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Transport Infrastructure Ireland

TII Publications

GE PE DN CC OP AM RE

Design for Durability

DN-STR-03012
October 2016

DN Design

Standards

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TII Publication Title	*Design for Durability*
TII Publication Number	*DN-STR-03012*

Activity	*Design (DN)*		**Document Set**	*Standards*
Stream	*Structures (STR)*		**Publication Date**	*October 2016*
Document Number	*03012*		**Historical Reference**	**NRA BD 57**

TII Publications Website

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TII Publications

Activity:	Design (DN)
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Set:	Standards

Contents

Updates to TII Publications resulting in changes to

Design for Durability DN-STR-03012

Date:	December 2017
Page No:	5
Section No:	Section 2.5

Amendment Details:

The following minor amendment has been incorporated into the October 2016 version of this Standard:

a) Section 2.5 has been updated to clarify the requirements to maintain a minimum clear distance of 600mm between the top of the buried structure and the external face of the underside of the drainage pipe.

Contents Table

1. Introduction

1.1 General

It has been found that the durability of many bridges in Transport Infrastructure Ireland's stock has been limited by decisions made at the design stage in relation to the bridge configuration and the choice of details. Feedback from the inspection and maintenance of road structures has highlighted durability problems even where materials, specification and construction practices have been satisfactory. These problems can often be linked to a design philosophy in which minimising the initial cost was paramount. Inadequate consideration may have been given to the long-term performance and maintenance of the structure either in the choice of structural form or in the design of construction details. This has, in too many cases, resulted in maintenance problems requiring costly repair. Consequently, Transport Infrastructure Ireland is keen to promote the concept of design for durability, thereby shifting the emphasis to a lowest whole life cost design philosophy.

This standard supersedes DN-STR-03012-Design for Durability dated June 2016.

The principal changes from the previous standard are:

i) Amendments to Appendix B – Concrete Cover Requirements.

1.2 Scope

The purpose of this Standard is to give requirements which, when used in conjunction with the existing framework of Transport Infrastructure Ireland's design standards for road structures, will improve the durability and minimise the whole-life costs of new structures.

This Standard considers various ways in which the design can contribute to the durability of a structure and identifies aspects of structural form and details, which require special attention. Many items covered in this document are acknowledged by designers as being good practice but their use has not been as widespread as would be desirable. Certain aspects of specification of materials, construction practices, inspection, and maintenance relating to durability, which are dealt with in more detail in TII Publications (Standards), are also briefly mentioned.

It should be emphasised that this Standard is not comprehensive and sets only minimum requirements. Designers should use their judgement and experience to ensure that durability aspects are catered for adequately in new structures.

The figures incorporated in this Standard are only indicative. Designers should satisfy themselves as to the suitability of the suggested details to specific designs.

1.3 Implementation

This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of Transport Infrastructure Ireland, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with Transport Infrastructure Ireland.

It is the responsibility of the Design Organisation to prepare designs, which will be durable. This applies both in the overall concept and in the details of the design. Designs shall either comply with the requirements of this Standard, or contain alternative provisions, which will ensure adequate durability. Such alternative provisions will be subject to an approved departure from standards.

1.4 Definitions

Serviceability is the ability of structures to fulfil, without restriction, all the needs which they are designed to satisfy. In the design of a road structure, these needs include:

i) The ability to carry without restriction all normal traffic permitted to use the structure;

ii) Maintenance of user safety by provision of adequate containment, separation of classes of users, effective evacuation of surface water etc.;

iii) Maintenance of user comfort by avoiding excessive deflections, vibrations, uneven running surfaces, etc.;

iv) Avoidance of public concern caused by excessive deflections, vibrations, cracking of structural elements, etc.;

v) Maintenance of acceptable appearance by avoiding unsightly cracking, staining, deflection etc.

In the design of structures, however, the first of the above needs is supplemented by a separate check on the maximum load carrying capacity, known as the ultimate limit state. The ability to carry abnormal vehicles is also a need, which Transport Infrastructure Ireland's new structures must satisfy, but the occurrence of such loading is deemed infrequent and not relevant to the maintenance of the structure's serviceability.

Durability is the ability of materials or structures to resist, for a certain period of time and with regular maintenance, all the effects to which they are subjected, so that no significant change occurs in their serviceability. In the design of road structures, the target period during which structures must remain durable, corresponds to the design life as defined in Chapter 2 of this document.

Durability is influenced by the following factors:

i) Design and detailing;

ii) Specification of materials used in construction;

iii) Quality of construction.

The control of items (ii) and (iii) is achieved through the use of accepted standards and procedures. However, the design of structures is not so readily associated with the achievement of durability, beyond such considerations as cover to reinforcement, crack width limitation or minimum steel plate thickness. This lack of attention to the durability aspect of design has resulted in premature loss of serviceability in many road structures.

1.5 Departures from Standards

In exceptional situations, Transport Infrastructure Ireland may be prepared to agree to a Departure from Standard where the standard is not realistically achievable. Design Organisations faced by such situations and wishing to consider pursuing this course shall discuss any such option at an early stage in design with Transport Infrastructure Ireland. Proposals to adopt Departures from Standard must be submitted by the Design Organisation to Transport Infrastructure Ireland in accordance with GE-GEN-01005 - Departures from Standards and Specification and formal approval be received before incorporation into a design layout. The Design Organisation shall record the fact that a Departure has been used in the design and the corresponding reasons for its use. The record shall be contained in the Technical Acceptance Report in accordance with DN-STR-03001-Technical Acceptance of Road Structures on Motorways and Other National Roads.

2. Improved Durability – Conceptual / Preliminary Design Stage

2.1 General

The type of structure selected for a particular location can have an important bearing on its durability. This chapter identifies minimum requirements for overall structural forms and layouts which are known to perform well from a durability perspective. The use of gabions as part of any structure shall not be permitted.

2.2 Design Life

The design life for all structures shall be 120 years unless otherwise stated below:

i) The design life for replaceable structural parts (i.e. bearings, waterproofing systems, expansion joints, parapets and safety barriers) shall be 50 years;

ii) The design life for short term structures (i.e. CCTV masts / high mast lighting and bridge gantries / access systems) shall be 50 years;

iii) The design life for temporary structures shall be 10 years;

iv) The design life for environmental noise barriers shall be as set out in CC-SPW-00300 - Specification for Road Works Series 300 - Fencing and Environmental Barriers.

2.3 Integral Design

The design for bridges of length not exceeding 60 metres, measured between the front faces of the end supports, and with skew angle not exceeding 30 degrees shall ensure that such bridges shall be fully integral.

Fully integral construction shall be defined as:

- End Supports:

A monolithic connection between the substructure and superstructure with no expansion joints or bearings at the end supports.

- Intermediate Supports:

A monolithic connection between the bridge deck and intermediate supports (no bearings) or in the case of steel plate girder decks, bridge deck supported on bearings. In both cases the bridge deck to be continuous over intermediate supports.

All integral abutments shall be designed, detailed and constructed so as to accommodate all imposed actions thereby avoiding future repairs to distressed pavement which may form above inadequately formed integral abutments.

Where practicable, the design for bridges of length exceeding 60 metres, measured between the front faces of the end supports, and/or with skew angle exceeding 30 degrees shall also be fully integral. Where fully integral construction is not possible, the design of such bridges shall be semi integral.

Semi integral construction shall be defined as:

- End Supports:

Construction of the end supports involving no expansion joint but with bearings (for example, with an end screen wall).

- Intermediate Supports:

A monolithic connection between the bridge deck and intermediate supports (no bearings) or in the case of steel plate girder decks, bridge deck supported on bearings. In both cases the bridge deck to be continuous over intermediate supports.

The design of bridges which are fully articulated (i.e. supported off bearings at all support points and containing expansion joints) shall only be accepted in special circumstances and where agreed with TII via the Structures Technical Acceptance process (see DN-STR-03001-Technical Acceptance of Road Structures on Motorways and Other National Roads). Where the use of a fully articulated structure is agreed, particular attention shall be paid to inspection and maintenance access arrangements for the joints and bearings as detailed in the remainder of this document.

Run-on slabs shall not generally be provided, due to the potential for ongoing maintenance problems, unless special circumstances exist. Where it is considered by the Design Organisation that a run on slab is required, this fact shall be brought to the attention of TII via the Structures Technical Acceptance process (see DN-STR-03001-Technical Acceptance of Road Structures on Motorways and Other National Roads) at the earliest possible stage.

2.4 Structural Continuity

All bridges shall be designed as continuous over intermediate supports. Such continuity shall be full continuity of the whole bridge deck structure (slab and beams where appropriate). Partial continuity, (generally by the slab only), shall not be permitted due to the difficulty in maintaining uninspectable faces. Where it is considered by the Design Organisation that a fully continuous structure can not be provided, this fact shall be brought to the attention of TII via the Structures Technical Acceptance process (see DN-STR-03001-Technical Acceptance of Road Structures on Motorways and Other National Roads.) at the earliest possible stage

There are serious inspection, construction and maintenance problems associated with in-span discontinuities, generally referred to as ‘half-joints’. Half-joints shall not be provided in bridge decks.

Deck hinges must not be used in bridges, unless there are adequate facilities for inspection and maintenance and specific agreement with TII is sought.

2.5 Drainage

The proposed method of draining any bridge deck and adjoining road shall be considered during the conceptual / preliminary design stage. Bridge decks shall be designed to shed water as quickly and efficiently as possible. Refer to Chapter 3 for further details.

All bridge decks shall be provided with an adequate surface water drainage system or bridge deck drainage system.

The use of intermittent side inlet gullies shall not be permitted. Where gullies are required, a continuous run of gullies shall be provided over the whole length of the bridge deck.

