Highway Structures & Bridges
Contract preparation

CP 484 Instructions for specifiers for CC 484 Concrete repairs

(formerly Series NG 5700)

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Latest release notes

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Foreword

This document provides specifier instructions for the production of the works specific requirements for CC 484 Concrete repairs.

This document does not form part of the works specification.

The works specification is made up of both the Specification for Highway Works and the works specific requirements completed by the Specifier.

This document is applicable for contracts throughout the UK, complemented by the additional specification requirements and contractual changes of each Overseeing Organisation.

Users are responsible for applying all appropriate documents applicable to their contract.

Users are responsible for archiving contract documentation in accordance with the user's quality management system.

1. Quality plans for concrete repairs

General requirements for specialist activity quality plans for concrete repairs

1.1 The specialist activity quality plans for concrete repair works shall be prepared in accordance with "Quality Plans" in Section 6 of GC 101 [Ref 13.N].

Quality plan documentation requirements for concrete repairs

1.2 The following Documentation shall be submitted for concrete repair works prior to the commencement of concrete repair work: specialist activity quality plan for concrete repairs.

1.3 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to : specialist activity quality plan for concrete repairs.

1.4 The following Documentation shall be submitted for concrete repair works prior to the commencement of concrete repair works: detailed method statements for concrete repair works.

1.5 Method statements for concrete repair works shall include at least the following information and activities:.

1. location of concrete repair activities;
2. erection, maintenance and removal of traffic management;
3. erection, maintenance and removal of temporary access, temporary falsework and temporary protection;
4. cleaning of surfaces prior to inspection for defects;
5. concrete investigation work;
6. phasing of concrete repairs;
7. removal of defective concrete;
8. preparation of substrate and cracks;
9. treatment of reinforcement;
10. technical data sheets and COSHH sheets for repair products and other proprietary products proposed for the permanent works;

11. processing of recyclable arisings e.g. water, concrete, reinforcement;

12. disposal of non-recyclable arisings e.g. hazardous materials, contaminated water, contaminated concrete;

13. installation of steel reinforcement;

14. installation of other proprietary concrete repair products (e.g galvanic anodes etc);

15. erection, maintenance and removal of formwork;

16. application of repair concrete or mortar products;

17. curing and protection of concrete repairs;

18. Injection or filling of concrete cracks;

19. testing for contract compliance.

2. Investigation of concrete condition prior to concrete removal and substrate preparation

General requirements for investigation and testing of concrete condition

2.1 A visual inspection and hammer sounding survey shall be undertaken to confirm the current condition of the specified areas of existing concrete before removal of concrete.

2.2 The non-destructive survey or intrusive survey to establish the current condition of concrete where required in specified areas shall be as stated in CC 484/WSR/002.

2.3 Requirements for investigation and testing of the concrete condition of reinforced concrete highway structures shall be in accordance with CS 462 [Ref 40.N].

Verification requirements for confirming current condition of the existing concrete prior to concrete removal

Visual inspection to verify existing concrete condition prior to concrete removal

2.4 Verification shall be undertaken for confirming the existing concrete condition by visual inspection.

2.5 The frequency of the visual inspection to confirm the existing concrete condition shall be at least once per structure, prior to other investigations, concrete removal or substrate preparation stages.

2.6 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to confirming the concrete condition by visual inspection prior to other investigations, concrete removal and substrate preparation stages.

2.7 The visual inspection prior to concrete removal or substrate preparation shall comprise a survey of the existing concrete condition of all areas of exposed concrete, unless otherwise stated in CC 484/WSR/002.

SI.2.7a The areas of concrete to undergo a visual inspection of the existing concrete condition shall be [select one or more from: all areas of visually exposed concrete, the areas of defective concrete identified in the construction drawings, old repairs, hidden/covered concrete identified in

the construction drawings, deck areas identified in the construction drawings].

SI.2.7b The scope of visual inspection of concrete condition shall be [select one from: General Inspection, Principal Inspection] in accordance with CS 450 [Ref 15.N].

2.8 The visual inspection shall confirm the current extent of defective concrete and cracking prior to hammer sounding survey, further investigations of the concrete condition, concrete removal or substrate preparation stage in accordance with CS 462 [Ref 40.N] and Section 9 of BS EN 1504-10 [Ref 32.N].

2.9 The following Documentation shall be submitted for the visual inspection to confirm the existing concrete condition prior to the commencement of the works: Notification of the intention to undertake the visual inspection to confirm the existing concrete condition.

2.10 Documentation for Notification of the intention to undertake the visual inspection to confirm the concrete condition shall be submitted at least 2 working days prior to the commencement of the works.

2.11 The concrete surfaces of all visually exposed concrete shall be cleaned of graffiti, dirt, organic growths, and debris prior to the visual inspection to confirm the existing concrete condition, unless otherwise stated in CC 484/WSR/002.

SI.2.11 The areas of concrete surfaces to be cleaned prior to visual inspection to confirm the concrete condition shall be [select one or more from: all areas of visually exposed concrete, the areas of defective concrete identified on the construction drawings, old repairs, hidden/covered concrete identified in the construction drawings, deck areas identified in the construction drawings].

2.12 Where reinforced concrete structural elements are to receive impressed current cathodic protection, any redundant embedded or surface-mounted metal objects which are visible at the concrete surface shall be recorded in the survey and marked for removal.

2.13 Where reinforced concrete structural elements are to receive impressed current cathodic protection, other embedded or surface mounted metal objects still in use shall be recorded in the survey for isolation testing as part of the cathodic protection works in accordance with CC 485 [Ref 14.N].

2.14 Any previous repair areas containing steel-fibre reinforcement within structural elements that are to receive overlaid cathodic protection system shall be identified as defective concrete for concrete removal.

2.15 The following Documentation shall be submitted for confirming the current extent of defective concrete or new items for removal following the visual inspection to confirm the concrete condition prior to the commencement of other investigations to determine concrete condition, concrete removal or substrate preparation stage: Visual inspection concrete condition confirmation drawings.

2.16 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to Visual inspection on concrete condition confirmation drawings.

Hammer sounding survey to verify existing concrete condition prior to concrete removal

2.17 The hammer sounding survey shall confirm the extent of defective concrete and cracking prior to further investigations of the concrete condition, concrete removal or substrate preparation stage in accordance with CS 462 [Ref 40.N]and BS EN 1504-10 [Ref 32.N].

2.18 The requirement for hammer sounding survey to confirm the existing concrete condition of the structure shall be as specified in CC 484/WSR/002.

The requirement for hammer sounding survey to confirm the existing concrete condition of the structure				
Structure ID	**Structural element**	**Drawing reference(s)**	**Location on element**	**Hammer sounding survey area**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element that requires the hammer sounding survey.

c) Enter text, to cross reference relevant drawing(s).

d) Enter text, to identify the specific location that requires the hammer sounding survey.

e) Enter a number in units of m^2, to identify the size of the area to receive the hammer sounding survey..

2.19 Verification shall be undertaken for confirming the existing concrete condition by a hammer sounding survey prior to concrete removal and substrate preparation stage.

2.20 The frequency of the hammer sounding survey shall be at least once per structure, following the visual inspection to determine concrete condition and prior to other investigations, concrete removal or substrate preparation.

2.21 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to confirming the concrete condition by hammer sounding survey prior to other investigations concrete removal and substrate preparation stage.

2.22 The following Documentation shall be submitted for the hammer sounding survey to confirm the existing concrete condition prior to the commencement of the works: Notification of the intention to undertake the hammer sounding survey to confirm the existing concrete condition.

2.23 Documentation for Notification of the intention to undertake the hammer sounding survey to confirm the existing concrete condition shall be submitted at least 2 working days prior to the commencement of the works.

2.24 Hammer sounding surveys shall be undertaken on areas of defective concrete identified from the visual inspection concrete condition confirmation drawings.

2.25 The following Documentation shall be submitted for details of the new extent of delaminated concrete or additional cracking following the hammer sounding survey to confirm the concrete condition prior to the commencement of other investigations to determine concrete condition, concrete removal or substrate preparation: Marked up visual inspection concrete condition confirmation drawings incorporating hammer sounding survey findings.

2.26 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to Marked up visual inspection concrete condition confirmation drawings incorporating hammer sounding survey findings.

Verification requirements for determining condition of reinforced concrete by non-destructive survey using instruments

2.27 Verification for non-destructive testing using instruments at concrete surface to confirm reinforced concrete condition shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

2.28 The requirements for non-destructive testing using instruments at concrete surface to confirm reinforced concrete condition shall be as specified in CC 484/WSR/002.

The requirements for non-destructive testing using instruments at concrete surface to confirm reinforced concrete condition						
Structure ID	**Structural element**	**Drawing reference (s)**	**Location on element**	**Reinforcement cover survey required**	**Electrical potential mapping required**	**Grid spacing for electrical potential mapping**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter text, to identify the structural element which requires non-destructive investigation and testing.

c) Enter text, to cross reference relevant drawing(s).

d) Enter text, to identify the specific location which requires non-destructive investigation and testing.

e) Enter a value, from options yes, no, to identify the requirement to undertake a reinforcement cover survey at the test location.

f) Enter a value, from options yes, no, to identify the requirement to undertake electrical potential mapping at the test location.

g) Enter a number in units of mm, to identify the horizontal and vertical spacing of measurements.

The requirements for non-destructive testing using instruments at concrete surface to confirm reinforced concrete condition (continued)			
Structure ID	**Electrical resistivity testing required**	**Moisture content testing required**	**Other survey instrument testing required**
(a)	(h)	(i)	(j)

h) Enter a value, from options yes, no, to identify the requirement to undertake electrical resistivity testing at the test location.

i) Enter a value, from options yes, no, to identify the requirement to undertake testing of concrete moisture content at the test location.

j) Enter text, to identify any other survey instrument tests to be conducted at the test location.

2.29 Where structural elements are to receive cathodic protection, any previous repair areas exceeding the acceptable limits of electrical resistivity shall be identified for concrete removal and reinstatement.

2.30 Non-destructive survey using instruments shall be undertaken on areas of defective concrete identified from the marked up visual inspection concrete condition confirmation drawings incorporating hammer sounding survey findings.

2.31 The acceptable upper limit of electrical resistivity of previous repair areas to receive impressed current cathodic protection within an overlay shall be 150 kOhm.cm, unless otherwise stated in CC 484/WSR/002.

SI.2.31 The acceptable upper limit of electrical resistivity of previously repaired areas to receive impressed current cathodic protection within an overlay shall be [enter a number] .

Verification requirements for determining concrete condition by intrusive survey and sampling

2.32 The requirements for sampling of concrete to determine concrete condition using intrusive techniques shall be as specified in CC 484/WSR/002.

The requirements for sampling of concrete to determine concrete condition using intrusive techniques							
Structure ID	**Structural element**	**Drawing reference (s)**	**Location on element**	**Number of concrete breakouts to expose reinforcement**	**Length of concrete breakout to expose reinforcement**	**Width of concrete breakout to expose reinforcement**	**Depth of concrete breakout to expose reinforcement**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter text, to identify the structural element which requires intrusive investigation and testing.

c) Enter text, to cross reference relevant drawing(s).

d) Enter text, to identify the location for local removal of concrete for inspection or sampling.

e) Enter a number, to identify the number of breakouts required at the test location for electrical continuity testing of steel reinforcement or visual inspection of reinforcement.

f) Enter a number in units of mm, to identify the extent of concrete breakouts required at the test location.

g) Enter a number in units of mm, to identify the extent of concrete breakouts required at the test location.

h) Enter a number in units of mm, to identify the extent of concrete breakouts required at the test location.

The requirements for sampling of concrete to determine concrete conditio intrusive techniques (continued)									
Structure ID	**Number of locations for dust samples (chloride content)**	**Diameter of dust sample drill hole (for testing chloride content)**	**Depth of dust sample drill hole (for testing chloride content)**	**Depth increment of dust samples (for testing chloride content)**	**Number of core holes (for testing cement content)**	**Diameter of core hole (for testing cement content)**	**Depth of core hole (for testing cement content)**	**Number of drill holes for measuring carbonation depth**	**Diameter of drill hole for detecting carbonation depth**
(a)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)

i) Enter a number, to identify the number of locations where sets of dust samples are to be obtained for chloride ion content analysis.

j) Enter a number in units of mm, to identify the diameter of the drill hole required for the chloride ion profiles.

k) Enter a number in units of mm, to identify the total depth of the drill hole required for the chloride ion profiles.

l) Enter a number in units of mm, to identify the depth increment of each dust sample within the chloride ion profile.

m) Enter a number, to identify the extent of coring existing concrete to obtain samples for subsequent cement content analysis in the laboratory.

n) Enter a number in units of mm, to identify the diameter of core holes required to obtain samples for subsequent cement content analysis in the laboratory.

o) Enter a number in units of mm, to identify the total depth of the hole to be cored for subsequent cement content analysis in the laboratory.

p) Enter a number, to identify the number of open core holes where the carbonation depth shall be measured.

q) Enter a number in units of mm, to identify the diameter of the drill hole required for carbonation test.

r) Enter a number in units of mm, to identify the depth of drill hole required for carbonation test.

The requirements for sampling of concrete to determine concrete condition using intrusive techniques (continued)				
Structure ID	**Number of core samples (for testing compressive strength or density)**	**Diameter of core sample (for testing compressive strength or density)**	**Depth of core sample (for testing compressive strength or density)**	**Other intrusive samples required**
(a)	(s)	(t)	(u)	(v)

s) Enter a number, to identify the extent of coring to obtain samples for further testing of existing concrete compressive strength.

t) Enter a number in units of mm, to identify the diameter of the core required for subsequent testing of compressive strength or density in the laboratory.

u) Enter a number in units of mm, to identify the total depth of the core required for subsequent testing of compressive strength or density in the laboratory.

v) Enter text, to identify any other intrusive samples to be removed at the test location.

2.33 Verification for intrusive survey of concrete to confirm concrete condition shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

Verification requirements for in-situ testing of existing concrete within drill holes or breakouts

2.34 Verification for in-situ testing of existing concrete within drill holes or breakouts shall be undertaken by an accredited testing laboratory in

compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

2.35 The requirements for in-situ testing of existing concrete within drill holes or breakouts shall be as specified in CC 484/WSR/002.

The requirements for in-situ testing of existing concrete within drill holes or breakouts			
Structure ID	**Structural element**	**Number of concrete carbonation tests**	**Number of tests to confirm electrical continuity of reinforcement**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter text, to identify the structural element which requires in-situ testing.

c) Enter a number, to specify the number of tests to measure the depth of carbonated concrete within drilled holes.

d) Enter a number, to specify the number of locations where an electrical continuity test is required.

Verification requirements for laboratory testing of samples to determine concrete contamination or concrete strength

2.36 Verification for laboratory testing of extracted samples shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

2.37 The requirements for laboratory testing of samples to determine concrete contamination or concrete strength condition shall be as specified in CC 484/WSR/002.

The requirements for laboratory testing of samples to determine concrete contamination or concrete strength condition					
Structure ID	**Structural element**	**Number of concrete cores for testing compressive strength**	**Total number of concrete dust samples for testing chloride content**	**Number of core samples for testing cement content**	**Other laboratory tests required**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter a unique reference, to identify the structural element which requires laboratory testing of samples obtained from the element.

c) Enter a number, to specify the number of compressive strength tests to be carried out in the laboratory.

d) Enter a number, to specify the total number of chloride content tests required, comprising the number of drill holes multiplied by the number of depth increments.

e) Enter a number, to specify the number of cores from which samples for determining cement content are required.

f) Enter text, to identify any other laboratory tests required.

Documentation requirements for investigation and testing and concrete condition

2.38 The following Documentation shall be submitted for the investigation and testing of the concrete condition for highway structures prior to the commencement of concrete repair works: a concrete investigation report in accordance with CS 462 [Ref 40.N].

2.39 Documentation for the investigation and testing of concrete condition shall be submitted at least 5 working days prior to the commencement of concrete removal or repair work for highway structures.

3. Concrete removal and substrate preparation

General requirements for concrete removal

3.1 A visual inspection and hammer sounding survey shall be undertaken to confirm the current extent of defective concrete prior to concrete removal and substrate preparation in accordance with "Investigation of concrete condition prior to concrete removal and substrate preparation" in Section 2 of this document.

Methods of concrete removal

3.2 Concrete removal shall be undertaken in accordance with Section 7 of BS EN 1504-10 [Ref 32.N].

3.3 One or more of the following methods of concrete removal shall be used to remove concrete from reinforced or mass concrete structures.

1. high-pressure or ultra-high-pressure water jetting (hydro-demolition);

2. lightweight electric or lightweight pneumatic demolition breaker (mechanical breakout);

3. small hand tools (manual breakout).

Protection of vulnerable elements before and during concrete removal

3.4 The following elements shall be protected against damage during high-pressure water jetting and the removal of concrete by any other means:.

1. any structural components that function for the safe movement or articulation of the structure;

2. exposed electrical cabling;

3. suspended drainage pipes and drainage downpipes;

4. ducts and ducting;

5. structural steelwork;

6. structural bearings;

7. electrical boxes;

8. lighting units;

9. cathodic protection systems; and

10. any other vulnerable parts or fixtures on the existing structure.

Requirements when using high-pressure water jetting for removing concrete

3.5 Water used for high-pressure water jetting shall not contaminate the repair surface.

3.6 Anti-freeze or other chemicals shall not be added to water used for high-pressure water jetting.

3.7 Water used for high-pressure water jetting shall be clean, fresh and potable complying with BS EN 1008 [Ref 21.N].

3.8 Any water entering prestressing system sheaths or post-tensioned ducts during concrete removal activities shall be removed from around strands so they are not left with a permanently damp environment.

Management of concrete removal activities

3.9 Work areas including the working platform shall be regularly cleared of standing water and accumulating concrete demolition material arising from concrete removal activities to reduce health and safety risks associated with a build up of slipping and tripping hazards and overloading of access platforms.

Avoidance of damage to adjacent reinforced concrete or reinforcement during removal of defective concrete

3.10 Existing concrete to be retained adjacent to, or beneath the specified concrete removal profile, shall not be damaged, except where additional concrete is removed beyond the apparent limit of reinforcement corrosion.

3.11 Existing reinforcement, prestressing strands, steel tendons and post-tensioned ducts being retained in the structure shall not be damaged during concrete removal or concrete reinstatement, except for superficial cleaning of the steel surface.

3.12 Temporary protection measures shall be installed to avoid damage to areas of the structure or structural elements outside the repair area, and to avoid damage to reinforcement within the repair area.

3.13 The temporary protection measures during the removal of concrete shall be as stated in CC 484/WSR/003.

SI.3.13 The temporary protection measures during the removal of concrete shall be [enter free text].

3.14 Bituminous surfacing or any fill material overlaying the structural deck concrete shall be removed down to the structural reinforced concrete deck slab before executing any saw cutting to prepare reinforced concrete at a construction joint.

Requirements for extent of the void by removing defective concrete

3.15 The extent of concrete removal shall be as specified in CC 484/WSR/003.

The extent of concrete removal					
Structure ID	**Structural element**	**Drawing/ model reference(s)**	**Nominal area of concrete removal**	**Nominal depth of concrete removal**	**Minimum depth behind steel reinforcement**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter text, to identify the element which requires concrete removal.

c) Enter text, to cross reference relevant drawing(s)/model(s).

d) Enter a number in units of m^2, to identify the total surface area of concrete for removal for the structural element referenced.

e) Enter a number in units of mm, to identify the nominal depth of concrete removal from the surface of the structural element consisting of delaminated concrete and any intact existing concrete to behind the outer reinforcement layer.

f) Enter a number in units of mm, to identify the total depth of concrete removal behind existing steel reinforcement for the structural element referenced.

Extent of concrete removal on deck soffits and vertical surfaces

3.16 Concrete removal on a deck soffit or vertical surfaces located above and adjacent to road traffic lanes or trackbed of a live railway shall be undertaken to a minimum depth of 25mm behind reinforcing bars within

the area of concrete removal, subject to a minimum of one reinforcing bar for small repair areas less than 0.05m^2.

Extent of concrete removal to expose full extent of corroded reinforcement

3.17 Where existing reinforcement is still corroded at the perimeter of the specified or otherwise agreed concrete removal area, further concrete shall be removed to expose a continuous length of at least 100mm of uncorroded reinforcement having no more surface deterioration than represented by rust grade A in accordance with BS EN ISO 8501-1 [Ref 24.N].

3.18 Verification shall be undertaken for bar corrosion inspection in accordance with rust grade A in accordance with BS EN ISO 8501-1 [Ref 24.N].

3.19 The frequency of bar corrosion inspection shall be every reinforcement bar within the broken out area.

3.20 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to bar corrosion inspection.

Trimming at the perimeter of a repair void

3.21 The perimeter of the concrete repair area shall be broken back to a regular shape comprising a minimum of four straight lines e.g. square, rectangle, rectilinear polygon.

Requirements for sequencing concrete removal

3.22 The removal of concrete shall be undertaken in accordance with sequencing restrictions to ensure continued structural integrity of structural element or structure as a whole.

3.23 Sequencing restrictions for concrete removal shall be as described in CC 484/WSR/003.

Sequencing restrictions for concrete removal			
Structure ID	**Structural element**	**Sequencing restrictions**	**Hold points for phased concrete removal**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter text, to identify the structural element that requires concrete removal to be sequenced.

c) Enter text, to identify the concrete removal sequencing restrictions.

d) Enter text, to identify hold points for phased concrete removal.

3.24 Where sequencing restrictions for concrete removal do not include specified hold points, subsequent stages of concrete removal shall not be commenced until the previously repaired areas have achieved the specified minimum cube strength before loading is permitted, or where strength is not specified, have achieved at least the minimum compressive strength associated with the required BS EN 1504-3 [Ref 33.N]strength class.

3.25 The minimum cube strength of repair concrete before loading is permitted and the BS EN 1504-3 [Ref 33.N]repair product strength class for previously repaired areas shall be as stated in CC 484/WSR/004.

3.26 Prior to commencing the subsequent stages of concrete removal, hammer sounding surveys shall be undertaken to confirm the integrity of the newly completed repairs in accordance with "Investigation of concrete condition prior to concrete removal and substrate preparation" in Section 2 of this document.

Requirements for concrete removal where working around tensioned components in prestressed and post-tensioned beams

3.27 The restrictions on concrete removal using high pressure water jetting to reduce the risk of water ingress to ducted post-tensioning systems in structural elements shall be as stated in CC 484/WSR/003.

3.28 Methods and restrictions on concrete removal when working around existing prestressing systems, including pretensioned strands and post-tensioning ducts, tendons and anchorages shall be as specified in CC 484/WSR/003.

Methods and restrictions on concrete removal when working around existing prestressing systems, including pretensioned strands and post-tensioning ducts, tendons and anchorages				
Structure ID	**Method(s) of initial concrete removal permitted for structural elements containing prestressing systems**	**Maximum depth of initial concrete removal permitted adjacent to structural elements containing prestressing systems**	**Method(s) of concrete removal permitted in closer proximity to prestressing systems**	**Minimum concrete cover to remain in place when removing concrete adjacent to prestressing system**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter one or more values, from options high-pressure water jetting, lightweight electric demolition breaker, small hand tools, to select the permitted methods of initial concrete removal of the structural elements containing prestressing systems.

c) Enter a number in units of mm, to limit the depth of concrete removal at surface elements containing prestressing systems.

d) Enter one or more values, from options high pressure water jetting, lightweight electric/pneumatic demolition breaker, small hand tools, to select the permitted methods of initial concrete removal in close proximity to prestressing systems.

e) Enter a number in units of mm, to specify the minimum cover of concrete to be left when removing concrete in close proximity to prestressing systems.

