Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 364
Formation of continuity joints in bridge decks

(formerly BA 82/00)

Revision 0

Summary
This document provides information on the design of continuity joints in trafficked concrete bridge decks for the effects of early age vibration and differential deflection of the decks.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

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 Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Mar 2020	CD 364 replaces BA 82/00. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes BA 82/00, which is withdrawn.

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 provides requirements and advice on the design of continuity joints in trafficked concrete bridge decks for the effects of early age vibration and differential deflection of the decks.

Assumptions made in the preparation of this document

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

Abbreviations

Abbreviations

Abbreviation	Definition
ACI	American Concrete Institute
SHW	Specification for Highway Works

Terms and definitions

Terms

Term	Definition
Deck widening	The construction of a new part of a concrete deck cast against any of the following using continuity joints in order to widen the deck: 1) an existing bridge deck; 2) the previously constructed part of a new bridge deck being built in several stages; 3) the previously constructed part of an existing bridge deck being reconstructed in stages.
Differential deflection	The relative vertical movement between the existing and new parts of the deck resulting from applied structural actions.
In-fill strip method	Construction of a parallel deck followed by an in-fill strip as a second stage.
Interface	Where the new part of the concrete deck meets the existing part.
Motorway and all-purpose trunk roads	Collective term to indicate those parts of the UK highway and road network for which one of the Overseeing Organisations is the responsible highway or road authority.

1. Scope

Aspects covered

1.1 This document shall be used for the design of construction joints to achieve continuity in concrete bridge decks being widened, built in stages or reconstructed in stages.

1.2 This document shall apply for longitudinal joints in bridge decks where continuity is achieved in the finished state by casting concrete against an existing bridge deck, with continuity of reinforcement, to result in monolithic construction.

NOTE 1 *This document covers the design of continuity joints in trafficked concrete bridge decks for the effects of early age vibration and differential deflection of the decks during concrete setting and hardening.*

NOTE 2 *This document does not cover the effects of creep or shrinkage.*

NOTE 3 *Specification requirements for the formation of continuity joints in bridge decks are given in MCHW Series 1700 [Ref 3.I].*

1.3 Use of this document shall be restricted to bridge superstructures.

Implementation

1.4 This document shall be implemented forthwith on all schemes involving bridge deck widening using continuity joints 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

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

2. Deck widening design

General requirements

2.1 A widened concrete bridge deck shall be monolithic without any permanent longitudinal joints or gaps.

2.2 A scheme for a concrete bridge deck widening using continuity joints shall be designed for the following:

1) the effects of vibrations from traffic between the existing and new parts of the deck;
2) the effects of differential vertical deflection between the existing and new parts of the deck; and
3) the effects of temporary propping if proposed.

2.2.1 The concrete bridge deck widening may be achieved by:

1) construction of a new part of the deck which is attached directly to the existing trafficked deck; or
2) construction of a separate parallel deck followed by an in-fill strip as a second stage (in-fill strip method).

NOTE 1 *The in-fill strip method can be used to mitigate potential defects caused by differential deflections and vibrations.*

NOTE 2 *The decision on the method of a concrete deck widening is influenced by design constraints and structural implications including traffic volume, composition, and speed, together with traffic-induced vibrations and differential deflections while the concrete matures. Guidance is given in ACI 345.2R-13 [Ref 2.I].*

2.2.2 Where the differential deflection and vibration limits set out in the following clauses are measured, anticipated or calculated as being exceeded, the design may include a dynamic analysis of the combined structure using the properties of immature concrete to determine the effects of traffic-induced vibrations and deflections.

2.3 Where the in-fill strip method is used, the design drawings shall state that the in-fill strip is not to be constructed until the first phase deck concrete has achieved the specified characteristic strength, or at least 14 days after placement, whichever is the latter.

2.3.1 The in-fill strip may be supported using temporary transverse supports spanning from the existing deck.

2.4 The design drawings shall clearly state any constraints on the construction of the deck widening.

NOTE *The constraints on the construction of the deck widening can include:*

1) traffic speed;
2) weight restrictions;
3) phasing of demolition and construction;
4) temporary vehicle restraint system; and
5) any additional temporary works or supports.

Control of deflection

2.5 The design for the concrete deck widening shall include the effects of differential deflection between the new and existing parts of the deck before the new concrete achieves the specified characteristic strength.

2.6 The differential deflection between the new and existing parts of the deck at the interface shall be limited to the following until the concrete achieves the specified characteristic strength, or at least 7 days after placement, whichever is the latter:

1) 6mm due to the weight of fresh concrete when the concrete for the new part of the deck is poured; and
2) 1mm due to traffic actions.

