



THE HIGHWAYS AGENCY

BD 27/86



THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT



THE WELSH OFFICE
Y SWYDDFA GYMREIG



THE DEPARTMENT OF THE ENVIRONMENT FOR
NORTHERN IRELAND

Materials for The Repair of Concrete Highway Structures

Summary: This Standard gives the model specification clauses for materials used in carrying out repairs to concrete highway structures.

VOLUME 3	HIGHWAY STRUCTURES: INSPECTION AND MAINTENANCE
SECTION 3	REPAIR

PART

BD 27/86

**MATERIALS FOR THE REPAIR OF
CONCRETE HIGHWAY
STRUCTURES**

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1. INTRODUCTION

1.1 For concrete repairs to be effective it is necessary to use materials and techniques that will give significantly added protection to highway structures. Failure to do this will result in a recurring maintenance problem. This standard therefore gives requirements for repair materials and techniques based on the best of current practice.

1.2 Where reference is made to the Specification it shall be taken as referring to the 6th Edition of the Department of Transport's Specification for Highway Works.

2. SCOPE

2.1 This Departmental Standard gives model specification clauses for replacement concrete in vertical and horizontal locations, sprayed concrete, repair mortars and impregnation. The associated Advice Note BA 23/86 gives background information on investigation and repair.

3. MODEL SPECIFICATION FOR REPLACEMENT CONCRETE FOR DECKS AND VERTICAL SURFACES TO PIERS, COLUMNS AND ABUTMENTS

3.1 General

(a) The concrete shall be a designed mix for special structural concrete as defined in Clause 1701 of the Specification and shall comply with the requirements of the 1700 Series of the Specification amended as shown below.

3.2 Cement

(a) Cement shall be a mixture of 35% BS 12 (Portland Cement) and 65% BS 6699 (Ground granulated blastfurnace slag for use with Portland Cement).

3.3 Aggregates

(a) The maximum aggregate size shall be no greater than 10mm.

3.4 Admixtures

(a) The Contractor shall demonstrate by means of trial mixes, the action of the admixture he proposes to use to the Engineer's approval.

3.5 Concrete Grade and Class

(a) The characteristic strength of the concrete shall be 50 N/mm².

3.6 Minimum Cement Content and Maximum Water/Cement Ratio

(a) The cement content shall be not less than 400 kg/m³ and the water cement ratio shall be not greater than 0.40.

3.7 Trial Mixes

(a) When tested in accordance with ASTM C232 Method A there shall be no bleed water.

(b) The flow measured in accordance with BS 1881: Part 105 shall be greater than 400mm, without signs of segregation or bleeding.

3.8 Placing

(a) In addition to the requirements of Clause 1709 of the Specification the joint surface shall be saturated for a minimum of two hours before concrete is placed against it.

(b) Immediately after placing and for 14 days thereafter concrete shall be protected against harmful effects of weather including rain, rapid temperature changes, frost and from drying out. Alternatively subject to the approval of the Engineer impregnation may be carried out after 7 days as described in Clause 7.3 (b). The methods of protection used shall in all cases be subject to the approval of the Engineer. Proprietary curing membranes shall not be used.

4. MODEL SPECIFICATION FOR REPLACEMENT CONCRETE FOR THE SIDES AND SOFFITS OF BEAMS AND CROSSHEADS

4.1 Proprietary Repair Materials

- (a) Cement shall comply with Clause 1702 of the Specification.
- (b) Cement content shall be not less than 400 Kg/m³.
- (c) The content of equivalent sodium oxide in the mix shall be restricted or non reactive aggregates shall be used, as defined in the relevant clauses of the 1700 Series of the Specification.
- (d) The total chloride ion content of the materials shall not exceed 0.3 per cent of the mass of cement. Any chloride or admixtures containing chloride salts shall not be used.
- (e) The aggregate shall be well graded with the maximum size not exceeding 10mm, and comply with Clause 1702.2 of the Specification.

