Estimate of technical and economic benefits of a new space composite structure

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Abstract. There is a problem of excessive laboriousness and materials consumption resulting from irrational using of materials in construction. This situation is caused by inconsistencies existing structural concepts to modern requirements of construction industry. It has a direct impact on the overall implementation cost of the project. That is why there is a need for a new structure, which makes it possible to save materials and reduce a construction complexity. Such structure is the new space composite structure. There is summary information about the estimate of technical and economic benefits of a new space composite structure in the paper. Task of paper is arrangement information about estimate of technical and economic benefits of a new space composite structure. Based on the previous research results, there is the optimum ratio for the structure in the paper; also, a relationship between the depth of the module and the span for the new space composite structure were defined. The estimate of both the technical-economic parameters and the advantages of the new space composite structure were described. The estimation results show the effectiveness of the new space composite structure to 10%-37% compared to traditional reinforced concrete structures.

1 Introduction

Improvement of construction sector is accompanied by regular introduction new designs. An important factor in developing constructive solutions is the use of reliable, advanced and lightweight materials. The researchers focus mainly on the study of the stress-strain state of beams, columns, slabs, bridge structures, structures for metallurgical and mining industry, etc. [1-3].

The study of new space composite structures is the actual problem because use such structures in the building construction would save labour and materials. The new space composite structure is a bearing system that consists of concrete slab and space lattice composed of steel tubes or other cross section elements. The distinctive feature of the new space composite structure is a flexible lower belt made of cable or other flexible elements,

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which are only in tensile. The new space composite structure is collected of the individual lightweight modules [4].

Manufacturing technology is divided into two independent processes: the production of steel lattice and the formation of the slab. Another distinctive feature of the new space composite structures is their versatility by changing the lengths of the bottom chord can be given different curvatures of structure, buildings or structures any complexity and shape.

2 Literature review

Analysis of recent papers and publications has shown that composite slabs or shells frequently stand out from other composite steel and concrete structures, specifically combining concrete slabs (top chord) and steel rod elements (steel lattice). In such constructions, slabs can be unloaded by means of steel rods. A study of the strength and deformability of the steel and concrete composite structure that consists of steel T-section beams and concrete monolithic slab which are combined with anchors [5]. In [6] a structure was proposed that consists of modular steel elements, top and bottom chords and reinforced concrete slab without anchors.

Considering the above items, the idea to combine the slabs and rods for joint performance in a structure by the new way is the unique and distinguishes the proposed structure among existing as a new type of structure. The concept of the proposed solution is a synthesis of an experience and new developments that consist of the modular elements, the purpose of which is to decrease complexity and difficulty of manufacturing technology, assembly and installation [7].

Efficiency of the constructive solution of spatial structures and their elements were investigated and confirmed earlier [8].

An analysis of previous works shows there is no summary information about the estimate of technical and economic benefits of the new space composite structure. The objective of this article is arrangement information about the estimate of technical and economic benefits of the new space composite structure.

3 Results and Discussions

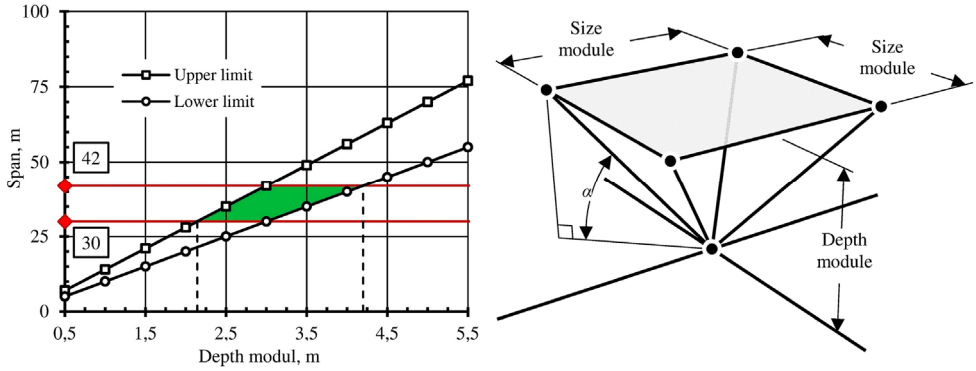
As it is well known, in the design of building structures often face the problem of finding certain geometric parameters of a structure or its elements, which must satisfy a number of conditions to ensure the normal functioning of the building or structure. The importance of solving this task consist in defining the right geometric parameters, which help to reduce material consumption while ensuring rigidity and reliability of structures with the same bearing capacity comparable options [9]. In most cases, to obtain optimal geometric parameters of structures, it is necessary to use high-strength materials [10].

Solving the problem of choosing the geometric parameters is especially important for the new space composite structure because the lower belt of the structure made of flexible rods, which by their nature and the essence are not designed to in compression. Thus, there is no need to use rigid and massive types of a metal profile to provide the design load-carrying capacity and rigidity of the structure. This feature of the new space composite structure very closely linked to the ability to use high-strength steels to manufacturing elements of the bottom chord, because it is known that for stretched elements effectively apply high-strength steel.

Regarding the possibility of application of the optimization methods, the essence of which is to changing the structure geometry or determining individual geometric dimensions for each item, is unacceptable for the new space composite structure, as it

contradicts the essence of the structure, it is using modular elements. Finding the optimal height to span ratio of the module elements is another issue that is closely related to designing of the new space composite structure.

