IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Development and static testing of the 18x6 m SSU-TTMBF spatial structural unit

To cite this article: S. Deordiev *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **136** 012018

Development and static testing of the 18x6 m SSU-TTMBF spatial structural unit

S. DEORDIEV[1,a], A. FROLOVSKAIA[2,b], M. KRASIEV[3,c]

[1]School of Engineering and Construction, Siberian Federal University, 82 Svobodny,Krasnoyarsk,660041 Russia
[2]School of Engineering and Construction, Siberian Federal University, 82 Svobodny,Krasnoyarsk,660041 Russia
[3]School of Engineering and Construction, Siberian Federal University, 82 Svobodny,Krasnoyarsk,660041 Russia

E-mail: [a]yevtifeva@mail.ru, [b]tereshkova81@mail.ru, [c]anger7992@gmail.com

Abstract. The aim of this work is the development of a fragment of the structural covering, consisting of a triangular block of frames, the choice of step size (width) of the structural unit and a study of its mode of deformation by comparing experimental and theoretical results of research.

1. Introduction

In the design of a structural unit [1] a spatial 18x3 m triangular timber-metal block frame (18x3m TTMBF) (Fig. 1) is adopted [2, 3, 4] as a basis. It has synthesized the best properties of previously developed unit frames [5, 6]: the lower belt has a parabolic shape, the grid is spaced regularly along the length of the structure, efforts from the lower belt are transmitted to the panels of the top belt at a slight angle to the wood grains.

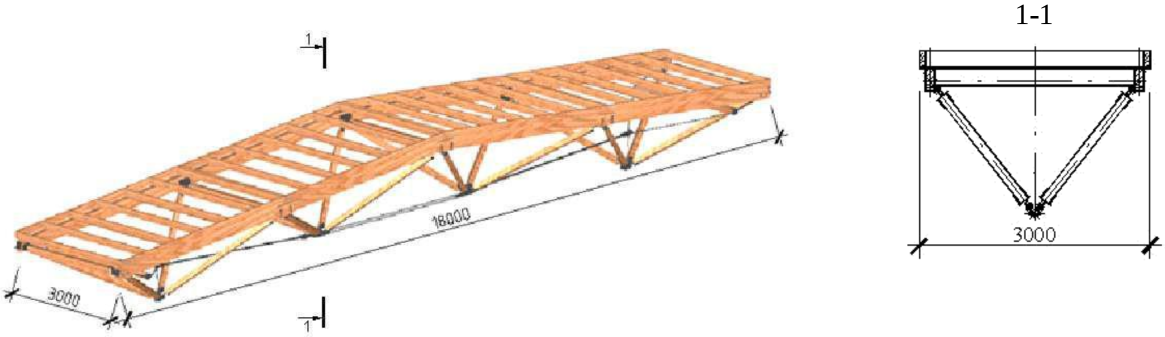

Figure 1.General view of the 18x3 m TTMBF structure.

In the choice of geometric dimensions the following options for the structure layout were considered 1) 18 x 6 m; 2) 18 x 9 m; 3) 18 x 12 m (Fig. 2). Comparison of the structures was performed by the numerical method according to three indicators: 1) efforts in the upper belt; 2) efforts in the lower belt; 3) efforts in braces.

