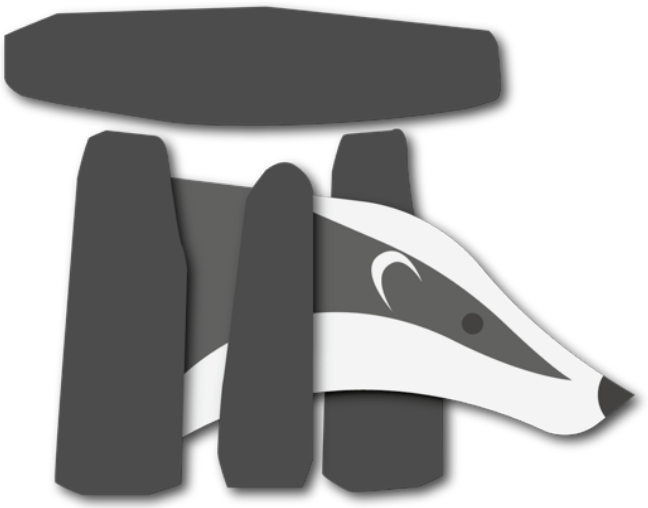

highways england

QS4E
Outline Approval in Principle (AIP) for:
Green Bridge Four

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APPENDICES

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Project Details

Name of project: A303 – Amesbury to Berwick Down in Wiltshire.

Name of bridge or structure: Longbarrow Land Bridge (Green Bridge 4)

Structure reference No.: TBA

Summary

This Outline AIP covers the Green Bridge Four Structure. This document records the agreed basis and outline criteria to be carried forwards for the detailed design of a highway structure in accordance with Highways England's Technical Approval (TA) procedures as outlined in CG 300. These procedures are required to give increased assurance for the required execution of highway structures.

Expected construction dates of scheme from 2023 to 2028.

1 HIGHWAY DETAILS

1.1 Type of highway

This is a proposed Dual 2-lane all-purpose carriageway (D2AP) widths in the in accordance with CD 127. Above the superstructure there is continuity to a restricted byway of 3m wide with two verges (1m and 4m respectively) and fences are placed on both sides of the byway.

1.2 Permitted traffic speed

The current proposal is for a 70-mph speed limit on this section of the highway network. During contraflow for planned maintenance, a reduced 40mph speed limit will be adopted or as deemed necessary to maintain safety.

1.3 Existing restrictions

Green bridge 4 structure should be constructed in accordance with the tunnel procurement materials and should be in line with the western portal structures solution.

The finished ground level over green bridge 4 shall replicate the existing ground levels.

Green bridge 4 shall be between 148m and 149.9m wide.

The structure shall respect the minimum headroom required for the A303 road. (5300mm plus sag curve compensation)

2 SITE DETAILS

2.1 Obstacles crossed

Proposed green bridge four structure will span over the new A303 road alignment, adjacent to the current A303. Site within World Heritage Site, thus DCO in place and mitigations in accordance with Detailed Archaeological Mitigation Strategy.

3 PROPOSED STRUCTURE

3.1 Description of structure and design working life

The Green Bridge four structure will be designed for a design working life of 120 years in accordance with Table NA.2.1 of British National Annex to BS EN 1990:2002.

This is a structure located around chainage 6+489 of the new A303. The structure is a reinforced concrete deck carrying a new restricted byway over the new A303. The structure is backfilled to respect the current ground floor level.

3.2 Structural type

Reinforced concrete slabs and walls, 1200mm thick each one. Cast in-situ reinforced concrete structure for walls and deck. The reinforced concrete deck slab is voided slab.

3.3 Foundation type

Cast in-situ shallow foundation, spread footings. Cross section of the footing 6500x2000mm.

The foundation includes a shear key 1000x1000mm to increase the sliding resistance.

3.4 Span arrangements

Span between support = 28.10m.

3.5 Articulation arrangements

Fully integral structure, with moment resistance joint between deck and abutments

3.6 Classes and levels

A) Consequence class

For the main structure CC2 in accordance with CD 350, Table 7.2.

B) Reliability class

RC2 for whole structure and K_{FI} taken as 1.0, in accordance with CD 350, Table 7.2.

C) Inspection level

Design Supervision Level 2. Inspection Level 2 as required by CD 350, Table 7.2.

3.7 Road restraint systems requirements

No road restraint systems are considered under Green Bridge 4. The lateral walls of the structure will be designed for road impact.

3.8 Proposals for water management.

Spray applied waterproofing and geocomposite membrane will be provided in all surfaces of concrete in contact with the backfilling after placing precast concrete structure.

Infiltration water in the backfill will be deviated with buried pipes located by the foundations that will connect to earth works drainage system in verge.

3.9 Proposed arrangements for future maintenance and inspection

A) Traffic management

It is expected that in order to safely carry out detailed inspection and certain specified maintenance activities, access under Green Bridge 4 will be via the carriageway during tunnel closures.

The tunnel systems will allow the closure of only a single bore for these inspections, giving the option that when a tunnel bore is closed the other tunnel bore will be capable of operating under contraflow.

B) Arrangements for future maintenance and inspection of structure. Access arrangements to structure.

The inspection and survey programme and methodology for the structures Assets shall include the baseline survey and inspection requirements in accordance with bellow baseline survey and inspection requirements:

- Bridge structures:
- General inspection frequency: Year three (3) of Maintenance Period and two (2) yearly thereafter.
- Principal Inspection frequency: Year one (1) and year five (5) of Maintenance Period and six (6) yearly Thereafter.

3.10 Environment and sustainability

Utilizing the efficient engineering solution of soil nail walls, as opposed to diaphragm walls, reduces material usage which benefits the environment embedded carbon dioxide is also reduced.

