Appendix B

Carlow & Wexford Bridges Rehabilitation Contract - Scheme Inspection and Rehabilitation Report

TO 268 Leinster Bridges Rehabilitation Contract No. 2 Part 2 Carlow and Wexford Bridges - Change Order No. 1

Inspection and Rehabilitation Report

Draft Issue
April 2016

Client:
Kildare County Council
Áras Chill Dara
Devoy Park
Naas
Co. Kildare

Consulting Engineer:
Roughan & O'Donovan – Aecom
Alliance
Arena House
Arena Road
Sandyford
Dublin 18

Eirspan TO 268 Leinster Bridges Rehabilitation Contract No. 2 – 2015
Part 2 Carlow and Wexford Bridges – Change Order No. 1

Inspection and Rehabilitation Report

Document No: ..... 15.135.10 Pt2 CO1- IR

Author:..... Peter King

Checker: ..... Marc Jones

Approver:..... Marc Jones

Document No	Revision	Description	Made	Checked	Approved	Date
15.135.10 Pt2 CO1- IR	-	Inspection and Rehabilitation Report	PK	RMJ	RMJ	April 2016

Eirspan TO 268 Leinster Bridges Rehabilitation Contract No. 2 – 2015
Part 2 Carlow and Wexford Bridges – Change Order No. 1

Inspection and Rehabilitation Report

TABLE OF CONTENTS

1. INTRODUCTION

Roughan & O'Donovan – Aecom Alliance (ROD) were appointed by the National Roads Authority in the Letter of Acceptance issued during the pre-commissioning meeting on 26th March 2015 (NRA Task Order No 268) as part of the EIRSPAN Bridge Management System, to undertake the design of refurbishment works to 15 no. bridges across the council areas of Fingal, Kildare, Laois, South Dublin, Wicklow and Wexford. The contract is separated into two separate works contracts. Part 1 of the contract is for the Joint Rehabilitation of 11 no. bridges in Fingal, Kildare, Laois, South Dublin and Wicklow. Part 2 of the Contract relates to the refurbishment of 4 no. bridges in Co. Wexford. Under Change Order No. 1 dated November 2015, ROD were asked to submit a proposal for the design of rehabilitation works for an additional 4 no. structures, 3 no. bridges located in County Carlow and 1 no. bridge in County Wexford. ROD was instructed to proceed with the Change Order in an email dated 02nd February 2016. This Inspection Report relates to Change Order no. 1 of this contract only.

The brief from the Client includes for the preparation of an Inspection Report detailing the findings of the site inspection and outlining ROD's proposals for the rehabilitation of the bridges. As the structural investigation (SI) has not yet been carried out at the time of completion of this report, the proposals for rehabilitation have been based on assumptions which will be updated on receipt of the findings of the structural investigation if necessary.

The contract requires that the exact scope of rehabilitation works is to be determined by ROD following the site inspection and structural investigation. However, in line with the requirements of the scheme brief, the contract shall as a minimum include for the following rehabilitation works;

CW-N80-004.00 Boggan Bridge

(a) Waterproofing and re-surfacing of the bridge deck;
(b) Installation of safety barriers at the bridge structure;
(c) Construction of a masonry parapet wall on the eastern side of the structure with consideration given to the increasing in height of the western parapet;
(d) Concrete and masonry repairs to the superstructure and substructure.

CW-N80-006.00 Ballintrane Bridge

(a) Waterproofing and re-surfacing of the bridge deck;
(b) Installation of safety barriers at the bridge structure;
(c) Replacement of existing bridge parapet (aluminium and masonry) with a compliant parapet system;
(d) Reconstruction of parapet edge beam to facilitate new parapet and comply with current standards;

CW-N81-001.00 Closh Bridge

(a) Waterproofing and re-surfacing of the bridge deck;
(b) Installation of safety barriers at the bridge structure;
(c) Reconstruction of masonry bridge parapet.

WX-N11-003.00 Glebe Bridge

(a) Crack Injection of reinforced concrete elements.

(b) Circumferential cracks will require stitching/grouting/repair

(c) Masonry repointing/repair/grouting.

(d) Scour remedial works

(e) Repairs to river embankments

Following early stage discussions with KNRO the following repairs were removed from the scope of proposed rehabilitation works for Glebe Bridge:

(f) Waterproofing of reinforced concrete deck slab;

(g) Construction of parapets.

2. DOCUMENTS RECEIVED

Structure 1 – Structure ID CW-N80-004.00
Stage 1 Assessment Report, January 2010
Inventory and Principal Inspection Report, 2012

Structure 2 – Structure ID CW-N80-006.00
Stage 1 Assessment Report, January 2010
Inventory and Principal Inspection Report, 2012

Structure 3 – Structure ID CW-N81-001.00
Stage 1 Assessment Report, June 2010
Inventory and Principal Inspection Report, 2012

Structure 4 – Structure ID WX-N11-003.00
Stage 1 Assessment Report, July 2005
Inventory and Principal Inspection Report 2012

3. CW-N80-004.00 BOGGAN BRIDGE

3.1 Description of Structure

Boggan Bridge comprises a 3.70m single span masonry arch structure widened on the east side with a 3.77m span in-situ reinforced concrete slab cast on concrete abutments. The arch is 7.50m wide and the slab is 9.73m wide. The bridge carries the N80 National Secondary Road in a north-south direction east of the village of Ballon, County Cawlow. The carriageway is positioned such that it bears primarily on the concrete slab component (4.7m width) with only 2.8m of the carriageway over the masonry arch section.

3.2 Visual Inspection of Structure

The site inspection of Boggan Bridge was carried out on Tuesday 16th February 2016 by Mr Peter King and Mr. Mark Nilan of Roughan & O'Donovan – Aecom Alliance. Owen O'Keefe of the ROD environmental department was also on site to carry out the ecological assessment which has been addressed in a separate report. The weather conditions were wet with an ambient temperature of approximately 8°C. The inspection included a detailed visual examination and photographic record of all relevant components of the structure. The findings of the visual inspection are illustrated in photographs included in Appendix B.

The HRA bridge surfacing was observed to be in good condition with no evidence of rutting, settlement or loss of surface texture (see Photograph 1). There is a narrow strip of DBM surfacing along the front face of the raised verge kerbline which appears to have been laid as part of the installation of the concrete raised verges. Concrete verges have been constructed between the edge of carriageway and parapets to replace soft verges and were found to be in good condition with only routine maintenance required to clear the open channel drains. The bridge carries a relatively straight section of the N80 with only gentle horizontal curves on approaches. No safety barriers are provided on approaches with timber post and rail fencing demarking the road boundary. 2 no. field accesses exist on the east side of the carriageway, one either side of the bridge. There is also a commemorative plaque located adjacent to the field access on the northeast approach.

At 0.27m high (measured above the adjoining paved surface), the west parapet does not meet the height requirements specified in Clause 3.10 of NRA BD 52/16 – 'The Design of Vehicle and Pedestrian Parapets' (see Photograph 2). In addition, the parapet does not meet the containment requirements outlined in Table 3/1 of the standard. There is no effective vehicle parapet provided along the east side of the bridge, however, the timber post and rail fencing acts as pedestrian guardrail (see Photograph 3).

Service enquiries are ongoing at the time of completion of this report. However, responses received to date confirm the presence of underground Eir services in the east verge (1x100mm diameter polypropylene duct) and Irish Water underground services in the west verge (1x100mm diameter UPVC watermain). There are a number of associated air/scour valves visible in the west verge (see Photograph 4). Slit trenches will be carried out as part of the proposed investigation works to identify all services crossing the structure.

The west spandrel wall and wingwalls consist of finely dressed, quarry-faced square-cut granite stonework. The walls appear to be in very good condition with no evidence of structural distress noted (see Photograph 5). The walls appear to have been recently repointed.

The west embankments are generally well vegetated and stable. However, there is evidence of scour and slippage of the northeast and southeast embankments. This issue is exacerbated by the lack of proper wingwalls on the east side of the structure to prevent loss of material from behind the abutments. The boulder/drystone wingwall provided on the southeast embankment has been undermined by scour and appears to be unstable (see Photographs 6 and 7). The northeast embankment also shows evidence of erosion and loss of material from behind the north abutment (see Photograph 8). Both of the east embankments require regarding and the installation of a suitable embankment protection system to prevent further erosion.

The expressed arch and arch barrel are also constructed from finely dressed quarry faced ashlar masonry and were found to be in very good condition with only minor seepage and resultant staining and calcite deposits noted at the west end of the barrel. The arch shape is very good and there is no evidence of structural distress in the form of cracking, deformation or displaced arch voussoirs. The barrel is well pointed and appears to have been recently repointed (see Photograph 9).

The in-situ reinforced concrete deck appeared to be in good condition with no significant defects noted. The entire soffit was heavily stained indicating that it is regularly wet but was found to be relatively dry at the time of inspection (see Photograph 10).

The masonry abutments also consist of granite ashlar masonry. Inspection of the abutments showed that there were no signs of flexural cracking, rotation or differential settlement which would be indicative of structural distress due either to overload or movement of the substructure. Minor leakage and associated staining was noted at the west ends of the abutments (see Photograph 11). All visible areas of the masonry abutments are well pointed (see Photograph 12). The concrete abutments were also found to be in good condition and show no evidence of structural distress due to overload or movement. The concrete finish is poor with widespread honeycombing and seepage/algal staining evident throughout (See Photograph 13). Photos of the east and west elevation have been included as photographs 14 and 15 respectively.

