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| FINAL REPORT | Development of preferred solution - Master Design |
| CASE 3 | Justification Report Animal Overpass |
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Technical and additional documents

Basis of assignment

- [U1] Assignment order (contract) No 8/2017-120-X/X for the provision of expert services, Riga
- [U2] Mini competition_SBS-Cases-R0.2
- [U3] Bridge Inventory; Rail Baltica; 02.04.2019

Project-specific documents

- [U4] Rail Baltica Official Website
- [U5] Design guidelines general requirements; Rail Baltica; 25.03.2019
- [U6] Architecture, Landscape and Visual Identity design Guidelines; Rail Baltica; 08.03.2019

Additional documents

- [U7] Flue-Fluegelausbildung; Bundesanstalt für Straßenwesen bast; 12.2009
- [U8] RiL804; DB Netz AG; 01.11.2018
- [U9] Was-Brückenentwässerung; Bundesanstalt für Straßenwesen bast; 12.2009
- [U10] <https://www.beboarch.com/>

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1 General

1.1 Necessity of measure, traffic routes, local boundary condition

New high-speed railway line Rail Baltica will cross habitats of wild animals. To ensure a safe passage of wild animals over Rail Baltica line animal overpasses are planned. A balance between local requirements and natural form structure has to be found for animal overpasses.

This justification report does not deal with a single building structure, but with a general solution for animal overpasses. Each animal overpass on railway line Rail Baltica has to be planned separately considering local boundary conditions, but this report shall give a design basis for such bridge types in a general, theoretical situation.

This justification report is based on one fictional design (see Annex 3_2_001). This solution shows a wide opening as shown on left side in Figure 1. The design concept is also thinkable for a small opening (Figure 1 right). We advise to do the animal overpasses without ways on each side and realize underpasses as small openings as shown in Figure 1 right. In our justification report, drawings and estimation of costs for the wide opening solution is shown because it is the more complicated solution. Nevertheless, small openings are the better alternative for animal overpasses. Unless specified differently, the following description and estimation of costs are based on wide opening solution.

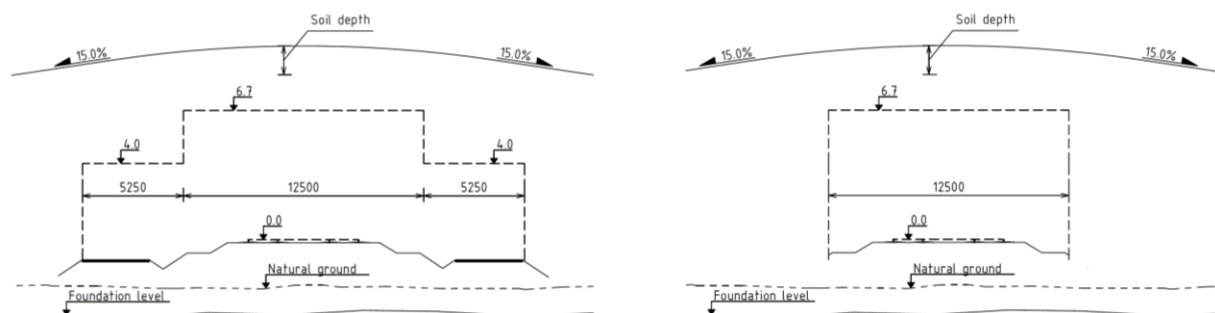


Figure 1: Section A-A - Case 3.1 (left) and Case 3.2 (right) [U2]

1.2 Load assumptions

This general planning of animal overpasses does not include a static calculation, because it is depending on local boundary conditions (e.g. soil conditions) and geometric parameters of the bridge. Load assumptions for a static calculation of each bridge can be taken from design guidelines of Rail Baltica [U5].

1.3 Construction design

Requirements for animal crossings lead to arch bridge or in certain cases tunnel solutions as shown in Figure 2. Therefore, prefabricated concrete slab elements can be used. They can be produced and lift in segments and connected in arch centre without creating a hinge. For smaller solutions segments can also be transported from precast factory.