This applies to the excavation method for the structure execution.

3.11 Durability - materials and finishes

The durability of materials utilized will be such that the design life of 120 years is met with concrete specification in accordance with BS8500-1:2015. All concrete elements, in permanent contact with the soil shall be spray applied waterproofing and geocomposite membrane.

The in situ concrete elements shall be grade C32/40 minimum and will have an unformed face. The sprayed concrete facing will be reinforced with mesh, with a minimum concrete cover of 55mm.

Reinforcement shall be High Yield Grade B500B or B500C ‘Ribbed’ bars conforming to BS 4449:2005+A2:2009 and BS EN 10080:2005 with a characteristic yield strength fy = 500MPa

The final finish to all in situ concrete pours will be determined during detailed design to suit the agreed design vision and noise reduction requirements. The lower 1.5m of the road facing walls will serve as the Vehicle Restraint System (VRS) so will be smooth finished in warm natural colours.

Buried concrete elements, in permanent contact with the soil shall be painted with two coats of cut back bitumen or equivalent. This is in addition to the waterproofing layer described in Section **3.1**.

Finishes of the structures are aligns with Design Vision:

- Wall finish inside Green Bridges: Precast concrete in warm colour. Timber shutter texture, grain direction parallel with direction of travel.
- Edge treatment: Reinforcement concrete, smooth finish, warm colour.
- Pedestrian Fence: Bespoke galvanized steel fence system.

3.12 Risks and hazards considered for design, execution, maintenance and demolition. Consultation with and/or agreement from Overseeing Organisation

Early identification of risks in accordance with CDM regulations as referred to in **Appendix D**.

3.13 Estimated cost of proposed structure together with other structural forms considered (including where appropriate proprietary manufactured structure), and the reasons for their rejection (including comparative whole life costs with dates of estimates)

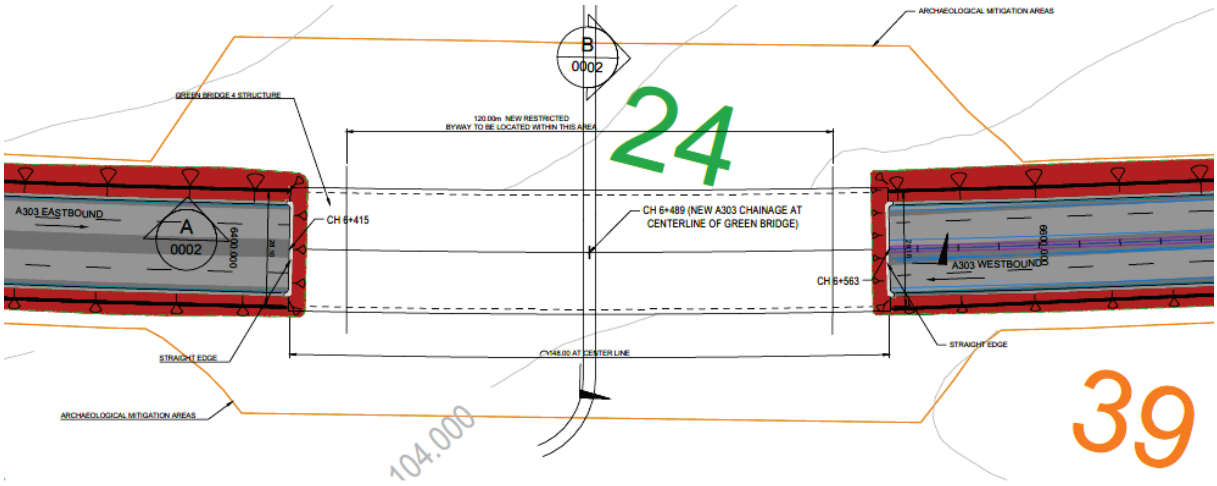
Provided in the Financial Submission.

3.14 Proposed arrangements for construction

A) Construction of structure

Top down excavation, in levels, to expose soil face and soil nails installed before next level excavated. Then bottom up construction for the structure.

- Excavation of top 2.50m with 1:2 slope, inside the limits of the DAMS restrictions



- Excavation with soil nailing retaining walls 1:10 slope
- Foundation execution
- Lateral walls execution
- Top deck slab execution with scaffolding
- Waterproofing and backfilling
- Execution of road pavement and finishing

B) Traffic management

It is anticipated that traffic management will not be required as the Green Bridge 4 structure do not interact with the existing A303. This will be confirmed during detailed design.

C) Service diversions

No existing services in place.

D) Interface with existing structures

There are no structures in the immediate vicinity of the proposed green bridge four structure rather than the cutting area of the western tunnel approach so coordination between both method statement should be considered.

4 DESIGN CRITERIA

4.1 Actions

A) Permanent actions

Permanent actions will be applied in accordance with BS EN 1991-1-1 including the National Annex.

B) Snow, wind and thermal actions

Wind and snow loads are not significant for the design of the structure. Thermal actions will be considered for the shrinkage effects in the structure as per BS EN 1991-1-1.

C) Actions relating to normal traffic under AW regulations and C&U regulations

LM1 and LM2 as per the UK National Annex to BS EN1991-2:2003 and PD6688-2:2011.

Dispersal of load through fill shall be in accordance with PD 6694-1:2011.

The design will consider the most onerous loading during its operational life.

D) Actions relating to General Order traffic under STGO regulations

Not applicable.

E) Footway or footbridge variable actions

Variable actions considered in the footpath around the edge in accordance with BS EN 1991-2.

F) Actions relating to Special Order traffic, provision for exceptional abnormal indivisible; loads including location of vehicle track on deck cross-section

The structure will not be designed for Special Order Traffic i.e., abnormal indivisible loads.

