

Contents

PREFACE	v
CREDITS	vii
LIST OF SYMBOLS	ix
1. Flow around a cylinder in steady current	
1.1 Regimes of flow around a smooth, circular cylinder	1
1.2 Vortex shedding	6
1.2.1 Vortex-shedding frequency	10
1.2.2 Correlation length	28
References	33
2. Forces on a cylinder in steady current	
2.1 Drag and lift	37
2.2 Mean drag	40
2.3 Oscillating drag and lift	50
2.4 Effect of cross-sectional shape on force coefficients	52
2.5 Effect of incoming turbulence on force coefficients	53
2.6 Effect of angle of attack on force coefficients	55
2.7 Forces on a cylinder near a wall	57
References	70
3. Flow around a cylinder in oscillatory flows	
3.1 Flow regimes as a function of Keulegan-Carpenter number ..	74
3.2 Vortex-shedding regimes	78
3.3 Effect of Reynolds number on flow regimes	89
3.4 Effect of wall proximity on flow regimes	92
3.5 Correlation length	104
3.6 Streaming	116
References	120

4. Forces on a cylinder in regular waves

4.1	In-line force in oscillatory flow	123
4.1.1	Hydrodynamic mass	124
4.1.2	Froude-Krylov force	129
4.1.3	The Morison equation	130
4.1.4	In-line force coefficients	133
4.1.5	Goodness-of-fit of the Morison equation	147
4.2	Lift force in oscillatory flow	149
4.3	Effect of roughness	153
4.4	Effect of coexisting current	157
4.5	Effect of angle of attack	161
4.6	Effect of orbital motion	163
4.6.1	Vertical cylinder	163
4.6.2	Horizontal cylinder	169
4.7	Forces on a cylinder near a wall	180
4.8	Forces resulting from breaking-wave impact	187
	References	201

5. Mathematical and numerical treatment of flow around a cylinder

5.1	Direct solutions of Navier-Stokes equations	210
5.1.1	Governing equations	211
5.1.2	The Oseen (1910) and Lamb (1911) solution	211
5.1.3	Numerical solutions	219
5.1.4	Application to oscillatory flow	227
5.2	Discrete vortex methods	233
5.2.1	Numerical simulation of vorticity transport	234
5.2.2	Procedure used in the implementation of discrete vortex method	237
5.2.3	Application areas	242
5.3	Hydrodynamic stability approach	248
	References	266

6. Diffraction effect. Forces on large bodies

6.1	Vertical circular cylinder	276
6.1.1	Analytical solution for potential flow around a vertical circular cylinder	276
6.1.2	Total force on unit-height of cylinder	282
6.1.3	Total force over the depth and the overturning moment	287
6.2	Horizontal circular cylinder near or on the seabottom. Pipelines	289
	References	295

7. Forces on a cylinder in irregular waves

7.1	Statistical treatment of irregular waves	297
7.1.1	Statistical properties of surface elevation	298
7.1.2	Statistical properties of wave height	312
7.1.3	Statistical properties of wave period	315
7.1.4	Long-term wave statistics	318
7.2	Forces on cylinders in irregular waves	319
7.2.1	Force coefficients	319
7.2.2	Force spectra	325
7.2.3	Forces on pipelines in irregular waves	328
7.2.4	Forces on vertical cylinders in directional irregular waves	330
	References	330

8. Flow-induced vibrations of a free cylinder in steady currents

8.1	A summary of solutions to vibration equation	335
8.1.1	Free vibrations without viscous damping	336
8.1.2	Free vibrations with viscous damping	336
8.1.3	Forced vibrations with viscous damping	338
8.2	Damping of structures	342
8.2.1	Structural damping	342
8.2.2	Fluid damping in still fluid	346
8.3	Cross-flow vortex-induced vibrations of a circular cylinder	353
8.3.1	Feng's experiment	354
8.3.2	Non-dimensional variables influencing cross-flow vibrations	364
8.4	In-line vibrations of a circular cylinder	376
8.5	Flow around and forces on a vibrating cylinder	383
8.5.1	Cylinder oscillating in the cross-flow direction	383
8.5.2	Cylinder oscillating in in-line direction	396
8.6	Galloping	397
8.7	Suppression of vibrations	407
	References	413

9. Flow-induced vibrations of a free cylinder in waves

9.1	Introduction	418
9.2	Cross-flow vibrations	421
9.2.1	General features	423
9.2.2	Effect of mass ratio and stability parameter	432
9.2.3	Effect of Reynolds number and surface roughness	432
9.2.4	Cross-flow vibrations in irregular waves	436
9.3	In-line vibrations	441
9.4	In-line oscillatory motion	443
9.5	Flow around and forces on a vibrating cylinder	445
	References	450

10. Vibrations of marine pipelines	
10.1 Cross-flow vibrations of pipelines	455
10.1.1 Cross-flow vibrations of pipelines in steady current	455
10.1.2 Cross-flow vibrations of pipelines in waves	465
10.2 In-line vibrations and in-line motions of pipelines	471
10.3 Effect of Reynolds number	473
10.4 Effect of scoured trench	479
10.5 Vibrations of pipelines in irregular waves	481
10.6 Effect of angle of attack	486
10.7 Forces on a vibrating pipeline	486
References	491
11. Mathematical modelling of flow-induced vibrations	
11.1 The steady-current case	497
11.1.1 Simple models	497
11.1.2 Flow-field models	499
11.2 The wave case	503
11.3 Integrated models	506
References	510
APPENDIX I. Force coefficients for various cross-sectional shapes	514
APPENDIX II. Hydrodynamic-mass coefficients for two- and three- dimensional bodies	517
APPENDIX III. Small amplitude, linear waves	519
REFERENCES FOR APPENDICES	521
AUTHOR INDEX	522
SUBJECT INDEX	527