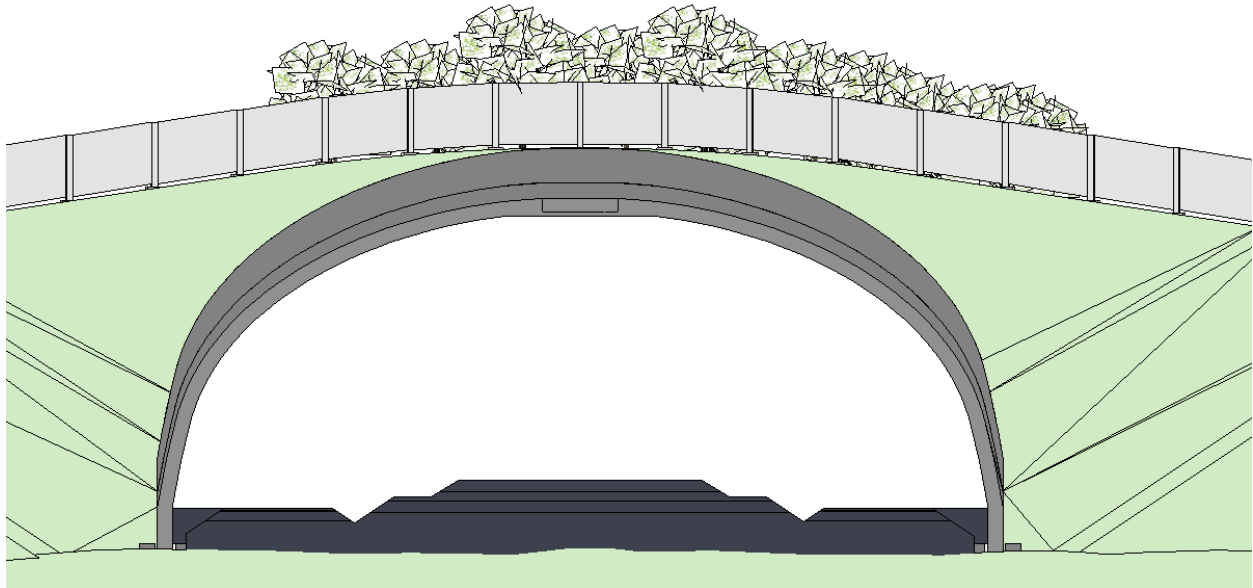


Figure 2: south view animal overpass

Considering rural local boundary conditions and good soil condition this solution is very economical (as shown in estimation of costs annex 3_1). For difficult soil conditions it could be necessary to choose another structure or another foundation for animal overpasses.

Minimum characteristic values of building materials for animal overpasses are listed in Annex 3_2_001.

2 Soil conditions, foundation

2.1 Soil conditions

It is necessary to investigate soil conditions for each bridge. Soil investigation has to be made especially in foundation axis. For the general animal overpass planning, soil conditions which lead to spread footing are assumed.

Backfilling has to be compressed layer wise to ensure transmission of forces from structure to embankment. Layer thickness is around 30 cm.

2.2 Groundwater, water pumping

Depending on groundwater level, water pumping during construction phase might be necessary. Since Baltic states are very flat countries, water pumping is often necessary. Therefore, water pumping is calculated in estimation of costs with a lump sum of 10.000 € (see estimation of costs Annex 3_1).

Depending on landscape a factor (factor of difficulty) to calculate the costs depending on the amount of water pumping can be added.

2.3 Footing

In this fictional design soil conditions for spread footing are assumed. Estimation of costs and quantities and construction planning are based on using spread footing like shown in Figure 3.

