

# Contents

<b>Preface</b>	<b>ix</b>
<b>Symbols</b>	<b>xi</b>
<b>1 Introduction</b>	<b>1</b>
<b>2 Wind Climate</b>	<b>5</b>
2.1 Meteorological Classification	5
2.2 Global Atmospheric Circulation	6
2.3 Geostrophic Wind and Gradient Wind	11
2.4 Thermally Generated Secondary Circulation (Typhoons)	15
2.5 Local Weather Systems	16
<b>3 The Atmospheric Boundary Layer—Natural Wind</b>	<b>19</b>
3.1 Turbulent Wind	19
3.2 Mean Wind Velocity—Wind Profile	24
3.3 Inhomogeneous Terrain	31
3.4 Extreme Winds	33
3.5 Wind Turbulence	38
3.5.1 Standard deviation of the turbulence components	38
3.5.2 Time scales and integral length scales	39
3.5.3 Power-spectral density function	41
3.5.4 Correlation between turbulence at two points	44
3.5.5 Wind turbulence according to Eurocode 1	48
<b>4 Static Wind Load</b>	<b>49</b>
4.1 Extreme Static Load	49
4.2 Wind Load on Buildings	50
4.3 Wind Load at a Surface Point—A Mathematical Description	55

4.4	Total Wind Load on a Structure—Davenport's Model	56
4.5	Aerodynamic Admittance Function	61
4.5.1	Normalized co-spectrum of surface pressures	61
4.5.2	Line-like areas	62
4.5.3	Rectangular areas	64
4.6	Peak Factor for a Gaussian Process	66
4.7	Internal Wind Load	68
4.8	Static Wind Load According to Eurocode 1	68
4.8.1	Wind pressures	68
4.8.2	Global wind forces	70
4.8.3	Size-effect factor	73
<b>5</b>	<b>Along-wind Response, SDOF Structures</b>	<b>75</b>
5.1	Equivalent Static Load and Dynamic Response	75
5.2	Wind Load on Point-like Structures	76
5.3	Wind Load on Large Structures	77
5.4	Gust Response Factor	78
<b>6</b>	<b>The Along-wind Response of Bluff Bodies</b>	<b>79</b>
6.1	Assumptions	79
6.2	Joint Acceptance Functions and Size Reduction Functions	81
6.3	Extreme Structural Response	81
6.4	Response of Line-like Structures	82
6.4.1	Mean response	83
6.4.2	Background turbulent response	84
6.4.3	Resonant turbulent response	87
6.5	Response of Plate-like Structures	91
6.5.1	Mean response	91
6.5.2	Background turbulent response	92
6.5.3	Resonant turbulent response	94
6.5.4	Modes with constant signs	95
6.5.5	Modes with changing signs	96
6.6	Design Procedures	97
6.6.1	Design procedure for mode shapes with constant sign	98
6.6.2	Design procedure for mode shapes with changing sign	102
6.6.3	Structures with complicated mode shapes	104
6.7	Discussion of Eurocode 1	106
<b>7</b>	<b>Cross-wind Vibrations Induced by Vortex Shedding</b>	<b>109</b>
7.1	Physical Background	110
7.2	Vortex Shedding on a Nominally Stationary Structure	113
7.3	Crosswind Loading Caused by Structural Motion	116

7.4	Vortex Shedding Response Based on the Spectral Model	121
7.4.1	Spectral vortex shedding response	121
7.4.2	The Canadian code NBC 1990	124
7.4.3	The CICIND model code	126
7.4.4	Comparison of predicted and observed responses—concrete chimneys	127
7.5	Vortex Shedding Response Based on the Vortex Resonance Model	128
7.5.1	Vortex resonance response	128
7.5.2	Eurocode 1	130
7.5.3	Comparison between predicted and observed response—steel structures	132
7.6	Design	135
7.7	Reduction of Vortex-induced Vibrations	136
7.8	Example: A Steel Chimney 60 Metres Tall	137
<b>8</b>	<b>Wind Load on Bridges</b>	<b>143</b>
8.1	Mean Wind Load on Bridge Decks	145
8.2	Motion-induced Wind Load	147
8.2.1	Bridge-deck sections	148
8.2.2	Modal loads	149
8.2.3	Aerodynamic derivatives	150
8.2.4	Natural frequencies and damping ratios in wind	153
8.3	Buffeting Vibrations	155
8.4	Coupled Flutter Vibrations	161
8.5	Flutter Vibrations of Suspension Bridges During Construction	166
8.6	Eurocode 1 Clauses on Bridges	172
<b>9</b>	<b>Galloping</b>	<b>173</b>
<b>10</b>	<b>Wind-tunnel Testing</b>	<b>177</b>
10.1	Model Laws	178
10.1.1	Froude's model law	180
10.1.2	Reynolds' model law	180
10.1.3	Jensen's model law	183
10.2	Wind-tunnel Technique	186
<b>Appendix A</b>	<b>Random Variables and Stochastic Processes</b>	<b>191</b>
A.1	One Random Variable	191
A.2	Two Random Variables	194
A.3	Stochastic Processes	196
A.4	Threshold Crossings and Extreme Values	202

<b>Appendix B</b>	<b>Calculation of Multiple Integrals</b>	<b>207</b>
<b>Appendix C</b>	<b>Vibrations of Linear Structures</b>	<b>211</b>
	C.1 Orthogonality of Mode Shapes	211
	C.2 Equation of Motion	213
	C.3 Response to External Loading	213
<b>Appendix D</b>	<b>Solving Flutter Equations</b>	<b>217</b>
	<b>References</b>	<b>221</b>
	<b>Index</b>	<b>227</b>