3.3 Proposed Remedial Work

In accordance with the requirements of the scheme brief, the contract shall as a minimum include for the following rehabilitation works to the structure;

(a) Waterproofing and re-surfacing of the bridge deck;

(b) Installation of safety barriers at the bridge structure;

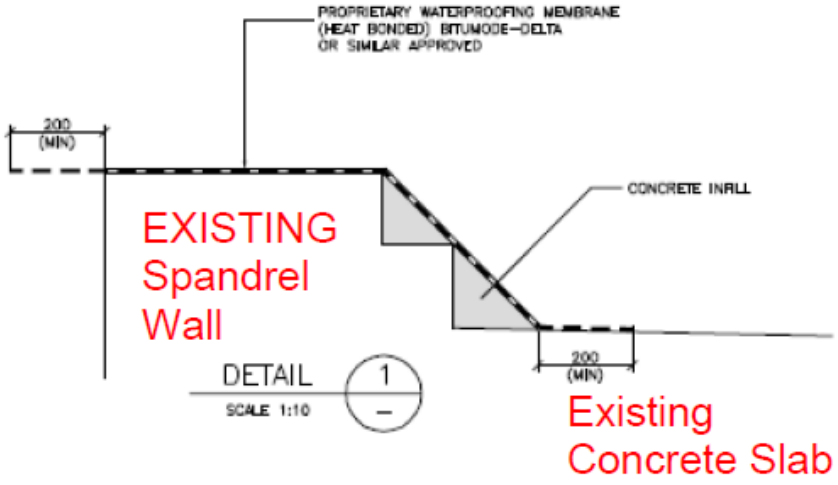
(c) Construction of a masonry parapet wall on the eastern side of the structure with consideration given to the increasing in height of the western parapet;

(d) Concrete and masonry repairs to the superstructure and substructure.

The above works shall be individually discussed followed by any additional works arising from the site inspection.

3.3.1 Waterproofing and Re-surfacing of the Bridge Deck

The concrete bridge deck will be waterproofed with an approved spray applied membrane with current IAB / BBA Certificate. The bridge deck waterproofing will extend down the back of the abutment walls for a distance of 200mm below the deck soffit. A 20mm thick sand asphalt protective layer will be provided above the waterproofing system. A suitable concrete slab/spandrel wall interface detail will be designed following receipt of the findings of the structural investigation. Observations on site confirmed that the existing spandrel wall was left in place at the interface as part of the widening works. Detail 1 below shows a typical interface waterproofing detail used by ROD for similar works.



A review of the Stage 1 Assessment report and associated structural investigation report indicates that there is no existing bridge deck waterproofing system to the top of the reinforced concrete deck. However, the Works Proposals will include for concrete repairs to the deck in order to provide a suitable substrate to receive the proposed waterproofing system.

The existing east concrete verge will be broken out to facilitate installation of the proposed waterproofing system and reinstated to the original line and level afterwards.

3.3.2 Installation of Safety Barriers

A new safety barrier system is required at the bridge. The containment, extents and alignment of safety barriers shall be designed to the requirements of NRA TD 19/15 following receipt of the topographical survey. Terminals will also conform to NRA TD

19/15. Provisionally, it is proposed that safety barriers run continuously across the structure negating the need for transitions into existing parapets. In accordance with Table 5/5 of TD 19/15 a safety barrier will be provided for a minimum of 30m in advance of the approach end and 15-30m after the departure end of the vehicle parapet.

Initially, the possibility of relocating the field accesses on the northeast approach and southeast departure will be investigated. The location of the gate and the arrangement of boundary fencing on the southeast departure would tend to indicate that relocation of this access will not be feasible (see Photograph 16). A review of the relevant landownership folio (see Figure 3.3 below) further supports this assumption.

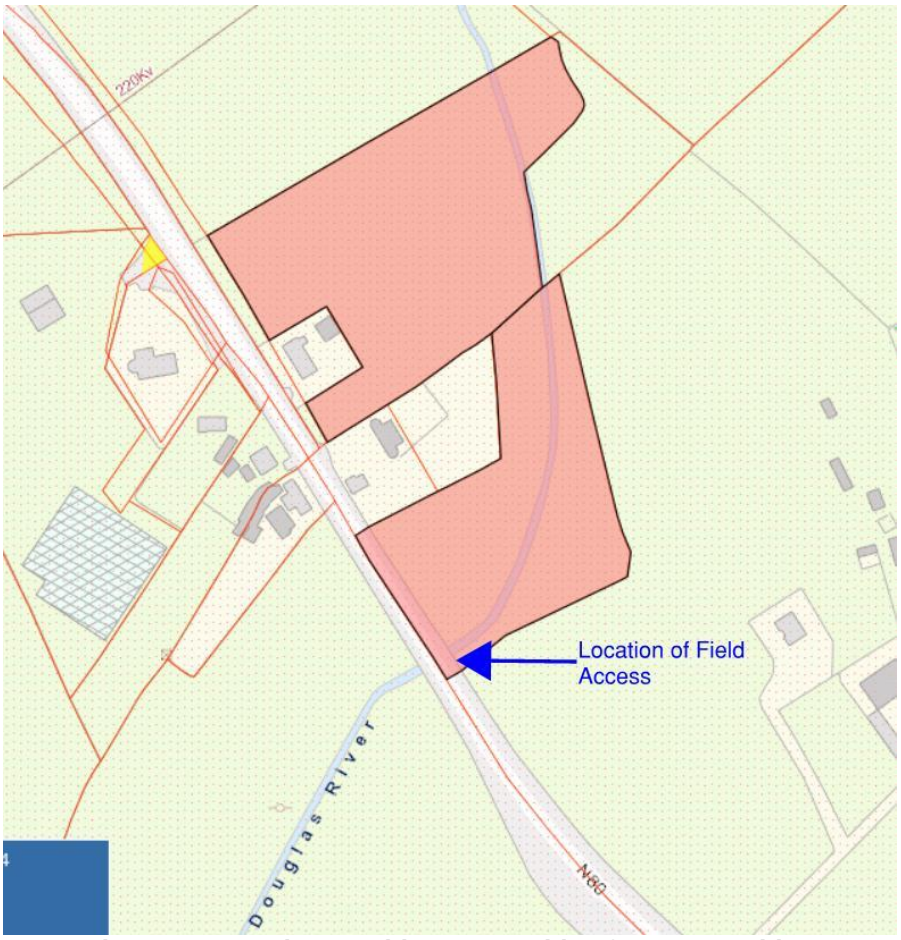


Figure 3.3: Landownership at East Side of Boggan Bridge

Where relocation of either of the field accesses is not possible a Departure from Standard will be required to allow for an opening in the barrier or the omission of barriers at that location.

It is proposed that a bolted down barrier system is provided over the extents of the concrete verges.

3.3.3 Construction of Masonry Parapets

It is proposed that a 1.0m high solid granite masonry parapet wall is constructed along the east side of the bridge to match that provided on the west side. It is also proposed that that the existing masonry parapet on the west side of the structure is raised from 0.3m high to 1.0m high with granite masonry matching the existing to meet the height requirements of Clause 6.3 of BS6779 Part 4. The use of the1.0m

height requirement given in BS6779 is considered to be more appropriate than the 1.25m height requirement of BD 52/16. The parapets will act as edge protection as opposed to vehicle parapets.

Similarly, the proposed parapets will not be designed to achieve the H2 containment requirement outlined in Table 3/1 of NRA BD 52/16. The safety barrier system described above will provide a complaint vehicle restraint system with the masonry parapets only providing edge protection.

3.3.4 Concrete and Masonry Repairs

Based on the findings of the visual inspection, no repointing or masonry repairs are required to the arch barrel, spandrel wall or abutments. In accordance with current best practice it is not proposed to remove calcite deposits from the stonework. These works are potentially damaging and yield no real benefit to the structure. It is likely that the leakage through the arch barrel at the west end of the bridge is associated with the watermain above and therefore it is not proposed to address this issue as part of the proposed works.

No repairs are required to the concrete section of the structure. Damp staining will be addressed via the installation of bridge deck waterproofing and honeycombing to abutments is aesthetic only.

3.3.5 Repairs to Eastern Embankments

As outlined above, there is evidence of scour and slippage of the northeast and southeast embankments. The boulder/drystone wingwall provided on the southeast embankment has been undermined by scour and appears to be unstable (see Photographs 6 and 7) and the northeast embankment also shows evidence of erosion and loss of material from behind the north abutment (see Photograph 8). It is proposed that both of the east embankments are regarded and a suitable embankment protection system is installed to prevent further erosion. This is likely to comprise the installation of gabion walls backfilled with a suitable imported fill.

