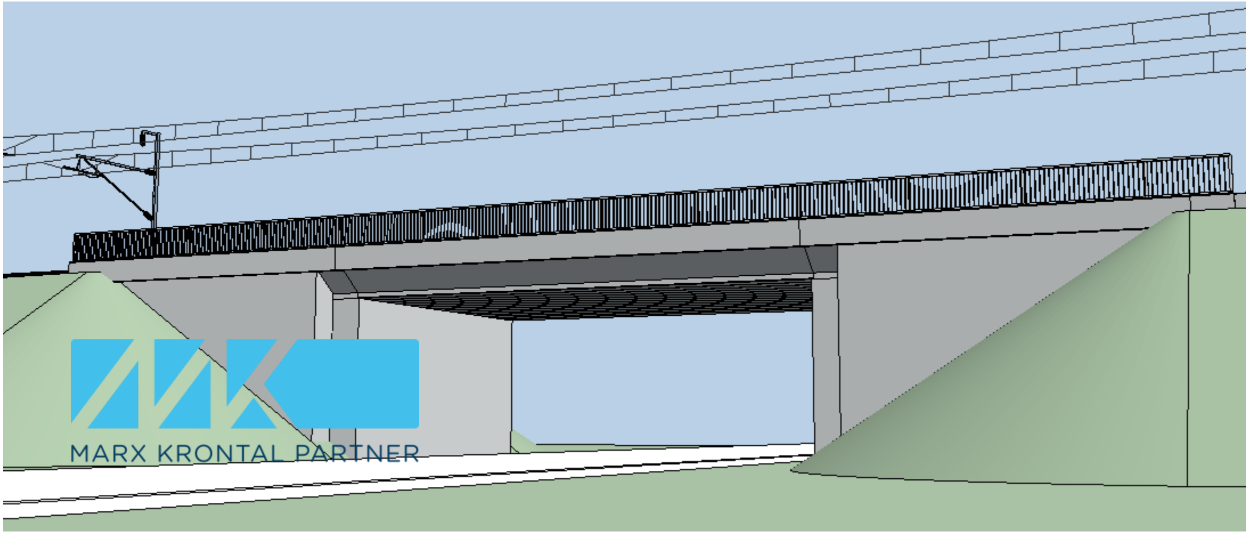

PROJECT	**Rail Baltica** SBS-Study
FINAL REPORT	**Development of preferred solution - Master Design**
CASE 1	**Justification Report Underpass**
PERFORMANCE PERIOD	07/2019 until 09/2019
PRINCIPAL	RB Rail AS Vasco Amaral; Rita Grigāne K. Valdemara 8-7 LV-1010 Riga Latvia
SERVICE PROVIDER	MKP GmbH Uhlemeyerstraße 9+11 30175 Hannover T +49 511 515154-0 E info.hannover@marxkrontal.com
PROJECT NUMBER INTERNAL	04119
EDITOR	Justine Bange, M.Sc
DATE	Hannover, 27.09.2019
INDEX	a

Co-financed by the Connecting Europe Facility of the European Union

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

Additional documents

[U6] Flue-Fluegelausbildung; Bundesanstalt für Straßenwesen bast; 12.2009

[U7] RiL804; DB Netz AG;01.11.2018

[U8] Was-Brückenentwässerung; Bundesanstalt für Straßenwesen bast; 12.2009

[U9] VDEI- Verband Deutscher Eisenbahn-Ingenieure E.V. - information Konstruktiver IngenieurBau Nr.05

Table of content

1 General

1.1 Necessity of measure, traffic routes, local boundary condition

New high-speed railway line Rail Baltica will cross small roads or rivers. An underpass is the structure that carries Rail Baltica railway line over this small roads or rivers. Typical underpasses are short (horizontal clearance 10 – 20 m) and often single-span (longer multi-span underpasses are called “rail viaducts” and are covered separately in Case 2 Annex 2_0).

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

1.2 Load assumptions

This general planning of underpasses 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

The main overall design concept for railway bridges and road overpasses is a straight and clear language of design.

Straight abutments build the end of the bridge. With put back wing walls the carrying system is presented as shown in Figure 1.

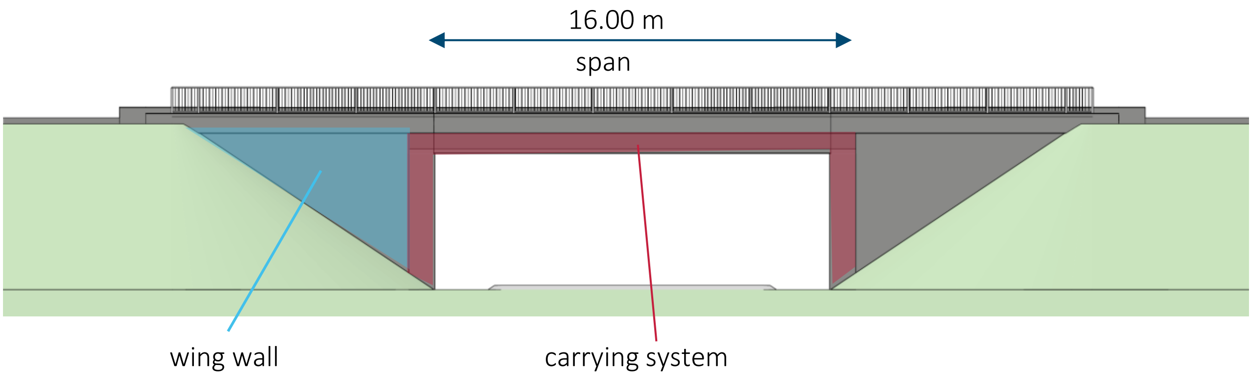

Figure 1: side view underpass

In this planning phase the superstructure is designed with a slenderness of l/h = 16. Due to inclined edge girders visual slenderness is even higher.

