APPENDIX A – Structural Reports Referred

Company	Report Title	Date / Reference
	Structural Report on the Middle Terrace	1983
Stantec	Madeira Drive Terraces Special Inspection	March 2021
HOP Consulting	Brighton Seafront Railings Assessment	January 2001
HOP Consulting	Brighton Seafront Railings Assessment – Report No.2 Supplementary	September 2001
Brighton & Hove City Council	Listed Building Consent	BH2022/02578
Brighton & Hove City Council	Grant of Planning Permission	BH2022/02577

APPENDIX B – Tensile Test Results Cast Iron

Faculty of Science and Engineering

University of Brighton

School Office 01273 642288
Direct line: 642270

School of the Environment
Professor Peter Gardiner
BSc(Eng) MEng PhD CEng FICE
Head of School

Hemsley Orrell Partnership
41 Church Road
Hove
Attn: John Scatchard

Cockcroft Building Moulsecoomb
Brighton BN2 4GJ
Telephone 01273 600900
Fax 01273 642285
E-Mail: environment@brighton.ac.uk

July 17th 2001

Dear Mr Scatchard

Re: Testing of cast iron samples from Brighton Seafront railings

Please find enclosed our report on the tensile tests of the specimens taken from the section of seafront railings.

For comparison purposes you may find the BCSA publication "Historical Structural Steelwork Handbook" a useful guide. Section 6.3 on allowable sresses quotes a value of 6 tons/in2 or 92.7N/mm2 (ultimate) (cast iron in tension) as "conservative". The specimens from the seafront railings are therefore comfortably within this category.

The publication also recommends a safety factor of 5, giving allowable stresses in tension of 18.5N/mm2.

However it could be considered that this level of safety factor is an upper limit and could be adjusted according to the quality of the material.

If you require any further assistance then feel free to contact me. Apologies again for the long delay.

Yours sincerely

Malcolm Dawes

CAST IRON SAMPLES
FROM
BRIGHTON SEAFRONT RAILINGS

REPORT ON
TENSILE TESTS
CARRIED OUT FOR
HEMSLEY ORRELL PARTNERSHIP

Prepared for: John Scatchard
Hemsley Orrell Partnership
41 Church Road
Hove

Prepared by: Malcolm Dawes
Civil Engineering Division
Brighton University

17th July 2001

TESTING OF CAST IRON SAMPLES

SAMPLES SUPPLIED BY HEMSLEY ORRELL PARTNERSHIP
ORIGIN - BRIGHTON SEAFRONT RAILINGS

DESCRIPTION

A section of the vertical post from the railings was supplied by Hemsley Orrell Partnership. Three tensile testing pieces 150mm in length were machined from this sample, each with a reduced circular cross-sectional area over a gauge length of 70mm. The ends of the specimens were threaded to provide anchorage points for testing.

The three specimens were tested in a Mayes tensile testing machine. The load was applied at a uniform rate and the failure load recorded. The results of the testing are detailed on the next page.

TEST RESULTS

SPECIMEN A

Diameter of test piece along gauge length - 7.81mm
Failure load - 5.72kN
Failure stress (based on original csa) - 119N/mm2

SPECIMEN B

Diameter of test piece along gauge length - 7.85mm
Failure load - 5.78kN
Failure stress (based on original csa) - 119N/mm2

SPECIMEN C

Diameter of test piece along gauge length - 7.85mm
Failure load - 5.57kN
Failure stress (based on original csa) - 115N/mm2

Confirmation of results

Malcolm Dawes
Senior Lecturer
Civil Engineering Division
Brighton University

17 July 2001

ALLNOTT 0273-786 044

ALVECHURCH
BIRMINGHAM B48 7QB
Telephone: Redditch 66414 (5 lines)
Telegrams: CIRA BIRMINGHAM TELEX
Telex: 337125

07

BCIRA

Director:
H. MORROGH, C.B.E., D.Sc.(hc), F.I.M., F.I.B.F., F.R.S.
Deputy Director:
I. C. H. HUGHES, M.Sc., F.I.M., F.I.B.F.
Secretary:
T. E. WHITESIDE, M.B.E., F.C.A.

Your ref Order No. SD 31833
Our ref AA/SJF/S.41939

2nd April, 1980

REF. 3595
-8 APR 1980

Mr. Clayton,
Borough Engineers Dept.,
30 Kings Road,
BRIGHTON
BN1 1PD

Dear Mr. Clayton,

I refer to your Order No. SD 31833 and the samples you sent to BCIRA for examination.

The grey cast iron samples were taken from a structural column which had fractured, the structure forming part of an elevated walk-way known as Madeira Terrace. The terrace was built in about 1895 and I understand is occasionally used as a spectator gallery.

The results obtained on the samples at BCIRA were as follows:-

METAL COMPOSITION

TC %	Si %	Mn %	S %	P %
3.33	2.28	0.41	0.08	1.2

MECHANICAL PROPERTIES

Tensile Strength (0.564 diameter test bar)	9.6 tons/in^2 (148 N/mm^2)
Compression Strength (0.564 diameter x 1.128 long bar)	39.8 tons/in^2 (615 N/mm^2)
Youngs Modulus of Elasticity (Sonic bar)	17.2 x 10^6 lb/in^2
Density	7.08 g/cm^3
Hardness	154, 162 HB (10/3000)

Our charge for this service is £52.55. The invoice will follow at the end of the month.

COMMENTS

The British Standard specification for grey cast iron (BS.1452: 1977) quotes grades which are based on the minimum tensile requirements of a separately cast 30 mm test bar. However, a close relationship exists

Scottish Laboratories: BLANTYRE INDUSTRIAL ESTATE GLASGOW G72 0UP Telephone: BLANTYRE 823486 Telex 779471
BCIRA — A Company Limited by Guarantee — Registered in England No 174990 — Registered Office Alvechurch Birmingham.

between chemical composition and tensile strength and based upon this factor it would be expected that the iron would today satisfactorily meet the tensile requirements of grade 150 and possibly grade 180.

These strengths, however, will be found only in these sections that cool at the same rate as the centres of a 30 mm test bar. A grade 180 iron, giving a minimum tensile strength of 180 N/mm^2 in a 30 mm bar would be expected to give a 220 N/mm^2 in a wall section of 20 mm and only about 110 N/mm^2 in a 100 mm section. This is shown clearly in the enclosed figure. Other related properties, compression, hardness and so on, vary correspondingly with the actual tensile roughly in accordance with the appropriate sections.

This is a low strength grade of iron and therefore finds limited use for engineering components requiredfor any significant levels of stress in service. However, it is used even today in light castings for building, municipal and domestic application.

I have enclosed part of Chapter 8 referring to beams and columns taken from "Cast Iron - Physical and Engineering Properties" by Dr. H. T. Angus. (Published by Butterworths). This gives details of slenderness ratios and buckling loads for columns using various grades of cast iron. The samples we have examined would be comparable to the soft grade of iron mentioned in the text. I have also enclosed from the same book appropriate design stresses and factors of safety for grey cast iron.

Yours sincerely,

A Alderson

A. ALDERSON

Enc. Pages 41, 476 - 483, 451 - 459 - Book by Dr. H. T. Angus

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Total Quality. Assured.

UKAS TESTING 0084

NDT Services Limited
99 Victory Road
Derby
DE24 8EL

Tel +44 1332 275820
ndt@intertek.com
intertek.com

CERTIFICATE OF TEST

Customer	: CAST IRON WELDING SERVICES LTD Samson Road Hermitage Industrial Estate Coalville Leicester LE67 3FP	**Order No**	: 48924
		W/O No	: -
		Inc Rel Note	: -
		Report No	: 0052319/001/E1
		Issue No	: 1
		Test Date	: 31-Mar-23
FAO	: Peter Palmer	**Page**	: 1 of 1

Identification : Tensiles 1 to 12
Description : Tensile Test
Other Info : -
Quantity : 1
Material : Cast Iron
Batch/Cast No : WO No: 35293 **Serial No:** -
Specification/Procedure : BS EN ISO 6892-1:2019
Acceptance Standard : Factual Report

Tensile Test

Specification : BS EN ISO 6892-1:2019 **Procedure :** MCP64 / MCP76
Type : Round **Temperature :** 23 °C
Plant No : 2570 **Gauge Length :**
Test Rate : A24 **UNC ± :** Rm/Rp 10 N/mm². Z 1%. A 0.5%
Inspector Name : Gavin Steven **Cert Comment :**

Results	**Dimensions (mm)**		**Proof Stress (MPa)**		**Tensile Strength (MPa)**	**Ratio of Yield to Tensile**	**Elongation (%)**	**Reduction of area (%)**	**Comments**	**Status**
Sample Details	**Diameter**	**Area**								
T1	10.06	79.50	-	-	161	-	-	-	-	N/A
T2	10.11	80.29	-	-	176	-	-	-	-	N/A
T3	10.02	78.86	-	-	158	-	-	-	-	N/A
T4	10.00	78.55	-	-	155	-	-	-	-	N/A
T5	10.12	80.45	-	-	147	-	-	-	-	N/A
T6	10.02	78.86	-	-	142	-	-	-	-	N/A
T7	10.02	78.86	-	-	154	-	-	-	-	N/A
T8	10.07	79.65	-	-	175	-	-	-	-	N/A
T9	9.86	76.37	-	-	165	-	-	-	-	N/A
T10	10.04	79.18	-	-	142	-	-	-	-	N/A
T11	10.06	79.50	-	-	158	-	-	-	-	N/A
T12	5.32	22.23	-	-	159	-	-	-	-	N/A

Comments

Tested in accordance with clients order requirements.

Unless otherwise stated, statements of conformity were made using the decision rule of 'simple acceptance'.
The reported expanded uncertainty (U) is based on a standard uncertainty multiplied by a coverage factor of K=2, providing a level of confidence of approximately 95%

For **ndt services limited**

NDT 108

Issue Date: 31-Mar-23 **Gavin Steven**

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APPENDIX C – Extract of Historical Steelwork Handbook

HISTORICAL STRUCTURAL STEELWORK HANDBOOK

Properties of U.K. and European Cast Iron, Wrought Iron and Steel Sections including Design, Load and Stress Data since the Mid 19th Century

Compiled and Written by

W. Bates CEng FIStructE

Published by

4 Whitehall Court, Westminster, London SW1A 2ES
Telephone: 071-839 8566

British Library Cataloguing in Publication Data

UDC 624.94.014.2
ISBN 0 85073 015 5

Bates, W.
Historical structural steelwork handbook.
1. Commercial buildings — Handbooks, manuals, etc.
2. Structural frames — Handbooks, manuals, etc.
3. Columns, Iron and steel — Handbooks, manuals etc.
4. Trusses — Handbooks, manuals, etc.
5. Industrial buildings — Handbooks, manuals, etc.
I. Title
693' .71 TH4311

ISBN 0-85073-015-5

The British Constructional Steelwork Association Ltd (BCSA) is the national representative organisation for the Constructional Steelwork Industry: its Member companies undertake the design fabrication and erection of steelwork for all forms of construction in building and civil engineering. Associate Members are those principal companies involved in the purchase, design or supply of components, materials, services, etc. related to the industry. The princpal objectives of the Association are to promote the use of structural steelwork; to assist specifiers and clients; to ensure that the capabilities and activities of the industry are widely understood and to provide members with professional services in technical, commercial, contractual and quality assurance matters

This book is one of a series of publications produced by the BCSA to give practical advice and guidance to all personnel engaged in working with structural steelwork in the construction industry. For details of other publications contact the BCSA.

