14th Japanese-German Bridge Symposium

TU Munich, Germany

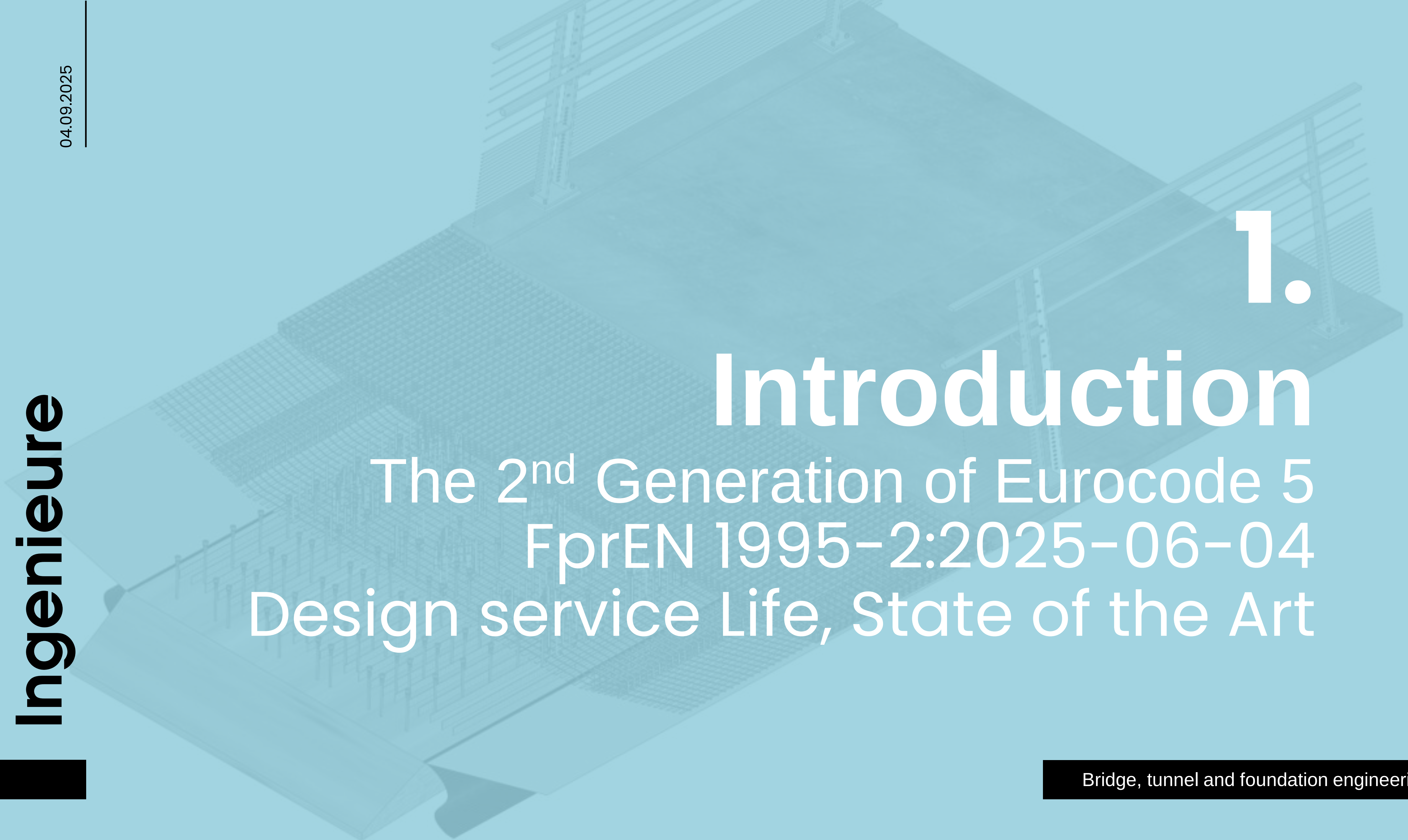
Harrer Ingenieure

Gesellschaft Beratender Ingenieure VBI mbH

Harmonized European Specifications for Bridge Design and Dimensioning: The Eurocode FprEN 1995-2 Timber bridges

Matthias Gerold

Karlsruhe, 18. September 2025



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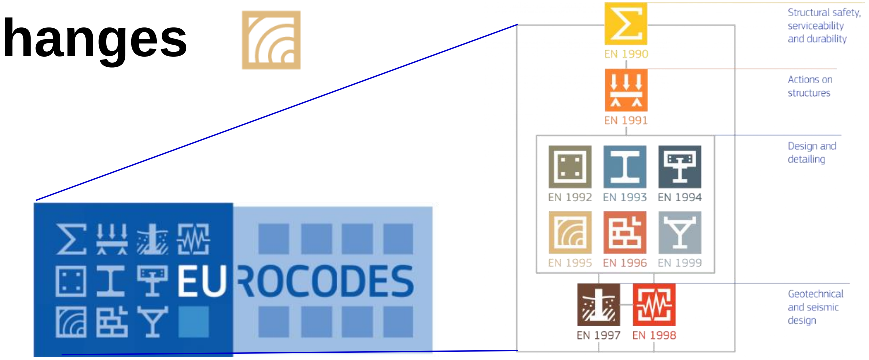
1. Introduction

The 2nd Generation of Eurocode 5
FprEN 1995-2:2025-06-04
Design service Life, State of the Art

Bridge, tunnel and foundation engineering

The 2nd Generation of Eurocode 5 series 2027 – Key changes



European design standards – Eurocodes

Source: European Commission, 2021

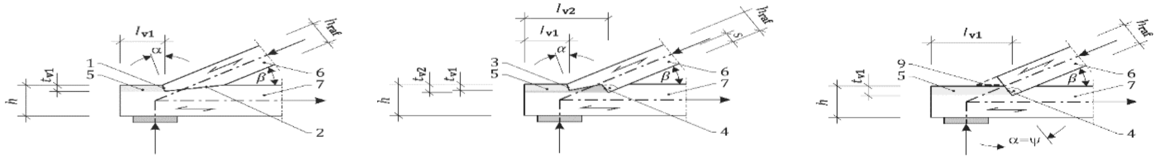
- Harmonization with the whole Eurocode family
- Ease of use (e.g. clear structure)
- Come together: Widely varying developments in timber within Europe
- Enormous developments of timber structures in the past 20 years → Implementation of

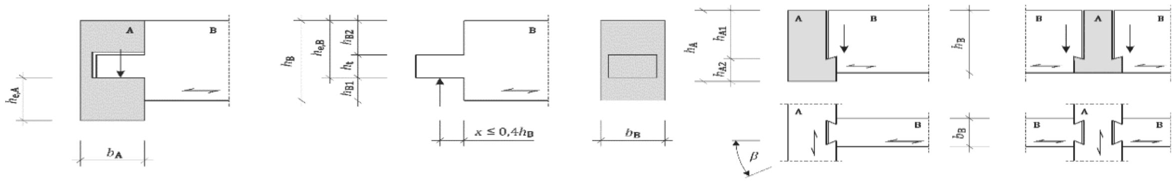
➢ Regional construction methods

(e.g. carpentry connections,

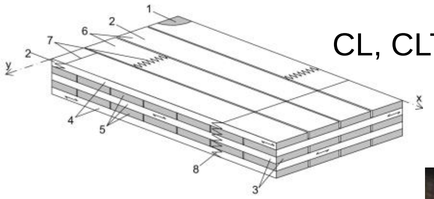
notched members and holes in beams,

reinforcements)

