Lessons Learned Reuse Prefab elements (girders)

based on Dutch experience

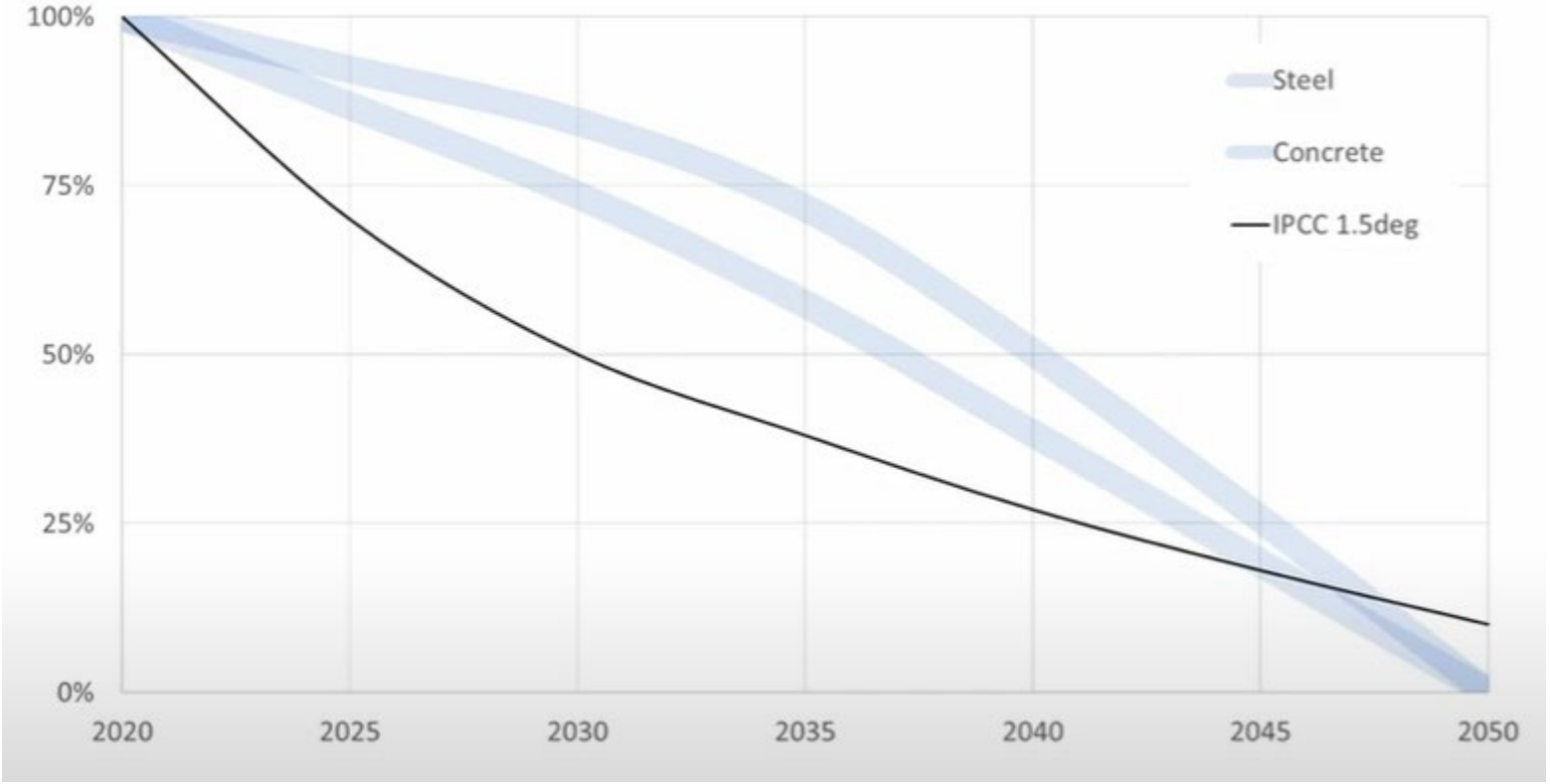
BZ1141-102-104-RHD-CB-XX-PP-S-0001
Open
Rob Vergoossen
October 3rd, 2025

