Appendix J2

Preliminary Design Report

Scherzer Bridges

Preliminary Design Report – Consultation STA-1b

Categories 1, 2 & 3

Scheme

Name and Location: Ringsend to City Centre Core Bus Corridor Scheme

Structure(s)

Name and nature of the Structure(s): Scherzer Bridges

Preliminary Design Report

Reference	BCIDD-ROT-STR-ZZ-0016-XX-00-RP-CB-0015
Revision	L01
Date	21/10/2022

Submitted by

Signed:	
Name:	Matthew Ryan
Position:	(Team Leader)
Organisation:	Roughan & O'Donovan Consulting Engineers
Date:	21/10/2022

Structures Section confirmation of consultation:

Signed: ____________________

Name: ____________________

Position: ____________________

Date: ____________________

RINGSEND TO CITY CENTRE CORE BUS CORRIDOR SCHEME PRELIMINARY DESIGN REPORT – SCHERZER BRIDGES

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Brief

Roughan & O'Donovan-TYPSA have prepared this report for the National Transportation Authority (NTA) for the relocation of the Scherzer bridges as part of the Ringsend to City Centre Core Bus Corridor Scheme.

1.2 Background Information

The proposed scheme for Ringsend to City Centre aims to provide enhanced walking, cycling and bus infrastructure, which will enable and deliver efficient, safe and integrated sustainable transport movement to this corridor.

Priority for buses is provided along the entire route consisting primarily of dedicated bus lanes in both directions, with alternative measures proposed at particularly constrained locations along the scheme. Cycle tracks and footpaths will also be provided separate from the bus lanes. At constrained points, it is necessary to build new structures or widen the existing ones to provide adequate space for the new road layout. In that regard, it is proposed that the existing Scherzer bridges be dismantled, shot-blasted, painted and relocated adjacent to newly proposed bridges (Ringsend 01 at Georges Dock and Ringsend 03 at Spencer Dock).

This document relates to the Preliminary Design Report in respect of the relocation of the Scherzer bridges in accordance with DN-STR-03001 (April 2019). A location drawing of this structure within the scheme is provided in the Appendices, as well as a general arrangement drawings of the new location for each of the two pairs of Scherzer Bridges.

The relocation of the Scherzer bridges will allow an increase in the existing road capacity for public transport and pedestrians at Custom House Quay and North Wall Quay. Cycling lanes will be located on the relocated Scherzer bridges adjacent to the proposed Ringsend 01 and 03 bridges.

Photographs of the structures taken during a site visit are included in Appendix 1.

1.3 Previous Studies

Reports prepared and published for this structure to date include:

- BCID-ROT-ERW-GI_0016-RP-CR-0001 – Geotechnical Interpretive Report: Ringsend Corridor

2. SITE & FUNCTION

2.1 Site Location

There are two pairs of Scherzer Bridges. Georges Dock Scherzer Bridges are situated at the location of the proposed Ringsend 01 Bridge on Custom House Quay and Spencer Dock Scherzer Bridges are situated at the location of the proposed Ringsend 03 bridge on North Wall Quay. Each pair are located adjacent to each other and are in operation at the time this report is written. Due to their historic and unique nature, the existing Scherzer bridges are to be dismantled, taken off site, repaired, repainted and relocated to either side of the proposed Ringsend 01 and 03 bridges to carry the new cycle lane and footpaths. The site location plan is included in Appendix 2.

2.2 Function of the Structure

The objective of the relocation of the Scherzer bridges is to increase the width of the existing carriageway. This allows unimpeded passage of the bus lanes and a footpath, as well as existing traffic lanes, at Custom House Quay / North Wall Quay. Proposed lanes for cyclist and the southern footpath will be on the relocated Scherzer's Bridges.

2.3 Choice of Location

The location of the structure was chosen to facilitate the proposed Ringsend to city centre corridor, taking into account the layout and roadway requirements in terms of space for proposed lanes, footpaths, maximum slopes, etc.

2.4 Site Description and Topography

The sites of the proposed structures are located in an urban area, close to Dublin's city centre. Consequently, there are existing buildings and infrastructure in the direct vicinity of the new structure.

2.5 Vertical and Horizontal Alignments

Horizontal and vertical road alignments at the bridge locations are described below. The proposed general arrangement drawings are shown in Appendix 2.

Horizontal Alignment

The horizontal alignment is straight across both pairs of bridges.

Vertical Alignment

The proposed vertical road alignment at the location of the Scherzer Bridges follow the alignment of the existing road, which is relatively flat.

2.6 Cross-Sectional Dimensions on the Alignments

The proposed cross section at the structure location is constrained by the width of the Scherzer bridges. As proposed structures Ringsend 01 and 03 will carry mainline traffic, the relocated Scherzer bridges will be designed to carry cycle and pedestrian traffic. The proposed cross section is as follows:

Table 2.1: Scherzer bridges Cross-Section

Parameter	Value
Footpath	3.50 m
Cycleway	4.0 m
Out-to-Out Width	**8.50 m**

2.7 Existing Underground and Overground Services

A list of the existing services located in close proximity to the Scherzer bridges is outlined below.

Low and Medium Voltage Electricity Lines

ESB low voltage underground lines are present at the structure’s location. These may need to be diverted following discussions with ESB.

High Voltage Electricity Lines

Desktop services tracking to date indicate low and medium voltage underground lines in the vicinity of the structure which may need to be diverted following discussions with the ESB. There appear to be no high voltage lines, however, these will need to be verified by the Contractor on site.

Telecommunications

Desktop services tracking to date indicate some telecommunication cables in the vicinity of the structure which may need to be diverted following discussions with the provider. Exact locations will need to be verified by the Contractor on site.

Water Supply

Desktop services tracking to date indicate water mains at the structures location which may need to be diverted following discussions with Irish Water. Exact locations will need to be verified by the Contractor on site.

Gas Networks

Desktop services tracking to date indicate gas mains at the structures location which may need to be diverted following discussions with Gas Networks Ireland. Exact locations will need to be verified by the Contractor on site.

2.8 Geotechnical Summary

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

At the date of this report there is a GI contract available that aims to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors.

2.9 Hydrology and Hydraulic Summary

The bridges will have minimal effect on the hydrology in the area. Although they cross the George's Dock and Royal Canals, they will not be affected as the existing headroom is maintained.

2.10 Archaeological Summary

An Environmental Impact Assessment Report (EIAR) is currently being prepared that considers archaeological impacts along the mainline alignment.

2.11 Environmental Summary

An Environmental Impact Assessment Report (EIAR) is currently being prepared and it considered the mainline alignment at the structure locations and its impact on the environment and local communities. All likely significant environmental effects are assessed, and mitigation is proposed as necessary in the Environmental Impact Assessment Report. A conservation report on the bridges has been included in Appendix 4.

3. STRUCTURE & AESTHETICS

3.1 General Description of Recommended Works

The existing Scherzer bridges are protected structures. They comprise steel bascule (or rolling lift) bridges, constructed in 1911, to control the raising and lowering of the North Wall Quay / Custom house Quay roadway to allow clearance for access to Georges Dock and the Royal Canal by water underneath. To facilitate the construction of the proposed widened bus corridor scheme, the Scherzer bridges shall be dismantled and removed off site, shot blasted, re-painted (including any repairs necessary) and then re-assembled adjacent to the proposed Ringsend 01 and 03 bridges. New foundations will be constructed to support the Scherzer bridges at their proposed location. The relocated bridges will be used to carry the new cycle lane and footpaths which will increase the overall width of the existing carriageway.

3.2 Aesthetic Considerations

The Scherzer bridges are historic structures and will be kept in the existing form. All structural steel shall be cleaned, repaired where necessary and repainted.

The level of the Scherzer’s bridges after the relocation will match the level of the existing carriageway, maintaining the overall aesthetic to the area while providing continuity to the bus and traffic lanes to North Wall Quay.

3.3 Proposals for the Recommended Structure

3.3.1 Proposed Category

The proposed bridges are Category 2 structures.

3.3.2 Span Arrangements

The Scherzer bridges are single span structures. The span on Georges Dock Scherzer Bridges is approximately 16.5m, with a skew of approximately 15 degrees. The span on Spencer Dock (Royal Canal) Scherzer Bridges is approximately 13m, with zero skew.

3.3.3 Minimum Headroom Provided

The minimum headroom provided shall be no lower than the proposed headroom of adjacent bridges Ringsend 01 and 03. The headroom on and below the bridges will be as per the existing scenario.

3.3.4 Approaches (incl. Run-on Arrangements)

The approaches are generally on a suitable formation or using a compacted acceptable material finished with a capping layer. Full road construction is used over the embankment fill up to the back of the end abutments. It is not proposed to use run on slabs.

3.3.5 Foundation Type

The Scherzer Bridges will be supported by new foundations at their proposed locations. The foundations shall comprise insitu reinforced concrete pilecaps supported by bored in-situ reinforced concrete piles (Ø0.50m). The foundations will be designed so as not impose any additional surcharge loading on the canal or River Liffey quay walls.

3.3.6 Substructure

The Scherzer bridges will be sitting directly on the top of the embedded foundations (pile caps).

3.3.7 Superstructure

The Scherzer bridges will be re-assembled and maintained in the existing form.

3.3.8 Articulation Arrangements (Joints and Bearings)

The structures will be re-assembled in the existing form. Saw cut joints will be provided in the pavement and footpath at the back of each abutment.

3.3.9 Vehicle Restraint System

Not applicable.

3.3.10 Drainage

Not applicable.

3.3.11 Durability

Corrosion protection for the Scherzer bridges shall be carried out in accordance with the maintenance painting clauses of Series 1900 of the TII Specification.

In addition, the specification of suitable materials will enhance durability and reduce the maintenance liability. The following measures are proposed:

- Durable concrete to be provided in accordance with TII DN-STR-03012 (formerly BD 57);
- Buried concrete surfaces to be waterproofed in accordance with the TII Specification for Road Works;
- Stainless steel reinforcement to be provided in elements that are subject to de-icing salts and that are particularly vulnerable;
- Bridge deck to be waterproofed with a spray applied system that has a current BBA / IAB Certificate;

3.3.12 Sustainability

Sustainable development has been considered to enable a cost-effective and sustainable solution which has a minimal impact on the surrounding environment.

The proposed relocation of the Scherzer Bridges is considered a more sustainable solution than building a new bridge for the following reasons:

- Scherzer bridges will be reused as part of enhancing the sustainable transport movement at this corridor.
- Concrete is manufactured in Ireland while steel is imported;
- Local cement and aggregates are used in the production of concrete for the foundations;

It is proposed to adopt 50% ground granulated blast furnace slag (GGBS) as cement replacement in the mix design for all in-situ concrete which reduces CO2 emissions.

3.3.13 Inspection and Maintenance

The inspection of bridges shall be carried out in accordance with TII procedures by suitably qualified personnel who shall be responsible for providing the relevant equipment and establishing traffic management appropriate to the type of inspection being carried out.

Inspection of most parts of the bridges can be done from finished road level. Inspection of the soffit of the proposed bridge shall be carried out from George's Dock Canal / Spencer Dock.

The top of the structure will be accessible from North Wall Quay / Custom House Quay. The underside can be inspected from George's Dock Canal / Spencer Dock.

Superstructure

All structural steelwork surfaces will be visible for inspection. The overhead assembly can be inspected using a mobile elevated working platform (MEWP) or scissor lift under a temporary lane closure.

Substructures

The substructures consist of in situ reinforced concrete mostly buried, which should not incur any substantial maintenance costs.

Parapets

Parapets will be shot blasted and painted in accordance with the maintenance painting clauses of Series 1900 of the Specification

4. SAFETY

4.1 Traffic Management during Construction

Traffic management will be required during refurbishment of the Scherzer bridges. Diversions will be needed in order to build the proposed bridge and to relocate the existing Scherzer bridges.

4.2 Safety during Construction

The Designer will comply with the General Principles of Prevention (of accidents) as specified in the First Schedule of the Safety, Health and Welfare at Work (General Application) Regulation and liaise with the Project Supervisor for the Design Stage (PSDP) appointed by the Client and the Project Supervisor appointed for the Construction Stage as required by the "Safety, Health and Welfare at Work (Construction) Regulations, 2013".

4.3 Safety in Use

The headroom and cross section will be as per the existing which satisfies the minimum requirements of TII DN-GEO- 03036 (formerly ref. TD 27) for pedestrian and cycleways.

4.4 Lighting

Lighting under the bridges is not required. Lighting over the bridges will be provided in accordance with BS-5489-1.

5. COST

5.1 Budget Estimate in Current Year (incl. Whole Life Cost)

The estimated cost for the relocation and refurbishment of each pair of Scherzer bridges (including proposed foundations) is around €600,000€ - €800,000 based on ROD experience on similar projects.

Basis of Cost Estimate

The cost estimate has been produced on the following basis:

- Figures are given in Euro
- Excludes land acquisition and rights of way;
- Excludes preliminaries;
- The Construction Cost Estimate does not include for fees associated with the following:
    - Additional SI and Topo;
    - Environmental Assessment;
    - Detailed Design and Checking;
    - Contract Administration;
    - Site Supervision during Construction.

6. DESIGN ASSESSMENT CRITERIA

6.1 Actions

The structures foundations will be designed in accordance with IS EN 1991 Eurocode 1: Actions on Structures and, in particular, Part 1-1: General Actions, Part 1-3: Snow Loads, Part 1-4 Wind Loads, Part 1- 5 Thermal Actions, Part 1-6 Execution, Part 1-7 Accidental Actions and IS EN 1991 Part 2 Traffic Loads on Bridges as amended by the relevant Irish National Annexes.

6.1.1 Permanent Actions

The following nominal densities will be adopted:

- Reinforced concrete 25 kN/m^3
- Structural steelwork 77 kN/m^3
- Pavement 23 kN/m^3
- Backfill to structures 20 kN/m^3

6.1.2 Snow, Wind and Thermal Actions

Snow action may be ignored due to the geographical location as outlined in IS EN 1990:2002 + NA:2010. Thermal actions Approach 2 will be used in accordance with clause NA.2.3 of the Irish National Annex to IS EN 1991-1-5. Wind load will be assessed in accordance with IS EN 1991-1-4:2005 and the associated National Annex.

6.1.3 Actions relating to Normal Traffic

The structures will not be designed for vehicular loading. However, service and emergency vehicles will be considered.

6.1.4 Actions relating to Abnormal Traffic

N/A

6.1.5 Footway Live Loading

The structures will be designed for footway loading in accordance with IS EN 1991-2 load model LM4 (crowd loading). This consists of a uniformly distributed load (q_{fk}) of 5kN/m^2 and a concentrated load (Q_{fwk}) of 20kN as defined in section 5 of IS EN 1991-2 and the Irish National Annex.

6.1.6 Provision for Exceptional Abnormal Loads

None.

6.1.7 Accidental Actions

Accidental actions will be considered in accordance with I.S. EN 1991-1-7.

6.1.8 Actions during Construction

The design shall take account of any adverse loading during construction as outlined in IS EN 1991-1-6 and its National Annex. Specifically, the design shall take account of required construction vehicles and the actions will be applied as described in section 6.1.3 above.

6.1.9 Any Special Loading not Covered Above

Fatigue Load Model - Fatigue load models shall be in accordance with IS EN 1991-2:2003 Cl. 4.6 and specifically Load Models 4.

6.2 Authorities Consulted

The following is a list of Authorities to be consulted as part of the scheme:

- Local Authorities – Dublin City Council;
- ESB;
- Gas Networks Ireland;
- Irish Water;
- Waterways Ireland.

6.3 Proposed Departures from Standards

There are no existing departures applied for at this stage of the design process.

6.4 Proposed Methods of Dealing with Aspects not Covered by Standards

Agreed departures to be incorporated into the design – however at this stage no departures have been applied for.

7. GROUND CONDITIONS

7.1 Geotechnical Classification

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

A GI contract has recently been completed which aims to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors. The GI includes boreholes, trial pits, dynamic probes, standpipes/piezometer installation and monitoring, in-situ testing, geotechnical and environmental laboratory testing and preparation of a factual report, all in accordance with the “Specification and Related Documents for Ground Investigation in Ireland”.

7.2 Description of the Ground Conditions and Compatibility with Proposed Foundation Design

The following table shows the expected depth to bedrock, based on the data from the Desktop Review, as well as the depth of the encountered bedrock in the GI undertaken. Note that some of the boreholes were terminated at a shorter length, before encountering the bedrock strata.

Table 7.1: Encountered bedrock in the vicinity of Ringsend 01 and 03

Borehole Ref.	Depth to Encountered Bedrock	Depth to N SPT Values of Refusal
R16-CP01	10-15m	5.0m
R16-CP02	10-15m	6.0m
R16-CP03	15-20m	12.5m
R16-CP04	15-20m	12.5m

Additional information regarding the geological profile and location of the boreholes can be found on the Geotechnical Interpretation Report, document No. BCID-ROT-ERW_GI-0016-RP-CR-0001. An extract of the Geotechnical Interpretation Report is included in Appendix 3.

Based on the current site investigation information provided, it is proposed to use piled foundations to support the Scherzer bridges.

8. DRAWINGS & DOCUMENTS

8.1 List of All Documents Accompanying the Submission

Appendix 1 – Photographs:

(4No. of photos)

Appendix 2 – Site Location and Drawings

- BCIDD-ROT-STR_KP-0016_XX_00-DR-SS-0001 – CBC 16 Ringsend to City Centre core Bus Corridor Scheme - Bridges and Retaining Structures - Key Plan
- BCIDD-ROT-STR_ZZ-0016_XX_00-DR-SS-0019 – GEORGE'S Dock SCHERZER BRIDGES PROPOSED FOUNDATION DESIGN.
- BCIDD-ROT-STR_ZZ-0016_XX_00-DR-SS-0020 – ROYAL CANAL SCHERZER BRIDGES PROPOSED FOUNDATION DESIGN

Appendix 3 – Relevant Extracts from Ground Investigation Report

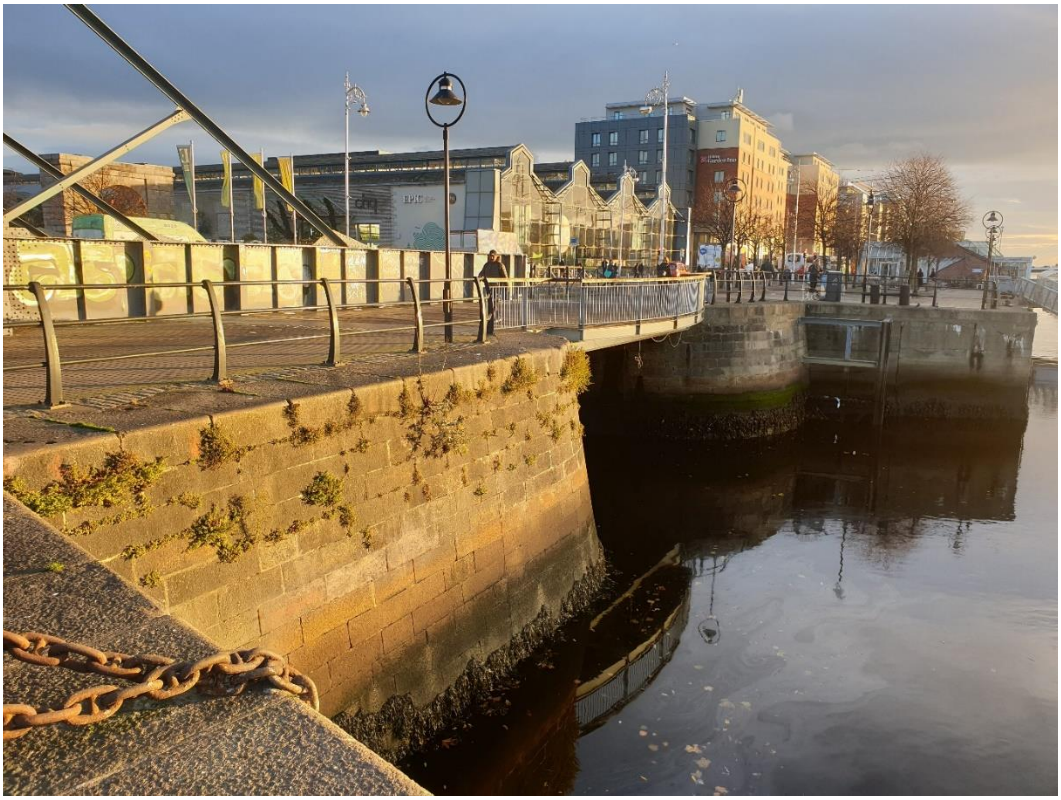
(6No. of pages)

Appendix 4 – Other Relevant Documentation/Reports

Relocation of Scherzer Bridges, Dublin City: Industrial Heritage and Options Appraisal

APPENDIX 1
PHOTOGRAPHS

Existing George's Dock Scherzer's bridges to be relocated – looking from the River Liffey



New location of Scherzer's bridges next to the River Liffey

Scherzer's bridge rolling lift mechanism

Location of proposed Ringsend 01 bridge

APPENDIX 2
DRAWINGS

Project Ireland 2040
Building Ireland's Future

Rev	Date	Drn	Chk'd	App'd	Description
M01	06/04/2022	JGE	EFD	SMG	ISSUE FOR PHASE 4: PLANNING

Client: NTA Údarás Náisiúnta Iompair National Transport Authority

Engineering Designer: ROD Roughan & O'Donovan TYPSA

Programme Title: **BUSCONNECTS DUBLIN CORE BUS CORRIDORS INFRASTRUCTURE WORKS**

Drawing Title: CBC 16 RINGSEND TO CITY CENTRE CORE BUS CORRIDOR SCHEME BRIDGES & RETAINING STRUCTURES KEY PLAN

Date	Scale	Drawn	Checked	Approved
06/04/2022	1:10000 @ A1 1:20000 @ A3	JGE	EFD	SMG

Project Code	Originator Code	QMS Code	Drawing File Name	Sheet Number	Status	Rev
BCIDD	NTA		BCIDD-ROT-STR_KP-0016_XX_00-DR-SS-0001	01 of 01	A	M01

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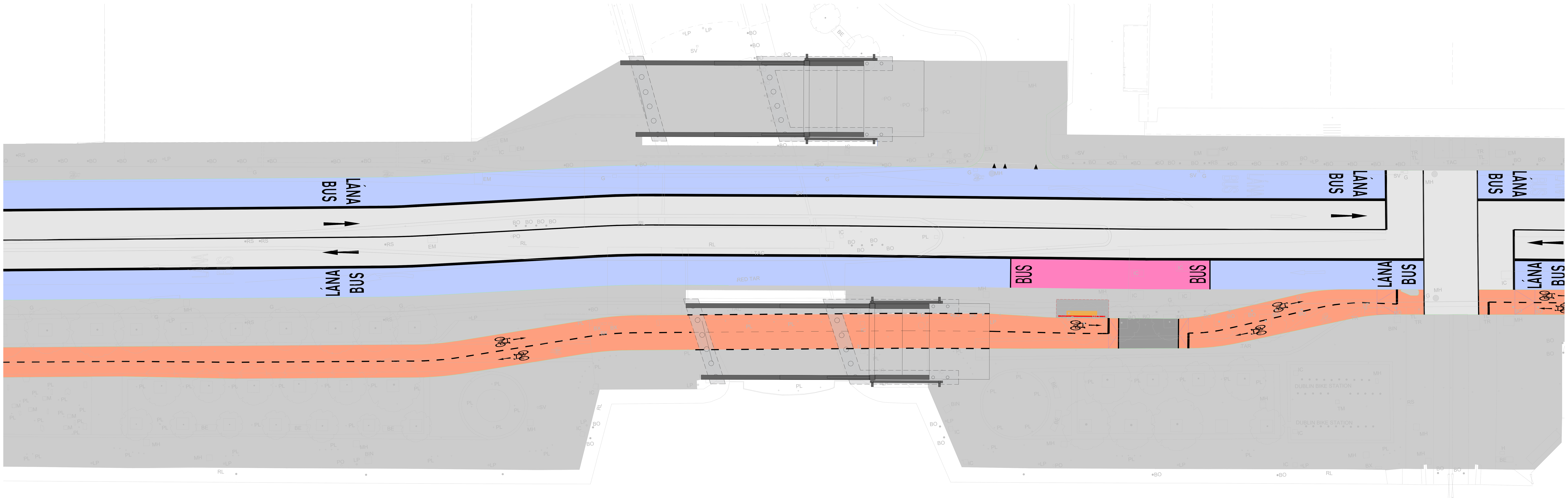
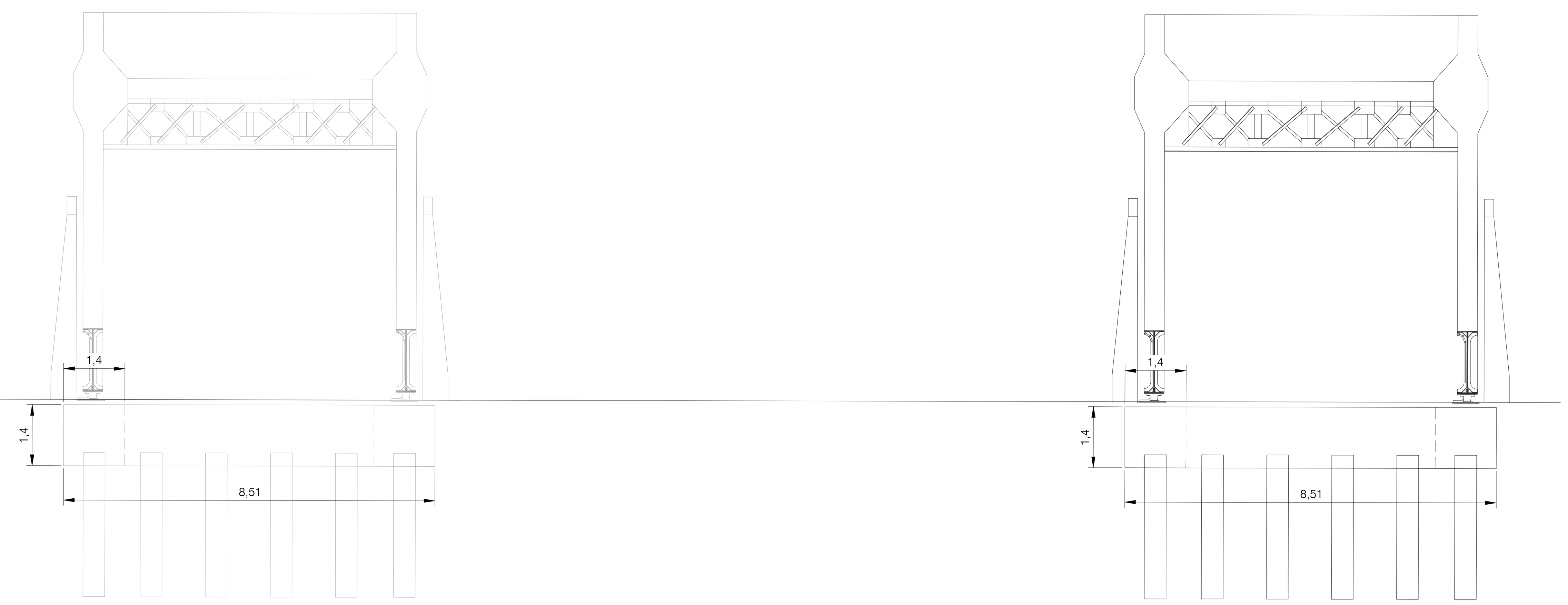
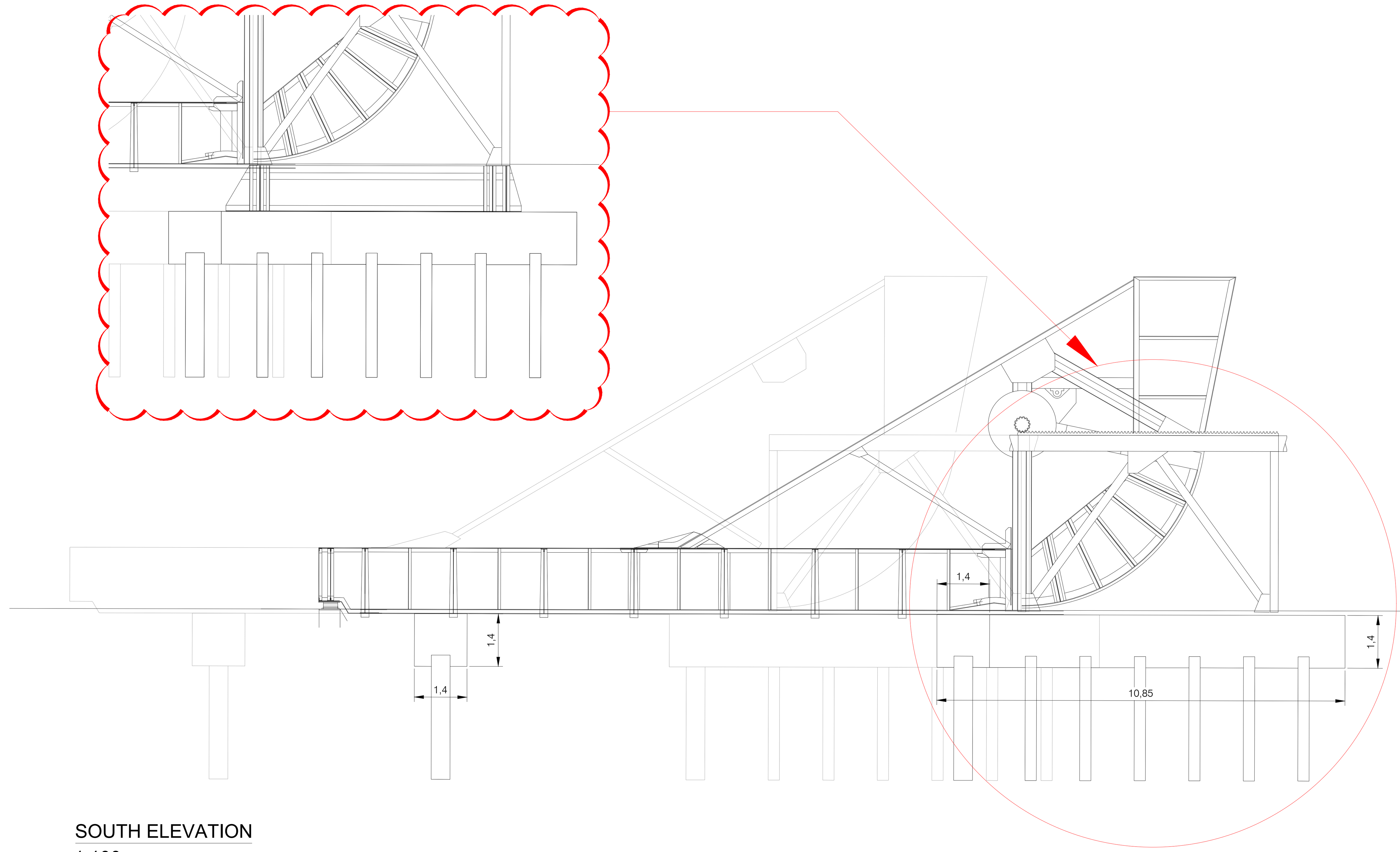


PLAN VIEW
1:200



EAST ELEVATION
1:100



SOUTH ELEVATION
1:100

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Project Ireland 2040
Building Ireland's Future

Rev	Date	Drn	Chk'd	App'd	Description
M01	30/06/2022	AG	EOC	SMG	ISSUED FOR PHASE 4: PLANNING

Client	NTA Údarás Náisiúnta Iompair National Transport Authority
Engineering Designer	ROD Roughan & O'Donovan, TYPSA
Programme Title	BUSCONNECTS DUBLIN CORE BUS CORRIDORS INFRASTRUCTURE WORKS
Drawing Title	GEORGE'S DOCK SCHERZER BRIDGES PROPOSED FOUNDATION DESIGN
Date	30/06/2022
Scale	1:100 @ A1, 1:200 @ A3
Drawn	AG
Checked	EOC
Approved	SMG
Programme Code	BCIDD
Originator Code	ROT
QMS Code	
Drawing File Name	BCIDD-ROT-STR_ZZ-0016_XX_00-DR-SS-0019
Sheet Number	19 of 20
Status	A
Rev	M01

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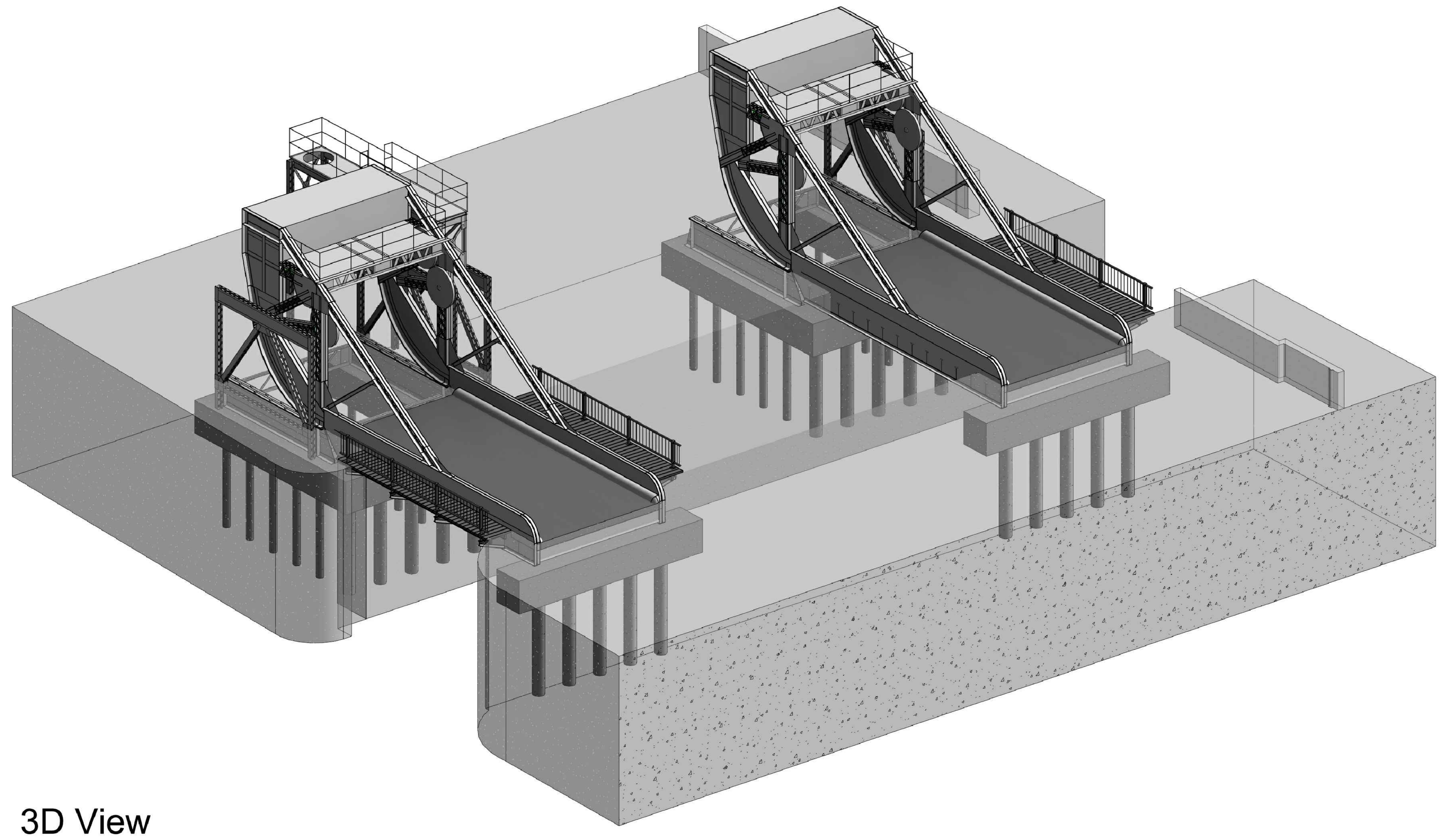
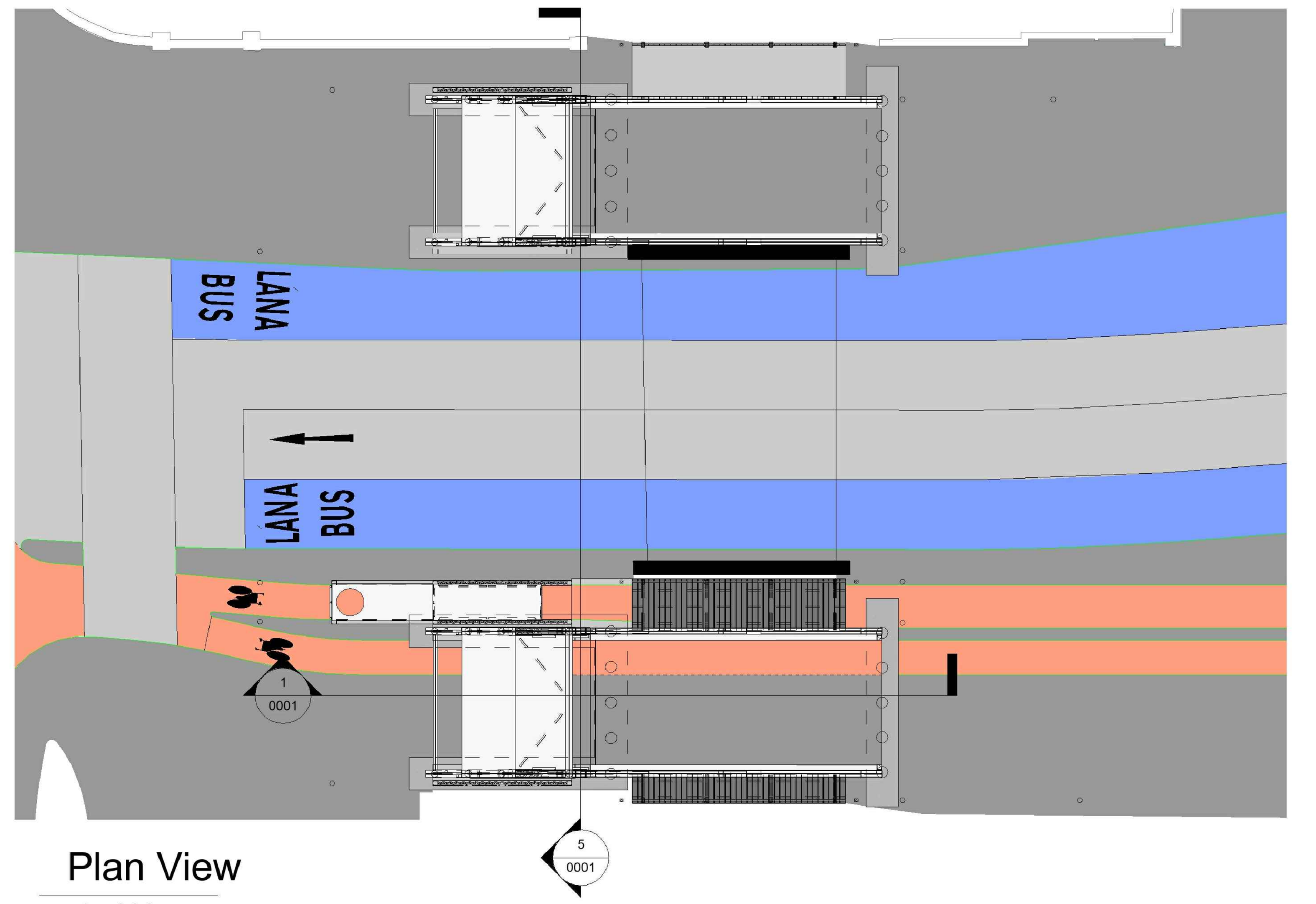


