DROP ANALYSIS OF THE SKID LANDING GEAR OF THE LIGHT HELICOPTER.

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ABSTRACT

The analysis of helicopter during landing includes both complicated experimental tests and numerical calculation. Up to now very simple models in helicopter engineering have been used in Russia. Contemporary investigation of these problems involves using modern engineering software. The mechanical models included in these software allow to describe highly nonlinear dynamic behavior of engineering structure. This article contains rudimentary step-by-step development of numerical model to analyze behavior of skid landing gear in order to obtain optimal numerical model. Main points of the optimal numerical model are related to reducing cost of the verification experiment as well as hardware requirements. The base software for numerical activities is LS-DYNA with pre- and post- processors in ANSYS.

INTRODUCTION

The safety problem during landing of helicopter leads to the crash and drop problem of the whole helicopter. Meanwhile, as it was proved by experimental investigation, the main part during landing is the skid landing gear, because of damping and energy absorbing properties of the structure. This part of the helicopter also plays crucial role in defining the "safety landing velocity". We use a term "safety landing velocity" for the velocity of helicopter during which a helicopter crew is still in safety. Impact modeling with only landing gear as a dumping element of the structure became practice in impact analysis during landing.

APPROACH TO MODELING PROBLEM.

The main goal of the investigation is to obtain optimal numerical model that allows to calculate various situation during landing. The crucial role in the modeling of a real structure with the help of various engineering software plays verification process. In the case of complicated engineering structure, it can be provided only by experiment. A series of detailed experiments are quite expensive, as well as a huge numerical model also takes a lot of computer times. With regard to this situation, we chosen a simple approach. It consist of series simple experiments proved by convenient numerical model. Three various models were under consideration. The only one beam loaded quasistatically until its damage was the first simple structure. The next step was also one beam but stressed by impact dynamic load. And the last one was a simplified model of the whole helicopter. Therefore, we considered a series of numerical calculations proved by experiment results, following a principle from an easy to a complex. We called it hierarchy of models.

The numerical model of the helicopter.
Consider the whole model of helicopter. It is a last model in our hierarchy, but it gave us view of the problem.

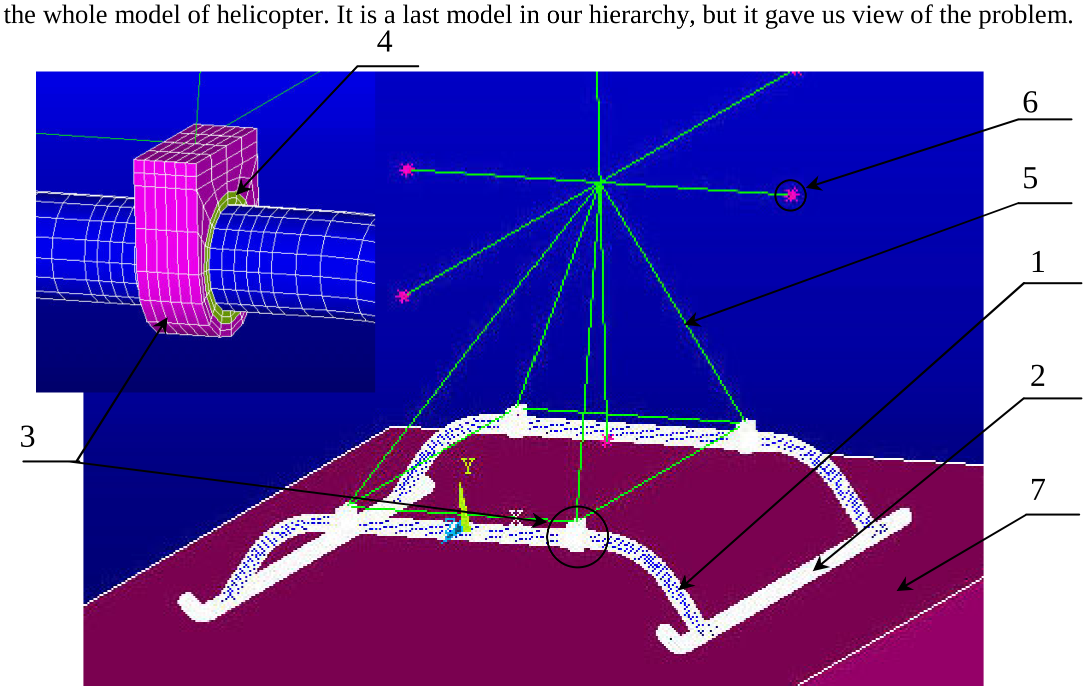

Figure 1. Model of helicopter.

Cross beams (1) is connected to the skid beam (2) by means of special joint that can be regarded as stiff during landing. Load from the helicopter onto skid-landing gear is transfered by means of hangers (3). Cross beams (1) can slide into hangers (3) due to soft hub (4) made of polymer material with low friction coefficient. The helicopter hull is modeled as a rigid frame structure (5). In order to apply inertia loads mass elements (6) were attached at appropriate distances from the mass center. The land was assumed flat and modeled with one rigid element (7).

