THE SUPPORT PROCESS, SIMULATION RESERCH DESIGN AND STRUCTURE OF THE NEW HELICOPTER'S CONSTRUCTION SCHEMATICS WITH SPECIAL EMPHASIS ON GROUND RESONANCE PHENOMENON

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Introduction

During design work on the new construction of a light unmanned helicopter an attempt was made to map the actual design of the helicopter and built the helicopter mode using the finite element method. Calculations made using this method were intended as a support for construction work. In addition, this model could be used as a simulator for the real resonance tests and the first attempts to disassemble the rotor. Such an approach to the design and testing of the real structure allowed us to examine in detail the dangers that may occur when tested on a real object. The main reasons for using the model were to determine the natural frequency of the structure, reproduction attempts resonance (excitation harmonic force) simulations of the rotor to detach from zero to nominal speed and landing simulations of asymmetric structures on the ground.

1. MODEL

2.1. Basic parameters.

Presented at work computational model helicopter has been modeled using finite element software ANSYS. It contains a carefully mapped grid helicopter skid landing gear with the characteristics of the shock absorbers, shaft rotor mast with driving gears, rotor, along with those of the deviations silencers main rotor. The composite beam tail was imaged using beam elements in terms of mass. The remaining items of equipment such as engine, fuel tanks, equipment design, the front part of the hull were modeled using the masses gathered and assigned to the appropriate nodes on the structure. The components used to build the model are: Shell43, Pipe20, Mass21, Link8, Pipe16, Beam189, BEam4, Link10, Beam44. An important element of the presented work is to introduce a model reaction contact between the chassis and the ground and the possibility of taking your skids off the ground. It is very important while analyzing the phenomenon of resonance, which is impossible using classical analytical methods.

Basic data calculation model:

Weight - 1100 [kg]

Center of gravity:

XC = 3.5413 - 0.0413 [m] from the point of intersection of the axis of the rotor shaft and the tail rotor along the axis X,

YC = 0.86332 - 0.00086 [m] from the point of intersection of the axis of the rotor shaft and the tail rotor along the Y axis,

ZC = 1.9441 [m] - from the point of intersection of the axis of the rotor shaft and the tail rotor axis Z and the moments of inertia were:

IXX = 0.3867 kgm 2 +07
IYY = 0.1587 E 08 kgm 2
IZZ = 0.1229 E 08 kgm 2
IXY = -2429 kgm 2
IYZ = -1299 kgm 2
IZX = -0.6341 E 07 kgm 2
Weight of main rotor 39 [kg].

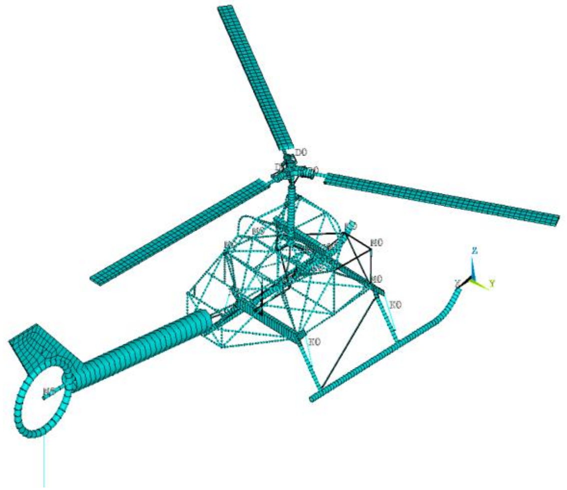


Fig. 1 The Helicopter model prepared in finite element method.

Fig. 2 Model of the helicopter in finite element method.

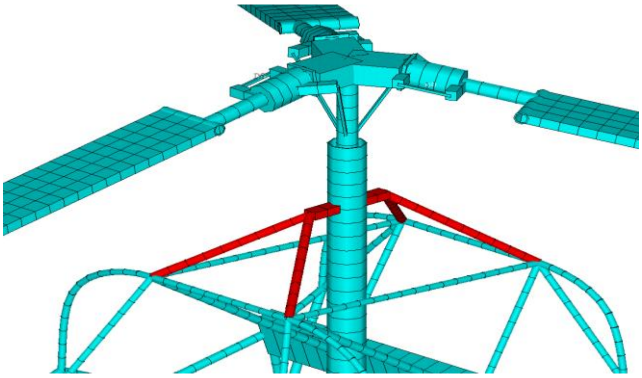


Fig. 3. The change in the construction after simulation.

