

# Contents

<b>Preface.....</b>	<b>X</b>
<b>Acknowledgements (Optional).....</b>	<b>X</b>
<b>Abbreviations / Acronyms used in this Guide.....</b>	<b>X</b>
<b>1. Introduction.....</b>	<b>1</b>
1.1 Scope .....	1
1.1.1 Concrete – A Specific Example .....	1
1.1.2 De Sitter’s Law of Fives .....	2
1.1.3 Guidance.....	4
1.1.4 Extent of Application .....	4
<b>2. Civil Infrastructure Asset Management.....</b>	<b>6</b>
<b>3. Roles and Responsibilities .....</b>	<b>8</b>
3.1 Industry-Independent Organisation Chart.....	8
3.1.1 Plant Manager.....	8
3.1.2 Unit / Facilities Infrastructure Owner.....	8
3.1.3 Civil Engineer.....	9
3.1.4 Infrastructure Inspector.....	9
3.1.5 Infrastructure Maintenance Team.....	9
3.1.6 Civil Construction / Maintenance Supervisor.....	9
3.1.7 Engineering Contractor.....	9
3.2 Asset Owner and Plant Owner Extended Responsibilities / Duty of Care.....	11
<b>4. Assets’ Register and Owner .....</b>	<b>13</b>
<b>5. Degradation and Deterioration Mechanisms.....</b>	<b>15</b>
5.1 Degradation and Deterioration .....	15
5.2 Reinforced Concrete .....	16
5.2.1 Typical Degradation Mechanisms.....	16
5.2.2 Other Degradation Mechanisms.....	18
5.3 Structural Steelwork .....	18
5.3.1 Environmental Factors.....	19
5.3.2 Corrosion .....	19
5.3.3 Corrosion Areas and Types.....	20
5.4 Examples of Civil Structure Defects.....	22

<b>6. Categorisation of Critical Assets.....</b>	<b>26</b>
6.1 Categorisation of Critical Assets .....	26
6.2 Definitions of Criticality .....	27
6.3 Identifying Critical Assets .....	28
<b>7. Asset Plan.....</b>	<b>30</b>
7.1 Life Cycle of Asset Plan .....	31
7.2 Benefit of Asset Plan.....	33
<b>8. Defining the Inspection Programme .....</b>	<b>36</b>
8.1 Inspection Programme .....	36
8.2 Basic Steps when Setting Up an Inspection Programme .....	36
8.3 Competence of inspectors .....	37
8.3.1 Qualification/ Education.....	37
8.3.2 Training.....	37
8.3.3 Experience .....	37
8.4 Types of Inspection.....	38
8.4.1 Time-based Approach .....	38
8.4.2 Alternative Approaches.....	38
8.5 Other Stake Holders.....	41
8.6 Managing Inspection Programmes.....	42
<b>9. Inspection of Assets.....</b>	<b>43</b>
<b>10.Risk Assessment (Structural Assessment as applicable) / Repair Planning .....</b>	<b>45</b>
10.1 Condition / Integrity Assessment .....	45
10.2 Risk Assessment.....	47
10.2.1 Assessment of Civil Buildings and Structures .....	48
10.2.2 Structural Evaluation.....	49
10.3 Repair Planning .....	49
<b>11.Executing Repairs .....</b>	<b>51</b>
11.1 Preventive Maintenance.....	51
11.2 Executing Repairs.....	51
11.3 Additional Material.....	52
<b>12.Conclusion.....</b>	<b>54</b>
<b>Appendix A – Feedback from SCE Forum Sessions .....</b>	<b>55</b>
<b>Appendix B – EEMUA Posters (to be included in this section).....</b>	<b>58</b>
<b>Appendix C – Non-Exhaustive List of Civil, Structural and Building Assets in the Process, Industrial and Production Environment**.....</b>	<b>68</b>
<b>Appendix D – Critical Infrastructure Definition and Categorisation Methodology for Asset Management.....</b>	<b>72</b>

<b>Appendix E – Asset Matrix Risk Breakdown and Evaluation for Steel Structures Management ....</b>	<b>76</b>
<b>Appendix F – Additional Examples of Defects in Civil Structures .....</b>	<b>81</b>
<b>Appendix G – DROPS Dropped Object Consequence Calculator.....</b>	<b>90</b>
<b>Appendix H – Examples of Software Databases used in Industry for collecting, analysing, managing and reporting inspection data.....</b>	<b>91</b>