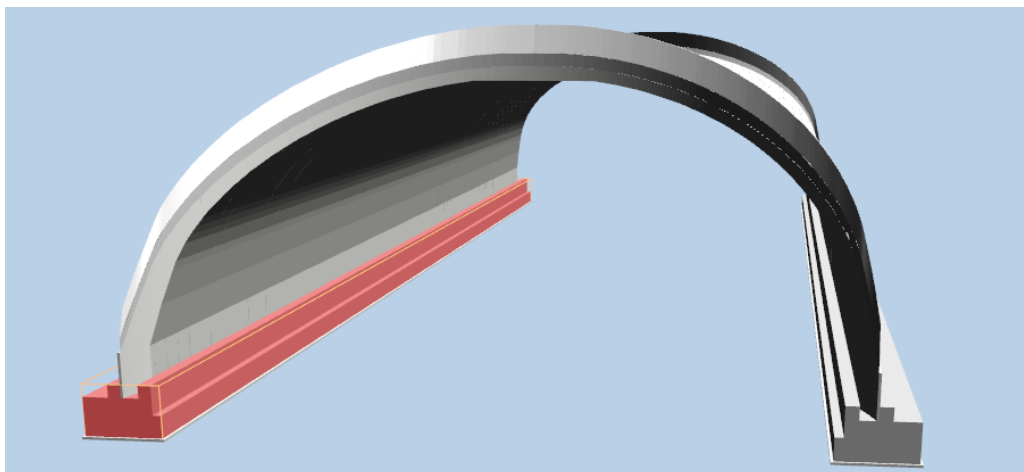


Figure 3: spread footing

For other soil conditions also spread footing with previous soil improvement or deep founding (see Figure 5) is thinkable.

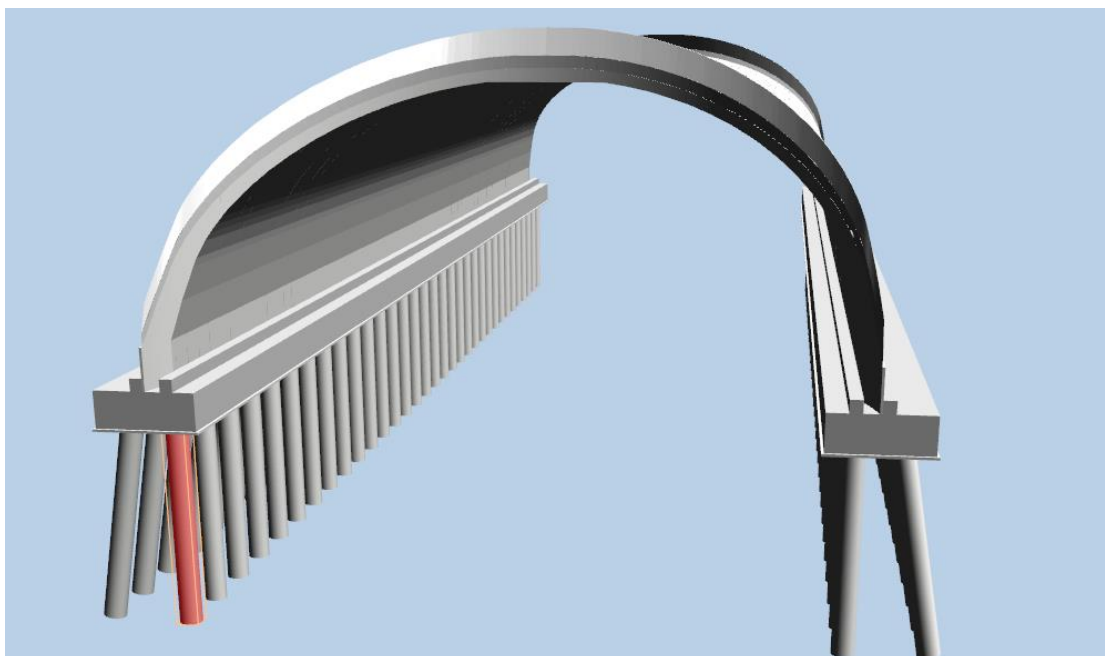


Figure 4: deep founding

2.4 Investigation regarding contamination and explosive ordnance

For general animal overpass planning no investigation regarding contamination and explosive ordnance is included in calculations. Depending on local boundary conditions the expense for these investigations has to be taken into account.

