17th International Conference
ENGINEERING MECHANICS 2011
Svratka, Czech Republic, 9 – 12 May 2011

LANDING SHOCK AEROELASTIC RESPONSE ANALYSIS OF UTILITY AIRCRAFT

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Abstract: *The paper deals with the aircraft landing shock aeroelastic response analysis. The analysis was performed as a part of the aircraft certification in order to fulfill the CS / FAR 23 § 23.479(d) regulation requirement. The FE model used for the former flutter analyses was utilized. The excitation force was based on the landing gear drop test results. The airflow parameters were set according the aircraft flight envelope and the regulation statements. The modal transient aeroelastic response solution was employed. The structure response was evaluated at the engine center of gravity and the selected points on the wing.*

Keywords: ***Aeroelasticity, aeroelastic response, landing shock response, EV-55 aircraft.***

1. Introduction

EV-55 aircraft is a high-wing utility aircraft for 9 - 14 passengers certified according the *CS 23* airworthiness regulations at the normal category. The wingspan is *16.1 m*; the maximal take-off weight is *4600 kg*; the aeroelastic certification altitude is *3100 m* and the maximal level flight velocity is $452\ km.h^{-1}$.

According the mentioned regulation, the aircraft with the significant overlapping masses (e.g. wing mounted engines) must be designed with respect to the dynamic forces for the level landing conditions defined by the regulation (*CS 23 §23.479(d)*). Therefore it is mandatory to perform the analysis of the load factor at the engine centre of gravity for the defined landing conditions.

2. Analytical Model and Used Methods

Respecting the demand to minimize the analysis effort and the available input data we decided to utilize the aeroelastic computational model used for the former flutter analyses (see Čečrdle, Maleček & Černý (2011)). Note that the ordinarily used approach of the aircraft landing response analysis is to use the multi-body simulation including the landing gear characteristics (stiffness and damping) and the aircraft global dynamic model.

The structural model (see Fig. 1) is a beam-like model, the aerodynamic model (see Fig. 1) is based on the Wing - Body Interference unsteady aerodynamic theory. Both models are interpolated by means of beam splines. Model is prepared as a half-span model with the appropriate boundary condition at the plane of symmetry (symmetric, antisymmetric).

For the landing shock response analyses, the former model was adapted. The mass model was adjusted for the landing gear down configuration and additional auxiliary nodes (excitation and response acquisition points) were included. The excitation force is based on the main landing gear drop test with the expected descent velocity of $V_y = 3.048\ m.s^{-1}$. The excitation signal was included in the time domain. The landing level flight velocity was expected $V_{TD} = 148\ km.h^{-1}$. The analysis was performed by means of the NASTRAN program system, the aeroelastic transient response solution was employed. This solution relies on the Fourier transform technique. It is separated into three phases: Firstly, the loads (defined in the time domain) are transformed into the frequency domain. Then the responses are computed in the frequency domain and finally the responses are transformed back to the time domain. The theoretical background of the used solution is given by Rodden and Johnson (1994).

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The aerodynamic model included no correction for the compressibility (*M = 0*), the dynamic pressure of *q = 1035.57 Pa* was given from the V_{TD} and the altitude of H = 0. For the structural damping, the viscous model was used. The damping ratio was considered either as conservative estimation (*1%*) or as the maximal value accepted by the regulation (*2%*). The analyses were performed for the two mass configurations of the model. The mass configurations were realized as a compromise between the regulation specifications and the mass configurations available at the existing model:

1) wing fuel loading of 100%; average fuselage loading; total weight of 4700 kg;

2) wing fuel loading of 0 %; maximal cargo fuselage loading; total weight of 4654 kg.