Static analysis of the cross beam.

The first model that has been analyzed numerically as well as experimentally is presented at Figure 2. The main goal of this model is to verify contact mechanism between the hub of a hanger (2) and the cross beam (1). ANSYS/Structural has been used for modeling at this stage. Cross beam (1) was modeled by shell element with multilinear plastic material assuming isotropic hardening. The rest were modeled by solid with linear elastic material for the hanger and nonlinear elastic one for the hub. In order to describe contact condition within structure hub cross-beam, high-order contact elements have been used. This structure has a hinged bearing at hangers, and loaded symmetrically by forces at cantilever ends. Quite compartible with experiment results have been obtained by the model with 2136 elements. Figure 3 shows good correlation between calculated load-deflection curve and experimental one. This correlation has been achieved by choosing material properties for the hub slightly stiffer then it was, because of the fact that the hanger was prestressed during assembly. The beam has been loaded until its damage (till one can see intensive plastic deformation) and this load was well predictable by numerical calculation as a point of numerical divergence.

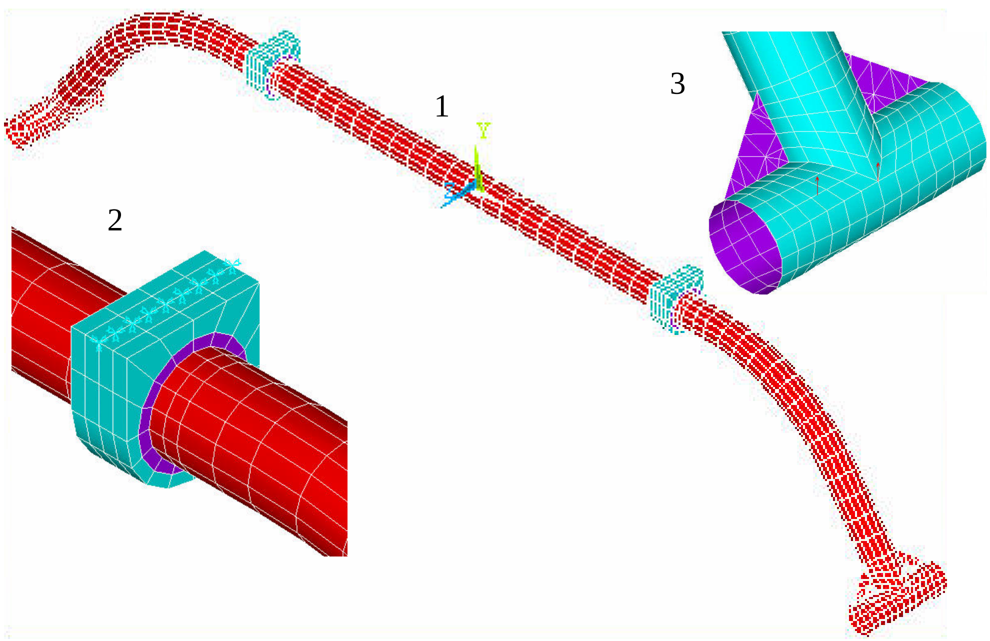

Figure 2. Model for the static analysis.

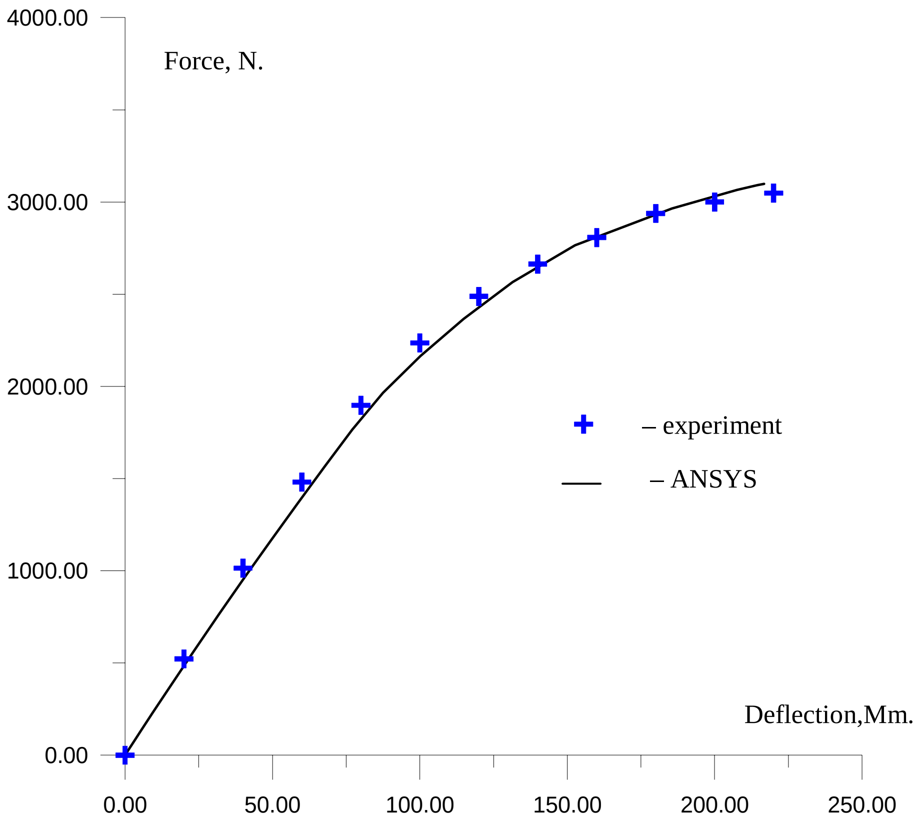

Figure 3. Load-deflection curve for the quasistatic analysis.

