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ANALYSIS OF STRESS-STRAIN STATE OF THE STEEL-CONCRETE COMPOSITE RIBBED SLAB AS A PART OF THE SPATIAL GRID-CABLE SUSPENDED STRUCTURE

The nature of deformation and stress distribution in steel-concrete ribbed composite slab that is part of the space module of the steel and concrete grid-cable composite structure with span of 30 m were investigated. The plate was made with 20 mm thick and the size in terms 1.5×1.5 m. The plate has 30 mm height and 50 mm width ribs that giving the plate additional rigidity. Strengthening steel-concrete composite plate is provided with woven nets from steel wire by a diameter of 0.9 mm and a cell size of 12×12 mm. Connections woven reinforcing nets with each other is performed using embedded parts. The ribs were reinforced with rods of class A400C diameter of 6 mm. The design is made from the fine concrete C25/30. Analysis of stress-strain state the design was made with a numerical method. For the modeling of the physical and mechanical properties of the materials of the plates have been reduced characteristics. The main parameters were reduced modulus of elasticity plate and ribs.

Keywords: *steel-concrete composite material, plate, modulus of elasticity, stress-strained state.*

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АНАЛІЗ НАПРУЖЕНО-ДЕФОРМОВАНОГО СТАНУ АРМОЦЕМЕНТНОЇ РЕБРИСТОЇ ПЛИТИ, ЯКА Є ЧАСТИНОЮ ПРОСТОРОВОЇ СТРУКТУРНО-ВАНТОВОЇ КОНСТРУКЦІЇ

Досліджено характер деформування та розподіл напружень в армоцементній ребристій плиті, яка є частиною просторового модуля структурно-вантової сталезалізобетонної конструкції прольотом 30 м. Плита виконана товщиною 20 мм і розмірами на плані 1,5×1,5 м, має ребра висотою 30 мм і шириною 50 мм, які надають плиті додаткової жорсткості. Зміцнення плити забезпечено плетеними сітками зі сталевого дроту діаметром 0,9 мм і розміром чарунки 12×12 мм. З'єднання плетених армувальних сіток між собою виконано за допомогою закладних деталей. Ребра жорсткості армовано стрижневою арматурою класу А400С діаметром 6 мм. Конструкцію виготовлено з дрібнозернистого бетону марки 300. Аналіз напружено-деформованого стану досліджуваної конструкції виконано за допомогою чисельного методу. Для моделювання фізико-механічних властивостей матеріалів плити було виведено приведені характеристики. Основними параметрами були приведені модулі пружності плити і ребр жорсткості.

Ключові слова: *сталезалізобетон, плита, модуль пружності, напружено-деформований стан.*

Introduction. The development of the construction industry needs to change and implementation of the latest designs. The obligatory condition for a successful implementation of design concepts into real sector of the construction are their researching and compliance with today's requirements. The design that completely satisfies these requirements is the steel and concrete grid-cable suspended composite (SCGSC) structure this is the rod-plate system that has the modern concept. The originality of this concept lies in combining in a structure of various elements, the effectiveness of which is determined by the terms of their particular location in structure. The SCGC construction consists of three structural elements: a lattice, a top and bottom chords. As the bottom chord, use the steel-concrete composite ribbed (SCCR) slab.

Analysis of recent sources of research and publications has shown that steel and concrete composite is a material that were used very widely in various fields of construction [1 – 3]. There are research papers that described the study of stress-strain state of individual elements of the SCGC structures or small-scale samples and models with experimental and theoretical ways [4] among a number of research papers that aimed at studying the steel and concrete composite constructions [5 – 10].

The method of computer modeling describes in [11] to calculate steel and concrete composite slabs. There is a calculation of the steel and concrete composite slabs with steel belt contour in [12].

Highlight unsolved parts of the general problem. The analysis of previous works has shown that full-size samples of the SCCR slabs for the SCGSC structure have not studied yet. This is the reason and given the importance of the confirmation of the reinforcing efficiency of the invention, the research of the stress-strain state of the SCCR slab is actual subject.

