
**Simplified design of prestressed
concrete bridges —**

**Part 1:
I-girder bridges**

Conception simplifiée des ponts en béton précontraint —

Partie 1: Ponts à poutres en I

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Contents

Page

Foreword.....	vii
Introduction.....	viii
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Symbols and abbreviated terms.....	6
5 Design and construction procedure.....	10
5.1 Procedure.....	10
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.....	13
5.2.5 Specifications.....	13
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 Maximum span length.....	13
6.1.5 Maximum difference in span length.....	13
6.1.6 Maximum cantilever length.....	14
6.1.7 Maximum height of bridge.....	14
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
6.2.1 General.....	15
6.2.2 Deflection serviceability verification.....	16
6.3 Ultimate limit state design format.....	17
6.3.1 General.....	17
6.3.2 Required factored loads.....	18
6.3.3 Design strength.....	18
6.4 Serviceability limit state design format.....	18
7 Structural systems and layout.....	19
7.1 Description of the components of the structure.....	19
7.1.1 General.....	19
7.1.2 Superstructure system.....	19
7.1.3 Substructure system.....	19
7.1.4 Foundation.....	19
7.2 General guide.....	19
7.2.1 Architectural guide.....	19
7.2.2 General structural guides for the project.....	20
7.3 Structural layout.....	20
7.3.1 General structural layout.....	20
7.3.2 Vertical layout.....	21
7.3.3 Cross beams.....	22
7.4 Feasibility under the document.....	22

8	Actions (Loads)	22
8.1	General	22
8.2	Dead loads	23
8.2.1	General	23
8.2.2	Structural elements	23
8.2.3	Non-structural elements	23
8.3	Live loads	24
8.3.1	General	24
8.3.2	Design truck	24
8.3.3	Design lane load	24
8.3.4	Pedestrian bridges	24
8.3.5	Dynamic effect of live loads	25
8.4	Longitudinal forces	26
8.5	Earth pressure	26
8.6	Wind loads	26
8.7	Earthquake inertial forces	27
8.7.1	General	27
8.7.2	Seismic hazard	27
8.7.3	No seismic hazard zones:	27
8.7.4	Low seismic hazard zones:	27
8.7.5	Intermediate seismic hazard zones:	27
8.7.6	High seismic hazard zones:	28
8.7.7	Soil profile types	32
8.7.8	Site effects	33
8.7.9	Design response spectral ordinates	33
8.7.10	Seismic equivalent uniformly distributed load	34
8.7.11	Fundamental mode shape	34
8.7.12	Lateral equivalent design forces	35
8.8	Jacking and post-tensioning forces	35
8.8.1	Jacking forces	35
8.8.2	Forces for post-tensioning anchorage	36
8.9	Thermal forces	36
8.10	Load combinations	38
8.10.1	Ultimate loads	38
8.10.2	Service loads	38
9	Design requirements	38
9.1	Scope	38
9.2	Additional requirements	38
9.3	Materials for structural concrete	38
9.3.1	General	38
9.3.2	Cement	38
9.3.3	Aggregates	39
9.3.4	Water	39
9.3.5	Steel reinforcement	39
9.3.6	Prestressing steel	39
9.3.7	Post-tensioning anchorages and couplers	40
9.3.8	Ducts	41
9.3.9	Admixtures	41
9.3.10	Storage of materials	41
9.3.11	Minimum and maximum reinforcement bar diameter	41
9.4	Concrete mixture proportioning	42
9.4.1	General	42
9.4.2	Durability requirements	42
9.4.3	Required average compressive strength	43
9.4.4	Proportioning of the concrete mixture	43
9.5	Concrete cover of reinforcement	44
9.5.1	Minimum concrete cover	44
9.5.2	Special corrosion protection	45