G) Accidental actions

Actions during construction will be considered in accordance with BS EN 1991-1-6:2005 and its UK National Annex.

Vehicle impact loads on lateral walls and on the structure edge will be applied in accordance with BS EN 1991-1-7 including the National Annex and PD6688-2:2011, where applicable.

Actions due to explosion are not considered.

H) Actions during construction

We will consider actions during construction for any temporary backfill of machinery above the bridge in accordance with BS EN 1991-1-6:2005 and its UK National Annex.

I) Any special action not covered above

Not applicable

4.2 Heavy or high load route requirements and arrangements being made to preserve the route, including any provision for future heavier loads or future widening

Not considered

4.3 Proposed minimum headroom to be provided

Minimum headroom = 5300mm plus sag curve compensation. Additional +200mm to accommodate lighting solution above the carriageway

4.4 Authorities consulted and any special conditions required

The Stakeholder Design Consultation Group (SDGC) comprises of representation from English Heritage Trust, Historic England, The National Trust and Wiltshire Council. This group, and the organizations stakeholders represented by the group, will be consulted throughout the detailed design process.

4.5 Standards and documents listed in the technical approval schedule (TAS)

Technical Approval Schedule (TAS) is in **Appendix A** to this OAIP.

4.6 Proposed departures from standards given in 4.5

To be confirmed at the detail design stage. None identified at this time.

4.7 Proposed departures relating to methods for dealing with aspects not covered by standards in 4.5

To be confirmed at the detail design stage. None identified at this time.

4.8 Proposed safety critical fixings

None

5 STRUCTURAL ANALYSIS

5.1 Methods of analysis proposed for superstructure, substructure and foundations

Closed form solutions used for the initial assessment to size the elements for this stage of design. Upon award of the detailed design, a structural analysis model will be created using software such as Robot Structural Analysis.

5.2 Description and diagram of idealised structure to be used for analysis

The structure has been simplified as shown below with fixed-fixed connections and fixed supports.

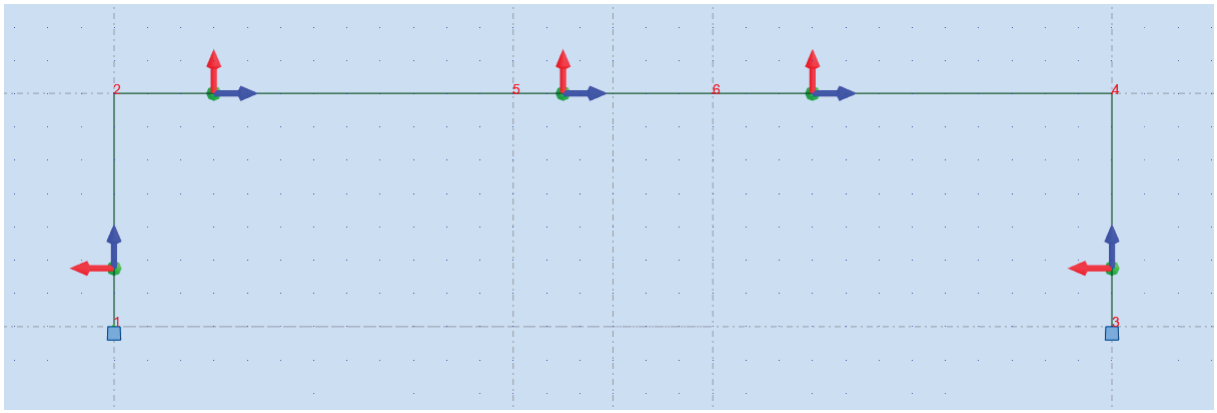


Fig. 5-1: Idealised Robot Structural Analysis Model

The below table is composed of the loadings utilised in both the closed form calculations as well as for input into the Robot Structural model.

Table 5-1: Input load table

	Case	Load type	List						
	1:SW	self-weight	1to4 6	Whole structur	-Z	Factor=1.00	MEMO:		
	2:BW	uniform load		PX=0.0	PZ=-10.00	global	not project.	absolute	BE=0.0
	2:BW	uniform load		PX=0.0	PZ=-23.00	global	not project.	absolute	BE=0.0
	2:BW	uniform load		PX=0.0	PZ=-63.00	global	not project.	absolute	BE=0.0
	2:BW	uniform load		PX=0.0	PZ=-128.00	global	not project.	absolute	BE=0.0
	3:EW	uniform load		PX=70.00	PZ=0.0	global	not project.	absolute	BE=0.0
	3:EW	uniform load		PX=31.00	PZ=0.0	global	not project.	absolute	BE=0.0
	3:EW	uniform load		PX=11.50	PZ=0.0	global	not project.	absolute	BE=0.0
	3:EW	uniform load		PX=-31.00	PZ=0.0	global	not project.	absolute	BE=0.0
	3:EW	uniform load		PX=-70.00	PZ=0.0	global	not project.	absolute	BE=0.0
	3:EW	uniform load		PX=-11.50	PZ=0.0	global	not project.	absolute	BE=0.0
	4:LL1	trapezoidal load (2p)		X1=0.0	PX1=0.0	PZ1=-110.00	X2=1.40	PX2=0.0	PZ2=-110.00
	4:LL1	trapezoidal load (2p)		X1=0.60	PX1=0.0	PZ1=-110.00	X2=2.00	PX2=0.0	PZ2=-110.00
	5:LL2	uniform load		PX=0.0	PZ=-55.00	global	not project.	absolute	BE=0.0
	6:LL3	uniform load		PX=0.0	PZ=-30.00	global	not project.	absolute	BE=0.0
	2:BW	uniform load	3 4 6	PX=0.0	PZ=-18.00	global	not project.	absolute	BE=0.0
	3:EW	trapezoidal load (2p)	1	X1=0.0	PX1=79.00	PZ1=0.0	X2=1.00	PX2=9.00	PZ2=0.0
	3:EW	trapezoidal load (2p)	2	X1=0.0	PX1=-79.00	PZ1=0.0	X2=1.00	PX2=-9.00	PZ2=0.0
	4:LL1	uniform load	3	PX=0.0	PZ=-50.00	global	not project.	absolute	BE=0.0

5.3 Assumptions intended for calculation of structural element stiffness

Reinforcement concrete section properties will be based on the gross, uncracked concrete cross-section.

