

БУДІВЕЛЬНІ КОНСТРУКЦІЇ

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CONNECTIONS SYSTEMS OF THE COMPOSITE CABLE SPACE FRAME

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The analysis of researches spatial and composite structures with the purpose of revealing the most effective designs of knots and joints is carried out. New types connections have been developed for the assembly of a space steel reinforced concrete structure-hinged structure. The feature of the developed nodes is the use of single-bolted joints. The design of the developed joints allows you to obtain an economic benefit through the efficient use of materials.

Keywords: bar, cable, composite, joint, node, slab, structure.

Introduction

Sometimes there is a problem in building sector in construction of different buildings. The problem consists in the complexity of work and material overruns. Such situation in the construction has caused by contradiction existing design solutions to modern requirements, which over time morally and physically have outdated. It directly effects of overall cost and construction duration of object. Therefore, there is a need to improve or develop the new designs, including space structures and connection system for them, which would permit to achieve savings of materials and to reduce complexity of construction processes. This caused appearance of the new concept of the composite cable space system [1], which combines both the data and results of previous studies [2 – 4] and will have both positive and unique properties.

Development of airport infrastructure except machinery and equipment modernization requires modernization, changes or rebuild existing structures and construction new buildings. Structures that completely satisfy the demanding requirements for buildings of modern airports are the composite cable space frames that are a combination of steel space trusses, steel cables or bars and slabs (Fig. 1) that used for not only cover or protect from aggressive external factors, rain, snow and other atmospheric influences but also used as bearing element. The composite cable space frame was patented. The slab for these structures except concrete can be made from glass, plastic and other modern materials. Choice of material depends on building function.

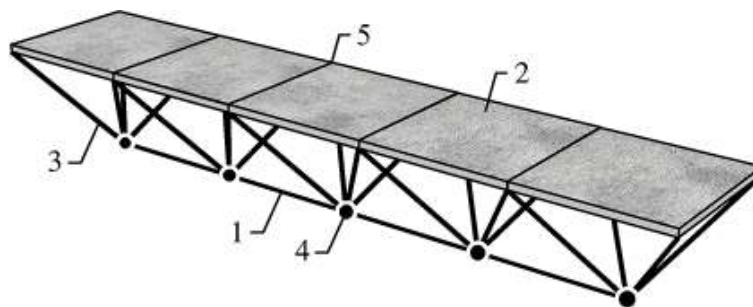


Fig. 1. Part of the steel and concrete composite cable space frame:

1 – cable or bar (bottom chord); 2 – slab (top chord); 3 – web; 4 – connection of top chords; 5 – connection of bottom chords

In designing composite cable space frames, the connecting system is one of the most crucial points, not only for the shape and geometry accommodation, but also for the local and global stability of the structure.

World experience to provide proper solutions in connection systems on the spatial structure considering structural and geometrical requirements, a lot of researchers have provided recently different types and forms [5].

Overview

In [6] reported that over 250 different types of connecting systems have been suggested or used in practice, and there are around 50 commercial firms, which have tried to specialize in the manufacture of proprietary connection systems for spatial structures, each with its own types and forms that are difficult to compare. Unfortunately, many of these systems have not proved attainment of great success mainly because of the complexity of the connecting method. In [7] presented wide list of connection type with a node and its a comprehensive survey of the jointing systems all over the world. In accordance [8] all the connection techniques can be divided into three main groups: with a node, without a node, and with prefabricated units.

Concerning composite structures the analysis of recent sources of research and publications has shown that such structures is used very widely in various construction fields [9 – 15]. Currently the main direction of research composite structures is related with the improvement of methods of calculation and constructive solutions as well as study influence of different loads on the stress-strained state [16 – 19].

The analysis of previous studies has shown that most of the steel and concrete composite structures is monolithic. However, prefabricated structures, which would allow building various surface, have not completely developed yet.

Task formulation

Based on overviews of existing connection systems and their advantages and disadvantages, to design and present effective and reliable connection system for composite cable space frame.