9.6	Minimum reinforcement bend diameter	45
9.7	Standard hook dimensions	46
9.8	Bar spacing and maximum aggregate size	47
9.8.1	General	47
9.8.2	Maximum nominal coarse aggregate size	47
9.8.3	Minimum clear spacing between parallel bars in a layer	48
9.8.4	Minimum clear spacing between parallel layers of reinforcement	48
9.8.5	Minimum clear spacing between longitudinal bars in columns	48
9.8.6	Clear spacing between parallel lap splices	49
9.8.7	Maximum flexural reinforcement spacing in solid slabs	49
9.8.8	Maximum shrinkage and temperature reinforcement spacing in solid slabs	49
9.8.9	Maximum reinforcement spacing in structural concrete walls	50
9.8.10	Minimum spacing of prestressing tendons and ducts	51
9.8.11	Maximum spacing of prestressing tendons in slabs	52
9.8.12	Couplers in post-tensioning tendons	52
9.9	Development length, lap splicing and anchorage of reinforcement	52
9.9.1	Development length	52
9.9.2	Lap splice dimensions	54
9.9.3	Minimum standard hook anchorage distance	54
9.10	Limits for longitudinal reinforcement	55
9.10.1	General	55
9.10.2	Solid slabs and footings	55
9.10.3	Girders, beams and joists	56
9.10.4	Columns	58
9.10.5	Structural concrete walls	59
9.11	Minimum amounts of transverse reinforcement	59
9.11.1	General	59
9.11.2	Slabs	59
9.11.3	Girders, beams and joists	59
9.11.4	Columns	60
9.11.5	Structural concrete walls	62
10	Stress limitations	63
10.1	Stress limitations for prestressing tendons	63
10.2	Stress limitations for concrete	64
10.2.1	For temporary stresses before losses-fully prestressed components	66
10.2.2	For stresses at serviceability limit state after losses-fully prestressed components	67
11	Loss of prestress	68
11.1	Total loss of prestress	68
11.2	Instantaneous losses	69
11.2.1	Anchorage set	69
11.2.2	Friction	69
11.2.3	Elastic shortening	70
11.3	Approximate estimate of time-dependent losses	70
12	Details of tendon	73
12.1	Tendon confinement	73
12.1.1	General	73
12.1.2	Effects of curved tendons	74
12.2	External tendon supports	75
12.3	Post-tensioned anchorage zones	75
12.3.1	General	75
12.3.2	General zone and local zone	75
12.3.3	Design of general zone	76
12.3.4	Design of local zone	78
12.4	Pretensioned anchorage zones	79
12.4.1	Bursting resistance	79
12.4.2	Confinement reinforcement	79

13	Superstructure	79
13.1	Strength of members subjected to flexural moments	79
13.1.1	General	79
13.1.2	Factored flexural moment at section and distribution factor method for moment	80
13.1.3	Minimum design flexural moment strength	80
13.1.4	Nominal moment strength of PSC I-girder with deck	80
13.1.5	T-beam effect	83
13.2	Strength of members subjected to shear stresses	85
13.2.1	General	85
13.2.2	Factored shear and distribution factor method for shear	85
13.2.3	Design shear strength	85
13.2.4	Cohesion and friction factors	86
13.2.5	Interface shear strength and minimum area of interface shear reinforcement	87
13.3	Decks	87
13.4	Solid slabs supported on girders, beams, or joists	87
13.5	Girders, beams, joists	87
13.6	Railings	87
14	Substructure	87
14.1	Girders that are part of a frame	87
14.2	Strength of members subjected to axial loads with or without flexure	87
14.3	Torsion	88
14.4	Bearing strength	88
14.5	Columns and piers	88
14.6	Concrete walls	88
15	Foundations	88
15.1	Foundation type and capacity	88
15.2	Subsurface exploration and testing programs	88
15.3	Dimensioning of the foundation elements	88
15.4	Footings	88
15.5	Foundation mats	88
15.6	Footings on piles	88
15.7	Foundation beams	88
15.8	Retaining walls	88
16	Lateral load resisting system	88
16.1	General	88
16.2	Specified lateral forces	89
16.3	Lateral force resisting structural system	89
16.4	Minimum amount of structural concrete walls	89
16.5	Special reinforcement details for seismic zones	89
17	Bearings	89
17.1	General	89
17.2	Multiple roller bearings	89
17.3	Elastomeric bearings	89
17.4	Anchorage	89
17.5	Design forces for supporting structure	89
Annex A (informative) Equivalent formulae for material factors		90
Annex B (informative) Beam deflection		92
Bibliography		93

