THE NON-LINEAR STRENGTH-WORK OF ALL BODY CONSTRUCTIONS THE HELICOPTER IS - 2 DURING FAILURE LANDING

Kazimierz Stanisław Frączek

Institute of Aeronautics
Department of New Technology
Krakowska Avenue 110/114, 02-256 Warsaw, Poland
tel.: + 48 22 8460011, ext. 489
e-mail: kaz@ilot.edu.pl

Abstract

The article presents the phases of helicopter's flight during the failure of the power - driven system. On the basis of Federal Regulations part 27, which demands the throw from the height of 19 inches, some computer simulations of dynamical construction work were performed. Accordingly to the F.R.27 a thin wall constructions cannot be damaged permanently. In order to show the correct work of the helicopters construction a structure model was built using the finite element method. The paper contains only the work of some main elements, which influence the safety of passengers. The final conclusions were formulated based on the assessment of the method of analysis and based on the results of analytical simulations done on the movements and increasing inertia forces were introduced to the model. In order to analyse the construction its work of resistance was assessed as well as the safety factor. Due to the increasing load, we observed that a deformation of some elements was increasing in a non-linear manner. Therefore the analysis had to be done using the non-linear methods. The loads during landing without power are too much more as during optimal method, which was been presents in [1], the probability landing on ice with failure engine is very small, the non-linear analysis was necessary, because loads on deformed structure were bigger than in linear analysis, the landing without power is all safe in all extremely situations. The article describes construction's prototype.

Keywords: *transport, helicopter, mechanic, FEM, non-linear analysis*

1. Introduction

I have continued to improve safety and reliability wherever can. The travel with using an airplanes or helicopters contains three phases: start, flight and landing. The failure of engine in airplane during flight means trouble with forced landing. For rotorcrafts this phase is good know and has presented [1]. When we have observed loss of power, or no power pilot's reactions, ought to be quick. The first recommendation is to decrease angle of attack at all blades of main rotor. Further, when helicopter go down and blades are given power from air. During at this time, the pilot should set blades angle of attack so that vertical velocity would be minimal. When the helicopter is near Earth, pilot increase angle of attacks at all blades of main rotor. It is possible, because kinetic energy has been changed on damped force.

Never the lees helicopter has vertical speed in the end this kinetics energy of all body ought to change on inertial work of landing gear. The reaction from Earth on landing gear of helicopter IS - 2 have changed value in time and also changed places. This point where acting reaction forces depended on the deformations of landing gear. Deformations of those elements are dependent on coefficient of friction between Earth and the landing gear. The coefficient fiction is less when we have been landing on ice and bending moment of transverses elements of gear has been maximal.

My aim was present non-linear work of the constructions of helicopter IS - 2 and present nonlinear method. The necessarily theory I had presented earlier in: [3].This paper present practical usage of those non-linear theory.

2. Loads

The method of landing with autorotation ought to be known for all pilots after practically training, because time for manoeuvre is less than as 20 [s]. The helicopter is changing positions in three directions of translations and rotations as has sown in Fig. 1, where variables are shown:

(x, y, h) - translations in horizontal and vertical direction,
(U, V, W) - linear velocity,
(Φ,Θ,Ψ) - angular rotations,
(P, Q, R) - angular velocity.