3 Construction ends and substructure

3.1 Construction ends

The presented design of animal overpasses shows bevelled ends using cut-off precast arch units (see Figure 5). Depending on landscape and space requirement other end treatments like standard spandrel walls (Figure 6) and spandrel and wing walls (Figure 7) are thinkable as following figures present:

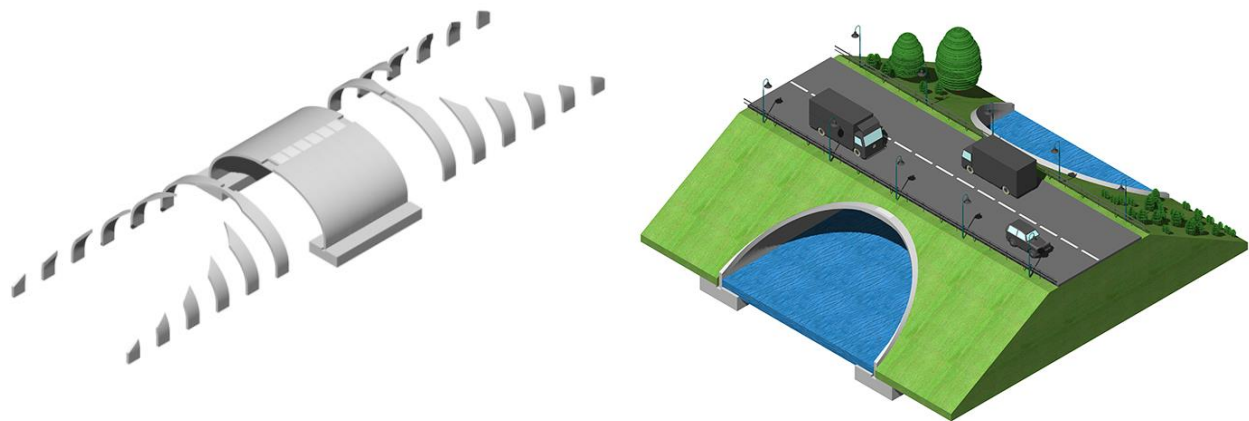


Figure 5: bevelled ends [U10]

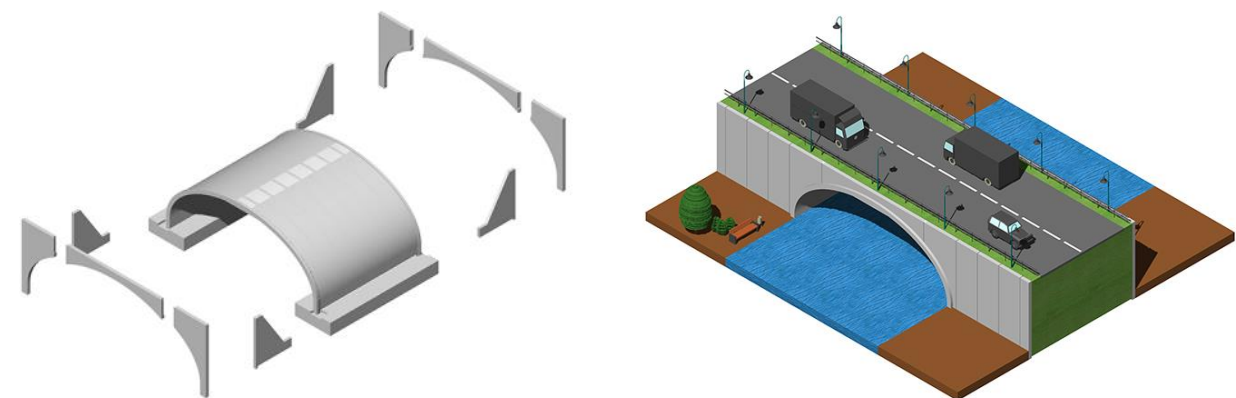


Figure 6: standard spandrel walls [U10]