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 5, *Simplified design standard for concrete structures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The aim of this document is to provide rules for the design and construction of relatively short span prestressed concrete I-girder bridges. This document is developed for countries that do not have existing national standards on this subject and to offer to local regulatory authorities an alternative for the design of relatively small bridges that abound in urban overpasses and over creeks and rivers everywhere. This document may not be used in place of a national standard unless specifically considered and accepted by the national standards body or other appropriate regulatory organization. The design rules are based on simplified worldwide-accepted strength design models. This document is self-contained; therefore, loads, simplified analysis procedures and design specifications are included, as well as minimum acceptable construction practice guidelines.

The minimum dimensional guidelines contained in this document are intended to account for undesirable side effects that require more sophisticated analysis and design procedures. Material and construction guidelines are aimed at site-mixed concrete as well as ready-mixed concrete, and steel of the minimum available strength grades.

The earthquake resistance guidelines are included to account for the numerous regions of the world which lie in earthquake prone areas. The earthquake resistance for zones with high seismic hazard is based on the employment of structural concrete walls (shear walls) that limit the lateral deformations of the structure and provide for its lateral strength, in place of piers or frames that can be used in zones with intermediate, low or no significant earthquake hazard.

This document contains provisions that can be modified by the national standards body due to local design and construction requirements and practices. The specifications that can be modified are included using ["boxed values"]. The national standards body is expected to review the "boxed values" and may substitute alternative definitive values for these elements for use in the national application of this document.

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Simplified design of prestressed concrete bridges —

Part 1: I-girder bridges

1 Scope

This document provides information to perform the design of the prestressed concrete I-girder bridge for road that complies with the limitations established in 6.1. The rules of design set forth in this document are simplifications of more elaborate requirements.

Designs and details for new road bridges address structural integrity by considering the following:

- the use of continuity and redundancy to provide one or more alternate paths;
- structural members and bearing seat widths that are resistant to damage or instability; and
- external protection systems to minimize the effects of reasonably conceived severe loads.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 28842, *Guidelines for simplified design of reinforced concrete bridges*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

admixture

material other than water, aggregate, or hydraulic cement, used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties

3.2

anchorage

device used to anchor a non-structural element to the structural framing

3.3

beam

horizontal, or nearly horizontal, structural member supported at one (such as a cantilever) or more points, but not throughout its length, transversely supporting a *load* (3.31), and subjected primarily to flexure

3.4

clearance

distance by which one thing clears another; the space between them

3.5

compression reinforcement

reinforcement provided to resist compression stresses induced by flexural moments acting on the member section

3.6

specified compressive strength

compressive cylinder strength of concrete used in design and evaluated in accordance with the appropriate ISO standard, expressed in megapascals (MPa)

Note 1 to entry: Whenever the quantity f_c' is under a radical sign ($\sqrt{f_c'}$), the positive square root of numerical value only is intended, and the result has units of megapascals (MPa).

3.7

confinement hook

hook (3.22) on a *stirrup* (3.46), hoop, or *crosstie* (3.11) having a bend not less than 135° with a six-diameter (but not less than 75 mm) extension that engages the *longitudinal reinforcement* (3.32) and projects into the interior of the stirrup or hoop

3.8

confinement stirrup

closed *stirrup* (3.46), *tie* (3.49) or continuously wound spiral

Note 1 to entry: A closed stirrup or tie can be made up of several reinforcement elements each having *confinement hooks* (3.7) at both ends. A continuously wound spiral should have a confinement hook at both ends.

3.9

corrosion

gradual removal or weakening of metal from its surface that requires the presence of humidity and oxygen, and is helped by the presence of other materials

3.10

cover

thickness of concrete between surface of any reinforcing bar and the nearest face of the concrete member

3.11

crosstie

continuous reinforcing bar having a 135° *hook* (3.22) at one end and a hook not less than 90° at least a six-diameter extension at the other end

Note 1 to entry: The hooks should engage peripheral longitudinal bars. The 90° hooks of two successive crossties engaging the same longitudinal bars should be alternated end for end.