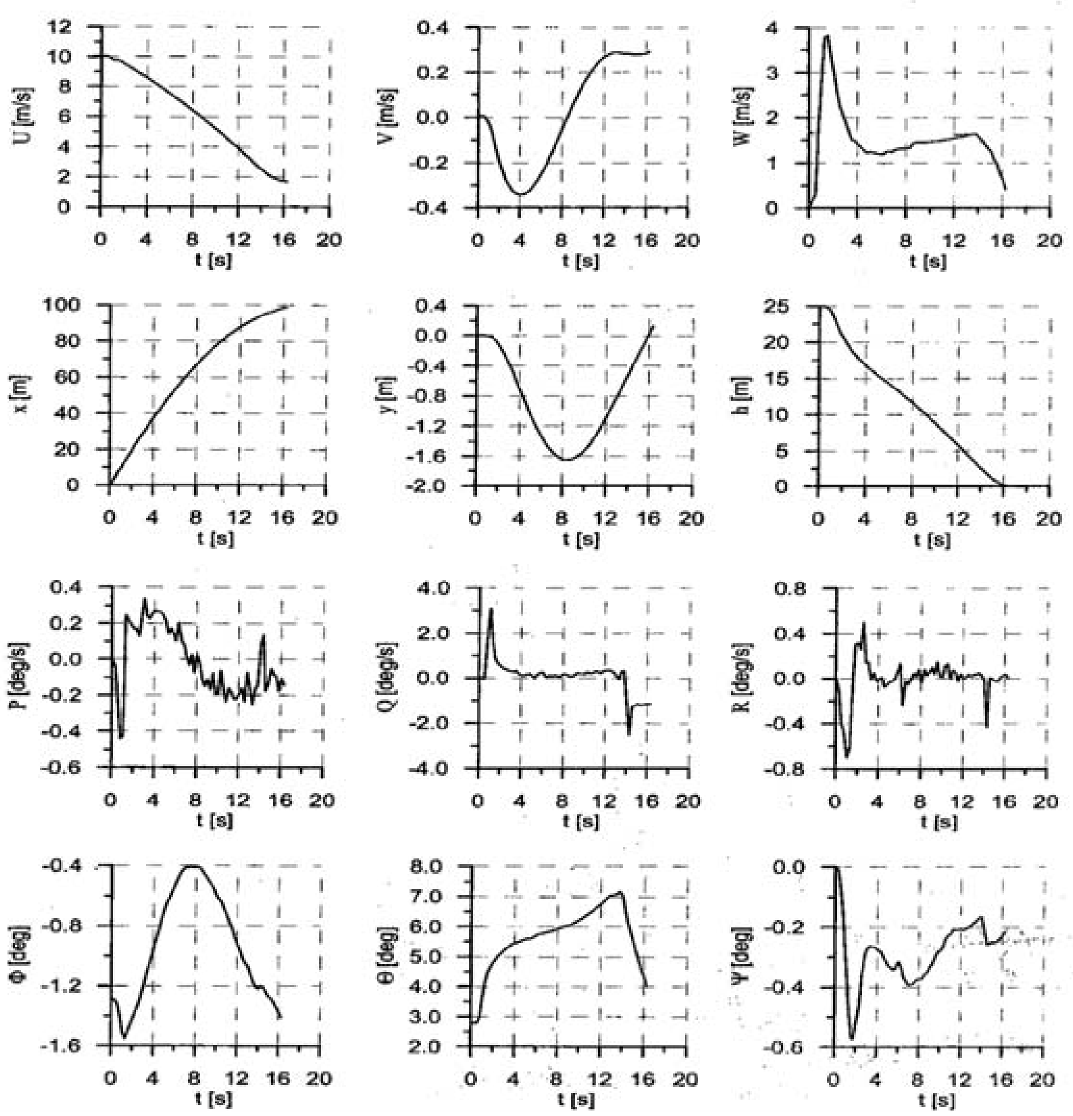

Fig. 1. Parameters of helicopter during optimal landing without power system

Generally we have been using Federal Regulation Part 27 to create limits (max.) of loads acting on construction of helicopter during failure landing, because pilots can some time make it better - with less vertical speed. Knowing height drop, given in FAR 27 we can obtain vertical speed from the following formula:

$$\frac{W^2}{2} = gh, \tag{1}$$

where:
w - vertical speed of all body of helicopter [m/s],
g - acceleration of gravity [m/s^2],
h - height drop.

For example, if permissible height drop is equal 13 in. - it mean vertical speed w = 2.54[m/s]. The limit for permissible falling speed from FAR 27 and compared with results of optimal simulate falling past failure engine of helicopter we can see, requirements in FAR 27 are very strong and has covered all dangerous situations during failure landing.

3. The structural model of Helicopter IS - 2

The structure of helicopter contains all structural elements with density and mechanical properties. For numerical analysis of dynamical work I had to add points with cumulated masses. In this structural model has worked some elements with more elasticity, which connect landing gear and elements of cabin. The main elements, which has absorbed kinetically energy of all elements of this helicopters into potential energy in form has bended arc.

The arc deformations have been large compared to cross beam of cabin and those elasticity elements mitigate internal forces.

