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RESEARCH OF LIGHTWEIGHT MONOLITHIC REINFORCED CONCRETE SLABS WITH THE USE OF PLASTIC INSERTS

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Abstract. The paper presents technology for installation of floor slabs lightened with plastic inserts which are preliminary stressed under construction conditions. Efficiency of such constructive solution is determined by the action of preliminary concrete compression in the tensile zone while reducing structure dead weight due to voids arrangement. Floor slabs of prestressed reinforced concrete in comparison with unstressed concrete have considerably smaller deflections and increased crack resistance, having the same strength, which allows to cover large spans with an equal section of the element. The resulting ratios of the slab thickness, the consumption of concrete and reinforcement in the girderless monolithic reinforced-concrete framework, depending on the span length of the frame building, show the advantage of using prestressed reinforcement rather than conventional. To lighten the construction of the floor slabs, a variety of shaped plastic inserts are proposed to use. The main requirements for materials and products for the making voids in the body of the construction and prestressing of the slab reinforcement are given. Analysis of technical and economic indicators of effective design solutions allows us to conclude that they are used for building spans, when using monolithic reinforced concrete slabs with unstressed concrete is impossible.

Keywords: preliminary stressed concrete, concrete, plastic inserts, technology of arrangement, economic effect.

ИССЛЕДОВАНИЯ ОБЛЕГЧЕННЫХ МОНОЛИТНЫХ ЖЕЛЕЗОБЕТОННЫХ ПЕРЕКРЫТИЙ С ПРИМЕНЕНИЕМ ПЛАСТИКОВЫХ ПУСТОТООБРАЗОВАТЕЛЕЙ

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Аннотация. Представлена технология устройства облегченной пластиковыми пустотообразователями предварительно-напряженной в построечных условиях плиты перекрытия. Эффективность такого конструктивного решения обусловлена действием предварительного обжатия бетона растянутой зоны при снижении собственного веса конструкции за счет устройства пустот. Для облегчения конструкции перекрытия предложено использовать пустотообразователи различной формы. Установлена зависимость длины пролета от толщины перекрытия. Выявлено, что при одинаковом размере пролета использование предварительно-напряженной арматуры позволяет значительно сократить расход бетона и арматуры.

Ключевые слова: предварительно-напряженный железобетон, пустотообразователи, технология устройства, экономический эффект.

ДОСЛІДЖЕННЯ ПОЛЕГШЕНИХ МОНОЛІТНИХ ЗАЛІЗОБЕТОННИХ ПЕРЕКРИТТІВ З ВИКОРИСТАННЯМ ПЛАСТИКОВИХ ПУСТОТОУТВОРЮВАЧІВ

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Анотація. Наведена технологія влаштування полегшеної пластиковими пустотоутворювачами попередньо-напруженої в умовах будівництва плити перекриття. Ефективність такого конструктивного рішення зумовлена дією попереднього стиску бетону розтягнутої зони при знижені власної ваги конструкції за рахунок влаштування пустот. Для полегшення конструкції перекриття запропоновано використовувати пустотоутворювачі різної форми. Встановлено залежність довжини прольоту від товщини перекриття. Виявлено, що при однаковому розмірі прольоту використання попередньо-напруженої арматури дозволяє значно скоротити витрату бетону і арматури.

Ключові слова: попередньо-напружений залізобетон, пустотоутворювачі, технологія влаштування, економічний ефект.

Formulation of the problem. When erecting monolithic framed buildings, one of the main technological tasks is to reduce the material and labor intensity of production. The construction-technological solutions used for these purposes are very diverse and effective in their own way. It is possible to highlight the solution of the actual task - to increase step of columns of the framed building while maintaining the load-bearing capacity of the frame as a whole.

Analysis of recent research and publications. Nowadays, in the construction industry of our country, new approaches to solve the main technological problems are needed, which are the reduction of material and labor for construction and installation work on the construction site [1-3]. As our experience and experience in the construction industry of foreign countries show, the use of prestressing of reinforced concrete slabs makes it possible to increase their bearing capacity, crack resistance and rigidity significantly. This, in turn, allows to reduce the cross-section of the bent elements, and, thus, reduce the weight of the framed building. It should be noted that additionally reduction in weight of monolithic floor slab is achieved by organizing the hollow by setting plastic inserts of various shapes used in modern advanced technologies. Thus, the symbiosis of the two technologies should lead to the solution of the basic technological problems of the modern construction industry.

