

## BIM Reference Manual

### Table of Contents

|                                       |            |
|---------------------------------------|------------|
| <b>1.0 CHAPTER 1 - TIMBER .....</b>   | <b>1-1</b> |
| 1.1 Characteristics of Timber .....   | 1-1        |
| 1.2 Factors Affecting Strength.....   | 1-2        |
| 1.2.1 Decay .....                     | 1-2        |
| 1.2.2 Checks .....                    | 1-3        |
| 1.2.3 Split .....                     | 1-3        |
| 1.2.4 Shake .....                     | 1-3        |
| 1.2.5 Chemical Attack .....           | 1-4        |
| 1.2.6 Fire .....                      | 1-4        |
| 1.2.7 Abrasion .....                  | 1-4        |
| 1.2.8 Collision and Overloads .....   | 1-4        |
| 1.3 Testing Methods.....              | 1-4        |
| 1.3.1 Destructive Testing.....        | 1-5        |
| 1.3.2 Visual Inspection .....         | 1-5        |
| 1.3.3 Sounding .....                  | 1-5        |
| 1.3.4 Ultrasonics.....                | 1-6        |
| 1.3.5 Moisture Meter .....            | 1-6        |
| 1.4 Comparision of Test Methods ..... | 1-6        |
| 1.5 Major Inspection Items .....      | 1-7        |
| 1.5.1 Fasteners .....                 | 1-7        |
| 1.5.2 Wearing Surface.....            | 1-7        |
| 1.5.3 Stringers and Caps.....         | 1-8        |
| 1.5.4 Piles.....                      | 1-8        |
| 1.6 Timber Treatment.....             | 1-8        |
| <b>2.0 CHAPTER 2 - CONCRETE .....</b> | <b>2-1</b> |
| 2.1 Definition .....                  | 2-1        |
| 2.2 Aggregate.....                    | 2-1        |
| 2.3 Cement.....                       | 2-1        |
| 2.4 Admixtures .....                  | 2-2        |
| 2.4.1 Air Entraining.....             | 2-2        |
| 2.4.2 Water Reducers .....            | 2-3        |
| 2.4.3 Silica Fume.....                | 2-3        |
| 2.4.4 Fly Ash .....                   | 2-3        |
| 2.4.5 Steel and Propylene Fibre.....  | 2-4        |
| 2.4.6 Self Compacting Concrete .....  | 2-4        |
| 2.5 Factors Affecting Strength.....   | 2-4        |
| 2.5.1 Water.....                      | 2-4        |
| 2.5.2 Aggregate Soundness.....        | 2-5        |

|        |   |      |
|--------|---|------|
| 2.5.3  | Sand .....                                    | 2-5  |
| 2.6    | Development of Strength.....                  | 2-6  |
| 2.6.1  | Hydration .....                               | 2-6  |
| 2.6.2  | Curing.....                                   | 2-6  |
| 2.6.3  | Finish and Durability.....                    | 2-7  |
| 2.7    | Properties of Hardened Concrete.....          | 2-7  |
| 2.7.1  | Compressive Strength, Flexural Strength ..... | 2-7  |
| 2.7.2  | Shrinkage .....                               | 2-8  |
| 2.7.3  | Creep.....                                    | 2-9  |
| 2.8    | Cracks and Deterioration in Concrete .....    | 2-9  |
| 2.8.1  | Shrinkage Cracks .....                        | 2-9  |
| 2.8.2  | Crazing Cracks.....                           | 2-10 |
| 2.8.3  | D-Cracks .....                                | 2-10 |
| 2.8.4  | Flexural Cracks .....                         | 2-10 |
| 2.8.5  | Diagonal Cracks .....                         | 2-10 |
| 2.8.6  | Cracking in Prestressed Girders .....         | 2-11 |
| 2.8.7  | Scaling.....                                  | 2-12 |
| 2.8.8  | Spalling.....                                 | 2-12 |
| 2.8.9  | Pop-out.....                                  | 2-12 |
| 2.8.10 | Punch-outs .....                              | 2-13 |
| 2.8.11 | Scouring / Abrasion .....                     | 2-13 |
| 2.8.12 | Carbonation .....                             | 2-13 |
| 2.8.13 | Leaching and Efflorescence .....              | 2-13 |
| 2.8.14 | Damage to Reinforcement .....                 | 2-14 |
| 2.8.15 | Concrete Voids or Honeycomb.....              | 2-14 |
| 2.8.16 | Chemical Spills .....                         | 2-14 |
| 2.8.17 | Fatigue in Concrete .....                     | 2-15 |
| 2.9    | Field testing of Concrete .....               | 2-15 |
| 2.9.1  | Chain Drag .....                              | 2-15 |
| 2.9.2  | Rebound Hammer .....                          | 2-15 |
| 2.9.3  | Coring.....                                   | 2-16 |
| 2.9.4  | Pull-out Test .....                           | 2-17 |
| 2.9.5  | Windsor Probe.....                            | 2-18 |
| 2.9.6  | Ultrasonic Pulse Velocity.....                | 2-18 |
| 2.9.7  | Chloride Ion Content .....                    | 2-18 |
| 2.9.8  | CSE Testing .....                             | 2-19 |
| 2.9.9  | Thermography .....                            | 2-19 |
| 2.9.10 | Radar.....                                    | 2-19 |
| 2.9.11 | Other Testing Methods .....                   | 2-20 |
| 2.10   | Concrete Girders .....                        | 2-20 |
| 2.10.1 | Precast Girders .....                         | 2-20 |
| 2.10.2 | Prestressed Girders .....                     | 2-20 |
| 2.10.3 | Protection of Reinforcement.....              | 2-21 |
| 2.10.4 | Highways Loadings .....                       | 2-21 |
| 2.10.5 | Load Sharing .....                            | 2-22 |
| 2.10.6 | Early Concrete Girders .....                  | 2-22 |

