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WORKS EXECUTION ORGANIZATION AT BUILDING RECONSTRUCTION AND RENOVATION WITH USAGE OF SLABS LIFTING METHOD

The article considers works execution organization at reconstruction and renovation of residential and public buildings for embedded systems with usage of slabs lifting method at restrained urban conditions. The paper suggests usage features of the slabs lifting method at building reconstruction conditions. The technology of reconstruction with the usage of slabs lifting method allows to refuse practically the use of lifting cranes and to reduce significantly (up to 50%) the required building area compared with the lifting crane construction methods of embedded structures. It allows to perform the reconstruction without restriction of traffic on adjoining streets and to perform construction in restrained urban conditions.

Keywords: *organization, reconstruction, renovated buildings, embedded systems, floor slab panels, slabs lifting method.*

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ОРГАНІЗАЦІЯ ВИКОНАННЯ РОБІТ ПРИ РЕКОНСТРУКЦІЇ ТА ВІДНОВЛЕННІ БУДІВЕЛЬ ЗА ДОПОМОГОЮ МЕТОДУ ПІДЙОМУ ПЕРЕКРИТТІВ

Розглянуто організацію виконання робіт при реконструкції та відновленні житлових і громадських будівель шляхом зведення вбудованих систем методом підйому перекриттів в умовах щільної міської забудови. Наведено особливості використання методу підйому перекриттів в умовах реконструкції будівель. Виявлено, що технологія реконструкції з використанням методу підйому перекриттів дозволяє практично відмовитися від використання підйомних кранів та значно (до 50%) зменшити необхідну площу будівельного майданчика порівняно з крановими способами зведення вбудованих конструкцій. Це дозволяє виконувати реконструкцію без обмеження руху транспорту по прилеглих вулицях і здійснювати будівництво в умовах щільної міської забудови.

Ключові слова: *організація, реконструкція, відновлення будівлі, вбудовані системи, плити перекриття, метод підйому перекриттів.*

Introduction. Reconstruction of old urban development residential buildings, having, as a rule, historical significance and creating an architectural character of the city central part, is undoubtedly actual. The topicality is conditioned by the necessity of preserving the architectural integrity of historical development and, at the same time, the need for adaptation of planning concepts and buildings constructive concepts to the new operating conditions. The main reasons for the need of reconstruction are the discrepancy of existing planning concepts with modern conditions and the usage of wooden structures as ceiling structures. Due to long operating terms, wooden structures, as a rule, are generally at insufficient condition and require replacement or cannot withstand to the new increased operational loads. One of the such buildings reconstruction methods is the construction of embedded systems with the preservation of existing enclosure structures (Figure 1). To the features of works execution at the reconstruction of buildings at restrained urban conditions, especially in the central, historical parts of the cities it should be considered considerably limited size of the building area.

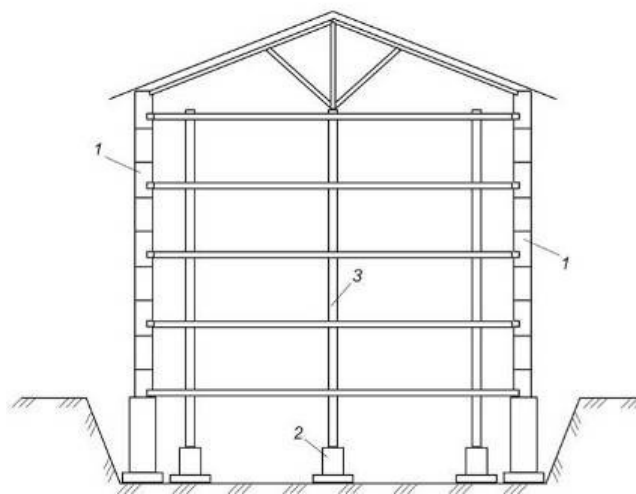


Figure 1 – Building reconstruction with the usage of enclosure structures:
 1 – existing enclosure structures; 2 – foundation of the embedded system;
 3 – embedded structures