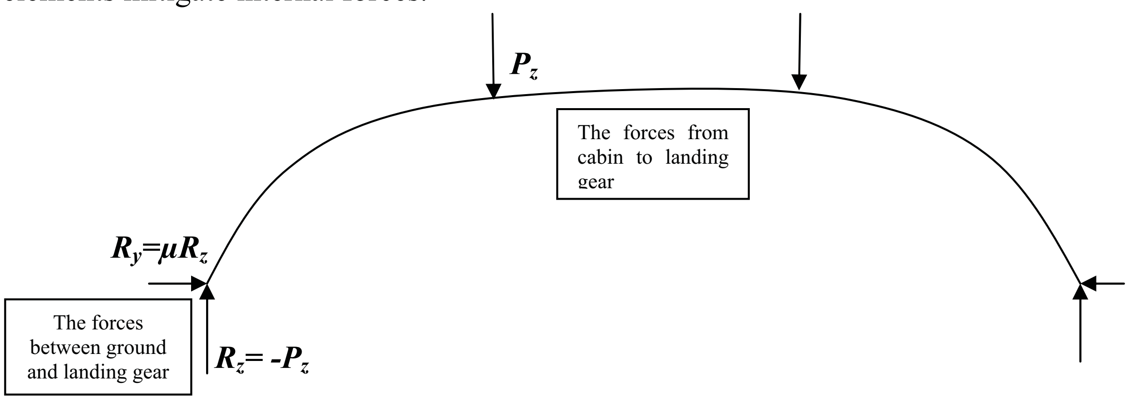

Fig. 2. The draft has sowed places of acting forces during landing phase on frontal gear of IS-2 helicopter

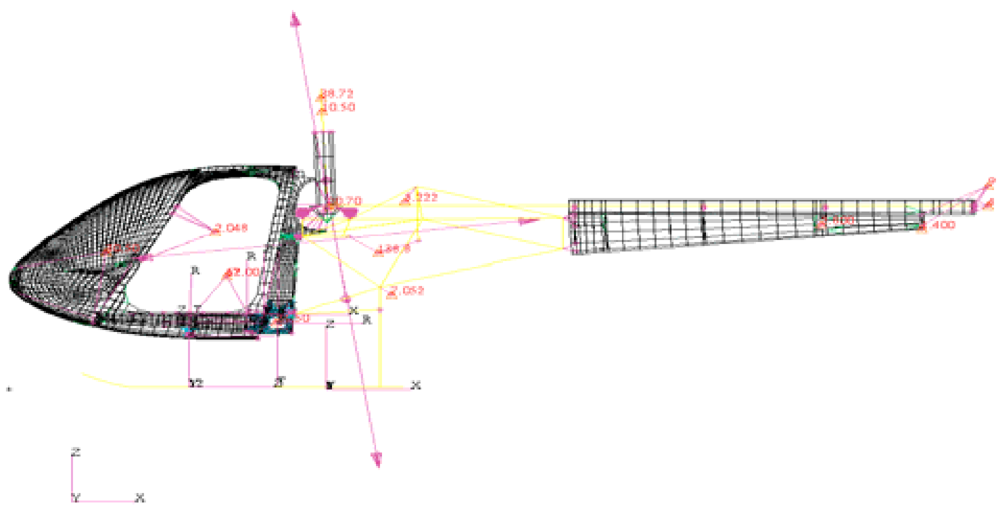

Fig. 3. The structural model of Helicopter IS - 2 with added coupled mass connected with structure using rigid body elements

4. Non-linear analysis

Aim of this numerical analysis was prove structures of helicopter without practical test, because we have only one prototype and loads in this fall are extremely. We have changed stiffens of landing gear, which ought to begin deform in linear range. Second has been deforming structures of cabin of helicopter. The optimal situation is, when the cabin in maximal loads doesn't contact with Erath. The places of forces acting on landing gear depend on its deformations. This analysis has shown explicitly, that destructing loads depend on deformations and changed resulting stresses in main elements were different.

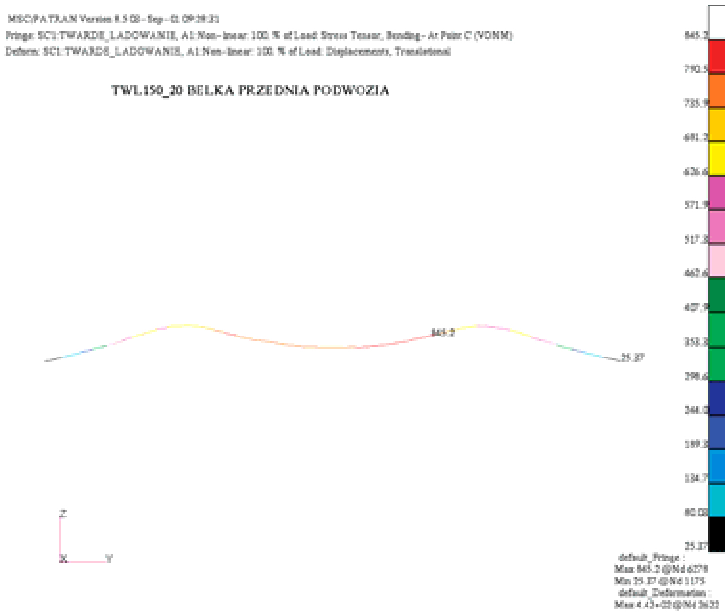

Fig. 4. The frontal landing gear with value of stresses in [MPa] on deformations structures