Contact details - Haskoning

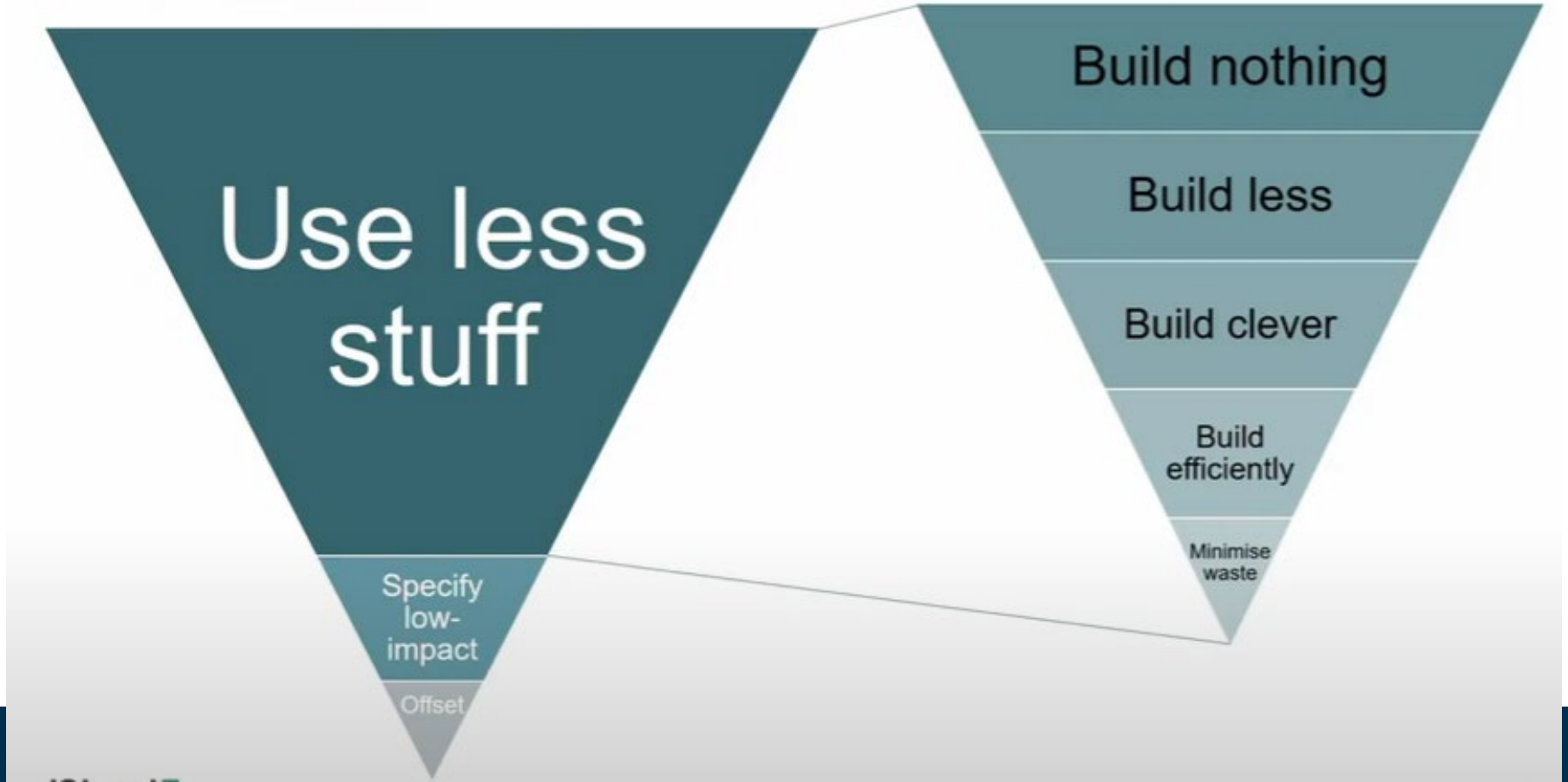
- Rob Vergoossen
  Leading Professional Concrete Bridges
  rob.vergoossen@haskoning.com
- +31 6 1070 2527
- https://global.haskoning.com
- Haskoning Delft
- CEG TU Delft (on Friday)

- Core Member IABSE Technical Committee
- Member of FIB, IALCCE
- Member of Betoninnovatieloket, Independent Committee Sustainable Concrete, various Task Groups and Coding Committees and Scientific Committees of symposia.

Mind the gap


100%
75%
50%
25%
0%
2020
2025
2030
2035
2040
2045
2050
Steel
Concrete
IPCC 1.5deg

Lower impact design



Introduction

- SBIR tender RWS Circular Bridges and Overpasses 2020: 32 tenderers
- Feasibility study RHDHV; Selection: 3 parties for pilot, 2021
- Formed for pilot project Reuse consortium Liggers2.0, 2021
- Successful pilot project for the A1 Hoog Burel overpass completed, ~~2022~~2023 (Meedenbrug Appingedam 2022; N386 De Groeve ~~2023~~2025)

- Follow-up assignment RWS to (Liggers2.0 and Closing the Loop)
  = Groene Liggers

Scaling up from reuse tens to <u>hundreds</u> of beams in the coming years.