The design for structures shall ensure that bridge decks shall project beyond the substructure in such a manner as to prevent water running down piers and abutments.

Mainline road drainage shall not be carried over, across or through any structure. Mainline road drainage may be carried over buried structures where there is sufficient fill above the structure to both accommodate the drainage run and also to maintain a minimum clear distance of 600mm between the top of the buried structure and the external face of the underside of the drainage pipe.

2.6 Buried Structures

Subject to any overriding requirements relating to cost, cost benefit (including impacts on overall scheme earthworks balance), clearance, spans and aesthetics, structures of the buried type shall be provided for all bridges.

All structures must achieve the design life specified in this document. In the case of corrugated steel buried structures a combination of sacrificial steel thickness and galvanising shall be provided to achieve the design life. Furthermore a secondary protective coating system shall be applied to permanently accessible surfaces with a life to the first maintenance of six years. Such secondary protective system shall not be taken into account in the determination of the Design life of any such Structure.

Where a corrugated steel structure carries water or effluent, reinforced concrete invert protection with a 120 year design life shall be provided in accordance with the requirements of DN-STR-03003-Design of Corrugated Steel Buried Structures with Spans Greater Than 0.9 Metres and up to 8 Metres.

2.7 Box Section Bridge Decks

Where practicable, the size of box sections in concrete or steel bridge decks shall be such that proper inspection and maintenance can be carried out within the box.

If it is not possible to provide safe access to the interior of the box, steel box sections shall be sealed to prevent water or airborne pollutants from entering the interior of the box.

If it is not possible to provide safe access to the interior of concrete boxes, all reasonable efforts shall be taken to prevent water or airborne pollutants from entering the interior of the box, however, drainage holes shall also be provided (as per Chapter 3) and the exposure class for concrete within the box shall be in accordance with Appendix A.

Voided slab and cellular decks shall also comply with the requirements above.

2.8 Access

Detailed requirements for the inspection and maintenance of structures are included in Chapter 5 of this standard. However, at preliminary / conceptual design stage, the design shall include the following provisions for access to any structure:

a) Access for routine inspection;

b) Access for cleaning, maintenance and painting;

c) Access, where appropriate, for prestressing tendon or stay cable replacement;

d) Access to closed cells or box sections as per Section 2.7 above;

e) Access to parts that may require maintenance or replacement during the life of the structure, for instance, bearings, joints, anchorage locations, drainage, pipes, manholes, lubrication of moving parts, lighting systems, etc.;

f) Access for jacking at bearings and for their removal and replacement.

2.9 Bridge Abutment Galleries

All bridges which are fully articulated and / or which use in situ post-tensioned construction for the deck shall be provided with abutment galleries of the form illustrated in Figure 2.1.

The design of any such structure shall not include abutment details which create inaccessible areas which are vulnerable to concrete contamination by de-icing salts through leakage at joints or which are difficult to inspect and maintain.

2.10 Substructures

Exposed structural steelwork shall not be permitted for use in the substructure of any bridge with the exception of corrugated steel buried structures.

2.11 Retaining Walls

All retaining walls, including wingwalls and reinforced earth solutions, shall be detailed with a coping and a drip check.

2.12 Post-tensioned Structures

Grouted post-tensioned bridge Structures shall be designed, executed and completed in accordance with the latest edition of Concrete Society Technical Report No 72 “Durable Post-Tensioned Concrete Structures”.

Full scale grout trials, in accordance with CC-SPW-01700 - Specification for Road Works Series 1700 - Structural Concrete shall be required prior to execution of any in-situ post tensioned bridge and after completion of every fifth post tensioned structure thereafter. All full-scale grout trials shall be to the profile of a typical tendon in each structure and shall be over the full length of the tendon contained in each such structure design.

2.13 Segmental Construction

Precast concrete segmental construction shall use external post-tensioning systems. Segmental construction using internal grouted tendons shall not be accepted. Where it is considered by the Design Organisation that this form of construction is required, this shall require a Departure from Standards.

2.14 Cable Replacement

Structures containing cable stays or unbonded prestressing strands shall be designed and detailed to facilitate cable or strand replacement.

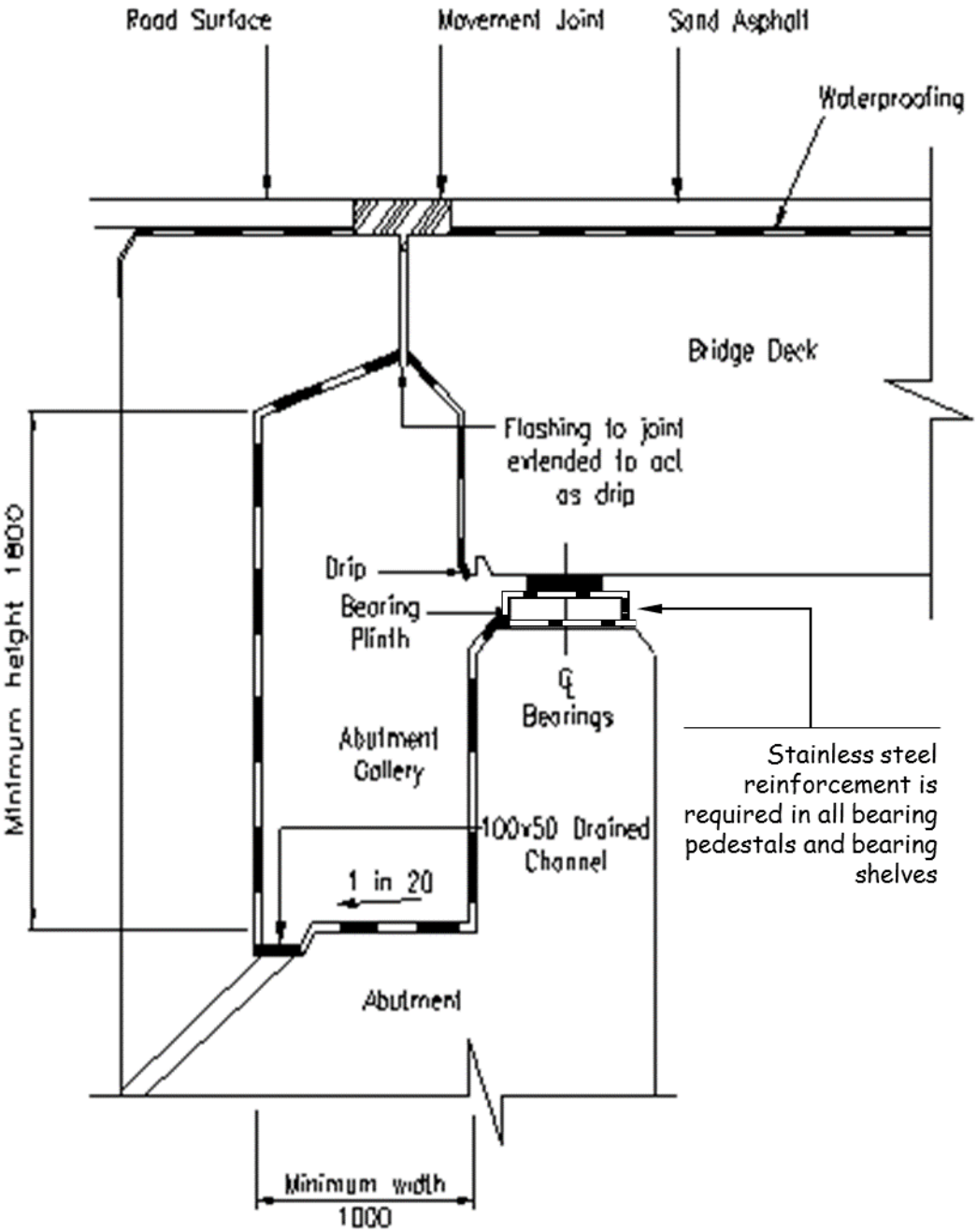


Figure 2.1: Abutment Gallery

3. Improved Durability – Detailed Design Stage

3.1 General

The life of a bridge can be considerably enhanced at little additional expense by sound detailing of structural elements. This chapter gives minimum requirements on aspects of detailed design, which are known to enhance durability. For guidance on proven details, Design Organisations are referred to the CIRIA Report C543 “Bridge Detailing Guide” (Soubry, 2001).

3.2 Reinforcement Cover

The nominal concrete cover (cnom) to be specified on the drawings is defined in IS EN 1992-1-1 as the sum of the minimum cover (cmin) and an allowance for deviation (Δcdev). Notwithstanding any information to the contrary in IS EN 1992 or IS EN 206-1 or their respective national annexes, the minimum cover for durability to reinforcement in concrete structures (cmin,dur) shall be in accordance with the requirements set out in Table B.1 in Appendix B to this standard.

The appropriate concrete exposure class to use on national roads structures shall be in accordance with Appendix A to this standard, unless an alternative arrangement has been agreed with TII via the Structures Technical Acceptance process (see DN-STR-03001-Technical Acceptance of Road Structures on Motorways and Other National Roads).

With reference to Figure 2.1, and notwithstanding any other requirements of this standard, if circumstances arise which demand a detail which cannot be waterproofed and cannot be accessed for maintenance, a minimum concrete cover to reinforcement of 80mm shall be provided to those concrete faces directly below the movement joint.

3.3 Drainage

Systems for the drainage of surface water from bridges shall be so detailed that water is not allowed to fall freely from the bridge deck.

Openings through bridge decks for surface water drainage and the routing of surface water discharge through steel box sections shall not be permitted.

