Steel Structure with Textile Membranes for Renovation of an Existing Built-up Area

Dimitar DAKOV
Prof. Dr. Eng.
UACEG – Sofia
Sofia, Bulgaria
Dakov_fce@uacg.bg

Born in 1942. M.Sc. in structural engineering. Head of department of Steel, Timber and Plastic Structures, UACEG. Head of the Bulgarian working groups for structural Eurocodes for timber and aluminium structures. Consulting Engineer for steel, timber and aluminium structures

Vatyu TANEV
Assist. Prof. Dr. Eng.
UACEG – Sofia
Sofia, Bulgaria
Tanev_fce@uacg.bg

Born in 1976, M.Sc. in structural engineering, UACEG. Ph.D. thesis on lightweight structures in 2005. Consulting engineers for steel and textile membrane structures.

Summary

Three different types of textile membranes, used in the global architectural-structural solutions for renovation of an existing Summer Theatre near the sea beach have been presented. The most interesting in the structural complex is the retractable roof, which covers the amphitheatre hall. The bearing tubular steel structure is entirely exposed and situated above the roofing. Special attention has been paid to the detailing of the structural joints and connections between textile membranes and tubular steel structures.

Keywords: Tubular steel structures, textile membrane, renovation, retractable roof, prestressing, structural joints.

1. Introduction

Contemporary structures with textile membranes have been used for different purposes in wide range of building systems. It is possible to cover large spaces with free boundaries using minimum points of support and ensure abundant varieties for natural light transmission. Two of the most valuable advantages of the textile membrane structures are their “connectibility” and “convertibility”. These lead to easy adaptability to the existing buildings and possibility of “opening” and “closing” of the space for a short time. The connectibility and convertibility are properties inherent to the textile membranes, and in this case they are used in the most suitable manner.

The current paper presents the realization of the new roof using textile membrane over the existing buildings of the Summer Theatre in Bourgas (Bulgaria). The higher architectural demands for such kind of buildings have been satisfied and at the same time it became possible to have fast “unfolding” and “folding” of the movable part of the roof according to the specific needs.

2. Design concept

It was not allowed to make any changes to the existing buildings according to the requirements of the tender documents and the new architectural and structural elements had to be added in a natural way to the existing landscape pattern. During the renovation three new structural parts have been added to the existing theatre.

The architectural and structural solutions take into account the restrictions imposed by the existing buildings (plan configurations, possibilities for support, way of hanging, the architectural appearance, access for erection, etc.) and give a new appearance to the resort town with its expressive form.

https://doi.org/10.2749/222137908796293451

The different parts of the roof have been composed as separate membranes, which have different plan configuration and way of connecting to the supporting structure thus ensuring a better architectural effect (Fig. 1). The structural steel parts have been connected in a common system. This leads to a higher efficiency and reliability of the whole structure but complicates the structural design and the numerical models.

Fig. 1: General view at the process of folding

3. Some specific features of the steel structure, driving mechanisms and pre-stressing

The main steel structure was composed by two space lattice arches situated in parallel to the longitudinal axis of the theatre. The span of the arches is 39,4m and they have circular shape. The radius of curvature of the bottom chord is 24m. The structural and numerical model assumes that the arch has pinned supports. The cross section is a trapezoidal and the four main chords are hot rolled tubes Ø193,7x10, while the lattice is made from cold formed tubes Ø139,7x5, Ø114,3x4 and Ø76,1x4. All the structural joints have been done with direct connection between the tubes.

Two transverse lattice girders connect the main arches to each other. The transverse lattice girders have been used also for suspension of the permanent roofing over the stage and boxes. The chords of the transverse trusses are made from tubes Ø139,7x5 while the lattice members were designed with tubes Ø76,1x4 and Ø60,3x3,5.

The retractable textile membrane was suspended at special trolley, which runs on the rail- and cable-ways. The synchronized movement over the rail- and cable-ways lead to some technological difficulties but at the same time satisfied to maximum level the architectural requirements and restrictions imposed by the existing building. Hydraulic devices at six supporting points have done the initial pre-stressing of the membrane needed for reaching the target geometry. The processes of “opening”, “closing” and prestressing of the textile membrane have been done fully automatically by means of remote control.

4. Conclusions:

The application of textile membranes in-between or next to existing building parts has a great potential for development. When the interaction between the textile membrane and load-bearing steel structures is taken into account in the design it is possible to achieve new and effective structural solutions with great architectural effects. For that purpose good collaboration between the architects and engineers is essential.