4. CW-N80-006.00 BALLINTRANE BRIDGE

4.1 Description of Structure

Ballintrane Bridge, built in 1988 / 1989, comprises 26 no. precast beams, considered to be inverted T3 beams, and an in-situ concrete in-fill slab. The top of the 120mm thick slab has been overlaid with waterproofing/protective layer and road pavement, with no fill cover. Since its construction an overlay of 150 – 250mm of HRA has been laid over the existing carriageway and footpaths so that the new level of the surface course is flush with the top of the parapet upstands. An aluminium parapet type P2 113 km/hr with mesh infill has been installed over the length of the bridge. Outside the limits of the bridge, starting at the end supports is a masonry parapet. The bridge articulation comprises elastomeric bearings, which bear the load of the precast beam and in-situ slab directly on reinforced concrete abutment walls. The bridge has a span (abutment wall to abutment wall measured square) of 10.0m. The out-to-out width of the bridge is 14m.

4.2 Visual Inspection of Structure

The site inspection of Ballintrane Bridge was carried out on Tuesday 16th February 2016 by Mr Peter King and Mr. Mark Nilan of Roughan & O'Donovan – Aecom Alliance. Owen O'Keefe of the ROD environmental department was also on site to carry out the

ecological assessment which is the subject of a separate report. The weather conditions were wet with an ambient temperature of approximately 8^{o}C. The inspection included a detailed visual examination and photographic record of all relevant components of the structure. The findings of the visual inspection are illustrated in photographs included in Appendix B.

The bridge surfacing was observed to be in good condition with no evidence of rutting, settlement or loss of surface texture (see Photograph 17). The surface course comprises HRA surfacing in the carriageway and hard shoulders with a 300-500mm strip of DBM along the base of the parapets. There are no visible expansion joints on the bridge surface and the record drawings show "20mm Flexcell expansion joint" filling the expansion gap from carriageway level down to the bearing shelf. Flexcell is a bitumen impregnated rigid joint filler board and does conform to the any of the bridge deck expansion joint types outlined in NRA BD 33/94 Expansion Joints for Use in Highway Bridge Decks.

The bridge carries a straight section of road with no significant horizontal or vertical curves on the approaches or over the bridge. Short lengths of non-compliant timber post safety barrier are provided on approaches (northwest and southeast) with no barriers provided on either departure (see Photograph 18). No safety barrier terminals or parapet transitions are provided.

The aluminium parapets provided along both sides of the structure were found to be in reasonably good condition but at 0.98m high (measured above the adjoining paved surface) do not meet the height requirements specified in Clause 3.10 of NRA BD 52/16 - The Design of Vehicle and Pedestrian Parapets (see Photograph 19). In addition, the parapets do not have the requisite 50mm upstand above the adjoining surface and are abutted by masonry parapet walls at all four corners which together do not constitute a compliant vehicle restraint system. The as-built drawings indicate P2 containment which is equivalent to N1 containment by modern standards. This is significantly below the current H2 containment requirement outlined in Table 3/1 of NRA BD 52/16.

Service enquiries are ongoing at the time of completion of this report. However, responses received to date and observations made on site confirm the presence of an overhead Eir service just north of the bridge. The overhead wire appears to terminate at the northeast corner of the bridge and may be buried in the northern verge from this point onwards. There is also a 150mm diameter HDPE Irish Water main fixed to the north face of the structure (see Photograph 20). Slit trenches will be carried out as part of the proposed investigation works to identify all services crossing the structure.

Reinforced concrete wingwalls run perpendicular to abutments on the north side and parallel to abutments on the south side. The walls were found to be in good condition with no significant defects noted (see Photographs 21 and 22). The soffit of the deck (soffits of inverted T Beams), precast edge panels and abutments were inspected and showed no evidence of structural distress (see Photographs 23-25). However, leakage was noted emanating from the bearing shelf and precast edge panels onto the sides of the abutments at all four corners of the deck (see Photograph 26). Furthermore, although abutment faces and beam soffits were dry at the time of inspection, leakage staining was observed in numerous areas indicating that leakage is an ongoing problem (see Photograph 27). These findings are in keeping with the leakage observed during the 2010 Inspection for Assessment. The elastomeric bearings were inspected with a restricted view but appeared to be in good condition.

4.3 Proposed Remedial Work

In accordance with the requirements of the scheme brief, the contract shall as a minimum include for the following rehabilitation works to the structure;

(a) Waterproofing and re-surfacing of the bridge deck;

(b) Installation of safety barriers at the bridge structure;

(c) Replacement of existing bridge parapet (aluminium and masonry) with a compliant parapet system;

(d) Reconstruction of parapet edge beam to facilitate new parapet and comply with current standards;

The above works shall be individually discussed followed by any additional works arising from the site inspection.

4.3.1 Waterproofing and Re-surfacing of Bridge Deck

The bridge deck will be waterproofed with an approved spray applied membrane with current IAB / BBA Certificate. The bridge deck waterproofing will extend down the back of the abutment walls for a distance of 200mm below the deck soffit. A 20mm thick sand asphalt protective layer will be provided above the waterproofing system.

A review of the record drawings received shows a waterproofing system labelled “Diamite Bridge Deck Waterproofing”. A review of the Stage 1 Assessment report and associated structural investigation suggests that the system comprises robust bituminous sheeting with a relatively thin aluminium top layer (see Photographs 28 and 29).

In ROD’s experience bituminous membrane systems, if intact, can be firmly adhered to the deck, requiring considerable effort to remove. More information on the type, condition and adherence of the existing waterproofing system will be available following receipt of the structural investigation report. The contract documents will include for the removal of the existing waterproofing system and any repairs required to the concrete deck in order to provide a suitable substrate to receive the proposed waterproofing system.

4.3.2 Installation of Safety Barriers at the Bridge Structure

A new safety barrier system is required at the bridge. The containment, extents and alignment of safety barriers shall be designed to the requirements of NRA TD 19/15 following receipt of the topographical survey. Terminals and Transitions will also conform to NRA TD 19/15. In accordance with Table 5/5 of this document a safety barrier will be provided for a minimum of 30m in advance of the approach end and 15-30m after the departure end of the vehicle parapet. Departure lengths may have to be extended to allow for minimum tested lengths of approved barrier systems.

Difficulties arise in providing a safety barrier on the northeast departure. There isn’t sufficient distance between the end of the parapet and the access to the dwelling (approx 14m) to provide the minimum “tested length” of safety barrier with terminal. In addition, a barrier at this location may impinge on sight visibility envelopes from the dwelling and adjacent farm access (see Photograph 30). The following proposals are under consideration:

- Option 1: Omit a safety barrier at this departure location. The parapet is deemed to be “Very Low Risk” when assessed in accordance with IAN 97/07;
- Option 2: With a view to avoiding an unprotected parapet end, provide a masonry clad reinforced concrete wall flared from the parapet end to tie in with

the existing dwelling boundary wall. The concrete wall will require a restraining slab in order to provide N2 containment. This option is likely to require a diversion of the large diameter watermain running under the verge at this location;

- Option 3: Construct a solid masonry wall along the same alignment described for option 2. This option would negate the need for a restraining slab and associated watermain diversion works but will only achieve N1 containment;

All three options will require a Departure from Standard.

4.3.3 Replacement of Existing Bridge Parapet with Compliant System

The proposed parapets shall comply with NRA BD 52/16 and EN 1317. Table 3/1 of NRA BD 52/16 requires an H2 containment level for new parapets on new bridges. However, Clause 1.4 states that, for the replacement of existing parapets on existing bridges, the Designer should agree with Transport Infrastructure Ireland the extent to which the document is appropriate and where compliance with the containment levels would give rise to undue cost implications, a risk based approach for identifying the appropriate containment level shall be used. Accordingly, ROD carried out a risk assessment of the existing parapets in accordance with UK Highways Agency Interim Advice Note 97/07 using Figure 5.1 and Table B3. The risk assessment indicated that the parapets are considered to be “Very Low Risk” and suggest that no upgrade works are required and categorised as “Monitor Only” in accordance with Figure 5.1. Accordingly, the following options are proposed:

- Option 1: Do nothing. The parapets are deemed to be “Very Low Risk” when assessed in accordance with IAN 97/07;
- Option 2: Upgrade parapets to N2 Containment. This is the minimum upgrade suggested under IAN 97/07;
- Option 3: Upgrade Parapets to H2 Containment to bring them in line with Table 3/1 of NRA BD 52/16;

Where upgrade works are under consideration, 1.25m high galvanised steel parapets with mesh infill will be provided along both sides of the bridge. This dimension meets the height criteria described in Clause 3.10 of BD 52/16. The parapets will be provided over a 21m length which exceeds the manufacturer’s minimum required length of 12m dictated by their “tested length”. This length corresponds with the start and end points of the existing parapets including the masonry end walls. The parapet will be anchored to the edge panels (after modification) over the bridge deck (see Section 4.3.4) and anchored to the existing wingwalls (after modification) on the northeast and northwest approaches.

At the south side of the structure, the masonry sections of the parapet do not bear on the wingwalls which run alongside the river parallel to the abutments (see Photograph 31). Details of the masonry parapet foundations on this side of the bridge are unknown but will be ascertained via the forthcoming structural investigation. However, it is highly unlikely that the existing foundations will provide sufficient stability or structural capacity for either an N2 or H2 parapet system and a new reinforced concrete restraining slab will be required. An H2 replacement foundation is likely to take the form of a restraining slab similar to that shown in Figure 4.3(a) below. The restraining slab required to achieve N2 Containment would be somewhat lighter.