Closed drainage systems shall be sufficiently robust to withstand damage during cleaning, as this has been an important cause of problems on many existing bridges. They shall also be resistant to damage from all commonly occurring chemical spillages on the road surface. Drainage systems shall be designed and detailed so as to accommodate movement of the structure.

Drainage waters from bridge decks shall not be discharged into the drainage layers behind abutments.

Drainage systems integral with the structure, for instance gullies cast into beams and pipes cast into columns, shall not be used. On short span bridges surface water shall be collected off the bridge deck.

A positive drainage system shall be provided to all structures to drain any water percolating through the surfacing and collecting on the waterproof membrane. The top surface of all bridge decks shall have adequate falls to avoid ponding, especially in the vicinity of deck movement joints.

Drainage systems shall be provided with adequate facilities for inspection, rodding and cleaning operations. Rodding access shall be provided so that rodding lengths are straight or virtually straight, and do not normally exceed 45m on straight runs. All gullies shall be fully trapped.

The Design Organisation shall record the proposed methods of cleaning and maintaining the proposed drainage systems, which shall minimise the need for traffic management, for inclusion in the Safety File.

All bridge abutments, buried structures and earth retaining structures shall be provided with a positive drainage system to the earth faces in accordance with the Specification for Works in TII Publications (Standards). Such drainage systems shall include for future access and rodding.

Holes shall be provided to drain the voids of bridge decks (subject to the overriding requirements of Chapter 2 of this document), such as box beams and cellular and voided slabs, as water may find its way into these voids causing corrosion and deterioration. Box members shall be provided with sealed access hatches or manhole covers to prevent leakage into the box. Adequate and effective ventilation and drainage holes shall also be provided to reduce condensation and eliminate any ponding inside the box as a result of the possible ingress of water. Ventilation and drainage holes shall be detailed to prevent access and colonisation by birds and animals.

Bearing shelves and expansion joints in structures shall be provided with a positive drainage system tied into the road drainage system and such drainage systems shall be accessible for cleaning and rodding.

3.4 Drip Checks

Drip checks shall be provided in the design for structures at all edge beams, deck ends over abutments and other locations such as copings to retaining walls and reinforced earth bridge abutments and wingwalls to prevent water running back along horizontal or vertical surfaces.

The preferred form of drip check is an unreinforced concrete downstand. Alternatively, if a groove type drip check is to be used, the full cover required by TII Publications (Standards) measured from the inside of the groove to the outer most reinforcement, including links, shall be provided.

3.5 Waterproofing

Bridge deck waterproofing systems shall be spray applied, satisfy the requirements of DN-STR-03009 - Waterproofing and Surfacing of Concrete Bridge Decks and shall be capable of being non-destructively tested. Where waterproofing membranes may be subject to direct foot traffic, they shall be sufficiently robust to withstand such use, and shall not be slippery.

As a minimum, and notwithstanding any other requirements, the following surfaces shall be protected with a bridge deck waterproofing system as detailed above:

i) The deck slab between parapet upstands;

ii) The parapet upstands to a height of 100 millimetres minimum above adjacent deck slab level;

iii) The vertical faces at deck ends;

iv) The back of abutment walls for integral bridges, from bridge deck level to a level 200mm below the construction joint between superstructure and substructure;

v) All internal faces of service troughs in bridge decks;

vi) The top face of abutment bearing shelves;

vii) All inaccessible areas which may be at risk due to leakage;

viii) All internal faces of abutment galleries;

ix) All accessible faces of run on slabs;

x) Top surface of parapet support slabs.

Where buried box sections are to be used for bridge structures including accommodation underpasses, the upper surface of the bottom slab shall be waterproofed with a bridge deck waterproofing system.

All exposed concrete in bridge superstructures, substructures, and box structures, culverts and retaining walls, shall be impregnated with a hydrophobic pore liner in accordance with TII Specification for Works except internal faces of culverts carrying watercourses and drainage.

All buried concrete faces of structures not requiring bridge deck waterproofing in accordance with this section, shall be treated with two coats of epoxy resin waterproofing for below ground concrete in accordance with TII Specification for Works.

Notwithstanding any other requirements in TII Publications (Standards), where buried box sections are to be used for bridge structures including accommodation underpasses, the top surface, and the top of the adjoining vertical external surfaces to a level of 200mm below the soffit of the top slab, shall be protected with a suitable waterproofing system in accordance the following:

i) Where the depth of cover to the buried box section is less than 1m (including the road pavement), the waterproofing system shall be a proprietary spray applied system in accordance with DN-STR-03009- Waterproofing and Surfacing of Concrete Bridge Decks and CC-SPW-02000- Specification for Road Works Series 2000- Waterproofing for Concrete Structures.

ii) Where the depth of cover to the buried box section is greater than 1m and less than 3m (including the road pavement), the waterproofing system shall be a proprietary spray applied system in accordance with DN-STR-03009- Waterproofing and Surfacing of Concrete Bridge Decks and CC-SPW-02000- Specification for Road Works Series 2000- Waterproofing for Concrete Structures. As an alternative to this, an approved sheet membrane waterproofing system may be used provided that the sheet membrane system is protected by a nominally reinforced concrete screed, laid to falls, and wrapped around the corners of the buried box section.

iii) Where the depth of cover to the buried box section is greater than 3m (including the road pavement), the waterproofing system shall be a proprietary spray applied system in accordance with DN-STR-03009- Waterproofing and Surfacing of Concrete Bridge Decks and CC-SPW-02000- Specification for Road Works Series 2000- Waterproofing for Concrete Structures. As an alternative to this, either an approved sheet membrane waterproofing system may be used or 2 coats of epoxy resin waterproofing paint may be used provided that the sheet membrane system or the epoxy resin are protected by a nominally reinforced concrete screed, laid to falls, and wrapped around the corners of the buried box section.

3.6 Expansion Joints

The choice of expansion joint for any particular structure shall be appropriate to the anticipated level of movement in the structure and also to the level of traffic to be carried by the structure.

Expansion joints shall be watertight when installed into any structure and shall be designed to remain watertight for a minimum of 10 years following opening of the structure to traffic.

Notwithstanding the requirements above, asphaltic plug type expansion joints shall not be used for structures carrying national roads or forming part of grade separated interchanges on national roads.

3.7 Structural Steelwork

Structural steelwork shall be protected using a paint system appropriate to an Inland or Marine environment, depending on its location, and "Difficult" access (all as defined in CC-GSW-01900 - Notes for Guidance on the Specification for Road Works Series NG 1900 - Protection of Steelwork Against Corrosion), and shall comply, as a minimum, with all of the following durability requirements:

i) That no maintenance shall be required for up to 12 years;

ii) That minor maintenance may be required from 12 years;

iii) That major maintenance shall not be required before 20 years.

The design for structures shall ensure that steelwork shall be designed and detailed so as to prevent the accumulation of water, dirt and debris. Simple connections and weld details, which are easier to inspect and maintain, shall be used wherever possible.

Intermittent fillet welds shall not be used, except in situations where the welded connections are completely protected from the weather, for example, where they are wholly inside a closed box structure. In such cases appropriate fatigue checks shall be carried out.

Steel parapets shall be protected by galvanising only, and shall comply with the following:

i) Galvanising coverage rate shall be in accordance with EN ISO 1461;

ii) Stainless steel bolts shall be used for holding down the parapet and for all other system fixings including cradles to a depth of 100mm below finished concrete surface;

iii) The finished galvanised surface shall be smooth and free from sharp projections.

3.8 Sealing of Joints

In the design for structures, other than drainage culverts, the joint detail between the pre-cast units for pre-cast concrete units, box culverts, arches and the like shall contain all of the following:

i) External surfaces shall be provided with a continuous 200 millimetres wide strip of membrane bonded with high quality adhesive with compressible back up rod;

ii) Between units, a continuous hydrophilic seal with appropriate dimension shall be provided;

iii) Internal surfaces shall be provided with a continuous two-part polysulphide sealant of appropriate dimensions.

In the design for drainage culverts, the joint detail between pre-cast units for pre-cast concrete units, box culverts, arches and the like shall contain all of the following:

i) A continuous preformed compressible sealing strip between adjacent units and

ii) For internal surfaces, joints shall be pointed with an elastomeric or bitumen based sealant.

A compressible sealant is required between all parapet upstand units, whether pre-cast or insitu concrete.

3.9 Prestressing

Post-tensioned structures using external or unbonded tendons and cable stayed structures shall be designed and detailed such that inspection of all individual tendons and their eventual replacement is possible without restricting traffic on the road.

Debonded tendons at the end of precast pretensioned beams shall be protected against corrosion.

The Designer shall verify that all concrete within a prestressed beam outside the faces of intermediate or end diaphragms shall remain in compression under the Frequent load combination.

The external faces of embedded beams shall be scabbled.

The maximum permissible top tension in a prestressed beam at transfer shall be limited to 0.75 $f_{ctm(t)}$.

3.10 Mechanical Bearings

Mechanical bearings where permitted in the design for structures, shall be either steel with protection of steelwork against corrosion in accordance with CC-SPW-01900 - Specification for Road Works Series 1900 - Protection of Steelwork Against Corrosion, or stainless steel with the following grades:

i) Plates and flats shall be 1.4362, 1.4401 or 1.4436 to IS EN 10088;

ii) Sliding surfaces shall be 1.4362 or 1.4436 to IS EN 10088 and

iii) Fasteners shall be A4-70 or A5-80.

3.11 Voided Slab Construction

Where the design for structures contains voided slab construction, the difference in level of concrete on either side of the void formers during pouring of the concrete shall be controlled to avoid movement of the formers and shall include all of the following:

i) That such difference in level shall not exceed 150 millimetres and

ii) That provision shall be made for the compaction of the concrete below the void formers and for drainage of the formed voids.

