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COMPARATIVE CHARACTERISTICS OF THE SPATIAL GRID-CABLE STEEL-CONCRETE COMPOSITE SLAB

Наведено результати теоретичних розрахунків матеріальних і трудових ресурсів, які затрачаються на виготовлення і зведення структурно-вантових сталезалізобетонних конструкцій покриттів будівель та споруд різного призначення. Також було визначенно деякі порівняльні характеристики досліджуваної конструкції, наприклад, такі як вага, несуча здатність тощо. Просторова структурно-вантова сталезалізобетонна плита є новим типом збірних конструкцій для великопрольотних покриттів і оболонок. Особливість такої конструкції полягає в її конструктивному рішенні. Така конструкція складається з просторової решітки, верхнього і нижнього поясів. Просторова структурно-вантова сталезалізобетонна плита складається з певної кількості просторових сталезалізобетонних модулів, які являють собою поєднання залізобетонних плит і сталевих стрижнів, виготовлених з відрізків сталевих труб. Модулі поєднуються один з одним у вузлах за допомогою спеціальних болтових з'єднань. Як верхній пояс використовують залізобетонну плиту, а як нижній – сталевий канат. Техніко-економічні показники розраховано для однієї секції покриття з розмірами у плані 30×6 м. Отримані дані свідчать про ефективність та доцільність застосування досліджуваних конструкцій у покриттях будівель і споруд різного призначення. Результати досліджень показують, що із застосуванням структурно-вантових сталезалізобетонних конструкцій вага покриття знижується на 32–72 %, затрати праці – на 10 % порівняно з аналогом.

Ключові слова: сталезалізобетон, структура, ванта, плита, решітка, трудомісткість.

The paper studies the theoretical calculations of the material and human resources that is needed for manufacturing and construction the spatial grid-cable steel-concrete composite slab. Some comparative characteristics of the construction were estimated such as weight, bearing capacity etc. The spatial grid-cable steel-concrete composite slab is the new kind of a construction for long-span roofs and shells. The feature of the construction is in its the constructive concept. This construction consists of the diagonal members, the top and the bottom chords. The spatial grid-cable steel-concrete composite slab consists of some number of the spatial steel-concrete modules, which are a combination of reinforced concrete slabs and steel diagonal members that are made of segments of steel tubes. The modules are connected to each other in nodes by using special bolted connections. The top chord are made of reinforced concrete slab and the bottom chord are made of steel cables. Calculations of technical and economic indicators were solved on the example of one section of the roof of the size of 30×6 m. These data demonstrate the effectiveness and feasibility of studied structures in the shells of buildings and structures of various function. Studies show that the use of the spatial grid-cable steel-concrete composite slab allows reducing the weight of the roof by 32–72 %, the laboriousness – by 10 % compared to analog.

Key words: steel-concrete composite, structure, cable, slab, lattice, laboriousness.

Introduction. There is a problem of an excessive laboriousness and materials consumption, which appears in consequence of does not rational using of materials in construction. This situation has developed because of inconsistencies existing structural concepts to modern requirements of the construction industry. These factors have direct impact on the overall cost and duration implementation of the project. That is why there is a need in new constructions with structural concepts, which largely make it possible to save materials and reduce complexity of construction. These structures are the spatial grid-cable steel-concrete composite slabs (Fig. 1). Steel-concrete composite structure was used for creating the new construction because this material is reliable, has studied well and is used very widely in various fields of construction [1-3]. The essence of the spatial grid-cable steel-concrete composite slab lies in rational and efficient use of materials and the behavior of structural elements. The spatial grid-cable steel-concrete composite slab consists of the bottom chord (Fig. 2) and the spatial modules (Fig. 3) that includes the diagonals and the top chord. The spatial modules are connected with bolts to each other to the construction (Fig. 4). The top chord can be made of reinforced concrete or ferrocement slabs it is depends on the type of reinforcement. The bottom chord is made of flexible elements that are able to resist tensile forces only. The grid has spatial structure and consists of rods are made of steel tubes segments. The total weight and complexity of the construction was reduced compared to analog through such the structure. In addition, there is no need to use expensive roofing materials and spend time on their installation, because the top chord of the construction, besides the bearing function provides barrier function and protects the internal space of the building from weathering.

