TU1406
COST ACTION

QUALITY SPECIFICATIONS FOR ROADWAY BRIDGES,
STANDARDIZATION AT A EUROPEAN LEVEL

TU1406 WG4 Final report Appendix A12

Bridge case study

Concrete Girder Bridge, Vierlingbrug Netherlands

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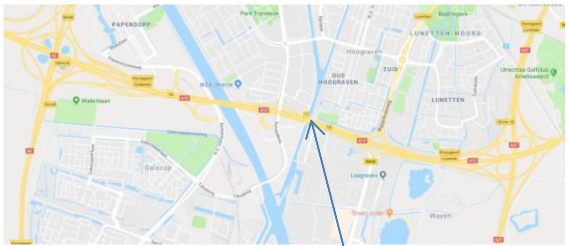
CONTENTS

1. GENERAL DATA OFF THE BRIDGE

1.1. BASIC INFORMATION

The Vierlingbridge is located in the Dutch main road network in the A12 motorway nearby the city of Utrecht, see figure 1, and consists of 4 bridges (kunstwerken). The motorway A12 is a direct west-east connection from Den Hague, Gouda, Utrecht and Arnhem to Germany.
This inspection report concerns the southern part of the Vierlingbridge with codenumber 31H-013-04 Zuidelijke parallelbaan. See figure 2.



Dutch main road network with A12 (blue line) Figure 1 location Vierlingbridge

Figure 2

The bridge consists of a 4 spans concrete construction and crosses local roads, cycle paths and the Vaartse Rijn, a small channel, see figure 3.

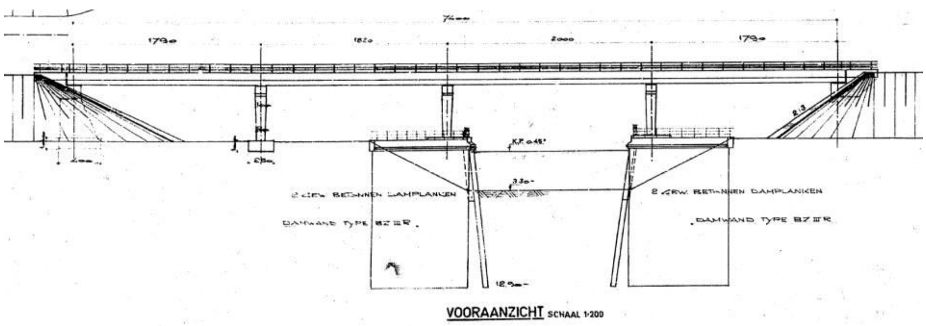


Figure 3

1.2. PASSPORT COMPLEX 31H-013-04

Complex 31H-013	
Complexnaam:	Vierlingbrug
Omschrijving complex:	Bruggen over de Vaartsche Rijn
Milieu 1:	
Milieu 2:	
Bijzonderheden:	
Aantal beheerobjecten:	4

Geografische locatie			
RDX:	136.052	**RDY:**	452.333
Latitude North (GPS)	52.0589713603996	**Latitude East (GPS)**	5.11092135459279

Complex	**Beheerobject nummer**	**Beheerobject code**	**Beheerobject omschrijving**
31H-013	01	31H-013-01	Brug over de Vaartscherijn in de noordelijke
31H-013	02	31H-013-02	Brug over de Vaartscherijn in de noordelijke
31H-013	03	31H-013-03	Brug over de Vaartsche Rijn in de zuidelijke
31H-013	04	31H-013-04	Brug over de Vaartsche Rijn in de zuidelijke

Beheerobjectcode 31H-013-04			
Naam:	Vierlingbrug		
Omschrijving beheerobject:	Brug over de Vaartsche Rijn in de zuidelijke parallelbaan		
Objectsoort:	Bruggen (vast)	**Classificatie:**	Beton klein
Aard:	Droog	**Netwerk:**	HWN
Uniek:	Nee		

Rijksweg:	12	**Route:**	A12
Traject:	RW 12 : MN Z (40,5 - 102,56)		
Hectometer:	60,3 + 70	**Rel. tot weg:**	in RW
Letter:	x		

RDX:	136.041	**RDY:**	452.307
Stichtingsjaar:	1969	**Sloopjaar:**	
Status:	in gebruik	**Asbest:**	Veilig-nondestructief
Archiefcode:	31H-303-00	**Cultuurhistorie:**	Groen
		Aantal objectdelen	1
Datum laatste Instandhouding sinspectie	15-10-2014	**Interval Instandhoudingsi nspectie**	6 Jaar