NOTE *The differential deflection between the new and existing parts of the deck is influenced by:*

1) the development of the immature concrete strength in the new part of the deck;

2) the elastic modulus of the immature concrete;

3) traffic on the existing deck; and

4) the sequence of formwork removal.

2.6.1 Where the new and existing parts of the deck are of dissimilar construction forms and have different stiffnesses, the relative deflection characteristics of the existing and new parts of the deck should be taken into account.

NOTE *The relative deflection characteristics of dissimilar existing and new parts of the deck can be used to inform the predictive methods of calculating differential deflection.*

2.6.2 Differential deflection may be limited by designing the new part of the deck in a similar manner as the existing part, by using temporary propping or by using the in-fill strip method.

2.7 The design drawings shall state that the formwork is removed after the concrete achieves the specified characteristic strength, or at least 7 days after placement, whichever is the latter.

NOTE *Early removal of formwork leads to a higher initial deflection in the new part of the deck prior to the concrete maturing.*

2.8 Predictive methods of calculating deflection shall be verified by measurement and monitoring in the following situations until the concrete achieves the specified characteristic strength, or at least 7 days after placement, whichever is the latter:

1) deck widening by attaching a new part of the deck directly to the existing trafficked deck;

2) deck widening using the in-fill strip method with traffic running less than 1m to the interface.

Control of vibration

2.9 Measures to protect the new part of the deck from the effects of vibrations until the new concrete achieves the specified characteristic strength shall be included in the design.

NOTE *Vibration in the freshly placed concrete can result in reduced anchorage bond due to the reinforcement moving relative to the immature concrete, causing cracks in the concrete which can be filled with weak diluted grout.*

2.9.1 Measures to protect the new part of the deck from the effects of vibrations may include:

1) temporary propping to the trafficked deck; and

2) keeping formwork independent from the trafficked deck.

2.10 Traffic induced vibrations at the interface of the deck widening shall be limited to a peak particle velocity of 5mm/s until the concrete achieves the specified characteristic strength, or at least 7 days after placement, whichever is the latter.

2.10.1 The peak particle velocity of the existing deck may be determined by:

1) monitoring the vibrations caused by traffic prior to construction commencing; or

2) undertaking a dynamic analysis on the structure.

NOTE *The measured peak particle velocity of the structure provides an indication of damage risk to immature concrete due to transmitted vibrations.*

2.11 Predictive methods of calculating vibrations shall be verified by measurement and monitoring, until the concrete achieves the specified characteristic strength, or at least 7 days after placement, whichever is the latter.

Concrete mix design

2.12 Concrete mixes shall be specified to avoid segregation caused by traffic induced vibrations during the period of setting and early strength development.

NOTE *High slump concrete mixes are prone to bleeding and segregation when exposed to traffic induced vibrations, which can result in lower bond and compressive strengths.*

2.13 Concrete slump for the construction of the new part of the deck shall be specified to a maximum slump limit of 100mm for pumped or placed mixes.

NOTE *The 100mm limit on concrete slump is taken from ACI 345.2R-13 [Ref 2.I].*

2.13.1 Concrete mixes with slump between 25mm to 50mm should be used as they are less prone to bleeding and segregation.

Reinforcement details

2.14 Reinforcement shall be continuous across the continuity joint.

2.14.1 Continuity of reinforcement may be achieved either by full lap lengths in accordance with BS EN 1992-2 [Ref 1.N], or by use of reinforcement couplers in accordance with MCHW Series 1700 [Ref 3.I].

2.14.2 Continuity of reinforcement may be achieved by specifying drill and fixed starter bars in accordance with CD 372 [Ref 1.I] where the vibration at the interface does not exceed the peak particle velocity of 5mm/s.

2.15 Design drawings of the deck widening shall clearly require that:

1) existing deck concrete is removed to expose the length of existing reinforcement required to make a continuous connection;
2) the removal of existing deck concrete does not damage the existing reinforcement; and
3) the reinforcement within the in-fill strip is tied securely at all bar intersections.

2.16 For the in-fill strip method, the reinforcement of the existing deck shall not extend beyond the in-fill strip to lap with new reinforcement.

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 1.N	BSI. BS EN 1992-2, 'Eurocode 2. Design of concrete structures. Part 2: Concrete bridges. Design and detailing rules'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

4. Informative references

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

Ref 1.I	Highways England. CD 372, 'Design of post-installed anchors and reinforcing bar connections in concrete'
Ref 2.I	American Concrete Institute . ACI 345.2R-13 , 'Guide for widening highway bridges'
Ref 3.I	Highways England. MCHW Series 1700, 'Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works - Series 1700 Structural Concrete.'