2. Analisys.

2.1 Modal Analisys.

The primary goal of modal analysis in the finite element method is to determine the frequency and form of vibration of the system in this case, the supporting structure helicopter. For the calculation method, the issue boils down to mapping the real object by a finite number of elements described in the adopted coordinate system and assigning them appropriate for each degree of freedom. Each of the elements of defined mass is described by the following equation.

(1) $M(\frac{d^2q}{dt^2})+K\cdot q=0$

where:
M - matrix mass (inertia)
K - stiffness matrix
q - generalized displacement vector (vector degrees of freedom of the system)
t - time

The solution of the above system will have the following form:

(2) $q=q_0\cdot\cos(\omega t)$

where:
q_0 - vector amplitude vibrations
ω - circular frequency of self-

The second time derivative of the above equation after inserting it into the equation (1) gives the following linear equation:

(3) $(K-M\omega^2)\cdot q_0=0$

This equation makes sense with a non-zero solution when the characteristic determinant is equal to 0:

(4) $Det(K-M\omega)=0$

After expanding the above determinant we obtain a polynomial of n - the point of the ω^2. When setting the roots of this polynomial, e.g. Lanczos method in the finite element method we obtain the frequency of vibration of the structure.

Table 1. The frequency of vibration of the structure.

No.	Frequency [Hz]
1	1,07
2	1,10
3	1,18
4	2,57
5	3,32
6	4,05
7	8,29
8	11,52
9	13,27
10	13,49
11	20,43

In order to illustrate the structure below shows the deformation of deformation of the structure for the chosen vibration frequency.

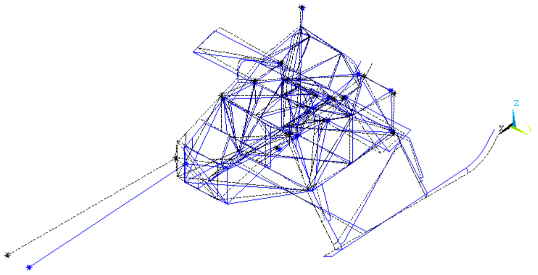


Fig. 4 The figure for the frequency of 1,074 Hz. Tail beam deviations in the XY plane.

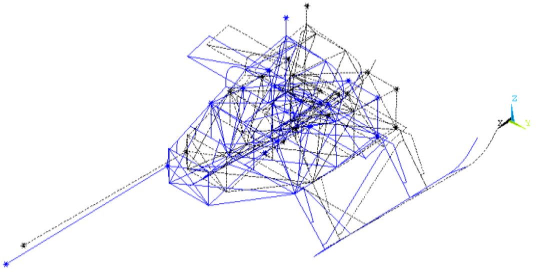


Fig. 5 The figure for the frequency of 1.10 Hz. The Vertical movements of the fuselage.

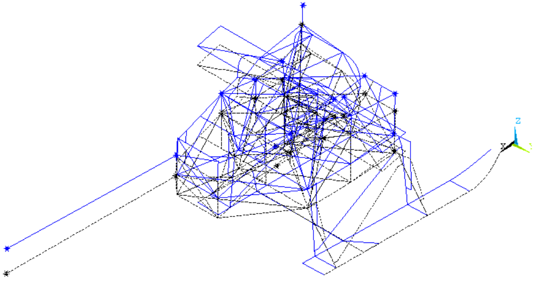


Fig. 6 The figure for the frequency of 1,10 Hz. The Vertical movements of the fuselage.

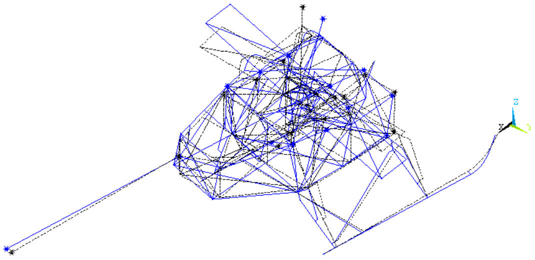


Fig. 7 The figure for the frequency of 3.32. Movements the center of the hub in ZY plane directions.