Instanties			
Eigenaar:	RWS MN / MN District Zuid	**Provincie 1:**	Utrecht
Beheerder:	RWS MN / MN District Zuid	**Gemeente 1:**	Utrecht (gem.)
Ond. plichtig	RWS MN / MN District Zuid		
Beheergebied	RWS MN / MN District Zuid	**Provincie 2:**	
Insp Instantie:	RWS GPO / RPC Noord-West	**Gemeente 2:**	

Inspectievoorzieningen
-

Objectdeel 04	
Omschrijving:	Zuidelijke brug par.baan
Archiefcode:	31H-303-00
Objectnummer:	4
Stichtingsjaar:	1969
Sloopjaar:	
Ontwerper:	Dir.Sluizen + stuwen
Objectsoort:	Vaste brug
Object type:	Ligger

Ontwerp specificatie 04	Waarde	Eenheid
Aantal overspanningen	4	st
Belastingscoefficient	1	
Kruishoek	100	gon
Lengte	74	m1
Maximale constructiebreedte	16.71	m1
Stootcoefficient	1	

1.3. TRAFFIC INFORMATION

1.3.1. TRAFFICINTENSITY

The traffic intensity on the A12 at the Vierlingbridge is 21930 vehicles per/day.

This is divided into 4 categories:	Al = 11000,	person cars
	L1 = 9920,	person cars
	L2 = 522,	trucks
	L3 = 488.	trucks

(Data information form 2017)

1.3.2. DIVERSION ROUTE

Traffic should be diverted during the execution work. This can be done via the national road network.
The southern diversion, the green line, via trafficjunction Oude Rijn and the A2 to junction Everdingen and then the A27.
The northern diversion, the red line, via trafficjunction Oude Rijn and the A2, exit Maarssen N230 and the A27. (Red line).

1.4. FOUNDATION

The foundation of the abutment A are steel piles, KP 25 filled with concrete or sand. The abutment E and the piers, B, C and D, are precast concrete piles, dimensions 400x400 mm.
An anchored steel sheet piling was installed on the Vaartsche rijn, near piers C and D. The anchor bar is Ø2 1/4 " and 16000 mm long. The steel sheet piling is a type BZIII3, long 13500 mm. See figure 4.

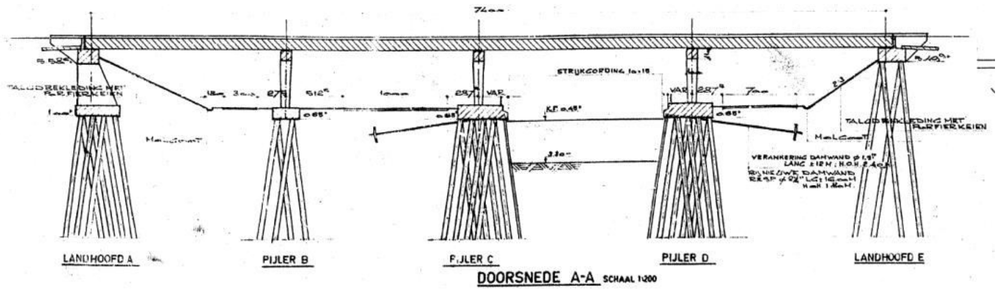
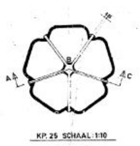


Figure 4



steel pile KP 25

1.5. SUBSTRUCTURE

The abutments and the piers are executed in reinforced concrete.
Abutment A is low-lying and abutment E is high-lying. See figure 4. The squares columns at the piers, dimensions 800x800 mm are with a lower beam connected. On the lower beam are the bearings arranged for the pre-cast concrete beams. See figure 6.

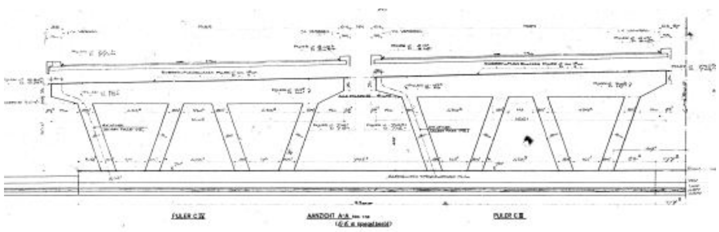


Figure 6

1.6. SUPERSTRUCTURE

The superstructure is made of prestressed prefab-beams. See figure 7 and 8. The spans are, respectively, field A-B 17900 mm, field B-C 18200 mm, field C-D 20000 mm and field D-E 17900 mm. The totally length off the bridge is 74000 mm. A pressure layer, with a thickness of 200 mm reinforced concrete, has been poured onto the prefab beams. See figure 9. The open expansion joints are located at the abutments. There are no joints located near by the piers. At the location of the piers are the prefab-beams coupled with a coupling beam and imposed on bearings. See figure 9.

