COST ACTION TU1406
QUALITY SPECIFICATIONS FOR ROADWAY BRIDGES,
STANDARDIZATION AT A EUROPEAN LEVEL

COST TU1406 WG4 Final report Appendix A8

Bridge Case study

Frame bridge SBB Glattfelden Switzerland

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CONTENTS

1. INTRODUCTION

The Glattfelden bridge was selected as a case study bridge due to planned strengthening works because of limitations for heavy transport route of Switzerland. Since Switzerland has advanced bridge quality control and different conditional data has been collected within past 6 years, then it is a good opportunity to compare the expert judgement of Kanton Zürich representatives with COST TU1406 Quality Control Plan suggestions. Unfortunately Switzerland database is non-homogenized with COST TU1406 definitions, so some of the final performance goals are combined.

2. GENERAL DATA OF THE BRIDGE

The Glattfelden Rail Overpass 058-009(GRO 058-009) connects the municipality of Glattfelden with the major northern access road to Zurich and Zurich airport. It was built in 1941 as a reinforced concrete structure.
The structure is skew to the railway line at an angle of 51.3 degrees. It consists of 5 spans with 4 integral piers that rest on shallow foundations. The two abutments have sliding bearing plates. In total, the bridge has a length of 55.4 m at centre and of 61.1 m at the outer edge. Its integral slab bridge deck has a minimal depth of 40 cm. Over the piers the bridge deck has haunches with a depth of up to 200 cm. The total width of the bridge deck is 10.9 m. In longitudinal direction, it has a gradient of 0.73% (drop towards Glattfelden) and a transverse gradient of 2%. The road surface is drained through pipes embedded in the slab under the walkways. Figure 1 gives an impression of the overall structure. (Mumtaz *et al,* 2017)

Fig. 1 Side view of the bridge (left side)

Fig. 2. Side view from under the bridge (right side)

The bridge design project is available in paper form and scanned (Fig.3).

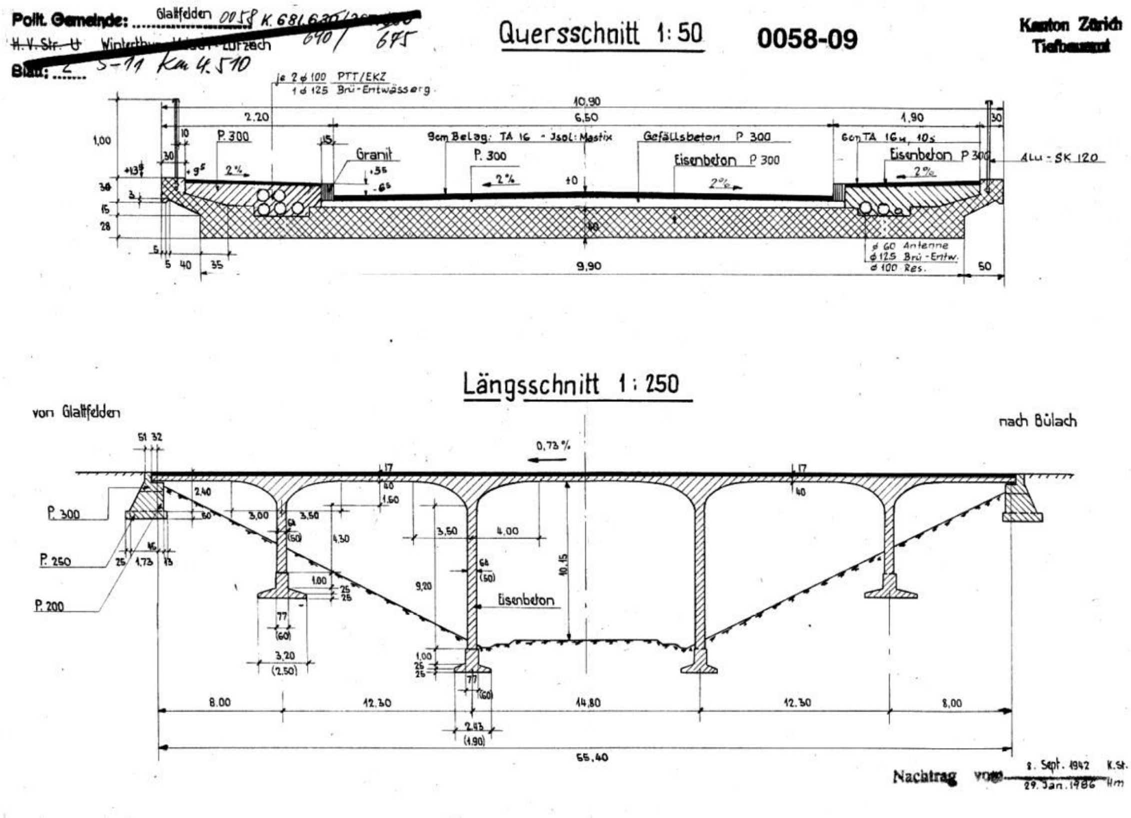


Fig. 3. Design drawings of Glattfelden bridge

2.1. TRAFFIC INFORMATION

The last information about the traffic are from the last counting in 2013.
Number of cars / 24h : 25 000
Percentage of the heavy vehicles from the total amount / 24h : 6%

2.2. SUBSTRUCTURE

Substructure is formed by the abutments, which are not part of the frame, and piers, which are part of the frame, constructed from the reinforced concrete. Piers are solid wall type. The abutments are of reinforced concrete and have a shallow foundation and so have the piers.

