Contents

1			m	5			
2	Shell Element Formulations for General Nonlinear						
	Ana	Analysis. Modeling Techniques					
	2.1		uction	9			
	2.2	The Standard A-I-Z Quadrilateral Shell Element					
		for Linear Analysis					
		2.2.1	Linear Analysis Kinematics	10			
		2.2.2	Stress-Strain Relations	13			
		2.2.3	The Locking Problem	14			
		2.2.4		15			
	2.3	The M	IITC4 Quadrilateral Shell Element for Linear Analysis	15			
	2.4	•					
		2.4.1	Infinitesimal Strains Problems: Total Lagrangean				
			Formulation	16			
		2.4.2	Finite Strains	18			
	2.5						
		2.5.1	The Nodal Director Vectors	19			
		2.5.2	Number of d.o.f. per Node	19			
	Refe	erences		20			
3	Coll	anse ar	nd Post-Collapse Behavior of Steel Pipes. Finite				
			odels	23			
	3.1		uction	23			
	3.2						
		of Very Long Pipes					
		3.2.1	Formulation of the 2D Models	23 24			
		3.2.2	Two Dimensional Finite Element Results				
		- · · · -	Versus Experimental Results	24			
		3.2.3	Strain Hardening Effect	27			
		3.2.4	Effect of Ovality, Eccentricity and Residual Stresses	28			

viii Contents

	3.3	Three Dimensional Finite Element Model						
		of Very Long Pipes						
		3.3.1 Formulation of a 3D Model for Very Long Pipes 29						
		3.3.2 Validation of the Finite Element Model 32						
		3.3.3 Pipes Under Bending Plus External Pressure						
	3.4	Three Dimensional Finite Element Model of Finite Pipes 39						
		3.4.1 Residual Stresses						
	3.5	Main Observations						
	Refe	rences						
4	Experimental Validation of the Finite Element Models.							
	Applications: Slotted Pipes and Axial Loads							
	4.1	Introduction						
	4.2	The Experimental Validation Program						
		4.2.1 Full-Scale Tests						
	4.3	Validation of the Finite Element Results						
		4.3.1 Numerical Results						
	4.4	Application: Validation for Slotted Pipes						
		4.4.1 Numerical Model						
		4.4.2 Numerical Results						
	4.5	Application: Collapse of Steel Pipes Under External Pressure						
		and Axial Tension						
	4.6	Main Observations						
		prences						
	1010	Actives						
5	Coli	Collapse and Post-Collapse Behavior of Deepwater Pipelines						
		Buckle Arrestors: Cross-Over Mechanisms						
	5.1	Introduction						
	5.2	Experimental Results						
		5.2.1 Experimental Set-up						
		5.2.2 Geometrical Characterization of the Tested Samples						
		5.2.3 Mechanical Characterization of the Tested Samples 7						
	5.3	The Finite Element Model						
	5.4	Validation of the Finite Element Results						
	٥	5.4.1 Exploring the Finite Element Model						
		5.4.2 Comparison Between the Finite Element						
		and Experimental Results						
	5.5	Main Observations						
		prences						
	Kell							
6		Conclusions						
	6.1	The Usage of 2D and 3D Models						
	6.2	Nonlinearities						
	63	Follower Loads 8						

ontents		ix
6.4	Material Modeling	89
6.5	Modeling of Residual Stresses	89
6.6	Code Verification and Model Validation	89
Refe	rences	90

91

Appendix: Imperfections Measuring System.....

Contents