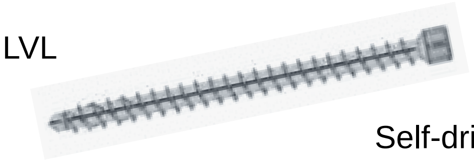




➢ New materials and fasteners / connectors



CL, CLT, LVL



Self-drilling, -tapping screws

➢ New building techniques and constructions

e.g. timber-concrete composite (TCC), deck plates

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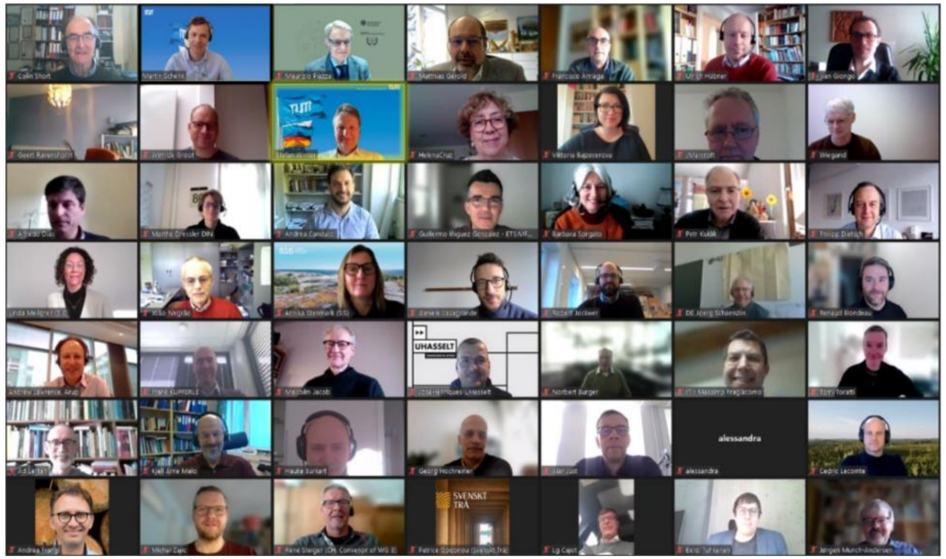
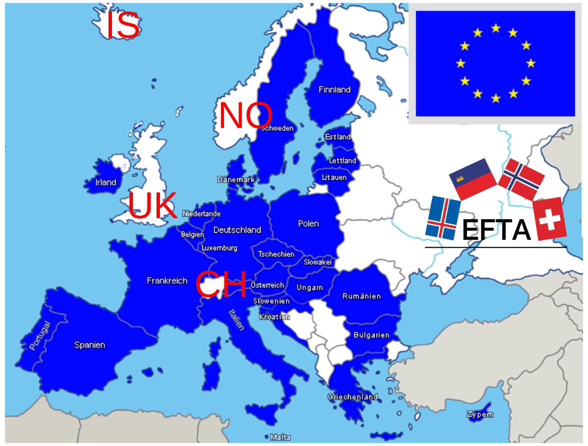
The 2nd Generation of Eurocode 5 – drafting work



A team of ~50 NSB's, ~200 subcommittee members

(and many more in the subgroups)



Standardisation work via **CEN**

(Comité Européen de Normalisation;

European Committee for Standardisation;

Europäische Komitee für Normung)

Drafting work – **Use of verbal forms** according to CEN-rules:

shall requirement strictly to be followed

should recommendation (highly); alternative approach where technically justified

may permission within the limits of Eurocodes

- EN 1995-1:
  - Part 1: General rules and rules for buildings
  - Part 2: Fire Design
  - Part 3: Timber-Concrete Composite Structures new
- EN 1995-2: Bridges
- EN 1995-3: Execution new

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Sustainability of timber bridges: Durability, Design service life

Implementation Design Service Life T_{lf} aus EN 1990:2023 in FprEN 1995-2:2025-06-04

FprEN 1995-2, **Table 4.1 (NDP) – Categories for Timber Bridges and parts of timber bridges based on their design service life**

	Category of timber bridges and parts of timber bridges	Design Service Life, T_{lf} [years] [a]	Service class (SC)	Design service life
1	Protected timber bridges (see 4.1.2.2)	100	2	Infrastructure projects; e.g. bridges
2	Timber bridges with reduced protection (see 4.1.2.3)	50	3	Residential buildings
3	Replaceable structural parts (of rows 1 and 2) [b] (see 4.1.2.4) [b]	25	3	Residential buildings and bridges
4	Temporary structures and unprotected timber members of timber bridges [c] (see 4.1.2.5)	≤ 10	3	Residential buildings and bridges

[a] The design service life for bridges is given in EN 1990:2023, Table A.2.2 (NDP).

[b] See 4.1.2.4(5) and (6) for durability specifications for steel components.

[c] See also EN 1990:2023, Table A.2.2 (NDP) footnote c. for treatment of structures that can be dismantled and reused.

Wood moisture content in **Service Class** (SC) **2** : $\omega_{up,mean}$ ≤ 20 %

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Sustainability of timber bridges: Protected bridges, State of the Art

Basically good structural wood protection („protected“ – see German standard DIN 68800)

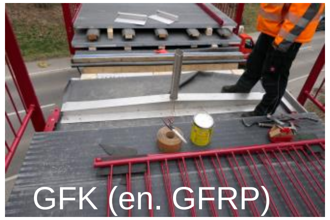
Wangen (CH)

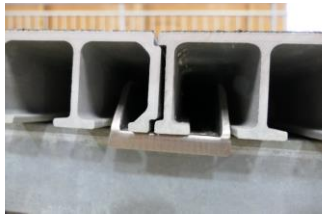
Lucern (CH), **1333**

Wangen (CH), **1550**

→ Service life (then) significantly over 100 years !

Bad Säckingen (D) / Stein a.R. (CH), **1570**





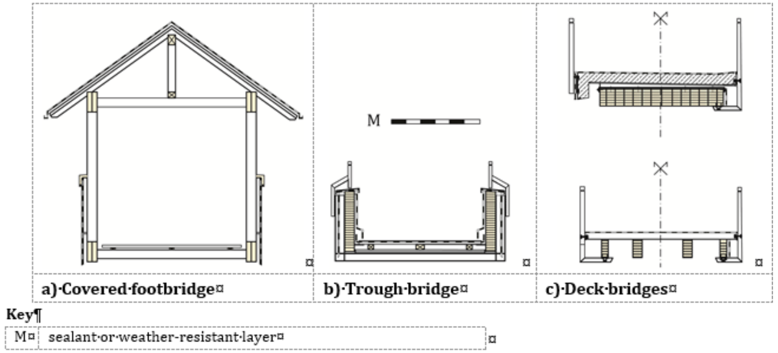
Most important changes in FprEN 1995-2:2025-06-04

Related terms and definitions FprEN 1995-2:2025-06-04, 3.1

3.1.1

protected bridge

Bridge in which all main members are *protected members* (3.1.2.)