Considering rural local boundary conditions this solution is a very economical solution (as shown in MCA annex 0_5). In urban situations another design could be more advantageous.

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 underpass planning, good soil conditions for spread footing are assumed.

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 might be necessary. Therefore, water pumping is calculated in estimation of costs with a lump sum of 10.000 € (see estimation of costs Annex 1_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 (Figure 2 left) are assumed. Calculations and construction planning are based on assumption of good soil conditions to use shallow foundation.

For other soil conditions also spread footing with previous soil improvement or deep foundation (Figure 2 right) is thinkable.

spread footing deep foundation as alternative

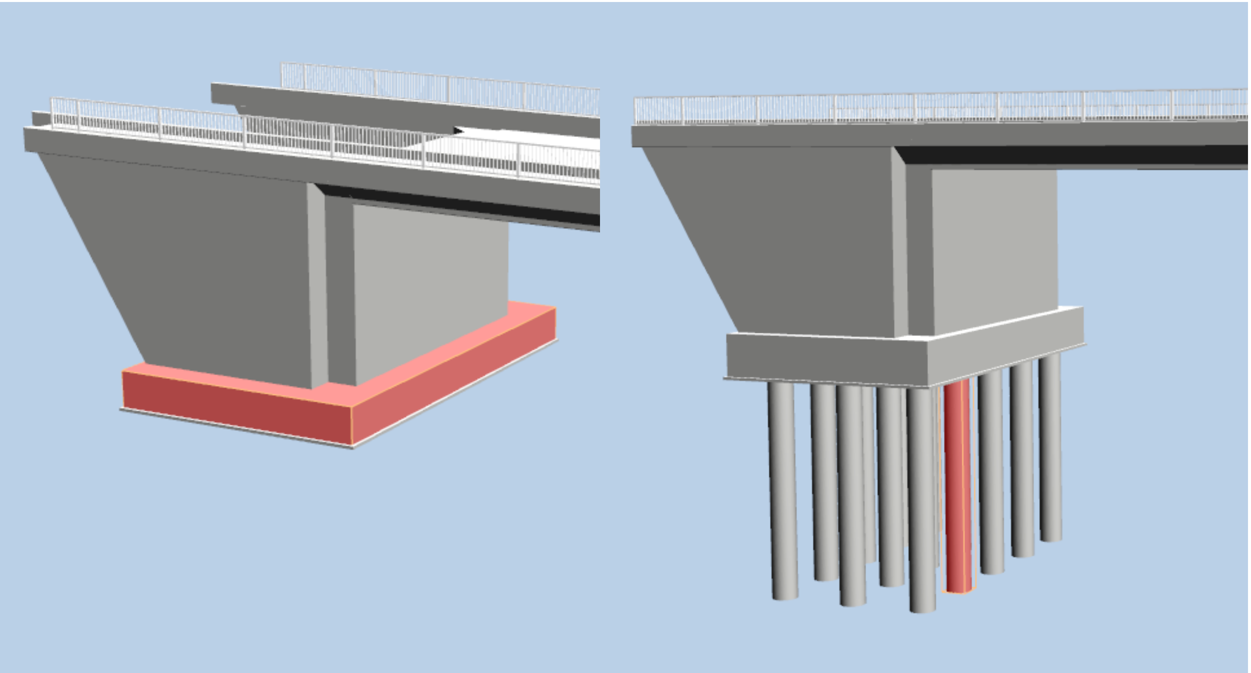

Figure 2: kinds of foundation; spread footing (left) and deep foundation (right)

2.4 Investigation regarding contamination and explosive ordnance

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

3 Substructure

3.1 Abutment, wing walls, backfill

Abutments and wing walls (east and west) are based on a 1.20 m thick spread footing. The footing is set on a granular subbase.

Abutment and wing walls shall be constructed with concrete C 30/37. Reinforcing steel type B 500 B has to be used.

The wing walls have a constant thickness of 1.00 m and a length of about 10.00 m. They are designed according standard drawings by the German Federal Ministery of Transport, Building and Urban Development RiZ Flü 1 (Picture 1) [U6].

The angle of wing walls can differ depending on landscape situation. Especially for underpasses this angle defines the design and visual impact (see Figure 3, Figure 4 and Figure 5).

- Angled wing walls: difficult to build, construction time is longer than parallel wing walls, most economical solution in comparison to parallel and perpendicular wing walls
- Parallel wing walls: easy to build, construction can be done in a short time, wing wall does not disturb existing embankment, but not most economical arrangement
- Perpendicular wing walls: building less difficult than angled wing walls, continuous alignment with bridge deck which can be used to support railings, disturbs existing embankment