Formulation of the problem. Task consists in study the stress-strain state of the full-size samples SCCR slabs using the results of previous studies and given the features structural concept.

The main material and results. Calculation was made on the example of the SCGSC shell with span 30 m (Fig. 1). The shell consists SCCR slabs with 20 mm thick and the size in terms1.5×1.5 m (Fig. 2). The plate has 30 mm height and 50 mm width ribs that giving the plate additional rigidity. Strengthening steel-concrete composite plate is provided with woven nets from steel wire by a diameter of 0.9 mm and a cell size of 12×12 mm. Connections woven reinforcing nets with each other is performed using embedded parts. The ribs were reinforced with rods of class A400C diameter of 6 mm. The design is made from the fine concrete C25/30.

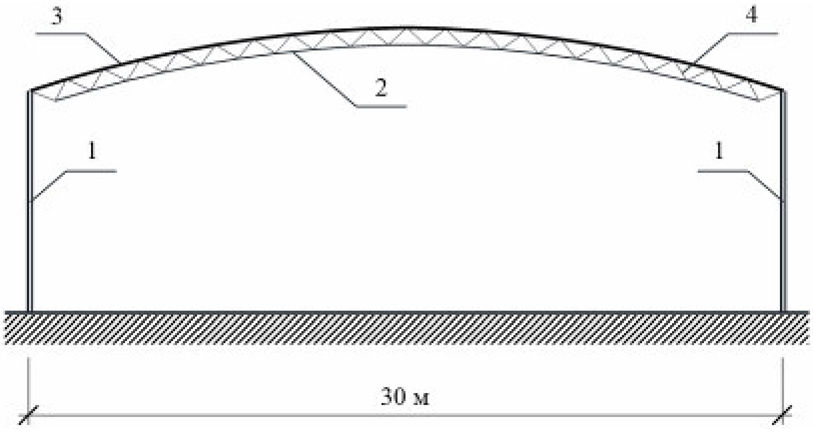

Figure 1 – The steel and concrete grid-cable suspended composite shell:
1 – a column; 2 – a bottom chord;
3 – the steel-concrete composite ribbed (SCCR) slab; 4 – a lattice