1st Edition April 84 1M
2nd Impression March 87 0.4M
3rd Impression April 90 0.3M
4th Impression April 91 0.5M
Printed by The Chameleon Press Limited, 5-25 Burr Road, London SW18 4SG.

PREFACE

One of the most regular questions the BCSA is asked as part of its advisory service to the public is to identify a steel section from its accessible dimensions and suggest ways of determining its load bearing capacity.

This publication has been prepared to enable clients, architects, and engineers to have a comprehensive guide to the various factors that need to be considered in assessing the load bearing capacity of an existing steel framed building. The text is supplemented with advice on how to proceed with such structural investigations and deriving additional data by simple calculation.

The author was the Chief Structural Engineer of Redpath Dorman Long and has had wide experience of this type of work.

This book can be summarised as being a guide to over a century of building in iron and steel sections containing information on properties of materials, profiles, loads and stresses.

ACKNOWLEDGEMENTS

In compiling this work the author has received help and encouragement from sources too numerous to mention in detail. However special reference must be made to:

British Standards Institution
Institution of Structural Engineers
London County Council
British Steel Corporation

to former colleagues and to the very many people with whom he serves on technical committees both in this country, and in Europe. Without their help so freely given this publication could not have been compiled in its present form.

Copies of current British Standards can be obtained from the British Standards Institution, Linford Wood, Milton Keynes MK14 6LE.

CONTENTS

SECTION NO. 6 Design stresses

6.1 Introduction

As no official requirements were available prior to the early part of this century, working stresses were very much left to the engineer to settle for himself.

It was of course fully understood that the ultimate or, breaking strengths of materials must be appreciably reduced before being used in design, by dividing by:—

(a) A factor of safety

(b) Factors depending upon the manner in which the member in question was to be used.

The factor of safety was usually fixed having regard to the reliability of the material and the relationship between the dead and the live load increments.

The Dorman Long and Company 1887 Handbook, gave safe distributed loads on beams at 1/3rd, 1/4th and 1/5th the breaking strain, suggesting factors of safety of 3, 4 or 5 were in common use about that time.

As Wrought Iron and Steel were generally accepted as being more consistant than Cast Iron, lower factors of safety were adopted for the former than the latter.

It must be remembered that factors of safety are related to the ultimate strength of a material, but some time before this ultimate is reached the material will have become unservicable due to yield or other changes in state occuring. The true margin of safety is therefore much lower than the factor itself implies.

The second factor which must be observed in arriving at design stresses is the tendancy to buckle rather than fracture under direct compression. This is particularly true of columns where long slender columns can fail by buckling with insignificant direct load, and equally true, of compression flanges of beams when these are not adequately restrained laterally.

Since the turn of the century represented major changes in design rules etc the subject of design stresses will be covered in two separate periods, before 1900 in 6.3 and 6.4 and after 1900 in 6.5 and 6.6.

The stresses in this book relate to elastic allowable, sometimes also referred to as permissable or working stress methods of design. Care should be taken when attempting to use the information herein with other design methods viz. plastic design and limit state design.

6.2 Symbols

During the period under review in this publication a variety of symbols have been used to represent the same quantity. In the interests of uniformity the following will be assigned to the different items shown:—

P	=	Breaking load
A	=	Area of section
I	=	Moment of Inertia
Z	=	Modulus of Section
r	=	Radius of Gyration
L	=	Actual length
ℓ	=	Effective length — sometimes called equivalent length
d	=	smallest dimension of section
c	=	Slenderness Ratio = ℓ/r or L/r
pc	=	allowable axial stress in compression
pt	=	allowable axial stress in tension
pbc	=	allowable bending stress in compression
pbt	=	allowable bending stress in tension
pq	=	allowable shear stress
M	=	material constant in Goodmans formula
N	=	shape constant in Goodmans formula
E	=	Young's Modulus of Elasticity
K	=	Factor of Safety
p	=	safe compressive stress for short length of material sometimes called the squash load.
a	=	Rankine's material constant
e	=	American material constant
BM	=	Bending Moment
D	=	overall depth of section
W	=	applied load
x	=	lever arm
yt, yc	=	edge distances from centroid

6.3 Allowable stresses in beams before year 1900

6.3.1 Cast Iron Beams

In section 2.2 the average values of the ultimate strength of good quality cast iron are given as:—

6 tons/sq inch (92.7 N/mm^2) in tension
32 tons/sq inch (494.2 N/mm^2) in compression
8 tons/sq inch (123.6 N/mm^2) in shear

Whilst conservative averages were quoted it was still considered desirable to use a safety factor of 5, which gives the following allowable stresses:—

pbt or pt	=	1.2 tons/sq inch (18.5 N/mm^2)
pbc	=	6.4 tons/sq inch (98.8 N/mm^2)
pq	=	1.6 tons/sq inch (24.7 N/mm^2)

Though it is not specifically mentioned pbc must be reduced if necessary to allow for lateral instability of the compression flange but this did not often occur from the nature of floor construction in that era.

6.3.2 Wrought Iron Beams

The figures quoted in 1879 for the ultimate strength values of wrought iron, which were generally accepted were:—

21 tons/sq inch (324.3 N/mm^2) in tension
16 tons/sq inch (247.1 N/mm^2) in compression
20 tons/sq inch (308.9 N/mm^2) in shear

A factor of safety of 4 was considered as satisfactory which gives allowable stresses of:—

pbt or pt	=	5.25 tons/sq inch (81.1 N/mm^2)
pbc	=	4.0 tons/sq inch (61.8 N/mm^2)
pq	=	5.0 tons/sq inch (77.2 N/mm^2)

It has been reported that when the Forth Railway Bridge was being designed the use of steel instead of wrought iron was advocated "as the design stress could be increased from 5 tons/sq inch (77.2 N/mm^2) to 6.5 tons/sq inch (100.4 N/mm^2)". This suggests the use of 5 tons/sq inch in both tension and compression especially as it is stated that the ductile nature of the metal made observations on compressive strength difficult.

It is recommended therefore that when checking Wrought Iron beams a figure of 5 tons/sq inch (77.2 N/mm^2) should be used for pbt and pbc provided of course that the compression flange is adequately restrained laterally.

6.3.3 Mild Steel Beams

Mild steel beams began to replace wrought iron beams soon after 1850 and by the year 1900 had almost entirely taken over from the latter.

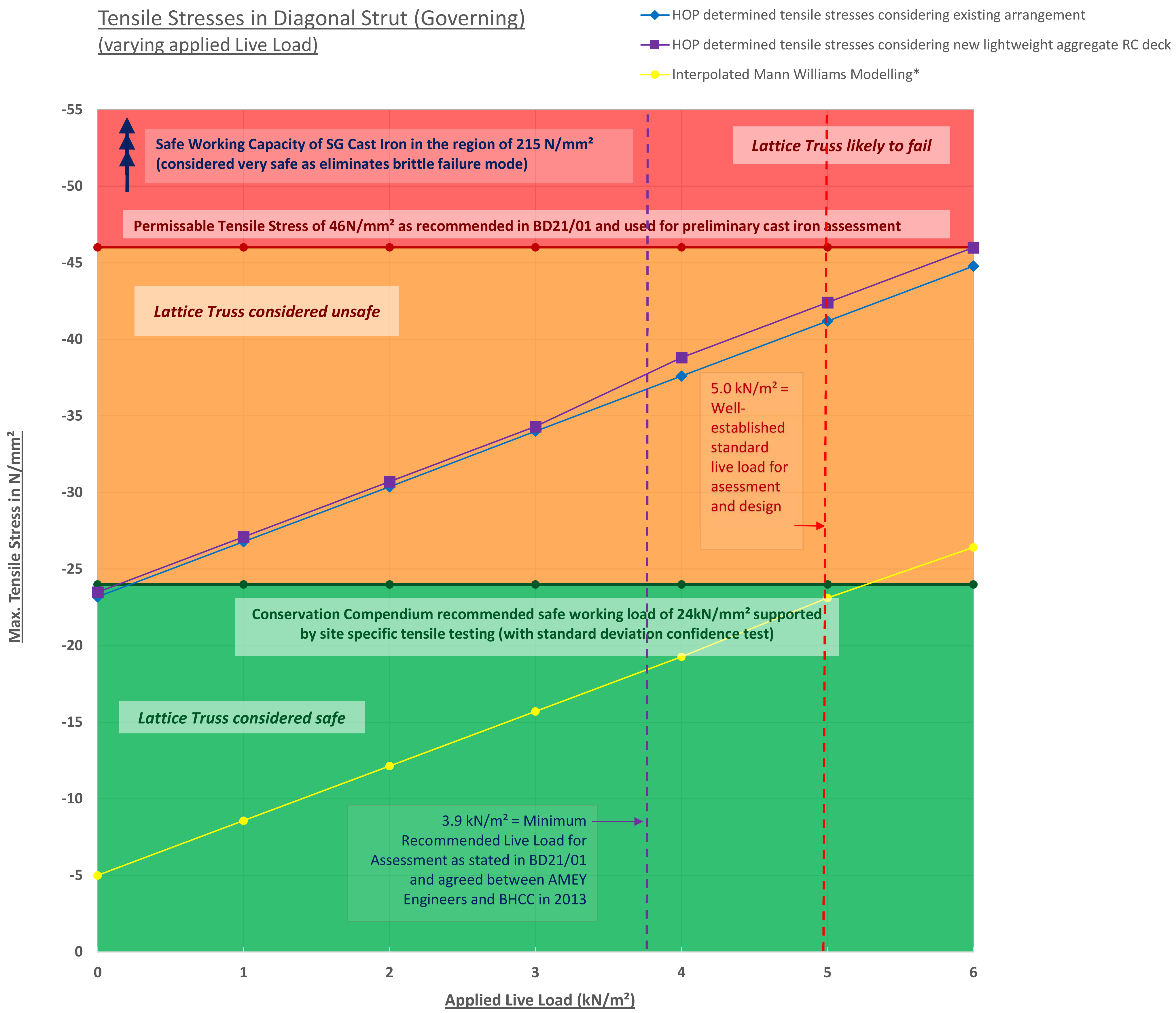
Figures quoted in 1879 for the average ultimate strength of mild steel are:—

28 to 32 tons/sq inch (432.4 to 494.2 N/mm^2) in tension
30 tons/sq inch (463.3 N/mm^2) in compression
24 tons/sq inch (370.7 N/mm^2) in shear

Using a factor of safety of 4 this gives allowable stresses as follows:—

pbt and pt	=	7 tons/sq inch (108.1 N/mm^2)
pbc	=	7½ tons/sq inch (115.8 N/mm^2)
pq	=	6 tons/sq inch (92.7 N/mm^2)

APPENDIX D – Truss Sensitivity Analysis Summary



*(interpolated from Tensile Stress of 23.12
N/mm² when applied live load = 5 kN/m²

APPENDIX E– Iron reuse flow diagram

Madeira Terraces Refurbishment - Process for Assessment of (historical) Iron & steelwork for Reuse

This flowchart summarises the key processes for the identification and refurbishment of substructure elements for reuse.

