

TABLE OF CONTENTS.

	PAGE.
INTRODUCTION	■
PART I. THE DESIGN OF RETAINING WALLS.	
Semi-fluids	3
Retaining Walls	4
Rankine's Theory	5
Coulomb's Theory	5
Weyrauch's Solution	6
Cain's Solution	6
Rebhann's Solution	6
Trautwine's Solution	6
Nomenclature	7
CHAPTER I. RANKINE'S THEORY.	
Ellipse of Stress	8
Case 1	10
Case 2	11
Case 3	12
Equation of	15
Angle of Repose	17
Vertical Retaining Wall without Surcharge	18
Vertical Retaining Wall with Surcharge	18
Inclined Retaining Wall	22
Foundations in Earth	26
CHAPTER IA. RANKINE'S THEORY MODIFIED.	
Introduction	28
Rankine's Solution Modified	28

Values of j	34
Values of k	35
Values of M	37

CHAPTER II. COULOMB'S THEORY.

Algebraic Method	40
Graphic Method	44
Wall with Loaded Filling	45
Surcharge Negative	47
Cain's Formulas	48
Values of k	50
Values of M	52

CHAPTER III. DESIGN OF MASONRY RETAINING WALLS.

Center of pressure	54
• Stability of Retaining Walls	55
Overturning	55
Sliding	55
Crushing	56
General Principles of Design	58
Problem 1	60
Problem 2	63
Problem 3	68
Empirical Method	70
Trautwine's Rules	71
Value of Empirical Rules	72
Data	73
Specifications for Concrete Retaining Walls	74

CHAPTER IV. REINFORCED CONCRETE RETAINING WALLS.

Introduction	78
General Principles of Design	78
Proportions of Wall	78
Materials	79

Working Stresses	79
Spacing of Bars	80
Length of Bar to Imbed in Concrete	80
Expansion and Contraction	80
Design of Reinforced Concrete Retaining Walls	81
Problem 1	82
Problem 2	91
Examples of Retaining Walls	102
C. M. & St. P. R. R. Walls	102
Reclamation Service Walls	104
Pittsburg, Pa., Walls	108
Illinois Central R. R. Walls	110
Corrugated Bar Co. Walls	114
Specifications	115

CHAPTER IV_A. EFFECT OF COHESION. — STRESSES IN BRACING OF
TRENCHES. — STRESSES IN TUNNELS.

Effect of Cohesion	116
Stresses in Bracing of Trenches	117
Pressure on Sewers	120
Temporary Retaining Walls	120
Pressures on Tunnels	121

CHAPTER V. EXPERIMENTS ON RETAINING WALLS.

Experiments by M. M. L. Leygue	123
Experiments by Sir Benjamin Baker	123
Experiments by E. P. Goodrich	124
Internal Friction	126
Compressibility of Solids	127
Prof. Wm. Cain's Discussion of Experiments	127
Criticisms of Theoretical Investigations	129
Author's Conclusions	130

CHAPTER VI. EXAMPLES OF RETAINING WALLS.

Concrete Retaining Wall, Illinois Central R. R. Chicago, Ill.	132
Retaining Walls for Detroit Tunnel	133
Retaining Wall in Pennsylvania Ave. Subway, Philadelphia, Pa. . .	134
Retaining Wall at Black Lick, O.	137
Retaining Walls, New York Central Terminal, New York, N. Y. .	138
Retaining Walls, C. B. & Q. Ry., Galesburg, Ill.	140
Retaining Walls, Rapid Transit Tunnel, Philadelphia, Pa.	140
Retaining Wall at Bridge 123, Great Northern Ry.	142
Hennebique System Retaining Wall	143
Retaining Walls, Railway Terminal Station, Atlanta, Ga.	145
Examples of 27 Plain Gravity Walls	Folding Insert.
Retaining Wall for West Alameda Ave. Subway, Denver, Colo. .	148
Retaining Wall for San Carlos Arch	149

CHAPTER VII. METHODS OF CONSTRUCTION AND COST OF
RETAINING WALLS.

Cost of Masonry Retaining Walls	150
Concrete Retaining Walls, Methods of Constructing Forms	151
Mixing and Placing Concrete	155
Cost of Reinforced Concrete Retaining Walls	156

CHAPTER VIIA. NOTES ON DESIGN OF RETAINING WALLS AND
PRESSURES IN SAND BOXES.

Design of Retaining Walls and Abutments	164
Pressures in Sand Boxes	164f
Approximate Design of Reinforced Concrete Retaining Walls . .	164g
Stresses in Wedge-Shaped Reinforced Concrete Beams	164j
Problems in Design of Concrete Retaining Walls	164j

PART II. THE DESIGN OF COAL BINS, ORE BINS, ETC.