Documentation requirements for competency of operatives proposed for concrete removal

3.29 The following Documentation shall be submitted for evidence of proposed operatives' competency in concrete removal prior to the commencement of concrete removal: Evidence of qualifications, training and experience of proposed operatives to demonstrate that the proposed operatives are competent, trained, qualified, and have recent experience of removing concrete using the methods specified.

3.30 The following Documentation shall be submitted for the safe system of work proposed for concrete removal prior to the commencement of

concrete removal: Risk assessment and method statement describing safe system of work for undertaking the concrete removal, including control methods for preventing over-break of concrete.

Verification of concrete removal method - pre-construction removal trials

3.31 Trial areas of concrete removal shall be undertaken for non-linear surface profiles, high strength concrete structural elements or alternative methods of concrete removal.

3.32 Verification shall be undertaken for concrete removal for non-linear surface profiles, high strength concrete structural elements or alternative methods of concrete removal by trial areas of concrete removal.

3.33 The frequency of trial areas demonstrating concrete removal method shall be one per non-linear surface profile, high strength concrete structural element or alternative method of concrete removal unless otherwise stated in CC 484/WSR/003.

3.34 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to trial areas for concrete removal.

3.35 The following Documentation shall be submitted for trial areas of concrete removal prior to the commencement of trial areas for concrete removal: Notification of the intention to execute trials for concrete removal.

3.36 Documentation for Notification of the intention to execute trials for concrete removal shall be submitted at least 2 working days prior to executing the trial areas of concrete removal.

3.37 The requirements for trial areas of concrete removal shall be as specified in CC 484/WSR/003.

The requirements for trial areas of concrete removal							
Structure ID	**Structural element**	**Concrete removal method**	**Additional notes on trial of removal method**	**Frequency of trial areas per removal method**	**Length of each trial area**	**Width of each trial area**	**Depth of each trial area**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter text, to identify the element or smaller scale model of the structure requiring trial areas of concrete removal.

c) Enter a value, from options high-pressure water jetting, lightweight electric demolition breaker, hand tools, alternative removal method, to identify the method of concrete removal being trialled.

d) Enter text, to identify any particular comments or goals in relation to the trial areas.

e) Enter a number, to identify the number of trial areas for each non-linear surface profile section, high strength concrete structural element or alternative method of concrete removal.

f) Enter a number in units of mm, to identify the size of the trial area.

g) Enter a number in units of mm, to identify the size of the trial area.

h) Enter a number in units of mm, to identify the size of the trial area.

3.38 Access to the concrete removal trial areas shall be provided for witnessing the trial and later inspection of the completed concrete removal trial.

Verification requirements following concrete removal by inspection and survey of post-breakout concrete substrate, reinforcement and vulnerable elements

3.39 Verification shall be undertaken for damage to the concrete substrate, exposed steel reinforcement and vulnerable elements by visual inspection of the concrete substrate, exposed steel reinforcement and vulnerable elements.

3.40 The frequency of visual inspection of the concrete substrate, exposed steel reinforcement and vulnerable elements shall be once per structure following concrete removal.

3.41 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to visual inspection of the concrete substrate, exposed steel reinforcement and vulnerable elements.

3.42 A hammer sounding survey following concrete removal to the specified profile shall identify defective concrete under the prepared substrate within the concrete repair area in accordance with Section 9 of BS EN 1504-10 [Ref 32.N].

3.43 The following Documentation shall be submitted for the post-breakout substrate inspection prior to the commencement of the post-breakout substrate inspection: Notification of the intention to undertake the visual inspection and hammer sounding survey of the substrate following concrete removal.

3.44 Documentation for Notification of the intention to undertake the post-breakout visual inspection and hammer sounding survey of the substrate following concrete removal shall be submitted at least 2 working days prior to the commencement of the post-breakout visual inspection and hammer sounding survey of the substrate following concrete removal.

3.45 Verification shall be undertaken for identifying additional defective concrete in the prepared substrate within the repair area by hammer sounding survey following concrete removal to the specified profile in accordance with Section 9 of BS EN 1504-10 [Ref 32.N].

3.46 The frequency of hammer sounding survey following concrete removal shall be once within each repair area following concrete removal.

3.47 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the hammer sounding survey following concrete removal.

3.48 A visual inspection following concrete removal shall identify damage of the concrete substrate, exposed steel reinforcement and vulnerable elements following concrete removal in accordance with Section 9 of BS EN 1504-10 [Ref 32.N].

3.49 Additional areas of defective concrete identified by the post breakout inspection and hammer sounding survey shall be marked for removal on the prepared substrate.

Documentation requirements for identifying defective concrete at the specified substrate profile

3.50 The following Documentation shall be submitted for additional areas of defective concrete identified by the post breakout inspection and hammer sounding survey hollow sounding prior to the commencement of the removal of additional defective concrete areas beneath the substrate: Notification of the reasons and intention for undertaking additional concrete removal beneath the prepared substrate prepared to the specified profile.

3.51 Documentation for Notification of the reasons and intention for undertaking additional concrete removal beneath the substrate shall be submitted at least 4 working days prior to the commencement of the removal of additional areas of defective concrete beneath the substrate prepared to the specified profile.

3.52 Agreed areas of hollow or loose concrete beneath the substrate prepared to the specified profile shall be removed prior to undertaking concrete repairs.

Product requirements for preparation of existing concrete substrate

3.53 The existing concrete substrate within the repair area, including the edges round the perimeter shall be prepared in accordance with the repair product manufacturer's instructions or, if this is not given, to concrete surface profile grade CSP6 or rougher in accordance with Technical Guideline 310.2R [Ref 41.N].

3.54 Concrete substrates prepared by mechanical removal of concrete shall be further roughened using abrasive media to achieve a similar profile to that achievable by high-pressure water jetting.

3.55 The concrete substrate in soffit repair areas shall be profiled to reduce the risk of air becoming trapped during concreting, by enabling repair material to flow freely into all voids and be continuously in contact with the existing concrete.

3.56 The prepared concrete substrate shall be cleaned to be free of dust, debris, oil, laitance and any other loose material.

3.57 The surface of the prepared concrete substrate shall be checked for cleanliness in accordance with Section 9 of BS EN 1504-10 [Ref 32.N].

Verification of preparation standard and cleanliness of concrete substrate

3.58 Verification shall be undertaken for standard of surface preparation and surface cleanliness of prepared concrete substrate in accordance with Section 9 of BS EN 1504-10 [Ref 32.N].

3.59 The frequency of checking standard of surface preparation and substrate cleanliness check shall be every completed breakout area.

3.60 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to standard of substrate preparation and substrate surface cleanliness check.

3.61 Where hydraulic (CC) and polymer hydraulic (PCC) repair products are proposed for concrete restoration, or when pre-wetting of the concrete substrate is recommended by the manufacturer for reactive polymer (PC) repair products, the prepared substrate shall be continuously wetted with potable water for a minimum period of four hours, or some shorter wetting period recommended by the repair product manufacturer’s instructions.

3.62 Any surface water remaining on the concrete substrate or reinforcement shall be removed prior to placement of the repair material.

3.63 A bonding primer shall only be used on the prepared concrete substrate when recommended by the repair product manufacturer’s instructions.

Preparation of the concrete substrate at the perimeter of the repair area

3.64 The perimeter of each repair area shall be prepared to ensure at least a minimum thickness of repair material adjacent to the perimeter (e.g. to avoid feather edging) or to prevent overbreak of concrete beyond the specified area.

3.65 Concrete shall be removed at the perimeter of a repair area to a depth of 15mm or more, but no closer to the existing reinforcement than 10mm.

3.66 The concrete substrate within the repair area shall be prepared to the specified linear profile with an accuracy of between +5mm profile peak to -15mm profile trough with no significant localised peaks.

Product requirements for preparation of existing steel reinforcement

3.67 The surface of existing steel reinforcement shall be prepared in accordance with "Steel reinforcement for concrete repairs" in Section 8 of this document.

General requirements for handling and disposal of waste and contaminated water arising from concrete removal

3.68 Quality plans for handling and disposal of waste and contaminated water arising from concrete removal shall comply with "Quality plans for concrete repairs" in Section 1 of this document.

3.69 The management and monitoring of site arisings and waste from concrete removal activities shall comply with "Management of material assets and waste" in Section 2 of GC 103 [Ref 8.N].

3.70 Solid waste material removed from the structure shall not be reused for restoring the existing concrete.

3.71 Water arising from high-pressure water jetting operations shall be assumed to be contaminated.

3.72 Contaminated water from concrete removal shall be collected and contained near the working area and processed in a manner which ensures that pollution of the environment does not occur.

3.73 Contaminated water from concrete removal shall not be allowed to drain away into the ground, surface water sewers including highway drains, hidden voids in the existing structure, watercourses or the sea.

Requirements for handling, monitoring and disposal of hazardous waste materials

3.74 Residual risks and hazards identified during design stage risk assessment with potential to impose limitations on handling and disposal of known or suspected hazardous waste materials arising from concrete removal, shall be as identified in CC 484/WSR/003.

Residual risks and hazards identified during design stage risk assessment with potential to impose limitations on handling and disposal of known or suspected hazardous waste materials arising from concrete removal,				
Structure ID	**Structural element**	**Details of residual risks or other hazardous waste materials**	**Handling requirements**	**Disposal requirements**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element where hazardous materials are known or suspected.

c) Enter text, to identify the type of known or suspected hazardous waste materials.

d) Enter text, to identify special handling requirements for the known or suspected hazardous waste materials.

e) Enter text, to identify special disposal requirements for the known or suspected hazardous waste materials.

3.75 The management of hazardous waste materials that are known or suspected to be present in structural elements shall comply with "Management of material assets and waste" in Section 2 of GC 103 [Ref 8.N].

3.76 Reporting and monitoring of hazardous materials that are known or suspected to be present in structural elements shall comply with "Health and safety restrictions, reporting and monitoring" in Section 4 of GC 102 [Ref 42.N].

Documentation requirements for disposal of solid waste and contaminated water arising from concrete removal

3.77 Management and reporting of the disposal of waste during construction shall be recorded as part of the 'live' Environmental Management Plan in accordance with Section 4 of LA 110 [Ref 16.N].

3.78 The following Documentation shall be submitted for disposal of solid waste and contaminated water arising from concrete removal activities prior to the commencement of removing, handling or disposing of waste and contaminated water arising from concrete removal activities: ..

1. Records of consultation, agreements and permissions from relevant national or local environmental or planning authorities

2. Proposals for disposal of waste identified in the live Environmental Management Plan

3.79 The following Documentation for disposal of solid waste and contaminated water arising from concrete removal activities shall be submitted as continuous records: copies of documents relating to disposal of solid waste and contaminated water from concrete removal activities as follows.

1. waste transfer notes (WTNs), hazardous waste consignment notes (HWCNs) or special waste consignment notes (SWCNs)

2. any other disposal receipts from licensed waste management tips

3.80 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to documents relating to disposal of solid waste and contaminated water arising from concrete removal activities.

4. Concrete repairs - general requirements

General requirements of products for repair of concrete

4.1 The system of Assessment and Verification of Constancy of Performance (or Attestation of conformity) for repair concrete or mortar products used for concrete repair work shall be 2+ (for uses in buildings and civil engineering works) in accordance with Annex ZA.2 of BS EN 1504-3 [Ref 33.N].

4.2 Binders used in repair concrete or mortar products shall be chemical types CC (hydraulic), PCC (polymer hydraulic) or PC (reactive polymer) as defined in BS EN 1504-1 [Ref 29.N].

4.3 Chemical type PC (reactive polymer) proprietary hand-applied repair concrete or mortar products shall only be used for hand-applied concrete repairs in accordance with "Hand-applied repair concrete or mortar" in Section 5 of this document.

Marking and labelling of repair concrete or mortar products for concrete repairs

4.4 Marking and labelling for repair concrete or mortar products for concrete repairs shall be provided in accordance with BS EN 1504-8 [Ref 26.N].

Supply and storage of repair concrete or mortar products and other materials intended for concrete repairs

4.5 Repair concrete or mortar products shall be supplied and stored in accordance with the manufacturer's instructions and BS EN 1504-10 [Ref 32.N].

Product performance requirements for repair concrete or mortar in accordance with BS EN 1504-3

4.6 Concrete repair products shall be compliant with BS EN 1504-3 [Ref 33.N].

4.7 The concrete repair products shall meet the performance characteristics as stated in table 1 of BS EN 1504-3 [Ref 33.N] 'for all intended uses' and for the elastic modulus performance characteristic.

4.8 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to concrete repair products 'for all intended uses' and for the elastic modulus performance characteristic.

4.9 The elastic modulus performance characteristic in table 1 of BS EN 1504-3 [Ref 33.N] shall be included with 'all intended uses' for declaration of concrete repair product performance.

4.10 Performance characteristics and requirements as defined in Table 3 of BS EN 1504-3 of concrete repair products shall be as shown in table 4.10.

Table 4.10 Performance characteristics and requirements as defined in Table 3 of BS EN 1504-3 of concrete repair products for 'all intended uses'			
Performance characteristic	Performance requirement for class R4 concrete repair product	Performance requirement for class R3 concrete repair product	Performance requirement for class R2 concrete repair product
Compressive strength	≥ 45 MPa	≥ 25 MPa	≥15 MPa
Chloride ion content	≤ 0.05 %	≤ 0.05 %	≤ 0.05 %
Adhesive bond	≥ 2.0 MPa	≥ 1.5 MPa	≥ 0.8 MPa
Restrained shrinkage/ expansion	Bond strength after test ≥ 2.0 MPa	Bond strength after test ≥ 1.5 MPa	Bond strength after test ≥ 0.8 MPa
Carbonation resistance for durability	dk ≤ control concrete (MC(0,45))	dk ≤ control concrete (MC(0,45))	dk ≤ control concrete (MC(0,45))
Elastic modulus	≥20 GPa	≥15 GPa	No requirement

4.11 Performance characteristics 'for certain intended uses' defined in table 1 of BS EN 1504-3 where required for concrete repair products shall be as specified in CC 484/WSR/004.

Performance characteristics 'for certain intended uses' defined in table 1 of BS EN 1504-3 where required for concrete repair products						
Structure ID	**Structural element**	**Repair area ID**	**Thermal compatibility for BS EN 13687 Part 1 (freeze-thaw)**	**Coefficient of thermal expansion**	**Value of coefficient of thermal expansion where specified**	**Capillary absorption (water permeability)**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter a unique reference, to identify the element requiring repair.

c) Enter a unique reference.

d) Enter a value, from options yes, no, to identify the need for the concrete repair product to satisfy the thermal compatibility for freeze thaw performance characteristic in accordance with BS EN 1504-3 [Ref 33.N].

e) Enter a value, from options yes, no, to identify the need for the concrete repair product to satisfy the requirement for coefficient of thermal expansion performance characteristic in accordance with BS EN 1504-3 [Ref 33.N].

f) Enter a number, to identify the value of the coefficient of thermal expansion where specified for the concrete repair product.

g) Enter a value, from options yes, no, to identify the need for the concrete repair product to satisfy the requirement for capillary absorption performance characteristic in accordance with BS EN 1504-3 [Ref 33.N].

4.12 Concrete repair products 'for certain intended uses' shall be compliant with BS EN 1504-3 [Ref 33.N].

4.13 The concrete repairs products for 'certain intended uses' shall meet the performance characteristics as stated in table 3 of BS EN 1504-3 [Ref 33.N].

4.14 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to repairs products for 'certain intended uses'.

Limitations on use and compatibility of repair concrete or mortar products for concrete repairs

4.15 BS EN 1504-3 [Ref 33.N]strength class R1 repair concrete or mortar products shall not be used in concrete repairs.

4.16 BS EN 1504-3 [Ref 33.N]Strength class R2 repair concrete or mortar products shall only be used for small or superficial repair areas using hand-applied repair methods in accordance with "Hand-applied repair concrete or mortar" in Section 5 of this document.

4.17 Where no strength class is specified, BS EN 1504-3 [Ref 33.N]Class R4 repair concrete or mortar products shall be used in concrete repairs.

4.18 Chemical type PC (reactive polymer) proprietary repair concrete or mortar products, or products containing conductive fibres or electrically conductive additives or admixtures shall not be used where a system of galvanic anodes or a cathodic protection system are to be installed over the repair.

4.19 Repair concretes or mortar products shall be compatible with the requirements for "Steel reinforcement for concrete repairs" in Section 8 of this document.

4.20 Repair concretes or mortar products shall be compatible with the requirements for "Galvanic anodes for control of incipient anode effect" in Section 9 of this document.

4.21 Repair concretes or mortar products shall be compatible with the requirements for "Filling or injecting cracks & voids in concrete" in Section 10 of this document.

Contractor design requirements for repair of reinforced concrete structural elements

4.22 The design of concrete repairs for reinforced concrete highway structures shall be in accordance with CC 484/WSR/004.

4.23 The requirements for "Technical approval of highway structures" in Section 18 of GC 101 [Ref 13.N] shall apply to the design of concrete repairs for reinforced concrete highway structures.

4.24 The requirements for "Contractor design" in Section 17 of GC 101 [Ref 13.N] shall apply to the design of concrete repairs for reinforced concrete highway structures.

4.25 Concrete repair work to be Contractor designed items shall be as stated in CC 484/WSR/004.

Concrete repair work to be Contractor designed items						
Structure or asset ID	**Reference of concrete element**	**Location of repairs on concrete element**	**Model or drawing reference (s)**	**Description of concrete repair design required**	**CG 300 [Ref 51.N] technical approval category for repair to concrete structures**	**Site specific constraints**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter a unique reference, to identify the concrete element for which the repair details are to be designed.

c) Enter a unique reference, to specify where on the element repairs need to be designed.

d) Enter a unique reference, to provide reference(s) of drawing or model where extent of repairs to be designed are shown.

e) Enter a unique reference, to give a brief description of what shall be designed.

f) Enter a value, from options Category 0, Category 1, Category 2, N/A, to state the CG 300 [Ref 51.N]technical approval category agreed with the TAA for design of repairs to concrete highway structures.

g) Enter text, to provide a brief description of any relevant site specific constraints.

4.26 Concrete repairs for reinforced concrete elements of highway structures, permanent legacy road restraint systems or surface water channels shall be designed in accordance with CS 462 [Ref 40.N].

Product requirements to achieve compatibility of repair concrete or mortar with existing concrete

4.27 Methods of concrete restoration from table 1 of BS EN 1504-9 assumed for selection of suitable concrete repair products shall be as specified in CC 484/WSR/004.

Methods of concrete restoration from table 1 of BS EN 1504-9 assumed for selection of suitable concrete repair products			
Structure ID	**Structural element**	**Repair area ID**	**Assumed method(s) of concrete restoration**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter text, to identify the element requiring repair.

c) Enter a unique reference.

d) Enter one or more values, from options 3.1 hand-applied, 3.2 recasting with flowable material, 3.3 spray-applied, to identify the anticipated method or methods of concrete restoration in accordance with BS EN 1504-9 [Ref 30.N], Table 1 to enable the selection of suitable concrete repair products.

4.28 Further information for selection of suitable repair concrete or mortar products to repair reinforced concrete highway structures shall be as specified in CC 484/WSR/004.

Further information for selection of suitable repair concrete or mortar products to repair reinforced concrete highway structures								
Structure ID	**Structural element**	**Repair area ID**	**BS EN 1504-3 repair product strength class**	**BS EN 13501-1 fire class**	**Minimum cube compressive strength of repair concrete at 28 days**	**Static elastic modulus of existing concrete**	**Requirement for galvanic anodes to be provided within repair areas**	**Minimum compressive cube strength of repair concrete before loading is permitted**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)

a) Enter a unique reference.

b) Enter a unique reference, to identify the element requiring concrete repair.

c) Enter a unique reference.

d) Enter a value, from options Class R4, Class R3, Class R2, to identify the strength class of the repair product in accordance with BS EN 1504-3 [Ref 33.N].

e) Enter a value, from options Class A1, Class A2, Class B, Class C, Class D, Class E, Class F, Not applicable, to identify the performance characteristics of the repair product for exposure to fire in accordance with BS EN 13501-1 [Ref 11.N] and BS 9999 [Ref 12.N].

f) Enter a number in units of N/mm^2, to identify the characteristic compressive strength of the repair concrete required where strength of existing concrete is greater than 50 N/mm^2.

g) Enter a number in units of N/mm^2, to record the static elastic modulus of the existing concrete substrate to be repaired and identify the compatibility requirements of the repaired concrete when in tension or compression and subject to frequent cycles of transient loading.

h) Enter a value, from options yes, no, to identify the requirements for compatibility of the concrete repair product where galvanic anodes are proposed in repairs.

i) Enter a number in units of N/mm^2, to identify the minimum compressive cube strength the concrete repair product is required to achieve before loading of the repaired structure or structural element is permitted.

Product verification requirements for repair concrete or mortar

Repair product statement

4.29 The following Documentation shall be submitted for proposed repair products and systems prior to the commencement of concrete repair works: Repair product statement.

4.30 The repair product statement shall include the following information:.

1. reference to the structure ID, structural element to be repaired and repair area ID;

2. reference to the repair methods anticipated or specified;

3. a list of products proposed for the concrete repair work;

4. the Declaration of Performance for each construction product or system in accordance with GC 101 [Ref 13.N];

5. certificate confirming galvanic anodes and embedded reference electrodes conform with the requirements of this document;

6. the manufacturer’s instructions for use, technical data sheets;

7. manufacturer’s health and safety information, including COSHH data.

4.31 The following information required for the repair product statement shall be as stated in CC 484/WSR/004.

1. structure ID

2. structural element to be repaired

3. repair area ID

4. repair methods anticipated or specified

4.32 The certificate of conformance for galvanic anodes and reference electrodes shall be in accordance with "Galvanic anodes for control of incipient anode effect" in Section 9 of this document.

Installation verification requirements for trial execution of repair method

4.33 Verification shall be undertaken for proposed method for executing concrete repair using trial areas to demonstrate the methods of concrete repair.

4.34 The frequency of trial areas to demonstrate method of concrete repair shall be one for each proposed method of concrete repair per structure unless otherwise stated in CC 484/WSR/004.

4.35 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to trial areas to demonstrate the methods of concrete repair.

4.36 Trial areas to demonstrate methods of executing concrete repair shall be as specified in CC 484/WSR/004.

Trial areas to demonstrate methods of executing concrete repair								
Structure ID	**Structural element**	**In-situ or scale model**	**Concrete repair method**	**Number of trial areas**	**Location of trial area on structural element**	**Length of each trial area**	**Width of each trial area**	**Depth of each trial area**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)

a) Enter a unique reference.

b) Enter text, to identify the element or smaller scale model of the structure requiring trial areas.

c) Enter a value, from options in-situ, scale model, to identify whether the trial area is executed in-situ on the existing structure or on a scale model.

d) Enter a value, from options hand-applied, flowable, to identify the type of trial application.

e) Enter a number, to identify the number of trial areas for each structural element.

f) Enter text, to identify the location of the trial area on the structural element.

g) Enter a number in units of mm, to identify the size of the trial area.

h) Enter a number in units of mm, to identify the size of the trial area.

i) Enter a number in units of mm, to identify the size of the trial area.

Trial areas to demonstrate methods of executing concrete repair (continued)		
Structure ID	**Surface finish of trial areas**	**Specific requirements for trial areas**
(a)	(j)	(k)

j) Enter a value, from options U1, U2, U3, U4, U5, F1, F2, F3, F4, F5,, to identify the surface finish required for the trial areas.

k) Enter text, to identify any particular requirements or goals in relation to the trial areas.

4.37 Trial areas for spray-applied repair concrete or mortar shall comply with the installation and verification requirements for test panels in "Sprayed repair concrete or mortar" in Section 7 of this document.