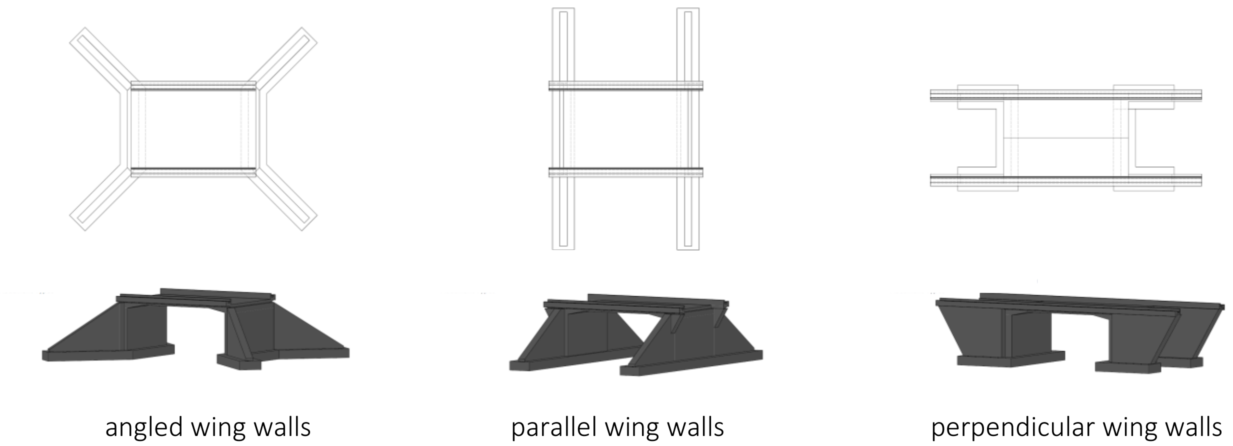

Figure 3: types of wing walls

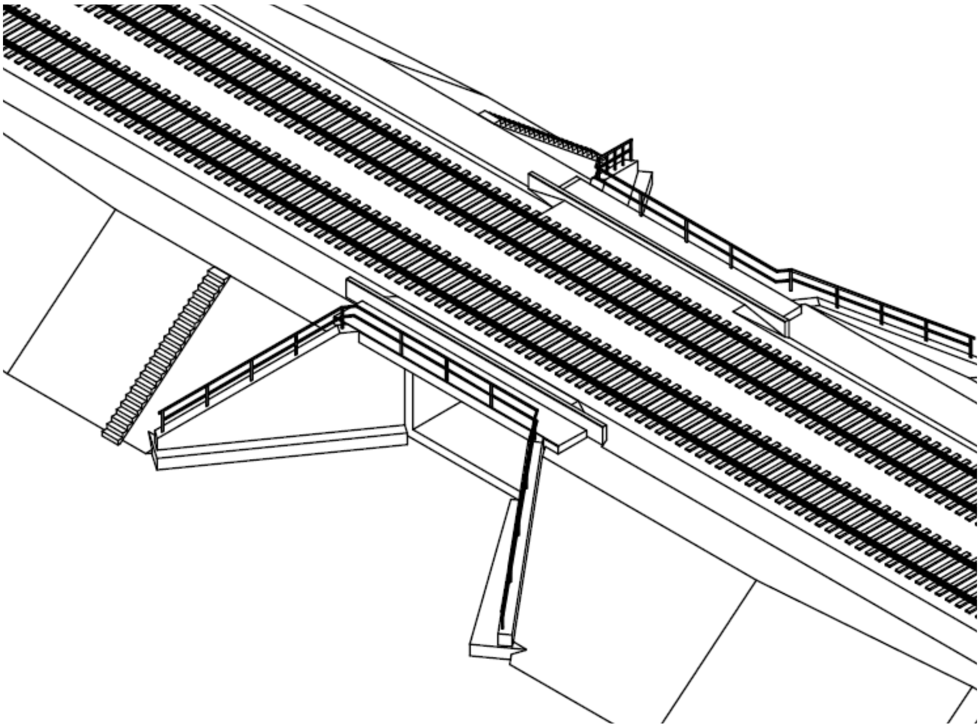

Figure 4: landscape form for underpasses with angled wing walls [U7]

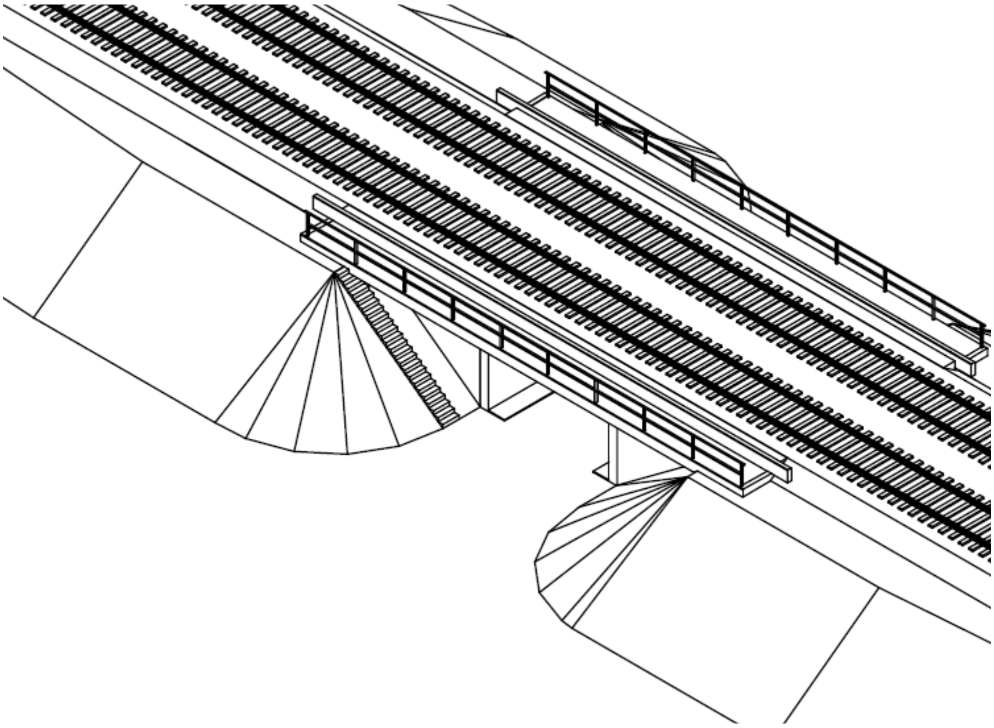

Figure 5: landscape form for underpasses with perpendicular wing walls [U7]

In this theoretical case perpendicular wing walls are chosen, because it is the best compromise considering all three components building difficulty, construction time and visual appearance. Depending on landscape also angled wing walls or parallel wing walls can be advantageous.