5.4 Proposed range of soil parameters to be used in the design of earth retaining elements

This applies for the abutments and lateral walls of the bridge.

Earth pressures are obtained as per conservative assumption values below in order to obtain a conservative design of the structure.

Backfill above the structure is assumed to be Type 1A as per MCHW

Table 5-2: Ground parameters

Ground	Weight Density	Shear resistance
Backfilling around the structure	γ' = 20 kN/m3	Φ' = 30° C’ = 0 MPa

6 GEOTECHNICAL CONDITIONS

6.1 Acceptance of recommendations of the ground investigation report (reference/dates) to be used in the design and reasons for any proposed changes

A summary of the Geotechnical Report reviewed is included in **Appendix B**. Assessed preliminary design soil parameters are also included in **Appendix B**.

6.2 Summary of design for highway structure in the ground investigation report

Refer to **Appendix B** for preliminary soil design parameters.

6.3 Differential settlement to be allowed for in the design of the structure

It is considered a maximum allowable settlement for the footings of 25mm.

6.4 If the ground investigation report is not yet available, state when the results are expected and list the sources of information used to justify the preliminary choice of foundations

N/A

7 CHECK

7.1 Proposed category and design supervision level

Category 2 as per clause 3.9 of CG300

7.2 If category 3, name of proposed independent checker

Not applicable

7.3 Erection proposals or temporary works for which types S and P proposals will be required, listing structural parts of the permanent structure affected with reasons

TBD

8 DRAWINGS AND DOCUMENTS

8.1 List of drawings (including numbers) and documents accompanying the submission

Table 8-1: Drawings and Documents

Document	Number
Plant & elevation	HE551506-BGR-SBR-Z3BRYA0Z-DR-S-0001
Sections and details	HE551506-BGR-SBR-Z3BRYA0Z-DR-S-0002

9 THE ABOVE IS SUBMITTED FOR ACCEPTANCE

We confirm that details of the temporary works design will be/have been passed to the permanent works designer for review[16].

Signed _____
Name _____Design Team Leader
Engineering Qualifications _____
Name of Organisation _____
Date _____

Signed _____
Name _____Check Team Leader
Engineering Qualifications _____
Name of Organisation _____
Date _____

10 THE ABOVE IS REJECTED/AGREED SUBJECT TO THE AMENDMENTS AND CONDITIONS SHOWN BELOW

Signed _____
Name _____
Position held _____
Engineering Qualifications _____
TAA _____
Date _____

Appendix A – Technical Approval Schedule (TAS)

Schedule of Documents Relating to Design of Highway Bridges and Structures

Eurocodes and Associated UK National Annexes

Eurocode part	Title	Amendment / Corrigenda	Notes
Eurocode 0	**Basis of structural design**		
BS EN 1990:2002 +A1:2005	Eurocode 0: Basis of structural design	+A1:2005 Incorporating corrigenda December 2008 and April 2010	See CD 350 section 7 for additional guidance.
NA to BS EN 1990:2002 + A1:2005	UK National Annex to Eurocode 0 Basis of structural design	National Amendment No.1	See CD 350 section 7 for additional guidance.
Eurocode 1	**Actions on structures**		
BS EN 1991-1-1:2002	Eurocode 1: Actions on structures. General Actions. Densities, self-weight, imposed load for buildings	Corrigenda December 2004 and March 2009	
NA to BS EN 1991-1-1:2002	UK National Annex to Eurocode 1: Actions on structures. General Actions. Densities, self-weight, imposed load for buildings	Corrigenda July 2019	
BS EN 1991-1-4:2005 + A1:2010	Eurocode 1: Actions on structures. General Actions. Thermal actions	+A1:2010 Corrigenda July 2009 and January 2010	
NA to BS EN 1991-1-4:2003	UK National Annex to Eurocode 1: Actions on structures. General Actions. Thermal actions	National Amendment No.1	
BS EN 1991-1-5:2003	Eurocode 1: Actions on structures. General Actions. Thermal actions	Corrigenda December 2004 and March 2009	
NA to BS EN 1991-1-5:2003	UK National Annex to Eurocode 1: Actions on structures. General Actions. Thermal actions	-	
BS EN 1991-1-6:2005	Eurocode 1: Actions on structures. General Actions. Actions during execution	Corrigenda July 2008, November 2012 and February 2013	