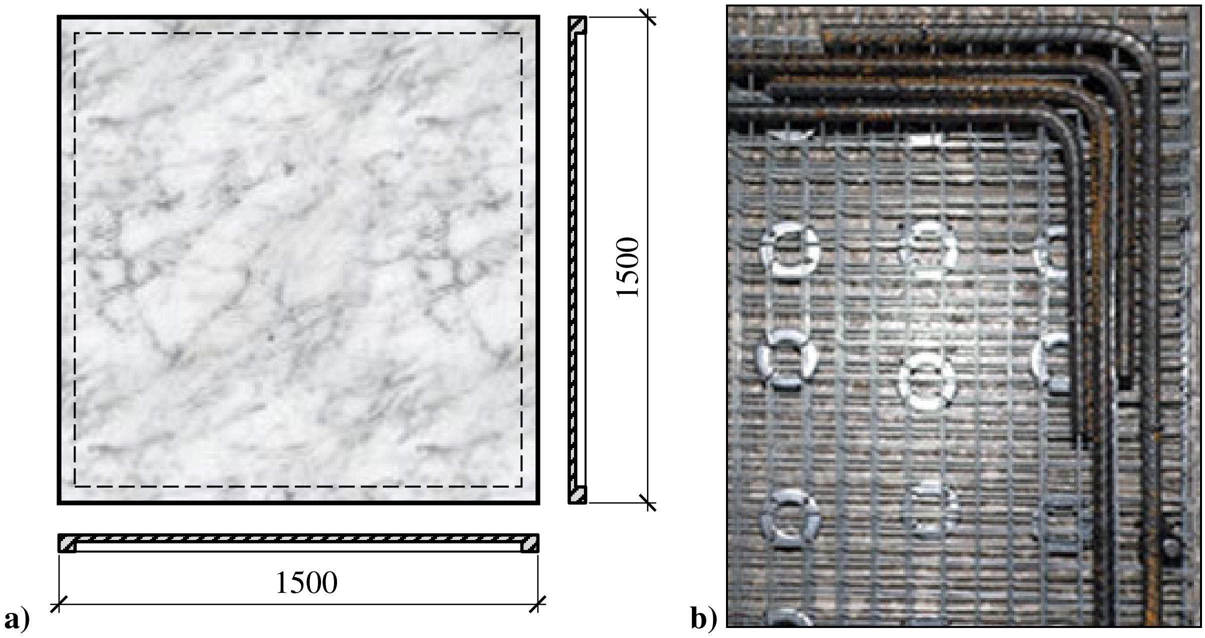

Figure 2 – The steel-concrete composite ribbed (SCCR) slab (a) and the reinforcement of SCCR slab (b)

Analysis of stress-strain state of the SCCR slab has investigated with the FE method. For this had been defined physical and mechanical properties of materials by experimental way (Fig. 3) and the average modulus of elasticity for different parts of the SCCR slab by the method described by E. Lysenko (Fig. 4, a). There is the boundary conditionals on Fig. 4, b. The result of the solving is contours of stresses (Fig. 5 – Fig. 7) of the SCCR slab.

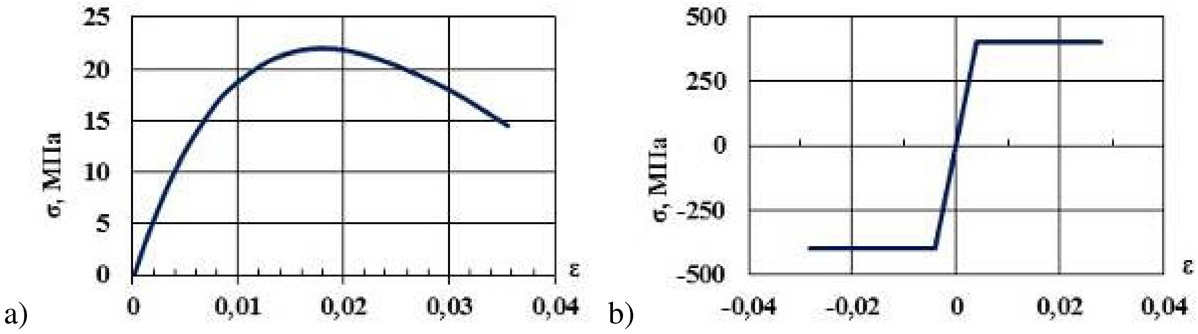

Figure 3 – The stress-strain curve: a) concrete C25/30; b) steel reinforcement A400C

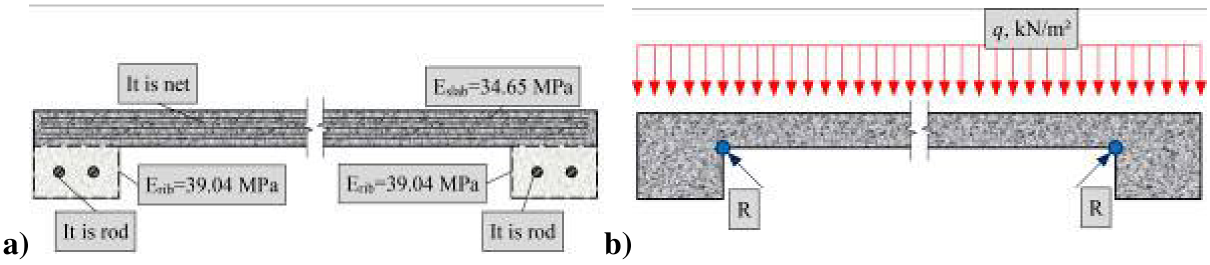

Figure 4 – The average modulus of elasticity for different parts of the SCCR slab (a) and boundary conditionals (b)

