

CONTENTS

<i>Preface</i>	<i>xi</i>
1 Description of random seas	1
1.1 Stochastic concept as applied to ocean waves	1
1.1.1 Introduction	1
1.1.2 Ocean waves as a Gaussian random process	2
1.1.3 Random seas	4
1.2 Mathematical presentation of random waves	8
1.3 Stochastic prediction of wave characteristics	9
2 Spectral analysis	13
2.1 Spectral analysis of random waves	13
2.1.1 Fundamentals of stochastic processes	13
2.1.2 Auto-correlation function	15
2.1.3 Spectral density function (spectrum)	16
2.1.4 Wiener–Khintchine theorem	18
2.1.5 Spectral analysis of two wave records	19
2.1.6 Wave-number spectrum	22
2.1.7 Wave velocity and acceleration spectra	25
2.2 Characteristics of wave spectra	26
2.3 Wave spectral formulations	33
2.3.1 Pierson–Moskowitz spectrum	33
2.3.2 Two-parameter spectrum	35
2.3.3 Spectral formulation as a function of ω^{-5}	36
2.3.4 Six-parameter spectrum	39
2.3.5 JONSWAP spectrum	42
2.3.6 TMA spectrum	48
2.4 Modification of wave spectrum for moving systems	50
2.5 Higher-order spectral analysis	52
3 Wave amplitude and height	58
3.1 Introduction	58
3.2 Probability distribution of amplitudes with narrow-band spectrum	60
3.2.1 Derivation of probability density function	60
3.2.2 Wave envelope process	64

viii CONTENTS

3.3	Probability distribution of wave maxima with non-narrow-band spectrum	66
3.4	Joint distribution of two wave amplitudes	73
3.5	Probability distribution of peak-to-trough excursions (wave height)	78
3.6	Significant wave height	81
3.7	Probability distribution of half-cycle excursions	84
3.8	Long-term wave height distribution	88
3.9	Statistical analysis of amplitude and height from wave records	91
3.9.1	Introduction	91
3.9.2	Maximum likelihood estimation	92
3.9.3	Estimation of Rayleigh distribution parameter from a small number of observations	95
3.9.4	Goodness-of-fit tests	99
4	Wave height and associated period	103
4.1	Introduction	103
4.2	Joint probability distribution of wave height and period	104
4.3	Joint probability distribution of positive maxima and time interval	110
4.4	Probability distribution of wave period	114
4.5	Joint probability distribution of wave height and direction of wave energy travel	118
5	Sea severity	123
5.1	Statistical presentation of sea severity	123
5.1.1	Probability distribution of significant wave height	123
5.1.2	Joint probability distribution of significant wave height and period	130
5.1.3	Time series analysis of sea state data	135
5.2	Hurricane-associated seas	137
5.2.1	Introduction	137
5.2.2	Sea severity measured during hurricanes	138
5.2.3	Wave spectra and wave height in hurricane-generated seas	141
6	Estimation of extreme wave height and sea state	149
6.1	Basic concept of extreme values	149
6.2	Probable and design extreme wave height	151
6.3	Estimation of extreme wave height and sea state from data	159
6.4	Extreme wave height in a non-stationary sea state	164
6.5	Asymptotic distributions of largest waves and sea states	165
6.5.1	Type I asymptotic extreme value distribution	167
6.5.2	Type III asymptotic extreme value distribution	170

CONTENTS

ix

7 Directional characteristics of random seas	175
7.1 Introduction	175
7.2 Principle of evaluation of directional wave spectra	176
7.2.1 Wave probe array	176
7.2.2 Floating buoys	180
7.2.3 Pressure and current meters	188
7.3 Analysis of directional energy spreading function	190
7.4 Estimation of directional energy spreading from data	196
7.4.1 Maximum likelihood method	196
7.4.2 Maximum entropy method	207
7.4.3 Application of a Bayesian method	212
7.5 Formulation of the wave energy spreading function	216
8 Special wave events	218
8.1 Breaking waves	218
8.1.1 Wave breaking criteria	218
8.1.2 Probability of occurrence of wave breaking	222
8.1.3 Energy loss resulting from wave breaking	229
8.2 Group waves	232
8.2.1 Introduction	232
8.2.2 Statistical properties through the envelope process approach	235
8.2.3 Statistical properties through the Markov chain approach	246
8.3 Freak waves	252
9 Non-Gaussian waves (waves in finite water depth)	255
9.1 Introduction	255
9.2 Probability distribution of non-Gaussian waves	257
9.2.1 Gram–Charlier series distribution	257
9.2.2 Distribution based on Stokes waves	265
9.2.3 Distribution based on the concept of nonlinear system	269
9.3 Probability distribution of peaks and troughs	275
9.4 Transformation from Gaussian to non-Gaussian waves	280
Appendix A. Fundamentals of probability theory	283
Appendix B. Fundamentals of stochastic process theory	294
Appendix C. Fourier transform and Hilbert transform	300
<i>References</i>	304
<i>Index</i>	317