According Ril 804 [U7] backfill needs a special quality for railway bridges. Therefore, two areas of backfill are needed (compare to Figure 6). In the first backfill area (directly behind abutment wall; chequered area) a qualified soil improvement is necessary. In the second backfill area (striped area) a layer wise backfill with layer thickness ≤ 30 cm is necessary.

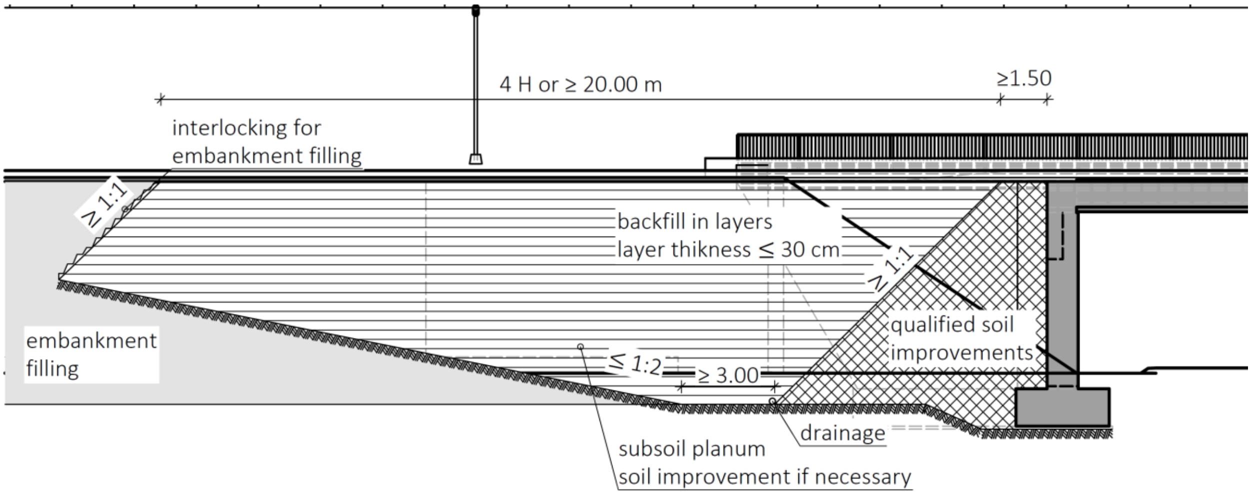

Figure 6: backfill for high-speed railway lines according Ril 804 [U7]

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 superstructure and substructure. The visible surfaces of superstructure are mainly very smooth due to prefabricated surfaces. To contrast visible surfaces of substructure 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. We advise against colouring of concrete parts to get a contrast of surfaces. Colour of coloured concrete fades over the years. Concrete elements get an unnatural look. Furthermore, coloured surfaces may attract unauthorized graffiti artists. Additionally, costs per cubic metres concrete will increase about 10-20 %.

4 Superstructure

4.1 Load-bearing structure

The superstructure is a single-span plate construction. The plate construction is made out of two components: the prefabricated girders and an in-situ concrete deck as shown in Figure 7. Span is 16.00 m with constant construction height of 1.00 m. Relation of span to height is l/h =16.

