Exercise 5: Examination of a structure – actions effects

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

Background and objective

The Guillermaux road bridge is a reinforced concrete structure spanning the River Broye at Payerne, see Figure 1. 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 located in an urban environment and is currently used by 8,400 vehicles per day and also pedestrians. Only regular heavy traffic (40 to) is allowed.

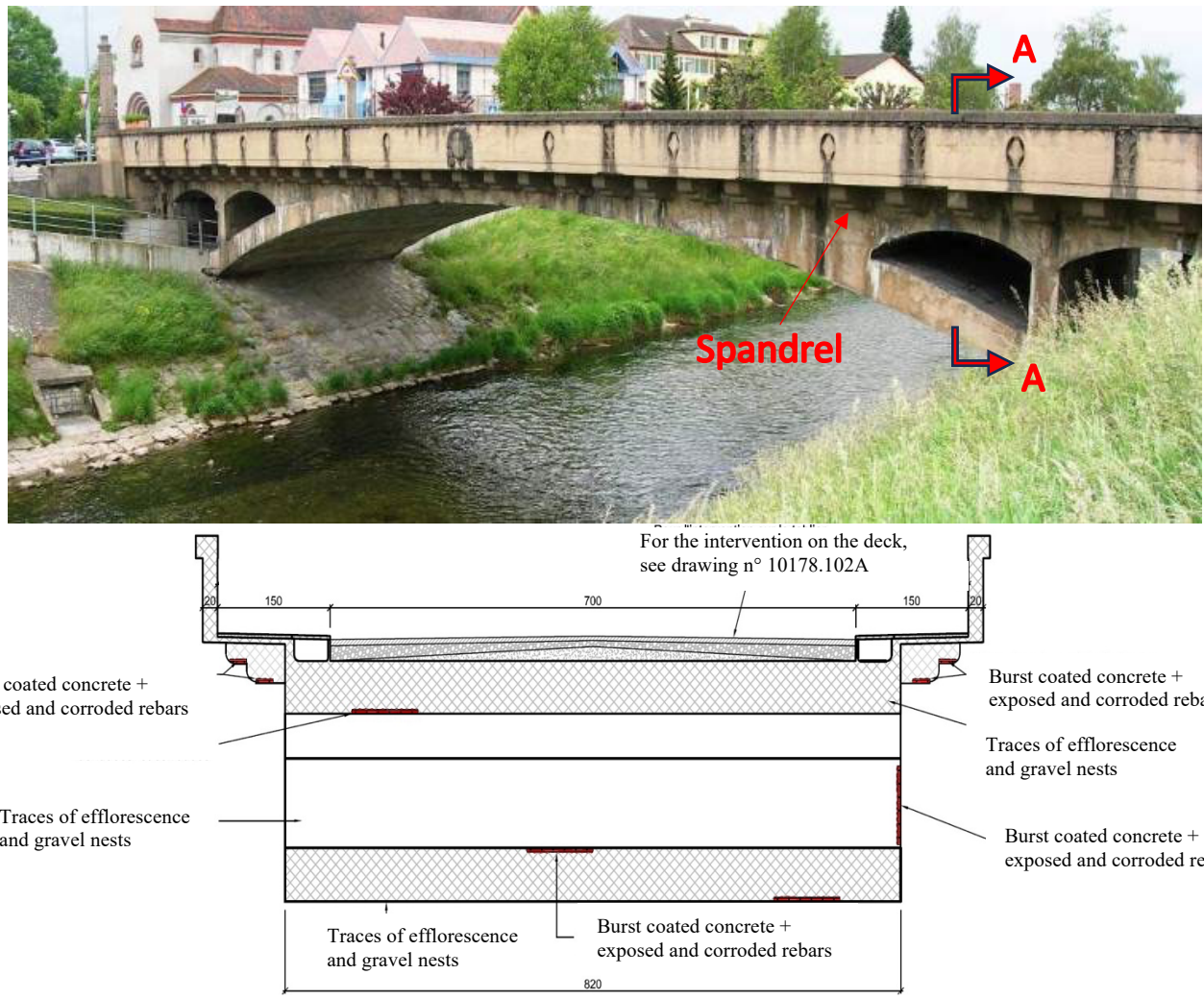

Figure 1: Guillermaux bridge and cross-section A-A [unit cm] indicating its existing condition

The primary load-bearing structure of the bridge is a three-pins 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 2).

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.

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

First 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.

Then concentrate on traffic loads, determine the load models and characteristic values of the updated traffic actions acting on the load-bearing structure and list the examination verifications to carry out when analyzing the structure.

