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STRESS AND STRAIN STATES OF PLATES FROM ARDDOR’S PANORAMIC STRUCTURE

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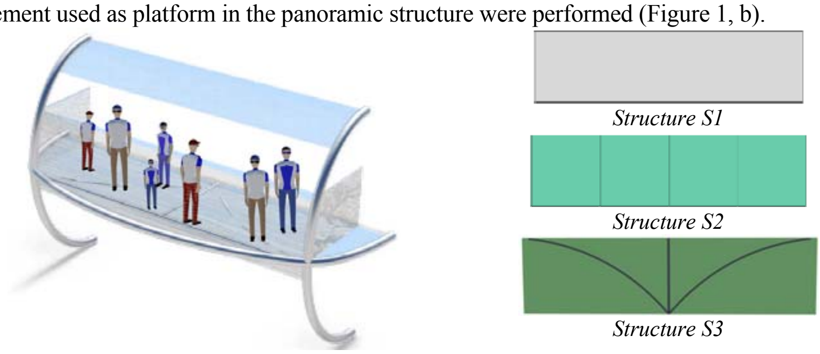
ABSTRACT
The paper presents the plates modelling and simulation from ARDDOR panoramic structure which has a modern design developed in 3D CAD Catia. In accordance with Kirchhoff – Love theory, the stress and strain states are analyses with the finite elements method (FEM) taking into account different cases of plate's stiffening and loads (self weight, wind, etc.), the element's stability and entire structure in its ensemble. Based on numerical results combined with esthetical, functional and security criteria the optimum structure of ARDDOR panoramic was established.
Keywords: stress and strain states, stiffness, plate, panoramic

1. INTRODUCTION
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, which have highlighted the natural beauty, history by creating access and visitation areas seemingly inaccessible places. In this paper is presented the panoramic ARDDOR (Figure 1, a) 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 – Barsa (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 1, b).



a) *b)*

Figure 1. Design of ARDDOR Panoramic

Figure 2. Panoramic viwes of Brasov city

These panoramic posts must meet several criteria: aesthetic to be beautiful, to harmonize with the landscape in which it integrates; function: to provide visibility and view over the desired; resistance: should withstand the expected traffic of travel, the time-varying applications due to high static and dynamic - wind, rain, to resist time from the point of view of materials, to be anchored in the structure in the ambient environment; security: to ensure the safety of tourists in safeguards (parapet, railings, canopy / coating) or slip surfaces provided with de-icing system, lighting elements; environmental protection: do not spoil the habitat area to tap renewable energy (solar panels, wind turbines).

2. NUMERICAL MODEL OF PLATES FROM ARDDOR STRUCTURE

Because the platform is one of the highlights of the panoramic structures, were modeled and analyzed three different stiffener plate made of three different materials (wood, glass, steel), with dimensions (length x width) 6500 mm x1700 mm. The floor is stressed by own weight and tourists weight which is considered as a pressure with uniform distribution, *p*. The structure was designed to safely hold the weight of up to 15 tourists, with medium mass of 80 kg. Besides static analysis of the structure, dynamics analysis was performed and determining the eigenvalues and frequencies response. The total number of simulations depends on the number of design variables which are presented in Table 1 [1, 2, 3].

Table 1.The properties used in preprocessing step

Characteristics	*Structure 1 (S1)*	*Structure 2 (S2)*	*Structure 3 (S3)*
Young's Modulus E [MPa]	13000	70000	210000
Thickness h [mm]	20; 40; 60		
Density ρ [Kg/m^3]	500	1000	1500
Poisson's Coefficient ν	0.3	0.2	0.3

For finite element modeling and simulation ABAQUS CAE soft was used. Idealization of structure was based on simple rectangular plate taking into account the median surface [4,5,6]. The structure was discretized into 1105 elements quadrilateral (quad) with a total of 1188 nodes. The equivalent joint between floor and bars systems were clamped edges of plates (Figure 3).

