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RESEARCHES ON THE BUCKLING TEST OF A TRIPOD COMPONENTS USED IN EMERGENCIES

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Abstract: : *The tripod used for emergencies has been analyzed in different positioning cases of its legs to its symmetry axis (the symmetry axis being the support of the buckling force), simulating different accidentally scenarios within the rescue interventions. Each case has been three times analyzed, to each analyze being related one type of material(Al2014, Al6082 and carbon fiber); the analysis have been performed by the help of finite element analysis, using ANSYS software.*
Key words: *Buckling, FEM, ANSYS, tripod*

1. INTRODUCTION

The buckling represents a side bending physical phenomenon (many times sudden bending) of a slender body (at which a dimension is much bigger than the others two), subjected to a longitudinal compressing force. This term, of “buckling”, it is used by engineers. There are two types of buckling: *fork type buckling* and *distortion-amplifying type buckling*. In most cases of buckling, in real conditions appear distortion-amplifying type forces. It is unlikely to have a fork type buckling.

The minimum buckling force is presented within the formula:

$$\mathrm{Fcr} = \frac{\pi^2 * E * I}{l^2} \quad (1)$$

E – modulus of elasticity
I – moment of inertia
l – bar length

The buckling analysis of a tripod components, being the object of this research, it is realized by the help of finite element analysis (FEM), using ANSYS software. The method is used as an instrument of tensile analysis also for variety of technical and scientific assessments, such as: thermal, shock, electrical, e.g. Nowadays, FEM is applied not only to linear analysis but also to nonlinear analysis, such as plasticity and ductility. The ANSYS software is simulating program of static, dynamic, thermic, electrical, e.g., analysis. Thus, the method has become an important instrument when designing a new product.

The engineers and designers, within an engineering system must pass through a process of modelling, simulating, overviewing, analyzing, designing, prototyping, testing and manufacturing. The FEM modelling process contents 4 steps: *geometrical modeling*, *meshing*, *specifying material properties* and *specifying boundaries*, *initial conditions* and *loading conditions*. Model meshing supposes dividing it in a finite number of elements, these elements can be uni dimensional, bi dimensional, or tridimensional (that can be tetrahedral or hexagonal – with six sides). For a complex 3D structure it is used a tridimensional meshing network.

2. WORKING CONDITIONS

The tripod is used for emergencies, is an important accessory and is a component of intervention rescue team. The tripod is composed of several components, the most stressed being the three double-walled feet. While rescue interventions, the three feet are stressed by compressive forces, therefore, the tripod is stressed to buckling. The device is considered as being buckled when the feet shape submits distortions such as bending to exterior or to interior.

Each foot of the tripod can spins in a vertical plane (the plane being fixed by the symmetry axis of the tripod – the axis is also the support of the acting force and the symmetry axis of the feet), from 0° to 30°, 60° and 90°. The 90°angle is considered when the foot of the tripod takes the role of bearing (support) on a side wall. Being known that each foot can lock itself in the three positions (30°, 60°, 90°), through combining these positions, resulted seven using cases of this device within the rescue activities, for accidentally working conditions while rescuing.

Positioning cases of the tripod are (figure 2.1):

Case 1 – All feet are positioned at 30°, related to the symmetry axis.

Case 2 – Two feet are positioned at 30° and the third one at 60°.

Case 3 – Two feet are positioned at 30° and the third one at 90°.

Case 4 – One foot is positioned at 30° and the other two at 60°.

Case 5 – One foot is positioned at 30°, one at 60° and one at 90°.

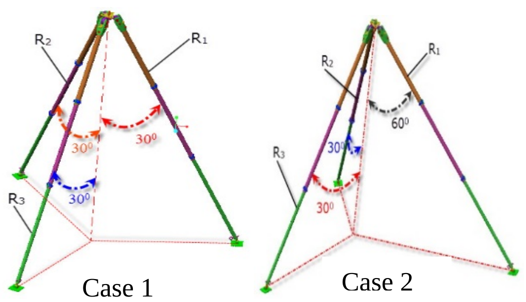
Case 6 – All feet are positioned at 60°.

Case 7 – Two feet are positioned at 60° and one at 90°.