The load-bearing structure was modelled using a 2-D bar model as shown in the figure below, which also shows the sections considered to be critical for structural safety verifications:

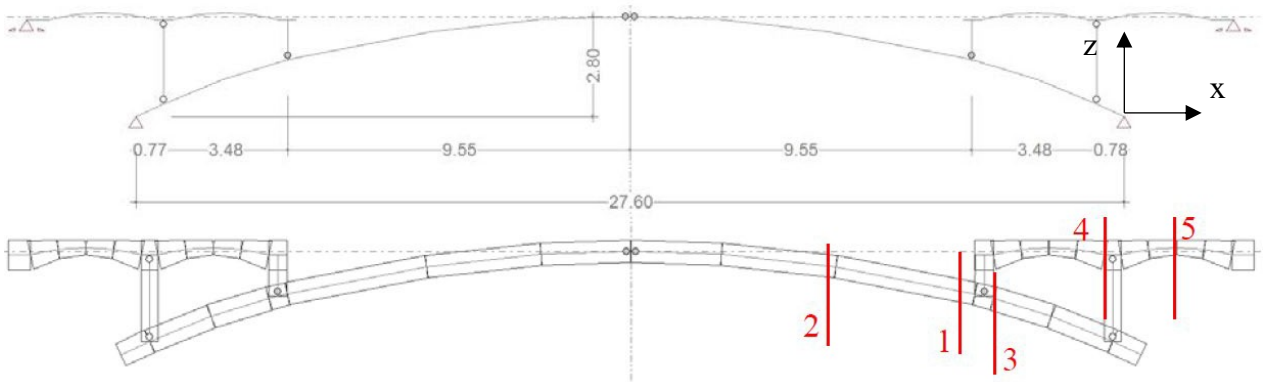

Figure 2: 2-D bar model of the Guillermaux bridge and critical sections for verification [unit m]

Using this model of the structure and applying the relevant loads, the values of the internal forces in the critical sections were calculated. The forces obtained (characteristic values) are summarized in Table 1. Explanations on the symbols:

M- x = minimum value from envelope from the traffic load positions at a given location x

M+x = maximum value from envelope at a given location x

Pe- = minimum value from envelope in exterior cross-beam (Pi is for interior)

Pe+ = maximum value from envelope in exterior cross-beam

SupportFx, SupportFz = horizontal, resp. vertical, component of reaction force at arch support

Table 1: Characteristic values of the internal forces for the relevant individual actions

Internal force and section denomination	Deck				Cross walls	
	Section 4 (support)		Section 5 (mid-span)		externe	Interne
	M [kNm]	V [kN]	M [kNm]	V [kN]	N [kN]	N [kN]
M-4	-760	226	-	-	-	-
M+4_Pe+	493	129	-	-	271	-
M-5	-	-	-407	193	-	-
M+5	-	-	298	227	-	-
Pe-	-	-	-	-	-790	-
Pi-	-	-	-	-	-	-439
Pi+	-	-	-	-	-	206
Imposed load	-329	164	-107	93	-329	14
Self-weight	-491	359	-74	151	-816	-167

Internal force and section denomination	Arch										
	Section 1			Section 2			Section 3			Arch support	
	M [kNm]	N [kN]	V [kN]	M [kNm]	N [kN]	V [kN]	M [kNm]	N [kN]	V [kN]	X [kN]	Z [kN]
M-2	-	-	-	-1153	-1882	152	-	-	-	-	-
M+2	-	-	-	1297	-963	235	-	-	-	-	-
M-1_M-3	-1161	-1955	113	-	-	-	-1132	-1978	102	-	-
M+1	1371	-685	196	-	-	-	-	-	-	-	-
M+3	-	-	-	-	-	-	1120	-540	235	-	-
M-4	-	-	-	-	-	-	-	-	-	-	-
M+4_Pe+	-	-	-	-	-	-	-	-	-	-1258	99
M-5	-	-	-	-	-	-	-	-	-	-	-
M+5	-	-	-	-	-	-	-	-	-	-	-
Pe-	-	-	-	-	-	-	-	-	-	-288	846
Pi-	-	-	-	-	-	-	-	-	-	-	-
Pi+	-	-	-	-	-	-	-	-	-	-	-
SupportFx	-	-	-	-	-	-	-	-	-	-2074	479
SupportFz	-	-	-	-	-	-	-	-	-	-829	955
Imposed load	567	-3271	503	425	-3141	206	-121	-3303	285	-3117	1427
Self-weight	393	-4986	213	137	-4901	249	183	-5068	184	-4856	2935

Question 2

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. List any requirement needed to be able to update the partial load factors. To get the updated examination values, use the summary of the results of the analysis of the structure (characteristic values of the forces), compute the different possible combinations, keep the determinant one for bending to get the .

Note: this document is 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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