MECÂNICA ESTRUTURAL – 10371/10391/10411

2015/2016

Assignment 2

OBJECTIVES

To learn how to use a commercial computer program to determine the modal shapes and natural frequencies of vibration of an aircraft structure and gain experience in solving such problems.

1. PROBLEM

It is required to analyse a rectangular wing of a small unmanned aircraft in terms of its natural modes of vibration.

The geometry and material properties of the rectangular wing are given in Table 1 and Table 2, respectively. The wing is assumed to be clamped at the root and is composed of skins, spars, and ribs. The wing considered has 2 C-shaped spars, located at 30% and 60% of the chord, and 5 ribs distributed uniformly along the wing span. Both skin and spars are made of aluminium. In particular, these components have the following dimensions: skin thickness $t_0 = 0.4$ mm, spar cap height $h_1 = 0.4$ mm, spar cap width $l_1 = 10$ mm, spar web thickness $t_1 = 0.4$ mm. The ribs are made of PVC foam Airex® C70.75 with 6.2 mm of thickness. These dimensions are collected in Table 3. The aerofoil of the wing is a modified version of the SG6042. The coordinates of the aerofoil are found in Table 4. A general CAD model of the rectangular wing is seen in Figure 1.

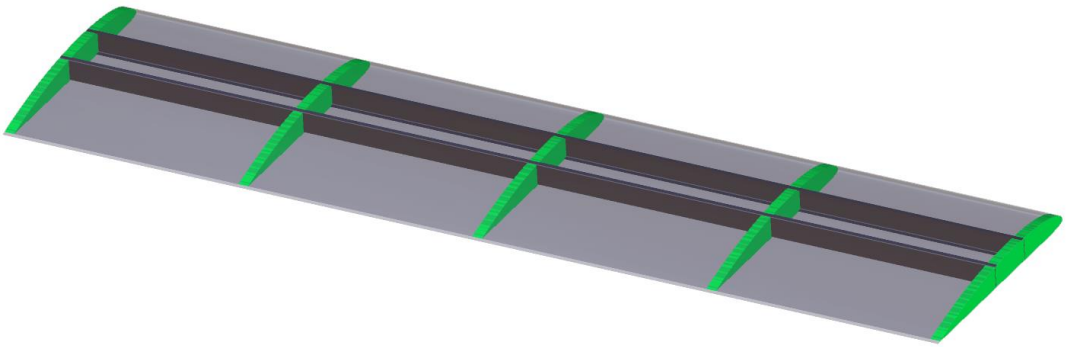

Figure 1: Wing components.

In order to obtain the mode shapes and the corresponding natural frequencies of vibration a finite element (FE) model must be set up in a commercial software package. The first six modes should be obtained. A report should be written explaining the construction of the FE model and containing the mode shapes in graphical form. The results should be discussed taking into account the following: wing mass, wing stiffness, possible impact on aeroelastic behaviour.

2. DATA

Material and geometry data of the wing and its structural components are given below.

Table 1: Wing geometry.

semi-span, m	1.2
tip twist, deg	0
dihedral, deg	0
chord, m	0.25

Table 2: Material properties.

Property	Skin and Spars (Aluminium 6061-T6)	Ribs (Airex C70.75)
density, kg/m^3	2700	80
Young's modulus, MPa	68900	66
shear modulus, MPa	26000	30
Poisson's ratio	0.33	0.1

Table 3: Dimensions of structural elements.

Structural variable	Value
spars position [chord fraction] (root and tip)	0.3/0.6
spars web thickness, mm (root and tip)	0.4
spars cap height, mm (root and tip)	0.4
spars cap width, mm (root and tip)	10.0
ribs position [semi-span fraction] (LE and TE)	0.0/0.25/0.5/0.75/1.0
ribs thickness, mm	6.2
skin thickness, mm	0.4

Table 4: Aerofoil coordinates.

x/c	y/c	x/c	y/c	x/c	y/c
1.000000	0.000000	0.209656	0.076807	0.214556	-0.016416
0.993692	0.001682	0.192858	0.074783	0.232664	-0.016037
0.981957	0.005159	0.176251	0.072533	0.250805	-0.015658
0.967890	0.009351	0.159815	0.070029	0.268972	-0.015278
0.952747	0.013633	0.143570	0.067264	0.287152	-0.014899
0.936987	0.017740	0.127644	0.064237	0.305338	-0.014518
0.920534	0.021735	0.112121	0.060924	0.323530	-0.014138
0.903586	0.025680	0.097051	0.057304	0.341739	-0.013758
0.886434	0.029541	0.082565	0.053383	0.359960	-0.013377
0.869146	0.033317	0.068960	0.049218	0.378174	-0.012996
0.851755	0.037014	0.056507	0.044852	0.396368	-0.012616
0.834336	0.040626	0.045379	0.040365	0.414542	-0.012236
0.816940	0.044135	0.035800	0.035928	0.432693	-0.011857
0.799533	0.047540	0.027881	0.031703	0.450818	-0.011478
0.782110	0.050847	0.021497	0.027755	0.468916	-0.011100
0.764745	0.054033	0.016376	0.024082	0.486998	-0.010722
0.747482	0.057069	0.012283	0.020702	0.505079	-0.010344
0.730304	0.059939	0.009021	0.017607	0.523171	-0.009966
0.713128	0.062638	0.006424	0.014742	0.541279	-0.009587
0.695871	0.065187	0.004362	0.012063	0.559407	-0.009208
0.678546	0.067597	0.002778	0.009548	0.577559	-0.008829
0.661209	0.069860	0.001624	0.007186	0.595736	-0.008449
0.643875	0.071972	0.000825	0.004960	0.613944	-0.008069
0.626528	0.073934	0.000292	0.002833	0.632174	-0.007688
0.609143	0.075749	-0.000031	0.000766	0.650396	-0.007307
0.591707	0.077422	-0.000096	-0.001225	0.668578	-0.006927
0.574237	0.078960	0.000237	-0.003093	0.686703	-0.006548
0.556761	0.080359	0.001116	-0.004810	0.704774	-0.006170
0.539295	0.081616	0.002549	-0.006384	0.722804	-0.005793
0.521835	0.082730	0.004463	-0.007797	0.740809	-0.005417
0.504361	0.083698	0.006812	-0.009017	0.758778	-0.005042
0.486853	0.084525	0.009669	-0.010092	0.776683	-0.004667
0.469333	0.085215	0.013103	-0.011164	0.794524	-0.004294
0.451851	0.085762	0.017223	-0.012298	0.812330	-0.003922
0.434401	0.086158	0.022212	-0.013427	0.830106	-0.003551
0.416930	0.086402	0.028418	-0.014480	0.847830	-0.003180
0.399430	0.086500	0.036410	-0.015461	0.865461	-0.002812
0.381950	0.086455	0.046687	-0.016372	0.882983	-0.002446
0.364524	0.086258	0.059303	-0.017120	0.900433	-0.002081
0.347140	0.085900	0.074102	-0.017672	0.917765	-0.001719
0.329776	0.085379	0.090360	-0.018037	0.934827	-0.001362
0.312427	0.084690	0.107372	-0.018222	0.951493	-0.001014
0.295103	0.083835	0.124875	-0.018270	0.967382	-0.000682
0.277835	0.082810	0.142600	-0.017920	0.981597	-0.000385
0.260653	0.081606	0.160444	-0.017547	0.993518	-0.000135
0.243572	0.080214	0.178421	-0.017171	1.000000	0.000000
0.226578	0.078617	0.196475	-0.016794		