4. Improved Durability – Materials

4.1 General

The choice of appropriate materials, which resist the deterioration mechanisms that most structures are exposed to, can, for a modest increase in construction cost, significantly reduce the whole life cost of any structure. This chapter gives minimum requirements on the choice of materials which are known to enhance the durability of structures.

4.2 Concrete

Where structural concrete with steel reinforcement shall be used in the structures design, the minimum concrete grade (to IS EN 206) that shall apply to the design for structures shall comply with all of the following:

i) Superstructure concrete - Grade 32/40;

ii) Footway/verge infill concrete - Grade 25/30;

iii) Substructure concrete above base level - Grade 32/40;

iv) Substructure concrete foundation - Grade 32/40;

v) Pre-cast concrete - Grade 40/50.

The maximum water/cement ratio used in the design for structural concrete with steel reinforcement shall be in accordance with the requirements set out in Table B.1 in Appendix B to this standard.

The design for all concrete mixes for buried components shall ensure durability taking into account the chemical composition of the soil and groundwater in addition to the stated strength requirements.

Kickers (starter stubs) are required in the construction of all columns.

4.3 Splash Zone

The Splash Zone shall be that part of a bridge or other structure subject to spray from the adjacent road surface.

The Splash Zone shall be defined as follows:

i) The Splash Zone for a structure shall be the zone extending across the carriageway and for 8 metres on either side beyond the edge of the hard shoulder, hard strip or carriageway. This corresponds to dimension ‘x’ in Clause 4.2 of IS EN 1992–2 and the Irish National Annex to IS EN 1992–2;

ii) The Splash Zone for a structure shall encompass the bridge deck sides and soffit where the minimum clearance to the deck soffit above the carriageway below shall be less than 7.5 metres. This corresponds to dimension ‘y’ in Clause 4.2 of IS EN 1992–2 and the Irish National Annex to IS EN 1992–2;

iii) The Splash Zone for a Structure shall always include the parapet edge beams of the bridge Structure.

Within the Splash Zone for a structure all exposed structural concrete shall be either air-entrained or shall have a minimum concrete strength class of C40/50 to IS EN 206. Additionally, for all exposed concrete within the Splash Zone one of the following two options shall be adopted:

i) Concrete shall have a minimum 50 percent ground granulated blast furnace slag and surface impregnation in accordance with CC-SPW-01700-Specification for Road Works Series 1700-Structural Concrete with the exception of precast pre-tensioned pre-stressed beams of Grade 50/60 concrete or more to IS EN 206 which shall not be required to have ground granulated blast furnace slag or

ii) Concrete will be reinforced with type 1.4301 or 1.4362 Stainless Steel to IS EN 10088 where the steel shall be embedded in concrete, otherwise type 1.4362 or 1.4436 Stainless Steel to IS EN 10088.

4.4 Stainless Steel Reinforcement

Notwithstanding any other provisions of TII Publications (Standards), for all structures carrying national roads or forming part of grade separated interchanges on national roads, stainless steel reinforcement Type 1.4301 or 1.4362 to IS EN 10088 shall be used for all reinforcement within parapet edge beams and below movement joints on bearing shelves and in bearing plinths.

Reinforcement used in the design for structures to tie parapet edge beams to the bridge deck shall comply with one of the following:

i) Shall be stainless steel reinforcement Type 1.4301 or 1.4362 to IS EN 10088 or

ii) Shall be protected by bridge deck waterproofing system and the cover to the face of the parapet edge beam shall be in excess of 80mm.

Where the design for structures contains run on slabs, stainless steel Type 1.4362 or 1.4436 Grade 500 to IS EN 10088 shall be used in connecting the transition slabs to the abutments.

4.5 Weathering Steel

Where weathering steel shall be used in the design for structures, the environmental criteria shall be "severe" as defined in DN-STR-03002 - Weathering Steel for Highway Structures.

4.6 Fasteners and Anchorages

Fasteners and anchorages, including but not limited to bolts, washers and sockets, for attachment to any roadside structure, including gantry bases and retaining walls, shall be stainless steel type A4-70 or A5-80. Provision shall be made in the design for structures to prevent electrolytic corrosion of dissimilar metals. For anchorage systems stainless steel shall be utilised to a minimum of 100mm below finished concrete surface.

5. Detailed Requirements – Inspection and Maintenance

5.1 General

It is vital that the design of structures includes for general inspection and maintenance and also for the specific replacement of elements such as bearings which have a lesser design life than the overall structure. This chapter gives minimum requirements to facilitate the future inspection and maintenance of structures.

5.2 Access - General

Provision for safe access shall be made at all structures for all of the following, as appropriate:

a) Routine inspection;

b) Cleaning, maintenance and painting;

c) Prestressing tendon or stay cable replacement;

d) Inspection within closed cells or box sections as per Chapter 2;

e) Access to parts that may require maintenance or replacement during the life of the structure, for instance, bearings, joints, anchorage locations, drainage, pipes, manholes, lubrication of moving parts, lighting systems, etc.;

f) Jacking at bearings and for their removal and replacement.

Public access to any of the facilities provided for the use of structure inspection or maintenance shall be prevented by means of suitable barriers, covers and the like. Colonisation of accessible areas by plants, animals or birds shall be prevented by the application of suitable measures.

5.3 Access & Lighting to Voids

Subject to the requirements of Chapter 2, where voided elements of bridge structures (for example box girder decks, voided piers, voided abutment stems, inspection galleries and the like) are of sufficient size to allow internal inspection, personnel access shall be provided as per all of the following:

i) For all mainline overbridges, access to abutment galleries shall be from the minor road over the bridge. Suitable permanent access steps shall be provided to facilitate access to abutment galleries;

ii) Access to the voids shall be from the underside of the bridge;

iii) Entry points shall be placed in such positions as to give convenient access, and where their use would not cause interference to traffic;

iv) All entry points and access ways within the voids shall be suitably sized and designed to allow for the evacuation of a casualty, on a stretcher and the like if necessary;

v) Specific emergency routes and exits shall be identified clearly by signs and shall be provided with lighting where appropriate;

vi) Entry points to the voids, where provided, shall be carefully located and detailed so as to minimise their visibility to passing traffic;

vii) Access points to the voids shall not be permitted on surfaces visible on the main bridge elevation, with the exception of access doors and ancillary arrangements for accessing abutment inspection galleries;

viii) All permanent services, equipment and the like in the Design shall be capable of withstanding the prevailing environmental conditions including ingress of dust and water and the natural movement of the structure;

ix) Permanent access ladders or steps, as appropriate, shall be provided at changes in level within the voids;

x) Access ladders and steps shall be provided with guardrails;

xi) All walking surfaces shall be non-slip, compatible where appropriate with waterproofing membranes, shall avoid details which create a risk of tripping and shall be self-draining;

xii) The interior of fabricated steel box sections where access shall be required to be provided in the Design shall be painted a light colour to improve visibility;

xiii) Where appropriate, a permanent lighting system with permanent power supply shall be provided for access routes and access chambers.

Lighting levels in the design for structures shall be a minimum of 30 lux. Additional emergency lighting shall be provided along emergency routes having a minimum intensity of 0.2 lux and having a separate battery operated power supply. Warning notices and signs shall be provided to all mains power boards, valves and the like, where their operation may affect the safety of persons entering voids within structures.

All access points to galleries and voids and the like in the Design for Structures shall be secured from unauthorized access by means of lockable steel doors or grills.

5.4 Bearing Inspection and Replacement

Inspection platforms shall be provided in front of the abutments to overbridges for both integral and non-integral structures in accordance with the requirements of CIRIA C543 ‘Bridge Detailing Guide’.

Where bridge bearings shall be used in the design of structures they shall be replaceable without requiring the removal of any structural concrete or welding of structural steelwork.

Provision shall be made in the design for structures to allow for jacking during any subsequent bearing replacement.

Provision shall be made in the design for structures such that no more than one traffic lane over the structure shall be closed to traffic during all necessary work to replace bearings.

5.5 Services

Service ducts / pipes (including drainage pipes) shall not be located on or adjacent to any external face of a structure. The attachment of service ducts / pipes (including drainage pipes) to the exterior of any structure shall not be permitted.

6. References

6.1 TII Publications (Standards) References

CC-SPW-00300 - Specification for Road Works Series 300 - Fencing and Environmental Barriers

CC-SPW-01700 - Specification for Road Works Series 1700-Structural Concrete

CC-SPW-01900 - Specification for Road Works Series 1900 - Protection of Steelwork against Corrosion

CC-GSW-01900 - Notes for Guidance on the Specification for Road Works Series NG 1900 - Protection of Steelwork against Corrosion

DN-STR-03001 - Technical Acceptance of Road Structures on Motorways and Other National Roads

DN-STR-03002 - Weathering Steel for Highway Structures

DN-STR-03003 - Design of Corrugated Steel Buried Structures with Spans Greater Than 0.9 Metres and up to 8 Metres [and Correction, February 2002]

DN-STR-03009 - Waterproofing and Surfacing of Concrete Bridge Decks

6.2 References to IS/EN/BS Standards

IS EN 1992-2:2005, Eurocode 2: Design of Concrete Structures. Concrete bridges – design and detailing rules.

Irish National Annex to IS EN 1992-2:2005, Eurocode 2: Design of Concrete Structures. Concrete bridges – design and detailing rules.

IS EN 206-1:2002, Concrete – specification, performance, production and conformity

Irish National Annex to IS EN 206-1:2002, Concrete – specification, performance, production and conformity

IS EN ISO 1461:2009, Hot dip galvanized coatings on fabricated iron and steel articles – specifications and test methods

IS EN 10088 – 1, Stainless Steel. Part 1, List of Stainless Steels.