Results of previous studies show that the spatial grid-cable steel-concrete composite slabs combine the advantages of space frame, reinforced concrete and cable-stayed structures [4]. The effectiveness of structural concept and optimal geometric dimensions have been found [5]. The spatial grid-cable steel-concrete composite slabs are reliable and have nice aesthetic appearance due to original spatial shapes and outlines [6]. The advantages of the constructions have been found on the analysis of previously conducted studies, but the lack of feasibility study creates obstacles to the implementation in practice of construction. Therefore, it is necessary to prove the effectiveness of the spatial grid-cable steel-concrete composite slabs to increase interest and implementation them in the real sector of the construction.

The purpose of study is to calculate of technical and economic parameters of the spatial grid-cable steel-concrete composite slabs and validity of feasibility of using them in different buildings and structures.

Research results. It is necessary to perform the calculation of the technical and economic parameters and to assess the advantages the new construction compared with existing analogues to determine the scope of the spatial grid-cable steel-concrete composite slabs. A cell of a roof of a one-story industrial building with span of 30 m and 6 m column step has been taken for comparative analysis. Firstly, the analysis of the weight has been conducted between of the spatial grid-cable steel-concrete composite (SGCSCC) slab 6 × 1 m (Table 1) and typical series of reinforced concrete slabs (Fig. 4).

