## **Contents**

Pre	eface				XI
Lis	t of cont	ributors ameldorg eulovnegle e			XV
1	Solving large-scale linear problems in solid and structural mechanics				1
	M. Po	npadrakakis			
	1.1	Introduction			1
	1.2	Iterative equation solving			2
	1.3	Global preconditioners			7
	1.4	Element-based preconditoners			10
	1.5	Domain decomposition-based preconditioners			21
	1.6	Performance of the methods under finite precision arithme	etic		26
	1.7	Concluding remarks			30
		Acknowledgements			32
		Bibliography			32
2	Solvin	Solving large linearized systems in mechanics			
		ur-Omid			
	2.1	Introduction			39
	2.2	Lanczos algorithm			43
	2.3	Conjugate gradient algorithm			45
	2.4	Loss of orthogonality			47
	2.5	Element-by-element preconditioning			49
	2.6	Substructure by substructure preconditioning			51
		Numerical examples			54
	2.8	Conclusions			62
		Acknowledgements			62
		Bibliography		39: W	62
3	Adar	otive iterative solvers in finite elements			65
	J. Mandel				03
	J. IVIC	andel			
	3.1	Introduction			65
	3.2	그 가장하다 수 있다면 보면 하면 보다 보는 것이 되었다면 되었다면 보다 되었다면			66
	3.3				70
	3.4				76
	3.5	Discussion and directions for future research			81

viii	CONTENTS

	3.6 Conclusion	86
	Acknowledgements	86
	Bibliography	86
1	Solution of large boundary element equations	89
4	Solution of large boundary element equations  J. H. Kane and K. G. Prasad	07
	4.1 Essentials of multi-zone boundary element analysis	89
	4.2 Equation solving in <b>BEA</b>	97
	4.3 Numerical results	107
	4.4 Conclusions	119
	Acknowledgements .	121
	Bibliography	121
5	Solution of large eigenvalue problems	125
	G. Gambolati	
	5.1 Introduction	125
	5.2 Eigenproblems in engineering	128
	0 1	131
	5.3 Optimization of <b>Rayleigh</b> quotients by accelerated conjugate gradients	135
	5.4 Preconditioning 5.5 Lanczos method	136
	5.6 Numerical results	140
		150
	<del></del>	151
	Acknowledgements	151
	Bibliography	101
6	Lanczos eigensolution method for high-performance computers	157
	S. W. Bostic	
	6.1 Introduction	157
	6.2 Application to structural problems	158
	6.3 Lanczos method	162
	6.4 Computational analysis	164
	6.5 Implementation of the Lanczos method	168
	6.6 Applications	172
	6.7 Summary	179
	Bibliography	180
7	structural mechanics	183
	M. Papadrakakis	
	7.1 Introduction	183
	7.2 Explicit methods	184
	7.3 Implicit methods	186
	7.4 Tracing equilibrium paths	194
	7.5 The line search	204
	7.6 Numerical examples	208
	7.7 Concluding remarks	210
	Acknowledgements	218
	Bibliography	218
	÷ , ;	

8	Mode	superposition meth	Methods for optimization of large-sho	225
	P. Lég	er		
	8.1	ntroduction		225
	8.2	Dynamic response analysi	s by vector superposition methods	226
	8.3	.oad-dependent transform	nation vectors	231
	8.4	Application examples	12.4 Unsatzation of the problem	234
	8.5	Mode superposition method	ods for non-linear dynamic analysis	242
	8.6	Conclusions	12.6 Sequential quadratic programming: quasi	253
		Bibliography		254
9			ime integration methods for	259
	struct	ıral and interaction	system dynamics	
	K. C.	ark		
	9.1	Introduction		259
	9.2	Solution techniques for m	ultibody dynamics	260
	9.3	Algorithms for control-struc	cture interaction simulation	269
	9.4	Solution methods for cour	oled thermal-structural analysis	277
	9.5	Application examples	and mornar share share share as a collection of the	282
	9.6	Closing remarks		297
	7.0	Acknowledgements		298
		Bibliography		298
		, and the second		2.0
10	seq	oled field problems lential and parallel Doltsinis	— solution techniques for processing	301
				301
	11		ipled fold problem	303
	1	2 Formulation of the couple	d problem taken as a whole	312
		3 Solution of the couple	divided into physical subdomains	312
		4 The coupled problem	coupled field problems	326
			coupled lield problems	336
				341
		7 Applications Bibliography		353
11	Dir	ct time-integration	methods: stabilized space—time finite	357
			incompressible flows	
	S. 1	littal and T. E. Tezduy	ar	
	1	.1 Introduction		357
		2 The governing equation	ons of unsteady incompressible flows	360
		.3 The stabilized space- integration method	time finite element formulation — a direct time-	361
		.4 The grouped element vectorization/paralleli	-by-element (GEBE) iteration method and	364
		F The clustered elemen	t-by-element (CEBE) iteration method	369
		1.5 The clustered elemen	y flows past a circular cylinder	370
			y none past a choalar symmetry	386
		1.7 Concluding remarks		387
		Acknowledgements		387
		Bibliography		507

## X CONTENT8

12	Methods for optimization of large-scale systems	391	
	J. S. Arora		
	12.1 Introduction		
	12.2 Design optimization model	391	
	12.3 Basic concepts related to numerical algorithms	394	
	12.4 Linearization of the problem	399	
	12.5 Methods based on linear approximations	399	
	12.6 Sequential quadratic programming: quasi-Newton methods	410	
	12.7 Numerical implementation aspects	417	
	12.8 Applications of optimization techniques	418	
	12.9 Practical design optimization: structural design with finite elements	418	
	12.10 Optimization of large systems	422	
	12.11 Concluding remarks	424	
	Bibliography	425	
13	Automatic generation of finite element models  M. S. Shephard	431	
	13.1 Introduction	431	
	13.2 Definition of a valid <b>inite</b> element mesh	432	
	13.3 Key components/issues in automatic mesh generation	437	
	13.4 Octree mesh generators	442	
	13.5 Delaunay, advancing front (paving), and medial (symmetric) axis transformation mesh generators	447	
	13.6 Integration of automatic mesh generation with geometric modelling	451	
	13.7 Efficient parallel solution of automatically generated adaptive meshes	453	
	Acknowledgements	458	
	Bibliography	458	
ما+، ، ۸	par Indov	461	
Author Index			
Subject index		467	