6.3 Other Miscellaneous References

Soubry, M., 2001. CIRIA Report C543, Bridge Detailing Guide. Construction Industry Research and Information Association, London.

Technical Report TR72, Durable Post-Tensioned Concrete Bridges (2002).

Appendix A:

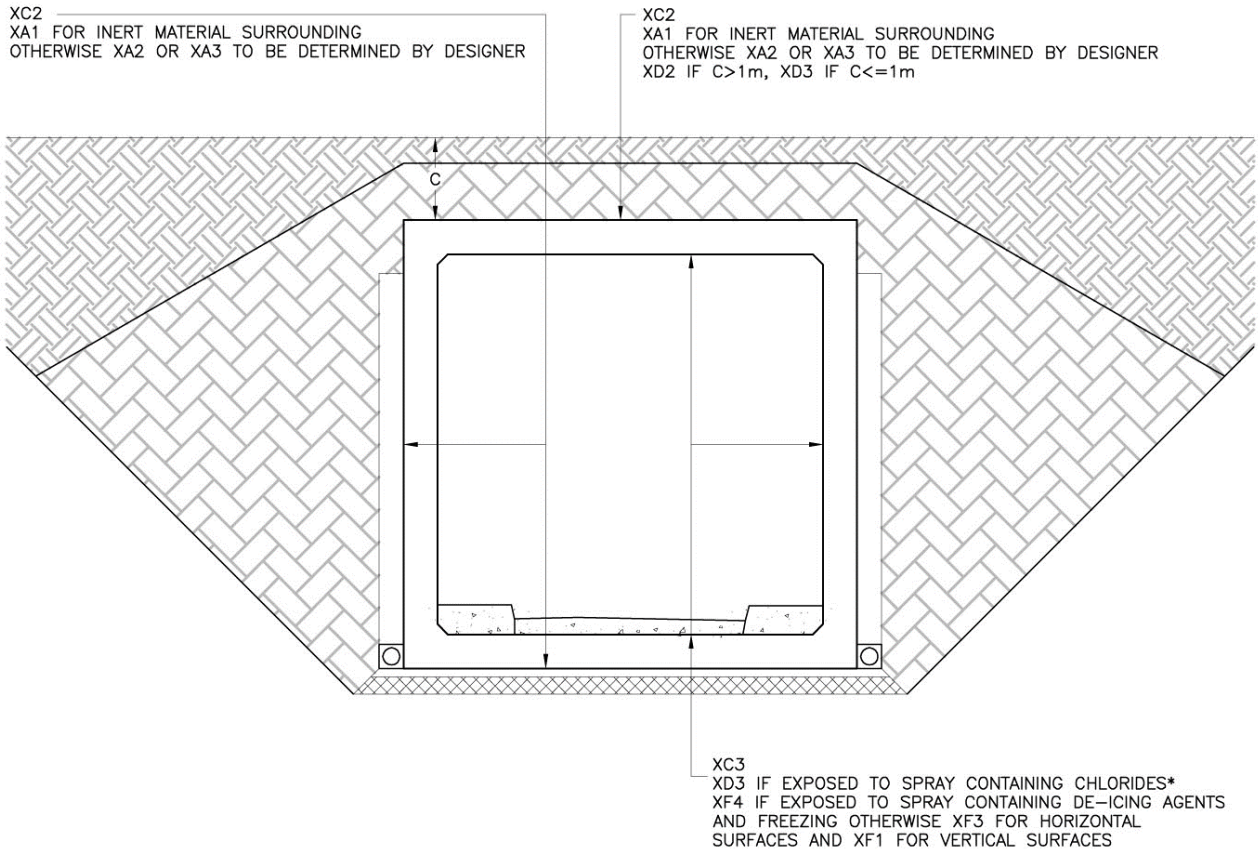
Exposure Class Diagrams

Appendix A – Exposure Class Diagrams

The following diagrams (Figures A.1 to A.11 inclusive) give standard requirements for the exposure class to be applied to various elements of typical national road bridge structures.

Figures A.1 to A.11 inclusive do not explicitly include guidance on XS exposure classes. The following general guidance applies with respect to XS exposure class:

- Exposure Class XS1 is to be applied if the structure is located near to or on the coast.
- Exposure Class XS2 is to be applied to any element of a structure permanently submerged in sea water.
- Exposure Class XS3 is to be applied to any element of a structure located within a marine environment subjected to alternate wetting and drying, such as in a tidal zone or subject to sea water spray or splashing.



**Note: The interior of underpasses will only be exposed to spray containing chlorides if the road through the underpass is a national primary or secondary road.*

Figure A.1 Underpass Structure carrying Road Over

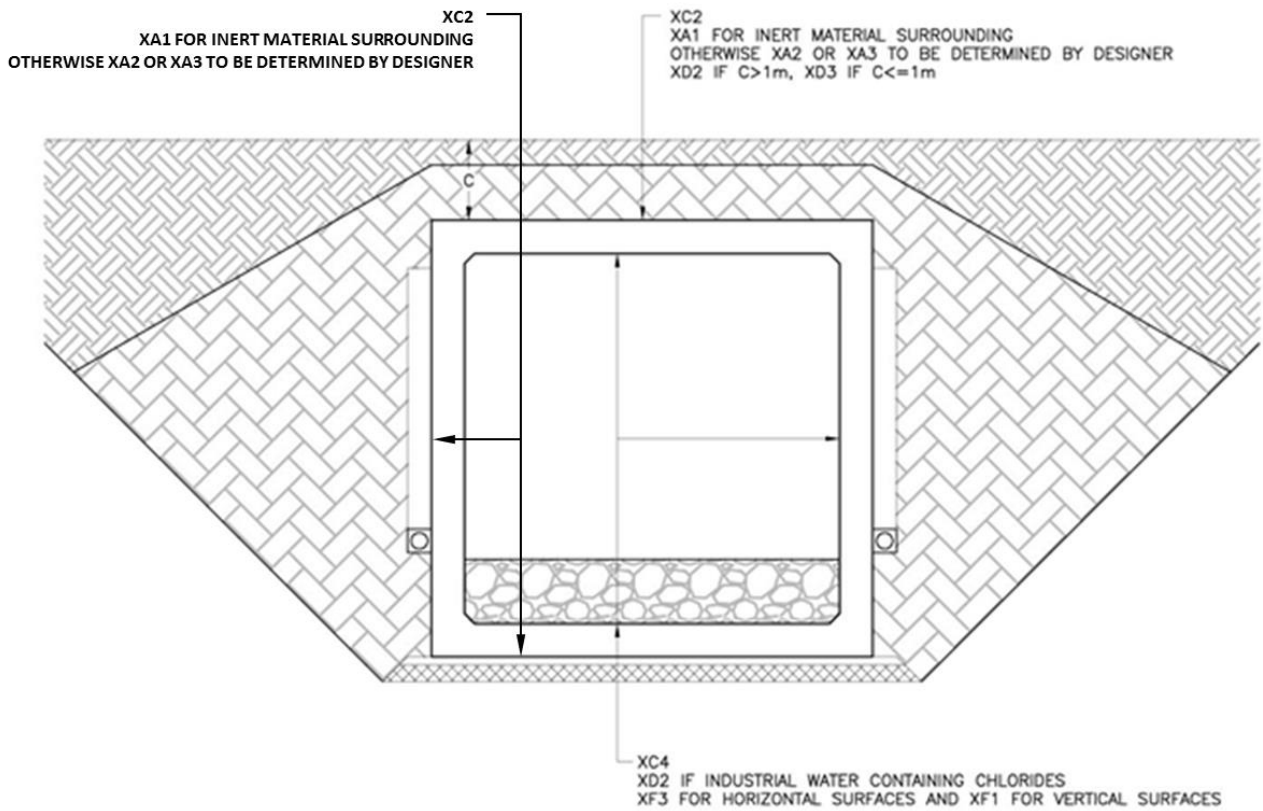


Figure A.2 Culvert Structure carrying Road Over

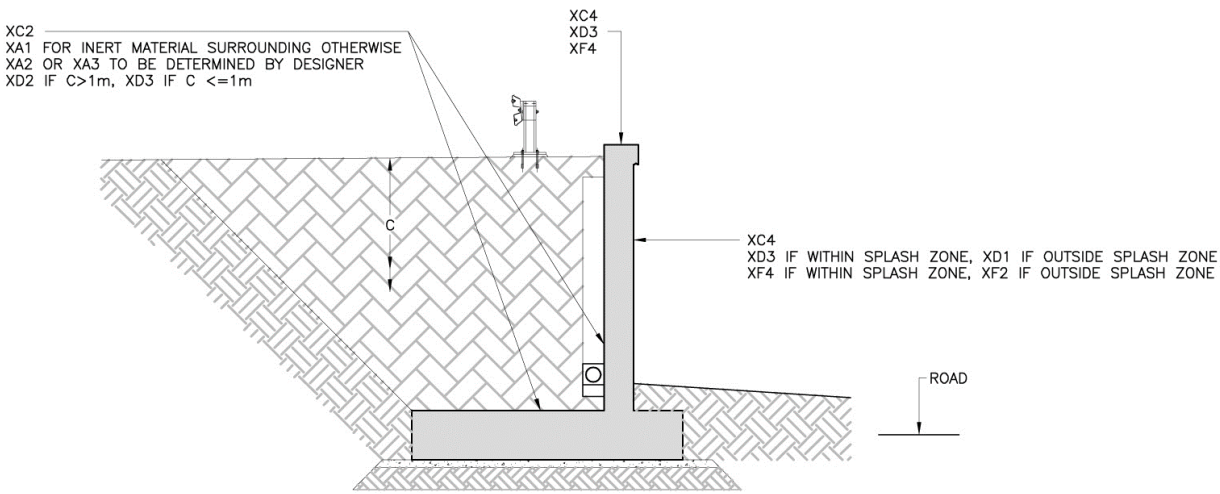


Figure A.3 Wingwall / Retaining Wall (Road Over and Adjacent)

