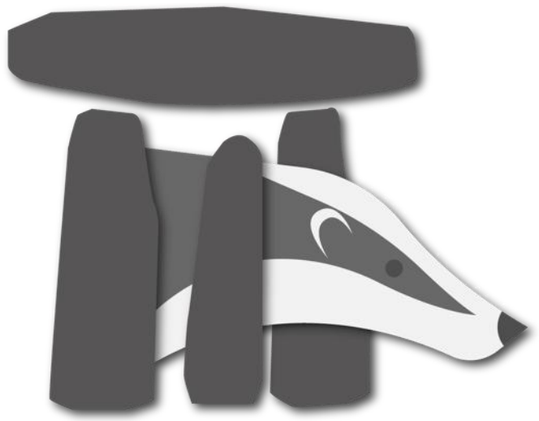


highways england

Western Tunnel Approach | QS-4B | Delivery Methodology | Construction Methodology for the Western Tunnel Approach

4. Your construction methodology for the western cut and cover tunnel section, the western cut retaining structures, the western tunnel services building and Green Bridge Four shall provide the following information as a minimum:

4.1. a detailed breakdown and description of the stages of construction including:
- 4.1.1 the excavation of the western cut;
- 4.1.2 the substructure construction methodology, including piling methods and the TBM launch slab;
- 4.1.3 construction of the retaining structures;
- 4.1.4 the deck and cover construction;
- 4.1.5 construction of the tunnel services building;

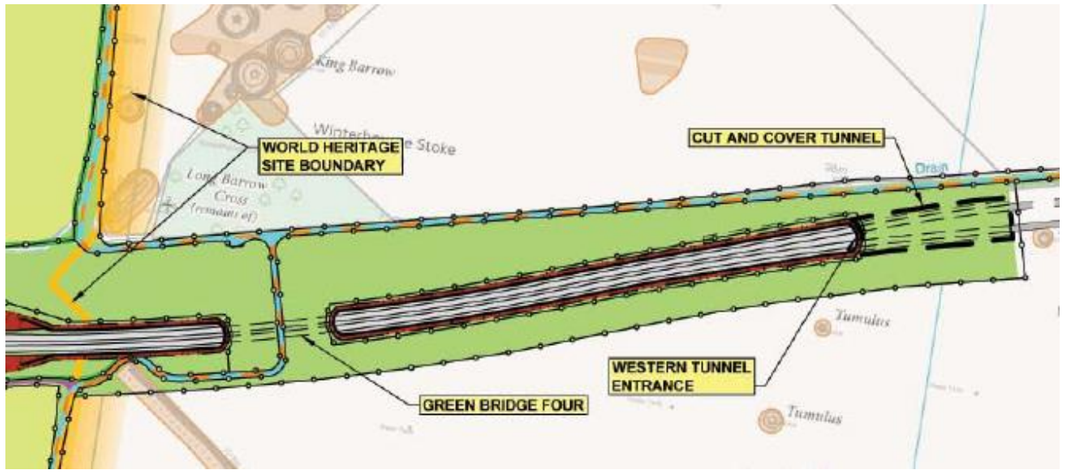
4.2. temporary works and temporary structures required for each stage of construction, including:
- 4.2.1 the significant items of temporary works, such as the launch slab and the temporary portal structure;
- 4.2.2 temporary works for the management ground water;
- 4.2.3 the locations and outline details of hoarding and temporary fencing;

4.3. protective measures which will be implemented for environment and heritage assets and the wider historic landscape of the WHS;

4.4. the key construction risks that are uniquely associated with the construction of this Scheme area and the proposed mitigation.

4.1. Detailed breakdown and description of the stages of construction

This submission relates to the construction methodology to be performed by BADGER to build the Western Tunnel Approach section, which includes the Western Cut and Cover Tunnel section, the Western Cut Retaining Structures, the Western Tunnel Services Building and Green Bridge 4.