Table 2.1

Properties of materials

	U.M.	**Al2014**	**Al6082**	**Carbon fiber**
Density	g/cm^3	2.8	2.71	1.6
Ultimate Tensile Strength	MPa	483	310	600
Modulus of Elasticity	GPa	72.4	70	70
Poisson's Ratio	-	0.33	0.33	0.1



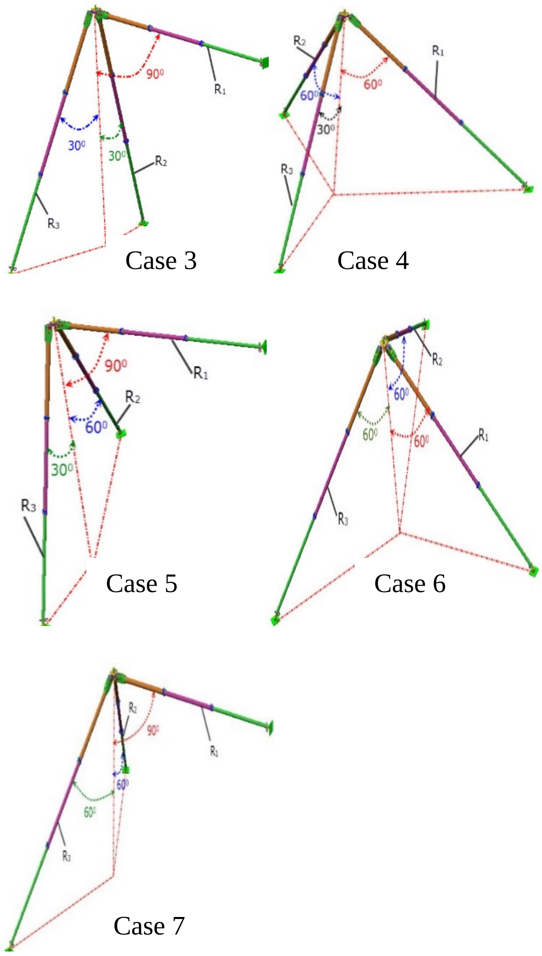


Fig. 2.1. Positioning of tripod feet

3. TESTING AND RESULTS

The tripod has been tested at a compressive force of 30000N, that means a 300 Kg weight (that must be supported by this tripod), multiplied with a safe coefficient, c=10.

At the end of FEM (see figure 3.1) performed according to the above presented loading cases within figure 2.1, for specific materials, resulted the values of buckling total distortions, according to the chart from figure 3.2 and for the buckling coefficient, these values are indicated within the chart from figure 3.3 for all positioning cases.

Within the above chart is presented the distribution of distortion buckling values of the three materials used to manufacture the tripod for all positioning cases. The values of displacement are caused by the critical buckling forces of buckling coefficients, presented within figure 3.3 for each positioning case.

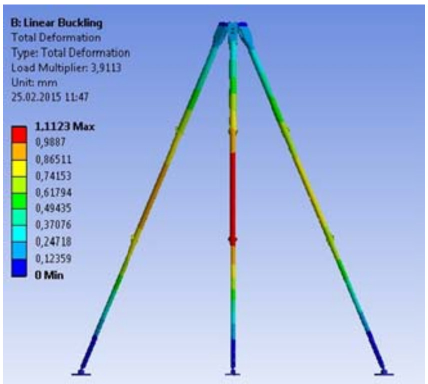
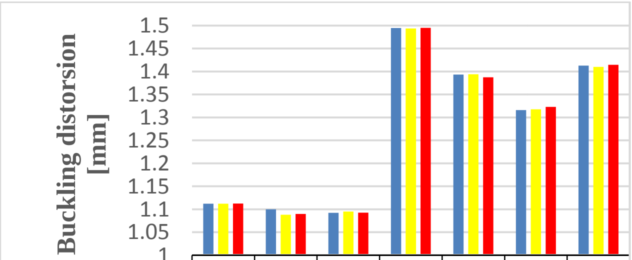


Fig. 3.1. Buckling test – Case 1: carbon fiber



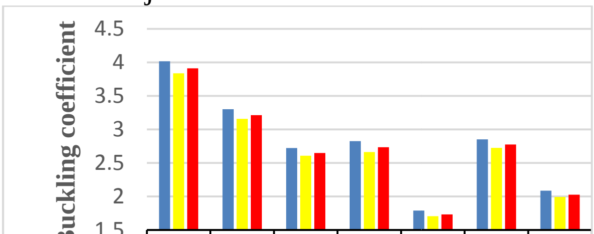
	1	2	3	4	5	6	7
Al2014	1.112	1.1	1.092	1.495	1.393	1.316	1.413
Al6082	1.112	1.088	1.095	1.494	1.394	1.318	1.41
Carbon Fiber	1.112	1.09	1.093	1.495	1.387	1.323	1.415