3D View

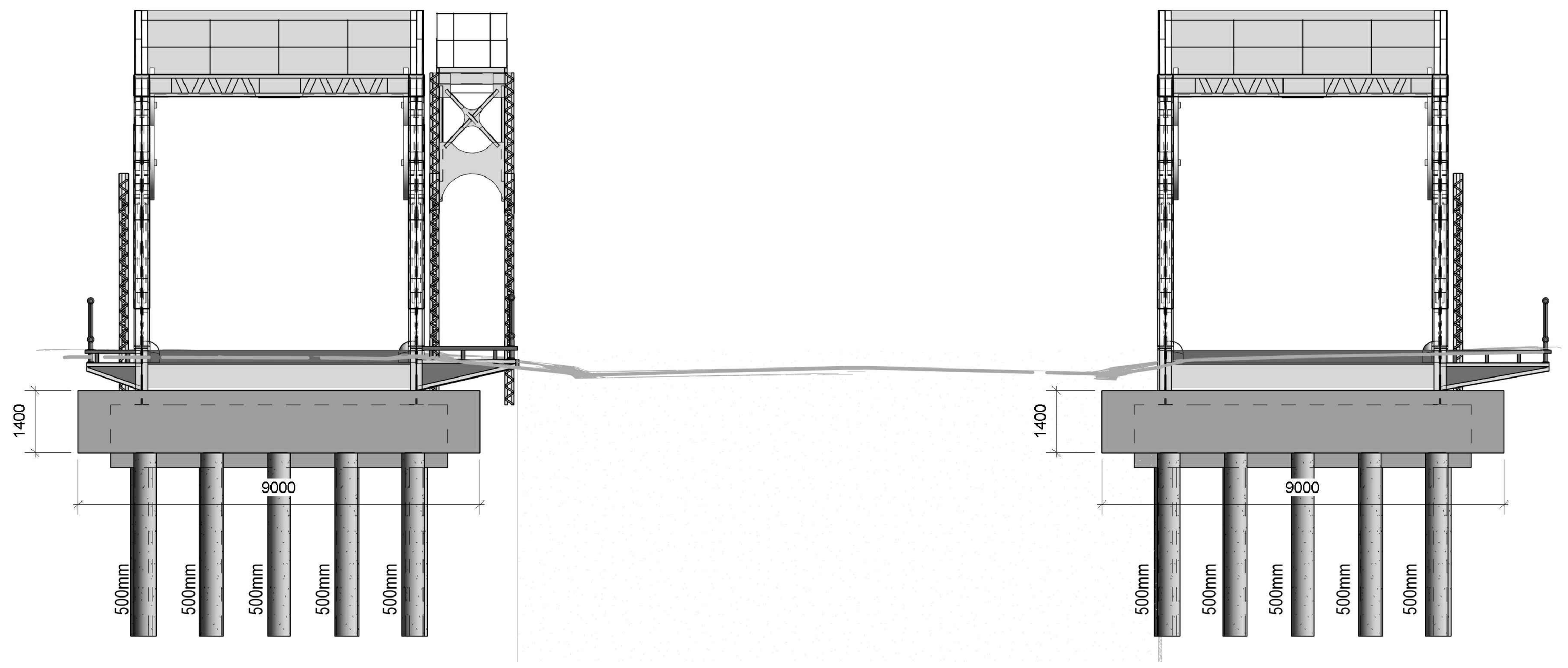


Plan View

1 : 200

NOTES:

1. LENGTH OF PILES 5m SUBJECT TO GI. DIAMETER AS SHOWN.
2. FOUNDATION LAYOUT ASSUMES THE BRIDGES ARE TO BE RECOMISSIONNED
3. DEPTH TO BEDROCK IS CURRENTLY UNKNOWN AND WILL BE DETERMINED AS PART OF DETAILED DESIGN.
4. PILE CAPS BEHIND CAPPING STONES
5. SEE ACCOMPANYING TYPICAL CROSS SECTION



East Elevation

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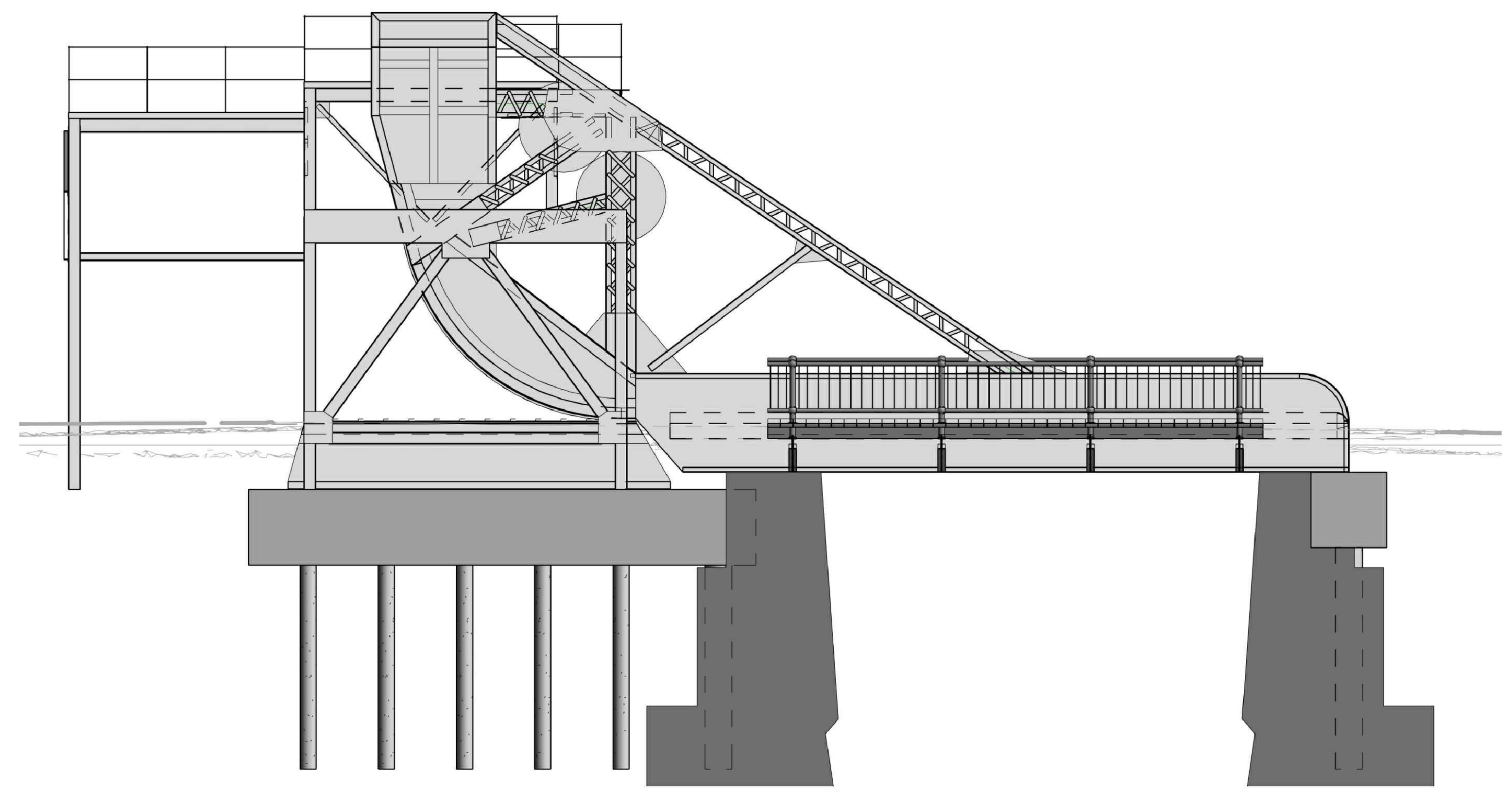

South Elevation

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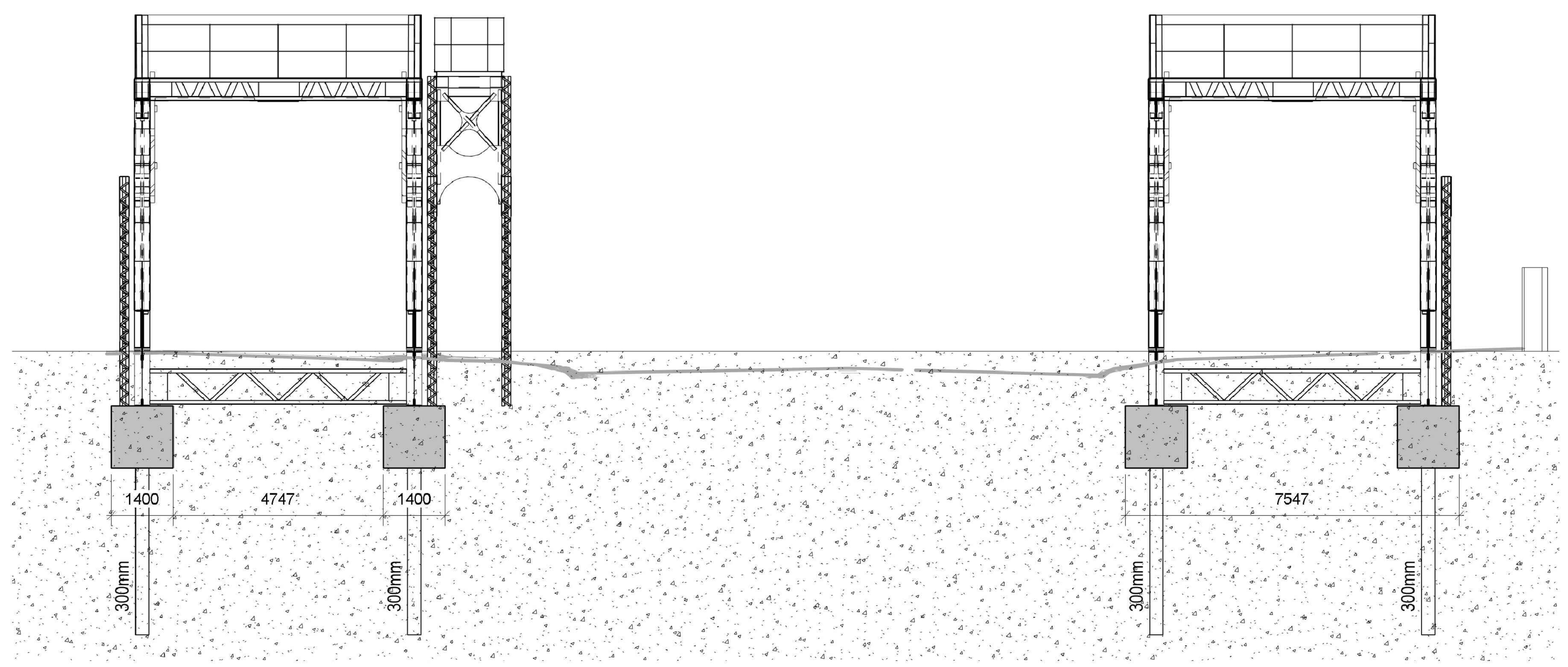

Section B-B

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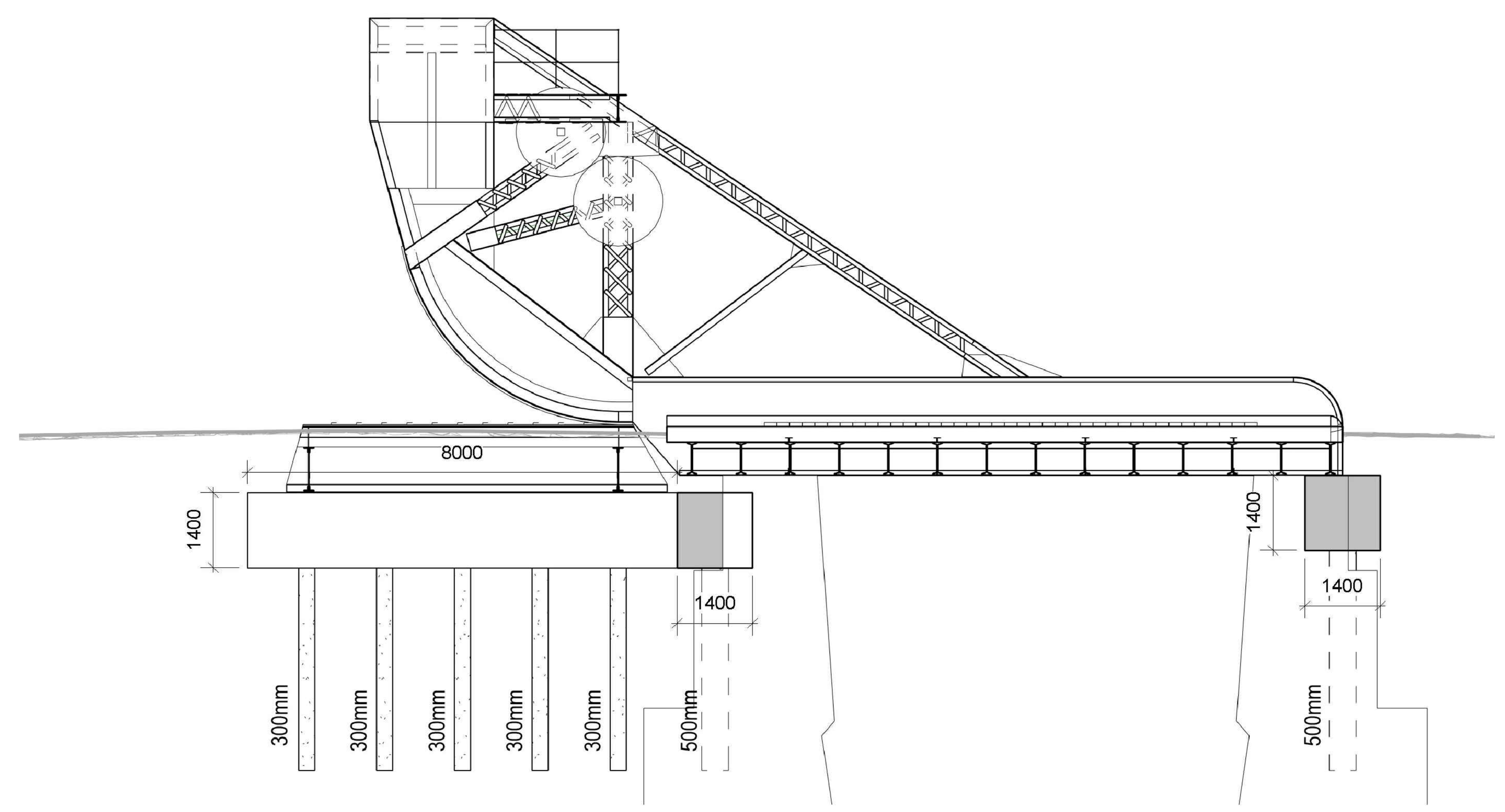

Section A-A

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Project Ireland 2040
Building Ireland's Future

Rev	Date	Drn	Chk'd	App'd	Description
M01	30/06/2022	AG	EOC	SMG	ISSUED FOR PHASE 4: PLANNING

Client: NTA Údarás Náisiúnta Iompair National Transport Authority

Engineering Designer: ROD ROUGHAN & O'DONOVAN TYPSA

Programme Title: **BUSCONNECTS DUBLIN CORE BUS CORRIDORS INFRASTRUCTURE WORKS**

Drawing Title: ROYAL CANAL SCHERZER BRIDGES PROPOSED FOUNDATION DESIGN

Date	Scale	Drawn	Checked	Approved
30/06/2022	1:100 @ A1 1:200 @ A3	AG	EOC	SMG

Programme Code	Originator Code	QMS Code	Drawing File Name	Sheet Number	Status	Rev
BCIDD	ROT		BCIDD-ROT-STR_ZZ-0016_XX_00-DR-SS-0020	20 of 20	A	M01

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APPENDIX 3
RELEVANT EXTRACTS FROM GROUND INVESTIGATION REPORT

1. INTRODUCTION AND DESKTOP REVIEW

The existing site investigation information for the area has been taken from the Geological Survey of Ireland (GSi) website and the British Geological Survey (BGS) website, including the Quaternary and Bedrock Geology of Dublin and Depth of Bedrock digital maps.

The following selection of published papers has found to be of relevance to estimate the lithology and geotechnical properties:

- "Geotechnical properties of Dublin boulder clay". Authors: Long, Michael M and Menkiti, Christopher O. Sept 2007, Géotechnique 57 (7): 595-611. Published by the ICE.
- Ground Investigation Report of the National Pediatric Hospital Project, Dublin. Roughan & O'Donovan Consulting Engineers, January 2015.

1.1 Overview of geotechnical conditions along the Project.

Quaternary sediments cover up to 80% of the Dublin region. Quaternary thicknesses at the city area range from 5 to 20m. Maximum thicknesses are recorded along a Tertiary channel occurring on the north shore of the River Liffey valley, reaching 45m, and along a channel-like feature running along the south margin of the Dodder valley Quaternary sediments, with a thickness of 15 to 25 m.

The most commonly occurring Quaternary deposit in the area has been termed locally as the Dublin Boulder Clay. It is a glacial deposit derived from the Lower Carboniferous Limestone and it is classified by its two main members: the Black Boulder Clay (BkBC) and the Brown Boulder Clay (BrBC). The Brown Boulder Clay is less consolidated and since it overlies the Black Boulder Clay it has been interpreted as its weathered upper layer.

The Upper Brown Boulder Clay (UBrBC) is the outcome of the oxidation of the clay particles in the top 2m to 3m of the UBkBC, resulting in a change in colour from black to brown and a lower strength material. It is usually described as thick stiff to very stiff brown, slightly sandy clay, with rare silt / gravel lenses and some rootlets, particularly in the upper metre.

The Upper Black Dublin Boulder Clay (UBkBC) is a very stiff, dark grey, slightly sandy clay, with some gravel and cobbles. It is typically 4 m to 12 m thick.

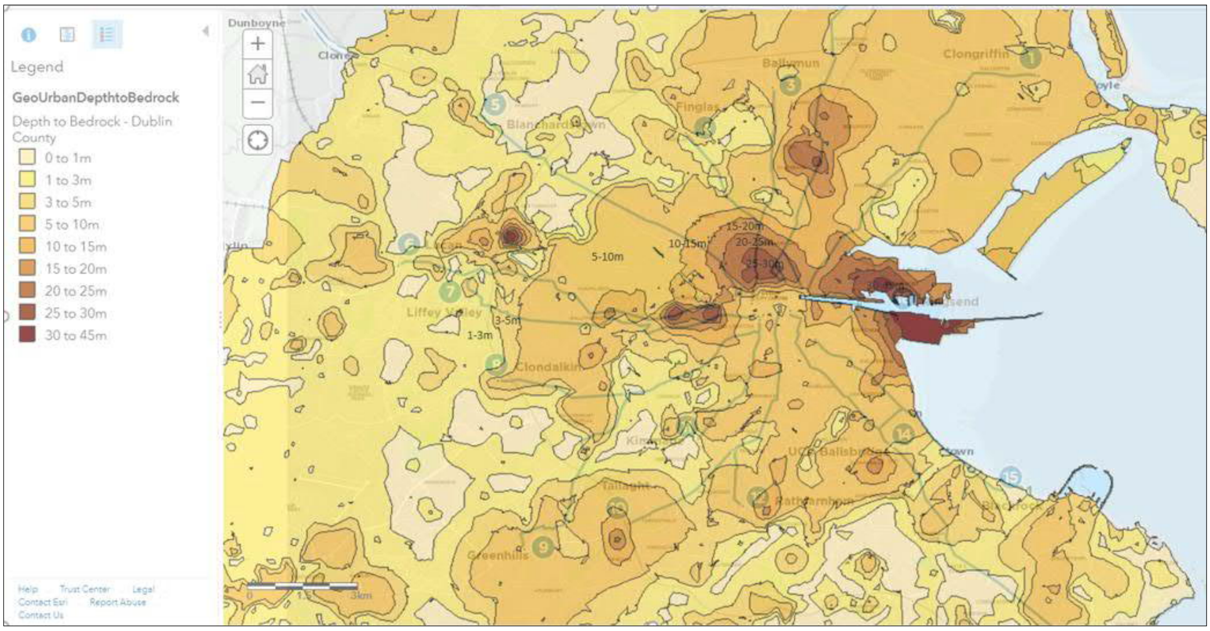
The Lower Brown Dublin Boulder Clay (LBrBC) exists as a 5 m to 9 m thick hard, brown, silty clay, with gravel, cobbles and boulders. It has previously been called the "sandy boulder clay" as it is similar to but siltier than the UBkBC above.

The Lower Black Dublin Boulder Clay (LBkBC) is a patchy layer of hard slightly sandy gravelly clay with an abundance of boulders. Its thickness does not exceed 4 m and is typically less than 2 m.

Note that not all four distinct formations of the Dublin Boulder Clay are always present. The upper two units though have been proven at all investigation sites across the city.

Bedrock close to the surface occurs mostly along the main riverbeds as well as the coastline and the higher ground areas of the Howth peninsula. The bedrock map of Ireland shows a wide variety of rock types which have originated at different periods of geological time. Underlaying the project area consists of Lower Carboniferous Limestone of the Lucan Formation (Calp), which is typically described as a dark grey to black fine grained limestone.

The following image from the Geological Survey Ireland website shows the expected depth to Bedrock.



Depth of Bedrock from the Geological Survey Ireland website

The water pressures correspond to hydrostatic conditions with a groundwater table about 2m below ground level.

- *Summary of Desktop Review.*

The following preliminary lithology and geotechnical properties has been assumed based on the Desktop Review:

Layer	Depth	Thickness	Undrained shear strength, c_u (kPa)
Made ground / Urban / Alluvium	0 to 1 m	1	0
Upper Brown Boulder Clay, UBrBC	1 to 3 m	2	80
Upper Black Boulder Clay, UBkBC	3 to 10 m	7	200
Lower Brown Boulder Clay, LBrBC	10 to 18 m	8	400
Lower Black Boulder Clay, LBkBC	18 to 22 m	4	600
Bedrock	>22 m	N/A	>600

The expected depth to bedrock has been included in Section 2.

2. SUMMARY OF GROUND INVESTIGATION CONTRACT

At the date of this document, there are two GI contracts underway. Lot 1, which includes projects C and D , and Lot 2, which covers A and B projects.

Proposed ground investigation works aim to assess the geology of the site and determine the ground properties and conditions to enable the design of Bus Connects Core Bus Corridors. The GI provides for boreholes, trial pits, dynamic probes, standpipes/piezometer installation and monitoring, in-situ testing, geotechnical and environmental laboratory testing and preparation of a factual report, all in accordance with the "*Specification and Related Documents for Ground Investigation in Ireland*".

At the Project D schemes (Ballymun/Finglas to City Centre, Kimmage to City Centre and Ringsend to City Centre), there are 21 proposed investigation points, consisting of Cable Percussion (CP) and Rotary Core (RC) boreholes as well as few windowless dynamic samples (WS) in restricted space areas. The location of these points can be found in the form of drawings in the "*BusConnects Detailed Ground Investigation – Stage 1 – LOT 1*", February 2020.

In situ tests mainly include standard penetration tests. Laboratory tests mainly include particle size distribution, Atterberg limits, density and moisture content to identify soils and direct shear strength, triaxial CU or UU and uniaxial compression to determine the strength of the soil/rock.

For more details see the "*BusConnects Detailed Ground Investigation – Stage 1 – LOT 1*", February 2020.

For the Ringsend to City Centre Core Bus Corridor Scheme, the following investigation points have been proposed:

Borehole Ref.	Expected Depth to Bedrock	Borehole Depth (m) – Cable Percussion	Borehole Depth (m) – Rotary Core
R16-CP01	10-15m	15	-
R16-CP02	10-15m	15	-
R16-CP03	15-20m	15	-
R16-CP04	15-20m	15	-

3. SUMMARY OF FACTUAL REPORT

The following factual report was issued as part of the Lot 1 GI:

- Detailed Stage 1 Lot 1 Route 16. June 2021

Completed investigation points are as summarised below:

Structure	Borehole Ref.	Expected Depth to Bedrock	Borehole Depth (m) – Cable Percussion	Borehole Depth (m) – Rotary Core	Notes
Ringsend 01	R16-CP01	10-15m	5.0	-	
	R16-CP02	10-15m	9.1	-	
Ringsend 03	R16-CP03	15-20m	12.3	-	
	R16-CP04	15-20m	13.5	-	

The GI works undertaken comprise 4 No. Cable Percussion Boreholes to a maximum depth of 13.5m BGL; 22 SPT tests at 1 metre intervals alternating with disturbed samples and 6 GWL recordings.

13 disturbed samples were taken at each change of soil consistency or between SPT tests and 4 undisturbed samples (UT100) where ground conditions permit. Geotechnical testing consisting of 13 moisture content, 2 Atterberg limits, 2 Bulk Density and 9 Particle Size Distribution. Soil strength testing consisted of 4 Vane tests and 4 Shear Box.

Environmental & Chemical testing consisted of 19 Suite E samples and 1 pH and organic matter content test.

4. OVERVIEW OF SOIL CLASSIFICATION

4.1 Made ground

Made Ground deposits were encountered beneath the Topsoil/Surfacing and were present to depths of between 2.50m and 5.30m BGL.

Made ground deposits were described generally as either brown, sandy gravelly Clay with cobbles or greyish brown clayey gravely Sand with occasional cobbles and contained occasional fragments of concrete, plastic, red brick and wood.

Note that a culvert was encountered in borehole R16-CP02 between 3.0 and 5.3m, which was noted as a void on the log.

The Particle Size Distribution tests confirm that generally the Made ground deposits are well-graded graded with percentages of sands between 22% and 53% and percentages of gravels between 31% and 69%.

PH and total organic carbon (TOC) were determined at R16-CP04 at 0.5m depth. Organic matter content (OMC) was estimated from TOC. PH, TOC and OMC values were 9.3, 1.6% w/w C and 2.8% w/w respectively.

Asbestos was detected at 0.5m depth at borehole R16-CP03.

4.2 Cohesive deposits

Cohesive deposits were encountered beneath the Made Ground or interbedded with Granular Deposits and were described typically as grey slightly sandy silty CLAY.

The strength of the cohesive deposits was typically very soft till depths of 11.7mBGL.

Cohesive deposits found to be a CLAY of high plasticity, with a plasticity index ranging between 29% and 31%. Particle Size Distribution tests confirm generally well-graded deposits with percentages of sands and gravels ranging between 11% and 15% and 2% and 5%, respectively.

4.3 Granular deposits

Granular deposits were encountered interbedded with cohesive deposits in the majority of holes and were typically described as either greyish sandy sub rounded to rounded fine to coarse GRAVEL with occasional cobbles or gravelly fine to coarse SAND.

Based on the SPT N values the deposits vary from loose to dense.

Particle Size Distribution tests confirm generally well-graded deposits with percentages of sands and gravels ranging between 18% and 58% and 33% and 69%, respectively.

5. SUMMARY OF GROUND INVESTIGATION INTERPRETATIVE REPORT

For RingsenD to City Centre CBC scheme, the following lithology and soil strength properties has been assumed based on the GI findings:

Layer	Depth (m)	SPT	Undrained shear strength, c_u (kPa)
Topsoil, Concrete	0 to 0.5	-	-
Made Ground: Brown Clay (possibly UBrBC) / Sand / Gravel	0.5 to 6	6	40
Very soft silty Grey Clay (only found in 2 out of 4 boreholes)	6 to 12	3.5	20
Gravel	Top level between 6 and 12m	50	325

- 2 Vane tests at Made Ground Sand layer, defined as brown very sandy Gravel or brown very gravelly Sand, have shown Peak shear strength values higher than 146 KPa.
- 2 Vane tests at soft silty clay layer, shown Peak shear strength values between 11 and 13 kPa.
- 2 Shear Box tests at Made Ground Sand layer, defined as brown silty (very) gravelly Sand, shown angle of peak shearing resistant values between 34 and 44 degrees and effective cohesion values between 4 and 13 kPa.

The geological geotechnical ground profile can be found at Appendix 1.

Ground parameters from in situ and lab tests are shown in Appendix 2.

6. HIDROGEOLOGY

Groundwater was noted during the investigation although the exploratory holes did not remain open for sufficiently long periods of time to establish the hydrogeological regime. However, standpipes were installed to allow the equilibrium groundwater level to be determined.

Groundwater levels recorded during the GI works are summarized below:

Date:	20/4/21	16/6/21
R16-CP01	4.46	4.72
R16-CP02	5.03*	-
R16-CP03	-	2.47
R16-CP04	3.73	4.40
* Water depth might be unrepresentative due to culvert		

7. GEOTECHNICAL INPUT TO STRUCTURES

The following table shows the expected depth to bedrock, based on the data from the Desktop Review, as well as the depth of the encountered bedrock in the GI undertaken.

Note that most of the boreholes were terminated at a shorter length, before encountering the bedrock strata. Therefore, the expected depth to bedrock could not be confirmed.

Structure	Permanent loads / Variable loads (KN)	Borehole Ref.	Expected Depth to Bedrock	Depth to encountered Bedrock	Depth to N_{SPT} values of Refusal	Piles estimated length (m)
Ringsend 01 D=0.5m	294 / 623	R16-CP01	10-15m	-	5m	11.0
		R16-CP02	10-15m	-	6m	11.5
Ringsend 02 D=0.2m	50	R16-CP03	15-20m	-	12.5m	11.5
		R16-CP04	15-20m	-	12.5m	12.5
Ringsend 03 D=0.5m	210 / 604	R16-CP03	15-20m	-	12.5m	15.5
		R16-CP04	15-20m	-	12.5m	16.5

A preliminary number of the characteristic compressive resistance of piles has been obtained following the alternative procedure in accordance with the Eurocode 7 and the Irish National Annex. This procedure makes use of the ground parameters (such as the undrained shear strength, c_u) to estimate the shaft and base compressive resistance of piles.

Cu values have been derived from SPT values obtained in each borehole following the SPT-Cu relationship proposed by Stroud and Butler (1975). Calcs can be found at Appendix 3.

In Ringsend 01 and 03 0.5m diameter driven piles embedded in the Dublin boulder clay and Ringsend 02 0.2m piles, the estimated piles length that satisfies the ULS is as detailed in the table above.

APPENDIX 4
OTHER RELEVANT DOCUMENTATION/REPORTS

Relocation of Scherzer Bridges, Dublin City:

Industrial Heritage and Options Appraisal


Fred Hamond, John Kelly

&

Fergal McNamara

Brady Shipman Martin

7L ARCHITECTS

for

Roughan & O'Donovan and National Transport Authority

February 2021

Contents

Preface

The purpose of this report is to inform the design development of Core Bus Corridor (CBC) No.16 of 'BusConnects Dublin' that will connect Ringsend to the City Centre, by testing the feasibility of the retention and conservation of two pairs of historic Scherzer bridges located on the North Quays. The challenge addressed by this report is how best to conserve the historic character of the bridges whilst also enabling BusConnects Dublin's objectives to be delivered.

The objective of the BusConnects programme of the National Transport Authority (NTA) is to improve bus services in Irish cities, focussing on the enhancement of bus routes in urban areas and the creation of priority bus corridors. As noted in the Preferred Route Option Report the aim of BusConnects is: *to transform Dublin's bus system, with the Core Bus Corridor project aiming to provide 230km of dedicated bus lanes and 200km of cycle lanes on sixteen of the busiest bus corridors in and out of the city centre. This project is fundamental to addressing the congestion issues in the Dublin region with the population due to grow by 25% by 2040, bringing it to almost 1.55 million.*

In order to increase the capacity and quality of bus services between the City Centre and Ringsend along the Quays and the expanding North Lotts district adjacent to Dublin Port, the need has been identified for a four-lane road, including two for buses, along the north side of the Liffey. Lying directly on the proposed route are two pairs of Scherzer lifting bridges, all of which are included as Protected Structures in Dublin City Council's Development Plan 2016-22. This statutory protection is in recognition of their architectural and engineering significance.

During the route selection stage, the Scherzer bridges were identified as pinch points along the CBC route. It was determined through the analysis various different criteria (e.g. economic, social, environmental, and cultural) that their relocation would be required to fulfil the objectives of BusConnects Dublin. The assessment concluded that: *… the relocation of the historic Scherzer Bridges to an appropriate new location and the provision of new bridges in between are preferable. This will allow the hazard traffic poses to the bridges and vice versa to be better addressed.*

For the purposes of assessing the feasibility of conserving the Scherzer bridges on the north Quays as part of this process, it is assumed that the case for two dedicated bus lanes in addition to the existing two-lane carriageway has been made elsewhere to meet the requirements of BusConnects Dublin along CBC route 16.

It should be noted that, because of the of the Covid-19 pandemic, historical research and site surveys were restricted due of lockdown and travel restrictions imposed since March 2020 and which are still in force at the time of writing.