Introduction	165
------------------------	-----

CHAPTER VIII. TYPES OF COAL BINS, ORE BINS, ETC.

Suspension Bunkers	166
------------------------------	-----

Hopper Bins	168
Circular Bins	170

CHAPTER IX. STRESSES IN BINS.

Introduction	173
Stresses in Bin Walls	173
Tables of Pressures on Vertical Bin Walls	178
Bituminous Coal Bin	179
Anthracite Coal Bin	180
Sand Bin	181
Ash Bin	182
Pressure on Bin Walls Calculated by Trautwine's Formulas	183
Stresses in Hopper Bins	186
Hopper Bin, Surface Level:	
First Method	187
Second Method	188
Calculation of Stresses in Framework	190
Center of Gravity of a Trapezoid	190
Hopper Bin, Surface Heaped	191
Calculation of Stresses in Framework	193
Hopper Bin, Top Surface Surcharged	193
Hopper Bin, Top Surface Surcharged and of Indefinite Extent	194
Stresses in Suspension Bunkers	197
Length of Curve	200
Diagram for Suspension Bunkers	202
Stresses in Conical Bin Bottoms	204
Stresses in Spherical Bin Bottoms	205
Stresses in a Circular Girder	206
Stresses in Columns	211

CHAPTER X. EXPERIMENTS ON PRESSURES ON BIN WALLS.

Portland Cement Materials	213
Coal and Ashes	214
Weight and Angle of Repose	215

Angle of Friction on Bin Walls	215
Self-cleaning Hoppers	216

CHAPTER XI. THE DESIGN OF BINS.

Introduction	217
Flat Plates	217
Diagram for Square Plates	218
Buckle Plates	218
Rivets and Riveted Joints	220
Investigation of Riveted Joints	221
Allowable Stresses in Rivets	224
Standards for Rivets and Riveting	227
Conventional Signs for Rivets	228
Design of Stiffeners	229
Bin Gates	230
Specifications	233
Painting	234
Freezing in Bins	235

CHAPTER XII. EXAMPLES AND DETAILS OF BINS.

Introduction	236
Suspension Bunkers :	
Lackawanna Steel Co.'s Bins	236
Rapid Transit Subway Power House Coal Bunkers	238
Hopper Bins:	
Cananea Consolidated Copper Co.'s Bins	239
Details of Hopper Coal Bins	240
Coal Storage Plant, Cincinnati Water Works	243
Reinforced Concrete Coal and Coke Bins for Key City Gas Co.	243
Steel and Concrete Coal Storage Plant	248
Coaling Station at Morrisville, Pa.	249
Coal Bin, Interborough Rapid Transit Co.	252
Timber Ore Docks, Escanaba, Mich.	253

Circular Bins :

Ore Bins for Old Dominion Copper Mining and Smelting Co.	257
Cement Storage Bins. Illinois Steel Co., Chicago. Ill.	259
Reinforced Concrete Sand Bins. New Brighton. N. J.	263
Reinforced Concrete Coal Pocket. Atlantic City Water Works	265
Reinforced Concrete Sand Bins, Peerless Brick Co.	267
Railway Coaling Station	269

CHAPTER XIII. COST OF BINS.

Introduction	271
Cost of Steel Bins	271
Cost of Material	271
Cost of Fabrication	274
Cost of Drafting	274
Cost of Mill Details	275
Shop Cost	278
Cost of Erection	279
Cost of Placing and Bolting	279
Cost of Riveting	279
Cost of Reinforced Concrete Bins	280
Relative Costs of Bins	280
Cost of Painting	280
Actual Cost of Reinforced Concrete Coal Bins	281

CHAPTER XIV. METHODS OF HANDLING MATERIALS.

Introduction	283
Elevators	283
Steel Screw Conveyors	285
Belt Conveyors	288
Push Plate Conveyors	290
Traveling Trough Conveyors	291
Pneumatic Conveyors	292
Cable Conveyors	294

Car with Rope Haulage	294
Miscellaneous Methods	294

PART III. THE DESIGN OF GRAIN BINS AND ELEVATORS

Introduction	295
--------------------	-----

CHAPTER XV. TYPES OF GRAIN ELEVATORS.

Introduction	297
Timber Elevators	297
Steel Elevators	299
Working House Steel Elevator	300
Working House and Steel Storage Bins	301
Concrete Elevators	303
Tile Elevators	304
Brick Elevators	304
Comparison of Different Types	305

CHAPTER XVI. STRESSES IN GRAIN BINS.