2.3. SUPERSTRUCTURE

The superstructure consists of cast in-situ reinforced concrete slab, 2 rubber profile deformation joints and 8 simple steel (sheet) bearings at both ends.

2.4. ACCESSORIES

The cover of deck plate is asphalt layer and the safety railings are made from galvanized steel. Slope protection is made from reinforced concrete.
The waterproofing is made of polymer Bitumen and parapets are from aluminum.

2.5. LOAD CAPACITY

The load capacity of the bridge is considered as a heavy load transport route type II (240t), but the bridge is part of a heavy load transport route type I (480t) and is downgraded at moment to type II. (DSP AG, 2012).

2.6. GENERAL DATA ACCORDING TO WG3

Table 1.General data of Glattfelden bridge

Structure type	Other relevant data (can be expanded as needed)									
	Location	Environmental exposure	Seismicity	Building year	Length, m	Width, m	Traffic volume	Previous intervention		
								Date	Type	Cost (CHF)
FC1	Switzerland, S11, 4.637 km	rural		1940	56.04	10.9	25000 (2013)	1959		
								1965	Repair	33209.65
								1975	Repair	1434.55
								1977	Repair	3974
								31.12.1986	Repair	315057
								31.12.2001	Partial repair	83041.8
								10.07.2007	Small repair	12265.9

3. TECHNICAL CONDITION

Technical condition is collected from DSP AG report (2012). Previously collected data is shown in Table 2.

Table 2. Previously collected conditional information from inspections by the inspectors of the Kanton Zürich

			Observations					
Date	Performance cluster	Performance indicator	Failure mode	Location/position - Vulnerable zone	Degradation process (Damages/symptoms)	Primary Key Performance Indicator	Assessment level	Performance value
31.12.1991	Rating	Condition rating				Rating	System	2
13.09.1996	Rating	Condition rating	*Horizontal cracks in pillars, voids, flaking (due to patching, pavementswith ruts.*			Rating	System	2
07.09.2001	Rating	Condition rating	*Flaking (partly from old patchwork), road surface has ruts (partly milled), displacements in the pavement. Longitudinal cracks, edge beam has l flaking*			Rating	System	2
04.09.2006	Rating	Condition rating	*Spalling under deck (not in railway area).*			Rating	System	2
09.09.2011	Rating	Condition rating				Rating	System	2
10.03.2014	Rating	Condition rating				Rating	System	3
10.03.2014	Related to loads	Traffic loading				*Rating*	System	3
21.08.2014	Rating	Condition rating	*The corrosion was not stopped with repair in 2007*			Rating	System	3

3.1. COLLECTION OF DEFECTS

The types of defects discovered on the analyzed bridge are listed below and sketch of defect locations are shown on Fig.5.
Main defects

- High carbonation and increased chloride content at bottom view
- High carbonation in pillars
- Spalling of Concrete Cover of Reinforced Concrete Deck (mid span)
- Efflorescence (abutments, overhang)
- Cracks in concrete (few visible in piers, overhang/deck plate)
- Reinforcement exposure (deck plate, piers)
- Corrosion of expansion joint

