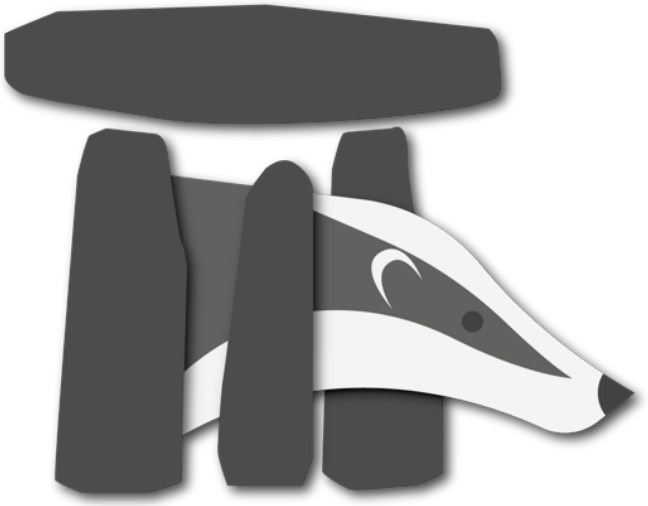

highways england

QS8C
Outline Approval in Principle (AIP) for:
Green Bridge Three

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APPENDICES

Project Details

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

Name of bridge or structure: Longbarrow Junction Overbridge (Green Bridge 3)

Structure reference No.: TBA

Summary

This Outline AIP covers the Green Bridge Three 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

Under Green Bridge Three is the A303 road, a Dual 2-lane all-purpose carriageway (D2AP) with traffic lane widths in accordance with CD 127. Over Green Bridge Three the A360 road, Dual 2-lane all-purpose carriageway (D2AP) with traffic lane widths in accordance with CD 127 with minimum verge width 2.50m.

1.2 Permitted traffic speed

A303 under the structure – National Speed Limit for dual carriageway (70mph)

(The eastbound carriageway will be subject to variable speed control related to traffic management for the A303 Stonehenge Tunnel)

A360 link on the structure – A 40mph speed limit will apply.

1.3 Existing restrictions

The Longbarrow Junction Overbridge shall be designed and constructed as a single span, fully integral, arch overbridge structure carrying the A360 over the new A303.

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 Three structure will span over the new A303 road alignment, adjacent to the current A303 road.

3 PROPOSED STRUCTURE

3.1 Description of structure and design working life

The Green Bridge Three 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.

Waterproofing system will be designed also for the same design working life of 120 years due to the impossible maintenance on the waterproofing under the backfill.

For the parapets design working life of 50 years in accordance with Table 7.1 of CD 350 The Design of Highway Structures is considered.

This is a structure located around chainage 5+657 of the A303, the structure is an arch overbridge structure carrying the A360 over the new A303. The structure is backfilled to allow the A360 above the structure.

In situ concrete foundation and concrete upstand is designed for the support of the arch elements and a precast piece to fit design vision approach is located on each side of the upstand.

3.2 Structural type

Bridge structure with precast concrete arch-shaped segmental units. Thickness of the arch = 500mm

3.3 Foundation type

Cast in-situ shallow foundation, spread footings. Cross section of the footing 7000x2000mm.

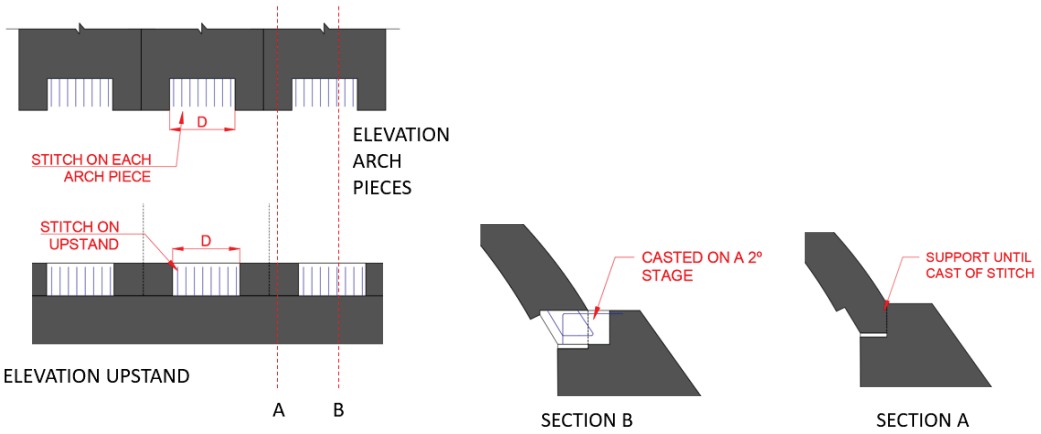
The foundation includes an in-situ upstand 3.60m height to allow the support of the arches without clashing with the A303 minimum headroom required.

