

Contents

1	Introduction	1
1.1	Design Codes of Practice for Jacket Platforms	1
1.2	Geographic Region of Offshore Malaysia	3
1.3	Uncertainty	4
1.3.1	Uncertainty of Resistance	4
1.4	Uncertainty of Loads	5
1.5	Structural Safety and Reliability	6
1.5.1	Environmental Load Factor for Component and Joint	6
1.5.2	System Reliability and Environmental Load Factor	8
1.6	Bayesian Updating of Probability of Failure	8
1.7	Outline of the Chapters	9
	References	10
2	Past Developments	13
2.1	Design Codes of Practice for Jacket Platforms	13
2.1.1	API RP2A-WSD	14
2.1.2	API RP2A-LRFD/ISO 19902	15
2.1.3	Benefits of Limit State Design Code	15
2.1.4	Safety Factor	16
2.2	Geographic Region of Offshore Malaysia	17
2.2.1	History of Offshore Oil Production	17
2.2.2	Jacket Platform Design in Malaysia	18
2.3	Uncertainty	18
2.3.1	Uncertainty of Loads and Resistance	19
2.3.2	Basic Uncertainty	19
2.3.3	Sources of Uncertainty	20
2.3.4	Parameters of Uncertainty	21
2.3.5	Types of Resistance Uncertainty	22

2.4	Resistance Uncertainty-Background Study	24
2.4.1	Material Uncertainty.	25
2.4.2	Characteristic Resistance	26
2.4.3	Geometric Uncertainty	26
2.4.4	Resistance Model Uncertainty	26
2.4.5	Critical Review of Resistance Uncertainty.	27
2.5	Load Uncertainty	28
2.5.1	Load Uncertainty Parameters	28
2.5.2	Statistical Data Uncertainty for Environmental Load	29
2.5.3	Critical Analysis of Load Uncertainty	33
2.6	Environmental Load Modelling of Jacket Response	33
2.6.1	Environmental Load Uncertainty Model	33
2.6.2	Dead Load	34
2.6.3	Live Load	34
2.7	Structural Reliability	34
2.7.1	Reliability Levels	35
2.7.2	Parameters of Structural Reliability	35
2.7.3	Review of Structural Reliability Methods	39
2.8	Component Reliability and Previous Work	41
2.8.1	Component Reliability Index-critical Review	42
2.9	Resistance Factor	42
2.10	Joint Reliability and Previous Work.	42
2.10.1	Joint Reliability Index-critical Review.	43
2.11	Reliability and Environmental Load Factor	43
2.11.1	Code Calibration	44
2.12	Nonlinear Collapse Analysis	44
2.13	System Reliability and Reserve Strength Ratio (RSR)	45
2.13.1	Previous Work on System Reliability and Load Factors	46
2.13.2	System-based Environmental Load Factor-Critical Review	46
2.14	Assessment of Jacket	47
2.14.1	Bayesian Updating and Probability of Failure	47
2.14.2	Damaged Structural Members	48
2.14.3	Critical Review of Updating of Probability of Failure	48
2.15	Summary	49
	References	49