NA to BS EN 1991-1-6:2005	UK National Annex to Eurocode 1: Actions on structures. General Actions. Actions during execution	-	
BS EN 1991-1-7:2006 +A1:2014	Eurocode 1: Actions on structures. General Actions. Accidental actions	+A1: 2014 Corrigendum February 2010	
NA+A1 to BS EN 1991-1-7:2006+A1:2014	UK National Annex to Eurocode 1: Actions on structures. Part 1-7: Accidental actions	+A1:2014 Incorporating corrigenda August 2014 and November 2015	See CD 350 for additional guidance.
BS EN 1991-2:2003	Eurocode 1: Actions on structures. Traffic loads on bridges	Corrigenda December 2004 and February 2010	See CD 350 section 7 for additional guidance.
NA to BS EN 1991-2:2003	UK National Annex to Eurocode 1: Actions on structures. Traffic loads on bridges	Corrigendum No.1	See CD 350 section 7 for additional guidance.
Eurocode 2	**Design of concrete structures**		
BS EN 1992-1-1:2004 + A1:2014	Eurocode 2: Design of concrete structures– Part 1-1: General rules and rules for buildings	Incorporating corrigendum January 2008, November 2010 and January 2014	
NA + A2:2014 to BS EN 1992-1-1:2004 + A1:2014	UK National Annex to Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings		
BS EN 1992-2:2005	Eurocode 2: Design of concrete structures – Part 2: Concrete bridges – Design and detailing rules	Corrigendum July 2008	
NA to BS EN 1992-2:2005	UK National Annex to Eurocode 2: Design of concrete structure – Part 2: Concrete bridges – Design and detailing rules	-	
Eurocode 7	**Geotechnical design**		
BS EN 1997-1:2004+A1:2013	Eurocode 7: Geotechnical design – Part 1 General rules	+A1:2013 Corrigendum February 2009	

NA+A1 to BS EN 1997-1:2004+A1:2013	UK National Annex to Eurocode 7: Geotechnical design – Part 1 General rules	+A1:2013 Incorporating Corrigendum No.1	
BS EN 1997-2:2007	Eurocode 7: Geotechnical design – Part 2 Ground investigation and testing	Corrigendum June 2010	
NA to BS EN 1997-2:2007	UK National Annex to Eurocode 7: Geotechnical design – Part 2 Ground investigation and testing	-	

Bsi Published Documents

For guidance only unless clauses are otherwise specified in BD 100/16 Annex B.

Doc No.	Title
PD 6688-1-1:2011	Recommendations for the design of structures to BS EN 1991-1-1
PD 6688-1-7:2009 +A1:2014	Recommendations for the design of structures to BS EN 1991-1-7
PD 6688-2:2011	Recommendations for the design of structures to BS EN 1991-2
PD 6687-1:2010	Background paper to the UK National Annexes to BS EN 1992-1 and BS EN 1992-3
PD 6687-2:2008	Recommendations for the design of structures to BS EN 1992-2:2005
PD 6695-1-10:2009	Recommendations for the design of structures to BS EN 1993-1-10
PD 6694-1:2011	Recommendations for the design of structures subject to traffic loading to BS EN 1997-1

Execution Standards referenced in British Standards or Eurocodes

Doc No.	Title	
BS EN 13670:2009 Incorporating corrigenda October 2015 and November 2015	Execution of concrete structures	

Product Standards referenced in British Standards or Eurocodes

Doc No.	Title	
BS EN 206:2013	Concrete – Specification, performance, production and conformity	Corrigendum May 2014
BS EN 10080:2005	Steel for the reinforcement of concrete – Weldable reinforcing steel - General	
BS EN 15050:2007 + A1:2012	Precast concrete products – Bridge elements	See BD100 clause 2.18 for additional guidance.

British Standards

Doc No.	Title	

BS 4449:2005+A2:2009	Steel for the reinforcement of concrete	
BS 8500-1:2015+A1:2016	Concrete – Complementary British Standard to BS EN 206: Method of specifying and guidance for the specifier.	Incorporating Corrigendum No.1
BS 8500-2:2015+A1:2016	Concrete – Complementary British Standard to BS EN 206: Specification for constituent materials and concrete.	
BS 8666:2005	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete	Incorporating Amendment No.1

The Manual Contract Document for Highway Works (MCHW)

Doc No.	Title	
MCHW Volume 1: **May 2017**	Specification for Highway Works	*Specification compliant with the execution standards must be used. A Departure is necessary for the parts where a compliant revision has not been published.*
MCHW Volume 2: **May 2017**	Notes for guidance on the Specification for Highway Works	*Notes for guidance compliant with the execution standards must be used. A Departure is necessary for the parts where a compliant revision has not been published.*
MCHW Volume 3: **February 2017**	Highway Construction Details	

The Design Manual for Roads and Bridges (DMRB) – Highway Structures & Bridges

Doc No.	Title	Notes
GG 101 Revision 0	Introduction to the Design Manual for Roads and Bridges	Replaces GD 01/16
GG 102 Revision 0	Quality Management Systems for Highway Design	Replaces GD 02/16
GG 103 Revision 0	Introduction and general requirements for sustainable development and design	
GG 104 Revision 0	Requirements for Safety Risk Assessment	Replaces GD04/12 and IAN 191/16
GG 184	Specification for the use of Computer Aided Design	Replaces IAN 184/16
CG 300 Revision 0	Technical approval of highway structures	Supersedes BD 2/12
CG 302 Revision 0	As-built, operational and maintenance records for highway structures	Supersedes BD 62/07
CG 303 Revision 0	Quality assurance scheme for paints and similar protective coatings	Supersedes BD 35/14
CG 305 Revision 0	Identification marking of highway structures	Supersedes BD 45/93