4.2 Water

- (a) If water for the Works is not available from a Public Utility Undertaking supply, the Engineer's approval shall be obtained regarding the source of supply and manner of its use. When required by the Engineer the Contractor shall arrange for tests of the water to be carried out in accordance with BS 3148. Water from the sea or tidal rivers shall not be used.

4.3 Strength

- (a) The specified minimum 28 day strength of the concrete shall be 50 N/mm² determined as described in Clause 4.6 (d).

4.4 Delivery and Storage of Material

- (a) The Contractor shall supply with each batch or part of a batch of the material delivered to the Site, certificates furnished by the formulator or his agent stating:
 - (i) Formulator's name and address.
 - (ii) Formulator's agent's name and address where applicable.
 - (iii) Material identification.
 - (iv) Batch reference number, size of batch and number of containers in the delivery order.
 - (v) Date of manufacture.
 - (vi) Evidence that the chloride contents are less than specified in Clause 4.1(d).
- (b) Containers shall be damp proof and readily emptied of their contents.

- (c) Containers shall be marked with the following information:
- (i) Material identification.
 - (ii) Batch reference number.
 - (iii) Formulator's name.
 - (iv) Net weight.
 - (v) Any warnings or precautions concerning the contents.
- (d) The material shall be stored in a dry environment free from extremes of cold and heat.
- (e) Material shall not be older than 3 months or lesser period specified by the formulator, when incorporated in the Works.
- (f) The materials shall not be removed from the store for use in the Works until immediately prior to mixing.

4.5 Site Mixing, Placing and Curing

- (a) Mixing and placing shall be carried out strictly in accordance with the formulator's written instructions together with the following additional conditions:
- (i) The water cement ratio shall not exceed 0.4. The water content shall be determined during Approval Tests, approved by the Engineer and maintained for Batch Tests, Works Tests and in the Works within $\pm 2\%$ of the agreed content.
 - (ii) The material shall be incorporated in the Works within 20 minutes of completion of mixing, or such lesser period as stated by the formulator.
 - (iii) No extra water shall be added after the original mixing.
 - (iv) The material shall not be mixed or placed in the Works at ambient temperatures lower than 5°C .
 - (v) The surface temperature of the concrete shall be maintained at not less than 5°C until the concrete reaches a strength of 5 N/mm^2 as determined by tests on cubes that were cured under similar conditions to the structural concrete in a manner approved by the Engineer.
- (b) Replacement concrete shall not be placed against other concrete which has been in position for more than 30 minutes unless a construction joint is formed in accordance with Clause 1709 of the Specification. In addition the joint surface shall be saturated for a minimum of 2 hours before concrete is placed against it. When replacement concrete has been in place for 4 hours, or less as directed by the Engineer, no further concrete shall be placed against it for a further 20 hours.
- (c) Vibration shall not be used.
- (d) Immediately after placing and for 14 days thereafter, concrete shall be protected against harmful effects of weather including rain, rapid temperature changes, frost and from drying out. Alternatively subject to the approval of the Engineer impregnation may be carried out after 7 days as described in Clause 7.3 (b). The methods of protection used shall in all cases be subject to the approval of the Engineer. Proprietary curing membranes shall not be used.
- (e) When the mix proportions have been approved by the Engineer no variations shall be made in the manufacture, supply, mix proportions or method of mixing of the material without the consent of the Engineer.

4.6 Approval Tests

(a) Before work commences on the Site all properties of the proposed replacement concrete shall be demonstrated by the Contractor and the formulator's representative by carrying out tests specified below in a laboratory approved by the Engineer. Where required in the Contract procedure trials shall be carried out on the model shown in Fig 2 modified to represent actual reinforcement details:

(i) The tests shall be carried out in the presence of and to the satisfaction of the Engineer who shall receive certified copies of the results of all tests.

(ii) The mixer and method of mixing shall be the same as that to be used in the Works.

(b) Flow Trough Test

(i) For each flow test, sufficient quantity of the replacement concrete shall be mixed in a mixer approved by the formulator.

(ii) The flow characteristics of the concrete shall be assessed at an ambient temperature of between 5°C and 20°C in the flow trough shown in Fig 1.