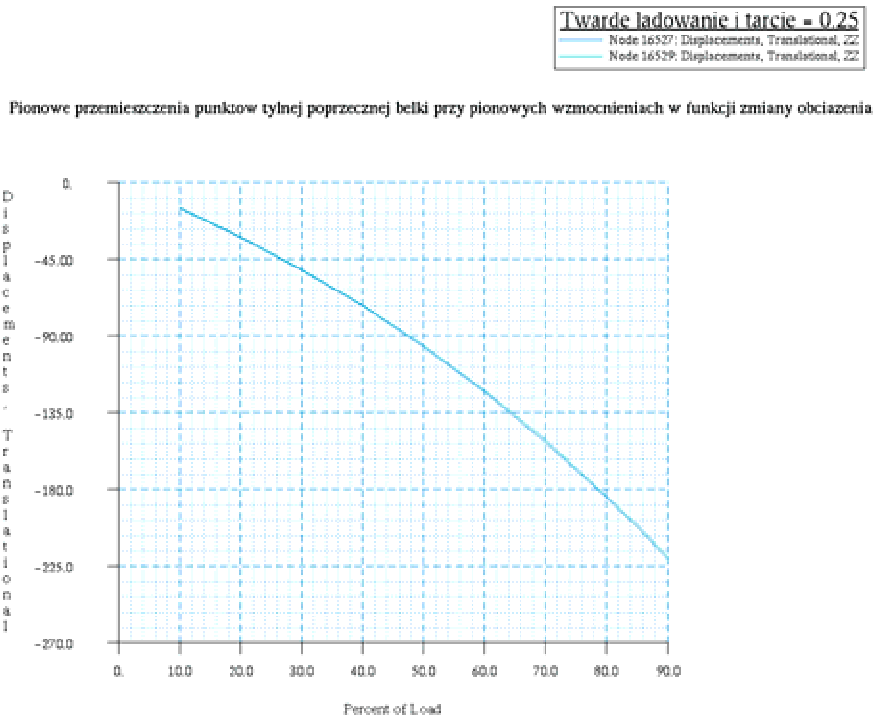

Fig. 5. The diagram of vertical displacement in [mm] on beck landing gear in function percent of load

The displacements and stresses past non-linear analysis, which has been sown on Fig. 5-6 that both are non-linear end higher as in linear analysis. The probability is small, that landing has been on ice with maximal speed to down without power.

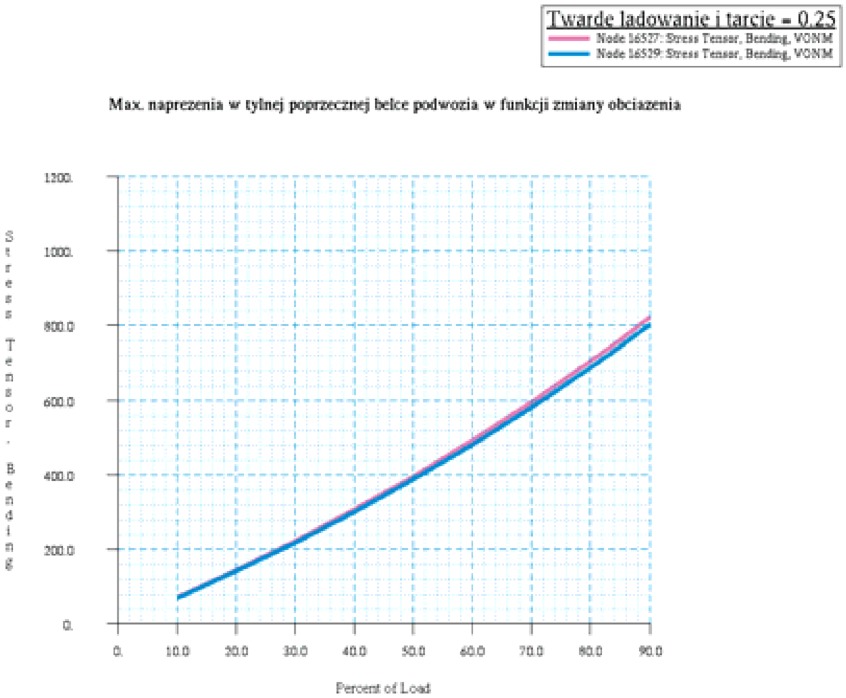

Fig. 6. The diagram stresses in [MPa] on beck landing gear in function percent of load