Drop-test of the cross-beam.

After verification of the contact algorithm in the hub-beam joint, dynamic test has been provided. The beam loaded by additional dead loads has been dropped from the hight H. From this point and further, LS-DYNA has been used to simulate this experiment. Here we specified the following elements and material models: Belytschko-Wong-Chiang shell element with bilinear isotropic materials assuming kinematic hardening for the skid and cross beam; solid element with elastic properties for hangers and hubs and solid element with rigid material properties for the ground. Under assumption of small hight, contact zones are easy predictable apriory, therefore node-to-surface contact approach has been specified. There were two contact pairs: between hubs and cross-beam as well as between skid-beam and ground. The model with 3561 was found suitable enough to correlate with experiment results. Figure 4 shows node displacements in coordinate directions during impact and figure 5 shows evolution of equivalent Von-Mises stress in contact nodes.

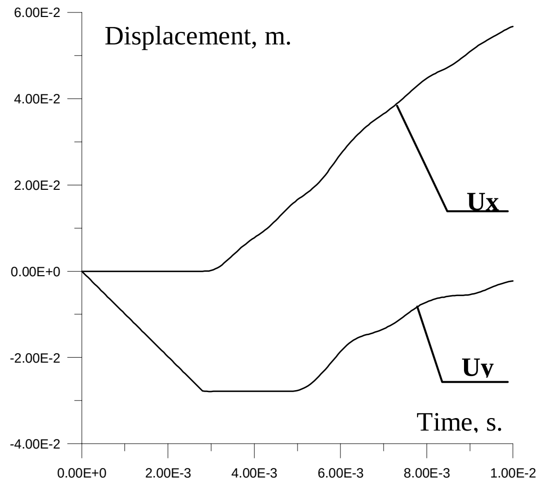

Figure 4. Evolution of the displacement at a contact node.

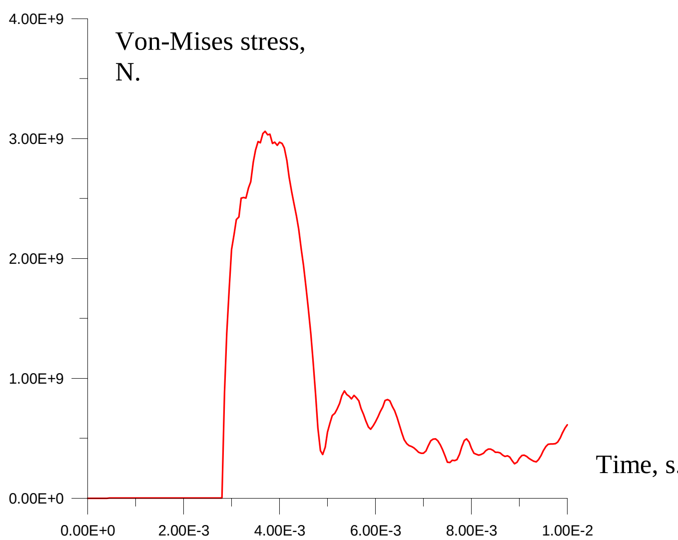

Figure 4. Evolution of the Von-Mises stress at a contact node.

Drop test of the helicopter.

Last model examined in both experimental and numerical ways is the model discussed in details earlier (Figure 1). In this model helicopter hull is a combination rigid frame modeled by beam rigid element and 6 material mass points modeled by mass element. Three contact pairs have been specified: surface-to-surface contact pair for hub and cross-beam joints and two node-to-surface contact pairs for the cross-beam and ground as well as for the skid-beam and ground. Cross-beams are allowed to slide into hangers. This model also includes friction sliding and skidding between skid-beam and ground. It has been numerically revealed two spring back behavior of the helicopter during various landing situations. The skid landing gear has its first contact with ground, then after springing back, the gear has met the ground again. The equivalent Von-Mises stress in the second contact is more greater then in the first contact. Simple techniques that were used before that failed to describe this behaviour and thus predicted only first impact.

CONCLUSION

This approach did not have a goal to describe a great variety of nonlinear mechanical behavior of a structure during impact and crash. Authors completely recognized a great amount of techniques developed in the world. The only goal of this is to get continuum contact-impact model as simple as possible, but from two points of view: from the one point of view the model must be complete enough to describe main peculiarities during landing, from the other point the model must be simple in order to be easily verified. Whereas, this model required a small amount of computer times as well as experimental tests, it was found very suitable for industrial practice.

ACKNOWLEDGMENTS

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