(iii) The temperature of the materials and mixer shall be as close as possible to those expected during the Contract.

(iv) The funnel shall be fitted with a rubber bung and charged with 6 litres of concrete. On the release of the bung the concrete shall flow along the trough and the length of the flow shall be measured. The minimum length of flow along the trough for each test shall be 450mm, without signs of segregation or bleeding.

(c) Flow Tests for Horizontal Soffit Surfaces

(i) The flow characteristics for repairs to soffits shall be assessed by pouring the concrete mix having the same water:cement ratio as in Clause 4.6 (b) into the model shown in Fig 2. The pre-cast concrete slab shall be wetted for 2 hours before the test but the surface shall be free of surplus water at the time of test. The concrete shall be poured from one side of the model until the level of the concrete has reached at least 10mm above the underside of the top plate. The material shall be placed in the model in one pour.

(ii) After 24 hours the top plate shall be removed and the exposed surface shall be lightly brushed with a stiff bristle brush to remove any surface cement skin which may be covering voids. The exposed surface of the concrete shall be examined for air-pockets, cracks and other defects.

(iii) The temperature of the mixer and material for each test shall be as in Clause 4.6 (b).

(iv) The trial shall be deemed successful if the concrete thus formed is homogeneous and free from air-pockets.

(d) Compressive Strength Tests

(i) These shall be carried out to determine the compressive strength of the concrete at 20°C.

(ii) Test cubes shall be made in 100mm metal moulds to BS 1881: Part 108. The moulds shall be carefully filled by pouring concrete through a funnel to produce void free specimens. There shall be no compaction. The cubes shall be cured in accordance with BS 1881: Part 111. Testing shall be carried out in accordance with BS 1881: Part 116.

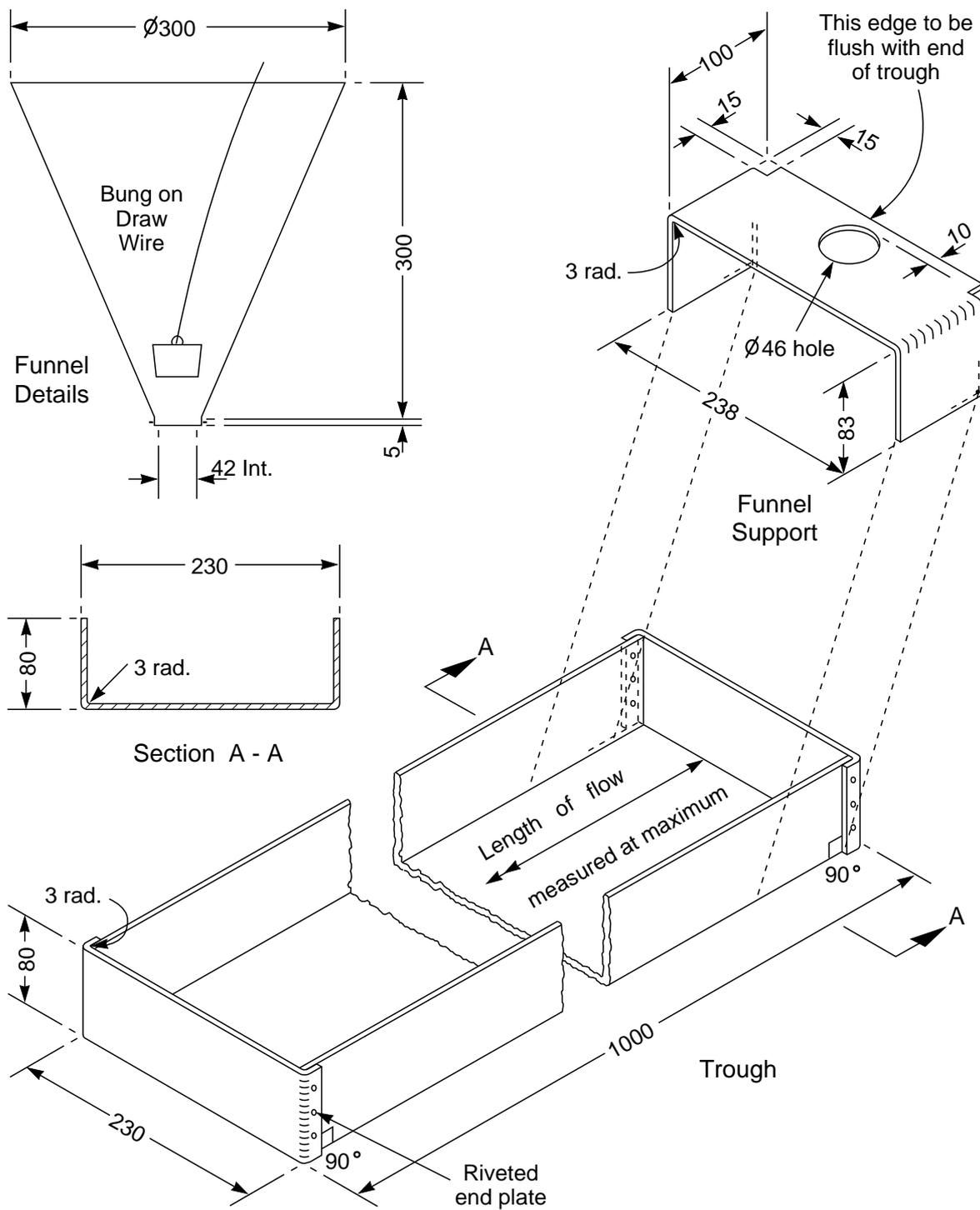
(iii) The specified minimum strength shall be established using a set of three cubes. The requirement shall be satisfied if none of the compressive strengths obtained is lower than the specified value, and the difference between the highest and lowest values is not more than 20% of the average.