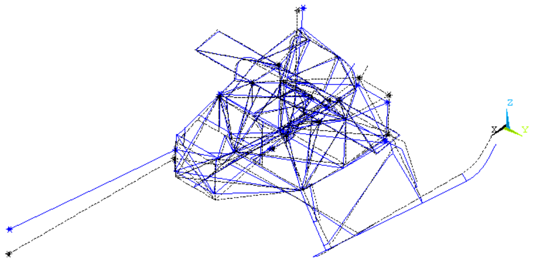


Fig. 8 The figure for the frequency of 4,05Hz. Movements the center of the hub in ZX plane directions.

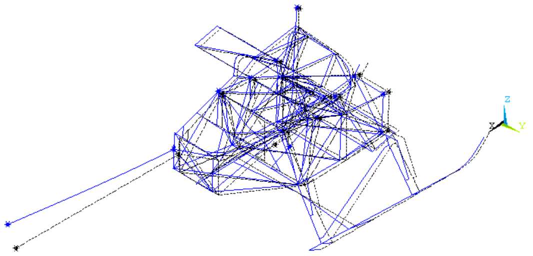


Fig. 9 The figure for the frequency of 8.29 Hz. Tail beam deviations in the XY plane.

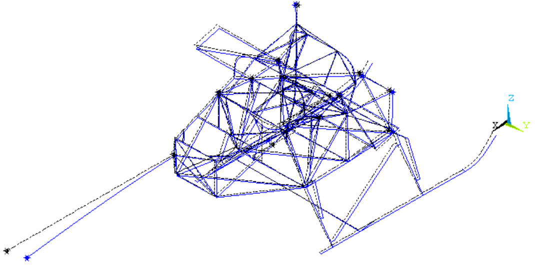


Fig. 10 The figure for the frequency of 11.52 Hz. Tail boom deviations in the XY plane.

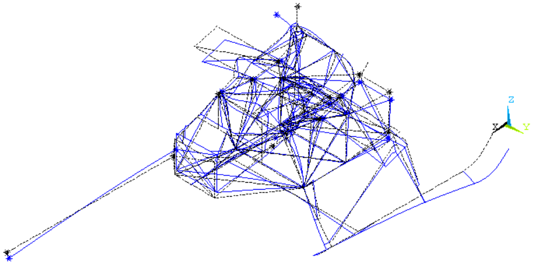


Fig. 11 The figure for the frequency of 20,43 Hz. Tail boom deviations in the XY plane.

2.2 Harmonic Analisys.

Despite the many simplifications that have occurred in this model, changes in vector vibration (vibration frequency and form) due to changes in structural parameters (changes in characteristics of the shock absorbers) should be an order of magnitude more accurate than the "zero" vector vibration and therefore should be useful for adjusting subsequent phases of the experimental trials. The following charts show the relationship amplitude [mm] of the frequency Hz] extortion for excitation of longitudinal hull strength of 200N. These results are only indicative because, based on the study we will be able to accurately assess the size of the amplitudes through appropriate selection of the damping factor in the construction of the finite element method. The presented model is the next stage of development for simulation of ground resonance.

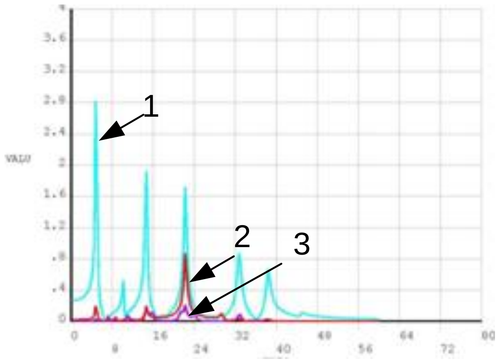


Fig. 12 The amplitude of the X(1)Y(2)Z(3) – axis as a function of frequency Hz.

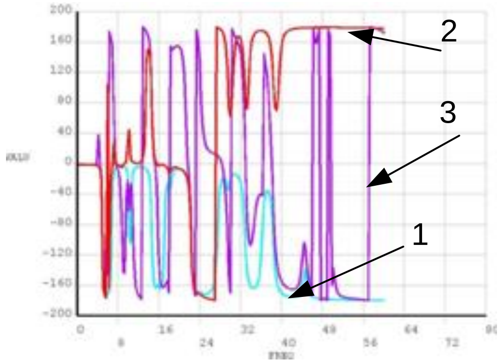


Fig. 13 Phase displacement X(1)Y(2)Z(3) as a function of frequency Hz.

