Dunkellin River and Aggard Stream Flood Relief Scheme

Architectural heritage and conservation report on completed works at Dunkellin and Craughwell bridges which are protected structures.
Final Report March 2022

Aerial view of Craughwell Pedestrian Bridge following completion of works

Aerial view of Dunkellin bridge following completion of works
Photographs courtesy of Galway County Council

Prepared by

Gerry McManus, conservation architect
B. Arch., M. Arch. Sc., MRIAI Conservation Grade 2 accredited.
Rockmount, Claregalway, Co. Galway

For

Galway County Council,
County Buildings,
Prospect Hill,
Galway

March 2022

Contents

List of other relevant documents/sources of information

All information is on file with Galway County Council.
Drawings and documents prepared by Tobin Consulting Engineers
Drawings and documents prepared by OPW
Reports and assessments prepared by Dominic Delaney, archaeologist
Reports and assessments prepared by RPS Group, environmental consultancy
Design drawings and information prepared by Sean Harrington architect
Drawings and documents prepared by Ward and Burke Construction Ltd., design and build contractors, and their advisors and suppliers

Acknowledgements
My thanks to Galway County Council for giving me the opportunity to work on this project, and to Enda Gallagher A/Senior Executive Engineer, in particular, who provided all the administrative support necessary to achieve the best possible architectural and conservation result for the two bridges. Many thanks also to all the consultants, contractors and tradespeople for help and cooperation given to me, and in appreciation of their work, particularly on those parts of the project which were most important to me.

Executive Summary

This report is prepared with reference to compliance with Condition 6 of the Grant of Planning Permission, Ref 07JA0035.

It concerns the flood relief works carried out in 2018-2020 at Craughwell Pedestrian Bridge and Dunkellin Bridge, which are protected structures.

Both bridges have considerable cultural significance, and have important architectural, archaeological, historical, and technical characteristics, as well as being important structures in their locality and beyond.

In addition, the river and the bridges have important environmental aspects, supporting aquatic life, birds, and other flora and fauna including bats.

A multi-disciplinary team was required to design and bring the flood relief project to completion.

Works at Craughwell bridge consisted of

1. The deepening of the river channels and associated work to provide flood relief including the use of the bypass channel.
2. The sealing of the bridge deck to protect the structure below from water ingress.
3. Repair of the cutwaters and parapet/guarding walls.
4. The consolidation of the wicker centring.

Works at Dunkellin bridge were originally planned to include the replacement of one of the 6 bridge arches with a wider span arch, and reducing the level of the flood plain.

During the early stage of works in August 2018, two of the bridge arches at Dunkellin collapsed, including the main river arch.

This required a redesign of proposals for a more extensive intervention but gave an opportunity for a new infill design which ultimately succeeded in successfully marrying the new into the original structure to form a harmonious composition.

Works at Craughwell and Dunkellin provided high quality solutions to adapting the bridges to accommodate the flood relief works, in tandem with repair of the original bridge structures.

As per good practice with all historic structures, the bridges and their stonework should be inspected and monitored on an on-going basis.

It is advisable that some further consolidation work which could not be undertaken at Craughwell in 2020 due to budget and time constraints, should be undertaken in the short term.

Dunkellin River and Aggard Stream Flood Relief Scheme

Architectural heritage and conservation report on completed works at Dunkellin and Craughwell bridges which are protected structures.

Introduction

Application was made by Galway County Council for approval under section 175 of the Planning and Development Act 2000, as amended, in accordance with plans and particulars, including an environmental impact statement and a Natura impact statement, lodged with An Bord Pleanála on the 9th Day of October, 2014.
For
Proposed Development: Proposed Dunkellin River an Aggard Stream Flood Relief Scheme, County Galway.

An Bord Pleanala decided to approve the proposed works for the Dunkellin River and Aggard Stream Flood Relief Scheme in March 2016 with conditions, Reference Number 07.JA0035. The proposed works included alterations to the protected bridge structures at Dunkellin and Craughwell. Condition number 6 relates to the protected structures:

6. While achieving the aims of the proposed development, the works proposed to the protected bridge structures at Craughwell and Dunkellin shall:

- *a. be undertaken in accordance with the requirements of the Architectural Heritage Protection Guidelines for Planning Authorities, issued by the Department of Arts, Heritage and the Gaeltacht (2011).*
- *b. respect the design, form, scale, materials, proportions and function of the original structures, and*
- *c. be supervised by a Conservation Architect qualified to at least Grade II RIAI or equivalent.*

Revised plans and particulars illustrating compliance with these requirements shall be made available for public inspection at the offices of the local authority prior to commencement of development and for a following period at least until completion of construction.

This report describes the alterations and amendments undertaken to the initial designs to ensure compliance with the above condition, and records the completed works to the two bridges from the viewpoint of architectural heritage conservation and protection. Archaeological reports by Dominic Delaney, consultant archaeologist of Dominic Delaney and Associates, provide an archaeological perspective which is a related historical viewpoint. Environmental, engineering, and other reports provide other perspectives. Tobin Consulting Engineers provided the overall scheme design for the flood relief works, including structural and civil engineering aspects, as well as project managing the scheme.

I provided an initial Conservation Assessment report on the five bridges affected by the proposed Flood Relief Scheme, including the bridges at Dunkellin and Craughwell. The first draft was submitted to Galway County Council in November 2016, as a result of which amendments were made to the proposed designs prepared by Tobin Consulting Engineers. The final revised Conservation Assessment report was completed in April 2017. In this report I concluded that the revised designs should enable compliance with condition 6 of the Bord Pleanala decision.

This Conservation Report on Completed Works provides an annotated photographic record of my monitoring of the in-progress and completed conservation works on the two bridges, and how the alterations necessary for the flood relief works affected the historic fabric of the bridges.

Prior to and during works, the existing bridge fabric was studied and comprehensively recorded by Dominic Delaney, Archaeologist. He provided archaeological monitoring of all excavation works associated with the works to the bridges, and applied for necessary licenses etc. See his reports.

RPS Group provided environmental monitoring of the works during construction. The historic stonework of early bridges often provides habitats for birds and bats and this was the case in Craughwell and works had to be timed to avoid disturbing them. Aquatic life also had to be protected.

As referred to above, Tobin Consulting Engineers provided the design for the overall Flood Relief Scheme and associated work to the bridges affected, including structural analysis and design proposals to a particular level, as per contractual arrangements. They project managed the job during construction. The contractual arrangements for detailed design and construction differed for different parts of the scheme. Information on these arrangements is available elsewhere, but it is noted that the works at Craughwell were undertaken by the Office of Public Works, and the works at Dunkellin bridge were undertaken under a 'Design and Build' contract where Ward and Burke Construction Ltd. were the appointed contractors.

Compliance with the planning condition

Works to

> *6a) be undertaken in accordance with the requirements of the Architectural Heritage Protection Guidelines for Planning Authorities, issued by the Department of Arts, Heritage and the Gaeltacht (2011).*

The Architectural Heritage Protection Guidelines provide comprehensive general advice on how works to a protected structure might be approached. This report will outline how the design decisions made in relation to the two bridges respected the advice in the Guidelines, and how the Methods of Work were, in my opinion, based on my periodic site inspections, and relying on information and certification from the contractors and other parties involved in the design and execution of the Works, in substantial compliance with the Guidelines.

Chapter 7 of the Guidelines sets out the Conservation principles. The purpose of this section is, among other things, to ensure that

structures or parts of structures which are of special interest are identified

and

the architectural heritage is protected (by protecting the character of protected structures and their contexts).

The conservation principles are set out in detail under the headings

Keeping a building in use
Researching and Analysing
Using Expert Conservation Advice
Protecting the Special Interest
Promoting Minimum Intervention
Respecting Earlier Alterations of Interest
Repairing rather than Replacing
Promoting Honestly of Repairs and Alterations
Using Appropriate Materials and Methods
Ensuring Reversibility of Alterations
Avoiding Incremental Damage
Discouraging the Use of Architectural Salvage from other Buildings
Complying with the Building Regulations

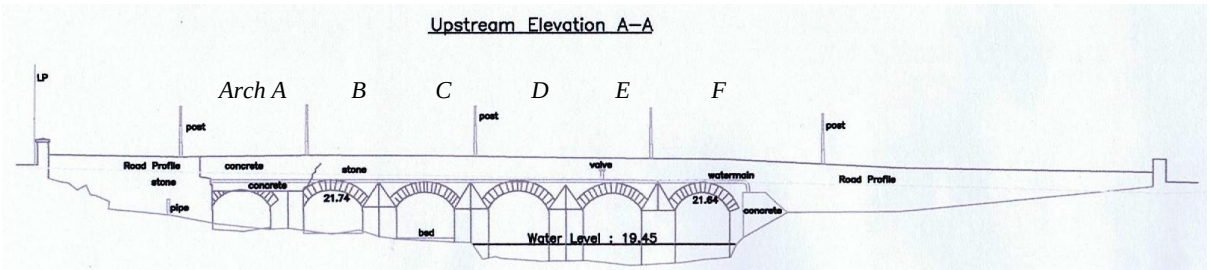
These principles were followed in so far as they applied, and in so far as possible, at the bridges at Craughwell and Dunkellin. The literal application of the principles was not always possible, but the overall approach to the necessary alterations of the protected structures was informed by them with a view to compliance with condition 6b of the Planning Permission which stated that

works should

> *6b) respect the design, form, scale, materials, proportions and function of the original structures,*

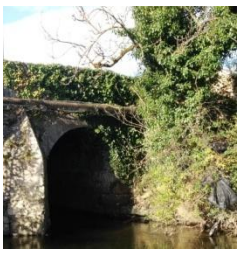
1.0 Craughwell Pedestrian Bridge.

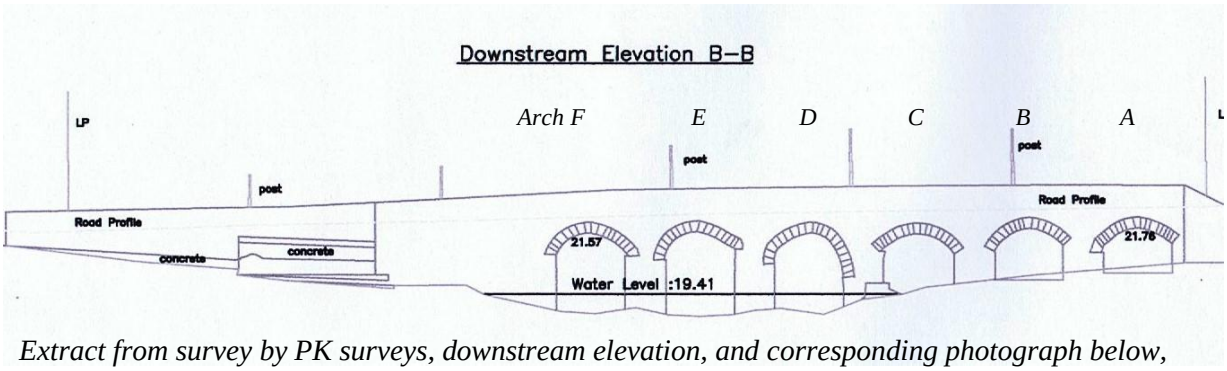
The survey drawings and photographs on this page were made as part of my Conservation Assessment Report in 2016/2017.