4.7 Batch Acceptance Tests

- (a) Each batch of material delivered to the Site shall be tested as specified below. The material shall be taken at random from one or more containers from the same batch.
- (b) Flow trough test shall be carried out as specified in Clause 4.6(b).
- (c) Flow tests for horizontal surfaces shall be carried out as specified in Clause 4.6(c).
- (d) Compressive strength tests shall be carried out as specified in Clause 4.6 (d).

4.8 Site Tests

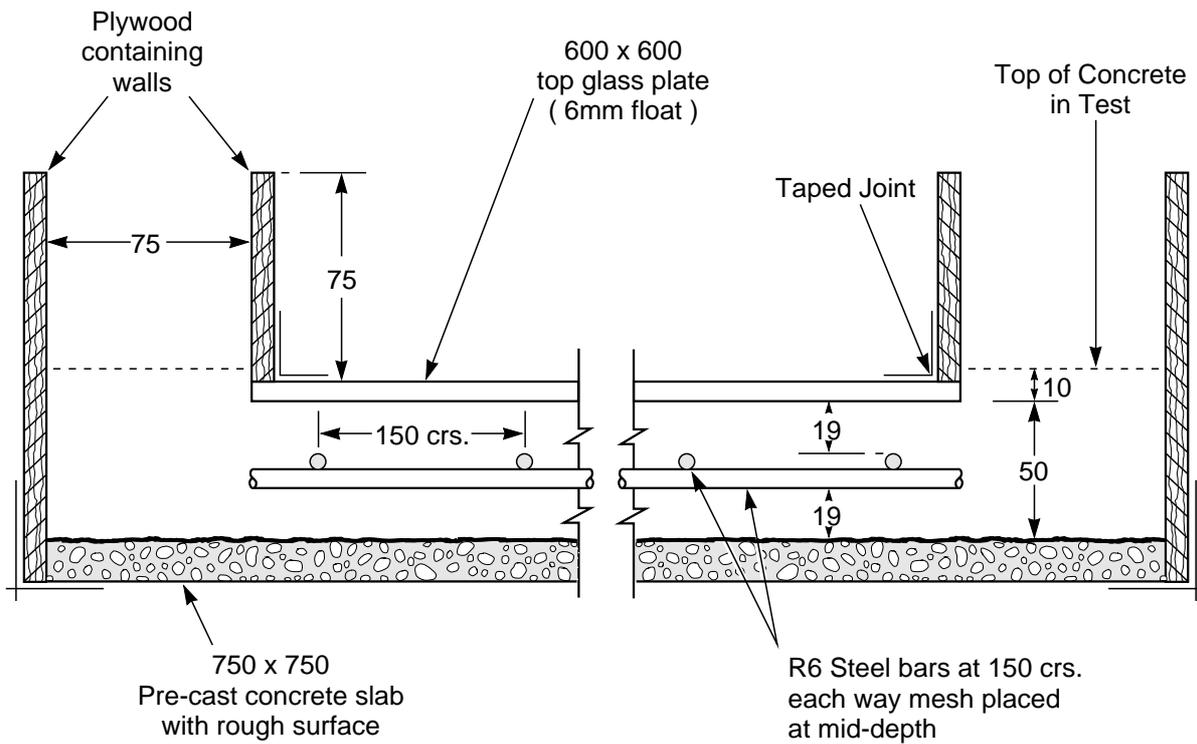
- (a) Three cubes from each batch mixed for placing in the Works shall be tested for compressive strength as specified in Clause 4.6(d).



