National Roads Authority
An tÚdarás um Bóithre Náisiúnta

Volume 1 Section 3
Part 1

NRA BD 24/00

The Design of Concrete Road Bridges and Structures

Use of BS 5400: Part 4: 1990

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Summary:

This Standard covers the use of BS 5400: Part 4: 1990 for the design of concrete road bridges and other structures on motorways and other national roads.

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VOLUME 1 HIGHWAY STRUCTURES: APPROVAL PROCEDURES AND GENERAL DESIGN
SECTION 3 GENERAL DESIGN

PART 1

NRA BD 24/00

THE DESIGN OF CONCRETE ROAD BRIDGES AND STRUCTURES USE OF BS 5400: PART 4: 1990

Contents

1. INTRODUCTION

General

1.1 The purpose of this Standard is to implement the 1990 edition of BS 5400: Part 4.

1.2 Where this Standard is applied for the design of precast concrete elements which are procured through a contract incorporating the NRA Specification for Road Works, products conforming to equivalent standards and specifications of other member states of the European Union will be acceptable in accordance with the terms of Clauses 104 and 105 of that Specification. Any contract for the procurement of precast concrete elements which does not include these Clauses must contain a suitable clause of mutual recognition having the same effect, regarding which advice should be sought.

1.3 This Standard provides specification requirements for use in public purchasing contracts. It does not lay down legislation requirements for products and materials used in road construction in Ireland.

Scope

1.4 This Standard covers the use of BS 5400: Part 4: 1990, for the design of structural concrete in bridges and other road structures. It sets out the National Roads Authority's particular requirements where these differ from, or are more comprehensive than, those given in the British Standard.

1.5 This Standard does not cover the design of buried rigid pipe structures. Such structures shall be designed in accordance with the requirements of BD 82 (DMRB 2.2.10).

2. USE OF THE BRITISH STANDARD

General

2.1 The design of all concrete bridges and other road structures which are funded by the National Roads Authority shall be carried out in accordance with BS 5400: Part 4: 1990 as amended by this Standard. Where reference is made to any Part of BS 5400, this shall be taken as a reference to that Part as implemented by the National Roads Authority.

2.2 The amendments to BS 5400: Part 4 which are necessary to meet the National Roads Authority's requirements are given in Annex A to this Standard. The amendments are listed under the relevant clause numbers of BS 5400: Part 4. Annex A is technically identical to the Interim Advice Note (IAN5) issued by the UK Highways Agency in July 1996.

Additional Requirements

2.3 The clauses in BS 5400: Part 4: 1990 that are expressed in the form of recommendations using the word "should" are to be considered as mandatory.

2.4 Where reference is made in BS 5400: Part 4 to the relevant or appropriate "Bridge Authority", this shall be taken to be both the National Roads Authority and the Local Authority responsible for roads and bridges.

2.5 For the serviceability limit state requirements of prestressed concrete members given in Clause 4.2.2 of BS 5400: Part 4:-

a. The following shall be considered to be lightly trafficked structures:

i. accommodation bridges;

ii. bridleway bridges;

iii. foot/cycle track bridges.

b. All members shall be checked as being in Class 2 for load combinations 2 to 5.

2.6 For the design of plain concrete structures and cast in-situ reinforced concrete structures, the requirements of BD 57 (DMRB 1.3.7) shall be taken into account in order to provide durability.

2.7 For the design of concrete bridges and other structures with external and unbonded prestressing, the additional requirements of BD 58 (DMRB 1.3.9) shall be taken into account.

2.8 For the design of both reinforced concrete members and post-tensioned concrete members prior to prestressing, the additional requirements of BD 28 (DMRB 1.3) shall be taken into account in order to control thermal cracking.

3. POST TENSIONED GROUTED DUCT CONCRETE BRIDGES

Design

3.1 In general the design of bonded post-tensioned concrete bridges should be in accordance with the requirements of BS 5400 : Part 4 as implemented by this Standard. However there are a number of matters concerned with the detailed design of such structures which require careful consideration to ensure that the steel tendons and anchorages are properly protected from corrosion. These matters are fully described in the Concrete Society's Technical Report TR47, Durable Bonded Post-Tensioned Concrete Bridges, and it is considered important that the detailed recommendations of the report be followed. A fundamental aspect of the TR47 recommendations is the idea of multi-layer protection against corrosion, which is associated with the belief that there are a number of factors which can all contribute to making bonded post-tensioned structures durable.