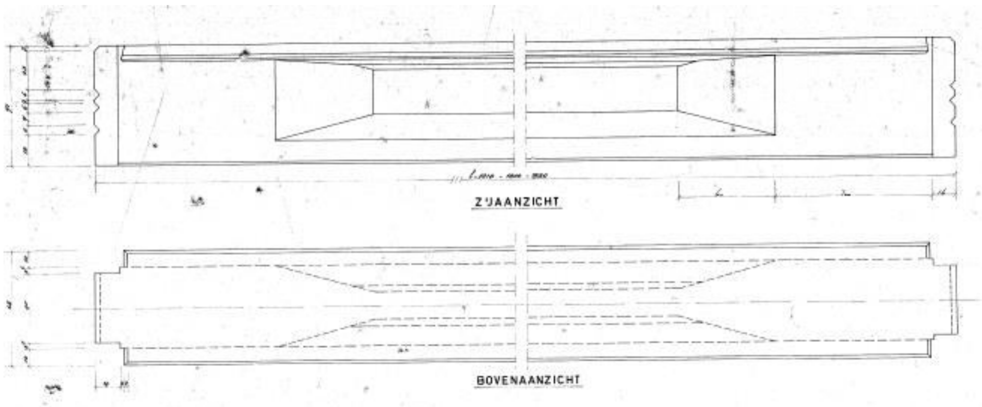


Figure 7

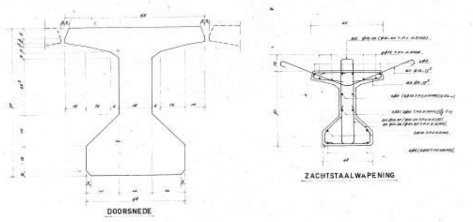


Figure 8

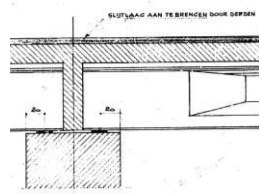
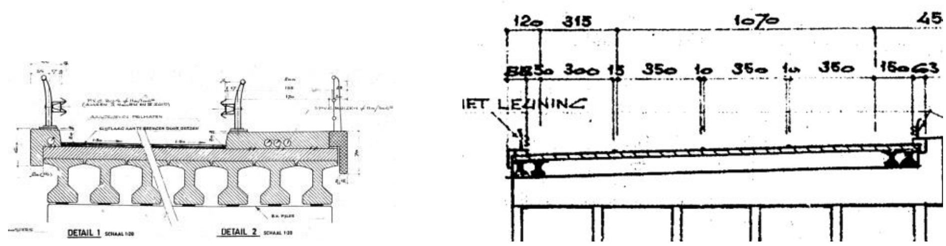


Figure 9

1.7. ACCESSORIES

The bridge deck is paved.
The embossed elements are made of reinforced concrete and equipped with cable casings for cables and pipes. On both sides of the bridge is a guide rail with an integrated handrail placed.
The rainwater on the deck is installed on the end of the wing walls and connected to the sewersystem.
The slope at the abutments under the drivingdeck is finished with basaltblocks.



Principle details deck

1.8. LOAD CAPACITY

No information.