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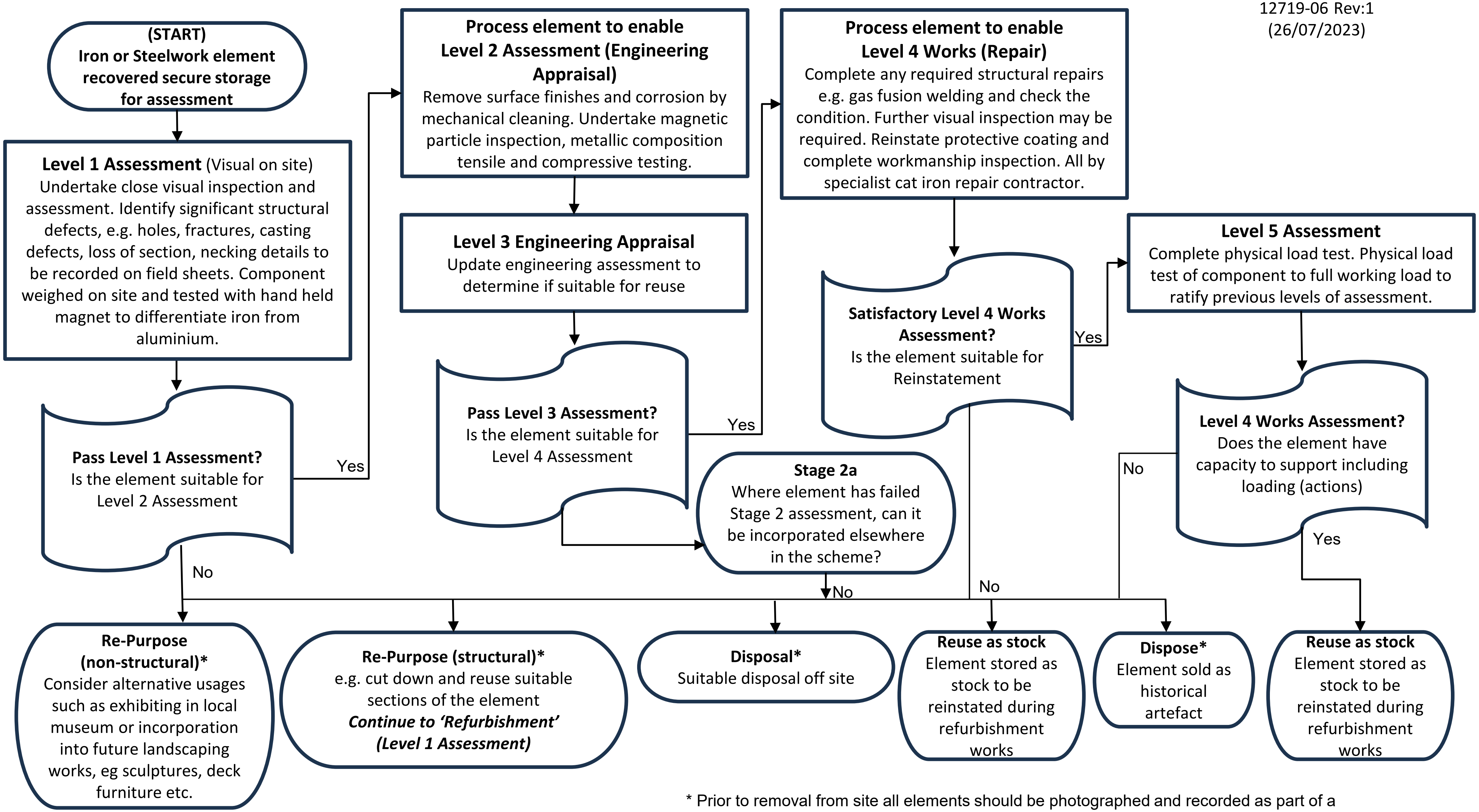
12719-06 Rev:1
(26/07/2023)



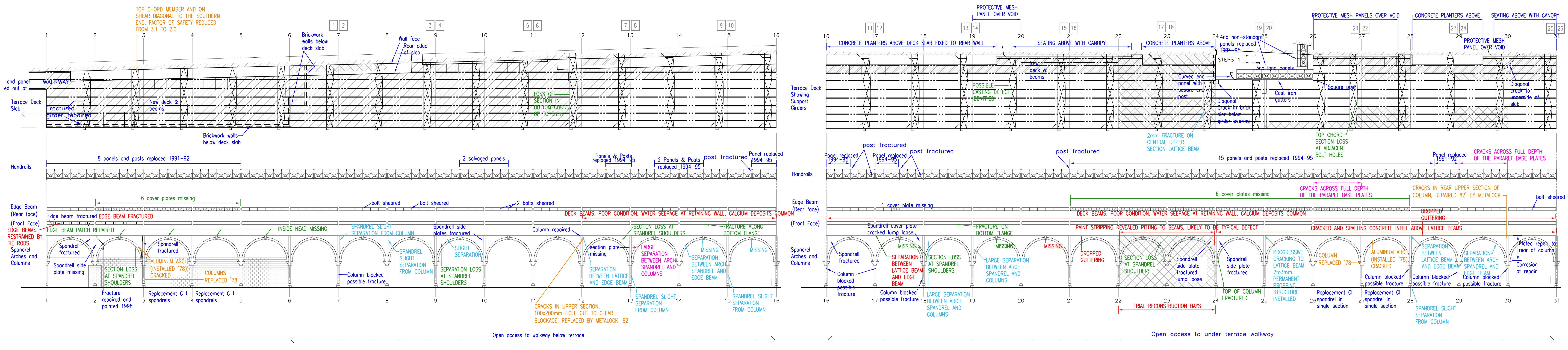
* Prior to removal from site all elements should be photographed and recorded as part of a Historical Building Record.

** For example, has a satisfactory dry film paint thickness been achieved and specialist cast iron repair contractors QA to achieve warrantee.

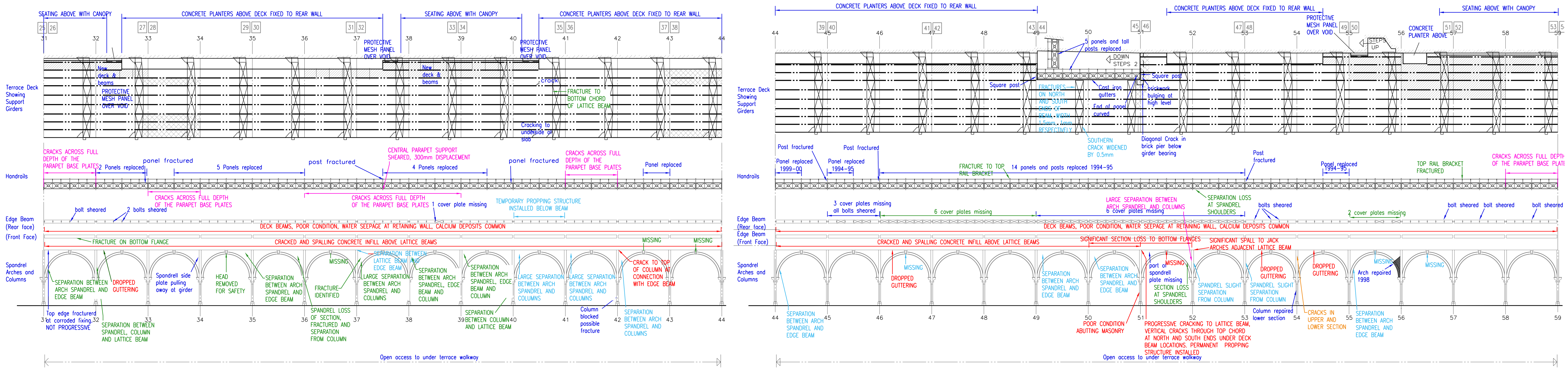
APPENDIX F – Historical Defects Log

Project/Task No. 12719/06 Scale: AS SHOWN ORIGINAL DRAWING SIZE A1

KEY PLAN
(NTS)



PLAN AND ELEVATIONS
(GRIDLINES 1–31)
(1:200)



PLAN AND ELEVATIONS
(GRIDLINES 31–59)
(1:200)

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(iii) Any discrepancy on this drawing is to be reported immediately to the partnership for clarification.

(iv) The contractor is responsible for all temporary works and for the stability of the works in progress.

(v) Defect observations noted on this drawing are those previously made by others, are for information purposes only and are not intended to be exhaustive. HOP does not take responsibility for the accuracy of these observations.

LEGEND

- OBSERVATIONS MADE BY M.F.D Clayton 1983
- OBSERVATIONS MADE BY OTHERS BETWEEN'92 AND '04
- OBSERVATIONS MADE BY HOP FOR '08 '10 AND '2020
- OBSERVATIONS MADE BY AMEY BETWEEN '12 AND '14
- OBSERVATIONS MADE BY PETER BRETT BETWEEN '15 AND '19
- OBSERVATIONS MADE BY STANTEC BETWEEN '20 AND '21
- POTENTIAL TARGET AREA FOR MT30

NOTE:

THESE DRAWINGS ARE INTENDED TO PROVIDE A SUMMARY OF KNOWN PREVIOUS FINDINGS BY OTHERS, COLLATED FROM SOURCES AVAILABLE TO HOP AT THE TIME OF PRODUCTION. THESE DRAWINGS ARE BY NO MEANS EXHAUSTIVE AND, GIVEN THE KNOWN POOR CONDITION OF THE STRUCTURE, IT IS HIGHLY LIKELY THAT FURTHER HIDDEN DEFECTS AND HISTORIC REPAIRS ARE PRESENT. THESE DRAWINGS CONSIDER THE ACCESSIBLE MADEIRA TERRACE SUPERSTRUCTURE ONLY.