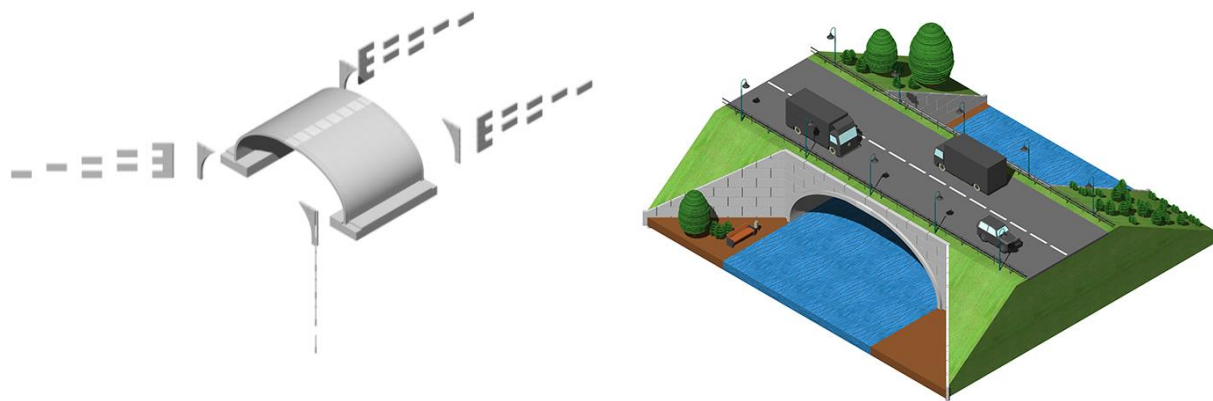


Figure 7: spandrel and wing walls [U10]

3.2 Piers

-lapse-

3.3 Visible surfaces

For bridge design the interaction of surfaces is a big factor. Care should be taken for a good interaction between surfaces of bridge parts. The visible surfaces of superstructure are very smooth due to prefabricated surfaces but can only be seen from under the animal crossing. To contrast visible surfaces of other concrete elements like edge closing concrete board from the smooth superstructure surfaces different ways of formwork can be used:

- Formwork panels
- Planed planks
- Non-planed planks

Also, orientation of formwork can be used to produce a significant surface. Not only concrete surfaces but also the surface of noise barrier/ anti-glare fences has an influence on visual effect.

4 Superstructure

4.1 Load-bearing structure

Superstructure is an arch structure. Made of several prefabricated half-arches. One prefabricated segment is shown in Figure 8.

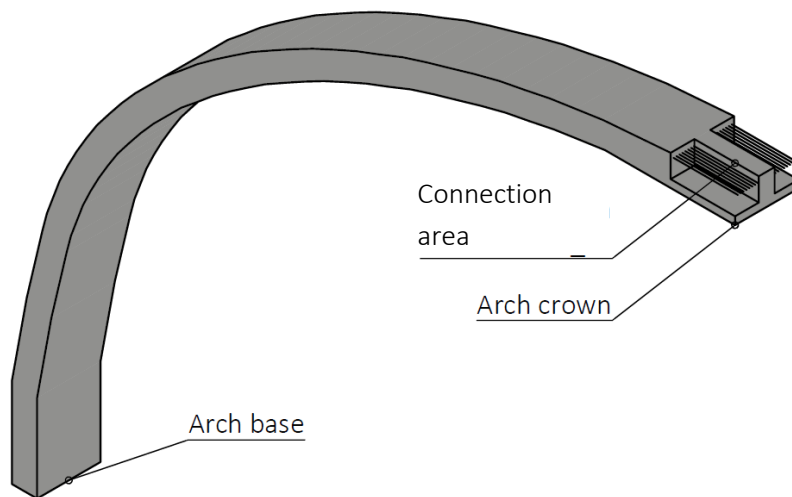


Figure 8: prefabricated segment

This very slender solution takes benefit of structural arch effect. The half-arches are connected in arch centre with reinforcement and in-situ concrete (see Figure 9).