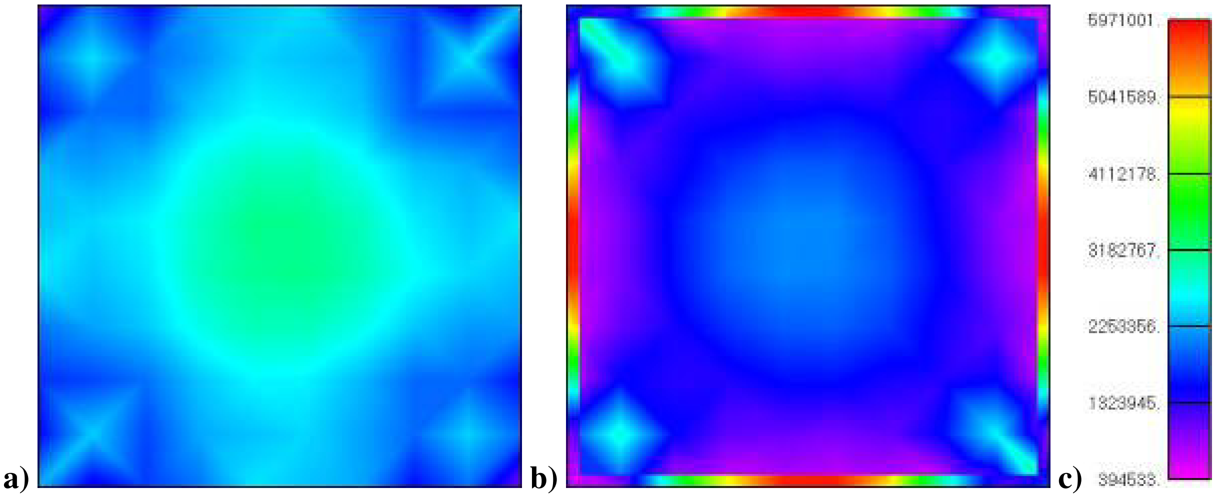

Figure 5 – The solid Von Mises stress contour, N/m²:
a) top of the SCCR slab; b) bottom of the SCCR slab;
c) criteria levels of the stress contour

There is the Solid Von Mises Stress contour on the Fig. 5 shows that maximum stresses have appeared in the ribs. The value of the maximum stresses in the ribs higher than stresses in the middle of slab almost in two times 5.97 MPa /3.18 MPa≈1.88. It means ribs were involved in the joint operation together with SCCR slab.