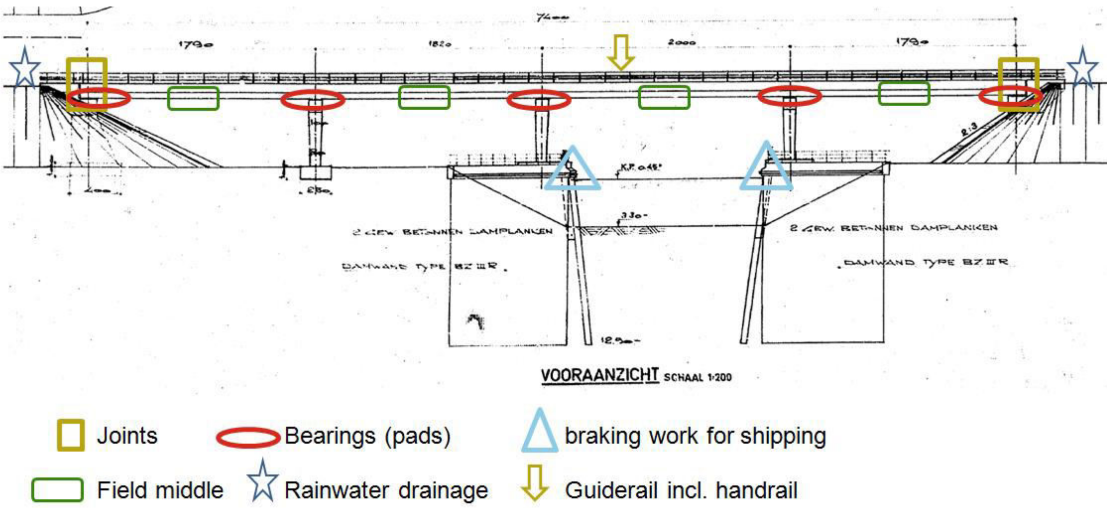
1.9. CONDITION RATING

The Vierlingbridge was calculated in 2007 for shear force. The conclusion of this calculation for the bridge was not exceeding the limit value.

The inspection of 2013, rapportage 2014 carried out by a certified company gave a classification 2 (is in good condition).

1.10. VULNERABILITY

The vulnerable areas are presented in the image below.



2. TECHNICAL CONDITION

2.1. INSPECTED PARTS INCL. FINDINGS

- spalling and cracks on reinforcement concrete
- reinforcement visible in the construction
- the leakage in the construction and the joints.
- the bearings
- expansion joints
- cracks and deformation pavement
- pollution and corrosion of accessories

2.1.1. FOUNDATION

The foundation and the steel sheet pilling incl. screen is not visible and is not included in this inspection.

2.1.2. SUBSTRUCTURE

- The substructure is fully coated. I cannot find a date in the DISK dossier, but it appears from previous inspection that it was submitted before 2009.
- Inhibitions work for shipping
  By piers C is the inhibitions works lightly damaged at various places and slightly overgrown. A part is missing just outside the bridge. See photo 6944 and 6890.
  By piers D is the inhibitions work undamaged and in a good condition.


6944


6890

- **Abutment A**
  No spalling or reinforcement visible in the construction.
  There are a few crack on the side of the abutment. This starts at the front wall and slants downwards at an angle of approx. 45 gr. The crack is water-bearing with a width of approximately 0.2 mm. See photo 6919 and 7001. A crack between the slave and the front wall at the location of the 2 driving lanes is 0.4 mm. see photo 7004. The crack width is difficult to measure due to the presence of the coating.
  Due to the moisture between the coating and the concrete, it bulges and releases. See photo 7000 and 7001.


6919

7001


7000


7004


7005


6940

- **Piers B-C-D**
  No spalling, cracks or reinforcement visible in the construction. No check on the bearings.
  The piers are polluted between the prefab beams with traces of bird droppings.
  Visually no leakage of the flexible joint visible. See photo 6998.

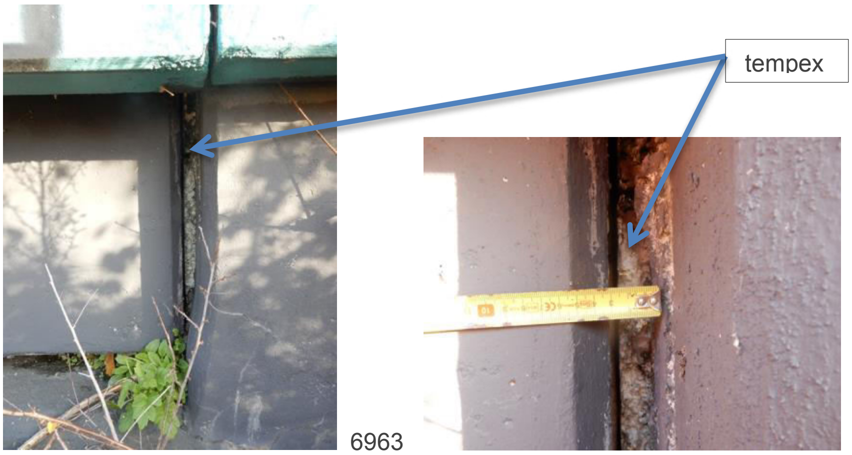
- **Abutment E**
  No spalling or reinforcement visible in the construction.
  There is 1 crack on the side of the abutment. This starts at the front wall and slants downwards at an angle of approx. 45 gr. The crack is water-bearing. See photo 6965.
  The cracking is visible in a previous repair carried out before 2009 (coating). See photo 6966


6965


6966

The cracks are on the same location and orientation as abutment A.