This requirement essentially affects the possibilities of construction equipment and lifting cranes use. In some cases, the usage of lifting cranes requires the restriction or cessation of vehicles for a long time, and sometimes, the usage of lifting cranes is impossible at all. The foregoing leads to refuse of the usage prefabricated reinforced concrete structures and to use monolithic reinforced concrete structures as structures of the built-in frame. However, the usage of monolithic structures still requires the use of lifting cranes for the reinforcement cages and formwork supply. One of the methods allowing us to abandon the lifting cranes usage during the erection of built-in structures almost completely is the slabs lifting method [1].

Review of the latest research sources and publications. Recently, due to the actuality of the need for residential and public buildings of the old urban development reconstruction, a large number of works, was devoted to this question by both domestic [2 – 6] and foreign authors [7 – 15]. In works [2 – 6] the peculiarities of the foregoing buildings reconstruction, the problems of construction equipment use in the conditions of the limited size building area are considered, and the usage of prefabricated and monolithic reinforced concrete as a material of embedded structures is compared. It is concluded that the reconstruction of the old urban development buildings by replacing the ceiling structures and construction of built-in

structures allows to preserve the architectural character of the cities historical part and at the same time to adapt buildings to the new conditions of exploitation. The works of foreign authors are often devoted to the issues of the concrete objects reconstruction [7 – 9], some parts of the works are devoted to the historic building structures strengthening [10 – 12]. Works [13 – 15] discuss the general issues of historical buildings reconstruction.

Definition of unsolved aspects of the problem. Despite the large number of works on the topic, until this time, the method of foregoing building reconstruction has not been proposed. There was no method that would allow to abandon usage of lifting cranes completely, to facilitate work organization under conditions of the building area limited size significantly and to refuse vehicles movement. The possibility of lifting slabs method usage for the reconstruction of buildings was not considered.

Problem statement. To analyze the peculiarities of lifting slabs method usage for the reconstruction of residential and public buildings by constructing embedded systems. To identify the benefits of these buildings reconstruction method use in comparison with other methods.

Basic material and results. As it has been shown [1], the construction of multistory frame buildings with a monolithic or prefabricated monolithic reinforced concrete frame by the lifting slabs method is to create the entire complex of floor slab panels on the ground surface or on a floor slab panel above the underground part. After floor slab panels installation and attainment it is required reinforced concrete strengthening, the floor slab panels lifting up to the design position on previously erected columns using lifts.

This method has the following sequence of work:

1) erection of building underground part by the traditional method, that anticipates the erection of column foundations, installation of the underground part columns, installation of building underground part envelope, floor slab panels, etc. (Figure 2);

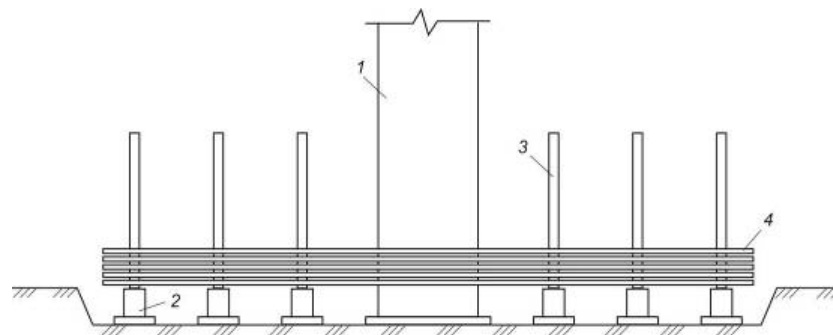


Figure 2 – Erection of the building with the slabs lifting method usage:

1 – stiffening core; 2 – foundations; 3 – columns; 4 – complex of the floor slab panels