The document has been developed in compliance with:

- The DCO Documents
- Volume 2 Part 2 (Design and Technical Requirements)
- Outline Environmental Management Plan
- Detailed Archeological Mitigation Strategy
- Contract drawings
- Data Room documents
- Tender Documents in general including Public and Confidential responses to the Competitive Queries and Tender Amendments.

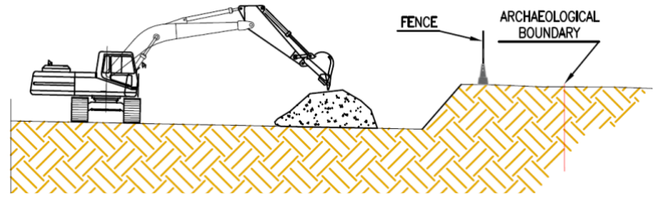
4.1.1. Excavation of the western cut

The western cut sections will extend from CH 6200 to CH 6415 and then beyond Green Bridge 4 from CH 6563 to the portal at CH 7200.

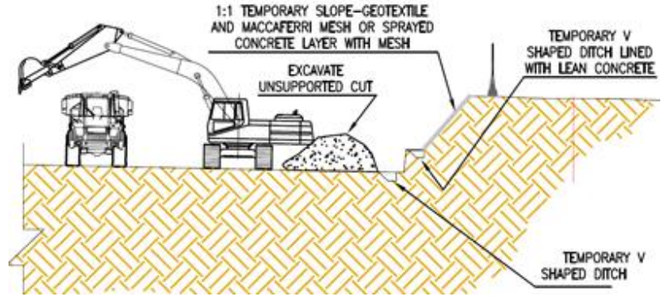
After the execution of preparatory works including general clearing, erection of fences and hoardings, the execution of geotechnical, archeological, and environmental surveys can be completed. Temporary haul roads within the WHS will be within the footprint of the permanent work as per requirement 10.3.1 of Vol 2 Part 2.

The excavation will be performed as per following typical section steps:

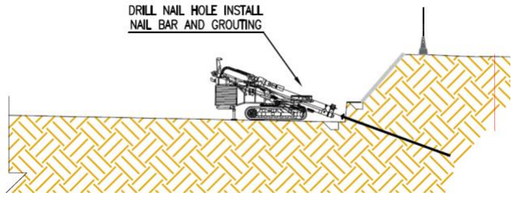
1. Temporary fencing installation and access to work site.



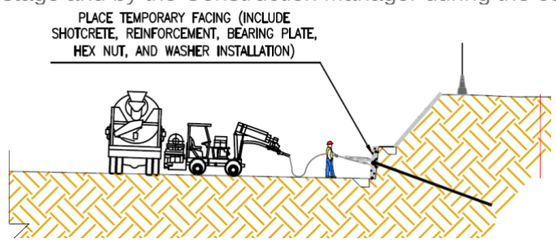
2. Excavation of unsupported cut (1-2 m high). A temporary V shape foot drain will be done along the side to collect the water runoff from the excavated during the subsequent excavation stages.



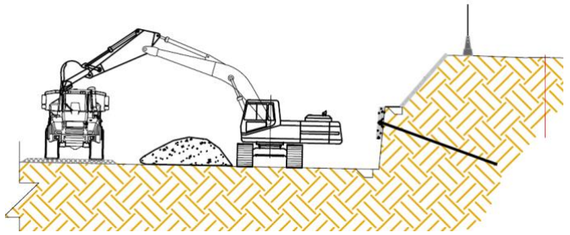
3. If the unsupported cut results in a 1:1 slope based on the DAMS boundary restriction, the surface will be stabilized by geotextile Maccaferri mesh or sprayed concrete layer with mesh (to be removed before the final backfilling). A temporary “V” shaped temporary dich will be executed at the base of the slope thus at the top of retaining wall, the diches will collect run off water.