Reuse business as usual Reuse unless…

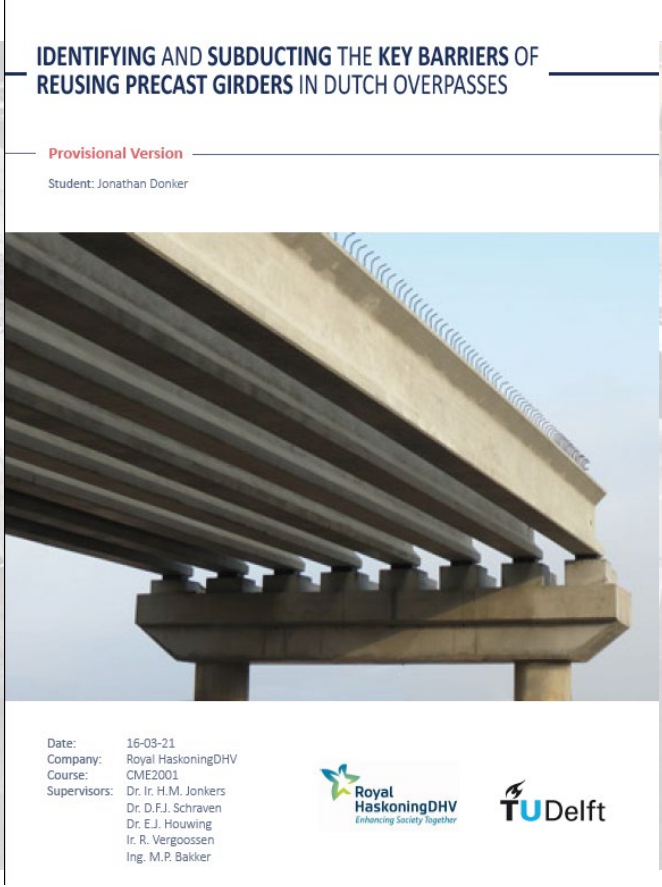
Re-use of girders sounds logic?

Why is this not happening already?

Investigation of barriers (TU Delft)

- 29 scientific structured interviews
  - 18 companies/ organisations
  - All actors in infrastructure sector

- Key barriers
  - Laws & Regulations
  - Remaining service life
  - Ignorance
  - Mindset
  - Financial



IDENTIFYING AND SUBDUCTING THE KEY BARRIERS OF REUSING PRECAST GIRDERS IN DUTCH OVERPASSES

Provisional Version

Student: Jonathan Donker

Date: 16-03-21
Company: Royal HaskoningDHV
Course: CME2001
Supervisors: Dr. Ir. H.M. Jonkers
Dr. D.F.J. Schraven
Dr. E.J. Houwing
Ir. R. Vergoossen
Ing. M.P. Bakker

Concrete Strength

- Desing (RVB) K600 ($f_{cm;cube}$ = 71 MPa) conform RBK → C40/50
- Delivery under certificate nr. 704 → Maximum standard deviation 40 kgf/cm^2 → $f_{ck;cube}$ = 64 MPa, f_{ck} = 52 MPa → C52/64 (or in current standard classes C50/60)
- 16 cores (in 2006) $f_{cm;cube}$ = 96,5 MPa → f_{ck} = 60 MPa → C60/73 incl. k_t
- HIP girders Large-scale research (RWS 2010-2011); 55 cores/11 complexes $f_{cm;cube}$ = 97,5 MPa → f_{ck} = 66 MPa → C66/81 incl. k_t

	f_{ck}	$f_{ck;cube}$	f_{cm}	$f_{cm;cube;is}$	f_{ctm}	$f_{ctk;0.05}$	f_{cd}	f_{ctd}
K600 (RBK)	40	50	48	- (71)	3,5	2,46	26,7	1,64
K600 (cert.)	52	64	60	- (71)	4,1	2,9	34,7	1,93
Coring 2006	60	73	68	96,5	4,35	3,05	34,0	1,73
RBK C55/67 Large-scale research	66	81	74	97,5 +40%	4,5	3,2	37,6	1,79 -10%

$f_{ctm;sp;is}$ = 5,25 MPa → $f_{ctm;is}$ = 4,73 MPa (+16%)
$f_{ctk;0.05;is}$ = 3,70 MPa (+29%); f_{ctd} = 2,10 MPa

Data from design calculations / drawings

- Daily production
  - After approx. 16 hours of hardening; R.V.B. > 300 kgf/cm^2 (productionnorm 415 kgf/cm^2 or 450 kgf/cm^2)