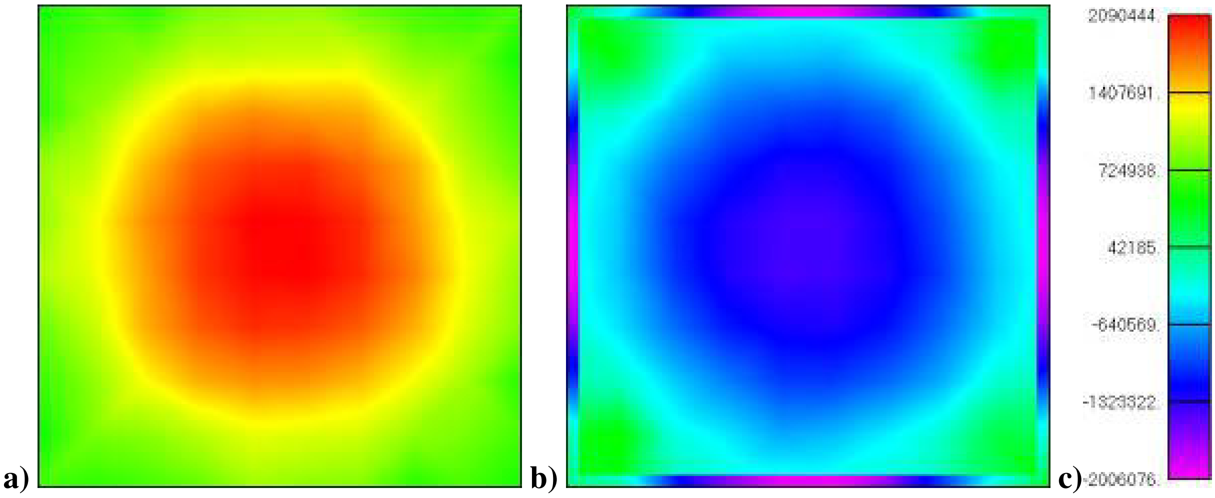

Figure 6 – The solid mean stress contour, N/m²:
a) top of the SCCR slab; b) bottom of the SCCR slab;
c) criteria levels of the stress contour

There is solid mean stress contour on the Fig. 6 shows zones where compressive and tensile stresses have appeared. The compressive and tensile stresses are approximately equal among themselves. There are mean stresses in the ribs have changed sign from «+» at the end to «–» at the middle point of the rib. It means the SCCR slab has been bended. There are mean stresses in the slab have decreased from the middle to the end radially.

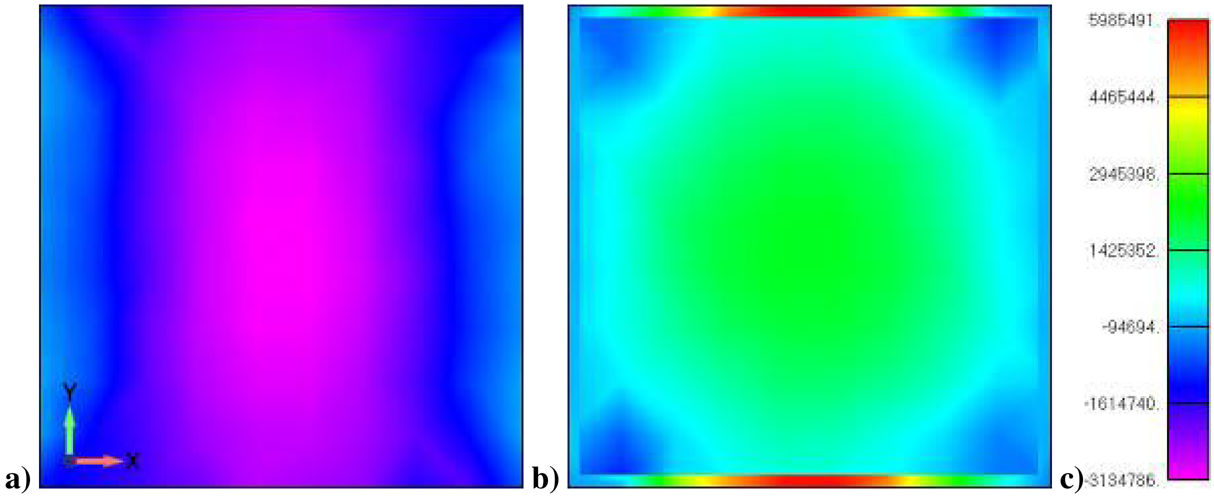

Figure 7 – The solid X normal stress contour, N/m²:
a) top of the SCCR slab; b) bottom of the SCCR slab;
c) criteria levels of the stress contour

