Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 372
Design of post-installed anchors and reinforcing bar connections in concrete

(formerly IAN 104/15)

Revision 0

Summary
This document provides design requirements for post-installed anchors and reinforcing bar connections - collectively referred to as fixings - in concrete, including the conceptual design and detailed design requirements for both new and existing structures.

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 372 replaces IAN 104/15. This full document has been re-written to make it compliant with the new Highways England drafting rules. In addition to the content formerly in IAN 104/15, appropriately updated to reflect the current EU and UK standards, requirements and advice on the conceptual design of fixings have been added, ensuring alignment with the CIRIA C778 to ensure they can be effectively managed in the future. The content in Annex A of IAN 104/15 has been moved to the Specification for Highway Works.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes IAN 104/15, which is withdrawn.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

Post-installed fixings in concrete, which include mechanical and bonded anchors and bonded reinforcing bars, are regularly used in works relating to highway structures.

Fixings can offer a cost-effective solution for making attachments or extensions to new and existing concrete structures. The use of fixings can mitigate the need for extensive breakout of the parent concrete. They can also have benefits in reducing disruption to the highway network, reducing requirements for traffic management and reducing the duration of the construction programme.

Post-installed fixings are used for a wide range of applications, including fixing ancillary equipment to concrete surfaces, attaching environmental barriers to structures, provision of extensions to concrete elements such as construction of new parapet upstands, strengthening or extending foundations and substructures, fixing temporary works to the edge of bridges to facilitate parapet replacement, and attaching walkways to the sides of structures.

Recent guidance (CIRIA C778 [Ref 6.I]) highlights that fixings can introduce risks in the long term management of structures, and that effective management of risks is greatly influenced by the design and the quality of installation of fixings.

This document gives requirements and advice for the design of post-installed fixings in both new and existing concrete structures, providing key information that is required to manage risks and maintain a safe and serviceable network, and implements the recommendations made in CIRIA C778 [Ref 6.I] for the design of new fixings to ensure they can be effectively managed in the future and to minimise the future risk of the fixings.

In addition to the content formerly in IAN 104/15, appropriately updated to reflect the current EU and UK standards, requirements and advice on the conceptual design of fixings have been added, and construction and installation requirements have been moved to the MCHW Series 1700 [Ref 14.N].

Fixings are a construction product and are therefore covered by the 2011/305/EU [Ref 17.N], which includes provision for CE marking of products not covered by a harmonised standard, through the system of European Assessment Documents (EADs) and European Technical Assessments (ETAs).

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 13.N] apply to this document.

Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard, technical specification or quality mark, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 13.N].

Abbreviations and symbols

Abbreviations

Abbreviation	Definition
AIP	Approval in Principle
EAD	European Assessment Document
ETA	European Technical Assessment (Some superseded documents use the term European Technical Approvals which has the same abbreviation - this is now an outdated term and is not used in this document)
SLS	Serviceability limit state
ULS	Ultimate limit state

Symbols

Symbol	Definition
d	Nominal diameter of the anchor/reinforcing bar (mm)

Terms and definitions

Terms and definitions

Term	Definition
Anchor	Manufactured device or element for achieving a connection between a fixture and the base material, with potential to act in tension, shear or combined tension and shear. Includes mechanical and bonded anchors. This document only covers post-installed anchors and not cast-in anchors.
Base material	Material of a structure into which a post-installed reinforcing bar or anchor is installed. In this document the base material is concrete.
Bonded anchor	Anchor where the gap between metal element and base material is filled with a bonding material and the strength of the anchor depends on the performance of the bonding material.
Bonding material	Cementitious material or resin providing a bond between a metal element and the concrete.
Design working life	Assumed period for which a fixing is to be used for its intended purpose without major repair being necessary. The following terms are used in other documents and are taken as synonymous: service life; working life; design life; design service life.
Fastener	See "anchor". Term used in BS EN 1992-4 [Ref 7.N]
Fastening	See "anchor".
Fire-critical fixings	Fixings that: 1) are at risk of exposure to fire; and, 2) have a high consequence if they fail during fire.
Fixture	Element or component to be fixed to the base material. In the case of post installed reinforcing bars the fixture is commonly additional concrete to be cast after the post-installed reinforcing bars have been installed.
Fixing	Anchor or post-installed reinforcing bar connection.
Fixing system concept design	Determination of the arrangement and type of fixings to support a fixture, including the arrangement of any supporting framework or base-plate. Does not include determining the specific fixing product or size.
Mechanical anchor	Anchor where the strength depends on the direct reaction of the embedded device against the base material.
Post-installed anchor	Anchor installed in a drilled hole after the concrete base material has been cast. Does not include cast-in components.
Post-installed reinforcing bar	Reinforcement installed in a drilled hole after the concrete base material has been cast, used to form a post-installed reinforcing bar connection.

Terms and definitions (continued)

Term	Definition
Post-installed reinforcing bar connection	A reinforcing bar (or tension rod) and bonding material achieving a connection between a fixture and the base material, behaving similar to a cast-in reinforcing bar assumed to act in tension but not shear. It is possible for short reinforcing bars to be designed and act as anchors (see anchor).
Rebar	Reinforcing bar.
Robustness	The ability of a structure to sustain adverse and unforeseen events and limit local damage to an extent that is not disproportionate to the cause.
Safety critical application	Application in which the failure of a post-installed reinforcement connection or anchor can, in accordance with BS 8539 [Ref 1.I]: 1) result in the collapse or partial collapse of the structure; 2) cause risk to human life; 3) lead to significant economic loss.
Safety critical fixing	Fixing used in a safety-critical application.
Support framework	Structural component, not part of the fixture, to connect the fixture to the fixings. Can comprise of a steel bracket or frame.

1. Scope

Aspects covered

Concept design of fixing system

1.1 Where designs of new structures or modifications to existing structures create a need or a potential need for fixings, then fixings shall be identified and classified in accordance with this document.

1.2 The conceptual arrangement of the fixing system, including for robustness, maintenance and inspection, shall be designed in accordance with this document.

Design of fixings

1.3 The design of post-installed anchors and reinforcing bar connections in concrete for permanent and temporary works shall be undertaken in accordance with this document.

NOTE 1 Specification requirements for post-installed anchors and reinforcing bar connections are given in MCHW Series 1700 [Ref 14.N].