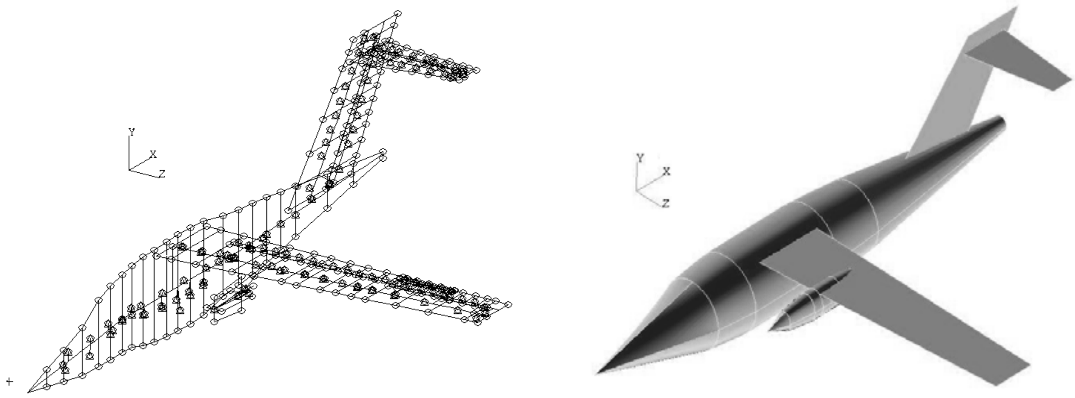

Fig. 1: Structural and Aerodynamic Model.

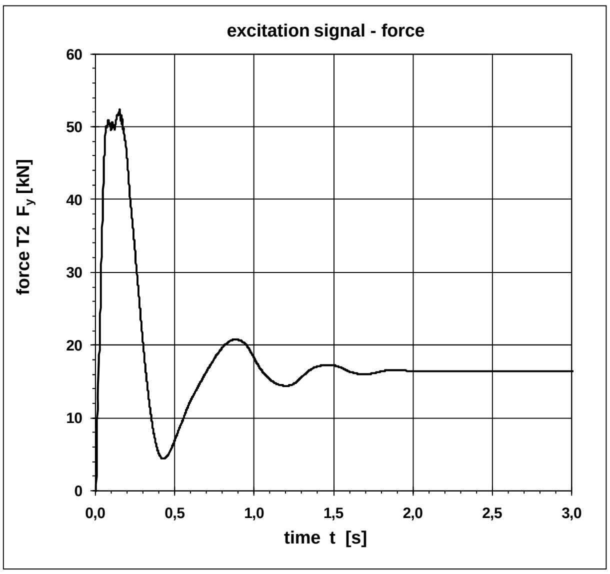

Fig. 2: Excitation force.

3. Analyses and Results

The excitation signal (see Fig. 2) was applied to the main gear point, the structure response was acquired at the engine centre of gravity and the selected points on the wing (see Fig. 3). The structure response, it means displacement, velocity and acceleration in the vertical direction for the structural damping ratio of *1%* and the mass configuration nr.1 is presented in Figs. 4 - 6. The maximal acceleration at the engine centre of gravity was 5.62 $m.s^{-2}$; at the wing tip point (W4) it was 56.05 $m.s^{-2}$.

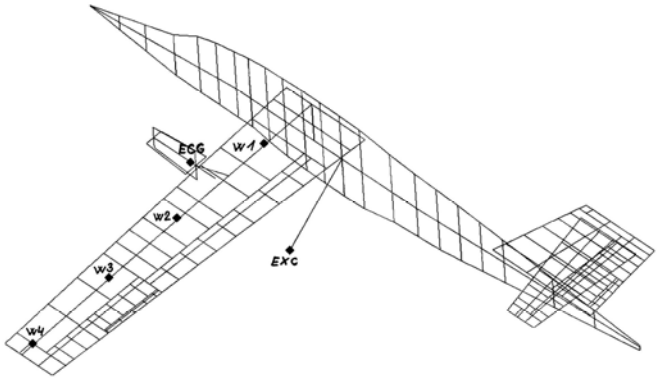

Fig. 3: Excitation and response acquisition points.

