

Advances
in
Aircraft Structures

Editor

Jaffar Syed Mohamed Ali

Erwin Sulaema



IIUM Press

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011
©IIUM Press, IIUM

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without any prior written permission of the publisher.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

ISBN: 978-967-418-148-2

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :

IIUM PRINTING SDN. BHD.

No. 1, Jalan Industri Batu Caves 1/3

Taman Perindustrian Batu Caves

Batu Caves Centre Point

68100 Batu Caves

Selangor Darul Ehsan

CONTENTS

Preface	i
Contents	ii
Contributing Author	iv
Aircraft Structural Design and Testing	
1 Design of IIUM Aircraft Fuselage Using Composite Material (5168/20218)	1
2 Fabrication and Testing of IIUM Aircraft Fuselage Structure Made of Composite Laminate Material (5168/20223)	8
3 Design and Fabrication of Fuselage Model for Laboratory Purpose (5168/20225)	16
4 Simulation of Fuselage Model for Laboratory Purpose (5168/20228)	24
5 Propeller Blade Stress Analysis using CATIA (4625/20230)	30
6 Lateral Crushing of Composite Fuselages (4625/20232)	37
7 Corrosion Detection in Aircraft Structures by Ultrasonic Method (4980/20233)	45
8 Fatigue Damage Characterization of Aluminum Alloy Plates (4980/20235)	55
Composite Structures	
9 Determination of Mechanical Properties of Corrugated Hybrid Composite (5168/20237)	63
10 Composite Failure Mechanism of Corrugated Hybrid Composite Subjected to Bending Loading (5168/20239)	70
11 Study of Energy Absorption of Foam-Filled Honeycomb Structure (5168/20241)	79
12 Experimental Study of Indentation on Composite Structure (5168/20245)	86
13 Simulation Study of Composite Structure Subjected to 3 Points Bending Load (5168/20246)	93
14 Experimental Study of the Strength of Sandwich Structure with Honeycomb Core (5168/20248)	101
15 Buckling of Composite Columns (4625/20249)	107
16 Buckling of Composite Perforated Plates (4625/20253)	117
17 Structural Analysis of an Active Beam (4625/20254)	125
18 Characterization of Composite Materials using Full Field Data (6377/20256)	131

19	Application of Virtual Fields Method to Composite Plate Bending Problem	(6377/20262)	137
20	Mode I Delamination Simulation using LS-DYNA	(3563/20263)	143

Structural Instability

21	Buckling of Long Column	(4625/20264)	150
22	Buckling of Thin Walled Sections	(4625/20265)	158
23	Effect of Boundary Conditions on the Buckling Behavior of Perforated Plates	(4625/20266)	167
24	Effect of Cutout Shape on the Critical Buckling Load of Perforated Plates.	(4625/20267)	174
25	Experimental Determination of Critical Buckling Load for a Perforated Plate	(4625/20268)	182
26	Accurate Geometric Stiffness Matrix Formulation of Beam Finite Element	(6327/20269)	190

Structure Analytical Methods

27	The Constitutive Equation Gap Method	(6377/20270)	198
28	The Equilibrium Gap Method	(6377/20271)	202
29	The Reciprocity Gap Method	(6377/20272)	206
30	The Virtual Fields Method	(6377/20273)	210
31	Numerical Construction of Piecewise Virtual Fields	(6377/20274)	215
32	Numerical Model of Noise Effect in Full Field Data	(6377/20274)	221
33	Optimized Virtual Fields with Noise Minimization	(6377/20276)	227
34	Axial Stiffness Matrix of Non-Uniform Bernoulli-Euler Bar Elements		233
35	Finite Element Model Updating	(6427/20279)	240

Chapter 30

The Virtual Fields Method

Syed Muhammad Kashif

Abstract

This chapter discusses virtual fields method which is used for characterization of composite or anisotropic material with the use of full field heterogeneous deformation data. The method has shown very promising results when used for identification of materials constitutive properties and a set of full field data. This chapter discusses the basic working principle of the method and then it discusses the various developments made to its further enrichment. For the case of composite plates the method has been tested in various conditions from static to dynamic, from linear to non-linear and also it has been applied to the case of damage characterization.

Keywords: *Finite element method, direct solution, inverse methods, model updating, iterative procedure, non-linear material model.*

1. Introduction

The virtual fields method (VFM) can be applied in cases where a full-field strain measurement is available. Such a strain field is in fact derived from the experimental full-field displacement measurements. The basic idea of the VFM lies in writing the global static equilibrium of the tested specimen with the principle of virtual work. Considering a plane-stress state with no body forces, the principle of virtual work writes as follows