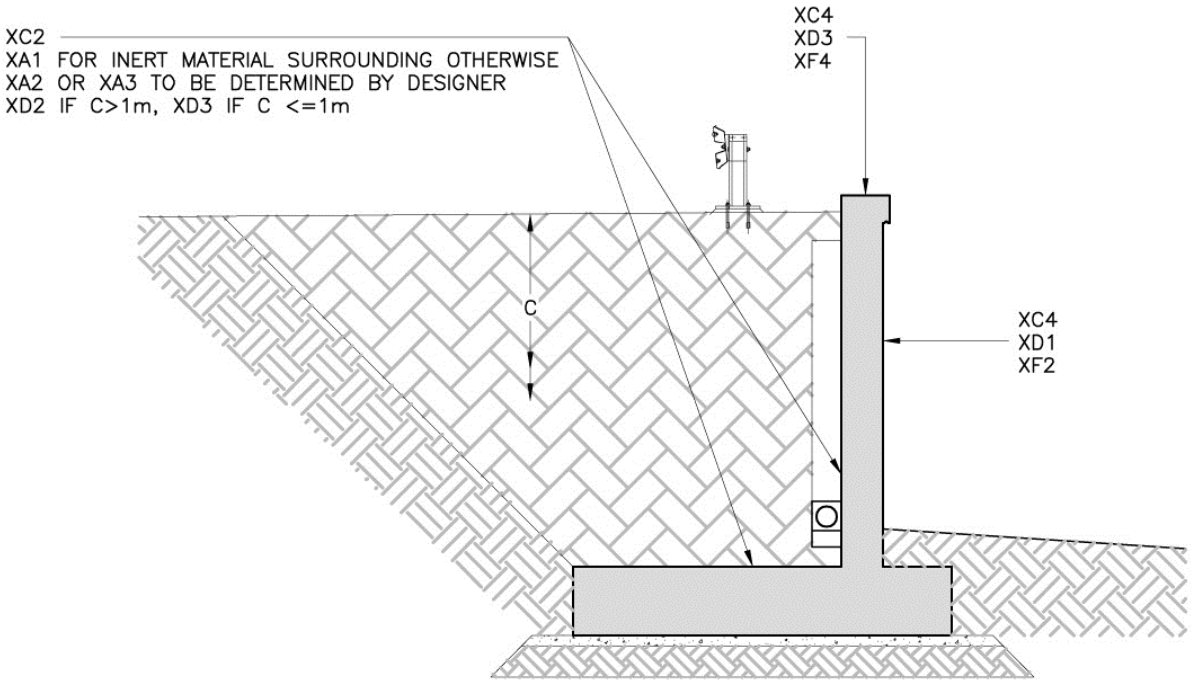


Figure A.4 Wingwall / Retaining Wall (Road Over only)

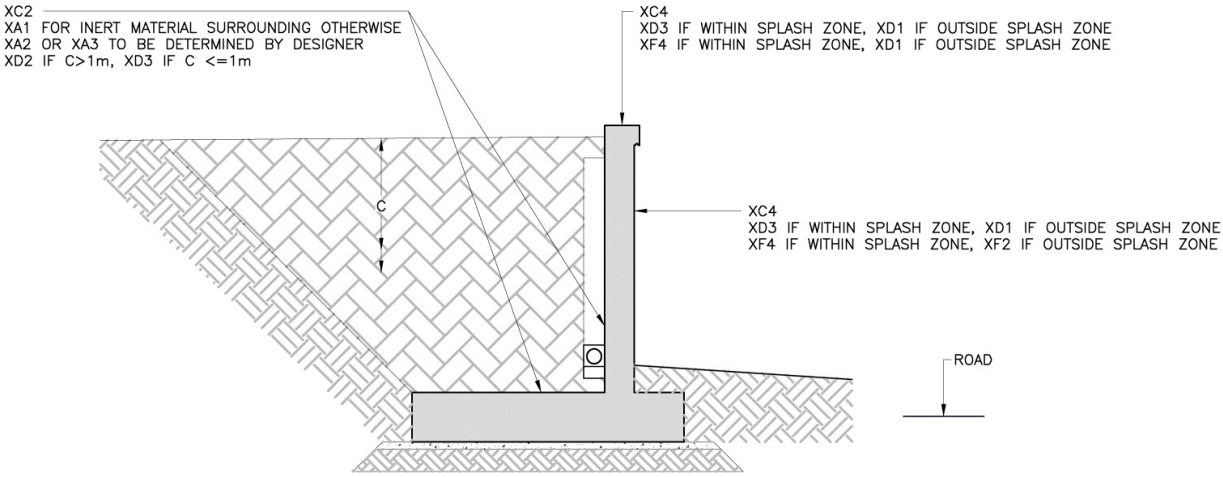


Figure A.5 Wingwall / Retaining Wall (Road Adjacent only)

