ISO 21725-2:2021-11 (E)

Simplified design of prestressed concrete bridges - Part 2: Box-girder bridges

Contents

Page

Foreword ..... **viii**

Introduction ..... **ix**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 Symbols and abbreviated terms **6**

5 Design and construction procedure **9**
5.1 Procedure 9
5.1.1 General 9
5.2 Design documentation 12
5.2.1 General 12
5.2.2 Calculation report 12
5.2.3 Geotechnical report 12
5.2.4 Structural drawings 12
5.2.5 Specifications 12

6 General provisions **13**
6.1 Limitations 13
6.1.1 General 13
6.1.2 Permitted use 13
6.1.3 Maximum number of spans 13
6.1.4 Recommended span length 13
6.1.5 Maximum difference in span length 13
6.1.6 Maximum cantilever length 13
6.1.7 Maximum height of bridge 13
6.1.8 Maximum number of lanes 14
6.1.9 Width limitations 14
6.1.10 Clearances 14
6.1.11 Maximum skew angle 15
6.1.12 Maximum bridge horizontal curvature 15
6.1.13 Cross-section variation 15
6.1.14 Interaction between superstructure and substructure 15
6.2 Limit states 15
6.3 Ultimate limit state design format 16
6.3.1 General 16
6.3.2 Required factored loads 16
6.3.3 Design strength 17
6.4 Serviceability limit state design format 17

7 Structural systems and layout **17**
7.1 Description of the components of the structure 17
7.1.1 General 17
7.1.2 Superstructure system 17
7.1.3 Substructure system 17
7.1.4 Foundation 18
7.2 General guide 18
7.2.1 Architectural guide 18
7.2.2 General structural guides for the project 18
7.3 Structural layout 19

7.3.1 General structural layout 19
7.3.2 Vertical layout 19
7.4 Feasibility under the guidelines 20

8 Actions (Loads) 21
8.1 General 21
8.2 Dead loads 21
8.2.1 General 21
8.2.2 Structural elements 21
8.2.3 Non-structural elements 21
8.3 Live loads 22
8.3.1 General 22
8.3.2 Design truck 22
8.3.3 Design lane load 22
8.3.4 Dynamic effect of live loads 23
8.4 Longitudinal forces 23
8.5 Earth pressure 23
8.6 Wind loads 24
8.7 Earthquake inertial forces 24
8.7.1 General 24
8.7.2 Seismic hazard 24
8.7.3 No seismic hazard zones: 24
8.7.4 Low seismic hazard zones: 25
8.7.5 Intermediate seismic hazard zones: 25
8.7.6 High seismic hazard zones: 25
8.7.7 Soil profile types 29
8.7.8 Site effects 30
8.7.9 Design response spectral ordinates 30
8.7.10 Seismic equivalent uniformly distributed load 31
8.7.11 Fundamental mode shape 31
8.7.12 Lateral equivalent design forces 32
8.8 Jacking and post-tensioning forces 32
8.8.1 Jacking forces 32
8.8.2 Forces for post-tensioning anchorage 33
8.9 Thermal effects 33
8.9.1 Seasonal variation 33
8.9.2 Thermal coefficient 33
8.9.3 Differential temperature 33
8.10 Load combinations 33
8.10.1 Ultimate loads 33
8.10.2 Service loads 33

9 Structural analysis 34
9.1 General 34
9.1.1 B-region and D-region 34
9.1.2 Elastic behaviour 34
9.1.3 Small deflection theory 34
9.1.4 Secondary moments 34
9.1.5 Time-dependent properties of concrete 34
9.1.6 Geometric imperfections 34
9.1.7 Frame analysis 34
9.2 Longitudinal analysis 34
9.3 Transverse analysis 35
9.3.1 Empirical method 35
9.3.2 Approximate method 35
9.3.3 Refined method 36

10 Design requirements 37
10.1 General 37
10.2 Box girder cross-section dimensions and details 37
10.2.1 Minimum flange thickness 37
10.2.2 Minimum web thickness 37
10.2.3 Length of top flange cantilever 37
10.2.4 Overall cross-section dimensions 38