Extract from survey by PK surveys, upstream elevation, and corresponding photographs below, 2016

Arch A *B* *C* *D* *E* *F*





Extract from survey by PK surveys, downstream elevation, and corresponding photograph below, 2016

Arch F *E* *D* *C* *B* *A*

Oblique view, downstream facade.

1.1 Description

The bridge is described in the NIAH[1] survey as follows:
"*Six-arch limestone road bridge over Craughwell River, built c.1600 and widened to west perhaps late seventeenth century[2] and to east c.1780. Original bridge was ten feet wide, early widening added two feet and later widening added same width again as original bridge. Formerly in use as vehicular bridge, now bypassed and in use as pedestrian bridge. Well preserved wicker centring to soffits of earliest part, and partly hidden arch ring towards west side of bridge, is of irregular voussoirs. Rubble stone walls, piers and parapet walls. Piers apparently refaced in squared limestone blocks, perhaps at time of latest work. Segmental arches to east elevation with cut-stone voussoirs and dressed stone V-cutwaters. Pointed round and segmental to west elevation.*"

In line with the principles set out in Chapter 7 of the guidelines for Planning Authorities, Dominic Delaney, Archaeologist, was appointed to do extensive research, recording and analysing prior to the start of works. He identified the different phases of the bridge construction and the features of each part of the fabric. He summarises as follows:

Phase 1 (16th/17th century): The original bridge was 3.1m wide. The arches, now sandwiched between the later additions, survive intact. The soffits contain well-preserved wicker centering and the partly-hidden arch rings are of irregular limestone voussoirs. The original pier walls do not survive as the walls were completely refaced during the 3rd phase of works c.1780.

Phase 2 (late 17th)[3]: The bridge was widened 0.9m to the west. Projecting stones or corbels on either side of the pier walls are associated with the method of construction for the arches. The pier walls and arch rings are built of roughly worked limestone blocks and voussoirs.

Phase 3 (late 18th): The width of the bridge was almost doubled with the addition of 3.5m to the east. The pier walls, V-shaped cutwaters and arch rings are built of cut and dressed limestone blocks. The channels were floored with large cobble-type stones and boulders. The pier walls of the original bridge were re-faced with squared limestone blocks.

Phase 4 (Mid/Late 19th): The canalisation of the river in the late 19th century involved the deepening of the riverbed in the 3 northern arches. This work necessitated the removal of the cobbled flooring and underpinning of the pier walls. The 3 southern arches were not impacted by the works. These arches are dry except in conditions of high water.

1.2 Cultural significance

As a prerequisite to its protection the special characteristics of the bridge were identified.

The bridge is a protected structure, no.3023 in Galway County Council's Record of Protected Structures. The bridge is registered under the National Monuments Acts and has RMP number GA096-185 and is scheduled for inclusion in the next revision of the Record of Monuments and Places.
The special interest and characteristics which define the cultural significance of the bridge were identified and defined as follows.

- The bridge has aesthetic value - each phase of the bridge was designed to be both functional and aesthetically pleasing. The detailing of the bridge is of a high standard and well executed

[1] National Inventory of Architectural Heritage

[2] More likely date of shortly after the 1727 Road Act which made 12 feet the minimum width of a bridge.
[3] More likely date of shortly after the 1727 Road Act which made 12 feet the minimum width of a bridge

with each phase having its own style of stonework, testament to the skill of the local craftsmen that built it.

- The bridge exhibits particular construction techniques which are of technical/scientific interest, and it is of additional interest because it contains three distinct, though similar, types of construction, each indicative of the engineering of their periods.

- The bridge is of historic interest as an important element in the national road infrastructure for four centuries. It was also a key component in the development of Craughwell village and its current attractive condition and use as an amenity indicates its importance to the local community.

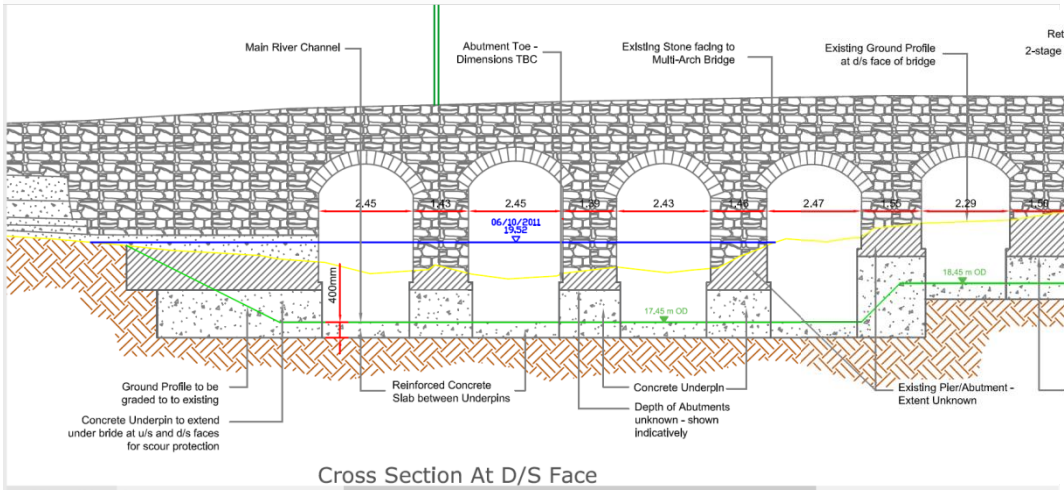
- Its early date adds to its significance and the survival of well-preserved wicker centring gives it archaeological as well as architectural interest.

In summary, Craughwell pedestrian bridge is of considerable cultural significance. The bridge has architectural and archaeological significance because of its design, its age (c.1600 with later additions), its technical interest, and its history.

The necessity for flood relief works meant that alterations to the bridge were required while at the same time ensuring that the above important characteristics were respected and preserved.

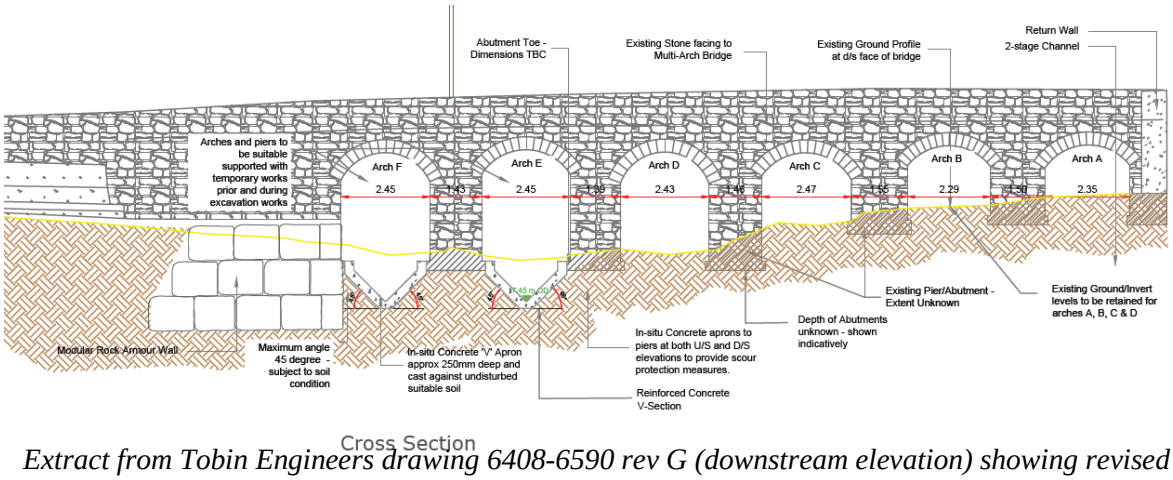
1.3 Original Proposals

The original design for flood relief works at the bridge involved the deepening of the channels under all the arch vaults as per the drawing below. This was considered a reasonable proposal in principle as it allowed the preservation of the original structure. Proposals were drawn up by Tobin Consulting Engineers.



Extract from Tobin Engineers drawing 6408-6590 rev A showing proposed underpinning of piers including cut waters, and the deepening of the channels under all the arch vaults.

However, as the detailed design work progressed, and in the light of a detailed assessment of the vulnerabilities of the historic structure, an alternative proposal was drawn up. The deepening of two channels, in tandem with the use of a bypass channel, was projected to be adequate to mitigate the flood risk, and this proposal was confirmed as the way forward, This provided a much improved solution in heritage protection terms, in that it required much less interference with the historic fabric (following the principle of Minimum Intervention as set out in the Guidelines), and it has in fact been very successful in execution. See Tobin's drawing below.



Extract from Tobin Engineers drawing 6408-6590 rev G (downstream elevation) showing revised scheme for underpinning and deepening of channels – this was the scheme which was executed. Note that this scheme avoids major intervention to arch D which was found to be in relatively poor structural condition in Tobin's 2018 report[4]

The execution of the flood relief works at Craughwell bridge was undertaken by the OPW and their records and Tobin Engineers detailed design drawings and calculations provide a comprehensive description of the works. My account which follows highlights areas of interest and concern to me, these being the heritage and conservation aspects.

1.4 Description and record photographs of works

The works to the bridge had four different aspects.

i. The deepening of the river channels and associated work to provide flood relief including the use of the bypass channel.
ii. The sealing of the bridge deck to protect the structure below from water ingress.
iii. Repair of the cutwaters and parapet/guarding walls.
iv. The consolidation of the wicker centring.

1.4.1 Deepening of the channels below arch vaults E and F

Photographic and drawn records of the existing fabric were taken by the archaeologist.

Work was commenced in the summer of 2019 when water levels were low and all water was diverted to the bypass channel so that the river bed below the historic bridge was dry. Extensive temporary works were necessary to protect and prop the existing historic fabric during alteration work and specially designed site specific temporary works were erected. Netting also had to be erected to prevent the re-entry of birds and bats once they had departed/ceased to use their nests.

[4] Tobin Consulting Engineers: Structural Condition

Photographs from August 2019

Netting was erected below the vaults to prevent roosting by bats and birds except where nests or roosts were already established (as in arched vault D) where access to nests was left open for as long as they were being used.

Netting also served to catch any debris which might fall during works.