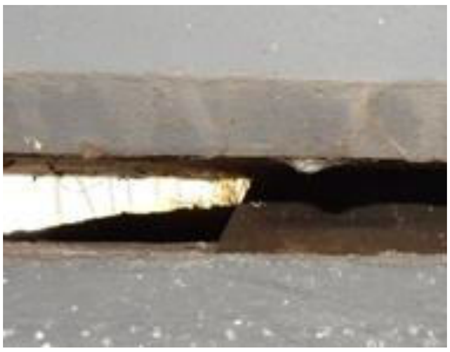
Note:
At the time of building this bridge, the material tempex was used as a formwork material. The tempex has never been removed. See photo 6963 and 6964. The movements made by the driving deck as a result of, inter alia, temperature can not be absorbed by the joint opening. This causes pressure on the frontwall. With the result that the frontwall is pushed away. This explains the position and the direction of the crack.



6963 6964

- **Abutment bearings**
  All bearings have a deformation in the longitudinal direction of the field. (side frontwand) See photo 6939 and 6975. Is explainable see note by abutment.
  The bearings have no visual defects. With a number of bearings are the ridges of the steel plates visible.


6975


6939

2.1.3. SUPERSTRUCTURE

- No cracks or enforcement are visually present in the superstructure prefab girder deck.
  No leakage was observed between the prefab beams.
  Field A-B see photo 6900 and 6897

6900

6897

Field C - D photo 6956 and 6957

6956

6957

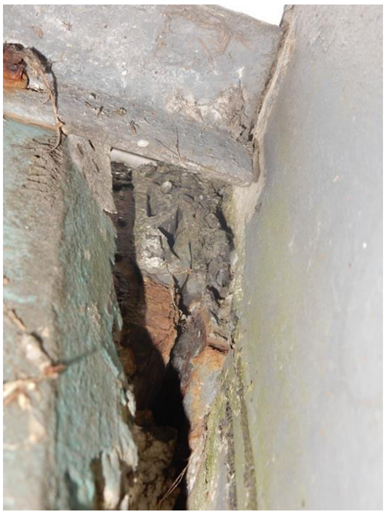
2.1.4. ACCESSORIES

- **Expansion joints**
  No corrosion or wear is visible on the mounted part of the expansion joint. The unreaded section is subject to corrosion. The rubber profile is in poor condition and properly headlined and in the tracks it seems that it is broken. See photo 6986. This is probably the cause of the leakage at the abutments.
  The connection between the asphalt driving deck and the expansion joint is reasonable. The connection off the expansion joint / asphalt embankment is in a bad condition. See photo 6988.

6986

6986

6988

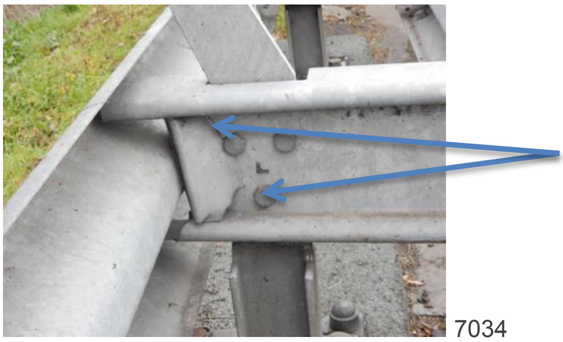


7008

- **Rainwater**
  All rainwater from the viaduct is collected in wells behind the abutments and discharged via the sewage system. See photo 6904 and 6917
  We were lucky during the inspection that had been carried out a few weeks earlier.

 6904  6917

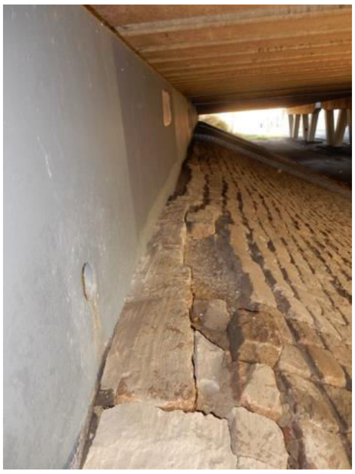
- **Guiderail and handrail**
  The guide rail on the road deck off the bridge has been replaced before 2013. See photo 6991, 6995. The guide rail has been torn in place at various positions. Wingwall abutment A. See photo 7034.
  The handrail at Pier D is damaged / missing in several places. See photo 6946

 6991  7034

 6995  6946

- **Slope covering.**
  The slope cover is slightly overgrown on both outside off the viaduct. See photo 6901. A few blocks are missing from abutment A and by abutment E a small reparation. See photo 6930 and photo 7025. No subsidence observed.