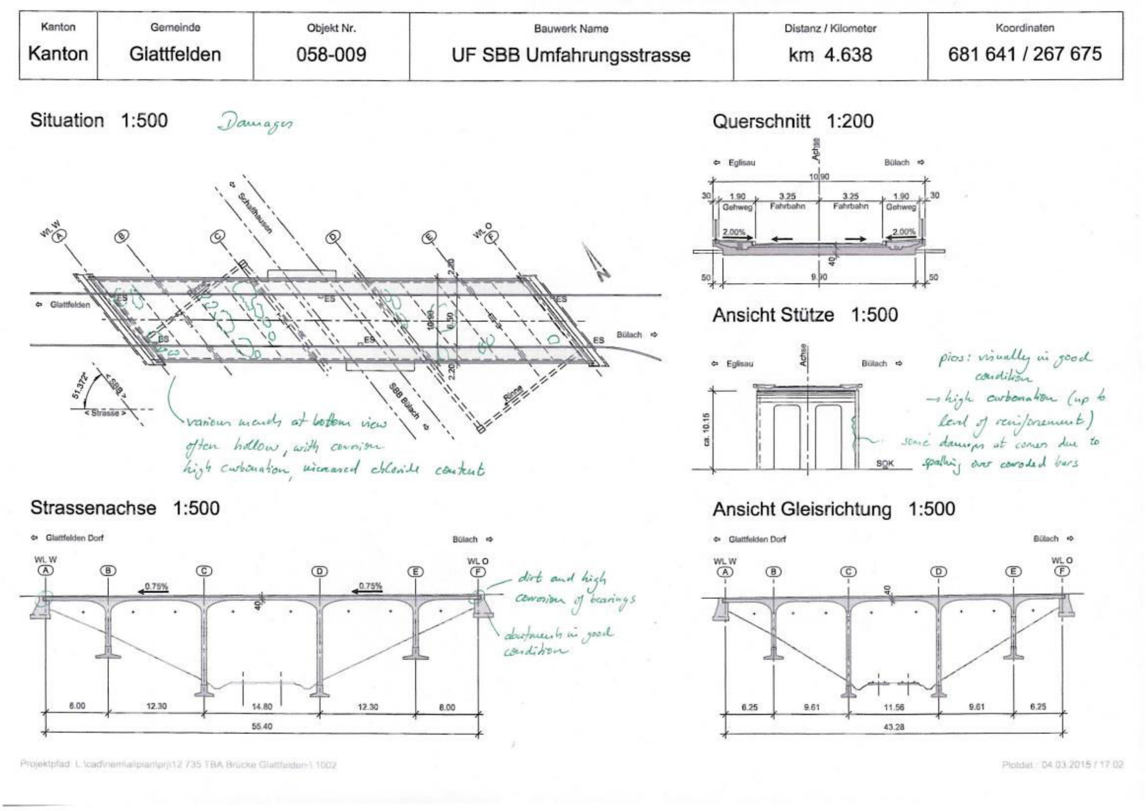


Fig. 4. Damage locations and explanation

3.2. DEFECTS OF THE MAIN STRUCTURAL ELEMENTS

3.2.1. ABUTMENTS

Fig. 5 Deterioration of the abutment

3.2.2. PIERS

Fig. 6 Vertical crack in a pier

3.2.3. BRIDGE DECK

Fig. 7 Spalling of concrete cover in middle span

Fig. 8 Longitudinal crack in the overhang of the bridge deck

Fig. 9 Transverse crack in the cantilever of bridge deck

Fig. 10 Exposed rebar on bridge deck

3.2.4. EXPANSION JOINT

Fig. 11 Corrosion at an expansion joint

4. POTENTIAL FAILURE MODE OF THE BRIDGE

The critical areas of the bridge are presented in Fig 12. In accordance with current condition of the bridge following failures are considered:

- Bridge slab failure to bending moments in lateral direction – global bridge deck failure due to loss of stability under live load due to concrete degradation (spalling, cracks), insufficient reinforcement and corrosion.
- Bridge slab failure to bending moments in longitudinal direction – global bridge deck failure due to loss of stability under live load due to concrete degradation (cracks), insufficient reinforcement and corrosion.
- Loss of pier stability – stability loss of one pier due to cracking and overload.

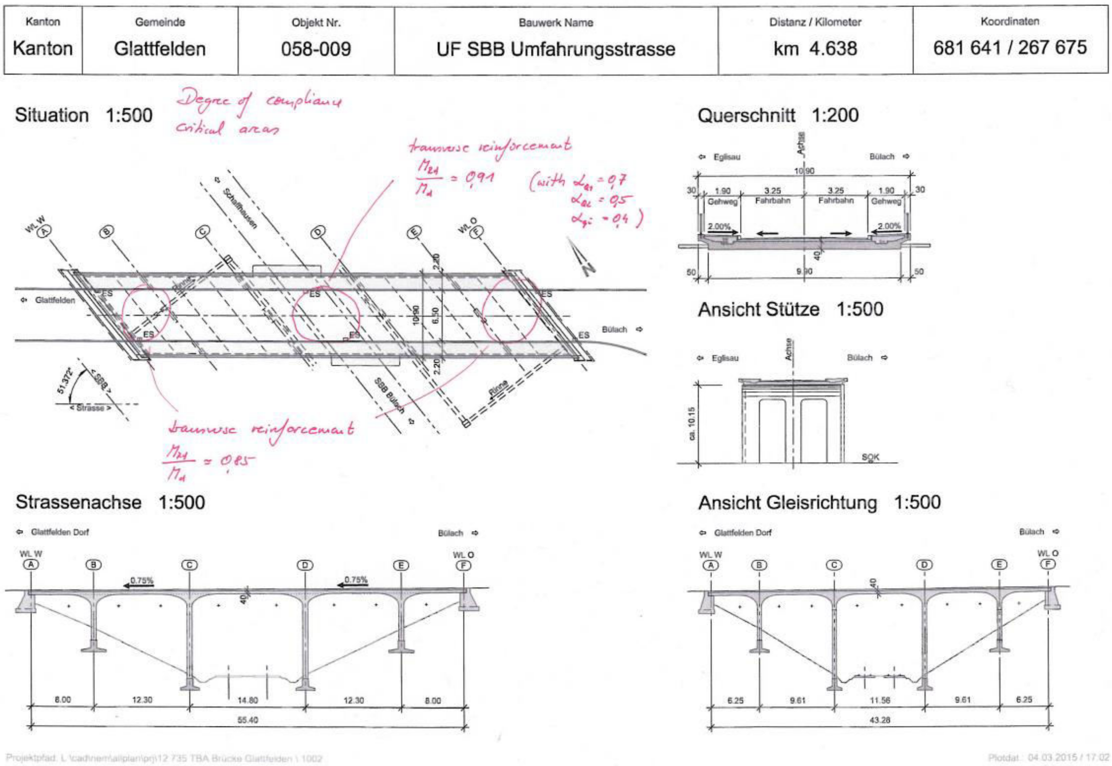


Fig. 12. Potential vulnerable zones and reduction factors according to calculations.