Goal. The main purpose of this work isinvestigation of construction-technological solutions at the organization of a prestressed reinforced concrete floor slabs lightened with plastic hollow inserts in the conditions of a construction site.

Statement of the main material. The floor slabs of prestressed reinforced concrete in comparison with unstressed concrete have considerably smaller deflections and increased crack resistance, having the same strength, which allows to cover large spans with an equal section of the element.

The use of progressive structural and technological schemes for erecting buildings that suppose the use of prestressed reinforced concrete technology in the construction process is applied in girderless monolithic reinforced concrete framework.

As a result of prestressed reinforced concrete use, it is possible to reduce the total weight of buildings up to 40% and significantly reduce the material consumption (consumption of reinforcement and concrete) while maintaining a high level of reliability of structures, while reducing the cost of building up to 30% [1]. Along with the economic effect, the prestressing technology of the reinforcement makes it possible to expand the architectural and planning solutions of the designed buildings and structures for various intents significantly.

As the results of the research show, the data which are presented in the graphs of the ratio of floor slabs thickness, the consumption of concrete and reinforcement in the girderless monolithic reinforced concrete framework, depending on the length of a building span are shown in figures 1, 2, the use of prestressed reinforcement allows to reduce the thickness of floor slab while maintaining the span size in 1,8 times. It is worth noting that the effectiveness of the use of prestressed reinforced concrete growing with the increase in the span of a building.

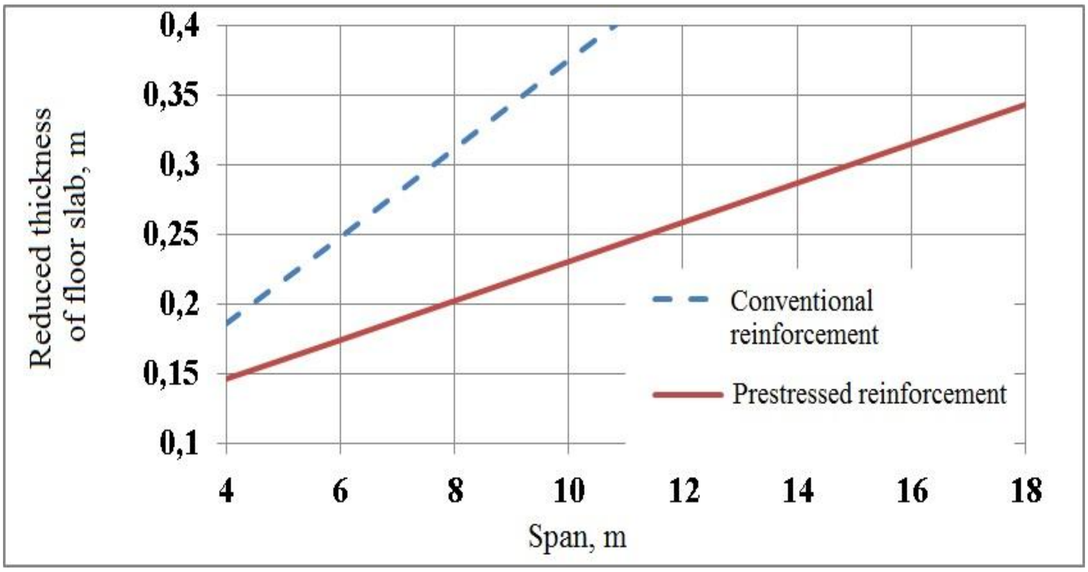

Fig. 1. Ratio of length span and slab thickness in buildings with the use of prestressed and conventional reinforcement