10.2.5 Longitudinal slope ... 38
10.3 Materials for structural concrete ... 39
10.3.1 General ... 39
10.3.2 Cement ... 39
10.3.3 Aggregates ... 39
10.3.4 Water ... 39
10.3.5 Steel reinforcement ... 39
10.3.6 Prestressing steel ... 40
10.3.7 Post-tensioning anchorages and couplers ... 40
10.3.8 Ducts ... 41
10.3.9 Admixtures ... 41
10.3.10 Storage of materials ... 41
10.3.11 Minimum and maximum reinforcement bar diameter ... 42
10.4 Concrete mixture proportioning ... 42
10.4.1 General ... 42
10.4.2 Durability requirements ... 42
10.4.3 Required average compressive strength ... 43
10.4.4 Proportioning of the concrete mixture ... 43
10.5 Concrete cover of reinforcement ... 44
10.5.1 Minimum concrete cover ... 44
10.5.2 Special corrosion protection ... 45
10.6 Minimum reinforcement bend diameter ... 45
10.7 Standard hook dimensions ... 45
10.8 Bar spacing and maximum aggregate size ... 45
10.8.1 General ... 45
10.8.2 Maximum nominal coarse aggregate size ... 45
10.8.3 Minimum clear spacing between parallel bars in a layer ... 46
10.8.4 Minimum clear spacing between parallel layers of reinforcement ... 46
10.8.5 Clear spacing between parallel lap splices ... 46
10.8.6 Maximum flexural reinforcement spacing in solid slabs ... 47
10.8.7 Maximum shrinkage and temperature reinforcement spacing in solid slabs ... 47
10.8.8 Maximum reinforcement spacing in structural concrete walls ... 47
10.8.9 Minimum spacing of prestressing tendons and ducts ... 48
10.8.10 Maximum spacing of prestressing tendons in slabs ... 49
10.8.11 Couplers in post-tensioning tendons ... 49
10.9 Development length, lap splicing and anchorage of reinforcement ... 49
10.9.1 Development length ... 49
10.9.2 Lap splice dimensions ... 50
10.10 Limits for longitudinal reinforcement ... 51
10.10.1 General ... 51
10.10.2 Shrinkage and temperature reinforcement ... 51
10.10.3 Minimum area of tension flexural reinforcement ... 52

11 Stress limitations ... 52
11.1 Stress limitations for prestressing tendons ... 52
11.2 Stress limitations for concrete ... 53
11.2.1 For temporary stresses before losses-fully prestressed components ... 53
11.2.2 For stresses at serviceability limit state after losses-fully prestressed components ... 54

12 Loss of prestress ... 55
12.1 Total loss of prestress ... 55
12.2 Instantaneous losses ... 56

12.2.1 Anchorage set 56
12.2.2 Friction 56
12.2.3 Elastic shortening 57
12.3 Approximate estimate of time-dependent losses 57

13 Details of tendon 60
13.1 Tendon confinement 60
13.1.1 General 60
13.1.2 Effects of curved tendons 60
13.2 External tendon supports 61
13.3 Post-tensioned anchorage zones 61
13.3.1 General 61
13.3.2 General zone and local zone 61
13.3.3 Design of general zone 62
13.3.4 Design of local zone 64

14 Superstructure 65
14.1 Strength of members subjected to flexural moments 65
14.1.1 General 65
14.1.2 Factored flexural moment at section 65
14.1.3 Minimum design flexural moment strength 65
14.1.4 Nominal moment strength of PSC box girder 65
14.2 Strength of members subjected to shear stresses 69
14.2.1 General 69
14.2.2 Factored shear 69
14.2.3 Design shear strength 69
14.2.4 Design of shear reinforcement 69
14.3 Girders, beams, joists 70
14.4 Details of box girder 70
14.4.1 Flange and web thickness 70
14.4.2 Reinforcement 70
14.5 Diaphragms 71
14.6 Opening 71
14.7 Railings 73
14.8 Splices of strand 73
14.9 Continuous structure 73
14.9.1 Scope of application 73
14.9.2 General design 73
14.9.3 Structural analysis 73
14.9.4 Fixed support 75
14.9.5 Intermediate support 76

15 Substructure 77
15.1 Girders that are part of a frame 77
15.2 Strength of members subjected to axial loads with or without flexure 77
15.3 Torsion 77
15.4 Bearing strength 77
15.5 Columns and piers 77
15.6 Concrete walls 77

16 Foundations 77
16.1 Foundation type and capacity 77
16.2 Subsurface exploration and testing programs 77
16.3 Dimensioning of the foundation elements 77
16.4 Footings 78
16.5 Foundation mats 78
16.6 Footings on piles 78
16.7 Foundation beams 78
16.8 Retaining walls 78

17 Lateral load resisting system 78

17.1 General 78
17.2 Specified lateral forces 78
17.3 Lateral force resisting structural system 78
17.4 Minimum amount of structural concrete walls 78
17.5 Special reinforcement details for seismic zones 78

18 Bearings 78
18.1 General 78
18.2 Multiple roller bearings 78
18.3 Elastomeric bearings 78
18.4 Anchorage 79
18.5 Design forces for supporting structure 79

Annex A (informative) **Equivalent formulae for material factors 80**

Bibliography 82