The assistance of Lar Joye, Heritage Director of the Dublin Port Company, in researching the history of the Scherzer bridges is gratefully acknowledged.

Fred Hamond *Industrial Archaeologist*

John Kelly *Brady Shipman Martin*

Fergal McNamara *7L Architects*

16 February 2021

Summary

This report explores the feasibility of relocating two pairs of Scherzer bridges on the North Quays to deliver BusConnects Dublin's objective of creating a dedicated bus route (CR 16) to and from Dublin City Centre. The study entailed the recording and assessment of the bridges in their current state, and researching their historical development.

Scherzer bridges were an innovation type of lifting Bridge patented by William Scherzer in 1893. They were first introduced to Ireland in 1905-06. Under the direction of Sir John Purser Griffith, two were erected in 1910-12 by the Dublin Port & Docks Board (DP&DB) over the entrance to the Royal Canal on North Wall Quay. A second pair was also installed by the DP&DB in 1932-34 over the entrance to George's Dock on Custom House Quay, this time under the direction of Joseph Mallagh.

An initial inspection of the bridges over the Royal Canal shows them to survive in a reasonably complete state. Although still capable of operation to facilitate boat access to the sea lock at this end of the canal, their spans have been temporarily clamped shut and they are now rarely, if ever, opened. The Scherzers at George's Dock have been permanently shut since 2001 and George's Dock is now dry. Although also in good condition, this pair is less complete and no longer capable of operation.

The four bridges are of national importance in terms of their architecture, technology and engineering interest and are Protected Structures in the Dublin City Development Plan 2016-22. Only eight were ever built in Ireland. The pair on the Royal Canal are now the earliest complete examples to survive, whilst the ones at George's Dock were the last to be built in the country.

Given the bridges' heritage significance, the strategy adopted here is to retain them as close as possible to each other in their present localities, minimise any loss of physical fabric and, at the same time, minimise any negative impacts upon adjacent built heritage features and their settings. The bridges' public amenity value is also considered.

An initial analysis of various relocation options showed that it will be impossible to retain either or both bridges in situ if BusConnects Dublin's objective is to be delivered, namely the creation of two dedicated bus lanes in addition to the existing two-lane road. Repositioning them both is the only feasible way forward.

In the case of the Royal Canal bridges, the preferred option is to move them apart to accommodate a fixed new bridge and also raising the deck levels of all the bridges by c.100cm. The new road bridge would carry two lanes of general traffic and two for buses, whilst the Scherzers would be reserved for pedestrians and cyclists. This option minimises loss of physical fabric on the bridges and adjacent heritage features, makes the bridges' dynamic loading more sustainable, creates an opportunity to enhance the public's appreciation and understanding of them, and also future-proofs the Royal Canal and North Wall Quay in the face of rising sea levels brought about by climate change.

At George’s Dock, the preferred option is also to move the two bridges apart to accommodate a new fixed four-lane road span and reserve the Scherzers for foot and cycle traffic. It is also recommended that both bridges be turned through 180 degrees so that the impact on the adjacent Stack B is reduced. This will also make the bridges more prominent and greatly enhance the public realm hereabouts.

The report concludes with recommendations for further research and field survey and highlights key stages in their repositioning and conservation should these recommendations be adopted.

1. Introduction

1.1 Bridge locations

Both pairs of bridges under review carry vehicular traffic and were designed to open to enable boats to pass underneath (fig 1.1). One pair is on North Wall Quay and spans the entrance to the Royal Canal and Spencer Dock. It dates from the 1910s and is still capable of operation. The other two are on Custom House Quay and span the former entrance to George's Dock. They date from the 1930s but are no longer openable for boat traffic as the Dock is long defunct.

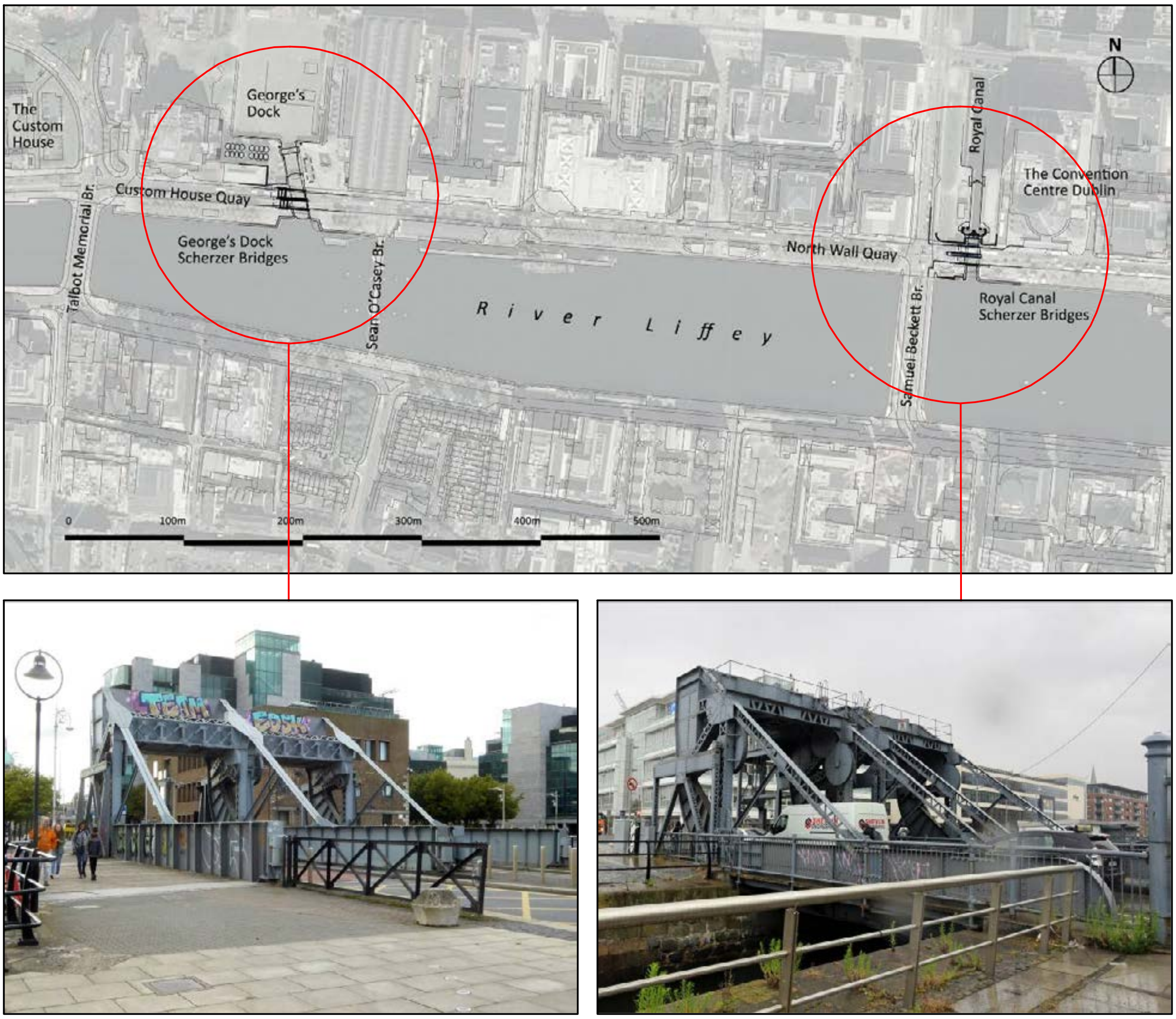


Fig 1.1 Locations of Scherzer bridges across entrance to George's Dock *(left)* and Royal Canal *(right).*

1.2 Bridge proposals

The BusConnects Dublin project has identified the need to provide a four-lane carriageway along the quays to facilitate dedicated bus and general traffic lanes in both directions, and also pedestrian and cycle facilities along the quayside. New fixed bridges will be required at Custom House Quay and North Wall Quay and it will be necessary to relocate the Scherzer bridges to make way for the new bridges.

1.3 Moveable bridges

Where a road spans a navigable waterway and it is not feasible to create a sufficient air gap between them to enable boats to pass underneath, the only option is to install a moveable span. Such spans would normally be closed to facilitate the movement of road traffic but they could also be temporarily opened to let boats through underneath.

Because of the close juxtaposition of a busy road network with railways, canals and working port, Dublin's Docklands are unique in Ireland for the variety of moveable bridges which once operated in that locality: lifting and roller drawbridges, swivel bridges, vertical lifting bridges, and bascule bridges. Three such bridges are still in operation today over the Liffey: the Tom Clarke bridge between East Wall and Ringsend (a 1984 bascule bridge with below-ground counterweight), Sean O'Casey bridge (a pedestrian swivel bridge of 2005), and the Samuel Beckett Bridge (a cable-stayed swivel bridge of 2007).

1.4 Scherzer bridges

The four Scherzer bridges under review are patented variants of the bascule type of lifting bridge. A bascule bridge has a span which is hinged and counter-weighted at one end so that its outer end can be raised with minimal effort. They are named after William Scherzer who patented their design in 1893 and set up the Scherzer Rolling Lift Bridge Co in Chicago to manufacture them and license their use by others (fig 1.2).[1]

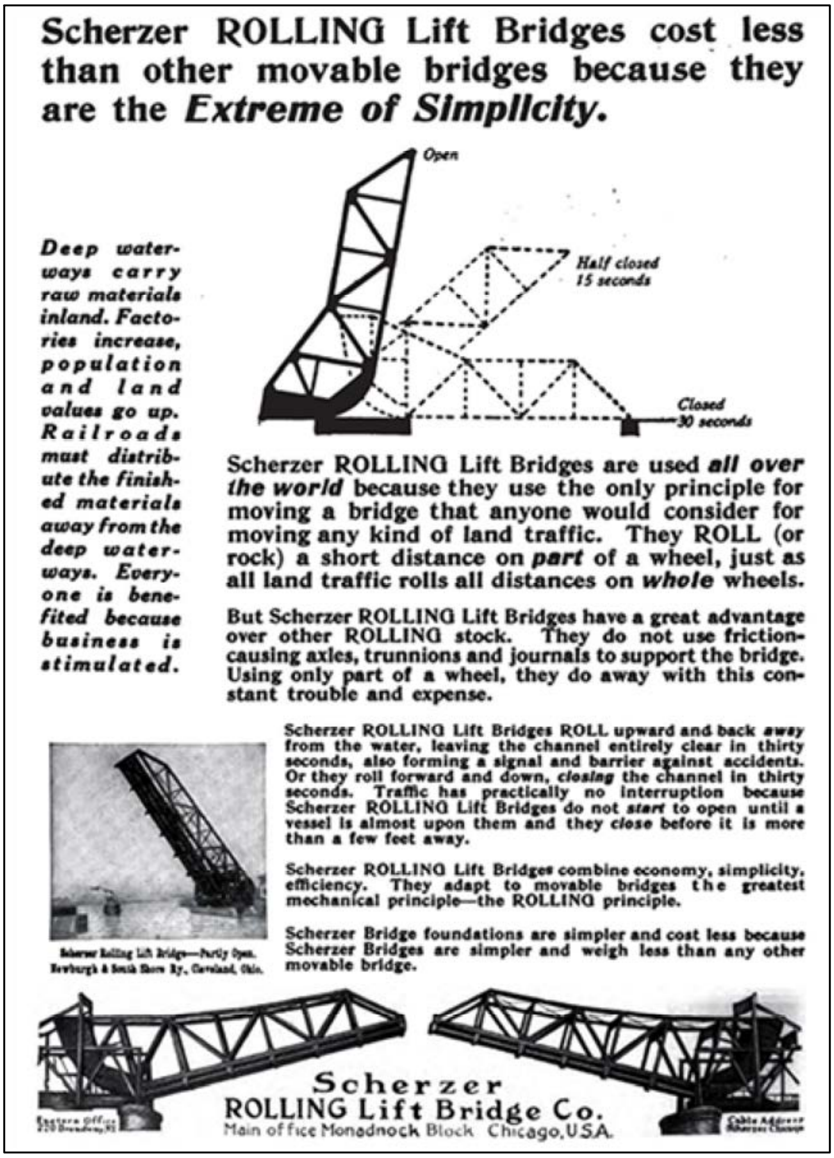


Fig 1.2 Advertisement for Scherzer bridge, 1913 *(www.builtdublin.com).*

[1] For further details, see *Scherzer Rolling Lift Bridges: Their Inception, Development & Use*, published by the Scherzer Rolling Lift Bridge Co in 1916. It is available on-line at <https://archive.org/details/ScherzerRollingLiftBridgesTheirInceptionDevelopmentAndUse/mode/2up>.

As noted in the above advertisement, the key feature that differentiates a Scherzer from a bascule bridge is that the former's span simultaneously opens and moves backwards (fig 1.3). Unlike bascules, its span is not hinged to an abutment. Rather, it is connected along both sides to heavy metal quadrants, the back ends of which are connected to a massive counterweight. A horizontal drive shaft runs through the centre of gravity of the span-counterweight assembly. This point also coincides with the centre of rotation of the entire assembly. If this shaft is moved backwards, the entire assembly rocks back on its quadrants along track plates, causing the outer end of the span to rise. The only power required is that to move the assembly back and forth, rather than lift it as would be the case with a bascule.

The drive shaft is rotated by an electric motor through a series of gears. Affixed to each end of the shaft is a pinion gear which, as it rotates, engages with a cogged rack on a fixed horizontal frame. Turning the shaft causes the pinions to travel along the rack and drag the span-counterweight assembly with them. This forces the quadrants to rock backwards and the span to open. Turning the shaft in the reverse direction causes the assembly to roll forwards and the span to close.

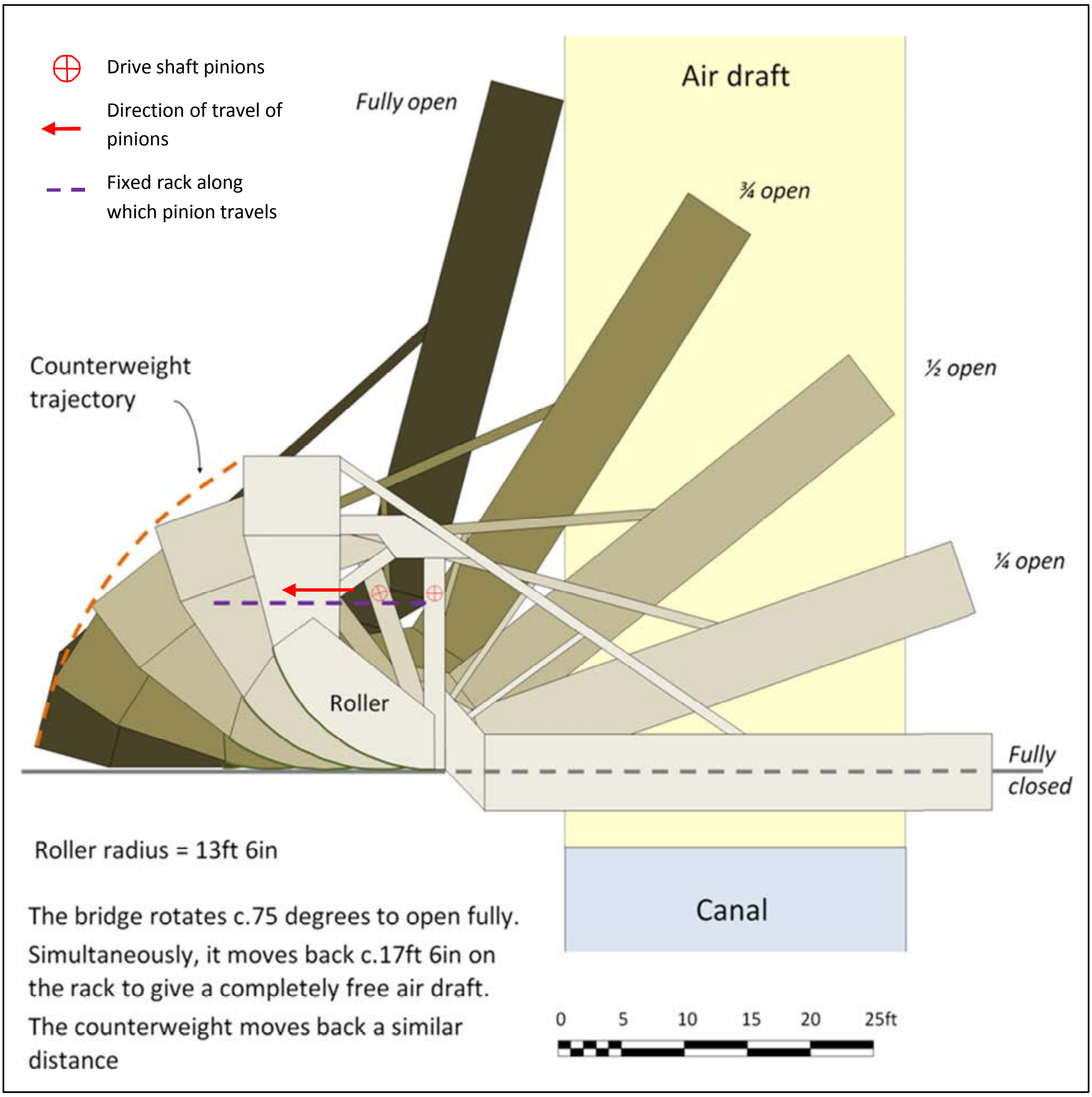
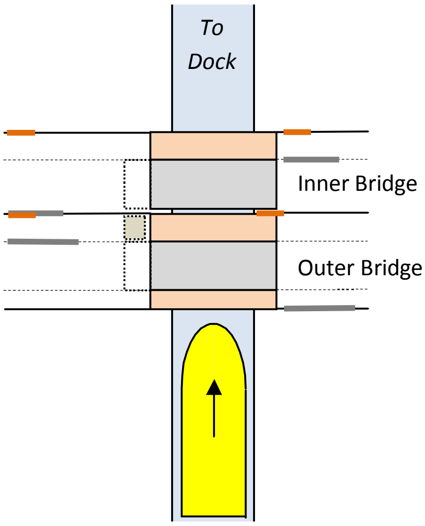


Fig 1.3 Operation of Scherzer bridge (based on Royal Canal, Dublin).

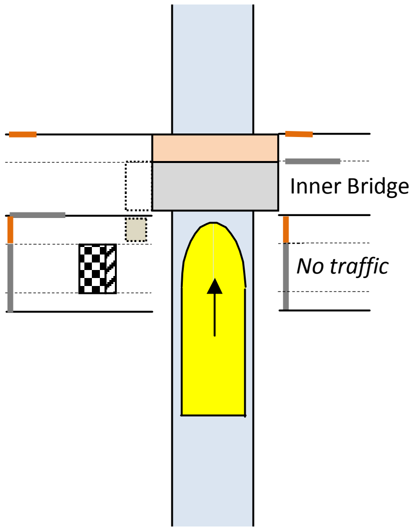
Apart from their simplicity of design and modest power requirements, another advantage of Scherzer bridges is that a completely clear air draft is created without having to open the spans fully to the 90 degree position. It therefore takes less time to operate than a standard bascule.

One Scherzer bridge would normally suffice at a particular location. The only drawback is that road traffic is at a complete standstill whilst the bridge is opening and closing. Using two bridges in tandem, all traffic is stopped only for the time it takes a boat to traverse the width of one of the bridges rather than both of them (fig 1.4). This saving in time might seem insignificant but given the high volume of road and canal traffic when the bridges were in use, the overall saving would have been considerable in the long term.

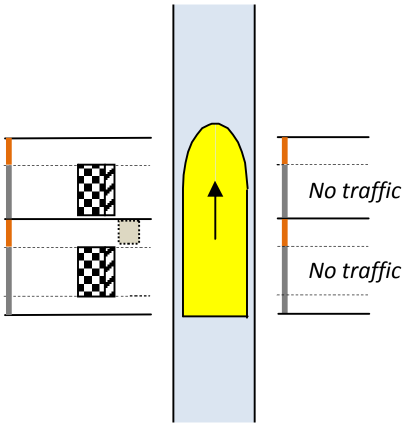
Only eight Scherzer bridges were ever constructed in Ireland, all in the first half of the 20th century (Appendix 1). The two over the Royal Canal are now the earliest surviving examples which are still in an operable state, whilst the two at George's Dock are the last in Ireland to have been built.



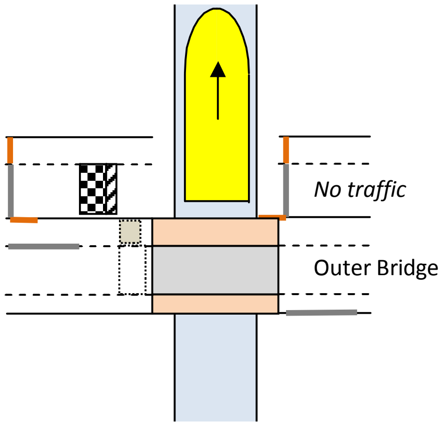
1. Road traffic passes over both bridges as boat approaches along canal from river.



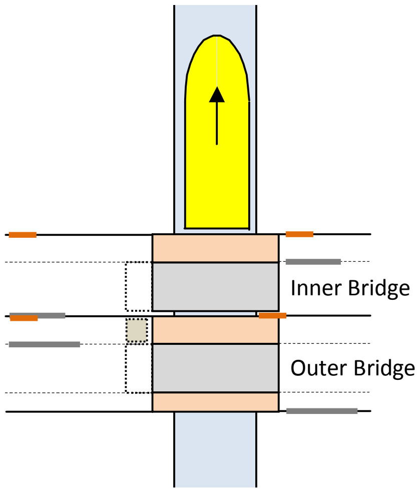
2. Outer Bridge is raised to let boat passes under. All road traffic is rerouted across Inner Bridge.



3. Inner Bridge now raised to let boat pass under. Outer Bridge remains raised so both bridges are now closed to all road traffic.



4. Outer Bridge is closed once boat passes under. All road traffic is rerouted across Outer Bridge.



5. Inner Bridge closed once boat passes under. Both road lanes now in use once again.

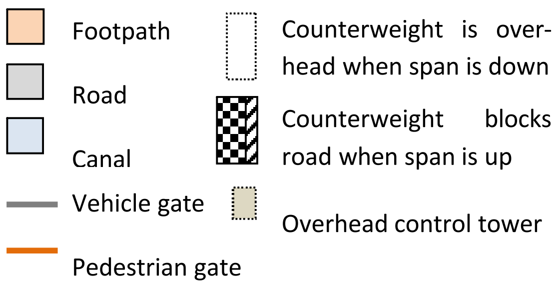


Fig 1.4 Operation of Scherzer bridges for road and canal traffic.

2. Options appraisal methodology

The methodology used for assessing the various options for relocating the bridges is largely informed by the planning regulations and various international charters relating to the built heritage.

2.1 Planning context

The National Development Plan 2018-2027 sets out the significant level of investment which underpins the National Planning Framework and drives its implementation over the ten-year period. In Chapter 5 of the Plan, *National Strategic Outcomes* are set out including BusConnects Dublin as a *Strategic Investment Priority for Sustainable Mobility*. The North Quays are also included as a core radial bus corridor in the *Transport Strategy for the Greater Dublin Area 2016-2035* prepared by the National Transport Authority.

Record of Protected Structures

A 'Structure' is defined by the Local Government (Planning and Development) Act of 1999 as - *any building, structure, excavation, or other thing constructed or made on, in or under any land, or any part of a structure*. The Government publication *Architectural Heritage Protection Guidelines for Planning Authorities* (2004) expanded on the definition of 'structure' to include (a) the interior of the structure, (b) the land lying within the curtilage of the structure, (c) any other structures lying within that curtilage and their interiors, and (d) all fixtures and features which form part of the interior or exterior of the above structures.

A 'Protected Structure' is defined in the 1999 Act as any structure or specified part of a structure, which is included in the Record of Protected Structures (RPS) of the local authority Development Plan. The bridges at North Wall Quay (registration number 912) and Custom House Docks (reg.no. 896) are included in the RPS of the Dublin City Development Plan 2016-2022.

Industrial heritage is also the subject of Chapter 11.1.1.5 of the Dublin City Development Plan 2016-22 administered by Dublin City Council. One objective of the Plan (CHCO10) is to take cognisance of the City's industrial heritage in assessing planning applications. The Council will also implement and promote the *Dublin Principles* (see below) and proposes to review the Dublin City Industrial Heritage Record (DCIHR).

Nizhny Tagil Charter

Given the heritage significance of the Scherzer bridges, it is pertinent to briefly review those international charters and principles which are particularly relevant to industrial heritage. The Nizhny Tagil Charter for the Industrial Heritage was adopted jointly by ICOMOS (International Council of Monuments and Sites) and TICCIH (The International Committee for the Conservation of Industrial Heritage) in July 2003. ICOMOS is a professional association that advises UNESCO on the conservation of historic sites and which is, in turn, advised by TICCIH in relation to industrial heritage. The Nizhny Tagil Charter was the first internationally recognised reference text to guide the protection and conservation of industrial heritage. It sets out definitions of industrial heritage and its cultural significance - its values, the importance of research and recording, procedures for its protection, maintenance and conservation, education and training and, finally, presentation and interpretation.

Dublin Principles

Following a TICCIH convention in 2011, *The Dublin Principles* were adopted by ICOMOS to assist in the documentation, protection, conservation and appreciation of industrial heritage as part of the heritage of human societies around the World. This document expands on the Nizhny Tagil Charter and notes a particular emphasis on industrial heritage dating from the Industrial Revolution in the Modern Era – including power generation, production, transport processes and technologies. It also includes reference to less tangible aspects of industrial heritage such as commercial and trade interactions, new social and cultural patterns and underlines the need to archive associated documentation. It emphasizes important values such as functionality, reversibility and recording.

Part I sets out the importance of research and documentation so that industrial technologies and processes can be properly understood and contextualised. Part II concerns the continued use and functional integrity of industrial heritage. Part III emphasizes the importance of adaptive re-use in the sustainable conservation of industrial heritage and its settings. Part IV is concerned with the importance of presenting and communicating the values of industrial heritage.

2.2 Conservation rationale

It is the task of the conservation professional to translate the various charters and principles into a strategy for the conservation of a particular historic site, artefact or process. Every place and every task poses a challenge to reach the high standards demanded in these documents. Where change is proposed, the task is to manage the process to ensure the conservation of the cultural heritage, especially where intervention is required.

Of particular relevance to the Scherzer bridges is Part III of the *Dublin Principles* which notes that interventions should be reversible. In addition, *dismantling and relocating are only acceptable in extraordinary cases when the destruction of the site is required by objectively proved overwhelming economic or social needs.*

In assessing options for conserving the Scherzer bridges, it is assumed that the case has been proven elsewhere for providing two dedicated bus lanes and cycle lanes along the north Quays to replace the existing two lanes of traffic and footpaths. As noted above, the economic and social aspects of the route selection process are beyond the scope of this assessment, having been undertaken at the initial route selection stage of the BusConnects Dublin programme.

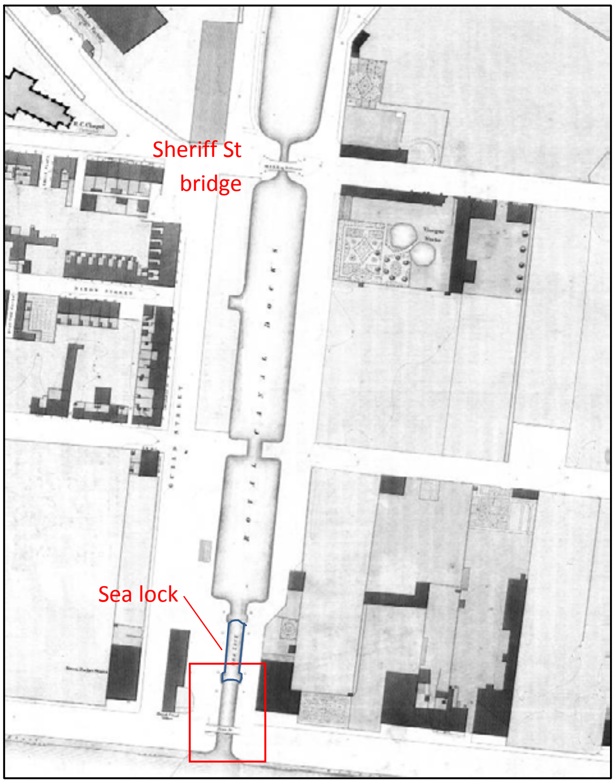
The objective of the options analysis for each pair of Scherzer bridges is to retain their industrial heritage significance as far as possible following the provision of additional traffic lanes. As part of the process, it became apparent that each pair of bridges needs to be relocated in order to accommodate the proposed new road scheme. However, following an initial appraisal, it was concluded that their relocation elsewhere so that they could be kept together was an unacceptable worst-case scenario with regard to their conservation. For these reasons, only the options which kept them as close as possible to one another in the vicinities their present locations were evaluated. The actual criteria used to assess the various options will be discussed in detail under each pair of bridges.

3. History of the Royal Canal bridges

In the two centuries since the first bridge was erected over the entrance to the Royal Canal, there have been no fewer than six bridges at this location.

3.1 Swivel Bridge

The Royal Canal initially ran from Dublin - Broadstone to Mullingar and opened in 1806.[2] Around 1809, it was connected into the tidal River Liffey with the completion of the Royal Canal Docks and a 113ft long x 27ft wide sea lock. The approach to the lock from the Liffey was spanned by a double-leaf, single-lane swivel bridge (i.e. one that rotates about a vertical axis). This bridge is captioned as 'Draw Br' on 1838 OS map, although it was never a lifting bridge as this designation implies (fig 3.1).



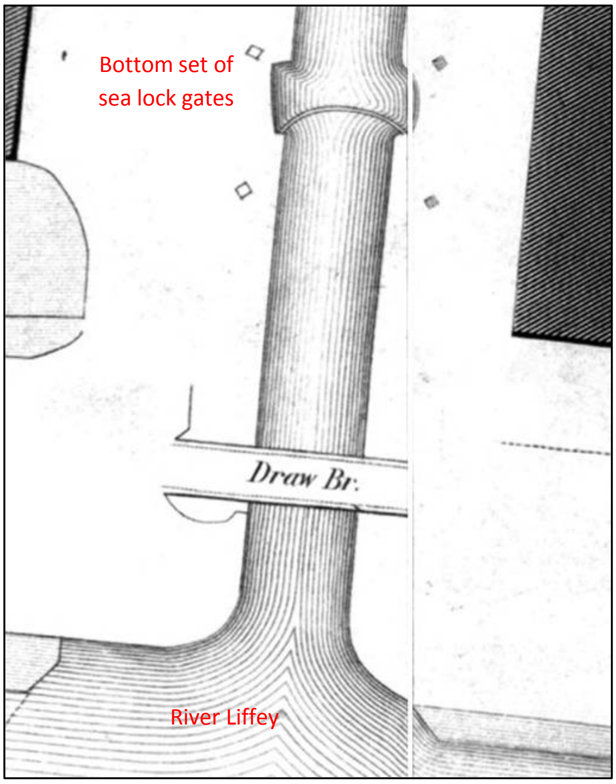


Fig 3.1 1838 map showing the Royal Canal Dock and moveable bridge at its entrance from the Liffey
(OS 1:1056 map, Dublin City sheets 15 and 16).

3.2 Rolling drawbridge

In 1845, the Royal Canal Company was purchased by the Midland & Great Western Railway Co (MGWR). In 1860, they replaced the bridge with a rolling drawbridge capable of carrying two lanes of vehicular traffic.[3] Patented and erected by Messrs Turner & Gibson of the Hammersmith Works, Ballsbridge, this new bridge comprised a girder span pivoted centrally on a *horizontal* axis (fig 3.2). By lowering one end, the balanced opposite end rose clear of the road. Using a rack and pinion system, the entire span was then wound back along the line of the road to clear the canal. To close the bridge, the process was reversed.

[2] For a history of the Royal Canal see Ruth Delaney & Ian Bath (2010), *Ireland's Royal Canal, 1789-2009* (Dublin: Lilliput Press).
[3] Griffith, Sir John Purser (1913), 'Twin Scherzer bridges at Dublin', in *The Engineer*, 19 Sept 1913, pp 304-305, 308. Turner & Gibson installed an identical bridge at the entrance to George's Dock in the same year.

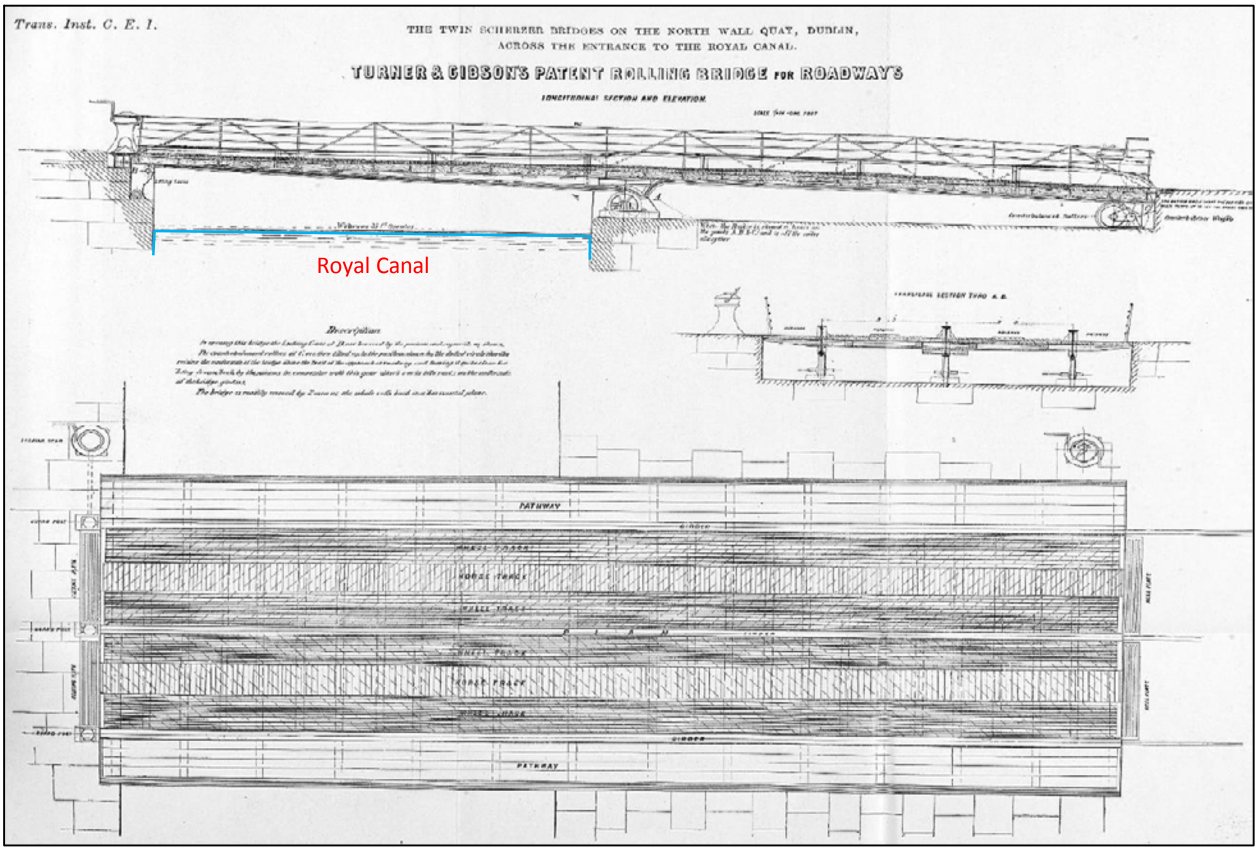


Fig 3.2 Elevation (looking south) and plan of drawbridge across canal entrance *(Griffith 1912, fig.2).*

Even though the new bridge was the property of the MGWR, the Ballast Board contributed £600 towards its cost on the grounds that it would also facilitate road traffic to and from the Port. It is captioned 'Draw Br' on the 1864 OS map (fig 3.3).

3.3 Enlargement of sea lock

Between 1870 and 1873, the MGWR extended the Royal Docks northwards beyond Sheriff Street as far as the Dublin-Drogheda railway line to create Spencer Dock. The fixed bridge at Sheriff St was replaced with a new swivel one named Spencer Bridge.[4] At the same time, the sea lock was extended southwards by 61ft, from 113ft to 174ft. However, no alterations were necessary to the drawbridge as it was not in the way of the repositioned lock gates (fig 3.4).

