

## Exercise 5: Examination of a structure – actions effects

Road bridge, determination of the values for examining the effect of actions

### Background

The Guillermaux road bridge is a reinforced concrete structure spanning the River Broye at Payerne. Built in 1920/21, it was one of the first reinforced concrete bridges in Switzerland. The designer was Louis Bosset (1880-1950), a Payerne architect, cantonal archaeologist (1934-1950) and mayor (1929-1941) of the town of Payerne. The structure is in an urban environment and is currently used by 8,400 vehicles per day and pedestrians. Only regular heavy traffic (40 to) is allowed.



Figure 1: Guillermaux bridge showing geometry and existing condition

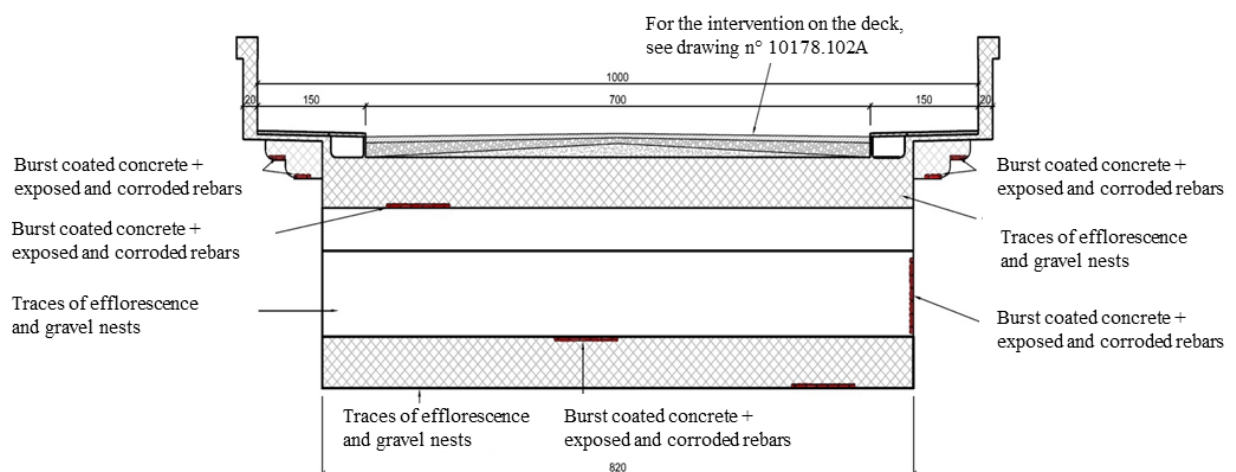


Figure 2: Cross-section A-A [cm] indicating its existing condition

The primary load-bearing structure of the bridge is a three-pin arch 0.60m thick and 8.2m wide. This low raising arch has a span of 27.6m and a key height of 2.8m, giving a ratio of height to span of approximately 1:10. Along the central section of the bridge, the carriageway rests on a non-reinforced concrete fill placed between two concrete spandrels with a maximum thickness of 1.4m. At the ends, the deck, in the form of two small arches, rests on two cross walls and is supported on the abutment walls (see also Figure 4).

The carriageway is 7.0m wide and carries two-way traffic. The two 1.5 m wide pavements to the sides of the carriageway are partly cantilevered. A pedestrian underpass dating back some thirty years has been built into the south-east abutment. Multiple deterioration phenomena are visible on the concrete surfaces as cross section in Figure 2 is showing. The bridge should undergo the examination process according to SIA 269.

### **Objective**

The aim of this exercise is to determine the examination values for the effect of the actions under normal use in the decisive sections of the load-bearing structure.

### **Question 1: Acting loads**

List all the examination situations loads, with their location on the bridge and if – or not – they need to be considered in combination with traffic.

**Hint:** Using SIA 269/1, structure the list in permanent loads, variable loads and accidental loads.

### **Question 2: Load models for traffic loads**

Concentrate on traffic loads, list the load models according to SIA 269/1 that need to be considered for analyzing the structure.

### **Question 3: Updating traffic actions**

Focusing on the load model 1 according to SIA 269/1: Determine the characteristic values of the updated traffic actions acting on the load-bearing structure. To help you visualize the transversal repartition of the traffic load, draw the characteristic values of the updated traffic actions on the cross section given in Figure 3. Assume that no exceptional transport is allowed on the bridge, that the static system can be seen as a slab bridge for updating traffic loads factors and that guardrails protect the sidewalks. No traffic loads need to be considered on the sidewalks.

