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NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Airbus Report
"AAL587 Crash: Study on Potential effect of Rudder Delamination"

(6 Pages)

1

AIRBUS

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TITRE : AAL587 Crash - Study on potential effect of Rudder Delamination

AUTEUR(S) : [redacted]

RESUME :

The purpose of the present note is to give the results on potential effect of delaminated Rudder on dynamic and flutter behaviour.

This analysis has been performed on two Rear Part Models (S19 + Fin + Rudder) delivered by AI-G Stress Office :

- Model with nominal Rudder,
- Model with partially delaminated Rudder skin.

Comparisons have been made on Modal Schema (frequencies and mode shapes) and flutter.

The study demonstrates a negligeable influence on dynamic and flutter behaviour of the partial Rudder skin delamination :

- Less than 0.4 % on frequencies up to 40 Hz,
- No noticable modifications of Mode shapes up to 40 Hz,
- No impact on flutter analysis results.

MOTS CLES : AEROELASTICITY

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1. INTRODUCTION

This note provides the results of flutter analysis performed on a rear part of A300-600 in order to assess the influence of a delamination of rudder above hinge 4. The flutter behaviour is compared with the nominal case (without delamination).

2. DYNAMIC MODEL

The analysis has been performed on two Rear Part Models (S19 + Fin + Rudder) of A300-600 delivered by AI-G Stress Office :

- Model with nominal rudder,
- Model with partially delaminated rudder skin

The structural models are defined in right aircraft coordinate system : x backwards, y on the right, z upwards. These models are NASTRAN finite elements models of the Vertical Tail Plane and Rear fuselage of A300-600 delivered by AIRBUS Germany. First model has a nominal rudder, while second has a partially delaminated rudder skin, derived from the delamination pattern observed after the AAL accident.

A lumped mass model was connected with the Finite Element Model in order to get a dynamic model.

3. MAIN MODAL SHAPES

Modes are computed with MSC/NASTRAN v70.5. The eigenvalues are computed up to 40Hz, and associated modal shapes are determined. Lanczos method was chosen to extract modes. We show the 5 first modal shapes for the two models.

3.1 NOMINAL RUDDER

This model consists of Rear fuselage and Vertical Tail Plane (VTP). VTP is composed of a Box and a nominal Rudder.

First VTP Bending Mode

3.3 MODAL COMPARISONS

The table below shows the impact of the delamination on frequencies up to 40 Hz.

Frequency		
Nominal Hz	delaminated Hz	comparison (%)
6,097	6,097	-0,01%
8,732	8,732	0,00%
10,713	10,714	0,00%
14,125	14,125	0,00%
15,160	15,139	-0,14%
17,230	17,230	0,00%
22,583	22,634	0,23%
26,037	26,036	0,00%
26,427	26,425	-0,01%
29,757	29,664	-0,31%
30,468	30,435	-0,11%
33,209	33,204	-0,01%
34,611	34,480	-0,38%
35,896	35,869	-0,08%
36,743	36,727	-0,04%
38,209	38,207	-0,01%
39,223	39,221	-0,01%

Up to 40Hz, the difference of frequency is smaller than 0.4%. The delaminated Rudder has no impact on the modal shapes.

4. FLUTTER ANALYSIS

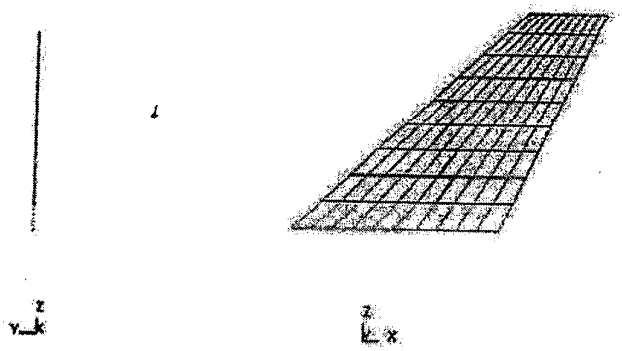
4.1 GENERALITIES

Aeroelasticity analysis are performed at Mach 0.4. Modal analysis are performed with NASTRAN rear part dynamic model. Flutter reponses are computed with an in house code using p-k method.

Flutter analysis uses modal bases computed with MSC/NASTRAN and matrix of aerodynamic influence coefficients computed with a Doublet Lattice Method in house software.

4.2 AERODYNAMIC DATA

View presented below shows the aerodynamic surfaces reference a300603mc used for the Doublet Lattice Method aerodynamic computation and for interpolation of modal shapes. Interpolation surfaces used in the calculations are VTP box and Rudder.



Front view Left view

Hypothesis

- unsteady aerodynamic : Hinge moment adjustment (on control surface),
- flutter curves are computed without structural damping,
- Values of reduced frequency are 0.002, 0.05, 0.1, 0.15, 0.3 and 0.6.

5. CONCLUSION

The delaminated Rudder has no influence on the normal modes. The modal shapes are similar between the two models. The differences are less than 0.4% for frequencies up to 40Hz.

The delaminated Rudder has no impact on the flutter analysis.

The modal and flutter behaviours are similar with delaminated Rudder skin and with nominal Rudder. Effect of Rudder delamination above hinge 4, derived from observations after AAL accident, are shown negligeable for dynamics.

6