As traffic (mainly coal boats) to and from the Royal Canal increased, road traffic delays grew more frequent along North Wall Quay. Seemingly it took a minimum of 22 minutes for a vessel to negotiate the bridges, and upwards of an hour if several came from both directions.

Since the late 1870s, there had been protracted discussions between the Dublin Port & Docks Board (DP&DB; the successor of the Ballast Board) and MGWR to resolve this problem. In 1885, Bindon Stoney, the Board's Engineer, proposed two swivel bridges - one in place of the existing drawbridge south of the bottom lock gates, and the other north of the top gates (fig 3.5). This proposal was rejected on the grounds that swivel bridges might impede vessels using the canal and the MGWR were also reluctant to give public access through its premises.

[4] *Freeman's Journal,* 12 April 1873.

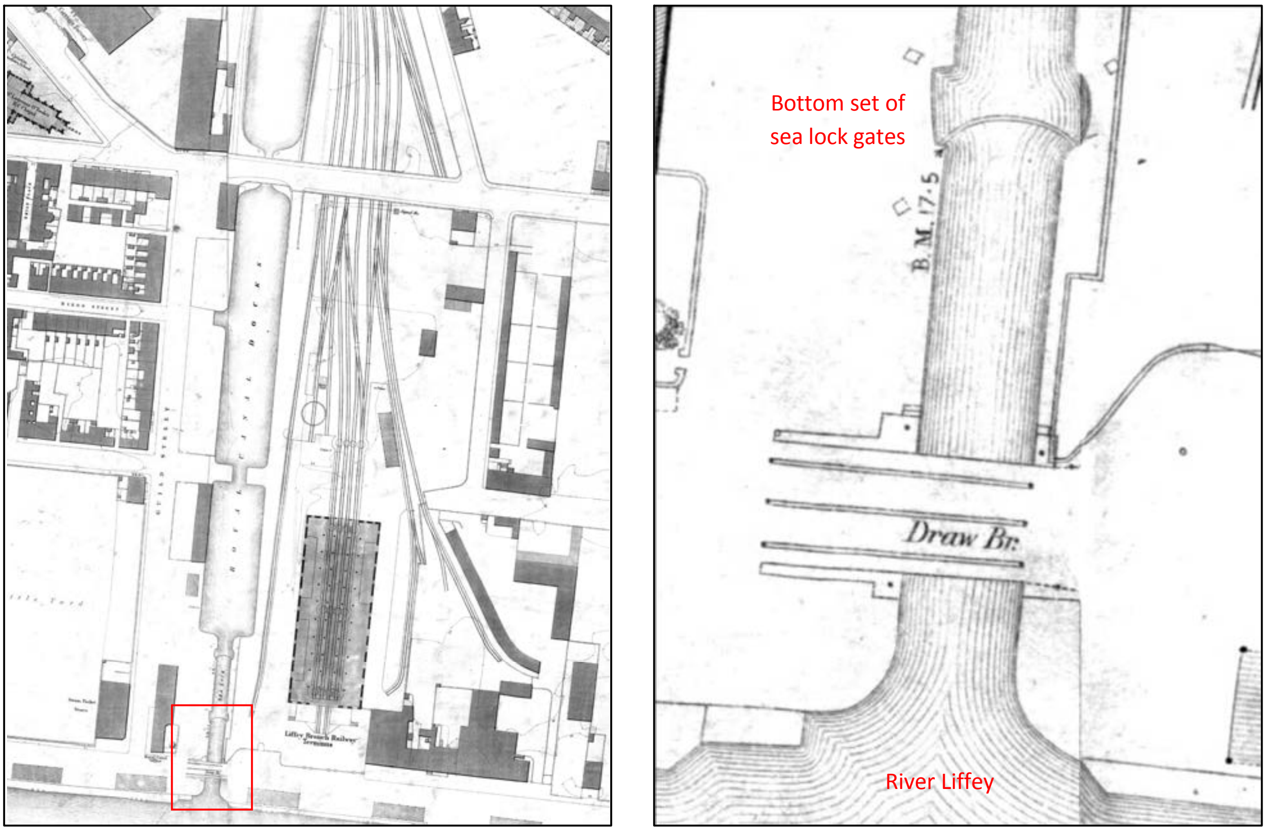


Fig 3.3 1864 map showing the Royal Canal Dock and new moveable bridge at its entrance from the Liffey. The bridge moved west when being opened *(OS 1:1056 map, Dublin City sheets 15 and 16).*

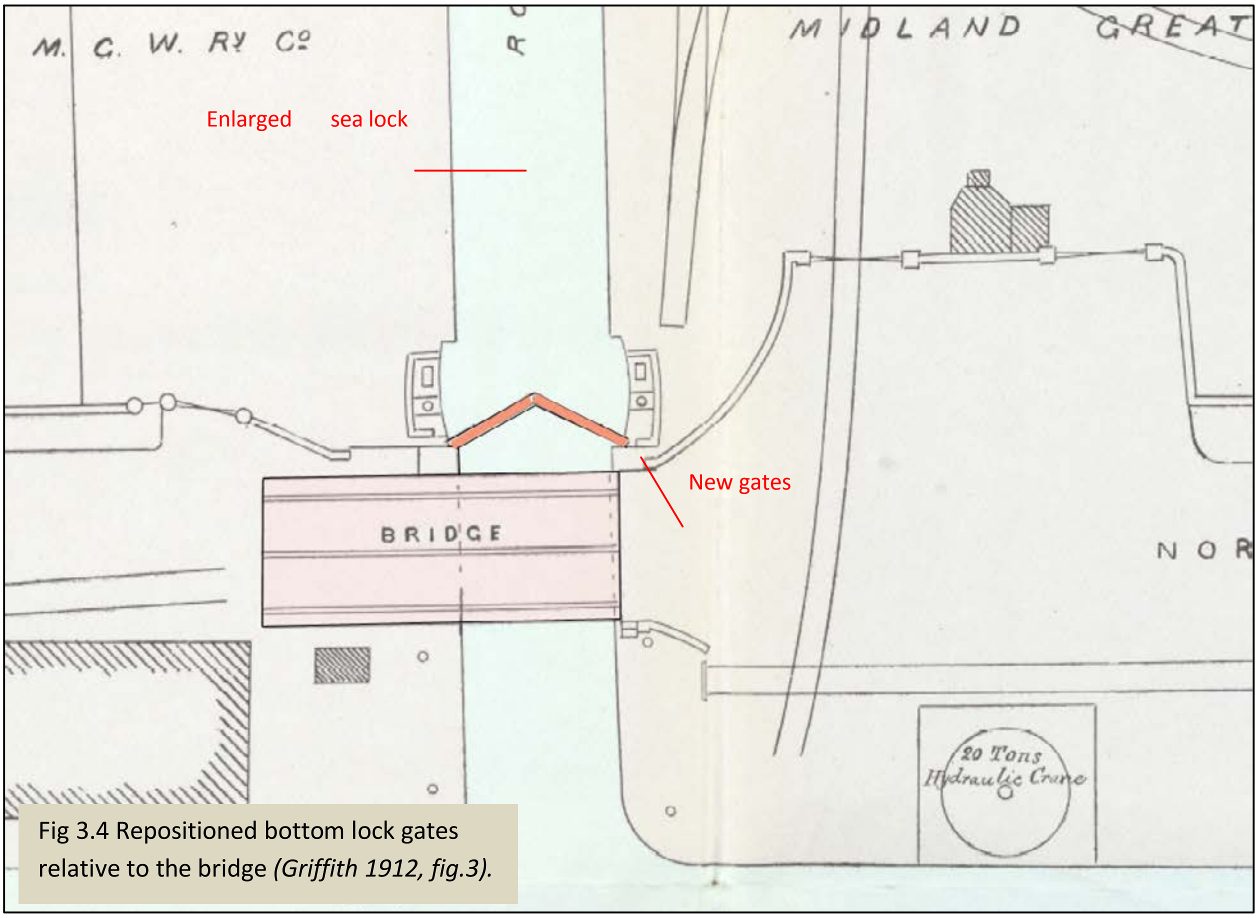


Fig 3.4 Repositioned bottom lock gates relative to the bridge *(Griffith 1912, fig.3).*

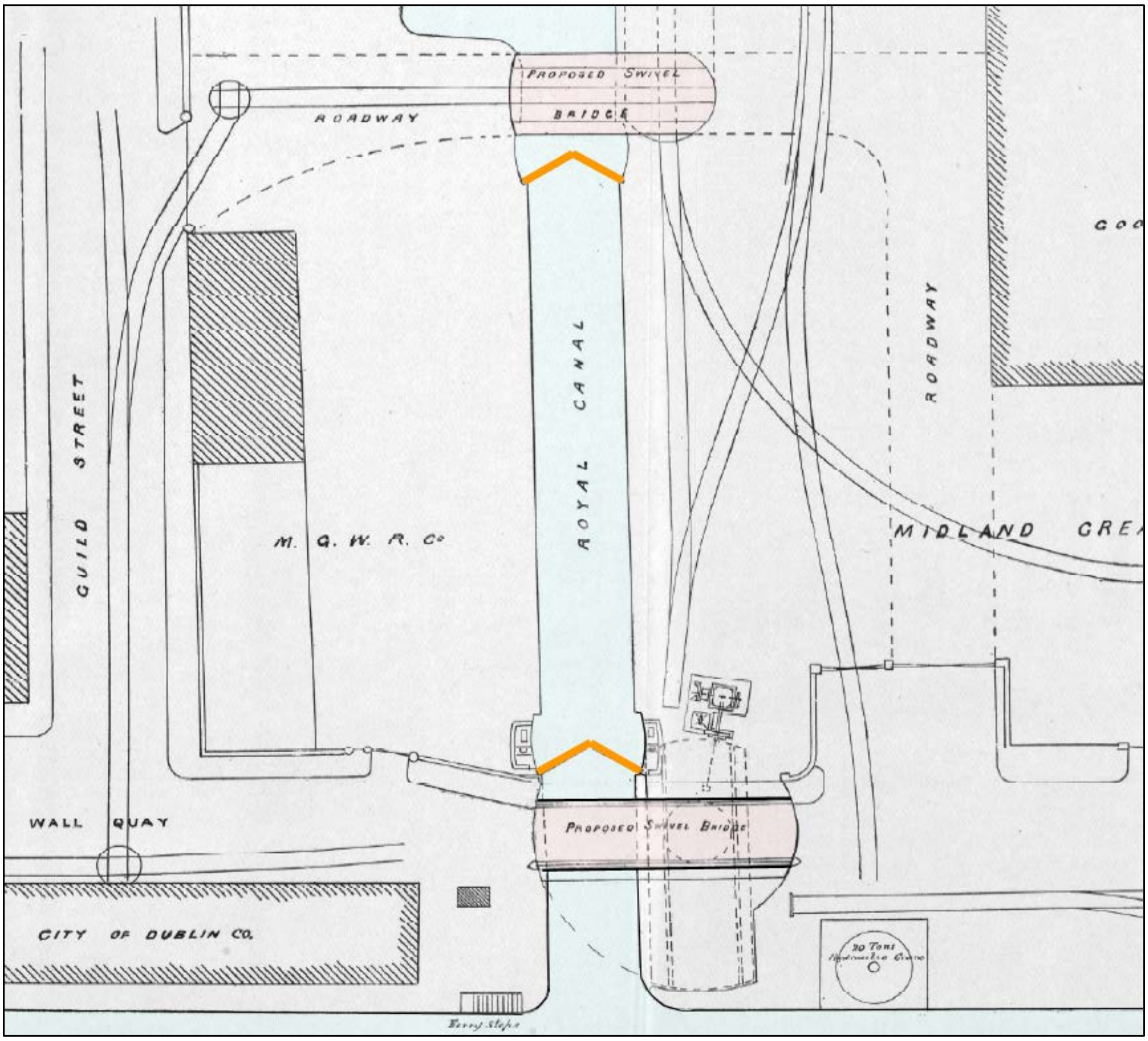


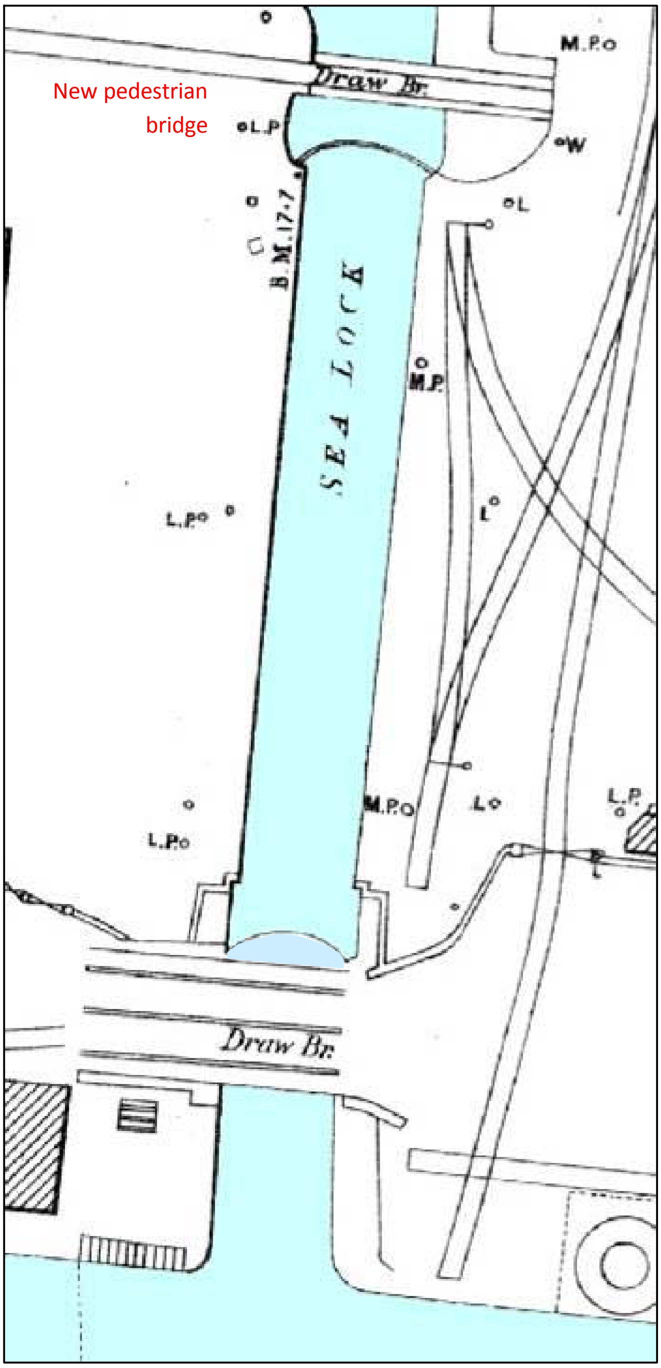
Fig 3.5 Stoney's swivel bridge proposals *(Griffith 1912, fig.4).*

Both the 1887 and 1907 OS maps shows little change to the 1864 edition except there is now a moveable pedestrian bridge at the north end of the sea lock rather than the vehicle bridge which Stoney had envisaged (fig 3.6).

3.4 Scherzer bridges

By the early 1900s, it was increasingly apparent that the rolling drawbridge was not longer fit for purpose. Apart from its physical deterioration, its narrowness now a bottleneck for road traffic and its slowness of operation added to the delays. The only solution was to replace it.

The new bridge had to be at least double the width of the existing one and there was just about enough room to accommodate it without encroaching unduly on MGWR land. Secondly, the new bridge had to be much quicker to operate to minimise traffic delays.



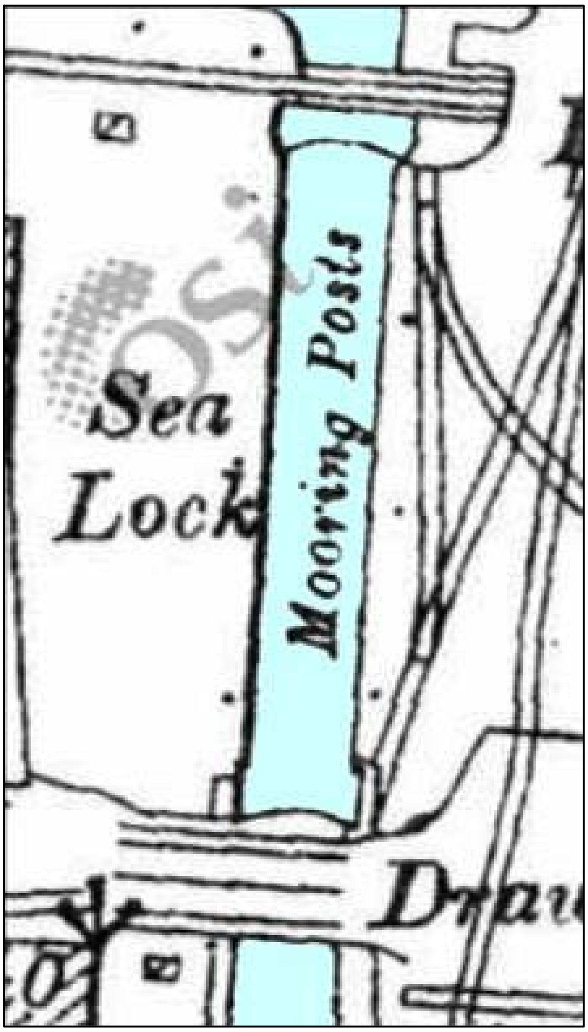


Fig 3.*6 Left:* 1887 map showing the Royal Canal Dock the same moveable bridge as before. The bottom lock gate is visible just beyond its north side *(OS 1:1056 map, Dublin City sheets 49, 50).*

Above: 1907 map showing the same moveable bridges as before *(OS 1:2500 map, Dublin sheets 18-08, 18-12).*

John Purser Griffith, the DP&DB's Engineer, resolved these issues by commissioning the Scherzer Rolling Lifting Bridge Co to design two identical side-by-side bridges (fig 3.7). A selection of original design drawings dated 1909 and 1910 are reproduced in Appendix 2.1 and historical photographs are presented in Appendix 2.2. A working model of the bridges can also be found in the foyer of the Old Museum Building at Trinity College Dublin.

The scheme went out to tender in June 1910.[5] The contract for the bridges' steelwork was awarded to Messrs Spencer & Co, millwrights and iron founders of Melksham, Wiltshire, whilst the civil engineering works (foundations, road/ footpath surfacing, and boundary walls) were carried out by the DP&DB using direct labour.[6]

[5] *Dublin Daily Express*, 1 June 1910.
[6] Dublin Port Co archive: drawings 7830 and 7837.

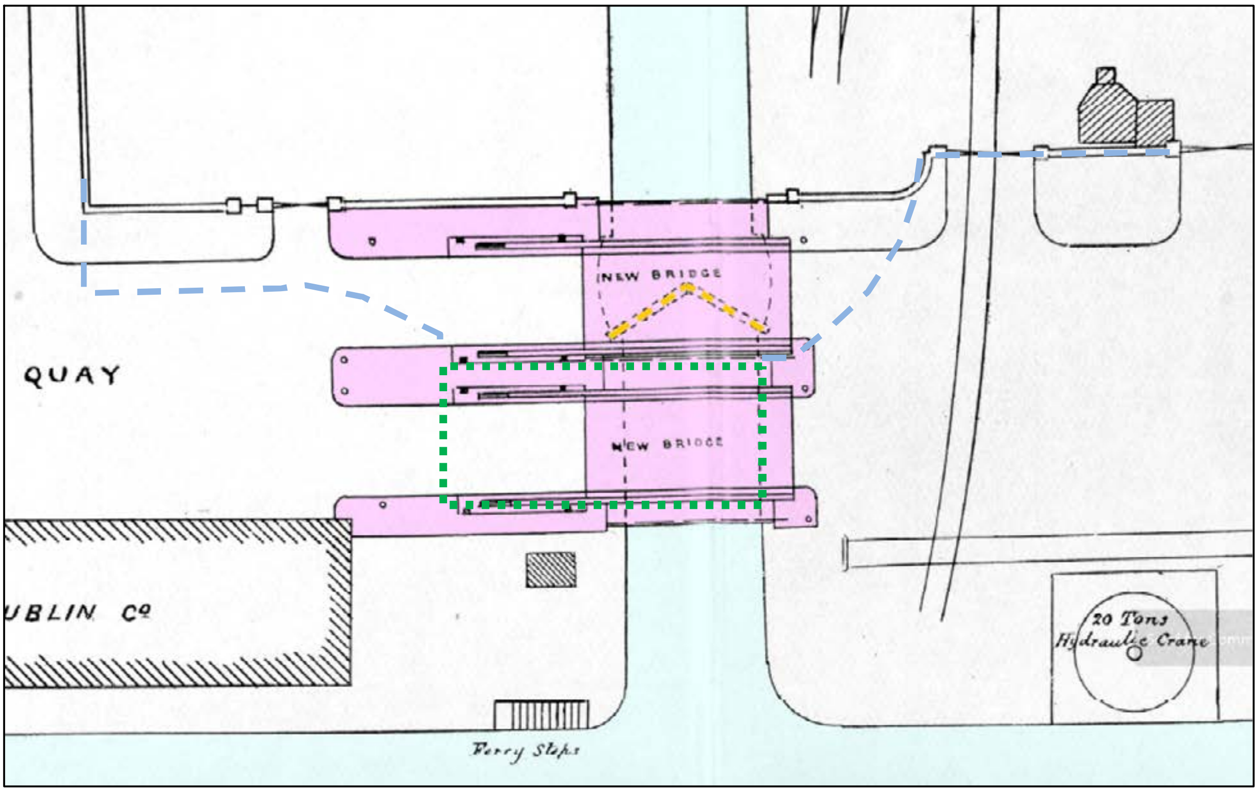


Fig 3.7 John Griffith's Scherzer bridges. The outline of the replaced rolling drawbridge is shown in green. The previous wall along the north side of the road (shown as a dashed blue line) was moved back to accommodate the new inner bridge, under which was the bottom pair of sea lock gates *(Griffith 1912, fig.5).*

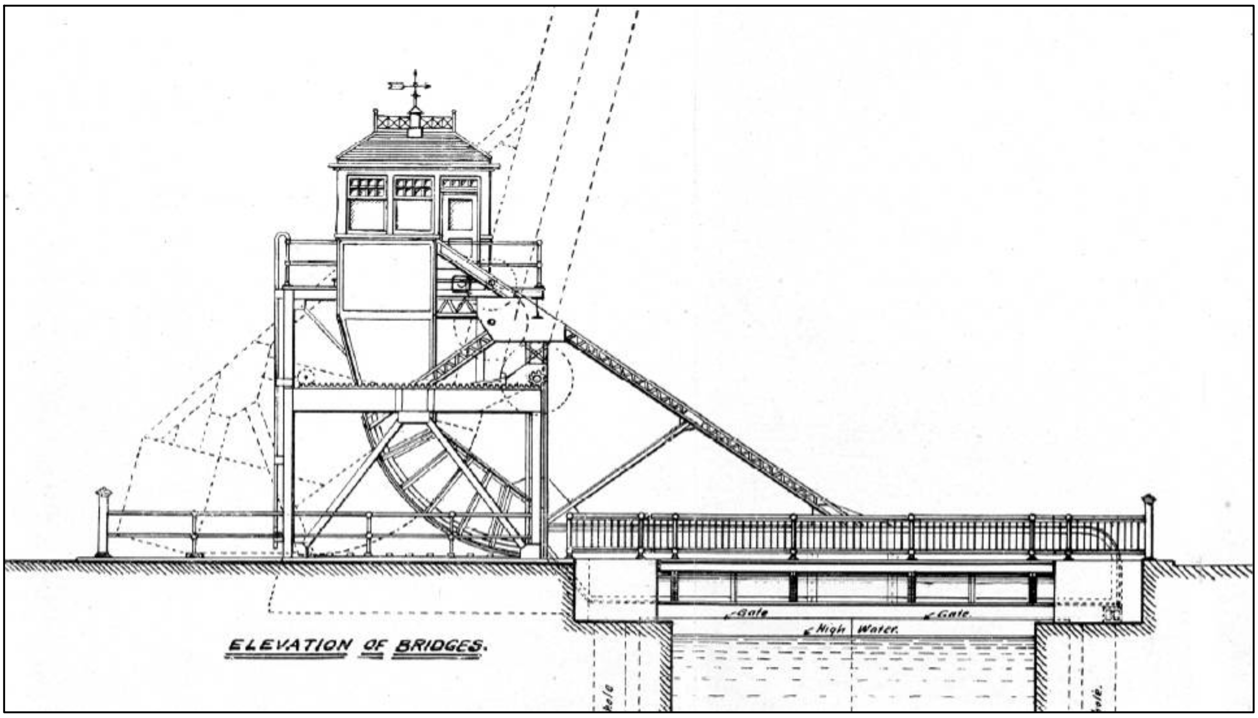
Full details of the contract and what it entailed will be found in the following two publications (Griffith was knighted in 1911):

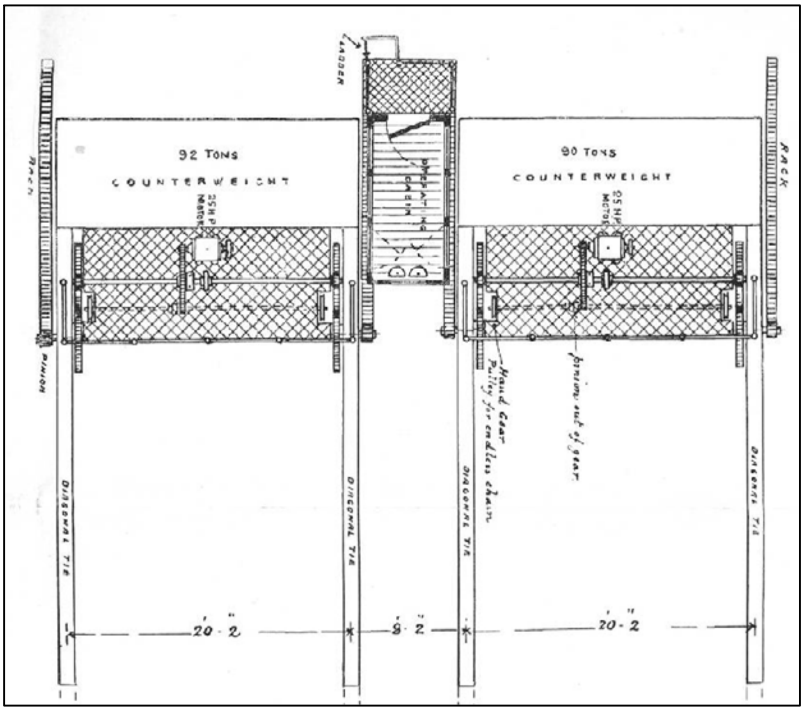
- Griffith, Sir John Purser (1912). 'The twin Scherzer bridges on the North Wall Quay, Dublin, across the entrance to the Royal Canal and Spencer Docks', in *Transactions Institution of Civil Engineers Ireland*, vol.38, pp 176-204. Selected drawings from this publication are reproduced in figure 3.8.
- Griffith, Sir John Purser (1913). 'Twin Scherzer bridges at Dublin', in *The Engineer*, 19 Sept 1913, pp 304-305, 308.

Under the terms of the contract, Messrs Spencer were obliged to pre-fabricate all the steelwork in their Melksham factory, then dismantle it and ship the components to Dublin for on-site re-assembly. Construction was programmed to maintain the flow of traffic along North Wall Quay for the duration of the contract. The first new bridge (Inner Bridge) was positioned immediately north of the existing drawbridge and, once completed in mid-1911, the traffic was rerouted over it. The drawbridge was then removed to make way for the second Scherzer (Outer Bridge). According to the contract, the latter should have been finished in December 1911, but work seemingly ran over into 1912.[7]

The total cost of the new bridges was £13,294 (€1.7m in today's money), of which over half (£7,374) went on the steelwork and £520 in fees to the Scherzer Bridge Co for the use of their patented design.

[7] A plaque on the side of the Inner Bridge's counterweight has a 1911 date. However, the outer one does not seem to have been completed until 1912: Griffith noted in his 1913 article (p.304) that the bridges were opened the *previous* year. Unfortunately, the Outer Bridge is now missing the date plaque shown on old photographs.





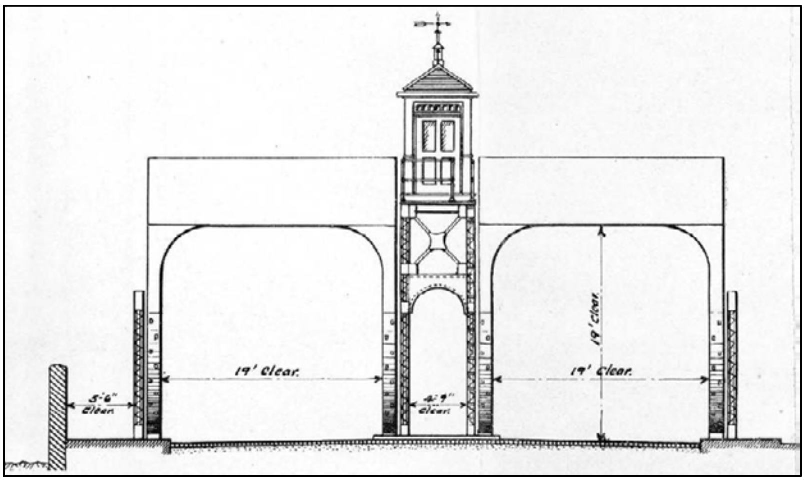


Fig 3.8 Scale drawings of the Scherzer bridges *(Griffith 1912, figs 6-8).*

Above: Side elevation from south. The width of the canal is 8.28m (27ft 2in) and the span's total length is 13.26m (43ft 6in).

Middle: Plan. The centre-centre width of each span is 6.15m (20ft 2in).

Bottom: End elevation from west. The clear width and headroom on both bridges is 5.79m (19ft 0in).

The main reason for choosing two single-lane bridges rather than a double-width one was, as explained above, to allow traffic to continue to flow along the Quay during construction. In section 1.4, it was noted there would also have been a slight reduction the time road traffic was delayed whilst boats passed through.

Griffith claimed that each bridge could be fully opened in 40 seconds and closed in 30. The average time for the pair of bridges to let a vessel to pass through was reduced from 22 minutes to an average of 4½ minutes. There was also an override mechanism which enabled the bridges to be operated by hand in the event of a power cut. Even then, the delay to traffic was still less that with the previous drawbridge.

The one unresolved issue was that the new Inner Bridge now spanned the bottom gates of the sea lock and their balance beams (i.e. long arms projecting from their landward ends) could no longer be accessed by the lock-keeper when the span was shut. Ideally, the gates should have been opened before the bridge was lifted to allow boats to pass to and from the lock without any additional delay.

To solve this problem, each gate was therefore connected via an elaborate series of shafts and gears along the tops of the canal's side walls to a hand-winch positioned just north of the Inner Bridge (fig 3.9). The modifications to the gates operating mechanism were carried out by Messrs Ross & Walpole whose premises were also on North Wall Quay.

By 1950, a second control cabin had been added to the west of the original one (see appendix 2.2). Whether it was supplementary or a replacement has yet to be determined.

Fig 3.9 One of the two winches used to open and close the repositioned timber lock gates underneath the Inner Bridge.

3.5 Recent developments

In 1961, under the provisions of the 1958 Transport Act, the Royal Canal is officially abandoned except for the reach between the Liffey and Spencer Dock. The two Scherzer bridges therefore continued to be maintained in an operational state.

In 2003-04, the bridges were restored to full working order by the Dublin Docklands Development Authority under the direction of John Cradock Ltd (Kilcullen). The replacement of any corroded steel-work was subcontracted to Messrs Steele & Co Ltd of New Ross.

In 2008, the bottom lock gates were replaced by a pair of curved hydraulic gates which also doubled as flood barriers (fig 3.10). As such, they were higher than the original gates so could not be accommodated underneath the Inner Bridge. They were therefore repositioned on the dock side of the bridge. This reduced the lock's length by 56ft, from 174ft to 118ft. The present lock is therefore around its original 113ft length.

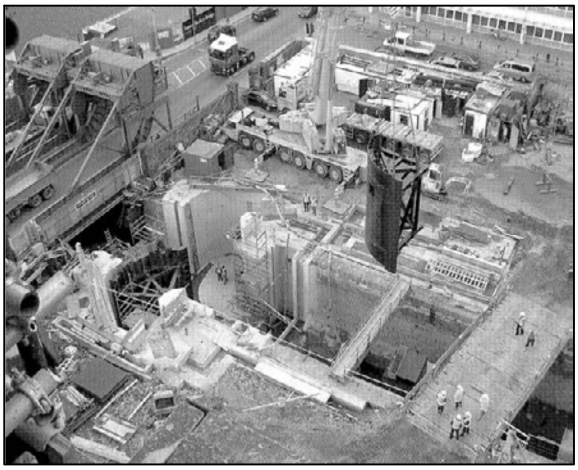


Fig 3.10 Installation of new sea lock gates, 2008 *(Delaney & Bath 2010, p.306).*

In 2010, the entire length of the Royal Canal was reopened between Dublin and the Shannon at Richmond Harbour, Clondra. A major obstacle to boat traffic at its Dublin end is the Newcomen lifting bridge which carries the railway line over the canal at the north end of Spencer Dock and which is only occasionally open. Another obstacle is the Scherzer bridges, the ends of which are now are now firmly clamped to their eastern abutments. The maximum size of vessel is therefore restricted to those which can clear the spans' undersides at low tide.

In December 2019, two new fixed, single-span bridges were placed side-by-side across the canal on the river side of the Outer Bridge - one (nearest the river) for pedestrians and the other for cyclists (fig 3.11). All the service ducts and cables are also rerouted under these two new bridges.

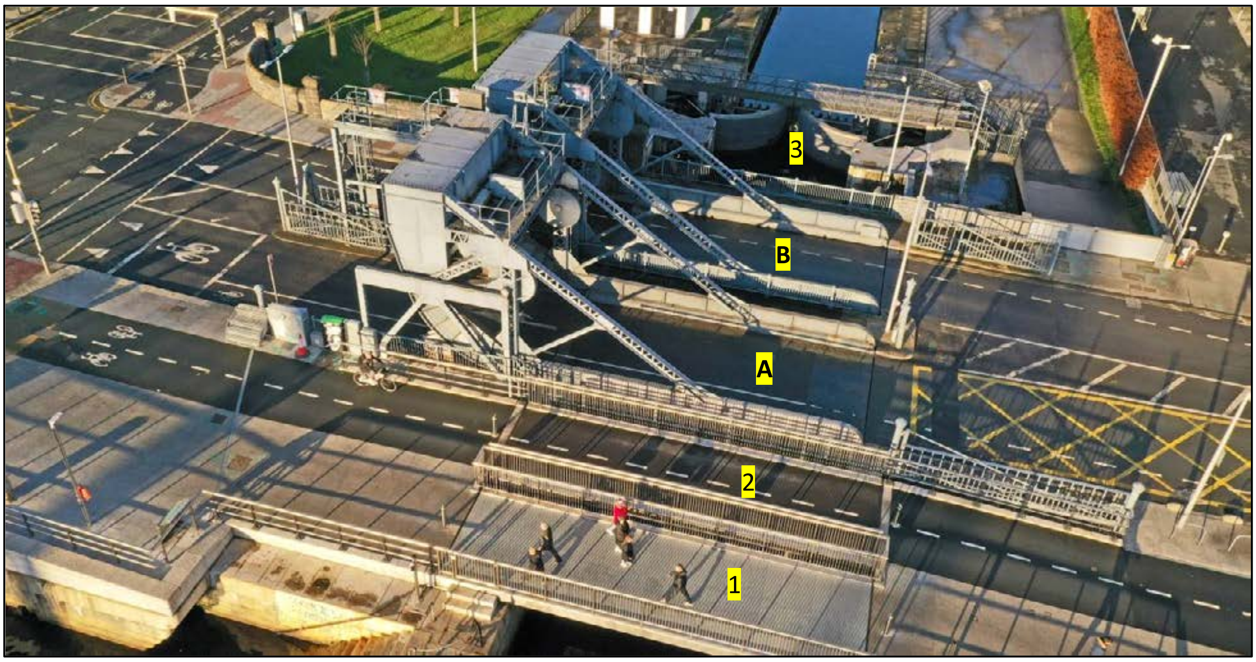


Fig 3.11 Aerial view of modern bridges over the Royal Canal from south, 2021. *Key:* A - Outer Scherzer; B - Inner Scherzer; 1 - 2019 foot bridge; 2 - 2019 cycle bridge; 3 - Bottom lock gates/ flood barrier.

