

FRANGIBLE COUPLING A SAFETY ELEMENT IN AIRPORTS' TRAFFIC

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Abstract: Any source of light from an airport area which is situated above the level of the runway must have a breaking section, which should give in the case of a collision with an airplane or any other vehicle. This breaking section is assured by a frangible coupling, which is an replacable part in the construction of the support. In this paper, we present the constructive solution of a frangible aluminum coupling, which must offer a breaking section at a height of maximum 38 millimeters above the level of the runway, for a height of the signal light of maximum 360 mm. The breaking section of the frangible coupling must resist at the air speeds behind a large plane, speeds that can go up to 480 km/h, and give in at a bending moment which is between 204 and 678 J. This frangible coupling was made by the firm ElectroMax Petroșani and was tested in the Strength of materials laboratory from the University of Petroșani.

Key words: frangible support, signal light, panel, airport.

1. INTRODUCTION

Romanian civil aeronautical regulation RACR - AD – PETA "The design and technical exploitation of airfields", edition 2/2015 from 11.05.2015, chapter 5, defines signal lights as needing to be frangible. Those that are situated near a runway must be low enough to ensure the existence of the safety distance for the screw or for the propellers of the reaction engines. Sometimes anchors or chains are used, in order to avoid for the signal lights that are torn from their supports be carried away by the blow of the engines or by the wind.

The guidance material looking the frangibility of signal lights is included in The Manual for the Designing of Airfields (ICAO Doc.9157), Part 6. The materials and configurations for the frangible structures must be appropriate for the desired use and must realize a structure as light as possible. The structures can be made of metallic

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or nonmetallic materials which are not affected by climatic conditions in the outdoors. The materials selected in order to fulfill the frangibility requirements must be strong, light and must have a reduced hardness module. Minimum weight is important, in order to ensure that the lowest quantity of energy is consumed in order to accelerate the signal lights' mass at the speed of the plane that hits it (The reference of the manual for designing the airfield ICAO, part 6, section 4.7.1.).

Nonmetallic materials can be especially conceived in order to offer excellent frangibility characteristics. However, their structural behavior can be difficult to analyze, because of the incertitude regarding their elasticity module or material isotropy. All the materials must be able to resist or be protected against climatic effects, including: temperature fluctuations, solar radiations, vibrations, bad weather (salt spray, wind, relative humidity) and corrosion (due to rain, snow, ice, sand, dirt or degradation materials) which are usually found in the air.

AC 150/5345 – 46 D regarding the plans of runway illumination offers guidance for light bodies situated along the runway. L-804 the elevated light bodies must have a frangibility point which is not larger than 1.5 inches (38 mm) above the runway.

For these devices, frangibility is attained by reducing the exterior diameter of the transversal section or by working on some holes or on other elements that reduce the effective resistance of the coupling at the height of 38 mm above the fixing foundation of the signal light (Fig. 1). Frangible coupling must work at temperatures of between -25o Celsius and +55o Celsius, at humidity between 0-100% and withstand wind speeds of up to 480 km/h. The coupling must break at a bending point placed between 204 and 678 J (Nm).



Fig. 1. Examples of frangible couplings.

2. ESTABLISHING A CONSTRUCTIVE SOLUTION FOR THE FRANGIBLE SIGNAL LIGHT SUPPORT

In figure 2, we show the general design of the signal light, which is made up of: 1 – signal light APP AL 008 02 WH; 2 – bracelet; 3 – M6x25 screw; 4 – aluminium tube $\Phi 40 \times 5$; 5 – frangible coupling G2": 6 – M6x16 screw; 7 – square base of 140x140.

