

Contents

Introduction	1
1 Evolution of Cable Supported Bridges	7
2 Cables	85
2.1 Basic Types of Cables	85
2.1.1 Helical bridge strands (spiral strands)	85
2.1.2 Locked-coil strands	87
2.1.3 Parallel-wire strands for suspension bridge main cables	88
2.1.4 New PWS stay cables	90
2.1.5 Parallel-strand stay cables	91
2.1.6 Bar stay cables	93
2.1.7 Multi-strand stay cables	94
2.1.8 Parallel-wire suspension bridge main cables	97
2.1.9 Comparison between different cable types	101
2.2 Corrosion Protection	102
2.2.1 Suspension bridge main cables	102
2.2.2 Stay cables	105
2.3 Mechanical Properties	109
2.3.1 Static strength	109
2.3.2 Relaxation	111
2.3.3 Fatigue strength	111
2.3.4 Hysteresis of helical strands	113
2.4 The Single Cable as a Structural Element	115
2.4.1 Transversally loaded cable	115
2.4.2 Axially loaded cable	126
2.5 Static Analysis of Cables	131
2.5.1 Equation of state for a cable subjected to vertical load	132
2.5.2 Stay cable under varying chord force	135
2.5.3 Limit length and efficiency ratio of a stay cable	143
2.6 Bending of Cables	148
2.7 Dynamic Behaviour of the Single Cable	157

3	Cable System	165
3.1	Introduction	165
3.1.1	Pure cable systems	165
3.1.2	Cable steel quantity comparison	170
3.1.3	Stability of the cable system	173
3.2	Suspension System	179
3.2.1	Dead load geometry	179
3.2.2	Preliminary cable dimensions	180
3.2.3	Quantity of cable steel	182
3.2.4	Quantity in the pylon	184
3.2.5	Total cost of cable system and pylon	185
3.2.6	Optimum pylon height	185
3.2.7	Size effect	187
3.2.8	Structural systems	188
3.3	Fan System	202
3.3.1	Anchor cable	202
3.3.2	Preliminary cable dimensions	205
3.3.3	Quantity of cable steel	206
3.3.4	Quantity in the pylon	208
3.3.5	Simplified expressions	208
3.3.6	Total cost of cable systems and pylons	209
3.3.7	Comparison between suspension and fan system	209
3.3.8	Inclined pylons	210
3.3.9	Deformational characteristics	213
3.3.10	Structural systems	217
3.3.11	Reduction of sag variations	221
3.4	Harp System	222
3.4.1	Dead load geometry	225
3.4.2	Intermediate supports	226
3.4.3	Preliminary cable dimensions	227
3.4.4	Quantity of cable steel	229
3.4.5	Quantity of the pylon	229
3.4.6	Simplified expressions	231
3.4.7	Total cost	231
3.4.8	Structural systems	231
3.5	Hybrid Suspension and Cable Stayed System	235
3.6	Multi-Span Cable System	239
3.6.1	True multi-span cable supported bridges	241
3.6.2	Non-traditional multi-span suspension bridges	246
3.6.3	Fixing of column-type pylons to piers	249
3.6.4	Triangular pylon structures	250
3.6.5	Horizontal tie cable between pylon tops	258
3.6.6	Comparison between deflections of different multi-span cable stayed systems	261
3.7	Cable Systems under Lateral Loading	265
3.8	Spatial Cable Systems	272
3.9	Oscillation of Cable Systems	278
3.9.1	Global oscillations	278
4	Deck (Stiffening Girder)	287
4.1	Action of the Deck	287
4.1.1	Axial stiffness	287

4.1.2	Flexural stiffness in the vertical direction	287
4.1.3	Flexural stiffness in the transverse direction	289
4.1.4	Torsional stiffness	291
4.2	Supporting Conditions	291
4.3	Distribution of Dead Load Moments	299
4.3.1	The dead load condition	302
4.4	Cross Section	310
4.4.1	Bridge floor	310
4.4.2	Cross section of the deck	310
4.4.3	Cross section of stiffening trusses	328
4.5	Partial Earth Anchoring	339
4.5.1	Limit of span length for self-anchored cable stayed bridges	343
4.5.2	Axial compression in the deck of the self anchored cable stayed bridge	344
4.5.3	Lateral bending of the deck	346
4.5.4	Partial earth anchoring of a cable stayed bridge	346
4.5.5	Improving the lateral stability	348
4.5.6	Construction procedure for partially earth anchored cable stayed bridges	349
5	Pylons	353
5.1	Introduction	353
5.2	Structural Behaviour of the Pylon	353
5.3	Pylons Subjected Primarily to Vertical Forces from the Cable System	367
5.4	Pylons Subjected to Longitudinal Forces from the Cable System	399
5.5	Cross Section	405
6	Cable Anchorage and Connection	413
6.1	Anchoring of the Single Strand	413
6.2	Connection between Cable and Deck	427
6.3	Connection between Main Cable and Hanger	433
6.4	Connection between Cable and Pylon	442
6.5	Connection between Cable and Anchor Block	452
7	Erection	463
7.1	Introduction	463
7.2	Construction of Pylons	463
7.3	Erection of Suspension Bridge Main Cables	472
7.4	Erection of Stay Cables	486
7.5	Deck Erection - Earth Anchored Suspension Bridges	489
7.6	Deck Erection - Self Anchored Cable Stayed Bridges	501
8	Aerodynamics	517
8.1	Historical Overview	517
8.1.1	Nineteenth-century bridge failures	517
8.1.2	Tacoma Narrows Bridge collapse	517
8.1.3	The Carmody Board	520
8.1.4	The Fykkesund Bridge	520
8.2	The Bridge Deck and Pylon	520
8.2.1	Torsional divergence	520
8.2.2	Coupled flutter	524
8.2.3	Buffeting	526

8.2.4	Vortex-shedding	531
8.2.5	Wind tunnel testing	532
8.2.6	During construction	537
8.2.7	Effects of vehicles	538
8.2.8	Pylon aerodynamics	538
8.2.9	Vibration control	541
8.2.10	Future trends	543
8.3	Cables	544
8.3.1	Introduction	544
8.3.2	Incidences of wind-induced cable vibrations	544
8.3.3	Rain-wind-induced vibrations	545
8.3.4	Dry galloping	546
8.3.5	Scruton number	549
8.3.6	Wake galloping	550
8.3.7	Aerodynamic countermeasures	551
8.3.8	Mechanical damping	583
8.3.9	Cable aerodynamic damping	557
8.3.10	Cross ties	557
9	Particular Issues	559
9.1	Pedestrian-Induced Vibrations	559
9.1.1	Lateral vibrations	559
9.1.2	Vertical vibrations	562
9.1.3	Serviceability limit states	565
9.1.4	Vibration control	567
9.2	Seismic Design	568
9.2.1	Earthquake intensity	569
9.2.2	Pylon design	569
9.2.3	Deck design	571
9.2.4	Foundations	571
9.2.5	Seismic analysis	572
9.3	Structural Health Monitoring	573
9.3.1	Equipment	573
9.4	Snow and Ice Removal and Prevention Systems	575
9.4.1	Mechanical removal	575
9.4.2	Thermal systems	577
9.4.3	Passive protection	577
	References	579
	Index	587