4. Royal Canal bridge descriptions

Although erected 110 years ago, both Scherzer bridges continue to serve their original function of carrying road traffic over the Royal Canal. They were supplemented in 2019 by a pair of fixed non-vehicular spans at their river end (fig 4.1). Attached to the north side of the Inner Bridge is a cantilevered pedestrian footpath which lifts with the main span. There is a similar footway along each side of the Outer Bridge, the north one of which gave access to the control cabin; both lift with the main span. When one or both spans were in the raised position, all traffic was stopped my means of gates at both ends which were manually swung into place by the bridge operator. Each bridge worked independently of the other and both are, in theory, still operable to allow canal traffic to pass. However, their lifting ends are now clamped shut to make the spans more rigid. This effectively limits the size of boats using the canal to those whose air draft is less that the gap between the undersides of the bridges and tide level.

As noted in the preface to this report, a detailed survey was limited by the Covid-19 restrictions. On the basis of limited field inspection, laser scanning and original drawings, however, it has been possible to prepare preliminary measured survey drawings (fig 4.2).

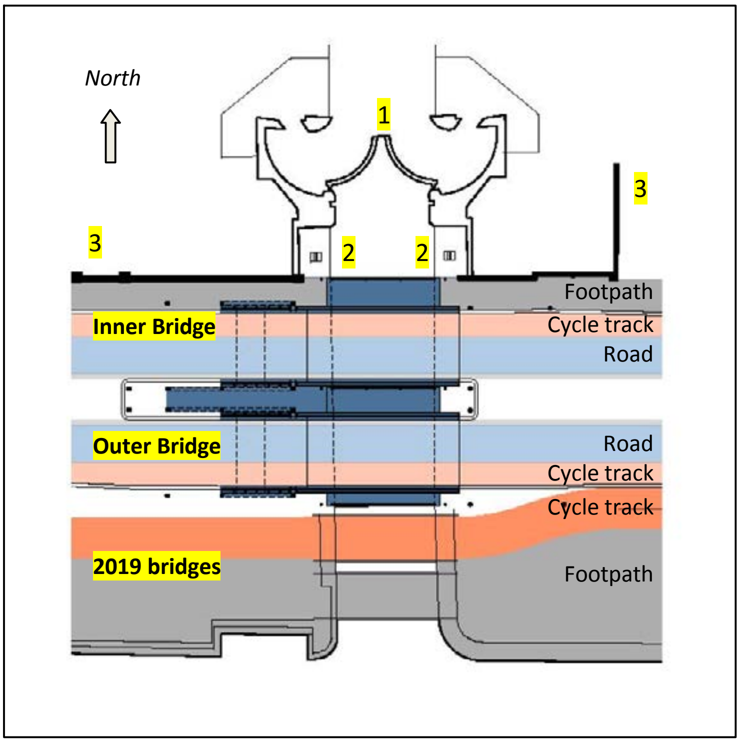


Fig 4.1 Plan of existing bridges over entrance to Royal Canal. *Key*: 1- Sea lock bottom gates (modern); 2 - Winches to open previous gates; 3 - Masonry wall along north side of Inner Bridge.

Cursory inspection suggests that both bridges are largely intact (fig 4.3). The two original motors mounted on platforms in front of their respective counterweights have been replaced with more modern ones. The original gearing to the pinions along the tops of the side racks has been retained, including the manual back-up system (but without its operating chains).

The original control cabin is long removed, although its platform survives between the two bridges. There were originally also two plaques on the west face of each counterweight, of which only the pair on the Inner Bridge survive. The left one reads "Scherzer Rolling Lift Bridge/ Patented by/ William Scherzer C.E./ [???]/ The Scherzer Rolling Lift Bridge Co Ltd/ Chicago [*??*]. The right-hand one reads "This bridge was built by/ the Dublin Port & Docks Board/ 1911./ Spencer & Co Ltd Melksham, Wilts/ Contractors for the steelwork & ?/ Sir John Purser Griffith [???]" All the gates for stopping the traffic are intact except for the pedestrian one at the NE end of the Outer Bridge.

Underneath the Inner Bridge, the defunct lock gate recesses are evident along with the gates' operating mechanisms (fig 4.4). The removal of several courses of stonework for the previous drawbridge is also evident. Just beyond the dock end of this bridge are the two winches which were once used to open and close the gates.

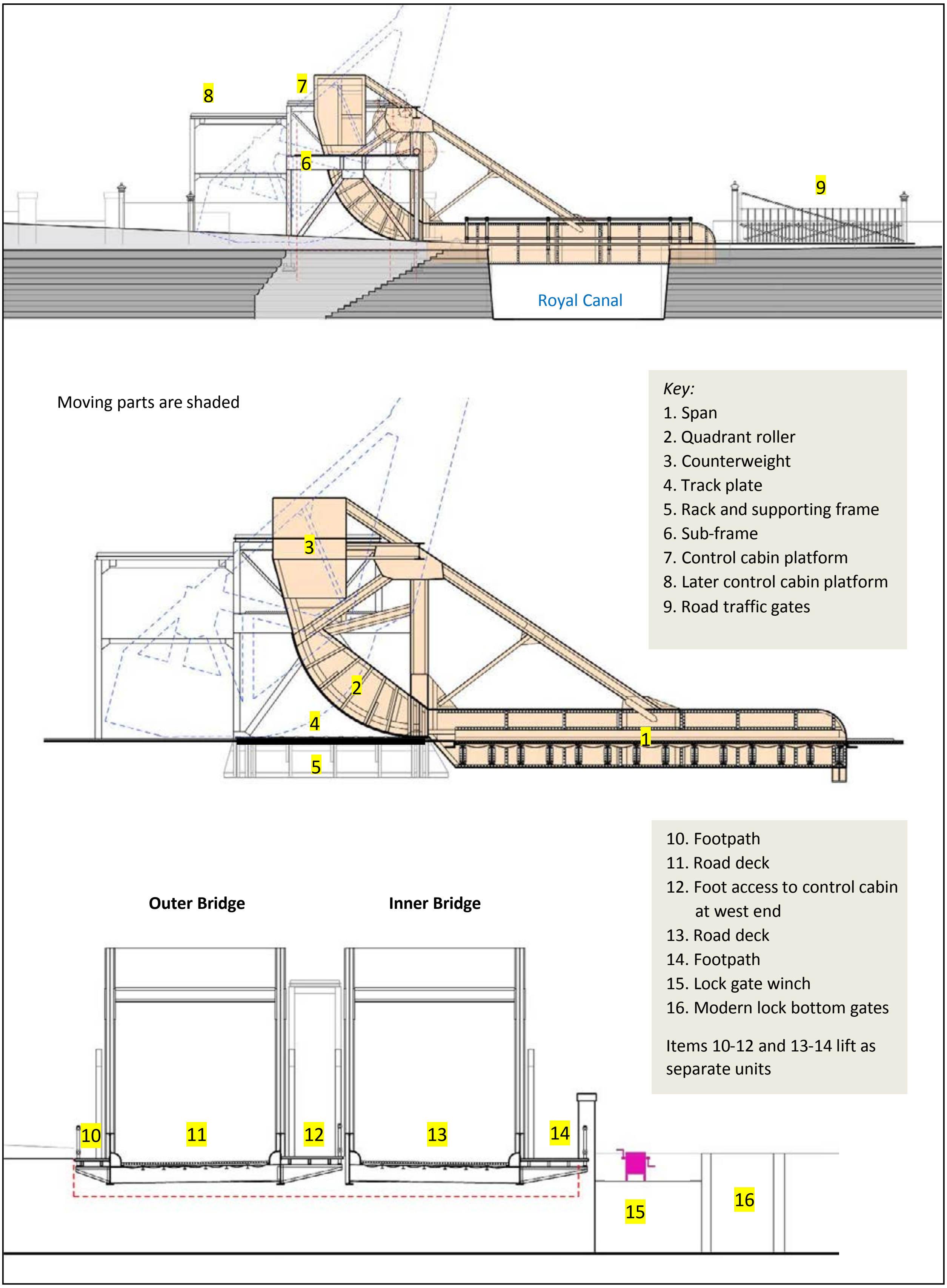


Fig 4.2 *Top:* Elevation of Outer Bridge, from south. *Middle:* Longitudinal section. *Bottom:* Cross-section, from east.

Fig 4.3 Contemporary photographs of Scherzer bridges over Royal Canal. *Top left* - From east; *Top right* - From west; *Middle left* - Quadrant roller; *Middle right* - From north; note lock gate winches in front. *Bottom left* - Track along winch bridge travels. *Bottom right* - Control cabin platform from east.

Inner Bridge showing the lock gate operating linkage along the top of its gate emplacement. The gates were operated using winches just beyond the bridge.

View E showing foot deck along N side of Outer Bridge *(right).* The Inner Bridge's span *(left)* is secured shut by means of the yellow clamp at bottom left.

Outer Bridge showing concrete pillow block along top of masonry side wall of canal. This replaced several removed courses of stonework.

Looking W showing one of the 2019 spans carried over the top of the canal's side wall. By contrast, the end of the Outer Bridge *(at right)* is let into its top.

Fig 4.4 Undersides of Scherzers spans and canal walls.

Close inspection indicates some minor damage caused by traffic impacts and there are also small patches of rust here and there (fig 4.5). However, there is nothing untoward which cannot be rectified through regular inspection and maintenance.

Fig 4.5 Traffic impact damage. *Left:* Bent flange on main girder at east end of Outer Bridge. *Right:* Damaged traffic control gatepost at west end of Inner Bridge.

5. Royal Canal options appraisal

The criteria chosen to evaluate the options for relocating the bridges are informed by the BusConnects Dublin objectives, planning regulations relevant to Protected Structures, and international charters relating to the conservation of industrial heritage. Various criteria were considered at the initial route selection stage but only those pertaining to the Architectural Heritage aspects of the project are dealt with in this report.

5.1 Options appraisal 1

Given the fact that these are now the earliest complete Scherzer bridges surviving in Ireland and also Protected Structures, scrapping them is not an option, nor is relocating them elsewhere as they would be removed from their original contexts. Rather, the strategy adopted here is to keep them as close as possible to each other and to their original (existing) positions. A number of different relocation scenarios were explored, all of which entailed moving them both horizontally and vertically.

Options

An initial analysis was carried out to determine the feasibility of separating the bridges to enable the proposed new bridge to pass between them along the existing road line. As noted in section 1.4, the bridges operated in tandem but had separate motors which were independently controlled from a cabin mounted on an overhead platform between them. It is proposed to split the bridges and move this platform with the outer one.

The degree to which the bridges can be physically separated is constrained at north by the bottom set of sea lock gates (which also double as a flood barrier) and on the south side by the River Liffey (no extension beyond the line of the quay wall is envisaged). With these constraints in mind, two options were considered in the initial appraisal (fig 5.1).

A The bridges would be moved apart to enable a two-lane road bridge to pass between them. The latter would be dedicated to general traffic, whilst the relocated Scherzer bridges would carry bus, cycle and pedestrian traffic. It would also be necessary to remove the innermost of the two 2019 bridges to make room for the relocated Outer Bridge. Its outer span would, however, be retained for pedestrians.

B The two Scherzers would be moved further apart than Option A to accommodate a four-lane bridge for general traffic and buses, with the relocated bridges being reserved for cyclists and pedestrians. It would be necessary to remove both 2019 spans, but their roles would still be performed by the relocated Outer Bridge.

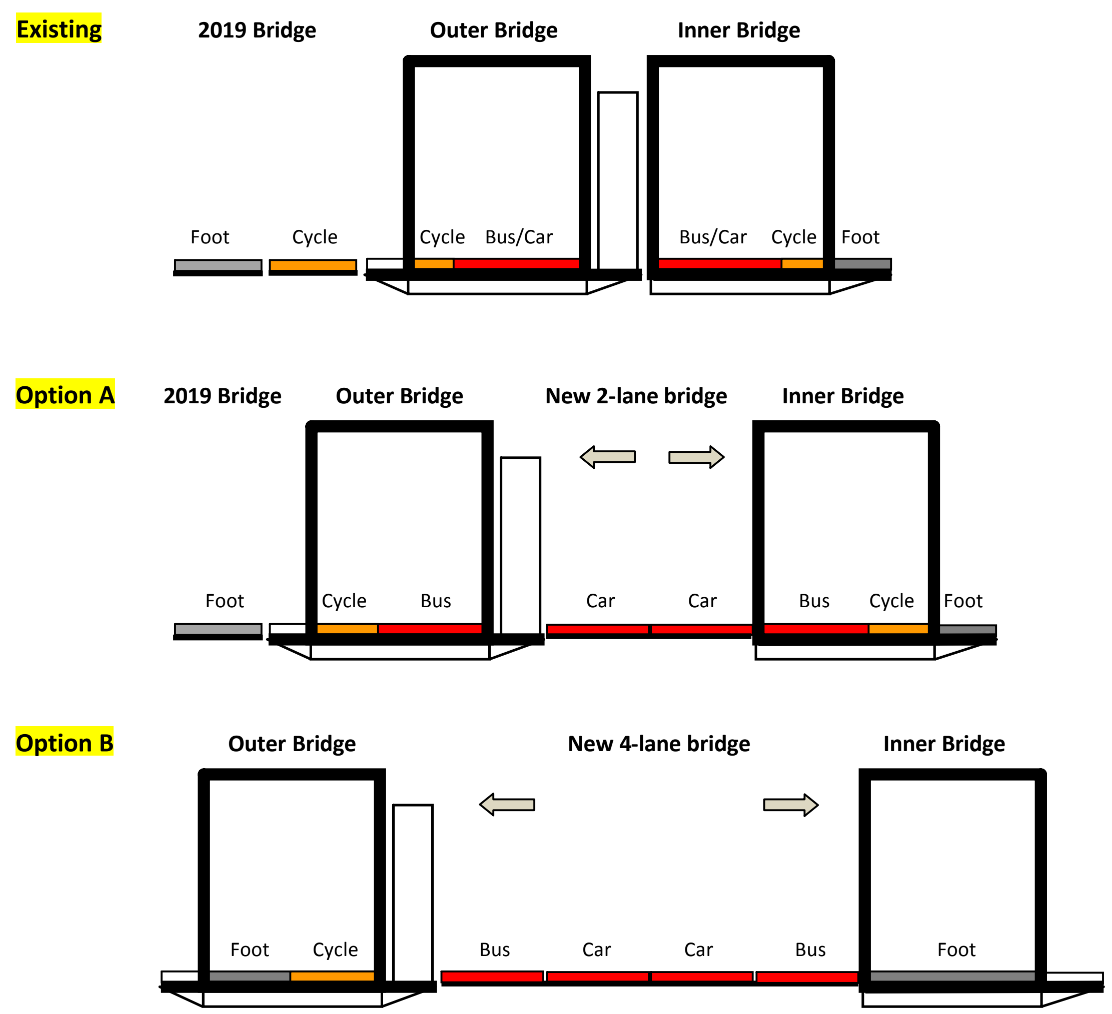


Fig 5.1 Options considered in appraisal 1.

Evaluation criteria

Five criteria were used to assess the potential consequences upon the bridges and their environs of implementing each of the above relocation options:

1. Physical integrity of bridges

   Both options will require the dismantling of the Scherzers. As noted in section 1.4, the moving assembly rolls along two track plates which are interconnected by a substantial steel sub-frame supported on multiple timber piles. The question arises as to how much of the existing bridge, both above- and below-ground is actually moved. There are two possible actions:

   - The sub-frame will be excavated and moved together with the track plates and above-ground components of the bridge to their new locations where they will be re-erected. However, the condition of the buried steelwork is unknown without actually excavating it. For the purposes of this assessment, it will be assumed that should the buried remains be excavated, they will be found to be no longer fit for purpose.

- Only the track plates and above-ground components will be moved. It would, or course, be preferable to conserve the frame in situ as evidence of the Scherzers' original locations. However, the feasibility of doing so will require more careful consideration when designing the new bridge. For the purposes of ranking this particular criterion, this action will be assumed along with the likelihood of the sub-frame being lost.

2. Physical integrity of associated historic buildings/structures

   As noted in section 3.4, the new 1870s' lock emplacement was spanned in the 1910s by the Inner Bridge. Although the timber gates are long gone, their emplacements survive along with the two operating winches at the dock end of the bridge.

   The bottom flanges of the principal girders of the Inner Scherzer are c.83.5cm below its deck. To move the span sideways would therefore require the removal of several courses of stonework along the tops of the sidewalls to accommodate the span at the same level as it is today.

   Another issue are the two winches for opening and closing the former lock gates. The tops of their metal casings are c.31.5cm above the Inner Scherzer's present deck level. They would therefore seriously impede the span being shifted sideways in the direction of the dock. Rather than removing them completely, it may be possible to sink them partially into the ground to clear the bottom flange of the principal girders. This mitigation would enable them to be retained as reminders of an episode in the canal's historical development. Its implementation will be assumed for the purposes of ranking this criterion for each option.

3. Landscape setting

   Apart from the quay wall and actual canal, the bridges' immediate environs have been redeveloped and the canal banks have also been completely relandscaped in the relatively recent past. The only built heritage feature hereabouts is the North Quay Wall which is a Protected Structure (reg.no. 5835).

   The 2019 bridges hide the entrance to the canal from view, and its visibility will be further restricted as the Inner Bridge is moved progressively northwards towards the modern lock gates.

4. Functionality

   As noted in section 3.5, both bridges were restored to working order in 2003-04. The original motors were replaced and the electrics upgraded, but the original gear trains were retained. In theory the bridges are still operable but in practise they are not as both spans are clamped shut to prevent them moving slightly as traffic passes over. Depending on the state of the tide, small vessels can still access the lock chamber even when the spans are closed. As sea levels rise, however, this air gap will diminish and potentially create difficulties for more canal users unless the bridges are still capable of being opened. For the purposes of this analysis, it is assumed that the repositioned Scherzers will still be operable.

Another functional consideration is the loading on each bridge. Although designed for 1930s traffic, they are still capable of carrying today's traffic. However, any reduction in such traffic, particularly heavy goods lorries, would certainly be beneficial as there will be less dynamic loading and also less risk of physical damage from traffic collisions. Most benefit would come by restricting the bridges to pedestrians and cyclists and this would also effectively remove any risk of further damage such as that shown in figure 4.5.

5. Public amenity

   The volume of traffic over the bridges does not make for a pleasant user experience, whether as a pedestrian or cyclist. As with the functionality criterion, both bridges would be better appreciated in greater safely if all vehicles were removed.

There are obviously many other relevant factors to be considered as well, e.g. third-party land acquisitions, construction costs, planning permissions, public safety etc. These relate to the construction phase of the project and are outside the scope of the present report which is limited to the operational phase of the 'Cultural and Industrial' aspects of the project's broader environmental multi-criteria analysis.

Ranking of options

Each criterion was scored on a seven-point scale relative to the existing situation. Half points were also used where necessary to rank particular options more precisely. The relative ranking scale used here is as follows:

Large beneficial	+ 3
Moderate beneficial	+ 2
Slight beneficial	+ 1
Neutral	0
Slight adverse	- 1
Moderate adverse	- 2
Large adverse	- 3

The existing situation is taken as the baseline and accorded a neutral score of '0'. Positive scores indicate that an option is more beneficial than the existing situation for that particular criterion. Conversely, a negative score indicates a worse situation than at present. Each criterion was given equal weight in gauging the overall impact of each option upon the bridges' overall heritage significance (table 5.1).

Option	Existing situation		Option A		Option B	
Criteria		Rank		Rank		Rank
1. Physical integrity of bridges	• Entire bridge remains in situ.	0	• Sub-frame will be lost.	- 1½	• As Option A.	- 1½
2. Physical integrity of associated features	• Canal walls remain intact. • Lock gate winches are not impeded.	0	• Some loss of stone-work along canal walls. • Lock gate winches require sinking.	- 1½	• As Option A.	- 1½
3. Landscape setting	• Both bridges make a positive contri-bution to the landscape.	0	• As existing situation.	0	• As existing situation.	0
4. Functionality	• Highly unlikely that the bridges will ever open. • High dynamic loads and risk of traffic damage.	0	• Possibility of at least one bridge opening; but buses would require temporary rerouting. • Less dynamic loads and reduced risk of traffic damage.	+ 1	• Most likelihood of at least one bridge opening without impeding road traffic. • Least dynamic loads and minimal risk of traffic damage.	+ 2
5. Public amenity	• Poor user experi-ence and little opportunity for public engagement.	0	• Improved user experience and some opportunity for public engage-ment.	+ 1	• Best user experience and best opportunity for public engage-ment.	+ 2
Overall score		**0**		**- 1**		**+ 1**

Table 5.1 Ranking of options by criteria for Royal Canal Scherzer bridges - stage 1.

It is evident from the above table that Option B would best retain the bridges' architectural, technical and engineering significance in the long-term: i.e. moving them apart to make way for a new four-lane bridge and restricting their use to pedestrians and cyclists (fig 5.2).

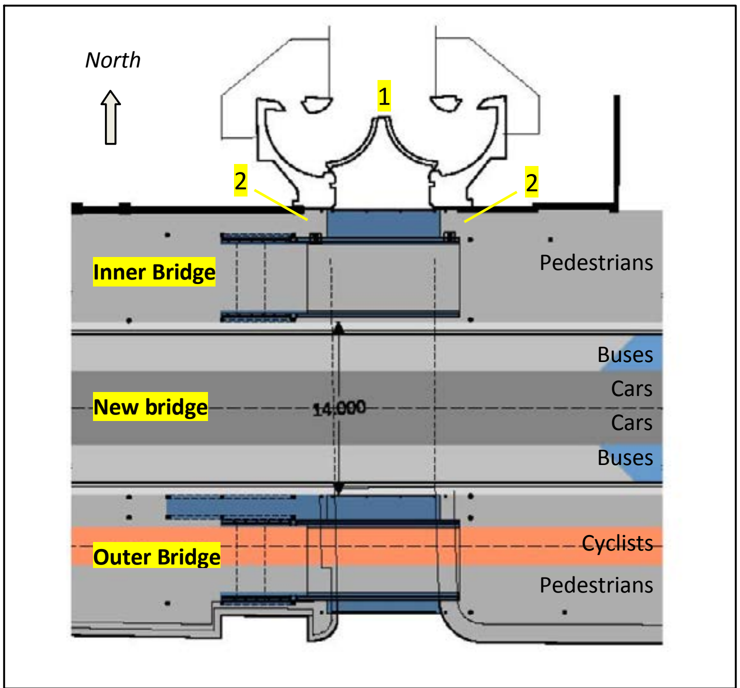


Fig 5.2 Plan of proposed reconfiguration of bridges over Royal Canal. *Key: 1* - Sea lock bottom gates (modern); 2 - Winches to operate previous gates (underneath repositioned Inner Bridge.

Although there will be some loss of original fabric (i.e. the buried sub-frame) and of stonework along the tops of the canal walls, they will be outweighed by the bridges' enhanced long-term functionality, user experience and potential for public engagement and appreciation. The two 2019 bridges would have to be completely removed to make way for the Outer Bridge but their functions would continued to be served by their replacement. Finally, the option to retain the bridges in an operational state is retained.

5.2 Options appraisal 2

Having selected Option B, the next step is to determine whether they might also be repositioned vertically to mitigate some of the negative impacts highlighted above. Alternative height levels for the relocated bridges were informed by two considerations:

1. The extent to which the relocated Scherzer bridges and the new road bridge would impact upon the existing granite capping of the canal walls, the historic quay wall and the two lock gate winches.
2. The potential to increase the clearance under the bridges to facilitate traffic in and out of the Royal Canal and thus mitigate rising sea levels brought about by climate change.

Three variants of Option B were considered (fig 5.3):

B1 The new 4-lane road bridge and both Scherzers would be raised by c.70cm above the present road surface, such that all their decks were level with each another. This figure is based on the assumption that the new road bridge's span will be c.70cm deep below its deck level.

Raising it by this amount would avoid it impacting on the sidewalls. Although the bottom flanges of the Scherzers' girders would still be c.15.5cm below the tops of the canal walls, but less stonework would potentially require removal. However, the tops of the winches would still be c.45cm above the bottom flange of the Inner span and require sinking by at least the same amount.

Raising the bridges would also require the existing approaches to be regraded at both ends to tie in with the deck of the new road bridge. It would also be necessary to raise the surface of the North Wall Quay so that it formed a continuous surface with the decks of the raised Scherzers. Such an addition should be reversible, of contemporary design, and stepped back from the existing granite copings along the river's edge to distinguish the new from the old.

It should be noted that the historic finishes east of the Scherzers have already been disturbed by construction and their original stone setts have been removed. To the west of the bridges, the installation of the Beckett Bridge at the higher level necessary for its operation impacted on levels adjacent to the Sherezers, and raising them will be beneficial to a degree.

B2 The new road bridge deck would be raised to c.70cm as option B1, but the Scherzers would be raised by 100cm above their present levels.

The bottoms of the Scherzer spans would definitely clear the side walls under this option and the winches would require sinking by only 15cm to clear the girders' undersides. The road approaches would require regrading as before, but the surface of the quay would require raising by an additional 30cm to bring it level with the Scherzers' decks.

B3 All the bridge decks would be raised by c.100cm above present road level. This has the same advantages, from a built heritage viewpoint, as Option B2. Moreover, depending on the design of the new road bridge's abutments, it may be possible to leave the buried Scherzer sub-frames in situ (as this is only a possibility, it has not been scored in the options appraisal). Further regrading of the road and topping of the quay wall would also be required to tie them into the new bridge deck levels.

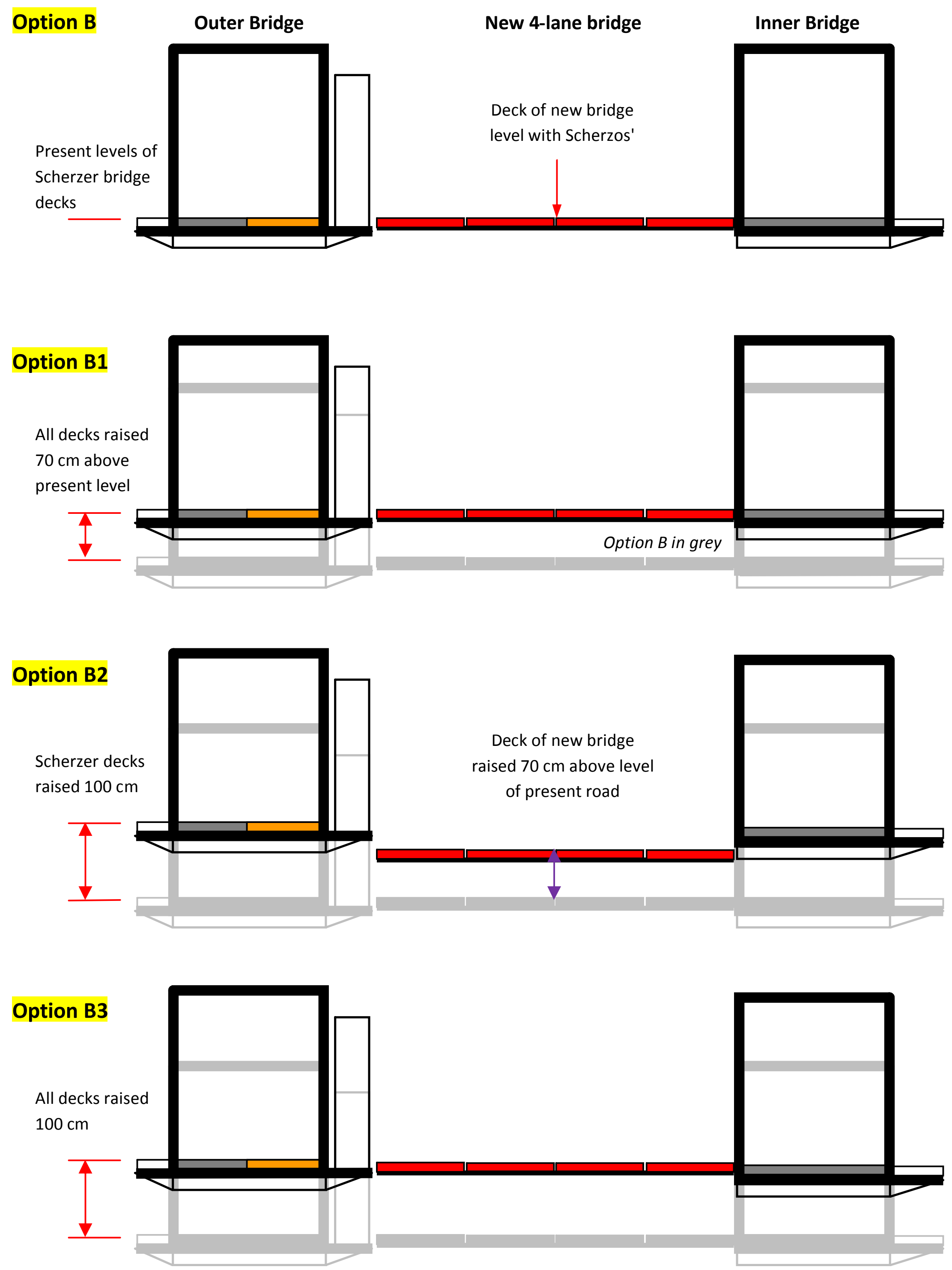


Fig 5.3 Option variants considered in appraisal 2.

As before, each criterion was ranked on the seven-point scale for all options (table 5.2).

Option	B	Option B1		Option B2		Option B3	
Criteria	Rank		Rank		Rank		Rank
1. Physical integrity of bridges	- 1½	As Option B.	- 1½	As Option B.	- 1½	As Option B.	- 1½
2. Physical integrity of associated features	- 1½	Less loss of canal wall stonework. Lock gate winches require sinking.	- 1	Less loss of canal wall stonework. Lock gate winches require less sinking.	- ½	No loss of canal wall stonework. Lock gate winches require least sinking.	0
3. Landscape setting	0	Existing road and quay graded to new deck levels.	- ½	As Option B1	- 1	As Option B1	- 1
4. Functionality	+ 2	As Option B. Clearance for canal users increased by 70cm.	+ 2½	As Option B1.	+ 2½	As Option B. Clearance for canal users increased by 100cm.	+ 3
5. Public amenity	+ 2	As Option B.	+ 2	As Option B.	+ 2	As Option B.	+ 2
Overall score	**+ 1**		**+ 1½**		**+ 1½**		**+ 2½**

Table 5.2 Ranking of options - stage 2 appraisal.

5.3 Appraisal conclusions

It is evident from tables 5.1 and 5.2 that the best option is B3, i.e. to raise both the proposed new bridge and Scherzers to 100cm above the present road level. This option would (1) retain all the above-ground components of the bridge, (2) have minimal impact on adjoining historical features, (3) enable one or both bridges to operate for demonstration purposes, (4) future-proof access to the canal, and (5) enable the Scherzers to continue to serve a useful purpose for pedestrians and cyclists.

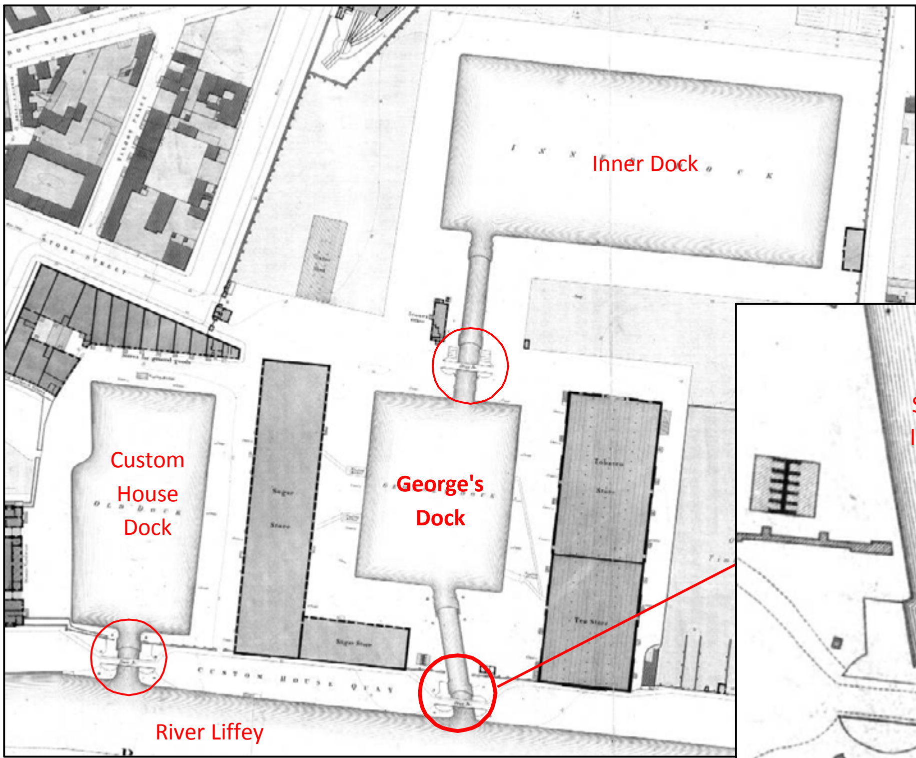
The absolute heights of the final deck levels and their tying-in with the existing road and footpaths on both approaches will be resolved at the detailed design stage of the project. The surface treatments of the raised footpaths and cycle tracks along the historic quay will also be carefully considered to ensure that they are clearly read as contemporary additions which will provide a high-quality public realm and setting for the historic bridges. There will also be the opportunity to restore the stone cube surface to the bridges (as depicted on Griffith's drawing in Appendix 2.1/ 7683), thus distinguishing them as part of the historic setting.

6. History of the George's Dock bridges

The erection of the fixed-arch Carlisle Bridge in 1796 (where O'Connell Bridge now stands) effectively marked the upstream limit of Dublin Port. This eastwards shift of maritime activity is exemplified by the Custom House which opened in 1791 to replace one near Essex Bridge (now Grattan Bridge). The Custom House Dock was opened by the Board of Works beside the new building in 1796, followed by George's Dock in 1821 (named after George IV), and the Inner (Revenue) Dock in 1824.

6.1 Swivel Bridge

To facilitate movement along the Quay whilst at the same time giving vessels access to the three docks, moveable bridges were erected over their entrance channels. Although all are captioned 'Draw Br' on 1838 OS map, they were actually double-leaf swivel spans, slightly offset from each other to allow for the skewed angles of the channels relative to the quay walls (fig 6.1).



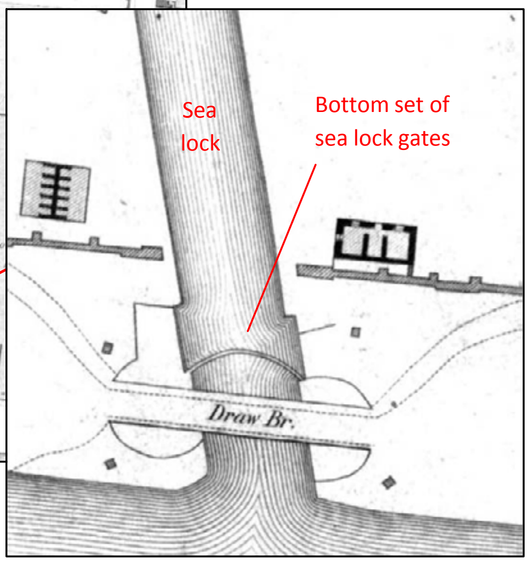


Fig 6.1 1838 map showing the early 1800s docks and position of the swivel bridge over the entrance to George's Dock from the Liffey. *(OS 1:1056 map, Dublin City sheet 15)*

6.2 Rolling drawbridge

In 1859-60, the swivel bridge at George's Dock was replaced with a rolling drawbridge of similar make, design and operation to the one installed at the same time over the Royal Canal (figs 6.2 and 6.3). It is captioned 'Draw Br' on the 1864 OS map which shows it positioned over the bottom set of lock gates (fig 6.4).