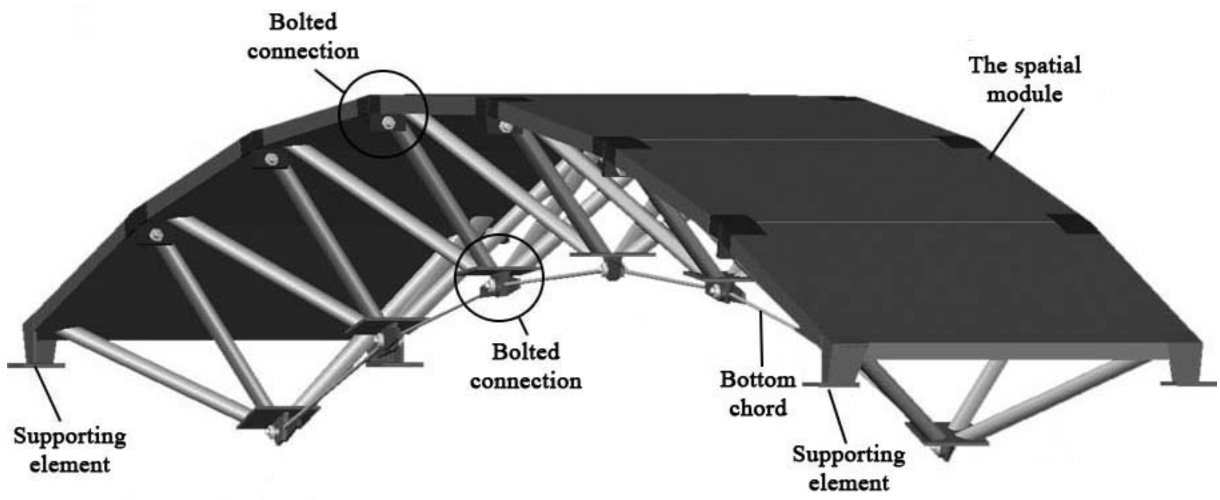


Fig. 1. The section of the spatial grid-cable steel-concrete composite shell

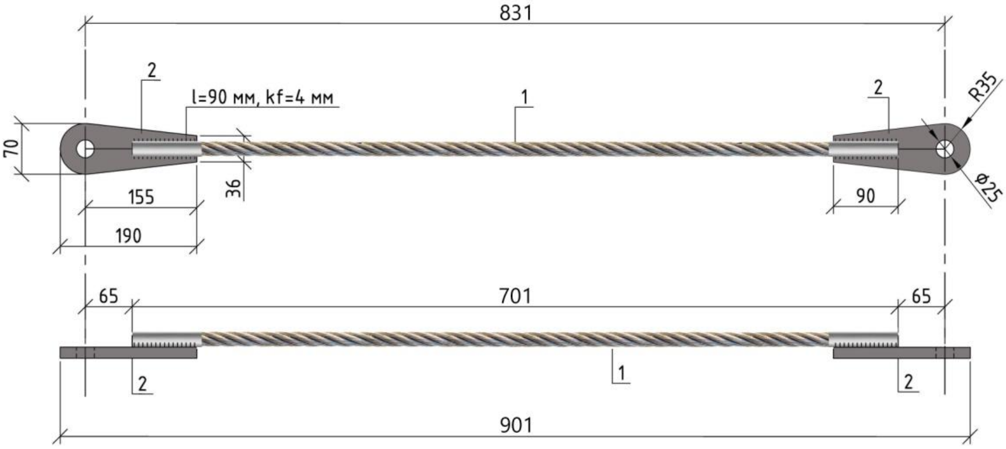
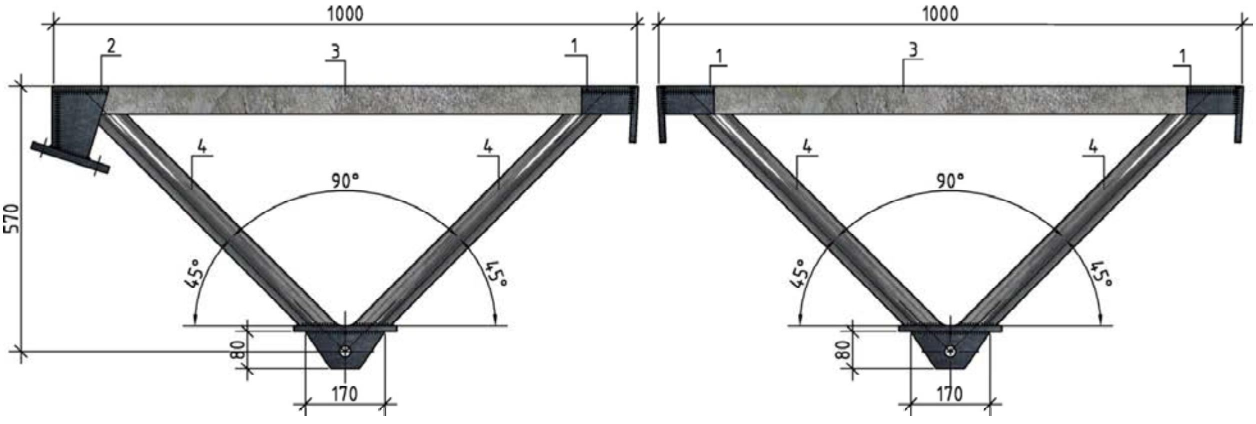
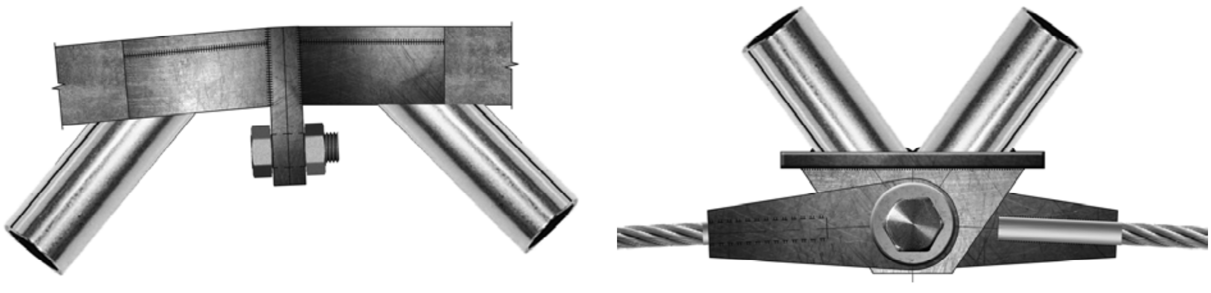


Fig. 2. The bottom chord of the spatial grid-cable steel-concrete composite slab:
1 – steel plate; 3 – steel cable



a *b*

Fig. 3. The supporting (a) and span (b) spatial modules of the spatial grid-cable steel-concrete composite slab:
1 – the detail for connections; 2 – the supporting element; 3 – the top chord; 4 – the diagonal



a *b*

Fig. 4. Bolted connections on top chord (a) and bottom chord (b)