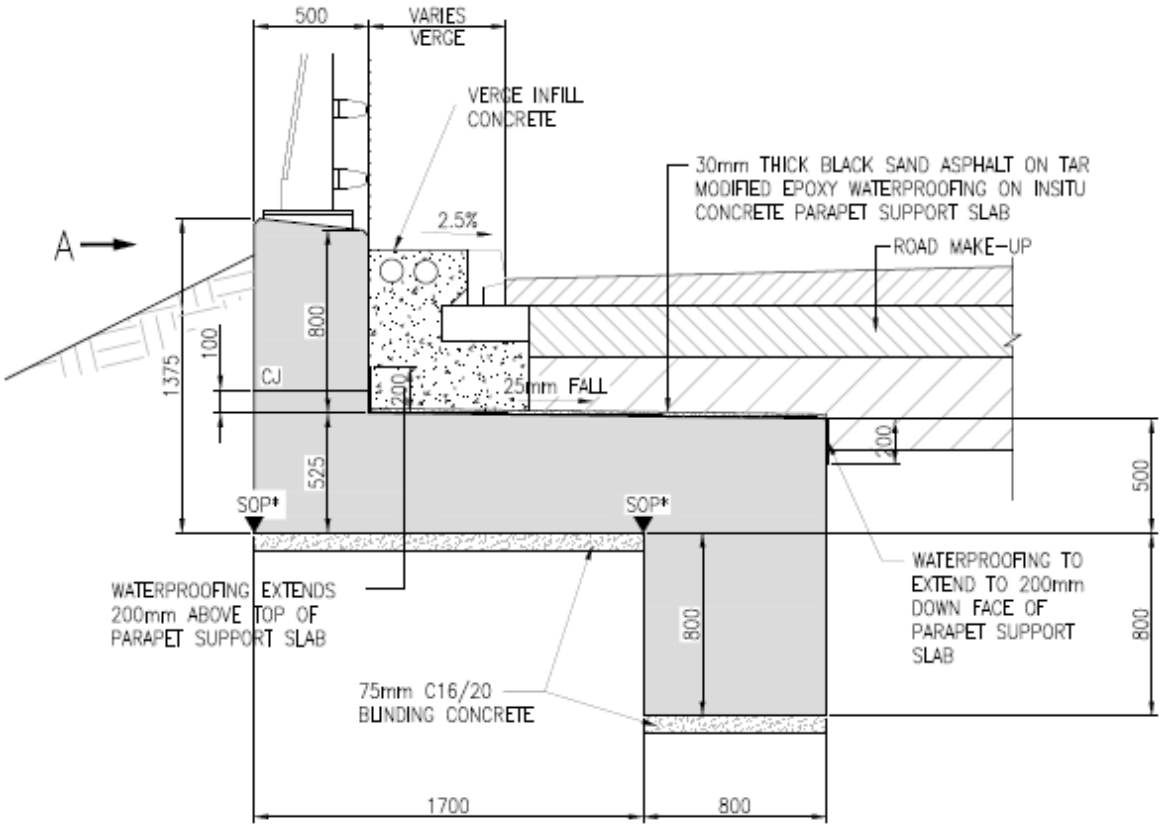


Figure 4.3(a) – Typical Restraining Slab Detail off Bridge Deck

Steel parapets shall be protected by galvanising only and the galvanising **coverage** rate shall be in accordance with EN ISO 1461. Stainless steel bolts shall be used for holding down the parapet and for all other system fixings.

4.3.4 Reconstruction of Parapet Edge Beam to Facilitate New Parapet and Comply with Current Standards

The forthcoming structural investigation will include a concrete breakout to verify the size, spacing and condition of the existing edge panel reinforcement. Following on from this, a structural check will be carried out to determine whether the existing edge panel reinforcement has sufficient structural capacity or whether strengthening is required. Where it is decided to proceed with parapet upgrade works, it is highly likely that strengthening will be required given the magnitude of the increase in containment required from an existing P2 (N1) system to either an N2 or H2 level of containment. These works will not only require a breakout of the edge panel but also localised breakouts (approx 1.2mx1.2m) to the top of the bridge deck at the base of all proposed parapet post locations. Figure 4.3 (b) below illustrates indicative edge panel strengthening measures. In addition, in order to comply with modern standards, the existing edge panels will be raised to provide a minimum upstand of 50mm above the adjoining paved surface.

It should be noted that the hydrodemolition required for these breakouts is inherently dangerous due to the uncontrollable nature of the process i.e. ejection of high velocity particles /aggregate. Extensive containment measures will be required to ensure the works can be carried out safely.

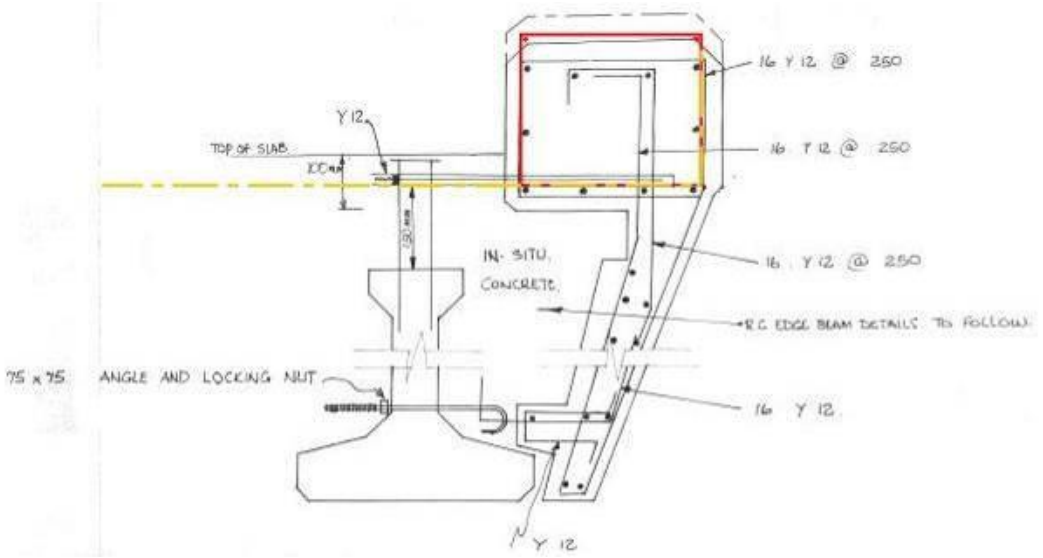


Figure 4.3(b): Indicative Edge Panel Strengthening Measures

4.3.5 Installation of Type 1 Bridge Deck Expansion Joints

In accordance with BD 33/94, the range of longitudinal movement due to changes in temperature was calculated in accordance with the composite version of BS 5400 Part 2 as implemented by BD 37 (DMRB 1.3). The expected range of thermal movement for the 11.3m long deck is approximately 5mm in total, 2.5mm at either joint. Consequently, a Type 1 "Buried joint under continuous surfacing" as described in Chapter 7 of BD 33/94 has sufficient capacity to accommodate the expected movement. By inspection, the maximum vertical movement between the two sides of the joint will not be critical for selection of a suitable joint device.

Given that there is no evidence of distress in the carriageway surfacing over the expansion gaps even without a joint device or saw-cut, the movement range of the proposed joint system will not be critical. The proposed joint will essentially act as a watertight seal preventing sub-surface water from entering the expansion gap. None-the-less, bitumen filled saw-cuts will be provided over each joint to reduce the possibility of cracking in the bridge surfacing.

5. CW-N81-001.00 CLOSH BRIDGE

5.1 Description of Structure

Closh Bridge comprises a 2.9m single span masonry arch structure extended with a reinforced concrete slab to the west, carrying the N81 over the River Douglas at high skew (31 degrees). The masonry arch component is 8.6m long and the concrete slab widening is 14.5m long. The carriageway is situated such that it crosses the concrete section of the bridge only. The masonry arch section carries a raised verge only.

5.2 Visual Inspection of Structure

The site inspection of Closh Bridge was carried out on Tuesday 16th February 2016 by Mr Peter King and Mr. Mark Nilan of Roughan & O'Donovan – Aecom Alliance. Owen O'Keefe of the ROD environmental department was also on site to carry out the ecological assessment which has been addressed in a separate report. The weather conditions were wet with an ambient temperature of approximately 8°C. The inspection included a detailed visual examination and photographic record of all relevant

components of the structure. The findings of the visual inspection are illustrated in photographs included in Appendix B.

The HRA bridge surfacing was observed to be in reasonable condition with no evidence of rutting or settlement and only minor loss of surface texture on the northbound lane (see Photograph 32). There is a narrow strip of DBM surfacing along the front face of the raised verge kerbline which appears to have been laid as part of the installation of the concrete raised verges. Concrete verges have been constructed between the edge of carriageway and parapets to replace soft verges and were found to be in good condition with only routine maintenance required to clear debris and vegetation from the open channel drains. The horizontal alignment is poor along this section of the N81 with horizontal curves on both approaches. No safety barriers are provided on approaches with timber post and rail fencing demarking the road boundary.