NEW BALANCE ROLLING BRIDGE.—
KENNY'S PATENT.

The undersigned beg to call the attention of Engineers and the Public to the above description of Opening Bridge, as now being constructed for the entrance to the St. George's Dock, Custom-house Quay, Dublin, for the Board of Works, which will be found superior to the ordinary Swivel Bridge, both in point of simplicity of Construction and Cost.

Plans and Specifications furnished, and Licenses granted on application to

TURNER & GIBSON,
Proprietors and Manufacturers,
Hammersmith Iron Works,
Ball's Bridge, Dublin.

vatories, Fruit Ranges, &c.
Iron Roofs for Railway Stations, Breweries, Gasworks, &c.
Entrance Gates, Fence Hurdles, &c.

Fig 6.2 Notice of erection of new bridge in *Irish Times,* 29 July 1859.

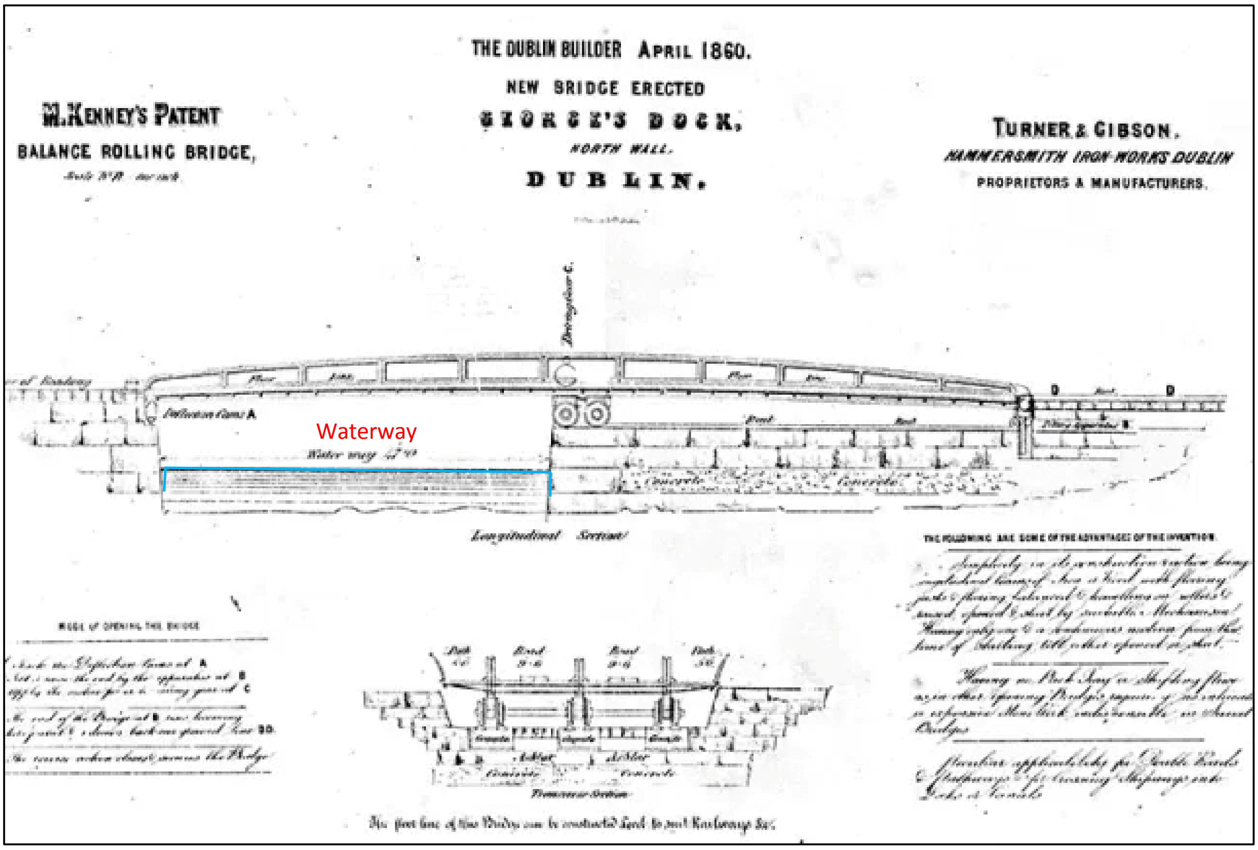


Fig 6.3 Elevation (looking north) and section of drawbridge over entrance to Dock. *(Dublin Builder, 1860)*

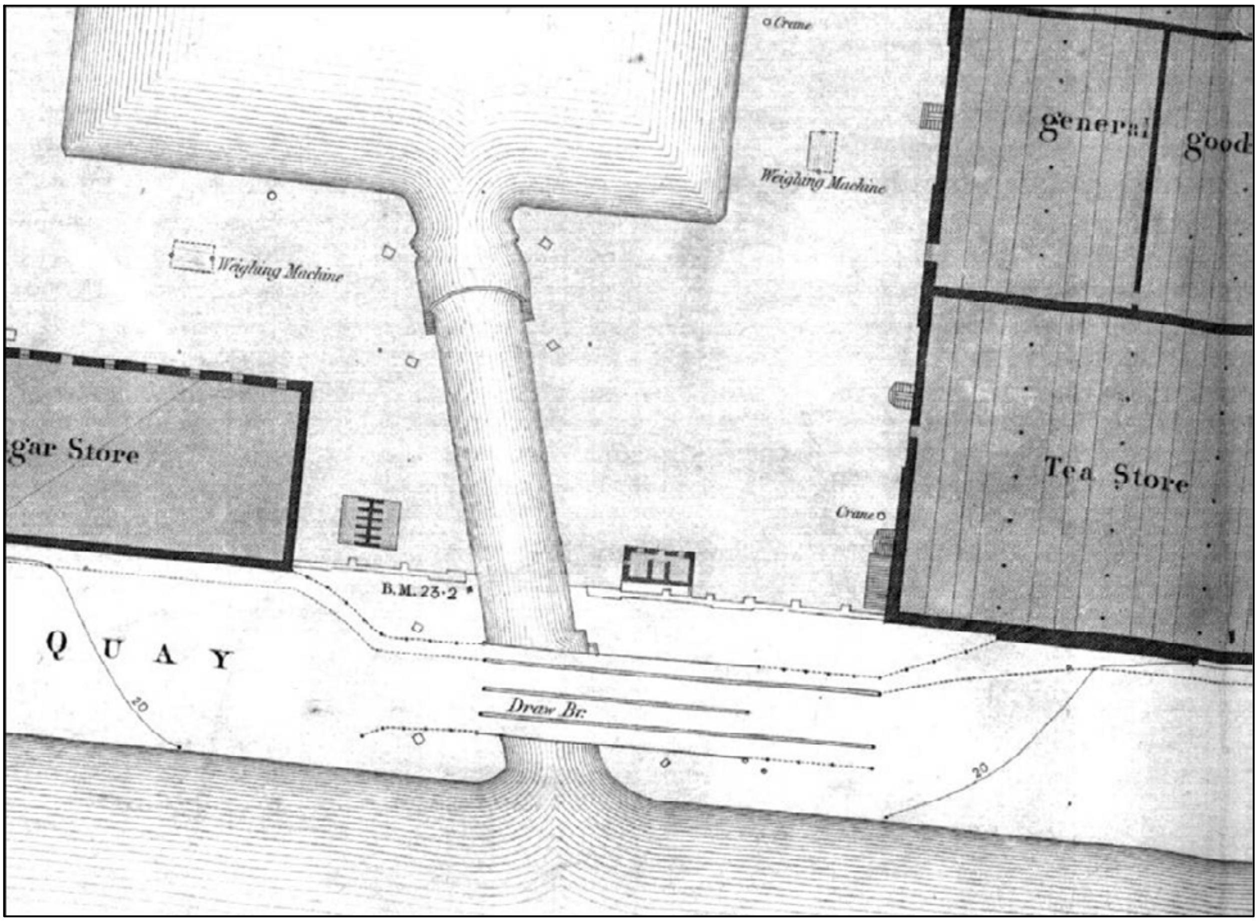


Fig 6.4 1864 map showing the new rolling drawbridge at the entrance to George's Dock The entire bridge moved eastwards when being opened *(OS 1:1056 map, Dublin City sheet 15).*

6.3 New swivel bridge

In 1884, the drawbridge over the entrance to George's Dock was replaced with a new swivel bridge.[8] It was commissioned by the Dublin Port & Docks Board which had acquired the Custom House Dock, George's Dock and the Inner Dock from the Government when it succeeded the Ballast Board in 1867.[9]

The new bridge is captioned 'Swivel Br' on the 1889 and 1907 OS maps and was positioned slightly north of the previous bridge, thus exposing the tops of the lock gates (fig 6.5). Unlike the original swivel bridge, this one had two traffic lanes but only a single leaf which pivoted about a point on the east side of the channel.

[8] The *Dublin Daily Express* of 23 Feb 1884 noted that this swivel bridge was almost complete. However, Thom's 1887 *Dublin Directory* (p.1273), noted that it had been opened for traffic on 12 Feb 1884 and was the designed by Bindon Stoney, the Dublin Port & Docks Board's Engineer.
[9] *Dublin Evening Mail,* 18 Jan 1866.

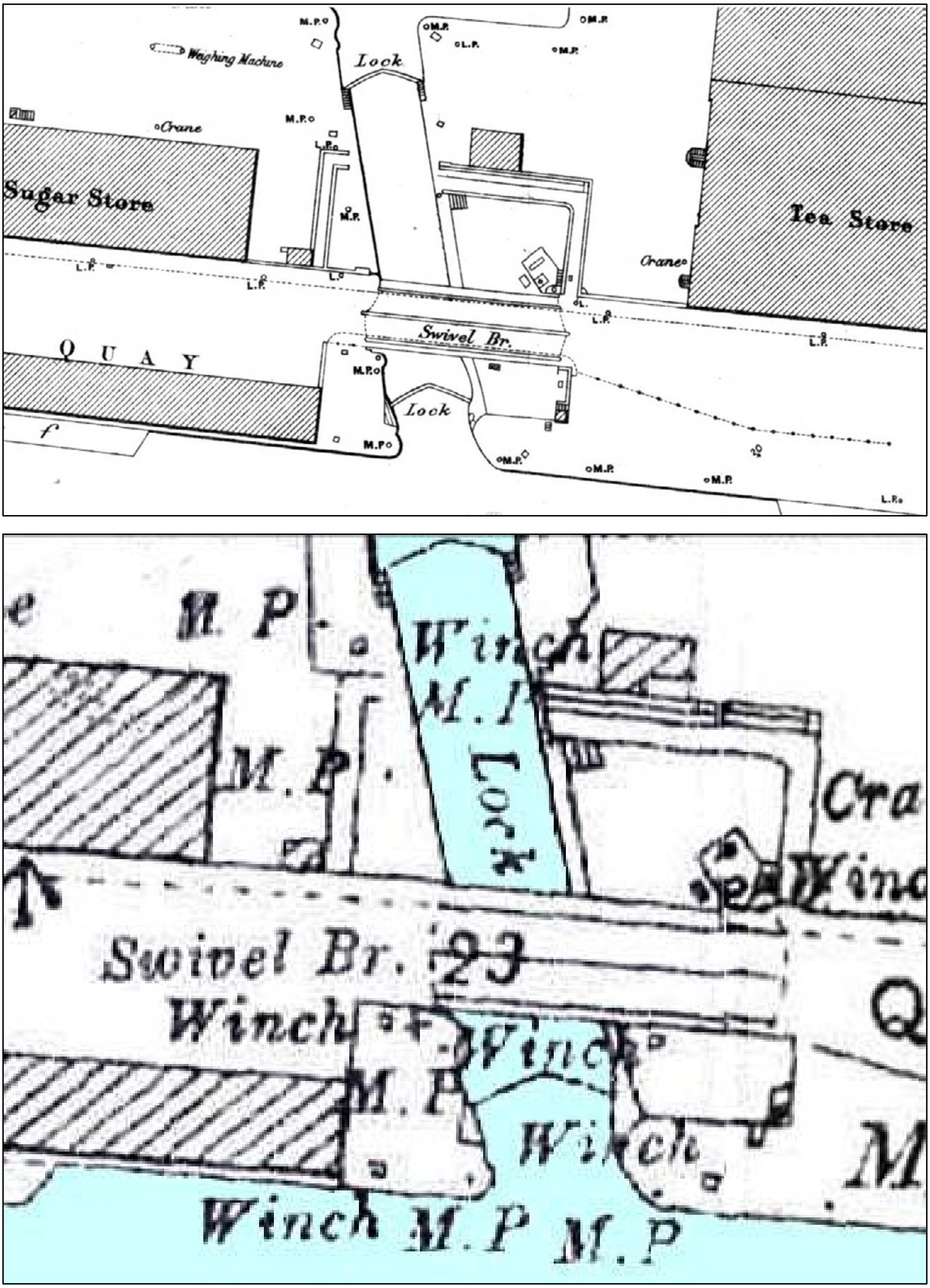


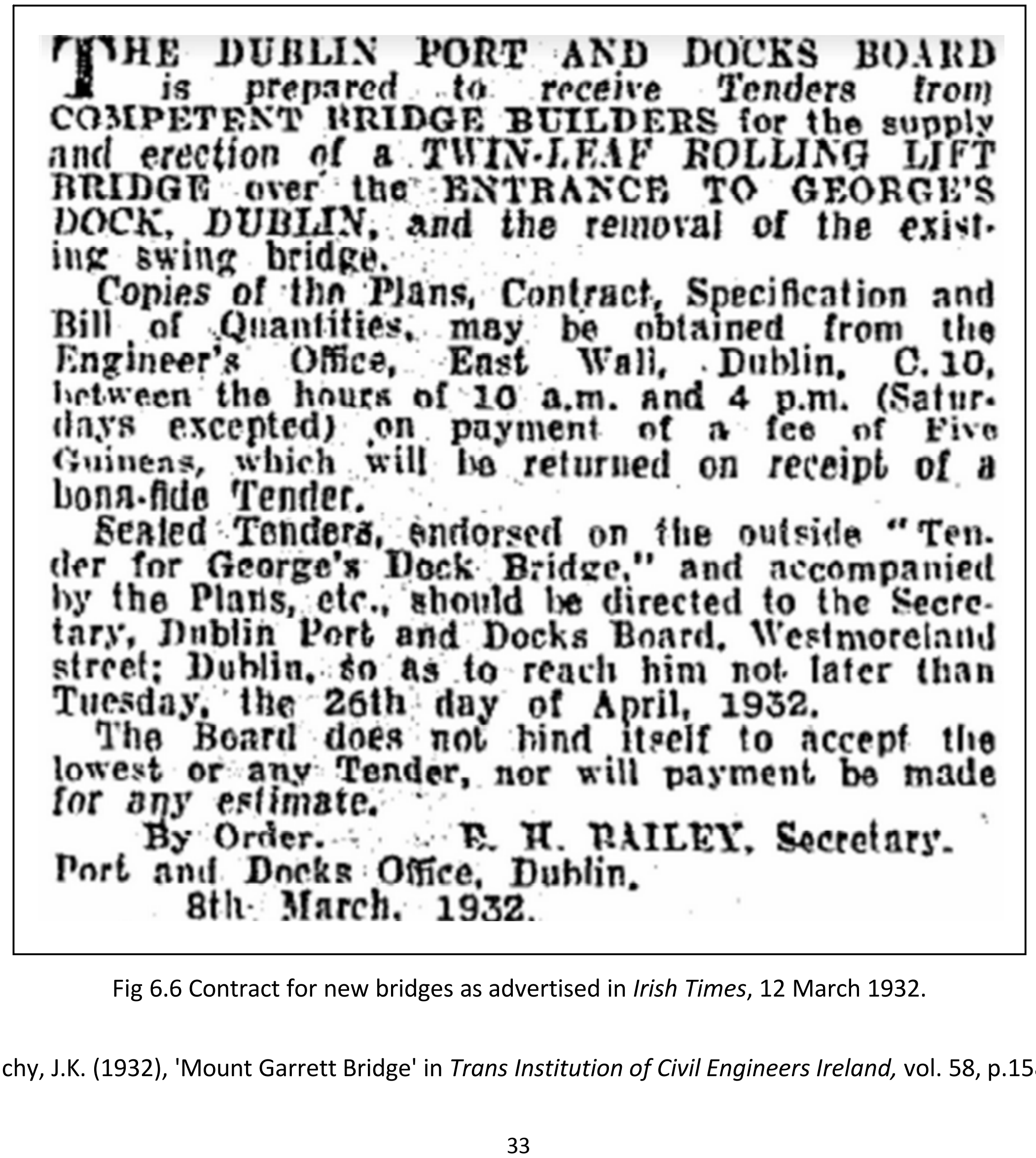
Fig 6.5 *Top:* 1889 map showing the replacement swivel bridge *(OS 1:1056 map, Dublin City sheet 58)*;
Bottom: 1907 map depiction *(OS 1:2500 map Dublin sheets 18-11 and 18-12).*

6.4 Scherzer bridges

The hindrance to traffic caused by the rolling drawbridge over the Royal Canal also pertained to some extent at the entrance to George's Docks. It was not until the 1930s that the issue was resolved with the swivel bridge's replacement with two Scherzer Bridges. The contract for their construction and removal of the existing bridge was advertised in 1932 (fig 6.6).

What little historical information as is currently available indicates that the work was well underway in 1933. An aerial photograph of that year shows the Outer Bridge being fabricated on the same alignment as the earlier rolling drawbridge (fig 6.7). As with the Scherzers over the Royal Canal, the two lanes of traffic along Custom House Quay continued to use the existing swivel bridge. Once the Outer Bridge was finished, the swivel bridge was removed and the second Scherzer erected. It was probably completed in 1934. Given that the Outer Bridge was now over the bottom end of the sea lock, it is uncertain how its gates were opened and closed thereafter.

The Port & Docks Board's Engineer at that time was Joseph Mallagh. He was well aware of Scherzer bridges, having played a role in the construction of one over the River Barrow at Mount Garrett several years previously.[10] Seemingly Scherzer's patent had expired, so the bridges' design may well have been Mallagh's own work rather than that of the Scherzer Rolling Lift Bridge Co. Unfortunately, no contract specifications and drawings have yet been found in the Dublin Port Company's Archive, nor is the name of the contractor known.



THE DUBLIN PORT AND DOCKS BOARD is prepared to receive Tenders from COMPETENT BRIDGE BUILDERS for the supply and erection of a TWIN-LEAF ROLLING LIFT BRIDGE over the ENTRANCE TO GEORGE'S DOCK, DUBLIN, and the removal of the existing swing bridge.

Copies of the Plans, Contract, Specification and Bill of Quantities, may be obtained from the Engineer's Office, East Wall, Dublin, C. 10, between the hours of 10 a.m. and 4 p.m. (Saturdays excepted) on payment of a fee of Five Guineas, which will be returned on receipt of a bona-fide Tender.

Sealed Tenders, endorsed on the outside "Tender for George's Dock Bridge," and accompanied by the Plans, etc., should be directed to the Secretary, Dublin Port and Docks Board, Westmoreland street; Dublin, so as to reach him not later than Tuesday, the 26th day of April, 1932.

The Board does not bind itself to accept the lowest or any Tender, nor will payment be made for any estimate.

By Order. E. H. BAILEY, Secretary.
Port and Docks Office, Dublin.
8th March, 1932.

Fig 6.6 Contract for new bridges as advertised in *Irish Times*, 12 March 1932.

[10] Maconchy, J.K. (1932), 'Mount Garrett Bridge' in *Trans Institution of Civil Engineers Ireland,* vol. 58, p.158.

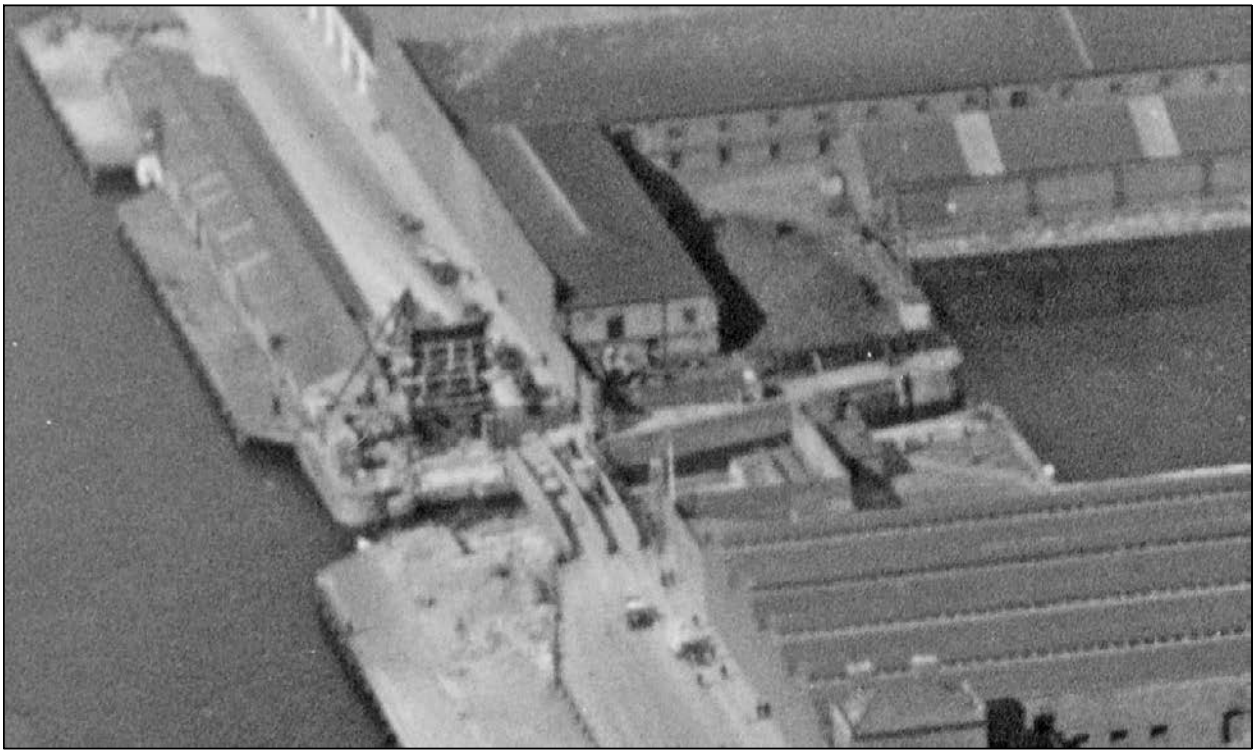


Fig 6.7 Aerial view from east showing Outer Scherzer under construction, 1933. *(Britain from Above, XPW043441)*

Mid-1900s aerial photographs show that the control cabin was mounted on an overhead platform at the SW end of the Outer Bridge and also that cantilevered footpaths were attached to the north side of the Inner Bridge and south side of the Outer Bridge (fig 6.8).

6.5 Recent developments

By the later 1900s, George's Dock and the Inner Dock had been abandoned and were derelict (the Custom House Dock had been infilled many years before). With the formation of the Custom House Docks Development Authority in 1987, the area began to be comprehensively redeveloped for commercial and residential use.

In 1998, the triumphal arch which formerly stood in Amiens Street was relocated here as a monumental feature. In 2001, the Scherzer bridges were designated by Dublin Corporation as 'public road bridges' under the Road Act 1994 Section 11(1). As a consequence, their spans were permanently fixed shut.[11]

In 2005, Stack A, a former tobacco and tea store along the east side of George's Dock designed by John Rennie in 1821, was converted into retail space. Now known as the CHQ Building, it also houses the Irish Emigration Museum. Stack B, a former sugar store at the SW end of the dock, has also been converted into office use.

[11] *Irish Independent,* 3 Aug 2001.

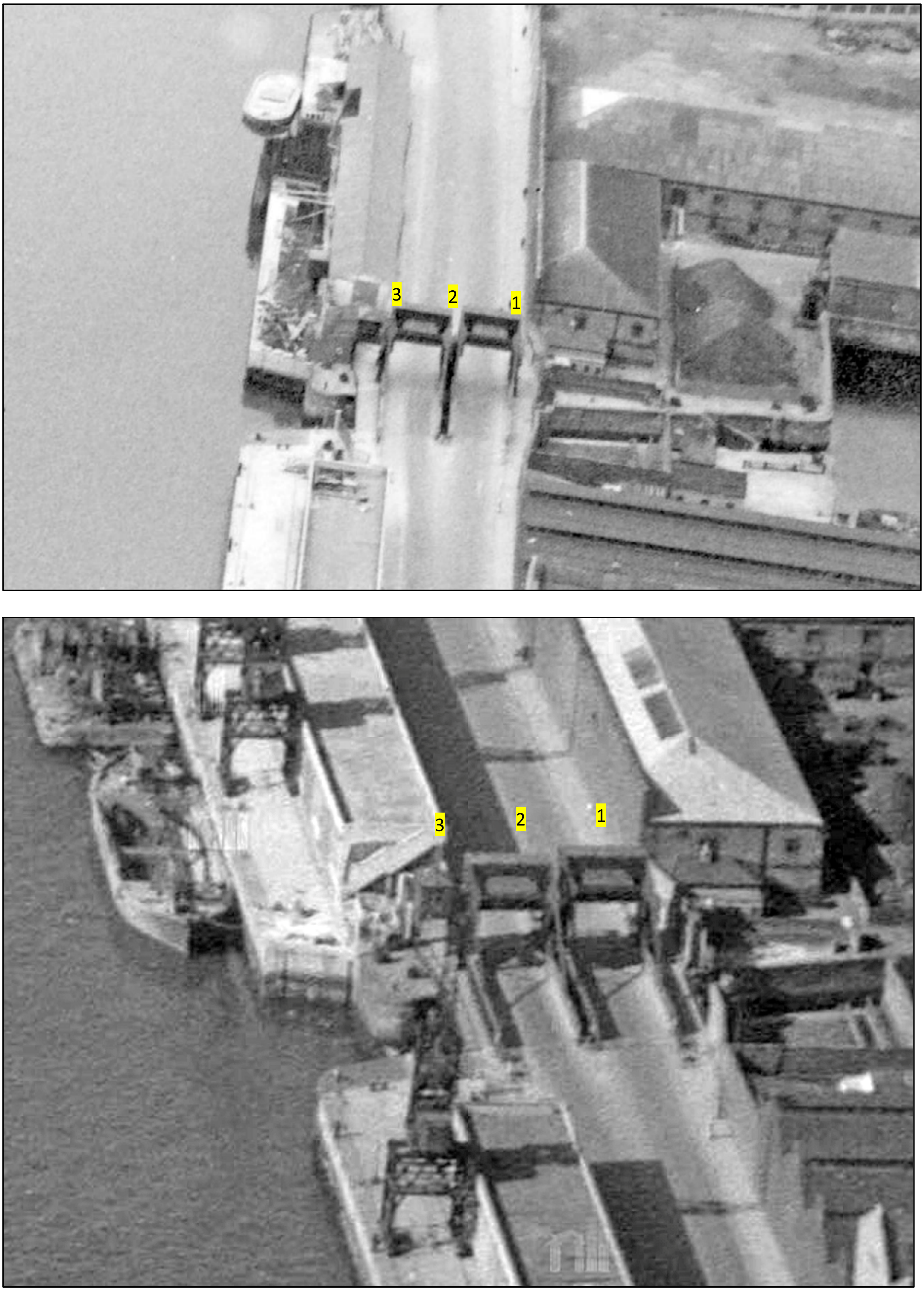


Fig 6.8 Aerial views of Scherzer bridges over entrance to George's Dock, from east. Top: 1949 *view (Britain from Above, XAW027127). Bottom:* 1955 *view (National Library Ireland, Morgan Aerial Photographic Collection). Key:* 1 - Inner Bridge, 2 - Outer Bridge, 3 - Overhead control cabin.

George's Dock was emptied of water and a concrete wall inserted across its entrance, just north of the bottom lock gates. A large platform was constructed on the bed of the dock by Dublin City Council for use as a temporary event space.

Three new fixed metal bridges were also erected over the entrance channel to the former dock: (1) a wide footbridge on the river side of the Outer Scherzer, (2) ditto on the dock side of the Inner Bridge and (3) a bridge over the gates at the north end of the lock chamber for vehicular access to a car park at the east end of Stack B (fig 6.9). It may have been around this time that the cantilevered footpaths were dismantled and the control cabin and its platform removed.

The most recent development has been the granting of planning permission for the conversion of George's Dock into a whitewater rafting centre.

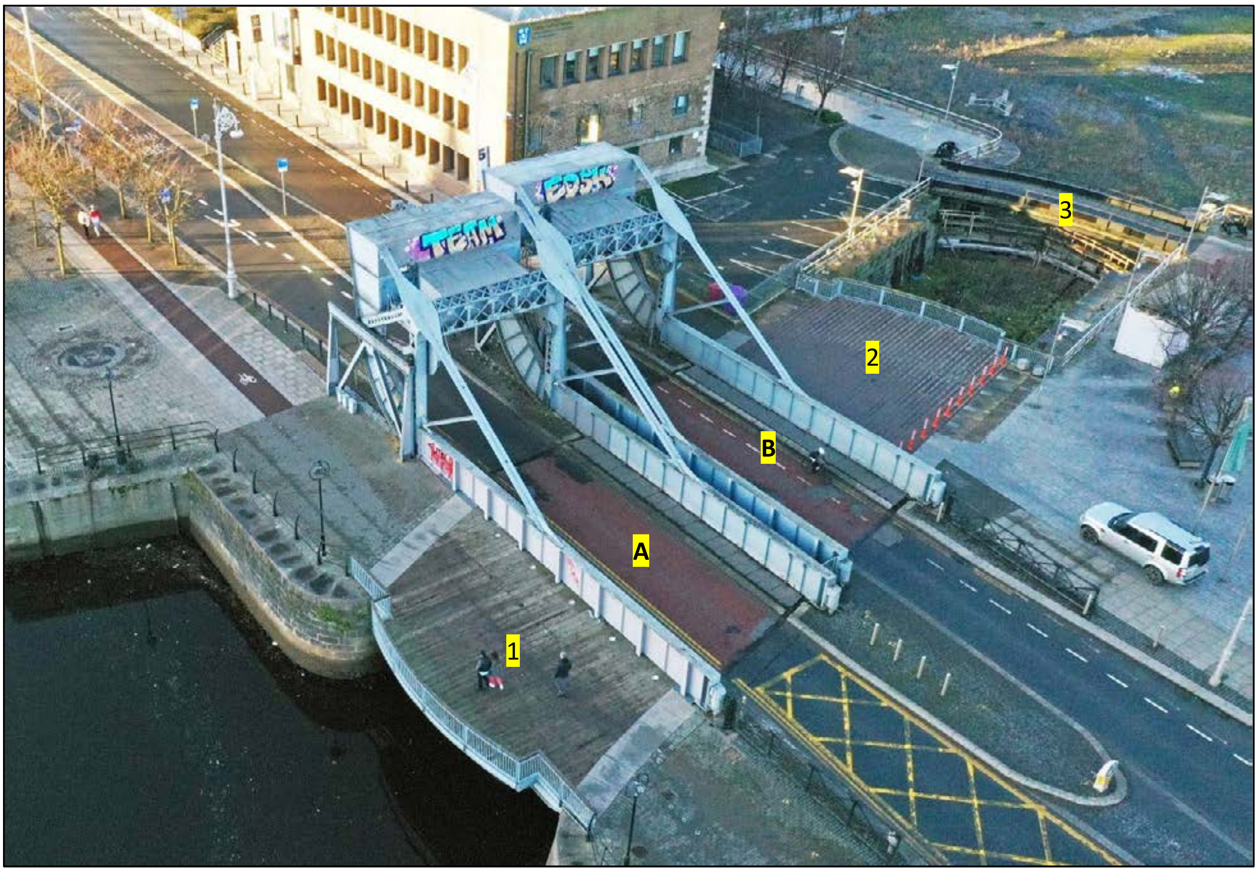


Fig 6.9 Aerial view of modern bridges over the entrance to George's Dock, from SE, 2021. *Key:* A - Outer Scherzer; B - Inner Scherzer; 1 - Modern foot bridge; 2 - Modern footbridge; 3- Vehicle access bridge.

7. George's Dock bridge descriptions

Although no longer operable, both Scherzer bridges continue to carry vehicles over the former entrance channel to George's Dock. However, their cantilevered footpaths have been superseded by modern footbridges at both ends (fig 7.1).

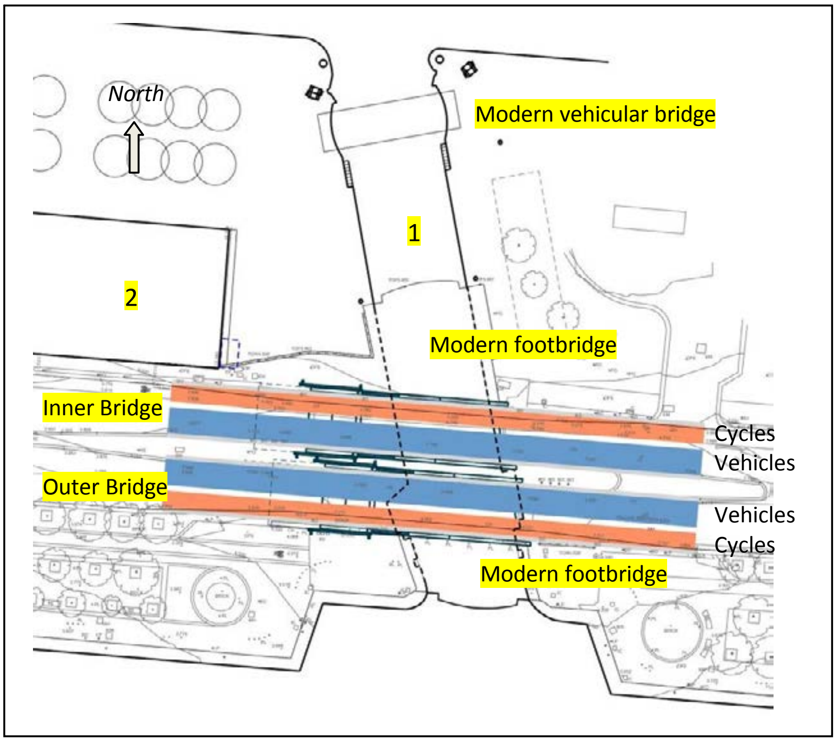


Fig 7.1 Plan of existing bridges over entrance to George's Dock. *Key:* 1 - Sea lock chamber; 2 - Stack B.

Because of Covid-19 restrictions, only a preliminary measured survey of the bridges was possible at this stage (fig 7.2). It is evident that the George's Dock Scherzers are more substantial structures that the pair over the Royal Canal (table 7.1).

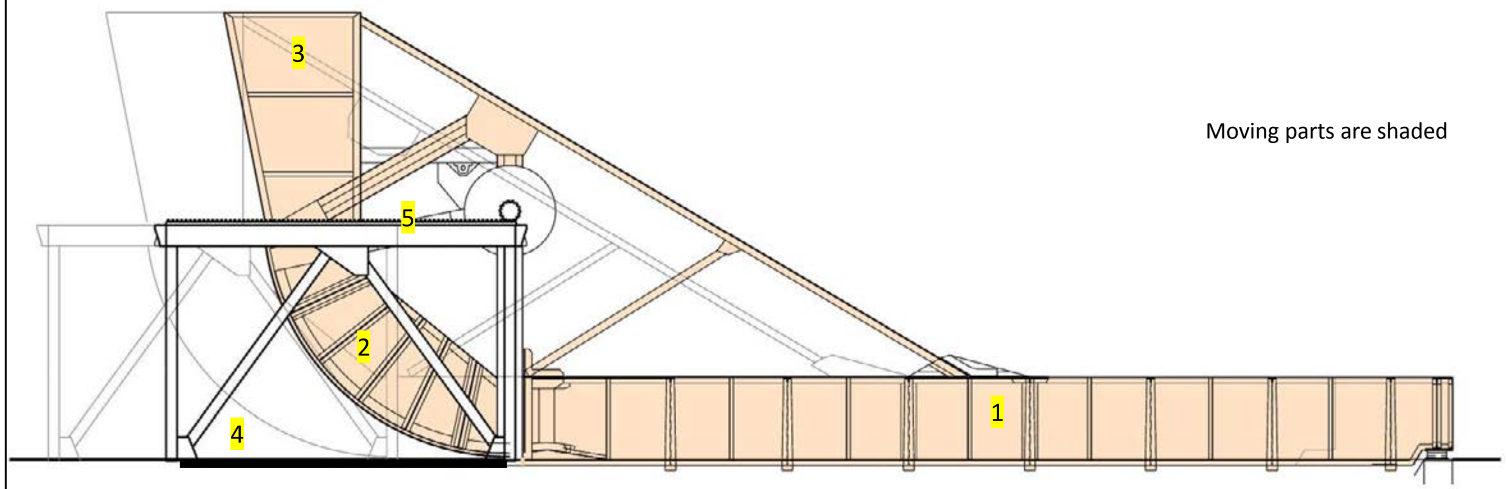
	George's Dock	Royal Canal
Span length (m)	18.69	13.29
Span width (m)	7.18	6.15
Channel gap (m)	11.37	8.28

Table 7.1 Dimensions of George's Dock and Royal Canal Scherzers.