2.3 Simulations.

Calculations of an unbalanced helicopter landing simulation were performed for two cases of helicopter design. The first case, the results of which are shown in figures (Pictures No. 15, 17, 19, 21, 23, 25, 27) was a case of a helicopter without members supporting the rotor shaft. By chance, the second was the case with additional support elements rotor shaft (Fig. 3), the results presented graphs (Pictures No. 14, 16, 18, 20, 22, 24, 26) The simulations were performed for the construction of descent speed of 2.5 m / s The angle of the structure was 20 °. In both variants of computational helicopter after contact with the ground at the end of the first second analysis followed by a decrease to zero lift. Introduction of additional elements to the structure was designed to eliminate the resonance surface.

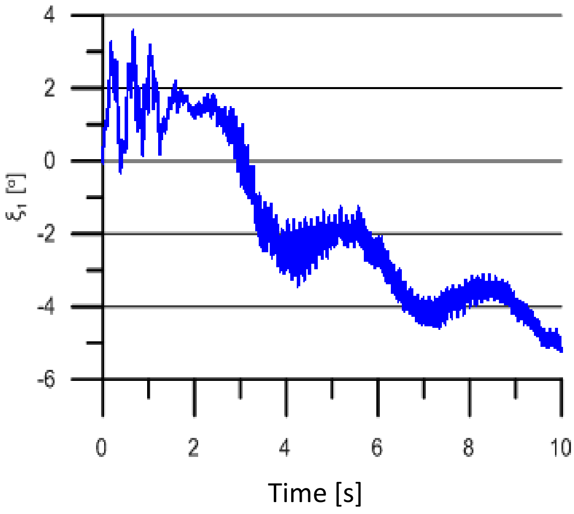


Fig. 14 The angle of deviations fluctuations blade in the plane of the rotor as a function of time for the blade no 1 for the helicopter with changes in the construction(Fig. 3).

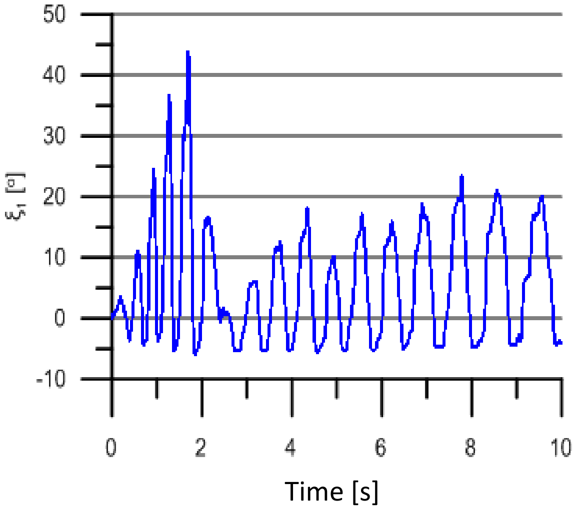


Fig. 15 The angle of deviations fluctuations blade in the plane of the rotor as a function of time for the blade no 1 for

the helicopter without changes in the construction.

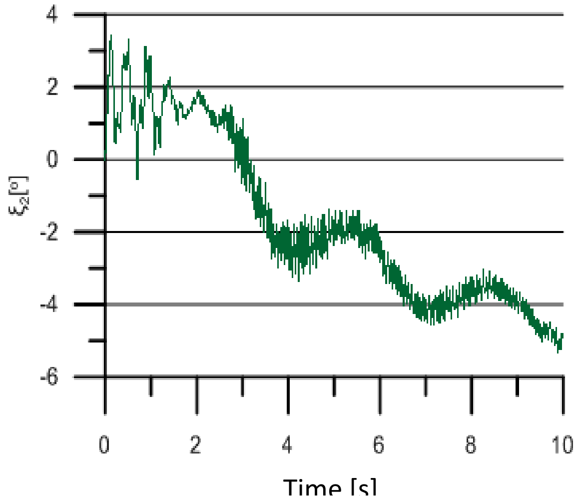


Fig. 16 The angle of deviations fluctuations blade in the plane of the rotor as a function of time for the blade no. 2 for the helicopter with changes in the construction (Fig. 3).