|            |   |            |
|------------|---|------------|
| 2.10.7     | Curb Units .....  | 2-23       |
| 2.10.8     | Girder Connections .....  | 2-23       |
| 2.10.9     | Problems with Connections .....                                 | 2-23       |
| 2.10.10    | Concrete Overlays.....  | 2-24       |
| 2.10.11    | Precast Concrete Strength .....                                 | 2-25       |
| 2.10.12    | Table of Precast Girders .....                                  | 2-25       |
| 2.10.12.1  | Type A. Abbreviation: PA .....                                  | 2-25       |
| 2.10.12.2  | Type G. Abbreviation: PG.....                                   | 2-25       |
| 2.10.12.3  | Type E. Abbreviation: PE .....                                  | 2-26       |
| 2.10.12.4  | Type H. Abbreviation: HH > HC > VH .....                        | 2-26       |
| 2.10.13    | Table of Prestressed Girders .....                              | 2-27       |
| 2.10.13.1  | Type O. Abbreviation: PO > OM.....                              | 2-27       |
| 2.10.13.2  | Type F (FENRICH). Abbreviation: FC > VF > LF > FM .....         | 2-28       |
| 2.10.13.3  | Type M. Abbreviation: PM > VM.....                              | 2-28       |
| 2.10.13.4  | Type VS. Abbreviation: VS > SM >SC .....                        | 2-29       |
| 2.10.13.5  | Type RD. Abbreviation: RD > RM.....                             | 2-29       |
| 2.10.13.6  | Type Deck Bulb T. Abbreviation: DBT > DBC .....                 | 2-30       |
| 2.10.13.7  | Type NU. Abbreviation: NU .....                                 | 2-30       |
| <b>3.0</b> | <b>CHAPTER 3 - STEEL .....</b>                                  | <b>3-1</b> |
| 3.1        | Introduction.....   | 3-1        |
| 3.2        | Structural Steel.....   | 3-1        |
| 3.2.1      | Manufacture of Steel .....                                      | 3-1        |
| 3.2.2      | Chemical Composition of Steel .....                             | 3-2        |
| 3.3        | Types of Structural Steel.....                                  | 3-4        |
| 3.4        | Mechanical Properties of Steel.....                             | 3-5        |
| 3.5        | Deterioration and Damage of Steel.....                          | 3-7        |
| 3.5.1      | Corrosion of Steel.....   | 3-7        |
| 3.5.1.1    | Types of Corrosion .....  | 3-7        |
| 3.5.1.2    | Corrosion Protection.....                                       | 3-8        |
| 3.5.2      | Fatigue of Structural Steel.....                                | 3-9        |
| 3.5.2.1    | Factors Affecting Fatigue Strength .....                        | 3-9        |
| 3.5.2.2    | Out of Plane Distortion .....                                   | 3-10       |
| 3.5.2.3    | Types of Fatigue Inspection .....                               | 3-11       |
| 3.5.2.4    | Comprehensive Fatigue Evaluations .....                         | 3-13       |
| 3.5.3      | Brittle Fracture of Structural Steel .....                      | 3-14       |
| 3.5.4      | Constraint Induced Fracture .....                               | 3-15       |
| 3.5.5      | Fire Damage.....  | 3-16       |
| 3.5.6      | Vehicular Impact.....   | 3-17       |
| 3.5.7      | Overload Damage .....   | 3-17       |
| 3.6        | Nondestructive Methods of Crack Detection in Steel Bridges..... | 3-18       |
| 3.6.1      | Radiographic Examination .....                                  | 3-18       |
| 3.6.2      | Ultrasonic Testing.....   | 3-19       |
| 3.6.3      | Dye Penetrant .....   | 3-19       |
| 3.6.4      | Magnetic Particle .....   | 3-20       |
| 3.6.5      | Eddy Current .....  | 3-20       |