3.4 Span arrangements

Span between support = 33.50m for the precast arch elements.

3.5 Articulation arrangements

The precast concrete arches are supported on the concrete upstand raised from the footings and both, arches and upstand, are designed with stitches in the concrete to allow an in-situ cast of the joint to achieve a fully integral connection.



The width of the stitch is mean to be maximized in detail design.

3.6 Classes and levels

A) Consequence class

For the main structure CC3 in accordance with CD 350, Table 7.2.

B) Reliability class

RC3 for whole structure and K_{FI} taken as 1.0, in accordance with CD 350, Table 7.2.

C) Inspection level

Design Supervision Level 3. Inspection Level 2 or 3 as required by CD 350, Table 7.2.

or whole or parts of structure, in accordance with CD 350, Table 7.2.

3.7 Road restraint systems requirements

A303 central reserve under the structure – H2 Containment Level Class B Impact Severity Level (ISL) rigid concrete safety barrier 0.9m high in accordance with requirements of Volume 2 scope Cl 5.1.2.

A303 verges under the structure – H2 Containment Level W4 Steel safety barrier 0.75m high.

A360 central reserve on the structure – H2 Containment Level Class B Impact Severity Level (ISL) rigid concrete safety barrier 0.9m high.

A360 edge of the structure – This is a 'green bridge' with earth bunds 2.0m high and 12.0m wide on either side of the carriageway at the back of 2.5m wide verges. No road restraint is proposed in the verges. Steel pedestrian fencing 1.05m high will be provided at the edge of the structure, behind the bunds to protect against falling onto the A303 carriageway below.

Containment classes will be further risk assessed using CD377 and the associated RRRAP at detailed design stage.

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 with connect to earth works drainage system in verge.

3.9 Proposed arrangements for future maintenance and inspection

A) 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.

Access for maintenance and inspection of the structure will be via the carriageway during lane deviations. Traffic will be diverted through the two roundabouts near the junction during the maintenance and inspection works.

3.10 Environment and sustainability

Using the precast concrete solution, instead of on-site reinforced concrete walls and slab, reduces material use and on-site quality controls, which benefits the environment and also reduces embedded carbon dioxide.

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 and pre-cast concrete elements shall be grade C32/40 minimum and concrete covers will be considered as per BS EN 1992-1-1:2004.

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.

Finishes of the structures are aligned 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: Precast 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 Financial Submission.

3.14 Proposed arrangements for construction

A) Construction of structure

- Cut excavation to the level of the foundations.
- Foundation execution, including concrete upstands with stitches for the connection with the upstand.
- Placing of precast concrete arch pieces (this phase is repeated for each arch ring). The arches will have stitches in the support to allow connection with the upstand.
- Cast in-situ of stitches of the arches and upstands, crown joints and loop joints between arch rings.
- Drainage pipes and waterproofing.
- Backfilling placed simultaneously from both sides.

- Placing of precast lateral pieces.
- Execution of road pavement and finishing.

B) Traffic management

Traffic management is expected to be necessary as the green bridge structure interacts with the existing A303 and the A360. Traffic will be redirected to both sides of the green bridge for the duration of the works, but the contractor will have to confirm this.

C) Service diversions

There is a duct with communication cables on the A360 road, a potential space must be left for diversions of ducts and Instalcom cables over the Green Bridge structure.

D) Interface with existing structures

There are no structures in the immediate vicinity of the proposed Green Bridge Three structure.

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 as per BS EN 1991-1-5. Due to the level of fill above they are not considered significant for the structure design, but this implication will be detailed in detail design.

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.

Outside the A360 carriageway, imposed loads over the footways and environmental bunds will be considered as per BS EN 1991-2:2003 Section 5 and NA Table NA.3. Additionally, LM4 (Crowd loading) will be considered.

