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EVALUATION OF STRESS AND STRAIN STATES BY FINITE ELEMENT METHOD OF PANORAMIC STRUCTURE MADE OF BARS AND PLATES

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Abstract: *This paper presents modal analysis of a panoramic structure made up of bars and plates in order to determine its own frequency. Panoramic structures are constructions by tourism purposes for which reason in our country they may be in a niche area of the economy in terms of existing and future travel demands. In this study, the structure has been designed to meet both the aesthetic, functional and endurance. The structure consists of rods and plates, was analyzed in terms of stresses and strains, as well as their frequencies by finite element method, varying the material and plate thickness. The most effective and optimum combinations were determined.*
Keywords: *strain, stress, plates, panoramic*

1. INTRODUCTION

The panoramic views of natural formations, protected archaeological areas are accessible to the public by creating access and visitation areas, which are known as "panoramic structure". In Romania, "National Strategy for Regional Development (SNDR), developed based on Regional Development Plans and the National Strategic Reference Framework 2007-2013 identified tourism development as a priority of regional development given the existing tourism potential in all regions. This justifies potential financial support to infrastructure rehabilitation and enhancement of tourist areas of natural, historical and cultural, for inclusion in the tourist circuit and their promotion to attract tourists". In this sense the easiest and least costly option would be the location of stations in places where there already panoramic tourist access (cable car lift, lift, paved roads or forest trails). The idea is inspired by the experience of other countries such as Austria, Germany, China, USA, Switzerland, Sweden, Norway, Peru, Mexico which have highlighted the natural beauty, history by creating access and visitation areas seemingly inaccessible places (Figure 1).

a) „Heaven's Gate" - China | b) „Grand Canyon Skywalk - USA | c) „5 fingers" - Austria | d) „Top of Tyrol" - Austria

Figure 1: Types of panoramic structures [7]

In this paper is presented the panoramic ARDDOR which carried out on a metal structure and floor with glass or acrylic being suspended from the cliff of the mountain Tampa - Postăvaru, about 400m above the city, offering panoramic views over the historical center of Brasov and surroundings – Bârsa (Figure 2). To choose the optimal structure and materials, the static and dynamic analysis of plates with different degrees of reinforcement used as platform in the panoramic structure were performed (Figure 3).

Figure 2: Panoramic views of Brasov city

The basic panoramic variant is made up of three main parts: the assembly (1) is the glass platform; subassembly (2) is a system of vertical and horizontal beams with annular section for supporting the structure; subassembly (3) is composed of several panels of transparent material (glass or acrylic glass, polyvinyl) and serves to protect tourists (Figure 3). In this paper, the stress and strain states of panoramic structure are analyzed with finite element method.

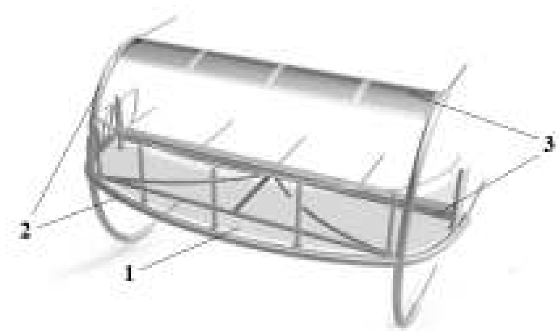


Figure 3. Design of ARDDOR Panoramic

2. EVALUATION OF STRESS AND STRAIN STATES BY FINITE ELEMENT METHOD

Geometry of entire structure was completed in Catia and imported into Abaqus CAE [1, 2]. The structure with dimensions (length x width) 6500 mm x1700 mm was embedded in the anchoring area placed on the end of vertical and horizontal bars [3,4.5,6]. The loading was distributed over the board surface as shown in Figure 4 and was calculated to safely hold the weight of up to 15 tourists, with medium mass of 80 kg. The structure was discretized using hexahedron elements. The material used for bars was aluminum with elastic modulus E = 69000 MPa and Poisson's ratio ν = 0.33 , and for plate structure several simulations were performed using different valuse of elastic modulus (E = 70000 MPa and Poisson's ratio ν = 0.33 , E_L = 13000 MPa, E_T=4000 MPa and Poisson's ratio ν = 0.2, E = 210000 MPa and Poisson's ratio ν = 0.3).Besides static analysis of the structure, dynamics analysis was performed and determining the eigenvalues and frequencies response.

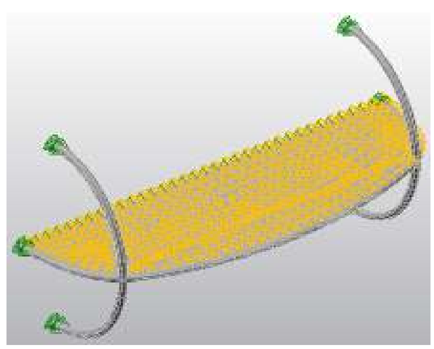
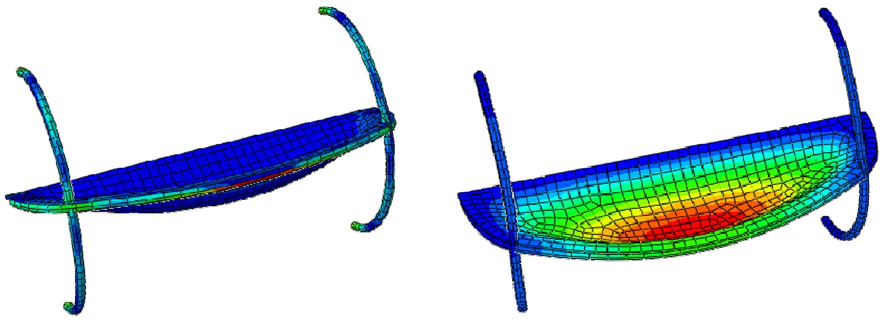


Figure 4: Equivalent loading and boundary conditions for the panoramic structure

Firstly, the stress-strain states of plates with different stiffening systems were obtained. The simulation results are presented in Figure 5. Stress distribution, shown in Figure 5 highlights high values in anchorage areas and in the joints between the bars and the horizontal bar half.