NOTE 2 Post-installed anchors include mechanical anchors (including expansion anchors, undercut anchors and concrete screws) and bonded anchors.

NOTE 3 Section 3 of this document defines the design requirements using the relevant European Assessment Documents (EADs) that apply in the design of post-installed anchors and reinforcing bar connections.

NOTE 4 Fixings for vehicle restraint systems, permanent bollards, traffic signs, lighting columns and CCTV masts are not covered by this document. These applications are addressed in the Specification for Highway Works MCHW [Ref 7.I] Series:

1) *400 for post-installed anchors for vehicle restraint systems;*
2) *1200 for permanent bollards and traffic signs;*
3) *1300 for lighting columns and CCTV masts.*

NOTE 5 Post-installed fixings in masonry are not covered by this document.

NOTE 6 There is greater variability in masonry substrates than in concrete and hence additional design, testing and installation considerations apply. Further guidance on masonry applications is available in BS 8539 [Ref 1.I].

NOTE 7 Plastic anchors, such as those covered by ETAG 020 [Ref 16.N] are not covered by this document.

NOTE 8 Non-structural applications where redundancy is provided in the system, such as those covered by EAD 330747-00-0601 [Ref 12.N], are not covered by this document.

Implementation

1.4 This document shall be implemented forthwith on all schemes involving the design of post-installed fixings on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 13.N].

Use of GG 101

1.5 The requirements contained in GG 101 [Ref 13.N] shall be followed in respect of activities covered by this document.

2. Concept design of fixing system

Identification

2.1 The need for post-installed fixings on a structure shall be identified.

NOTE 1 Early identification of potential need for fixings is important because it allows a coherent design to be developed that minimises long term risks and maintenance effort associated with fixings.

NOTE 2 In some cases (for example, when designing a new tunnel) it is possible and desirable to identify the need for post-installed fixings at an early stage, for example, during structural concept design.

NOTE 3 In other cases (for example the design of a new CCTV system to be connected to an existing bridge), the need for post-installed fixings can only be identified when the requirement for the fixture is defined, for example, during a modification or improvement project.

NOTE 4 Common locations where post-installed fixings are required are included in Table 2.1N4:

Table 2.1N4 Indicative locations where post-installed fixings can be required

Post-installed anchors	Post-installed reinforcing bar connections
Mechanical and electrical systems	Column strengthening
Lighting	Structural element to be cast in stages
Signage	Extension of an existing structure
Communications	New plinths for safety barrier / lighting column
Ventilation systems	Bearing plinth replacement
Cladding system	

Classification

2.2 Post-installed fixings shall be classified as either safety critical or non-safety critical.

NOTE 1 It is desirable and useful to undertake the classification at an early stage because this provides greater opportunity to mitigate or eliminate the risks associated with a safety critical fixing.

NOTE 2 The classification as safety critical or non-safety critical affects the following:

1) how a post-installed anchor/reinforcing bar is tested;

2) the information that needs to be provided for technical approval;

3) how it is managed in the future.

2.2.1 The classification should be undertaken using Table 2.2.2.

2.2.2 Where the answer to any of the questions in Table 2.2.2 is 'yes' then the fixing should be classified as safety critical.

Table 2.2.2 Safety critical fixings

	Question	Response
	If the fixing fails is there potential for...	
1	...one or more people to be killed or seriously injured?	Yes/no
2	...severe damage to one or more road vehicles or rail vehicles?	Yes/no
3	...structural failure of one or more structural members?	Yes/no
4	...failure of further fixings (progressive failure)?	Yes/no
5	...closure of a road, railway or a significant utility service?	Yes/no
6	...restoration of normal operation of the network to take longer than one week, taking into account investigation and access arrangements?	Yes/no

NOTE 1 The guidance in Table 2.2.2 expands on the formal definition of safety critical for use in highway works.

NOTE 2 In some cases in Table 2.2.2 the answer can be yes but justification can be provided that the fixings are not safety critical. For example, progressive failure does not always lead to loss of life or significant economic loss.

NOTE 3 Table 2.2.2 is taken from CIRIA C778 [Ref 6.I]. Further guidance and examples on classifying fixings is provided in CIRIA C778 [Ref 6.I].

2.2.3 Where there is doubt about whether the degree of redundancy is sufficient to avert adverse consequences if the fixing fails, then the fixings should be classified as safety critical.

2.2.4 Where there is an extremely high degree of redundancy such that failure of the fixing cannot lead to the adverse consequences listed in Table 2.2.2, and failure of multiple fixings by a common mode is not conceivable, then the fixings may be classified as non-safety critical.

NOTE 1 Redundancy contributes to achieving robustness, but there have been examples where the same mode of failure has affected numerous fixings on an installation, negating the benefits of redundancy. Therefore, the potential consequence of failure is more important in classifying a fixing or group of fixings as safety critical or non-safety critical, than is the exact degree of redundancy.

NOTE 2 Examples of situations that illustrate how the degree of redundancy can be related to the safety critical classification are given in Table 2.2.4N2.

Table 2.2.4N2 Examples illustrating how the degree of redundancy can be related to the safety critical classification

Example situation	Non-safety critical if...	Safety critical if...
Temporary works suspended from the side of a bridge deck to facilitate parapet replacement. The temporary works are to be supported by fixings anchored into the edge of the bridge deck.	…there are sufficient longitudinal members within the temporary works to redistribute loads in the event of failure at a group of anchors, and the adjacent anchors have sufficient resistance to accommodate the redistributed loads.	…each element of the temporary works is held in place by a small number of fixings, there is no mechanism to redistribute the load if these fixings fail and the collapse of the temporary works could cause injury or death.
Service duct carrying a significant utility service suspended from a bridge deck. The duct is to be attached to the deck using anchors supporting brackets.	…the service duct itself has sufficient structural resistance to span across a missing bracket, and the adjacent brackets and anchors have sufficient resistance to accommodate the additional redistributed load after loss of one bracket.	…the consequences of failure of the utility are high, for example, explosion of a gas main, or if the loss of one bracket could lead to failure of the utility itself, for example due to brittle duct materials or lack of rotation capacity, or the progressive failure of the anchors.
Environmental barrier to be fixed to the edge of a bridge deck using anchors where the support system is dependent on a small group of fixings.	…the consequence of failure is low, if the barrier is likely to only fall onto a non-trafficked area on the road side or a low height onto an inaccessible area below.	…failure of any of the small group of fixings could lead to failure of the support post, and the barrier could fall onto a live carriageway.
Construction of a parapet plinth on a bridge. The plinth is to be attached to the existing deck with anchored reinforcing bars.	...the plinth is continuous, as the failure of one reinforcement bar connection is unlikely to lead to a full failure of the plinth, and ultimate failure could also mobilise a dowel-type shear behaviour in the connection (even though not assumed in design).	...each parapet post is attached to a standalone plinth with a small number of local reinforcement bar connections, since impact on a parapet post could cause failure of the standalone plinth.
Traffic sign and associated bracket to be fixed to the edges of a bridge deck using anchors.	...the bracket is attached using two groups of fixings in different orientations with some acting in shear and some acting in tension.	...the bracket is attached using a small number of fixings in the same orientation.