3.12

deformed reinforcement

steel reinforcement that has deformations in its surface to increase its bond to the concrete

Note 1 to entry: The following steel reinforcement should be considered deformed reinforcement in this document: deformed reinforcing bars, deformed wire, welded plain wire fabric, and welded deformed wire fabric conforming to the appropriate ISO standards.

3.13

design strength

product of the *nominal strength* (3.35) multiplied by a *strength reduction factor* (3.47)

3.14**development length**

length of embedded reinforcement required to develop the *design strength* (3.13) of reinforcement at a critical section

3.15**development length**

<hook> shortest distance between the critical section (where the strength of the bar is to be developed) and a tangent to the outer edge of the 90° or 180° *hook* (3.22)

3.16**duct**

material creating a conduit in a concrete member to accommodate the *prestressing steel* (3.38) of a *post-tensioning* (3.37) *tendon* (3.48)

3.17**durability**

characteristic of a structure to resist gradual degradation of its serviceability in a given environment for the design service life

3.18**effective depth**

distance measured from extreme compression fibre to centroid of tension reinforcement

3.19**embedment length**

length of embedded reinforcement provided beyond a critical section

3.20**factored loads**

specified *nominal loads* (3.34) (forces) multiplied by the *load factors* (3.30) prescribed in this document

3.21**girder**

main horizontal support *beam* (3.3), usually supporting other beams

3.22**hook**

bend at the end of a reinforcing bar

Note 1 to entry: They are defined by the angle that the bend forms with the bar as either 90°, 180° or 135° hooks.

3.23**jacking force**

temporary force in prestressed concrete, exerted by the device that introduces tension into the *tendons* (3.48)

3.24**joist**

T-shaped *beam* (3.3) used in parallel series directly supporting deck *loads* (3.31), and supported in turn by larger *girders* (3.21), beams, or bearing structural concrete walls

3.25**lap splice**

splice between two reinforcing bars obtained by overlapping them for a specified length

3.26**limit state**

condition beyond which a structure or member becomes unfit for service and is judged either to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state)

3.27

live load

static and dynamic effect, in terms of forces applied on the structure, produced by the use of the bridge by pedestrians and/or vehicles and not including construction or environmental loads (3.31)

3.28

load combination

combination of *factored loads* (3.20) and forces as specified in this document

3.29

load effect

force and deformation produced in structural members by the applied loads (3.31)

3.30

load factor

factor that accounts for deviations of the actual load (3.31) from the *nominal load* (3.34), for uncertainties in the analysis that transforms the load into a *load effect* (3.29), and for the probability that more than one extreme load will occur simultaneously

3.31

load

force or other action that results from the weight of all bridge materials, pedestrians, vehicles, environmental effects, differential movement, and restrained dimensional changes

3.32

longitudinal reinforcement

reinforcement that is laid parallel to the longitudinal axis of the element, generally to account for flexural effects

3.33

mesh wire

welded-wire fabric reinforcement

3.34

nominal load

magnitude of the loads (3.31) specified in this document (dead, live, soil, wind, snow, rain, flood, and earthquake)

3.35

nominal strength

capacity of a structure or member to resist the effects of loads (3.31), as determined by computations using specified material strengths and dimensions and the Formulae set forth in this document

Note 1 to entry: Specified material strengths are derived from accepted principles of structural mechanics or by field tests or laboratory tests of scaled models, allowing for modelling effects and differences between laboratory and field conditions.

3.36

permanent load

load (3.31) in which variations over time are rare or of small magnitude

Note 1 to entry: All other loads are variable loads (see also 3.34).