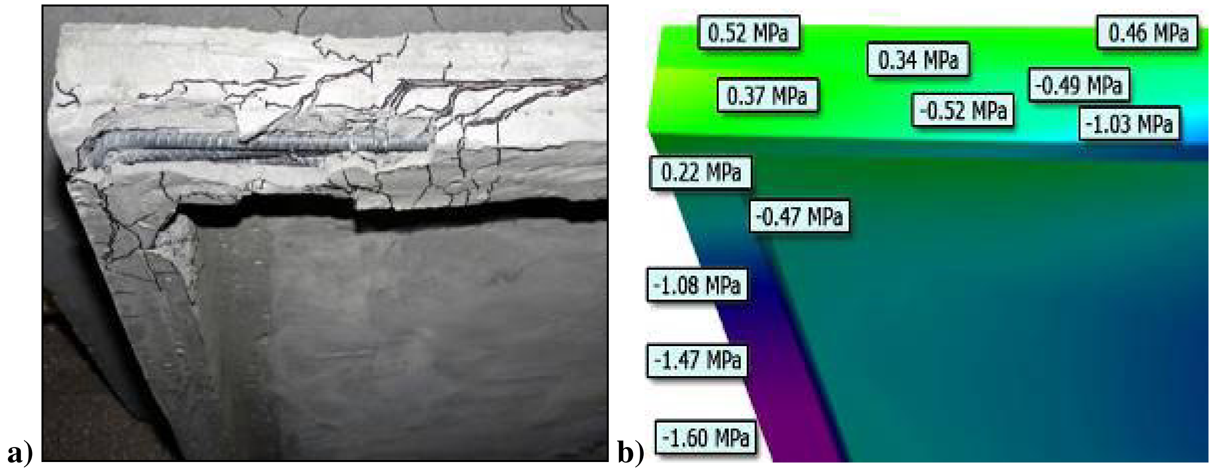

Figure 8 – The comparison of cracks in the experimental model (a) and the numerical model (b)

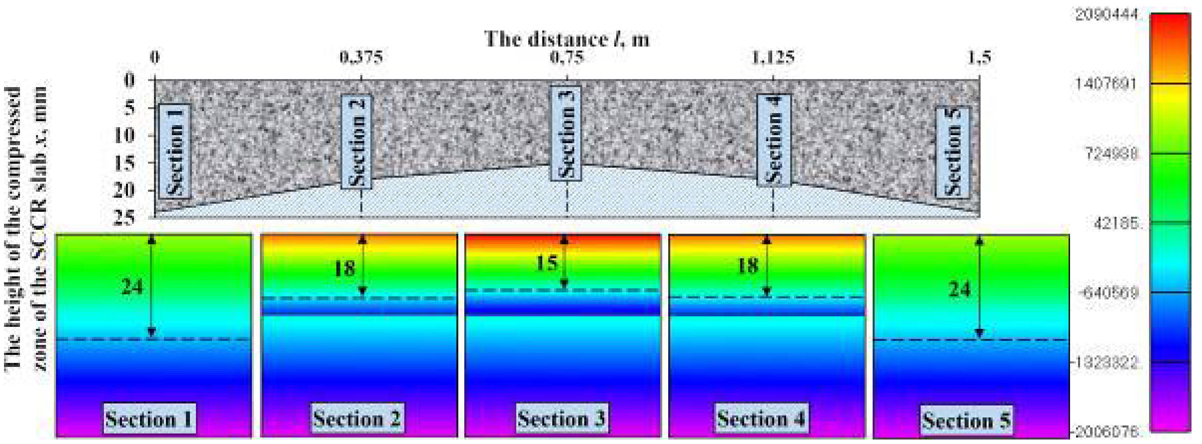

Figure 9 – The height of the compressed zone along the axes X and Y of the SCCR slab

Fig. 8 shows a comparison of cracks in the experimental model with the numerical model. It is evident that the stress-strained state of the experimental model and the numerical model is similar. If we trace an imaginary curve between stresses with different signs, we get direction of cracks formed in the experimental sample. Fig. 9 shows height of the compressed zone along the axes X or Y and obviously that it lower in the middle than at the sides.

Conclusions. The method described by E. Lysenko allows to obtain the average elastic modulus are used for numerical modeling behavior of the SCCR slab under load. Contour of the stresses and displacement were obtained with modeling behavior of the SCCR slab. Analysis of stress-strain state of the SCCR slab showed similarity data with the results that were obtained with experimental way. The stress state the SCCR slab indicates that ribs are behavior compatibility with slab. All this data proves effectiveness of the reinforcement the SCCR slab. It means that the SCCR slab can be designing with the FE method.

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