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NOTE:

DUE TO MAGNITUDE OF DEFECTS NOTED HISTORICALLY, NOT ALL DEFECTS TO RAILS AND BRACING HAS BEEN INCLUDED HERE

1:20 0 0.2m 0.4m 0.6m 0.8m 1m   1:50 0 0.5m 1m 1.5m 2m 2.5m   1:100 0 1m 2m 3m 4m 5m

Description	By	Aprvd.	Date	Rev.
ISSUED FOR INFORMATION	DJP	LRS	07.06.23	P1

ISSUED FOR INFORMATION

Title
PLAN SHOWING INITIAL CONDITION ASSESSMENT – SHEET 1of3

Project
MTR PROJECT
MADEIRA TERRACES, BRIGHTON

Client
BHCC

HOP
CONSULTING CIVIL AND STRUCTURAL ENGINEERS
HOP House, 41 Church Road
Hove, East Sussex BN3 2BE
www.hop.uk.com
ask@hop.uk.com
+44 (0)1273 223900

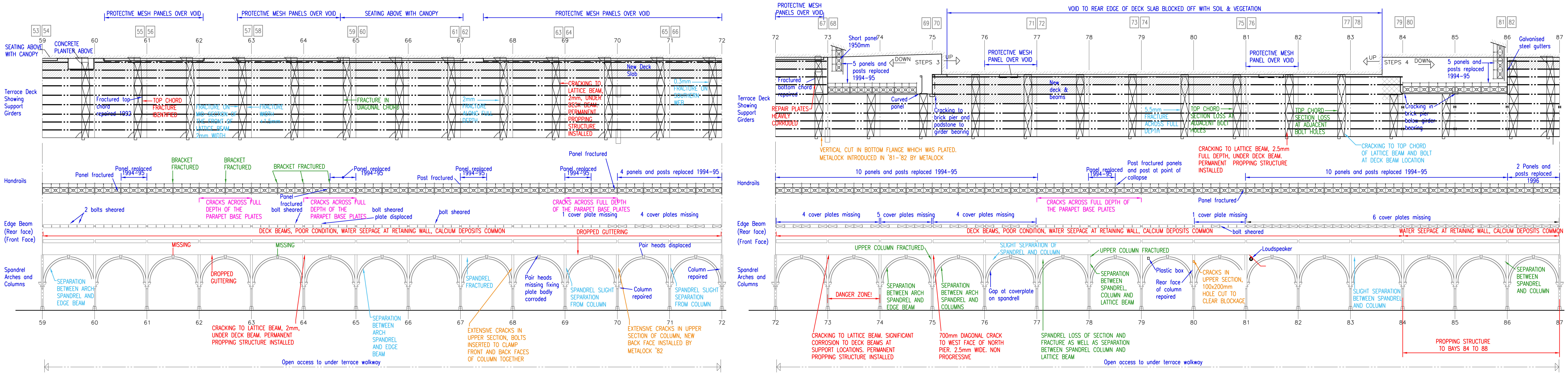
Drawing No. MTR–HOP–01–XX–DR–S–S001
Status S2
Rev. P1

Project/Task No. 12719/06 Scale: AS SHOWN ORIGINAL DRAWING SIZE A1

SHEET 2

KEY PLAN

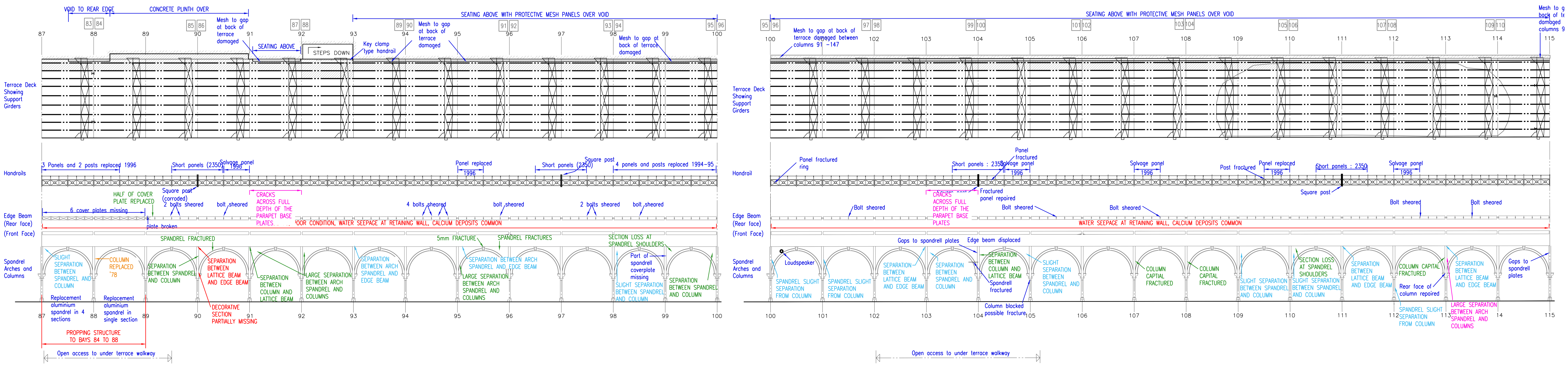
(NTS)



PLAN AND ELEVATIONS

(GRIDLINES 59–87)

(1:200)



PLAN AND ELEVATIONS

(GRIDLINES 87–115)

(1:200)

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- OBSERVATIONS MADE BY HOP FOR '08 '10 AND '2020
- OBSERVATIONS MADE BY AMEY BETWEEN '12 AND '14
- OBSERVATIONS MADE BY PETER BRETT BETWEEN '15 AND '19
- OBSERVATIONS MADE BY STANTEC BETWEEN '20 AND '21
- POTENTIAL TARGET AREA FOR MT30

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1:20 0 0.2m 0.4m 0.6m 0.8m 1m — 1:50 0 0.5m 1m 1.5m 2m 2.5m — 1:100 0 1m 2m 3m 4m 5m

P:\PROJECTS\12719 Madeira Terrace\Drawings\HOP\Task 9\12719-06 Defects Darius Ju-Pierre

Description	By	Aprvd.	Date	Rev.
ISSUED FOR INFORMATION	DJP	LRS	07.06.23	P1

ISSUED FOR INFORMATION

Title: PLAN SHOWING INITIAL CONDITION ASSESSMENT – SHEET 2of3

Project: MTR PROJECT MADEIRA TERRACES, BRIGHTON

Client: BHCC

HOP CONSULTING CIVIL AND STRUCTURAL ENGINEERS
HOP House, 41 Church Road
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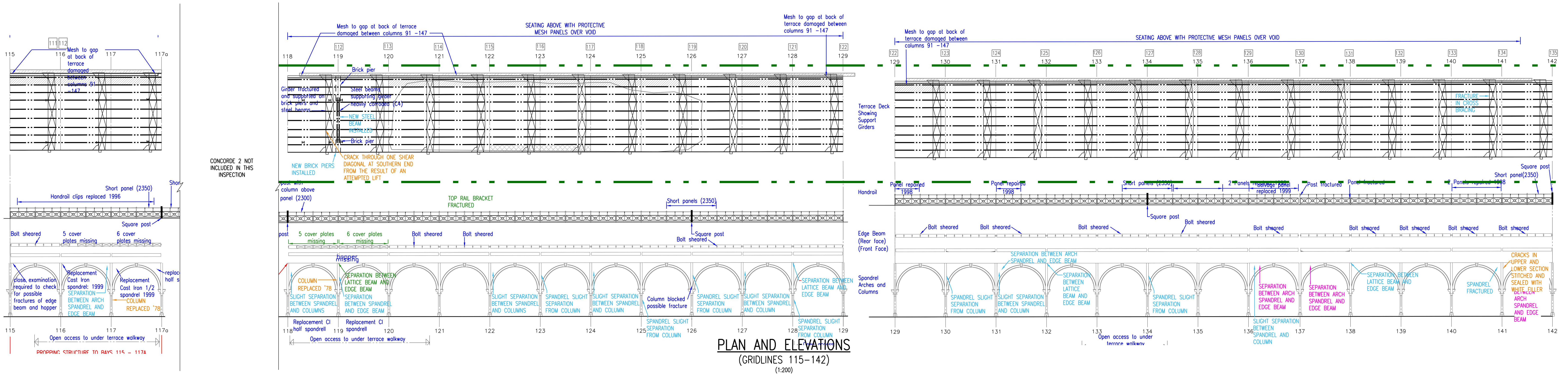
Drawing No. MTR–HOP–06–XX–DR–S–S002 Status S2 Rev. P1

Project/Task No. 12719/06 Scale: AS SHOWN ORIGINAL DRAWING SIZE A1

KEY PLAN

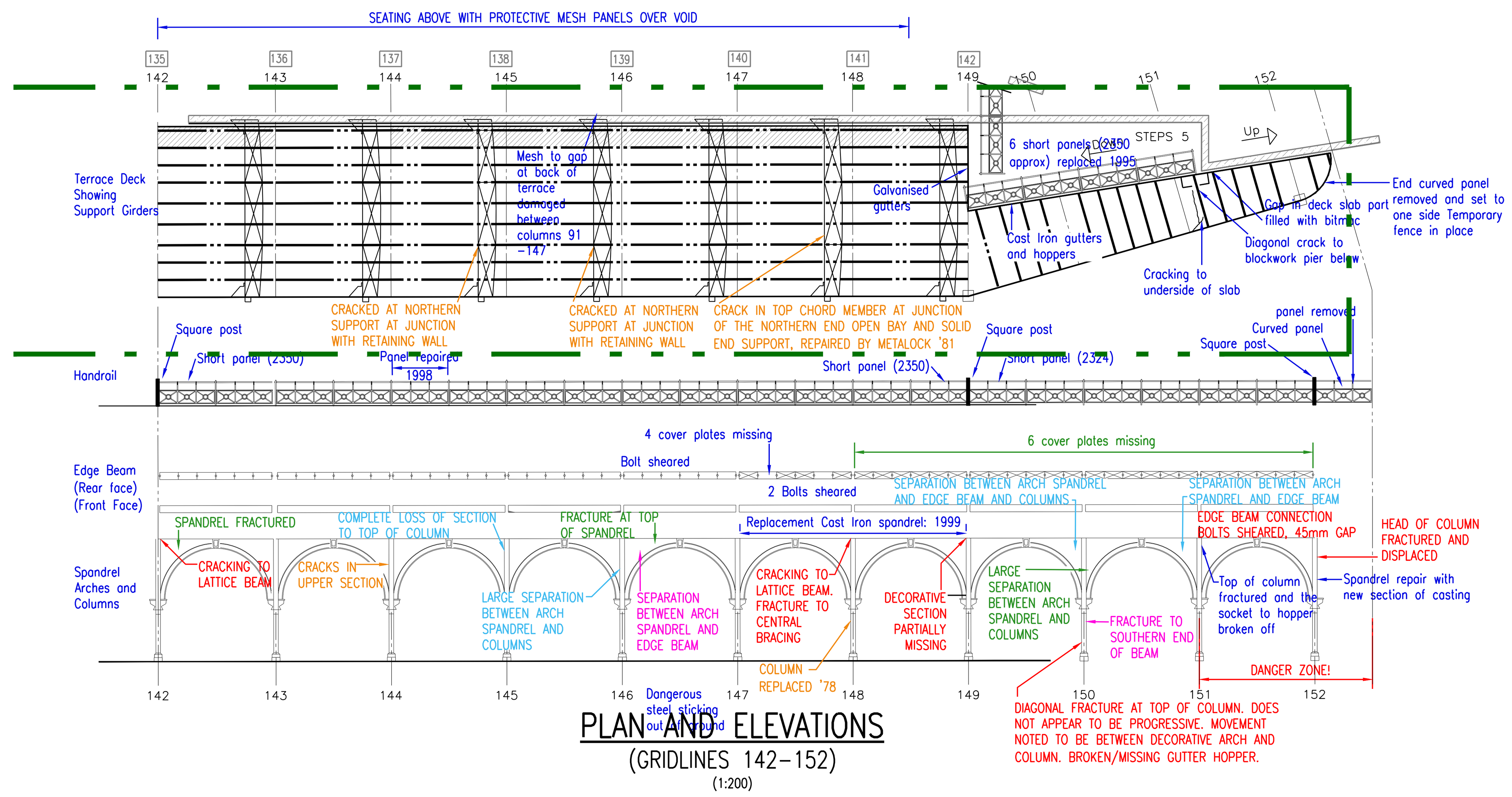
(NTS)



PLAN AND ELEVATIONS

(GRIDLINES 115–142)

(1:200)



PLAN AND ELEVATIONS

(GRIDLINES 142–152)

(1:200)

LEGEND

(orange)	OBSERVATIONS MADE BY M.F.D Clayton 1983
(blue)	OBSERVATIONS MADE BY OTHERS BETWEEN'92 AND '04
(red)	OBSERVATIONS MADE BY HOP FOR '08 '10 AND '2020
(green)	OBSERVATIONS MADE BY AMEY BETWEEN '12 AND '14
(light blue)	OBSERVATIONS MADE BY PETER BRETT BETWEEN '15 AND '19
(magenta)	OBSERVATIONS MADE BY STANTEC BETWEEN '20 AND '21
(green dash-dot line)	POTENTIAL TARGET AREA FOR MT30

1. GENERAL

(i) This drawing is not to be scaled, work to figured dimensions only, confirmed on site.