At 0.8m high (measured above the adjoining paved surface), the east parapet does not meet the height requirements specified in Clause 3.10 of NRA BD 52/16 – 'The Design of Vehicle and Pedestrian Parapets' (see Photograph 33). In addition, the parapet does not meet the containment requirements outlined in Table 3/1 of the standard. There is no effective vehicle parapet provided along the west side of the bridge, however, the timber post and rail fencing acts as pedestrian guardrail (see Photograph 34).

Service enquiries are ongoing at the time of completion of this report. However, observations on site and responses received to date confirm the presence of an overhead Eir line over the east verge and an Irish Water underground service also in the east verge (1x180mm diameter HDPE watermain). There are a number of associated air/scour valves visible in the east verge (see Photograph 35). Slit trenches will be carried out as part of the proposed investigation works to identify all services crossing the structure.

The east spandrel wall and wingwalls consist of finely dressed, quarry-faced square-cut granite stonework. The walls appear to be in very good condition with no evidence of structural distress noted (see Photograph 36). The walls appear to have been recently repointed.

The east embankments are generally well vegetated and stable. However, there is evidence of deformation and bulging of the southwest masonry river training wall. The short section of boulder/drystone masonry wall (approx 2.0m long x 2.0m high) has been undermined and appears to be unstable (see Photographs 37 and 38). The wall will need to be taken down and rebuilt with suitable scour protection, or replaced with an alternative rock armour or gabion basket system.

The expressed arch and arch barrel are also constructed from finely dressed quarry faced ashlar masonry and were found to be in very good condition with only minor seepage and resultant staining and calcite deposits noted at either end of the barrel over a length of approximately 1m. The arch shape is very good and there is no evidence of structural distress in the form of cracking, deformation or displaced arch voussoirs. The barrel is well pointed and appears to have been recently repointed (see Photograph 39).

The in-situ reinforced concrete deck appeared to be in good condition with no significant defects noted. The soffit was heavily stained with algal growth over a 3-4m length at the west end of the bridge indicating that it is regularly wet but was found to be relatively dry at the time of inspection (see Photograph 40).

The masonry abutments also consist of granite ashlar masonry. Inspection of the abutments showed that there were no signs of flexural cracking, rotation or differential settlement which would be indicative of structural distress due either to overload or movement of the substructure (see Photograph 41). All visible areas of the masonry abutments are well pointed (see Photograph 42). The concrete abutments were also found to be in good condition and show no evidence of structural distress due to overload or movement. The concrete finish is poor with widespread seepage staining evident throughout (See Photograph 43). Photos of the east and west elevations have been included as photographs 44 and 45 respectively.

5.3 Proposed Remedial Work

In accordance with the requirements of the scheme brief, the contract shall as a minimum include for the following rehabilitation works to the structure;

(a) Waterproofing and re-surfacing of the concrete bridge deck;

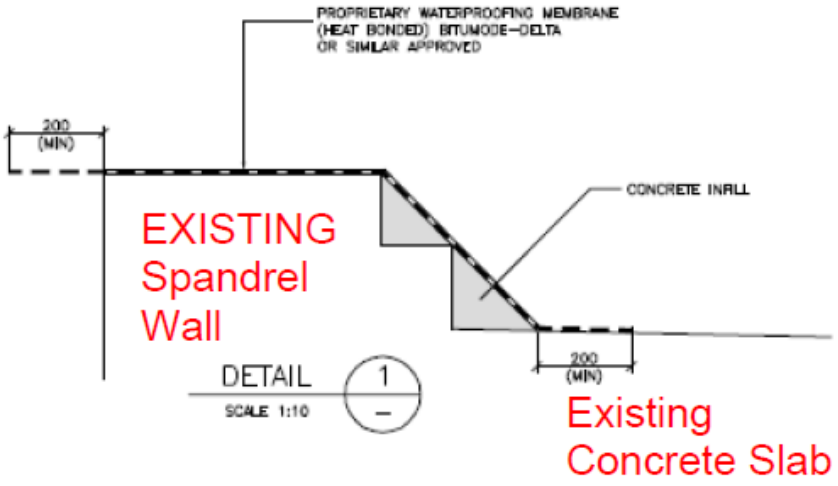
(b) Installation of safety barriers at the bridge structure;

(c) Reconstruction of masonry bridge parapet.

The above works shall be individually discussed followed by any additional works arising from the site inspection.

5.3.1 Waterproofing and Re-surfacing of the Bridge Deck

The concrete bridge deck will be waterproofed with an approved spray applied membrane with current IAB / BBA Certificate. The bridge deck waterproofing will extend down the back of the abutment walls for a distance of 200mm below the deck soffit. A 20mm thick sand asphalt protective layer will be provided above the waterproofing system. A suitable concrete slab/spandrel wall interface detail will be designed following receipt of the findings of the structural investigation. Observations on site confirmed that the existing spandrel wall was left in place at the interface as part of the widening works. Detail 1 below shows a typical interface waterproofing detail used by ROD for similar works.



A review of the Stage 1 Assessment report and associated structural investigation report indicates that there is no existing bridge deck waterproofing system to the top of the reinforced concrete deck. However, the Works Proposals will include for concrete repairs to the deck in order to provide a suitable substrate to receive the proposed waterproofing system.

The existing east concrete verge will be broken out to facilitate installation of the proposed waterproofing system and reinstated to the original line and level afterwards.

5.3.2 Installation of Safety Barriers

A new safety barrier system is required at the bridge. The containment, extents and alignment of safety barriers shall be designed to the requirements of NRA TD 19/15 following receipt of the topographical survey. Terminals will also conform to NRA TD 19/15. Provisionally, it is proposed that safety barriers run continuously across the structure negating the need for transitions into existing parapets. In accordance with Table 5/5 of TD 19/15 a safety barrier will be provided for a minimum of 30m in advance of the approach end and 15-30m after the departure end of the vehicle parapet. The barriers will be aligned so as to avoid any reduction in the sight visibility envelopes at the existing driveways 80m and 70m north and south of the structure respectively.

A number of existing hazards, mainly signage, may require relocation or alternatively a Departure from Standard may be necessary. The existing directional sign on the southwest approach appears to be passively safe. However, any obstacle within a safety barrier working width can compromise the expected failure mechanism in the event of a collision.

It is proposed that a bolted down barrier system is provided over the extents of the concrete verges.

5.3.3 Construction of Masonry Parapet

It is proposed that a 1.0m high solid granite masonry parapet wall is constructed along the west side of the bridge to match that provided on the east side. The use of the 1.0m height requirement given in BS6779 is considered to be more appropriate than the 1.25m height requirement of BD 52/16. The parapet will act as edge protection as opposed to a vehicle parapet.

Similarly, the proposed parapet will not be designed to achieve the H2 containment requirement outlined in Table 3/1 of NRA BD 52/16. The safety barrier system described above will provide a complaint vehicle restraint system with the masonry parapets providing edge protection only.

5.3.4 Concrete and Masonry Repairs

Based on the findings of the visual inspection, no repointing or masonry repairs are required to the arch barrel, spandrel wall or abutments. In accordance with current best practice it is not proposed to remove calcite deposits from the stonework. These works are potentially damaging and yield no real benefit to the structure. The amount of leakage through the arch barrel is insignificant and therefore we do not propose to address this issue as part of the proposed works.

No repairs are required to the concrete section of the structure. Damp staining will be addressed via the installation of bridge deck waterproofing and the poor finish and staining of abutments is aesthetic only.

5.3.5 Repairs to Southwest River Training Wall

As outlined above, there is evidence of deformation and bulging of the southwest masonry river training wall. The boulder/drystone wall has been undermined and appears to be unstable. It is proposed that the existing wall is either:

- Taking down and rebuilt to the existing line and level with suitable rock armour protection to the toe of the wall to prevent recurrence of the defect, or;
- Removal of the existing wall and installation of a gabion basket river training wall.

6. WX-N11-003.00 GLEBE BRIDGE

6.1 Description of Structure

Glebe Bridge comprises a 3.69m single span masonry arch bridge extended to the east with an in-situ concrete culvert with a span of 3.05m. The masonry arch and concrete culvert components of the bridge are 11.66m and 27.36m long respectively giving an overall length (elevation to elevation) of 39.02m. The N11 carriageway crosses the concrete culvert section of the bridge only. The masonry arch section carries a densely vegetated sloped verge including some mature trees. Both sections of the bridge are considered to be buried structures with a depth of fill varying from 0.6 to 5.2m.

6.2 Visual Inspection of Structure

The site inspection of Glebe Bridge was carried out on Tuesday 16th February 2016 by Mr Peter King and Mr. Mark Nilan of Roughan & O'Donovan – Aecom Alliance. Owen O'Keefe of the ROD environmental department was also on site to carry out the ecological assessment which has been addressed in a separate report. The weather conditions were wet with an ambient temperature of approximately 8°C. The inspection included a detailed visual examination and photographic record of all relevant components of the structure. The findings of the visual inspection are illustrated in photographs included in Appendix B.