5. MATERIAL TESTING

In addition to many inspections and assessments, material testing has been carried out on Glattfelden bridge. Material testing results are based on previous investigations made by Kanton Zürich experts in 2015. From which it is possible to see that concrete characteristics are as expected to be for all element groups. Attention must be drawn to measurements of concrete cover and carbonation. For example in columns (Table 3) the average concrete cover is 2 mm more than average carbonation depth, but measured values of concrete cover shows that in 25% the cover is less than 25 mm and for carbonation the maximum depth is 42 mm, so environment is suitable for reinforcement corrosion. Same conclusion can be made from half cell potential tests, where 30% measurements show minor corrosion and 10% critical corrosion.

Table 3. Material properties of superstructure according to Kanton Zürich investigation (DSP AG, 2012))

Component	Measurement	Result	
		Samples	Values
Bottom Side	1. Concrete Characteristics		
	a) Compressive Strength	3 Core ∅ 100	70 to 84 MPa ; C60/75
	b) Surface Tensile Strength	8 Core ∅ 50	0.3 to 3.5, Average 2.4 MPa
	c) Adhesive Tensile Strength	4 Core ∅ 50	0.4 to 2.25. Average 1.4 MPa
	d) Porosity	1 Core ∅ 50	Capillary Permeability 11.8 %
	2. Concrete Cover	816 Measured Points	Average= 29 mm Value < 10 mm 0% <20 mm 9% <25 mm 40 %
	3. Carbonation	Construction Concrete Re-profiling Concrete	Avg ≈ 25 mm, Max in cracks 42 mm Avg ≈ 20 mm
	4. Chloride Content (M%/C)	8 Drill dust samples from structure	Max. 2% ,4 samples >>0.4% Till 0.9 % in Re-profiling Concrete
	5. Corrosion KG	17 sample points	At all loations in Structural Concrete and Re-profiling Concrete, have very limited corrosion.6 samples have very high corrosion with 10 % area loss.
	6. Half Cell Potential	4 measurement areas	> -20mV No Corrosion 65% -20 to -100 mV Minor Corrosion 30 % <-100mV Critical 5 %
Top Side	1. Road finish and seals	Some parts of Roadway and walk ways and Visual inspection	TA 16 2-layered ΣPAK = 4900 mg / kg TA 10u + TA 16s ΣPAK = 13000 mg / kg
	2. Concrete Property a) Adhesive tensile strength (between top and repaired concrete)	8 core ∅ 50 mm	0.7 to 3.3 MPa, Average 1.9 Mpa
	3. Chloride Content (M%/C)	10 core ∅ 50 mm	All values ≤ 0.2 % except one value
	4. Corrosion KG	2 open pits	Top reinforcement mesh is corrosion free Pit F2 of structural concrete is Corrosion free Pit F1 has corrosion due to freez and thaw

Table 4. Material properties of columns according to Kanton Zürich investigation (DSP AG, 2012)

Component	Measurement	Result	
		Samples	Values
Column	1. Concrete Characteristics		
	a) Compressive Strength	3 Core ∅ 100	43 to 59 MPa; C40/50
	b) Water Absorption Coefficient	6 Core ∅ 50	0.08 to 0.43, Avg 0.32 $kg/m^2h^{0.5}$
	c) Porosity	2 Core ∅ 50	Capillary Permeability 10.2 %
	2. Concrete Cover	466 Measured Points	Average= 34 mm Value < 10 mm 2% <20 mm 12% <25 mm 25 %
	3. Carbonation	Structural Concrete 6 samples	Avg ≈ 32 mm, Max = 42 mm
	4. Chloride Content (M%/C)	5 Drill dust samples from structure	All values < 0.2 %
	5. Corrosion KG	6 sample points	All samples have good condition except one with QV = 10 %
	6. Half Cell Potential	1 measurement areas	> -20mV No Corrosion 60% -20 to -100 mV Minor Corrosion 30 % <-100mV Critical 10 %

Table 5. Material properties of columns according to Kanton Zürich investigation (DSP AG, 2012)

	Measurement		Result	
			Samples	Values
Abutment	1.	Concrete Cover	289 Measured Points	Average= 33 mm Value < 10 mm 5% <20 mm 22% <25 mm 28 %
	2.	Carbonation	4 samples	Avg ≈ 6 mm, Max = 11 mm
	3.	Chloride Content (M%/C)	2 Drill dust samples from structure	All values ≈0.2 %
	4.	Corrosion KG	4 sample points	All samples have good condition except one with QV > 10 %
	5.	Half Cell Potential	1 measurement areas	> -20mV No Corrosion 60% -20 to -100 mV Minor Corrosion 30 % <-100mV Critical 10 %

6. KEY PERFORMANCE INDICATORS

Key performance indicators are presented by two different approaches – first ones are in accordance with Switzerland management system and others are provided In accordance with COST TU1406 suggested approach.
The key performance indicators stated by representatives from Kanton Zürich which are country specific. It shows that Switzerland has already advanced quality control including indicators, which aren't homogenized with COST TU1406. The country specific indicators are:

- Reliability (structural safety + serviceability)
- Maintainability
- Durability
- Aesthetics
- Availability
- Safety
- Economy

The key performance indicators and performance goals are estimated by country representatives and do not comply with failure mode evaluation as suggested by WG3.