Main points of the research

The purpose of the study is to present the new kind of connection systems for composite cable space frame, which are made from modern and strength materials for civil construction in particular to cover halls, hangars for aircraft and other vehicles, garages for a large machinery, large-span buildings and structures of airports, etc. The novelty of the composite cable space frame lies in effective application properties of materials and structural concept [20]. The composite steel and concrete grid-cable construction as noted earlier consists of the three different kinds of structural elements: slabs, steel space trusses and steel cables. The steel space trusses are made from segments of steel tubes or rods. The slabs are used as the top chords, steel space trusses are used as diagonals and steel cables or bars are used as flexible bottom chords. The diagonals and slab create space module (Fig. 1) that is main element of the composite steel and concrete grid-cable construction. The space module can has different size and height (Fig. 2).

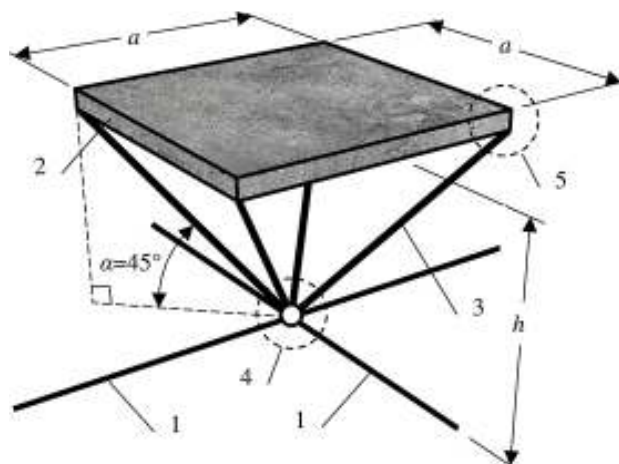


Fig. 2. The space module:

1 – cable or bar; 2 – slab; 3 – web; 4 – connection of top chords; 5 – connection of bottom chords

The space modules are jointed together in planes both of top and bottom chords by special nodes. These nodes are made as single-bolted joints in one direction. The space modules are connected in one or two directions. It is depend on how the steel and concrete composite cable space frame are going to use. If the steel and concrete composite cable space frame are assembled from the space modules as a slab (Fig. 3, a) then the space modules are jointed in one direction; if as a surface (Fig. 3, b) then the space modules are jointed in two directions.

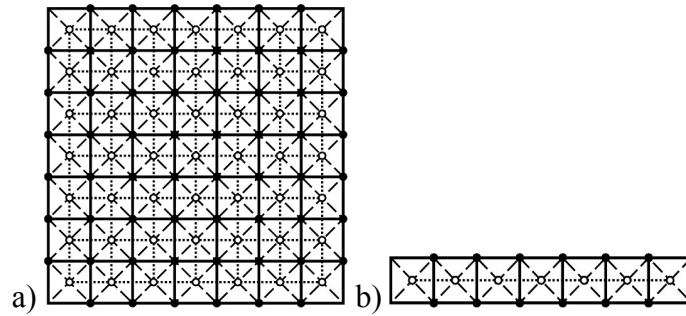


Fig. 3. The steel and concrete composite cable space frame assembled as a surface (a) and a slab (b)

Figure 4 shows a type of connection of space modules on top chord plane in two directions.