3.2 The detailed recommendations of TR47 concerned with design cover the following areas:

- expansion joints
- location of construction joints
- sealed duct system
- duct and anchorage layout
- bridge deck waterproofing systems
- drainage
- anchorage location and corrosion protection
- cracking
- vent locations
- access for inspection and maintenance.

3.3 Amongst the various recommendations in TR47 there are two which should be observed for all designs. Where it is intended to do otherwise, carefully detailed proposals and justifications should accompany the submission for Preliminary Approval.

a) Ducts are to be made from non-metallic material which can be jointed in such a way that there is an effective seal, which can be pressure tested, to prevent the ingress of contaminants.
b) No anchorages are to be placed in pockets formed in the top surface of bridge decks; however anchorages may be formed in blisters on the under surface of bridge deck slabs. In all cases the detailing recommended for a particular anchorage location should be followed.

Workmanship and Materials

3.4 The specification for the various materials, components and operations connected with the grouted duct form of post-tensioned construction shall be in accordance with the NRA Specification for Road Works.

Preliminary Approval Procedure

3.5 All new construction, strengthening and maintenance operations involving post-tensioned grouted duct construction techniques will be subject to Preliminary Approval procedures in accordance with NRA BD 2 (NRA DMRB 1.1). The design of the post-tensioning system will be classed as an aspect not covered by standards.

3.6 In order that schemes which propose the use of the internal grouted duct form of post-tensioning can be appraised technically, the Preliminary Approval documentation will need to cover the following points:

a) confirmation that the recommendations given in TR47 regarding the detailed design of the structure have been carefully studied and will be incorporated into the design where appropriate;
b) any non-compliance with the accepted TR47 recommendations should be noted with reasons for the non-compliance;
c) QA requirements will be included in the contract;
d) a requirement that the installation of the post-tensioning system should be carried out in

accordance with the recommendations of TR47.

3.7 Proposals for the use of grouted duct post-tensioned systems in bridges constructed from precast concrete segments will require early consultation with the National Roads Authority.

4. REFERENCES

4.1 The following documents are referred to in this Standard:

BS 5400: Steel, concrete and composite bridges: Part 4: 1990. Code of Practice for design of concrete bridges.

Concrete Society Technical Report TR47, Durable Bonded Post-tensioned Concrete Bridges, 1996.

Design Manual for Roads and Bridges (DMRB):

Volume 1 Highway Structures: Approval Procedures and General Design:

NRA BD 2 Technical Approval of Structures on Motorways and Other National Roads (NRA DMRB 1.1).

BD 57 Design for Durability (DMRB 1.3.7).

BD 58 The Design of Concrete Highway Bridges and Structures With External and Unbonded Prestressing (DMRB 1.3.9).

BD 28 Early Thermal Cracking of Concrete (DMRB 1.3).

BD 37 Loads for Highway Bridges (DMRB 1.3).

Volume 2 Highway Structures: Design (Substructures and Special Structures) Materials:

BD 82 Design of Buried Rigid Pipes.

Interim Advice Note IAN5, The Design of Concrete Highway Bridges and Structures, Use of BS 5400: Part 4: 1990. Highways Agency, London, July 1996.

NRA Manual of Contract Documents for Road Works, Volume 1: Specification for Road Works.

5. ENQUIRIES

5.1 All technical enquiries or comments on this Standard should be sent in writing to:

Head of Project Management and Engineering
National Roads Authority
St Martin's House
Waterloo Road
Dublin 4

……

E O'CONNOR
Head of Project Management and Engineering

ANNEX A : AMENDMENTS TO BS 5400: PART 4: 1990

The following is a list of amendments necessary to meet the National Roads Authority's requirements:

Page 3 Contents, Figures 5. Delete "stress".