Technical approval of fixings

2.3 Proposals for safety critical fixings shall be subject to technical approval in accordance with CG 300 [Ref 20.N].

NOTE 1 Technical approval provides the technical approval authority the opportunity to identify and assess the effect on future management, ensures that maintenance arrangements can be set out and triggers inclusion of the fixings within the asset record.

NOTE 2 Proposals for new fixings on new structures can be recorded in the Approval in Principle (AIP) (or equivalent) for the structure.

NOTE 3 Proposals for new fixings associated with other elements requiring AIP, such as mechanical and electrical installations, can be recorded in the mechanical and electrical AIP (or equivalent).

2.3.1 Information to be provided for technical approval should include:

1) the fixture supported;
2) the location on the structure;
3) the design working life of the fixing;
4) the future maintenance arrangements.

NOTE Requirements for design working life are given in Section 3. The respective design working life of the fixture and fixing can need early consideration to ensure that the proposals are viable, particularly where a design working life in excess of 50 years is required of the fixing.

Mitigating risks of fixings at concept design

2.4 Where safety critical fixings are proposed, the potential to eliminate the fixing or reduce the consequence of failure shall be reviewed.

NOTE 1 Safety critical fixings introduce the potential for a failure with high consequence and require greater future management effort.

NOTE 2 Some indicative strategies to remove the need for safety critical fixings are shown in Table 2.4N2 and can include re-design to remove the need for the fixing or adjustment of the design to avoid the fixing being safety critical.

Table 2.4N2 Indicative strategies to remove the need for safety critical fixings

Strategy	Example
Eliminate the fixture	Review whether the fixture is necessary given that it introduces a safety-critical fixing.
	Review whether project requirements can be satisfied using alternative solutions.
	Mount the fixture elsewhere, e.g. supported from the ground.
Make non-safety critical	Reduce the consequence of failure by changing the location of the fixture, e.g. away from a traffic lane.
	Make sufficiently robust that it is inconceivable that failure of a fixing can lead to collapse.
Alternatives to post installed anchors or reinforcing bar connections	Cast-in fixings.
	Alternative support, e.g. built-in beam.

2.5 The residual risk factors that affect the likelihood of future degradation of fixings shall be minimised.

NOTE 1 At the concept design stage, of the structure or of the fixing system, there can be an opportunity to make design decisions that reduce the long term probability of failure of a fixing.

NOTE 2 *Although anchors qualified with an European technical assessment (ETA) have a notional design working life, there is potential for the real working life to be shorter depending on design, execution, environment, use and maintenance conditions.*

2.5.1 Minimising the residual risk factors should be undertaken by:

1) understanding the applicable risk factors;
2) confirming which of the risk factors apply to the proposed design; and
3) reviewing whether a different design approach could reduce or remove the risk factor.

NOTE *Table 2.5.1N provides a summary of indicative risk factors and implications for concept design of fixing systems. Other risks can also apply, and various mitigation strategies are possible. Further guidance on risk factors is provided in CIRIA C778 [Ref 6.I].*

Table 2.5.1N Indicative risk factors and implications for concept design of fixing systems

Area	Detail	Implication of risk
Repetition	Large number of fixings to the same design and similar installation conditions (e.g. multiple similar installations or single large installation)	Could suffer from similar degradation in future from the same common cause; develop strategy to provide robustness; build in ways to test performance in the future.
Base material	Reinforced concrete	Likelihood of hitting reinforcement during drilling; specification of action to take if reinforcement is hit.
	Shotcrete	Interface between fixture connection and rough surface finish.
	Prestressed concrete	Potential unsuitability of post-installed fixings due to risk of destroying structural prestressing strand / tendons during drilling of holes.
	Cladding	Potential for fixings to be hidden.
Actions	Sustained tension	Suitability of fixing type (risk of creep; note that resin fixings with an appropriate ETA are suitable for use under sustained tension).
	Cyclic loading, shock load, exposure to vibration	Potential restriction of fixings which are suitable for these actions. Some of these actions are not covered by EADs. Supplementary justifications and test results needed from suppliers.
Environment	Water management (e.g. in tunnels)	Likelihood of fixing being exposed to damp conditions.
	Exposure to severe chemical pollution, e.g. exhaust fumes in road tunnels, de-icing salts	Selection of fixing material type and grade (special alloys of stainless steel required in these conditions).
	Damp, corrosive, temperature extremes, fire risk	Selection of fixing material type and grade. Unsuitability of some resins (e.g. some ETA's state fixings are only suitable for dry internal conditions.). Potential for loss of concrete cover during fire.
	Chlorides (e.g. marine environment, de-icing salts)	Potential for stress corrosion of stainless steel.

Table 2.5.1N Indicative risk factors and implications for concept design of fixing systems (continued)

Area	Detail	Implication of risk
Practicalities	Time available for installation (e.g. due to restricted access periods)	Susceptibility of fixing type to poor quality of installation. Curing time for resin before loading. Likelihood of satisfactory supervision.
	Installation conditions (e.g. night work, lighting conditions, working conditions including weather and temperature)	Susceptibility of fixing type to quality of installation.
	Installation position (e.g. overhead working)	Susceptibility of fixing type to quality of installation. Need for full penetration of vertical hole by resin systems.
	Achievable tolerances	Ability of fixture connection to accommodate realistically achievable tolerances.

Effect of fixings on structure

Loads transferred to structure

2.6 It shall be verified that the structure is able to withstand the design actions imposed through fixings, in combination with other actions.