The HRA bridge surfacing was observed to be in good condition with no evidence of rutting, settlement or loss of surface texture (see Photograph 46). The horizontal alignment is reasonably good along this section of the N11 with a gentle horizontal curve on the approach and departure. Safety barriers are provided along either side of the carriageway which appear to be a compliant N2 system and are in good condition. The western safety barrier terminates in a P4 full height terminal approximately 20m south of the bridge. A stone masonry wall boarders the carriageway from this point onwards (see Photograph 47). The inlet and outlet of this buried structure are removed from the carriageway by 13m and 11m respectively. Edge protection is provided via a masonry parapet at the outlet. No edge protection is provided at the inlet (see Photographs 48 and 49).

Service enquiries are ongoing at the time of completion of this report. However, responses received to date confirm the presence of a buried Eir service in the west verge (1x100mm diameter PP duct) and an Irish Water underground service in the east verge (1x250mm diameter asbestos watermain). Given the nature and location of the works proposed for Glebe Bridge, it is not proposed to carry out any intrusive exploratory works to locate these services more accurately.

The west spandrel wall and wingwalls consist of random rubble stonework, partially rendered with a sprayed cementitious layer which appears to have come away from the top half of the wall which is now subject to minor vegetation growth. The walls appear to be in reasonably good condition with no evidence of structural distress noted on the west elevation (see Photograph 50).

The embankments are overgrown and steep in places but in general appear stable. However, as per the previous Principal Inspection (February 2015), there is evidence of significant erosion and slippage of the southeast riverbank over an 11m length on the outside of the bend as the river turns through 30 degrees at the outlet (see Photographs 51 to 53). The relatively short section (approx 1m) of erosion noted on the northeast embankment was also still evident (see Photograph 54). Regarding and the installation of a suitable embankment protection system to prevent further erosion is required at these locations.

The expressed arch consists of finely dressed square cut limestone masonry and the barrel comprises random rubble sandstone masonry. Generally, the arch barrel is in reasonably good condition. The arch shape is good with no evidence of deformation or displaced arch voussoirs. The barrel is well pointed and appears to have been recently repointed (see Photograph 55). However, the 3 no. "foundation to foundation" circumferential cracks noted during the previous Principal Inspection have not been repaired. As before:

- The first crack is typically 40mm wide and is located one stone width in from the west face approximately corresponding with the back face of the spandrel wall (see Photograph 56). 3 no. Tell-tale crack gauges were installed as part of the previous PI, two of which have since failed. The remaining intact gauge reads 0.7mm of relative vertical movement over a period of 12 months. This relatively small reading may indicate slight settlement of the spandrel wall or could be down to installation error or thermal affects (see Photograph 57);
- The second full length circumferential crack is typically 9mm wide and is located approximately 5m from the west elevation. It appears to have been repaired in the past but has reopened (see Photograph 58);
- The third circumferential crack is 8mm wide at the springing and 18mm wide at the crown of the arch barrel. This crack is located 1m from the interface with the concrete slab structure and 10m from the west face of the bridge (see Photograph 59).

All of the observed cracking is likely to be historic and non-progressive. As mentioned, the masonry arch component of the bridge is not subjected to live loading so the observed cracking is more than likely due to historic settlement. However, given that there is a level of uncertainty associated with the widest of the cracks located near the west face, it is recommended that remedial works are carried out to tie back the spandrel wall and prevent any possible movement. Although there is no noticeable leaning of the wall, it's possible that it's sliding due to erosion of the adjacent riverbanks and/or lateral pressure applied by tree root networks behind it.

There is no critical need to stitch the cracks in order to reinstate the structure's ability to distribute load transversely along the arch barrel. At present, the cracks are causing the barrel to act as three separate structures and therefore reduce its overall capacity. However, by inspection, these three sections of arch have sufficient capacity to sustain the dead load to which they are subjected. Accordingly, a superficial repair by means of pressure grouting and repointing would be adequate to sustain the durability of the structure and prevent further deterioration.

The in-situ reinforced concrete deck was generally in good condition with no significant defects noted (See Photograph 60). A single 1mm wide full width longitudinal (direction of span) crack was noted 10.8m from the arch-slab interface (see Photograph 61). The crack connects vertical cracks on the north and south abutments as discussed in more detail below. The crack is probably due to shrinkage

owing to lack of movement joints and is not considered to be structurally significant. However, given its width, resin injection is recommended for durability reasons.

The masonry abutments consist of a mixture of squared and random rubble stone masonry. The inspection revealed no evidence of any significant defects that would be indicative of structural distress due to overload, and all visible areas were well pointed (see Photograph 62). The only defects noted were the cracks which were a continuation of the "foundation to foundation" circumferential cracking to the arch barrel discussed above (see Photograph 63).

The concrete abutments were found to be in fair condition (see Photograph 64). As noted in the previous Principal Inspection, there are numerous, wide full height cracks on both abutments, some as wide as 6mm (See Photographs 65 and 66). A summary of all abutment cracks noted during the inspection is provided in Table 1 below:

Description	Location	Typical Width	Length	Comments
Vertical crack	South abutment: 4.0m form arch/slab interface	0.3mm	1.2m	Starts at top of abutment and tapers out
Vertical crack	South abutment: 7.1m form arch/slab interface	0.2mm	1.0m	Starts at top of abutment and tapers out
Vertical crack	South abutment: 10.8m form arch/slab interface	6mm	Full height	Crack appears to coincide with construction joint in lower half of abutment
Vertical crack	North abutment: 10.3m form arch/slab interface	6mm	Full height	Demec stud readings of 63mm and 75mm obtained, no reference reading available
Vertical crack	13.8m form arch/slab interface	1.5mm	1.4m	Starts at top of abutment and tapers out
Vertical crack	North abutment: 17.1m form arch/slab interface	3mm at widest point	Full height	Widest at base and tapers out
Vertical crack	South abutment: 19.4m form arch/slab interface	2mm	Full height	-

Table 1: Summary of Cracking to Concrete Abutments

A covermeter survey was carried out and it was determined that the abutments are of mass concrete construction. No reinforcement was detected and none was visible in the 6mm wide crack described above. It can be reasonably concluded that the cracks are due to high stresses shortly after casting due to shrinkage and early thermal effects with no reinforcement to resist the stresses and no movement joints to release them. The massive nature of the abutments (1m thick) would also have contributed to the problem. The cracking is not a structural issue and there are no concerns as regards the durability of these mass concrete abutments. As such, no repairs are required.

The riverbed is cobbled under the masonry arch section of the bridge. This paving has begun to break up approximately 1-2m downstream from the west face of the bridge (see Photographs 66 and 67). Repairs are required to reinstate the cobbled invert or cast a new concrete invert slab.

6.3 Proposed Remedial Work

In accordance with the requirements of the scheme brief, the contract shall as a minimum include for the following rehabilitation works to the structure;

(a) Crack Injection of reinforced concrete elements.

(b) Circumferential cracks will require stitching/grouting/repair

(c) Masonry repointing/repair/grouting.

(d) Scour remedial works

(e) Repairs to river embankments

The above works shall be individually discussed followed by any additional works arising from the site inspection.

6.3.1 Crack Injection of Reinforced Concrete Elements

It is recommended that the 1mm wide, full width longitudinal crack in the soffit of the reinforced concrete slab deck is resin injected. The crack is probably due to shrinkage owing to lack of movement joints and is not considered to be structurally significant. However, given its width, resin injection is recommended for durability reasons.

The abutment cracking is not a structural issue and there are no concerns as regards the durability of these mass concrete abutments. As such, no repairs are proposed to either abutment.

6.3.2 Circumferential cracks will require stitching/grouting/repair

As outlined above, the observed cracking is likely to be historic and non-progressive. In addition, the masonry arch component of the bridge is not subjected to live loading so the observed cracking is more than likely due to historic settlement. However, given that there is a level of uncertainty associated with the widest of the cracks located near the west face, it is recommended that remedial works are carried out to tie back the spandrel wall and prevent any possible movement. Although there is no noticeable leaning of the wall, it's possible that it's sliding due to erosion of the adjacent riverbanks and/or lateral pressure applied by expanding tree root system behind it.

There is no critical need to stitch the cracks in order to reinstate the structure's ability to distribute load transversely along the arch barrel. At present, the cracks are causing the barrel to act as three separate structures and therefore reduce its overall capacity. However, by inspection, these three sections of arch have sufficient capacity to sustain the dead load to which they are subjected. Accordingly, a superficial repair by means of pressure grouting and repointing would be adequate to sustain the durability of the structure and prevent further deterioration.

Further to discussions with TII, it was agreed that consideration also be given to the installation of a proprietary stitching system (e.g. Cintec) if not cost prohibitive. The aim would be to stitch the separated expressed arch back to the arch barrel to provide additional stability.

6.3.3 Masonry Repointing/repair/grouting

Based on the findings of the visual inspection, no significant masonry repairs are required. However as described above, there is some vegetation growth on the west spandrel wall. These areas require vegetation removal, raking out of any loose/friable

mortar and repointing using lime mortar in accordance with the NRA 'Specification for Masonry Repointing' and accompanying Notes for Guidance. Based on the initial inspection, approximately 40% of the spandrel wall requires repointing. As outlined in Section 6.3.2, it is recommended that the circumferential cracking to the arch barrel is pressure grouted and/or repointed depending on crack widths.