Table 1

The weight of the spatial grid-cable steel-concrete composite slab (l×b×h=6×1×0.57 m)

№	Element	Number of elements, unit	Weight, kg		
			Unit	Result	Total
1	The supporting spatial modules	2	152.6	305.2	931.2
2	The span spatial modules	5	118.8	594.4	
3	The bottom chord	6	4.10	24.6	
4	Other details	-	-	7.0	

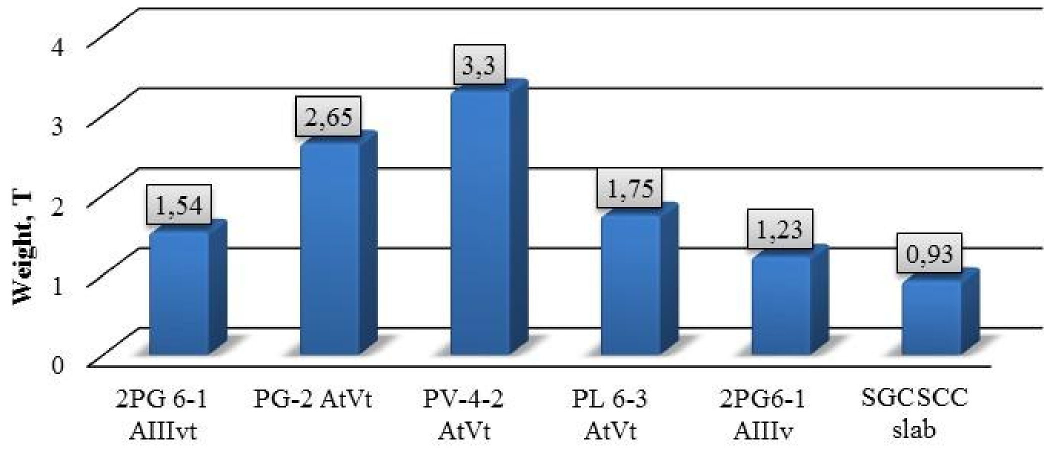


Fig. 5. Weight of the construction

Slabs that have been compared, are designed for load within 200–300 kg/m² (Fig. 6), therefore the ratio of weight slabs to their bearing capacity was determined for a more objective assessment of effectiveness of the design (Fig. 7).