(ii) This drawing is to be read in conjunction with all relevant architectural drawings, detailed specifications where applicable and all associated drawings in this series.

(iii) Any discrepancy on this drawing is to be reported immediately to the partnership for clarification.

(iv) The contractor is responsible for all temporary works and for the stability of the works in progress.

(v) Defect observations noted on this drawing are those previously made by others, are for information purposes only and are not intended to be exhaustive. HOP does not take responsibility for the accuracy of these observations.

NOTE:

THESE DRAWINGS ARE INTENDED TO PROVIDE A SUMMARY OF KNOWN PREVIOUS FINDINGS BY OTHERS, COLLATED FROM SOURCES AVAILABLE TO HOP AT THE TIME OF PRODUCTION. THESE DRAWINGS ARE BY NO MEANS EXHAUSTIVE AND, GIVEN THE KNOWN POOR CONDITION OF THE STRUCTURE, IT IS HIGHLY LIKELY THAT FURTHER HIDDEN DEFECTS AND HISTORIC REPAIRS ARE PRESENT. THESE DRAWINGS CONSIDER THE ACCESSIBLE MADEIRA TERRACE SUPERSTRUCTURE ONLY.

NOTE:

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NOTE:

DUE TO MAGNITUDE OF DEFECTS NOTED HISTORICALLY, NOT ALL DEFECTS TO RAILS AND BRACING HAS BEEN INCLUDED HERE

1:20 0 0.2m 0.4m 0.6m 0.8m 1m

1:50 0 0.5m 1m 1.5m 2m 2.5m

1:100 0 1m 2m 3m 4m 5m

Description	By	Aprvd.	Date	Rev.
ISSUED FOR INFORMATION	DJP	LRS	07.06.23	P1

ISSUED FOR INFORMATION

Title: PLAN SHOWING INITIAL CONDITION ASSESSMENT – SHEET 3of3

Project: MTR PROJECT MADEIRA TERRACES, BRIGHTON

Client: BHCC

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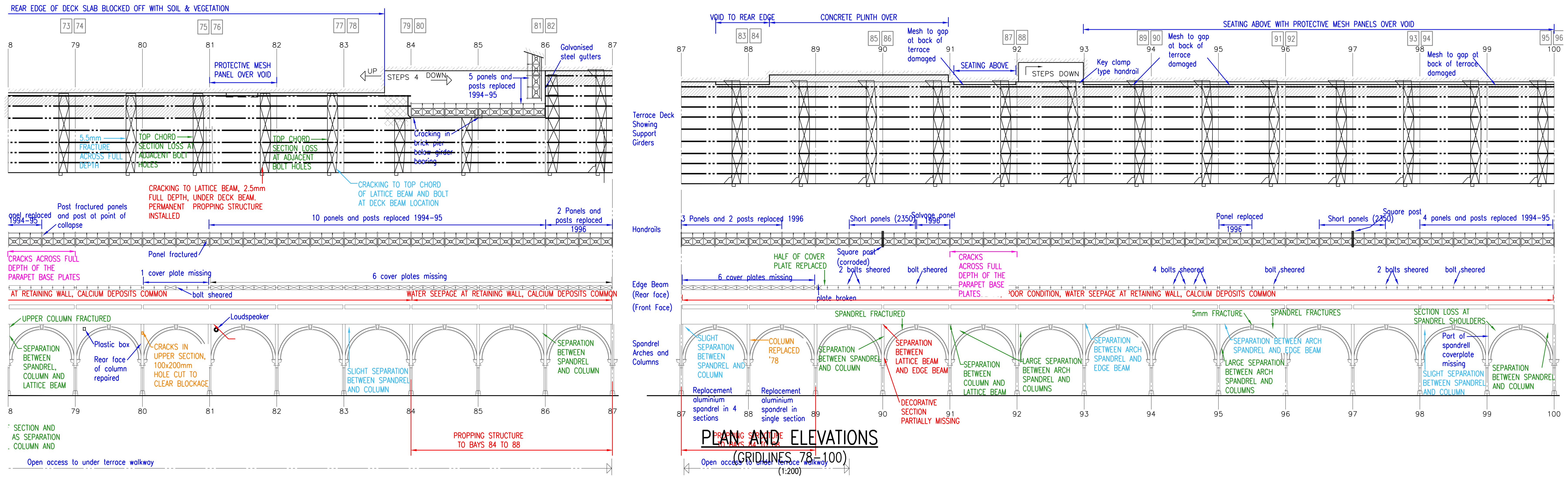
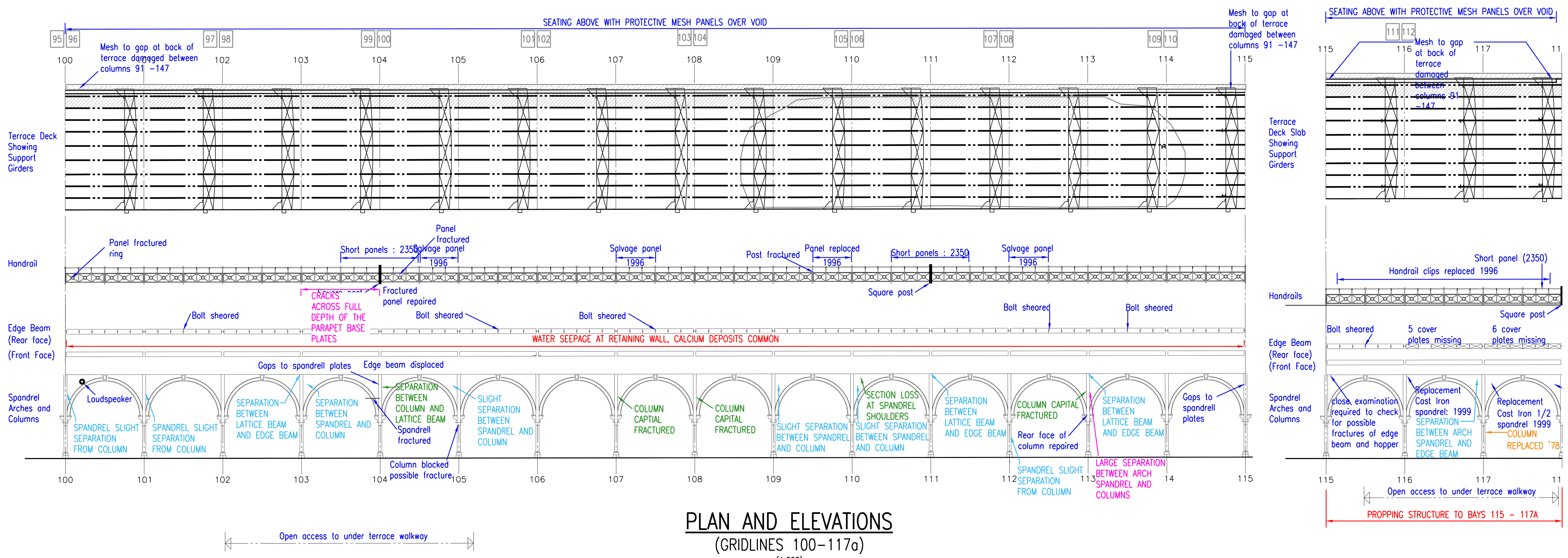
Drawing No. MTR–HOP–01–XX–DR–S–S003 Status S2 Rev. P1

Project/Task No. 12719/06 Scale: AS SHOWN ORIGINAL DRAWING SIZE A1

KEY PLAN
(NTS)



PLAN AND ELEVATIONS
(GRIDLINES 78-100)
(1:200)



PLAN AND ELEVATIONS
(GRIDLINES 100-117a)
(1:200)

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(v) Defect observations noted on this drawing are those previously made by others, are for information purposes only and are not intended to be exhaustive. HOP does not take responsibility for the accuracy of these observations.

LEGEND

- OBSERVATIONS MADE BY M.F.D Clayton 1983
- OBSERVATIONS MADE BY OTHERS BETWEEN'92 AND '04
- OBSERVATIONS MADE BY HOP FOR '08 '10 AND '2020
- OBSERVATIONS MADE BY AMEY BETWEEN '12 AND '14
- OBSERVATIONS MADE BY PETER BRETT BETWEEN '15 AND '19
- OBSERVATIONS MADE BY STANTEC BETWEEN '20 AND '21
- POTENTIAL TARGET AREA FOR MT30

NOTE:

THESE DRAWINGS ARE INTENDED TO PROVIDE A SUMMARY OF KNOWN PREVIOUS FINDINGS BY OTHERS, COLLATED FROM SOURCES AVAILABLE TO HOP AT THE TIME OF PRODUCTION. THESE DRAWINGS ARE BY NO MEANS EXHAUSTIVE AND, GIVEN THE KNOWN POOR CONDITION OF THE STRUCTURE, IT IS HIGHLY LIKELY THAT FURTHER HIDDEN DEFECTS AND HISTORIC REPAIRS ARE PRESENT. THESE DRAWINGS CONSIDER THE ACCESSIBLE MADEIRA TERRACE SUPERSTRUCTURE ONLY.

NOTE:

IT IS NOTED THAT SOME HISTORIC REPORTS REFER TO EARLIER COLUMN AND SPANDREL REPLACEMENTS COLLECTIVELY, AND IT IS NOT POSSIBLE TO DEFINITIVELY LOCATE ALL SUCH REPLACEMENTS. WHERE COLUMN REPLACEMENTS ARE KNOWN, IT IS ASSUMED THAT THE SPANDREL PANELS EITHER SIDE WERE ALSO REPLACED. ADDITIONALLY, IT HAS BEEN INTERPRETED THAT ALL REPLACEMENT SPANDREL PANELS ARE FORMED IN ALUMINIUM, HOWEVER IT IS SUSPECTED THAT COLUMNS HAVE BEEN REPLACED IN A MIX OF CAST IRON AND ALUMINIUM.