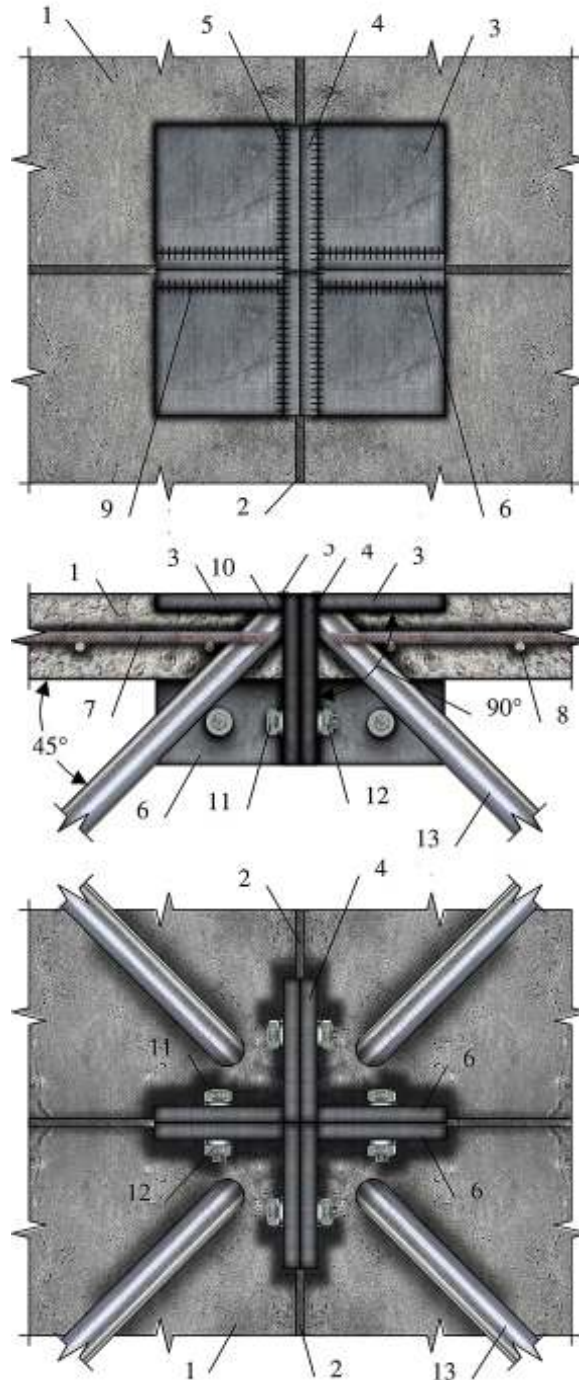


Fig. 4. Connection of space modules on top chord:

1 – concrete slab (top chord); 2 – sealed joint; 3, 4, 6 – steel plate; 5, 9, 10 – welded joint; 7, 8 – reinforcement; 11 – bolt; 12 – nut; 13 – web (tube)

The connections can be used also for curved slabs or surfaces. For this, the steel plates (1) and (2) should have angle among ourselves. The angle can be acute or obtuse (Fig. 5).

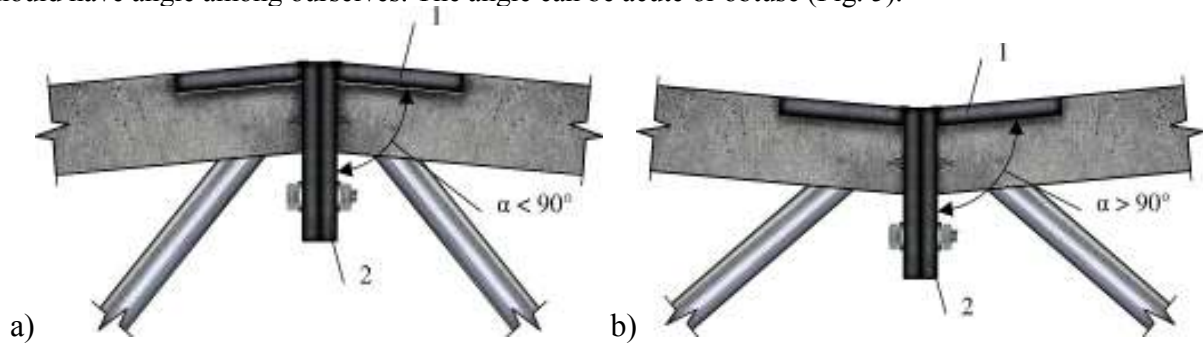


Fig. 5. Connection of space modules on top chord plane for curved structures:
a) for $\alpha < 90^\circ$; b) for $\alpha > 90^\circ$; 1, 2 – steel plate

There is an opportunity to assemble flat and curved covers (Fig. 6) for considerable range of areas by means presented connections.

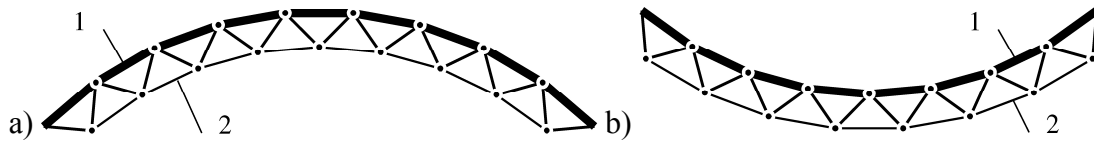


Fig. 6. The steel and concrete composite cable space frame made as curved covers by means presented connections:
1 – the top chord, 2 – the bottom chord

To connection of the space modules among ourselves on bottom chord also used single-bolted joints. For this in top point of tubes connection is need to weld a bolt (Fig. 7) through which the modular elements of bottom chord are jointed. However, for this there is needs to installation at the ends of the bottom chords special details (Fig. 8).