4.38 Verification shall be undertaken for the integrity of completed concrete repair trial areas by hammer sounding of trial areas in accordance with BS EN 1504-10 [Ref 32.N].

4.39 The frequency of hammer sounding of trial area shall be once on all completed and hardened concrete repair trial areas.

4.40 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to hammer sounding of trial areas.

4.41 Hollow sounding in-situ concrete repair trial areas shall be removed, and the repairs re-executed as part of the permanent works.

4.42 The following Documentation shall be submitted for execution of areas for trialling concrete repair method prior to the commencement of undertaking trial areas: Notification of the intention to execute one or more trial areas of proposed concrete repair method.

4.43 Documentation for Notification of the intention to execute the trial areas of proposed concrete repair method shall be submitted at least 2 working days in advance of executing the trial areas.

Installation requirements for repair concrete or mortar

General requirements for installation of concrete repairs using repair concrete or mortar

4.44 The BS EN 1504-9 [Ref 30.N] proposed or specified methods of concrete repair shall be executed in accordance with this document and BS EN 1504-10 [Ref 32.N].

4.45 The areas for concrete restoration shall be identical to those areas from which concrete is to be removed as identified in "Concrete removal and substrate preparation" in Section 3 of this document.

4.46 Installation of concrete repair products shall not commence until the concrete substrate has been prepared in accordance with "Concrete removal and substrate preparation" in Section 3 of this document.

4.47 Installation of concrete repair products shall not commence until reinforcement substrate has been prepared and any reinforcement welded joints have been verified in accordance with "Steel reinforcement for concrete repairs" in Section 8 of this document.

4.48 Where Type 1A galvanic anodes are required within the concrete repair, a conductive bridging material shall be provided within the concrete repair in accordance with "Galvanic anodes for control of incipient anode effect" in Section 9 of this document.

4.49 Installation of repair concrete or mortar shall be undertaken such that the repair concrete or mortar surrounds the conductive bridging material for Type 1A galvanic anodes.

4.50 The following Documentation shall be submitted for the intention to proceed with a section of concrete repair work prior to the commencement of the concrete repair work: Notification for the intention to proceed with concrete repair work in named location(s).

4.51 Documentation for Notification for the intention to proceed with the concrete repair work in named location(s) shall be submitted at least 2 working days in advance of the commencement of the concrete repair work.

Installation requirements for hand-applied, flowable and spray-applied repair concrete or mortar

4.52 Methods of repair shall be as defined for Principle 3 - Concrete restoration in section A.6.2.1.4 of BS EN 1504-9 [Ref 30.N].

4.53 Hand-applied repair concrete or mortar materials used for concrete restoration, shall comply with requirements in "Hand-applied repair concrete or mortar" in Section 5 of this document.

4.54 Flowable repair concrete or mortar materials used for concrete restoration, shall comply with requirements in "Flowable repair concrete or mortar" in Section 6 of this document.

4.55 Spray-applied repair concrete or mortar materials used for concrete restoration, shall comply with requirements in "Sprayed repair concrete or mortar" in Section 7 of this document.

Temporary falsework and formwork for concrete repairs

4.56 Temporary falsework and formwork for concrete repairs shall comply with "Falsework and formwork for structural concrete" in Section 3 of CC 482 [Ref 49.N].

4.57 Temporary formwork for concrete repairs shall comply with the requirements of BS EN 1504-10 [Ref 32.N] and BS EN 13670 [Ref 10.N].

4.58 The proposed formwork for concrete repairs shall be arranged to prevent the formation of voided areas in the completed repair.

Site mixing of repair concrete or mortar products for concrete repairs

4.59 Verification shall be undertaken for repair concrete or mortar products for concrete repairs to check contents of product containers are within the manufacturer's stated expiration date and that products will continue to be usable during the works.

4.60 The frequency of checking the use by or expiration dates on repair concrete or mortar product containers shall be at the point of delivery and prior to use.

4.61 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to checking the use by or expiration dates on repair concrete or mortar product containers.

4.62 A batch of fresh repair concrete or mortar shall be as defined in BS EN 1504-1 [Ref 29.N].

4.63 The quantity of water to be used for various applications of cement-based/cementitious repair concrete or mortar products shall be supplied with the delivery of a repair product unless indicated elsewhere on product packaging.

4.64 The amount of water added to repair concrete or mortar shall be in accordance with the manufacturer's instructions.

4.65 Only full containers of repair concrete or mortar shall be mixed for use.

4.66 Repair concrete or mortar shall not be proportioned on site.

4.67 Site mixing of all repair concrete or mortar products shall be carried out in accordance with the manufacturer’s instructions and BS EN 1504-10 [Ref 32.N].

4.68 Water used for mixing with hydraulic (CC) and polymer hydraulic (PCC) repair concrete or mortar shall be potable and comply with BS EN 1008 [Ref 21.N].

4.69 No other materials except water shall be added to hydraulic (CC) and polymer hydraulic (PCC) repair concrete or mortar before application, unless required by the manufacturer's instructions.

4.70 Additional water shall not be added to hydraulic (CC) and polymer hydraulic (PCC) repair concrete or mortar after the original mixing.

4.71 Repair concrete or mortar product constituent materials shall be mixed in accordance with the manufacturer's instructions using mechanical mixing equipment.

4.72 Repair concrete or mortar shall be agitated in the mixer until the material is placed as per the manufacturer's instructions.

4.73 Agitation of repair concrete or mortar shall not be undertaken such that it causes the segregation of repair product constituents.

Protection of vulnerable elements

4.74 Vulnerable existing structural elements to be protected against damage during concrete repair work shall be those listed in "Concrete removal and substrate preparation" in Section 3 of this document.

Placing and compaction of repair concrete or mortar

4.75 Repair concrete or mortar materials shall only be placed if ambient conditions and precipitation are within limits specified by the manufacturer at the location of repair.

4.76 Placement of the repair concrete or mortar shall commence before the substrate dries out following pre-wetting and not more than one hour after completion of pre-wetting in accordance with "Concrete removal and substrate preparation" in Section 3 of this document.

4.77 All repair concrete or mortar materials shall be placed and compacted in accordance with BS EN 1504-10 [Ref 32.N], BS EN 13670 [Ref 10.N]and the manufacturer's instructions.

4.78 The repair concrete or mortar material shall be placed so that it completely fills the repair area without voids.

4.79 Repair concrete or mortar material shall be placed in a single layer unless multiple layers are permitted by the manufacturer's instructions.

4.80 Where application of the repair concrete or mortar is permitted in more than a single layer, the maximum layer thickness stated in the manufacturer's instructions shall not be exceeded.

4.81 Where application of the repair concrete or mortar is permitted in more than a single layer, the underlying layer shall be prepared in accordance with the manufacturer’s instructions prior to application of each subsequent layer of repair concrete or mortar.

4.82 Repairs to a deck soffit located above road traffic lanes, a trackbed of a live railway or other areas accessible by the public shall not be placed in multiple layers, unless otherwise stated in CC 484/WSR/004.

4.83 The locations where repair concrete or mortar are permitted to be applied in multiple layers to a deck soffit located above road traffic lanes, a trackbed of a live railway or other areas accessible by the public shall be as described in CC 484/WSR/004.

The locations where repair concrete or mortar are permitted to be applied in multiple layers to a deck soffit located above road traffic lanes, a trackbed of a live railway or other areas accessible by the public				
Structure ID	**Structural element**	**Location on element**	**Drawing/model reference(s)**	**Repair area ID where multiple layers are permitted**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring repair.

c) Enter text, to identify the specific location where the repairs shall be applied in a single layer.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter a unique reference, to identify areas of repair where multiple layers of repair concrete or mortar are permitted.

4.84 Where a repair to reinforced concrete is multi-layered and required above road traffic lanes, trackbed of a live railway, or other areas accessible by the public, the outermost layer shall be installed so it surrounds the existing reinforcement to a minimum of 25mm behind the outer layer(s) of reinforcement.

Measuring ambient conditions and limiting conditions for placement of repair concrete or mortar

4.85 Quality control testing or observations of substrate characteristics , and measurement of ambient weather conditions and precipitation shall comprise the observations marked 'for all intended uses' in Table 5 of BS EN 1504-10 [Ref 32.N] for the relevant repair methods.

4.86 Repair concrete or mortar shall not be placed when the temperature of the substrate within each prepared repair area is lower than 5°C or higher than 30°C.

4.87 Verification shall be undertaken for physical ambient conditions by measurement of physical ambient conditions including concrete surface temperatures, shade air temperatures, relative humidity, precipitation, wind strength and dew point.

4.88 The frequency of measurement of physical ambient conditions including concrete surface temperatures, shade air temperatures, relative humidity, precipitation, wind strength and dew point shall be at completion of mixing and subsequently at intervals of 20 minutes during the placement of each batch of repair concrete.

4.89 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to measurement of physical ambient conditions including concrete surface temperatures, shade air temperatures, relative humidity, precipitation, wind strength and dew point.

4.90 Repair concrete, repair mortar or associated coatings shall not be placed nor continue to be placed if any of the ambient physical conditions shown in Table 4.90 apply.

Table 4.90 Limiting conditions for ceasing placement of repair materials

Physical condition	Location of temperature measurement	Repair product with binder chemical types (BS EN 1504-1) being applied to a prepared surface	Criteria for ceasing placement
Surface temperature of the existing concrete substrate	Within the repair void	All chemical binder types applied to any prepared substrate surface	Is less than either the manufacturer's minimum recommended temperature or +5°C, whichever is the greater. Is greater than the manufacturer's maximum recommended temperature or +30°C, whichever is

			the least.
Shade air temperature	Immediate environment of the repair	All chemical binder types applied to any prepared substrate surface	Is less than the manufacturer's minimum recommended temperature or +4°C, whichever is the greater.
Wind strength	Immediate environment of the repair	All chemical binder types applied to any prepared substrate surface	Is 8m/s or stronger.
Dew point	Immediate environment of the repair	Reactive polymer chemical binder type PC applied to any prepared substrate surface, or coatings/primers applied to steel substrate	Ambient temperature is less than 3°C above dew point temperature.

4.91 The following Documentation for measuring the ambient conditions during repair concrete or mortar placement shall be submitted as continuous records: measurements and written records of the concrete surface temperatures, ambient shade air temperatures, relative humidity, precipitation, wind strength and dew point to be taken throughout each day of material placement as described in BS EN 1504-10 [Ref 32.N].

4.92 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to measuring the ambient conditions during repair concrete or mortar placement.

Construction joints for concrete repairs

4.93 Where fresh repair concrete or mortar is to be placed against hardened repair concrete, a construction joint shall be formed in accordance with the manufacturer's instructions.

4.94 In the absence of manufacturer's instructions, the formation of a construction joint for concrete repairs shall comply with "Concreting of structural concrete" in Section 6 of CC 482 [Ref 49.N].

4.95 The repair concrete or mortar shall be deemed to be hardened when it has been in position for the longer of 30 minutes or the maximum workable time declared by the product manufacturer.

Surface profile of completed concrete repairs

4.96 The surface profile of completed concrete repairs shall be the same as the existing concrete it replaces, unless otherwise stated in CC 484/WSR/004.

4.97 Where surface profile is not to be the same as existing, the surface profile of completed concrete repairs shall be as specified in CC 484/WSR/004.

Where surface profile is not to be the same as existing, the surface profile of completed concrete repairs				
Structure ID	**Structural element**	**Repair area ID**	**Surface profile type**	**Other profile requirements**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring repair.

c) Enter a unique reference.

d) Enter a value, from options plane, curved, other profile, to identify the surface profile of the completed repair.

e) Enter text, to identify the requirements of the surface profile of the completed repair.

Formed surface finish of completed concrete repairs

4.98 The formed surface finish imparted by temporary formwork on completed concrete repairs shall comply with "Concreting of structural concrete" in Section 6 of CC 482 [Ref 49.N].

4.99 The formed surface finish imparted by temporary formwork to completed concrete repairs shall be class F2, unless otherwise stated in CC 484/WSR/004.

4.100 Where class F2 is not to be used, the formed surface finish imparted by temporary formwork on completed concrete repairs shall be as specified in CC 484/WSR/004.

Where class F2 is not to be used, the formed surface finish imparted by temporary formwork on completed concrete repairs			
Structure ID	**Structural element**	**Repair area ID**	**Formed surface finish**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring repair.

c) Enter a unique reference.

d) Enter a value, from options F1, F3, F4, F5, to identify the formed surface finish in accordance with CC 482 [Ref 49.N] of the completed repair.

Unformed surface finish of completed concrete repairs

4.101 The unformed surface finish of concrete repairs shall comply with "Concreting of structural concrete" in Section 6 of CC 482 [Ref 49.N].

4.102 The unformed surface finish of completed sprayed concrete repairs shall comply with "Sprayed repair concrete or mortar" in Section 7 of this document.

4.103 The unformed surface finish of a completed repair shall be a minimum of class U2 in accordance with CC 482 [Ref 49.N], unless otherwise stated in CC 484/WSR/004.

4.104 Where class U2 is not to be used, the unformed surface finish of a completed repair shall be as specified in CC 484/WSR/004.

Where class U2 is not to be used, the unformed surface finish of a completed repair			
Structure ID	**Structural element**	**Repair area ID**	**Unformed surface finish**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring repair.

c) Enter a unique reference.

d) Enter a value, from options U3, U4, U5, to identify the unformed surface finish in accordance with CC 482 [Ref 49.N] of the completed repair.

Geometrical tolerances on finished surface of completed concrete repairs

4.105 The geometrical tolerance on surface flatness of completed concrete repairs using flowable or hand applied materials shall not deviate from the specified profile by more than the following dimensions, unless otherwise stated in CC 484/WSR/004.

1. -5 mm to +10 mm using a 2 m long straightedge placed anywhere on the finished surface within a concrete repair with dimension of longest side greater than 1.5 m or

2. +/-5 mm using a 300 mm long straightedge placed anywhere on the finished surface within a concrete repair with dimension of longest side 1.5 m or less.

4.106 Where the deviations from the specified surface flatness profile are not to be used, geometrical tolerance on surface flatness of completed concrete repairs executed using flowable or hand applied materials shall be as specified in CC 484/WSR/004.

Where the deviations from the specified surface flatness profile are not to be used, geometrical tolerance on surface flatness of completed concrete repairs executed using flowable or hand applied materials				
Structure ID	**Structural element**	**Length of straightedge for measuring deviation of finished surface from specified surface flatness profile of repaired concrete**	**Critical dimension of repair area for measuring deviation from specified surface flatness profile using the indicated straightedge**	**'Geometrical tolerance on surface flatness of completed concrete repair'**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring a geometrical tolerance on surface flatness different to the default value.

c) Enter a number in units of m, to specify the length of straightedge for measuring the deviation from the required flatness profile.

d) Enter a number in units of m, to specify a maximum length for shorter repair areas or a minimum length for longer repair areas for checking surface flatness of repair.

e) Enter a number range (e.g. "40-60") in units of mm, to specify range of geometrical tolerance (low point to high point) with reference to the true specified flatness profile. Negative dimension signifies a depression in the true surface flatness profile and positive dimension a protrusion from the true surface flatness profile.

4.107 The geometrical tolerance on edge straightness of completed concrete repairs executed using flowable or hand applied materials shall not deviate from the specified profile by more than the following dimensions, unless otherwise stated in CC 484/WSR/004.

1. +/-10 mm using a 2 m long straightedge placed anywhere along the finished edge of a concrete repair greater than 1.5 m long.

2. +/-5 mm/m using a 300 mm long straightedge placed anywhere along the finished edge of a concrete repair 1.5 m long or less.

4.108 Where the deviations from the specified edge straightness profile are not to be used, geometrical tolerance on edge straightness of completed concrete repairs executed using flowable or hand applied materials shall be as specified in CC 484/WSR/004.

Where the deviations from the specified edge straightness profile are not to be used, geometrical tolerance on edge straightness of completed concrete repairs executed using flowable or hand applied materials				
Structure ID	**Structural element**	**Length of straightedge for measuring deviation of finished concrete edge from specified edge straightness profile**	**Critical dimension of repaired edge for measuring deviation from specified surface edge straightness profile using the indicated straightedge**	**Geometrical tolerance on edge straightness of completed concrete repair**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter a unique reference, to identify the structural element requiring a geometrical tolerance on surface edge straightness different to the default value.

c) Enter a number in units of m, to specify the length of straightedge for measuring the deviation from the required edge straightness profile.

d) Enter a number in units of m, to specify a maximum dimension of repaired edge for checking edge straightness of repair.

e) Enter a number range (e.g. "40-60") in units of mm, to specify range of geometrical tolerance (depressed point to protruding point) with reference to the true specified surface edge straightness profile.

Negative dimension signifies a depression in true straightness profile and positive dimension a protrusion from the true straightness profile.

4.109 The finished surface flatness and edge straightness of completed concrete repairs executed using spray-applied concrete or mortar shall not deviate from the specified profile by more than following dimensions.

1. +/-10 mm using a 2 m long straightedge placed anywhere on the surface or finished edge of a concrete repair greater than 1.5 m long or

2. +/-5 mm using a 300 mm long straightedge placed anywhere along the finished edge of a concrete repair 1.5m long or less.

4.110 Verification shall be undertaken for deviation from specified geometrical tolerance on the surface flatness of completed concrete repairs on completion of execution by measuring and comparing against permitted deviations in this section.

4.111 The frequency of the measurement of deviation from specified geometrical tolerance on the surface flatness of completed concrete repairs shall be two per square metre of repair subject to a minimum of one measurement per repair.

4.112 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to measurement of deviation from geometrical tolerance for surface flatness of completed concrete repairs.

4.113 Verification shall be undertaken for deviation from specified geometrical tolerance on the edge straightness of completed concrete repairs on completion of execution by measuring and comparing against permitted deviations in this section.

4.114 The frequency of the measurement of deviation from specified geometrical tolerance the edge straightness of completed concrete repairs shall be two per metre of edge subject to a minimum of one measurement per repaired edge.

4.115 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to measurement of deviation from geometrical tolerance for edge straightness of completed concrete repairs.

4.116 The following Documentation for measurement of deviation from the specified geometrical tolerance on the surface flatness or edge straightness of completed concrete repairs shall be submitted as continuous records: report with record of measurements of the deviations from specified geometrical tolerances of concrete repairs.

4.117 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to the report with record of measurements of deviation from specified geometrical tolerances of concrete repairs.

Protection of a completed concrete repair

4.118 The surface temperature of the repair material and the immediately surrounding existing concrete shall not fall below the minimum temperature specified in the manufacturer's instructions or 2°C, whichever is the higher temperature until the material has cured.

4.119 To prevent damage to the repair material, the completed repair shall be protected in accordance with BS EN 13670 [Ref 10.N] immediately after placing and for the following 14 days.

4.120 Concrete repairs of chemical type PC (reactive polymer) overlaid with hot bituminous surfacing materials shall not be trafficked until temperature of the bituminous materials has cooled to below 100°C.

Curing of a completed concrete repair

4.121 The curing and protection of a completed repair shall be in accordance with BS EN 1504-10 [Ref 32.N] and the manufacturer's instructions.

4.122 The curing class of concrete repairs shall be class 2 in accordance with BS EN 13670 [Ref 10.N], unless otherwise stated in CC 484/WSR/004.

4.123 Where class 2 is not to be used, the curing class of concrete repairs in accordance with BS EN 13670 [Ref 10.N] shall be as specified in CC 484/WSR/004.

Where class 2 is not to be used, the curing class of concrete repairs in accordance with BS EN 13670 [Ref 10.N]			
Structure ID	**Structural element**	**Repair area ID**	**Curing class**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring repair.

c) Enter a unique reference.

d) Enter a value, from options 1, 3, 4, to identify the curing class of concrete repairs in accordance with BS EN 13670 [Ref 10.N].

4.124 The use of curing liquids shall comply with "Concreting of structural concrete" in Section 6 of CC 482 [Ref 49.N].

4.125 The use of curing liquids shall comply with the instructions of the curing liquid manufacturer.

Treatment of areas with low cover to reinforcement

4.126 Low cover to reinforcement shall be defined as where the finished surface matches the profile of the existing concrete but the cover provided to reinforcement in the repair area does not achieve the minimum cover specified by the design in accordance with BS 8500-1 [Ref 4.N].

4.127 Where existing concrete is not to be removed, prior to installation of repair products to the substrate, the whole surface of the area with low cover to reinforcement including the perimeter shall be prepared in accordance with "Concrete removal and substrate preparation" in Section 3 of this document.

4.128 The prepared area shall be filled with repair material to achieve the required minimum cover and profile specified.

4.129 Chemical type PC (reactive polymer) proprietary repair products shall not be used for treatment of areas with low cover to reinforcement.

4.130 Treatment of areas with low cover to reinforcement by locally building up the cover above adjacent deck levels shall be prohibited on the top surface of reinforced concrete decks.

4.131 The depth of construction and the surface profile of reinstated concrete to treat areas with low cover to reinforcement shall be as detailed in CC 484/WSR/004.

The depth of construction and the surface profile of reinstated concrete to treat areas with low cover to reinforcement					
Structure ID	**Structural element**	**Repair area ID**	**Drawing/model reference(s)**	**Minimum cover depth**	**Surface finish**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter text, to identify the element which requires increased cover to reinforcement.

c) Enter a unique reference.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter a number in units of mm, to identify the minimum cover depth to reinforcement in low cover areas.

f) Enter a value, from options U1, U2, U3, U4, U5, F1, F2, F3, F4, F5, to identify the surface finish of concrete repair in low cover areas.

Installation requirements for quality control of concrete repair work

4.132 The execution class for management of repair work quality shall be class 2 in accordance with BS EN 1504-10 [Ref 32.N], unless otherwise stated in CC 484/WSR/004.

SI.4.132 The execution class for management of repair work quality in accordance with BS EN 1504-10 [Ref 32.N] shall be [select one from: class 1, class 3].

4.133 Verification shall be undertaken for quality control testing or observations described as "for all intended uses" of concrete repair works in accordance with BS EN 1504-10 [Ref 32.N]and BS EN 13670 [Ref 10.N].

4.134 The frequency of quality control tests and observations described as "for all intended uses" of the concrete repair works shall be in accordance with sub-clause 9.3 of BS EN 1504-10 [Ref 32.N].

4.135 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to quality control tests and observations described as "for all intended uses" of the concrete repair works.

4.136 The quality control testing or observations "for certain intended uses" of concrete repair work as defined in sub-clause 9.3 of BS EN 1504-10 [Ref 32.N] shall be as stated in CC 484/WSR/004.

4.137 Quality control testing or observations "for certain intended uses" of concrete repair work as defined in sub-clause 9.3 of BS EN 1504-10 shall be as specified in CC 484/WSR/004.

Quality control testing or observations "for certain intended uses" of concrete repair work as defined in sub-clause 9.3 of BS EN 1504-10							
Structure ID	**Repair area ID**	**Roughness testing**	**Surface tensile strength of substrate testing**	**Frequency of surface tensile strength of substrate testing where specified**	**Vibration testing**	**Frequency of vibration testing where specified**	**Thickness or cover of repair material during repairs testing**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter a value, from options yes, no, to identify need for roughness testing for the substrate in accordance with BS EN 1504-10 [Ref 32.N].

d) Enter a value, from options yes, no, to identify need for pull-off test for the substrate in accordance with BS EN 1504-10 [Ref 32.N].

e) Enter text, to identify frequency of for pull-off test for the substrate where this is required.

f) Enter a value, from options yes, no, to identify need for vibration testing for the substrate in accordance with BS EN 1504-10 [Ref 32.N].

g) Enter text, to identify the frequency of vibration testing where this is required.

h) Enter a value, from options yes, no, to identify need for measurement of thickness or cover of repair material in accordance with BS EN 1504-10 [Ref 32.N].

