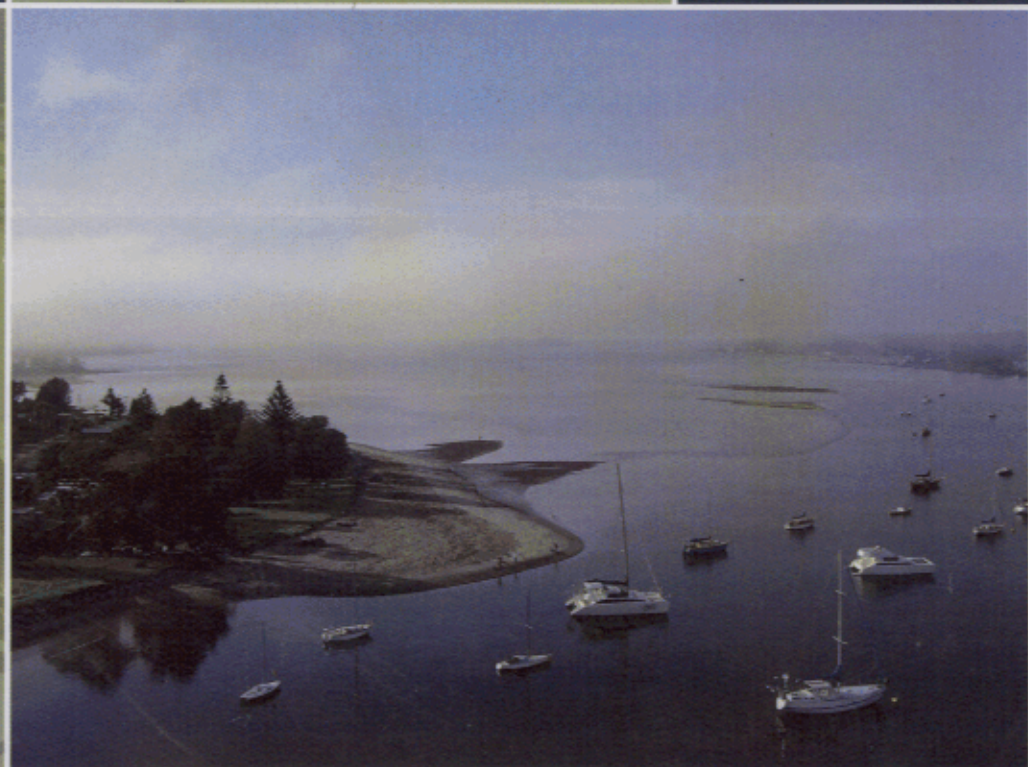




Fundamental Structural Analysis for Design



Brett Lemass
and
Anne Gardner

Table of Contents

Chapter		Page
1	DESIGN and ANALYSIS FUNDAMENTALS	1
1.1	The Design and Analysis Paradox	1
1.2	The Design Scenario - An Overview	2
1.3	The Design Process	3
1.3.1	<i>A Synthesised Design Process Model</i>	4
1.4	Design Process Components	5
1.4.1	<i>Conceptual Design</i>	5
1.4.2	<i>Detailed Design</i>	6
1.5	Fundamental Load Concepts	7
1.5.1	<i>Bateman's Bay Bridge Loading Data</i>	7
1.5.2	<i>Loads (forces)</i>	7
1.5.3	<i>Load Types</i>	9
1.5.4	<i>Types of Structural Action and Deformation</i>	13
1.5.5	<i>Load Paths</i>	14
2	STATIC EQUILIBRIUM FOR DESIGN	16
2.1	Static Equilibrium	16
2.2	Translational Equilibrium in 2-D	16
	<i>Example 1: 2-D Translational Equilibrium Problem Solving</i>	19
2.3	Translational Equilibrium in 3-D	20
2.4	Rotational Equilibrium	21
2.4.1	<i>External and Internal Moments</i>	23
2.5	Force Couple Moments	24
	<i>Example 2: Equating Moments for Problem Solving</i>	25
2.6	Structural Supports	27
2.7	Determinate And Indeterminate Structures	29
	<i>Example 3: Problem Solving for 2-D Reactions</i>	30
2.8	Internal Pins	34
	Discussion Exercises	35