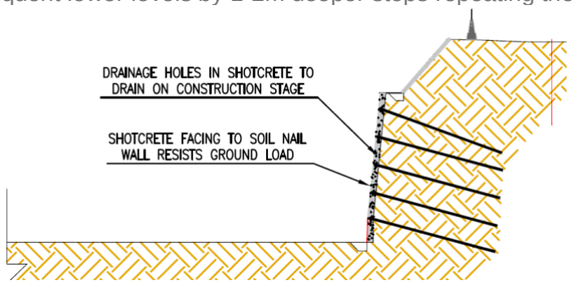
4. Permanent soil nailing installation. Drill the nail hole using specialized drilling equipment operated from the excavated platform, install and grout the nail. The soil nails are permanent and designed for 120 years design life; they are galvanized steel and have a sacrificial thickness to allow for corrosion over 120 years and contribute to final stability of the retaining structure **(TQ3A1.2, TQ3A2.2, TQ3A3.2, TQ3A4.2).** These TQs will be led and managed by the Design Manager throughout the design stage and by the Construction Manager during the construction phase..



5. Shotcrete installation. Place shotcrete, reinforcement, bearing plate, washer and hex nut installation placing of formers for drain holes and finally spraying of shotcrete to required thickness.



6. Construction of subsequent lower levels by 1-2m deeper steps repeating the three circles above.



7. Design invert elevation is achieved, retaining wall includes permanent soil nails, shotcrete layer, temporary V diches on top and on bottom of wall, drainage holes through shotcrete layer.

When the area is close to DAMS zone, it is envisaged that the soil nail has to be >4m below ground level thus the uppermost nail will be installed 0.5m below the bottom of the slope and will be angled at ~20° from the horizontal. In this way, the soil nails will be >4m below ground level when the DAMS zone is reached.
In other cases, such as the cut and cover section or other particular cases where there is a reduced available space to the DAMS boundary limit, a king post temporary support will be used to support the 4m height, thus respecting DAMS boundary.

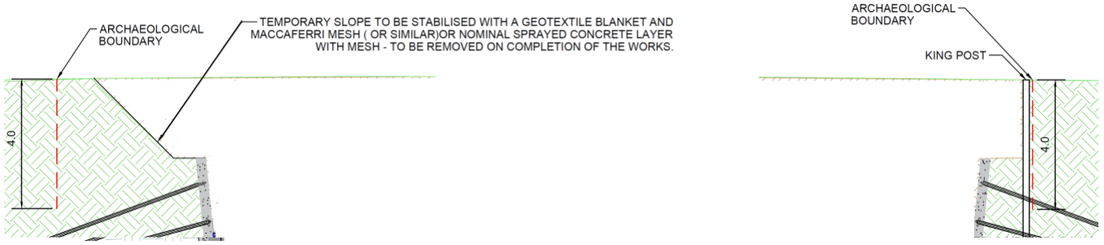


Figure 1: provision for angled permanent soil nails, temporary slope protection and temporary king post where DAMS boundary are close

Settlement Monitoring

The excavation activities will be implemented in a manner that any ground movement and vibration that the works could cause shall be minimized and an assessment of any potential risk of damages shall be carried out.
BADGER will prepare a Ground Movement Monitoring Strategy (GMMS) in order to comply with the Scope of Works, and the requirements of the Outline Environmental Management Plan (OEMP).
The main aim of the GMMS is to minimize the settlement and assess the risk of damage on any existing structures associated to the ground movements caused by the execution of the works.
The GMMS will include at least:

- describe the methodology and approach to assessing damage.
- show the predicted ground movement on settlement contour plans.
- establish the extent of the Zone of Influence and inform the horizontal extent of the instrumentation and monitoring plan to set up. In any case, the zone of influence will not be extended outside the site, and it will cover until 1mm settlement contour as best practice.
- assess the risk of damage to existing infrastructure, archaeology and cultural heritage.
- classify damage using an objective system.
- identifying where ground movement predictions result in an unacceptable level of damage occurring (including cosmetic).
- describe the mitigation and protective measures to be implemented when an unacceptable level of damage is predicted.