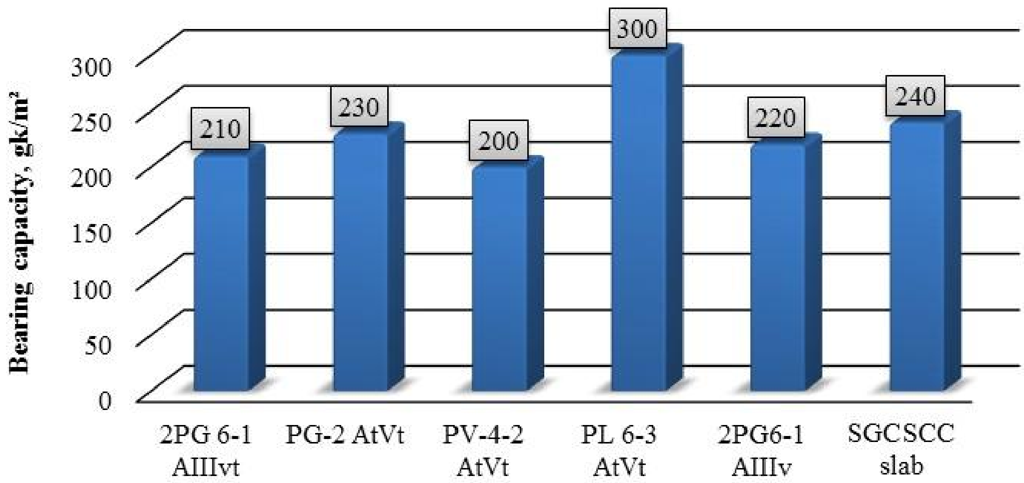


Fig. 6. Bearing capacity of the construction

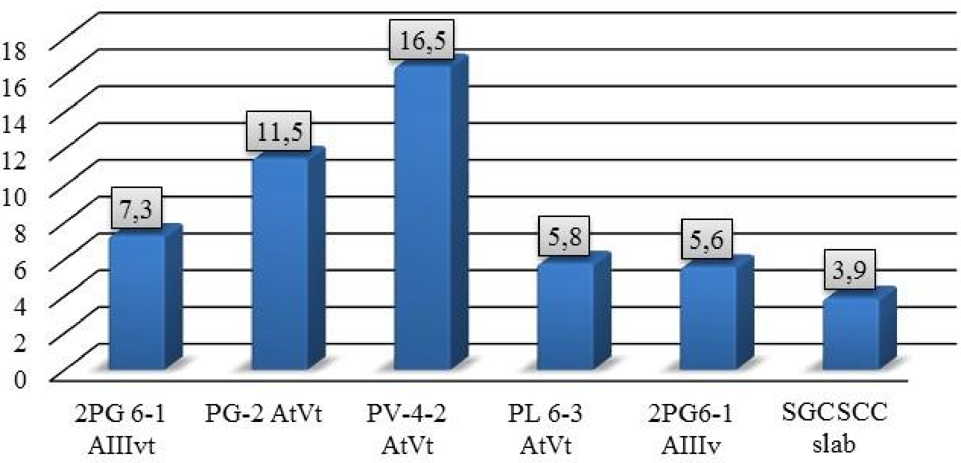


Fig. 7. The ratio of weight slabs to their bearing capacity

It have been found that the spatial grid-cable steel-concrete composite slab is lighter than a typical series of concrete slabs at 32–72 % with the same load capacity (Fig. 7).

After this, the comparison has been made between the complexity of the roof erection from the spatial grid-cable steel-concrete composite slab (Table 2) and typical prefabricated reinforced concrete structures (Table 3) for one-storey industrial building span of 30 m and 6 m column step. The laboriousness has been calculated for one cell of the roof 30×6 m. The spatial grid-cable steel-concrete composite roof system is an assembled unit from two grid-cable steel-concrete composite slabs that have been collected from 20 spatial modules (Fig. 8). Units and modules are interconnected by means of bolted connections.

Table 2

The laboriousness of the roof erection from the spatial grid-cable steel-concrete composite slab

№	Operation	Unit	Amount of work	Laboriousness	
				man-hour	machine-hour
1	Unloading of elements, cables, etc.	100 т	0.24	2.38	1.19
2	Consolidation of elements in the spatial units	1 unit 1 T	20.0 1.89	3.60 1.04	0.80 0.2
3	Installation of cables (the bottom chord elements)	1 cable	2.0	2.0	-
4	Installation of bolts	100 pcs.	0.54	7.77	-
5	Assembling the spatial units	pcs. 1 T	1.0 1.89	22.8 2.47	3.3 0.34
Total				42.06	5.83

Table 3

The laboriousness of the roof erection from typical prefabricated reinforced concrete structures

№	Operation	Unit	Amount of work	Laboriousness	
				man-hour	machine-hour
1	Unloading of elements (truss)	100 T	0.34	1.16	0.58
2	Unloading of elements (slabs)	100 T	0.24	1.10	0.55
3	Assembling elements (truss)	1 element	2.0	24.2	4.84
4	Assembling elements (slabs), the surface area to 18 m²	1 pcs.	10.0	13.2	3.30
5	Welding of joints	10 m	1.0	3.20	-
6	Concreting joints	100 m	0.90	3.87	-
Total				46.73	9.27

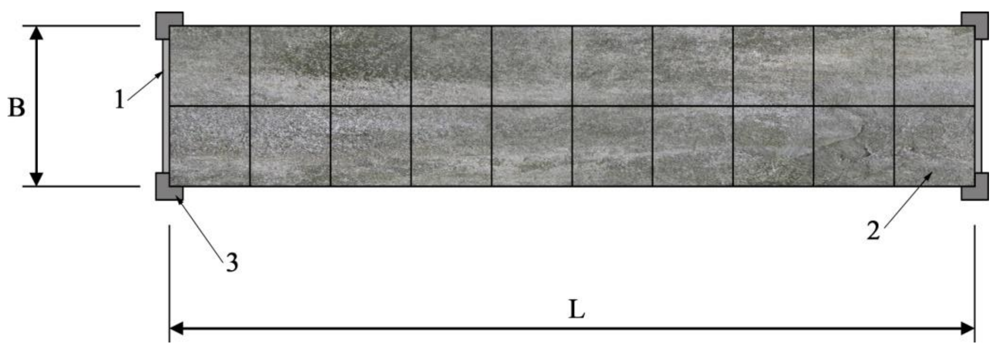


Fig. 8. The cell of the spatial grid-cable steel-concrete composite roof system:
1 – beam; 2 – the spatial grid-cable steel-concrete composite slab; 3 – support;
B – column step, 6 m; L – span of building, 30 m