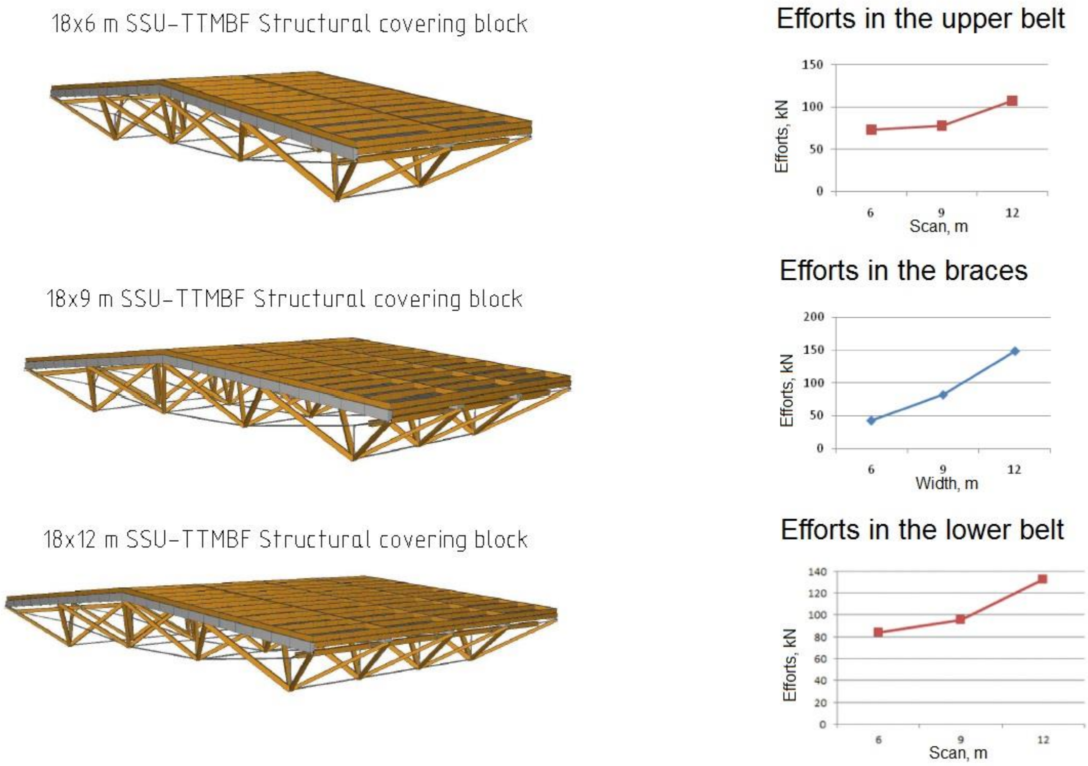

Figure 2.Comparison of efforts in structural blocks with different cells (6, 9, 12m).

In connection with the lowest deflections and efforts in the elements, it was decided to make a fragment of the structural block for further research, consisting of two unit frames with the dimensions of 18 x 6 m (18x6 m SSU-TTMBF) with a double belt. It should be noted also that the size of the structural block is the same and applicable to buildings with a 6m step for columns. Design was developed to the stage of working drawings.

2. Manufacture and assembly

The elements of the upper belt with 244x120 mm section and140x140 mm bracing section are laminated and manufactured on the basis of production of KLM Group Company in Krasnoyarsk. Extreme braces and the elements of the lower belt are made of metal because of emerging stretching forces in them. The structure consisting of two timber and metal block-frames is characterized as follows: the span is 18 m, nominal width is 6 m, and construction height at the mid-span is 2,293 m. The area covered is 108 m^2.

(a) (b)

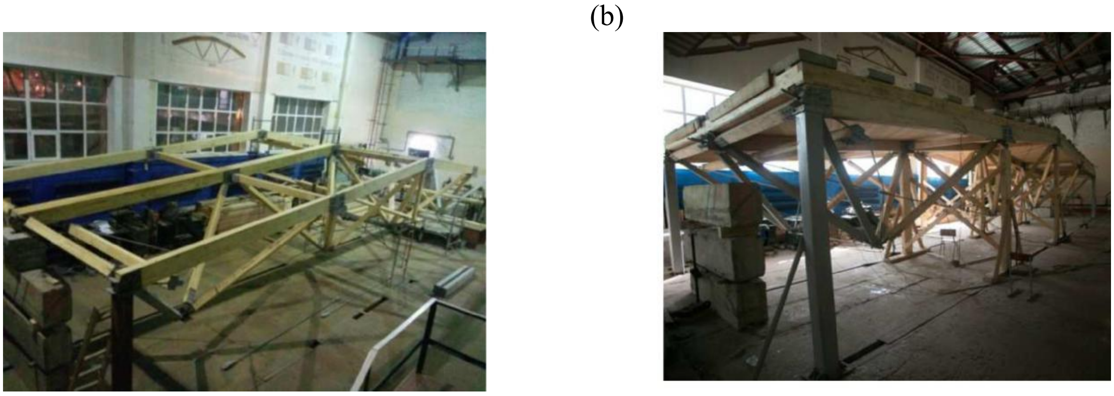

Figure 3. Assembly of a fragment of the structural block:
a) the main fabric of the structure; b) 18 × 6 structural block in design position.

