Mechanics of rigid body and structural calculus interconnection in applications

Mihai Bejan

1 Harbor and Naval Engineering and Management Department, "Mircea cel Batran" Naval Academy, 1st Fulgerului, Constanta 900218, Romania

Abstract. Mechanical structural calculus can be a complex task, considering quality and quantity of treated aspects. Mechanics of rigid body and structural analysis are two mechanical engineering well defined fields. Amazing, and in many cases favorable, calculus aspects of rigid body mechanics and strength of materials are interconnecting one each other, and so they validate the problem formulation and the solution. A complex application, floating crane, illustrates the above mentioned aspects.

1. Introduction

Mechanical engineering is one of the fields having and astonishing development in modern age. Many subfields evolved in such degree that becomes standalone fields itself. Two of these fields are rigid solid mechanics and strength of materials. In modern evolution, having an extended software as support, mechanics is computer aided. Displacements method formulation in strength of materials was the fundament of a quality improvement – Finite Element Method [*]. The structural calculus could be also computer aided – Computer Aided Engineering. Until recent period, these two types of calculus were realized separately [1]. In present it is a great concern to integrate different mechanical software in multidisciplinary assemblies.

A floating crane application reveals rigid solid mechanics and structural calculus interconnection.

2. Floating crane

The present study is based on a structural calculus of a floating crane. Displacement and stress values are in S.I. units. General loading case 1 considers the pontoon horizontal. Loading a is made for arm at 29° from horizontal and 32 t loading. The loading scheme is presented in figure 1.

![Figure 1. The loading scheme – case 1 a.](image-url)
The nodal von Mises equivalent stress distribution is presented in figure 2. The result displacements are revealed in figure 3.

Load case 1 b.
The second load case considers the pontoon in horizontal position, the arm at 29° from horizontal and 25 t loading.

![Figure 2. Nodal stresses](image)

Figure 2. Nodal stresses

![Figure 3. Result displacements](image)

Figure 3. Result displacements

Load case 1 c.
The third load case considers the pontoon in horizontal position, the arm at 29° from horizontal and unload – 0 t.

Load case 1 d.
This loading case considers the pontoon in horizontal position, the arm at 0° from horizontal and 25 t loading.

Load case 1 e.
The fifth load case considers the pontoon in horizontal position, the arm at 82° from horizontal and 32 t loading. The loading scheme is presented in figure 4.

![Figure 4. The loading scheme – case 1 e.](image)

Figure 4. The loading scheme – case 1 e.

The nodal von Mises equivalent stress distribution is presented in figure 5. The result displacements are revealed in figure 6.
A careful study of this load case reveals a slightly compression of the cable which operates the arm. It is a practically impossible situation. The compression stress level does not compromise the accuracy of the simulation but reveals an aspect of design regarding rigid solid mechanics. In the extreme position, completely high and maximum load, the arm has the tendency to be rotated to tower and cannot go down alone.

Load case 1 f.
The sixth load case considers the pontoon in horizontal position, the arm at $82^0$ from horizontal and unload $-0$ t.
The nodal von Mises equivalent stresses and the result displacements are lower than the allowable one. There are no special aspects to be mentioned.

Load case 1 g.
The seventh load case is the transport one. It considers the pontoon in horizontal position, the arm at $(-21)^0$ from horizontal and unload $-0$ t.
The nodal von Mises equivalent stresses and the result displacements are lower than the allowable one. There are no special aspects to be mentioned.

General loading case 2 considers the pontoon with $6^0$ rolling.
Loading a is made for arm at $29^0$ from horizontal and $32$ t loading. The loading scheme is presented in figure 8.
The nodal von Mises equivalent stress distribution is presented in figure 9. The result displacements are revealed in figure 10.

General loading case 3 considers the pontoon with 6° pitch. Loading a is made for arm at 29° from horizontal and 32 t loading. The loading scheme is presented in figure 11.
The nodal von Mises equivalent stress distribution is presented in figure 12. The result displacements are revealed in figure 13.

![Figure 12. Nodal stresses](image1)
![Figure 13. Result displacements](image2)

3. Conclusions

Aspects of the structural calculus regarding rigid solid mechanics
The quantitative evaluation of the cable in compression reveals an insignificant error that provides valuable information on the dynamics of the arm.
The arm does not return alone from the maximum raised position when is loaded.
Aspects of the rigid solid mechanics regarding structural calculus
A static equivalence of the dynamic load is achieved - 32t in static mode equivalent the behaviour of a 25t mass in dynamic mode.
Roll and pitch do not cause significant changes in results. Stresses and displacements are below allowable.

4. References

[1] ANSYS 16.2, 2015
[2] Bejan M., Rezistența materialelor, Editura Matrixrom, București, 2007.