|            |  |            |
|------------|--|------------|
| 3.6.6      | Comparison of Nondestructive Examination Methods .....           | 3-20       |
| 3.7        | Steel Beams and Girders .....                                    | 3-22       |
| 3.7.1      | General.....   | 3-22       |
| 3.7.2      | Inspection of Beams and Girders .....                            | 3-22       |
| 3.7.2.1    | Cover Plate .....  | 3-22       |
| 3.7.2.2    | Flange.....  | 3-23       |
| 3.7.2.3    | Web .....  | 3-23       |
| 3.7.2.4    | Stiffeners .....   | 3-23       |
| 3.7.2.5    | Splices .....  | 3-24       |
| 3.7.2.6    | Weld, Bolts, and Rivets .....                                    | 3-24       |
| 3.8        | Truss Bridges .....  | 3-24       |
| 3.8.1      | General.....   | 3-24       |
| 3.8.2      | Stresses .....   | 3-25       |
| 3.8.3      | Notation for Span & Truss Components.....                        | 3-25       |
| 3.8.4      | Inspection of Truss Components.....                              | 3-26       |
| 3.8.4.1    | Top Chord.....   | 3-26       |
| 3.8.4.2    | Batter Post.....   | 3-26       |
| 3.8.4.3    | Sway Bracing.....  | 3-26       |
| 3.8.4.4    | Lateral Bracing .....  | 3-27       |
| 3.8.4.5    | Diagonals.....   | 3-27       |
| 3.8.4.6    | Verticals.....   | 3-27       |
| 3.8.4.7    | Portals .....  | 3-28       |
| 3.8.4.8    | Connections.....   | 3-28       |
| 3.8.4.9    | Floor Beams .....  | 3-28       |
| 3.8.4.10   | Bottom Chord .....   | 3-29       |
| 3.8.4.11   | Stringers .....  | 3-30       |
| 3.8.4.12   | Pins.....  | 3-30       |
| <b>4.0</b> | <b>CHAPTER 4 - BEARINGS .....</b>                                | <b>4-1</b> |
| 4.1        | Purpose of Bearings.....   | 4-1        |
| 4.2        | Types of Bearings .....  | 4-1        |
| 4.3        | Common Defects and Problems of Bearings .....                    | 4-3        |
| <b>5.0</b> | <b>CHAPTER 5 - BRIDGERAILS .....</b>                             | <b>5-1</b> |
| 5.1        | Purpose of Bridgerails.....                                      | 5-1        |
| 5.2        | History/Background .....   | 5-1        |
| 5.3        | Bridgerail Types .....   | 5-2        |
| 5.3.1      | Early Bridgerails (1950 to mid 1960) .....                       | 5-2        |
| 5.3.2      | Second Generation Bridgerails (late 1960's to late 1990's) ..... | 5-5        |
| 5.3.3      | Current Bridgerail Types .....                                   | 5-8        |
| 5.4        | Bridgerail Transitions.....                                      | 5-12       |
| 5.4.1      | Background .....   | 5-12       |
| 5.4.2      | Transition Types.....  | 5-12       |
| 5.5        | Bridgerail Performance Levels .....                              | 5-15       |

|  |            |
|--|------------|
| <b>6.0 CHAPTER 6 - DECK JOINTS .....</b>   | <b>6-1</b> |
| 6.1 Purpose of Deck Joints .....   | 6-1        |
| 6.2 History/Background .....   | 6-1        |
| 6.3 Deck Joint Types and Problems.....   | 6-3        |
| 6.3.1 Finger Plate Joints.....   | 6-3        |
| 6.3.2 Gland Joints .....   | 6-6        |
| 6.3.3 Armoured Gland Joint .....   | 6-8        |
| 6.3.4 Asphalt Plug Joint.....  | 6-9        |
| 6.3.5 Sliding Plate Joint.....   | 6-10       |
| 6.3.6 Buffer Angle Joint .....   | 6-10       |
| <b>7.0 CHAPTER 7 - CULVERTS .....</b>  | <b>7-1</b> |
| 7.1 General.....   | 7-1        |
| 7.2 Types of Culverts .....  | 7-1        |
| 7.2.1 Timber Culverts .....  | 7-1        |
| 7.2.2 Concrete Culverts.....   | 7-1        |
| 7.2.3 Flexible Metal Culverts (CSP/SPCSP) .....                                  | 7-2        |
| 7.2.4 Arch Beam Culvert (ABC) and Culvert Arch Beam (CAB) .....                  | 7-4        |
| 7.3 Culvert Corrosion Protection .....   | 7-5        |
| 7.3.1 Culvert Coatings.....  | 7-5        |
| 7.3.2 Cathodic Protection .....  | 7-6        |
| 7.4 Common Problems/Defects .....  | 7-6        |
| 7.5 Repair of Culverts.....  | 7-10       |
| 7.6 Culvert Size/Hydraulic Capacity .....  | 7-15       |
| <b>8.0 CHAPTER 8 - PHOTOS OF TYPICAL CONCRETE GIRDER CRACKS AND DEFECTS.....</b> | <b>8-1</b> |