Substantial timber props were inserted to ensure stability of the structure during works. It was imperative that vibration or any disturbance to the existing structure was kept to an absolute minimum in order that historic fabric would not be lost, including the medieval wicker centring.
In this photograph deepening of the river channel has been done downstream of the bridge but lowering of the bed below the bridge itself has not begun. Building of concrete retaining walls at the abutment is underway.

Photograph from Sept 2019

Excavation below arches E and F has been completed and a section of the concrete 'V' apron is in place.

Photographs from October 2019

Downstream view, arches E and F in foreground. *Detail view of concrete apron.*
Concrete 'V' aprons are complete under arch vaults E and F and in-situ concrete aprons to base of piers to provide scour protection.

Floors below vaults D, C, B and A were not disturbed except to be cleared of debris. They remain as found.

Photograph from April 2019 of floored river bed below arch vault C. Probable c.1780 date.

Photographs from 2020

May 2020 prior to removal of upstream dam.

June 2020 when dam was dismantled and river restored to its primary channel. Bypass channel remains open to take water in the event of flood.

1.4.2 Sealing of the bridge deck

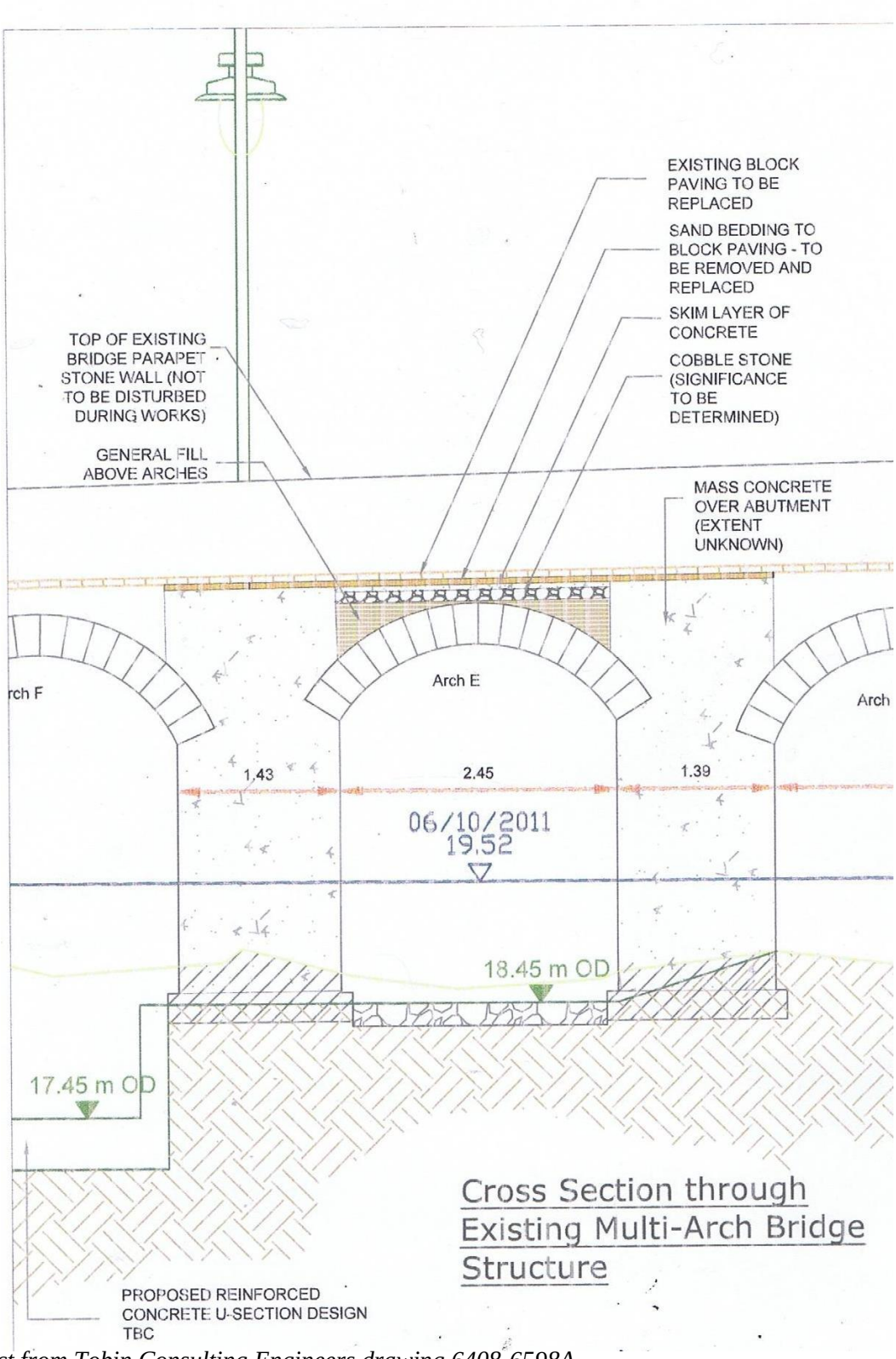
The 20th century brick paving laid in sand on the bridge deck when it was pedestrianised was porous and water penetrating through the structure was resulting in washout of mortar causing loosening of some stones in the vaults and loss of the wicker centring. Sealing of the bridge deck was necessary to alleviate these problems. Exploratory opening-up works were undertaken in August 2018 and further more comprehensive opening up was undertaken in April 2019 to enable the design to be finalised and resurfacing work to be commenced. Opening up was fully recorded by Dominic Delaney (see his reports). It was found that a relatively early (19th century?) cobbled surface survives in part over the stone vaults though the apices of the vaults are close to this surface. However the area over the piers between the vaults is covered in mass concrete, The depth of this concrete is not confirmed but is considered likely to be considerable. It is thought that this concrete may have been inserted to strengthen the bridge sometime c.1980 (?)[5] in anticipation of the transportation of a particular heavy load being delivered to Galway. See on following pages extracts from Tobin drawing 6408-6598A (dated March 19) showing section of bridge as found, and 6408-6597B (dated June 19) with proposals for resurfacing.

Photograph taken on 22 aug 2018 during exploratory works to establish construction below existing paving. Limited opening up is often necessary as part of research to allow informed decisions to be made about future works

Photographs taken August 2019

Skim layer of concrete over cobbles over arched vaults and mass concrete over the abutments

[5] Local reports this strengthening work was done when heavy material was being brought from Galway Docks to Tynagh mines. (Unconfirmed report)



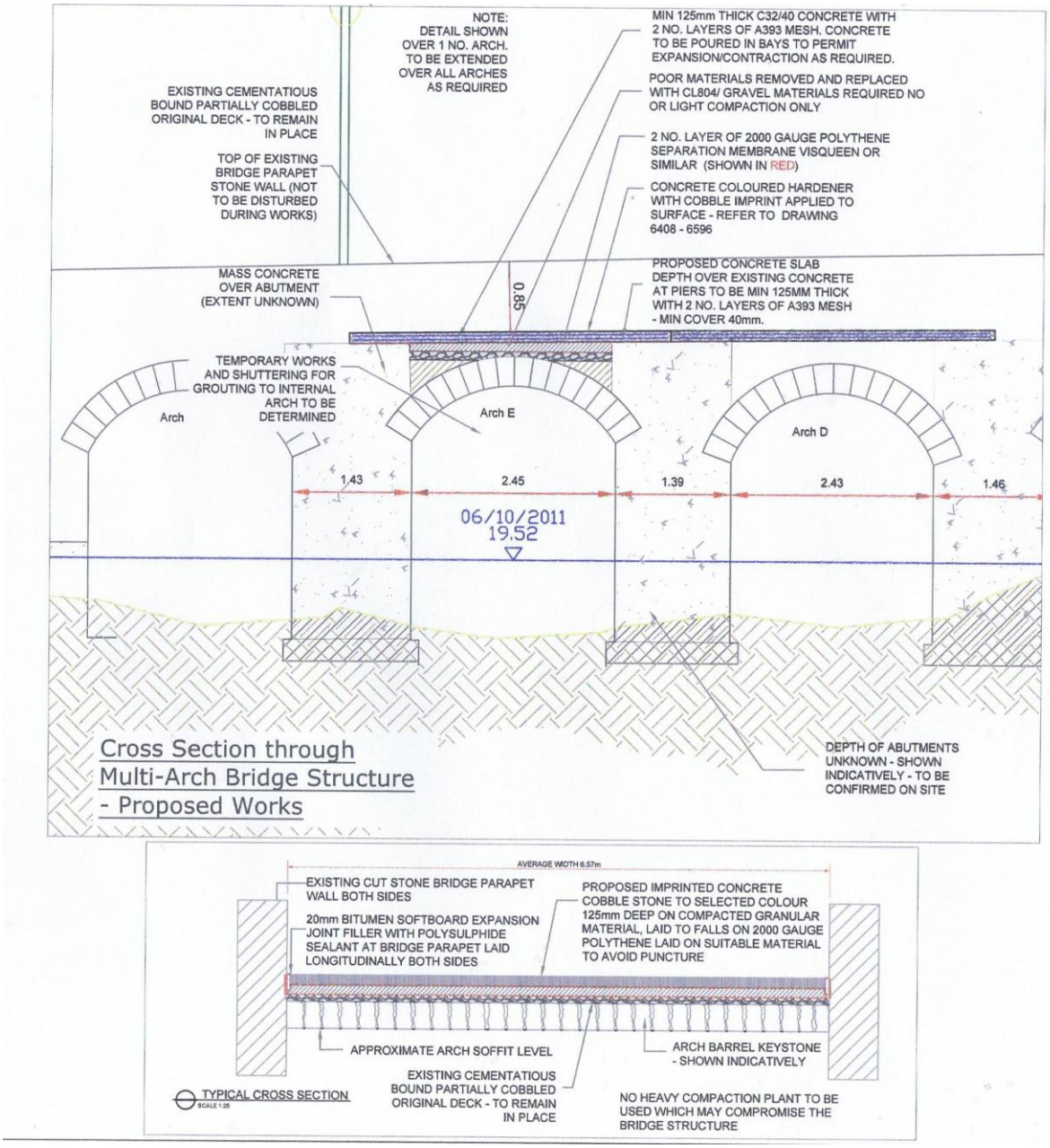
Extract from Tobin Consulting Engineers drawing 6408-6598A

The new surface for the bridge deck had to be impervious to protect the vaults below from water ingress. It was also important that any intervention would, in line with good conservation practice, be reversible, so that the historic fabric of the bridge, including the discovered cobbles and the structural vaults, would not be damaged, and could be revealed again in the future if desired. (Ensuring Reversibility of Alterations as per the Guidelines.) Following consultation with Galway County Council's conservation officer it was agreed that an imprinted concrete surface laid on an impervious

isolating membrane (DPM) and finished to give the appearance of cobbles would be suitable. A platinum grey colour was chosen as it would be in keeping with the surrounding stone walls. Surface texture and slip resistance were other important considerations.