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

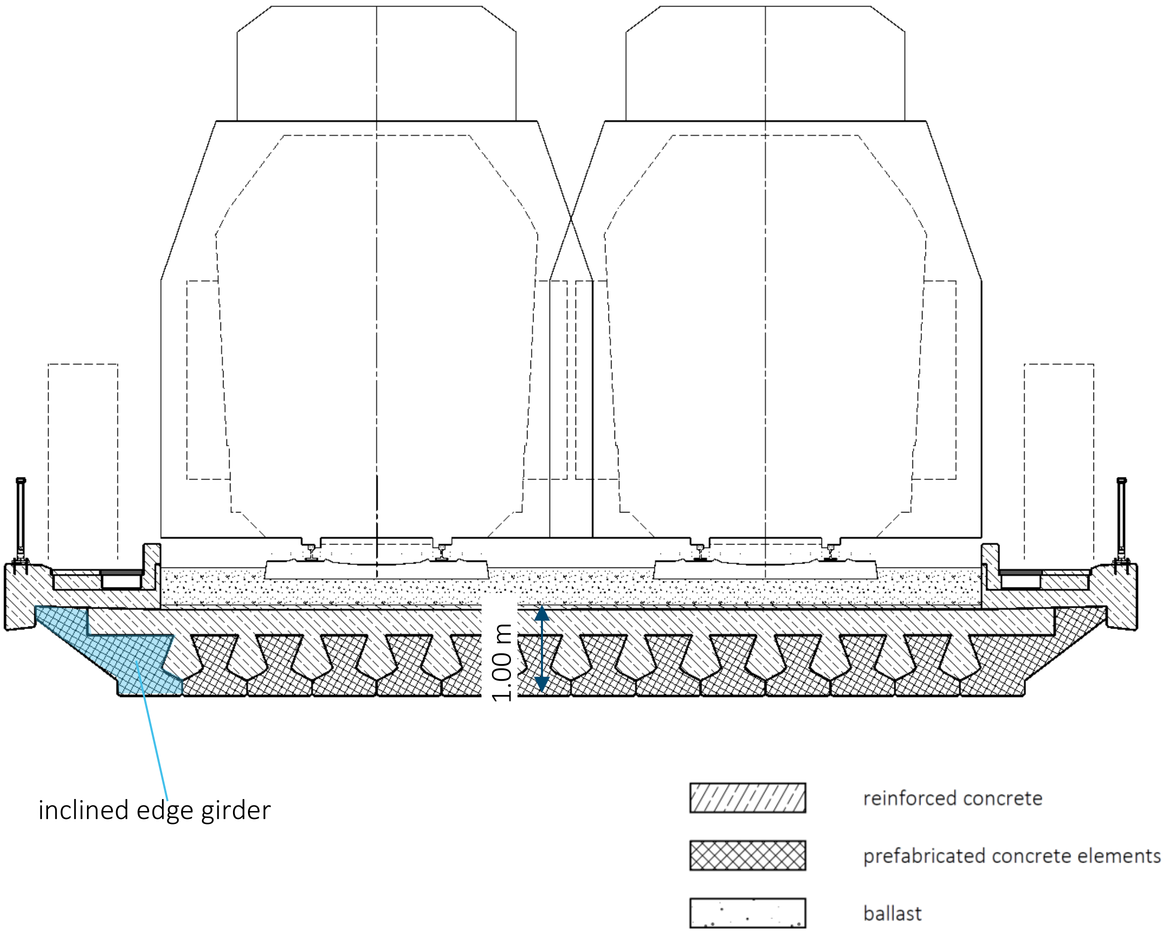

Figure 7: cross section underpass

Superstructure materials are:

- Concrete
- Reinforcing steel
- Prestressed strands

Characteristic values of building material depend on static proof and exposure class exposure classes can be assumed for railway bridges as shown in Figure 8 for railway bridges, crossing streets, cycle- and pedestrian routes and railway lines. Figure 9 shows exposure classes for railway bridges crossing water.

With estimated exposure class minimum compressive strength can be estimated with Table 1.

Minimum characteristic values for underpasses are listed in drawing Annex 1_2_001.

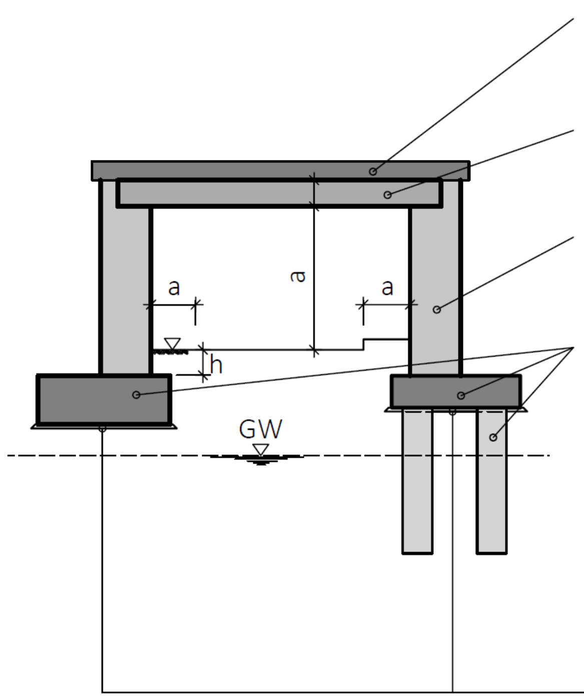

Figure 8: exposure classes for railway bridges, crossing streets, cycle- and pedestrian routes and railway lines according [U9]