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

D) Actions relating to General Order traffic under STGO regulations

SV80, SV100 and SV196 loading as per CD 350 Table 7.6.2 & the National Annex to BS EN 1991-2:2003 and PD6688-2:2011.

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

Vehicle impact loads on walls 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.

4.4 Authorities consulted and any special conditions required

Additionally, continuous collaboration within BADGER as well as with Highways England representatives allows for seamless incorporation of any change into the design, once agreed between all parties.

This project is the subject of a Development Consent Order (DCO). In preparation of the DCO application, consultation with interested third parties has been undertaken. The approved DCO will specify conditions for the design, construction and operation of the tunnel. It will also specify requirements for ongoing consultation with relevant third parties and set out various planning conditions to be discharged and approvals gained.

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

None

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

None

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 semi-elastic connection between the arch and the upstand to model stitch connection and horizontal elastic support K=50000 kN/m for the foundation.

Conservative assumptions for the stiffness of the upstand and the arches have been considered at this stage and will be refined in detailed design.

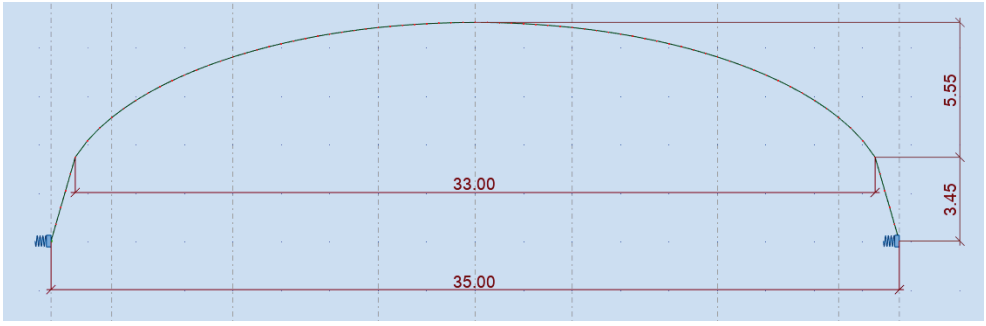


Figure 5-1: Idealised Robot Structural Analysis Model

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	1to10 138to17	Whole structur	-Z	Factor=1.00	MEMO:				
2:BW	uniform load	138to145 172t	PX=0.0	PZ=-10.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
2:BW	uniform load	146to157 180t	PX=0.0	PZ=-23.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
2:BW	uniform load	158to167 192t	PX=0.0	PZ=-63.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
2:BW	uniform load	1to10 168to17	PX=0.0	PZ=-128.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
3:EW	uniform load	1to5 168to170	PX=70.00	PZ=0.0	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
3:EW	uniform load	158to167	PX=31.00	PZ=0.0	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
3:EW	uniform load	138to141	PX=11.50	PZ=0.0	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
3:EW	uniform load	180to191	PX=-11.50	PZ=0.0	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
3:EW	uniform load	6to10 202to20	PX=-70.00	PZ=0.0	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
3:EW	uniform load	192to201	PX=-31.00	PZ=0.0	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
4:LL1	uniform load	138to140 172t	PX=0.0	PZ=-110.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
5:LL2	uniform load	155to160	PX=0.0	PZ=-55.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:
6:LL3	uniform load	1to5 161to170	PX=0.0	PZ=-30.00	global	not project.	absolute	BE=0.0	DZ=0.0	MEMO:

5.3 Assumptions intended for calculation of structural element stiffness

Precast 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

At this tender stage, earth pressures are obtained as per conservative assumption values below in order to obtain a conservative design of the structure.

Table 5-2: Ground parameters

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

It is considered that the backfill type above the Green Bridge Three structure is:

- Backfill next to the surface of the bridge (min. 2m) = Backfill granular material Type 6N/6P as per MCHW.
- Rest of the backfill = Backfill granular material Type 1 as per MCHW.

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

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 3 as per clause 3.9 of CG300.

7.2 If category 3, name of proposed independent checker

TBD in further design stage.