The case study approach is in accordance with COST TU1406, where key performance indicators are based on failure modes and agreed performance areas. These indicators are:

- Reliability
- Safety
- Availability
- Economy
- Environment*

*-if applicable

Furthermore, two life time cycle approaches are shown to evaluate all key performance indicators considered for the bridge in following 100 years.

First Referenced approach will follow the previous scenario, when bridge repair is needed, and only basic rehabilitation is done. The bridge defects are developed till bridge failure and finally the bridge is replaced with new structure.

Second Preventative approach considers the suggested scenario, when bridge will be strengthened and afterward repairs will keep the performance indicators above desired goals, preventing further defect development and overall damage to the structure.

For the cost related performance values, a discount rate of 2.5% will be applied and for other an expert judgement is used.

6.1. KEY PERFORMANCE INDICATORS OF SWITZERLAND

In accordance with current state of the described structure and Kanton Zürich the main indicators are defined as follows:

- Reliability (structural safety + serviceability) - The bridge does not meet the requirements of Swiss Standard SIA 261/1 (2003) for a heavy load transport route type I (480t), but it meets requirements for a heavy load transport route type II (240t), and for the updated normal road traffic according to SIA 269/1 (2011). After the planned reinforcement the bridge will meet the requirements for a heavy load transport route type I (480t) and the normal road traffic according to SIA 261 (2014).

- Maintainability (Economy) – keeping maintenance costs as low as possible

In order to reduce maintenance cost Kanton Zürich plans to eliminate the expansion joints at the abutments, so the structure will be "semi-integral", it means that there are bearings without expansion joints at the abutments.

- Durability – it is an overall qualitative performance indicator, which means that time frame between rehabilitations should be maximized using better materials, more qualified techniques etc.

For the Glattfelden bridge no rehabilitation required for the next 25 years, minor rehabilitation (new top asphalt layer, new railings) after 25 years and major interventions only after 50 years

- Aesthetics (Considered as social cost and added to Economy)

As the bridge is considered an aesthetically precious engineering work of art the strengthening and repair work has also to fulfil aesthetic criteria, i.e. uniform surfaces (no patchwork), only minor intervention to the hunched elevation.

- Availability – availability to traffic

The bridge cannot be closed completely at any time. This means that during rehabilitation work at least one lane has to be kept open for traffic. The deficiencies concerning road traffic loads are mentioned above.

- Safety - Protection roof over railway does not fulfil modern requirements.

- Economy – costs of different rehabilitation works

6.2. KEY PERFORMANCE INDICATORS ACCORDING TO COST TU1406 APPROACH

It is agreed that originally there are 4 KPIs, but since Swiss has more indicators, then it is important to merge the lists and define KPIs clearly.

- Reliability (Table 6) - The reliability is related to structural safety and serviceability. Assessment of reliability is not the same as assessment of a condition indicator, since the reliability:
    - takes into account “virgin” reliability (in some countries it is assumed that “virgin” capacity is at least equal to the load effects based on the codes of practice at the time of construction; often spare capacity may be present in reality, as shear capacity was not well understood in older codes of practice)
    - focuses on failure modes, and
    - related vulnerable zones

In this case the bridge does not meet the requirements of Swiss Standard SIA 261/1 (2003) for a heavy load transport route type I (480t), but it meets requirements for a heavy load transport route type II (240t), and for the updated normal road traffic according to SIA 269/1 (2011). The calculations have been made to 480 t heavy vehicles, which have been restricted to pass the bridge, and Eurocode LM1 (Fig 12), which shows that there is resistance reduction around 20% compared to virgin state, which means present load models.

Table 6. Scale related of reliability

Reliability	Quantitative scale (β)	Qualitative scale and urgency of intervention

scale		
1	>4.00	New bridges and old bridges with no resistance reduction.
2	3.25-4-00	Old bridges with no or marginal resistance reduction compared to the virgin state (< 8%).
3	2.50-3.25	Old bridges with some resistance reduction compared to the virgin state (8 – 17%). Reassessment should be performed before next inspection.
4	2.00-2.50	Old bridges with major resistance reduction compared to the virgin state (17 – 23%). Reassessment and possible intervention shall be performed shortly after inspection.
5	<2.00	Severe resistance reduction. Immediate action is required.

The above written scale is only valid when considering the governing failure mode (i.e. the most critical) in one of the vulnerable zones associated with the bridge type. Other failure modes and zones/areas are expected to have excessive capacity. The above written scale concerns only structural safety. However, similar definitions may apply for serviceability (e.g. reduction/loss of functionality).

- Safety - Safety issues are evaluated regarding user's safety, and these relate to all structural and non-structural components i.e. equipment. It should be noted that spalling from the deck slab and cornices implies the risk of injuries due to chunks of concrete falling and potentially hitting trains under the bridge and protection roof roof over railway does not fulfil modern requirements

Table 7. Scale related to safety

Reliability scale	Quantitative scale (β)	Qualitative scale and urgency of intervention
1	Injury return period > 100 years	No danger. It is very unlikely that a person could get injured because of the current bridge performance.
2	Injury return period > around 75 years	It is unlikely that a person could get injured because of current bridge performance.
3	Injury return period around 50 years	It is likely that a person could get minor injuries because of the current bridge performance. Intervention shall be performed before next inspection.
4	Injury return period around 20 years	It is likely that a person could get injured because of current bridge performance. Intervention shall be performed shortly after inspection.
5	Injury return period around 10 years	Immediate danger. It is very likely that a person could get injured because of current bridge performance. Immediate action is required.