railway briges, crossing waters

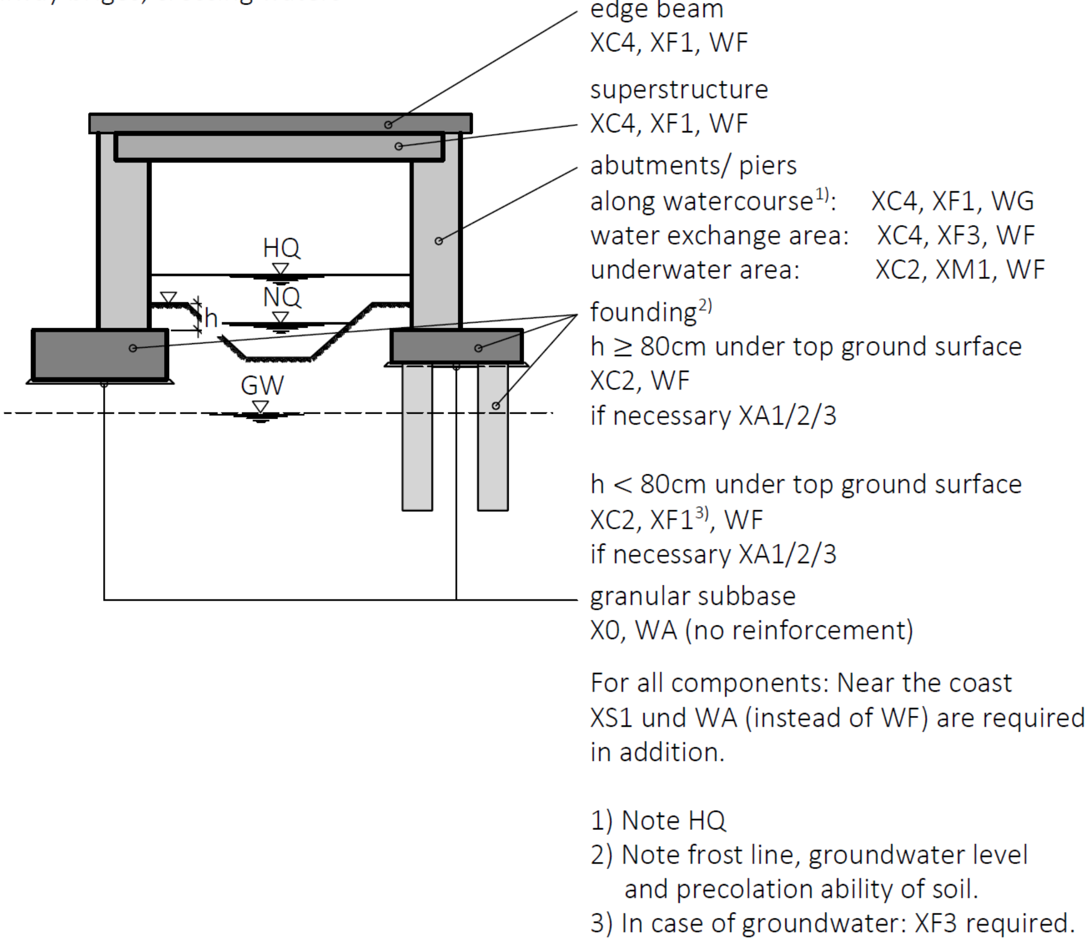

Figure 9: exposure classes for railway bridges, crossing waters according [U9]

Table 1: minimum compressive strength class due to exposure classes according [U9]

	Civil engineering railway bridges components reinforced [1,6]	exposure classes																					humidity class	minimum com-pression strenght class f_{ck}	concr. cover [3] c_{nom} [mm]	comment
		X0	XC				XD			XS			XF				XA			XM						
			1	2	3	4	1	2	3	1	2	3	1	3	2	4	1	2	3	1	2	3				
		no risk	carbonation				chloride			chloride/ sea			frost		frost/de-icing chemical		chemical attack [11]			wear			W			
1	granular subbase	X																						C 12/15	-	no reinforcement
2	founding*			X				X[5*]		X[7]			X*	X**	X[5]*								WF/ WA[7]	C 25/30 [1,3] C 30/37 [4,5,7]	55	* from 0,8 m under top ground surface XD/ XF are not required in general. Note frost line, ground-water level and pre-colation ability of soil!
3	founding* weak chemical attack			X				X[5]*		X[7]			X*	X**	X[5]*		X[2]						WF/ WA[7]	C 25/30 [1,3] C 30/37 [4,5,7]	55	
4	founding* moderate chemical attack			X				X[5]*		X[7]			X*	X**	X[5]*			X[2]					WF/ WA[7]	C 30/37 [4,5,7]	55	
5	founding* strong chemical attack			X				X[5]*		X[7]			X*	X**	X[5]*				X[2]				WF/ WA[7]	C 35/45 [2]	55	** XF3 in case of groundwater
6	abutments/ piers frost, no de-icing salt risk					X				X[7]			X										WF/ WA[7]	C 25/30 [2] C 30/37 [7]	45/55 [9]	
7	abutments/ piers frost, de-icing salt risk [5]					X		X[4,10]	X	X[7]					X[4,10]	X[13]							WA	C 30/37 [4,10] C 35/45 [2]	45/55 [9]	spray zone
8	abutments/ piers close to the water [12]- frost					X				X[7]			X										WF/ WA[7]	C 25/30 [2] C 30/37 [7]	45/55 [9]	
9	abutments/ piers close to the water [12]- frost, water exchange area					X				X[7]				X									WF/ WA[7]	C 30/37 [4]	45/55 [9]	
10	abutments/ piers close to the water [12]- underwater area		X							X[7]										X			WF/ WA[7]	C 30/37 [2]	45/55 [9]	
11	superstructure frost, no de-icing salt risk					X				X[7]			X										WF/ WA[7]	C 25/30 [2] C 30/37 [2,7]***	45	***prestressed concrete [3]
12	superstructure frost, de-icing salt risk [5]					X	X			X[7]					X								WA	C 30/37 [4]	45	spray zone
13	edge beam frost, no de-icing salt risk					X				X[7]			X										WF/ WA[7]	C 25/30 [2] C 30/37 [7]	35/25 [8]	
14	edge beam frost, de-icing salt rsik [5]					X	X			X[7]					X								WA	C 25/30LP [2,4] C 30/37 [7]	35/25 [8]	spray zone

[1] Ril 804.4201/ 4301 (01.05.2003)
[2] DIN-Fb 100 (2001) 4.1; T. 2; T. F.2
[3] DIN-Fb 102 (2003) 3.1.4; T. 4.101
[4] ZTV-ING (3-1; 07/06) section 4
[5] a < 10 m de-icing salt risk [1]
[6] w/z-value ≤ 0,5 [1]
[7] WA/ XS only near the coast
[8] contact to concrete
[9] contact to soil
[10] constructive measures for discharge of de-icing salt water, otherwise XD3/ XF4
[11] sulphate for XA must be stated explicitly
[12] no seawater
[13] only earth-moist concrete [2] (w/z-value ≤ 0,4)

4.2 Bearings, joints

The underpasses are planned as integral frames; thus, no bearings and joints are needed. Due to integral solution no expansion joints are needed. Only dummy joints/ controlled crack joints in abutments according Annex 5_0_002 have to be planned.