VOORSPANSTAAL		BETON	
soort	V.str. ϕ12	fabricaat cement	ENCI
kwaliteit	GP190	kwaliteit cement	B
certificaat S.B.B.B.	aanwezig	cement per m^3 beton in kg	375
treksterkte in kg/mm^2 σ_{ar}	190	kubussterkte bij voorsp. in kg/cm^2 $\bar{\sigma}'_w$	450
toelaatbare aanvangssp. in kg/mm^2 $\bar{\sigma}_{as}$	123,5	,, na 28 dagen in kg/cm^2 $\bar{\sigma}'_{w28}$	600
,, werksp. in kg/mm^2 $\bar{\sigma}_s$	104,5	druklaag $\bar{\sigma}'_{w28}$	300
elasticiteitsmodulus in kg/mm^2 E_s	20000	elasticiteitsmodulus in kg/cm^2 E_b	400 000

- Note: From R.O.B.K.1 (RWS – 1988) maximum **allowable** concrete quality (in design / calculation) B52.5 (C42.5/52.5)

Remaining service span (>100 years)

- Increase in strength (despite already high design strength)
  - From avg. 70 MPa to avg. approx. 100 MPa!
- Concrete cover meet 100 years of requirements for Eurocode new construction
  - (XD3/XS3 ; ≥ C45/55)
- Carbonation depth <1 mm after approx. 50 years
  - Time to start corrosion >> 100 years (∞)
- Chloride ingress negligible (<<0,4% in 0-10 mm) after approx. 50 years
  - Time to start corrosion >> 100 years (>1000)
- Not sensitive to other degradation mechanisms (i.e. ASR)
  - Low water-binder-ratio (<0,4), High density, good quality (control)
- No cracking
  - Elements designed for full compression under characteristic load combination (SLS)

Intermezzo if you are not a concrete structural engineer

- There are many bridges and overpasses (works of art) in the area of Rijkswaterstaat.
- Bridges with very large spans or movable.
- The innovation involves fixed bridges and overpassess with spans (10m-40m).
- Almost always made of concrete. Poured on site or the deck built with prefab beams.
- Prefab prestressed full beams, box beams, T-beams or these inverted T-beams.