**Hint:** First, read SIA 269/1 Chapter 10: Road traffic.

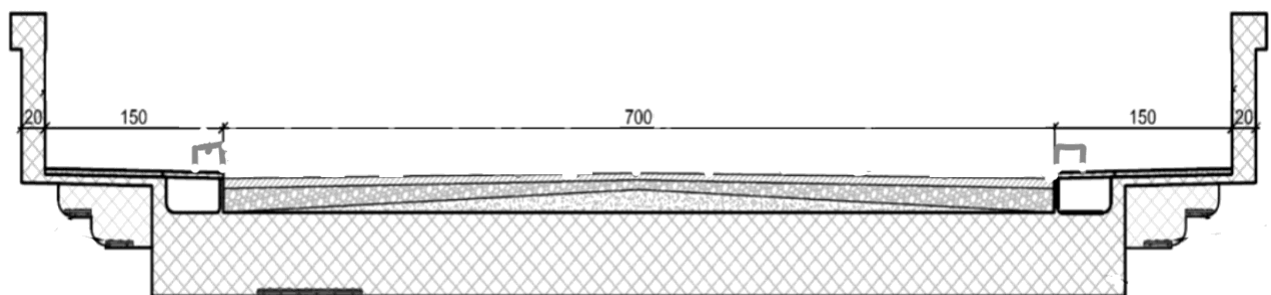


Figure 3: Cross section to resume characteristic values of the updated traffic actions [cm]

### **Question 4: Examination verifications**

List the examination verifications to carry out when analyzing the structural safety of the bridge. You can assume that traffic loads are the predominant action.

**Hint:** What are the main structural elements of the bridge? What internal forces are acting on them?

### **Question 5: Partial load factors**

What are the partial load factors for permanent and variable loads for this existing structure according to SIA 269? List all requirements needed to be able to update the partial load factors on permanent loads.

### **Question 6: Updated examination values**

Determine the updated examination values of the effect of the actions due to normal use for the verification of structural safety according to a deterministic approach.

The updated action effects were determined for you. The load-bearing structure was modelled using a 2-D bar model as shown in the Figure 4 **Error! Reference source not found.**. The relevant loads were applied. Figure 4 shows also the sections considered to be critical for structural safety verifications.

To get the updated examination values, use the summary of the results of the analysis of the structure (characteristic values of the forces) in Figure 5. Compute the different possible combinations and keep the determinant one for bending. For an arch bridge in reinforced concrete, the stress states due to bending are much worse than the compressive stresses.

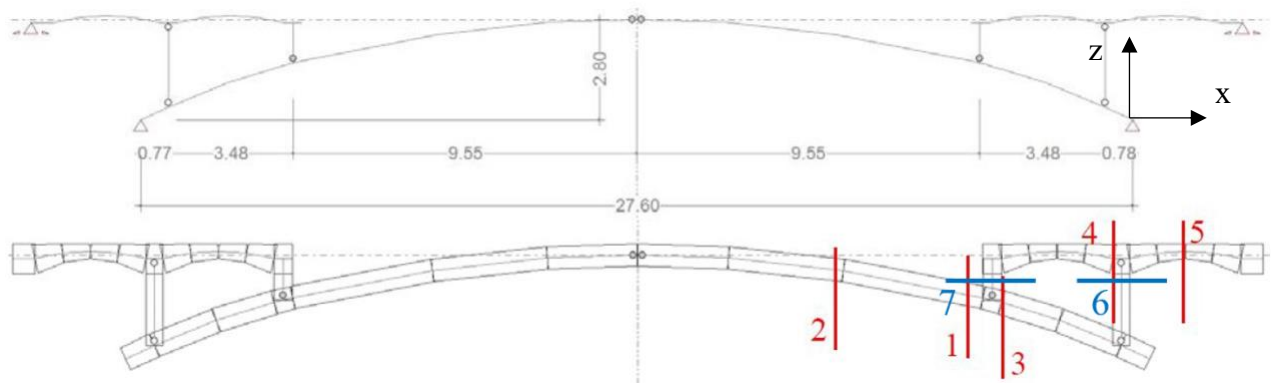


Figure 4: 2-D bar model of the Guillermaux bridge and critical sections for verification [m]

	Internal forces for variable actions ( $Q_k$ )					
	Envelop lower boundary			Envelop upper boundary		
	$M_{Qk,inf}$ [kNm]	$V_{Qk,inf}$ [kN]	$N_{Qk,inf}$ [kN]	$M_{Qk,sup}$ [kNm]	$V_{Qk,sup}$ [kN]	$N_{Qk,sup}$ [kN]
Section 1	-1161	113	-1955	1371	196	-685
Section 2	-1153	152	-1882	1297	235	-963
Section 3	-1132	102	-1978	1120	235	-540
Section 4	-760	226	0	493	129	0
Section 5	-407	193	0	298	227	0
Section 6	0	0	-271	0	0	790
Section 7	0	0	-439	0	0	206

	Internal forces for permanent loads ( $G_k$ )					
	Self-weight			Imposed loads		
	$M_{Gk,SW}$ [kNm]	$V_{Gk,SW}$ [kN]	$N_{Gk,SW}$ [kN]	$M_{Gk,IL}$ [kNm]	$V_{Gk,IL}$ [kN]	$N_{Gk,IL}$ [kN]
Section 1	393	213	-4986	567	503	-3271
Section 2	137	249	-4901	425	206	-3141
Section 3	183	184	-5068	-121	285	-3303
Section 4	-491	359	0	-329	164	0
Section 5	-74	151	0	-107	93	0
Section 6	0	0	-816	0	0	-329
Section 7	0	0	-167	0	0	14

Figure 5: Characteristic values of the internal forces for the relevant actions

**Note:** This document is adapted from a translation of the exercise 2, lecture notes Prof. Eugen Brühwiler “Structures existantes I: Examen et interventions – Bases”, 2022 edition, course CIVIL-436, courtesy of Prof. Brühwiler.

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