## Figures

Figure 1–1 An Example of De Sitter’s Law of Fives.....	3
Figure 1–2 Adaption of Tuuti’s Model.....	3
Figure 2–1 Civil Facilities Management Process Flowchart .....	7
Figure 3–1 Civil Facilities Management Process Flowchart – stage 1 .....	8
Figure 4–1 Civil Facilities Management Process Flowchart – stage 2 .....	13
Figure 5–1 Civil Facilities Management Process Flowchart – stage 3 .....	15
Figure 5–2 Corrosion cycle of steel.....	19
Figure 5–3 Concrete Column Cover Concrete Damaged.....	22
Figure 5–4 Damaged Concrete Beam.....	23
Figure 5–5 Bridge Abutment Concrete Damaged.....	23
Figure 5–6 Damaged Concrete due to Alkali-Silica Reaction.....	24
Figure 5–7 Eroded Coastal Embankment.....	24
Figure 5–8 Potholes on Road .....	25
Figure 6–1 Civil Facilities Management Process Flowchart – stage 4 .....	26
Figure 6–2 Criticality Assessment Framework (in-service).....	28
Figure 7–1 Civil Facilities Management Process Flowchart – stage 5 .....	30
Figure 7–2 Example of a Spreadsheet Asset Plan .....	31
Figure 7–3 Life Cycle of Asset Plan.....	31
Figure 8–1 Civil Facilities Management Process Flowchart – stage 6 .....	36
Figure 8–2 Criticality Matrix.....	39
Figure 8–3 Inspection Interval Factor.....	40
Figure 8–4 Present Failure Risk 1 .....	40
Figure 8–5 Present Failure Risk 2 .....	41
Figure 9–1 Civil Facilities Management Process Flowchart – stage 7 .....	43
Figure 10–1 Civil Facilities Management Process Flowchart – stage 8 .....	45
Figure 10–2 Flaw Assessment Process (Source – BS 7910) .....	46
Figure 11–1 Civil Facilities Management Process Flowchart – stage 9 .....	51
Figure 12–1 EEMUA ‘Chemicals’ Poster .....	59
Figure 12–2 EEMUA ‘Downsteam oil and gas’ Poster.....	60
Figure 12–3 EEMUA ‘Pharmaceuticals’ Poster .....	61
Figure 12–4 EEMUA ‘Power generation’ Poster .....	62

Figure 12–5 EEMUA ‘Renewables’ Poster .....	63
Figure 12–6 EEMUA ‘Storage’ Poster.....	64
Figure 12–7 EEMUA ‘Manufacturing’ Poster.....	65
Figure 12–8 EEMUA ‘Offshore’ Poster.....	66
Figure 12–9 EEMUA ‘Water and wastewater’ Poster.....	67
Figure 12–10 Criticality assessment framework (in-service).....	72
Figure App E Risk Matrix for Evaluating Steel Structures.....	76
Figure 12–11 Cracking of Concrete Cover .....	81
Figure 12–12 Severe Corrosion of Steel Beams Below Floor Plates.....	82
Figure 12–13 Corrosion of Steel Columns and Connections .....	82
Figure 12–14 Bird Nest Under Electrical Box.....	83
Figure 12–15 Spalling of Concrete Cover.....	83
Figure 12–16 Cracking and Breakdown of Concrete Cover Next to Process Drain .....	84
Figure 12–17 Site Modification of Concrete Cover When Installing Later Services exposing the reinforcement .....	84
Figure 12–18 Spalling of Concrete Cover at Top of Column.....	85
Figure 12–19 Corrosion at interface between stair treads and stringer beams .....	85
Figure 12–20 Severe Corrosion of Steel Column and Holding Down Bolts.....	86
Figure 12–21 Corrosion of Steel Beam.....	86
Figure 12–22 Corrosion of Steel Tray .....	87
Figure 12–23 Coating Breakdown Causing Corrosion of Steel Column Leading to Loss of Section .....	87
Figure 12–24 Spalled Section of Concrete Structure.....	88
Figure 12–25 Damage to Ceiling Above Walkway (Detail).....	88
Figure 12–26 Damage to Ceiling Above Walkway.....	89
Figure 12–27 Degradation of Concrete Tank with Collapse of Reinforcing Beam.....	89
Figure 12–28 Dropped Object Consequence Calculator .....	90
Figure 12–29 Example Software for Managing and Reporting Inspection Data .....	91
Figure 12–30 Example Software for Managing and Reporting Inspection Data – Spreadsheet ..	92
Figure 12–31 Example Software for Managing and Reporting Inspection Data – PCMS Equipment Screen (1).....	93
Figure 12–32 Example Software for Managing and Reporting Inspection Data – PCMS Equipment Screen (2).....	94
Figure 12–33 Example Software for Managing and Reporting Inspection Data – PCMS Component List Screen .....	95
Figure 12–34 Example Software for Managing and Reporting Inspection Data – PCMS Event Screen .....	96

**Tables**

Table 1–1 Typical Design Life Span.....	1
Table 5–1 Typical Corrosion Severity Categories .....	20
Table 6–1 Typical Design Life Span.....	27
Table 6–2 Consequence Level Definitions.....	29
Table D–1 Consequence level definitions.....	73
Table D–2 Infrastructure Categorisation (By Category).....	75
 <b>References.....</b>	 <b>97</b>
 <b>EEMUA Publications: Feedback Form.....</b>	 <b>99</b>
 <b>EEMUA Publications Catalogue .....</b>	 <b>100</b>