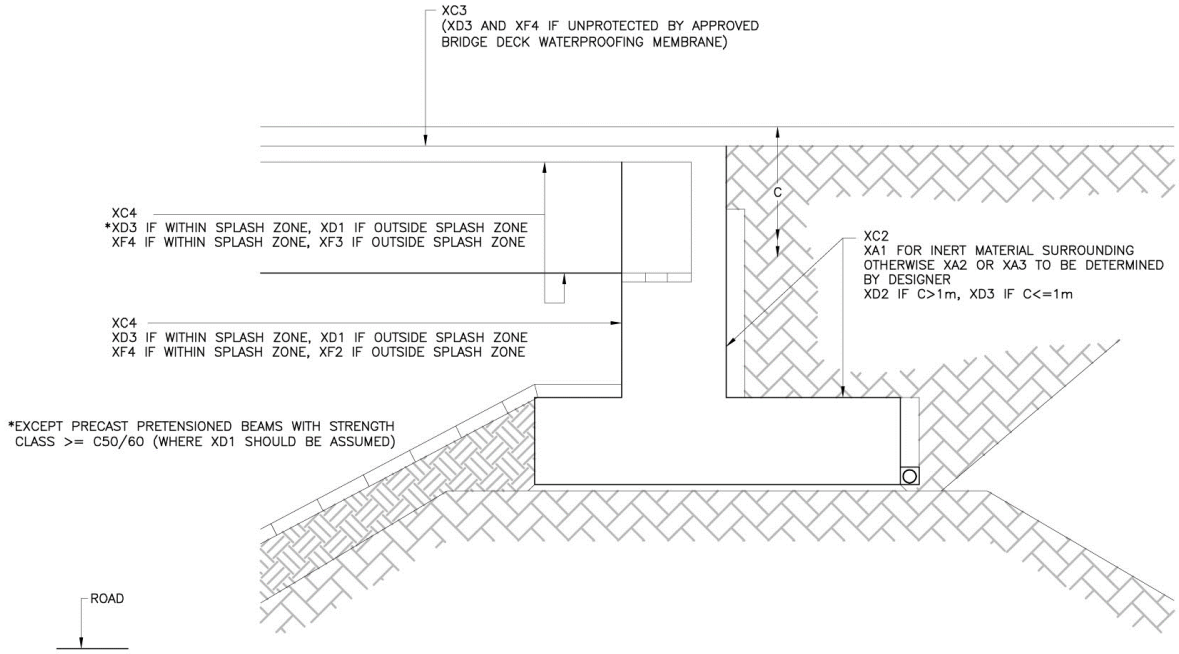


Figure A.6 Overbridge Structure (Road Over Road) – End Support

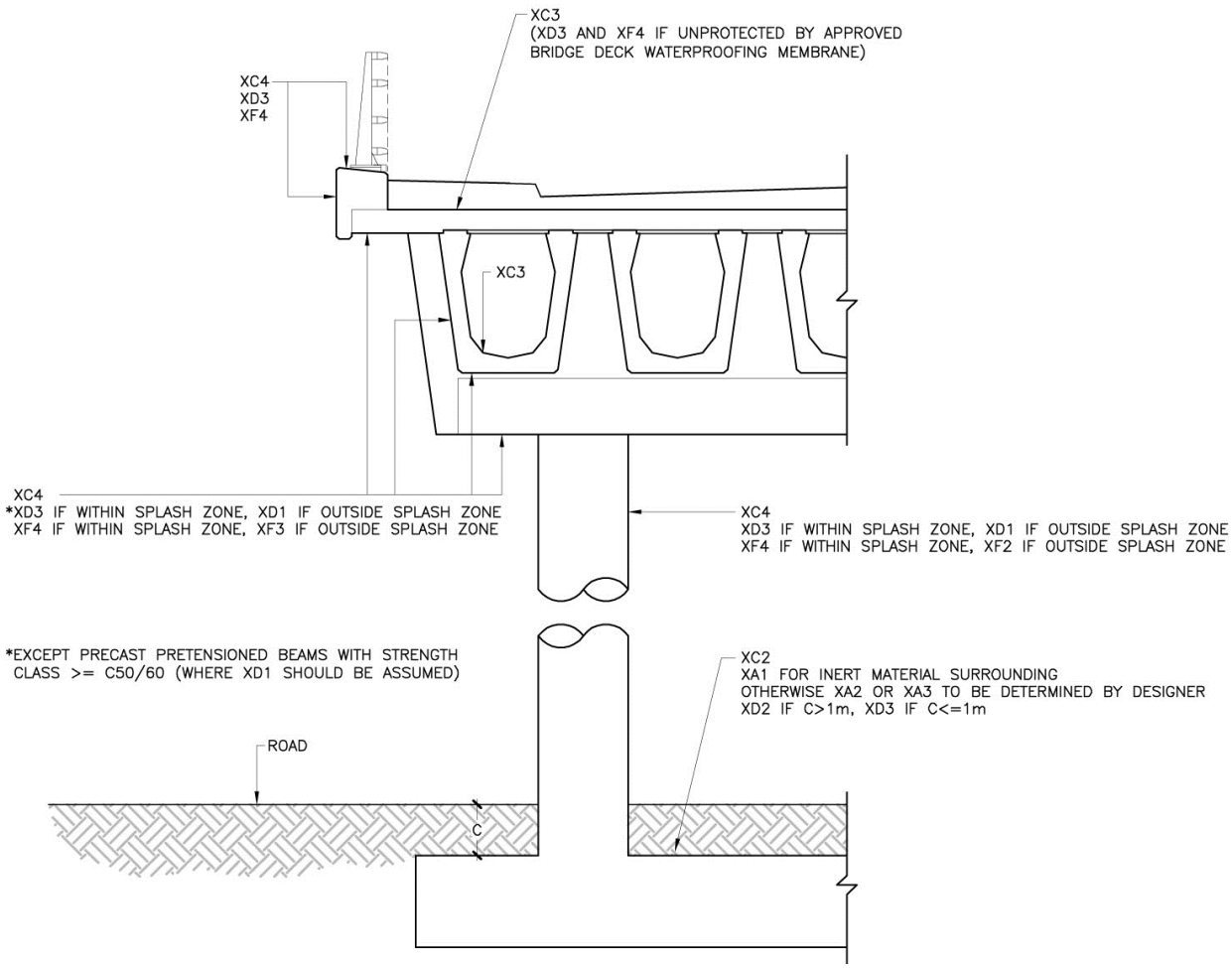


Figure A.7 Overbridge Structure (Road Over Road) – Intermediate Support & Deck

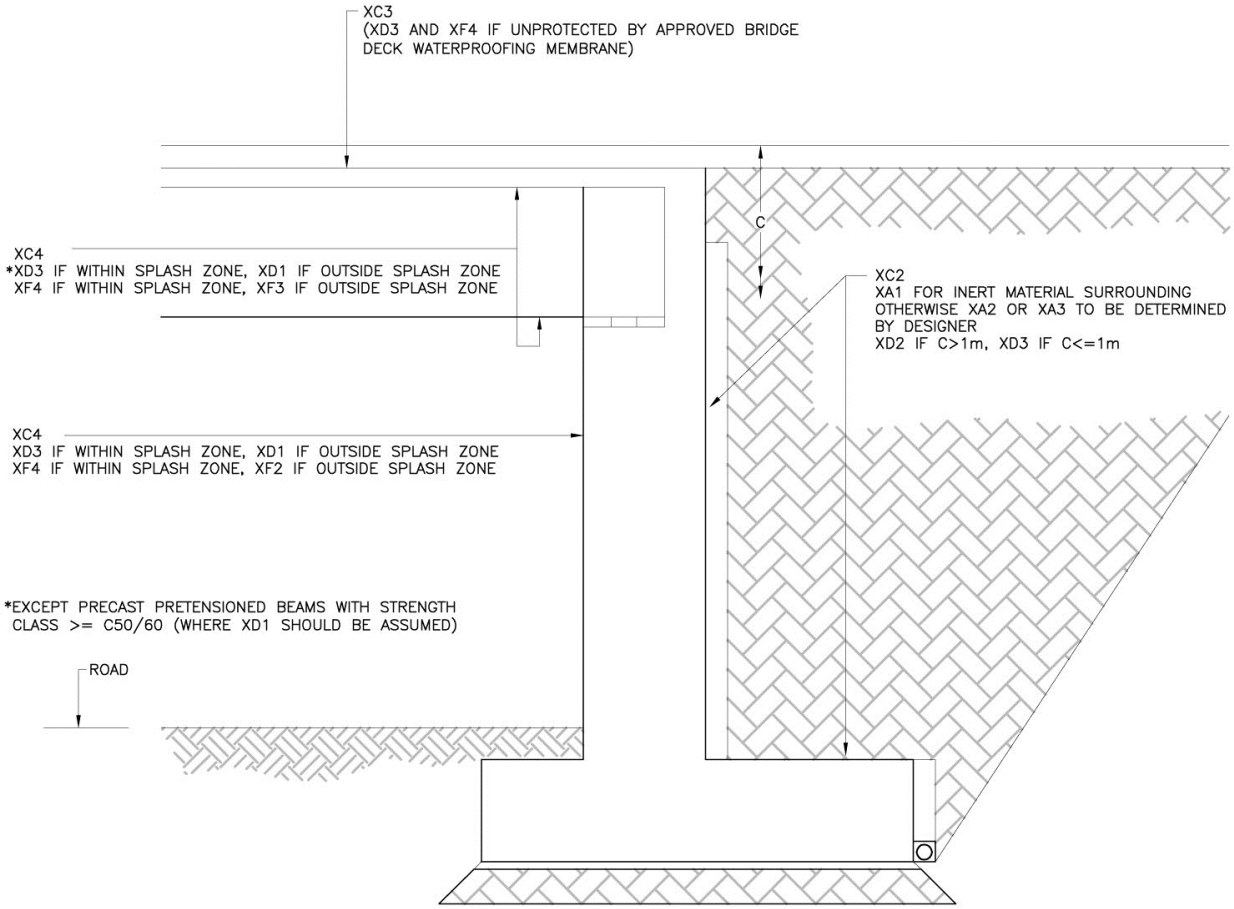


Figure A.8 Underbridge Structure (Road Over Road) – End Support

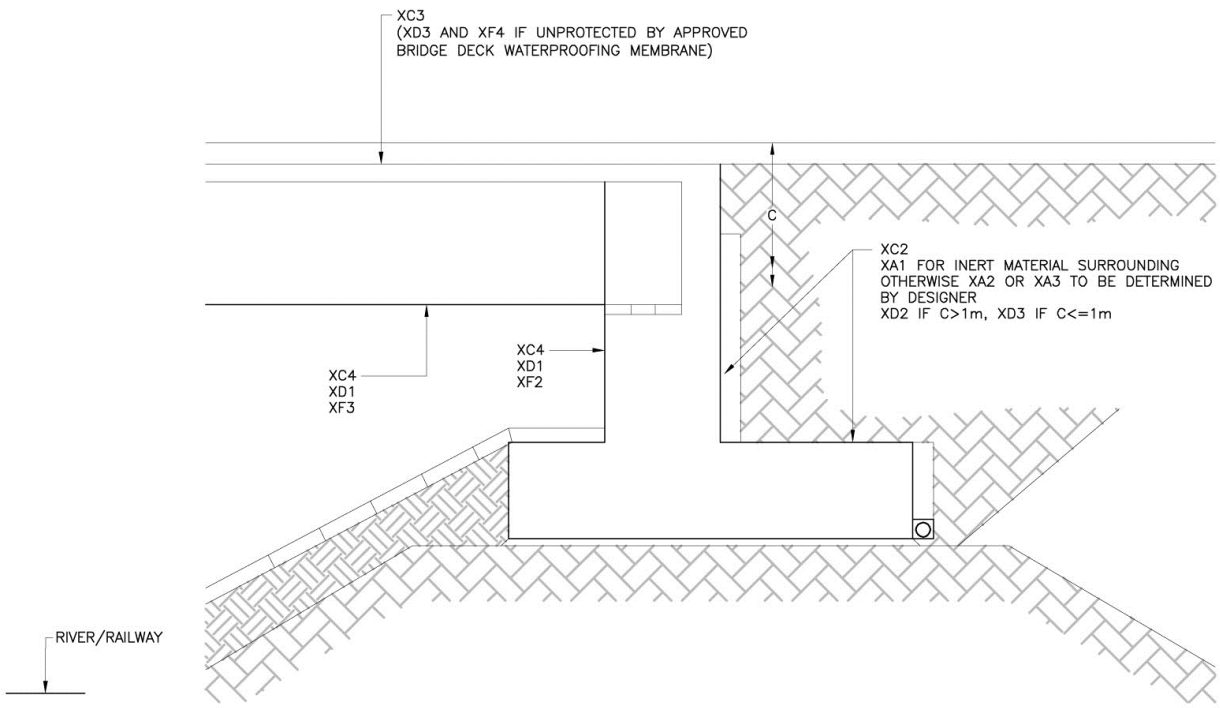


Figure A.9 Underbridge Structure (Road Over River / Railway) – End Support

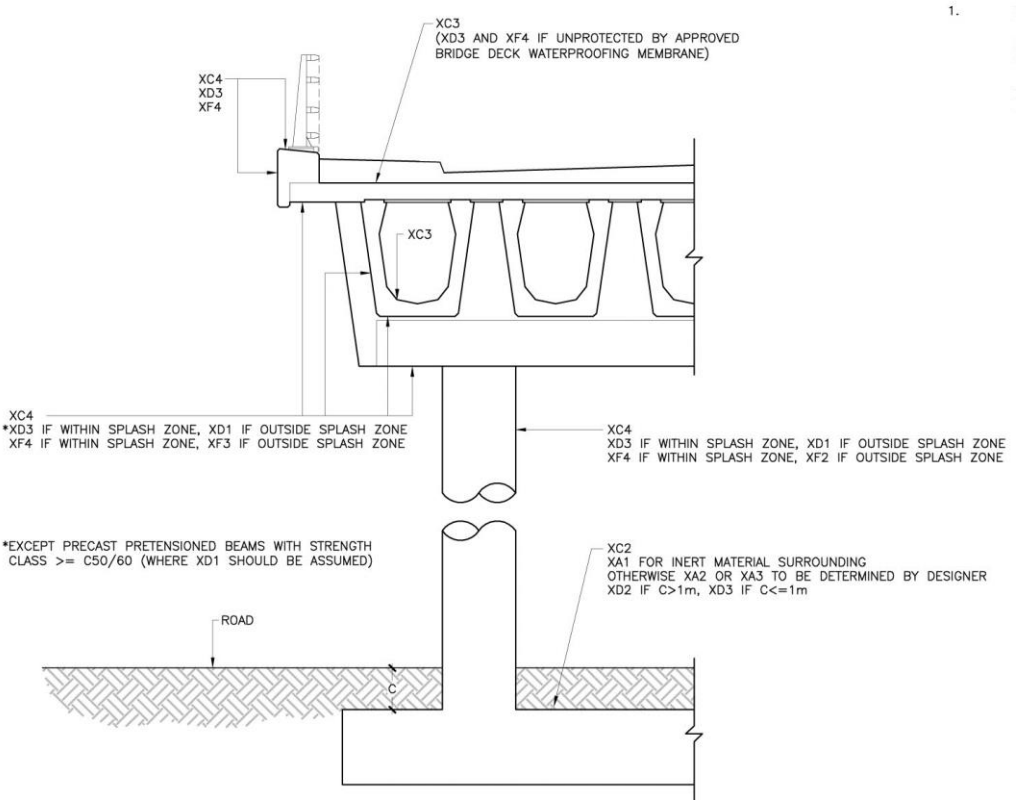


Figure A.10 Underbridge Structure (Road Over Road) – Intermediate Support & Deck

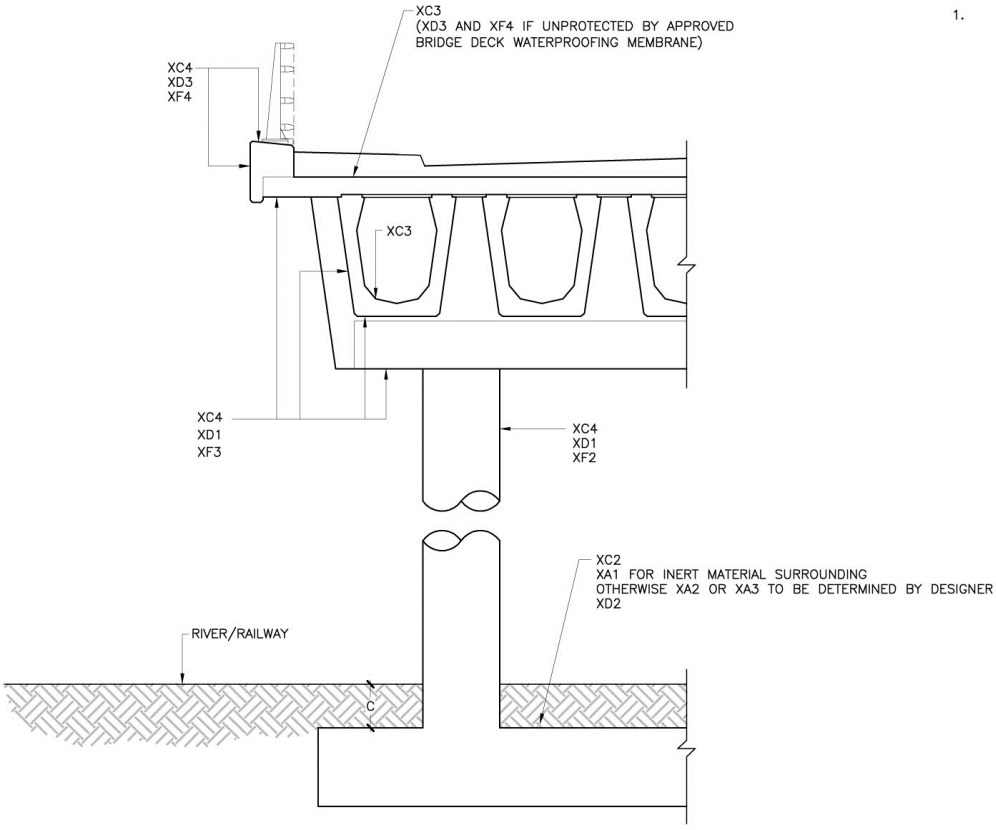


Figure A.11 Underbridge Structure (Road Over River / Railway) – Intermediate Support & Deck

Appendix B:

Concrete Cover Requirements

Appendix B – Concrete Cover Requirements

Table B.1 TII Cmin,dur Cover Requirements (based on modified IS EN 206 National Annex Table)

Class Designation	Description of the Environment	Examples	25	30	35	40	45	50	55	60	Cement Type
XC1	Dry or permanently wet	Concrete permanently submerged in non-aggressive water	C40/50 0.45 400								Cements and combinations **except** where the ggbs content exceeds 50%
			N/A	C32/40 0.50 340							Cements and combinations where the ggbs content exceeds 50%
XC2	Wet, rarely dry	Buried parts of structures (with potential of long term water contact) - most foundations	N/A	C40/50 0.45 400	C32/40 0.50 340						Cements and combinations **except** where the ggbs content exceeds 50%
			N/A	C40/50 0.45 400	C32/40 0.50 340	C28/35 0.50 340	C25/30 0.50 340				Cements and combinations where the ggbs content exceeds 50%
XC3	Moderate Humidity	Surface protected by bridge deck water-proofing or by permanent formwork; Interior surface of pedestrian subways, voided superstructures or cellular abutments	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340	C28/35 0.50 340	C25/30 0.50 340				Cements and combinations **except** where the ggbs content exceeds 50%
			N/A	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340	C28/35 0.50 340	C25/30 0.50 340			Cements and combinations where the ggbs content exceeds 50%
XC4	Cyclic wet & dry	Concrete subject to alternate wetting and drying	N/A	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340	C28/35 0.50 340	C25/30 0. 50 340			Cements and combinations **except** where the ggbs content exceeds 50%
			N/A	N/A	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340	C28/35 0.50 340	C25/30 0.50 340		Cements and combinations where the ggbs content exceeds 50%

Class Designation	Description of the Environment	Examples	25	30	35	40	45	50	55	60	Cement Type