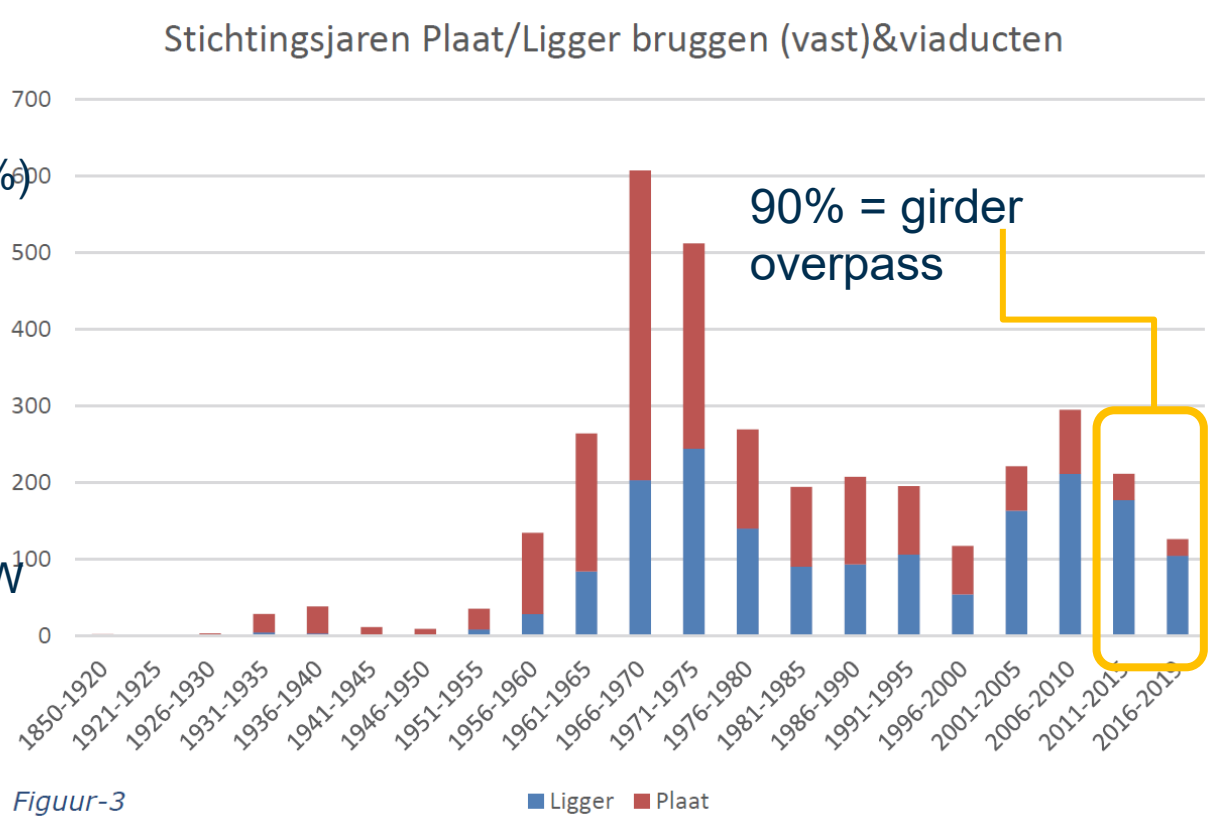
<u>Unfortunately for the reuse:</u>

- Do the viaducts in the Netherlands all have different lengths/spans
- Are we dealing with different intersection angles between the highway and the intersecting road, water or railway?
- So the solution must be flexible for different dimensions and intersection angles.

Impact

- 1637 girder overpasses (45%)
- Avg. age 25 year
- Avg. Angle of skew 15°
  - 32% straight, 25% >9°
- 1140 IN RW (70%)

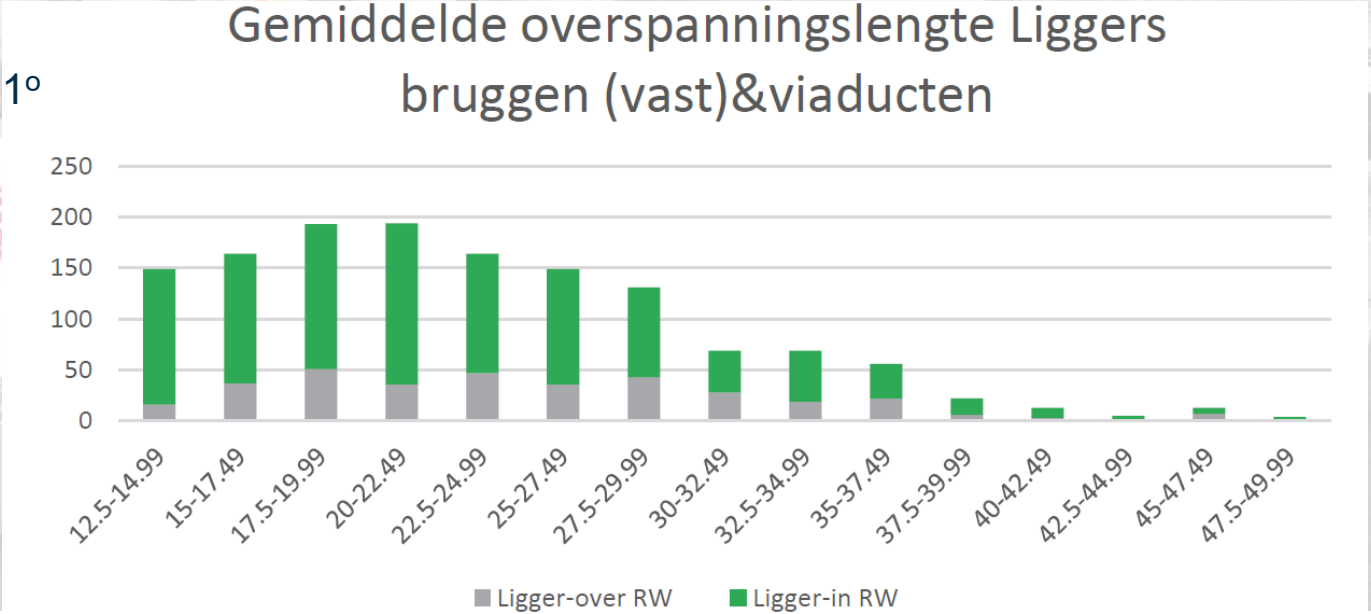
- Girder overpasses OVER RW
  - Avg. Age 29 years
  - Avg. Angle of skew 12°
  - 46% straight, 19% >9°



Figuur-3

Impact

- 7 to 10 girder overpasses per year demolished (Rijkswaterstaat)
- Avg. Age 40 year
- Avg. Angle of skew 11°