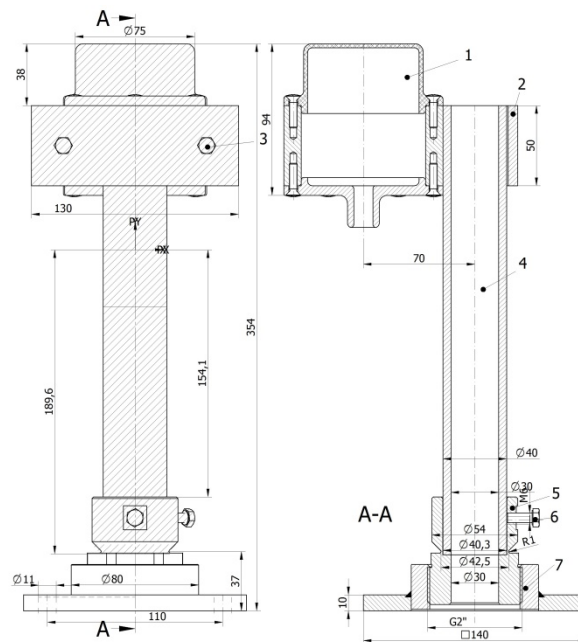


Fig. 2. The constructive solution for the support of the signal light APP AL 008 02 WH.

Based on these solutions, we drew a summary of calculus with the help of the software MathCAD, which allowed the checking of the bending of the tube in the area of its fixing in the coupling and of the breaking section of the frangible coupling for wind intensities situated between 240 and 480 km/h for an aluminium tube of $\Phi 35 \times 2$ mm and $\Phi 40 \times 5$ mm, which are shown in figure 3.a., curves 1 and 2. Also, we represented the bending tension in the tube of $\Phi 35 \times 2$ mm, for the minimum bending moment of 204 J, curve 3, and for the maximum value of 678 J, curve 6. The admissible tension for the tube made out of aluminium alloy EN WA 6082/ SR EN 755-2 was taken as equal to the flowing limit, which is of 250N/square mm, curve 5. We can observe that the bending tension of $432,8 \text{ N/mm}^2$, given by the maximum moment, curve 6, is much higher than the admissible tension, which imposes the choosing of the tube $\Phi 40 \times 5$ mm. Curve 5 represents the tension of maximum bending, of 153,05 N/square mm, from the tube $\Phi 40 \times 5$ mm, which is lower than the admissible tension.

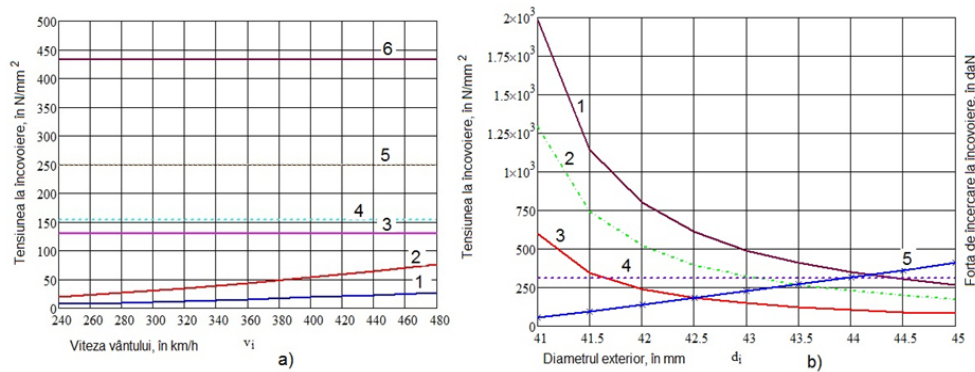


Fig. 3. The variation of the bending tension with the speed of the wind and the exterior diameter of the section of frangible coupling

In figure 3.b we show the variation of bending tension in the coupling section, according to exterior diameter, curves 1, 2 and 3 represent the variation of tension for the maximum, medium and minimum moments.

We can see that at a breaking resistance of 310 N/ square mm, the frangible coupling is made out of aluminum alloy EN WA 6082/SR EN 755-2, curve 4, intersects with the medium tension, curve 2, at an approximate diameter of 43 mm. Curve 5 represents the force of pressing for a force arm of 190 mm, which, for the 43 mm diameter, results in a breaking force of 240 daN.