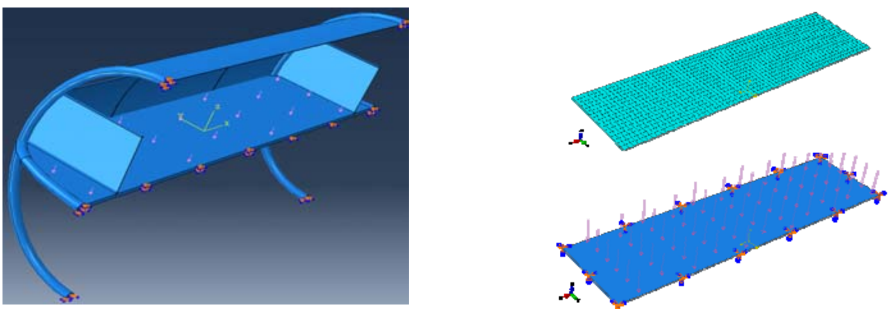
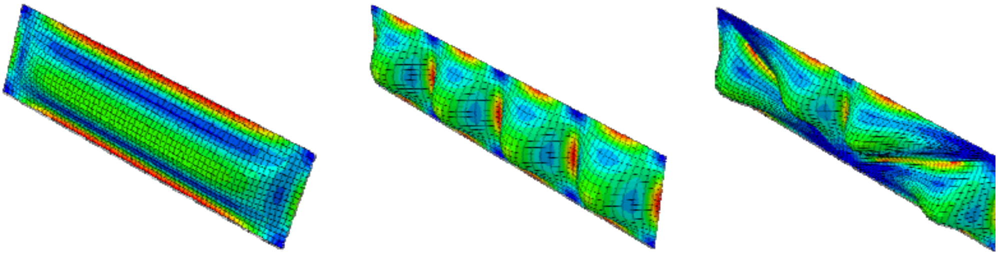


Figure 3. Discretization of geometrical model

3. RESULTS AND DISCUSSION

Firstly, the stress-strain states of plates with different stiffening systems were obtained. The simulation results are presented in Figure 4. The stiffening bars from plate structure reduce the amount of stress about twice (Figure 5). Also, the mechanical connection helps to reduce von Mises stresses developed in the plate (Figure 6).



Structure S1 *Structure S2* *Structure S3*

Figure 4. Distribution of von Mises stresses for E=70000 MPa, h=40 mm, ρ= 1000 kg/m^3

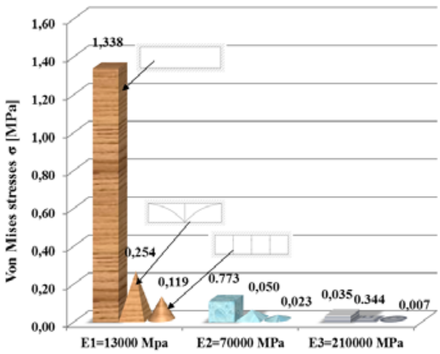


Figure 5. Influence of material properties and rigidity on von Mises stresses of plates

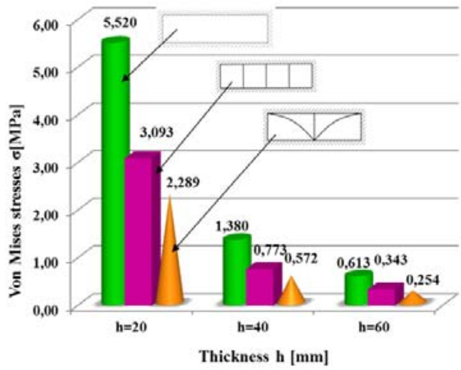


Figure 6. Influence of stiffening system and thickness on stress state

Concerning displacements and strain state, simple supported plate recorded the higher displacement compare to plates stiffening with three radial bars, in the same case of thickness and material (Figure 7).