Key:
M Sealant or weather-resistant layer
a) Covered footbridge
b) Trough bridge
c) Deck bridges

FprEN 1995-2, **Figure 3.1 — Examples of protected bridges**

3.1.2

protected member

structural member not exposed to direct weathering such as rain, snow or other sources of moisture ingress …

… weather protection, e.g. in form of claddings …, a sealed deck surface and an adequate roof overhang in both longitudinal and transversal directions (see Figure 3.1), …

→ Extension of design rules (among others) for:

- Durability (clause 6, Annex D)
- Inspection and maintenance (subclause 6.4, Annex E)
- special bridge structures, e.g. integral (TCC-)bridges, deck plates

Revision of the design rules for:

- Vibrations of bridges and damping of timber bridges (Annex F)

New design rules for:

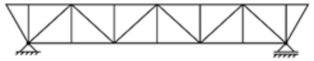
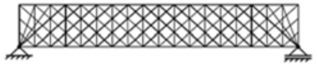
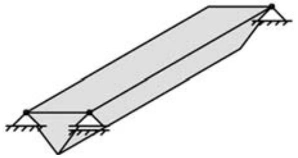
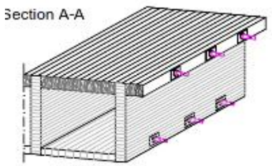
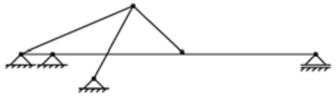
- Dimensional changes under enviromental conditions (Annex B)
- Seismic design of timber bridges (FprEN 1998-2, Annex C)

Standardization work:
Wooden bridges in earthquake area, types of timber bridges

FprEN 1998-2, **Table C.1 – Examples of Structural Types of Timber Bridges** (excerpt)






	j-b) Large span truss bridges $L \leq 150$ m	Not applicable	Single-span girder
	j-b) Lattice-truss bridges (tunnel) with carpentry joints $L \leq 90$ m	Not applicable	Single-span girder
	k-b) Hollow-box-girder bridges $L \leq 80$ m	Not applicable	Single-span girder
	k-b) T-beam and box girder bridges with stress-laminated timber deck (materials see EN 1995-2:2021, Figure 8.1) $L \leq 25$ m	Not applicable	Single-span or continuous girder
	k-b) Stressed ribbon bridges $L > 150$ m	j) Large-span timber truss portal frame structures	Continuous girder
	l-b) Cable-stayed bridges / Construction with pylons 50 m $\leq L \leq$ 200 m	Not applicable	Continuous girder

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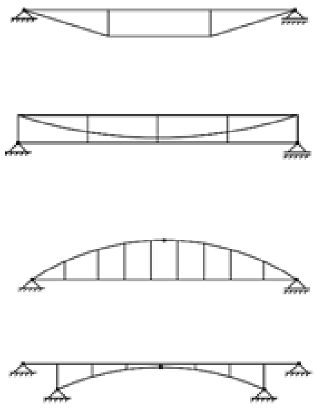
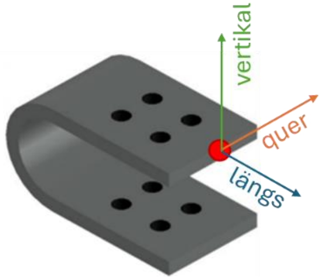
Standardization work: Timber bridges in earthquake areas

FprEN 1998-2, **Table C.1 – Examples of Structural Types of Timber Bridges** (excerpt)

	e-b) Strutted (or truss) frame bridges with dowel-type connections $L \leq 50$ m	e) Braced frame structure with dowel-type connections (longitudinal direction of the bridge)	Multi-span girder; joints between girder and piers with dowel-type fastener connections / fastener plasticization
	i-b) Tied-arch bridges $L \leq 40$ m; Suspension bridges $L \leq 50$ m; Arch bridges with or without hangers $L \leq 90$ m; Spandrel-braced bridges $L \leq 90$ m	i) Two-pin and three-pin arches, three-pin frames and dome structures	Single-span girder

UFPs (U-shape Flexural Plate) next to reinforced elastomer bearings



Ductility Classes, behavior-values

Type of ductile members	DC1	DC2		
	$q = q_S$	q_R	q_D	$q = q_S\, q_R\, q_D$
d-b) Integral abutment bridges, moment-resisting-frame structures including portal frames	1,5	1,1	1,3	2,2
e-b) Strutted (or truss) frame bridges with dowel-type connections, timber piers, horizontal bracings of bridges	1,5	1,0	1,3	2,0
f-b) Timber pier fixed on foundation	1,5	1,1	1,2	2,0
h-b) Crossings, draw bridges	1,5	n.a.	n.a.	n.a.
i-b) Tied-arch bridges, suspension bridges, arch bridges with or without hangers, spandrel-braced bridges	1,5	n.a.	n.a.	n.a.
j-b) Large-span truss bridges, lattice-truss bridges (tunnel) with carpentry joints	1,5	n.a.	n.a.	n.a.
k-b) Hollow-box-girder bridges, T-beam and box girder bridges with stress-laminated timber deck, stress ribbon bridges	1,5	n.a.	n.a.	n.a.
l-b) Cable-stayed bridges	1,5	n.a.	n.a.	n.a.

n.a. = not applicable

EN 1998-2, **Table C.2 – Values of q for timber bridges**

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2.

Extended Regulations on Durability –

Constructive measures for protected timber bridges

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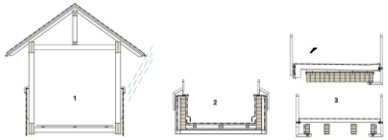
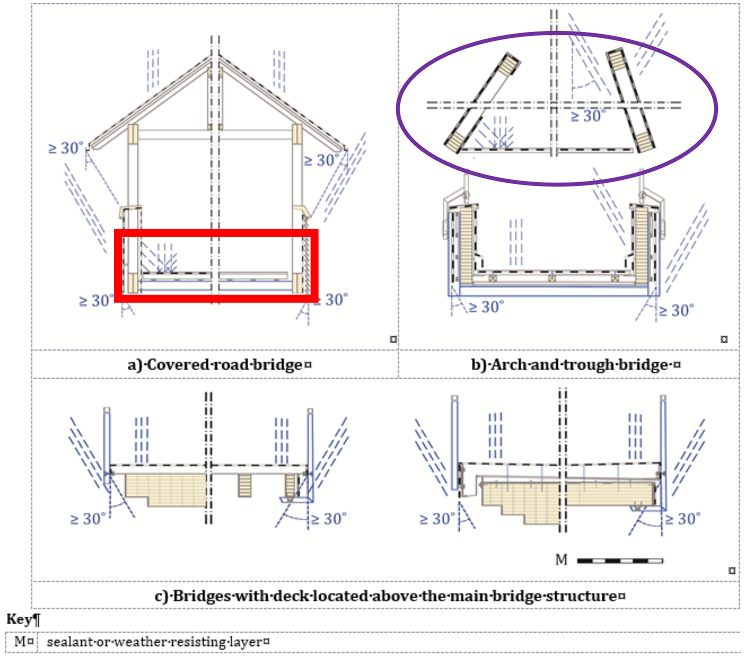
Sustainable wooden bridge construction – Constructive wood protection

System diagram Figure 3.1  supplemented and in more detail in FprEN 1995-2:2025-06-04, Annex D:



FprEN 1995-2, **Figure D.1 – Examples of Protected timber bridges**

Angle of windblown rain α under ≥ 30° relative to the vertical

a) Covered road bridge
b) Arch bridge (up) and Trough bridge
(with deck located at the base of the main bridge structure)
c) Bridge with deck located above the main bridge structure; e.g.
on the left: sealing system
on the right: timber-concrete-composite

→ Detailing Annex D – **Construction measures – Weather protection …**

Figure D.3 – …
by roof and boarding

Figure D.4 – …
of trough and arch bridge
by cladding

Figure D.5 - D.7 – … by waterproofing system /
by reinforced concrete-plates /
by glass fibre reinforced plastic (GFRP) planks