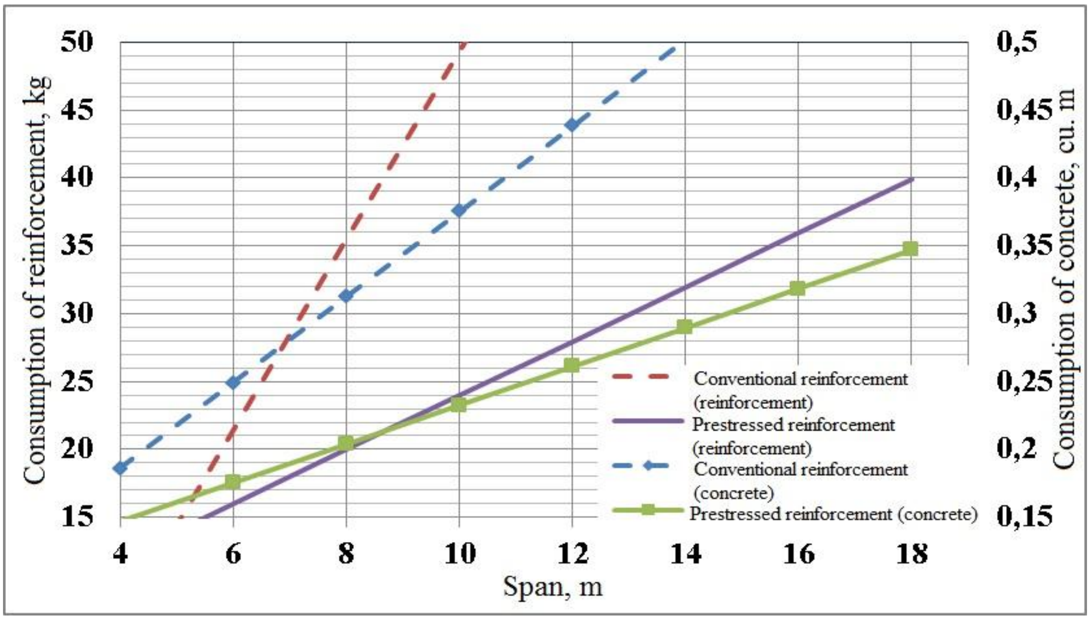

Fig. 2. Consumption of concrete and reinforcement in the girderless monolithic reinforced concrete framework of buildings, depending on the length of span with the use of prestressed and conventional reinforcement

Improvement of the construction solutions of monolithic reinforced concrete floor slabs with prestressing reinforcement on the construction site is possible with the use of non-removable hollow inserts (Fig. 3), which allow to reduce the weight of the structure by removing material from it, that does not participate in work, without impairing the strength characteristics. The reinforced concrete floor slabs with inserts can have a bearing capacity and bending stiffness more, but weight – by 20-40% less than solid elements.

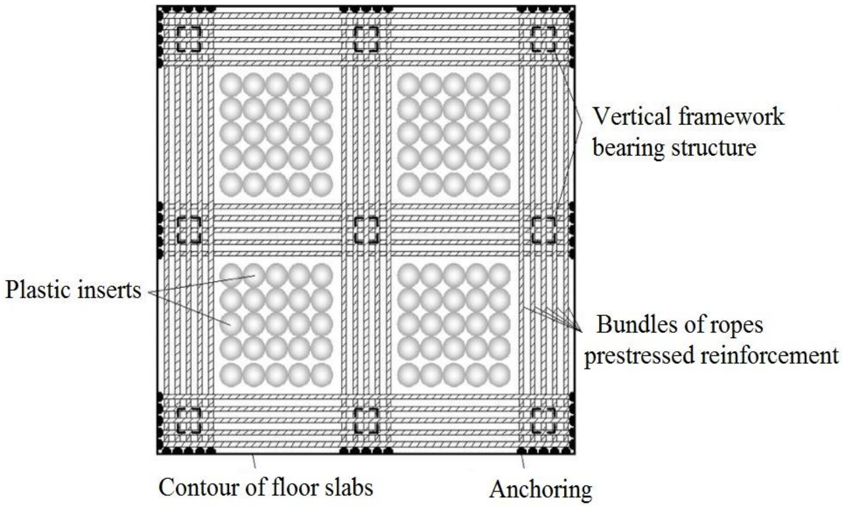

Fig. 3. The structure of monolithic prestressed slab with non-removable inserts

As a non-removable hollow inserts are widely used standardized modules of empty polymeric materials of various shapes, the technologies for the manufacture of lightweight reinforced concrete floor slabs with non-removable inserts include: Airdeck, BubbleDeck, Nautilus, Cobiax, Beeplate, DonutType, U-BootBeton and U-BahnBeton.

According to Airdeck technology [3], a factory produces the lower covering of the floor slab in the form of a prefabricated reinforced concrete structure with embedded plastic elements called lightweight boxes (air boxes). The lower covering of the floor slab has standard dimensions: a thickness of 0,06 m, a length of 9 m and a width of up to 4 m. The hollow inserts as air boxes are produced by injection molding recycled polypropylene. The working dimensions of the insert boxes are 0,2×0,2 m, and the height depends on the thickness of the floor slab and varies in the range from 0,12 to 0,35 m. The main technical and economic indicators of monolithic prestressed reinforced concrete floor slabs structures using Airdeck technology are given in the table.