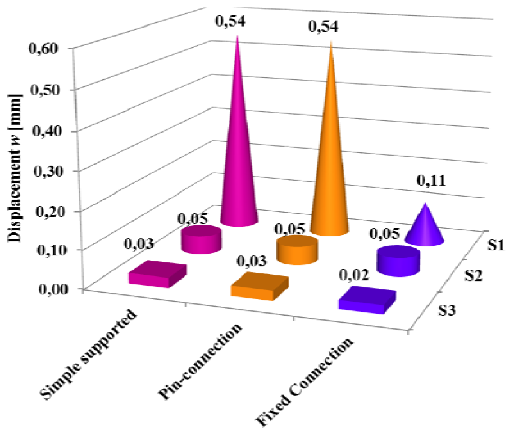
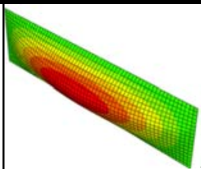
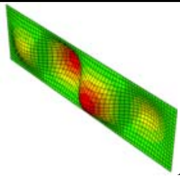
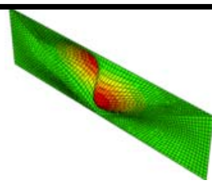
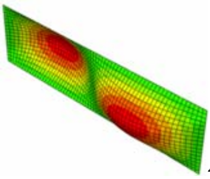
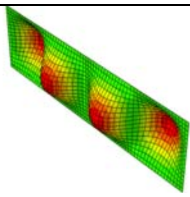
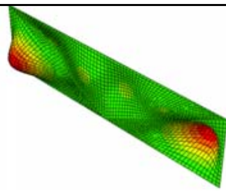
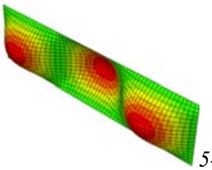
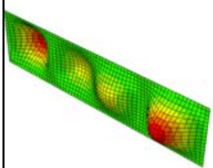
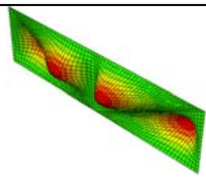


Figure 7. Variation of displacement for different mechanical connection and rigidity of plate

Secondly, the dynamical analyses were performed in terms of natural frequency and eigenvalues (Table 2). It can be noticed that natural frequencies increased with increasing of rigidity of plates, in constantly condition of dimensions, thickness, material properties and case of connection.

Table 2. Natural frequencies and modal shape of panoramic plates

Mode	Structure S1	Structure S2	Structure S3
1	 *36,275 Hz*	 *105,05 Hz*	 *150,4Hz*
2	 *43,107 Hz*	 *113,31Hz*	 *164,21Hz*
3	 *54,57Hz*	 *123,93 Hz*	 *168,25Hz*

4. CONCLUSIONS

The optimum design of structure consists of plate stiffening with three radial bars (S3), made of glass and fixed connection on edges. The glass used as floor and parapet assure a good visibility of entire panorama. Panoramic structure may be provided with lighting elements based on solar energy. Being an architectural structure it must fulfill both strength requirements and aesthetical one.

5. REFERENCES

[1] Dacko M, Nowak J.: Numerical simulation of stress and strain state induced by shrinkage of concrete in large-size plate, Journal of KONES Powertrain and Transport, Vol. 17, No. 1 2010;

[2] Stanciu Mariana, Curtu Ioan, Rosca I. Calin, Application of Modal Analysis on the Behaviour Diagnosis of Lignocelluloses Plates, in Proceedings of 14th International Research/Experts Conference „ Trends in the Development of Machinery and Associated Technology" TMT2010, 11-18 September 2010 – Mediterranean Cruise, ISSN 1840-4944, pp. 281-284.

[3] Năstăsescu, V., Bârsan, Gh., Metoda SPH (Smoothed Particle Hydrodynamics), Sibiu, Editura Academiei Fortelor Terestre "Nicolae Balcescu", 2012, ISBN 978-973-153-130-4

[4] Curtu, I., Stanciu, M.D., Motoc, D.L., "Diagnosis of dynamic behaviour of ligno-cellulose composite plates", in Proceedings of 14th European Conference on Composite Materials, Budapets, 2010, p. 75, ISBN 978-963-313-008-7

[5] Cozzens, R., CATIA V5 Workbook, Release 3, Editată de Schroff Development Corporation, 2009, ISBN: 978-1-58503-544-1

[6] Mocibob D., Belis J., Crisinel M., Lebet Jp. : Stress distribution at the load introduction point of glass plates subjected to compression, in Proceedings of the International Association for Shell and Spatial Structures (IASS) Symposium 2009, Valencia Evolution and Trends in Design, Analysis and Construction of Shell and Spatial Structures 28 September – 2 October 2009, Universidad Politecnica de Valencia, Spain