Prior to the laying of the DPM, minor works were undertaken consisting of the filling of voids or large gaps where there was obvious stone loss and which had to be addressed for structural reasons. In line with good conservation practice a lime/sand mortar mix was used for this work and stones of appropriate size and shape. (Using appropriate Materials and Methods as per the Guidelines.) A budget was applied for that would have facilitated a more expansive grouting and re-pointing exercise but this was not approved.

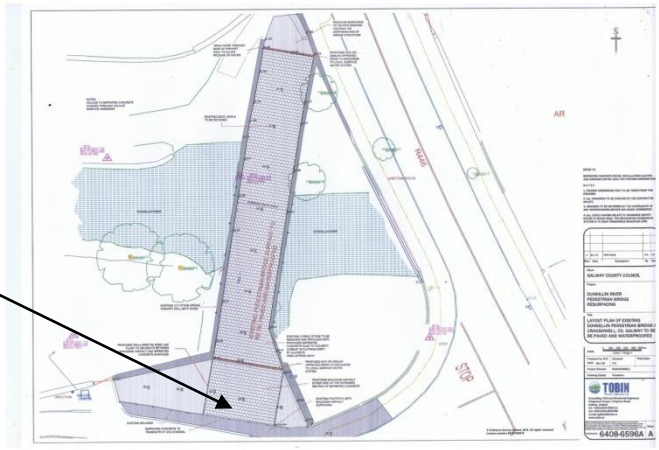
I believe that the waterproofing of the top deck was a key action and that it will have a positive impact on the bridge fabric and, in particular, will help prevent further deterioration of the wicker centring.



Extract from Tobin Consulting Engineers drawing 6408-6597B. Works proceeded on the basis of these proposals apart from the guarding wall/deck junction which was revisited during the consolidation works to the wicker centring (see that section of this report).

Tobin drawing showing plan view of resurfacing proposal.

New imprinted concrete surface follows the line of the old road as far as the existing footpath to provide a physical reminder of the route of the historic roadway and the approach to the bridge.



The laying of the imprinted concrete finish did not finally take place till November 2019. Weather conditions dictated that temporary protection over the entire bridge deck area was required. The existing falls for surface water run-off on the bridge were not altered. Drainage holes in the upstream parapet were kept open.

View of new surface in Nov 2019. Rectangular formwork around 'holes' in the surface mark the location of the supports for the temporary protection.

'Holes' were subsequently filled in in matching material.

Views of the south end of the bridge deck show the new imprinted concrete surface following the line of the old road, with tarmac infill either side.

1.4.3 Repair of cutwaters and parapet/guarding walls

The cutwaters which are in the main river channel between arches C and D, and E and F, were in poor condition, particularly that between C and D where a large sycamore sapling was growing. Some parts of the parapet guarding walls contained loose stones and mortar joints were locally badly washed out. The consolidation of the two cutwaters and the parapet walls was not done by the OPW but by Stankard Stone Masons under contract with Galway County Council.

Consolidation of the cutwaters involved complete dismantling and rebuilding of the cutwater between arches D and E where a large sycamore was growing, and limited resetting of stones and some replacement of damaged or missing stones in the cutwater between E and F. Both cutwaters were re-pointed following rebuilding/repair. The work was done in October / November 2019, which was late in the year so an NHL5 mix was specified. The available setting time for the mortar was also curtailed by the imminent date for the reintroduction of the diverted river water.

Stones were numbered prior to dismantling and re-erected in their original positions. Some stones had suffered damage with pieces spalled off and arrises no longer sharp but flaws were accepted and new stone was not introduced. During rebuilding of cutwater D/E the core of the cutwater was filled with a concrete mix as work progressed. This was accepted due to the difficult conditions and time constraints on the job, and because, due to the hard nature of the limestone, the use of cement should not be detrimental to the stonework.

27 Aug 19. Note positioning of large boulders in river bed as part of OPW strategy for water management

27 August 2019, cut waters prior to consolidation works.

30 October 2019 general and close-up view of cutwater D/E following dismantling.

Repaired cutwater D/E on 6 Nov 2019 prior to pointing. Lower stones have lost their sharp corners

Cutwaters on 7 Nov 2019. Pointing D/E is done but not yet finished/beaten back.

Work on completion – finish of the pointing in the joints is not satisfactory but natural weathering process is expected to improve the appearance. Time constraints in Nov 2019 did not allow revisiting of the work to improve the finish.

Repair of the parapet guarding walls

Repair of the parapet walls was due to be completed before the end of 2019 but due to various delays the work did not take place until 2020. Repairs were relatively minor in nature, consisting of localised resetting of loose stones, re-pointing, and repairs to the capping. The parapet walls had obviously been extensively repaired over the years with varying amounts of skill. It is the nature of bridge parapet walls that they are at high risk of mechanical damage due to vehicle impact. No alteration was made to the height of the parapet walls.

Budget did not allow general correction of previous ‘mistakes’ such as stones laid incorrectly or local concrete repairs, but where stones were loose they were rebedded in correct alignment where possible. An NHL3.5 lime/sand mix was used for repair and an NHL5 mix was used for the mortar capping.

Modern lamp standards were removed as part of the works in order to restore the traditional character of the bridge.

14 Sept 2020. Damaged stone and redundant light fixing. Tapping of wall to test for soundness revealed several loose stones

Capping in poor condition

Repaired section of wall, Oct 2020, upstream side, north end

New mortar capping, upstream side, south end

General view of repaired parapet walls

Aerial view of bridge from the west Aerial view of the bridge from the east. (courtesy Galway Co Co)

1.4.4 Consolidation of wicker centring

Consolidation of the wicker centring was undertaken under separate contract financed by Galway County Council. Contractors were Mathieu Mitchell Builders Ltd. The work was done in November 2020 following a bat survey and the erection of netting to exclude bats which were found to be again using the arches.

Consolidation was undertaken under vaults A, B, and C. using mortar injection techniques and careful pointing. Vault D was found to be extensively used by bats and it was decided that as the amount of surviving wicker there was so small that no intervention would be made. Consolidation was problematic under vaults E and F as these are the river arches. Consolidation was not undertaken at this time under these arches.

It should be noted that the vault stonework itself was in need of consolidation in some places. In tandem with the securing of the wicker centring in A, B, and C, consolidation of the stone underside of these vaults was also undertaken where feasible. It was not undertaken around the entrances to the vaults on both sides of the bridge (below the parapet walls) where water from above was still penetrating in large amounts. Further consolidation should be undertaken as necessary at a suitable time now that sealing of the deck is complete.

Consolidation of the vault stonework consisted of the tightening of loose stones by inserting wedges of suitable stone pieces and the vigorous throwing and securely pushing back of coarse mortar into joints between stones.

Consolidation of the wicker centring was done by injecting mortar behind exposed edges and into gaps and cracks in the wickerwork. Mortar for injection consisted of fine sand and lime putty mix, or where gaps were very small, pure lime putty. Mortar was of a fairly liquid consistency. This was injected using a 60ml syringe with an outlet diameter of 5mm.

Mortar for general consolidation consisted of a hot lime mix gauged with NHL3.5.

Sample photographs of Arch A follow illustrating the works. See my *Craughwell Pedestrian Bridge. Consolidation of wicker centring and arch vaults, report on works done Nov-Dec 2020* in appendix for more detailed account.

Aech A, View looking upstream
Photographs May 2020 prior to works

Closer view of wicker centring

View looking upstream
Fine mortar mix was injected behind the wicker centring to re-adhere it to the background stonework. New mortar is just visible at the edge of the wicker (circled red)

View looking upstream
General consolidation of vault stonework using pinnings and coarse mortar mix.

Photographs of Arch A, Nov 2020 post works

Views looking downstream, Arch A, post works.

1.5 Note on joint at parapet wall/deck junction, Dec 2021

The new deck surface appears to be successfully preventing water penetration through the bulk of the bridge surface, thus protecting the vaulted structure below, including the wicker centring. However, in Dec 2020 and in Nov 21, it was noted that the outer sections of the vaults below the parapet walls and inside them for a short way are completely saturated, having been subjected to persistent water penetration as water drained to the edge of the bridge deck. This is particularly so on the upstream side due to falls in the bridge deck towards this side, although the principal fall in the deck is from the south end to the north end of the bridge.

The consolidation of the stonework from the underside in these outer areas could not be completed as part of the works. This was due to time constraints on working with lime mortar as winter approached. Consolidation of the wickerwork was prioritised before the cold weather set in and the outer sections could not be tackled.

It was hoped that the sealing of the joint between the bridge deck and the parapet walls would reduce the volumes of water sufficiently so that a reasonable and moderate wetting/drying cycle would be established in the outer parts of the bridge vaults below the parapet walls. On inspection in November 2021 this has not established and the condition of these parts has not improved from that prior to works. This may be partly due to the fact that consolidation from the underside in the outer sections has not been done but it may be partly because the seal at the junction between the parapet wall and the bridge deck is not performing as anticipated. Conditions are worse on the upstream side of the bridge where there are several surface water outlets through the parapet wall.

1.6 Necessary further work at Craughwell pedestrian bridge

It will be necessary to undertake further works in these outer parts of the bridge. In November 2021 much growth of algae has established indicating that large amounts of water are penetrating. While there is no immediate evidence that conditions are significantly worsening[6], saturation and liquid water moving through the fabric could cause mortar wash-out, loosening of stonework, and instability. Additional remedial works should be planned in the short term. The conservation officer should be consulted and grant aid may be available to assist in financing the work.

1.7 On-going inspection and monitoring

The bridge and the stonework of all the vaults should be inspected and monitored, structurally and generally, on an on-going basis, by the relevant department in Galway county council. Note that due to the complex nature of the project, and the various different constraints, including particularly in the

[6] Structural assessments should be carried out by structural engineer.