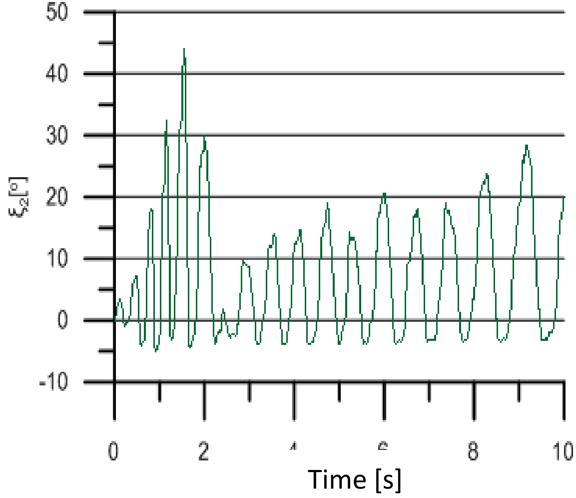


Fig. 17 The angle of deviations fluctuations blade in the plane of the rotor as a function of time for the blade no 2 for the helicopter without changes in the construction.

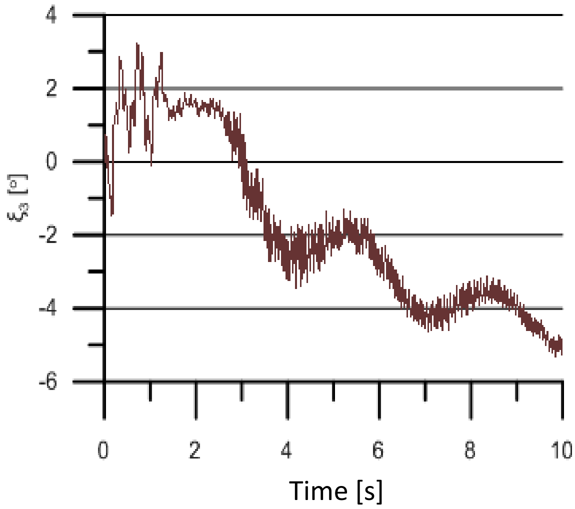


Fig 18 The angle of deviations fluctuations blade in the plane of the rotor as a function of time for the blade no 3 for the helicopter with changes in the construction (Fig. 3).

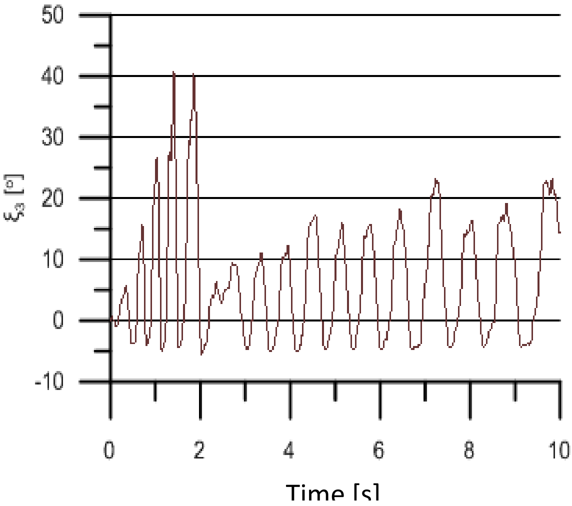
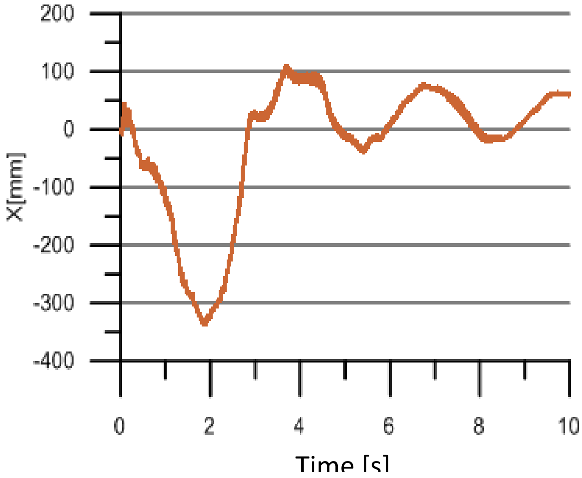


Fig. 19 The angle of deviations fluctuations blade in the plane of the rotor as a function of time for the blade no 3 for a helicopter without changes in the construction.