NOTE 1 *The fixing design method results in minimum edge distances, spacing and member thickness that are necessary to achieve the intended resistance of the fixing.*

NOTE 2 *In addition, actions imposed by the fixing can induce load effects such as moments, shears or torsion into the structure that need to be checked more remotely from the fixing particularly for slender members.*

2.6.1 The design should provide a hierarchy of strength in the following cases:

1) where the design load on a fixture is a notional accidental action that can be exceeded in practice;
2) where accidental impact on the fixture is conceivable even if there is no explicit accidental design load; and
3) where the failure of a fixture through concrete failure has potential to disproportionately compromise the structural integrity of the wider structure;

NOTE 1 *The concept of providing a hierarchy of strength requires there to be an explicit 'weakest element' in the structural system and then designing other elements to be stronger; this approach can assist in avoiding costly repairs to the main structural elements.*

NOTE 2 *Normal design of a fixing results in the actual fixing providing a design resistance equal to or greater than the design action. Therefore, if the design action of the fixing is also used in the structural design, there can be a possibility that the fixing is overloaded and at failure imposes a higher load and damages the structure.*

NOTE 3 *Where accidental actions are not involved and there is no potential for disproportionate damage, then the normal partial factors used in design provide an adequate level of structural reliability and there is no need to provide an explicit hierarchy of strength.*

NOTE 4 *This is a principle commonly used in the design of parapets. In the design of connections of vehicle parapets with actions in accordance with BS EN 1991-2 [Ref 3.I], the parapet post is designed as the weakest element. Both the structure and the fixing are designed for the failure load of the parapet, but there is no need for the structure also to be stronger than the fixing.*

2.6.2 A hierarchy of strength may be provided by taking the design action (applied to other elements) to be equal to the characteristic resistance of the weakest element and factoring by 1.25.

2.6.3 Where the fixing is intended to be the weakest element, then the characteristic resistance of the fixing may be defined and specified as an upper limit.

NOTE 1 *In practice, the fixing can be selected at a late stage of the structure design so it can be more practical to verify the structure against an assumed upper limit of fixing strength, rather than determine the exact fixing strength at this stage.*

NOTE 2 *Specification of internally threaded sockets can facilitate the rapid replacement of a damaged attachment or bolt.*

Reduced resistance due to drill holes

2.7 The resistance of the structure shall be verified taking into account the holes to be drilled for the fixings.

2.8 Fixings shall not be installed in locations where there is a risk of damage to prestressing strand, prestressing tendons or prestressing bars.

2.9 Where it is likely or intended that reinforcement is hit during drilling, then assumptions for lost reinforcement section area shall be defined and the assumed lost section area excluded from the verification.

2.10 Where it is assumed that the reinforcement remains undamaged during drilling, then this assumption shall be communicated clearly in the specification and drawings.

2.10.1 Where it is assumed that reinforcement is to be located on site prior to drilling and fixing locations revised to avoid reinforcement, then the fixture or support framework should be designed to accommodate the relocation of fixings.

2.11 Where it is proposed to install multiple fixings in line, then the resistance of the element shall be verified taking into account the potential for a plane of weakness.

Avoidance of damage

2.12 The proposed drill holes shall be capable of being made without wider damage to the concrete substrate.

NOTE For example, there is potential for the drilling to 'burst out' the rear of thin concrete sections.

2.13 Where it is proposed to install a fixing through bridge deck waterproofing, then the integrity of the waterproofing shall be maintained.

2.13.1 The design should include measures to repair and reinstate the waterproofing that assure the integrity of the joint with the existing waterproofing.

Design for testing

2.14 The fixing system shall be designed to allow for proof testing.

NOTE 1 Requirements for proof testing are given in Section 3.

NOTE 2 Space is needed for the testing equipment, including jacks, load transfer arrangement, and space for the tester.

2.14.1 Where testing of the works fixings is not possible due to geometrical constraints, sacrificial fixings may be provided and tested.

2.14.2 Sacrificial fixings should be located on the structure in the vicinity of the works fixings.

2.14.3 Sacrificial fixings should replicate the conditions and installation methods of the works fixings.

Design for robustness

2.15 Fixing systems that include safety critical fixings shall be designed with a defined strategy to provide robustness.

NOTE Robustness is a defined term; refer to terms and definitions.

2.15.1 Strategies to provide robustness may include:

1) segmentation, to limit the extent of failure;
2) limiting the exposure of the fixing to adverse and unforeseen events; and
3) redundancy, to allow load to be transferred in the event of failure of an element of the fixing system.

NOTE 1 Segmentation means dividing the fixing system into structurally-independent sections, such that a failure of one section is not transmitted into the next section.

NOTE 2 In some cases it can be possible to reduce the exposure of a fixing by adjusting its location, for example in relation to accidental impacts.

NOTE 3 Failure case studies show that there is potential for common-cause failure where the same failure mode can apply to large numbers of similar fixings. In the case of such systematic failures, a high overall factor of safety or high level of redundancy are not necessarily sufficient to prevent failure.

2.15.2 The fixing system design may allow for identifiable deformation to occur following failure of an element of the system, prior to total failure.

NOTE 1 *The provision of a ductile system can allow initial failures to be detected by inspections and acted upon prior to overall failure.*

NOTE 2 *Such identifiable deformation can be provided through deformation of support frameworks, or movement of secondary restraints, or load indicating elements.*

2.16 Fixing systems for permanent works that include safety critical fixings shall be designed to accommodate a failure of any single safety critical fixing as an accidental design situation, without collapse of the fixture.

2.16.1 For the failure cases, the partial factors relevant to the accidental design situation should be applied, in accordance with BS EN 1990 [Ref 11.N].

2.16.2 For all the failure cases, the remaining elements of the fixing system (such as base-plate, support framework, and other fixings) should be designed to carry the redistributed loads consistent with the failure cases.

NOTE *The critical design actions on fixings can be generated by this redistribution case, which is checked to avoid the possibility of an 'unzipping' progressive failure.*

2.16.3 A secondary restraint system may be an option to protect against failure of a primary fixing.

NOTE *Examples of secondary restraint include:*

1) lanyards;

2) safety chains;

3) a corbel or other structural device to 'catch' the fixture; and

4) a crash deck.

2.16.4 Where a secondary restraint is provided, the design of the restraint and associated fixings should include for dynamic effects, where there is potential for the fixture to drop due to slack before the restraint is mobilised.