- Availability – availability and restrictions to traffic.

The quantitative scale related to availability has been given in Table 8.

Table 8. Scale of KPI availability

Availability scale	Quantitative
1	No restrictions to traffic

2	Weight, speed and lane restrictions for heavy trucks
3	Closure except for cars and regular lorries. Possible lane restrictions for regular lorries.
4	Closure except for cars. Possible lane restrictions for cars.
5	Complete closure.

- Economy– costs of different rehabilitation works and in addition costs of maintenance and social costs, which are added from Swiss KPIs.

6.3. COLLECTED PERFORMANCE INDICATORS

The information was collected during preliminary inspection in July 2017, when the bridge was in full service and the railway track was also in regular operation. The bridge elements were classified and assessed according to AASHTO Bridge Inspection Guide Manual (AASHTO,2010) and summary of the results are normalized to scale of 1 to 4. Since the assessment was concentrated on damages quantities, then ratings safety and reliability are considered the same.
Reliability rating is used instead of condition rating, which is proposed by WG3. Unfortunately, AASHTO assessment does not include similar approach so collected performance indicators will not be used in this case study.

Table 9. Collected performance values

Group of elements	Observations													**Perfo**	
	Element	Type of cross-section	Date	Performance cluster	Performance	Performance metric: Primary	Performance metric: Secondary	Failure mode	Location/ position -	Degradation process	Primary Key Perform	Assessment level			
Superstructure	Deck plate	SA1/RC	7.2017	Rating	Damage	20%	Mid span	Bending moment failure	HMM	Spalling/exposure of steel	Reliability/Safety	Element	1.2	**1.2**	
Superstructure	Parapet	SA1/RC	7.2017	Rating	Damage	0%		Serviceability failure		Efflorescence	Reliability/Safety	Element	1		
Substructure	Abutments	AB2/RC	7.2017	Rating	Damage	25%		Serviceability failure		Efflorescence	Reliability/ Safety	Element	1.25	**1.25**	
Substructure	Pier	P3/RC	7.2017	Rating	Damage	5%		Serviceability failure		Cracks	Reliability/ Safety	Element	1.05		

Equipment	Expansion joints	Open structure Steel	7.2017	Rating	Damage	15%		Serviceability failure		Corrosion	Reliability/ Safety	Element	1.15	**1.15**
Equipment	Bearings	Steel plates	7.2017	Rating	Damage	-		Serviceability failure			Reliability/ Safety	Element	1	

The COST TU1406 approach data was collected considering vulnerable zones and failure modes based on defects. The data can be seen in Table 9. The information is collected from WG3 Final report. Performance cluster Table 7.4 Observations relevant for concrete girder and frame bridges.

Table 10. Collection of defects

Structure type	Group of elements	Observations						
		Element	Type of cross-section	Date	Performance cluster	Performance indicator	Performance metric	
							Primary	Secondary
FC1	Superstructure	Deck plate	SA1/RC	2017	Bearing capacity	Change of static scheme	Mid span	Lateral
			SA1/RC		Bearing capacity	Change of static scheme	Mid span	Longitudinal
			SA1/RC		Bearing capacity	Change of static scheme	Mid span	Lateral
			SA1/RC		Bearing capacity	Change of static scheme	Mid span	Longitudinal
			SA1/RC		Material properties	Concrete quality	20%	Bottom
			SA1/RC		Material properties	Chloride content - Symptom	50%	Bottom
			SA1/RC		Defects	Damage	20%	Bottom
			SA1/RC		Defects	Damage Symptom	0%	Outer beam
			SA1/RC		Defects	Damage	5%	Outer beam
			SA1/RC		Defects	Damage	20%	Bottom
	Substructure	Abutment	AB2		Material properties	Concrete quality	40%	
		Abutment	AB2		Defects	Damage Symptom	25%	Abutment F
		Pier	P5		Defects	Damage	5%	Pier B
		Pier	P5		Defects	Damage	5%	Pier B
		Pier	P5		Material properties	Concrete quality	50%	Pier B
		Pier	P5		Material properties	Concrete quality	40%	Pier B
	Equipment	Expansion joints			Joints	Deficiency	15%	Joint F
		Protection roof over railway			Requirements	Standard		Longitudinal

In table 10 it is shown, where different type of indicators has been collected. In the table there are four main type of performance clusters: related to bearing capacity, defects, material properties and equipment requirements. Material properties are based on tests, which results are shown in tables 3-5. The metrics are based on visual inspections and are not accurate measurements.