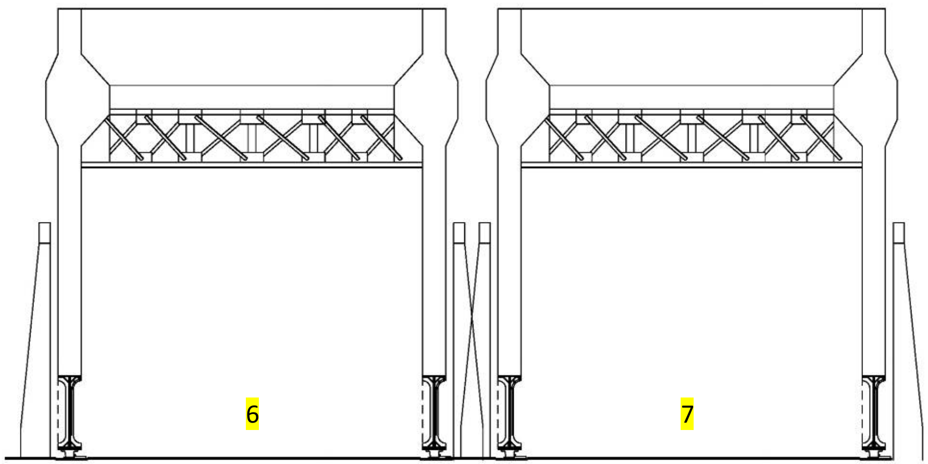
Without the original drawings and a detailed inspection, it is difficult to determine how many original components are now missing or have been replaced. The control cabin and cantilevered footpaths have been removed along with most of the traffic control gates and probably also the operating motors. Of special note is the survival of compressed air buffers at the opening ends of the spans (fig 7.3); these cushioned the impact on the sidewall when the span fell shut.

Underneath the Outer Bridge, the timber lock gates are still in place (fig 7.4). These match the ones at the north end of the lock chamber, underneath the modern bridge. Whilst the operating winches are still in place at the latter, the means of opening and closing the gates under the Outer Bridge has yet to be determined. The stonework along the tops of the walls has also been altered to accommodate the various replacement bridges.

There is evidence of traffic impact damage and also patches of rust here and there (fig 7.5). Overall, however, the bridges survive in good condition, albeit no longer fully complete.



Moving parts are shaded



Key:
1. Span
2. Quadrant roller
3. Counterweight
4. Track plate
5. Rack and supporting frame
6. Outer bridge road deck
7. Inner bridge road deck

Fig 7.2 *Top:* Elevation of Outer Bridge, from south. *Bottom:* End elevation, from east.

Fig 7.3 Contemporary photographs of Scherzer bridges at George's Dock. *Top left* - From SW; *Top right* - From NE; *Middle left* - Rack and pinion (at right end of rack); *Middle right* - Air buffers at lifting end of spans. *Bottom* - Quadrant rollers and toothed track plates along which they travel.

Looking S underneath the Scherzers towards the Liffey. At the far end, the lock gates are visible under the Inner Bridge.

Concrete wall across lock chamber, with drainage pipes along bottom.

Curved timber lock gate on west side of channel underneath Outer Bridge.

Lock gate on east side. Note the vertical slot at right for timber baulks to cut the channel off from the river.

Fig 7.4 Undersides of Scherzers spans and lock gates.

Fig 7.5 *Left:* Incomplete spur gear on Outer Bridge. Note also bent flange on cross member due to strike from a high load. *Above:* Minor rusting on flange plates.

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8. George's Dock options appraisal

As with the evaluation of the various options for repositioning the Scherzer bridges over the Royal Canal, only those criteria relating to the architectural heritage aspects of the proposed road scheme are considered here.

8.1 Relocation restrictions

As with the bridges on the Royal Canal, it is proposed to separate the bridges to enable the new road bridge to pass between them on the same alignment. As before, the strategy is to keep the Scherzers as close as possible to their existing positions. Unlike the situation on the Royal Canal there are a number of Protected Structures and other built heritage features of interest in the vicinity of the Scherzers at George's Dock (fig 8.1). Stack B, to the west of the bridges, incorporates fabric from an early 19th century sugar store but is not included in the RPS or the National Inventory of Architectural Heritage. The sole archaeological monument is an 18th century glasshouse (DU018-020152) which lies just beyond the west end of Stack B, well away from the bridges.

RPS site (also recorded by NIAH)

NIAH site (not in RPS)

RMP site

Fig 8.1 Built heritage features in the vicinity of the Scherzer bridges.

From the above map, the only heritage features relevant to the Scherzers' relocation are the lock chamber on their north side and North Wall Quay. Stack B is obviously a physical barrier to the west and there is also a further potential constraint on the east side of the lock chamber where planning permission has been granted for a new building for the whitewater rafting facility.

8.2 Options appraisal

The option of moving the bridges only slightly apart was dismissed for the same reasons as Option A for the Royal Canal. Relocating the Inner Bridge to the north end of the lock chamber in place of the modern vehicle access bridge was also considered but rejected as it would impinge too much on the existing lock gates and winches. Four options were eventually shortlisted for evaluation (fig 8.2):

A The two Scherzers would be moved apart to accommodate a four-lane bridge for cars and buses. The relocated bridges would be reserved for cyclists and pedestrians. It would be necessary to dismantle the modern bridges on either side, but their roles would continue to be served by the Scherzers.

B As Option A, but the Inner Bridge would be moved slightly further north to enable the continuation of the footpath along the south side of Stack B eastwards on the same alignment.

C As Option A, but both bridges would be rotated through 180 degrees so that their overhead counterweights are now on the east side of the canal and not up against Stack B.

D As Option B, but both bridges would be flipped so that their counterweights are on the east side.

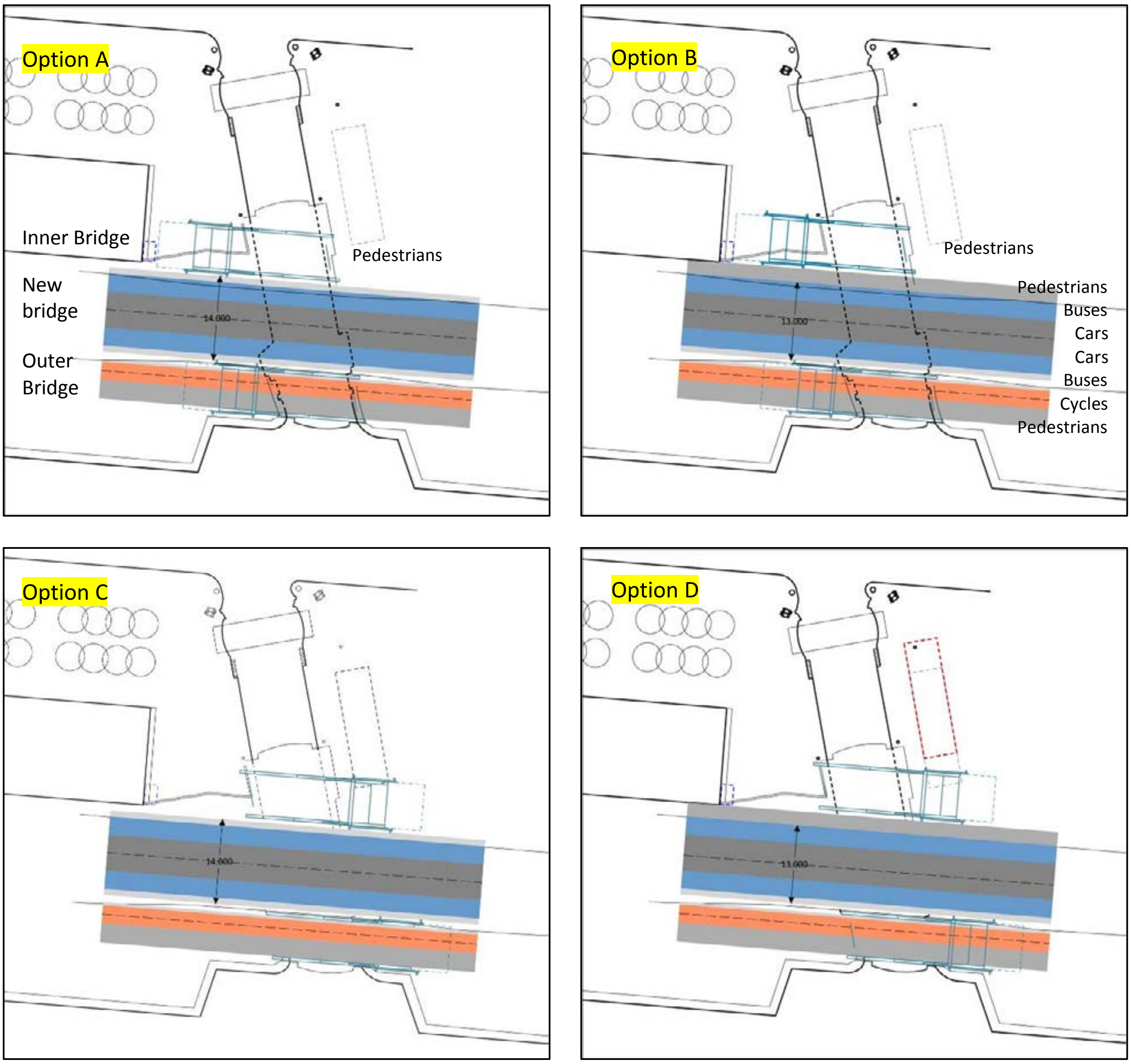


Fig 8.2 Options for repositioning Scherzer bridges.

Evaluation criteria

The same five criteria used in relation to the Royal Canal bridges was also used to determine the likely consequences of relocating the George's Dock bridges: (1) physical integrity of bridges, (2) physical integrity of associated historic buildings/structures, (3) landscape setting, (4) functionality, and (5) public amenity. As before, other considerations such as third-party land acquisitions and wayleaves are beyond the scope of this report.

Ranking of options

Each option is ranked for the above criteria using the same seven-point ranking system as before, and again with half-point scores where finer differentiation is required (table 7.1).

8.3 Appraisal conclusions

The table clearly shows that either Option C or D would best retain the bridges' heritage value in the long-term, i.e. moving them apart to make way for a new four-lane bridge, reversing their orientation, and restricting their use to pedestrians and cyclists. Either option would enable the Inner Bridge to be restored to an operational state for demonstration purposes without impeding on Stack B as it rolled backwards.

The insertion of a footpath between the new road bridge and relocated Inner Scherzer would be a matter for the more detailed design stage of the project, as would any consideration of raising the height of the decks.

Option	Existing situation		Option A		Option B		Option C		Option D	
Criteria		Rank		Rank		Rank		Rank		Rank
1. Physical integrity of bridges	• Entire bridge remains in situ.	0	• Sub-frame will be lost.	- 1½	• As Option A.	- 1½	• As Option A.	- 1½	• As Option A.	- 1½
2. Physical integrity of associated features	• Canal walls remain intact. • Lock gates remain in situ	0	• Some loss of stone-work along canal walls.	- 1	• As Option A.	- 1	• As Option A.	- 1	• As Option A.	- 1
3. Landscape setting	• Both bridges make a positive contri-bution to the landscape.	0	• Inner Bridge now hidden from view on approach from west. • Counterweight of Inner Bridge will be closer to Stack B.	- 2	• As option B. • Counterweight of Inner Bridge will be even closer to Stack B.	- 2½	• The Inner Bridge will be more prominent as more distant from adjacent buildings. • No visual impact on Stack B.	+ 2	• As Option C.	+ 2
4. Functionality	• High dynamic loading and high potential for traffic impacts.	0	• Reduced dynamic loading and minimal traffic damage as both bridges now for pedestrian/cycle use only.	+ 3	• As Option A.	+ 3	• As Option A.	+ 3	• As Option A.	+ 3
5. Public amenity	• Poor user experi-ence and little opportunity for public engagement.	0	• Good user experi-ence and opportunity for public engagement.	+ 2	• As Option A.	+ 2	• As Option A.	+ 2	• As Option A.	+ 2
Overall score		**0**		**+ ½**		**0**		**+ 4½**		**+ 4½**

Table 7.1 Ranking of options by criteria for George's Dock Scherzer bridges.

9. Bridge conservation

9.1 Conservation principles

The strategy behind the options' appraisal for both pairs of bridges has been to retain them as close as possible to their existing positions. Moreover, their long-term survival is believed to be better secured if they are repurposed for non-vehicular traffic and thus kept in use rather than being preserved as defunct monuments which are less likely to be maintained than functional structures.

In implementing whichever options are chosen, the general approach to the bridges' conservation will be to do *as little as possible and as much as is necessary*. Surviving historical fabric should always be treated with care, the first priority being to maintain and repair rather than to remove and replace.

9.2 Options' implementation

The following list of tasks outlines what will be required to carry out any of the above relocation options. It does not purport to be exhaustive and the order of work will depend to a large extent on the sequencing of the new road bridge's construction programme.

Recording

- A complete photographic and measured survey should be made. The latter will entail an extension of the laser survey already carried out and will include the bridges' undersides and associated components (e.g. control cabin, railings, gates) and also adjoining features such as the masonry approach walls on the north side of the Inner Bridge and also canal features (walls, gate emplacements, and winches).
- A comprehensive survey should be made of the completeness and condition of the bridges' components. This will inform the bridges' disassembly, repair and rebuilding. It should also differentiate those components which are original fabric from items which have been replaced or were added at a later date.

Decommissioning works

- Temporary bridges will be provided as necessary to maintain the necessary connectivities during decommissioning and reconstruction.
- The bridges' above-ground components should be carefully dismantled only in so far as necessary to enable them to be repaired and moved to their new location with minimal intervention. This will include the moving components (spans, quadrant rollers, counterweights, motor and drive gears, all of which might possibly be lifted as a single unit), racks and frames, track plates (having separated them from the sub-frame), and overhead platform. The electrics will also require decommissioning in the case of the Royal Canal bridges. Where existing components are sound and their relocation feasible without further dismantling, their fixings, joints and seams should all be left intact.
- The feasibility of leaving intact the below-ground supporting frame for the bridges' track plates should be investigated further as this would mitigate to some extent the loss of original fabric. If they need to be removed, they should be carefully excavated and recorded by way of photographs and measured drawings.

- Associated elements such as railings, gateposts, kerbs, and the stone wall along the north side of the Inner Bridge over the Royal Canal, should be dismantled and stored for repair and reconstruction.
- All the modern bridges should be removed and placed in storage for possible re-use elsewhere at a later date.

Enabling works

- Foundations for the relocated Scherzers will include piles, pile caps and ground beams to support the original track plates and loadings thereon (assuming the original steel substructures are not reused).
- In the case of the Royal Canal, the lock gate winches will be sunk as required to accommodate the repositioned bridges.

Recommissioning works

- The restored bridges will be reassembled at their new locations. The overhead platform be kept as part of the Outer Bridge over the Royal Canal. Consideration will also be given to replicating its control cabin. This could improve the interpretation of the bridges and be made accessible for guided visits. Carefully designed information panels would enhance the interpretation of the bridges and their fascinating design.
- For the Royal Canal bridges, it is also intended to reinstate the various operating mechanisms and electrical controls so that they remain in an operational state after being repositioned. These could be opened during events to demonstrate the impressive mechanism. At the time of writing, the only working Scherzer in Britain and Ireland is Inchinnan Bridge over the White Cart Water on the A8 near Renfrew, Scotland, <https://www.youtube.com/watch?v=qCqBi243v1A>.
- Associated works will include reinstatement of the ancillary railings, gateposts, stone wall etc once the bridges are repositioned.
- New high-quality paving will be laid to tie in the relocated bridge decks with the adjoining quays. The actual surface treatments of the new footpaths and cycleways will require further consideration to clearly differentiate them from the quays' existing historic fabric. One option would be to restore the stone cube surface on the bridge spans, if these have not survived below the bitumen road surface.

Appendices:

1. Scherzer bridges in Ireland

2.1 Original drawings of Scherzer bridges over Royal Canal

2.1 Historical photographs of Scherzer bridges over Royal Canal

Appendix 1: Scherzer bridges in Ireland

Eight Scherzer bridges were constructed at six different locations (fig A1.1). In chronological order they are as follows:

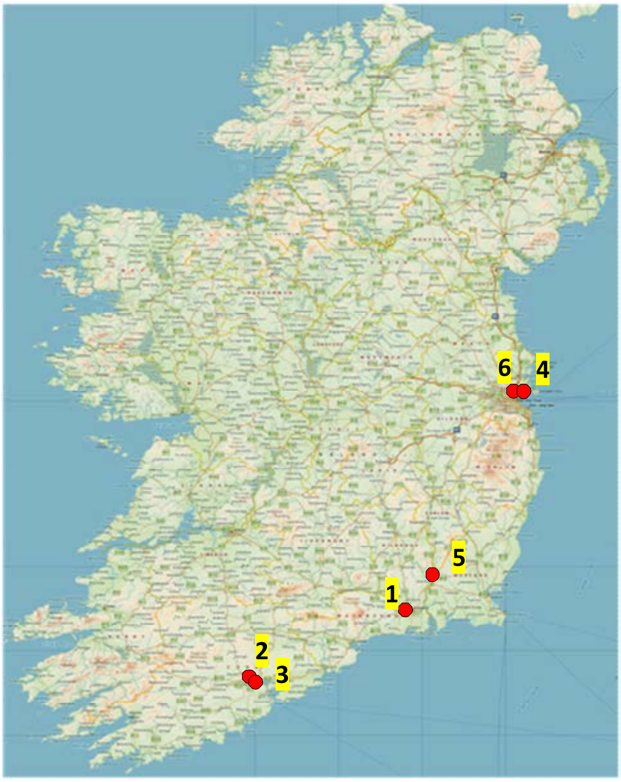


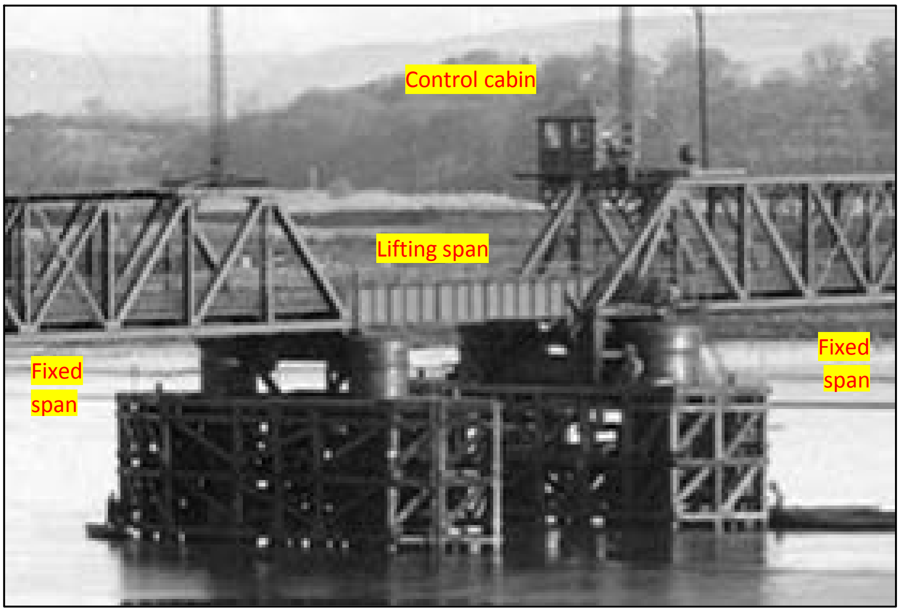
Fig A1.1 Locations of Scherzer bridges in Ireland (in chronological order).

Key:

1. Suir Railway Viaduct (1905-06).
2. Brian Boru Bridge, Cork (1911).
3. Clontarf Bridge, Cork (1911).
4. North Wall Quay, Dublin (x2; 1910-12).
5. Mount Garrett Bridge (1929-30).
6. Custom House Quay, Dublin (x2; 1932-34).

1. Suir Railway Viaduct Waterford

The first Scherzer bridge in Ireland was built in 1905-06 by the Fishguard and Rosslare Railways & Harbour Co to carry a single track line over the River Suir just upstream from Waterford City (fig A1.2). It comprised multiple fixed spans and a 50ft wide Scherzer opening span in the middle. The steelwork was supplied by Messrs Arrol, Glasgow. Although long defunct, much of the bridge still survives but its Scherzer section has been removed.



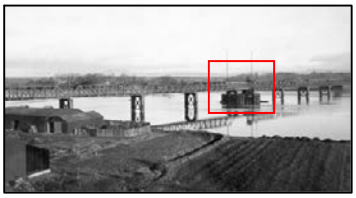


Fig A1.2 Suir Viaduct, Waterford, 1906. *(Sir William Arrol Collection, Historic Scotland: Canmore SC 554594).*

2. Brian Boru Bridge, Cork City

This bridge was completed in 1911 and opened in 1912 to carry the Cork City Railway over the North Channel of the River Lee (fig A1.3). It worked in tandem with the Clontarf Bridge, a short distance to its south. When the railway was closed in 1976, the bridge continued in use for road traffic. Around 1981, the counterweight, quadrant rollers and control cabin were removed, leaving only the actual span which now functions as a fixed road bridge.

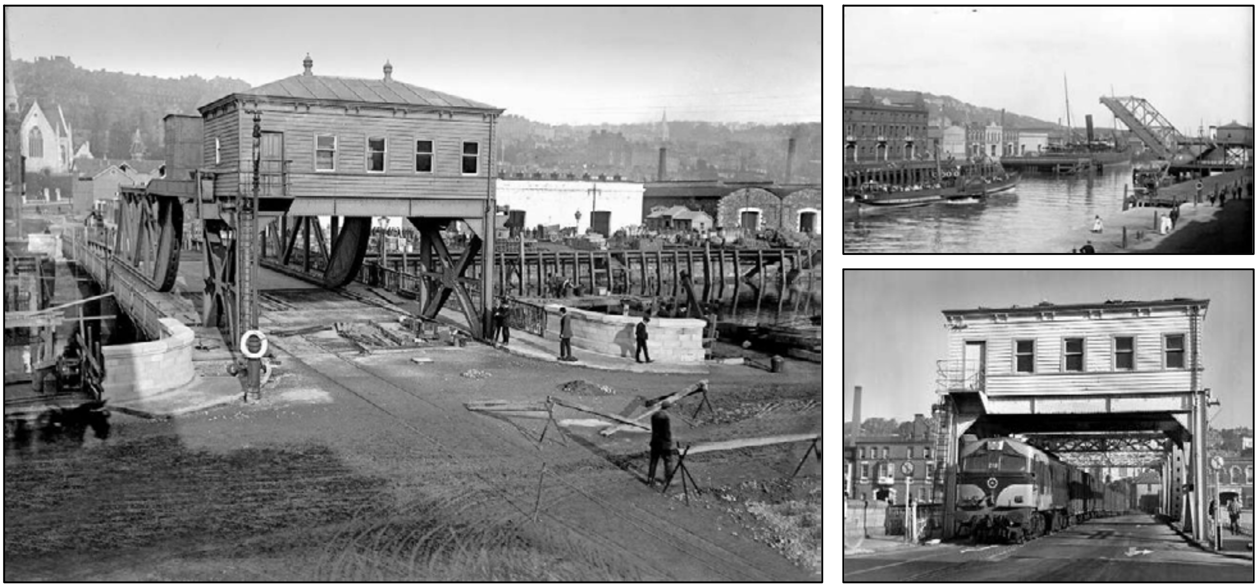


Fig A1.3 Clockwise from above: Brian Boru Bridge, Cork, 1911 *(insert credit)*; Bridge in open position *(insert credit)*; CIE loco crossing bridge, 1976 *(insert ref).*

3. Clontarf Bridge, Cork City

This bridge carried the railway over the South Channel of the River Lee but is otherwise the same in all respects to the Brian Boru Bridge (fig A1.4).

Fig A1.4 Clontarf Bridge, 1989*. (www.oldphotosofcork.wordpress.com)*

4. North Wall Quay, Dublin

As noted in section 3.4, these two bridges were commissioned by the Dublin Port and Docks Board under the direction of its Engineer, Sir John Purser Griffith. The Inner Bridge dates to 1910-11 and the outer one to 1911-12. They are still used by road traffic and also, in theory, openable for canal traffic.

5. Mount Garrett Bridge

This bridge was completed 1929 and opened in 1930 to carry a public road over River Barrow on the Wexford-Kilkenny border, 3km north of New Ross (fig A1.5). It was designed by Joseph Mallagh, Engineer to Dublin Port & Docks Board, and heavily influenced by Griffith's 1910-12 Scherzer bridges in Dublin.

For a detailed technical description see Maconchy, J.K. (1932), 'Mount Garrett Bridge' in *Transactions Institution of Civil Engineers Ireland,* vol. 58, pp 147-198. This article is also on-line at <https://www.tcd.ie/library/digitalcollections/home/#folder_id=1097&pidtopage=ICEI-058_181&entry_point=180>.

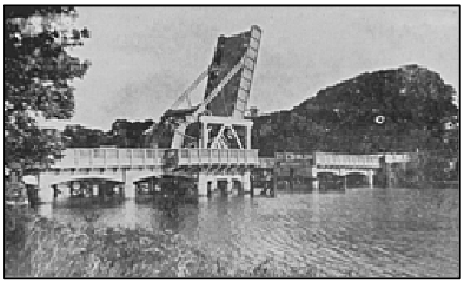


Fig A1.5 Above: Mount Garrett Bridge in 1930 *(Maconchy, 1932.* Left: As it is today *(NIAH, 15702907).*

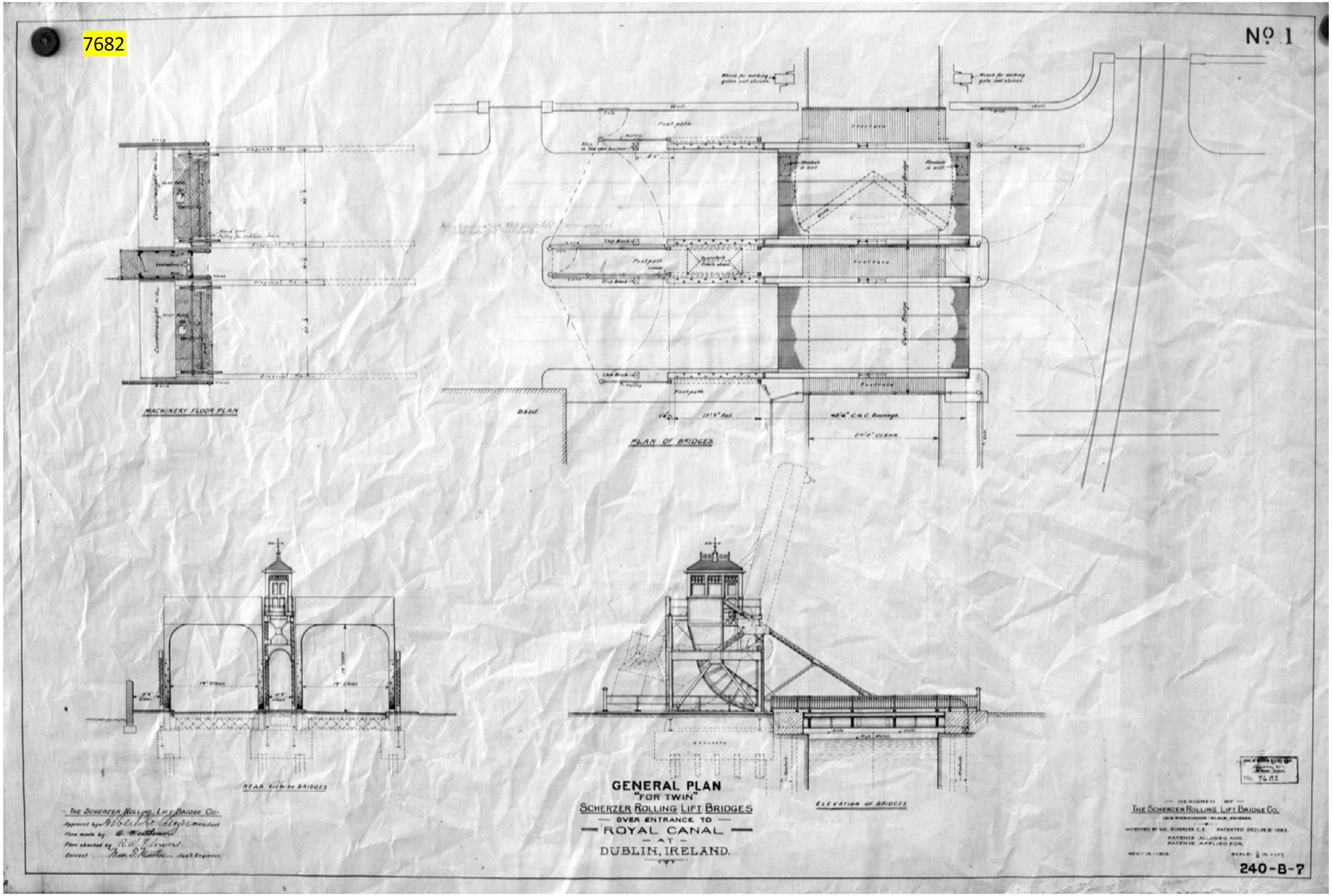
6. Custom House Quay, Dublin

This pair of bridges has been discussed in section 6.4. They are of identical function to the ones on North Wall Quay but date from 1932-34. They are also the work of the Dublin Port and Docks Board, this time to the design of Joseph Mallagh, the Board's Engineer. They are the last Scherzers to be have been erected in Ireland. Although they still carry road traffic, they have lost their control cabin and the span permanently fixed in the closed position.

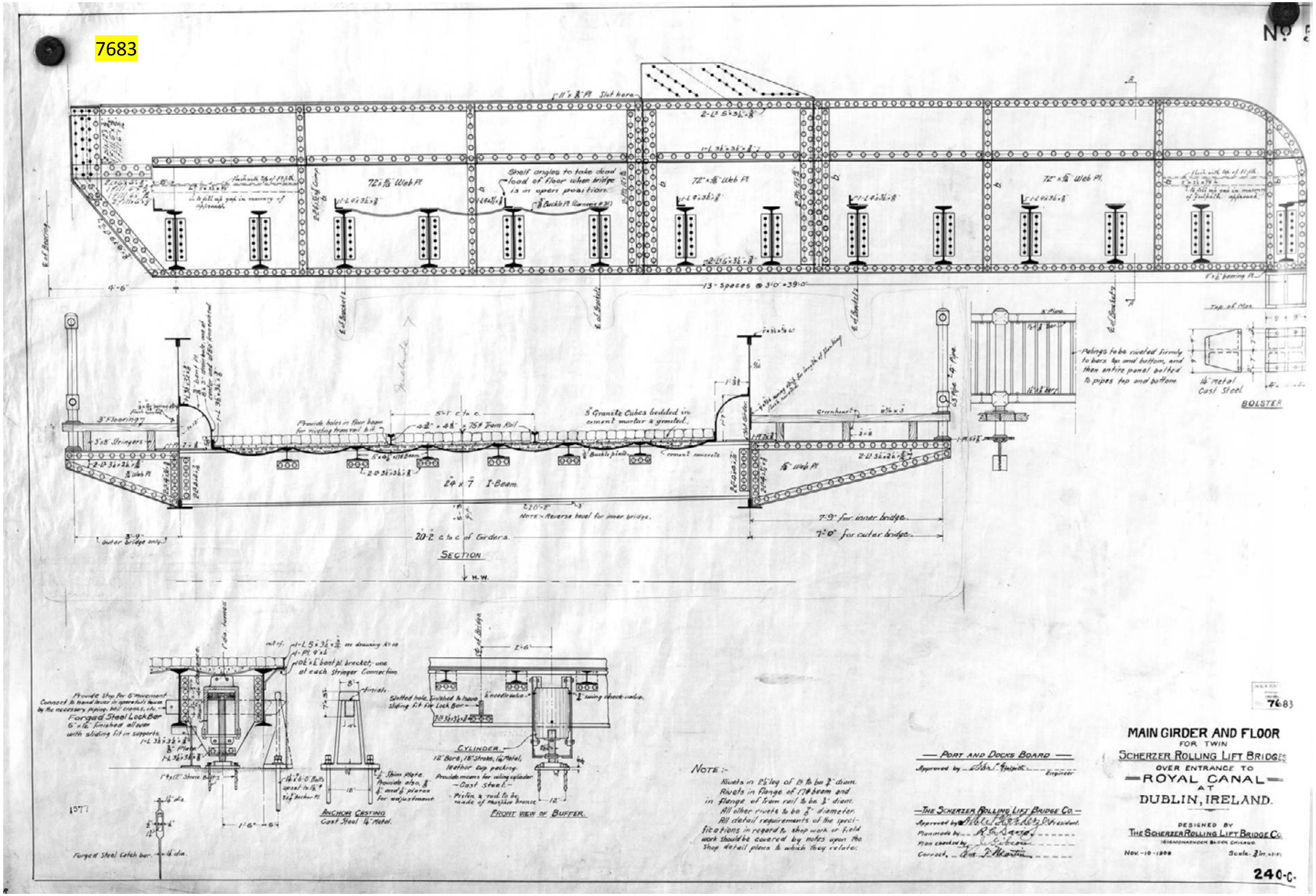
Appendix 2.1: Original drawings of Scherzer bridges over Royal Canal

The Dublin Port Co's Archive contains the following drawings (asterisked ones are reproduced here).