6901


6930


7025

3. KEY PERFORMANCES INDICATORS

3.1. CURRENT STATE EVALUATION

<table>
<tr><th>Structure</th><th rowspan="2">Group</th><th rowspan="2">Component</th><th rowspan="2">Material</th><th rowspan="2">Design & Construction</th><th rowspan="2">Failure mode</th><th>Location/</th><th rowspan="2">Damage /Observation</th><th>Damage</th><th rowspan="2">KPI</th><th rowspan="2" colspan="2">Performance Indicator component level</th><th colspan="2">Performance value</th><th rowspan="2">Estimated failure time [years]</th><th rowspan="2">costs</th></tr>
<tr><th>type</th><th>Position</th><th>process</th><th>R</th><th>S</th></tr>
<tr><td rowspan="11">Girder beams</td><td rowspan="11">Structural elements</td><td rowspan="4">Main Girders</td><td rowspan="4">Post-Tensioned Precast Concrete</td><td rowspan="4">1969</td><td rowspan="3">Bending failure mode</td><td rowspan="2">Middle span, bottom of the girder</td><td>Exposed rebars, Exposed tendon</td><td>Corrosion</td><td rowspan="8">Reliability (Structure safety) Reliability</td><td>2.0</td><td rowspan="4">3.5</td><td rowspan="11">2.9</td><td rowspan="11">3.0</td><td>40</td><td></td></tr>
<tr><td>Crack, spalling</td><td>Deteriotation</td><td>2.0</td><td>40</td><td></td></tr>
<tr><td>Anchorage zone of pre-tension</td><td>Cracks, spalling (monitoring)</td><td>Deteriotation</td><td>2.0</td><td>5</td><td>€ 15.000,-</td></tr>
<tr><td>Shear failure mode</td><td>Beamheads</td><td>Prestressing force lossing (monitoring)</td><td>Corrosion</td><td>3.5</td><td>5</td><td>€ 25.000,-</td></tr>
<tr><td rowspan="3">Pier</td><td rowspan="3">Reinforced concrete</td><td rowspan="3">1969</td><td>Shear failure mode</td><td>foundation</td><td>Cracks</td><td>Deteriotation</td><td>2.0</td><td rowspan="3">2.0</td><td>40</td><td></td></tr>
<tr><td>Shear failure mode</td><td>columns</td><td>Spalling Cracks</td><td>Deteriotation</td><td>2.0</td><td>40</td><td></td></tr>
<tr><td>Shear failure mode</td><td>lower beam</td><td>Diagonal Cracks</td><td>Collapse</td><td>2.0</td><td>40</td><td></td></tr>
<tr><td>Pressure layer</td><td>Reinforced concrete</td><td>1969</td><td>Bending</td><td>HMS/bottom</td><td>Delamination</td><td>Corrosion</td><td>2.0</td><td>2.0</td><td>20</td><td>€ 25.000,-</td></tr>
<tr><td>Bearings</td><td>Elastomeric</td><td>1969</td><td>Bearing Failure</td><td>Abutment 1 and abutment 5</td><td>bearing</td><td>Slant towards abutment</td><td>Reliability</td><td>3.5</td><td>3.5</td><td>5</td><td>€ 63.500,-</td></tr>
<tr><td rowspan="2">Abutment</td><td rowspan="2">Reinforced concrete</td><td rowspan="2">1969</td><td>Displacement frontwall</td><td>Abutment 1 (low lying)</td><td>crack water-bearing</td><td>Corrosion</td><td>Reliability</td><td>4.0</td><td>4.0</td><td>5</td><td>€ 120.000,-</td></tr>
<tr><td>Displacement frontwall</td><td>Abutment 5 (high lying)</td><td>crack water-bearing</td><td>Corrosion</td><td>Reliability</td><td>3.5</td><td>3.5</td><td>5</td><td>€ 120.000,-</td></tr>
</table>