Quality control testing or observations "for certain intended uses" of concrete repair work as defined in sub-clause 9.3 of BS EN 1504-10 (continued)						
Structure ID	**Compressive strength testing of cube samples made from fresh concrete**	**Cover testing for hardened repair**	**Adhesion of repair material testing**	**Compressive strength testing of hardened repair**	**Shrinkage cracking testing**	**Colour and texture of finished surfaces observation**
(a)	(i)	(j)	(k)	(l)	(m)	(n)

i) Enter a value, from options yes, no, to identify need for compressive strength testing of repair material made before or during repairs in accordance with BS EN 1504-10 [Ref 32.N].

j) Enter a value, from options yes, no, to identify need for cover testing for hardened repair in accordance with BS EN 1504-10 [Ref 32.N].

k) Enter a value, from options yes, no, to identify need for testing of adhesion of repair material to substrate in accordance with BS EN 1504-10 [Ref 32.N].

l) Enter a value, from options yes, no, to identify need for compressive strength testing of hardened repair material in accordance with BS EN 1504-10 [Ref 32.N].

m) Enter one or more values, from options yes, no, to identify need for shrinkage cracking testing or observation for hardened repairs in accordance with BS EN 1504-10 [Ref 32.N].

n) Enter a value, from options yes, no, to identify need for colour and texture of finished surfaces observation in accordance with BS EN 1504-10 [Ref 32.N] upon completion of concrete repairs.

Installation verification requirements for concrete repairs

Consistence and air content of fresh concrete or mortar repair products

4.138 Consistency testing shall be undertaken for fresh flowable repair concrete or mortar products and fresh wet spray-applied repair concrete or mortar products.

4.139 Verification for consistency testing of fresh flowable and wet spray-applied repair concrete or mortar material shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

4.140 Verification shall be undertaken for consistence of fresh flowable and wet spray-applied repair concrete or mortar material by consistency testing of fresh flowable and wet spray-applied repair concrete or mortar material in accordance with BS EN 12350-2 [Ref 55.N], BS EN 12350-3 [Ref 56.N], BS EN 12350-5 [Ref 54.N], BS EN 13395-2 [Ref 36.N]or BS EN 13395-3 [Ref 37.N].

4.141 The frequency of samples for consistency testing of fresh repair concrete or mortar material shall be once per batch of fresh flowable and wet spray-applied repair concrete or mortar material unless otherwise stated in CC 484/WSR/004.

4.142 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to consistency testing of fresh flowable and wet spray-applied repair concrete or mortar material.

4.143 Consistency testing of fresh flowable and wet spray-applied repair concrete or mortar material shall be as specified in CC 484/WSR/004.

Consistency testing of fresh flowable and wet spray-applied repair concrete or mortar material				
Structure ID	**Repair area ID**	**Total number of samples**	**Frequency of sampling for consistency testing**	**Consistency test method**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter a unique reference, to identify the repair area from which samples of fresh fresh flowable and wet spray-applied repair concrete or mortar material is to be taken.

c) Enter a number, to identify the total number of samples required to be taken from each batch of fresh flowable and wet spray-applied repair concrete or mortar material.

d) Enter a number, to identify the number of samples per batch required to be taken from the fresh flowable and wet spray-applied repair concrete or mortar material for consistency testing.

e) Enter one or more values, from options BS EN 12350-2 [Ref 55.N], BS EN 12350-3 [Ref 56.N], BS EN 12350-5 [Ref 54.N], BS EN 13395-2 [Ref 36.N], BS EN 13395-3 [Ref 37.N], to identify the consistency test method for samples for fresh flowable and wet spray-applied repair concrete or mortar material.

4.144 Verification for air content of fresh flowable concrete or mortar repair material shall be be undertaken in accordance with "Flowable repair concrete or mortar" in Section 6 of this document.

Compressive strength testing of hardened repair concrete or mortar

4.145 Verification shall be undertaken for concrete or mortar repair products by compressive strength testing of hardened repair concrete or mortar in accordance with BS EN 12390-3 [Ref 57.N] and BS EN 12190 [Ref 34.N].

4.146 The frequency of compressive strength testing shall be a minimum total of 6 cubes per batch of repair concrete or mortar material, comprising a minimum of 3 cubes at 7 days and a minimum of 3 cubes at 28 days to determine the overall strength development in the hardened condition.

4.147 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to compressive strength testing of hardened repair material.

4.148 Verification for compressive strength testing of repair concrete or mortar shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

4.149 Cube specimens of repair concrete for compressive testing shall be made in 100mm size in accordance with BS EN 12390-1 [Ref 62.N] and BS EN 12390-2 [Ref 61.N].

4.150 Cube or prism specimens of repair mortar for compressive testing shall be made of 40mm x 40mm cross section size in accordance with BS EN 12190 [Ref 25.N].

4.151 Cube and prism specimens for repair concrete and mortar shall be cured for 24 hours in moulds with the top surfaces covered by polythene sheets.

4.152 After 24 hours, the cube or prism specimens shall be stripped from the moulds and placed in sealed polythene bags adjacent to the repaired areas for a further 48 hours.

4.153 After a further 48 hours, the cube or prism specimens shall be removed from the polythene bags and continue to be stored alongside repaired areas at ambient temperatures until required for testing.

4.154 The requirements of making cube or prism specimens for independent testing shall be as stated in CC 484/WSR/004.

SI.4.154 The requirements of making cube or prism specimens for independent testing shall be [enter free text].

Hammer sounding of completed concrete repairs

4.155 Verification shall be undertaken for the integrity of all completed concrete repairs by hammer sounding.

4.156 The frequency of hammer sounding shall be once per repair area after completion and hardening of the concrete repair.

4.157 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to hammer sounding of completed repairs.

4.158 The following Documentation shall be submitted for undertaking hammer sounding survey of the completed repairs prior to the commencement of undertaking the test: Notification of the intention to undertake hammer sounding survey of the completed repairs.

4.159 Documentation for the notification of the intention to undertake hammer sounding survey of the completed repairs shall be submitted at least 2 working days in advance of the works.

4.160 Hollow sounding areas of concrete repair shall be removed, and the repairs be re-executed.

Electrical resistivity of completed concrete repairs containing galvanic anodes

4.161 The electrical resistivity of the completed concrete repairs containing galvanic anodes shall be measured in accordance with BS EN 1504-10 [Ref 32.N] and CS TR60 [Ref 7.N].

4.162 The electrical resistivity of completed concrete repairs containing Type 1A galvanic anodes shall not be less than 5 kOhm.cm and not be greater than 15 kOhm.cm.

4.163 Type 1A galvanic anodes shall be as defined in "Galvanic anodes for control of incipient anode effect" in Section 9 of this document.

4.164 Type 1B galvanic anodes shall be as defined in "Galvanic anodes for control of incipient anode effect" in Section 9 of this document.

4.165 Where the works include the installation of Type 1B galvanic anodes or post-installation of an impressed current cathodic protection system, the electrical resistivity of completed repairs shall not exceed 100 kOhm.cm, unless otherwise stated in CC 484/WSR/004.

SI.4.165 The maximum electrical resistivity of completed repairs shall be [enter a number] .

4.166 Electrical resistivity verification specific to sprayed concrete or mortar test panels shall be in accordance with "Sprayed repair concrete or mortar" in Section 7 of this document.

4.167 Verification shall be undertaken for the electrical resistivity of completed repairs by electrical resistivity testing.

4.168 The frequency of electrical resistivity testing shall be once per repair area at least 28 days after installation of the concrete repairs.

4.169 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to electrical resistivity testing of completed repairs.

4.170 Verification for the electrical resistivity of completed concrete repairs shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

4.171 The extent of electrical resistivity testing of completed concrete repairs shall be as specified in CC 484/WSR/004.

The extent of electrical resistivity testing of completed concrete repairs					
Structure ID	**Structural element**	**Repair area or crack ID**	**Drawing/model reference(s)**	**Location on element**	**Number of resistivity tests**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter text, to identify the structural element that requires testing.

c) Enter a unique reference.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter text, to identify the specific location that requires testing.

f) Enter a number, to identify the number of tests to be conducted.

Coring of completed concrete repairs

4.172 Coring from completed concrete repairs shall be undertaken in accordance with BS EN 12504-1 [Ref 52.N].

4.173 Cores shall be extracted from repair areas or sprayed concrete repair test panels after the repair material compressive cube strength has exceeded 15 MPa.

4.174 Requirements for extracting cores specific to completed sprayed concrete or mortar repair test panels and completed permanent works for sprayed concrete or mortar repairs shall be in accordance with "Sprayed repair concrete or mortar" in Section 7 of this document.

4.175 Requirements for extracting cores specific to completed crack filling or injection repairs shall be in accordance with "Filling or injecting cracks & voids in concrete" in Section 10 of this document.

4.176 The location of coring shall be adjusted locally on site to avoid damage to reinforcement, prestressing strands, tendons and ducts and other structurally critical elements.

4.177 Coring shall be stopped immediately if a reinforcing bar is encountered and an alternative location selected which is close to the specified location.

4.178 The minimum depth of an extracted core for compressive strength testing shall be in accordance with BS EN 14488-4 [Ref 63.N].

4.179 The cores to be extracted from completed repair areas shall be as specified in CC 484/WSR/004.

The cores to be extracted from completed repair areas						
Structure ID	**Repair area ID, crack ID for location of cores**	**Location of core if not otherwise specified**	**Cores through filled crack or injected crack for inspection**	**Number of cores from specified area of repair, filled crack or injected crack**	**Diameter of cores**	**Minimum depth of cores**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter a unique reference, to describe location of core if not otherwise referenced by repair id etc.

d) Enter a value, from options yes, no, to identify whether cores specified are to be extracted from lengths of crack filling or crack injection for inspection.

e) Enter a number, to identify the total number of cores to be extracted from each specified repaired area or repaired crack for later inspection or testing.

f) Enter a number in units of mm, to identify the diameter for the cores to be extracted.

g) Enter a number in units of mm, to identify the minimum depth for the cores to be extracted.

4.180 The following Documentation for extracting cores for visual inspection and testing shall be submitted as continuous records: written and photographic evidence of the condition of the cores.

4.181 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to extracting cores for visual inspection and testing.

Integrity of completed concrete repairs by visual inspection of cores

4.182 A visual inspection of all extracted cores shall be undertaken prior to destructive compressive strength testing of the cores.

4.183 Verification shall be undertaken for the integrity of completed repairs by the visual inspection of extracted cores.

4.184 The frequency of the visual inspection of extracted cores shall be for all cores following extraction.

4.185 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the visual inspection of extracted cores.

4.186 The following Documentation for evidence of the extracted cores and the cored holes from concrete repairs shall be submitted as continuous records: Photographs of cores extracted from concrete repairs and the interior of cored holes.

4.187 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to Photographs of cores extracted from concrete repairs and the interior of cored holes.

Adhesion of concrete repairs to concrete substrate

4.188 The cores to be drilled or drilled and extracted and used for pull-off testing shall be as specified in CC 484/WSR/004.

The cores to be drilled or drilled and extracted and used for pull-off testing						
Structure ID	**Structural element**	**Repair area ID or crack ID**	**Drawing/ model reference(s)**	**Location on element**	**Number of cores for pull off testing**	**Minimum adhesion strength of repair at the existing substrate**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter text, to identify the structural element that requires coring.

c) Enter a unique reference.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter text, to identify the specific location that requires coring.

f) Enter a number, to identify the number of extracted cores to be used for pull-off testing.

g) Enter a number in units of MPa, to specify minimum target adhesion strength at interface between repair and existing concrete substrate - see table A.3 of BS EN 1504-10 [Ref 32.N]B.

4.189 Verification shall be undertaken for adhesion of completed concrete repairs by pull-off tests on extracted or in-situ cores.

4.190 The frequency of pull-off tests for extracted or in-situ cores specified for pull-off testing shall be the earlier of 28 days following installation of the repair material or after the repair has attained its characteristic compressive strength.

4.191 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to pull-off tests of completed concrete repairs.

4.192 Coring for pull-off testing for concrete repairs except for sprayed concrete or mortar repairs shall be undertaken in accordance with BS EN 1542 [Ref 38.N].

4.193 Requirements specific to pull-off testing for completed sprayed concrete or mortar repairs shall be in accordance with "Sprayed repair concrete or mortar" in Section 7 of this document.

4.194 Any tested cores where the failure occurs fully within the concrete substrate and where the adhesion bond strength is less than $1N/mm^2$ shall not count as part of the results from which the mean adhesion bond strength is calculated.

4.195 Additional coring and pull-off tests shall be undertaken until tested adhesion bond strength of concrete repairs is greater than the specified minimum adhesion strength at the existing substrate.

4.196 The minimum adhesion strength of repair at the existing substrate shall be as stated in CC 484/WSR/004.

Compressive strength of extracted cores

4.197 The compressive strength of extracted cores shall be determined in accordance with BS EN 12390-3 [Ref 57.N] and BS EN 12504-1 [Ref 52.N].

4.198 The compressive strength of tested samples shall be equal to or higher than the specified strength class of the repair product.

4.199 Requirements specific to compressive strength testing on extracted cores for completed sprayed concrete or mortar repair test panels shall be in accordance with "Sprayed repair concrete or mortar" in Section 7 of this document.

4.200 Verification shall be undertaken for completed repairs by compressive strength testing of extracted cores at 28 days or later following the installation of the concrete repair materials.

4.201 The frequency of compressive strength testing of extracted cores shall be on all cores identified for compressive strength testing.

4.202 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to compressive strength testing of extracted cores.

4.203 Verification for compressive strength testing of extracted cores shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

4.204 The number of extracted cores to be used for compressive strength testing shall be as specified in CC 484/WSR/004.

The number of extracted cores to be used for compressive strength testing				
Structure ID	**Structural element**	**Drawing/ model reference(s)**	**Repair area or crack ID**	**Number of extracted cores from each repair area for compressive testing**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element that requires coring.

c) Enter text, to cross reference relevant drawing(s)/model(s).

d) Enter a unique reference.

e) Enter a number, to identify the number of extracted cores from each repair area to be used for compressive strength testing.

Measurement of voids within completed concrete repairs

4.205 Voids on the exposed surfaces of all extracted cores and cored holes shall be measured.

4.206 The total area of voids shall not exceed 3% of the exposed surface area of the core or the corresponding surface area of the cored hole.

4.207 Verification for measurement of voids on the exposed surfaces of the extracted cores and cored holes shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

4.208 Verification shall be undertaken for completed concrete repairs by measurement of voids on the exposed surfaces of the extracted cores and cored holes.

4.209 The frequency of the measurement of voids on the exposed surfaces of extracted cores and cored holes shall be for every core and hole following the extraction of cores.

4.210 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the measurement of voids within the exposed surfaces of the extracted cores and cored holes.

4.211 The following Documentation shall be submitted for the intention to visually inspect and measure the voids of the exposed surfaces of the extracted cores and cored holes prior to the commencement of visual inspection and measurement of voids: Notification of the intention to visually inspect and measure the voids of the exposed surfaces of the extracted cores and cored holes.

4.212 Documentation for Notification of the intention to visually inspect and measure the voids of the exposed surfaces of the extracted cores and cored holes shall be submitted at least 2 working days in advance of the works.

Reinstatement of cored holes

4.213 The reinstatement of cored holes with repair material shall commence after completion of the core extraction and sampling.

4.214 All dust and debris shall be removed from each cored hole prior to reinstatement with repair material.

4.215 The surface of each cored hole shall be roughened and pre-wetted prior to reinstatement with repair material.

4.216 The cored holes shall be prepared, reinstated, protected and cured in accordance with this Specification and the manufacturer's instructions.

Documentation requirements for completed concrete repairs inspection and testing

Concrete repairs inspection and testing report

4.217 The following Documentation shall be submitted for the visual inspection and testing of completed repairs prior to the commencement of satisfactory completion of concrete repair works: Completed concrete repairs inspection and testing report.

4.218 The completed concrete repairs inspection and testing report shall provide an interpretive analysis of the observations and measurements undertaken, including; the consistency and air content of repair material, compressive strength of hardened repair material, integrity of repairs by hammer sounding, electrical conductivity, integrity of extracted cores by visual inspection, adhesion strength on the concrete substrate, compressive strength of extracted cores and the measurement of voids on the exposed surfaces of all extracted cores and cored holes.

4.219 Observations, measurements and testing shall be in accordance with BS EN 12504-1 [Ref 52.N], BS EN 14488-4 [Ref 63.N]or BS EN 12390-3 [Ref 57.N].

4.220 Access arrangements to the concrete repair areas shall remain available for use until at least 4 working days after the Concrete repairs inspection and testing report has been submitted.

4.221 Where completed repairs do not comply with the performance or verification requirements, access arrangements to the concrete repair areas shall remain available for use until the concrete repair work is verified as compliant.

5. Hand-applied repair concrete or mortar

Product requirements for hand-applied repair concrete or mortar

5.1 The performance requirements for repair concrete or mortar products intended to be hand-applied shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Product verification requirements for hand-applied repair concrete or mortar

5.2 The product verification requirements for hand-applied repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Installation requirements for hand-applied repair concrete or mortar

5.3 The installation requirements for hand-applied repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

5.4 Chemical type PC (reactive polymer) proprietary hand-applied repair concrete or mortar products shall only be used for small and superficial concrete repairs where no carbon steel reinforcement is exposed.

5.5 The maximum area of chemical type PC (reactive polymer) hand-applied repair concrete or mortar areas shall be 0.1 m^2, unless otherwise stated in CC 484/WSR/005.

SI.5.5 The maximum area of chemical type PC (reactive polymer) hand-applied repair concrete or mortar areas shall be [enter a number] .

5.6 The maximum depth of chemical type PC (reactive polymer) hand-applied repair concrete or mortar areas shall 10 mm, unless otherwise stated in CC 484/WSR/005.

SI.5.6 The maximum depth of chemical type PC (reactive polymer) hand-applied repair concrete or mortar areas shall be [enter a number] .

Installation verification requirements for repairs executed using hand-applied repair concrete or mortar

5.7 The installation verification requirements for hand-applied repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

6. Flowable repair concrete or mortar

Product requirements for flowable repair concrete or mortar

6.1 The performance requirements for repair concrete or mortar products intended to be flowable shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

6.2 Flowable concrete or mortar proprietary repair products shall be of chemical type CC (hydraulic) or PCC (polymer hydraulic) in accordance with BS EN 1504-1 [Ref 29.N].

6.3 Strength class R1 and class R2 repair products in accordance with BS EN 1504-3 [Ref 33.N] shall not be used for flowable repair concrete or mortar applications.

Selection of flowable repair concrete or mortar

6.4 The performance requirements of flowable repair material shall be as specified in CC 484/WSR/006.

The performance requirements of flowable repair material					
Structure ID	**Structural element**	**Face of structural element to be repaired**	**Repair area ID**	**Contractor required to design repairs to a soffit using flowable repair materials**	**Repair material flowability class**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter text, to identify the element which requires concrete repair with flowable repair products.

c) Enter a value, from options vertical, upper surface, soffit surface, to specified which face of element shall be repaired.

d) Enter a unique reference.

e) Enter a value, from options yes, no, to specify if soffit repairs using flowable materials shall be designed by the Contractor.

f) Enter a value, from options high flow, normal flow, to identify the flowability performance characteristic of the repair material.

Requirements for Contractor design of repairs to concrete soffits using flowable repair concrete or mortar

6.5 Flowable repair concrete or mortar proposed by the Contractor for repairing soffits shall be designed in accordance with CS 462 [Ref 40.N].

6.6 The design of repairs to a soffit by the Contractor using flowable repair concrete or mortar shall be in accordance with CC 484/WSR/006.

6.7 The requirements for "Technical approval of highway structures" in Section 18 of GC 101 [Ref 13.N] shall apply to the design of repairs to a soffit by the Contractor using flowable repair concrete or mortar.

6.8 The requirements for "Contractor design" in Section 17 of GC 101 [Ref 13.N] shall apply to the design of repairs by the Contractor using flowable repair concrete or mortar.

Product verification requirements for flowable repair concrete or mortar

6.9 The product verification requirements for flowable repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Installation requirements for flowable repair concrete or mortar

6.10 The installation requirements for flowable repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Workability (consistence) of fresh flowable repair concrete or mortar

6.11 The minimum workability of fresh high flow repair concrete or mortar products before and during placement shall be a flow length of at least 750mm in 30 seconds or less, when measured in accordance with BS EN 13395-2 [Ref 36.N]or BS EN 13395-3 [Ref 37.N].

6.12 The minimum workability of fresh normal flow repair concrete or mortar products before and during placement shall be a flow length of at least 450mm in 30 seconds or less, when measured in accordance with BS EN 13395-2 [Ref 36.N] or BS EN 13395-3 [Ref 37.N].

Air content of fresh flowable repair concrete or mortar

6.13 The maximum air content of fresh flowable repair concrete or mortar before placement shall be 7% when measured in accordance with BS EN 12350-7 [Ref 53.N].

Placement and compaction of flowable repair concrete or mortar

6.14 The flowable repair material shall flow freely into the repair void to be filled.

6.15 The flowable repair material within the repair void shall not be compacted using mechanical vibration other than tapping the formwork with a hammer to expel trapped air.

6.16 Fresh flowable repair materials shall not be dropped into place from a height exceeding 500mm or above the limiting height specified by the manufacturer's instructions.

Installation verification requirements for repairs executed using flowable repair concrete or mortar

6.17 The installation verification requirements for flowable repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Compressive strength testing of hardened flowable repair concrete or mortar

6.18 Flowable repair material used for making test samples (cubes or cylinders) in accordance with BS EN 12190 [Ref 25.N] shall not be compacted in the moulds.

Workability (consistence) of fresh flowable concrete or mortar

6.19 Verification shall be undertaken for fresh flowable mortar or concrete repair material by the measurement of workability in accordance with BS EN 13395-2 [Ref 36.N]or BS EN 13395-3 [Ref 37.N].

6.20 The frequency of the measurement of workability shall be undertaken on one sample of fresh flowable repair material for each batch of repair material prior to placement.

6.21 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the measurement of workability.

6.22 A batch of fresh flowable repair material shall be as defined in BS EN 1504-1 [Ref 29.N].

6.23 Verification for the measurement of workability shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

Air content of fresh flowable concrete or mortar

6.24 Verification shall be undertaken for fresh flowable concrete or mortar repair material by the measurement of air content in accordance with BS EN 12350-7 [Ref 53.N].

6.25 The frequency of the measurement of air content shall be once for each fresh batch of flowable concrete or mortar repair material prior to placement unless otherwise stated in CC 484/WSR/006.

SI.6.25 The frequency of measurement of air content for each fresh batch of flowable concrete or mortar repair material shall be [enter free text].

6.26 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the measurement of air content.

6.27 Verification for fresh flowable concrete or mortar repair material by the measurement of air content shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

Completed flowable concrete repairs inspection and testing report

6.28 A concrete repairs inspection and testing report for flowable concrete repairs shall be submitted in accordance with "Concrete repairs - general requirements" in Section 4 of this document.

6.29 The flowable concrete repairs testing report shall provide an interpretive analysis of the observations and measurements undertaken, including; the flowability in accordance with BS EN 13395-2 [Ref 36.N]or BS EN 13395-3 [Ref 37.N]and air content of fresh flowable material in accordance with BS EN 12350-7 [Ref 53.N].