Page 10 Clause 4.2.2. Delete "Where type HB loading is to be taken into account, only 25 units should be considered", and substitute the following:

"Live loading should generally comprise Type HA only. However, for transverse cantilever slabs, transversely and two-way spanning slabs and central reserves, the loading shall be in accordance with the composite version of BS 5400: Part 2 Clause 6.4.3 (Appendix A of BD 37 (DMRB 1.3)) except that only 30 units of HB loading shall be considered in any notional lane."

Page 12 Clause 4.7. Delete paragraph beginning "For unwelded reinforcement …", and substitute:

"For unwelded reinforcing bars, the effective stress range under load combination 1 for the serviceability limit state under HA loading only, shall be limited to the following values:

Spans	**bars $\leq$ 16mm dia**	**bars > 16mm dia**
less than 3.5m	280 N/mm^2	220 N/mm^2
3.5 – 5m	250 N/mm^2	190 N/mm^2
5m – 10m	195 N/mm^2	150 N/mm^2
10m – 200m	155 N/mm^2	120 N/mm^2
200m and greater	250 N/mm^2	190 N/mm^2

Alternatively, the fatigue life may be determined in accordance with BS 5400: Part 10 using the following parameters for the σ_r-N relationship:

bars $\leq$16mm dia; m = 9, $K_2 = 0.75 \times 10^{27}$
bars >16mm dia; m = 9, $K_2 = 0.07 \times 10^{27}$

A fatigue check is not required for the local effects of wheel loads applied directly to a slab spanning between beams or webs provided that the following conditions are met:

(i) the clear span to overall depth ratio of the slab does not exceed 18;
(ii) the slab acts compositely with its supporting beams or webs;
(iii) either (a) the slab acts compositely with transverse diaphragms or (b) the width of the slab perpendicular to its span exceeds three times its clear span.

The effective stress range to be used in fatigue assessment should be obtained by adding 60% of the range from zero stress to maximum compressive stress to that part of the range from zero stress to maximum tensile stress."

Page 16 Table 6. Cold reduced steel wire, characteristic strength: delete "485" and substitute "460".

Page 17 Clause 5.3.2.2. Delete clause.

Page 18 Clause 5.3.3.2. Last paragraph: delete "bonding" and substitute "bending".

Page 24 Clause 5.5.3.3. Delete clause.

Page 26 Clause 5.5.6. Add at end of clause:
"In calculating the ultimate shear capacity of a circular column, the area of longitudinal reinforcement A_s to be used to calculate v_c shall be taken as the area of reinforcement which is in the half of the column opposite the extreme compression fibre. The effective depth shall be taken as the distance from the extreme fibre with maximum compression to the centroid of this reinforcement. The web width shall be taken as the column diameter."

Page 28 Clause 5.8.2. Third paragraph: after "given in Table 13" add "for precast concrete and the values given in Table 13 increased by 10mm for cast in-situ concrete,".

Page 31 Clause 5.8.6.6. First paragraph, (e): add "(See 7.3.2.3)". Third paragraph: delete "in (c) and (d)" and substitute, "in (c), (d) and (e)".

Clause 5.8.6.7. First paragraph: reposition last sentence "The length of the lap … compression reinforcement." in new paragraph at end of Clause.

Page 38 Clause 6.3.3.2. Delete clause.

Page 48 Clause 7.3.2.1 (d). Delete "threading of bars" and substitute "parallel threading of bars and tapered threads".

Clause 7.3.2.3 (a). Delete "The" and substitute "Parallel".

Before paragraph beginning "Where there is a risk …" add "d) Taper threaded bars may be joined by the use of internally taper threaded couplers".

Delete last paragraph beginning "The structural design of special threaded connections …", and substitute:

"The structural design of threaded connections should be based on tests in accordance with 5.8.6.6, including behaviour under fatigue conditions where relevant. Where tests have shown the strength of the threaded connection to be greater than or equal to the characteristic strength of the parent bars, the strength of the joint may be based on the specified characteristic strength of the joined bars divided by the appropriate γ_m factor."

Page 49 Clause 7.3.3. Last paragraph, beginning "For cement mortar joints…", delete "$1.5N/mm^2$" and substitute "$2.5N/mm^2$".

Page 52 Clause 7.5.5. In the definition of n_w delete "load per unit load" and substitute "load per unit length".