NOTES:

1. Trough and funnel to be made of galvanised steel (14 gauge).
2. Trough to be horizontal while concrete being poured.
3. All dimensions in mm.

Fig 1. Flow Trough and Funnel



NOTES:-

1. Concrete to be mixed and poured using Contractor's proposed site apparatus and poured until it reaches underside of top plate and has risen up containing walls to depth of at least 10mm.
2. All dimensions in mm.
3. Wooden, 20 x 20 spacers at corners required to support glass.

Fig 2. Model Flow Test for Horizontal Surfaces

5. MODEL SPECIFICATION FOR SPRAYED CONCRETE

5.1 General

(a) The concrete shall be a designed mix for special structural concrete as defined in Clause 1701 of the Specification and shall comply with the requirements of the 1700 Series of the Specification amended as shown below.

5.2 Aggregate

(a) Maximum aggregate size shall be 10mm.

5.3 Fibres

(a) Fibres where required shall be the 25mm stainless steel melt extract type.

5.4 Strength

- (a) The characteristic strength shall be 40 N/mm².
- (b) Concrete samples shall be taken from remixed deposited concrete.

5.5 Workmanship

- (a) The Contractor shall demonstrate by procedure trials the suitability of the proposed mix, the method of working, and the competence of the operators.
- (b) Where required by the Engineer, the Contractor shall cut 100mm diameter cores to determine the quality of the deposited concrete.

5.6 Reinforcement

(a) Where shown in the Contract, reinforcement fixed to prepared surfaces shall consist of 100mm x 100mm x 1.65 kg/m² welded steel fabric. It shall be carefully bent to follow the shape of the members, and held in position using concrete anchors spaced at not less than two per sq m. The fabric shall be spaced at not less than 25mm from the surface of the existing concrete. Mesh should be lapped one and one half squares and reinforcement shall be staggered and spaced to allow complete encasement by the concrete.

5.7 Normal spraying procedure

- (a) Light timber profiles or guide wires shall be fixed on all main arrisses in order to provide eyeable lines in the finished work.
- (b) No concrete shall be sprayed in air temperatures less than 5°C. Surfaces shall be clean and damp but free of standing water before spraying concrete. Freshly sprayed concrete shall be protected from rain or water until the surface is sufficiently hard to resist damage.
- (c) Sprayed concrete shall be applied under sufficient pressure in an even manner so as to give a dense and homogeneous covering to the surface. It shall be applied in two or more coats as necessary and the surface of each coat washed down before the next is applied.

(d) The thickness of each layer of sprayed concrete shall be 50 mm or as shown in the Contract and unless stated otherwise in the Contract a minimum finished cover of 40 mm shall be provided to the steel reinforcing fabric. Except where otherwise stated in the Contract, the final coat shall be left unscreeded with the characteristic rough cast finish from the gun.