7. Sprayed repair concrete or mortar

General requirements for sprayed repair concrete or mortar

7.1 The requirements of sprayed concrete or mortar repair proprietary products shall be as specified in CC 484/WSR/007.

The requirements of sprayed concrete or mortar repair proprietary products				
Structure ID	**Structural element**	**Repair area ID**	**Sprayed concrete application process**	**Slump class required for wet-spray products**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the element which requires concrete repair with sprayed concrete or mortar repair products.

c) Enter a unique reference.

d) Enter a value, from options dry-spray, wet-spray, dry-spray or wet-spray, to identify the required application process of the repair product.

e) Enter a value, from options S1, S2, S3, S4, S5, N/A, to identify the required consistence of wet-spray repair products prior to application in accordance with BS EN 206 [Ref 3.N].

7.2 The specified slump class of a wet spray-applied repair concrete or mortar product shall be in accordance with BS EN 206 [Ref 3.N].

7.3 Non-proprietary designed concrete mixes shall not be used for sprayed concrete or mortar repairs to concrete structures.

7.4 The nominal maximum aggregate size of spray-applied repair concrete shall be 8mm.

7.5 The nominal maximum aggregate size of spray-applied repair mortar shall be 3mm.

Product requirements for spray-applied repair concrete or mortar

7.6 Sprayed concrete or mortar products for the repair of concrete structures shall be chemical type CC (hydraulic) or PCC (polymer

hydraulic) proprietary repair products in accordance with BS EN 1504-1 [Ref 29.N].

7.7 The performance requirements for proprietary repair concrete or mortar products intended to be spray-applied shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Repair product statement for sprayed concrete or mortar products

7.8 A repair product statement for spray-applied repair concrete or mortar products shall be submitted in accordance with "Concrete repairs - general requirements" in Section 4 of this document.

Documentation requirements for pre-installation qualification of sprayed concrete operatives

7.9 The following Documentation shall be submitted for evidence of proposed sprayed operatives' competency in undertaking spray-applied repair concrete or mortar activities prior to the commencement of spray-applied repair concrete or mortar works: Evidence of qualifications, training and experience of proposed operatives to demonstrate that proposed operatives are competent, trained, qualified and have recent experience of undertaking spray-applied repair concrete or mortar activities.

7.10 Evidence of qualifications, training and experience of proposed operatives to demonstrate that proposed operatives are competent, trained, qualified and have recent experience of undertaking spray-applied repair concrete or mortar activities. shall include either:.

1. relevant and current certificates of competence issued under a recognised industry scheme with a minimum of 2 years post qualification experience of concrete spraying; or

2. minimum of 10 years of experience undertaking sprayed concrete activities with references being provided.

General requirements for execution of spray-applied repair concrete or mortar test panels

7.11 Test panels for spray-applied repair concrete or mortar products shall be constructed using the same spray-applied repair concrete or mortar product, mixing, spray equipment, spraying method and inclinations proposed for use in the permanent works.

7.12 Monitoring points for shrinkage measurement in test panels shall comprise at least three gauge studs installed at equal spacing and a gauge length in accordance with BS EN 12390-16 [Ref 60.N].

7.13 Measurement of electrical resistivity of sprayed concrete or mortar in test panels shall only be required where galvanic anodes are specified within concrete repairs.

7.14 Where electrical resistivity of sprayed concrete or mortar is to be tested using stainless steel pins cast into a plain concrete test panel, the pins shall be inserted into concrete when still fresh after spraying.

7.15 Cube samples removed from spray-applied repair concrete or mortar test panels for electrical resistivity testing shall not contain reinforcement.

7.16 Sprayed concrete or mortar test panels shall be be cured and protected on site in accordance with BS EN 14487-2 [Ref 44.N] for 7 days or in accordance with the period indicated in the manufacturer's instructions, whichever is the longer period.

7.17 Monitoring points for shrinkage measurement of sprayed concrete or mortar in test panels shall not be disturbed or damaged when cores or other specimens are removed from the panel for destructive testing.

7.18 The timber mould spray-applied repair concrete or mortar test panels shall not be moved until at least 36 hours after installation of sprayed concrete or mortar.

7.19 Spray-applied repair concrete or mortar test panels and any samples extracted from test panels shall be protected to prevent damage or moisture loss during transportation to a testing laboratory.

7.20 The spray-applied repair concrete or mortar test panels shall be kept for at least 56 days.

Installation requirements for spray-applied repair concrete or mortar test panels executed in timber moulds

7.21 The timber mould for spray-applied repair concrete or mortar test panels shall have minimum dimensions of 750mm length x 750mm width x 150mm depth, unless otherwise stated in CC 484/WSR/007.

SI.7.21a The length of the timber moulds shall be [enter a number] .

SI.7.21b The width of the timber moulds shall be [enter a number] .

SI.7.21c The depth of the timber moulds shall be [enter a number] .

7.22 Timber moulds for spray applied repair concrete or mortar test panels shall not be coated with release agents.

7.23 Steel reinforcement bars with diameter, spacing and orientation similar to the existing reinforced concrete element proposed for repair shall be installed within at least one of the timber mould test panels.

7.24 Where the existing structure has more than one inclination, two timber mould test panels shall be produced at each inclination for each sprayed concrete or mortar product.

7.25 Installation requirements for timber mould spray-applied repair concrete or mortar test panels for concrete repairs shall be as specified in CC 484/WSR/007.

Installation requirements for timber mould spray-applied repair concrete panels for concrete repairs							
Test panel reference	**Inclination category of test panel**	**Reinforcement required within test panel**	**Diameter of vertical reinforcement**	**Spacing of vertical reinforcement**	**Diameter of horizontal reinforcement**	**Spacing of horizontal reinforcement**	**Other requirements**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter a value, from options horizontal soffit (inclination to horizontal, 0° to 5°), horizontal upper surface (inclination to horizontal, 0° to 5°), vertical (inclination to horizontal, 80° to 90°, inclined (inclination to horizontal, 5° to 80°), to identify the category of inclination for the test panel.

c) Enter a value, from options yes, no, to identify the requirement to install steel reinforcement within the test panel.

d) Enter a number in units of mm, to identify the diameter of vertical reinforcement within the test panel.

e) Enter a number in units of mm, to identify the spacing of vertical reinforcement within the test panel.

f) Enter a number in units of mm, to identify the diameter of horizontal reinforcement within the test panel.

g) Enter a number in units of mm, to identify the spacing of horizontal reinforcement within the test panel.

h) Enter text, to identify any other requirements for the arrangement of reinforcement within the test panel.

i) Enter text, to identify any particular comments or goals in relation to the test panel.

Installation requirements for spray-applied repair concrete or mortar test panels executed in-situ on the existing structure

7.26 In-situ spray-applied repair concrete or mortar test panels shall be undertaken by spray-applying repair concrete or mortar product into prepared areas of the concrete substrate on an existing structural element specified for repairs.

7.27 In-situ spray-applied repair concrete or mortar test panels shall have minimum dimensions of 750mm length x 750mm width x 150mm depth, unless otherwise stated in CC 484/WSR/007.

7.28 Spray-applied repair concrete or mortar test panels constructed in-situ shall be as specified in CC 484/WSR/007.

Spray-applied repair concrete or mortar test panels constructed in-situ						
Structure ID	**Repair area ID**	**Existing small scale model**	**Minimum length of in-situ spray-applied repair concrete or mortar test panel**	**Minimum width of in-situ spray-applied repair concrete or mortar test panel**	**Minimum depth of in-situ spray-applied repair concrete or mortar test panel**	**Sequencing restrictions**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter a unique reference, to identify the repair area for use as in-situ sprayed concrete test panel.

c) Enter a value, from options yes, no, to identify an existing small scale model of the structural element to be used for test panel.

d) Enter a number in units of mm, to identify the minimum length of the proposed in-situ sprayed concrete or mortar test panel.

e) Enter a number in units of mm, to identify the minimum width of the proposed in-situ sprayed concrete or mortar test panel.

f) Enter a number in units of mm, to identify the minimum depth of the proposed in-situ sprayed concrete or mortar test panel.

g) Enter text, to identify sequencing restrictions in the construction of the in-situ spray-applied repair concrete or mortar test panel to avoid compromising the structural integrity of the existing structure.

Installation requirements for spray-applied repair concrete or mortar test panels executed in-situ on small-scale models

7.29 Spray-applied repair concrete or mortar test panels executed on existing small scale reinforced concrete models of the structural element to demonstrate application of spray-applied repair concrete or mortar shall have minimum dimensions of 750mm length x 750mm width x 150mm depth, unless otherwise stated in CC 484/WSR/007.

SI.7.29a The minimum length of repair test panels within small scale models of structural elements proposed for repairs shall be [enter a number] .

SI.7.29b The minimum width of repair test panels within small scale models of structural elements proposed for repairs shall be [enter a number] .

SI.7.29c The minimum depth of repair test panels within small scale models of structural elements proposed for repairs shall be [enter a number] .

Installation verification requirements for sample removal following execution of spray-applied repair or mortar test panels

Coring of spray-applied repair concrete or mortar test panels

7.30 Cores from in-situ spray-applied repair concrete or mortar test panels shall be undertaken in accordance with "Concrete repairs - general requirements" in Section 4 of this document.

7.31 Cores through reinforcement to verify shadowing behind reinforcement shall not be required for in-situ spray-applied repair concrete or mortar test panels.

7.32 All samples for testing shall not include any concrete from within 125mm of the edge of the spray-applied repair concrete or mortar test panel.

7.33 All samples for testing shall be extracted when the concrete is mature enough to resist stresses from cutting or coring equipment without damage or reduction in strength properties.

7.34 The number and extent of cores to be extracted from spray-applied repair concrete or mortar test panels shall be as specified in CC 484/WSR/007.

The number and extent of cores to be extracted from spray-applied repair concrete or mortar test panels					
Test panel reference	**Drawing/ model reference(s)**	**Number of cores from each test panel**	**Diameter of cores**	**Minimum depth of cores**	**Core through reinforcement in small scale model or timber test panels**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter text, to cross reference relevant drawing(s)/model(s).

c) Enter a number, to identify the total number of cores to be extracted from each test panel for the purposes of testing.

d) Enter a number in units of mm, to identify the diameter of the cores to be extracted.

e) Enter a number in units of mm, to identify the minimum depth of cores to be extracted.

f) Enter a value, from options yes, no, to specify whether cores are to be extracted through reinforcement for small scale model or timber test panels.

Installation verification requirements for execution of spray-applied repair concrete or mortar products using test panels

Number of test panels required

7.35 The product verification requirements for spray-applied repair concrete or mortar, including installation verification for trial execution using sprayed-applied repair concrete or mortar test panels shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

7.36 Verification shall be undertaken for installation of spray-applied repair concrete or mortar using in-situ test panels, small scale model test panels or timber mould test panels.

7.37 The frequency of spray-applied repair concrete or mortar test panels shall be a minimum of 3 number per spray-applied repair concrete or mortar product unless otherwise stated in CC 484/WSR/007.

SI.7.37 The frequency of spray-applied repair concrete or mortar test panels per spray-applied repair concrete or mortar product shall be [enter a number].

7.38 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to spray-applied repair concrete or mortar test panels.

Verifying adhesion strength of spray-applied repair concrete or mortar installed in test panels executed in-situ on the existing structure or on small scale model

7.39 Pull-off testing shall not be undertaken on sprayed concrete or mortar placed in timber mould test panels.

7.40 Verification shall be undertaken for the adhesion of spray-applied repair concrete or mortar to the concrete substrate within in-situ test panels by pull-off testing in accordance with BS EN 14488-4 [Ref 63.N].

7.41 The frequency of pull-off testing within spray-applied repair concrete or mortar in-situ test panels shall be 1 no. for each in-situ test panel 28 days following installation of the in-situ or small scale sprayed concrete test panel.

7.42 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to pull-off testing within spray-applied repair concrete or mortar in-situ test panels.

7.43 The tested adhesion strength of spray-applied repair concrete or mortar in in-situ test panels shall be as stated in CC 484/WSR/007.

SI.7.43 The minimum adhesion strength of spray-applied repair concrete or mortar in in-situ test panels shall be [enter a number] .

Verifying shrinkage of spray-applied repair concrete or mortar installed in test panels

7.44 The shrinkage of spray-applied repair concrete or mortar in the test panels shall be determined in accordance with BS EN 12390-16 [Ref 60.N].

7.45 Verification shall be undertaken for shrinkage of spray-applied repair concrete or mortar in test panels in accordance with BS EN 12390-16 [Ref

60.N] by measuring the length between adjacent monitoring points to confirm that the percentage of shrinkage expressed as the average decrease in dimension compared with the original dimension is less than 0.07%.

7.46 The frequency of length measurements to determine shrinkage of spray-applied repair concrete or mortar in test panels shall be at the following intervals for each test panel.

1. at casting;

2. at 7-day intervals to 28 days;

3. a final measurement at 56 days.

7.47 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to shrinkage measurements of spray-applied repair concrete or mortar in test panels.

7.48 The ambient air and surface temperatures shall be recorded during each shrinkage measurement of the spray-applied repair concrete or mortar test panels.

7.49 The following Documentation shall be submitted for ambient air and surface temperature measurements prior to the commencement of shrinkage measurement of spray-applied repair concrete or mortar test panels: Ambient air and surface temperature records during shrinkage measurements of spray-applied repair concrete or mortar test panels.

Verifying electrical resistivity of spray-applied repair concrete or mortar installed in test panels

7.50 The verification for electrical resistivity of the spray-applied repair concrete or mortar test panels shall be in accordance with the electrical resistivity testing for completed repairs set out within "Concrete repairs - general requirements" in Section 4 of this document.

7.51 Measurements of electrical resistivity for spray-applied repair concrete or mortar test panels shall be carried out on either:.

1. 150mm cube samples with embedded stainless steel pins, removed from the sprayed concrete test panel; or

2. the concrete remaining in the test panel with embedded stainless steel pins.

7.52 Electrical resistivity of unreinforced spray-applied repair concrete or mortar test panels shall be measured in accordance with methods

described in CS TR60 [Ref 7.N]and the test equipment manufacturers instructions.

7.53 Verification shall be undertaken for electrical resistivity of spray-applied repair concrete or mortar installed in test panels by electrical resistivity testing in accordance with BS EN 1504-10 [Ref 32.N] and CS TR60 [Ref 7.N].

7.54 The frequency of electrical resistivity testing shall be undertaken once for each spray-applied repair concrete or mortar test panel at 28 days after installation unless otherwise stated in CC 484/WSR/007.

SI.7.54 The frequency of electrical resistivity testing of each spray-applied repair concrete or mortar test panel shall be [enter free text].

7.55 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to electrical resistivity testing of spray-applied repair concrete or mortar test panels.

Verifying integrity of spray-applied repair concrete or mortar in test panels by visual inspection

7.56 Visual inspection of all extracted cores from spray-applied repair concrete or mortar test panels to verify integrity shall be in accordance with the verification for integrity of completed concrete repairs set out within "Concrete repairs - general requirements" in Section 4 of this document.

Verification of compressive strength of extracted cores from spray-applied repair concrete or mortar test panels

7.57 The average 28-day compressive strength of the extracted cores of spray-applied repair concrete or mortar test panels shall be verified in accordance BS EN 14488-1 [Ref 64.N] and "Concrete repairs - general requirements" in Section 4 of this document.

7.58 The difference between the highest and lowest values of the 28-day compressive strength test shall not be more than 20% of the average values of 28-day compressive strength for the cores removed from each spray-applied repair concrete or mortar test panel.

7.59 Compressive strength tests to be carried out on extracted cores from spray-applied repair concrete or mortar test panels shall be as specified in CC 484/WSR/007.

Compressive strength tests to be carried out on extracted cores from spray-applied repair concrete or mortar test panels		
Test panel reference	**Drawing/model reference(s)**	**Number of compressive strength tests on cores from each panel**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter text, to cross reference relevant drawing(s)/model(s).

c) Enter a number, to specify the number of compressive strength tests to be done on extracted cores from each test panel.

Verification of elastic modulus of extracted cores from spray-applied repair concrete or mortar test panels

7.60 Verification shall be undertaken for spray-applied repair concrete or mortar test panels by elastic modulus testing of extracted cores in accordance with BS EN 12390-13 [Ref 59.N].

7.61 The frequency of elastic modulus testing of extracted cores shall be at 28 days following completion of the spray-applied repair concrete or mortar test panels.

7.62 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to elastic modulus testing of extracted cores from spray-applied repair concrete or mortar test panels.

7.63 Verification for elastic modulus testing of extracted cores from spray-applied repair concrete or mortar test panels shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

7.64 The average 28-day elastic modulus of the extracted cores from spray-applied repair concrete or mortar test panels shall be in accordance with the performance characteristics stated in "Concrete repairs - general requirements" in Section 4 of this document.

7.65 The difference between the highest and lowest values of the 28-day elastic modulus test shall not be more than 20% of the average value of elastic modulus for the cores removed from each spray-applied repair concrete or mortar test panel.

7.66 Elastic modulus tests to be carried out on extracted cores from spray-applied repair concrete or mortar test panels shall be as specified in CC 484/WSR/007.

Elastic modulus tests to be carried out on extracted cores from spray-applied repair concrete or mortar test panels		
Test panel reference	**Drawing/model reference(s)**	**Number of elastic modulus tests on cores from each panel**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter text, to cross reference relevant drawing(s)/model(s).

c) Enter a number, to identify the number of elastic modulus tests to be done on extracted cores from each test panel.

Verification of integrity of spray-applied repair concrete or mortar in test panels by measurement of voids

7.67 Verification for the measurement of voids on the exposed surfaces of the extracted cores and cored holes from the spray-applied repair concrete or mortar test panels shall be in accordance with the measurement of voids for completed repairs set out within "Concrete repairs - general requirements" in Section 4 of this document.

Verification of shadowing behind steel reinforcement bars used in spray-applied repair concrete or mortar test panels

7.68 The extent of shadowing behind steel reinforcement (voids created behind steel reinforcement due to poor quality application of sprayed material) shall not exceed 3% of the exposed surface area of the core or the corresponding surface area of the cored hole within the spray-applied repair concrete or mortar test panel.

7.69 Verification shall be undertaken for spray-applied repair concrete or mortar test panels by the visual inspection and measurement of extracted cores through reinforcement from small scale model or timber mould test panels to determine the extent of shadowing (voids created behind steel reinforcement due to poor quality application of sprayed material).

7.70 The frequency of the visual inspection and measurement of extracted cores through reinforcement to determine the extent of shadowing shall be on completion of the spray-applied repair concrete or mortar test panels.

7.71 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the visual inspection and measurement of extracted cores through reinforcement to determine the extent of shadowing.

7.72 The number of extracted cores through reinforcement from spray-applied repair concrete or mortar small scale model or timber mould test

panels to be used to identify shadowing behind steel reinforcement shall be as specified in CC 484/WSR/007.

The number of extracted cores through reinforcement from spray-applied repair concrete or mortar small scale model or timber mould test panels to be used to identify shadowing behind steel reinforcement		
Test panel reference	**Drawing/model reference(s)**	**Number of cores from each test panel to be used for determining extent of shadowing**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter text, to cross reference relevant drawing(s)/model(s).

c) Enter a number, to identify the number of cores from each spray-applied repair concrete or mortar test panel to determine the extent of shadowing behind steel reinforcement bars.

7.73 The following Documentation for evidence of extracted cores through reinforcement and the cored holes in the sprayed concrete test panel shall be submitted as continuous records: Photographs of extracted cores through reinforcement and the cored holes in the spray-applied repair concrete or mortar test panel.

7.74 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to Photographs of extracted cores through reinforcement and the cored holes in the spray-applied repair concrete or mortar test panel.

7.75 Cores drilled through reinforcement from spray-applied repair concrete or mortar test panels shall not be used for destructive testing.

Verification of density of extracted cores from spray-applied repair concrete or mortar test panels

7.76 Verification shall be undertaken for the density of extracted cores from spray-applied repair concrete or mortar test panels by undertaking density testing in accordance with BS EN 12390-7 [Ref 58.N].

7.77 The frequency of density testing of extracted cores from spray-applied repair concrete or mortar test panels shall be at 28 days following completion of the sprayed concrete test panels.

7.78 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to density testing of extracted cores from spray-applied repair concrete or mortar test panels.

7.79 The number of density tests to be carried out on extracted cores from spray-applied repair concrete or mortar test panels shall be as specified in CC 484/WSR/007.

The number of density tests to be carried out on extracted cores from spray-applied repair concrete or mortar test panels		
Test panel reference	**Drawing/model reference(s)**	**Number of density tests on cores from each test panel**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter a unique reference, to cross reference relevant drawing(s)/model(s).

c) Enter a number, to identify the number of density tests to be done on extracted cores from each spray-applied repair concrete or mortar test panel.

Spray-applied repair concrete or mortar test panel inspection and testing report

7.80 The following Documentation shall be submitted for the visual inspection and testing of the spray-applied repair concrete or mortar test panels prior to the commencement of spray-applied repair concrete or mortar works: Spray-applied repair concrete or mortar test panel inspection and testing report.

7.81 Documentation for Spray-applied repair concrete or mortar test panel inspection and testing report shall be submitted at least 10 working days prior to the commencement of spray-applied repair concrete or mortar works.

7.82 The spray-applied repair concrete or mortar test panel inspection and testing report shall comply with BS EN 12504-1 [Ref 52.N] including Annex NA of BS EN 12504-1 [Ref 52.N]plus apparent density, voidage, age, curing conditions, test results, test certificates and performance threshold values.

7.83 The spray-applied repair concrete or mortar test panel inspection and testing report shall provide an interpretive analysis of the observations and measurements undertaken, including; shrinkage cracking, electrical resistivity, integrity of extracted cores by visual inspection, compressive strength of extracted cores, adhesion strength, elastic modulus of extracted cores, measurement of voids on the exposed surfaces of all extracted cores and cored holes, the presence of shadowing behind steel reinforcement bars and density testing of cores.

Installation requirements for spray-applied repair concrete or mortar products

7.84 Sprayed concrete or mortar installation shall not commence until the verification of the test panels are completed and the sprayed concrete or mortar product and execution has achieved the product verification requirements for test panels specified in this document.

7.85 The installation requirements for spray-applied repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

7.86 Dry-spray and wet-spray application processes shall not be used within the same repair area.

7.87 The application of sprayed concrete or mortar shall be undertaken using the same application process as verified in the sprayed concrete or mortar test panels.

7.88 Each spray-applied proprietary repair concrete or mortar product shall be installed in accordance with the manufacturer's recommended application process.

Removal of in-situ spray-applied repair concrete or mortar test panels

7.89 Where a spray-applied repair concrete or mortar test panel executed in-situ does not achieve the installation requirements set out within this document, the test panel shall be removed prior to commencement of the spray-applied repair concrete or mortar works.

7.90 Removal of the in-situ spray-applied repair concrete or mortar test panels and preparation of the substrate shall be undertaken in accordance with "Concrete removal and substrate preparation" in Section 3 of this document.

Conformity control of sprayed concrete or mortar

7.91 The inspection category of sprayed concrete or mortar repairs to concrete highway structures shall be Category 3 in accordance with BS EN 14487-1 [Ref 43.N], unless otherwise stated in CC 484/WSR/007.

SI.7.91 The inspection category of sprayed concrete or mortar repairs to concrete highway structures undertaken in accordance with BS EN 14487-1 [Ref 43.N] shall be [select one from: Category 1, Category 2].

Placing and compaction of spray-applied repair concrete or mortar materials

7.92 The application of spray-applied repair concrete or mortar shall be in accordance with the manufacturer's instructions for use and BS EN 1504-10 [Ref 32.N].

7.93 On completion of the spray-applied repair concrete or mortar activities, all remaining over sprayed material from structural elements and other elements of the highway adjacent to the working areas shall be removed in accordance with BS EN 1504-10 [Ref 32.N] and BS EN 14487-2 [Ref 44.N].

