DIGITAL CONSTRUCTION OF THE SIGNALING/ RESCUE SYSTEM LOCATED IN COASTAL AQUATIC AREAS

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For signaling and rescue, at international level, modular systems made of composite structures are used, which ensure the maintaining at the water surface of them, in a fixed point, in any meteorological conditions etc. According to the diversity of activities carried out in the marine and/ or river sector and depending on them, worldwide signaling systems are applied: for the safety of navigation, for data recording and processing activities and for the marking of ecological protection areas (National Strategy for Sustainable Development of Romania 2030, 2017; La Depeche, 2014). For this last category, the signaling of the navigable channel is made in accordance with the "Basic Regulations for Navigation on the Danube" edited by the Danube Commission, 1991 edition, Budapest, while for the maritime buoyage system the IALA agreement is used, concluded in Paris, on the 15th April 1982 and involves the use of floats and buoys made of composite materials. The work aims to create a digital signaling/ rescue system applied in the coastal aquatic area (Council Regulation (EC) No. 509/2006; Decision No. 1600/2002/EC). In this respect, using FEM modelling, the geometric domain was defined, the composite structure of which the system is made was modeled, the structure with finite elements was generated (discretization, properties modelling, specific finite elements obtaining), the constraints and loads were modeled and finally, in the post-processing stage, the results (deformation, Von Mises stress, displacements) were visualized and studied.

Keywords: modelling, FEM, numerical analysis, digital construction.

INTRODUCTION

The worldwide signaling systems are applied as follows:

i) For the safety of navigation, in order to carry out the vessel traffic in safe conditions, by marking the passage corridors to avoid the areas with reefs or rocks (Multiannual National Strategic Plan on Aquaculture 2014-2020).

ii) For data recording and processing activities, in order to record the parameters that characterize the marine environment, namely: data on speed and direction of surface and depth currents, wind speed and direction, water and air temperature etc. (EC Communication, 2018).

iii) For the marking of ecological protection areas, in order to protect the areas considered ecological reserves; tourist and leisure activities, within the beaches and marinas; marking the risk areas: (deep waters with rocky bottom and strong currents) and for marking the passage corridors of the boats based on the beaches (EC Communication, 2006).

For this last category, the signaling of the navigable channel is made in accordance with the "Basic Regulations for Navigation on the Danube" edited by the Danube Commission, 1991 edition, Budapest, while for the maritime buoyage system the IALA agreement is used, concluded in Paris, on the 15th April 1982 and involves the use of floats and buoys made of composite materials (EEA Report No 8/2012).

MATERIALS AND METHODS

For modelling the geometric domain of the problem, the sketcher module was used.

The dimensional constraints for the Part Design module used in order to obtain the 3D image were: height: 600 mm; base diameter: 1000 mm. Figure 1 sequentially visualizes the dimensioning of the ME, made using Part Design (Shaft).

Figure 1. Sequential configuration made with Part Design

After checking the model and discretizing the created geometry, the calculation conditions were identified, the values corresponding to for 4 bf and 8 bf were identified, respectively (Table 1).

It should be noted that, in the situation where the system will be located in running water, hydrometeorological conditions (necessary for calculation) cannot be more difficult than those in the open sea, so the stress to which the system was subjected were the most difficult.

Table 1. The values corresponding for 4 bf and 8 bf

Beaufort Scale	4 bf	8 bf
Wind speed	11 – 15 kt (20 - 88 km/h)	34 – 40 kt (62 - 74 km/h)
Sea conditions	Height wave, max. 1.5 m; Small waves with rolling crests	Height wave: 6-7.5 m; Big waves with arched crest
On the land	The dust rises; The pennant stretches, taking a horizontal position	The trees branches break; The vehicles can go out of control

The constraints for both 4 bf and 8 bf were done on the entire circumference of the lower base (which is submerged in water) (Figure 2).

Figure 2. Preparation for simulation: a – single view; b – multiple view

The loads were directed to: distributed force and distributed pressure. The views of these constraints are shown in figure 3.