A problem which was analyzed in the calculus program is in the behavior of the critical section of the frangible coupling at the phenomenon of tiredness. For a number of 10^6 cycles of pulses solicitations of the breaking section of the coupling, given by a wind speed of 240 km/h and a joining radius in the zone of the breaking of the coupling of 1 mm, we obtained a safety coefficient of 0,876, and for a radius of 0,5 mm, a safety coefficient of 0,561.

In order to show the influence of the joining radius from the zone of the breaking of the coupling, we undertook an analysis with a finite element of the frangible coupling at the static solicitation given by the maximum moment, in figure 4.a for a radius of 0,5 mm and in the figure 4.b. for a radius of 1 mm. We can see that greater tensions have resulted than in the case of the classic formula, and the rapport between the two maximum tensions is 1.36 times smaller than the rapport between the coefficients of tiredness resistance of 1,56.

Next, the M10 screws were checked, group 6.8., for the fixing of the base of the signal light on the foundation, regarding the stretching solicitations, crushing of the fillet, and the result was the smallest coefficient of safety at crushing, of 2,2, for the case in which a single screw is at work. Also, the base of the signal light's support was checked, which, for a sheet of 10 mm and a pap of 69 mm, did not verify at maximum solicitation, having a safety coefficient of 0,73, and the increaser of the pap's diameter at 79 mm was needed, and the coefficient grew at 1,33.

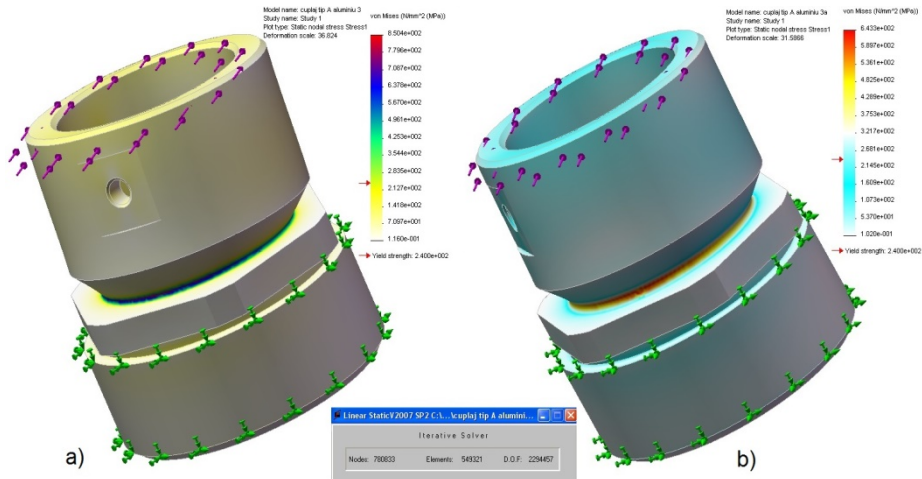


Fig. 4. The analysis of the frangible coupling using the method of the finite element

3. ESTABLISHING THE CONSTRUCTIVE SOLUTION FOR THE FRANGIBLE SUPPORT FOR THE PANEL

In figure 5 we show the general design of the panel, which is made up of: 1 – basys 140x300; frangible coupling G2”; 3 – support foot from aluminum tube $\phi 60 \times 4$; 4 – light panel 900x900x100.