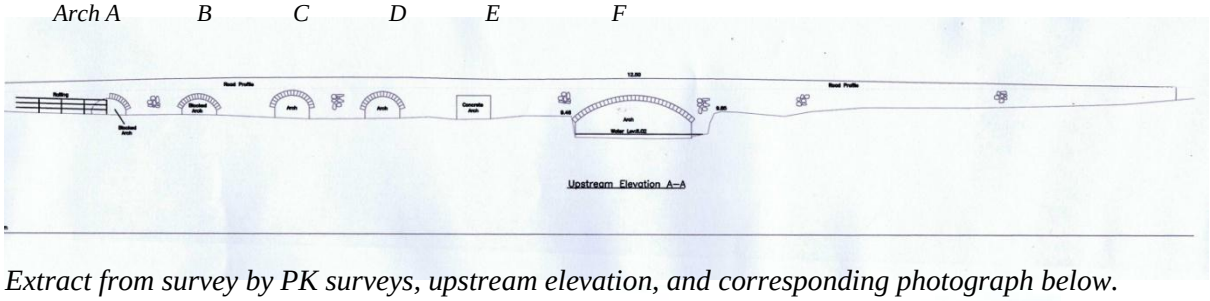
case of arch D, the need to protect roosting bats, that not all of the structural issues highlighted in Tobin Engineer's *Structural Condition Report of Multi-Arch Bridge in Craughwell, Co. Galway, 10/10/18*, have been addressed during the course of the works. Care of historic structures requires on-going commitment to maintenance and repair.

Nov 2021 Extensive algae growth below outer part of vault, upstream side.

2.0 Dunkellin Bridge

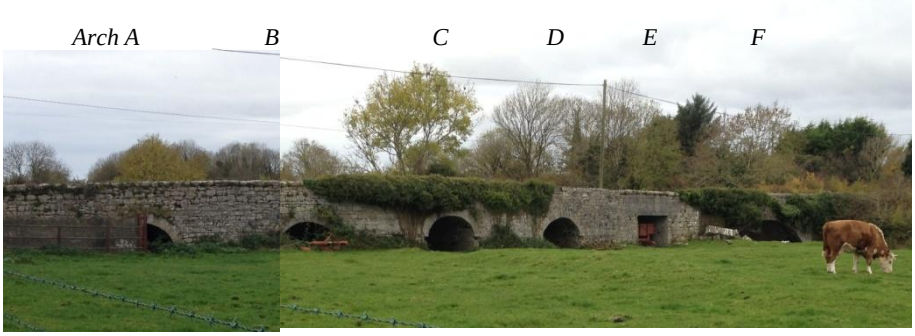
The survey drawings and photographs on this page were made as part of my Conservation Assessment Report in 2016/2017.

Arch A B C D E F

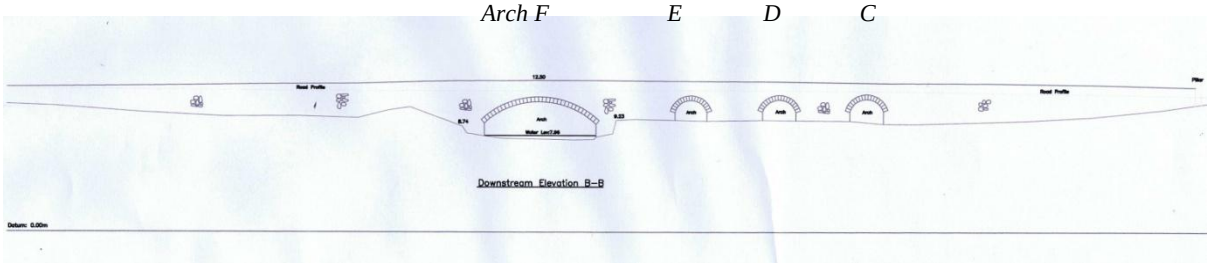


Extract from survey by PK surveys, upstream elevation, and corresponding photograph below.

Arch A B C D E F



Arch F E D C



Extract from survey by PK surveys, downstream elevation and corresponding photograph, below.

Arch F E D C

2.1 Description of bridge prior to 2018-2020 works

Six-arch bridge; longer-span, segmental river arch, dates to when the river was canalised in the mid 19th century, and adjoining 5-arch earlier bridge to south, now dry. Earliest part which carried a road of about 4,25m wide dates to the late 17th/early 18th century. (Note that the construction technique exhibited here is the same as that of the second phase of the Craughwell pedestrian bridge which is dated to around the same time.) This bridge was extended to the west, probably late 18th century, by adding 3m to the width. Two arches (arches A and B in drawing below) were not extended at this time and the functioning bridge was reduced to a 3-arch structure.

Early arches are semi-circular, or, in the case of C, elliptical , (upstream side only). Two arches retain the remains of cutwaters (arches C and D) and one has been altered to a square concrete arch (arch E) on the upstream side, in the 20th century. Arch C would appear to have been the main river arch with the other arches being flood eyes. Arch F represents the new bridge erected over the river following its canalisation sometime in the second half of the 19th century (after the OS1 survey but before the 1st revision of c. 1900).

See also Dominic Delaney, Archaeologist's report, September 2016 where he discusses the context of the bridge in terms of adjacent archaeological sites and the evident importance of the site in medieval times.

2.2 Cultural significance

As a prerequisite to its protection the special characteristics of the bridge were identified. Dunkellin bridge is a protected structure listed in Galway County Council's Record of Protected Structures, no. 3561.

The bridge is no. 30410332 in the NIAH[7] survey and is classified as being of Regional importance, with categories of special interest being *architectural* and *technical*.

- The bridge has aesthetic value - each phase of the bridge was designed to be both functional and aesthetically pleasing. The detailing of the bridge is of a high standard and well executed with each phase having its own style of stonework, testament to the skill of the local craftsmen that built it.

- The bridge exhibits particular construction techniques which are of technical/scientific interest, and it is of additional interest because it contains three different types of construction, - two very similar and one obviously more modern.

- The bridge is of historic interest as one of the group of structures in what was a centre of considerable importance in medieval times. While the bridge is not as early as some of the other structures, its earliest form was certainly built to serve an established route of some significance.

- Its early date adds to its significance and gives it archaeological as well as architectural interest.

2.3 Original design proposals

During the design process for flood relief at the Dunkellin Bridge it was recognised that there should be minimal interference with the bridge so that its character, form, and features of architectural value would be preserved following the relief works.

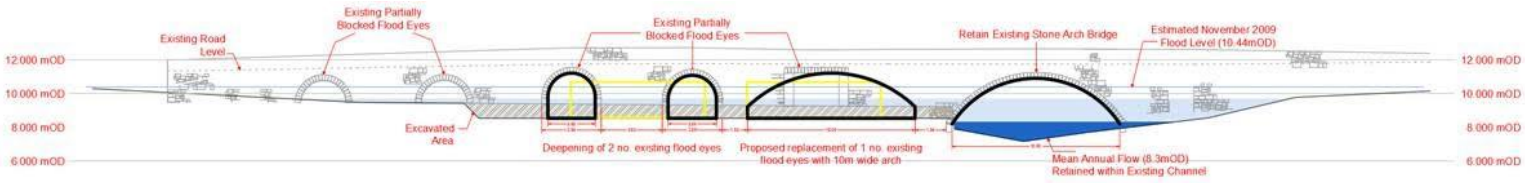
The arches, their number and their form, were integral to the design of the bridge, and, ideally, proposals should have allowed for the retention of the arches in their existing form.

However, calculations and design modelling carried out by Tobin Engineers indicated that the retention of all of the arches in their existing form would have meant that the main river channel (below arch F) would have to be deepened to afford the necessary level of flood protection. This was deemed to risk unacceptable consequences for the local ecology including the Dunkellin Turlough[8].

A compromise between architectural / archaeological and ecological and hydro-geological considerations had to be reached.

[7] National Inventory of Architectural Heritage
[8] See discussion in letter from RPS consultancy to Sean Langan, Area Eng., Galway Co. Co. dated 11 April 2017

The revised proposals involved the demolition of one bridge arch, arch E, which was already partly altered, and its replacement with a wider span arch similar in design to the adjoining 19th century arch. The remaining four late 17th/ early 18th century arches, and the 19th century arch, were proposed to be retained.



Extract from Tobin Engineers drawing showing proposals, Feb 2017, for replacement of one existing arched flood eye (arch E), and retention and deepening of 2 original arched flood eyes (arches C and D).

A 'Design and Build' contract was tendered and awarded on the basis of these proposals. Ward and Burke Construction Ltd. was awarded the contract and preliminary work commenced on site in July 2018.

Work began with the excavation and deepening of the flood plain beyond arch B over as far as the main river bed. This was followed by removal of accumulated material in arches C, D, E. In line with good conservation practice, all this work was monitored by the archaeologist, Dominic Delaney, and the original flagged river bed below the arches was recorded by him.

As detailed in plans drawn up the Design and Build contractor, work proceeded to the planned removal of the already altered arch E. However, due to the poor structural condition of the stonework, this arch E, and the adjacent main span arch F, unfortunately collapsed during this construction work. This meant that following an immediate urgent clean up and salvage operation, work on site had to stop and revised plans had to be drawn up to accommodate the altered situation.

2.4 Revised designs

With arches E and F collapsed, Galway County Council were then tasked with rebuilding the collapsed bridge arch F, and also had the opportunity to reconsider proposals for the adjacent arch E opening, which was originally to be extended. The total void in the bridge now extended to 30m.

As the intervention into the original bridge structure would now be more extensive than originally planned, discussions took place between the Council and me, the conservation architect, and it was agreed that a Design Architect with experience in bridge design, should be appointed to advise on the new intervention. Such advice would ensure that the design proposals would be of the highest quality and in line with good conservation practice.

Following a tendering process Sean Harrington Architects were appointed to undertake the Design Architect's role. Sean Harrington has prepared the Design Architect's Account which follows. This explains the design strategy and details how it is consistent with good conservation practice and takes due account of Condition 6 of the Planning Permission.

2.5 Design Architect's Account *By Sean Harrington, architect.*

The Repair and Rebuilding of Dunkellin Bridge, Co Galway.

The bridge at Dunkellin Co Galway is a 55m long multi arch stone bridge. It spans the wide floodplain of the Dunkellin River in south County Galway, giving the appearance of a horizontal continuation of the adjacent dry stone field walls, reminiscent of many similar rural bridges in Ireland. The oldest surviving sections date from the 17th Century, with later additions dating from the 19th Century.

Significantly, the main river arch dated from the 1840's, and was built as a modification to the original bridge as part of a series of flood protection works along the Dunkellin River at that time, to increase the opening to ease the flow of the river through the bridge during flooding.

The resulting bridge therefore incorporated elements from different eras, each evidenced by differing stone building techniques, engineering developments and stylistic and finishing techniques of each period of construction.

Despite this variation, the bridge read as a consistent whole, due to the horizontal continuum of the parapets, and the local stone material used throughout. It is a fine example of a rural, multi-arch historic stone bridge of regional significance and is consequently listed as a Protected Structure in the Co. Galway Development Plan.

In recent years there has been increasing frequency and extremes of heavy and prolonged rainfall (most notably 2005 and 2009) due to climate change. This has put pressure on the Dunkellin River, with pinch points such at Dunkellin Bridge leading to fluvial back up, and consequently flooding of farmland and properties up-stream.