3	Research Applications	55
3.1	Introduction	55
3.2	Resistance Uncertainty for Jacket Platforms in Malaysia	56
3.2.1	Collection of Data for Resistance Parameters	56
3.2.2	Statistical Analysis of Geometric and Material Variables	58
3.2.3	Component and Joint Stress Model Uncertainty	59
3.3	Load Uncertainty for Offshore Jacket Platforms in Malaysia	62
3.3.1	ISO and Metocean Criteria	62
3.3.2	Environmental Load Uncertainty Parameters	63
3.3.3	Geographical Data for Environmental Load Parameters for Offshore Malaysia	66
3.3.4	Statistical Analysis of Environmental Load Parameters	66
3.3.5	Weibull Distribution	67
3.3.6	Gumbel Distribution	69
3.3.7	Environmental Load for SACS	71
3.4	Structural Reliability	72
3.4.1	Form	73
3.4.2	Monte Carlo Simulations for Determination of Probability of Failure	75
3.4.3	Selection of Jacket Platforms for Reliability Analysis	76
3.4.4	SACS Analysis	77
3.4.5	Load Ratios	79
3.4.6	Soil Conditions Effect on Component and Joint	80
3.5	Component Reliability	81
3.5.1	Single Stresses Case Study: Axial Tension	82
3.6	Joint Reliability	84
3.6.1	Target Reliability	85
3.7	Environmental Load Factor	85
3.8	Resistance Factor	85
3.9	System Reliability-Based Environmental Loads	85
3.9.1	SACS Collapse Module	86
3.9.2	Collapse Analysis of Jacket	87
3.9.3	SACS Load Model	88
3.9.4	SACS Jacket Model for Pushover Analysis	88
3.9.5	Wave and Current Loads in Malaysia	89
3.9.6	Curve Fitting	90
3.9.7	Safety Factor for Jacket System: API WSD and ISO 19902	90
3.9.8	Limit State Function for System Environmental Loading	92
3.9.9	Target System Probability of Failure	92

3.10	System-Based Environmental Load Factor	93
3.11	Assessment of Jacket Platform.	93
3.11.1	Uncertainty Model for Resistance and Load	94
3.11.2	Bayesian Updating of Probability of Failure-Intact Structure	94
3.11.3	Bayesian Updating of Probability of Failure-Damaged Structure	96
3.12	Summary	96
	References.	98
4	Uncertainty Modelling of Resistance.	101
4.1	Introduction	101
4.2	Resistance Uncertainty.	101
4.3	Statistical Properties of Fundamental Variable for Resistance.	102
4.3.1	Geometric Properties	103
4.3.2	Material Properties	106
4.4	Probabilistic Model Stresses Used in ISO Code 19902.	108
4.4.1	Component Stresses	109
4.4.2	Joint Stresses	112
4.5	Summary	123
	References.	124
5	Uncertainty Modelling of Load	125
5.1	Introduction	125
5.2	Load Factor and Uncertainty	125
5.3	Load Uncertainty	126
5.4	Wave and Current Directionality for Offshore Malaysia.	126
5.4.1	South China Sea	127
5.4.2	Wave	128
5.4.3	Current	130
5.5	Wave Load Models.	132
5.5.1	PMO Region.	132
5.5.2	SBO Region	134
5.5.3	SKO Region	136
5.5.4	Gulf of Mexico (GOM) and North Sea (NS)	137
5.6	Wind Load Model	139
5.6.1	PMO Region.	139
5.6.2	SBO Region	141
5.6.3	SKO Region	143
5.6.4	Gulf of Mexico (GOM) and North Sea (NS)	143
5.7	Current Load Model.	146
5.7.1	PMO Region.	146
5.7.2	SBO Region	146
5.7.3	SKO Region	147
5.7.4	Gulf of Mexico (GOM) and North Sea (NS)	150

5.8	Summary	152
	References	153
6	Tubular Strength Comparison of Offshore Jacket Structures Under API RP 2A and ISO 19902.	155
6.1	Introduction	155
6.2	Design Codes for Jackets	156
6.3	Numerical Analysis Background	159
6.4	Comparison of Tubular Strength Equations in Different Codes	159
6.4.1	Axial Tension	160
6.4.2	Axial Compression	161
6.4.3	Bending	166
6.4.4	Shear	167
6.4.5	Hydrostatic Pressure (Hoop Buckling)	167
6.4.6	Combined Stresses Without Hydrostatic Pressure	169
6.4.7	Combined Stresses with Hydrostatic Pressure	170
6.5	Summary	171
	References	172
7	Component Reliability and Environmental Load Factor	175
7.1	Introduction	175
7.2	Selection of Members	175
7.3	Component Target Reliability	177
7.4	Component Reliability Analysis	178
7.4.1	Code Stresses	178
7.4.2	Sensitivity Analysis	182
7.4.3	Effect of Variation of Environmental Load Factor	183
7.4.4	Effect of Column Slenderness Ratio	183
7.4.5	Calibration Points for Jackets	186
7.4.6	Selection of Environmental Load Factor	186
7.4.7	PMO Platform	187
7.4.8	SBO Platform	189
7.4.9	SKO Region	191
7.5	All Regions and All Components Combined Result	194
7.6	Resistance Factor	195
7.6.1	Axial Tension	195
7.6.2	Axial Compression	196
7.7	Summary	196
	References	197
8	Joint Reliability Analysis and Environmental Load Factor	199
8.1	Introduction	199
8.2	Selection of Joints	199