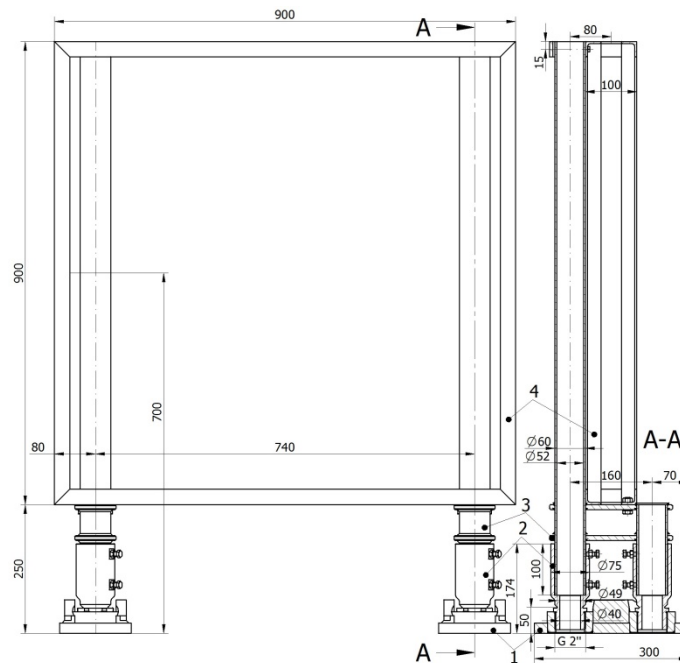


Fig. 5. The constructive solution of the panel's support.

Based on this constructive solution, a calculus summary was made using the software MathCAD, which allowed the checking of the tube's bending in the fixing zone in the coupling and of the breaking section of the frangible coupling for wind intensities of between 240 and 480 km/h, for an aluminum tube of $\Phi 60 \times 4$ mm. Also, the support of the light panel must break at a bending moment between 45 and 55 kJ (kNm), if the height of the panel is higher than 1,2 m.

Due to the light panel's dimensions being at the limit, we tried obtaining a support that would resist at the bending moments required by the Manual for designing airfields (ICAO Doc. 9157), Part 6. In order to allow the airship to pass in the case it hit the support structure, the support structure must break, detach or bend to ground level.

With the help of the geometrical characteristics of the critical sections of the support's foot, shown in figure 6, for the zone of the joining of the tube with the frangible coupling (fig.6.a.), and for the zone of the breaking of the frangible coupling (fig. 6.b.).

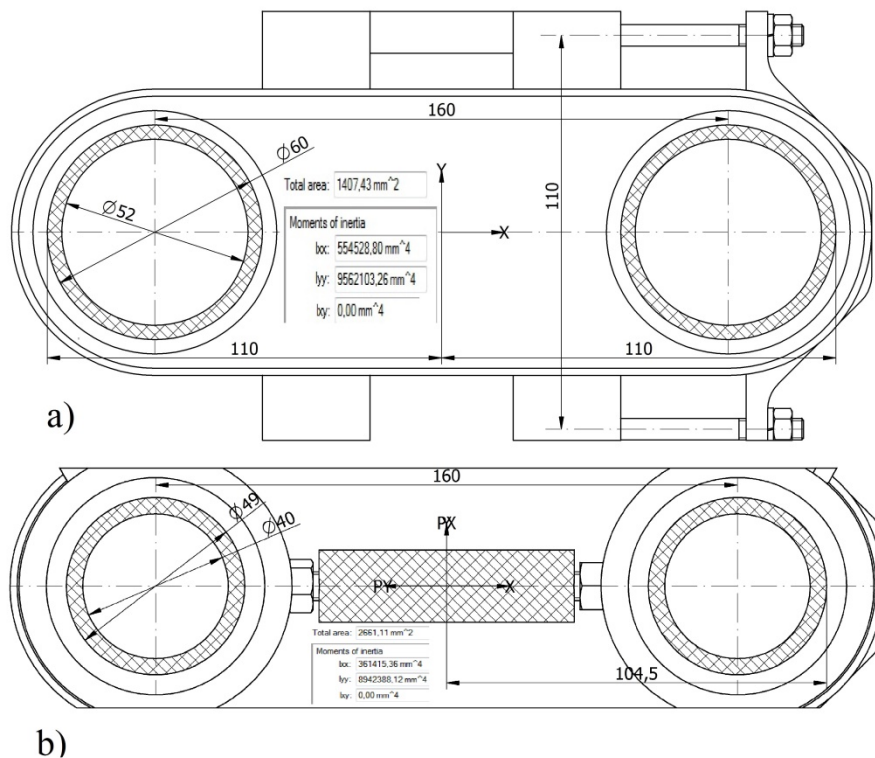


Fig. 6. The geometrical characteristics of the critical sections of the support

For the aluminum alloy EN WA 6082 in N/ square mm, SR EN 755-2, which has a minimum flowing limit of 260 N/square mm and the breaking resistance of 310 N/square mm, the resulting wind safety coefficients for the tube were of 5,3 and for the

moment of maximum breaking of 1,02. These safety coefficients were obtained by reporting to the flowing limit, which excludes the deformation of the tube.