To address this, in 2016 Galway County Council proposed remedial flood-relief works to the bridge. This involved widening one of the side arches, which had been already partly altered, the opening of a second arch that previously only extended to half the bridge width and to lowering and widening the immediate river valley floor so that the side arches could assist in easing the flow of the river when in flood condition. Due to the poor structural condition of the stonework, two of the existing arches, including the main span, unfortunately collapsed during the construction works in 2018.

The Council were then tasked with rebuilding the collapsed bridge and also had the opportunity to reconsider proposals for the adjacent arch opening, which was originally to be extended. The total void in the bridge now extended to 30m. At which stage we were appointed to assist conservation architect Gerry McManus and Tobin Consulting Engineers to design the new infill element.

As the bridge is a Protected Structure, the new section was to be designed to be good conservation, in agreement with Galway County Council Planning Department and Conservation and Heritage officer, and with An Bord Pleanala (as part of a critical infrastructure project).

Other constraints included the hydraulic demands of the river in a flooding scenario, and the physical, environmental, and cost constraints of building over the river in a relatively inaccessible location. Furthermore, as this section of the bridge was to now classify as new construction, there was a requirement to comply with current structural and traffic safety constraints, which would not have been the case if the existing bridge had simply been repaired. This would dictate higher parapet heights, increased horizontal load parapet strengths, and would have a fundamental impact on foundations and the structural engineering design of the span.

As good design is always integral to good conservation, our role as bridge architects was to identify a suitable replacement strategy, as replicating the collapsed section was now not possible, and work with Gerry McManus and Tobin Consulting Engineers to design the replacement section.

To guide our design development we initially identified the key elements of the original bridge that gave it its aesthetic spirit and heritage value. These included;

- The visual solidity of both bridge flanks, or walls. "More wall than void"
- Type, texture, colour and pattern of the original stonework.
- Craftsmanship of the stonework.
- Openings as arches.
- Rhythm of arches.
- Hierarchy of arches.
- Stone parapet as seamless upward continuation of the main flank walls.
- The continuous horizontal stone parapet heights
- Layers of history being visually evident; at least 3 generations of stonework, and bridge technology.

In all matters we were guided by the ICOMOS (International Charter for the Conservation and Restoration of Monuments and Sites) Venice Charter, specifically Article 12;
"Replacements of missing parts must integrate harmoniously with the whole, but at the same time must be distinguishable from the original so that restoration does not falsify the artistic or historic evidence."
In this context, and due to the contemporary technical, regulatory, fluvial, vehicular traffic and maintenance demands, it was decided against building a replica of the original bridge.

Consequently, working closely with the conservation architect and with consistent support from Galway County Council, our agreed strategy was twofold:

1. to retain as much of the remaining stonework on the site as possible. This included careful repairs, using lime mortars and traditional techniques, of the remaining standing elements, and an intention to reuse as much of the collapsed original stone material in any new build elements.
2. to design a contemporary infill, in the spirit of the original. This was to be a new and sensitive layer of history, clearly identifiable from the existing, but in harmony.

Our aim was to maximise the fluvial opening size in a sensible, buildable and economic way. This would mean that we would not need to reduce the level of the adjacent flood plain excessively and therefore we would not need to underpin the adjacent flood eyes, thereby avoiding archaeological issues and collapse risks associated with underpinning.

Structurally it was important to minimise lateral structural loads at foundation level (and therefore complex and expensive foundations) adjacent to the fragile existing stonework and in the environmentally sensitive river. Consequently the structural span was achieved using a series of horizontal pre-stressed 600mm deep concrete beams, with vertical loads only at their bearing points, which would not have been possible with a structural arch. Using precast beams had other significant advantages; they could be easily lifted in from the banks and would not require work in, or directly adjacent to the river, thereby minimising time on site and meaning the original EIS and NIS could remain largely unaltered.

However it was important to avoid the appearance of the flat beams, which would have been foreign to the overall aesthetic of the bridge. We also wanted to increase the visual solidity of the bridge when seen in elevation. Accordingly, we fixed precast concrete panels to the outer edges of the beams that projected up to form the traffic barrier parapets, and down towards the river to form an arch shape. This created a large new arched opening that referenced the collapsed arch, continuing the rhythm of multiple arches across the flood plain valley.

The next design challenge was to clearly express the concrete structural elements as a new layer of history, but at the same time to pay respect to the existing stone bridge.

To do this we clad the concrete flank walls reusing the existing stone from the collapse, laid in and pointed with lime sand mortar to maintain the aesthetic spirit of the old bridge. However, for visual clarity it was important that this stone appeared as cladding and not structural or load bearing. This was achieved using careful detailing;

- The clad stone stopped short of the existing structural stone at both ends of the arch, to clearly articulate the new layer, and not confuse the onlooker about what is old and what is new.
- The top of the stone cladding matched the parapet level of the existing stone parapet adjacent, at approximately 800mm from road level, to maintain the horizontal line across the valley. However, the concrete structural wall inside the cladding projected 300mm higher, to provide adequate parapet height and strength to meet code requirements.
- At the base of these concrete flank panels, we included a projecting boot along the arch edge that visually supports the applied stone cladding, both to emphasise the structural nature of the concrete and the applied nature of the stone cladding. This arching boot remains visible below the applied stone, and references the stone voussoirs of the adjacent existing stone arches. This concrete arch appears to spring from new concrete abutments at each end. As part of the abutments, new shaped fair-faced concrete cut-waters were created on the upstream side of the bridge, to replace the lost stone cut-waters.

The resulting bridge, under the stewardship of Galway County Council, now has another layer of history, of today, that pays respect to the previous layers, fulfils all the contemporary technical, structural, traffic and fluvial design requirements, clearly tells the story without confusion about what is old and what is new, and hopefully adds to the elegance, grace and simplicity of the overall composition.

Sean Harrington
Sean Harrington Architects
June 2021

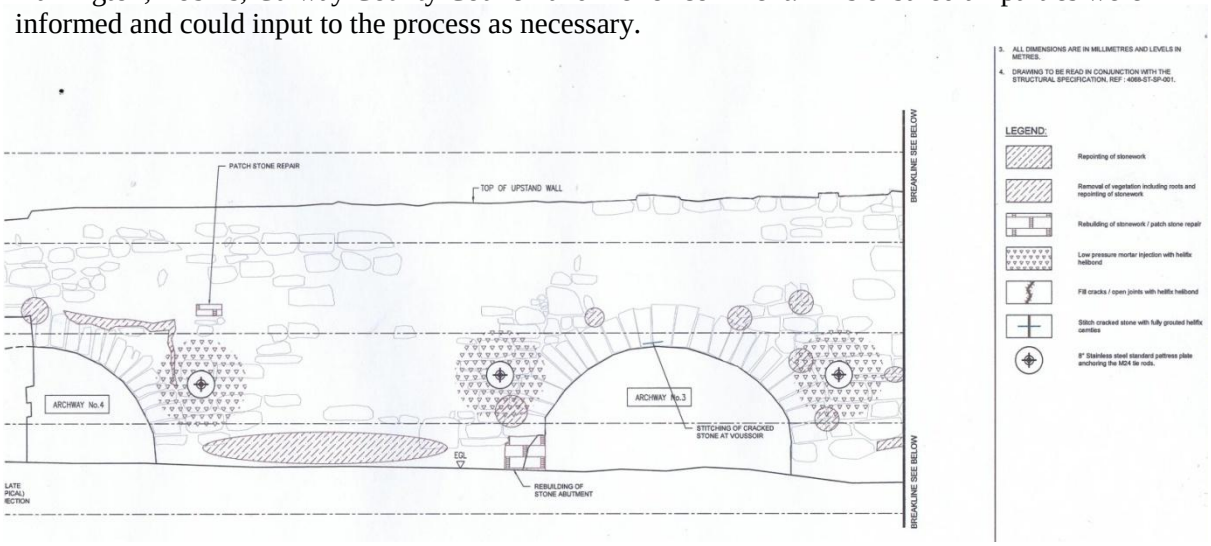
New arch, which replaced arches E and F, completed, downstream side.

arches D and C

2.6 Dunkellin bridge, the construction process, including repairs.
2.6.1 Discussion

The design process by Sean Harrington involved extensive consultation between him and Tobin Engineers, Ward and Burke the Design and Build contractors, their engineering advisors Byrne Looby, Banagher Precast Concrete who constructed the structural elements for the new bridge span, Galway County Council and me, where the design for the new bridge arch was worked out to a detailed level. In tandem with this process, detailed drawings and specifications were prepared by Byrne Looby for the repair of the surviving original arches. This process included a detailed structural analysis. Byrne Looby is a large engineering consultancy firm with several speciality subsections including conservation[9], and their team brought suitable skills to the Dunkellin bridge project.

Examples of specialist drawings are included below but full sets of all drawings are available in Galway county council files. As they were prepared drawings by specialists were forwarded to Sean Harrington, Tobins, Galway County Council and me for comment. This ensured all parties were informed and could input to the process as necessary.

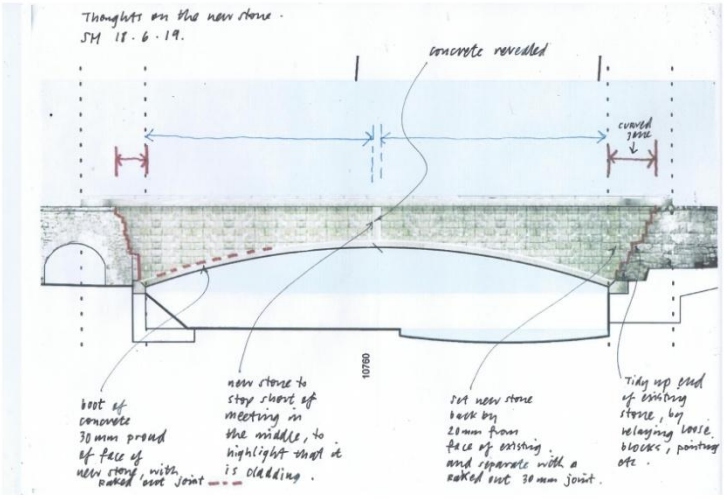


Extract from Byrne Looby drawing L1068-ST-DWG-020, Oct 2018 (repair of arches A and B)

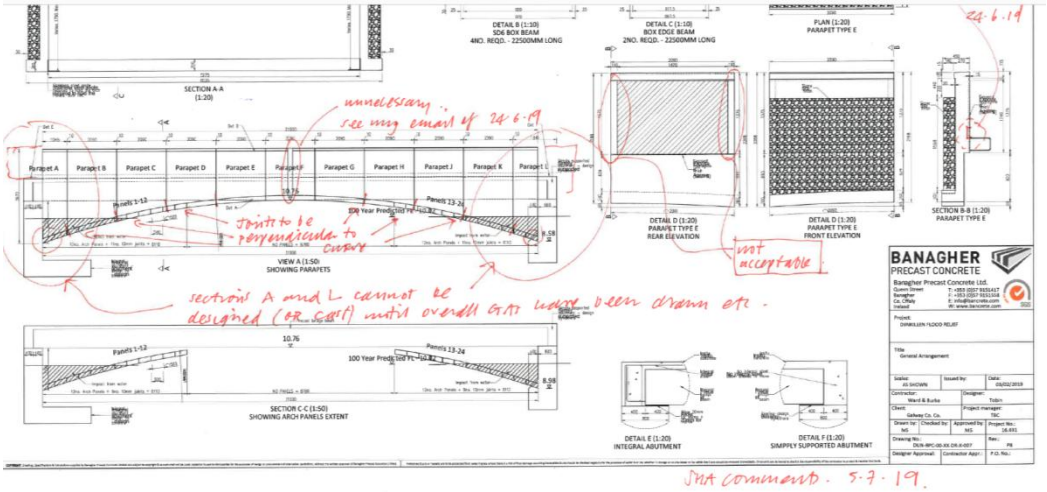
[9] Byrne Looby drew on the expertise of Sinclair Johnston Engineers for some of the work.