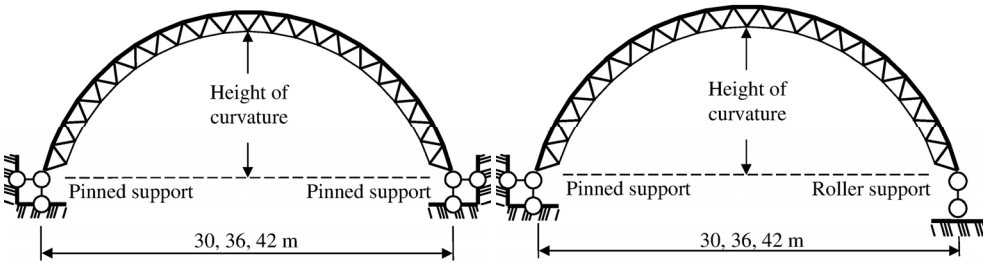
Based on the research results [11] that present the optimum ratio for the previously mentioned parameters for structures, which composed of steel trusses and concrete slabs, were defined relationship between the depth module and the span for the new space composite structure (Fig. 1).



(a) (b)

Fig. 1. The depth–span curve for the new space composite structure (a) and space module for the new space composite structure (b).

Knowing the optimum depth of the module can determine the size of the module. However, it should be noted that determination the optimal height to span ratio is the most important for a beam type of the space composite structure that has a small curvature. For the arch type structure, the main issue is to determine the geometrical parameters of curvature and boundary conditions (Fig. 2), which ensure efforts distribution in structure elements so that the top chord will be only in compression and the bottom chord in tension.



(a) (b)

Fig. 2. Types of support of the new space composite structure: pinned–pinned support (a); pinned–roller support (b).

In [12] described the results of research, the task of which was to determine the geometrical parameters of curvature of the new space composite structure with pinned-pinned support (Fig. 2, a). The results of the research have shown the optimal spans of the space composite structure are distances 30, 36 and 42 m. The optimal height of curvature for the spanning structure 30 m is between 1400 and 1450 mm; the optimal height of curvature for the spanning structure 36 m is between 1460 and 1570 mm; the optimal height of curvature for the spanning structure 42 m is between 1580 and 2100 mm. For the new space composite structure with pinned-roller support (Fig. 2, b) the optimal height of curvature may be 10 times higher than in the previous case. Thus, the pinned-roller support

gives more opportunities to build different structures. This has been confirmed by experimental research, which was conducted on a full-scale test of the new space composite structure [13].

There is a need to perform the estimate of the technical and economic parameters and to estimate the advantages the new space composite structure compared to existing analogues to determine the field of application of the new space composite structure. Such estimate of both the technical-economic parameters and the advantages of the new space composite structure was obtained in [14]. The estimation results show the effectiveness of the new space composite structure to 10-37% compared to traditional reinforced concrete structures (Fig. 3).

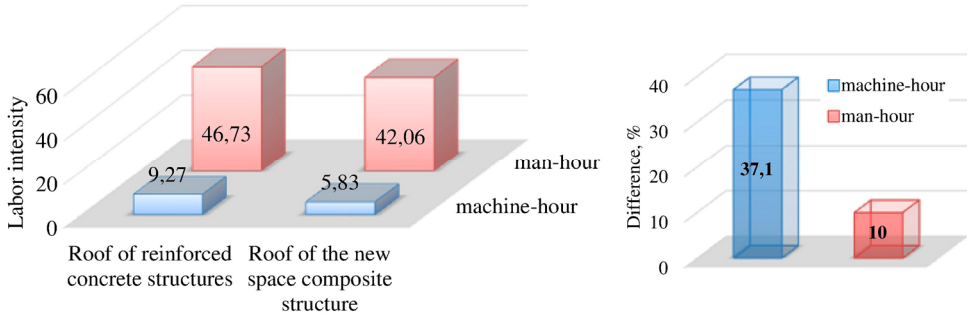


Fig. 3. The technical and economic benefits of a new space composite structure [14]: labor intensity (a); the difference (b).

Research confirms the effectiveness of constructive solutions of the new space composite structure because labour costs of installation and the consumption of materials are reducing compared with analogues.

4 Conclusion

The new space composite structure is the new kind of a structure for long-span systems and shells. The main feature of the structure consists in the structural concept. The new space composite structure has significant advantages; in particular, the structure is lighter and has lower complexity in both manufacturing and assembly than analogues. The new space composite structure consists of the bottom chord; and space modules, which combine both a reinforced concrete slab and a lattice made of a steel tube. This structural concept makes it possible to save materials due to its rational using.

Calculations of technical and economic indicators were solved. These data show the effectiveness and feasibility of the new space composite structure of the different designation. The studies have shown the use of the new space composite structure allows reducing the weight by 32-72%; the man-hour by 10% and the machine-hour by 37,1% in comparison with existing analogues [14].

The new space composite structure is both reliable and efficient in exploitation it has been confirmed by both analytical studies and numerically investigation of the stress-strain state; structural concept allows saving materials it has been confirmed by both experimental and theoretical evidence.

In conclusion, it should be noted that the new space composite structure has different types and shapes; it allows using the structure successfully in construction of different buildings or structures.

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