The structure is designed with the use of interchangeable laminated plates for the top belt (Fig. 3b, 4). Geometrical scheme of the block frame is arranged in such a way that its joints are located on the arc of a square parabola, and interchangeable braces have the same length. This provides the most favorable conditions for the belts and grids. The lower belt is designed of round steel.

In the assembly process the quality of execution of elements of design (facing precision, welding quality of steel parts, etc.) was thoroughly checked. All in all two block-frames with dimensions of 18×3 m were assembled. Finally, the assembly of individual block frames in a single covering unit (Fig. 3 a, b) was carried out when assembling the second block frame with the help of cross-connection of extreme top neighboring belts by connecting elements and transverse elements of the lower belt.

3. Preparation and testing

A prototype structural unit made in natural size was subjected to tests of a short-term static load. Before testing visual and instrumental inspection for compliance of the structural unit with general design dimensions was carried out.

The order and intensity of loading according to the levels of applied load are shown in Table 1. The structure was subjected to static tests, short-term uniformly distributed load of intensity q = 2.44 kN/m2. The structural covering unit was loaded by weight tarred concrete blocks with a weight of 0.60 kN and beams with an average weight of 0.54 kN. Board laying was used to distribute load pressure evenly along the length of the transverse ribs of the upper belt. Scheme of loading is shown in Figure 4.

Table 1.Order and intensity of the structure loading

Number of loading level	Intensity of loading, kPa			
	Levels		Total	
	External load	Including own weight	External load	Including own weight
1	0.35	0.85	0.35	0.85
2	0.30	0.80	0.65	1.15
3	0.3	0.80	0.95	1.45
4	0.3	0.80	1.25	1.75
5	0.3	0.80	1.55	2.05
6	0.394	0.894	1.94	2.44

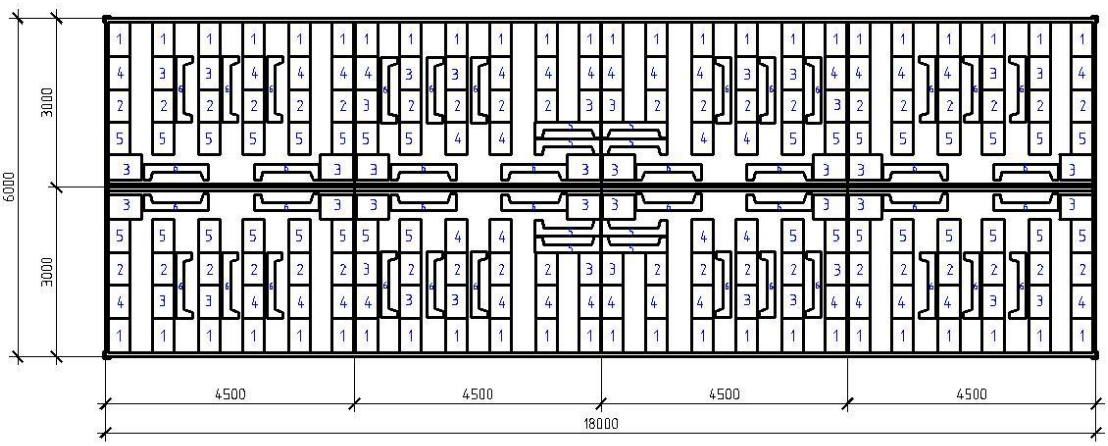

Figure 4. Scheme of the structure loading by concrete blocks

To fix the stresses in the elements of the structure a MMTC-64.01 tensometric system was used. The system is used to automate the collection and measurement of signals from strain gauges, installed on the

IOP Conf. Series: Earth and Environmental Science **136** (2018) 012018 doi:10.1088/1755-1315/136/1/012018

elements of the structure, subsequent processing and registration of measuring information by means of computer technology. To determine the amount of displacement of individual points of the structure, Aistov 6-ПАО deflectometers were used (Fig. 5).