Techniques used for the repair of stonework and structural repair were well recognised conservation/consolidation methods, including the use of pattress plates and tie rods, mortar injection, local patch rebuilding of stonework and re-pointing. Lime/sand mortar was used for repairs except where structural requirements dictated localised use of cementitious grout such as around tie rods and plates. Locally sourced sands were used as per good practice. Stonemasons used for repair of stonework were known to me and provided a generally satisfactory standard of work.

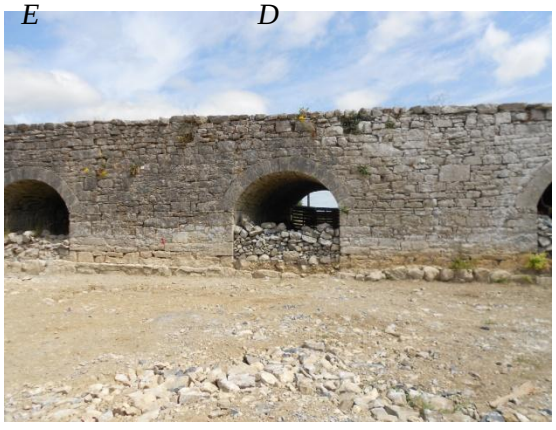
Sketch drawing from Sean Harrington in June 2019 detailing his design ideas



Sean Harrington comments on Banagher Precast Concrete general arrangement drawing in July 2019 in preparation for manufacture.



2.6.2 Annotated photographs recording the construction process.



Photographs taken on 19 July 2018 following lowering of the flood plain, downstream views.

Photographs taken 10 August 2018
Accumulated material on arch floor being removed.
Joint between earlier and later construction clearly visible on underside of the vault.

17th and 18th century flooring exposed following removal of accumulated material.

See Dominic Delaney's Dec 2018 'Dunkellin Bridge, Dunkellin, Co. Galway – Archaeological Assessement' for detailed records and discussion.

The collapse of the bridge arches at Dunkellin occurred on 22 Aug 2018.

Photographs taken April 2019. Views of northern side of Arch F abutment following collapse. Note that the curved wall where the road narrowed at the bridge abutment survived. It was considered important that this example of skilled 19th century stone craftsmanship be preserved and this was done. Suggestions of widening the bridge which would have involved the loss of this element were rejected as not in line with good conservation practice.

Remains of the abutment on the south side of Arch F.

Arch D is shored after the collapse.

Photographs taken April 2019. Comprehensive careful sorting of stone was undertaken following the collapse.

Photographs taken July 2019.
Sample panels of stonework were erected for approval in preparation for building of stone cladding.

Sample panel of re-pointing for approval.
Texture of mortar is in keeping with original.
Washed chip was added to the sand.

July 2019, re-pointing and raking out in progress on different parts of the upstream side of the bridge.

Re-pointing and patch repair well progressed on downstream face of bridge.

July 2019, preparatory work underway for new concrete support at northern abutment.

September 2019, upstream face, pattress plates and tie rods have been inserted. Stone repair and re-pointing complete

Base of cutwater between arches C and D.

New concrete bearing under construction at south abutment of new bridge span.

General view of downstream face, arches D and C.

View of repaired guarding wall, downstream face.

General view of repaired guarding walls at southern approach to new bridge span.

October 2019. Stone cladding commenced on the concrete 'boot' of the precast panels of the new bridge span.

Concrete elements at the junction with the surviving stonework are cast in situ to allow careful site adjustment (north abutment)

November 2019. Downstream face, concrete elements substantially complete, stone cladding progressing

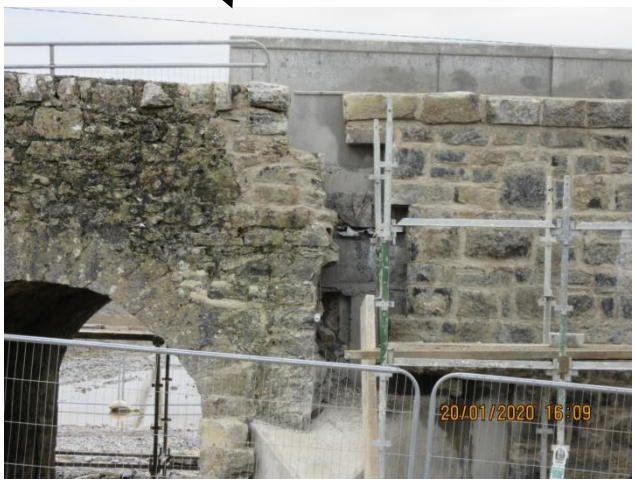
View of underside of new bridge span

Stone cladding not commenced on upstream side. Note that the original curved stone wall at this north abutment is well preserved.

View of new bridge deck. New concrete guarding walls have to meet present day codes regarding height and strength.

January 2020, stone cladding on the sides of the new bridge is close to completion
Upstream side looking north

Close-up view of top of new concrete cut water and articulated break between original stonework and new stone cladding.
General view of same



View of break between new bridge span and arch D, downstream side.

General view of downstream face, arches D and C

Photographs taken in October 2020 when work was substantially complete.

General view from north end, upstream side. The retained curved wall detail enhances the composition, confirming the decision to reject the possible option to increase the width of the bridge following the collapse.

Upstream view from south with new concrete cutwater at arch D in foreground

Upstream view with the uncovered base of the original stone cut water between arches C and D. The stonework of the cutwater was consolidated with displaced stones reinstated in original locations where this could be established. Other salvaged stone was used to consolidate the core and to replace a few missing facing stones where necessary for stability. In line with good conservation practice conjectural rebuilding was not undertaken.

Underside view of new bridge span showing infill panels following the curve of the arch and concealing the horizontal precast beams forming the bridge deck.

View under the new bridge span looking upstream.

General view of upstream face of the bridge. For structural reasons the existing part infilling of arch A was not undone but the 20th century cement based plaster was carefully removed from the voussoirs to allow appreciation of the original arch and the rhythm of the whole composition.

View of the bridge deck and guarding wall (looking north). Cut stone cladding was applied to the face of the concrete wall to soften its impact. Cut stone was used to clearly distinguish it from the original walls.

2.7 On-going inspection and monitoring

As per good practice with all historic structures, the bridge arches and the stonework of all the vaults should be inspected and monitored on an on-going basis.

Views taken in May 2021. General view looking north.

View of north-west junction

Other view of north-west junction where curved wall meets new guarding wall

General view of upstream face from north.

General view of downstream face from south

Drone footage, April 2021, provided by Galway County Council.

Downstream face

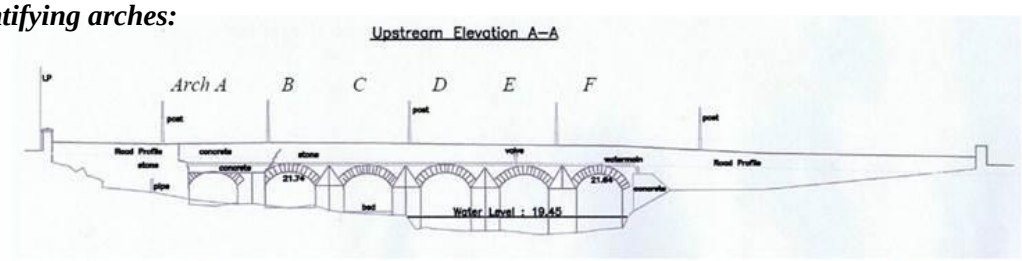
Upstream face ↑

Appendix 1

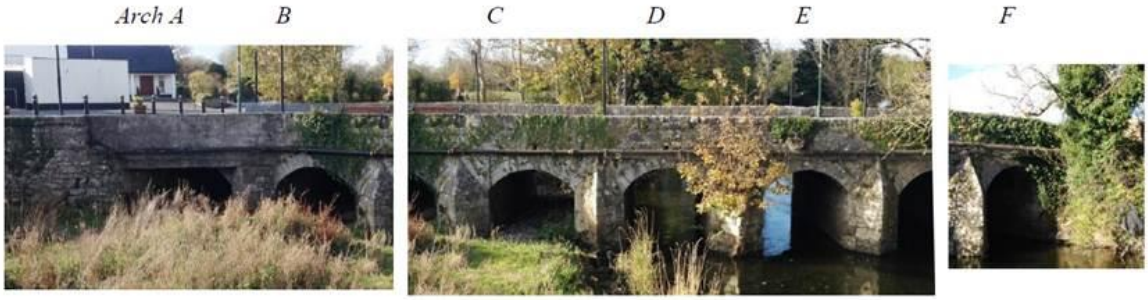
Craughwell Pedestrian Bridge.
Consolidation of wicker centring and arch vaults, report on works done Nov-Dec 2020

Contents

Key to identifying arches:



Extract from survey by PK surveys, upstream elevation, and corresponding photographs below.



Introduction

Wicker centring is extant on the underside of the vaults of the earliest part of the bridge. It survives in the largest amount on the underside of the vault of arch B. The vault of arch A retains about half of the original amount, vaults C, E, F retain somewhat less than half. Vault D retains only two small fragments of its wicker work. A rough sketch plan survey of the extent of the surviving wicker centring on vaults A,B,C, D, was made on the 25th May 2019. See copies on following pages. Vaults E and F were inaccessible on the day of the survey.

Flood relief works at the bridge were undertaken by the OPW. These were completed in 2020. The wicker work was carefully protected during the flood relief works, and only a very small loss of material has been noted (in vault B - see page 6). Protection and consolidation of the wicker centring was highlighted as important during planning and monitoring of the flood relief scheme.