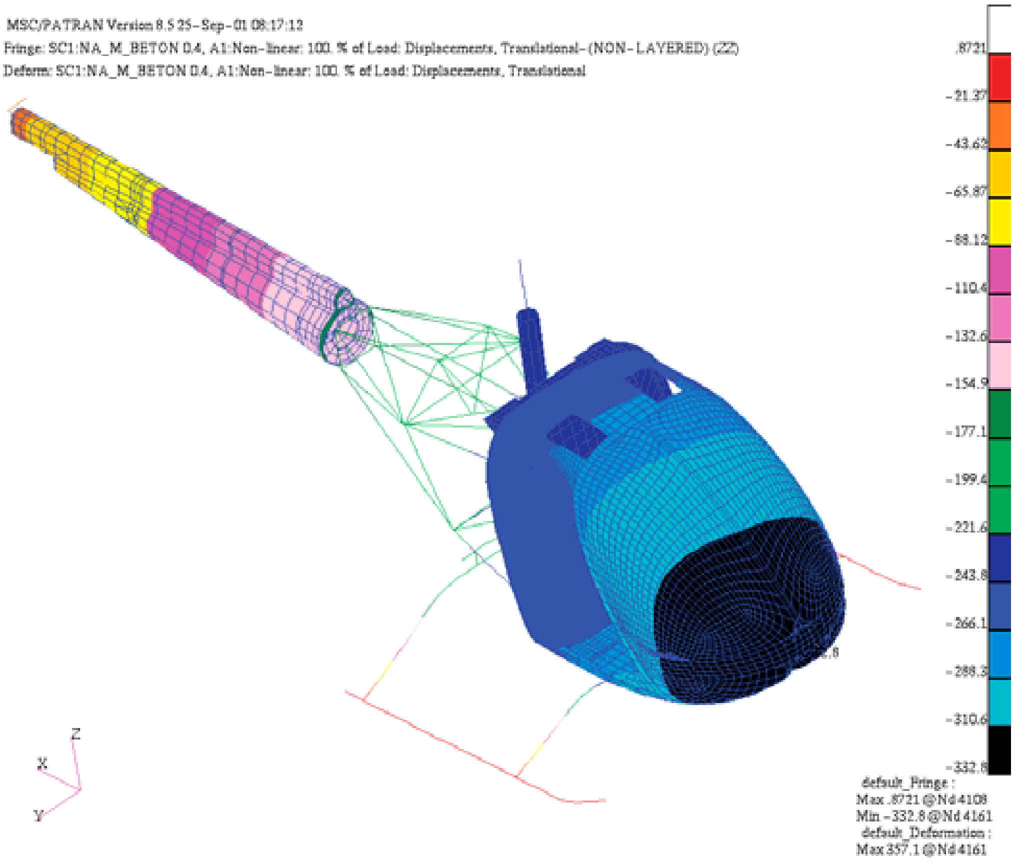

Fig. 7. Displacements in [mm] of all body helicopters IS -2 during landing on ice without power engine and with maximal speed drop

The landing on concrete is more safety as on ice because coefficient of fictions has been higher and bending moment acting on landing gear also has been less.

5. Conclusions

- The loads during landing without power are too much more as during optimal method, which was been presents in [1].
- The probability landing on ice with failure engine is very small.
- The non-linear analysis was necessary, because loads on deformed structure were bigger than in linear analysis.
- The landing without power is all safe in all extremely situations.

References

[1] Bibik, P., Gajda, K., Narkiewicz, J., *Metoda optymalnego sterowania śmigłowca w autorotacji,* Journal of Aeronautica Integra 1/2008.
[2] Federal Requirements of Aeronautics Part 27 - Waszyngton, D. C.
[3] Frączek, K., *A., Method of non-linear dynamics on purpose construction light helicopter IS - 2,* Journal of KONES2006 Vol. 13. No. 3.
[4] Szablewski, K., Jancelewicz, B., Łucjanek, W., *Wstęp do konstrukcji śmigłowców, WKŁ 2002.*