Instrumentation and Monitoring (I&M)

A specific plan for monitoring and mitigating settlement and vibration effects due to excavation shall be produced in order to control any potential risk of damage to adjacent structures and the Works themselves.
The I&M plans will define as a minimum the following parts:

- Instrumentation types and locations.
- Acceptable limits (trigger level of each instrument reading) and reading frequencies.
- Contingency plan in case limits criteria is exceeded and pertinent actions to carry out (mitigation, protective or remedial measures).
- I&M report and review meetings to address the progress of the excavation activities and to present and assess the data obtained.

The effects of ground movement and vibrations arising from the cut activities will be assessed to avoid:

- any affection to heritage assets.
- disturbances to building occupants or damages on buildings and infrastructures.

Statutory Undertakers will be consulted to establish and define the damage acceptance criteria (including trigger levels) and any potential mitigation and protective measures when required and also identify measures and responsibility for remedial actions arising from the monitoring to ensure the protection of the assets.
The Trigger levels will be defined in detailed design and be revised following the installation of the monitoring instrumentation and the conditions surveys. However, at least two levels shall be considered:

- Alert level: ground behavior is still within the design expectations but is approaching to the envelope (maximum allowed value).
- Alarm level: ground behavior has reached the anticipated envelope and any further movement will be beyond the design limits. Note that asset damage may not be expected at this level; however, the contingency plan shall be activated with the implementation of mitigation and protective measures.

The Instrumentation and monitoring activities will be conducted at the following stages of the project:

- **Pre-Construction**: monitoring will be undertaken to provide a baseline reading, in which this data will be compared with during the Works. To develop this baseline monitoring, a radar interferometry technology (INSAR) will be proposed. This is a remote sensing modality that permits to monitor large project areas as it uses radar images obtained by the satellites to estimated ground movements and variations on surface.
- **Construction:** monitoring will take place according to the I&M plan and the data will be recorded, compiled and compared with the relevant baseline readings from the pre-construction phase. Detailed instrumentation sections will be implemented on relevant project areas (Stonehenge Bottom, Custodian Cottage and Barrows, A303 and Utilities) within the zone of influence defined.
- **Post-construction**: the monitoring frequency will reduce but continue until stable measurements are reached by the long-term monitoring or until movement rate is 2mm per annum or less over a minimum of 6 months. Use of INSAR technology is also recommended for this I&M stage. Automatic

electronic systems shall be used for this purpose in order to collect, process and make available the data on a web based I&M system in real-time using AGS format.

The measures after prediction of unacceptable movement assessed at detail design stage will be:

- Undertake more detailed structural analysis of affected buildings / assets
- Undertake pre-construction examination (of the cottages)
- Set agreed triggers and include in a monitoring plan to understand what will be done at each level of ground movement and what the responsibilities are
- Baseline monitoring
- Additional SI to understand where the poorer ground might be (soil nail walls)
- Increase thickness of the SCL element of the soil nail wall.

If any alert level or alarm level will occur during construction the mitigation measures will be:

- Increase the number excavation stages to more of a lower height
- Close up the soil nails
- Reduce the length of each excavation level to minimize exposed ground.

4.1.2. The substructure construction methodology, including piling methods and the TBM launch slab

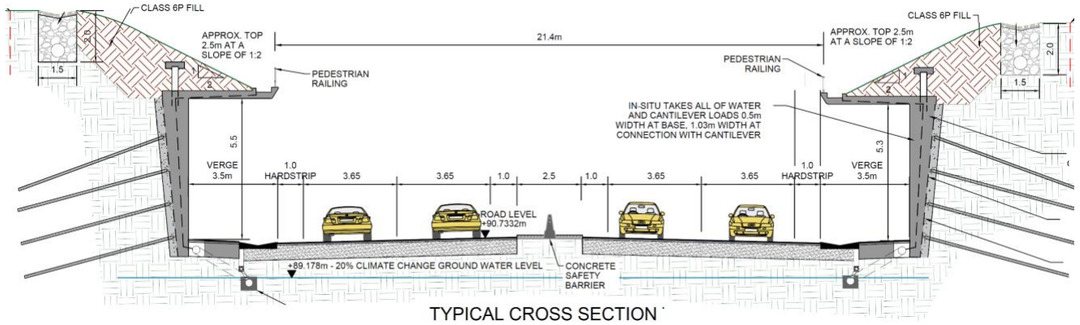
For the western tunnel approach, substructure elements will be executed for the construction of the Green Bridge 4, the cut and cover and tunnel services building. These substructure elements will be detailed in the subsequent points:

