

# Contents

Foreword	i
Preface	vii
1. Introduction to post-tensioning concrete bridges	1
1.1 Introduction	1
1.2 Durability experiences and case study of post-tensioned bridges	3
1.2.1 PT bridges in France	3
1.2.2 PT bridges in the U.K.	6
1.2.3 PT bridges in the U.S.A.	8
1.2.4 PT bridges in Norway	10
1.2.5 PT bridges in Brazil	11
1.2.6 PT bridges in Germany	12
1.2.7 PT bridges in Japan	14
1.2.8 PT bridges in Switzerland	17
1.2.9 PT bridges in Slovakia	18
1.3 References	20
2. Review of current practice of bridge management	22
2.1 Structural inspections	22
2.2 Numerical strength assessment	24
2.3 Monitoring and management	24
2.4 Future developments	24
2.5 References	25
3. Risk review, risk assessment and risk management for PT concrete bridges	26
3.1 Introduction	26
3.2 UK management process	27
3.2.1 Risk review	27
3.2.2 Structure risk assessment	29
3.2.3 Risk management	32
3.2.4 Prioritisation of inspections and repair works	33
3.3 Risk analysis process in France	34
3.3.1 Sétra guide to risk analysis	34
3.3.2 Evaluation of hazard, vulnerability and issues	35
3.3.3 Some details on this risk analysis	37
3.3.2. Details on the assessment of the robustness/vulnerability	38

3.4 Conclusion	38
3.5 References	39
4. Inspection	40
4.1 General	40
4.1.1 Definition and objectives of inspection	40
4.1.2 Preparation of inspection	40
4.1.3 Inspection types	41
4.1.4 Qualification of inspection personnel	41
4.2 Points of attention in inspection	41
4.2.1 Cracking	41
4.2.2 Water management systems	45
4.2.3 Deflections	45
4.2.4 Concrete spalling	46
4.2.5 Construction joints	46
4.2.6 Bearings	46
4.2.7 External tendons	47
4.3 Record of inspection	47
4.4 References	47
5. Investigations	48
5.1 Introduction	48
5.2 Non-destructive testing methods for the diagnosis of prestressing	49
5.2.1 Usual or current techniques	49
5.2.2 Monitoring of prestressing tendons	57
5.2.3 Techniques under development	58
5.3 Intrusive or destructive methods	61
5.3.1 Drilling holes to tendons	61
5.3.2 Cutting access ports	62
5.3.3 Grout cap removal	62
5.3.4 Inspection of the tendon and grout condition, and collection of samples	62
5.3.5 Measure of void volumes	64
5.3.6 Laboratory investigations: metallography on steels mineralogical analysis of grout	64
5.3.7 Core drills and percussion drills to evaluate concrete quality of the structure, carbonation front, chloride ingress	64

5.4 Determination of in-situ mechanical and structural characteristics	67
5.4.1 Measurement of prestress forces	67
5.4.2 Measurement of concrete stresses	69
5.4.3 Evaluation of the structural behaviour	70
5.5 Evaluation of the structural behaviour	72
5.5.1 Analysis and verification of the design	72
5.5.2 Proof load	73
5.6 Conclusion	73
5.7 References	74
<b>6. Intervention</b>	<b>77</b>
6.1 Introduction	77
6.2 Detailed structural assessment	77
6.3 Monitoring	77
6.4 Remove load	78
6.5 Securing the work area	78
6.6 Repair Methods	78
6.6.1 Void filling	78
6.6.2 Duct repair	79
6.6.3 Repair of inspection windows internal PT	80
6.6.4 Corrosion inhibitors	81
6.7 Replacing external tendons	82
6.8 Strengthening methods	83
6.8.1 Additional prestressing tendons	83
6.9 Rebuild	85
6.10 References	85
<b>Glossary</b>	<b>86</b>
<b>Appendixes</b>	<b>87</b>
Appendix A - Tables and practical application of chapter 3	87
Appendix A.1 - A bridge specific example of a structure risk assessment	87
Appendix A.2 - Two examples of risk ratings	102
Appendix A.3 - Scores associated with general design factors as shown in reference 3-2 Table 6	103
Appendix A.4 - Scores associated with material factors as shown in reference 3-2 Table 7	104
Appendix A.5 - Example of a risk analysis for 15 bridges in accordance with the Sétra methodology as reference 3-2	105

Appendix B - Repair project reports	108
Appendix B.1 Saint-Cloud Viaduct, Saint-Cloud - France, 2009	108
Appendix B.2 Strengthening of the Ružín bridge, Slovakia, 2017	109
Appendix B.3 A52 Clifton Bridge, Nottingham, UK, 2021	110
Appendix B.4 Agudim Viaduct, Leiria, Portugal, 2019	111
Appendix B.5 Pykes Creek, Victoria, Australia, 2018	112
Appendix C - Typical defect of bridges related to prestressing tendons	113
Appendix C.1 Randomness of corrosion of tendons in beam and slab bridges (VIPP type)	113
Appendix C.2 Failure of external grouted tendons due to the presence of a white paste inside the duct.	115
Appendix C.3 Brittle failure of prestressing wires caused by a susceptibility to stress cracking corrosion.	117
Appendix D - <i>fib</i> bulletins, which are at least partially dealing with some issues concerning the management of post-tensioned bridges.	119