Construction joints in spray-applied repair concrete or mortar

7.94 Construction joints in spray-applied repair concrete or mortar areas shall be sloped back at 120° to the substrate or cut back square to the reinforcement (at 90° to the substrate) and then sloped back at 120° to the substrate to provide a mechanical key, unless otherwise stated in CC 484/WSR/007.

SI.7.94a The angle of slope of the construction joint between the spray-applied repair concrete or mortar surface and the reinforcement (in relation to the substrate) shall be [enter a number] .

SI.7.94b The angle of slope of the construction joint between the reinforcement and the substrate (in relation to the substrate) shall be [enter a number] .

7.95 The construction joint shall be thoroughly cleaned, with all laitance and loose material removed, and pre-wetted prior to the placement of more sprayed concrete.

Curing of a completed spray-applied repair concrete or mortar repair

7.96 Completed repairs constructed using spray-applied repair concrete or mortar products shall be cured and protected in accordance with BS EN 14487-2 [Ref 44.N], or in accordance with the period indicated in the manufacturer's instructions, whichever is the longer period.

7.97 The curing class of completed repairs using spray-applied repair concrete or mortar products shall be curing class 4 in accordance with BS EN 13670 [Ref 10.N].

Surface finish of completed spray-applied repair concrete or mortar repairs

7.98 The surface finish of completed spray-applied repair concrete or mortar repairs shall be in accordance with BS EN 14487-2 [Ref 44.N].

7.99 The surface finish of completed spray-applied repair concrete or mortar repairs shall be left as-sprayed from the nozzle, unless otherwise stated in CC 484/WSR/007.

SI.7.99 The surface finish of completed spray-applied repair concrete or mortar repairs shall be [select one from: U3 using cut and flash method, U3 to first layer using light trowelling from wooden float, U3 to first layer using light trowelling from steel float].

Installation verification of repairs using spray-applied repair concrete or mortar

7.100 The installation verification requirements and documentation for completed spray-applied repair concrete or mortar shall comply with "Concrete repairs - general requirements" in Section 4 of this document.

Verification requirements for in-situ adhesion testing of completed repairs

7.101 Verification shall be undertaken for adhesion of spray-applied repair concrete or mortar repairs to concrete substrate by pull-off testing in accordance with BS EN 14488-4 [Ref 63.N].

7.102 The frequency of pull-off testing for spray-applied repair concrete or mortar repairs shall be once for each spray-applied repair concrete or mortar repair area at 28 days following installation of the spray-applied repair concrete or mortar material.

7.103 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to pull-off testing for spray-applied repair concrete or mortar repairs.

7.104 The minimum depth of the core for pull-off testing shall be in accordance with BS EN 14488-4 [Ref 63.N].

7.105 The tested adhesion strength of completed spray-applied repair concrete or mortar repairs shall be as stated in CC 484/WSR/007.

SI.7.105 The minimum adhesion strength of spray-applied repair concrete or mortar repairs shall be [enter a number] .

8. Steel reinforcement for concrete repairs

General requirements of products for steel reinforcement corrosion protection and reinforcement anchoring used in concrete repairs

8.1 The system of assessment and verification of constancy of performance (or attestation of conformity) for anchoring or corrosion protection products or systems used for concrete repair work shall be 2+ (for uses in buildings and civil engineering works) in accordance with Annex ZA.2 of BS EN 1504-6 [Ref 27.N] and BS EN 1504-7 [Ref 31.N].

Product requirements for steel reinforcement in concrete repairs

Steel reinforcement bars for concrete repairs

8.2 Steel reinforcement for use in concrete repairs shall be carbon steel in accordance with "Steel reinforcement for structural concrete" in Section 4 of CC 482 [Ref 49.N].

Reinforcement dowels for concrete repairs

8.3 Reinforcement dowels shall be stainless steel made from steel designation 1.4429 or 1.4436 and grade 500 complying with BS 6744 [Ref 45.N].

Reinforcement couplers for concrete repairs

8.4 Reinforcement couplers shall be compliant with BS 8597 [Ref 48.N].

8.5 Reinforcement couplers shall be certified for Class D fatigue resistance in accordance with Annex B.2 of BS 8597 [Ref 48.N].

8.6 Reinforcement coupler material shall be compatible with the existing or new steel reinforcement material.

8.7 Grouted couplers shall not be used in concrete repairs.

Tying wire for concrete repairs

8.8 Tying wire for securing steel reinforcement shall comply with "Steel reinforcement for structural concrete" in Section 4 of CC 482 [Ref 49.N].

Requirements of products and systems for corrosion protection of steel reinforcement in concrete repairs

8.9 Corrosion protection products and systems for steel reinforcement in concrete repairs shall not be used on the surface of prepared steel reinforcement, unless otherwise stated in CC 484/WSR/008.

8.10 Where corrosion protection products and systems are required for steel reinforcement, they shall be applied to the surface of prepared steel reinforcement as specified in CC 484/WSR/008.

Where corrosion protection products and systems are required for steel reinforcement, they			
Structure ID	**Structural element reference**	**Location of repairs on structural element**	**Corrosion protection products and systems for steel reinforcement**
(a)	(b)	(c)	(d)

a) Enter a unique reference.

b) Enter a unique reference, to identify the concrete element for which the repair details are to be designed.

c) Enter a unique reference, to specify the elements proposed for repair where the corrosion protection products and systems for steel reinforcement are permitted.

d) Enter a value, from options active coating, barrier coating, to identify the type of corrosion protection products and systems specified for application to the steel reinforcement within the repair area.

8.11 The term 'performance characteristic' for corrosion protection products and systems for steel reinforcement in concrete repairs shall be defined as referring to both performance characteristic and performance requirement in BS EN 1504-7 [Ref 31.N].

8.12 Corrosion protection products and systems shall be compliant with BS EN 1504-7 [Ref 31.N].

8.13 The performance requirements for proposed corrosion protection products and systems shall meet the performance characteristics as stated in table 3 of BS EN 1504-7 [Ref 31.N].

8.14 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to corrosion protection products and systems.

8.15 Performance for the proposed corrosion protection products and systems shall be declared for all essential characteristics listed in table ZA.1 of BS EN 1504-7 [Ref 31.N].

Requirements of products and systems for anchoring of steel reinforcement bars and dowels for concrete repairs

8.16 Anchoring products and systems shall be compliant with BS EN 1504-6 [Ref 27.N].

8.17 The performance requirements for proposed anchoring products and systems shall meet the performance characteristics as stated in table 3 of BS EN 1504-6 [Ref 27.N].

8.18 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to anchoring products and systems.

8.19 Reinforcement anchoring products shall be mixed and installed in accordance with the manufacturer's instructions.

8.20 The glass transition temperature for reactive polymer (PC) anchoring products and systems shall be greater than 60°C.

8.21 The fire classification in accordance with BS EN 13501-1 [Ref 11.N] for anchoring products and systems shall be as stated in CC 484/WSR/008.

SI.8.21 The fire classification of anchoring products and systems shall be [select one from: Class A1, Class A2, Class B, Class C, Class D, Class E, Class F].

Verification requirements for identifying section loss of existing steel reinforcement exposed in concrete breakout

8.22 Verification shall be undertaken for the exposed existing steel reinforcement within the concrete breakout area by measurement of section loss.

8.23 The frequency of section loss measurement of the existing exposed steel reinforcement within the concrete breakout area shall be all exposed bars.

8.24 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to the measurement of section loss of the exposed existing steel reinforcement within the concrete breakout area.

Acceptable limit of section loss in exposed existing steel reinforcement

8.25 The acceptable limit of section loss of exposed steel reinforcement within the concrete breakout area shall be 10%, unless otherwise stated in CC 484/WSR/008.

SI.8.25 The acceptable limit of section loss of exposed steel reinforcement within the concrete breakout area shall be [enter a number] .

Installation requirements for welding of reinforcement in concrete repairs

General requirements for welding of reinforcement in concrete repairs

8.26 Welding of reinforcement within repairs shall only be undertaken where one of the situations below applies.

1. welding of replacement reinforcement to existing bars is specified in CC 484/WSR/008 as a permitted method of splicing bars within repairs.

2. welding of reinforcement is not specified as a permitted method of splicing bars but following removal of existing concrete, it is apparent that lapping or coupling of additional or replacement steel reinforcement cannot be undertaken in accordance with the construction drawings;

8.27 The following Documentation shall be submitted for the notification of where installation of additional or replacement steel reinforcement by lapping of reinforcement or using reinforcement couplers cannot be undertaken in accordance with the construction drawings prior to the commencement of installation of additional or replacement steel reinforcement: Notification of where installation of additional or replacement steel reinforcement by lapping of reinforcement or using reinforcement couplers cannot be undertaken in accordance with the construction drawings.

8.28 Documentation for Notification of where installation of additional or replacement steel reinforcement by lapping of reinforcement or using reinforcement couplers cannot be undertaken in accordance with the construction drawings shall be submitted within 5 working days following removal of existing concrete.

8.29 Welding of reinforcement shall not be undertaken within a bridge deck, unless otherwise stated in CC 484/WSR/008.

SI.8.29 The welding of reinforcement in a bridge deck shall only be undertaken within the following areas: [enter free text].

8.30 Site welding of stainless steel reinforcement or dowels shall not be permitted.

8.31 Requirements for welded joints between new and existing steel reinforcement shall be as specified in CC 484/WSR/008.

Requirements for welded joints between new and existing steel reinforcement				
Concrete breakout area ID	**Requirement for welded joints between new and existing steel reinforcement**	**Welded joint method**	**Drawing/ model reference**	**Contractor design of welded joints between new and existing steel reinforcement**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter a value, from options yes, no, to identify whether welded joints between new and existing reinforcement are required.

c) Enter a value, from options butt joint, lap joint, strap joint, cross joint, N/A, to identify the method of welding for each concrete breakout area.

d) Enter text, to provide the reference of drawing or model where details of welded joints are shown. State N/A if welding is not permitted.

e) Enter a value, from options yes, no, to indicate whether the Contractor is required to design the specified welded joints between new and existing reinforcement.

Contractor design for welding of reinforcement in concrete repairs

8.32 The design of welded joints between new and existing steel reinforcement where it is evident following the removal of existing concrete that the installation of additional or replacement steel reinforcement by lapping of reinforcement or using reinforcement couplers cannot be undertaken in accordance with the construction drawings shall be in accordance with CC 484/WSR/008.

8.33 The requirements for "Technical approval of highway structures" in Section 18 of GC 101 [Ref 13.N] shall apply to the design of welded joints between new and existing steel reinforcement in accordance with BS EN 1992-1-1 [Ref 9.N] and BS EN ISO 17660-1 [Ref 66.N] including requirements for UK nationally determined parameters in Table NA.1 and fatigue loading.

8.34 The requirements for "Contractor design" in Section 17 of GC 101 [Ref 13.N] shall apply to welded joints between new and existing steel reinforcement.

Installation verification of welded test joints of steel reinforcement for concrete repairs

8.35 The minimum number of welded test joints undertaken shall be in accordance with the examination and testing requirements of BS EN ISO 17660-1 [Ref 66.N].

8.36 Verification shall be undertaken for welded test joints by visual inspection in accordance with BS EN ISO 17660-1 [Ref 66.N].

8.37 The frequency of visual inspection of welded test joints shall be for every welded test joint on completion.

8.38 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to visual inspection of welded test joints.

8.39 Verification shall be undertaken for welded test joints by magnetic particle inspection in accordance with BS EN 17638 [Ref 22.N].

8.40 The frequency of magnetic particle inspection shall be for every test joint on completion.

8.41 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to magnetic particle inspection.

8.42 Verification shall be undertaken for welded test joints by testing in tension, shear and bending in accordance with BS EN ISO 17660-1 [Ref 66.N].

8.43 The frequency of tension, shear and bending testing of welded test joints shall be for one joint per structural element for every trial.

8.44 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to tension, shear and bending testing of welded test joints.

8.45 Verification shall be undertaken for welded test joints by hardness survey in accordance with BS EN ISO 17660-1 [Ref 66.N] UK national annex in Table NA.1.

8.46 The frequency of hardness survey of welded test joints shall be for one test joint on completion.

8.47 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to hardness survey of welded test joints.

8.48 The hardness survey shall be conducted to one welded test joint, unless otherwise stated in CC 484/WSR/008.

SI.8.48 The number of welded test joints subject to the hardness survey shall be [enter a number].

8.49 The requirements for welded test joints shall be as specified in CC 484/WSR/008.

The requirements for welded test joints						
Welded test joint ID	**Welded test joint method**	**Bar diameter 1**	**Bar diameter 2**	**Bar diameter 3**	**Minimum length of welded test joint**	**Additional notes**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter a value, from options butt joint, lap joint, strap joint, cross joint, to identify the method of welding for each test joint.

c) Enter a number in units of mm, to identify the diameter of the steel reinforcement to be welded.

d) Enter a number in units of mm, to identify the diameter of the steel reinforcement to be welded.

e) Enter a number in units of mm, to identify the diameter of the steel reinforcement to be welded.

f) Enter a number in units of mm, to identify the minimum length of the welded joint.

g) Enter text, to identify any particular comments or goals in relation to the welded test joint.

8.50 The following Documentation shall be submitted for the visual inspection and testing of the welded test joints prior to the commencement of welding new and existing steel reinforcement within concrete repair works: Welded test joints inspection and testing report.

8.51 Documentation for Welded test joints inspection and testing report shall be submitted at least 5 working days prior to the commencement of welding new and existing steel reinforcement within concrete repair works.

8.52 The welded test joints inspection and testing report shall provide an interpretive analysis of the observations and measurements undertaken in accordance with BS EN ISO 17660-1 [Ref 66.N], including; visual inspection, magnetic particle inspection, testing in tension, shear and bending and hardness survey.

Installation requirements for steel reinforcement in concrete repairs

Preparation of exposed steel reinforcement for concrete repairs

8.53 Corrosion products and contamination (e.g. chlorides, debris, oil etc) on the surface of the steel reinforcement or other steel substrate or in any pitting shall be removed by cleaning of exposed steel surfaces within the concrete breakout area.

8.54 The whole exposed surface of each existing steel reinforcement bar or other steel substrate shall be prepared to standard Sa 2.5 in accordance with BS EN ISO 8501-1 [Ref 24.N], unless otherwise stated in CC 484/WSR/008.

SI.8.54a The surface preparation grade in accordance with BS EN ISO 8501-1 [Ref 24.N] of exposed steel reinforcement shall be [select one or more from: Sa 3, St 3].

SI.8.54b The surface preparation grade in accordance with BS EN ISO 8501-1 [Ref 24.N] of steel substrate surfaces other than reinforcement bars shall be [select one or more from: Sa 2, Sa 3, St 3].

8.55 Immediately prior to the application of the repair material, the prepared surface of steel reinforcement shall be clean with only light flash-rusting permitted.

8.56 The extent of flash-rusting shall be visually determined in accordance with SSPC SP 12 / NACE No.5 [Ref 50.N].

8.57 Corrosion protection products and systems for the corrosion protection of prepared steel reinforcement shall be applied in accordance with the manufacturer's instructions.

8.58 Bonding primers shall only be used on the prepared reinforcement when recommended by the manufacturer for the proposed repair product.

Additional steel reinforcement to resist early thermal cracking for concrete repairs

8.59 Requirements for additional steel reinforcement within the concrete breakout area to reduce the risk of early thermal cracking shall be as specified in CC 484/WSR/008.

Requirements for additional steel reinforcement within the concrete breakout area to reduce the risk of early thermal cracking	
Concrete breakout area ID	**Additional steel reinforcement bar or fabric requirements**
(a)	(b)

a) Enter a unique reference.

b) Enter text, to identify the additional reinforcement required for each concrete breakout area.

Installing additional or replacement steel reinforcement for concrete repairs

8.60 Existing steel reinforcement with section losses greater than the acceptable limit shall be treated as follows:.

1. existing damaged bars to be removed and replaced with new carbon steel reinforcement with one of the allowed methods of splicing; or

2. existing damaged bars to be left in place and supplemented with additional carbon steel reinforcement with one of the allowed methods of splicing.

8.61 To restore the cross-sectional area, the new steel reinforcement shall be the same diameter as the original reinforcement prior to corrosion damage or a larger diameter.

8.62 The splicing of replacement or additional steel reinforcement to existing shall be as specified in CC 484/WSR/008.

The splicing of replacement or additional steel reinforcement to existing	
Concrete breakout area ID	**Permitted method(s) of reinforcement splicing**
(a)	(b)

a) Enter a unique reference.

b) Enter one or more values, from options lapping, mechanical coupling, welding, to identify the permitted method or methods of reinforcement splicing.

8.63 Additional or replacement steel reinforcement shall be positioned to achieve at least the same concrete cover as the adjacent existing bars.

8.64 Existing or new reinforcement bars or fabric consisting of different metallic materials shall be isolated from direct contact with each other to prevent occurrence of bimetallic corrosion.

Lapping of reinforcement for concrete repairs

8.65 The requirements for lapping of new steel reinforcement to existing reinforcement shall be as stated in CC 484/WSR/008.

SI.8.65 The minimum lapping length of new steel reinforcement to existing reinforcement expressed as a multiple of the diameter of existing reinforcement shall be [enter a number].

8.66 Tying wire in accordance with CC 482 [Ref 49.N] shall be used to secure lapped reinforcement and all bar intersections within the concrete breakout area.

Reinforcement couplers for concrete repairs

8.67 Reinforcement couplers for concrete repairs shall be installed in accordance with the manufacturer's instructions.

8.68 The minimum concrete cover to reinforcement couplers shall be as stated in CC 484/WSR/008.

SI.8.68 The minimum cover of concrete shall be [enter a number] .

Installation requirements for welding of reinforcement in concrete repairs

8.69 The welding of reinforcement in the concrete repair works shall not commence until the verification of the welded test joints has been completed in accordance with the examination and testing requirements of BS EN ISO 17660-1 [Ref 66.N].

8.70 Welded joints for steel reinforcement in concrete repairs shall be undertaken using welding process ISO 4063-111 - manual metal arc welding in accordance with BS EN ISO 17660-1 [Ref 66.N] and BS EN 13670 [Ref 10.N].

8.71 The following Documentation shall be submitted for welding new and existing steel reinforcement prior to the commencement of welding new and existing steel reinforcement: Details of the proposed welding procedure for welded joints between new and existing steel reinforcement.

8.72 Documentation for Details of the proposed welding procedure for welded joints between new and existing steel reinforcement shall be

submitted at least 5 working days prior to commencement of welding new and existing steel reinforcement.

Installation requirements for products and systems for anchoring of steel reinforcement bars and dowels in concrete repairs

8.73 The installation of products for the anchoring of steel reinforcement bars and dowels in concrete repairs shall comply with the requirements in "Steel reinforcement for structural concrete" in Section 4 of CC 482 [Ref 49.N].

Installation verification requirements for steel reinforcement in concrete repairs

Measurement of lap lengths for lapped reinforcement bars

8.74 Verification shall be undertaken for lap lengths between new and existing steel reinforcement in concrete repairs by measurement of lap lengths between new and existing steel reinforcement.

8.75 The frequency of measurement of lap lengths between new and existing steel reinforcement shall be once for all lapped reinforcement bars in concrete repairs.

8.76 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to measurement of lap lengths between new and existing steel reinforcement.

Inspection of completed surface preparation for steel reinforcement and other steel surfaces

8.77 Verification shall be undertaken for existing reinforcement or other steel substrate exposed in the area to be repaired by inspection of standard of surface preparation and cleanliness.

8.78 The frequency of inspection of standard of surface preparation and cleanliness shall be every reinforcing bar or all other steel surfaces exposed in the areas to be repaired.

8.79 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to inspection of standard of surface preparation and cleanliness of steel reinforcing bars or other steel surfaces.

Inspection and testing of completed reinforcement welded joints in concrete repairs

8.80 Verification shall be undertaken for completed welded joints by visual inspection in accordance with BS EN ISO 17660-1 [Ref 66.N].

8.81 The frequency of visual inspection of welded joint shall be 100% of welded joints following completion of welding unless otherwise stated in CC 484/WSR/008.

8.82 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to visual inspection of welded joints.

8.83 Verification shall be undertaken for completed welded joints by magnetic particle inspection in accordance with BS EN 17638 [Ref 22.N].

8.84 The frequency of magnetic particle inspection shall be to 25% of welded joints on completion of welding unless otherwise stated in CC 484/WSR/008.

8.85 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to magnetic particle inspection of completed welded joints.

8.86 Verification shall be undertaken for completed welded joints by hardness testing in accordance with BS EN ISO 6507-1 [Ref 18.N], BS EN ISO 6507-2 [Ref 19.N]and BS EN ISO 6507-3 [Ref 17.N].

8.87 The frequency of hardness testing of welded joints shall be 10% of welded joints on completion of welding unless otherwise stated in CC 484/WSR/008.

8.88 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to hardness testing of completed welded joints.

8.89 Verification shall be undertaken for completed welded joints by ultrasonic testing in accordance with BS EN ISO 17640 [Ref 23.N].

8.90 The frequency of ultrasonic testing of welded joints shall be 10% of welded joints on completion of welding unless otherwise stated in CC 484/WSR/008.

8.91 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to ultrasonic testing of completed welded joint.

8.92 The inspection and testing of completed reinforcement welded joints in concrete repairs shall be as specified in CC 484/WSR/008.

The inspection and testing of completed reinforcement welded joints in concrete repairs				
Concrete breakout area ID	**Percentage of welded joints subject to visual inspection**	**Percentage of welded joints subject to magnetic particle inspection**	**Percentage of welded joints subject to hardness testing**	**Percentage of welded joints subject to ultrasonic testing**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter a number in units of %, to identify the percentage of welded joints within the breakout area subject to visual inspection.

c) Enter a number in units of %, to identify the percentage of welded joints within the breakout area subject to magnetic particle inspection.

d) Enter a number in units of %, to identify the percentage of welded joints within the breakout area subject to hardness testing.

e) Enter a number in units of %, to identify the percentage of welded joints within the breakout area subject to ultrasonic testing.

8.93 The following Documentation shall be submitted for inspection and testing of completed reinforcement welded joints in concrete repairs prior to the commencement of concrete repairs: Completed reinforcement welded joints inspection and testing report.

8.94 Documentation for Completed reinforcement welded joints inspection and testing report shall be submitted 5 working days prior to commencing the concrete repair material installation.

9. Galvanic anodes for control of incipient anode effect

General requirements for galvanic anode products and systems

9.1 Galvanic anode Type 1A products shall consist of anode units tied directly to existing reinforcement and embedded within the proposed concrete repair.

9.2 Galvanic anode Type 1B products shall consist of anode units installed in backfilled holes drilled into the existing concrete substrate within the proposed concrete repair and electrically connected to existing reinforcement.

9.3 Galvanic anodes shall have a core consisting of pure zinc, or zinc with limited alloying additions, complying with one of the following three material options:.

1. Primary zinc, grade Z2, in accordance with BS EN 1179 [Ref 68.N];

2. Special high-grade zinc in accordance with ASTM B418 [Ref 46.N];

3. Special high-grade zinc in accordance with ASTM B6 [Ref 47.N]with suitable alloying additions conforming to the limits in table 1 of ASTM B418 [Ref 46.N].

9.4 Galvanic anodes shall have one or more corrosion resistant wires or strips which protrude from the core of the anode and are long enough to form an effective electrical connection between the anode and the existing reinforcement.

9.5 The galvanic metal element, activating agent and the backfill material shall not generate chemicals which could increase the corrosion risk to the reinforcing steel throughout the service life of the system.

9.6 Galvanic anodes shall be compatible with other components parts of the anode system.

9.7 Chemical reaction products of a galvanic anode shall not cause damage to the repaired concrete nor the existing concrete.