6.3.4 Scour Remedial Works

As outlined above, the riverbed is cobbled under the masonry arch section of the bridge and has begun to break up approximately 1-2m downstream from the west face of the bridge. It is proposed that scour protection measures in the form of a new concrete invert slab with downstand is cast at this location to prevent further erosion of the riverbed. TII has advised ROD that their preference is not to cast protruding stones into the invert slab as this has resulted in a trip hazard for maintenance personnel in the past.

6.3.5 Repairs to River Embankments

As outlined above, there is evidence of significant erosion and slippage of the southeast riverbank over an 11m length on the outside of the bend as the river turns through 30 degrees at the bridge outlet. In addition, a relatively short section (approx 1m) of erosion was noted on the northeast embankment. It is proposed that both embankments are locally regarded and a suitable embankment protection system is installed to prevent further erosion. This is likely to comprise the installation of gabion walls backfilled with a suitable imported fill or an "Armourstone" rock armour system.

6.3.6 Other Required Remedial Works

- It is proposed that all vegetation including some mature trees are removed from the west embankment over the masonry arch section of the bridge to ensure expansive forces from their root systems aren't contributing to instability of the spandrel wall or damage to the arch barrel below;
- It is proposed that timber post and rail fencing is installed around the inlet headwall to act as edge protection;