For the zone of the breaking of the support through the frangible coupling, we have obtained wind safety coefficients of 15,8 and at the minimum breaking moment of 1,1 and at the maximum breaking moment of 1,9. These safety coefficients were obtained according to breaking resistance.

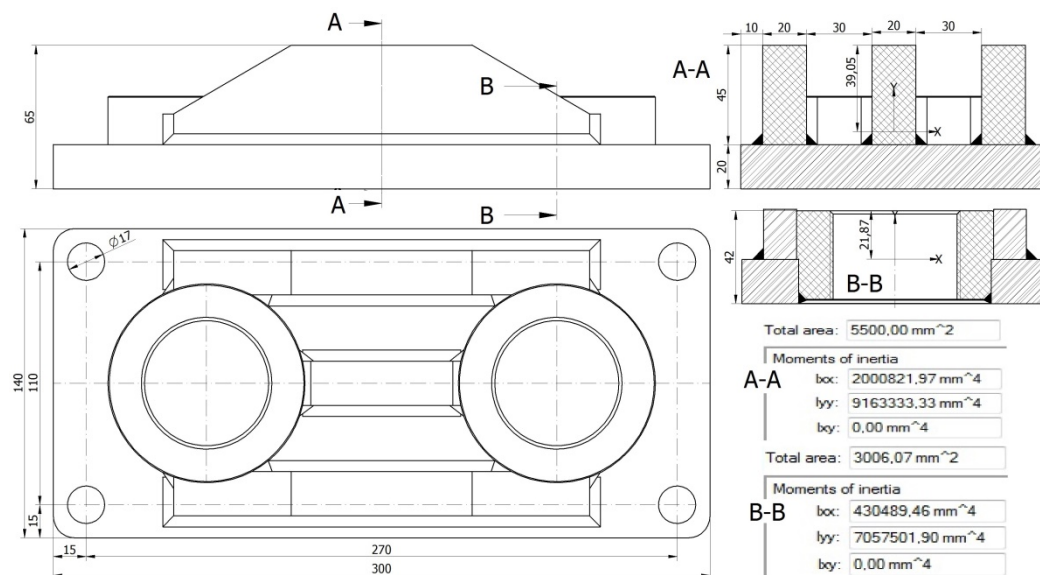


Fig. 7. The constructive form of the foot's base and the geometrical characteristics of the two critical sections

An important problem of the support foot of the light panel is the base, which must resist to the very intense moment of breaking of the support of between 44 and 55 kJ, at half of the foot. In figure 7 we show the constructive solution of the foot's base, with the geometrical characteristics of the critical sections, for which we obtained safety coefficients of over 1,8.

If the height of the light panel is lower than 1,2 m, we must only check at wind speed, which, through the constructive form of the panel, should not be higher than the bending moment of 240 Nm.

4. CONCLUSIONS

With the help of modern designing software, we were able to obtain a quality frangible coupling, which can be added to the portfolio of products of the firm ElectroMax Petroşani (fig. 8).

Due to the construction of the signal lights' support, we also modified its construction in comparison with figure 2, and we managed to power it with electrical

energy through a cable inserted through the interior of the signal light' support.

In the case of light panels with a height lower than 1,2 m, we can use the support from the signal light, which satisfies the requirement that the device must resist at a bending moment of 204 Nm, but it should break before the bending moment reaches 678 Nm (see figure 1). In this case, we must check at wind speed, which, through the constructive form of the panel, should not be higher than 240 Nm, or, at the limit, the moment of the breaking of the frangible coupling.



Fig. 8. Obtain a quality frangible coupling

For light panels higher than 1,2 m, we can use the constructive solution shown in this paper, with possibilities of improvement, constructively and technologically. Also, we can make a more detailed study of the variation of the distance between the two sustaining branches of the foot and of the support's foot basis.

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