Figure D.8 to **Figure D.10 Transition joints** as well as **Figure D.11** and **Figure D.12 Edge waterproofing systems on timber decks**

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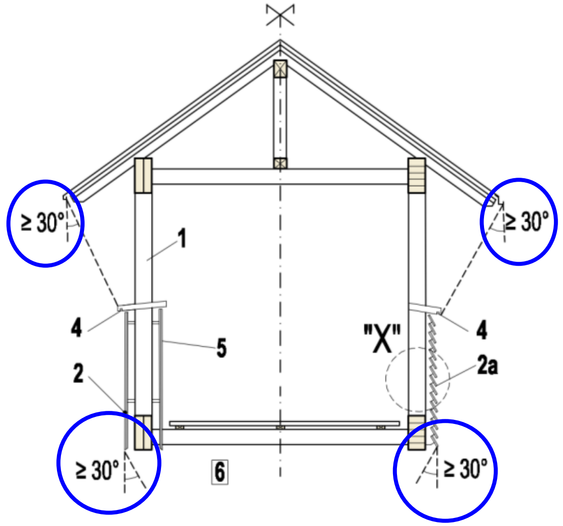
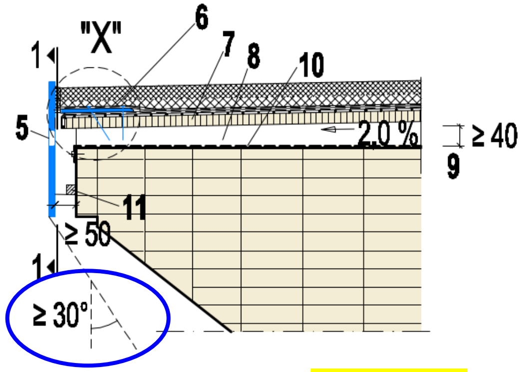
Sustainable wooden bridge construction – Constructive wood protection

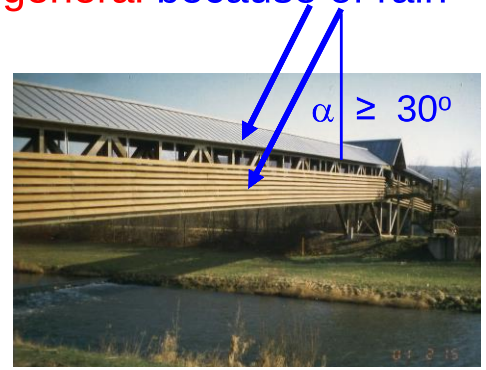
Examples for wood protection in general because of rain



from **Figure D.3**

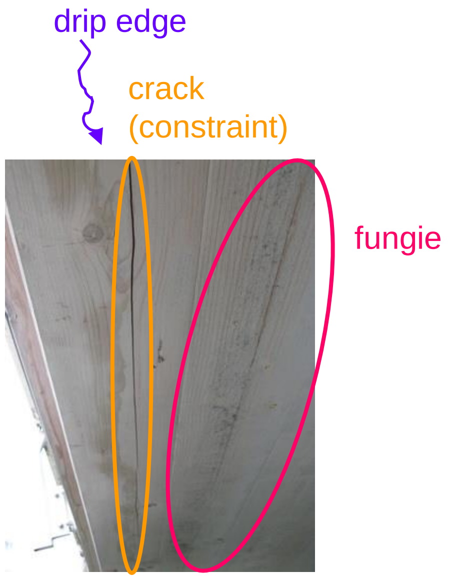


from **Figure D.5**

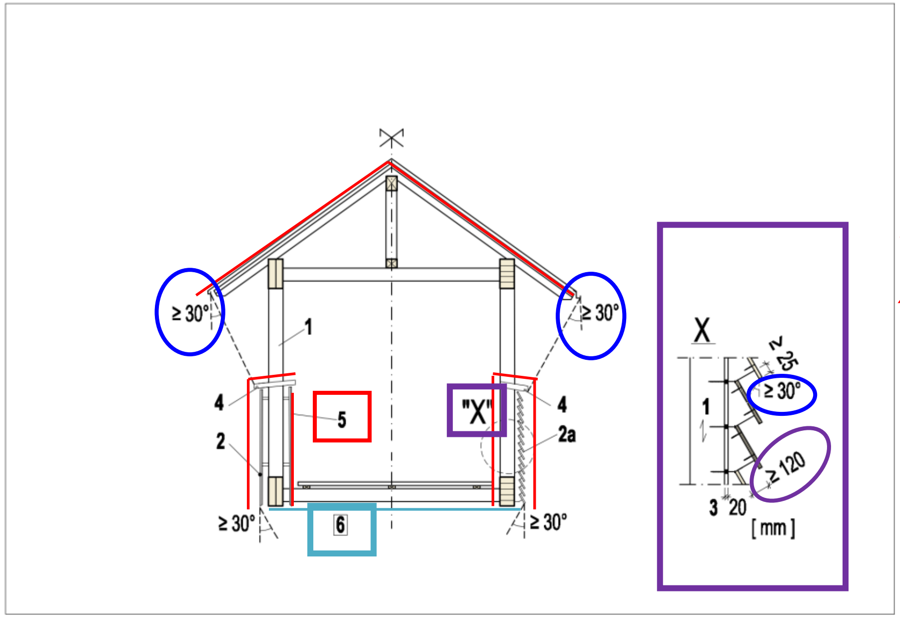


Pedestrian bridge over the river Wiese near Lörrach (D)

Surfaces covered by an overhang
and an angle of at least 30°
can often be regarded as protected.
The angle may be increased in
accordance with local experiences



Protected bridges – Details constructive wood protection



„ease of use“

Spacing of minimum 120 mm on shuttering elements can ensure possibility of inspection.

Spray from below (e.g. ≤ 2 m above waterfall)

Figure D.3 – Construction measures – Weather protection by roof and boarding

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Durability und sustainability modern timber bridges

Specifications on Durability and Quality Management in the basic document Eurocode 0 (EN 1990:2023)

3.1.2.27 Maintenance Definition

set of activities performed during the service life of the structure so that it fulfils the requirements for reliability

4.8 Quality management Recommendations – should-rules

(1) Appropriate quality management measures should be implemented to provide a structure that corresponds to the design requirements and assumptions.

(2) The following quality management measures should be implemented:

— organizational procedures in design, execution, use, and maintenance;

— controls at the stages of design, detailing, execution, use, and maintenance.

A.2.5 Durability Requirements – shall-rules

(1) All structural parts that rely on a design assumption of inspection or maintenance in order to satisfy their durability requirements over the design service life, shall be designed to permit inspection and maintenance.

Durability via protected bridges according to EN 1995-2 clause 6 and Annex D (informative)

Quality management → EN 1995-2, subclause 6.4 and Annex E (informative) Inspection and maintenance of timber bridges

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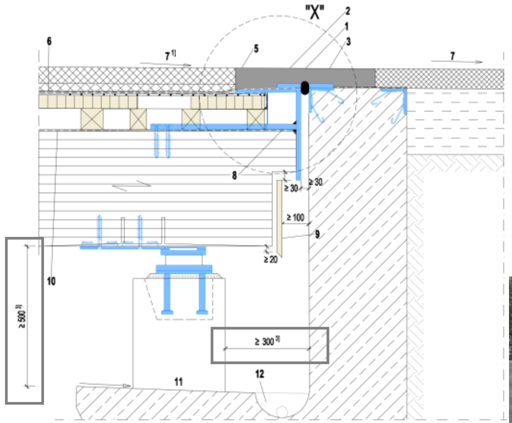
Sustainable: Maintenance management

FprEN 1995-2, 6.4 and Annex E (Inspection and maintenance, informative)

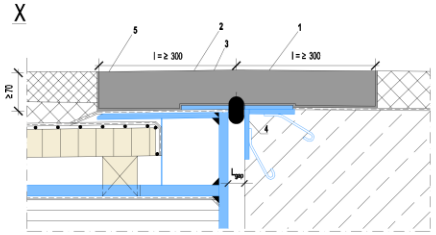
Wooden bridges should be designed to be easy to maintain and inspected regularly and responsibly. Reduce maintenance-intensive components such as bearings and transitions to a minimum (e.g. integral HBV bridges).

