Lighting Research on Models of Tent Structures Under Artificial Sky in the Research Institute of Construction Physics

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Abstract. Tent building structures are one of the types of modern structures. Their production is an actively developing branch of the construction industry. Having such advantages as light weight, quick construction, and if necessary-transformability and mobility, tent buildings and structures have a wide range of functional purpose. These are shopping and public centers, cinema and concert halls, exhibition halls, arboretums, mobile hospitals and many other purposes.

1. Introduction

The object of research was chosen a space-core dome with a tent covering, which serves as a multifunctional public center in the international tourist camp “Volga”, near the city of Kazan. The main purpose of the object-dining restaurant, cinema, concert and conference hall, dance floor. Bearing frame-spatial network dome (geodesic) of steel pipes with a diameter of 140 mm. the Outer fence is made of tent material "Volga-3" (Art. II46, z-d RTI, Yaroslavl), gray. The coverage area is 1225 m². The awning is suspended from the bottom to the frame with the help of the hoists of the Poppet type. The diameter of the dome-43 m, height-12.5 m. the capacity of the building, depending on the functions is:- a) dining room-restaurant – 600 people; b) cinema and concert hall-up to 800 people; C) dance floor – up to 1000 people. In this regard, the area under the dome was divided into functional zones (Fig. 1), each of which requires special natural and artificial lighting, which was the purpose of research.

At first, measurements of natural light were carried out, according to the characteristic sections, in a natural object. The illumination graphs are shown in Fig. 2 ("a" and "b"). With the aim of expanding research using razlichnogo materials magkahiwalay and constructorstring features (arrangement of additional light openings, colors of the wall, dismantling of structures, tenango of the lamp), was developed and produced models of the dome at a scale of 1:25 and 1:10 relative to natural structures, In this paper, we consider research conducted remodeli 1:25, under the artificial sky at NIISF. The experiment consisted of the following stages:

1. Selection of samples of tent materials in the amount of 3.
2. The study of lighting characteristics of selected samples of tent materials was carried out on the following devices: - fmsh-56M (Russia) and spectrophotometer "HITACHI" (Japan). Research data - see table. 1.
3. Research of natural light on the model of tent structures (M1: 25), under artificial sky in the "Laboratory of artificial lighting" (NIISF).
Table 1. Lighting characteristics of fabrics-film materials

| №п/п | Name, standart, condition, color, producer | Structural schemes TM. | FMSH – 56M | HITACHI |
|------|------------------------------------------|-----------------------|------------|---------|
|      |                                          |                       | τ  | α  | β   | τ  | ρ |
| 2    | “Teza, TU-17-21-231-78, Ivniipik, Ivanovo, new, wheel drive, amber |                       | 2  | 43 | 55  | 0,49 | -  | 50 |
| 6    | "Volga-3", Art. 1146, z-d RTI, Yaroslavl, Novy, TSV. Gray |                       | 03 | 28 | 72  | 0,41 | -  | 22 |
| 8    | Brand PVC "T", APCTP, new, wheel drive. milk white |                       | 37 | 60 | 3   | 168 | 17 | 58 |

The model of the space-rod frame (diameter – 1,8 m, height-0,5 m), represents 1/3 of the hemisphere (see Fig. 3), made of metal rods with a diameter of 8 mm., connected at the nodes of metal discs. Along the lower contour of the rods is missing the cord to which the disc is attached by means of suspensions of soft fencing (see Fig. 4).

Measurements of the light flux were made: - inside the model – selenium solar cells with a diameter of 10 mm., located on the photometric line, and outside – Luxmeter.

To identify the lighting characteristics of different variants of lighting devices and devices and translucent materials, studies were conducted on the model of tent structures with different light and coating shell materials. The design of the model allowed to determine the effect on the illumination of the frame, as well as the reflection coefficients of the shell surfaces, floor, walls.

Figure 1. Functional zone characteristics (1 – main, 2 – support, 3 – food court, 4 – transportation zone, 5 – bar, 6 – stage)

Figure 2. The illumination diagram

Figure 3. The dome’s structure

Figure 4. The experiment
First, the light medium in the dome structure was investigated at non-light-spray fabric coating and different types of spot-openings (table 2): A - vote auction light, and side light openings; B - same as A, but DOPOLNITEL are arranged round light openings with a diameter of 70 cm koeffitsientom light transmission = 0.9; In the hedgehog, and type B, round openings of 0.6, пола0,08, D - anti-aircraft franar with +0,0 with a diameter of 3 m, the floor is 0.08.