NOTE 1 *The actions on a fixing providing secondary restraint can be different to those on a primary fixing, and hence a different size or type of fixing can be needed.*

NOTE 2 *There can be beneficial improvements in robustness in selecting a different type of fixing for a secondary restraint system compared with the primary fixings, since this reduces the possibility of the same risk factors, degradation or failure mechanisms applying to both sets of fixings.*

2.16.5 Where a secondary restraint is provided, the fixture should not be able to move to a position that can cause harm to persons or traffic when the restraint is mobilised.

Design to facilitate future management

General

2.17 The fixing system shall be designed to facilitate future management.

NOTE 1 *Decisions taken during the design phase can have a significant impact on how the fixing is managed in future.*

NOTE 2 *The purpose of designing to facilitate future management is to make provisions in design that can enable an appropriate management regime to be followed in order that a tolerably low level of risk is maintained through the life of the fixing.*

NOTE 3 *The following sections provide requirements that facilitate future management under the following headings:*

1) design for inspection;

2) design for future testing; and

3) design for end-of-life.

Design for inspection

2.18 The fixing system and fixings shall be designed to facilitate future inspection.

2.18.1 Anchors should be observable without special access equipment.

NOTE *General inspections are visual inspections undertaken without special access equipment. It is desirable that information on anchors can be obtained from general inspections, in particular, signs of distortion, corrosion or cracking of the substrate.*

2.18.2 Anchors should be accessible at touching distance using a viable means of access.

NOTE *Touching distance access is required for principal inspections. Touching distance access is also important if investigations are required into condition or performance of the fixing.*

2.18.3 Space should be provided around the fixing system to allow for the means of access and the inspector.

NOTE *Where equipment is suspended from fixings, then access to the fixing using elevated platforms can be prevented by the size and position of the equipment.*

2.18.4 Joints between concrete elements connected using post installed reinforcement should be observable from at least one side.

NOTE *Signs of degradation of the post installed reinforcement can become visible at the surface of the joint. It is not possible to inspect the post installed reinforcement directly when it is used to connect two concrete elements.*

2.19 Safety critical anchors shall not be hidden.

NOTE *Guidance is provided in CIRIA C764 [Ref 5.I] on managing hidden defects in bridges. The report defines a hidden component as one that would not usually be visually inspected as part of a principal inspection. Components are hidden if they are inaccessible for inspection without excavation or removal of material or other structural components.*

2.20 Where the proposed access requires removal of panels or remote imaging such as endoscopes, then justification for the proposed means of access shall be provided.

Design for future testing

2.21 The benefits of including measures to enable future testing of safety critical fixings shall be evaluated.

NOTE 1 *Future testing refers to in-service testing during the design working life, rather than to proof testing following installation.*

NOTE 2 *The extra costs of including measures to enable testing can be relatively low if included from the start. Such measures can provide a future contingency for testing that could provide assurance that a fixing continues to achieve a certain resistance over time.*

NOTE 3 *The potential benefits of future testing are highest when some or all of the following apply:*

1) *high consequences of failure;*
2) *large number of similar fixings;*
3) *potential for degradation of the substrate or aspects of the substrate performance or strength are unknown (more likely in a retrofit application than a new structure);*
4) *permanent actions carried by the fixing are a low proportion of the design action (for example, when the fixing is intended to perform in an accidental design situation such as a vehicle impact);*
5) *the replacement of fixings would be particularly challenging*

NOTE 4 *Load testing in-service can be a costly and disruptive activity. In some cases access and traffic management costs can be comparable for installation of new fixings.*

2.22 Where measures to enable future testing of safety critical fixings are proposed, then the measures shall be documented in the maintenance records as defined in CG 300 [Ref 20.N].

NOTE *Guidance on planning for load testing of anchors is provided in CIRIA C778 [Ref 6.I].*

2.22.1 Where measures to enable future testing of safety critical fixings are proposed, a future testing strategy should be produced and included in the records, including:

1) type of test (for example, proof test);
2) test load;
3) envisaged test method, including means of applying load;
4) action to be taken in the event that the test load is not achieved; and
5) action to be taken in the event of damage to the fixing or substrate during the test.

2.22.2 Physical measures to enable future testing may include:

1) extra fixings included specifically and solely for future testing;
2) fixture/connection designed to enable testing, for example, detailing an extended thread to allow for attachment of a test rig, or allowing for testing without removal of the fixture; and
3) space to allow for the testing rig, which can include a spreader beam.

2.22.3 Where extra fixings are provided specifically for future testing, the extra fixings should be in locations and conditions that are representative of the other fixings.

2.22.4 Where it is proposed to apply a test load to the fixture rather than directly to the fixing, then the intended load on the fixing should be defined and related to the test load.

NOTE *For some arrangements of fixings, such as post installed reinforcement, it can be possible only to apply load to the fixture.*

Design for end-of-life

2.23 Design assumptions about the end-of-life of the fixing system and fixing shall be documented in the maintenance records as defined in CG 302 [Ref 2.N].

2.23.1 A viable method of removing the fixture should be identified and recorded.

2.23.2 Where potential interim replacement of fixings is included as part of a strategy to justify an extended design working life, then the intended method of replacement should be identified and recorded.

NOTE *Potential options to allow fixings to be replaced while the fixture remains in service can include:*

1) making provision for fixings to be installed at other locations along a support framework, where one is present;
2) allowing for progressive replacement of fixings whilst the fixture remains in place, with assumptions about the number of fixings that can be removed at any time during replacement.

Fire

2.24 Fire-critical fixings shall be identified, as those that:

1) are at risk of exposure to fire; and,
2) have a high consequence if they fail during fire.

2.24.1 Fixings in road tunnels should be classified as at risk of exposure to fire.

NOTE 1 *Open structures such as retaining walls and bridges that can be cleared of people relatively quickly are unlikely to include fixings with a high consequence of failure during a fire.*

NOTE 2 *A non-safety critical fixing has a low consequence of failure in normal conditions, hence is unlikely to have a high consequence of failure during fire.*

2.25 The performance of fire-critical fixings in a fire shall be consistent with the overall fire design strategy for the structure.

NOTE *A fire design strategy can have various objectives, including some or all of:*

1) means of escape and fire fighting;

2) continued provision of ventilation or smoke control;

3) provide fire resistance to reduce the chance of collapse;

4) protection of adjacent assets from fire, for example, by compartmentation.