Recommendation: Develop a maintenance strategy with a maintenance concept, inspection strategy and maintenance report.

The maintenance concept should include:
service life of all load-bearing elements,
structural wood protection measures,
cycles for the renewal of corrosion, protective coatings, transition joints, bearings and seals,
sensible maintenance measures such as cleaning the deck, benches and removing vegetation.



Horizontal distances between bearings or between bearings and the ballast wall of the abutment must be at least 0,5 m or 0,3 m, respectively;
vertical distance between the supports and the superstructure must be at least 0,5 m
(see Figures D.8 to D.10).



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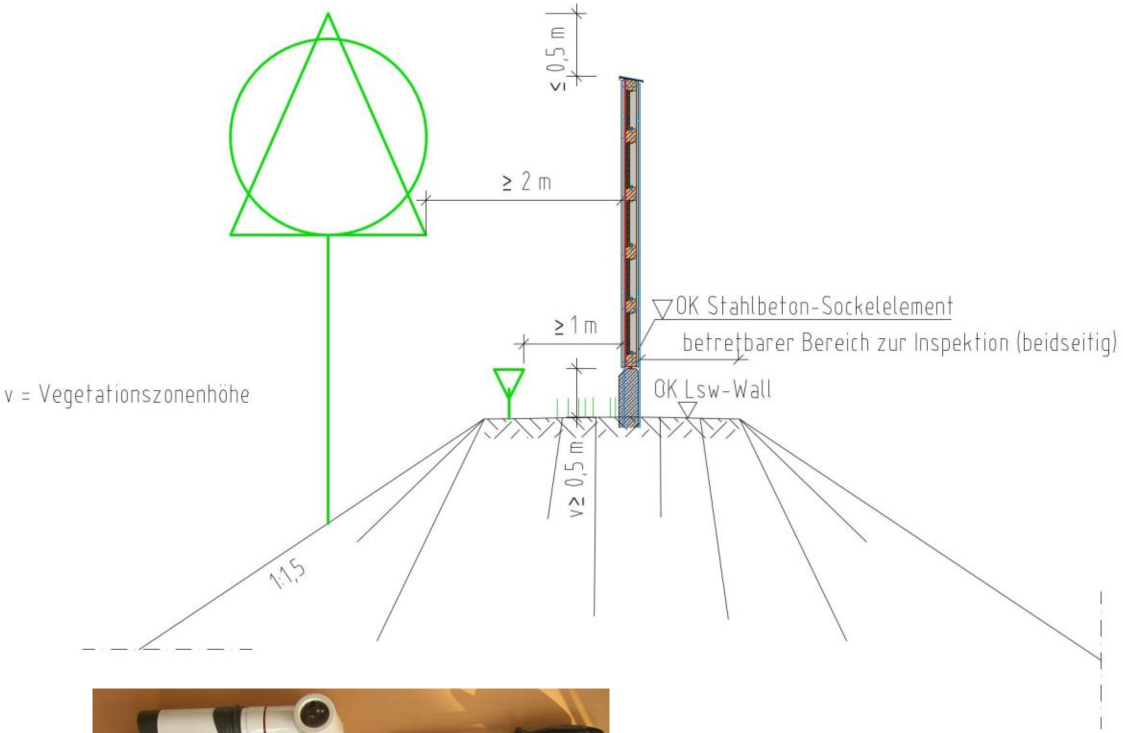
Sustainable: Inspection and maintenance

Removal of vegetation:
minimum distance of e.g. 2,0 m from tree crowns and large shrubs
(see also RE-ING Lsw H3-1)



Inspection strategy with visual and main inspections; to be carried out regularly by qualified personnel.
The usual intervals for inspections are 1 to 2 years for visual inspections and 5 to 6 years for general inspections

Consideration of the unrestricted testability of the main load-bearing components already in the design phase of new wooden bridges; that means e.g. removable cladding (see Figure D.4), open formwork elements with minimum spacing of 120 mm in accordance with Figure D.3

Possibility of determining wood moisture content at critical points; if necessary, by means of monitoring (Figure D.13).
As a basis for planning protective measures, the service class (UC) must be defined for each individual timber component; see Table D.1. The selection of a suitable wood species and its durability class (DC) is also based on the Use Class (UC).

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Sustainable Monitoring – Wood moisture content and temperature

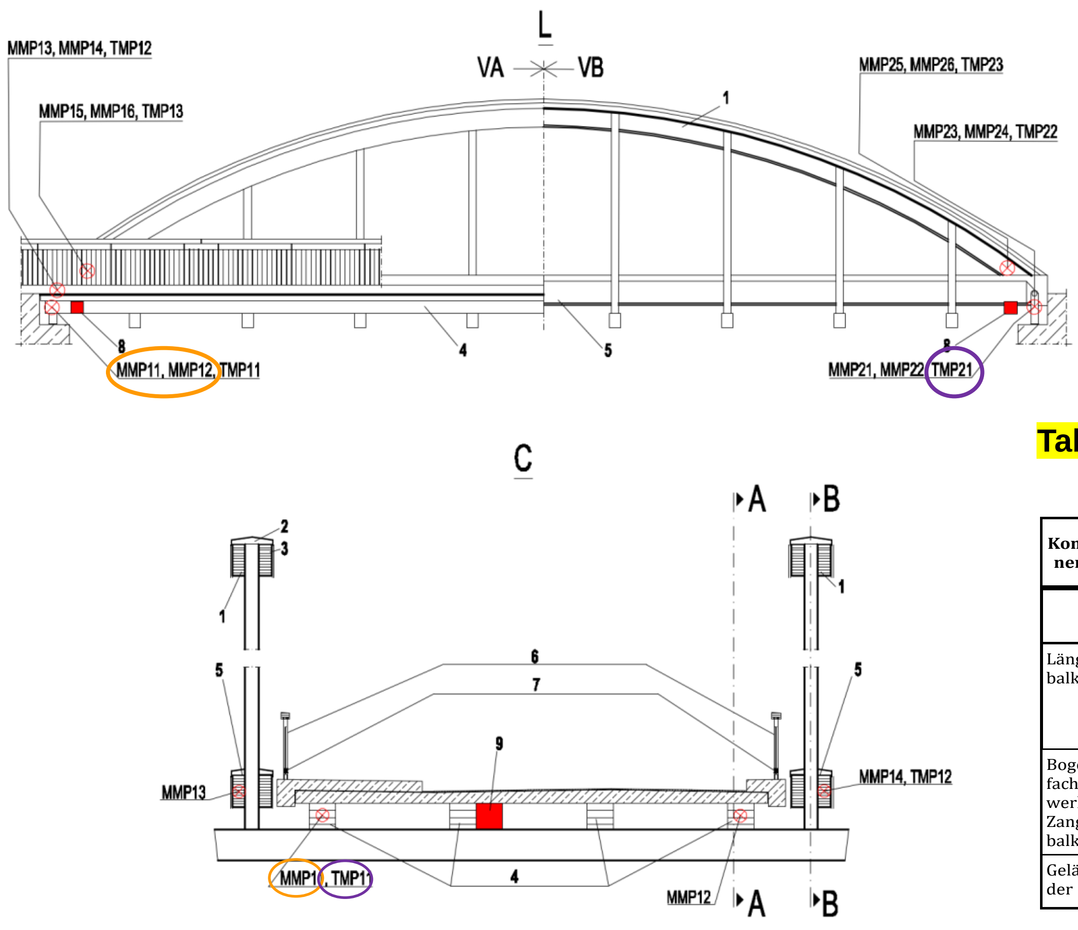

Figure D.13 – Moisture Monitoring – Example arch truss

The measuring depth should be 40 mm for

- moisture measurement point MMP
- temperature measurement point TMP

Table D.1 – Components of an arch road bridge (example)