CD 127 Revision 1	Cross-sections and headrooms	Replaces TD 27/05 and TD 70/08
CD 350 Revision 0	The design of highway structures	Supersedes BD 100/16, BA 57/01, BD 57/01 and IAN 124/11
CD 351 Revision 0	The design and appearance of highway structures	Supersedes BA 41/98
CD 352 Revision 0	Design of road tunnels	Supersedes BD 78/99
CD 355 Revision 0	Application of whole-life costs for design and maintenance of highway structures	Replaces BD 36/92 and BA 28/92
CD 356 Revision 1	Design of highway structures for hydraulic action	Supersedes BA 59/94
CD 357 Revision 1	Bridge expansion joints	Replaces BD 33/94, BA 26/94, IAN 168/12 and IAN 169/12
CD 358 Revision 1	Waterproofing and surfacing of concrete bridge decks	Replaces BD 47/99, BA 47/99 and IAN 96/07
CD 364 Revision 0	Formation of continuity joints in bridge decks	Replaces BA 82/00
CD 365 Revision 1	Portal and cantilever signs/signals gantries	Replaces BD 51/14, IAN 193/16, BE 7/04
CD 366 Revision 0	Design criteria for collision protection beams	Replaces BD 65/14
CD 369 Revision 0	Surface protection for concrete highway structures	Replaces BA 85/04
CD 372 Revision 0	Design of post-installed anchors and reinforcing bar connections in concrete	Supersedes IAN 104/15
CD 373 Revision 0	Impregnation of reinforced and prestressed concrete highway structures using hydrophobic pore-lining impregnants	Supersedes BD 43/03
CD 374 Revision 0	The use of recycled aggregates in structural concrete	Supersedes BA 92/07
CD 377 Revision 3	Requirements for road restraint systems	Supersedes TD 19/06
CD 622 Revision 1	Managing geotechnical risk	Replaces HD 22/08, BD 10/97 and HA 120/08
CS 461 Revision 0	Assessment and upgrading of in-service parapets	Supersedes BA 37/92 and IAN 97/07
GD 304	Designing health and safety into maintenance	Replaces IAN 69/15

Revision 2		
LA 104 Revision 1	Environmental assessment and monitoring	Supersedes HA 205/08, HD 48/08, IAN 125/15, and IAN 133/10
LA 106 Revision 1	Cultural heritage assessment	Supersedes HA 208/07, HA 60/92, HA 75/01
LA 110 Revision 0	Material assets and waste	Supersedes IAN 153/11

Interim Advice Notes

Doc No.	Title
IAN 105/08	Implementation of construction (design and management) 2007 and the withdrawal of SD 10 and SD 11

Miscellaneous

CIRIA C766 Control of cracking caused by restrained deformation in concrete
CIRIA C686 Safe access for maintenance and repair
CIRIA C760 Guidance on embedded retaining wall design

Appendix B – Geotechnical Design Report Summary

<table>
<tr><th colspan="4">GEOTECHNICAL ASSESSMENT SHEET</th></tr>
<tr><td>Project:</td><td>A303 Amesbury to Berwick Down</td><td>Rev: 0</td><td>Calc No:</td></tr>
<tr><td>Structure name:</td><td colspan="2">Foundation of Green Bridge Four</td><td>Date: 2021-02-04</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="3">Relevant exploratory boreholes:</td><td>References:</td></tr>
<tr><td colspan="3">
<table>
<tr><th>Chainage (approx.)</th><th>Borehole</th><th>Ground elevation (m)</th><th>Borehole depth (m)</th></tr>
<tr><td rowspan="6">6+489.00</td><td>RC197626-R71804</td><td>104.33</td><td>46.00</td></tr>
<tr><td>PC197510-R71701</td><td>105.22</td><td>49.05</td></tr>
<tr><td>PC197510-CP71701</td><td>105.10</td><td>48.00</td></tr>
<tr><td>PC197510-CP71702</td><td>102.72</td><td>48.04</td></tr>
<tr><td>733442-R71805</td><td>102.57</td><td>46.1</td></tr>
</table>
</td><td>
[1] Jacobs UK Ltd. (2020) A303 Amesbury to Berwick Down – Exploratory Hole Location Plan and Geological Long Section. Drawing HE551506-BGR-GEN-SWMLM00Z-DR-GE-0004
[2] A303 Tunnel Ground Model Technical Note HE551506-BGR-HGT-SWGN000Z-RP-Z-0001
[3] pGIR. Preliminary Ground Investigation Report, Oct 2018. HE551506-AMW-HGT-SW_GN_000_Z-RP-CE-0005-P02
[4] PC197510 A303 Amesbury to Berwick Down - Phase 7a (i) Factual Report AMENDED FINAL 05 Nov 19_Optimized. HE551506-HE-VSS-ZZ_GN_ZZ_Z-RP-KK-0167
[5] 733442_v3.ags A303 Stonehenge Phase 6 & 7 Ground Investigation
[6] pc197626v2.ags A303 Amesbury to Berwick Down - Phase 7A(II)
[7] CIRIA C574 Engineering in chalk
[8] Eurocode 7: Geotechnical Design – Part 1: General rules
[9] NA+A1:2014 to BS EN 1997-1:2004+A1:2013_UK National Annex to Eurocode 7: Geotechnical de-sign – Part 1: General rules
</td></tr>
<tr><td colspan="4">Proposed structure/foundation:</td></tr>
</table>

GEOTECHNICAL ASSESSMENT SHEET			
Project:	A303 Amesbury to Berwick Down	Rev: 0	Calc No:
Structure name:	Foundation of Green Bridge Four		Date: 2021-02-04

This green bridge is a rectangular frame structure. The current proposal is to construct shallow strip foundations of 6.5m in width, 148m in length and 2m in height. The base of the foundation is estimated at elevation +94m, that is, 2 m below road alignment elev. of +96m.

Existing ground level and expected elevation of foundation level:

Current ground levels are approximately +102 to +105m, as per relevant boreholes and topography. After a general excavation of the site of 8m, the under road will be at elev. +96m. For spread foundations, the excavation is expected to reach 2-2.50m in depth locally below road level. The base of the foundation to be located approximately at elevation +94m

Encountered Ground conditions:

The encountered ground conditions are shown in the next figure for all boreholes. In summary, based on the available information from the reference boreholes, the base of the foundation (elev. +94m) will be either on weathered chalk (R71805), or competent chalk and above the groundwater level assumed for design.

Borehole R71805 gives the most unfavourable ground conditions, and it will be taken as ground model for preliminary design.

