Design Manual for Roads and Bridges

Highway Structures & Bridges
Inspection & Assessment

CS 432
Inspection of buried concrete box structures

(formerly BA 88/04)

Version 1.0.1

Summary
This document details the inspection requirements for buried concrete box structures.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated National Highways team. The online feedback form for all enquiries and feedback can be accessed at: www.standardsforhighways.co.uk/feedback.

This is a controlled document.

Latest release notes

Document code	Version number	Date of publication of relevant change	Changes made to	Type of change
CS 432	1.0.1	February 2025	Core document	Incremental change to notes and editorial updates
Revision 2.0 [Version 1.0.1] update to reflect rebrand to National Highways.				

Previous versions

Document code	Version number	Date of publication of relevant change	Changes made to	Type of change
CS 432	1	March 2020		
CS 432	0	December 2019		

Foreword

Publishing information

This document is published by National Highways.

This document supersedes the inspection content of BA 88/04, and CS 432 Version 1.0.0.0, which are withdrawn.

Content on assessment has been moved to CS 459 [Ref 3.I].

Content on maintenance has been moved to CM 432 [Ref 3.N].

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document details specific inspection requirements for buried concrete box structures.

A number of documents for the assessment, inspection and maintenance of concrete structures have been written for concrete bridge decks such as CS 459 [Ref 3.I], CS 455 [Ref 5.N], CS 450 [Ref 1.N], CS 470 [Ref 4.N] and CS 451 [Ref 2.I]. Much of this information also applies to buried concrete box structures.

Assumptions made in the preparation of the document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

Terms and definitions

Term	Definition
Immediate risk structure	As defined in CS 470 [Ref 4.N].

1. Scope

Aspects covered

1.1 This document shall be used to determine the inspection requirements for buried concrete box structures, including the inspections necessary to identify, plan and the undertake appropriate maintenance and repair work [see CM 432 [Ref 3.N].

1.1.1 This document may also be used for buried concrete portal frame structures.

1.2 The inspection of buried concrete box structures shall be in accordance with CS 450 [Ref 1.N].

Implementation

1.3 This document shall be implemented forthwith on all schemes involving buried concrete box structures on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 2.N].

Use of GG 101

1.4 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.

2. Inspection

Purpose

2.1 Buried concrete box structures shall be inspected to identify and record the integrity and condition of the structure and its components.

2.2 The inspection shall provide information on both the severity and extent of any change in the structure to that originally constructed.

2.3 The results of an inspection shall be used to determine the type and timing of further interventions to the structure.

NOTE Interventions can include a structural review in accordance with CS 451 [Ref 2.I], assessment, further inspections, an enhanced monitoring regime, maintenance, repair or upgrading works.

2.4 Ancillary structures (for example, headwalls and wing walls) shall also be inspected where they could affect the function of the buried concrete box structure.

Inspection requirements

2.5 The requirements contained in CS 450 [Ref 1.N] shall be supplemented by the additional requirements in this section.

2.6 The inspection of buried concrete box structures shall identify, where present, the following common defects:

1) shrinkage cracks on cast in-situ structures;
2) differential settlement;
3) failure in the joints between structural units;
4) deterioration of the structural waterproofing and evidence of water ingress; and
5) localised deterioration due to detailing faults and poor workmanship during construction.

NOTE 1 Some problems occur with both cast in-situ and precast structures while other problems can be specific to the type of construction.

NOTE 2 Advice on the identification of common defects in buried concrete box structures is contained in Appendix A.

2.7 The inspection of buried concrete box structures shall also identify, where present, the following less common defects:

1) scour and undercutting of the end elevations;
2) mining or non-mining related subsidence resulting in ground movements in the vicinity of the structure;
3) degradation and deterioration of the reinforced concrete; and
4) cracking through excessive loading if cover depth is thin.

NOTE 1 Even where defects are infrequent, when they do occur they can have a severe effect on the structural integrity so it is important to identify them correctly.

NOTE 2 Advice on the identification of less common defects in buried concrete box structures is contained in Appendix A.

2.8 Data collected during the inspection of a buried concrete box structure shall include some or all of the following, with the amount and type collected and recorded dependant on the type of inspection and the degree of deterioration encountered:

1) evidence of tilting and rotation, in any direction;
2) evidence of settlement of the structure, including global and differential movements;

3) evidence of settlement of the structure, including global and differential movements;
4) extent and condition of exposed reinforcement;
5) extent and severity of any cracking;
6) depth of carbonation;
7) depth of penetration of chloride ions;
8) areas of seepage, presence of leachates and deposits and their chemical composition;
9) extent and location of areas of permeable concrete;
10) soundness of surface, for example using "hammer" tests;
11) results of half-cell potential surveys;
12) resistivity measurements;
13) depth of cover to reinforcement; and
14) condition of joints and seals.