Introduction	307
Janssen's Solution	307
Coefficients of Friction	310
Graphic Diagram	311
Hyperbolic or Napierian Logarithms	312
German Practice	313
Airy's Solution	314
Case I.—Shallow Bins	314
Case II.—Deep Bins	316
Graphic Solution	321
Vertical Pressures	322

CHAPTER XVII. EXPERIMENTS ON THE PRESSURE OF GRAIN IN DEEP BINS.

Introduction	323
Roberts' Experiments	324

Janssen's Experiments	324
Prante's Experiments	326
Toltz's Experiments	326
Airy's Experiments	327
The Author's Experiments	328
Jamieson's Experiments	328
Full Size Bins	328
Model Bins	331
Angle of Repose and Coefficient of Friction	338
Bovey's Experiments	339
Series I to IV	339
Series V	341
Lufft's Experiments	342
Pleissner's Experiments	345
Bins	345
Pressure Measuring Apparatus	346
The Tests	347
Value of k	349
Discussion of Experiments	350
Conclusions	351
University of Colorado Experiments	352
Conclusions, 1911	354

CHAPTER XVIII. THE DESIGN OF GRAIN BINS AND ELEVATORS.

Timber Grain Elevators	355
Specifications	355
Allowable Stresses in Timber	357
Circular Steel Bins	358
Rivets in Horizontal Joints	358
Stiffeners	359
Steel Country Elevators	362
Reinforced Concrete Country Grain Elevator	360
Rectangular Steel Bins	364

Metcalf Bin	364
Wind Mill Point Steel Grain Elevator	365
Cross Bracing	367
MacDonald Bin	369
The "Great Northern" Elevator	371
Specifications for Steel Work	372
Concrete Bins	375
Design of Horizontal Reinforcement	376
Design of Vertical Reinforcement	376
Stresses in Rectangular Bins	378
Design of Square Bins	382
Specifications for Concrete Bins	382
Specifications for Tile Bins	384
Bin Roofs	385
Foundations	387
Conveyors	388
Construction of Grain Bins	388
Moving Forms	389
Bin Forms for Fisher Flouring Mills	391

CHAPTER XIX. EXAMPLES OF GRAIN ELEVATORS.

Introduction	395
Independent Steel Elevator, Omaha, Neb.	395
Steel Grain Elevator, Great Northern Ry., West Superior, Wis.	409
Concrete Grain Elevator, Santa Fe System, Chicago	421
Canadian Pacific Concrete Grain Elevator, Port Arthur, Ontario	429
Canadian Northern Railway Tile Grain Bins, Port Arthur, Ontario	435
Reinforced Concrete Bins, Storage Annex, Great Northern Ry., West Superior, Wis.	441
Reinforced Concrete Grain Elevator, Grand Trunk Ry., Fort Wil- liam, Ontario	448
Reinforced Concrete Grain Elevator for F. C. Ayres Mercantile Co., Denver, Colo.	454

CHAPTER XX. COST OF GRAIN BINS AND ELEVATORS.

Cost of Steel Grain Elevator	468
Great Northern Ry. Steel Elevator	468
Independent Steel Elevator	468
Winona Steel Elevator	469
Miscellaneous Costs	469
Cost of Country Elevators	470
Cost of Reinforced Concrete Grain Bins	470
Cost of Reinforced Concrete Standpipe	471
Cost of Tile Bins	471
Cost of Reinforced Concrete Grain Elevators	472

APPENDIX I.

CONCRETE, PLAIN AND REINFORCED.

CHAPTER I.

Plain Concrete	473
Materials	473
Cement	474
Aggregates	478
Water	479
Proportioning Concrete	479
Mixing Concrete	481
Consistency	482
Depositing Concrete	483
Effect of Sea Water	485
Effect of Alkali	486
Water-Tightness	487
Strength of Concrete	489
Compression	489
Tension	490
Shear	490

Modulus of Elasticity	490
Bond Stress	491
Expansion and Contraction	492
Fire-proofing	493
Rust Protection	493

CHAPTER II.

Data for the Design of Reinforced Concrete Structures	494
Materials	494
Dimensions	494
Internal Stresses	494
Web Stresses	495
Working Stresses	495

CHAPTER III.

Formulas for the Design of Reinforced Concrete	498
Standard Notation	498
Stresses in Rectangular Beams	499
Stresses in T-Beams	504
Stresses in Beams Reinforced for Compression	507
Flexure and Direct Stress	509
Columns	513
Bond	513
Shearing Stresses	514
Diagonal Tension	515
Stresses in Stirrups	515
Spacing of Bars	517
Design of T-Beams	517
Floor Slabs	518
Bending Moments	518

CHAPTER IV.

Specifications for Reinforced Concrete Construction	520
---	-----

APPENDIX II.

Definitions of Masonry Terms 526
Specifications for Stone Masonry 531

APPENDIX III.

Specifications for Material and Workmanship for Steel Structures 536
Index 547