5.8 Curing

(a) Immediately after placing and for 14 days thereafter, concrete shall be protected against harmful effects of weather including rain, rapid temperature changes, frost and from drying out. Alternatively subject to the approval of the Engineer impregnation may be carried out after 7 days as described in Clause 7.3 (b). The methods of protection used shall in all cases be subject to the approval of the Engineer. Proprietary curing membranes shall not be used.

5.9 Fibre Reinforced Sprayed Concrete

- (a) The weight of fibres shall not exceed 5 per cent by weight of the combined weights of cement and aggregate.
- (b) Unless provided for otherwise a final 5 to 13mm thick coat of unreinforced gunite shall be applied to cover exposed fibres.
- (c) Fibre shall be added to the mix in such a manner that the fibres are evenly distributed and not bent.
- (d) The gun and the nozzle shall be electrically earthed.

6. MODEL SPECIFICATION FOR REPAIR MORTAR

6.1 Materials

- (a) Prebatched acrylic polymer modified cementitious mortars shall be used.
- (b) The water/cement ratio shall be not greater than 0.4.
- (c) The cement content shall be not less than 400 kg/m³.
- (d) The total chloride ion content of the materials shall not exceed 0.3 per cent of the mass of cement. Calcium chloride or admixtures containing chloride salts shall not be used.
- (e) The content of equivalent sodium oxide in the mortar shall be restricted or non-reactive aggregates shall be used, as defined in the relevant clauses of the 1700 Series of the Specification.

6.2 Delivery and Storage of Material

- (a) The Contractor shall supply with each batch of the material delivered to site, certificates furnished by the supplier stating:
 - (i) The polymer used.
 - (ii) Evidence that the chloride contents are less than specified in Clause 6.1(d).
- (b) The material shall be stored in a dry environment free from extremes of cold and heat.
- (c) The materials shall not be removed from the store for use in the Works until immediately prior to mixing.

6.3 Site Mixing, Placing and Curing

- (a) Mixing, placing and curing shall be carried out strictly in accordance with the supplier's instructions.
- (b) The material shall not be mixed or placed in the Works at ambient temperatures lower than 5 °C.
- (c) The material shall be incorporated in the Works within 1 hour of mixing.

7. MODEL SPECIFICATION FOR IMPREGNATION

7.1 Material

- (a) Monomeric alkyl alkoxy silane (isobutyl) undiluted shall be used.
- (b) The material shall be delivered in containers sealed by the supplier and stored in a dry covered environment unexposed to direct heat.
- (c) The containers shall not be opened until immediately prior to application of the material.
- (d) Where required by the Engineer the Contractor shall supply from batches delivered to site details of specific gravity and refractive index which shall comply with those specified by the supplier.

7.2 Workmanship

- (a) The work shall be carried out by applicators approved by the supplier.

7.3 Application

- (a) After 14 days curing of the concrete the material shall be applied evenly in two applications each at a rate of 300 ml/m² with a minimum interval of 2 hours.
- (b) Alternatively the first application may be made after 7 days curing of the concrete followed by the final application not less than 7 days later.
- (c) Areas to be treated shall be surface dry and if necessary protected from the weather before application.
- (d) Concrete surfaces shall be clean, free of dust and loose matter before treatment. Light grit blasting may be used if necessary.
- (e) Material shall not be applied in the following conditions:
 - (i) When the air temperature in the shade is below 5°C.
 - (ii) When the air temperature in the shade is greater than 35°C.
 - (iii) When it is raining unless suitable precautions have been taken which have been approved by the Engineer.
- (f) Application shall be made by wet spray, without misting, at a nozzle pressure not greater than 0.2 N/mm². The apparatus shall contain no water.

8. ENQUIRIES

Technical enquiries arising from the application of this Standard to a particular structure should be addressed to the TAA for that scheme.

All other enquiries or comments about this Departmental Standard should be sent in writing to:

Head of Bridges Engineering Division
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