming to its critical deadline. The layout of such premises is morally obsolete and does not fit to live in. Besides, buildings of this class have sizeable physical wear because of exploitation complexity on subsided soils. About fifth of old dwellings are deformed owing to subsidence of their foundations. The complex of protective measures, capable to provide required strength and operating buildings qualities in the cases of base soaking are absent.

Key words. Five-storey residential buildings, subsided grounds, camber, sag, rupture of walls, joints expansion closures, shear deformations.

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RELEVANCE OF THE PROBLEM

The purpose of this research is to systematize data of exploiting experience of five-storey residential standard construction buildings and to develop recommendations to be taken into consideration, for their available reconstruction [1].

To analyze and systematize data on quantitative and qualitative conditions of Zaporizhzhia housing resources, the necessary information and materials received from the city housing administration were collected and processed.

To obtain data on residential buildings which were erected and are being operated on Zaporizhzhia city subsided soils, we have collected and distributed the information, considering on the number of buildings storey and external walls material [2]. The quantitative conditions of Zaporizhzhia housing buildings estate include:

- 1…4-storey brick – 1620 buildings;
- 5-storey block – 119 buildings;
- 5-storey brick – 542 buildings;
- 5-storey panel –251 buildings;
- 9-storey panel – 538 buildings;
- 9-storey brick – 74 buildings;
- 9-storey block – 67 buildings;
- 12-storey brick – 16 buildings;
- 13…18-storey brick – 57 buildings.

Fig.1 shows the percentage distribution of Zaporizhzhia city residential buildings considering the storey number and walls materials.

Significant part of the housing resources consists of five-storey residential buildings − 912 pieces, which makes 23% of the total number of city's balance sheet buildings.

Five-storey residential buildings are divided into: brick (542 houses, 2523 entrances), panel (251 houses, 1361 entrances) and block (119 houses, 525 entrances) [2]. The buildings percentage by the external walls materials is: 60:27:13.

Five-storey residential buildings of Zaporizhzhia city were built in the period from the 50 s to the 70 s years of the last century, according to standard series 1-464, 1-464A, ВК-4, 1-437, 1-438, 1-442, 1-443, 1-480. Five-storey buildings typical projects of the first generation were based on several design schemes: with a narrow step of transverse bearing walls (series 1-464 − large-panel); with a mixed pitch of transverse bearing walls (1-464A, 2-468 and etc.); with three longitudinal bearing walls (series 1-447, 1-480, 1-511, 1-515 and etc.). The final city's buildings for standard projects were erected with brick walls (series 1-447 1-511) [2].

In the course of research on the analysis and systematization of operating data, information on five-storey residential buildings which were deformed as a result of subsided effect were

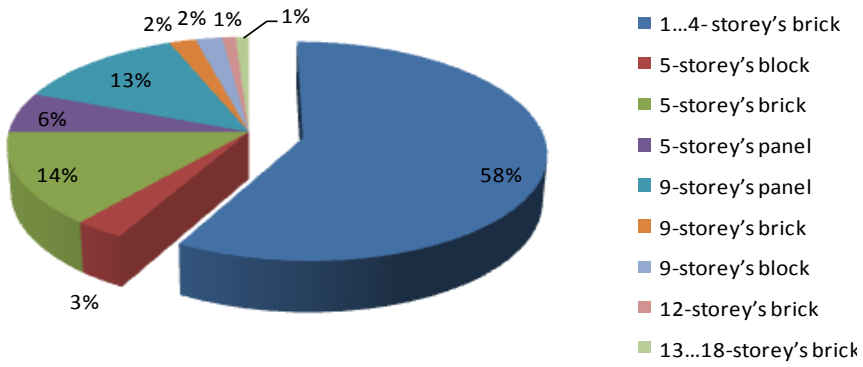

Fig.1. Distribution of Zaporizhzhia city housing estate considering the buildings storey number and walls materials

Table 1. Indexes of buildings deformation frequency, depending on materials type of exterior walls

Building type	Average operating time, years	Number of buildings, pcs.	Of them deformed, pcs.	Deformation percentage, %
Bricks	50	542	120	22
Panels	48	251	54	21
Blocks	49	119	22	18

allocated [3, 4]. The indexes of buildings deformation frequency, depending on materials type of exterior walls were determined. These data are given in Table 1.