NOTE:

DUE TO MAGNITUDE OF DEFECTS NOTED HISTORICALLY, NOT ALL DEFECTS TO RAILS AND BRACING HAS BEEN INCLUDED HERE

 1:20 0 0.2m 0.4m 0.6m 0.8m 1m 1:50 0 0.5m 1m 1.5m 2m 2.5m 1:100 0 1m 2m 3m 4m 5m

Description	By	Aprvd.	Date	Rev.
ISSUED FOR INFORMATION	DJP	LRS	07.06.23	P1

ISSUED FOR INFORMATION

Title: LOCATION PLAN

Project: MT30 PROJECT
MADEIRA TERRACES, BRIGHTON

Client: BHCC

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APPENDIX G – Balustrade Assessment

Project: Maderia Terrace S

Element: Balustrade Assessment

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By:	Chkd:	Date:	Job:	Task:	Sheet No:	Rev:
NJM	AE	20/7/22	12719	06	01	

Ref:

1.0 Introduction

The calculations should be read in conjunction with the 'Iron Reuse Strategy' for the project and with reference to all other project material.

These calculations set out to conduct a sensitivity analysis for Balustrade reuse or recast options. Calculations a theoretical and assume material strengths derived from site specific tensile testing. It is noted the population of test results was limited at the time of production and supplementary testing is recommended to be completed which may change these preliminary findings either toward or against reuse justification.

A number of departures from current codes for balustrade performance are presented for client consideration to balance the need for safety and the duty to preserve historic components protected under the Listed building act.

Contents

Project: Maderia Terrace

Element: Balustrade Assessment

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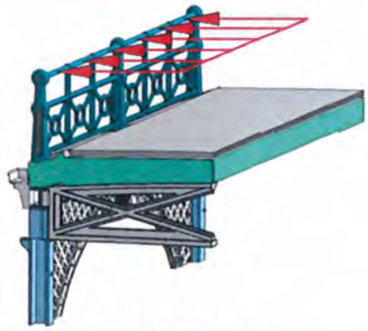
By:	Chkd:	Date:	Job:	Task:	Sheet No:	Rev:
NJH	AE	20/7/23	12719	06	02	

Ref:

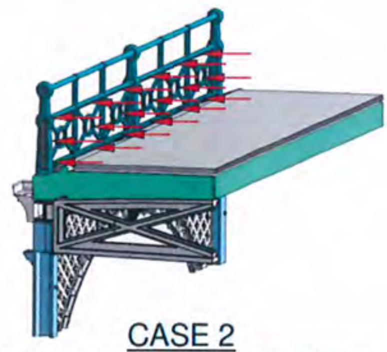
2.0 Loading.

BHCC have sought previous advice on seafront railings ref HOP report 9479/01 Jan 2001 and appended ROSPA and DMH opinions. This concluded the loading indicated in Fig 1 below which is supported by Eurocode BSEN 1991-1-1-2002



CASE 1
(UNIFORMLY DISTRIBUTED HORIZONTAL LINE LOAD 3kN/m APPLIED TO TOP RAIL)
(NTS)

Ref 3.0



CASE 2
(UNIFORMLY DISTRIBUTED PRESSURE APPLIED TO INFILL 1.5kNm^2)
(NTS)

Ref 4.0

CASE 3
(POINT LOAD APPLIED TO CRITICAL PARTS OF AN INFILL 1.5kN)
(NTS)

Ref 5.0

FIG 1 INDICATING BALUSTRAD LOADING REQUIREMENTS

Ref:

BS EN 1991-1-1:2002 and associated National Annex and Public Document defines loading requirements for parapets and balustrades. For areas susceptible to overcrowding greater than 3m wide. This results in a category C5 loading requirement with loading summarised in table 1 below:

Load Case	Load Requirement	Description
Case 1	3.0kN/m	Uniformly distributed horizontal line load applied to top rail
Case 2	1.5kN/m^2	Uniformly distributed pressure applied to infill panel
Case 3	1.5kN	Point load applied to critical parts of an infill panel

Table 1 - Summary of BS EN 1991-1-1:2002 loading requirements for balustrades.

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MH	AE	20/7/23	12719	06	04	

Ref:

3.0 Theoretical member checks

These follows member checks on individual components.

3.1 Top Rail check — Span 2.4m

$M_{ult} = 1.6 \times 3.0 \times \frac{2.4^2}{8} = 3.46$ kNm. $w_{serv} = 3.0$ kN/m

Existing top rails are formed in nominally 48.3mm CHS section formed in modern non original mild steel which has been galvanised. Wall thickness measured on site as nominally 3.3mm noting this may not be exact due to the presence of paint and galvanising.

Nearest hot rolled section 48.3 CHS 3.2mm assume in S275 for existing say

Check existing rail capacity

With ref to SCI blue book for 48.3 CHS 3.2

$M_c = 1.18$ kNm $< M_{ult} = 3.46$ kNm

Existing Rail Fails ULS check. Consider enhancing steel grade and wall thickness to pass assessment.

Try 48.3 CHS 6.3 in S355 steel

$M_c = 3.98$ kNm $> M_{ult} = 3.46$ kNm Passes ULS check ∴ OK

Check deflection $\delta_{allow} = 25$mm or $\frac{Span}{180}$ $I = 18.7$ cm^4 (Blue book)

$\delta_{actual} = \frac{5WL^4}{384EI} = \frac{5 \times 3.0 \times 2400^4}{384 \times 205 \times 10^6 \times 1.87 \times 10^{-7}} = 33.8$mm.

$\frac{Span}{250}$ 9.6mm Can't reasonably enhance further due to conservation constraints client to accept deflection departure. Noting some stiffening is likely due to intermediate Mullions

Adopt 48.3 CHS 6.3 Grade S355 top rail galvanised with enhanced " positional restraints at each standard to resist a shear of $3 \times \frac{2.4}{2} = 3.6$kN unfactored i.e low.

Project: M T

Element: Balustrade AGS

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Ref:

3.1.2 Check if a Teak timber alternative is feasible.

$M_{serv} = 2.16$ kNm.

Now consider solid teak alternative 48.3mm Diameter to match existing

$$I = \frac{\pi D^4}{64} = \frac{\pi \times 48.3^4}{64} = 267151\,mm^4$$

$$Z = \frac{\pi D^3}{32} = 11062\,mm^3.$$

check deflection first likely critical

$k_z = 0.8$ Service class 3 exposed external

σ, adm, par to grain for teak. $= 13.7\,N/mm^2$ } BS 5268 T14.

$E = 7400\,N/mm^2$ } Min

$$\delta_{actual} = \frac{5 \times 3 \times 2400^4}{384 \times 7400 \times 267151} = 655\,mm$$

Timber Alternative not suitable fails deflection significantly

Project: MT

Element: Balstrade A

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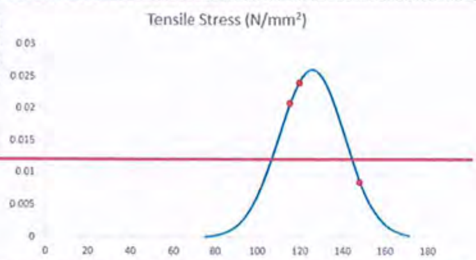
Ref:

3.2 <u>Infill Check</u>

An existing infill has been recovered from site and inspected by magnetic particle inspection (MPI) this revealed significant and consistent casting defects to principal horizontal spanning transoms which provide the only horizontal spanning members between supporting balustrade standards. This calculation assumes these defects are identified and repaired to full parent iron strength.

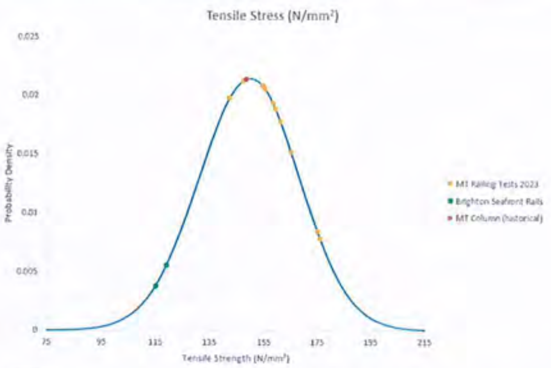
Tensile samples obtained from an infill have been taken (2023). Standard deviation analysis is provided below to derive an appropriate permissible stress

	Tensile Strength (N/mm2)	Norm Dist
	148	0.008620748
	119	0.024009066
	119	0.024009066
	115	0.020845838
Mean	125.25	
SD	15.2834333	
5th Percentile	100	



Element	Tensile Strength (N/mm2)	Probability Density
MT Column (historical)	148	0.021
Brighton Seafront Rails	119	0.006
	119	0.006
	115	0.004
MT Railing Tests 2023	161	0.018
	176	0.008
	158	0.019
	155	0.021
	147	0.021
	142	0.020
	154	0.021
	175	0.008
	165	0.015
	142	0.020
	158	0.019
	159	0.019

Mean: 149.6 N/mm2
Standard Distribution: 18.6 N/mm2
5th Percentile: 119.0 N/mm2



Permissible stress say $\frac{119}{5} = 23.8\,N/mm^2$.

This adopts a factor of safety of 5.0 as per recommendations in Historical Structural Steelwork handbook W Bates CEng FIStructE

Refer to photo 2 for a typical infill being bench tested.