3	MEMBER DESIGN FOR AXIAL LOADS	37
3.1	Trusses	37
3.2	Truss Stability and Determinacy	39
3.3	Analysis Of Trusses	41
3.3.1	<i>The Method Of Joints</i>	41
	<i>Example 4: Bateman's Bay Bridge Method of Joints Analysis</i>	42
3.3.2	<i>The Method Of Sections</i>	47
	<i>Example 5: Bateman's Bay Bridge Method of Sections Analysis</i>	47
3.4	Stress, Buckling and Deflection	49
3.4.1	<i>Stress</i>	49
	<i>Example 6: Bateman's Bay Bridge Tension Member Design</i>	50
3.4.2	<i>Strain</i>	51
3.4.3	<i>Relating Stress And Strain - Hooke's Law</i>	52
3.4.4	<i>Deflection Of Struts And Ties</i>	53
	<i>Example 7: Bateman's Bay Bridge Tension Member Deflection</i>	53
3.4.5	<i>The Buckling Strength Of Compression Members</i>	54
	<i>Example 8: Bateman's Bay Bridge Compression Member Design</i>	55
4	MEMBER DESIGN FOR SHEAR AND BENDING	58
4.1	Load Paths In Beams	58
4.2	Shear Force And Bending Moment Sign Conventions	59
4.3	How To Draw Shear Force Diagrams	60
	<i>Example 9: SFD for Bateman's Bay Bridge Cross Girder Point Loads</i>	61
4.4	How To Draw Bending Moment Diagrams	62
	<i>Example 10: BMD for Bateman's Bay Bridge Cross Girder Point Loads</i>	62
4.5	Relating Load, Shear Force And Bending Moment	64
	<i>Example 11: Complete SFD and BMD for Bateman's Bay Bridge Cross Girder</i>	65
4.6	Bending Stress	67
4.6.1	<i>Beam Bending</i>	67
4.7	Beam Bending Stress	71
	<i>Example 12: Conceptual Design of Bateman's Bay Bridge Stringers and Cross Girders (Simply Supported Assumption)</i>	72
4.8	Simplifying The Second Moment Of Area (I) for Rectangular Cross-Sections	75
	<i>Example 13: Conceptual Design of Bateman's Bay Bridge Box Girders (Stage 1)</i>	76
	Discussion Exercises	78

5	FROM STRENGTH to SERVICEABILITY DESIGN	82
5.1	Finding The Neutral Axis	82
5.2	The Parallel Axis Theorem	83
	<i>Example 14: Conceptual Design of Bateman's Bay Bridge</i>	
	Box Girders (Stage 2)	84
5.3	Deflection Of Beams	89
5.3.1	<i>Deflection Of Beams - Direct Integration</i>	89
	<i>Example 15: Deflection of Simply Supported UDLs by Direct Integration</i>	
	(Bateman's Bay Bridge Stringer Application)	90
5.3.2	<i>Beam Deflections Using Singularity Functions (Macauley's Method)</i>	92
	<i>Example 16: Deflection of Concentrated Loads by Macauley's Method</i>	
	(Bateman's Bay Bridge Stringer Application)	93
	Discussion Exercises	96
6	CONVERGENCE HEURISTICS for DESIGN and ANALYSIS	97
6.1	The Need For Design/Analysis Convergence	97
6.2	Heuristic Knowledge	97
6.3	Steel Design Sizing Heuristics	98
6.4	Reinforced Concrete Design Sizing Heuristics	100
6.5	Approximate Conceptual Analysis Techniques	102
6.6	Approximate Quantitative Analysis	103
6.6.1	<i>Vertical Loads On Rigid Building Frames</i>	103
	<i>Example 17: Conceptual Design of Bateman's Bay Bridge Stringers</i>	
	(Rigidly Supported Assumption)	104
6.6.2	<i>Lateral Loads On Rigid Portal Frames</i>	106
6.6.3	<i>Lateral Loads On Rigid Building Frames</i>	107
6.6.4	<i>Trusses With Two Diagonals In Each Panel</i>	108
	<i>Example 18: Conceptual Wind Load Design of Bateman's Bay Bridge</i>	
	(Lower Lateral Bracing Diagonals)	110
	APPENDIX A (Competency Exercises)	113
	REFERENCES	145