TYPES OF BUILDING'S DEFORMATION

The deformations of buildings are caused by vertical and horizontal displacements of the subsided soil surface during its soaking.

The following are shows the main types of building's deformation and the layout of the soaking areas. The building's deformation, depending on the character of uneven sedimentations and building's rigidity, can be conditionally divided into the following types [5 – 9].

The building's curvature with a camber is accompanied by the formation of vertical cracks with the greatest opening at the top of the building (Fig.2). The soaking source when building is cambered is mostly located at one of the building's edges.

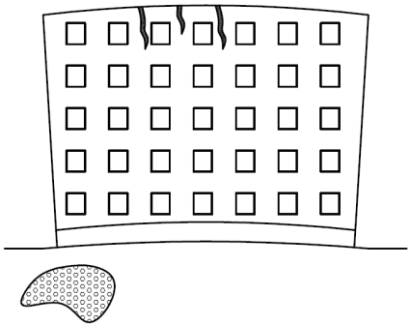

Fig.2. Building deformation type – camber

The building's curvature with convexity downward (sag) is characterized by vertical cracks with increased opening at the bottom of the building (Fig.3). The soaking area, as a rule, is placed near the greatest deformations.

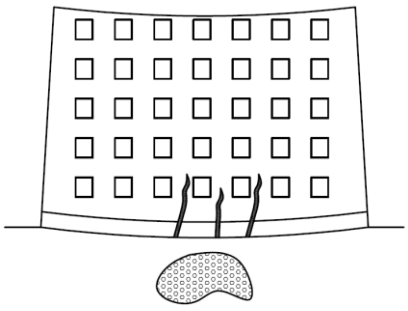

Fig.3. Building deformation type – sag

Local compression usually takes place at the top of the building, from the closure of the expansion joints (Fig.4). It is displayed in the form of adjacent walls sections crushing, balconies, cornices and the displacement of slabs. The soil soaking zone in this case is usually under the place of the expansion joint closure. Deformations of this kind are also possible from the building's sediments in the construction process, when relatively heavier building (brick's or block's next to a panel's or many-storey's building) is erected near the previously constructed building.

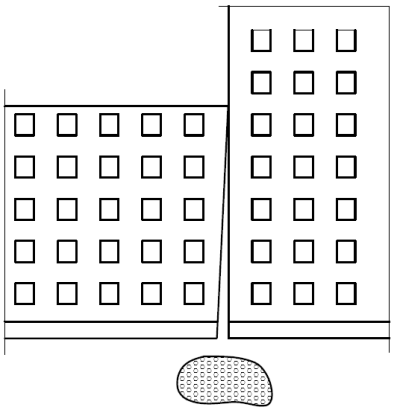

Fig.4. Building deformation type – joints expansion closures

When vertical walls are broken, cracks appear along the whole height, including the foundation (Fig.5). Such building's deformations are caused by horizontal deformations of the soil, accompanying its vertical subsidence. In this type of deformation, the loss of the partition bearing capacity can lead to a loss of the building's spatial rigidity because longitudinal walls separation from the transverse walls.

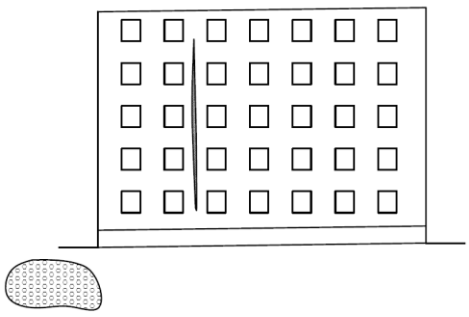

Fig.5. Building deformation type – vertical rupture of walls.

Shear deformations are accompanied by inclined cracks in the walls and vertical cracks in bends jumper (Fig.6). The soaking source may be placed in the area of upper inclined cracks location.