The dimensions of the openings are limited by the structural features of the frame and shell seams. From table 2 it is seen that in variants A and B the estimated value of Keo on the above experimental 10-23.4%, in options C and D – lower for 8-24%. This difference could be explained by the fact that the opening is being made using different technologies. The level of complexity of construction, diamond-shaped surface of the dome and shading elements’ presence also affected difference in results.

**Table 2. Lighting performance depending on the options of translucent awning construction**

| №  | Model’s structure | Average KEO, % | Lightning irregularity |
|----|------------------|----------------|----------------------|
|    |                  | Experimental  | Calculated           |
| A  | ![A diagram](image) | 0.9           | 1.0                  | 2.31:1                |
| B  | ![B diagram](image) | 1.79          | 1.37                 | 1.2:1                 |
| C  | ![C diagram](image) | 0.88          | 1.15                 | 1.69:1                |
| D  | ![D diagram](image) | 1.27          | 1.23                 | 3.74:1                |

All KEO values (both experimental and calculated) are lower than normal values which is 2-3%. Due to the fact that all types of light openings considered do not provide the required illumination, the experiments on models covered by yellow and white covering (τ=0.02 ;11=0.43 and τ=0.56 ;11=0.11 consequently).

Construction with yellow covering showed the average experimental value equal to 0.8%, average calculated value equal to 1.05%, with white coverage 32.2 and 47% systematically. Multiple reflection factor was defined. Its calculated value 24% higher than experimental for yellow covering and 31.5% higher than experimental for white covering. It should be mentioned that the yellow covering with extremely low values of τ and ρ (0.02 and 0.08) increase the natural illumination level.

The study on the model of the dome with light transparent coating allows us to draw the following conclusions the calculated values of Keo exceed the experimental values by 24-30 1%. This can be explained by the error associated with the scale of the fabric modeling structure semicolon on the results of calculations could have influenced the unevenness of the fabric and film structure, resulting in the value could be unstable point new paragraph due to multiple reflections in the dome creates additional illumination, constituting 18-19 percent of the total. The lighting conditions created in the most common type of tent construction of the dash bathed, covered with a yellow cloth with a very
low light transmission coefficient and a high coefficient of reflection of the dash can be estimated as favorable. In this dome is a uniform distribution.

In tent structures without light receptions creates a high uniformity of lighting. When the device in the enclosure of light openings of different designs, including the side, the uniformity of lighting may vary. The greatest unevenness of the bracket under the accepted norm 3 colon 1 bracket is noted in the model with light openings of type g, that is, with an anti-aircraft light aperture at the top of the dome. However, in some facilities, for example, in sports and cultural and entertainment, with the stands, just need high unevenness of lighting with a maximum value of e o in the Central part of the arena. Therefore, the question of uneven lighting and the corresponding lighting system in tent structures should be addressed in each case, based on the functional purpose of the structure.

Thus, research natural lighting in tent constructions under natural conditions and on models, and found the following. Adopted in the calculation of the coefficients not sufficiently reflect performance properties tensile structures aging of tissues and films, changing their shapes, colors, colors and technical properties. The influence of these factors on the accuracy of the calculations the more, the longer the life of the structure. In addition, a decrease in K e o and for the presence of various shading structural elements of devices for fixing shells to the frame, support assemblies, tension of shells, diamond-shaped formations on the enclosure and so on is not taken into account. Therefore, to improve the calculation of natural light of tent structures, it is necessary to further study these factors and develop methods of their accounting.

The experimental values of KEO obtained in models with light openings with a light-tight fabric coating for some variants are higher than the calculated ones by 8-24 percent, for others the dash is lower by 10-24%. This is due to the fact that different types of light openings were calculated by different methods, including approximate, the calculated coefficients were taken conditionally by analogy with the traditional, for some types of light openings used tent structures, not established light characteristics, the average weighted reflection coefficients in some versions of the model were lower than the accepted norms.

The experimental value of Keo in dome models with different translucent materials is lower than calculated by 24-31. 5% due to the influence of the scale of the structure of the coating fabric and joints of the shell elements. In addition, the heterogeneity of the structure of fabrics and films gives some error in determining the light transmission and reflection coefficient of the material.

In the dome model with yellow fabric, despite the very low values of the light transmission coefficient of the coating and the reflection coefficient of the KEO, still can be provided sufficient illumination. Depending on the conditions of visual work with the appropriate degree of light in such structures can provide acceptable levels of illumination and given the irregularity of lighting.

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