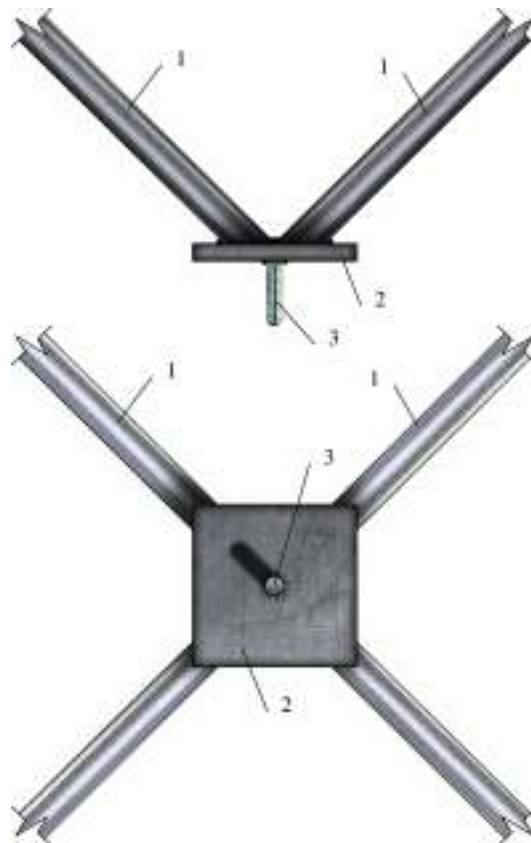


Fig. 7. Node for connection of flexible modular elements on bottom chord:
1 – web (tube), 2 – steel plate; 3 – bolt



Fig. 8. The ends of the bottom chords:
1 – steel rod, 2 – steel drop plate with a hole

Conclusions

The connectors for these structures are simpler than node systems for ordinary space grid structures because its members are connected with single bolted joints, which cause decrease of complexities in the mechanism of force transfer and reduce installation complexities.

The efficient of new types of the connections lies in low complexity of manufacturing and installation compared to existing systems. In addition, the main specifics the connection systems is using single-bolt joints. The connections can be applied in industrial and civil construction for construction both small and large span covering of different objects from composite cable space frames. The connections provides a significant economic benefit through the efficient usage of materials.

On top of that, assembling specifics and structural concept allow not only to save cost and time of construction but also to adjust the building site as effectively as possible.

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ВУЗЛОВІ З'ЄДНАННЯ ПРОСТОРОВИХ СТАЛЕЗАЛІЗОБЕТОННИХ СТРУКТУРНО-ВАНТОВИХ КОНСТРУКЦІЙ

Полтавський національний технічний університет імені Юрія Кондратюка

Проведений аналіз досліджень просторових і композитних конструкцій з метою виявлення найбільш ефективних конструкцій вузлів і з'єднань. Розроблені нові типи з'єднань для збірки просторової сталезалізобетонної структурно-вантової конструкції. Особливість розроблених вузлів полягає у використанні одно-болтових з'єднань. Конструкція розроблених з'єднань дозволяє отримати економічну вигоду за рахунок ефективного використання матеріалів.

Ключові слова: ванта, вузол, з'єднання, композит, конструкція, плита, стрижень.

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УЗЛОВЫЕ СОЕДИНЕНИЯ ПРОСТРАНСТВЕННЫХ СТАЛЕЖЕЛЕЗОБЕТОННЫХ СТРУКТУРНО-ВАНТОВЫХ КОНСТРУКЦИЙ

Полтавский национальный технический университет имени Юрия Кондратюка

Проведенный анализ исследований пространственных и композитных конструкций с целью выявления наиболее эффективных конструкций узлов и соединений. Разработаны новые типы соединений для сборки пространственной сталезалезобетонные структурно-вантовой конструкции. Особенность разработанных узлов заключается в использовании одно-болтовых соединений. Конструкция разработанных соединений позволяет получить экономическую выгоду за счет эффективного использования материалов.

Ключевые слова: ванта, композит, конструкция, плита, соединение, стержень, узел.

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