2.26 Fire design requirements for fire-critical fixings shall be defined and satisfied by the fixing design.

NOTE *Fire design requirements can include, as appropriate:*

1) design fire scenario;

2) fire model;

3) fire resistance class;

4) deformation limits in the fire.

2.26.1 The fire design requirements should be consistent with the purpose of the fixing and its role in the overall fire design strategy.

NOTE *For example, if a fixing supports a ventilation duct, and the fire life safety strategy relies on ventilation being maintained during the evacuation period, then the fixing cannot fail during that period.*

2.26.2 Fire design requirements may include design or mitigation measures, including:

1) design to provide fire resistance;

2) use fixings with load values certified against fire test results;

3) provide fire protection to fixings;

4) increase robustness of fixings to fire, for example, by using a greater embedment depth; or

5) verify performance of the complete system using fire tests.

3. Design of post-installed fixings

European assessment documents

3.1 Post-installed anchors and systems for post-installed reinforcement bar connections shall comply with an appropriate European assessment document (EAD).

NOTE 1 Compliance with an EAD means that a fixing has a European technical assessment (ETA).

NOTE 2 Relevant EADs are shown in Table 3.1N2.

Table 3.1N2 EADs

Type	EAD	Design method
Mechanical anchor	EAD 330232-00-0601 [Ref 15.N]	BS EN 1992-4 [Ref 7.N]
Bonded anchor	EAD 330499-00-0601 [Ref 3.N]	BS EN 1992-4 [Ref 7.N]
Post-installed reinforcement bar connections	EAD 330087-00-0601 [Ref 19.N]	BS EN 1992-1-1 [Ref 9.N] and BS EN 1991-1-2 [Ref 1.N]

NOTE 3 It is understood that a number of EADs are under preparation but are not yet published. EAD 332077-00-0601 is expected to cover post installed reinforcement bar connections with 100 year working life. EAD 330250-00-0601 is expected to cover post-installed anchors under fatigue cyclic loading.

Design working life

3.2 The design working life of a fixing shall be at least equal to that of the fixture.

NOTE 1 Design working lives assumed in design methods and EADs are generally 50 years.

NOTE 2 EAD 332077-00-0601 is not yet published but is expected to cover bonding materials for anchors with a design working life of 100 years.

Suitability for use

3.3 The design of post-installed fixings shall only incorporate products that are suitable for their intended application in accordance with the relevant EAD.

NOTE The EADs for fixings generally contain a number of different categories and options, and some options can be unsuitable for some applications.

3.3.1 Where an ETA is selected, the options covered by the ETA should be suitable for the intended application.

3.4 The options for the intended application shall be classified against relevant categories for the EAD, including those summarised in Table 3.4.

Table 3.4 Categories and options within EADs

	EAD 330087-00-0601 [Ref 19.N] Systems for post-installed rebar connections with mortar	**EAD 330499-00-0601 [Ref 3.N] Bonded fasteners for use in concrete**	**EAD 330232-00-0601 [Ref 15.N] Mechanical fasteners for use in concrete**
Concrete	Cracked Uncracked	Cracked Uncracked	Cracked Uncracked
Actions	Static or quasi-static Does not cover dynamic, fatigue, seismic	Static or quasi-static Seismic Does not cover dynamic, fatigue	Static or quasi-static Seismic Does not cover dynamic, fatigue
Fire	Exposure to fire is included	Does not include exposure to fire	Exposure to fire included for fasteners in cracked concrete only
Load direction	Tension only Shear transfer is carried by the interface between old and new concrete	Tension Shear Combined tension and shear	Tension Shear Combined tension and shear
Temperature range of the concrete substrate	T1 (-40ºC to 24/40ºC long / short term) T2 (-40ºC to 50/80ºC long / short term) T3 (-40ºC to T_{lt}/T_{st} >40ºC long / short term, T_{lt} and T_{st} can be defined)	T1 (-40ºC to 24/40ºC long / short term) T2 (-40ºC to 50/80ºC long / short term) T3 (-40ºC to T_{lt}/T_{st} >40ºC long / short term, T_{lt} and T_{st} can be defined)	-40ºC to +80ºC
Durability	Cl 0,20 Cl 0,40 (Chloride content class in accordance with BS EN 206 [Ref 4.N], BS 8500-1 [Ref 5.N] and BS 8500-2 [Ref 6.N])	X1 (dry internal) X2 (external) X3 (extreme chemical pollution including exposure to de-icing salts)	(1) (dry internal) (2) (external) (3) (extreme chemical pollution including exposure to de-icing salts)
EAD options	N/A	Table of 12 options (derived from some of the classifications above)	Table of 12 options (derived from some of the classifications above)
Drilling technique	Drilling methods as applied for by the manufacturer	Rotary hammer Diamond drilling	Manufacturer's instructions on drilling technology
Concrete installation condition	N/A	I1 (dry or wet) I2 (water-filled holes)	N/A
Installation direction	As applied for by the manufacturer. - Vertically downward - Horizontal - Vertically upwards	D1 (down) D2 (horizontal) D3 (upward)	N/A

NOTE Table 3.4 provides a summary to assist in classifying the intended application. It does not cover all categories nor fully describe all of the classifications.

3.4.1 The maximum and minimum temperatures of the concrete substrate should be determined in accordance with BS EN 1991-1-5 [Ref 8.N] and its National Annex.

3.4.2 For external applications in the United Kingdom a temperature range of T2 may be assumed.

3.4.3 Where the actions to be carried by fixings have been evaluated, but the selection of a particular fixing product is to be made by others at a later stage, then the following design information should be provided:

1) whether the application is safety critical or non-safety critical;
2) design values of actions at ultimate limit state (ULS) and serviceability limit state (SLS);
3) the options required for relevant categories in Table 3.4, including cracked/uncracked concrete, durability classification, etc.;
4) the characteristic concrete strength to be used in the design of the fixings;
5) any application-specific criteria relating to edge distance, centre spacings and embedment depth, such as a maximum embedment depth, or a pre-determined embedment length;
6) displacement limits for short and long-term loads at serviceability limit state;
7) details of the metal component when this has been pre-determined;
8) proof test requirements including number of tests and value of the test load.

Durability

Post-installed anchors

3.5 The durability classification for permanent bonded anchors not fully encased in concrete shall be either X2 or X3.

NOTE 1 X2 and X3 are classifications defined in EAD 330499-00-0601 [Ref 3.N]. Metal elements of X2 and X3 anchors are stainless steel.