2) the arrangement of the stiffening core, that ensures the durability of the building in the longitudinal and crosswise directions. As a rule, a stair enclosure with elevator shaft is placed inside the stiffening core;

3) installation, or placement of the ground floor monolithic columns;

4) installation of the floor slab panels complex round the building for the entire building area or section;

5) after the required reinforced concrete strength attainment of the floor slab panels, the lifting of slabs in an intermediate position with the usage of lifts fixed on the columns is accomplished;

6) installation or placement of the next level columns, moving the elevators and floor slab panels lifting;

7) after the lifting of all floor slab panels into the design position, the elevators are removed, next stage is the roof, enclosing structures arrangement, after that general construction works and finishing works are performed.

The advantages of such a method of building construction should include the fact that it can significantly reduce the usage of lifting cranes, and sometimes completely abandon their usage, significantly reduce the building area size; and in addition, due to lack of bearing walls inside the building; this method does not impose restrictions on the choice of design decisions.

This method was supposed to be used primarily for new construction, the usage of this method during the reconstruction was not considered.

From the analysis of this method advantages, it follows that its use during the reconstruction of buildings through the construction of embedded systems would be allowed for reconstruction without going beyond the constraints of restrained urban development conditions imposed on the construction. The method of floor slab panels lifting due to the refusal of cranes usage would allow reducing the building area size to almost the area size of the reconstructed building; refuse to restrict traffic and pedestrians and the operation of nearby objects.

The structure of the building reconstruction works by the proposed method will be as follows:

1) disassembling of the internal structures of the building is carried out. At the same time, disassembly should be conducted with strict sequence observance of the structures disassembling adopted in the technological plans. If necessary, the reinforcement of the enclosing structures is done;

2) the soil excavation under the foundations of the embedded system, the installation of monolithic foundations under the embedded structures are arranged. If necessary, there can be concrete mixture preparation at the object and feeding it with a light-weight concrete pump, located in the dimensions of the building. After the attainment required concrete strength, the waterproofing of the foundations and soil backing with compaction are carried out. If necessary, a reinforced concrete floor of the underground building part is arranged;

3) erection of first level monolithic columns is done. Formwork and reinforcement frames are installed from scaffold; the delivery of concrete mixture is carried out by a light-weight concrete pump;

4) installation of monolithic floor slab panel above the underground part of the building is carried out. Concrete is delivered centrally to the formwork by a concrete pump, located outside the building;

5) after the attainment required concrete strength of floor slab panel above the underground part, on its surface one after another the entire complex of floor slab panels (Figure 3) is arranged. Panels are separated by a separating layer;

6) after the attainment required concrete strength, the structures of the scaffold, formwork, prefabricated reinforced frameworks and a light-weight concrete pump are loaded onto the last plate for concreting the next level of columns;

7) elevators for lifting floor slab panels are installed on the headings of the first level columns [1]. Panels are lifted to an intermediate position and fixed (Figure 4);

8) concreting of the second level columns is carried out;

9) the lifting of the floor slab panels is continued after the attainment required concrete strength of the columns. The last two paragraphs are repeated until the concreting of the last level columns end and the lifting of all floor slab panels in the design position. After that, the joints between columns and slabs, between plates and enclosing structures are packed; the light-weight concrete pump is removed from the surface of the slab by a lifting crane. Installation of the building roofing, internal general construction works, and finishing works are operated by traditional methods.