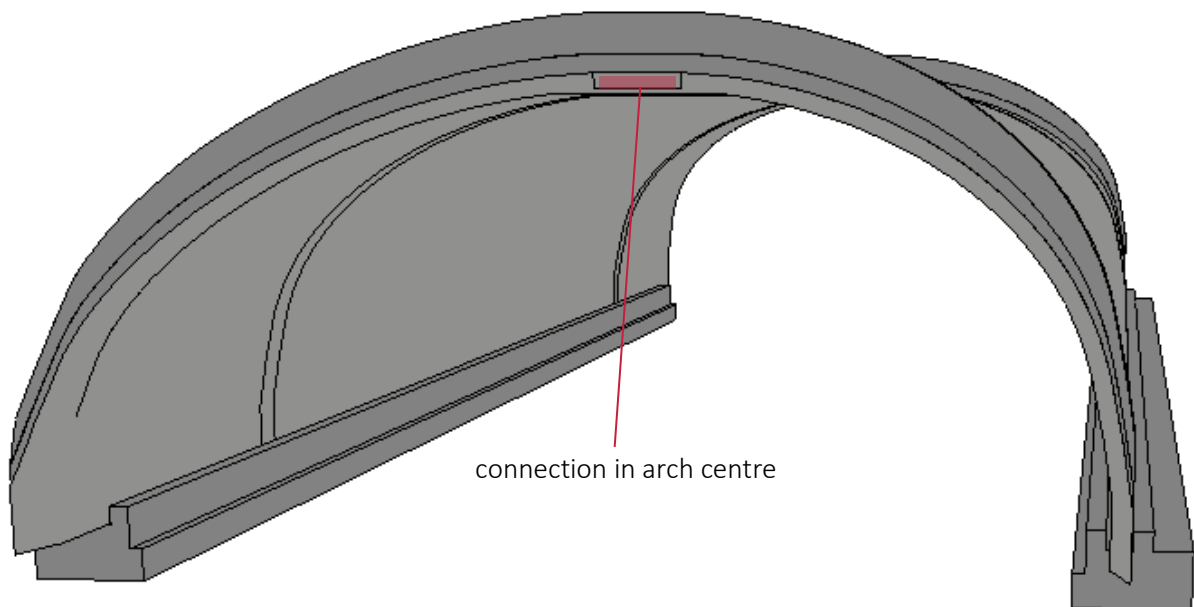


Figure 9: load-bearing structure

Due to small bridge height accessibility for inspection is possible from below with lifting platform.

4.2 Bearings, joints, expansion joints

There are no bearings or expansion joints needed. Only a connection joint in arch centre is needed.

4.3 Waterproofing, covering

Waterproofing has to protect the bridge against damaging effect of water, chemical substances and reduce the passage of steam. Waterproofing has to be designed and constructed in a way that all bridge components are protected against moisture penetration and/or penetration of surface water, seepage water and groundwater.

Waterproofing for superstructure of animal overpasses will be made of two layers. Detailed principles of waterproofing and covering are shown in Detail C3_A and Cross Section B-B in Annex 3_2_001.

4.4 Corrosion protection, protection against environmental influences

Noise barrier/ anti-glare fences and other equipment parts made of steel (e.g. railings, protection systems) need a coating system against corrosion.

5 Drainage system

5.1 Superstructure

There is no additional drainage pipe system to the system in Arch base (chapter 5.2) necessary for animal overpasses. Water follows the structure form and flows along waterproof membrane from superstructure arch centre to arch base.

5.2 Arch base

Drainage takes place along waterproof membrane of superstructure. The water runs in a partly porous run pipe (see Figure 10), which is placed on arch base and has a longitudinal incline off about 1%. High point is in the middle of the animal overpass and water is transported to both bridge ends.