APPENDIX A
PHOTOS

Photo 1 – Structure 1: View of Carriageway Surfacing

Photo 2 – Structure 1: View of West Parapet

Photo 3 – Structure 1: View of East Parapet

Photo 4 – Structure 1: View of Scour Valve in West Verge

Photo 5 - Structure 1: Spandrel Wall

Photo 6 – Structure 1: Erosion of Southeast Embankment

Photo 7 – Structure 1: Erosion of Southeast Embankment

Photo 8 – Structure 1: Erosion of Southwest Embankment

Photo 9 – Structure 1: View of Arch Barrel facing East

Photo 10 - Structure 1: View of Carriageway Surfacing

Photo 11 – Structure 1: Leakage at West End of South Masonry Abutment

Photo 12 – Structure 1: Evidence of Recent Repointing of Masonry Abutments

Photo 13 – Structure 1: Concrete Abutment

Photo 14 – Structure 1: East Elevation

Photo 15 – Structure 1: West Elevation

Photo 16 – Structure 1: View of Field Access on Southeast Departure

Photo 17 – Structure 2: View of Carriageway Surfacing

Photo 18 – Structure 2: View of West Departure

Photo 19 – Structure 2: View of South Parapet

Photo 20 – Structure 2: Watermain on North Face

Photo 21 – Structure 2: Concrete Wingwall at Northeast Corner

Photo 22 – Structure 2: Concrete Wingwall at Southeast Corner

Photo 23 – Structure 2: Bridge Soffit

Photo 24 – Structure 2: Precast Edge Panels on South Face

Photo 25 – Structure 2: View on West Abutment

Photo 26 – Structure 2: Leakage Above Abutment at Northeast Corner

Photo 27 – Structure 2: Staining on East Abutment

Photo 28 – Structure 2: Structural Investigation

Photo 29 – Structure 2: Waterproofing From Structural Investigation

Photo 30 – Structure 2: Private Entrance at Northeast Corner

Photo 31 – Structure 2: Masonry Parapet Wall at Southeast Corner

Photo 32 – Structure 3: View of Carriageway Surfacing

Photo 33 – Structure 3: Eastern Masonry Parapet Wall

Photo 34 – Structure 3: Timber Fence on West Raised Verge

Photo 35 – Structure 3: Eir/Scour Valve on East Raised Verge

Photo 36 – Structure 3: East Elevation

Photo 37 – Structure 3: Southwest Masonry River Training Wall

Photo 38 – Structure 3: Southwest Masonry River Training Wall

Photo 39 – Structure 3: View on Arch Barrel

Photo 40 – Structure 3: Reinforced Concrete Deck

Photo 41 – Structure 3: Northern Masonry Abutment

Photo 42 – Structure 3: Southern Masonry Abutment

Photo 43 – Structure 3: View on Concrete Abutments

Photo 44 – Structure 3: East Elevation

Photo 45 – Structure 3: West Elevation

Photo 46 – Structure 4: View on Carriageway Surfacing

Photo 47 – Structure 4: P4 Terminal on Western Approach

Photo 48 – Structure 4: View on Eastern Inlet

Photo 49 – Structure 4: View on West Masonry Parapet

Photo 50 – Structure 4: West Elevation

Photo 51 – Structure 4: Erosion of Southwest Embankment

Photo 52 – Structure 4: Erosion of Southwest Embankment

Photo 53 – Structure 4: Erosion of Southwest Embankment

Photo 54 – Structure 4: Northeast Embankment

Photo 55 – Structure 4: View on Arch Barrel

Photo 56 – Structure 4: Crack on West of Arch

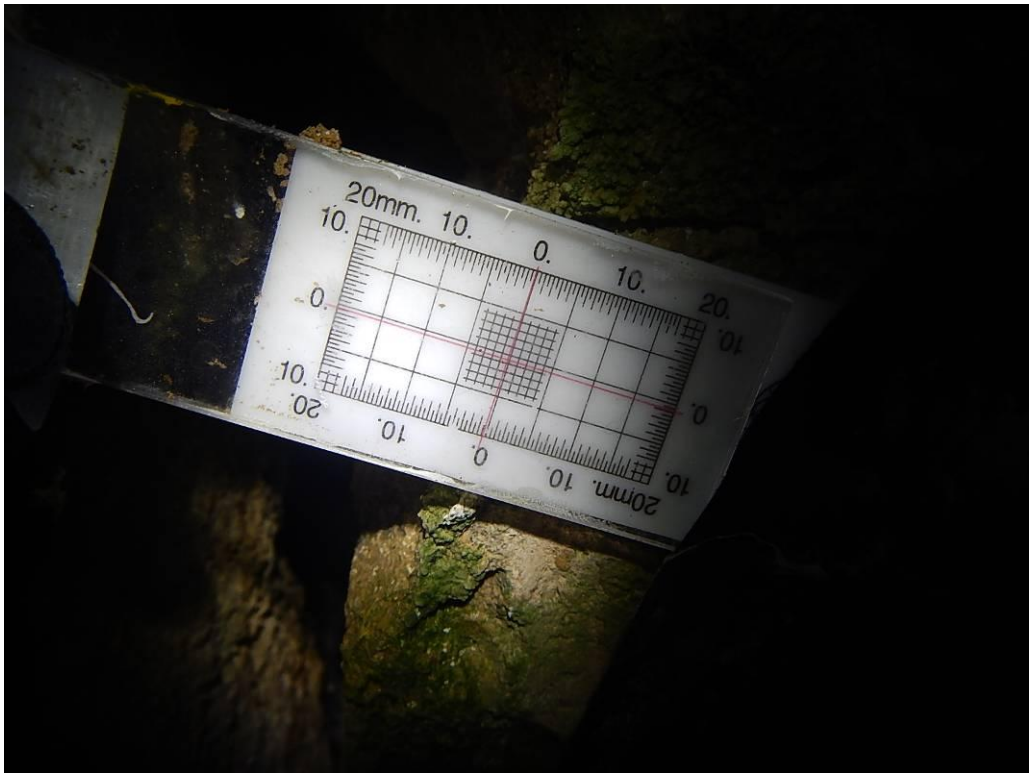


Photo 57 – Structure 4: Remaining Tell Tail

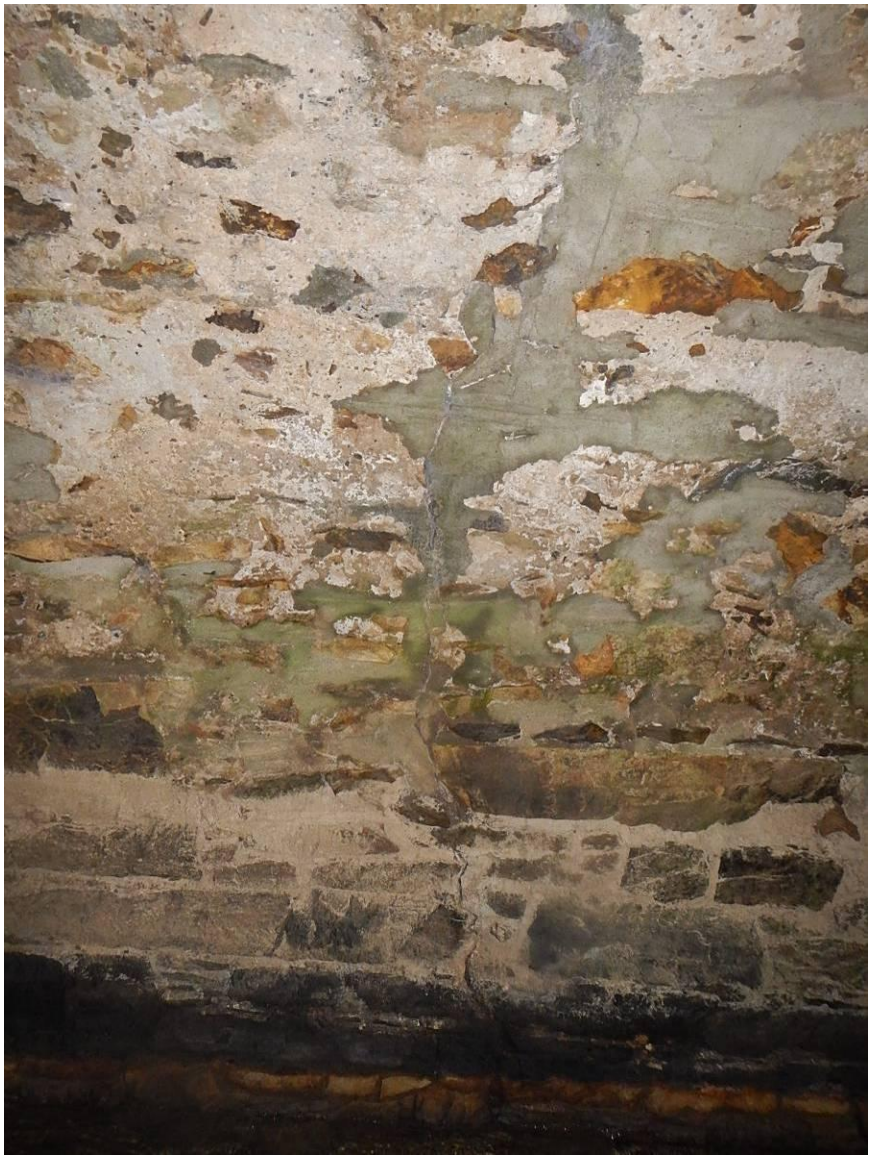


Photo 58 – Structure 4: Second Full Length Circumferential Crack

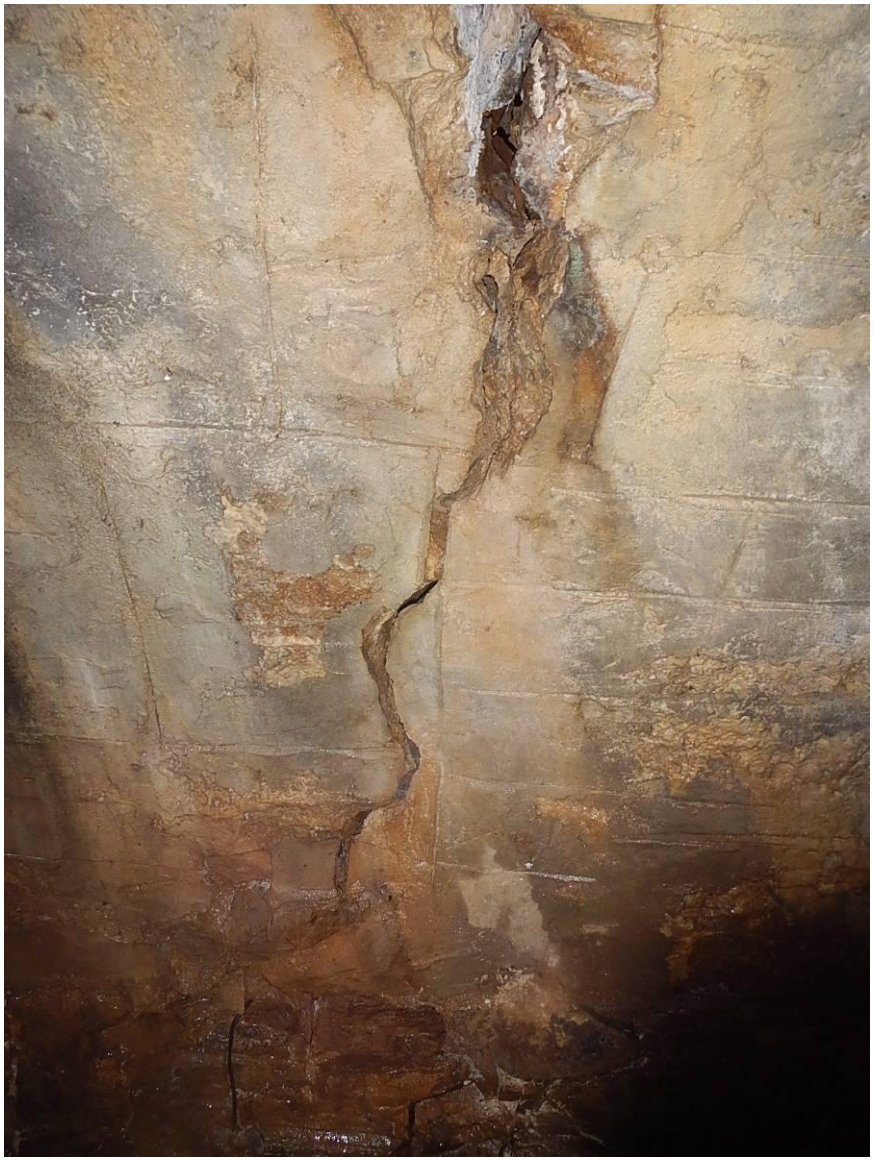


Photo 59 – Structure 4: Third Circumferential Crack

Photo 60 – Structure 4: Reinforced Concrete Deck

Photo 61 – Structure 4: Longitudinal Crack

Photo 62 – Structure 4: Masonry Abutment

Photo 63 – Structure 4: Circumferential Cracking to the Arch

Photo 64 – Structure 4: Concrete Abutment

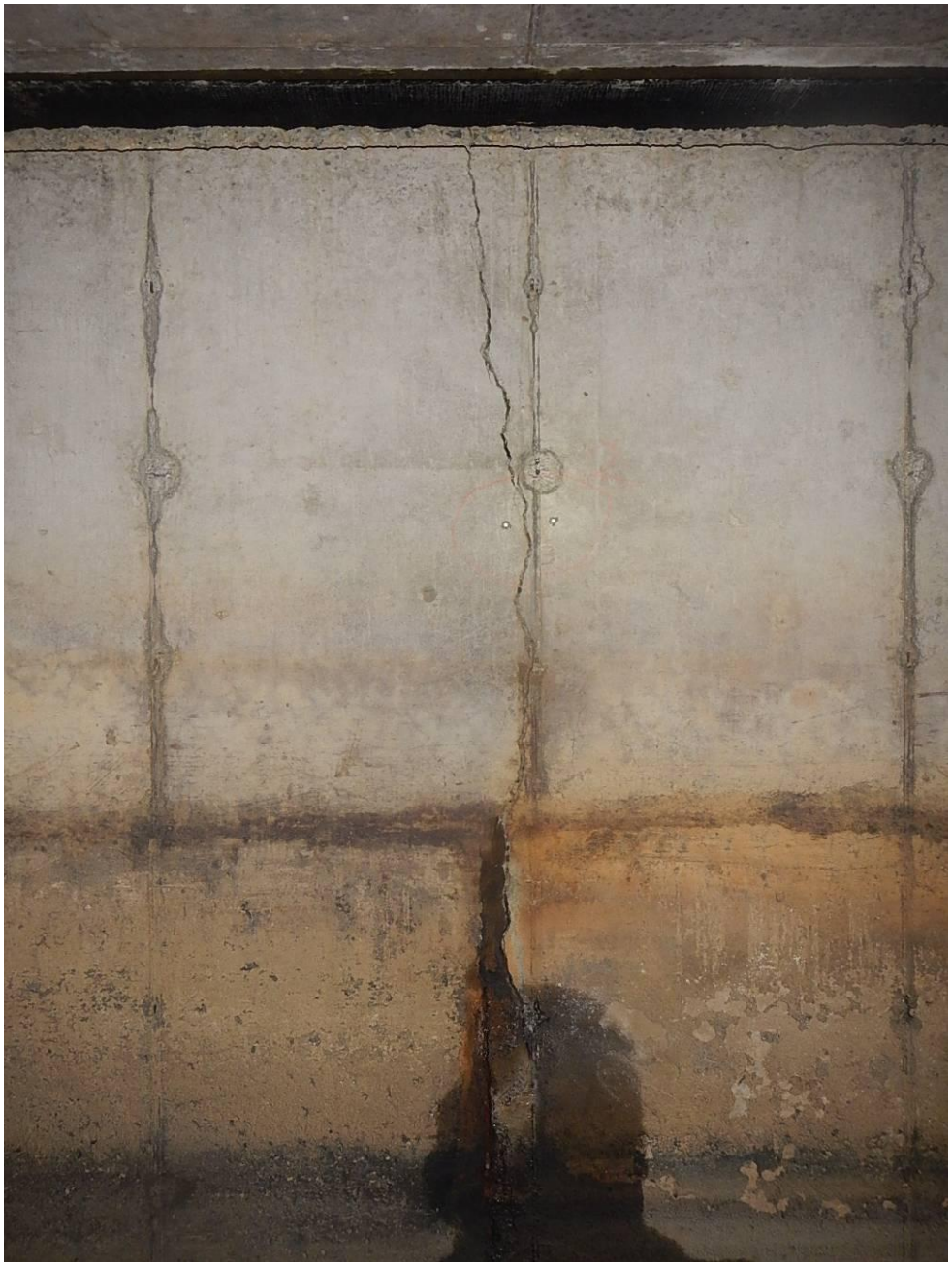


Photo 65 – Structure 4: Cracking on Abutment

Photo 66 – Structure 4: Cracking on Abutment

Photo 67 – Structure 4: View on Downstream

Photo 68 – Structure 4: View on Downstream