3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref.	**Document**
Ref 1.N	National Highways. CS 450, 'Inspection of highway structures'
Ref 2.N	National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	National Highways. CM 432, 'Maintenance of buried concrete box structures'
Ref 4.N	National Highways. CS 470, 'Management of sub-standard highway structures'
Ref 5.N	National Highways. CS 455, 'The assessment of concrete highway bridges and structures'

4. Informative references

The following documents are informative references for this document and provide supporting information.

Ref.	Document
Ref 1.I	Building Research Establishment. BRE SD-1, 'Special Digest 1:2005, Third edition, Concrete in aggressive ground.'
Ref 2.I	National Highways. CS 451, 'Structural review and assessment of highway structures'
Ref 3.I	National Highways. CS 459, 'The assessment of bridge substructures and retaining structures and buried structures'

Appendix A. Identification of common defects

A1 Identification of defects

A1.1 General

Defects to buried concrete box structures include the lack of, or breakdown of, waterproofing systems and poor drainage of the surrounding backfill. In most cases the subsequent deterioration, i.e. the spalling of the concrete cover to the reinforcement, has been associated with the ingress of groundwater.

At a number of sites, differential ground movements have been found to lead to the cracking of boxes and to the failure of joints between individual units. Less common defects found include undermining by scour, degradation of concrete by one or other chemical reactions and cracking induced by high loads.

A1.2 Background information on common defects

Shrinkage cracks can be evident on cast in-situ structures. These are usually as a result of the construction process and in most cases do not present a problem. However, on occasions the cracks can extend through the full thickness of the walls and slabs allowing the ingress of water (groundwater, carried effluent or both) to the reinforcing steel and compromises the long-term durability of the structure.

Precast units have been found to be less likely to exhibit shrinkage cracking because better control during casting ensured a denser and more consistent finish.

Differential settlement can occur under high embankments built on soft ground which can lead to vertical cracking of a buried concrete box structure. Buried concrete box structures can be inherently susceptible to differential ground movements unless they are provided with joints to accommodate this movement. In-situ concrete box structures can be particularly prone to cracking by differential movements when constructed with too large a spacing between movement joints.

With both in-situ and precast concrete box structures, differential ground movements can induce failure of the joints between units. Depending on the joint type, the movement needed to result in joint failure can vary. Differential movement can also result in cracking of the concrete in the wing walls and at the opening of joints between the wing walls and the box structure.

The deterioration of joints can result in the passage of water through the structure, often in preference to the designed drainage routes. This in turn can lead to the concrete adjacent to a joint spalling, with the associated risk of corrosion of the reinforcement.

Construction joints between the roof and side walls or the side walls and base can be at a higher risk of deterioration for cast in-situ structures than for precast structures.

Waterproofing of a structure can deteriorate over time, allowing ingress of water. Evidence suggests that waterproofing systems are most likely to fail near impaired construction joints. Structures with waterproofing membranes on their top slab and with drainage systems behind the side walls perform better than those without such features.

Poor detailing on early constructed structures, where the waterproofing membranes did not extend at least 200 mm down the sidewalls can contribute to a breakdown in the waterproofing system. Failure of the drainage system can also lead to a build up of hydrostatic pressure and possible leakage of the waterproofing system.

Faults in the detailing and poor workmanship during construction can lead to localised deterioration of the structure. The detailing of wing and head walls is sometimes a weak link in the overall design, leading to problems with cracking described above.

In some cases the top slab can be damaged by careless installation of parapets and safety fences above the structure with the holding down bolts penetrating through the roof of the structure allowing the ingress of water.

A1.3 Background information on less common defects

Scour and undercutting of the end elevations can occur with a culvert carrying a watercourse. If scour continues, the structure becomes undermined.

Mining of coal and other minerals can propagate ground movement near the structure. Information about mining activities should be held on the structure record file. Early signs of distress in the structure is often accompanied with severe differential movement. Older structures are most at risk in high-risk areas as recent structural designs should have taken the effects of mining subsidence into account.

Degradation of reinforced concrete can result from chemical reactions between constituents of the cement and the aggregate or between constituents in the concrete and the surrounding soils or groundwater. Alkali silica reaction is an expansive reaction of the alkali in cement and silica in the aggregate and can induce extensive cracking of concrete. Other reactions which can occur include the oxidation of reduced sulphur compounds (such as pyrite) in structural backfill to produce the thaumasite form of sulphate attack on buried concrete. The presence of chloride ions, derived from deicing salts, can promote the corrosion of the steel reinforcement.

Other than cases of deterioration of the concrete in box structures due to the presence of chloride ions, deterioration resulting from other chemical processes are rare. However where identified, expert advice may need to be sought on appropriate remedial measures.

Further information on the degradation of reinforced concrete due to aggressive ground and groundwater can be found in BRE SD-1 [Ref 1.I].

Cracking through excessive loading can be seen on structures with a particularly thin depth of cover and which were not designed to carry abnormal vehicle loads. The passage of heavy and abnormal vehicles can cause cracks to open and close which widen with time with the edges becoming fretted away by the movement of the structure or weathering.