Table 11. Observation of failure modes and performance values

Observations						Performance value	
Failure mode	Location/position - Vulnerable zone	Degradation process (Damages/symptoms)	Primary Key Performance Indicator	Assessment level	Time to failure, years		
Bending moment failure	HMM/Bott	Reinforcement deficiency	Availability	Element	25	2	2
Bending moment failure	HMM/Bott	Reinforcement deficiency	Availability	Element	100	1	
Bending moment failure	HMM/Bott	Reinforcement deficiency	Reliability	Element	25	3	3
Bending moment failure	HMM/Bott	Reinforcement deficiency	Reliability	Element	100	1	
Serviceability failure	Bottom	Carbonation	Reliability	Element	NA	3	
Serviceability failure	Bottom	Chloride contamination	Reliability	Element	NA	3	
Serviceability failure	Bottom	Exposure of reinforcement	Reliability	Element	NA	1	
Serviceability failure	Bottom	Efflorescence	Reliability	Element	NA	1	
Serviceability failure	Bottom	Cracks	Reliability	Element	NA	1	
Serviceability failure	Bottom	Spalling	Safety	Element	50	2	2
Serviceability failure		Corrosion (Half-Cell potential)	Reliability	Element	NA	1	1
Serviceability failure		Efflorescence	Reliability	Element	NA	1	
Stability failure		Cracks	Reliability	Element	NA	2	2
Serviceability failure		Exposure of reinforcement	Reliability	Element	NA	1	
Serviceability failure		Carbonation	Reliability	Element	NA	2	
Serviceability failure		Corrosion (Half-Cell potential)	Reliability	Element	NA	1	
Serviceability failure		Corrosion	Economics	Element	NA	3	3
	Bottom		Safety	Element	50	3	3

Table 11 is continuation of Table 10 and there shown the assessment of failure modes and final performance values. Performance values are based on Tables 6-8 and expert judgement of Swiss representatives from Kanton Zürich.

6.4. PRESENT SITUATION

The assessment can be concluded with spider diagram of present values, shown in Fig. 13. All values are based on previous assessment scenario and the explanation for the evaluation of different aspects are below:

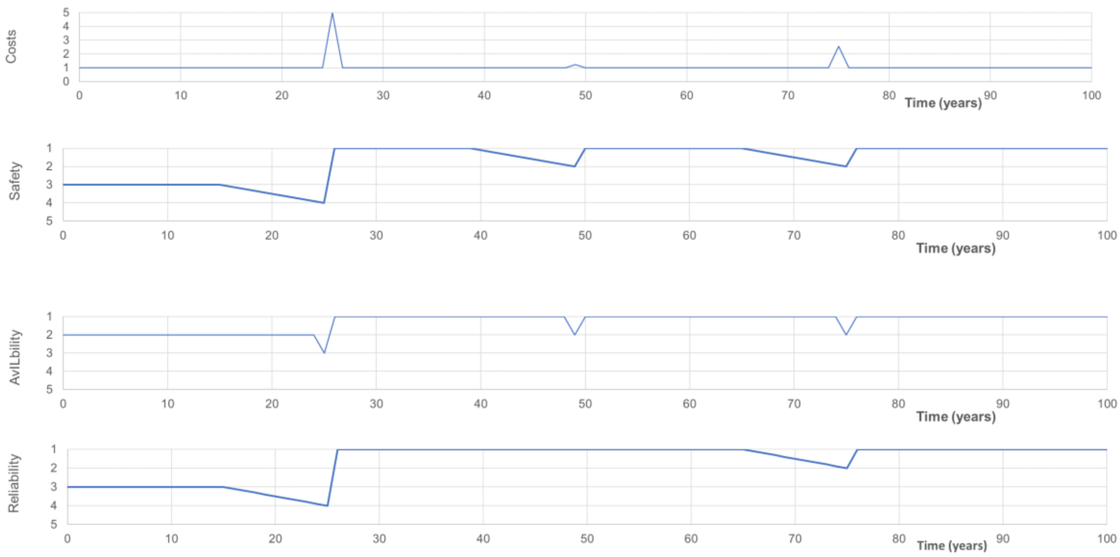
- Reliability – The ratio between resistance of transverse reinforcement to bending moment and designed values are 0,85 in end span and 0,91 in middle span. The reduction factor for LM1 traffic loads are also reduced α_{Q1} = 0.7; α_{Q2} = 0.5 and α_{qi} = 0.4, which are more than 20% less from present values. In conclusion the Reliability value is decided to be 3 as the resistance reduction is between 9-15%.
- Availability – The availability rating is based on the scale in Table 8. The bridge is closed for 480t heavy vehicles, but available for all traffic including 240t heavy vehicles.
- Safety – This KPI is based on the evaluation of protection roof over railway, which does not fulfill modern requirements and it can cause injury within next 50 years.
- *Cost – Cost is considered 3 as the structure was originally aesthetically valuable, but due to mortar patches the value is lower. Secondly, the maintenance costs for Kanton Zürich are higher because of corroding expansion joints.

*- The increase in costs are minor comparing to reconstruction costs, so the Cost KPI is excluded from present situation diagram.

Fig. 13. Snapshot of the KPIs.