Girder types

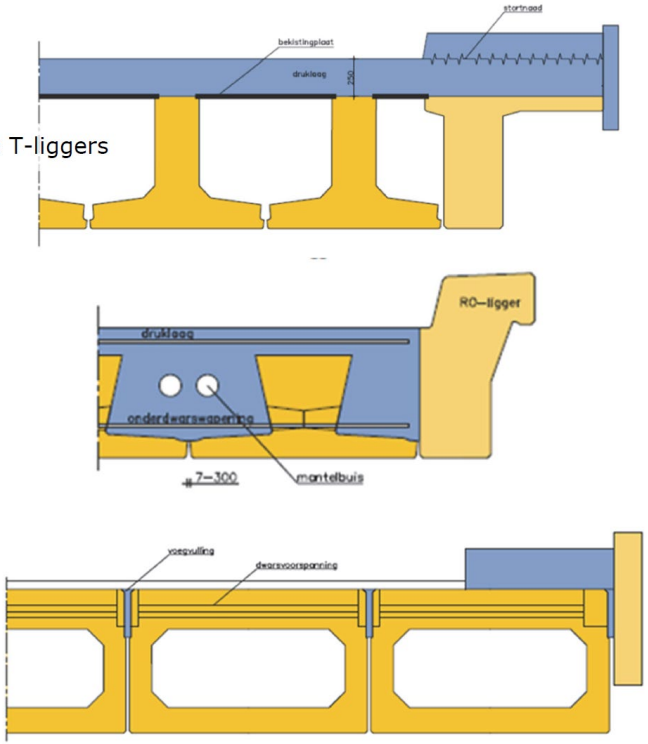
- (Inverted-)T with compression flange ca. 55%
- 17.5 m – 37.5 m

- Infill deck ca. 15%
- 8 m – 16 m

- Transversely posttensioned box-girders ca. 25%
- 25 m – 50 m (after ca. 1980)

- rest (T-contact, T-girder) ca. 5%

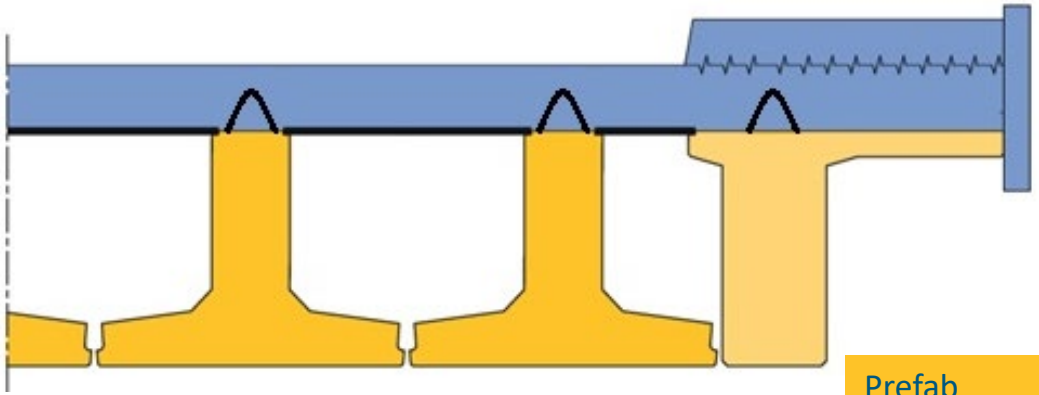
Omgekeerde T-liggers

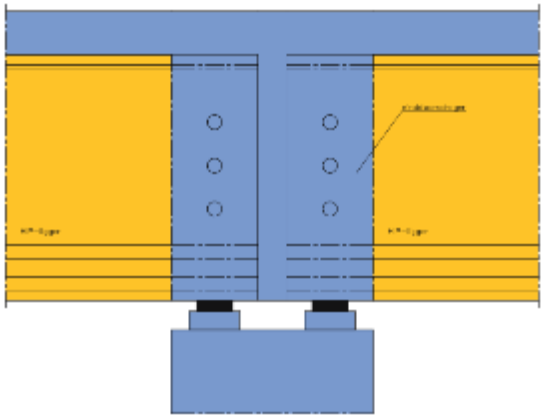


Figuur-1

Reusability of inverted T-beams

- <u>Unfortunately for the demountability:</u>
  - These are made into 1 bridge deck by using concrete poured on site.
  - Are there stirrups/brackets in the prefab beams that ensure the cohesion/interface with the concrete poured on site?.
    - *After removing the concrete, this reinforcement steel must be able to function again.*





Choice for direct reuse

Dismantling, transport and (temporary) storage

Modifying the beams

- Removing the on-site poured compression layer (deck slab)
- Shortening the beams and adapting to the new angle of skew
- Drilling holes for the passage of cross reinforcement

Result: Beams better than new!