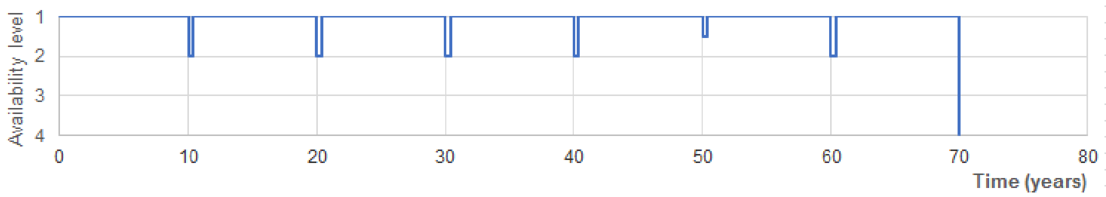
		Expansion Joint	Steel joint	1969	Deck movement Cyclic dynamic force due to traffic	Abutment 1 and abutment 5	Damaged by traffic	Corrosion	Reliability	3.5	**3.5**			**2**	**€ 80.000,-**
			Rubber Joint profil	?	Deck movement Cyclic dynamic force due to traffic	Abutment 1 and abutment 5	Worn and damaged	leaking	Reliability	3.5	**3.5**			**2**	**€ 4.000,-**
	Equipment	Safety barrier, Guadrails	Galvanized steel	2011	Falling of the deck	Safety barrier	Broken, missing parts, missing bolts, missing grout	Impact	Safety	4.0	4.0			**2**	**€ 32.000,-**
		Slope covering	Basalton rocks	1969	washout	Abutment 1 and abutment 5	missing parts	subsidence	Reliability	2.0	2.0			**40**	
		Rainwater	gutter	1969	washout	Overall	Water leaks	Washout by leaking	safety	2.5	2.5			**10**	**€15.000,-**
			poured asphalt	2012	spalling	Overall	Water leaks to the concrete slab	Corrosion	Reliability	2.5	2.5			**10**	**€3.000,=**
		Pavement	Asphalt	2012	Water drainage	Overall	Cracks and fraying of the asphalt	leaking	Reliability	3.0	3.0			**10**	**€ 35.000,-**

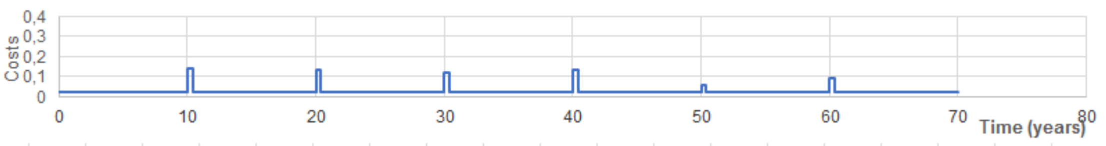
3.2. REFERENCED APPROACH

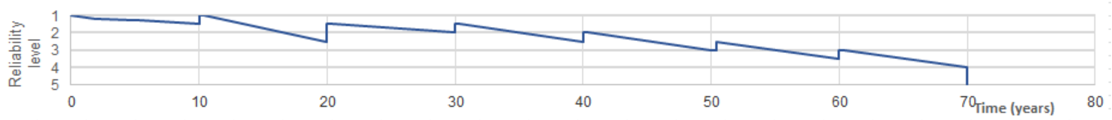
In this approach it is assumed that recommendations arising from inspections will only be carried out if the construction safety is at issue. This will result that the bridge having reached end of life in 2069.
The accessories will be taken along and replace during their indicated lifetime. (supports guiderail, joints, etc).
The costs of traffic measures are not included.
The total costs of this approach have been estimated at ± € 600,000 until the end of life (1969).

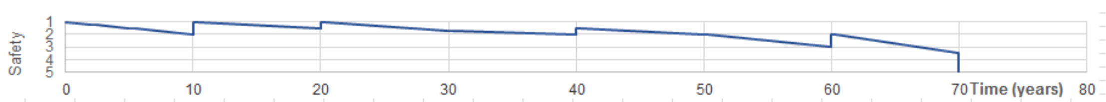
Assuming the maximum life of the accessories.

Rubber joint profile	every 10 years
Asphalt pavement	every 10 Years
Pressure layer	every 20 years (monitoring)
Safety barrier	every 20 years
Rain water	every 20 years
Bearings	every 25 years
Expansion joints	every 40 years







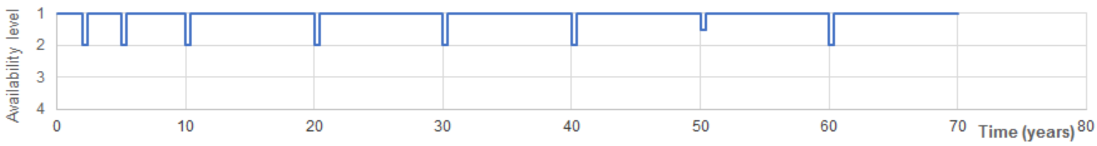


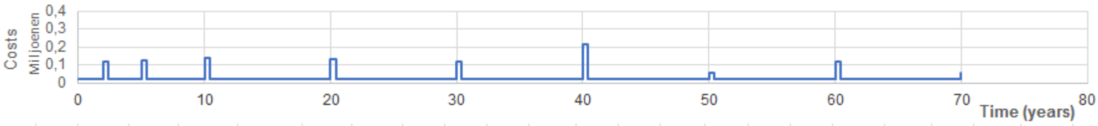
3.3. PREVENTATIVE APPROACH

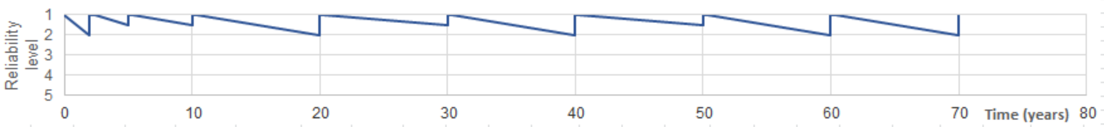
With this approach the bridge will be thoroughly at the abutments be addressed. The other construction parts are in good condition.