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 railway bridges has to be made of two layers. For underpasses one layer of self-adhesive synthetic sealing sheet and one layer of asphalt sheeting is planned as shown in Figure 10.

In track area waterproofing is covered with 5 cm thick protecting concrete layer.

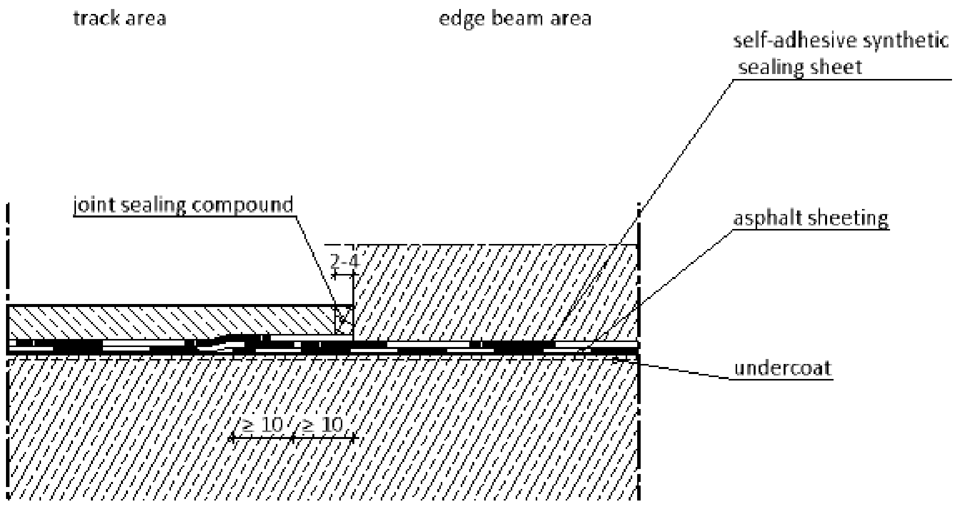

Figure 10: waterproofing for superstructure of railway bridges according RIL 804.6101 [U7]

Detailed principles of waterproofing and covering are shown in drawing “5_0_001_C1+C2_detail plan railway bridges I”.

4.4 Corrosion protection, protection against environmental influences

Railings and other equipment parts made of steel (e.g. noise cancelling walls, protection systems) need a coating system against corrosion.

5 Drainage system

5.1 Superstructure

Drainage planning needs to ensure sufficient drainage of track lane.

Bridges with bridge length less than 30 m – even without longitudinal incline – can be built without particular drainage system in superstructure.

5.2 Abutments

Drainage takes place in drainage walls along abutments (Figure 11). Therefore, drainage walls have to be included in drainage planning and have to be calculated to define dimensions of run pipe.

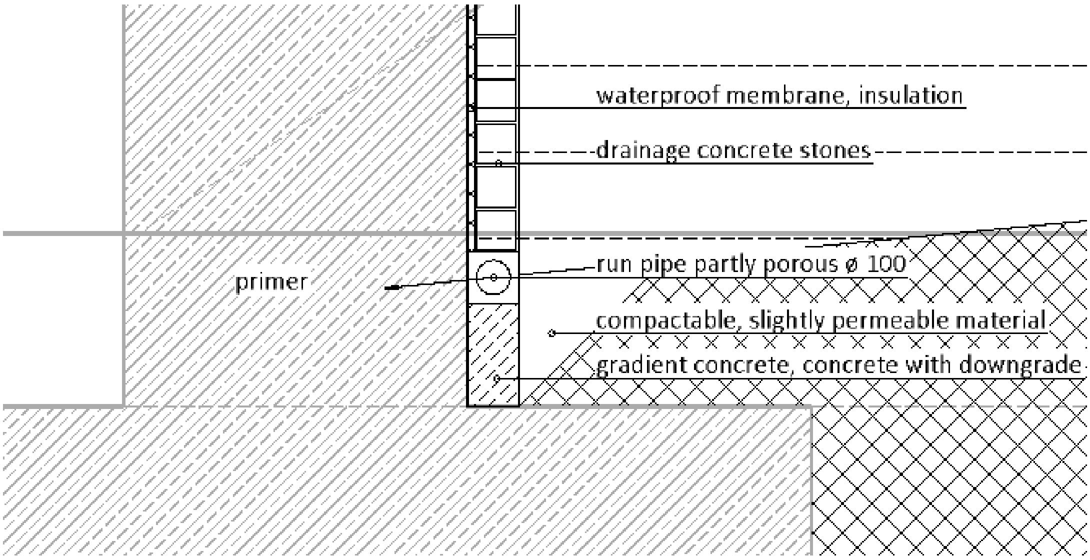

Figure 11: drainage system abutment according Was 7 [U8]

6 Restraint and protection systems

Railings

As railings bar railings with a bar distance of less than 120 mm are planned. For further geometrical details see drawing in Annex 5_0_001. The main principle of bar railings is shown in Figure 12.