Komponente	Gebrauchsklasse (UC) [Nutzungsklasse (SC)]	Schutzmaßnahme	Holzart	Dauerhaftigkeitsklasse (DC)
	EN 335 [prEN 1995-1-1]	**prEN 1995-2 Beispiele für die Detailgestaltung**	**EN 13556**	**EN 350:2016, Tabelle B.1**
Längs-balken	2 [2]	Witterungsschutz durch Deckplatte und Beplankung und Übergang 1, Schutz der Kanten (Schnittholz), Schutz vor Insekten-befall durch technische Trocknung, Sicht-barkeit und Kontrolle des Insektenbefalls	Fichte als Brett-schichtholz	4
Bogen-fach-werk / Zangen balken	2 [2]	Witterungsschutz durch Bekleidung und Schalung, Schutz vor Insekten durch technische Trocknung und Insekten-schutzgitter, Sichtprüfung alle 6 Jahre durch Abnahme der Bekleidungen	Fichte als Brett-schichtholz	4
Gelän-der	vertikal: 3.1 [3] horizontal: 3.2 [3]	keine, Instandhaltung Komponente	Europäische Lärche	3

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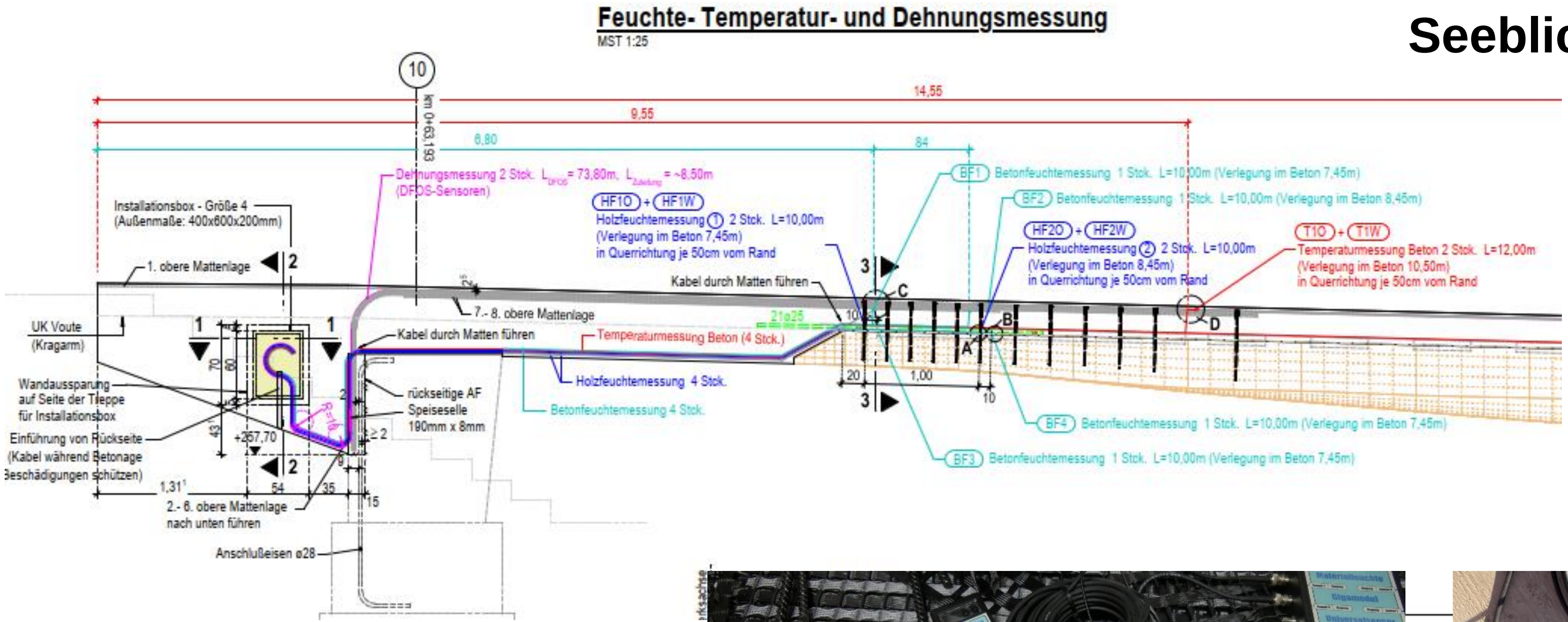
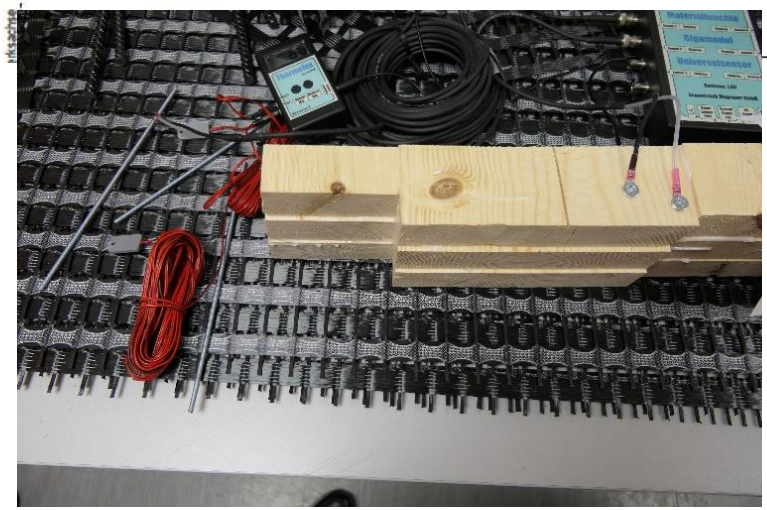
Humidity, temperature, and strain measurement; sensor technology

Seeblickweg, Stuttgart





Monitoring:

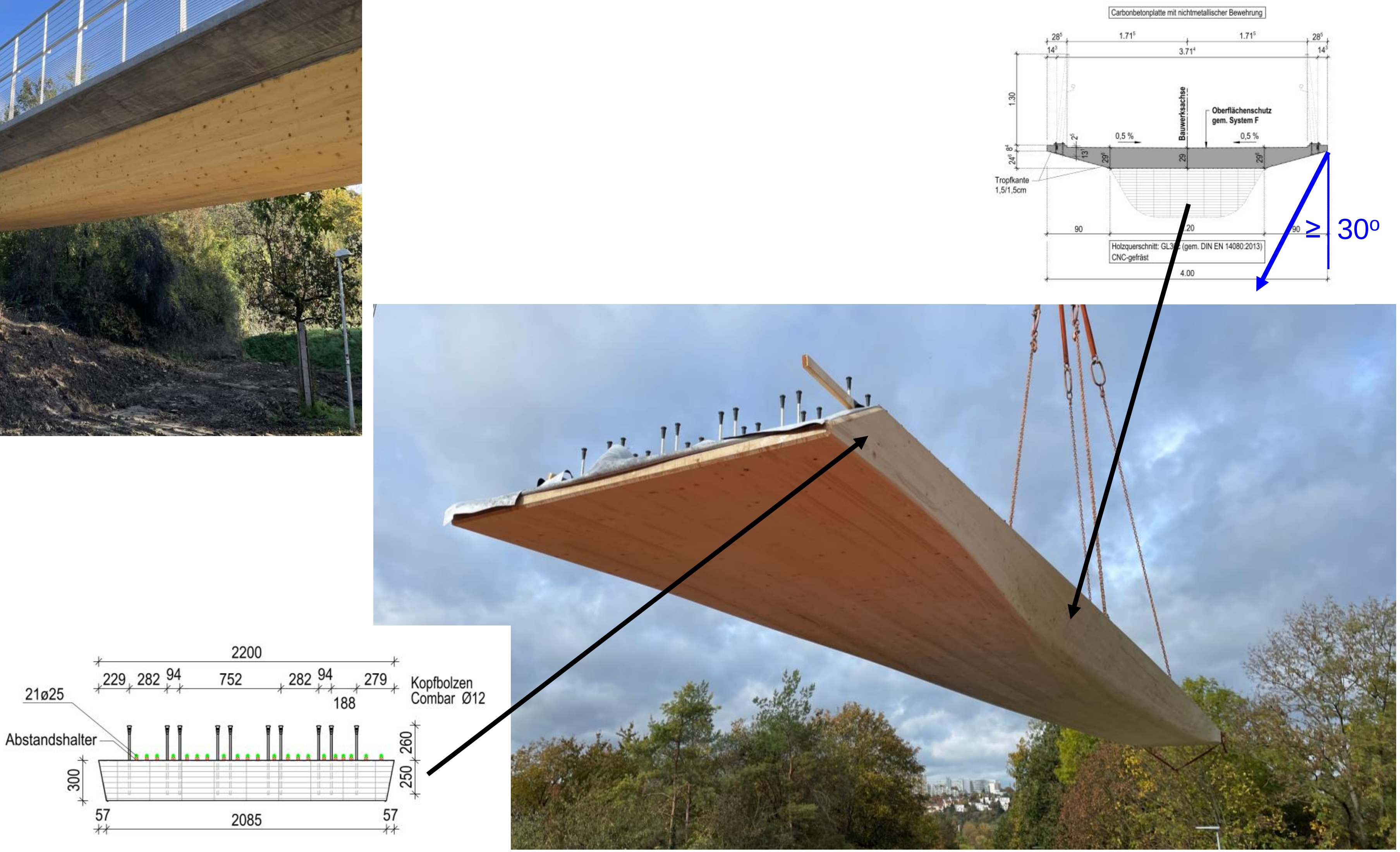
Crack width (concrete expansion);

Concrete temperature;

Concrete moisture;

timber moisture content.

Wood-carbon concrete composite bridge over Seeblickweg, Stuttgart



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Manufacture of beautifully shaped wooden beams using CNC milling

Film Balteschwiler AG, Laufenburg (CH)

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Wood-carbon concrete composite bridge

Use of non-metallic reinforcement: glass fibre reinforced plastic bars (ComBAR),

carbon mat reinforcement and shear connectors, composite: bonded HBV shear connectors (TiComTec)

Carbon concrete road slab: protection of block glued laminated girder

Film Balteschwiler AG, Laufenburg (CH)

Franklin-Steg Mannheim – world longest integral timber bridge

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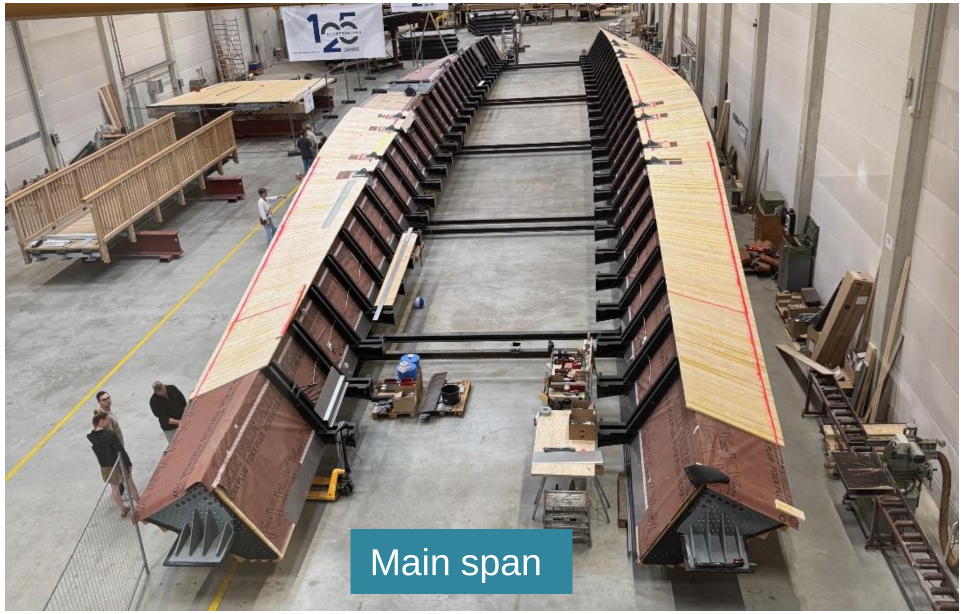
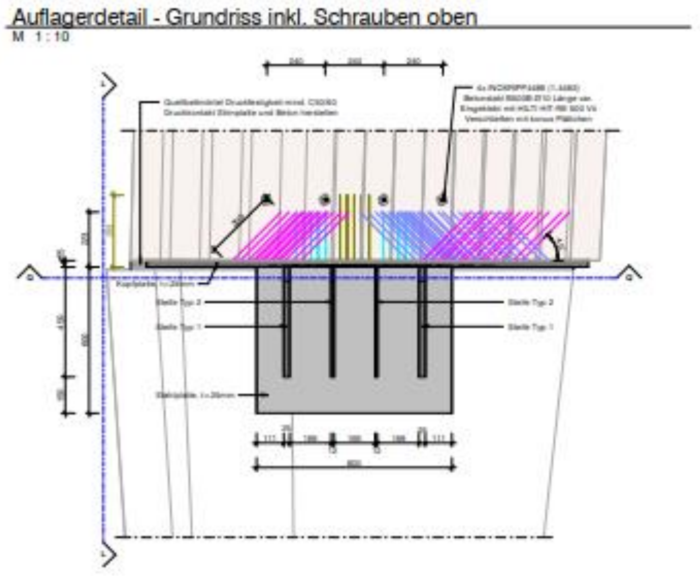
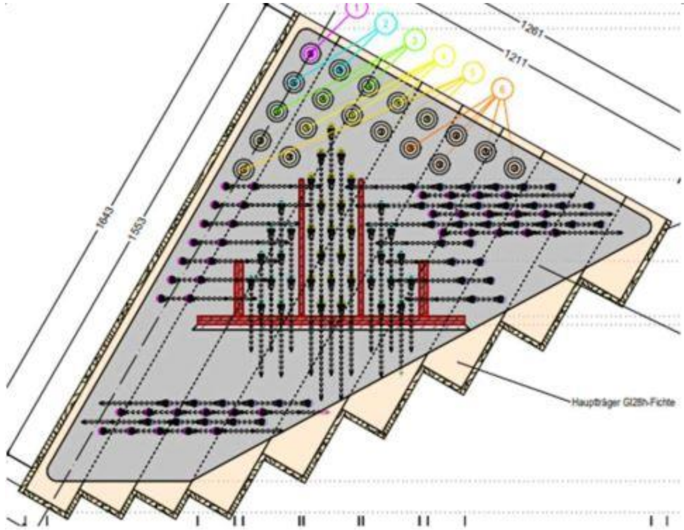
Main span (Trough bridge): Rigid connection timber to concrete