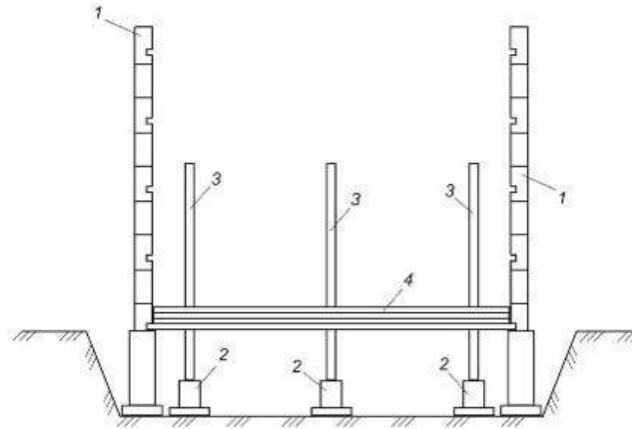


Figure 3 – Installation of embedded frame with usage a lifting slab panels method (stage of floor slab panels concreting):

1 – existing walls; 2 – foundations under embedded framework; 3 – columns;
4 – floor slab panels complex

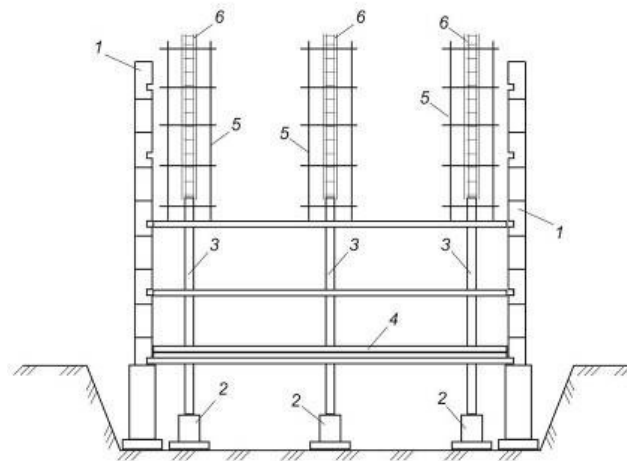


Figure 4 – Installation of embedded frame with usage a lifting slab panels method (stage of second level columns concreting):

1 – existing walls; 2 – foundations under embedded framework; 3 – columns;
4 – floor slab panels complex; 5 – scaffold; 6 – column formwork

As it has been shown in the given works, the proposed technology of buildings reconstruction allows to refuse the lifting cranes use during the works execution practically. It allows to increase the building general plan coefficient of compactness to 60 – 80%. With the usage of the traditional construction methods, this ratio is about 10 – 40%. The proposed method obviates the floor slab panel formwork installation and supports structures under it, as the formwork is pre-concreted slabs. This method allows to reduce the work complexity on the floor slabs installation significantly.

However, the usage of the lifting slabs method at the construction of embedded systems involves the manual assembly of column formwork, installation of reinforcing cages into the formwork, assembly and disassembly of scaffold, installation and removal of lifts.

The most effective method of construction organization is the streaming construction method and this method usage allows for definite significant advantages such as regularity and low intensity of resource consumption, reduction of construction time [7]. However, in the consideration case, the usage of this construction method is complicated by certain

conditions. One of these conditions is a relatively small building area size that complicates or makes it impossible to separate the building to the required number of work zones. As a rule, in most cases, such types of buildings could be divided up to a maximum of two work zones that is not enough for the streaming organization of the monolithic structures construction. However, such case does not mean that it is impossible to effectively organize the process of installing embedded systems by usage of lifting slabs method. At the same time, the greatest attention should be paid to the organization of work on the installation of floor slabs, since their share in the total construction complexity of embedded systems is 60 – 80%. Figure 5 shows an work indicative schedule on the floor slabs package installation.