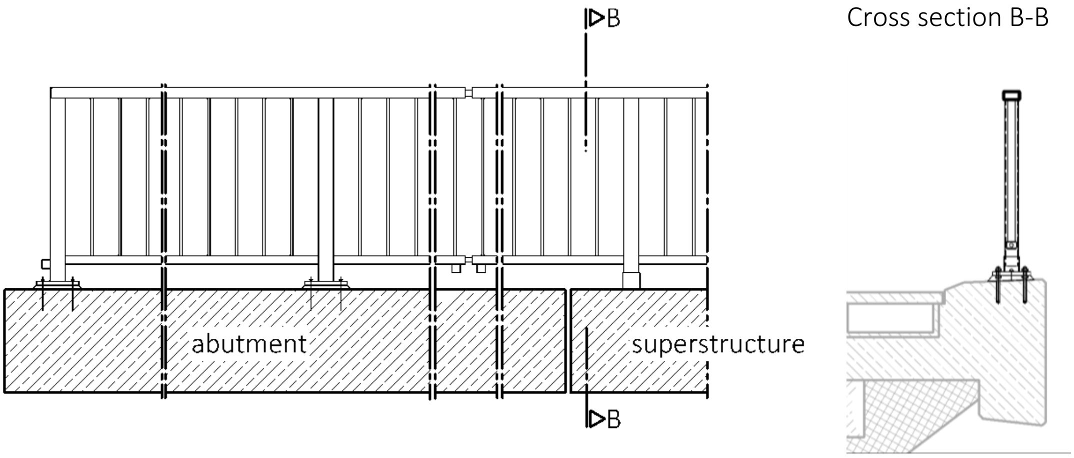

Figure 12: railing railway bridges according Ril 804 [U7] A-GEL-12

Noise protection walls

For general underpass planning no noise protection walls are included in calculations. They should be planned if local boundary conditions require noise protection. Centre distance for noise barrier on bridge is ≤ 2.50 m. In embankment area a centre distance of ≤ 5.00 m is necessary.

7 Accessibility

Accessibility for inspection is possible from below with lifting platform.

Accessorily via embankment stairs could be also possible. We advise against embankment stairs, because this enables unauthorized access to railway bridges. If embankment stairs are wanted, we advise to include them in emergency escape route planning (stair width large enough etc.).

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	1-2 WEEKS	
Access/ access road to construction site		depending on region and landscape situation
If necessary, redirect “crossing partner”		depending on traffic situation
Set site area		
2 EARTHWORK		
Produce planum	1-4 WEEKS	depends strongly on landscape situation
Build embankment	1-4 WEEKS	depends strongly on landscape situation
Pit excavation for spread footing of abutments	incl. in founding	depending on local conditions either open excavation or sheeting
Backfill layer wise	incl. in abutment	layer thickness around 30 cm in a high-quality consolidation
3 FOUNDING FOR ABUTMENTS	4-6 WEEKS PER FOUNDING AXIS INCL. PIT EXCAVATION DEPENDS ON TYPE OF FOUNDATION	
(pit excavation see earthwork)		
Granular subbase (abutment)		
Spread footing, foundation slab (abutment)		
- formwork		
- place reinforcement		incl. starter bars for abutment walls
- pouring concrete		
deep foundation as option instead of Spread footing (abutment)	+2 WEEKS PER AXIS	
- insertion of foundation piles		depending on soil condition either bored piles, displacement piles, driven pile incl. starter bars for foundation slab
- formwork foundation slab		
- place reinforcement for foundation slab		incl. starter bars for abutment walls
- pouring concrete for foundation slab		
4 SUBSTRUCTURE		
Abutment	5-7 WEEKS PER ABUTMENT AXIS INCL. BACKFILL	

Geometry as shown in drawing annex 1_2_001		in-situ concrete to ensure integral connection to superstructure, in this example perpendicular wing walls
abutment wall until constuction joint		
- formwork		
- place reinforcement		incl. starter bars for abutment wing walls and superstructure connection
- pouring concrete		
abutment wing walls		
- formwork		
- place reinforcement		
- pouring concrete		
(Backfill layer wise, see earthwork)		
5 SUPERSTRUCTURE		
support structure	ABOUT 1 WEEK	
-build support structure		if necessary, founding for support structure
- dismantling support structure		
superstructure		
prefabricated concrete elements	10-12 WEEKS INCL. CURING TIME	
- produce prefabricated concrete elements		in precast factory
- transport prefabricated concrete elements to side		
- place prefabricated concrete elements		on support structure on support structure and on abutment walls
in-situ concrete for superstructure and connection area	2-3 WEEKS	
- formwork for connection area + waterproofing bridge end		connection area between superstructure and substructure, waterproofing bridge end according detail C, Annex 5_0_001
- place reinforcement for in-situ superstructure and connection area		
- pouring concrete		
- let concrete dry	+14 DAYS	
6 EQUIPMENT		
Waterproofing edge beam	5 DAYS	
- layer wise annex 5_0_001 Detail A		

Build in-situ concrete edge beams	2-3 WEEKS	with anchoring for railing and if necessary for noise protection barrier
- install temporary formwork consoles - formwork - place reinforcement - pouring concrete		
protective concrete + waterproofing superstructure between edge beams	1 WEEK	
- reinforced protective concrete - waterproofing layer wise annex 5_0_001 Detail B		
Drainage system abutment	1 WEEK PER ABUTMENT	
- following detail E drainage annex 5_0_001		
Grounding, railing, cable-duct, joints, etc.	4 WEEKS	
- inner grounding - grounding of steel construction components to railway earthing - railing annex 5_0_001 - cable duct - if necessary, joints - if necessary, noise protection barrier		
Provide track (track geometry, ballast, sleepers, …)		incl. cables, overhead cable etc.
- has to be provided with whole railway line		

7 LANDSCAPING	1-4 WEEKS	
Depending on local boundary conditions		
8 FINALIZING WORK	1-2 WEEKS	
Clearing construction site		

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

9.2 Protective measures

Work for waterproofing might be problematical if ambient temperature is too low. Therefore, waterproofing has to either 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 1_1.

Final leaf

Hannover, 27.09.2019