Rigid connection Main span
at abutment south
(reinforced concrete column),
support force from dead load
1.350/4 kN = 337,5 kN





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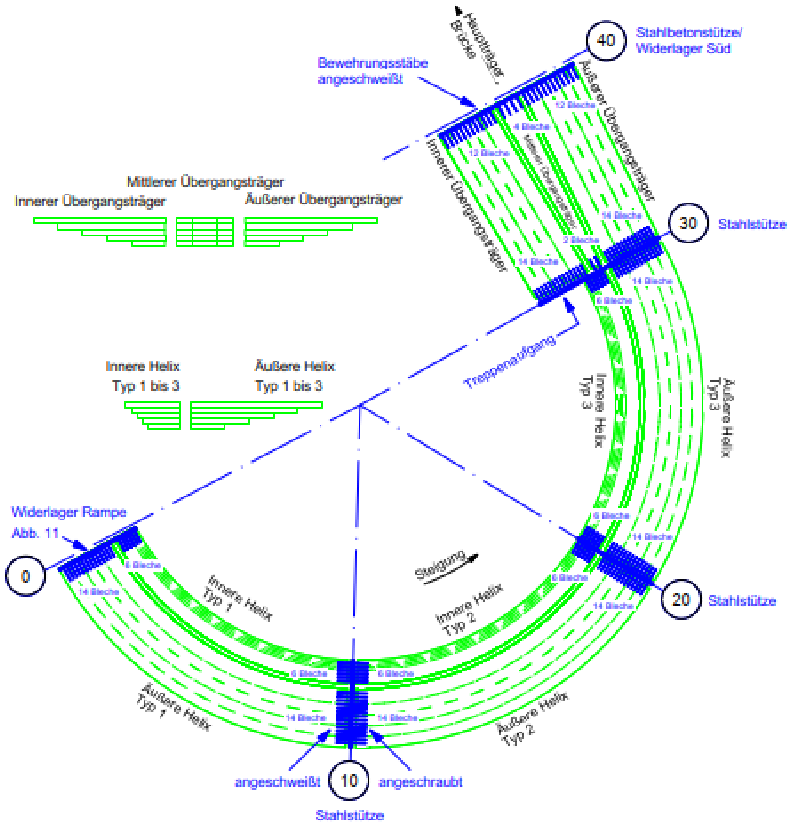
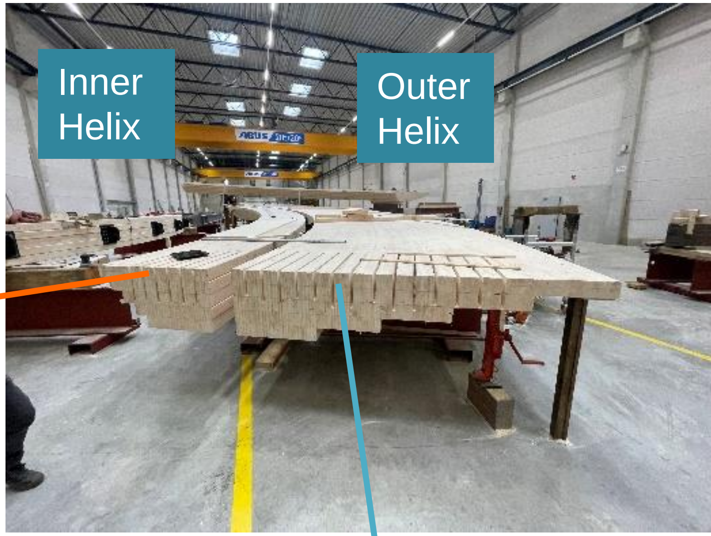
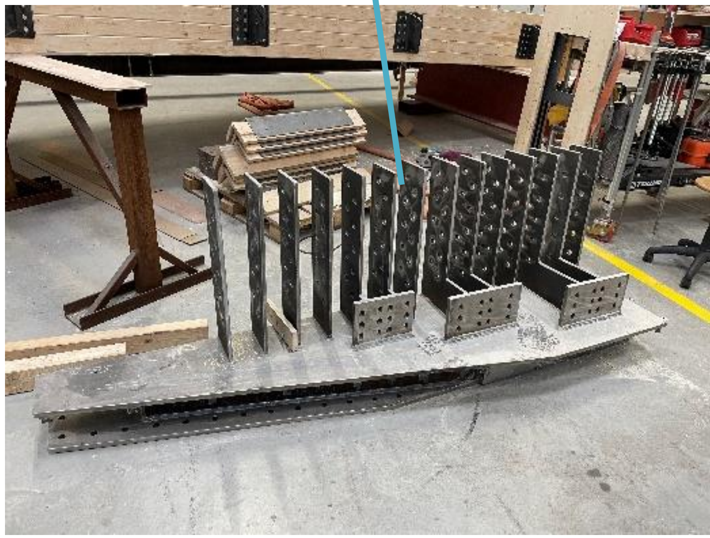
Helix (spindle carrier): Connection timber to concrete







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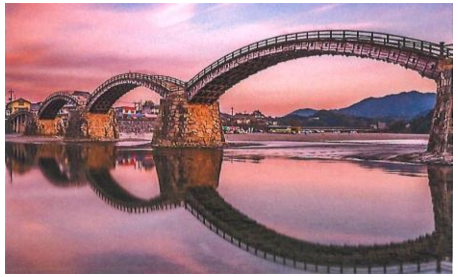
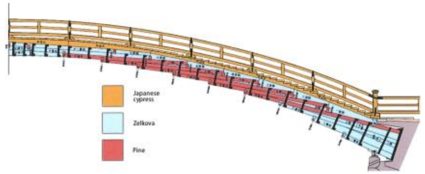
3. Conclusion

Sustainable modern timber bridges - Examples

robust



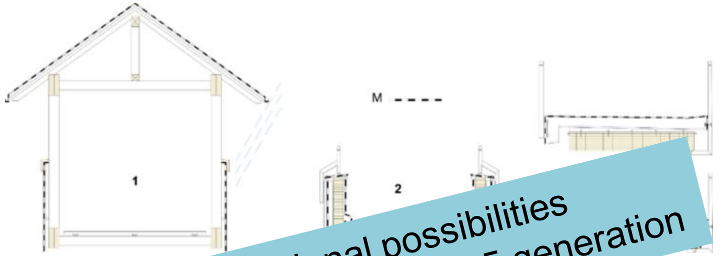


heavy-duty vehicle

sustainable

elegant - aesthetic

Recognised state of the art:
structurally protected, durable
→ greater acceptance again for timber bridges



Many additional possibilities thanks to the new EC 5 generation

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04.09.2025

14th Japanese-German Bridge Symposium

TU Munich, Germany

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Thank you for your attention.

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