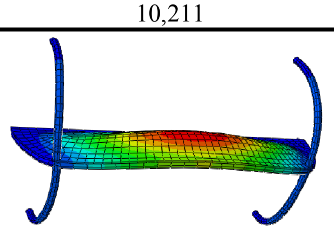
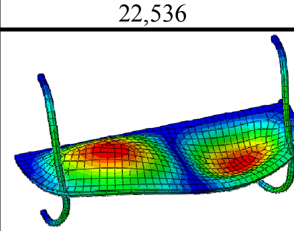
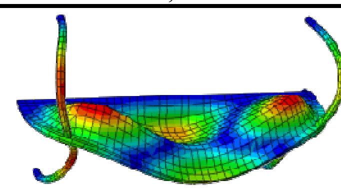
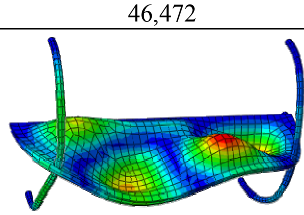
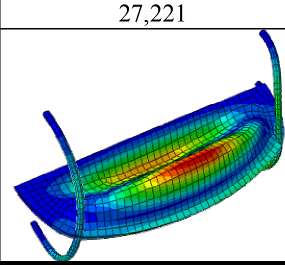
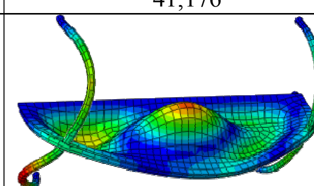
a) b)

Figure 5: Stress and strain states of analyzed structure: a) displacements; b) stress

Following the results of the FEM will be considered as the design and implementation of optimal structure to use procedures to ensure the stability and sustainability of the structure. Also the structures of the shelf plates are provided with reinforcement to minimize deformations in the center of the plate. Thus, it is proposed a system of stiffening of three bars and three radial bars.

In Table 1 are selected the most representative normal modes and modal shapes of the entire structure. Modal shapes shown in Table 1 shows how the bearing of the panoramic structure vibrates at its own frequency and harmonics. It is important to know the frequencies and modes to avoid resonance that may occur when developing forced vibration due to tourist traffic and wind / seismic

Table 1: Natural frequencies and modal shape of panoramic structure

Mode/ *f* [Hz]	(0,0) 10,211	(0,1) 22,536	(0,2) 32,28
			
Mode/ *f* [Hz]	(0,3) 46,472	(1,0) 27,221	(1,1) 41,176
			

3. RESULTS AND DISCUSSION

The results obtained in the analysis by FEM of the whole structure (denoted Str Int) were compared with those obtained for panoramic platform modeled as simple rectangular plate (denoted PS) or as curved contour plates (denoted PSC). In Figure 6 it can be noticed that with increasing of complexity of structure, the stress value increasing. With increasing of elasticity modulus, the stresses decrease. Figure 7 presents the variation of displacement with respect to material and shape parameters studied. The higher value of displacement is recorded in case of complex structure with wood plate – around 28 mm, the smaller one recording in case of a high rigidity plate (E=210000 MPa). From these results one can choose from the point of view of resistance and the aesthetic, gauge and costs. Thus, the optimum structure of panoramic ARDDOR consist of plate with three radial bars, with thickness h = 40 mm and made of acrylic glass (E = 70000 MPa).

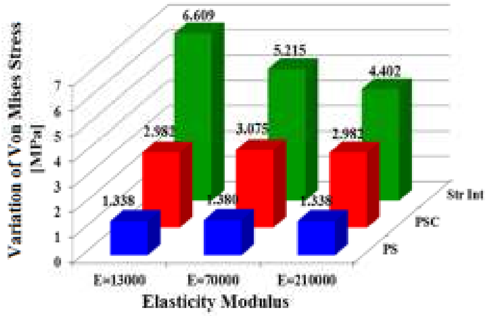


Figure 6: Variation of Von Mises stress reported to elasticity modulus and complexity of structure

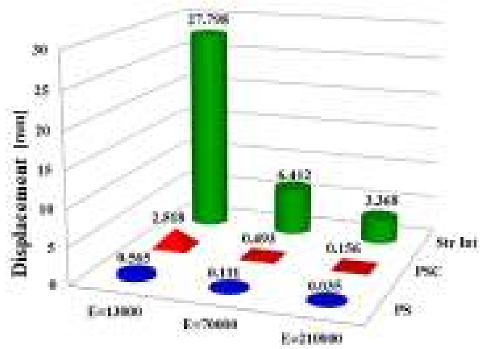


Figure 7: Variation of displacement reported to elasticity modulus and complexity of structure

4. CONCLUSSION

Panoramic structure ARDDOR consists of two basic elements: bars and plates. These elements are complex in their geometry, the method of attachment, the load on the subject and type of solidarity between them. Design and analysis of plates within the panoramic ARDDOR aimed at determining, through numerical simulations (FEM) and analytical optimal alternative that meets all the criteria proposed for this structure: aesthetic, functional, strength, security, environmental and economic.

5. REFERENCES

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