Marking and labelling of galvanic anodes, embedded reference electrodes and ancillary components

9.8 Galvanic anodes and embedded reference electrodes shall be marked with a manufacturer's unique product identifier.

Supply and storage of galvanic anodes, embedded reference electrodes and ancillary components

9.9 Galvanic anodes and ancillary components shall be supplied and stored in accordance with the manufacturer's instructions and BS EN 1504-10 [Ref 32.N].

Product requirements for performance of galvanic anodes

9.10 Galvanic anodes shall provide a protective zone of influence to steel reinforcement which extends at least 300mm beyond the perimeter of the repair area for the specified service life.

9.11 Evidence of successful performance in service of at least 5 years, shall be provided for galvanic anodes used on similar structures with comparable environmental exposure conditions where existing concrete adjacent to repaired concrete element does not show signs of corrosion or delamination.

Contractor design requirements for galvanic anode systems

9.12 Galvanic anode systems within concrete repairs to be Contractor design items shall be as specified in CC 484/WSR/009.

Galvanic anode systems within concrete repairs to be Contractor design items							
Structure ID	**Structural element**	**Repair area ID**	**Drawing/ model reference(s)**	**Steel reinforcement density ratio**	**Chloride ion concentration by weight of cement**	**Monitoring of galvanic anode system required**	**Where monitoring is required, type of monitoring**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring repair.

c) Enter a unique reference.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter a number, to identify the steel reinforcement density ratio of the repair area expressed as surface area of steel reinforcement divided by surface area of concrete substrate for the element in location of repair.

f) Enter a number in units of %, to identify chloride ion concentration in adjacent unrepaired concrete expressed as percentage by weight of cement.

g) Enter a value, from options yes, no, to specify whether long-term performance monitoring of galvanic anodes within repair is required.

h) Enter a value, from options not applicable, manual monitoring, remote monitoring, to monitoring type if monitoring required.

9.13 The design of galvanic anode systems for control of incipient anode effect shall be in accordance with CS 462 [Ref 40.N].

9.14 The requirements for "Contractor design" in Section 17 of GC 101 [Ref 13.N] shall apply to galvanic anode systems.

9.15 Proprietary galvanic anode systems shall be designed for a maintenance-free service life of at least 10 years when used to protect steel reinforcement located within existing concrete contaminated with chlorides, unless otherwise stated in CC 484/WSR/009.

SI.9.15 The maintenance-free service life of galvanic anodes shall be [enter a number] .

9.16 The design of permanent embedded reference electrodes for galvanic anode systems shall be in accordance with BS EN ISO 12696 [Ref 1.N].

9.17 The requirements for "Contractor design" in Section 17 of GC 101 [Ref 13.N] shall apply to permanent embedded reference electrodes.

Product requirements for reference electrodes used with galvanic anode systems for performance monitoring

9.18 Permanently embedded reference electrodes for long term monitoring of galvanic anode systems shall be compliant with BS EN ISO 12696 [Ref 1.N].

9.19 The embedded reference electrodes shall have a proven successful maintenance-free performance in service of at least 10 years on similar structures with comparable environmental exposure conditions, unless otherwise stated in CC 484/WSR/009.

9.20 Product requirements of reference electrodes for the performance monitoring of galvanic anodes shall be as specified in CC 484/WSR/009.

Product requirements of reference electrodes for the performance monitoring of galvanic anodes				
Structure ID	**Drawing/model reference**	**Reference electrode ID**	**Type of reference electrode**	**Service life of reference electrode**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter a unique reference, to provide reference(s) of drawing or model where ID and location of reference electrodes are shown.

c) Enter a unique reference, to provide reference of each reference electrode.

d) Enter a value, from options silver/silver chloride, manganese dioxide, to identify the type of reference electrode.

e) Enter a number in units of year, to specify the minimum service life.

9.21 The reference electrode potential shall remain thermodynamically stable during the service life of the embedded reference electrode, regardless of variations in concrete temperature.

9.22 Embedded reference electrodes shall be compatible with all other component parts in the galvanic anode system.

Product requirements for junction boxes used with galvanic anode systems for performance monitoring

9.23 Product requirements of junction boxes for the performance monitoring of galvanic anodes shall be as specified in CC 484/WSR/009.

Product requirements of junction boxes for the performance monitoring of galvanic anodes						
Structure ID	**Drawing/ model reference**	**Junction box ID**	**Service life of junction box**	**IP rating of junction box**	**IK rating of junction box**	**Junction box colour**
(a)	(b)	(c)	(d)	(e)	(f)	(g)

a) Enter a unique reference.

b) Enter a unique reference, to provide reference(s) of drawing or model where box ID and location of junction boxes are shown.

c) Enter a unique reference.

d) Enter a number in units of year, to specify the minimum service life.

e) Enter text, to specify the ingress protection rating in accordance with BS EN 60529 [Ref 6.N].

f) Enter text, to specify the impact protection of the junction box in accordance with BS EN 62262 [Ref 5.N].

g) Enter text, to specify colour of the junction box in accordance with RAL P1 [Ref 39.N].

Product requirements for cables used with galvanic anode systems for performance monitoring

9.24 Single core cable products for the performance monitoring of galvanic anodes shall comply with "Cables and cable management systems For Impressed Current Cathodic Protection Systems" in Section 16 of CC 485 [Ref 14.N].

Documentation requirements for product verification of galvanic anode systems

9.25 The following Documentation shall be submitted for galvanic anodes prior to the commencement of concrete repair works: Evidence of satisfactory performance of galvanic anodes without premature delamination of the concrete due to incipient anode corrosion immediately adjacent to and up to 300mm away from the repair perimeter for the specified design life.

9.26 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to Evidence of satisfactory performance of galvanic anodes without premature delamination of the concrete due to incipient anode corrosion immediately adjacent to and up to 300mm away from the repair perimeter for the specified design life.

9.27 The following Documentation shall be submitted for galvanic anodes prior to the commencement of concrete repair works: Evidence of the quality of the anode manufacturing process.

9.28 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to Evidence of the quality of the anode manufacturing process.

9.29 The following Documentation shall be submitted for galvanic anodes prior to the commencement of concrete repair works: Evidence consisting of 3 or more reports demonstrating successful performance of galvanic anode system in service of at least 5 years, where repaired concrete element does not show signs of corrosion or delamination.

9.30 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to Evidence consisting of 3 or more reports demonstrating successful performance of galvanic anode system in service of at least 5 years, where repaired concrete element does not show signs of corrosion or delamination.

9.31 The following Documentation shall be submitted for galvanic anodes and where specified embedded reference electrodes prior to the commencement of concrete repair works: Certificate confirming galvanic anodes and embedded reference electrodes conform with the requirements of this section of the document.

9.32 The requirements for "Documentation" in Section 2 of GC 101 [Ref 13.N] shall apply to Certificate confirming galvanic anodes and reference electrodes conform with the requirements of this document.

9.33 The following Documentation shall be submitted for cables used for performance monitoring of galvanic anode systems prior to the commencement of installation of cables: manufacturer's factory testing certification demonstrating conformity to the specified requirements.

General requirements for installation of galvanic anodes and reference electrodes

9.34 The installation of galvanic anodes and embedded reference electrodes shall be compliant with BS EN ISO 12696 [Ref 1.N]and the product manufacturer's instructions.

9.35 Installation of galvanic anode and reference electrodes shall be undertaken following preparation and cleaning of existing steel reinforcement, but not more than 3 hours afterwards.

Requirements for personnel installing, supervising installation and testing galvanic anode systems

9.36 The supervision of the installation of galvanic anodes and embedded reference electrodes shall be undertaken by qualified and certified personnel to Level 3 in reinforced concrete structures or higher in accordance with BS EN ISO 15257 [Ref 2.N].

9.37 The following Documentation shall be submitted for qualification and certification of personnel supervising the installation of galvanic anodes and embedded reference electrodes prior to the commencement of

installation of galvanic anodes and embedded reference electrodes within concrete repairs: Evidence of Level 3 or higher qualification and certification in accordance with BS EN ISO 15257 [Ref 2.N].

9.38 Documentation for Evidence of Level 3 or higher qualification and certification in accordance with BS EN ISO 15257 [Ref 2.N] shall be submitted at least 5 working days prior to the installation of galvanic anodes and embedded reference electrodes.

9.39 The testing of galvanic anodes and embedded reference electrodes and the undertaking of half-cell potential surveys shall be undertaken by qualified personnel certified to Level 2 or above in reinforced concrete structures in accordance with BS EN ISO 15257 [Ref 2.N].

9.40 The following Documentation shall be submitted for qualification and certification of personnel undertaking the testing of galvanic anodes and embedded reference electrodes, and half-cell potential surveys prior to the commencement of testing of galvanic anodes and embedded reference electrodes, and half-cell potential surveys: Evidence of Level 2 or higher qualification and certification in accordance with BS EN ISO 15257 [Ref 2.N].

9.41 Documentation for Evidence of Level 2 or higher qualification and certification in accordance with BS EN ISO 15257 [Ref 2.N] shall be submitted at least 5 working days prior to undertaking the testing of galvanic anodes and embedded reference electrodes, and half-cell potential surveys.

Installation requirements for galvanic anodes in concrete repairs

9.42 Installation requirements for galvanic anodes shall be as specified in CC 484/WSR/009.

Installation requirements for galvanic anodes								
Structure ID	**Structural element**	**Repair area ID**	**Drawing/ model reference(s)**	**Number of anodes**	**Maximum spacing**	**Type of monitoring if required**	**Diameter of drill hole for type 1B anodes**	**Depth of drill hole for type 1B anodes**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring galvanic anodes.

c) Enter a unique reference.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter a number, to identify the number of galvanic anodes in each repair area.

f) Enter a number in units of mm, to identify the maximum spacing between galvanic anodes around the perimeter of the repair area.

g) Enter a value, from options manual, remote, none, to identify the requirement for long-term performance monitoring of each repair area.

h) Enter a number in units of mm, to identify the diameter of pre-drilled holes required for the installation of the type 1B galvanic anode product.

i) Enter a number in units of mm, to identify the depth of pre-drilled holes required for the installation of the type 1B galvanic anode product.

Installation requirements for galvanic anodes (continued)	
Structure ID	**Number of negative connections**
(a)	(j)

j) Enter a number, to identify the number of negative connections to steel reinforcement for each repair area.

Installation of Type 1A galvanic anodes in concrete repairs

9.43 Type 1A galvanic anodes shall be installed within the repair area and a minimum of 25mm inside the perimeter.

9.44 Type 1A galvanic anodes shall be individually connected to steel reinforcement.

9.45 Type 1A galvanic anodes shall be positioned so that the specified minimum concrete cover to outer reinforcement is not reduced.

9.46 Where the existing cover is less than the specified concrete cover, Type 1A galvanic anodes shall be positioned to ensure the existing concrete cover is maintained.

9.47 Where the electrical resistivity of the repair concrete or mortar is expected to be greater than 15 kOhm.cm for completed repairs containing Type 1A galvanic anodes, a conductive bridging material shall be provided locally around each anode in accordance with the galvanic anode manufacturer's instructions.

9.48 Conductive bridging materials for Type 1A galvanic anodes shall provide electrical continuity between the Type 1A galvanic anode, the reinforcement and the existing concrete substrate.

9.49 Where spray-applied repair concrete or mortar is used to reinstate the broken out area, a conductive bridging material shall be provided around each Type 1A galvanic anode and installed to be in contact with the reinforcement and existing concrete substrate..

Installation of Type 1B galvanic anodes in concrete repairs

9.50 Type 1B galvanic anodes shall be installed in holes drilled within the area of removed concrete and immediately adjacent to the perimeter of the concrete repair.

9.51 Holes for type 1B galvanic anodes shall be drilled perpendicular to the substrate or at an angle to perpendicular so the end of the anode hole lies less than 100mm outside the perimeter of the repair area.

9.52 Drilling of holes for type 1B galvanic anodes shall not cause damage to the surrounding concrete substrate nor damage existing reinforcement bars.

9.53 Type 1B galvanic anodes shall either be individually connected to steel reinforcement or connected in series with a feeder wire in accordance with the manufacturer's instructions.

9.54 For the installation of Type 1B galvanic anodes connected in series with a feeder wire, the number of connections to steel reinforcement shall be provided in accordance with the manufacturer's instructions.

9.55 Type 1B galvanic anodes shall be installed to achieve a minimum concrete cover of 20mm for deck repairs or 15mm for vertical and overhead repairs.

9.56 Negative electrical connections between the Type 1B galvanic anode and the steel reinforcement shall be made in accordance with the manufacturer's instructions.

9.57 The backfill material used for bedding and surrounding the Type 1B galvanic anodes placed within pre-drilled holes shall surround each anode unit and completely fill the annular void, uniformly connecting each anode

with existing concrete to ensure continuous operation of the anode for the duration of the anode service life.

9.58 The backfill material shall maintain anode performance, accommodate anode corrosion products and resist acids generated at the anode/concrete interface during the service life of the anode.

9.59 The electrical resistivity of the backfill material for Type 1B galvanic anodes shall be in accordance with "Concrete repairs - general requirements" in Section 4 of this document.

Installation requirements of embedded reference electrodes for performance monitoring of galvanic anodes

9.60 Installation requirements for embedded reference electrodes shall be as specified in CC 484/WSR/009.

Installation requirements for embedded reference electrodes							
Structure ID	**Structural element**	**Repair area ID**	**Drawing/ model reference(s)**	**Type of embedded reference electrodes**	**Number of embedded reference electrodes**	**Location of embedded reference electrodes**	**Diameter of drill hole**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring embedded reference electrodes.

c) Enter a unique reference.

d) Enter text, to cross reference relevant drawing(s)/model(s).

e) Enter a value, from options silver/silver chloride, manganese dioxide, to identify the type of reference electrode to be installed.

f) Enter a number, to identify the number of embedded reference electrodes in each repair area.

g) Enter text, to identify the location of embedded reference electrodes in each repair area.

h) Enter a number in units of mm, to identify the diameter of the pre-drilled hole for the installation of the embedded reference electrode.

Installation requirements for embedded reference electrodes (continued)	
Structure ID	**Depth of drill hole**
(a)	(i)

i) Enter a number in units of mm, to identify the depth of the pre-drilled hole for the installation of the embedded reference electrode.

9.61 A separate negative test connection to steel reinforcement shall be made for each embedded reference electrode and connected in accordance with the manufacturer's instructions.

9.62 The backfill material used for bedding and surrounding embedded reference electrodes placed within pre-drilled holes shall be cementitious or polymer-modified cementitious material.

9.63 The backfill material shall surround the embedded reference electrode units to completely fill the annular void, uniformly connecting the embedded reference electrode with existing concrete and ensuring continuous operation of the embedded reference electrode for the duration of the service life.

9.64 The electrical resistivity for the backfill material for bedding and surrounding embedded reference electrodes shall be in accordance with "Concrete repairs - general requirements" in Section 4 of this document.

Installation requirements of junction boxes for performance monitoring of galvanic anodes

9.65 Installation requirements for junction boxes for the performance monitoring of galvanic anodes shall be as specified in CC 484/WSR/009.

Installation requirements for junction boxes for the performance monitoring of galvanic anodes								
Structure ID	**Structural element**	**Junction box ID**	**Junction box location**	**Drawing/ model reference(s)**	**Number of positive terminals**	**Number of negative terminals**	**Number of reference electrode terminals**	**Number of test connection terminals**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)

a) Enter a unique reference.

b) Enter a unique reference, to identify the structural element where the junction box will be located.

c) Enter a unique reference.

d) Enter text, to identify the location where on the structural element the junction box is to be installed.

e) Enter a unique reference, to provide reference(s) of drawing or model where location of junction box is shown.

f) Enter a number, to identify the number of positive terminals within the junction box.

g) Enter a number, to identify the number of negative terminals within the junction box.

h) Enter a number, to identify the number of reference electrode terminals within the junction box.

i) Enter a number, to identify the number of test connection terminals within the junction box.

Installation requirements for junction boxes for the performance monitoring of galvanic anodes (continued)				
Structure ID	**Power supply required**	**Type of power supply**	**Data logger required**	**Number of channels**
(a)	(j)	(k)	(l)	(m)

j) Enter a value, from options yes, no, to identify the requirement for a power supply.

k) Enter a value, from options battery, rechargeable battery, permanent connection to mains electricity, to identify the type of power supply for the junction box.

l) Enter a value, from options yes, no, to identify the requirement for a data logger.

m) Enter a number, to identify the number of channels required for the data logging equipment.

9.66 Internal dimensions of junction box shall be large enough to accommodate all terminals and cables and permit measurements and disconnection of either individual anodes or groups of anodes.

Installation requirements of cables for performance monitoring of galvanic anodes

9.67 Installation of cables shall comply with "Cables and cable management systems For Impressed Current Cathodic Protection Systems" in Section 16 of CC 485 [Ref 14.N].

9.68 Requirements for installation of single core cables shall be as specified in CC 484/WSR/009.

Requirements for installation of single core cables					
Structure ID	**Structural element**	**Drawing/model reference(s)**	**Anode zone ID**	**Single core cable ID**	**Single core cable type**
(a)	(b)	(c)	(d)	(e)	(f)

a) Enter a unique reference.

b) Enter text, to identify the element which requires the installation of single core cables.

c) Enter a unique reference, to identify reference of relevant drawing(s)/model(s).

d) Enter a unique reference.

e) Enter a unique reference.

f) Enter a value, from options DC positive, DC negative, reference electrode, monitoring test connection, to identify the purpose of the single core cable.

Installation requirements for continuity bonding of existing reinforcement

9.69 Galvanic anodes shall be made electrically continuous with the existing steel reinforcement during the installation of the galvanic anode system.

9.70 Electrically isolated steel reinforcement shall be made electrically continuous with the existing steel reinforcement in a repair area using any of the following options:.

1. Length of tying wire between electrically continuous and discontinuous steel reinforcement;

2. Welding of uncoated steel rod between electrically continuous and discontinuous steel reinforcement;

3. Connection of lengths of single core cables between electrically continuous and discontinuous steel reinforcement.

9.71 Tying wire for making steel electrically continuous shall comply with "Steel reinforcement for concrete repairs" in Section 8 of this document.

9.72 Welding for making steel reinforcement electrically continuous shall comply with the requirements for tack welding in accordance with BS EN ISO 17660-2 [Ref 67.N].

9.73 The establishment of electrical continuity of electrically isolated steel reinforcement shall be completed prior to galvanic anode installation and application of concrete repair materials.

Installation verification requirements for galvanic anode systems

Electrical continuity testing of steel reinforcement

9.74 The electrical continuity of steel reinforcement shall be tested at all intersections of steel reinforcement within the repair areas in accordance with BS EN ISO 12696 [Ref 1.N] and CS TR60 [Ref 7.N].

9.75 All rust and contamination on the surface of the steel reinforcement shall be locally removed prior to electrical continuity testing.

9.76 The cleaning and removal of rust and contamination from the surface of steel reinforcement shall comply with "Steel reinforcement for concrete repairs" in Section 8 of this document.

9.77 Electrical discontinuities in the top layer of reinforcement shall be deemed to be present if one or more of the following electrical conditions apply:.

1. DC resistance readings greater than 1.0 Ohm as an average of both forwards and reverse measuring directions between the electrically continuous and discontinuous steel reinforcement;

2. Fluctuating or unstable DC resistance readings;

3. An IR free potential difference greater than 1mV between the electrically continuous and discontinuous steel reinforcement.

9.78 Electrically discontinuities in the steel reinforcement shall be identified by either DC reverse polarity resistance or DC potential difference technique using a test instrument in accordance with BS EN ISO 12696 [Ref 1.N].

9.79 Steel reinforcement identified as electrically isolated from the electrical continuity testing shall be made electrically continuous by bonding to existing steel reinforcement in accordance with BS EN ISO 12696 [Ref 1.N].

9.80 Verification shall be undertaken for electrical continuity of steel reinforcement within the repair areas by electrical continuity testing.

9.81 The frequency of electrical continuity testing of steel reinforcement shall be prior to installation of the galvanic anode system and the undertaking of half-cell potential surveys.

9.82 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to electrical continuity testing of steel reinforcement.

9.83 The following Documentation for electrical continuity testing of steel reinforcement shall be submitted as continuous records: measurements and written records of continuity, bonding and re-checking.

9.84 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to continuity testing of steel reinforcement.

Electrical potential mapping survey by half-cell to verify the effectiveness of galvanic anode protection

9.85 Verification shall be undertaken for effectiveness of galvanic anode protection to steel reinforcement adjacent to concrete repair areas by half-cell electrical potential mapping survey.

9.86 The frequency of half-cell electrical potential mapping surveys for each structural element shall be a minimum of all the anodes installed in 20% of the repaired areas subject to a minimum of two repaired areas, or 10% of total installed anodes whichever is greater number of installed anodes for each structural element.

9.87 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to half-cell potential mapping survey of steel reinforcement.

9.88 Survey points for electrical potential mapping survey of steel reinforcement shall be located 250mm apart and at a distance of 250mm outside the perimeter of the repair area.

9.89 Half-cell electrical potential mapping surveys of steel reinforcement shall be undertaken twice as follows:.

1. following removal of defective concrete, before galvanic anodes are connected to the steel reinforcement and

2. following connection of anodes to the existing reinforcement, completion of repair and when the repair concrete is at least 14 days old

9.90 The half-cell electrical potential mapping survey shall be undertaken in accordance with ASTM C876 [Ref 20.N], CS TR60 [Ref 7.N] and TRL AG 9 [Ref 65.N].

9.91 Measurements of electrical potential shall be undertaken at the same survey points for each repair area tested.

9.92 The half-cell electrical potential mapping survey of steel reinforcement shall be undertaken on physically sound parent concrete.

9.93 Portable reference electrodes and measurement instruments shall comply with the requirements of BS EN ISO 12696 [Ref 1.N].

9.94 Copper (Cu)/Copper sulphate (saturated $CuSO_4$) reference electrodes (CSE) shall not be used as a portable reference electrode for half-cell potential mapping survey of steel reinforcement.

9.95 Verification for half-cell potential mapping survey shall be undertaken by an accredited testing laboratory in compliance with "Accredited laboratory" in Section 16 of GC 101 [Ref 13.N].

9.96 The following Documentation for half-cell electrical potential mapping survey of steel reinforcement shall be submitted as continuous records: Measurements, written records and annotated drawings of half-cell electrical potential mapping showing precise locations of survey points and galvanic anodes referenced in each repair area tested.

9.97 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to half-cell potential mapping survey of steel reinforcement.

9.98 Measurements, written records and annotated drawings of half-cell electrical potential mapping surveys shall record the make and type of instrument used for the survey.

Calibration of portable reference electrodes for half-cell electrical potential mapping survey of steel reinforcement

9.99 Portable reference electrodes shall be calibrated in accordance with BS EN ISO 12696 [Ref 1.N]prior to the start of each shift.

9.100 The following Documentation shall be submitted for standard unused portable reference electrodes prior to the commencement of any half-cell electrical potential mapping survey of steel reinforcement: valid calibration certificate.

9.101 Verification shall be undertaken for calibration of portable reference electrodes by checking against a laboratory standard unused electrode calibrated in a laboratory.

9.102 The frequency of calibration of portable reference electrode shall be prior to each use.

9.103 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to calibration of portable reference electrodes.

9.104 The following Documentation for calibration testing of portable reference electrodes shall be submitted as continuous records: measurements and written records of site calibration of portable reference electrodes.

9.105 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to calibration testing of portable reference electrodes.

Electrical continuity between galvanic anodes and steel reinforcement

9.106 The electrical continuity between galvanic anodes and connected steel reinforcement shall be confirmed by a resistance measurement less than 1.0 Ohm between the two metals when measured with a high-impedance multi-meter in accordance with BS EN ISO 12696 [Ref 1.N].