8.2.1	K-Joints	199
8.2.2	T/Y-Joints	202
8.2.3	X-Joints	203
8.3	Beta Factor (β) Effects (d/D) on Reliability Index.	206
8.3.1	K-Joints	206
8.3.2	T/Y-Joints	206
8.3.3	X-Joints	208
8.4	Gamma Factor (γ) Effects (D/2T)	209
8.4.1	K-Joints: Tension/Compression	210
8.4.2	T/Y-Joints	211
8.4.3	X-Joints	212
8.5	Variation of Environmental Load Factor	214
8.6	Calibration of API (WSD) and ISO (LRFD) Reliability Index.	215
8.7	Environmental Load Factor	216
8.7.1	PMO Region Platform	216
8.7.2	SBO Region Platform.	217
8.7.3	SKO Region	219
8.8	All Regions and All Joints Combined Result.	222
8.9	Summary	223
	References.	223
9	System Reliability-Based Environmental Loading	225
9.1	Introduction	225
9.2	System Strength Reliability	225
9.2.1	Wave and Current	226
9.2.2	Curve Fitting.	226
9.2.3	Selection of RSR for Jackets in Malaysia	230
9.3	System Environmental Load Factor.	232
9.4	Summary	239
	References.	239
10	Extension of Life of Jacket Platforms	241
10.1	Introduction	241
10.2	Collapse Analysis of Jacket	241
10.2.1	Wave Effect on Collapse Load	242
10.2.2	Directional Base Shear.	243
10.2.3	Wave Directional Effects on Collapse Base Shear.	243
10.2.4	System Redundancy	248
10.3	Updating the Probability of Failure	248
10.3.1	Sensitivity Analysis	248
10.3.2	Bayesian Updating the Probability of Failure	252
10.3.3	Bayesian Updating Probability of Failure with Damaged Members	257
10.4	Summary	262
	References.	262

11	Conclusions and Recommendations	263
11.1	Uncertainty	263
11.1.1	(a) Resistance Uncertainty	263
11.1.2	(b) Environmental Load Uncertainty	264
11.2	Load Factors	264
11.2.1	Component Reliability and Environmental Load Factor	264
11.2.2	Joint Reliability and Joint-based Environmental Load Factor	264
11.2.3	System-based Environmental Load Factor	265
11.3	Bayesian Updating of Probability of Failure for Reassessment	265
11.4	Future Work	265
11.5	Time Variant Reliability	266
11.6	Accidental Limit State	266
11.7	Operational Condition Reliability	266
11.8	Structural Reliability of Floaters	266
11.9	Environmental Load Parameter Modelling	266
11.10	Reassessment of Jacket	267
11.11	Bayesian Updating Due to Change of Conditions	267
11.12	Reliability of Offshore Mooring Foundations	267
	References	267
Appendix A: Tubular Member API WSD and ISO 19902		
	Code Provisions	269
Appendix B: Tubular Joints API WSD and ISO 19902		
	Code Provisions	271
Appendix C: MATLAB Programing		273
Appendix D: Load Ratios		289
Appendix E: Wave Load Against Corresponding Base Shear in 8 Directions at SBO, SKO1, SKO2 and SKO2a Jacket Platforms		291
Appendix F: Evaluation of RSR of 1.0 and System Redundancy		303
Glossary of Useful Terms		335

Environmental Load Factors and System Strength
Evaluation of Offshore Jacket Platforms

Nizamani, Z.

2015, XXII, 335 p. 296 illus., Hardcover

ISBN: 978-3-319-15050-5