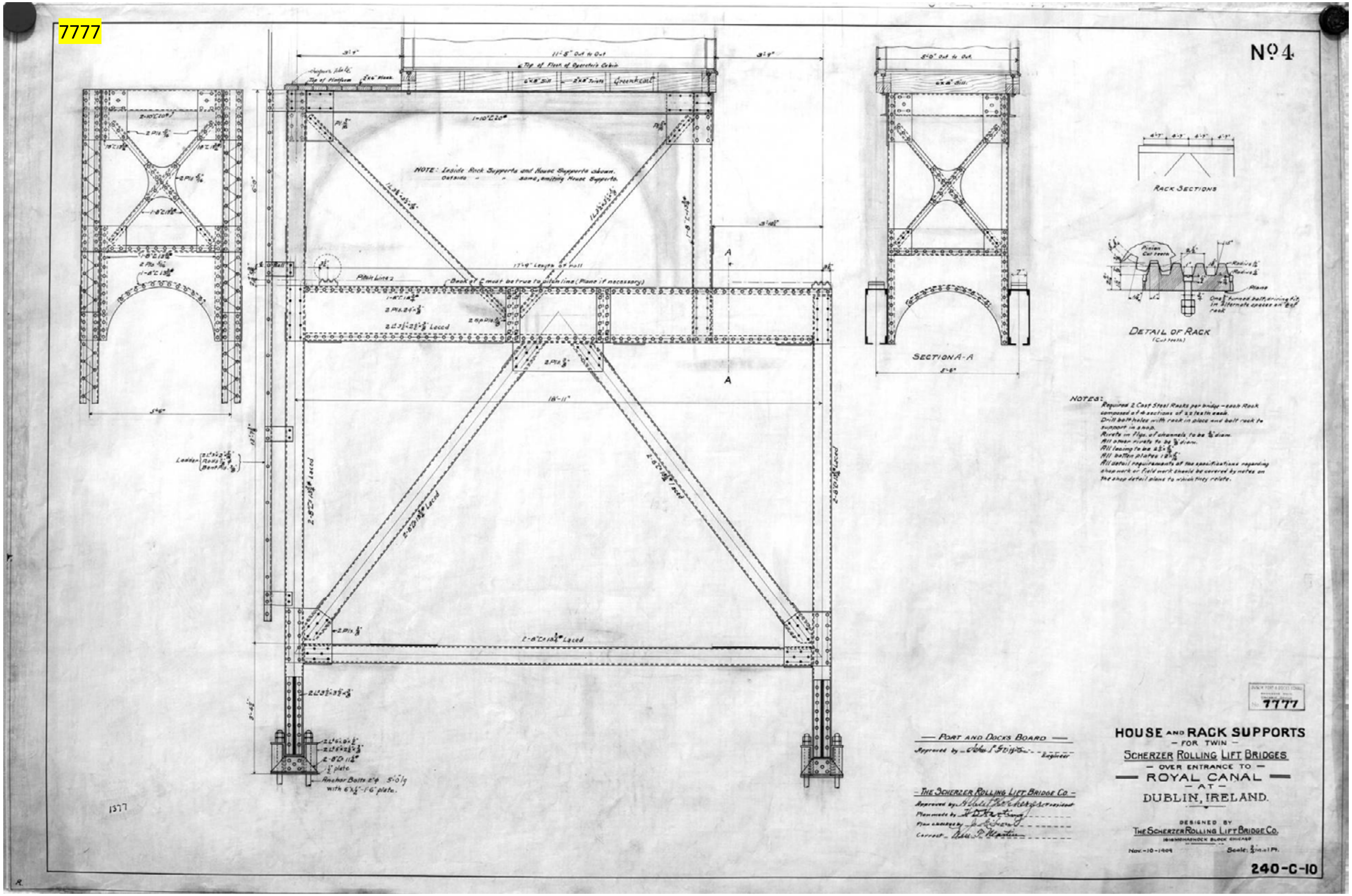
Cat.no	Content	Date
7682 *	General plans and elevations.	16 Nov 1909
7683 *	Main girder and deck sections.	10 Nov 1909
7775	Stress statistics.	13 Nov 1909
7776	Track girders and sub-frame.	11 Nov 1909
7777 *	Cabin and rack supports.	10 Nov 1909
7780 *	Gear trains.	16 Nov 1909
7781 *	Plans showing proposed sequence of construction.	9 May 1910
7782	Girder and railing detail.	13 May 1910
7799	Schematic electrical wiring diagram.	22 Nov 1910
7830	Track plate detailing.	July 1934
7837	Detail of road finishes.	31 Jan 1911



7682
Nº 1
MACHINERY FLOOR PLAN
PLAN OF BRIDGES
REAR VIEW OF BRIDGES
ELEVATION OF BRIDGES
GENERAL PLAN
"FOR TWIN"
SCHERZER ROLLING LIFT BRIDGES
OVER ENTRANCE TO
ROYAL CANAL
AT
DUBLIN, IRELAND.
THE SCHERZER ROLLING LIFT BRIDGE CO.
Approved by
President
Plan made by
Plan checked by
Correct
Ass't Engineer
DESIGNED BY
THE SCHERZER ROLLING LIFT BRIDGE CO.
PATENTS ALLOWED AND
PATENTS APPLIED FOR.
No. 7682
240-B-7

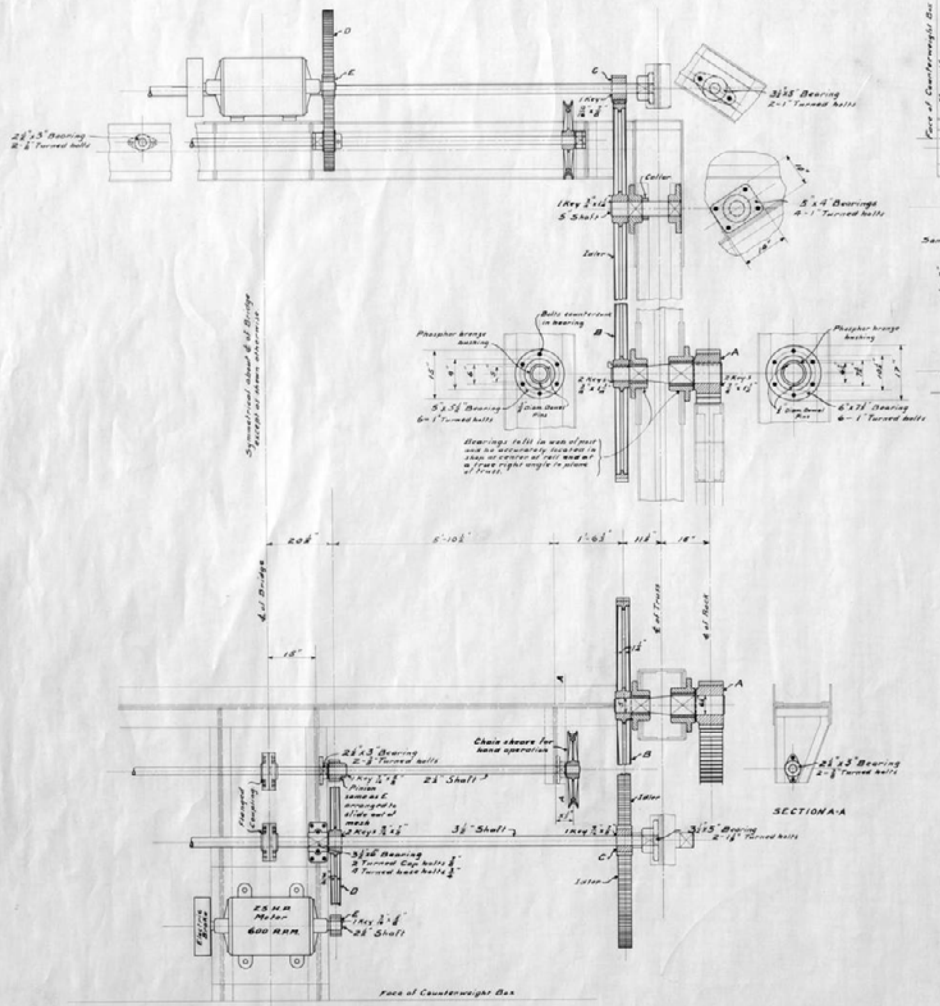


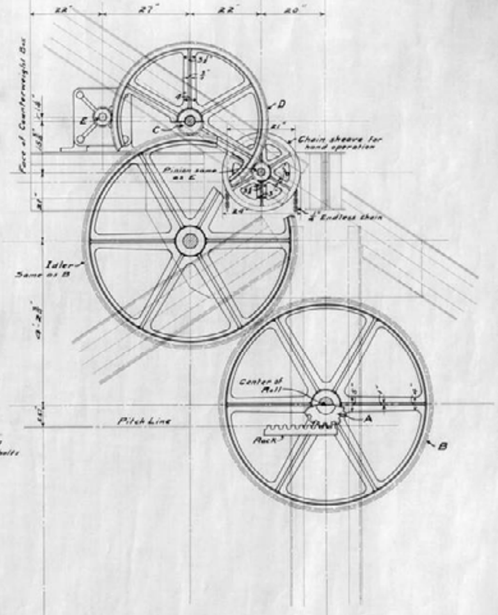
7683
MAIN GIRDER AND FLOOR
FOR TWIN
SCHERZER ROLLING LIFT BRIDGES
OVER ENTRANCE TO
ROYAL CANAL
AT
DUBLIN, IRELAND.
DESIGNED BY
THE SCHERZER ROLLING LIFT BRIDGE CO.
PORT AND DOCKS BOARD
THE SCHERZER ROLLING LIFT BRIDGE CO.
SECTION
ANCHOR CASTING
Cast Steel ¼" Metal.
FRONT VIEW OF BUFFER.
CYLINDER
BOLSTER
NOTE:-
Rivets in 2½" leg of L's to be ⅞" diam.
Rivets in flange of 17# beam and in flange of Tram rail to be ¾" diam.
All other rivets to be ⅞" diameter.
All detail requirements of the specifications in regard to shop work or field work should be covered by notes upon the Shop detail plans to which they relate.
20'-2" c. to c. of Girders.
13 - Spaces @ 3'-0" = 39'-0"
7'-9" for inner bridge.
7'-0" for outer bridge.
Nov.-10-1909
240-C.


7777
No. 4
NOTE: Inside Rack Supports and House Supports shown.
Pitch Line
Rack Sections
Detail of Rack
(Cut teeth)
Section A-A
18'-11"
Anchor Bolts
NOTES:
Required 2 Cast Steel Racks per bridge – each Rack
Drill bolt holes with rack in place and bolt rack to
support in shop.
All detail requirements of the specifications regarding
shop work or field work should be covered by notes on
the shop detail plans to which they relate.
— PORT AND DOCKS BOARD —
Approved by
Engineer
– THE SCHERZER ROLLING LIFT BRIDGE CO. –
Approved by
President
Plan made by
Plan checked by
Correct
No. 7777
HOUSE AND RACK SUPPORTS
– FOR TWIN –
SCHERZER ROLLING LIFT BRIDGES
– OVER ENTRANCE TO –
ROYAL CANAL
– AT –
DUBLIN, IRELAND.
DESIGNED BY
THE SCHERZER ROLLING LIFT BRIDGE CO.
Nov.-10-1909
240-C-10
1377

7780

No. 8





LIST OF GEARING FOR ONE OF TWIN BRIDGES.

GEAR	NUMBER REQUIRED	PITCH	FACE	NUMBER OF TEETH	PITCH DIAMETER
RACK	2	2½"	7"	——	——
PINION A	2	2½"	7"	14	11.14"
GEAR B	4	1¾"	4"	118	45.73
PINION C	2	1¾"	4½"	14	7.64
GEAR D	1	1¼"	3"	122	48.58
PINION E	2	1¼"	3½"	14	5.57

MACHINERY NOTES:

All castings to be of steel unless otherwise noted.
Pitch lines to be marked on all gears.
All pinions and gears to be cut.
All gearing to be protected from the weather by suitable covering.
All bearings to be babbitted unless otherwise noted.
Pressure grease cups to be provided for all bearings.
All bolts for bearings to be turned and have threaded ends turned down slightly less in diameter than body of bolt and provided with two nuts.
All bolt holes for bearings to be drilled in field unless otherwise noted.
Shafts over 3" in diameter must be forged steel, others may be cold rolled steel.
All collars to be secured in place with set screws, countersunk in shaft and secured with lock nuts.
Bridges to be provided with front lock operated from operating cabin.
Bridges to be operated by two 25 H.P. motors, 600 R.P.M. normal rating.
If motors having a different normal speed are used, the reduction in gears D and E should be changed proportionately.

— PORT AND DOCKS BOARD —
Approved by John P. Griffith Engineer.

— THE SCHERZER ROLLING LIFT BRIDGE CO. —
Approved by Albert H. Scherzer President.
Plan made by C. A. Lawrence
Plan checked by R. W. Flowers
Correct. Wm. P. Martin

7780

MACHINERY
— FOR TWIN —
SCHERZER ROLLING LIFT BRIDGES
— OVER ENTRANCE TO —
ROYAL CANAL
— AT —
DUBLIN, IRELAND.

DESIGNED BY
THE SCHERZER ROLLING LIFT BRIDGE CO.
— 1616 MONADNOCK BLOCK CHICAGO. —

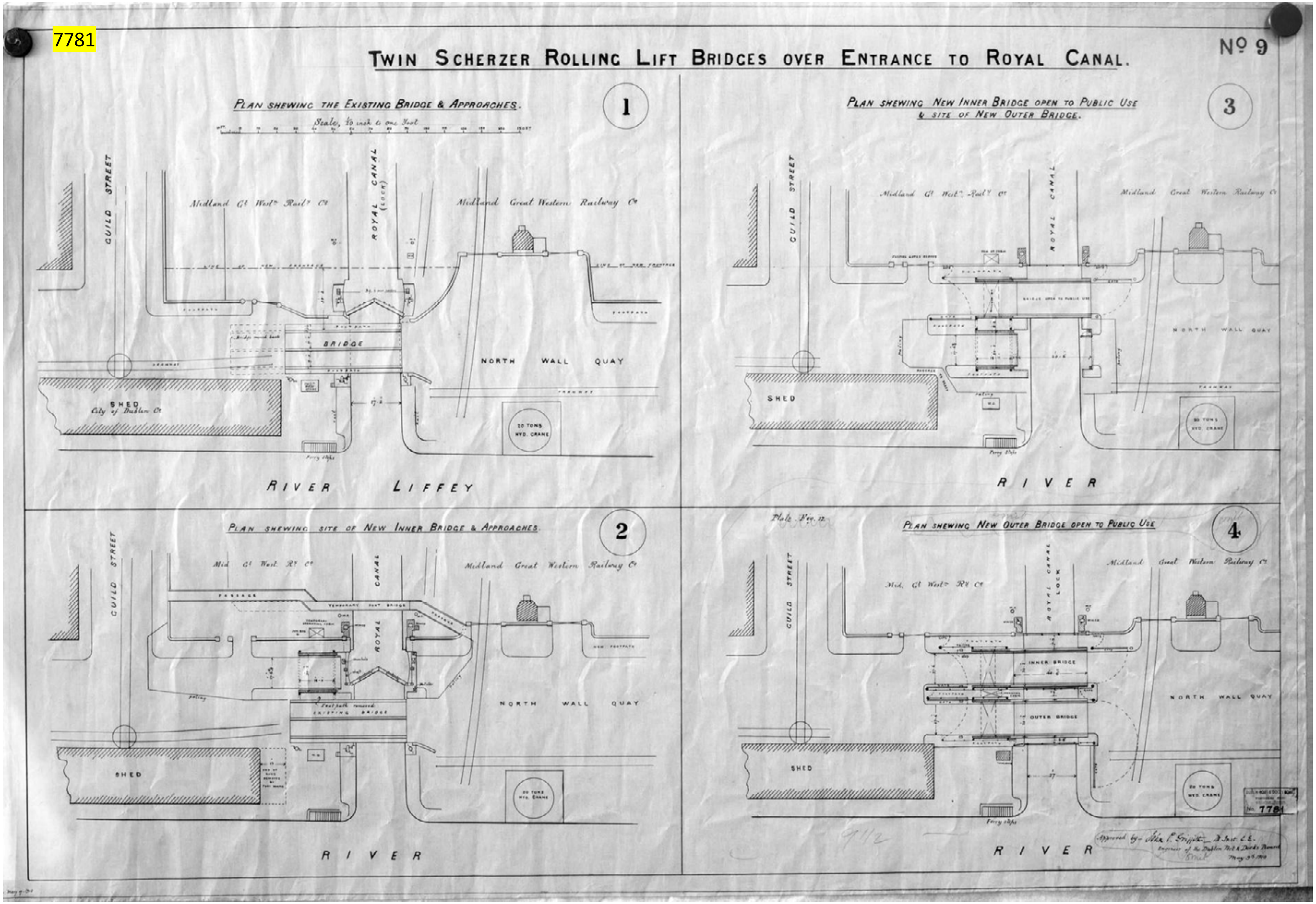
Nov. 16-1906

Scale: ½ in = 1 ft.

240-D-14.

1377

7781

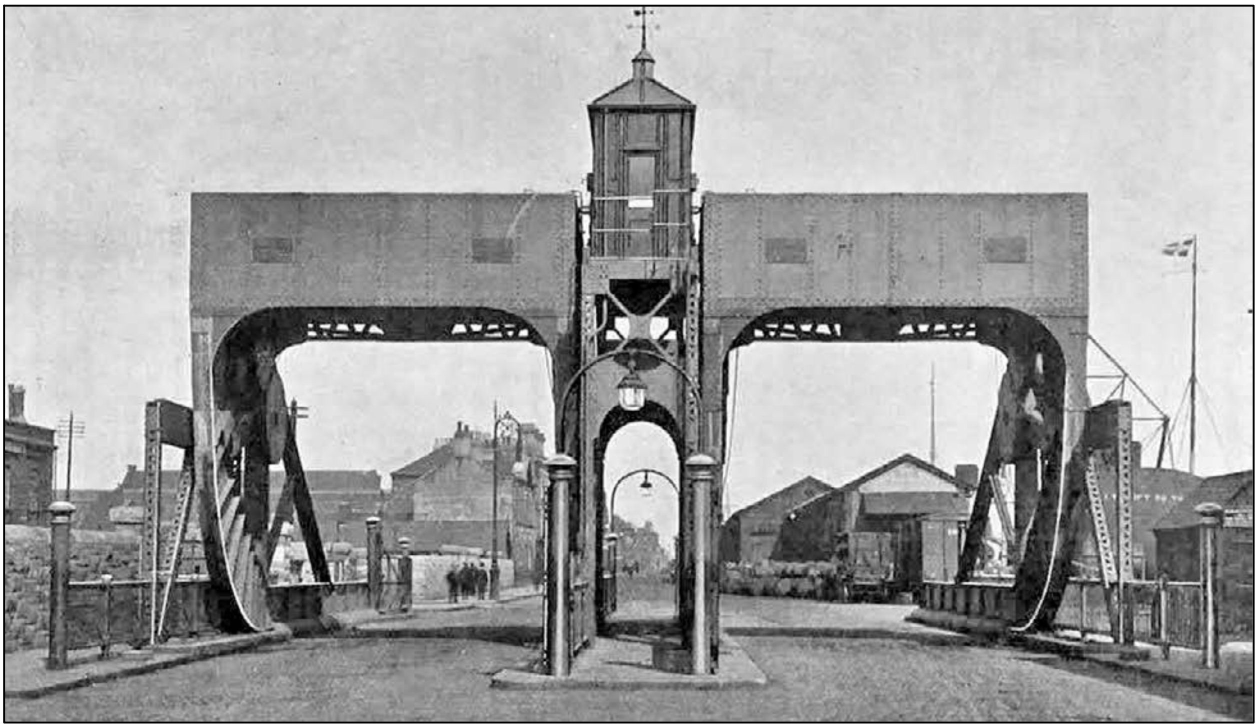


Nº 9
TWIN SCHERZER ROLLING LIFT BRIDGES OVER ENTRANCE TO ROYAL CANAL.
1
PLAN SHEWING THE EXISTING BRIDGE & APPROACHES.
Scale, 1/40 inch to one Foot
GUILD STREET
Midland Gt West. Railway Co
ROYAL CANAL (LOCK)
Midland Great Western Railway Co
BRIDGE
NORTH WALL QUAY
SHED
City of Dublin Co
Ferry Steps
RIVER LIFFEY
2
PLAN SHEWING SITE OF NEW INNER BRIDGE & APPROACHES.
GUILD STREET
Mid Gt West. Ry Co
CANAL
ROYAL
Midland Great Western Railway Co
TEMPORARY FOOT BRIDGE
Foot path removed
EXISTING BRIDGE
NORTH WALL QUAY
SHED
20 TONS HYD. CRANE
RIVER
3
PLAN SHEWING NEW INNER BRIDGE OPEN TO PUBLIC USE & SITE OF NEW OUTER BRIDGE.
GUILD STREET
Midland Gt West. Railway Co
ROYAL CANAL
Midland Great Western Railway Co
BRIDGE OPEN TO PUBLIC USE
NORTH WALL QUAY
SHED
20 TONS HYD. CRANE
Ferry Steps
RIVER
4
PLAN SHEWING NEW OUTER BRIDGE OPEN TO PUBLIC USE
GUILD STREET
Mid. Gt West. Ry Co
ROYAL CANAL LOCK
Midland Great Western Railway Co
INNER BRIDGE
OUTER BRIDGE
NORTH WALL QUAY
SHED
20 TONS HYD. CRANE
No. 7781
Ferry Steps
RIVER
Approved by - John P. Griffith M. Inst. C.E.
Engineer of the Dublin Port & Docks Board
May 5th 1910

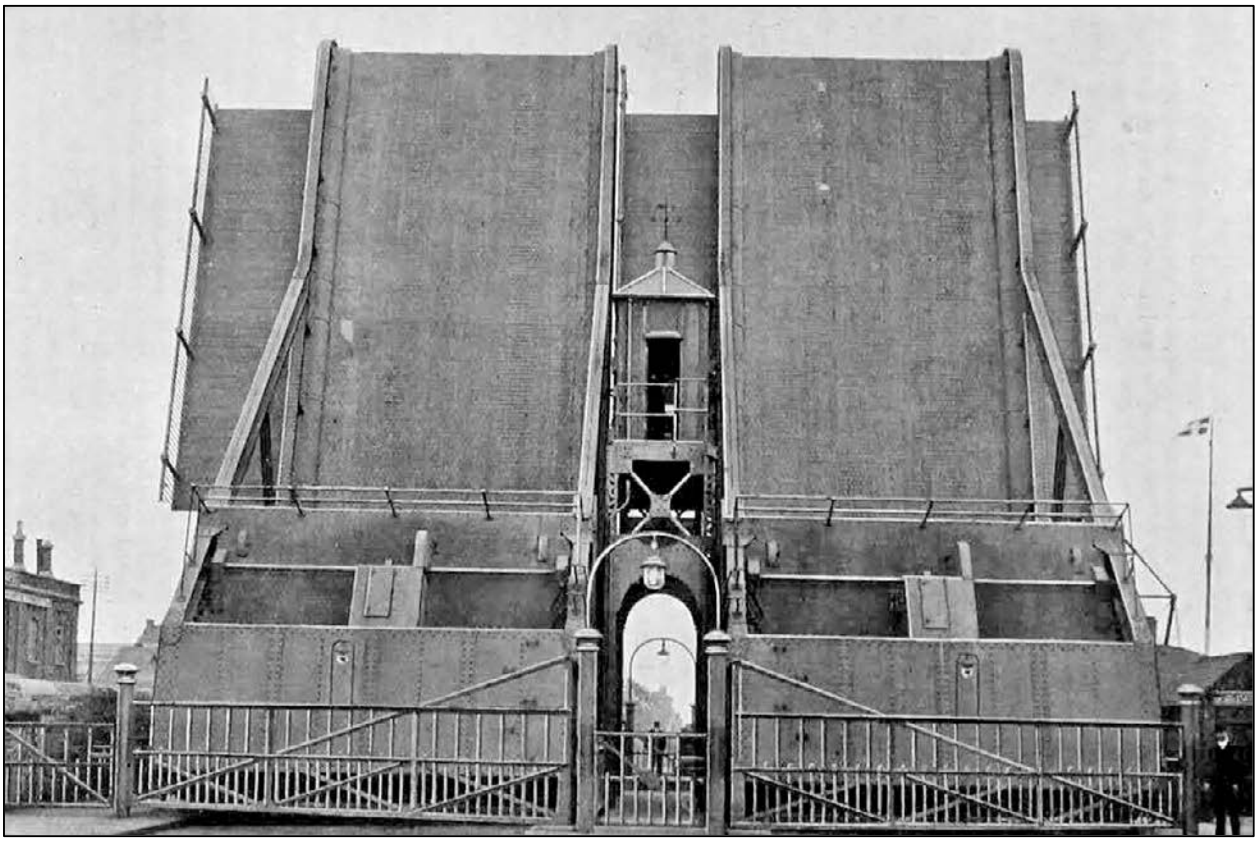
Appendix 2.2: Historical photographs of Scherzer bridges over Royal Canal

1913 View from west towards City end showing both bridges open for road traffic. The motors which powered each of the bridges is visible half-way along each gantry in front of the overhead counterweights. *(Griffith 1913)*

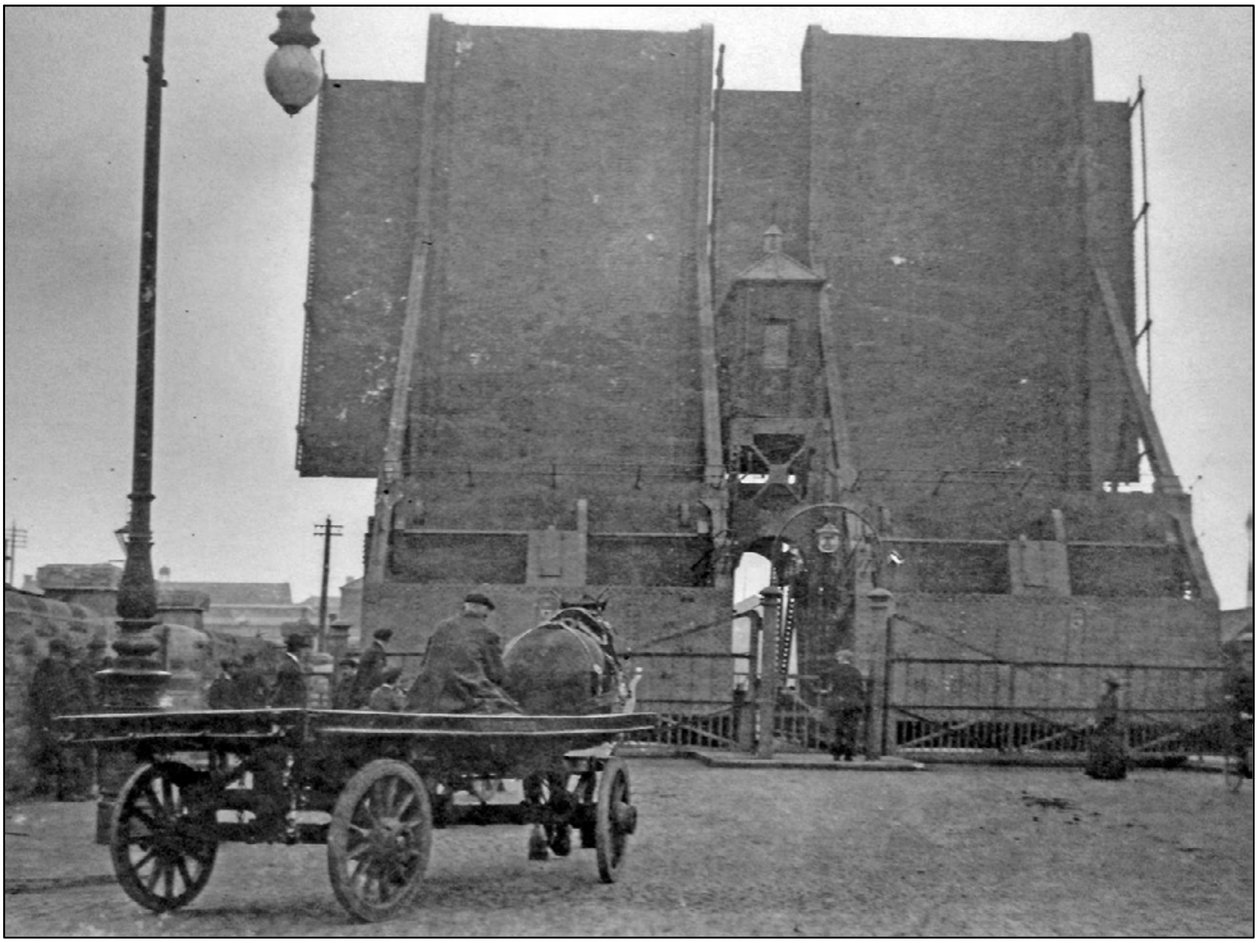
1913 View from west towards City end showing both bridges raised to permit boats to pass through underneath. *(Griffith 1913)*



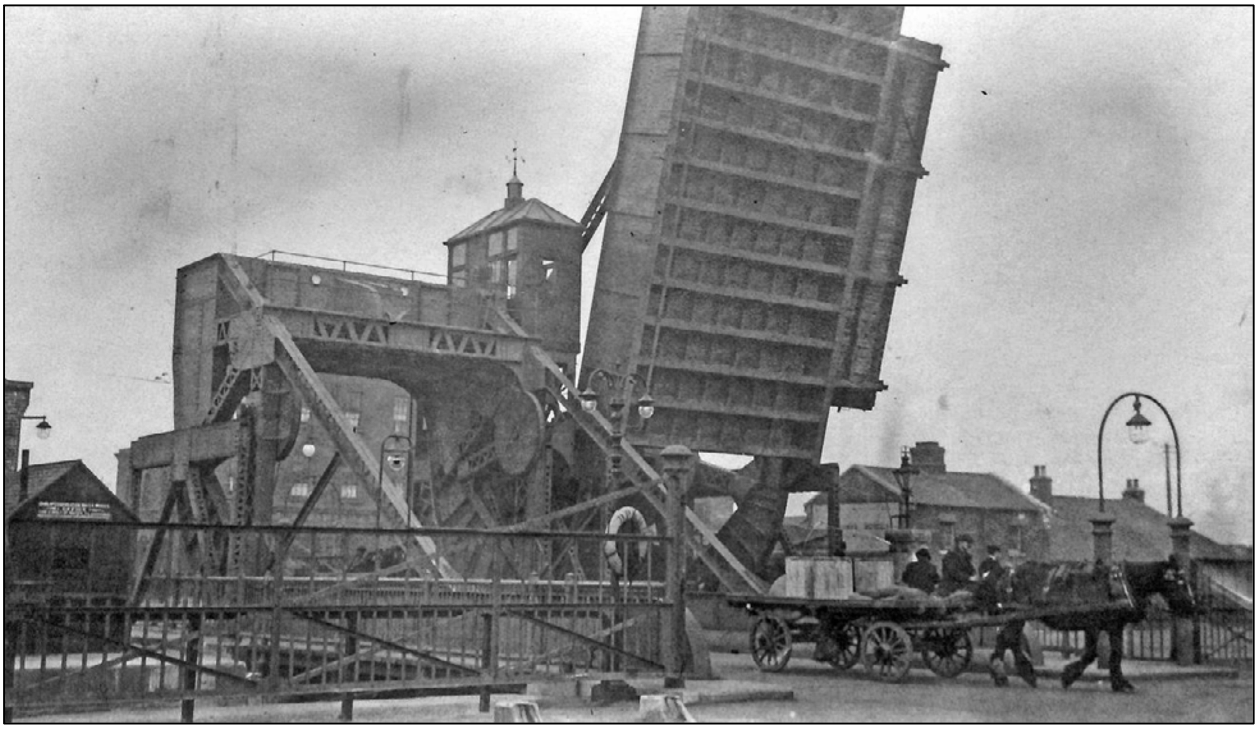
1913 View from to east from City end with both bridges open for road traffic. Note the pair of plaques attached to the faces of the overhead counterweights. *(Griffith 1913)*



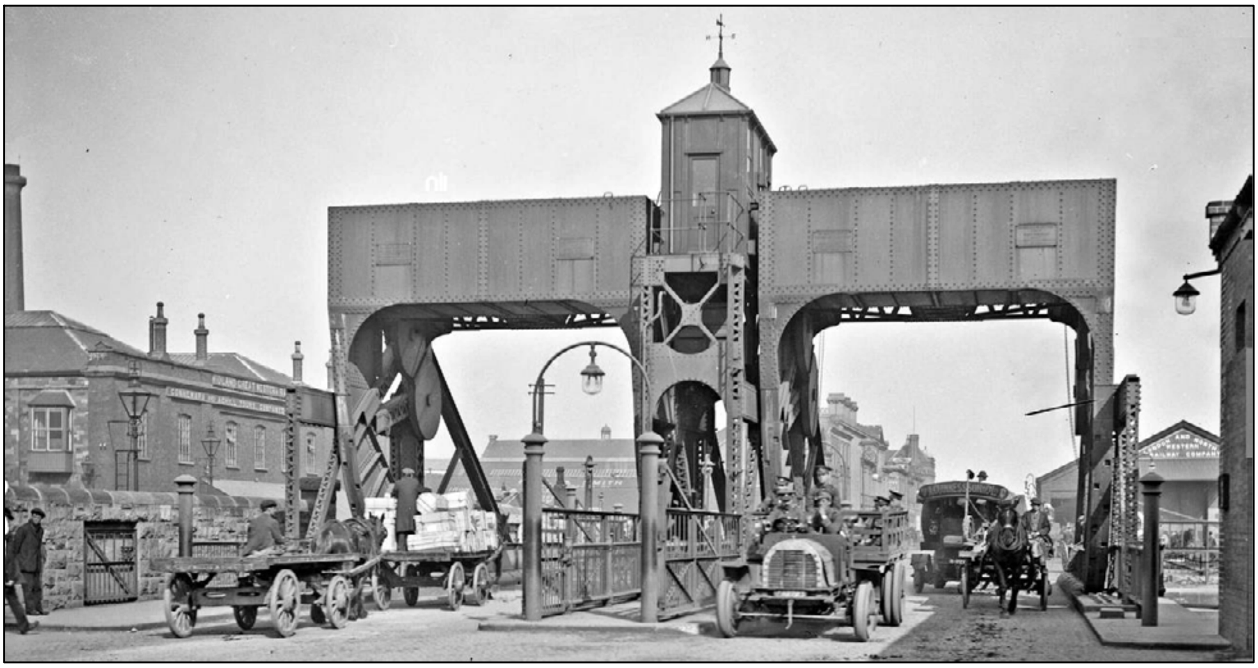
1913 view to east from City end with both bridges lifted. The two counterweights now form a barrier to road traffic in addition to the gates. Note also the housings for the motor and gears on the platform in front of the counterweights. *(Griffith 1913)*



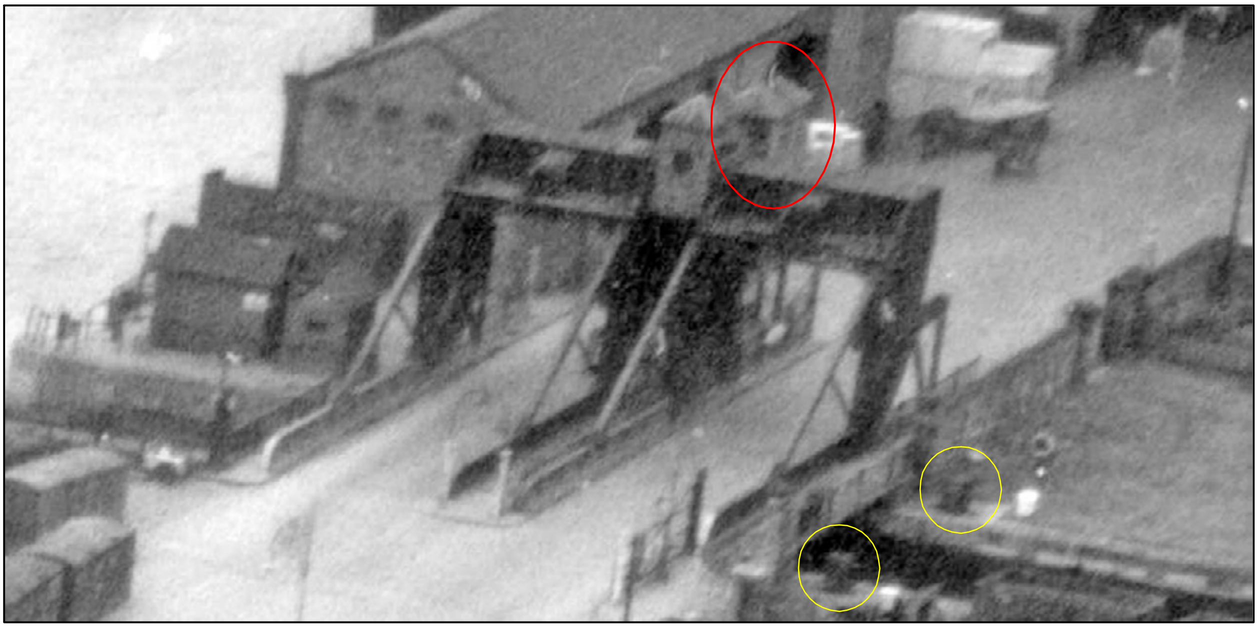
Another view (undated) of the raised spans. *(DPC Archive: Image 121)*



An undated view from SE with the inner span raised and the other closed. *(DPC Archive: Image 122)*



Undated view from City end with vehicular traffic in both directions. *(NLI Lawrence Collection, L_ROY_11592)*



Enlarged aerial view from NE, 1950. The original control cabin platform has now been extended towards the City end and a second cabin erected (circled in red). Note also the two winches (in yellow) which were installed to work the timber lock gates when the Inner Bridge was erected. They still exist but are no longer in use. *(Britain from Above, XAW032929)*