Note 1: Groundwater (GW) level for design is 20% Climate change GW level, as measured from the ground profile

Note 2: Chalk classification according to EGU codes in Table 2-1 of ref [2], and CIRIA field assessed (in brackets).

LEGEND	Soil and structureless chalk (=location of weathering depth)
	Weathered chalk(CRS4-CSR5-CSR6)
	Competent chalk(CR1-CR2-CR3)

Elev. (m)	RC197626-R71804	PC197510-R71701	PC197510-CP71701	PC197510-CP71702	733442-R71805
105		UND	SPT values		
104	CS9	CR2	49		
103	UND	(M, B2/3)	47	53	TS/CS7
102			27	30	CRS6
101			32	39	CR2(M,B3)
100			75	27	
99			53	39	CS7/CS8
98			61	29	CRS6
97	Road +96m		35	29	(L, B5)
96			35	34	
95	+94m	+94m	33		CRS6
94	CR2	CR2	32	47	(L, B5)
93	(M, A2)	(M, B2)			
92			34	37	CRS6
91				36	(L, C5)
90	Groundwater level +89m	+89m	43	39	
89		CR2	35	43	UND
88		(M, B2)	R-100		
87			34	36	+86m
86					CR3
85			44	R-100	(L, B2)
84					+83m
83			53	68	CR2/CR1
82					(MH, B2)
81			37	32	+80m
80					CR2(M,B3)
79			R-100	46	+78m
78			47	55	CR2
77			R-100	R-100	(M, B2)
76			49	R-100	
75	+74m				+74m
74	CR2/CR3		58	R-100	CR2
73	(LM, B1)		50	R-100	(M, B2)
72					
71			88	R-100	
70					+69m
69			56	R-100	AZCL
68			46	R-100	CR2
67					(M, B2)
66			R-100	R-100	
65	+64m				
64	UND				
63			92	R-100	
62				R-100	
61			R-100	R-100	
60			R-100	R-100	
59	+58m	+58m	R-100	R-100	
58		CR2/CR1		R-100	
57		(MH, B2)	R-100	R-100	
56					
55					

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Ground model for foundation design:

- Reference borehole for ground model is R71805
- Design GW elevation (m) = +89m
- Road elevation (m) = +96m
- Base of foundation elevation = +94m

The ground model has two layers, from top to bottom:

From elevation	To elevation	Ground description
+96m	+83m	Low density weathered chalk CRS6 (L, B5/C5/B2) with occasional loss of core
+83m	+55m (end of borehole)	Medium-high density Competent chalk CR2 (M, B2)

Therefore, the foundation is in the Low density weathered chalk CR6 (L, B5/C5/C2)

Parameters for design:

Eurocode 7 (Section 6.4) allows for different methods to analyse limit states in spread foundations:

Table 3.2.1 Methods to analyze limit states (after *Bond & Harris, 2008*)

Method	Description	Constraints
Direct	Carry out separate analyses for each limit state, both ultimate (ULS) and serviceability (SLS)	(ULS) Model envisaged failure mechanism (SLS) Use a serviceability calculation
Indirect	Use comparable experience with results of field & laboratory measurements & observations	Choose SLS loads to satisfy requirements of all limit states
Prescriptive	Use conventional & conservative design rules and specify control of construction	Use presumed bearing resistance

The chosen method here is the Indirect Method for Bearing resistance (ULS) and settlement (SLS), as CIRIA C574 includes a Shallow foundation design procedure based on Plate Loading test results for:

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- Medium/High density chalk, and
- Low-density chalk

Following Sections 7.5 and 7.8 of CIRIA C574, the proposed parameters of chalk, for use with the method in section 7.8:

LOW-DENSITY CHALK, GRADES B AND C	
E_S	= 200-700 MN/m^2
q_y	= 240-500 kN/m^2
E_y	= 15-35 MN/m^2
q_u	= 1.5-2 MN/m^2

Where:

- q_u is the Ultimate bearing capacity of chalk, and hence the Allowable bearing capacity is taken as $q_{all} = {}^{q_u}/_{3}$
- E_S is the secant modulus, as measured in plate load tests at a "standardized" applied stress of say, 200 kN/m^2. This stress is chosen because it provides a modulus at a stress level at or just a little below the likely applied stress in practice. The secant modulus is illustrated by the slope of the line OA in Figure 7.1 of CIRIA C574. Note the "applied stress" is taken to be the "net" stress, i.e., excluding the self-weight of the soil or the buried structure above the shallow foundation.
- q_y is the yield stress, as measured in plate load tests, above which settlements increase rapidly
- E_y is the yield modulus, when ρ/D exceeds about 0.4 per cent
- ρ/D is the ratio settlement/plate diameter

Proposed foundation:

Following CIRIA C574 Chapter 7.8, A spread foundation of minimum width of 6.5m, and a shear key at the base to increase resistance to sliding, is required to comply with the requirements of:

ULS – Bearing resistance

SLS- Overturning moment

SLS – Sliding resistance

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SLS – Allowable bearing pressures for settlement. This limit state is the one that defines the foundation size.			

Appendix C – CDM designer's risk register for the Green Bridge

Potential hazards and risk have been defined and will be detailled in further stages, early stage and risks will continue to be considered as the design develops. A detailed risk register will be developed during detailed design.