3.37

post-tensioning

method of prestressing reinforced concrete in which *tendons* (3.48) are tensioned after the concrete has attained a specified minimum strength or a specified minimum age

3.38

prestressing steel

high-strength steel elements such as wire, bar, or strands used to impart prestress forces to concrete

3.39**pretensioning**

method of prestressing in which *prestressing steel* (3.38) is tensioned before the concrete is placed

3.40**required factored strength**

strength of a member or cross-section required to resist *factored loads* (3.20) or related internal moments and forces in such combinations as are stipulated by this document

3.41**service load**

load (3.31) without *load factors* (3.30)

3.42**shrinkage and temperature reinforcement**

reinforcement normal to flexural reinforcement provided for shrinkage and temperature stresses in structural solid slabs and footings where flexural reinforcement extends in one direction only

3.43**skew**

difference or deviation from an expected or optimal value; in the case of bridges, deviation of the longitudinal axis of the deck with respect to a line perpendicular to the length of the abutments

3.44**slab (deck)**

upper flat part of a reinforced concrete deck carried by supporting *joists* (3.24), *beams* (3.3) or *girders* (3.21)

3.45**spiral reinforcement**

continuously wound reinforcement in the form of a cylindrical helix

3.46**stirrup**

reinforcement used to resist shear and torsion stresses in a structural member

Note 1 to entry: Typically, bars, wires or welded-wire fabric (plain or deformed) either single leg or bent into L, U, or rectangular shapes and located perpendicular to or at an angle to *longitudinal reinforcement* (3.32). (The term "stirrups" is usually applied to lateral reinforcement in *girders* (3.21), *beams* (3.3) and *joists* (3.24). The term "ties" to those in columns and walls, perhaps because they are intended also as confinement for the longitudinal reinforcement.) See also 3.49.

3.47**strength reduction factor**

coefficient that accounts for deviations of the actual strength from the *nominal strength* (3.35), according to the manner and consequences of failure

Note 1 to entry: Including the probability of understrength members due to variations in material strengths and dimensions, approximations in the design Formulae, to reflect the degree of ductility and required reliability on the member under the *load effects* (3.29) being considered, and to reflect the importance of the element in the structure.

3.48**tendon**

an assembly consisting of a tensioned element (such as a wire, bar, rod, strand, or a bundle of these elements) used to impart compressive stress in concrete, along with any associated components used to enclose and anchor the tensioned element

3.49

tie

loop of reinforcing bar or wire enclosing *longitudinal reinforcement* (3.32)

Note 1 to entry: A continuously wound bar or wire in the form of a circle, rectangle, or other polygon shape without re-entrant corners is acceptable.

3.50

transfer length

length from the end of the member where the *tendon* (3.48) stress is zero to the point along the tendon where the prestress is fully effective

3.51

transverse reinforcement

reinforcement located perpendicular to the longitudinal axis of the element, comprising *stirrups* (3.46), *ties* (3.49), *spiral reinforcement* (3.45), among others

3.52

yield strength

specified minimum yield strength or yield point of reinforcement

Note 1 to entry: The yield strength is expressed in units of megapascals (MPa).

Note 2 to entry: Applicable International Standards specify that the yield strength or yield point be determined in tension.

4 Symbols and abbreviated terms

Symbol	Explanation	Unit
a	depth of equivalent uniform compressive stress block	mm
a_0	acceleration limit	g
a_{eff}	lateral dimension of the effective bearing area measured parallel to the larger dimension of the cross-section	mm
a_l	lateral dimension of the anchorage device or group of devices in the direction considered	mm
a_p	peak acceleration	g
A	maximum area of the portion of the supporting surface that is similar to the loaded area and concentric with it and does not overlap similar areas for adjacent anchorage devices	mm ²
A_a	fraction of acceleration of gravity	—
A_b	effective bearing area	mm ²
A_c	area of concrete section	mm ²
A_{cc}	area of the confined column core, in a column with spiral reinforcement, measured centre to centre of the spiral	mm ²
A_{conf}	bearing area of the confined concrete in local zone	mm ²
A_{cv}	area of concrete section resisting shear transfer	mm ²
A_g	gross area of section of element	mm ²
A_{plate}	anchor bearing plate area	mm ²
A_{ps}	area of prestressing steel	mm ²
$A_{ps,d}$	area of prestressing steel corresponding to concrete deck	mm ²
A_s	area of longitudinal tension reinforcement	mm ²
A_s'	area of longitudinal compression reinforcement	mm ²
$A_{s,\text{min}}$	minimum area of longitudinal tension reinforcement	mm ²
A_{ss}	area of spiral reinforcement	mm ²