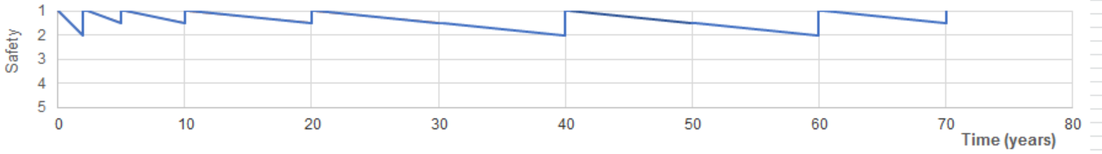
The expansion joints and the supports will be replaced over the next 5 years.
Monitoring the driving decks nearby the abutments.
Carefully examine and treat the water-carrying cracks at the abutments.
During the renovation of the expansion joint, remove the tempex in the joint gaps and around The bearings. This allows the construction to move freely again and to exert no pressure on the frontwall.
During this work, inspect the seam between the foundation gap and the frontwall for cracking. Depending on the inspection, carry out the required work. These cost are not included in this report.
Replacing the accessories when the end of the product's life has been reached. Assuming the maximum lifetime see 3.2 reference approach.
The costs of traffic measures are not included.

The total costs of this approach have been estimated at ± € 1.100,000 until the end of life (1969).



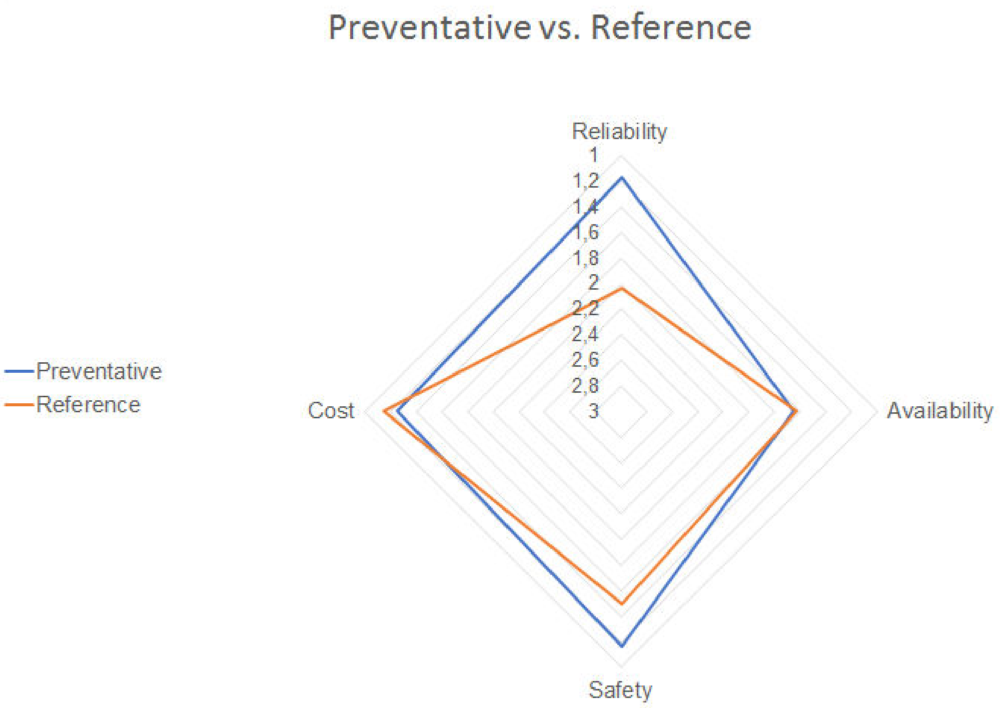






3.4. COMPARISON OFF THE APPROACHES

The two approaches are compared in the figure below, the spider diagram



The spider diagram shows that the costs at the reference approach are slightly more advantageous than in the preventative approach.
However, this does not outweigh the more favorable results of safety and reliability aspects. Moreover, the bridge is still in good condition at the end of its service life.

The analysis of the Spider-diagram shows that the preventive approach is more favorable.

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