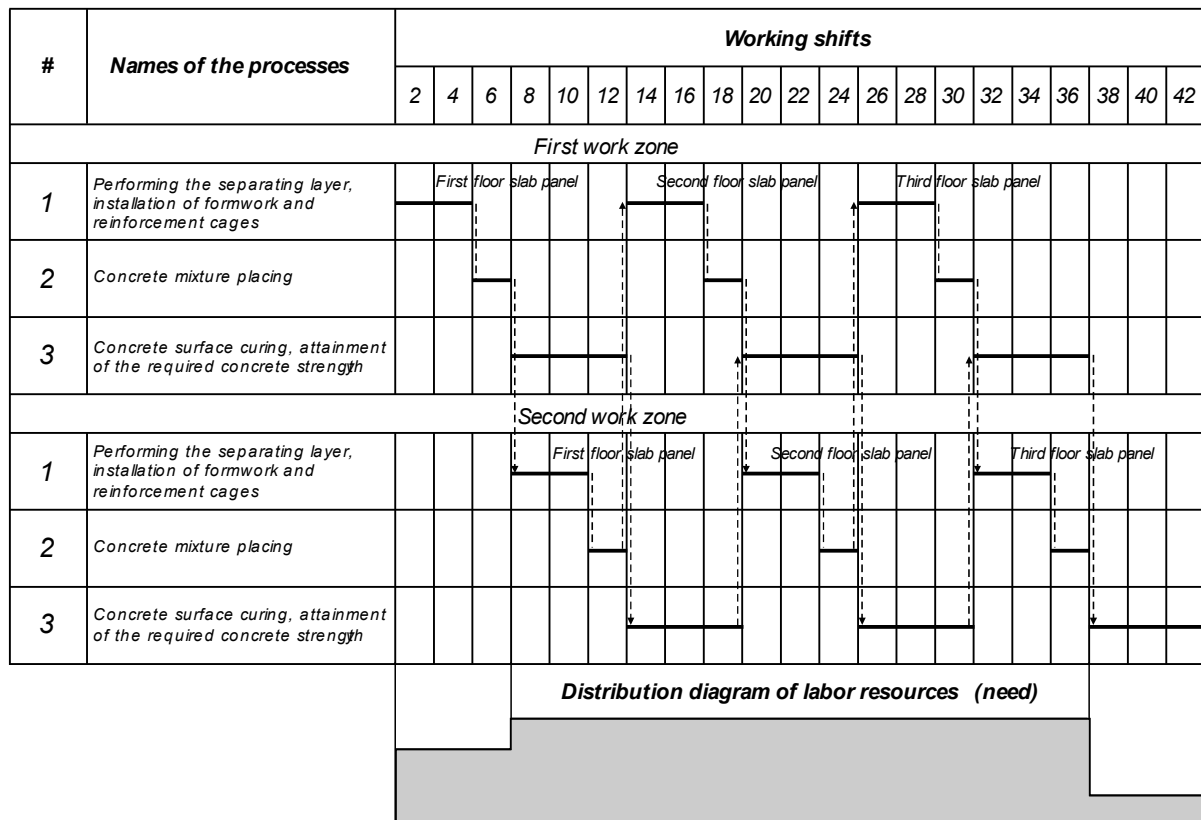


Figure 5 – Work schedule of floor slabs package installation by dividing the building into two work zones: arrowed lines show the workers transfer

As it has been seen from the chart shown in Figure 5, even when dividing the building into two working zones, the continuous work of the building team is organized. Due to this condition, the number of workers, duration of the distribution layer between the slabs installation work, the installation of reinforced frames and the concrete mixture placing should be the same with the duration of the concrete surface curing and attainment of the required concrete strength for the work start on the next slab. One of the conditions for such work organization is the use of integrated workers brigade combining the installation of reinforced frameworks and the concrete mixture placing. At the same time, as it is seen from the distribution diagram shown in Figure 5, the irregularity coefficient of labor resources usage is close to one.

Conclusions. The proposed buildings reconstruction technology can be used (after conducting an economic comparison with other possible methods of reconstruction in these conditions) for the reconstruction of residential and public buildings by installing embedded systems of monolithic reinforced concrete frame type.

The technology of reconstruction with the usage of slabs lifting method allows to refuse lifting cranes use and to reduce significantly (up to 50%) the required building area compared with the lifting crane construction methods of embedded structures significantly. It allows to perform the reconstruction without restriction of traffic on adjoining streets and to perform construction in restrained urban conditions.