9.107 Verification shall be undertaken for the electrical continuity between galvanic anodes and connected steel reinforcement by electrical continuity testing.

9.108 The frequency of electrical continuity testing between galvanic anodes and steel reinforcement shall be all galvanic anodes installed.

9.109 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to electrical continuity testing between galvanic anodes and steel reinforcement.

9.110 The following Documentation for electrical continuity testing between galvanic anodes and steel reinforcement shall be submitted as continuous records: measurements and written records of electrical continuity.

9.111 The requirements of "Records" in Section 3 of GC 101 [Ref 13.N] shall apply to electrical continuity testing between galvanic anodes and steel reinforcement.

10. Filling or injecting cracks & voids in concrete

General requirements for filling or injection products

10.1 Crack filling or injection products shall comply with BS EN 1504-5 [Ref 28.N].

10.2 Crack filling or injection products shall be formulated with hydraulic (H) or reactive polymer (P) binder as defined in BS EN 1504-5 [Ref 28.N], unless otherwise stated in CC 484/WSR/010.

SI.10.2 The binder of crack filling or injection products in accordance with BS EN 1504-5 [Ref 28.N] shall be [enter free text].

10.3 The system of assessment and verification of constancy of performance (or attestation of conformity) for all filling or injection products or systems used for concrete repair work shall be 2+ (for uses in buildings and civil engineering works) in accordance with Annex ZA.2 of BS EN 1504-5 [Ref 28.N].

Geometric properties of cracks and minor voids to be filled or injected

10.4 Location and dimensions of cracks, groups of similar cracks or voids to be repaired by filling or injection shall be as specified in CC 484/WSR/010.

Location and dimensions of cracks, groups of similar cracks or voids to be repaired by filling or injection							
Structure ID	**Structural element**	**Crack ID**	**Location of crack**	**Drawing/ model reference(s)**	**Length of crack**	**Minimum width of crack**	**Maximum width of crack**
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)

a) Enter a unique reference.

b) Enter text, to describe the structural element which requires crack filling or injection e.g. beam 4, deck 2.

c) Enter a unique reference.

d) Enter text, to identify location of crack/void defect area to be treated on the structural element e.g. East end, south side etc.

e) Enter text, to cross reference relevant drawing(s) or model(s).

f) Enter a number in units of mm, to identify the length of the crack to be filled or injected.

g) Enter a number in units of mm, to identify the minimum width of the crack to be filled or injected.

h) Enter a number in units of mm, to identify the maximum width of the crack to be filled or injected.

Location and dimensions of cracks, groups of similar cracks or voids to be repaired by filling or injection (continued)		
Structure ID	**Average width of crack**	**Depth of crack**
(a)	(i)	(j)

i) Enter a number in units of mm, to identify the average width of the crack to be filled or injected.

j) Enter a number in units of mm, to identify the depth of crack to be filled or injected..

BS EN 1504-9 repair method and BS EN 1504-5 function of products for filling or injecting cracks or minor voids

10.5 Method and function of concrete crack filling or injection products in accordance with BS EN 1504-5 shall be as specified in CC 484/WSR/010.

Method and function of concrete crack filling or injection products in accordance with BS EN 1504-5		
Crack ID	**BS EN 1504-9 [Ref 30.N]method of filling or injection required**	**Function of concrete crack filling or injection product**
(a)	(b)	(c)

a) Enter text, to identify unique reference for crack/void area to be treated.

b) Enter one or more values, from options method 1.5 Filling of cracks, method 4.5 Injecting cracks, voids or interstices, method 4.6 Filling cracks, voids or interstices, to identify the method the filling/injection product is used for to achieve the principles defined in BS EN 1504-9 [Ref 30.N].

c) Enter a value, from options force transmitting filling (category F), ductile filling (category D), swelling fitted filling (category S), to identify the intended function of filling/injection products in accordance with BS EN 1504-5 [Ref 28.N].

Product performance requirements for filling or injection of cracks in accordance with BS EN 1504-5

Requirements of crack filling or injection products for Category F force transmitting filling

10.6 Category F force transmitting filling crack filling or injection products shall be compliant with BS EN 1504-5 [Ref 28.N].

10.7 The category F force transmitting filling crack filling or injection products shall meet the performance characteristics as stated in table 1.a 'for all intended uses' and table 3.a of BS EN 1504-5 [Ref 28.N]for associated performance requirements.

10.8 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to category F force transmitting filling crack filling or injection products.

10.9 Adhesion by bond strength of category F force transmitting filling crack filling or injection products in accordance with BS EN 1504-5 shall be class F1, unless otherwise stated in CC 484/WSR/010.

Adhesion by bond strength of category F force transmitting filling crack filling or injection products in accordance with BS EN 1504-5		
Structure ID	**Crack ID**	**Adhesion by bond strength class of category F force transmitting filling crack filling or injection products**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter a value, from options F1, F2, to specify the adhesion by bond strength class of category F crack filling or injection products in accordance with BS EN 1504-5 [Ref 28.N].

10.10 The performance characteristics for 'certain intended uses' as defined in table 3.a of BS EN 1504-5 for category F force transmitting filling crack filling or injection products shall be as specified in CC 484/WSR/010.

The performance characteristics for 'certain intended uses' as defined in table 3.a of BS EN 1504-5 for category F force transmitting filling crack filling or injection products		
Structure ID	**Crack ID**	**Performance characteristics of category F force transmitting crack filling or injection products for 'certain intended uses' as defined in BS EN 1504-5 [Ref 28.N]**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter one or more values, from options adhesion by slant shear strength, glass transition temperature, chloride content, N/A, to specify performance characteristics for 'certain intended uses' as defined in BS EN 1504-5 [Ref 28.N]for category F force transmitting crack filling or injection products.

Requirements of crack filling or injection products for Category D ductile filling

10.11 Category D ductile filling crack filling or injection products shall be compliant with BS EN 1504-5 [Ref 28.N].

10.12 The category D ductile crack filling or injection products shall meet the performance characteristics as stated in table 1.b 'for all intended uses' and table 3.b of BS EN 1504-5 [Ref 28.N] for associated performance requirements.

10.13 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to category D ductile crack filling or injection products.

10.14 Watertightness of category D ductile crack filling or injection products in accordance with BS EN 1504-5 shall be class D1, unless otherwise stated in CC 484/WSR/010.

Watertightness of category D ductile crack filling or injection products in accordance with BS EN 1504-5		
Structure ID	**Crack ID**	**Watertightness class of category D ductile crack filling or injection products**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter a value, from options D1, D2, to specify the watertightness class of category D ductile crack filling or injection products in accordance with Annex A of BS EN 1504-5 [Ref 28.N].

10.15 The performance characteristics for 'certain intended uses' as defined in table 3.b of BS EN 1504-5 for category D ductile crack filling or injection products shall be as specified in CC 484/WSR/010.

The performance characteristics for 'certain intended uses' as defined in table 3.b of BS EN 1504-5 for category D ductile crack filling or injection products				
Structure ID	**Crack ID**	**Performance characteristics of category D ductile crack filling or injection products for 'certain intended uses' as defined in BS EN 1504-5 [Ref 28.N]**	**Glass transition temperature for category D ductile crack filling or injection products**	**Expansion ratio for category D ductile crack filling or injection products**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter one or more values, from options watertightness, glass transition temperature, expansion ratio and evolution, N/A, to specify performance characteristics for 'certain intended uses' as defined in BS EN 1504-5 [Ref 28.N] for category D ductile crack filling or injection products.

d) Enter a number in units of ºC, to specify the glass transition temperature for category D ductile crack filling or injection products where the glass transition temperature performance characteristic is specified.

e) Enter a number, to specify the expansion ratio for category D ductile crack filling or injection products where the expansion ratio performance characteristic is specified.

Requirements of crack filling or injection products for Category S swelling fitted filling

10.16 Category S swelling fitted filling crack filling or injection products shall be compliant with BS EN 1504-5 [Ref 28.N].

10.17 The category S swelling fitted filling crack filling or injection products shall meet the performance characteristics as stated in table 1.c

'for all intended uses' and table 3.c of BS EN 1504-5 [Ref 28.N]for associated performance requirements.

10.18 The requirements of "Designated standards" in Section 10 of GC 101 [Ref 13.N] shall apply to category S swelling fitted filling crack filling or injection products.

10.19 Watertightness of category S swelling fitted filling crack filling or injection products in accordance with BS EN 1504-5 shall be class S1, unless otherwise specified in CC 484/WSR/010.

Watertightness of category S swelling fitted filling crack filling or injection products in accordance with BS EN 1504-5		
Structure ID	**Crack ID**	**Water tightness class of category S swelling fitted filling crack filling or injection products**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter a value, from options S1, S2, to specify the watertightness class of category S swelling fitted filling crack filling or injection products in accordance with Annex A of BS EN 1504-5 [Ref 28.N].

10.20 The performance characteristics for 'certain intended uses' as defined in table 3.c of BS EN 1504-5 for category S swelling fitted filling crack filling or injection products shall be as specified in CC 484/WSR/010.

The performance characteristics for 'certain intended uses' as defined in table 3.c of BS EN 1504-5 for category S swelling fitted filling crack filling or injection products		
Structure ID	**Crack ID**	**Performance characteristics of category S swelling fitted filling crack filling or injection products for 'certain intended uses' as defined in BS EN 1504-5 [Ref 28.N]**
(a)	(b)	(c)

a) Enter a unique reference.

b) Enter a unique reference.

c) Enter one or more values, from options corrosion behaviour, N/A, to specify performance characteristics for 'certain intended uses' as defined in BS EN 1504-5 [Ref 28.N] for category S swelling fitted filling crack filling or injection products.

Verification requirements for surface condition of cracks or voids

Moisture content of concrete substrate and cracks

10.21 Installation of the crack filling or injection product shall not be undertaken where the moisture content of the concrete substrate and cracks exceeds the manufacturer's recommended threshold value for the maximum moisture content.

10.22 Verification shall be undertaken for the moisture content of the concrete substrate and cracks by the tests and observations in accordance with BS EN 1504-10 [Ref 32.N], observation No. 9.

10.23 The frequency of tests and observations in accordance with BS EN 1504-10 [Ref 32.N] shall be once per crack prior to application of the crack filling or injection product.

10.24 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to tests and observations in accordance with BS EN 1504-10 [Ref 32.N].

10.25 The testing requirements for determining the moisture content of the concrete substrate and cracks shall be as stated in CC 484/WSR/010.

SI.10.25 The testing requirements for determining the moisture content of the concrete substrate and cracks shall be [select one or more from: visual assessment of surface moisture, visual assessment of polythene film, relative humidity probes, electrical resistivity, drill or core samples for laboratory analysis].

Installation requirements for preparation of cracks prior to filling or injection

10.26 Debris lodged within the cracks and any surface contamination of the crack sides shall be removed before injection or filling in accordance with BS EN 1504-10 [Ref 32.N], observation no. 14.

10.27 The moisture content of the concrete substrate and cracks shall be reduced below the manufacturer's recommended threshold prior to installation of the crack filling or injection products.

10.28 The methods used for reducing the moisture content of the concrete substrate and cracks below the manufacturer's recommended threshold shall not cause damage to the concrete substrate.

Installation requirements for the mixing and application of crack filling or injection products

10.29 The mixing and application of category F, category D and category S crack filling or injection products shall be in accordance with annex A of BS EN 1504-10 [Ref 32.N]and the manufacturer's instructions.

10.30 The procedure for crack filling or injection shall ensure that all cracks and voids interconnected with surface cracks identified for repair are completely filled.

10.31 On completion of the crack filling or injection procedure, all spilled material shall be removed from adjacent surfaces of the structure.

Installation verification requirements for crack filling or injection products

Coring to demonstrate extent of crack filling or injection of repaired concrete

10.32 Cores shall be undertaken in accordance with "Concrete repairs - general requirements" in Section 4 of this document.

10.33 The minimum number of cores extracted shall be 3 cores for each specified function of crack filling or injection product in accordance with BS EN 1504-5 [Ref 28.N], unless otherwise stated in CC 484/WSR/004.

10.34 Cores to measure the degree of filling or injection of cracks for completed repairs shall be 50mm in diameter, unless otherwise stated in CC 484/WSR/004.

10.35 Cores to measure the degree of filling or injection of cracks for completed repairs shall be a minimum of 100mm in length.

Inspection and measurement of extent of completed crack filling or injection in cores

10.36 Verification shall be undertaken for the integrity of completed crack filling by inspecting the cores to measure the surface area of crack filling or crack injection as a percentage of the total surface area of crack visible in exposed surface of extracted cores.

10.37 The frequency of inspecting extracted cores to measure the percentage crack filling or crack injection by surface area of crack visible in exposed surface of extracted cores shall be once per core unless otherwise stated in CC 484/WSR/010.

SI.10.37 The frequency of inspecting extracted cores to measure the percentage of surface area of crack filling or crack injection by total surface area of crack visible in exposed surface of extracted cores shall be [enter a number].

10.38 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to inspecting extracted cores to measure the percentage of surface area of crack filling or crack injection by total surface area of crack visible in exposed surface of extracted cores.

10.39 The minimum percentage crack filling calculated by total surface area of the crack exposed in the core shall be 80%, unless otherwise stated in CC 484/WSR/010.

SI.10.39 The minimum percentage filling of cracks calculated by total surface area of crack exposed in the core shall be [enter a number] .

Tests for acceptance of completed crack filling or injection with Category F force transmitting filling product by compressive loading of cores to destruction

10.40 Where the percentage filling of cracks with category F force transmitting filling or injection material calculated by surface area of the crack exposed in the core is less than the specified minimum, the core strength and failure mode shall be verified by compressive testing to destruction.

10.41 Verification shall be undertaken for strength of cores extracted from cracks repaired using category F force transmitting materials where the percentage filling by surface area of the crack exposed in the core is less than the specified percentage, by loading the cores to destruction in compression.

10.42 The frequency of loading under compression to destruction of the extracted cores shall be once per core for each core extracted where the percentage filling by area of the crack exposed in the core is less than the specified minimum.

10.43 The requirements for "Verification" in Section 14 of GC 101 [Ref 13.N] shall apply to loading under compression to destruction of the cores.

10.44 Extracted cores tested by compressive strength testing to destruction when percentage filling for a category F force transmitting filling or injection material is less than the minimum specified shall be deemed satisfactory if either of the following failure conditions described in BS EN 12618-3 [Ref 35.N]apply.

1. a monolithic failure entirely within the concrete; or

2. where failure is predominantly along the glue line, a minimum core compressive strength of 20 MPa.

Documentation requirements for crack filling or injection testing

10.45 The following Documentation shall be submitted for testing of completed crack filling or injection prior to the commencement of satisfactory completion of crack filling or injection: Crack filling or injection testing report.

10.46 The crack filling or injection testing report shall provide an interpretive analysis of the observations and measurements undertaken for filling or injection of cracks, including; moisture content of concrete substrate and cracks, integrity of completed crack filling or injection, extent of crack filling, compressive strength of tested cores, failure mode of tested cores.

11. Temporary works for concrete repairs

General requirements for temporary works for concrete repairs

11.1 Temporary works for concrete repairs shall comply with "Temporary works" in Section 19 of GC 101 [Ref 13.N].

11.2 Site and structure specific constraints affecting the design of temporary works for concrete repairs shall be as described in CC 484/WSR/011.

Site and structure specific constraints affecting the design of temporary works for concrete repairs				
Structure ID	**Structural element**	**Type and purpose of temporary works**	**Drawing/ model reference(s)**	**Site and structure specific constraints affecting the design of temporary works**
(a)	(b)	(c)	(d)	(e)

a) Enter a unique reference.

b) Enter text, to identify the structural element requiring temporary works.

c) Enter text, to identify the type and purpose of the temporary works.

d) Enter text, to cross reference relevant drawing(s).

e) Enter text, to identify the constraints for the design of temporary works.

11.3 The minimum compressive cube strength of the concrete repairs before the temporary works are removed and loading is permitted shall meet the performance characteristics stated in CC 484/WSR/004.

12. 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	BSI. BS EN ISO 12696, 'Cathodic Protection of Steel in Concrete'
Ref 2.N	BSI. BS EN ISO 15257, 'Cathodic protection – Competence levels of cathodic protection persons – Basis for certification scheme'
Ref 3.N	BSI. BS EN 206, 'Concrete - specification, performance, production and conformity'
Ref 4.N	BSI. BS 8500-1, 'Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier.'
Ref 5.N	BSI. BS EN 62262, 'Degree of protection provided by enclosures for electrical equipment against external mechanical Impacts (IK code)'
Ref 6.N	BSI. BS EN 60529, 'Degrees of protection provided by enclosures (IP code). (Designated Standard - LVD)'
Ref 7.N	Concrete Society. CS TR60, 'Electrochemical Tests for Reinforcement Corrosion'
Ref 8.N	National Highways. GC 103 'Environment, Sustainability and Carbon Management'
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 13670, 'Execution of concrete structures'
Ref 11.N	BSI. BS EN 13501-1, 'Fire classification of construction products and building elements. Classification using data from reaction to fire tests'
Ref 12.N	BSI. BS 9999, 'Fire safety in the design, management and use of buildings - code of practice. '
Ref 13.N	National Highways. GC 101, 'General requirements for the Specification for Highway Works'
Ref 14.N	National Highways. CC 485, 'Impressed cathodic protection to reinforced concrete highway structures'

Ref 15.N	National Highways. CS 450, 'Inspection of highway structures'
Ref 16.N	National Highways. LA 110, 'Material assets and waste'
Ref 17.N	BSI. BS EN ISO 6507-3, 'Metallic materials. Vickers hardness test. Calibration of reference blocks '
Ref 18.N	BSI. BS EN ISO 6507-1, 'Metallic materials. Vickers hardness test. Test method'
Ref 19.N	BSI. BS EN ISO 6507-2, 'Metallic materials. Vickers hardness test. Verification and calibration of testing machines'
Ref 20.N	American Society for Testing and Materials. Subcommittee GO1.14. ASTM C876, 'Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete'
Ref 21.N	BSI. BS EN 1008, 'Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete.'
Ref 22.N	BSI. BS EN 17638, 'Non-destructive testing of welds. Magnetic particle testing'
Ref 23.N	BSI. BS EN ISO 17640, 'Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment'
Ref 24.N	BSI. BS EN ISO 8501-1, 'Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Rust grades and preparation grades of uncoated steel substrates and of steel substrates after removal of previous coatings'
Ref 25.N	BSI. BS EN 12190, 'Products and systems for the protection and repair of concrete structures - Test methods - Determination of compressive strength of repair mortar'
Ref 26.N	BSI. BS EN 1504-8, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and AVCP. Quality control and Assessment and verification of the constancy of performance (AVCP)'
Ref 27.N	BSI. BS EN 1504-6, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Anchoring of reinforcing steel bar (Designated Standard - CPR)'
Ref 28.N	BSI. BS EN 1504-5, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Concrete injection (Designated Standard - CPR)'

Ref 29.N	BSI. BS EN 1504-1, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Definitions'
Ref 30.N	BSI. BS EN 1504-9, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. General principles for use of products and systems'
Ref 31.N	BSI. BS EN 1504-7, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Reinforcement corrosion protection (Designated Standard - CPR)'
Ref 32.N	BSI. BS EN 1504-10, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Site application of products and systems and quality control of the works'
Ref 33.N	BSI. BS EN 1504-3, 'Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Structural and non-structural repair. (Designated Standard - CPR)'
Ref 34.N	BSI. BS EN 12190, 'Products and systems for the protection and repair of concrete structures. Test methods. Determination of compressive strength of repair mortar'
Ref 35.N	BSI. BS EN 12618-3, 'Products and systems for the protection and repair of concrete structures. Test methods. Determination of the adhesion of injection products, with or without thermal cycling. Slant shear method'
Ref 36.N	BSI. BS EN 13395-2, 'Products and systems for the protection and repair of concrete structures. Test methods. Determination of workability. Test for flow of grout or mortar'
Ref 37.N	BSI. BS EN 13395-3, 'Products and systems for the protection and repair of concrete structures. Test methods. Determination of workability. Test for flow of repair concrete'
Ref 38.N	BSI. BS EN 1542, 'Products and systems for the protection and repair of concrete structures. Test methods. Measurement of bond strength by pull-off'
Ref 39.N	Reichs-Ausschuß für Lieferbedingungen und Gütesicherung. https://www.ralcolorchart.com/. RAL P1, 'RAL Plastics P1 Colors'
Ref 40.N	National Highways. CS 462, 'Repair and management of deteriorated concrete highway structures'
Ref 41.N	International Concrete Repair Institute. Technical Guideline

	310.2R, 'Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays and Concrete Repair'
Ref 42.N	National Highways. GC 102 'Site and work constraints'
Ref 43.N	BSI. BS EN 14487-1, 'Sprayed concrete. Definitions, specifications and conformity'
Ref 44.N	BSI. BS EN 14487-2, 'Sprayed concrete. Execution'
Ref 45.N	BSI. BS 6744, 'Stainless steel bars for the reinforcement of and use in concrete, – Requirements and test methods'
Ref 46.N	American Society for Testing and Materials. ASTM B418, 'Standard specification for cast and wrought galvanic zinc anodes'
Ref 47.N	American Society for Testing and Materials. ASTM B6, 'Standard specification for zinc'
Ref 48.N	BSI. BS 8597, 'Steels for the reinforcement of concrete. Reinforcement couplers. Requirements and test methods'
Ref 49.N	National Highways. CC 482, 'Structural concrete'
Ref 50.N	The Society for Protective Coatings (SSPC) / NACE International (NACE). SSPC SP 12 / NACE No.5, 'Surface preparation and cleaning of metals by water-jetting prior to recoating'
Ref 51.N	National Highways. CG 300, 'Technical approval of highway structures'
Ref 52.N	BSI. BS EN 12504-1, 'Testing concrete in structures. Cored specimens. Taking, examining and testing in compression.'
Ref 53.N	BSI. BS EN 12350-7, 'Testing fresh concrete. Air content. Pressure methods'
Ref 54.N	BSI. BS EN 12350-5, 'Testing fresh concrete. Flow table test'
Ref 55.N	BSI. BS EN 12350-2, 'Testing fresh concrete. Slump test '
Ref 56.N	BSI. BS EN 12350-3, 'Testing fresh concrete. Vebe test '
Ref 57.N	BSI. BS EN 12390-3, 'Testing hardened concrete. Compressive strength of test specimens'
Ref 58.N	BSI. BS EN 12390-7, 'Testing hardened concrete. Density of hardened concrete.'
Ref 59.N	BSI. BS EN 12390-13, 'Testing hardened concrete. Determination of secant modulus of elasticity in compression'

Ref 60.N	BSI. BS EN 12390-16, 'Testing hardened concrete. Determination of the shrinkage of concrete.'
Ref 61.N	BSI. BS EN 12390-2, 'Testing hardened concrete. Making and curing specimens for strength tests'
Ref 62.N	BSI. BS EN 12390-1, 'Testing hardened concrete. Shape, dimensions and other requirements for specimens and moulds'
Ref 63.N	BSI. BS EN 14488-4, 'Testing sprayed concrete. Bond strength of cores by direct tension'
Ref 64.N	BSI. BS EN 14488-1, 'Testing sprayed concrete. Sampling fresh and hardened concrete'
Ref 65.N	Transport Research Laboratory. TRL AG 9, 'The Half-Cell Potential Method of Locating Corroding Reinforcement in Concrete Structures'
Ref 66.N	BSI. BS EN ISO 17660-1, 'Welding. Welding of reinforcing steel. Load-bearing welded joints'
Ref 67.N	BSI. BS EN ISO 17660-2, 'Welding. Welding of reinforcing steel. Non load-bearing welded joints'
Ref 68.N	BSI. BS EN 1179, 'Zinc and zinc alloys. Primary zinc'