Overpass Hoog Burel A1

- Reused girders in overpass over A1 for Rijkswaterstaat (CC3) with quality certificate by SGS Intron

- Award winner Dutch Concrete Prize 2024 – category groundbreaking construction

Sustainability gain project Hoog Burel

Reuse 16 girders in 2 out of 4 spans:

- 72 ton CO_2 saved
- 160 ton primary raw materials (gravel/sand/cement) saved
- MKI (ECI) per girder with 73% reduced and $CO_{2\text{-eq}}$ with 97%
- Homepage | SBIR Circulaire viaducten Hergebruik Liggers consortium Liggers2.0 (ireporting.nl)

CROW Guideline and protocol quality statement

- Open: Hergebruik - circulaireviaducten.nl en CROW Kennisbank

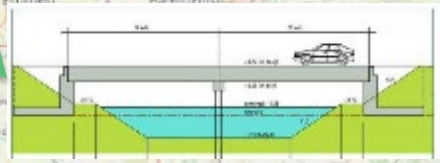
CROW-CUR Richtlijn 4:2023
Hergebruik constructieve prefab betonelementen

Matchmaking

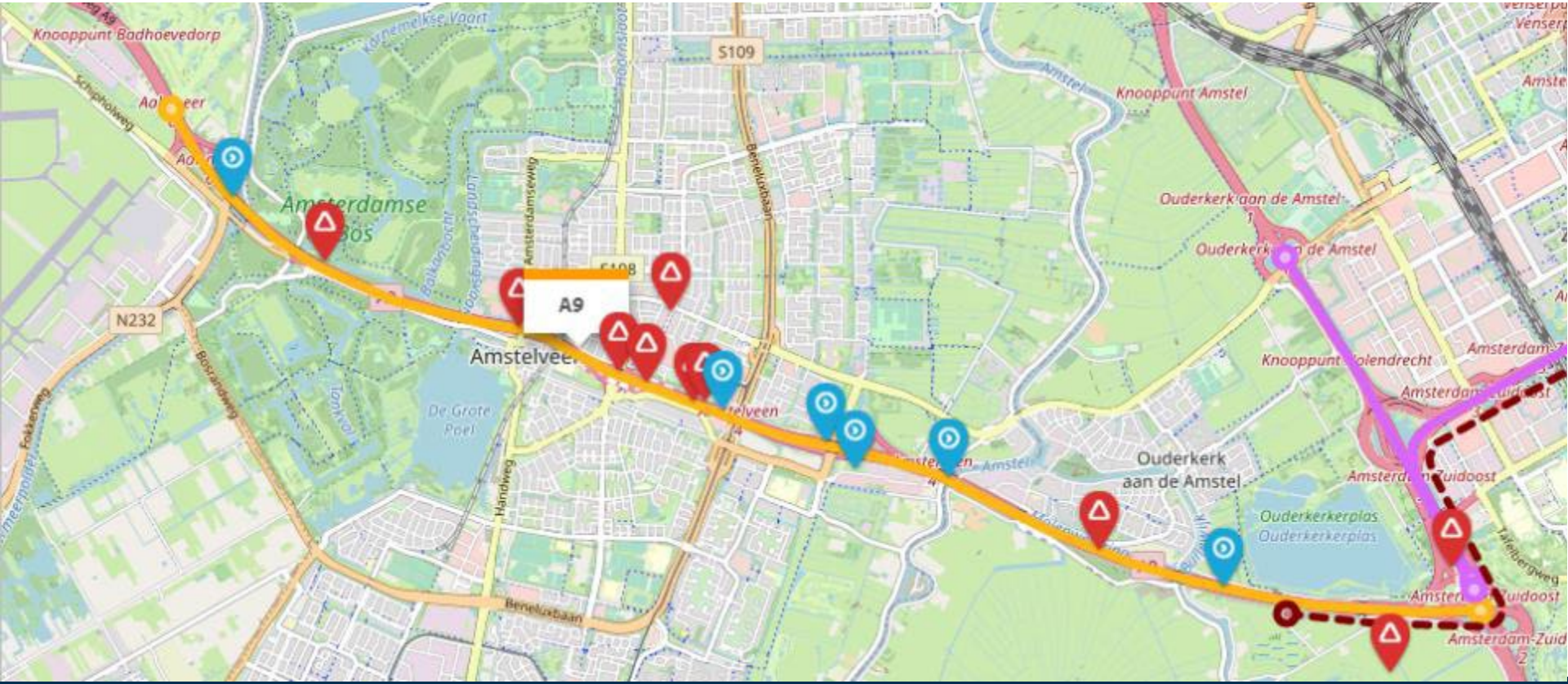
- Beams secured from:
  - A9 GDW: 6 girders, which were originally to be lifted and demolished
  - A7 ZRG: 26 beams originally planned to be demolished in situ
  - A9 BaHo: 300 beams original plaaned to be demolished in situ
- **Demand-driven match** made between required beams in viaduct A1 Hoog Burel and beams that become available from KW 21 A7 ZRG (completed 01-2023)

- **Supply-driven matches** Made between:
- Beams released from the A7 ZRG to the Oling Appingedam bridge (completed 03-2022)
- Beams released from A9 GDW to De Groeve viaduct (N386), Drenthe (completed 02-2025)
- Beams released from A9 BaHo to Vloedstegen bridge (N18), Overijssel (completer 06-2025)