XS1	Exposed to airborne salt but not in direct contact with sea water	Concrete in coastal areas adjacent to the sea (where surface may be exposed to sea water spray)	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400	C35/45 0.50 360	C32/40 0.50 340			CEM I, CEM II/A-L,LL,V
			N/A	N/A	C50/60 0.40 440	C40/50 0.45 400	C35/45 0.50 360	C32/40 0.50 340			CEM III/A, CEM II/B-V
			N/A	N/A	C50/60 0.40 440	C40/50 0.45 400	C35/45 0.50 360	C32/40 0.50 340			CEM III/B
XS2	Permanently submerged	Marine structures (concrete below mid-tide level where surface remains completely submerged and remains saturated)	N/A	N/A	N/A	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400		CEM I, CEM II/A-L,LL,V
			N/A	N/A	N/A	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400		CEM III/A, CEM II/B-V
			N/A	N/A	N/A	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400		CEM III/B
XS3	Tidal, splash & spray zones	Marine Structures (concrete in the upper tidal zone and the splash and spray zone)	N/A	N/A	N/A	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400		CEM I, CEM II/A-L,LL,V
			N/A	N/A	N/A	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400		CEM III/A, CEM II/B-V
			N/A	N/A	N/A	N/A	N/A	C50/60 0.40 440	C40/50 0.45 400		CEM III/B

Class Designation	Description of the Environment	Examples	25	30	35	40	45	50	55	60	Cement Type
XD1	Moderate Humidity	Structures remote from the carriageway (no exposure to de-icing salts); Bridge Deck soffits (external concrete sheltered from rain)	N/A	N/A	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340				CEM I, CEM II/A-L,LL,V
			N/A	N/A	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340				CEM III/A, CEM II/B-V
			N/A	N/A	C45/55 0.40 420	C35/45 0.50 360	C30/37 0.50 340				CEM III/B
XD2	Wet, rarely dry	Concrete totally immersed in water containing chlorides (industrial waters); Buried structures > 1m below carriageway	N/A	N/A	N/A	C50/60 0.40 440	C45/55 0.40 420	C35/45 0.50 360	C32/40 0.50 340		CEM I, CEM II/A-L,LL,V
			N/A	N/A	N/A	C50/60 0.40 440	C45/55 0.40 420	C35/45 0.50 360	C32/40 0.50 340		CEM III/A, CEM II/B-V
			N/A	N/A	N/A	C50/60 0.40 440	C45/55 0.40 420	C35/45 0.50 360	C32/40 0.50 340		CEM III/B
XD3	Cyclic wet & dry	Structures adjacent to the carriageway (surface exposed to de-icing salts); Bridge Parapet Edge Beams; Buried structures < 1m below carriageway	N/A	N/A	N/A	N/A	C50/60 0.40 440	C45/55 0.40 420	C40/50 0.45 400		CEM I, CEM II/A-L,LL,V
			N/A	N/A	N/A	N/A	C50/60 0.40 440	C45/55 0.40 420	C40/50 0.45 400		CEM III/A, CEM II/B-V
			N/A	N/A	N/A	N/A	C50/60 0.40 440	C45/55 0.40 420	C40/50 0.45 400		CEM III/B

Note 1: Requirements for exposure classes not shown in Table B.1 are provided in the National Annex to IS EN 206
Note 2: Please be aware of any project/contract specific requirements for the Type II additions.

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