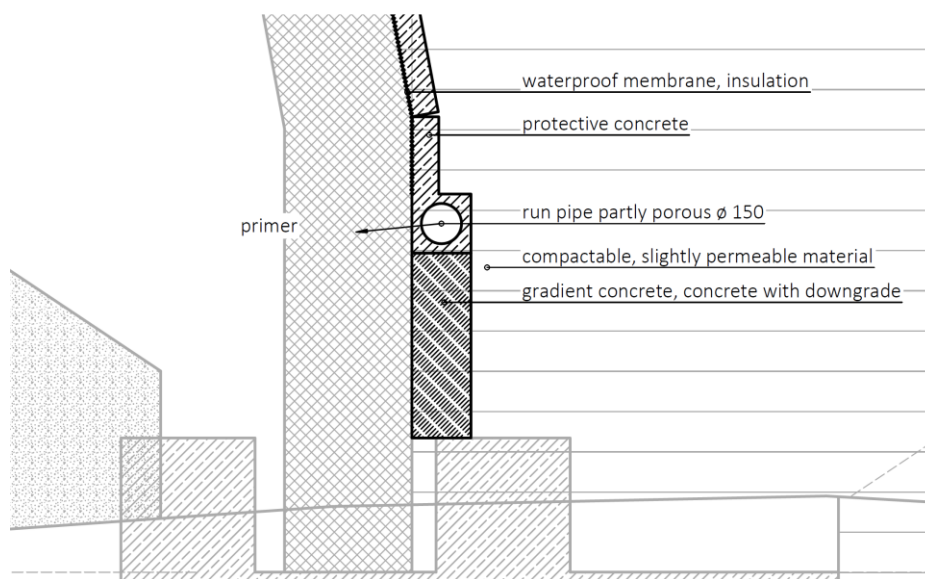


Figure 10: dewatering of animal overpasses on arch base

6 Restraint and protection systems

For animal overpasses noise barrier/ anti-glare fences are necessary. They should have at least a height of 2.00 m, but required height needs to be estimated for landscape and animal diversity in each situation.

Animal overpass ends with an edge closing, to ensure no slide of soil on railway line.

7 Accessibility

Accessibility for inspection is possible from below with lifting platform and has impact on railway operations while inspection time.

8 Other equipment

Grounding

All solid construction components have to be equipped with an inner grounding. All steel construction components (noise protection wall, parapets, ...) need grounding connections and need to be connected to railway earthing.

9 Construction, construction period

9.1 Construction process, construction period

| Construction process | Duration | Comments |
|--|---|--|
| 1 PREPARATORY WORKS | 2-3 WEEKS | |
| Access/ access road to construction site | | depending on region and landscape situation |
| If necessary, build an additional redirecting fence for animals | | depending on wildlife situation |
| Set site area | | |
| 2 EARTHWORK | | |
| Produce planum | 1-6 WEEKS | depends strongly on landscape situation |
| Build embankment | 6-8 WEEKS | depends strongly on landscape situation |
| Pit excavation for spread footing of spread footing of arch base | | depending on local conditions either open excavation or sheeting especially if soil improvement is needed |
| | incl. in founding | layer thickness around 30 cm in a high-quality consolidation |
| Backfill layer wise | | |
| 3 FOUNDING | 6-8 WEEKS PER FOUNDING AXIS INCL. PIT EXCAVATION DEPENDS ON TYPE OF FOUNDATION | |
| (pit excavation see earthwork) | | |
| Granular subbase | | |
| Spread footing, foundation slab | | |
| - formwork | | |
| - place reinforcement | | |
| - pouring concrete | | |
| deep foundation as option instead of Spread footing | + 6 WEEKS | |
| | | depending on soil condition either bored piles, displacement piles, driven pile incl. starter bars for foundation slab |
| - insertion of foundation piles | | |
| - formwork foundation slab | | |
| - place reinforcement for foundation slab | | |
| - pouring concrete for foundation slab | | |
| 4 SUPERSTRUCTURE AND ARCH ENDS | | |
| prefabricated concrete elements main structure | 20-25 WEEKS incl. CURING TIME | |

- produce prefabricated concrete elements

For wide opening produce prefabricated half-arches on site area. Due to geometry this prefabricated elements can't be transported. A prefabrication hall of single elements on site has to be installed. There single elements can be produced in nearly factory conditions. After concrete elements are hardened, they can be lifted in position. For small openings prefabrication is also thinkable in precast factory.