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, Sections and details	HE551506-BGR-SBR- Z2BRL00Z-DR-S-0001
Construction sequence	HE551506-BGR-SGN- Z2BRL00Z-DR-S-0001

9 THE ABOVE IS SUBMITTED FOR ACCEPTANCE

We confirm that details of the temporary works design will be/have been[15] 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	
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 BD100 Annex A 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 BD100 Annex A 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	-	
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 BD100 for additional guidance.
BS EN 1991-2:2003	Eurocode 1: Actions on structures. Traffic loads on bridges	Corrigenda December 2004 and February 2010	See BD100 Annex A 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 BD100 Annex A 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	-	
BS EN 1992-3:2006	Eurocode 2: Design of concrete structures – Part 3: Liquid retaining and containment structures	-	
NA to BS EN 1992-3:2006	UK National Annex to Eurocode 2: Design of concrete structure – Part 3:	-	

	Liquid retaining and containment structures		
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 *CD 350 Appendix A.*

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 1090-1:2009+A1:2011	Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components	
BS EN 1090-2:2008+A1:2011	Execution of steel structures and aluminium structures – Part 2: Technical requirements for the execution of steel structures	
BS EN 13670:2009 Incorporating corrigenda October	Execution of concrete structures	

2015 and November 2015		

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
BS 6164 2011	Code of Practice for Safety in Tunnelling in the Construction Industry	

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.*

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

Doc No.	Title
CG 300	Technical approval of highway structures
CG 300 TAS January 2021	Generic Technical Approval Schedule (TAS)
CG 302	As-built, operational and maintenance records for highway structures
CG 303	Quality assurance scheme for paints and similar protective coatings
CG 304	Conservation of highway structures
CG 305	Identification marking of highway structures
CD 350	The design of highway structures

CD 351	The design and appearance of highway structures
CD 355	Application of whole-life costs for design and maintenance of highway structures
CD 356 Revision 1	Design of highway structures for hydraulic action
CD 357 Revision 1	Bridge expansion joints
CD 358 Revision 2	Waterproofing and surfacing of concrete bridge decks
CD 359	Design requirements for permanent soffit formwork
CD 360 Revision 2	Use of compressive membrane action in bridge decks
CD 362 Revision 1	Enclosure of bridges
CD 363	Design rules for aerodynamic effects on bridges
CD 364	Formation of continuity joints in bridge decks
CD 366	Design criteria for collision protection beams
CD 367	Treatment of existing structures on highways widening schemes
CD 369	Surface protection for concrete highway structures
CD 372	Design of post-installed anchors and reinforcing bar connections in concrete
CD 373	Impregnation of reinforced and prestressed concrete highway structures using hydrophobic pore-lining impregnants
CD 374	The use of recycled aggregates in structural concrete
CD 375 Revision 1	Design of corrugated steel buried structures
CD 377 Revision 4	Requirements for road restraint systems
CD 378	Impact test and assessment criteria for truck mounted attenuators
CD 622	Managing geotechnical risk

Miscellaneous

CIRIA C574 Engineering in chalk
CIRIA C660 Early-age thermal crack control in concrete
CIRIA C686 Safe access for maintenance and repair
CIRIA C760 Guidance on embedded retaining wall design
British Tunnelling Society (BTS) and the Institution of Civil Engineers (ICE) – Specification for tunnelling, Third Edition, 2010 Association
PAS 8811:2017 Temporary works – Major infrastructure client procedures – Code of practice

Appendix B – Geotechnical Design Report Summary

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

Relevant exploratory boreholes:

Chainage (approx.)	Borehole	Ground elevation (m)	Borehole depth (m)
5+657.00	PC19751-R71301	110.87	50.00
	PC19751-CP71301	110.92	50.00
	PC19751-R71302	111.52	50.00
	PC19751-CP71302	111.59	50.05

References:

[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] 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

[4] CIRIA C574 Engineering in chalk

[5] Eurocode 7: Geotechnical Design – Part 1: General rules

[6] NA+A1:2014 to BS EN 1997-1:2004+A1:2013_UK National Annex to Eurocode 7: Geotechnical design – Part 1: General rules

Proposed structure/foundation:

The current proposal is to construct shallow strip foundations of 7m in width, 55m in length and 2m in height. The base of the foundation is estimated at elevation +98m, that is, 2 m below road alignment elev. of +100m.