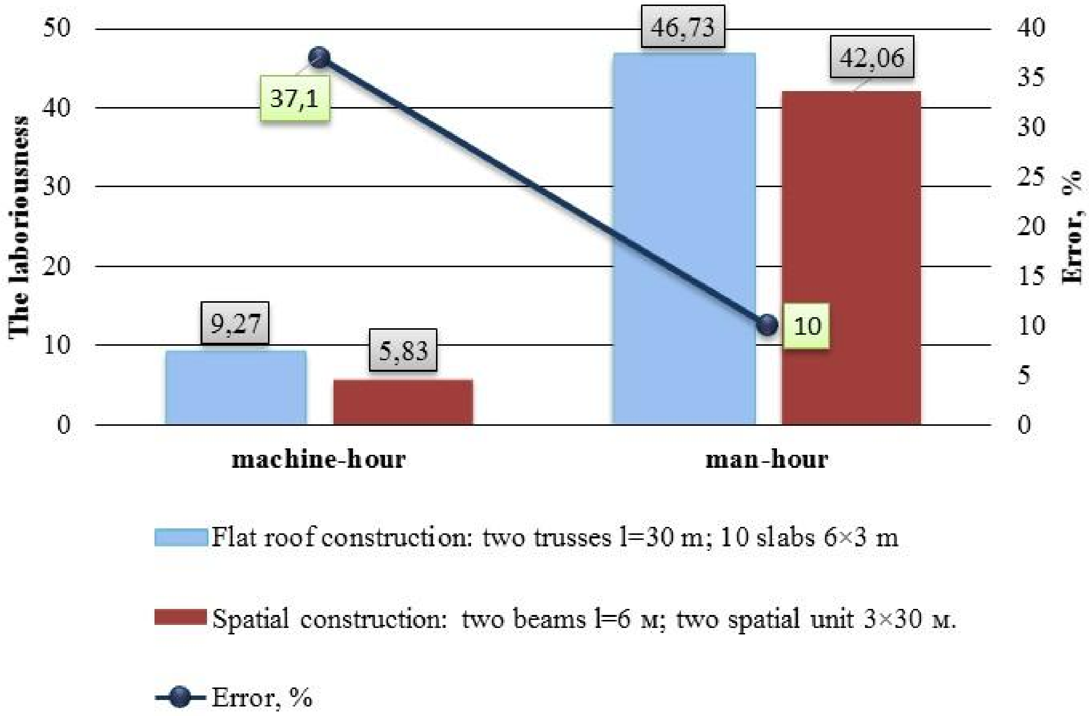


Fig. 9. Technical and economic comparison of the construction laboriousness of the spatial grid-cable steel-concrete composite and traditional reinforced concrete roof systems

It have been found that the spatial grid-cable steel-concrete composite roof system is lighter at 37 % than a traditional reinforced concrete roof system are made from typical series of concrete slabs (Fig. 8).

Conclusion. The spatial grid-cable steel-concrete composite slab is the new kind of a construction for long-span roof systems and shells. The main feature of the construction is the structural concept. This construction consists of the diagonal members, the top and the bottom chords. The spatial grid-cable steel-concrete composite slab consists of some number of the spatial steel-concrete modules. The modules are connected to each other in nodes by using special bolted connections. The top chord are made of reinforced concrete slab and the bottom chord are made of steel cables. Calculations of technical and economic indicators were solved on the example of one section of the roof of the size of 30×6 m. These data demonstrate the effectiveness and feasibility of studied structures in the shells of buildings and structures of various function. The studies show that the use of the spatial grid-cable steel-concrete composite slab allows reducing the weight of the roof by 32–72 %, the man-hour by 10 % and the machine-hour by 37.1 % in comparison with existing analogues.

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