- 4.1.3 Construction of the retaining structures. In this point we will address the Green Bridge 4 construction methodology.
- 4.1.4 Deck and cover construction, and
- 4.1.5 Construction of tunnel services building

Aligning to our design approach, no piling is expected in this Western Tunnel Approach.

4.1.3. Construction of the retaining structures

Construction of the retaining structures includes the construction of the retaining walls at both sides of the cut and the construction of the cantilever top edge which allows the landscape to extend over the retaining wall (refer to Technical Solution **QS-4A** and **TQ3B1.2, TQ3B2.2, TQ3B3.2, TQ3B4.2**, led by the Design Manager).



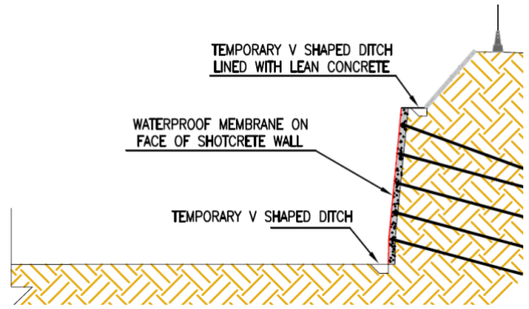
TYPICAL CROSS SECTION `

The retaining walls at both sides are made by permanent soil nails, a cast in place foundation integral connected to a cast in place final lining wall and a cast in place top edge cantilever.
The final finish to all in situ concrete will be determined during detailed design to suit the agreed design vision and noise reduction requirements and will be executed by special formwork to reproduce the intent of the external architectural finishing (rough textured finished concrete).

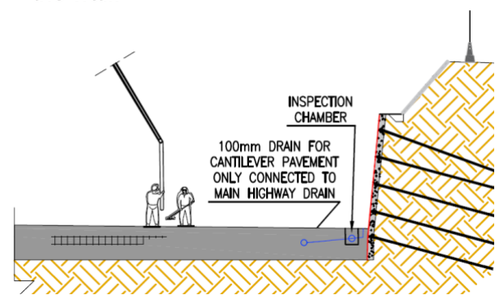
The soil nails are permanent and load carrying for 120 years design life. They are galvanized steel and have a sacrificial thickness to allow for corrosion over 120 years and contribute to final stability of the retaining structure.
Following the excavation procedures described in chapter 4.1.1, the subsequent phases to execute the retaining structures are the following:

1. **Installation of the waterproofing membrane:** on the shotcrete surface and removal of the temporary foot drain
2. **Concrete base slab foundation:** or invert slab **(**depending for the CH). It includes rebar placement, installation of drainage systems at verge and pouring of concrete.
3. **Cast in place wall:** installation of the reinforcement cages bars and shuttering / formwork. Before to pour the concrete, a dedicated drainage pipe will be installed trough the wall to connect the drainage system to the main line. An integral connection is foreseen between the foundation/invert and the wall.
4. **Cast in place cantilever:** installation of the reinforcement cages and shuttering / formwork. Before to pouring the concrete, a dedicated drainage pipe will be installed trough the top of the wall. An integral connection is foreseen between the wall and the cantilever slab.
   Extent of cantilever depends for CH,
5. **Backfilling, crest drain and landscape:** once the cantilever structure is finalized, the temporary V ditch and slope protection can be removed thus backfilling, permanent crest drain, and landscape will be laid to model the final configuration as per requirements and design vision.
   The backfilling material will be supplied from the road level as per requirement and the handrail will be installed on the top of the roof slab.