Project: M T

Element: Bal AGS

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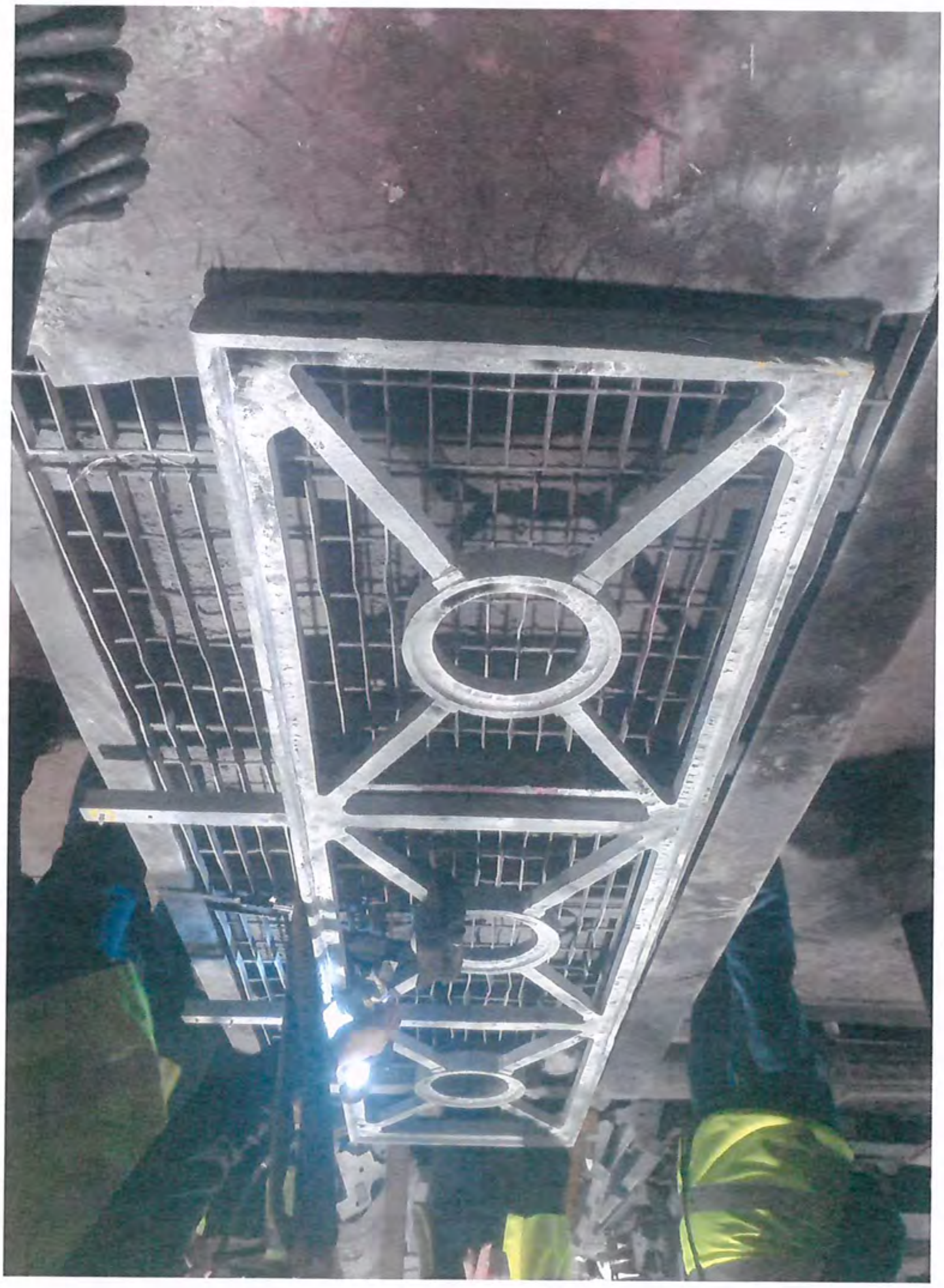

Photo 1 Indicating Existing infill recovered to bench test
Note variable geometry and 2 No. horizontal members
spanning nominally 2.4m (transom)

Project: MT

Element: Bal ASS

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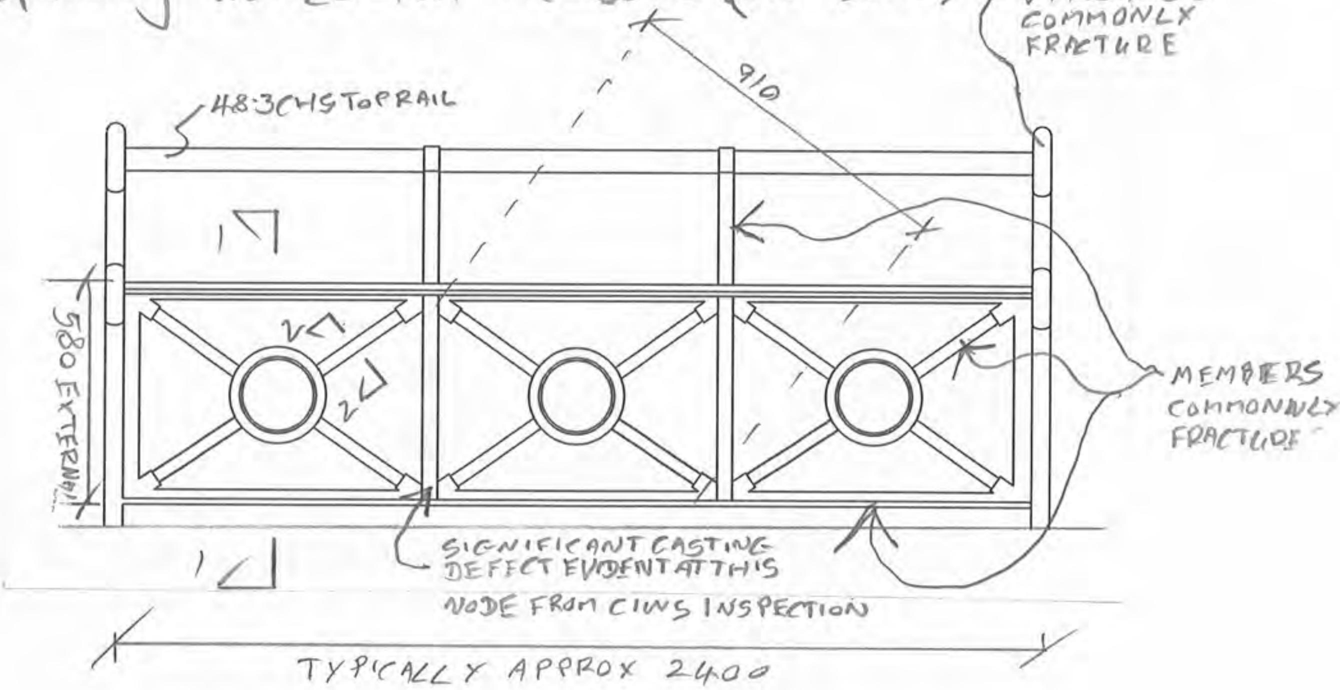
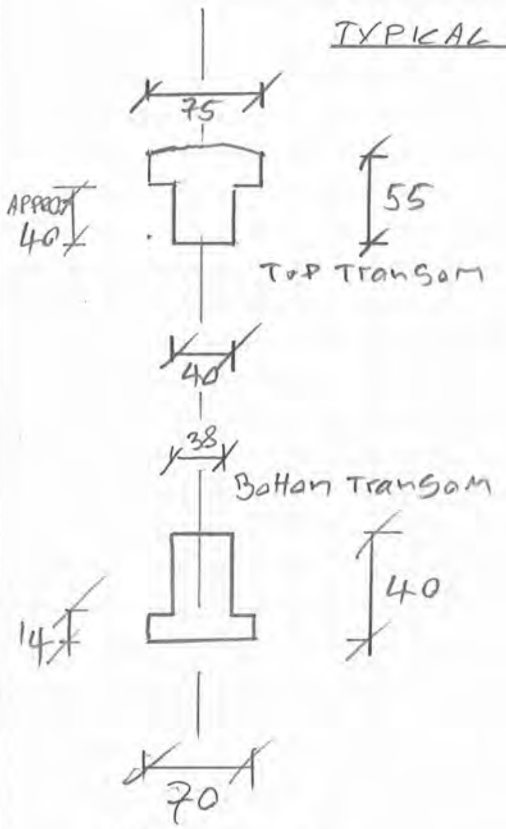
Ref:

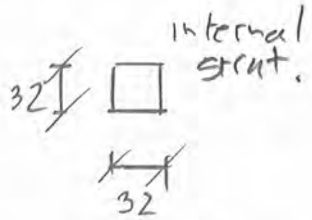
Assumed idealised section properties of principal spanning horizontal members (Transoms)



TYPICAL BALUSTRADE ARRANGEMENT
(1:20)



SECTION 1-1
(1:5)



SECTION 2-2
(1:5)

NOTE ALL SECTION SIZES HIGHLY VARIABLE WITH LOCALISED NECKING NOTED FROM GRIT BLAST INSPECTION AT CIWS YARD

Project: MT

Element: Bal ASS

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NH	AE	20/7/23	127/9	06	09	

Ref:

3.21 Bottom Transom check

Applied bending

$M_{serv} = 1.5 \times \frac{0.58}{2} \times \frac{2.4^2}{8} = 0.313\,kNM$.

Sectional Properties.

Input bottom left (x1,y1) and top right (x2,y2) hand corners of each rectangular member below.

	x1 mm	y1 mm	x2 mm	y2 mm	A mm^2	z mm	Az mm^3	Icc mm^4	y mm	Ah^2 mm^4
Member 1	0	0	14	70	980	35	34300	400167	-1.38	1860
Member 2	14	16	40	48	832	32	26624	70997	1.62	2190
Member 3	0	0	0	0	0	0	0	0	33.62	0
Member 4	0	0	0	0	0	0	0	0	33.62	0
					1812		60924	471164		4050

A = 18.12 cm^2

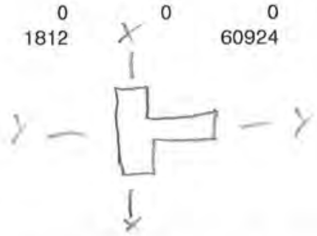
y = Az/A = 33.623 mm

Ixx = Icc + Ah^2 = 475213.8013 mm^4

Second Moment Axis, Ixx = 47.52138013 cm^4

Section Modulus, Zxx = 14.134 cm^3

Rxx = 16.19442102 mm



$I_{xx} = 47.5\,cm^4$ $(475000\,mm^4)$ $E = 66\text{-}94\,kN/mm^2$

$Z_{xx} = 14.134\,cm^3$ $(14134\,mm^3)$ SCI App Ext Iron & Steel

use $80 \times 10^6\,kN/m^2$ say Average

$M_{permissible} = \sigma Z = 23.8 \times 14134 = 336389\,NMM$

$= 0.336$.

$M_{serv} = 0.313\,kNM \approx M_{permissible} = 0.336\,kNM$.

NOTE CASTING DEFECTS WILL SIGNIFICANTLY REDUCE STRUCTURAL CAPACITY! THIS CHECK NOTES BOTTOM TRANSOM IS WORKING AT PERMISSIBLE STRESS HIGHLIGHT TO CLIENT IF EXISTING CAST IRON INFILLS ARE TO BE ADOPTED THIS CARRIES RISK.. RECOMEND RECAST IN SG IRON TO ELIMINATE RISK.

Deflection check

$\delta_{allow} = \frac{2400}{360} = 6.6\,mm$

$\delta \approx \frac{5wL^4}{384EI} = \frac{5 \times 1.5 \times \frac{0.58}{2} \times 2.4^4}{384 \times 80 \times 10^6 \times 4.75 \times 10^{-7}} = 4.9\,mm$

Deflection expected 4.9mm ∴ OK Brittle failure Governs.

Ref:

3.2.2 <u>Top transom check</u>

Applied Bending

$$M_{serv} = 1.5 \times \frac{1.1}{2} \times \frac{2.4^2}{8} = 0.594\,kNm.$$

Assumes posts are stretched to 1.1m with 50% of infill pressure resisted by top trasom.

Sectional Properties.