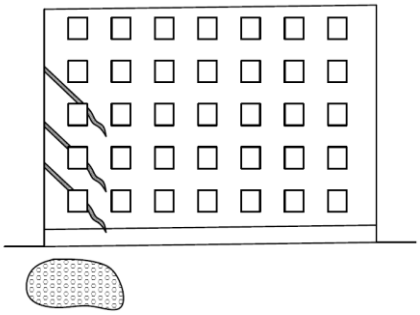

Fig.6. Building deformation type – shear deformations

The horizontal rupture is characterized by cracks appearing in horizontal or slightly slanted direction as a result of individual building sections subsidence (Fig.7). In such cases the buildings without special base preparation are mostly deformed and ground deformation occurs directly under their foundations. As a rule, the soaking area is located under the center of the cracks location.

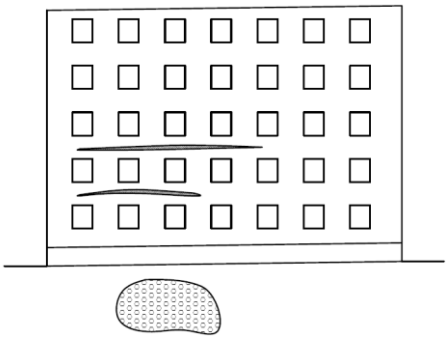

Fig.7. Building deformation type – horizontal rupture of walls

CAUSES OF BUILDING'S DEFORMATION

Uneven ground subsidence leads to stress-strain state change of foundations and over ground building structures and considering the peculiarities of walls material to their damages and cracks appearing. Cracks reduce the building's structural reliability, and sometimes its performance. Cracks in the walls can also appear, independently of the base and foundation condition. But in any case it is necessary to determine the cause of the damage [10 −14].

Fig. 8 shows the sequence of ascertaining the causes of damage.

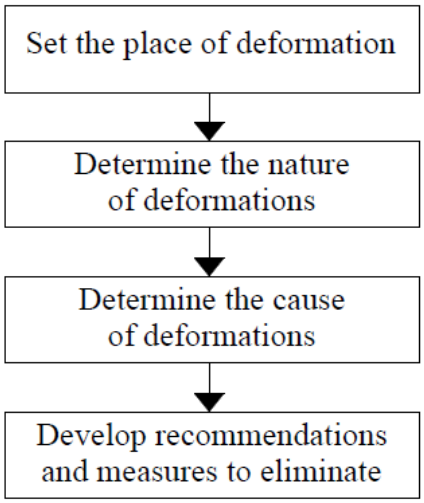

Fig.8. Sequence of deformation causes elimination

When the number of deformed five-storey buildings, had been determined, these buildings were inspected in details and documentation available from specialized laboratory of the city housing management was examined and then the causes of deformation were identified.

Let's consider the information about the types and causes of five-storey residential buildings deformations, which are presented in the Table 2 in more details.

The number of brick's buildings deformed by the camber is 55%, by the sag − 18%, by the shear deformations is 20%. The buildings with vertical walls rupture constitutes − 5% and with horizontal walls rupture − 2% were observed too. In deformed buildings, there is staircases displacement from the supports; and considerable cracking is observed within the most weakened place − the staircase. These buildings lose their operational capability because of the cracking in the walls, the peeling of the plaster and the skews of the openings.

Table 2. Information about the types and causes of five-storey residential buildings deformations

Building type	Type of deformation	Number of deformed buildings	The probability of revealing	Causes of deformation, (%)			
				Steeping with water			Incorrect lock
				Atmospheric	Sewerage	Water supply, heating mains.	
5-storey brick	Camber	66	0,55	0	70	30	0
	Sag	21	0,18	0	85	15	0
	Shear deform	24	0,20	0	70	30	0
	Vertical rupture	6	0,05	0	80	20	0
	Horizontal rupture	3	0,02	0	66	34	0
5-storey panel	Camber	16	0,3	0	60	40	0
	Sag	16	0,3	20	80	0	0
	Local compres	22	0,4	0	85	15	0
5-storey block	Camber	12	0,55	0	80	20	0
	Sag	7	0,35	15	35	50	0
	Shear deform	2	0,05	0	0	0	100
	Vertical rupture	1	0,05	100	0	0	0

Base soaking of the sewerage network (73% in average) and soaking of water or heating networks (27% in average) are the main course of buildings deformations in brick's five-storey's residential buildings.