Figure 5. An Aistov 6-ПАО- 0.01 deflectometer and a resistance strain gauge

The tests have revealed the following:

- The maximum stress in the compressed zone of the extreme top belt in the quarter span of the structure was 1.5 MPa (design value - 1.2 MPa); in the stretched zone of the extreme top belt in a quarter of the span - 2.6 MPa (design value - 2.1 MPa);

- The maximum stress in the compressed zone in the extreme top belt at a distance of 1/8 of the span from the ridge joint of the structure was 1.8 MPa (design value - 1.45 MPa); in the stretched zone of the extreme top belt at a distance of 1/8 of the span from the ridge joint - 2.8 MPa (design value of 2.25 MPa);

-The maximum tension of the compressed zone in the middle twin top belt at a distance of 1/8 of the span from the ridge joint was 2.4 MPa (design value is 1.95 MPa); respectively, in the stretched zone in the middle double top belt at a distance of 1/8 of the span from the ridge joint - 1.4 MPa (design value - 1.12 MPa);

- The maximum effort in the elements of a regular grid (braces) was 0.5 MPa (design value - 0.5 MPa);

- The maximum tensile effort in the elements of the lower belt was 157 MPa (design value - 134 MPa).

-The maximum deflections of the structural block were: in the extreme belt at ¼ of the span – 8.819 mm, in the average twin belt in the 1/4 span – 8.375 mm; in the ridge joint of the extreme belt - 7.233 mm; in the ridge joint of the middle twin belt – 6. 952 mm.

4. Analysis and conclusions

The results of experimental studies of static work of the 18x6 m SSU-TTMBF structural covering block based on triangular block-frames have led to the following conclusions:

1. There is a good convergence of theoretical and experimental meanings of stress values in the elements of a spatial structural block from triangular block-frames, namely: the average difference between the theoretical value found according to the results of the design structure calculations with software systems and the experimental meaning is equal to 23.1% in the upper belts and about 17.2% in the lower belts.

2. It has been found that an experimental prototype of the 18x6 m SSU-TTMBF structural block is characterized by sufficient rigidity, which is confirmed by the small value of its maximum deflection with a standard load f=60.07 mm, that is $\frac{1}{296} l$ (where l is the span of the structure), which is less than the limit value, regulated by normative documents [$\frac{1}{200} l$].

IOP Conf. Series: Earth and Environmental Science **136** (2018) 012018 doi:10.1088/1755-1315/136/1/012018

Developed joints of the main assembly elements (block frames) of the 18x6 m SSU-TTMBF structural unit ensure reliable operation of the structure and ease of assembly. Manufacture and assembly of the prototype unit have confirmed the structural manufacturability of the adopted constructive solutions. In future it is planned to conduct dynamic tests of a spatial structural block from triangular block frames with the study of the compliance of joint connections of the structure as a whole.

5. References

[1] K.V. Buchel: *ПСБ–ДМ-18.12 Spatial Structural 18×12m Timber – Metal Covering Block* in Modern Building Structures of Metal and Timber (Research Transactions, Odessa (2003), p. 37-40.

[2] I.S. Inzhutov, S.V. Deordiev: *Structure and Results of Tests of a Triangular Timber-Metal Block Frame* in Transactions of Higher Educational Establishments. Construction, 1998, Vol.10, p. 129-134.

[3] I.S. Inzhutov, S.V. Deordiev, P.A. Dmitriev, L.V. Endzhievskiy, S.A. Chernyshov, Patent 2136822 “Triangular block frame” (1999). The decision to grant a patent for invention.

[4] I.S. Inzhutov, S.V. Deordiev, P.A. Dmitriev, S.A. Chernyshov, L.V. Endzhievskiy, Patent 2136822 “Triangular block frame” (1999).

[5] S.N. Abovskaya: *New Spatial Steel –Iron – Concrete Covering Structures (*Stroyizdat, Krasnoyarsk 1992, 240p.)

[6] S.V. Deordiev: *Analysis of Possible Constructive Schemes of Block Frames with a Regular Grid* in Proceedings of XVI research conference devoted to 370 anniversary of Krasnoyarsk (Krasnoyarsk, 1998, p. 14-15).