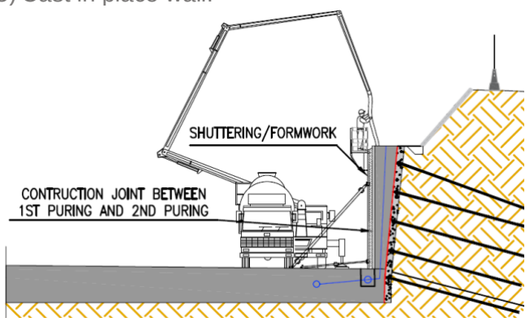
1) Installation of the waterproofing membrane.



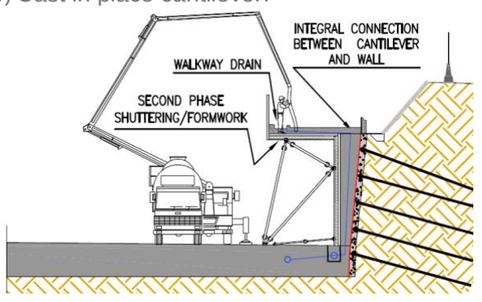
2) Cast Invert slab or base slab foundation of the wall.



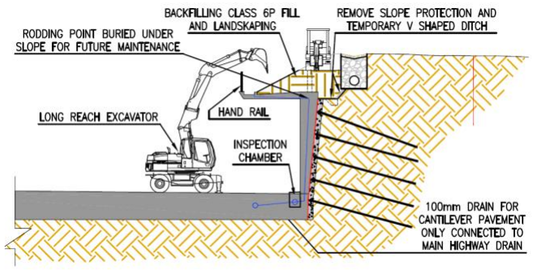
3) Cast in place wall.



4) Cast in place cantilever.



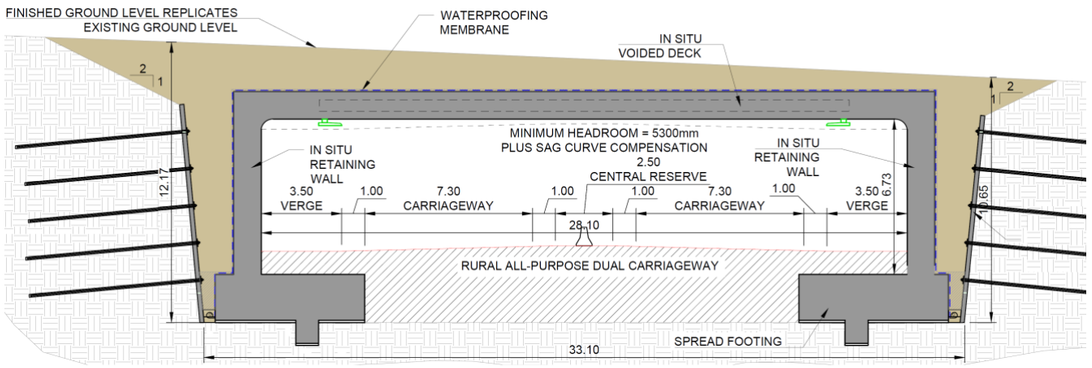
5) Backfilling with 6P material , crest drain and landscape.

