

Contents

1	Introduction	1
	References	5
2	Shell Element Formulations for General Nonlinear Analysis. Modeling Techniques	9
2.1	Introduction	9
2.2	The Standard A-I-Z Quadrilateral Shell Element for Linear Analysis	10
2.2.1	Linear Analysis Kinematics	10
2.2.2	Stress-Strain Relations	13
2.2.3	The Locking Problem	14
2.2.4	Solving the Locking Problem	15
2.3	The MITC4 Quadrilateral Shell Element for Linear Analysis	15
2.4	Nonlinear Analysis Using the MITC4 Element	16
2.4.1	Infinitesimal Strains Problems: Total Lagrangean Formulation	16
2.4.2	Finite Strains	18
2.5	Modeling Considerations	19
2.5.1	The Nodal Director Vectors	19
2.5.2	Number of d.o.f. per Node	19
	References	20
3	Collapse and Post-Collapse Behavior of Steel Pipes. Finite Element Models	23
3.1	Introduction	23
3.2	Two Dimensional Finite Element Models of Very Long Pipes	23
3.2.1	Formulation of the 2D Models	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

3.3	Three Dimensional Finite Element Model of Very Long Pipes	28
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	33
3.4	Three Dimensional Finite Element Model of Finite Pipes	39
3.4.1	Residual Stresses	39
3.5	Main Observations	40
	References	41
4	Experimental Validation of the Finite Element Models.	
	Applications: Slotted Pipes and Axial Loads	43
4.1	Introduction	43
4.2	The Experimental Validation Program	43
4.2.1	Full-Scale Tests	45
4.3	Validation of the Finite Element Results	49
4.3.1	Numerical Results	49
4.4	Application: Validation for Slotted Pipes	56
4.4.1	Numerical Model	58
4.4.2	Numerical Results	59
4.5	Application: Collapse of Steel Pipes Under External Pressure and Axial Tension	64
4.6	Main Observations	67
	References	68
5	Collapse and Post-Collapse Behavior of Deepwater Pipelines with Buckle Arrestors: Cross-Over Mechanisms	71
5.1	Introduction	71
5.2	Experimental Results	72
5.2.1	Experimental Set-up	72
5.2.2	Geometrical Characterization of the Tested Samples	74
5.2.3	Mechanical Characterization of the Tested Samples	75
5.3	The Finite Element Model	75
5.4	Validation of the Finite Element Results	79
5.4.1	Exploring the Finite Element Model	79
5.4.2	Comparison Between the Finite Element and Experimental Results	81
5.5	Main Observations	85
	References	86
6	Conclusions	87
6.1	The Usage of 2D and 3D Models	87
6.2	Nonlinearities	88
6.3	Follower Loads	89

Contents	ix
6.4 Material Modeling	89
6.5 Modeling of Residual Stresses	89
6.6 Code Verification and Model Validation	89
References	90
Appendix: Imperfections Measuring System	91

Finite Element Analysis of the Collapse and
Post-Collapse Behavior of Steel Pipes: Applications to
the Oil Industry

Dvorkin, E.N.; Toscano, R.G.

2013, VII, 98 p. 81 illus., 66 illus. in color., Softcover

ISBN: 978-3-642-37360-2