Goals: match as quickly as possible, store as short as possible, adjust as little as possible, as short as possible transport distances



360 beams to be harvested from A9 structures



Reuse of 216 beams on the A44 Motorway (2027-2029)

About 300 inverted T-girders are harvested

And about 40 T-contact girders

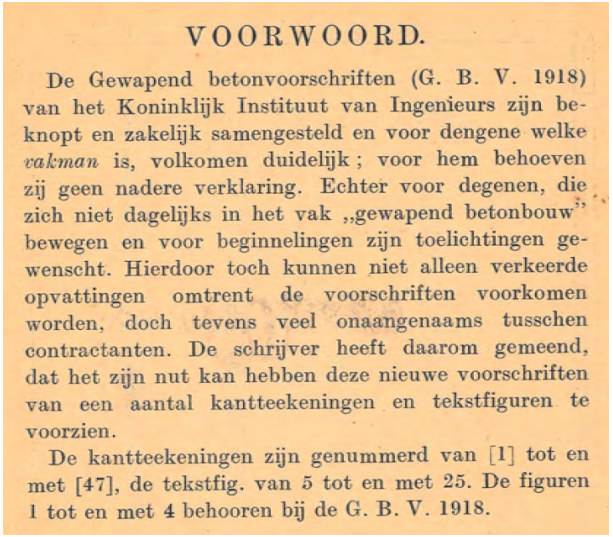
Bridge Appingedam: almost all elements reused

Bridge (fauna underpass) De Groeve (N386)

Vloedstegenbrug (Haaksbergen N18)

Testing of existing girders (at storage-hub)

Influence as a structural engineer

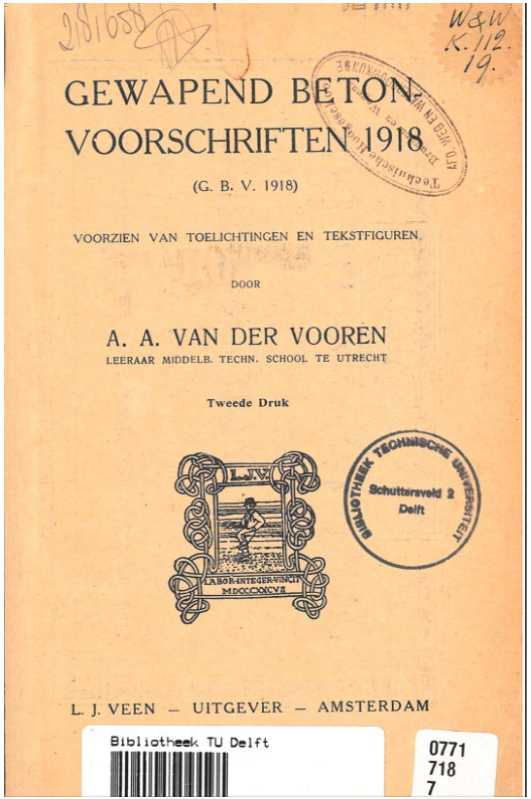


VOORWOORD.

De Gewapend betonvoorschriften (G. B. V. 1918) van het Koninklijk Instituut van Ingenieurs zijn beknopt en zakelijk samengesteld en voor dengene welke *vakman* is, volkomen duidelijk; voor hem behoeven zij geen nadere verklaring. Echter voor degenen, die zich niet dagelijks in het vak „gewapend betonbouw" bewegen en voor beginnelingen zijn toelichtingen gewenscht. Hierdoor toch kunnen niet alleen verkeerde opvattingen omtrent de voorschriften voorkomen worden, doch tevens veel onaangenaams tusschen contractanten. De schrijver heeft daarom gemeend, dat het zijn nut kan hebben deze nieuwe voorschriften van een aantal kantteekeningen en tekstfiguren te voorzien.

De kantteekeningen zijn genummerd van [1] tot en met [47], de tekstfig. van 5 tot en met 25. De figuren 1 tot en met 4 behooren bij de G. B. V. 1918.

- *"The intention of the regulations is to promote the technique of reinforced concrete. It is therefore not the intention that new construction methods should not be used or that they should be forced into the framework of these regulations for the calculation."*



GEWAPEND BETON VOORSCHRIFTEN 1918

(G. B. V. 1918)

VOORZIEN VAN TOELICHTINGEN EN TEKSTFIGUREN

DOOR

A. A. VAN DER VOOREN

LEERAAR MIDDELB. TECHN. SCHOOL TE UTRECHT

Tweede Druk

L. J. VEEN – UITGEVER – AMSTERDAM

Questions?