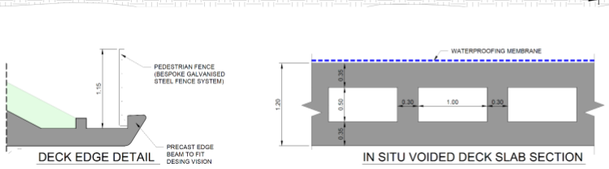


Design vision on retaining wall

GREEN BRIDGE 4

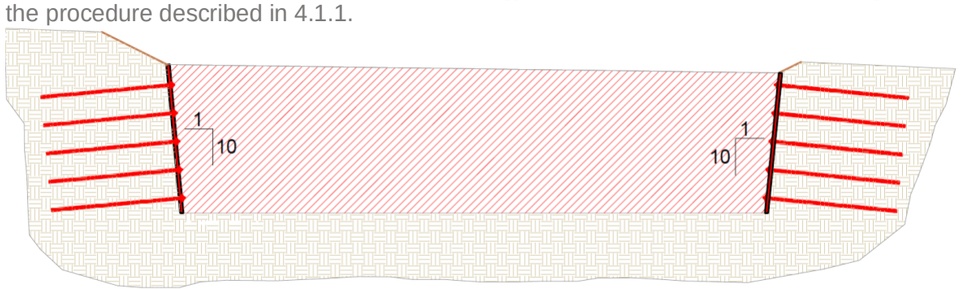
Proposed typical cross section for Green Bridge 4 is shown in the picture below and in the technical solution **QS-4A:**





The proposed construction sequence for the Green Bridge 4 is detailed below:

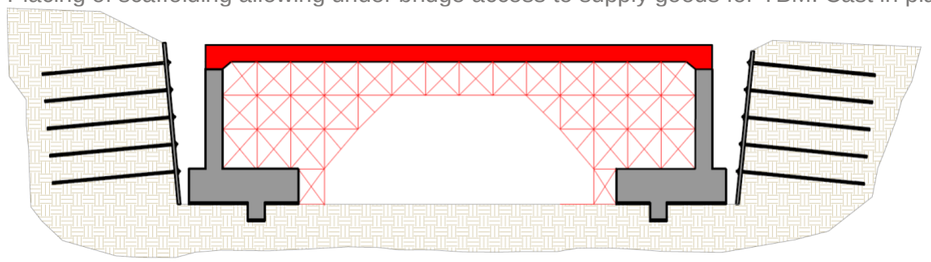
1. Execution of cut – The Construction methodology for the excavation and soil nailing will follow the procedure described in 4.1.1.



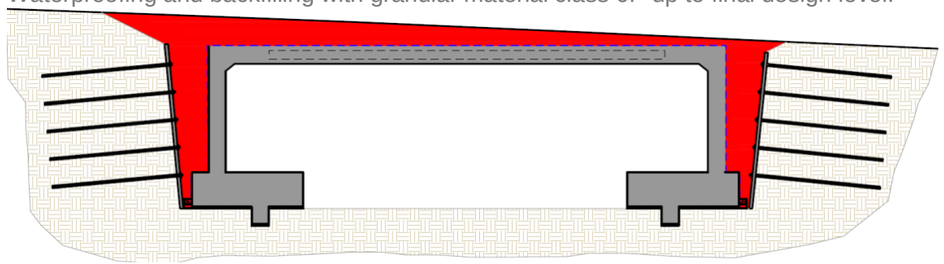
2. Execution of the foundation slab.

3. Construction of lateral walls.

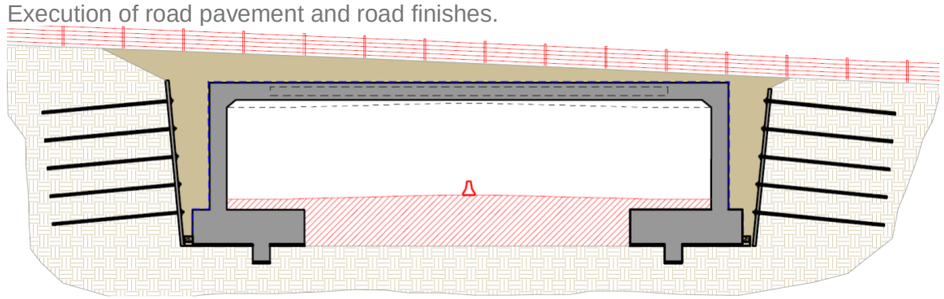
4. Placing of scaffolding allowing under bridge access to supply goods for TBM. Cast in place slab.



5. Waterproofing and backfilling with granular material class 6P up to final design level.



6. Execution of road pavement and road finishes.



7. Landscape and completion of final finishing.