NOTE 2 X2 classification includes anchors subject to external atmospheric exposure (including industrial and marine environments), or exposure in permanently damp internal conditions, if no particular aggressive conditions according to X3 exist.

NOTE 3 X3 classification includes anchors subject to particularly aggressive conditions such as permanent, alternating immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g. in desulphurization plants or road tunnels where de-icing materials are used).

3.6 The durability classification for permanent mechanical anchors not fully encased in concrete shall be either (2) or (3).

NOTE 1 (2) and (3) are classifications defined in EAD 330232-00-0601 [Ref 15.N]. Mechanical anchors classified as (2) or (3) are stainless steel.

NOTE 2 (2) and (3) classifications align with the classifications X2 and X3 for bonded anchors.

3.7 In aggressive environments, such as road tunnels, the durability classification for permanent anchors not fully encased in concrete shall be X3 (bonded anchors) / (3) (mechanical anchors).

3.8 Where temporary anchors are planned to be left in place after use, then the durability classification for the temporary anchor shall be the same as for an equivalent permanent anchor.

3.8.1 Where temporary anchors are planned to be removed after use, then lower durability classifications may be used.

Post-installed reinforcing bar connections

3.9 Where post-installed reinforcing bars are to be installed with some parts not fully encased in concrete, the reinforcing bar shall be of an austenitic stainless steel grade.

3.9.1 In standard highway environments, the grade should be austenitic steel with 16.5 to 18.5% chromium, 10 to 13% nickel and 2 to 3% molybdenum content or an equivalent corrosion resistant duplex steel grades, in accordance with BS EN 10088 [Ref 18.N].

3.9.2 In aggressive environments, such as road tunnels, the grade should be austenitic steel with 20% chromium, 20% nickel and 6% molybdenum content or an equivalent duplex steel grade.

Dissimilar metals

3.10 Dissimilar metals shall be isolated.

NOTE An example where dissimilar elements need to be isolated is a where a stainless steel mechanical anchor is installed directly adjacent to carbon steel reinforcement. There are concerns that corrosion resistance can be impaired in this situation and the existing carbon steel could already be active and be vulnerable to bi-metallic corrosion with the stainless steel.

3.10.1 The bonding material for post-installed fixings may be used to isolate dissimilar metals.

Design Method

3.11 Anchors shall be designed in accordance with the design method stated in the relevant EAD.

NOTE 1 Post-installed anchors are designed in accordance with BS EN 1992-4 [Ref 7.N].

NOTE 2 The ETA provides characteristic values that are used in the design method given in BS EN 1992-4 [Ref 7.N]. The design method cannot be applied without such values from an ETA. The ETA is the European technical product specification.

NOTE 3 In the design method for anchors, the element acts as an anchor bolt (which in the case of bonded anchors is generally a threaded rod, but can also be a short reinforcing bar acting as an anchor) stressed in tension, shear or combined tension and shear over a short embedment depth.

NOTE 4 Some older ETAs refer to TR 029 [Ref 2.I] or pre-norm versions of 1992-4 for the design of anchors. These design methods remain valid where stated in a valid ETA, although they have now been superseded by BS EN 1992-4 [Ref 7.N].

3.12 Post-installed reinforcing bar connections shall be designed in accordance with BS EN 1992-1-1 [Ref 9.N] and BS EN 1991-1-2 [Ref 1.N].

NOTE 1 The ETA provides characteristic values that are used to calculate the bond and anchorage length. The design method cannot be applied without such values from an ETA.

NOTE 2 In the design method for post-installed reinforcing bar connections, the element (a reinforcing bar or a tension rod) is intended to behave in the same way as a cast-in reinforcing bar and acts only in tension. This applies to most situations where existing and new concrete members are to be connected or to be made continuous.

3.13 For post-installed reinforcing bar connections design, the shear transfer between old and new concrete shall be designed in accordance with the rules on shear at the interface between concrete cast at different times within BS EN 1992-1-1 [Ref 9.N].

3.13.1 Where the interface been the fixture and and the base material has insufficient capacity, shear lugs or post installed anchors carrying shear should be provided in addition to the post-installed reinforcing bar connection.

3.14 Where a post-installed fixing is installed in a surface with a concrete repair, then the repair material shall be ignored in the design of the fixing.

NOTE *The design methods and testing that underpins an ETA assume that the concrete is continuous, but for a concrete repair there is potential for a plane of weakness at the interface between concrete surface and the repair material.*

Serviceability limit state (SLS)

3.15 Post-installed reinforcing bar connections shall satisfy the SLS criteria in BS EN 1992-1-1 [Ref 9.N].

3.16 The deformation of post-installed anchors under SLS loads shall not impair structural performance, appearance or durability.

NOTE 1 *In some applications (e.g. temporary works fixings, strengthening a structure to accommodate accidental loading etc.) deformation control is unlikely to be critical. However, in other cases (e.g. anchors subject to long-term loads), careful control of deformation is often of greater significance.*

NOTE 2 *The characteristic displacement of an anchor under tension and shear loading is given in its ETA.*

3.16.1 Displacement may be assumed to be proportional to applied load.

3.16.2 Where load/displacement data for a particular arrangement of embedment depth, concrete strength and bar diameter is not available, data applicable to a smaller embedment depth, lower concrete strength and smaller bar diameter may be used.

3.17 The design value of the displacement of an anchor shall not exceed the limiting displacements given in Table 3.19 for short and long-term loading at SLS.

Table 3.17 Deformation limits for anchors

	Maximum deformation under short-term loading	Maximum deformation under long-term loading
Tension	0.05d	0.12d
Shear	0.20d	0.30d

NOTE *d is the nominal diameter of the anchor in millimetres.*

3.18 The deformation limits shall be met at short and long-term concrete temperatures in accordance with the temperature classification selected from the EAD.

NOTE *Refer to Table 3.4 for the temperature classifications.*

3.18.1 Where displacement under load has significant adverse implications, more onerous project-specific limits should be defined.

Fire resistance

3.19 Where a fixing is fire-critical and the fire design strategy includes requirements for fire resistance, then fixings shall be designed for fire resistance based on the fire design requirements identified in Section 2.