BubbleDeck technology uses hollow spheres of spherical or elliptical shape from recycled plastic (polyethylene, polyvinylpropylene or polyvinylchloride) with a diameter of 0.18 to 0.36 m as hollow-forming agents [3], depending on the thickness of the concreting slab. The inserts are located inside the reinforcement module and are held in the design position due to the special shape of the cells of the lower and upper reinforcement mesh. The main technical and economic indicators of monolithic prestressed reinforced concrete floor slabs structures using BubbleDeck technology are given in the table.

According to the Cobiax technology [4, 5] for the organization lightweight reinforced concrete floor slabs, a technological reinforcement module is used for the spatial fixation hollow inserts in the body of the slab in the design position and it prevents a change in this position during concreting. In the reinforcing frame hollow inserts made of secondary polypropylene are put. There are two types of linear reinforcing modules with non-removable hollow inserts: in the form of an ellipsoid of rotation (the «Slim-Line» system) for concreting floor slabs from with thickness 0,2 to 0,35 m and in the form of a spherical ball (the «EcoLine» system) for slabs with thickness from 0,3 to 0,6 m.

Design of a monolithic reinforced concrete slab with the hollow inserts using Cobiax technology is carried out in a similar way to the design of massive reinforced concrete elements in accordance with the current building codes. At the first stage, the structure is calculated for the required load, its reinforcement is selected and its construction is performed. The calculation results are transferred to the Cobiax technology calculator for placing the reinforcement modules in the structure. Based on the results, the type of modules is selected, and design parameters are calculated. At the second stage, a more accurate calculation of strength of the structure with changed parameters is produced – weight of the slab and geometric dimensions (if necessary). The result of the calculation is the determination of the modules location and the final design parameters.

Table – Technical and economic indicators of floor slabs structures

Constructive thickness of floor slab, m	Volume of insert, m^3	Step of insert, m	Number of inserts, ps	Volume of inserts, m^3/m^2	Reduced thickness of floor slab, m
Non-removable hollow inserts by technology Airdeck					
0,22	0,0041	0,3	11	0,045	0,175
0,28	0,0063	0,3	11	0,069	0,211
0,34	0,0086	0,3	11	0,094	0,246
0,39	0,0105	0,3	11	0,115	0,275
0,45	0,0129	0,3	11	0,142	0,308
Non-removable hollow inserts by technology BubbleDeck					
0,28	0,0055	0,25	17,2	0,095	0,185
0,34	0,0103	0,3	11,2	0,115	0,225
0,39	0,0162	0,35	8,3	0,134	0,256
0,45	0,0244	0,4	6,2	0,153	0,297
Non-removable hollow inserts by technology Cobiax «Slim-Line»					
0,2	0,006364	0,35	8,8	0,056	0,144
0,25	0,008523	0,35	8,8	0,075	0,175
0,28	0,009545	0,35	8,8	0,084	0,196
0,3	0,010568	0,35	8,8	0,093	0,207
0,32	0,011591	0,35	8,8	0,102	0,218
0,35	0,012727	0,35	8,8	0,112	0,238
0,4	0,015341	0,35	8,8	0,135	0,265
Non-removable hollow inserts by technology Cobiax «Eco-Line»					
0,4	0,0103	0,3	11,2	0,115	0,285
0,45	0,0162	0,35	8,3	0,134	0,316
0,55	0,0334	0,45	5,1	0,172	0,378
0,6	0,0654	0,5	2,9	0,191	0,409

Conclusions. Presented application of the prestressing monolithic reinforced concrete floor slabs technology, together with the reduction of a structure weight with the setting hollow, non-removable plastic inserts. The resulting ratios of the slab thickness, the consumption of concrete and reinforcement in the girderless monolithic reinforced-concrete framework, depending on the span length of the frame building, show the advantage of using prestressed reinforcement rather than conventional. The main requirements for materials and products for the making of voids in the body of the construction and prestressing of the slab reinforcement are given. Analysis of technical and economic indicators of effective design solutions allows us to conclude that they are used for building spans, when using of monolithic reinforced concrete slabs with unstressed concrete is impossible.

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