Fig. 3.2. Distribution of buckling overall distortions

From the buckling distortions chart can be observed in case 1 of positioning a medium distortion of 1,11 mm for the three used materials, having a buckling coefficient (see figure 3.3) of approx. cf=4. This case of positioning is considered as being a normal case of usage of the tripod.

In case no. 2 of tripod positioning can be observed the value of buckling coefficient (figure 3.3). roughly 17% lower than the same value from case 1. Because in case 2, the foot positioned at 60 it is more stressed, it means that buckling appears at a lower buckling force. It can be observed a decreasing of buckling distortions (figure 3.2) by up to 2% as compared to case1, for all the three used materials.

It observes in case 3 of tripod loading a decreasing of buckling distortions (figure 3.2) by up to 2% for a value of the coefficient (figure 3.3) by up to 32% smaller than case1. In this case, the feet declined at 30 are symmetrically loaded, and the foot positioned at 90 has the role of a bearing (support) on a side wall/object.



	1	2	3	4	5	6	7
Al2014	4.015	3.302	2.721	2.826	1.79	2.852	2.085
Al6082	3.835	3.158	2.606	2.663	1.706	2.723	1.993
Carbon Fiber	3.911	3.213	2.648	2.733	1.732	2.775	2.027

Fig 3.3. Variation of buckling

For case 4 of positioning of tripod it observes an increasing by up to 34% of the distortion values (figure 3.2) having a buckling coefficient (figure 3.3) smaller by up to 28% as compared to case 1. In this case the feet positioned at 60 take over the biggest part of the loading force, therefore critical buckling force appears at a lower coefficient.

In case 5 it can observe (figure 3.2) an increasing by up to 25% of the distortion buckling values, for a buckling coefficient (figure 3.3) by up to 55% smaller than in case 1. In this case, the foot positioned at 60 takes over the biggest part of loading, leading to buckling at a much smaller critical force as compared to the critical buckling force applied in case 1.

In positioning case 6 it observes an increasing of buckling distortions (figure 3.2) by up to 18 as compared to case 1, for a buckling modulus (figure 3.3) by up to 30% smaller as compared to case 1. In this case the feet are positioned at 60 , making the loading force being uniform distributed on each foot. Because of the high angle, the critical buckling force appears at a smaller modulus as compared to that one from case 1.

In case 7 it can observe an increasing of buckling distortions (figure 3.2) by up to 27% as compared to loading case 1, having a critical buckling force smaller for a buckling modulus (figure 3.3) by up to 50% smaller than in loading case 1.

4. CONCLUSIONS

Analyzing the values from buckling modulus variation chart, it is recommended as the optimal material for manufacturing being Al 2014, because it has the biggest buckling modulus as compared to the two materials used for the above presented cases.

The risk of buckling occurring appears when the values of buckling modulus are sub unitary. Observing that the buckling modulus values according to the figure 3.3 for the three used materials for tripod testing in all positioning cases are supra unitary, it can say that there is no risk of buckling occurring, for any cases from those one specified above, for any material from those used.

Because the values of the buckling modulus for carbon fiber are supra unitary, these are recommended for manufacturing of the components of the tripod that are buckling stressed, as it has a smaller mass as compared to the other used materials.

5. ACKNOWLEDGMENT

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Cercetari privind incercarea la flambaj ale elementelor componente unui trepied utilizat in situatii de urgenta

Trepied utilizat pentru situatii de urgenta, a fost analizat in diferite cazuri de pozitionare ale picioarelor fata de axa de simetrie al acestuia (axa de simetrie fiind suportul fortei de actionare), simuland diferite medii accidentale de lucru in timpul interventiilor. Fiecare caz in parte a fost analizat de cate trei ori, fiecarei analize ii corespunde un material (Al2014, Al6082 si Fibra de Carbon), analizele au fost realizate cu ajutorul elementelor finite utilizand softul ANSYS.

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