Input bottom left (x1,y1) and top right (x2,y2) hand corners of each rectangular member below.

	x1 mm	y1 mm	x2 mm	y2 mm	A mm^2	z mm	Az mm^3	Icc mm^4	y mm	Ah^2 mm^4
Member 1	0	17.5	40	57.5	1600	37.5	60000	213333	0.00	0
Member 2	40	0	55	75	1125	37.5	42187.5	527344	0.00	0
Member 3	0	0	0	0	0	0	0	0	37.50	0
Member 4	0	0	0	0	0	0	0	0	37.50	0
					2725		102187.5	740677		0

A = 27.25 cm^2

y = Az/A = 37.500 mm

Ixx = Icc + Ah^2 = 740677.0833 mm^4

Second Moment Axis, Ixx = 74.06770833 cm^4

Section Modulus, Zxx = 19.751 cm^3

Rxx = 16.48660377 mm

$I_{xx} = 74.1\,cm^4$ $(74100\,mm^4)$

$Z_{xx} = 19.7\,cm^3$ $(19700\,mm^3)$

$M_{permissible} = \sigma Z = 23.8 \times 19700 = 468860\,Nmm$
$= 0.468\,kNm.$

SEE PREVIOUS RISK NOTE IN 4.1 WHICH IS APPLICABLE

<u>$M_{permissible} = 0.468 < 0.594 = M_{serv}$ ∴ Fails in britle failure.</u>

Deflection

$$\delta = \frac{5wL^4}{384EI} = \frac{5 \times 1.5 \times \frac{1.1}{2} \times 2.4^4}{384 \times 80 \times 10^6 \times 7.41 \times 10^{-7}} = 6.0\,mm \therefore ok$$

<u>Deflection not Likely governs and Low $< \frac{2400}{360} = 6.6\,mm$</u>

Project: Madeira T

Element: Bal A

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NJH	AE	20/7/23	1271a	06	11	

Ref:

3.2.3 intermediate diagonal strut check

Simply diagonal strut to a single member spanning 910mm and ✓, ignore nominal fixity due to single casting. ✓

$M_{serv} \approx \frac{PL}{6} = \frac{1.5 \times 0.91}{6} = 0.227$ kNm

$I = \frac{bd^3}{12} = \frac{0.032^4}{12} = 8.738 \times 10^{-8} m^4$

$Z = \frac{bd^2}{6} = \frac{0.032^3}{6} = 5.461 \times 10^{-6} m^3$

Brittle failure check

$M_{permissible} = \sigma Z = 23.8 \times 5461' = 0.13$ kNm

$M_{permissible} = 0.13$ kNm $< M_{applied} = 0.227$ kNm

Diagonal strut fails brittle failure check (Note also supported by visual failures evident) Ref photo 2 over

Deflection check

$\delta_{estimate} = \frac{PL^3}{48EI}$ conservative as assumes pinned ends

$= \frac{1.5 \times 0.91^3}{48 \times 20 \times 10^6 \times 0.873 \times 10^{-7}} = 3.37$ (conservative)

$\frac{0.910}{250} = \delta_{limit} = 3.6mm < \delta_{estimate}$

Deflection expected 3.37mm (conservative) $\approx \delta_{limit} = 3.6mm$
∴ OK Brittle failure governs

Project: Madeira T

Element: Bal ASS

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By: NJW	Chkd: AE	Date: 20/7/23	Job: 12719	Task: 06	Sheet No: 2	Rev:

Ref:

3.2.4 Photo 2 typical Defect evident.

APPENDIX H – Record of Site Visit 2023 05 02 Grit Blasting and MPI Inspection

SITE VISIT RECORD

Project Control Document **13**

PROJECT:		Project No:	12719-6
Madeira Terraces		Site Visit No:	14
SUBJECT: **Visit to Cast Iron Welding Services to review Grit Blasting Trail**			
Date of Visit:	2nd May 2023	Arrival Time:	10.30
Record prepared by:	Nigel Hosker	Departure Time:	15.30
Weather conditions:	Generally dry and sunny		

Site visited by:	Nigel Hosker (NJH)	Representing:	HOP Consulting Limited (HOP)

Visitor accompanied by:	Neil King (NK) – Purcell; Lian Harter (LH) – Purcell; Ian Graham (IG) - B&HCC CIWS Hosted the visit at their Offices and other facilities.

The purpose of the visit was to visit Cast Iron Welding services yard to meet the team and review grit blasting of components already received to their yard. Those from the project team included, Neil King, Nigel Hosker, Lian Harter, Ian Graham.

We met briefly in CIWS office and discussed the work that has already been done on processing data logs, logging of artifacts and tracking of components. We discussed what likely testing and inspection processes might be involved and what testing is completed for other Cast Iron Bridge components that CIWS deal with for other Authorities.

We then relocated to the workshop at a different site where CIWS kindly explained the fusion welding and repair process in general terms and we looked specifically at components from the Terraces that are works in hand.

Photograph 1 indicating metal tags used to identify artifacts.

It is proposed all artifacts are tagged with metal tags with a unique referencing such that artifacts would be auditable [1].

Photograph 2, indicating fusion welding process where component is locally heated and insulated then welded with oxyacetylene touch electrode and flux. CIWS noted the important of matching the grade of cast iron the parent metal metallurgy which is informed by sampling in their yard.

We discussed general casting defects and CIWS a fair amount of their work involves remedial works to new castings that have failed quality assurance checks. An example of a casting defect to a new casting is indicated in Photograph 3 which it is understood once remedied meets the components full specification.

Photograph 3, indicating an example of a casting defect in a new casting that was to be remedied by fusion welding to achieve full specification.

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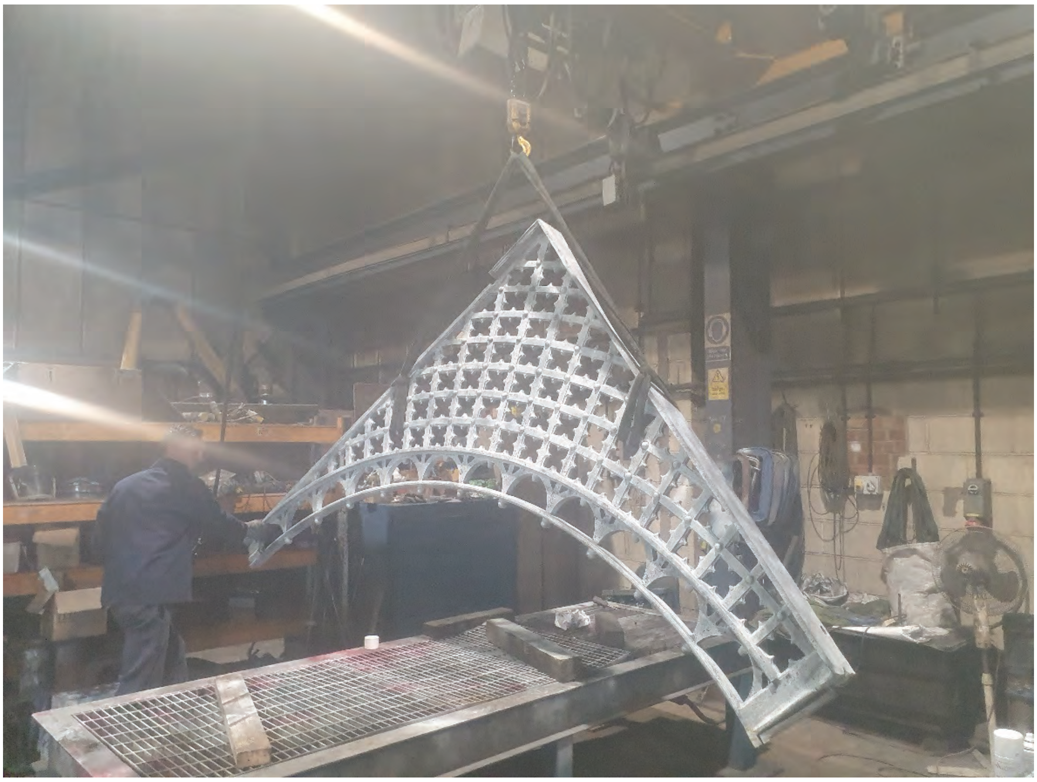
We moved to look at one of the two spandrel panels that had already been prepared and grit blasted ready for detailed visual inspection and inspection by Magnetic Particle Inspection (MPI).



Photograph 4, indicating 1 of 2 grit blasted spandrel panels awaiting inspection and non-destructive testing on the bench. Note the spandrel has been painted white in preparation for MPI inspection. In general, the grit blasting process had removed many years of paint layers and the intricate detailing and features of the original casting were far more evident.

At the time of the visit a CIWS operative was conducting MPI inspection to the half spandrel. Briefly this involves painting it white to provide better visual definition than the application of a ferrous partial spray. The component is then magnetised by electromagnet. Where a surface / near surface discontinuity exists the magnetic flux leaks and hence ferrous particles tend to align which can be seen visually on the white background indicating the presence of a defect. The defect is then marked up for further processing / repair.

At the time of the visit 7 defects had been identified to the half spandrel being inspected. NH asked if any were associated with bolt hole initiation corrosion. CIWS operative confirmed that none of the defects found had initiated at bolt holes. Later photographs indicate some of the more significant defects identified.

Photograph 5 indicating fracture to spandrel haunch zone note does not initiate or propagate to a bolt hole.

Photograph 6, indicating fracture to key stone (voussoir) bottom note the residual key stone component had not become free from the grit blasting preparation. This was investigated and it was found that the keystone section was extensively corroded, seized and partly fused into the groove in which it locates. CIWS operative managed to carefully tap this out with mallet and chisel exposing the original casting grove.

Photograph 7 indicating fracture to keystone top.

Photograph 8, extracted section of keystone that had fused with the locating grove, note the shiny fracture surface perhaps an indication graphitic corrosion.

Photograph 9, indicating fracture to spandrel haunch at the location where section properties curtail abruptly likely a stress concentration.

Photograph 10, seized bolt to corbel / spandrel connection. Bolt could not be readily removed without heat.

Photograph 11, indicating 2nd spandrel half which had not been grit blasted at the time of the visit though a significant full depth fracture was noted to the haunch propagating full depth through the entire shoulder of the spandrel. No bolt holes in the vicinity of the fracture.

Photograph 12, infill panel after grit blasting during MPI inspection.

Photograph 13, indicating bottom corner of balustrade infill, note historical in situ attempts have been made to weld the panel forming an ad hock repair. Weld quality was of poor quality. It is likely this was done to counter the balustrade panel joints which are generally reported to open up.

Photograph 14 & 15, indicating the balustrade infill panel at its junction with standard. Note the necing of the section left (no necking approx. 12mm) and right (necking 7mm).

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Photograph 16 & 17, indicating blow hole / casting defect to balustrade infill at 1/3 span of 1 of 2 transoms. The hole was probed with a screwdriver and found to be 'lobster pot' shaped as indicated by the orientation of the screwdriver. Hole depth was measured as 20mm with overall section of 35mm hence this is a significant defect resulting in a localise reduction in iron thickness of 15mm. CIWS are to prepare and expose the defect to establish significance. We discussed how this could be the located where molten iron entered the patten and hence all to mindful that this could be a consistent defect if this was how it was caused.

Distribution:	Katie Gutcher, Ian Graham, Abigail Hone, Katharine Pearce, Lian Harter, Lily Stephenson
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Notes to Recipients

This record is HOP Consulting Limited's understanding of the visit and intended actions arising therefrom. Your agreement that this is a true record of the visit will be assumed unless comments to the contrary are received in writing within five days of receipt of this record.

HOP site visits relate specifically to those matters covered and not part of works supervision. Any site checks are for the sole purpose of ensuring that the broad design intent is being complied with.