DESIGN HAZARD ELIMINATION AND REDUCTION REGISTER

Project Name	Design Stage	Engineering Discipline	Structure	Date	Document Reference
A303 Amesbury to Berwick Down (Stonehenge) - Green Bridge 4 Structure	Tender Design	Structures	Green Bridge 4	20 April 2021	**Quality Submission**

Ref:	Phase C/M/D	Activity	Potential Hazards	Risk	Person(s) Affect	L	S	R	Design Measures to Eliminate Hazards	Design Measures to Reduce Risk	Residual risk information to be provided going forward	L	S	R	Included on Drawing/Document No.'s - References
1.0	C	Construction of Green Bridge 4	In-Situ construction works	Injury to workforce	Site personnel	4	4	16	Design to allow the offsite manufacture where possible to ensure controlled conditions	Identification and Communication of design advice such as guidance on the equipment to be used	Competent contractor to be used and detailed construction risk assessment to be completed upon reward of detailed design	3	4	12	
2.0	C	Construction of Green Bridge 4	Crane movement and Lifting of materials	Dropping of heavy items, material during construction resulting in injury and death, and damage to materials and tunnel.	Site personnel	3	5	15	The use of mechanical hoists to be designed where possible to reduce lifting	Identification and Communication of design advice including the correct procedure for lifting materials and the use of crash/protection decks	Contractor to follow design advice and follow appropriate lifting procedures. Protection/Crash decks to be designed	2	5	10	
3.0	C	Construction of Green Bridge 4	Impact on construction schedule due to interference with tunnel procurement	Construction of green bridge four could be delayed if tunnel construction slow down or delays due to construction interruptions	Site personnel	3	5	15	Disassociate construction of green bridge 4 from construction of the tunnel	Provide simple structure design for easier construction	Contractor to adapt to any construction delay during tunnel execution	2	5	10	
4.0	C & M	Operation of Highways	Terrorist attack	Injury to public	Public	2	4	8	N/A	Security management and security features of building to be designed at detailed design stage, specialist advise to be sought at design stage	Contractor to follow design advice and build to design	1	4	4	
5.0	M	Repair and maintenance of operational highway, street furniture and landscaping	Difficulty in conducting repairs over operational highway	Vehicular accidents during maintenance causing injury and death	Public and site personnel	3	4	12	Design should be robust to ensure functionality of operational highway and design out maintenance requirement s where possible. Maintenance regime to be designed to reduce disruption and enable remote monitoring. Footpath and tunnel services building incorporated into design.	Safety features (such as walkways) to be designed at detailed design stage. Maintenance regime to be determined at detailed design stage	Residual risk information to be included in O&M manuals and the Health and Safety File. Closing the operational highway mitigates the risk of injury caused	1	4	4	
6.0	M	Operation of Highways	Heavier vehicle than considered in the design above Green Bridge 4	Damage to the structural stability and potential breakdown	Public and road user	2	3	6	Design should be robust and take extra resistance allowable and provide integral solutions where plastic behaviour in structure could appear	Include additional signalling with the limitation of load over the bridge as per design specifications	Maintenance team to take into account limitations in the programme	2	3	6	
7.0	C	Interaction between Green Bridge 4 and soil nail wall	Unexpected ground pressures transferred from the soil nail to the Green Bridge 4	Soil nail deflects in long term and transfer some earth pressures to the Green Bridge 4 abutments	Public	4	4	16	Design of the green bridge 4 to consider full long term earth pressures acting on the abutments of the structure	Design of the green bridge 4 to consider sort term earth pressures acting on the abutments of the structure	Contractor to follow soil nail construction requirements and method statement to ensure soil nail will withstand long term earth pressures	1	4	4	
8.0	C	Water flow in foundation excavation	Ground water higher than predicted in site investigation	Presence of water during foundation excavation	Site personnel	4	4	16	Further site investigation to establish maximum ground water level	Design for conservative values of ground water level and reduce foundation depth	Contractor to follow design advice and build to design	2	4	8	
9.0	C	Construction of Green Bridge 4	Interface with operational highways during the construction of highways infrastructure	Accidents involving site personnel and members of the public causing injury and potential death, damage to vehicles and plant	Site personnel and public	4	4	16	Design with consideration of nearby existing A303 to avoid site boundary interface. Where interface occurs lane closures as necessary.	Design for traffic management during the detailed design process.	Contractor to follow design advice and follow appropriate procedures and avoid site boundary interface with existing A303.	2	4	8	
10.0	C	Construction of Green Bridge 4	Impact on construction schedule due to interference with tunnel procurement	Construction of green bridge four could be delayed if tunnel construction slow down or delays due to construction interruptions	Site personnel	3	5	15	Disassociate construction of green bridge 4 from construction of the tunnel	Provide simple structure design for easier construction	Contractor to adapt to any construction delay during tunnel execution	2	5	10	
11.0	D	Use of highways by heavy vehicles	Overloading of highways base slab	Loading of road base slab exceeding the highways loading designed for, causing excessive deflection and damage to the roads, and injury to public	Public	3	4	12	Specifying restrictions on highways loading to prevent the use of the road by vehicles which are heavier than anticipated	Slab to be designed for loading from heavy vehicles according to highways standards and maximum loading to be made clear for the appropriate signage	Residual risk information to be included in O&M manuals and the Health and Safety File, signage to be put up on the highway to restrict vehicles heavier than anticipated	2	4	8	
12.0	C	Working on the WHS	Delays on the construction schedule due to unexpected archaeological assets	Impact on the construction schedule due to unexpected archaeological assets appear inside the working area outside the DAMs	Site personnel	3	4	12	Provide a design solution with minimized occupation impact on the working area	Define clear construction methodologies and taking into account the WHS restraints	Contractor to follow design advice and DARMs boundaries during all construction stage	1	4	4	
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Phase	
C	Construction
M	Maintain/Clean
D	Demolish/Adapt

Hierarchy of Mitigation

1. Eliminate hazard - design out
2. Reduce risk at source - amend design
3. Provide risk information - add to design

Prepared by:	**Team Badger**													**Date:**	**04 December 2020**
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