Picture No. 20 The amplitude of the displacement of the rotor hub in the X direction for the helicopter with changes in the construction (Fig. 3).

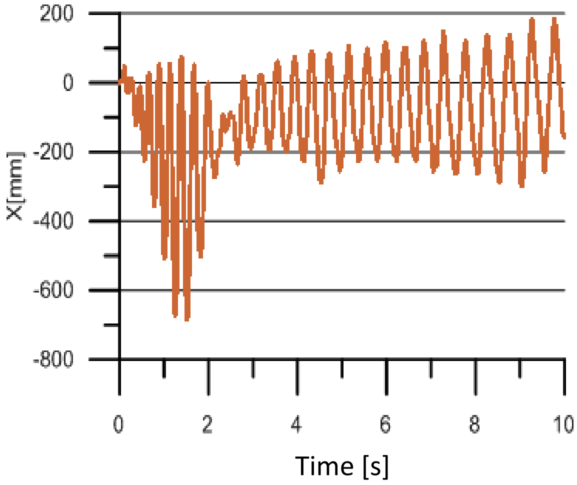


Fig. 18 The amplitude of the displacement of the rotor hub in the X direction for the helicopter without changes in the construction.

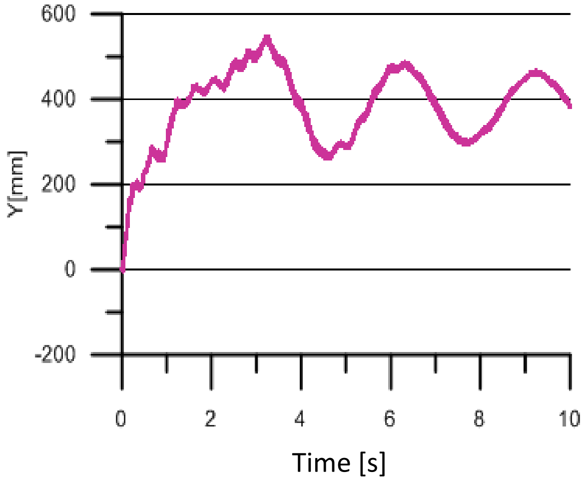


Fig. 19 The amplitude of the displacement of the rotor hub in the Y direction for the helicopter with changes in the construction (Fig. 3).

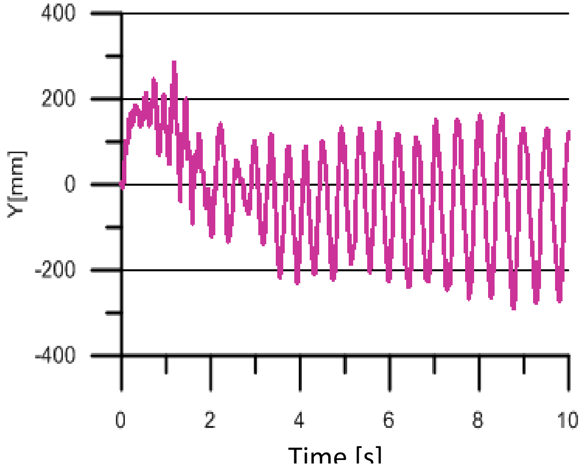


Fig. 20 The amplitude of the displacement of the rotor hub in the Y direction for the helicopter without changes in the construction..

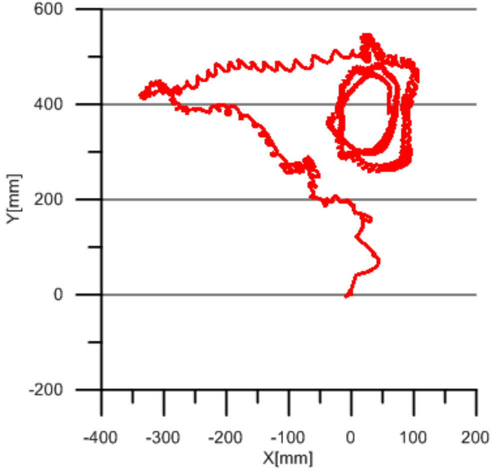


Fig. 21 Displacement of the rotor hub in the plane of the rotor (Fig. 3).