One of the criteria for such technology use is the presence of buildings stiffening core and stair enclosure walls cannot be disassembled.

References

1. Теличенко В. И. *Технология возведения зданий и сооружений: учеб. для строит. вузов* / В. И. Теличенко, О. М. Терентьев, А. А. Липидус. – М.: Высш. шк., 2004. – 446 с. ISBN 5-06-004441-6
2. Осипов А. Ф. *Особенности объемно-планировочных и конструктивных характеристик реконструируемых жилых зданий г. Киева* / А. Ф. Осипов, С. Ф. Акимов // *Строительство и техногенная безопасность*. – 2002. – Вып. 6. – С. 260 – 265.
3. Осипов А. Ф. *Возведение монолитных перекрытий при реконструкции жилых зданий* / А. Ф. Осипов, С. Ф. Акимов // *Нові технології в будівництві*. – К., 2005. – № 1. – С. 46 – 52.
4. Осипов А. Ф. *Реконструкция жилых зданий. Методы возведения монолитных перекрытий* / О. Ф. Осипов, С. Ф. Акимов // *Новини науки Придніпров'я*. – Дн-к, 2006. – № 3. – С. 9 – 15.
5. Осипов А. Ф. *Разработка организационно-технологических моделей замены перекрытий в зданиях исторической застройки* / А. Ф. Осипов, С. Ф. Акимов // *Строительство и техногенная безопасность*. – 2009. – № 29. – С. 101 – 108.
6. Воскобійник О. П. *Особливості технології виконання робіт при реконструкції будівель за допомогою вбудованих систем* / О. П. Воскобійник, Є. В. Дяченко // *Збірник наукових праць. Серія: Галузеве машинобудування, будівництво*. – Полтава, ПолтНТУ, 2012. – Вип. 33. – С. 43 – 48.
7. Caldwell M. *The Fort Stanwix Administrative History: A Superintendent's Perspective* / M. Caldwell // *The Public Historian*. – 2009. – Vol. 31, No. 2. – P. 55 – 62.
8. Korkmaz E. *Retrofitting Deniz Palace historic building for reusing* / E. Korkmaz, M. Vatan // *Intern. journal of electronics; mechanical and mechatronics engineering*. – İstanbul, 2013. – Vol.2-3. – P. 269 – 278.
9. Korkmaz E. *Research on Techniques Using For The Retrofitting Of Historical Masonry Structures – Case Study Deniz Palas Building* / E. Korkmaz, M. Vatan // *CHRESP: 8th EC Conf. on Sustaining Europe's Cultural Heritage (10-12.11.2008)*. – Ljubljana, Slovenia, 2008. – P. 18 – 21.
10. Guh T. J. *Seismic Retrofit of Historic Building Structures* / T. J. Guh, A. Altoontash // *8th U.S. National Conf. on Earthquake Engineering (18-22.04.2006)*. – San Francisco, California, USA, 2006. – P. 70 – 75.
11. El Gawady M. *A Review of Conventional Seismic Retrofitting Techniques for URM* / M. El Gawady, P. Lestuzzi, M. Badoux // *13th Intern. Brick and Block Masonry Conf. (4-7.07.2004)*. – Amsterdam, 2004. – P. 78 – 84.
12. Smith A. *Critical Review of Retrofitting Methods for Unreinforced Masonry Structures* / A. Smith, T. Redman // *EWB-UK Research Conf., The Royal Academy of Engineering*. – London, 2009. – 315 p.
13. Drury P. *Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment* / P. Drury, A. McPherson // *English Heritage*. – London, 2008. – 250 p.
14. Holland A. G. *The Reconstruction of Historical Buildings* / A. G. Holland. – Virginia Commonwealth University, Richmond, Virginia, 2011. – 120 p.
15. Green M. *Building Codes for Existing and Historic Buildings* / M. Green. – USA, Hoboken: Wiley, 2012. – 247 p. ISBN: 978-0-470-19591-8

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