Existing ground level and expected elevation of foundation level:

Current ground levels are approximately +111m, as per relevant boreholes and topography. After a general excavation of the site of 11m, the A303 road alignment will be at elev. +100m. 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 +98m

Encountered Ground conditions:

BOREHOLES			GROUND PROFILE		
Borehole	Ground elevation (m)	Borehole depth (m)	Soil and structureless chalk (=location of weathering depth)	Weathered chalk (CRS4-CSR5-CSR6)	Competent chalk (CR1-CR2-CR3)
R71301	110.87	50.00	0.0-6.52m ---------- 16.52-20.20m ---------- ---------- 27.0-35.0m ---------- 42.5-44.0m ----------	---------- ---------- ---------- ---------- 24.5-27.0m CRS6/CR2 (LM,A3)	---------- 6.52-16.52m CR2 (M,B2-M,A3-M,B3) ---------- 20.0-24.5m CR2 (M,B3) ---------- ---------- 35.0-42.5m CR2,CR1 (MH,A3-MH,B3) ---------- 44.0-50.0m CR2/CR1 (MH,A2)
CP71301	110.92	50.00			*This is a Cable Percussion borehole. SPT data indicates competent chalk may start at 25m depth (SPT>60)*
R71302	111.52	50.00	0.0-3.5m	3.5-23m CRS6/CR2 (LM,B2/3)	23.0-50.0m CR2/CR3 (LM,A2)
CP71302	111.59	50.05			*This is a Cable Percussion borehole. SPT data indicates competent chalk may start at 25m depth (SPT>60)*

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

Note 2: Road elev at +100m, current ground elevation at +111m

Note 3: Chalk classification according to EGU codes in Table 2-1 of ref [2], and CIRIA field assessed (in brackets).

Ground model for foundation design:

1. Reference borehole for ground model is R71302
2. Design GW elevation (m) = +87m
3. Road elevation (m) = +100m
4. Base of foundation elevation = +98m

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

From elevation	To elevation	Ground description
+100m	+88m	Low density weathered chalk CR6 (LM, B2/B3)
+88m	+61m (end of borehole)	Low density Competent chalk CR2/CR3 (LM, A2)

Therefore, the foundation is in the Low density weathered chalk CR6 (B2/B3)

Parameters for design:

Eurocode 7 (Section 6.4) allows for different methods to analyze 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:

1. Medium/High density chalk, and
2. 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/m2
q_y = 240-500 kN/m2
E_y = 15-35 MN/m2
q_u = 1.5-2 MN/m2

Where:

1.1. q_u is the Ultimate bearing capacity of chalk, and hence the Allowable bearing capacity is taken as $q_{all} = {}^{q_u}/_3$
2.1. E_S is the secant modulus, as measured in plate load tests at a "standardized" applied stress of say, 200 kN/m2. 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.
3.1. q_y is the yield stress, as measured in plate load tests, above which settlements increase rapidly
4.1. E_y is the yield modulus, when ρ/D exceeds about 0.4 per cent
5.1. ρ/D is the ratio settlement/plate diamete

Appendix C – CDM designer's risk register for the tunnel

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 Briddge 3	Tender Design	Structures	Green Bridge 3	04 February 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 3	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 contracto 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 3	Crane movement and Lifting of materials	Dropping of heavy items, material during construction resulting in injury and death, and damage to materials.	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 3	Impact on construction schedule due to interference with tunnel procurement	Construction of green bridge three could be delayed if tunnel construction slow down or delays due to construction interruptions	Site personnel	3	5	15	Dissassociate construction of green bridge 3 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 maintenacne requirement s where possible. Maintenance regime to be designed to reduce disruption and enable remote moitoing. Footpath and tunnel services building incorperated 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 3	Damage to the structural stability and potential breakdown	Public and road user	2	3	6	Design should be robust and take extra resistance allovable and provide itegral solutions where platic behaviour in structure could appear	Include additional signaling with the limitation of load over the bridge as per design specifications	Maintenance team to take into account limitations in the programme	1	3	3	
7.0	C	Construction of Green Bridge 3	Unvalanced backfill over green bridge 3 structure	Injury to workforce	Site personnel	2	6	12	Design to consider unvalanced loads on the backfill with assimetrical distribuitons of the earth pressures	Appropiate controls of the backfill works during construction and proper indications on the method statement	Competent contracto to be used and detailed construction risk assessment to be completed upon reward of detailed design	1	6	6	
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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 February 2021
Reviewed by:	Team Badger Internal									Date:	
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