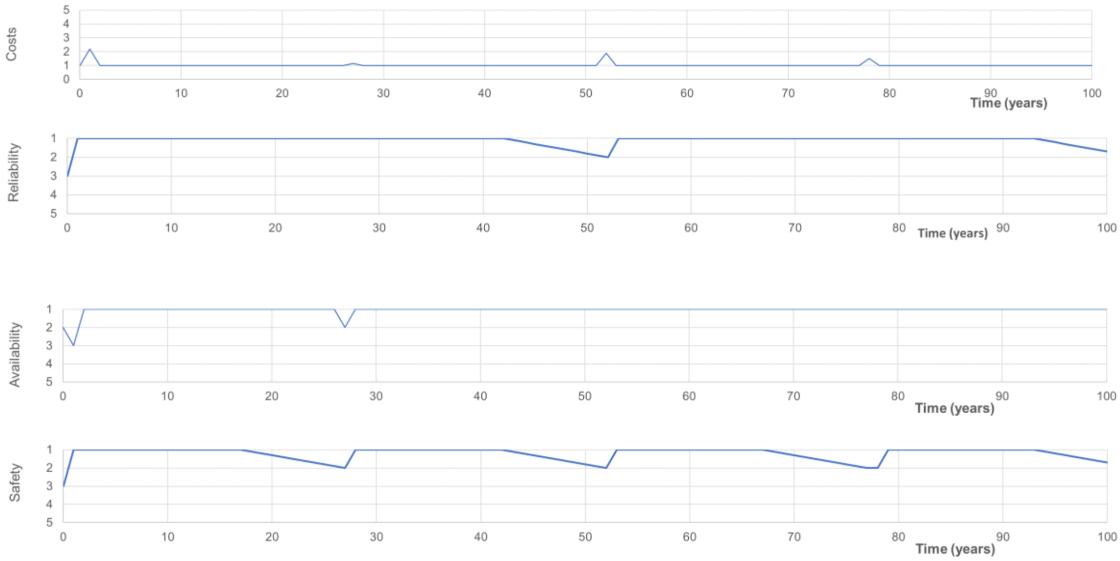
6.5. REFERENCED APPROACH

In referenced approach historical pattern is imitated, where only repairs are carried out until the reliability or availability for heavy load vehicles (240t) will be limited. After the performance goal of reliability or availability is passed the bridge will be reconstructed. The cost of reconstruction is considered 5 Million CHF in present value, small repair 150000 CHF and big repair 500000 CHF.
After reconstruction, the durability goal is considered, and pavement works are carried out every 25 years and overall repair after 50 years – the price will be 500000 CHF. Maintenance actions are not considered as a Cost, because Kanton Zürich is maintaining the bridge.



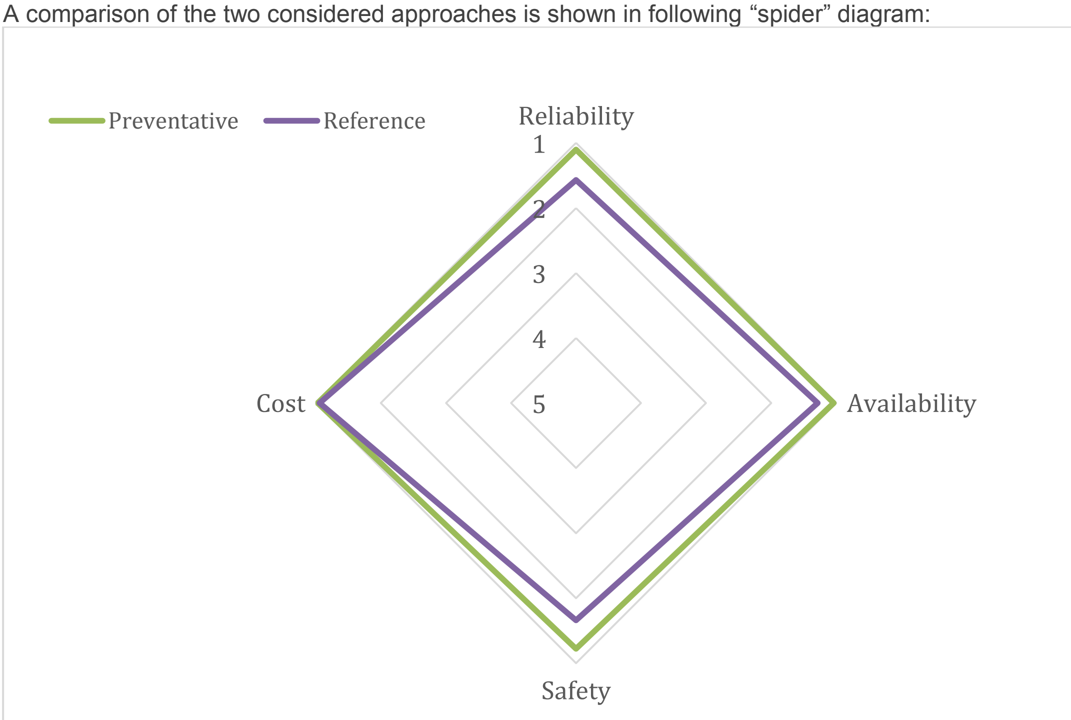
6.6. PREVENTATIVE APPROACH

In preventative approach the bridge will be repaired and strengthened in next year, because the reliability and availability for heavy load vehicles (480t) is already limited and there is no possibility to bypass the structure with reasonable range. The cost of strengthening and repair is considered 2.5 Million CHF in present value, small repair 150000 CHF (pavement change) after 25 years and big repair after 50 years with net present value 500000 CHF.



6.7. COMPARISON OF THE APPROACHES

A comparison of the two considered approaches is shown in following “spider” diagram:



The final results of the spider are average values of every key performance indicator.

According to the carried-out analysis the planned preventative approach is more appropriate for the Glattfelden bridge - the indicators shows more favorable results from all of the aspects.

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