The number of panel buildings, deformed over the camber and sag isn't significant and amounts − 30%, reciprocally. The most frequent deformations were revealed in the form of width expansion joints closure changes (40% in average). In buildings of this type, deformed joints are often filled with incompressible materials that deteriorate the working conditions of wall panels with a decrease in the seams width.

It was established that the most common cause of panel buildings deformations is the base soaking from sewerage networks (76% in average). Other causes of deformation are soaking from the water networks or heating networks (18% in average), atmospheric water (6% in average).

The number of block buildings deformed because of the camber is in the range of − 55% with the seams opening between the blocks, because of the sag − 35%, over to the shear deformations − 5%. Buildings with vertical gap in the walls are 5%. In general, the operational capability of the building is lost because of the cracks opening in blocks, the staircases displacement from the supports and the plaster peeling from the internal wall's blocks surfaces.

The most common cause of block buildings deformation is base soaking from the sewerage networks (55% in average). Other causes of deformation are soaking with atmospheric water − 9%, water supply or heating networks

soaking (27% in average). It was also revealed that base soaking as a result of wrong building compartments blocking is about 9%.

RECOMMENDATION

Since the five-storey buildings of typical standard design have exhausted all their operational resources it is necessary either to demolish or to reconstruct them in the near future. But the state has no funds for such buildings demolition; therefore it is more likely to reconstruct them. When reconstructing such buildings, different variants of premises replanning will be provided, which help to improve living conveniences.

The experience of five-storey residential buildings exploitation shows that absence of a complex measures against sedimentation considerably affects the operational reliability [15-19]. Therefore, during the reconstruction, it is necessary to provide waterproof measures, to eliminate the water hitting under the building. Analysis of deformation causes shows that in almost 75% of all cases, the soaking source was sewerage network leaks. So, during the reconstruction it is necessary to provide the full replacement of all intra-quarter sewage networks.

CONCLUSIONS

The classification of the housing recourses of Zaporozhzhia city considering storey number and walls materials of buildings was prepared, the data on the operational experience of five-storey residential buildings were systematized, the main types of buildings deformations were determined, and the causes of deformation were established.

The five-storey buildings of the typical standard design are morally obsolete, have sizeable physical depreciation. In order to improve the living conveniences of such buildings, their reconstruction is necessary [20 − 23].

Measures to improve the operational capability of five-storey residential buildings are proposed. These measures must be considered in the possible reconstruction process.

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Анализ эксплуатации жилых пятиэтажных зданий, возведенных на просадочных грунтах г. Запорожье

Виктор Шкода, Мария Сёмчина, Андрей Шкода

Аннотация. В статье выполнен анализ жилого фонда г. Запорожье, приведена классификация жилых зданий по этажности и материалу стен, выделены виды деформирования, даны рекомендации по повышению надежности эксплуатации пятиэтажных жилых зданий при их возможной реконструкции.

Значительную часть жилого фонда (примерно 25%) г. Запорожье составляют пятиэтажные жилые здания, так называемые «хрущевки», возведенные по типовым проектам в 50 − 60-х годах прошлого столетия. Срок эксплуатации этих зданий приближается к критическому. Планировка помещений морально устарела и не способствует комфортному проживанию в нем людей. Кроме этого, здания этого класса имеют и существенный физический износ, связанной со сложностью эксплуатации на просадочных грунтах. Примерно у пятой части всех зданий старой постройки наблюдаются деформации из-за просадки оснований. Это вызвано отсутствием необходимого комплекса защитных мероприятий, способного обеспечивать требуемые прочностные и эксплуатационные качества в случае замачивания основания.

Ключевые слова: пятиэтажные жилые здания, просадочные грунты, выгиб, прогиб, разрывы стен, замыкания деформационных швов, деформации сдвига.