- transport prefabricated concrete elements to side

only for small solution

- place prefabricated concrete elements

Lift prefabricated half-arches in founding as shown in Figure 11

support structure for arch ends

ABOUT 1 WEEK

- build support structure

if necessary, founding for support structure

- dismantling support structure

prefabricated concrete elements arch ends

7-8 WEEKS incl. CURING TIME

- place prefabricated arch ends on support structure and connect them with in-situ concrete edge closing

- formwork

- place reinforcement

- pouring concrete

in-situ connections

2-3 WEEKS

- connect prefabricated element in arch crown with

in-situ concrete

- clamp arch base by casting founding

- casting founding of arch ends

5 EQUIPMENT

waterproof

2-3 WEEKS

- topcoat structure with waterproofing layer (waterproof membrane + protective concrete)

protective concrete

2-3 WEEKS

- reinforced concrete

drainage system brige ends

2 WEEKS PER AXIS

- following detail C3_A drainage annex 3_2_001

Build in-situ concrete board

2-3 WEEKS

- formwork

- place reinforcement

- pouring concrete

| | |
|--|------------------|
| noise barrier/ anti-glare fences | 2-3 WEEKS |
| <ul style="list-style-type: none"> - founding of noise barrier/ anti-glare fences - installation of noise barrier/ anti-glare fences | |
| grounding | 2-3 DAYS |
| <ul style="list-style-type: none"> - inner grounding - grounding of steel construction components to railway earthing | |
| 6 LANDSCAPING | 6-8 WEEKS |
| Greening of animal overpass according Rail Baltica Requirements [U6] Depending on local boundary conditions | |
| 7 FINALIZING WORK | 2-3 WEEKS |
| Clearing construction site | |

ALL INFORMATION ABOUT DURATION ARE ROUGH REFERENCE VALUES.
 DURATION FOR PREPARATION, TRANSPORT AND LANDSCAPING DEPEND STRONGLY ON LANDSCAPE SITUATION.

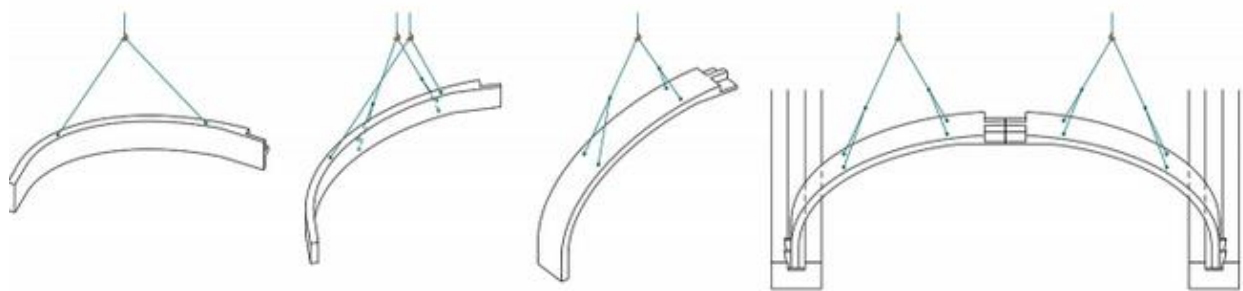


Figure 11: lift prefabricated half arches in founding [U10]

9.2 Protective measures

Work for waterproofing might be problematical if ambient temperature is too low. Therefore, waterproofing either has to take place when it is not too cold for the waterproofing material (the manufacturer's details are to be observed) or a waterproofing material for the special ambient temperature while waterproofing apply phase has to be planned in detailed design for the specific structure. Waterproofing work can be started 2 weeks after concreting.

10 Costs

The costs are roughly estimated. A list with costs and quantities can be seen in Annex 3_1.

| | | | |
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Final leaf

Hannover, 27.09.2019