NOTE 1 *Requirements for identification of fire-critical fixings are given in Section 2.*

NOTE 2 *Further guidance on design of fixings for fire resistance is provided in Fixings and fire [Ref 4.I].*

3.19.1 Compliance with fire design requirements may be demonstrated by an ETA that covers the requirements.

3.19.2 Fire resistance may be verified for a specified design fire scenario in accordance with BS EN 1991-1-2 [Ref 1.N] and BS EN 1992-4 [Ref 7.N].

3.19.3 Where the primary load effect is axial tension, the effects of fire may be mitigated by increasing the embedment depth to compensate for the loss of bond strength close to the surface of the concrete.

NOTE *When a structure is exposed to extreme heat or fire, the temperature at relatively shallow depths within the concrete can often be much lower than that at the concrete surface.*

3.19.4 BS EN 1992-1-2 [Ref 10.N] may be used for the design of concrete elements containing post-installed reinforcing bar connections having a high risk of exposure to fire.

3.19.5 The design of fire-critical post-installed reinforcement bar connections should be based on a reduced bond strength at elevated temperatures.

Proof test load

3.20 A proof test load shall be determined for each fixing.

NOTE 1 Proof testing is carried out after installation of the fixing to confirm the quality of the installation as the performance of fixings can be heavily influenced by workmanship and/or environmental conditions.

NOTE 2 Specification requirements for proof testing of fixings are given in MCHW Series 1700 [Ref 14.N].

3.21 For anchors carrying tension, the test load shall be a minimum of 1.1 times the ULS design tensile action.

3.22 For anchors carrying tension, the test load shall not exceed 1.1 times the ULS design tensile resistance.

3.23 For anchors carrying shear, the test load shall be equal to or greater than the ULS design tensile resistance.

3.24 For anchors carrying shear, the test load shall not exceed 1.1 times the ULS design tensile resistance.

3.25 For post-installed reinforcing bar connections, the test load shall be a minimum of 1.1 times the ULS design tensile action.

3.26 For post-installed reinforcing bar connections, the test load shall not exceed 1.1 times the ULS design resistance.

3.27 The number of proof tests shall be determined for each area of the works with a different size or type of fixing, different concrete strength and different installation direction in accordance with Table 3.29.

Table 3.27 Proof Tests

Is the fixing safety critical?	Minimum number of proof tests
No	3%*
Yes	10%*
	* Subject to a minimum of 3 fixings

NOTE For works involving the installation of very large numbers of anchors (e.g. > 1000), the percentage of anchors/rebars to be tested can be reduced with the agreement of the Technical Approval Authority

3.28 The locations of the proof tests shall be determined and specified.

3.28.1 The locations of the proof tests should be representative of the relevant area of the works.

Design records

3.29 The design records as set out in CG 302 [Ref 2.N] shall include the records defined in BS 8539 [Ref 1.I] that are relevant to design.

NOTE 1 The following sections of BS 8539 [Ref 1.I] are relevant:

1) information to be provided by the designer to the specifier;

2) information to be provided by the specifier to the contractor/installer.

NOTE 2 The following information is particularly important in the future management of the structure:

1) full description, including make, type, EAD, ETA and Declaration of Performance (where applicable), size, designation, manufacturer's reference number;

2) design actions and their nature;

3) *performance data, including characteristic resistance and design resistance ;*
4) *material details for fixing and resin where used (eg grade, corrosion resistance);*
5) *assumed substrate strength;*
6) *embedment depth;*
7) *minimum spacings, edge distances, base material thicknesses;*

4. 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 1991-1-2, 'Actions on structures exposed to fire'
Ref 2.N	Highways England. CG 302, 'As-built, operational and maintenance records for highway structures'
Ref 3.N	EOTA. EAD 330499-00-0601 , 'Bonded fasteners for use in concrete'
Ref 4.N	BSI. BS EN 206, 'Concrete - specification, performance, production and conformity '
Ref 5.N	BSI. BS 8500-1, 'Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier.'
Ref 6.N	BSI. BS 8500-2, 'Concrete. Complementary British Standard to BS EN 206. Specification for constituent materials and concrete.'
Ref 7.N	BSI. BS EN 1992-4, 'Design of concrete structures. Design of fastenings for use in concrete'
Ref 8.N	BSI. BS EN 1991-1-5, 'Eurocode 1: Actions on structures. Part 1-5: General actions – Thermal actions'
Ref 9.N	BSI. BS EN 1992-1-1, 'Eurocode 2: Design of concrete structures. General rules and rules for buildings'
Ref 10.N	BSI. BS EN 1992-1-2, 'Eurocode 2: Design of concrete structures.General rules - Structural fire design '
Ref 11.N	BSI. BS EN 1990, 'Eurocode: Basis of structural design'
Ref 12.N	EOTA. EAD 330747-00-0601, 'Fasteners for use in concrete for redundant non-structural systems'
Ref 13.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 14.N	Highways England. MCHW Series 1700, 'Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works - Series 1700 Structural Concrete'
Ref 15.N	EOTA. EAD 330232-00-0601, 'Mechanical fasteners in concrete'
Ref 16.N	EOTA. ETAG 020, 'Plastic Anchors'
Ref 17.N	2011/305/EU, 'Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directives 89/106/EEC'
Ref 18.N	BSI. BS EN 10088, 'Stainless steels (all parts)'
Ref 19.N	EOTA. EAD 330087-00-0601, 'Systems for post-installed rebar connections with mortar'
Ref 20.N	Highways England. CG 300, 'Technical approval of highway structures'

5. Informative references

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

Ref 1.I	BSI. BS 8539, 'Code of practice for the selection and installation of post-installed anchors in concrete and masonry'
Ref 2.I	EOTA. TR 029, 'Design of bonded anchors'
Ref 3.I	BSI. BS EN 1991-2, 'Eurocode 1. Actions on structures. Traffic loads on bridges'
Ref 4.I	CFA. Fixings and fire, 'Guidance note: fixings and fire'
Ref 5.I	CIRIA. Collins J et al. CIRIA C764, 'Hidden defects in bridges. Guidance for detection and maintenance'
Ref 6.I	CIRIA. CIRIA C778, 'Management of safety critical fixings in-service. Guidance for the management and design of safety-critical fixings'
Ref 7.I	Highways England. MCHW, 'Manual of Contract Documents for Highway Works'

Notification

This document was notified in draft to the European Commission in accordance with Technical Standards and Regulations Directive 2015/1535/EU.