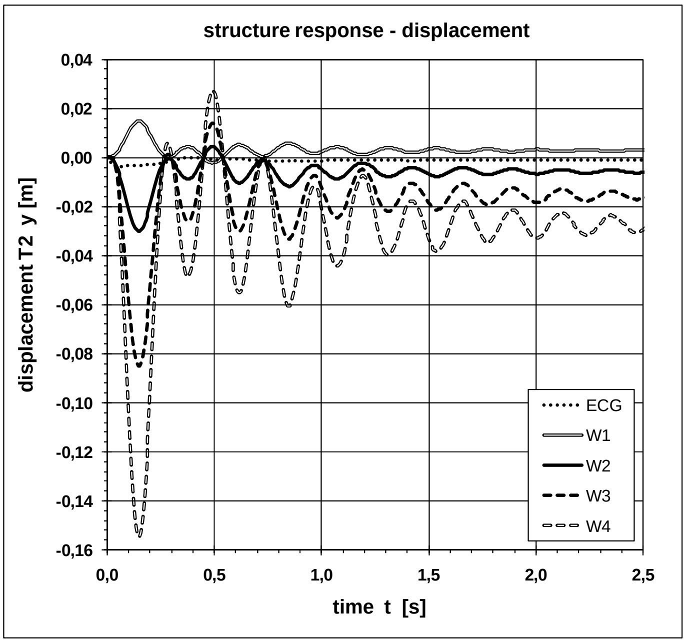

Fig. 4: Structure response - displacement.

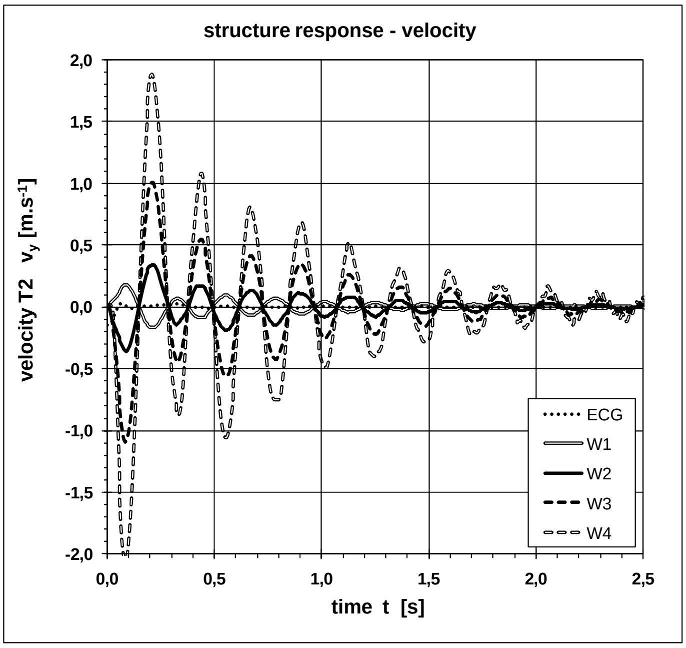

Fig. 5: Structure response - velocity.

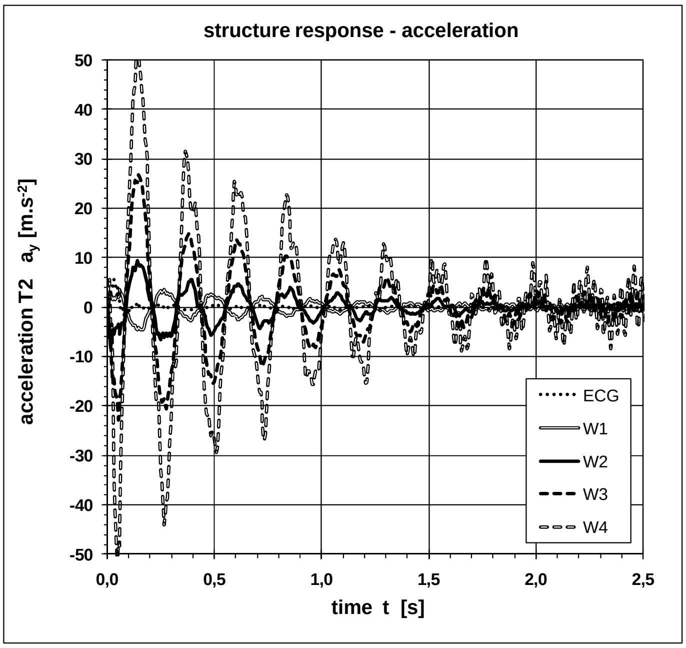

Fig. 6: Structure response - acceleration.

4. Conclusion

The paper describes the landing shock aeroelastic response analyses of the utility aircraft. There were utilized the results of the main landing gear drop test and the analytical model used for the former flutter analyses. The response was acquired at the engine centre of gravity and the selected points along the wingspan. The results will be used for the aircraft certification - it fulfill the requirements of the *CS 23 §23.479(d)* regulation. It will be also utilized as the input data for the follow-on fatigue analyses.

References

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