The material from which the signaling/ rescue system is considered to be made has the following characteristics (for both simulation conditions, 4 bf and 8 bf):

- warp// weft: 100% PES// 100% PES;
- warp// weft length density: 167dtex/ f32x2 / 250Z// 167dtex/ f32x2/ 120Z;
- breaking force, min. 300// 315 daN;
- warp// weft elongation at break, max. 20// 21%.

Figure 3. The views of the constraints

RESULTS AND DISCUSSIONS

Post-processing allowed the visualization of the results (for both stress conditions, at 4 bf and at 8 bf): deformation of the structure under the effect of dynamic pressure, Von Mises stress fields and distribution of displacement vectors. The state of tension in the system (possible cracks) that may occur at the contact of the composite structure with the fluid in turbulent motion was predicted using the Von Mises criterion.

Post-Processing Results - Stress at 4 bf

Figure 4 shows the images corresponding to the model calculation at 4 bf. Figure 4b and 4c show the interior deformation of the ME1 on different segments, visualization possible with the help of the section plane manipulated with the help of the compass (rotations, displacements). By dynamically changing the position of the plan, the results can be viewed in real time.

Figure 4. Deformation visualization of the signaling/ rescue system located in coastal areas; a - deformation ME1 from SC4; b - deformation SC4 and ME1 interior - single view; c - SC4 deformation and ME1 interior - multiple view

The Von Mises Stress result highlights the range of values for the minimum and maximum stresses that can occur in the required system at 4 bf. According to the analysis, the resulting values fall in the range $[5.26e+004; 1.78e+006]$ N/m². Given the value for admissible resistance of the textile material, it can be predicted that this and implicitly the composite structure will withstand the distributed force imposed for 4 bf.

The obtained images are shown in figure 5 and successively highlights the Von Mises values of the system.

The image obtained for the main stresses in the system subjected to the action of the distributed force and pressure for 4 bf is presented in figure 6. The main voltage tensor is represented in 3D in each node and is in the range of $[-2.81e+006; +2.99e+006]$ N/m².

Figure 5. Nodal values visualization of Von Mises stress for the signaling/ rescue system located in coastal areas (maritime and fluvial): a, b - image obtained with mesh view - single view; c - multiple view; d, e, f - cut plane analysis

Figure 6. The main stress tensor for the signaling/ rescue system located in coastal areas (maritime and fluvial)

Post-Processing Results - Stress at 8 bf

The images corresponding to the calculation at a stress of 8 bf are shown in figure 7a and 7b highlight the deformation of the system by means of its representation with the discretization network; in figure 8c is visualized the interior deformation on different segments (cut plane analysis).

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The analysis of the images highlights a large deformation of the system in the sense of implosion of the area exposed to the dynamic stresses that appear especially in the sea - shore direction.

Figure 7. Deformation of the signaling/ rescue system located in coastal areas (maritime and fluvial): a - material and mesh representation - single view; b - material and mesh representation - multiple view; c - cut plane analysis - multiple view

According to the analysis performed for the stress at 8 bf, the resulting values for Von Mises Stress (on node) fall within the range $[3.15e+008; 1.07e+010]$ N/m², for certain values exceeding the admissible resistance of the material, so the system will resist to the distributed force and pressures required for 8 bf.

The images obtained for Von Mises at a stress of 8 bf are shown in figure 8.

Figure 8. Visualization of the Von Mises system values - 8 bf: a –material and mesh; b - mesh; c, d - representation in multiple view; e - material representation; f - material representation - multiple view

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Figure 9 allows the visualization of the main stress tensor highlighting the fact that the values in each node and are in the range of $[-1.68e+010; 1.8e+010]$ N/m².

CONCLUSIONS

The modelling with FEM allowed the prediction of the possible responses of the signaling/ rescue system located in the aquatic coastal area.

Figure 9. The main stress tensor for 8 bf

The post-processing performed for conditions of 4 bf and 8 bf showed that the designed digital system that has as material from the composite structure made by specialists from INCDTP will resist the difficult conditions imposed by the field of use.

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