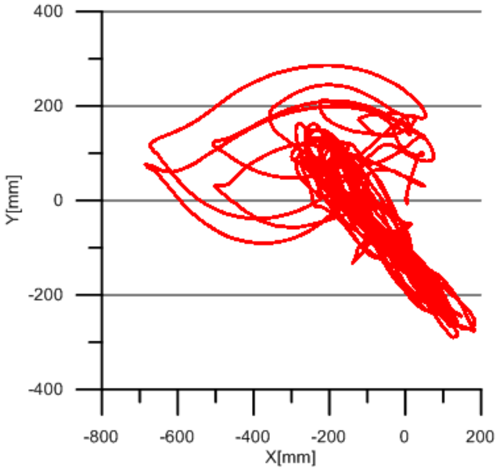


Fig. 22 Displacement of the rotor hub in the plane of the rotor.

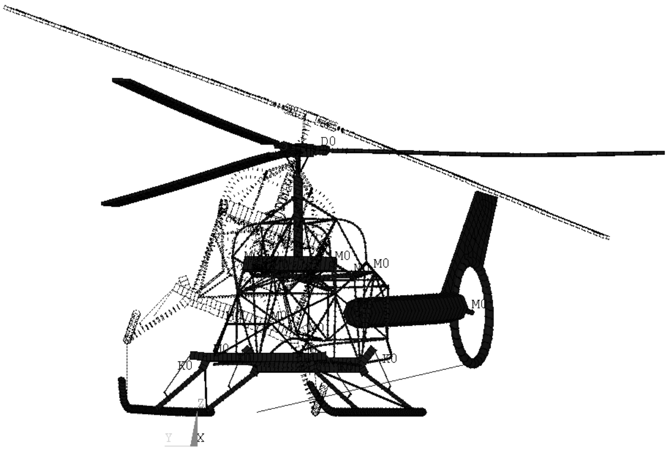


Fig. 23 View of the model helicopter at the start of the analysis (black intermittent) and end (black). for the helicopter with changes in the construction (Fig. 3).

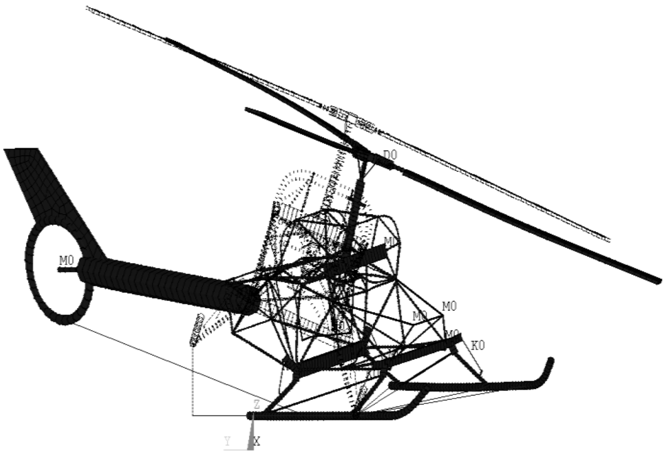


Fig. 24 View of the model helicopter at the start of the analysis (black intermittent) and end (black). for the helicopter without changes in the construction.

4. Conclusions.

Presented in this paper FEM model helicopter fuselage structure can be used to support the testing ground for ground resonance imaging system (free standing on bench), to simulate the potential risks that may occur during the rotor detaching from zero to nominal speed and for the analysis of potential unsymmetrical helicopter landing on the ground. Through the use of simulation models we can accurately (depending on the tuning of the model to the real object) predict the behavior of the structure during the test, and evaluate the safety based design solutions. Based on the results of the analysis carried out for a number of cases, which may have influenced the design of the helicopter we achieved fairly reliable results. As a result, we failed to predict the occurrence of resonance in the areas of design and test their character. It is very important when performing tests on actual construction. In the event of instability in the structure ≈ 6 Hz for the construction the danger can be avoided by quickly moving through the danger of resonance. This took place both during and after the detachment of the brake rotor. On this basis, it can be assumed that the application of the finite element method in implementing the project of light unmanned helicopter made a huge difference to the pace of the work of construction and safety during testing.

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