Summary description of works undertaken

Sealing of bridge deck

Sealing of the bridge deck has been undertaken by the OPW in 2020 and it is hoped that this will stabilise conditions under the bridge and favourably influence the survival of all the wicker centring into the future. The bridge deck was resurfaced. Resurfacing included the laying of a new concrete deck with an imprinted cobble pattern which was then surface sealed to exclude water. This work was completed prior to the separate works contract for the consolidation of the wicker centring.

Sealing of the junction between the new concrete surface and the guarding parapet walls remained to be done in late 2020. In preparation for the sealing of the junction, the joint between the concrete surface and the parapet wall was thoroughly cleaned out and the joints in the stonework at the base of the wall were raked out and re-pointed, using a lime/sand mortar mix. (This work was done as part of the wicker centring works.) The OPW then sealed the joint using liquid bitumen in early Dec 2020.

Consolidation of wicker centring
Consolidation of the wicker centring was undertaken under separate contract financed by Galway County Council. Consolidation was undertaken under vaults A, B, and C. using mortar injection techniques and careful pointing. This was done in November 2020 following a bat survey and the erection of netting to exclude bats which were found to be using the arches. Vault D was found to be extensively used by bats and it was decided that as the amount of surviving wicker there was so small that no intervention would be made. Consolidation was problematic under vaults E and F as these are the river arches. Consolidation was not undertaken at this time under these arches.

It should be noted that the vault stonework itself was in need of consolidation in some places. In tandem with the securing of the wicker centring in A, B, and C, consolidation of the stone underside of these vaults was also undertaken where feasible. It was not undertaken around the entrances to the vaults on both sides of the bridge (below the parapet walls) where water from above was still penetrating in large amounts. Further consolidation should be undertaken as necessary at a suitable time now that sealing of the deck is complete.

Consolidation of the vault stonework consisted of the tightening of loose stones by inserting wedges of suitable stone pieces and the vigorous throwing and securely pushing back of coarse mortar into joints between stones.

Consolidation of the wicker centring was done by injecting mortar behind exposed edges and into gaps and cracks in the wickerwork. Mortar for injection consisted of fine sand and lime putty mix, or where gaps were very small, pure lime putty. Mortar was of a fairly liquid consistency. This was injected using a 60ml syringe with an outlet diameter of 5mm.

Type of syringe used to carefully inject mortar behind and around the edges of the wicker centring where it had come away from the background or cracked.

Mortar for general consolidation consisted of a hot lime mix gauged with NHL3.5. Spec: 1 part quicklime to 1 part NHL3.5 to 6 parts sand. Different grades of sand were used to suit the size of joints with lime amounts to be adjusted (upwards) when necessary.

Note on joint at parapet wall/deck junction
It is noted that the outer sections of the vaults below the parapet walls and inside them for a short way are completely saturated, having been subjected to persistent water penetration as water drained to the edge of the bridge deck. This is particularly so on the upstream side due to falls in the bridge deck towards this side, although the principal fall in the deck is from the south end to the north end of the bridge. The new deck surface appears to be successfully preventing water penetration through the bulk of the bridge surface, thus protecting the vaulted structure below, including the wicker centring. However the outer sections remain vulnerable and consolidation could not be completed due to the extremely wet conditions.

The almost constant rain in the last 2-3 months of the year has meant the bridge structure has had little or no chance to dry out and its saturated condition below the parapets mean any fresh rainwater cannot be absorbed and runs straight through and drips from the underside. It is hoped that when improved drying conditions allow these areas to dry, that the sealing of the joint between the bridge deck and the parapet walls will reduce the volumes of water sufficiently so that a reasonable and

moderate wetting/drying cycle can be established in these parts of the bridge fabric. Consolidation of these areas should be completed when conditions allow.

On-going inspection and monitoring

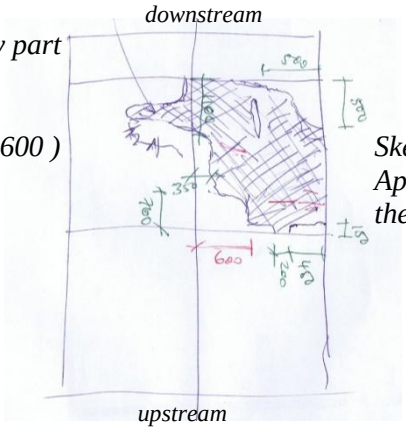
The bridge and the stonework of all the vaults should be inspected and monitored on an on-going basis. If saturation continues to occur in the outer parts then further intervention may be necessary. Saturation and liquid water moving through the fabric causing mortar wash-out can cause loosening of stonework and instability.

Arch A

Late 17th century part

Earliest part (c.1600)

C.1780 part



Sketch survey of wicker centring on vault A April 2019 Plan (shown as though looking through the bridge from the road over)

Photographs May 2020 prior to works

View looking upstream

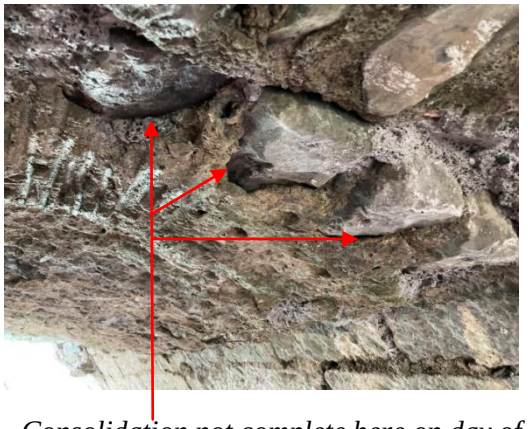
Closer view of wicker centring

Photographs Nov 2020 post works

View looking upstream
Fine mortar mix was injected behind the wicker centring to re-adhere it to the background stonework. New mortar is just visible at the edge of the wicker (circled red)

View looking upstream
General consolidation of vault stonework using pinnings and coarse mortar mix.

View looking downstream



Consolidation not complete here on day of inspection

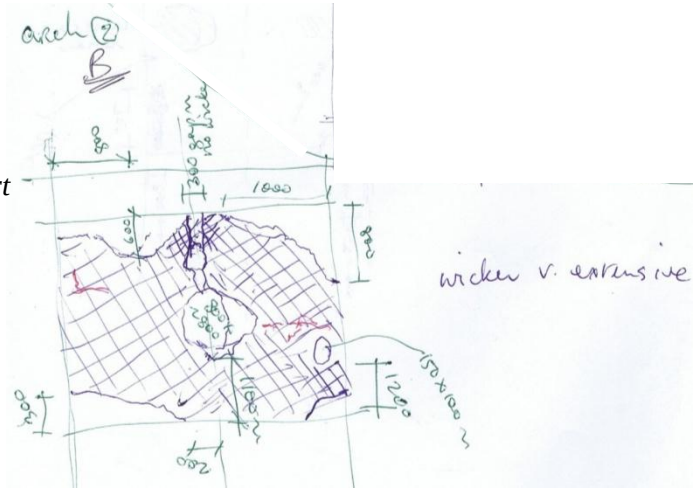
General view looking downstream

Arch B

Late 17th cen part

c.1600 part

c.1780 part



Sketch plan survey of wicker centring Arch B, April 2019

Photographs May 2020 prior to works

Looking upstream

Looking downstream

Photographs Nov 2020 post works

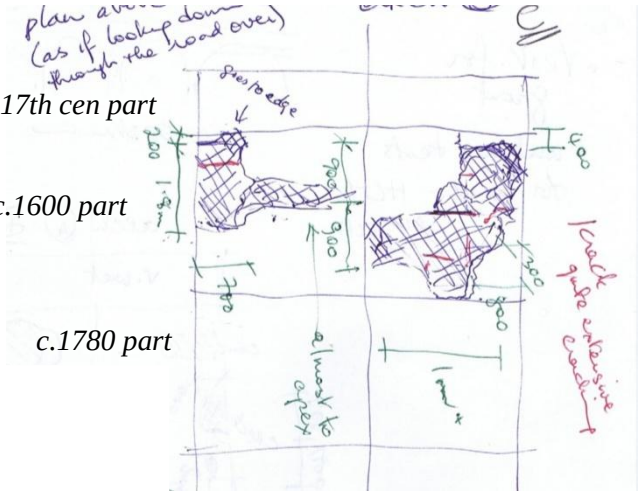
Looking upstream, consolidation of wicker edges and general consolidation of stonework

Further views looking upstream. Some loss of wicker noted on this side compared to extent recorded in April 2019

Looking downstream. ↑ General consolidation of vault seen in foreground.

Close-up views of consolidated edges of wicker

Arch C



Sketch plan survey of wicker centring Arch C, April 2019

Photographs May 2020 prior to works

Views looking upstream

Looking downstream

Photographs Nov 2020 post works

Looking downstream - large area of wicker intact.

Looking downstream. General consolidation not complete at vault edges (see foreground of photo) as sealing of bridge deck was not completed in November and water was coming through the structure in large quantities in these locations preventing the placing of mortar.

Looking upstream - general view

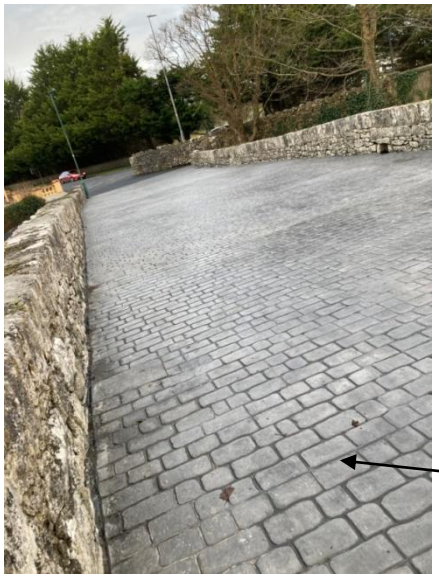
close-up of repair of cracks in wicker

Looking upstream - views of general consolidation of stonework

Time allowed some re-pointing of stonework on the west (downstream) side of the bridge face in tandem with the consolidation work below the vaults. This will help to mitigate the penetration of driving rain on this side, as well as generally consolidating the facing stonework.

General view of re-pointed stonework above arches A, B, and C on the downstream side.

Photographs Dec 2020 *Showing completed sealing of the bridge deck/parapet wall junction.*



View of sealed joint at an outlet in parapet wall.

General view on joint at west parapet wall.

View of joint at an outlet

General view of joint at east parapet wall

Report prepared by Gerry McManus B. Arch., M. Arch. Sc., MRIAI Conservation Grade 2 accredited.

Record of arches D, E and F. Photographs taken 19 Jul 2018.

Arch F

Arch E

Arch D