IABMAS
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Meeting Minutes

IABMAS Technical Committee on Bridge Load Testing

Zoom Meeting ID: 833 7004 3466 https://usfq.zoom.us/j/83370043466?from=addon
Thursday December 12th, 09:00 – 10:30 EST, 15:00 – 16:30 CET

Mission: *Bridge Load Testing is a field testing technique that can be used to obtain more information about the performance of bridges. In particular, diagnostic load tests can be used to quantify elements of structural performance such as transverse distribution, unintended composite action, repair effectiveness, etc. and the information of a diagnostic load test can serve to develop field-validated models of existing bridges that can be used to develop a more accurate assessment of the bridge's performance. Proof load testing can be used to demonstrate directly that a bridge can carry a load that is representative of the live load, provided that the bridge does not show signs of distress. Other types of load testing include testing for dynamic properties, and parameter-specific tests. Load test data as well as the analytical assessment of the data can be used to make more informed decisions and manage the life-cycle performance and maintenance of bridges.*

Aspects of bridge load testing that are of particular interest to bridge owners are having an overview of the typical uses for bridge load tests, the decision on when to load test or not, which information to obtain from the load test, and how this information can be used to reduce the uncertainties regarding the tested bridge. This committee is eager to learn about and disseminate the potential for applying new technologies for bridge load testing through learning from technologies used in other industries.

Associated with bridge load testing, the following topics are also of importance to this committee: instrumentation used during load testing and the interpretation of the obtained measurements during the load test, determination of required load, method of load application, methods of updating assessments using collected field data, the link between load testing and structural health monitoring, the uncertainties (probabilistic aspects as well as risks during test execution) associated with load testing, the interpretation of load test results, laboratory testing of bridge components to improve assessment methods in the field, and optimization of related costs keeping adequate reliability to spread their use worldwide.

The IABMAS Bridge Load Testing Committee aims to be an international committee of participants from academia, industry, and bridge owners, which provides a forum for the exchange of ideas on bridge load testing. Best practices as well as the insights from the development of national codes and guidelines will be exchanged among participants from countries that use load testing for the assessment of their *existing bridges, those who are exploring the possibilities of this method, and those who are in the process of standardizing the procedures or developing guidelines.*

Goals:

- *Organize dedicated sessions to the topic of load testing at IABMAS conferences.*
- *Develop national IABMAS group events on the topic of load testing.*
- *Exchange information on the use of load testing in different countries.*
- *Exchange lessons learned and best practices.*
- *Inform about case studies of bridge load testing.*
- *Communicate load testing guides or standards that have been developed.*
- *Provide a forum for new ideas and applications of technology.*
- *Identify potential research topics.*
- *Establish international collaborations.*
- *Liaise with relevant committees internationally outside of IABMAS and liaise with the national IABMAS groups.*

Committee Members

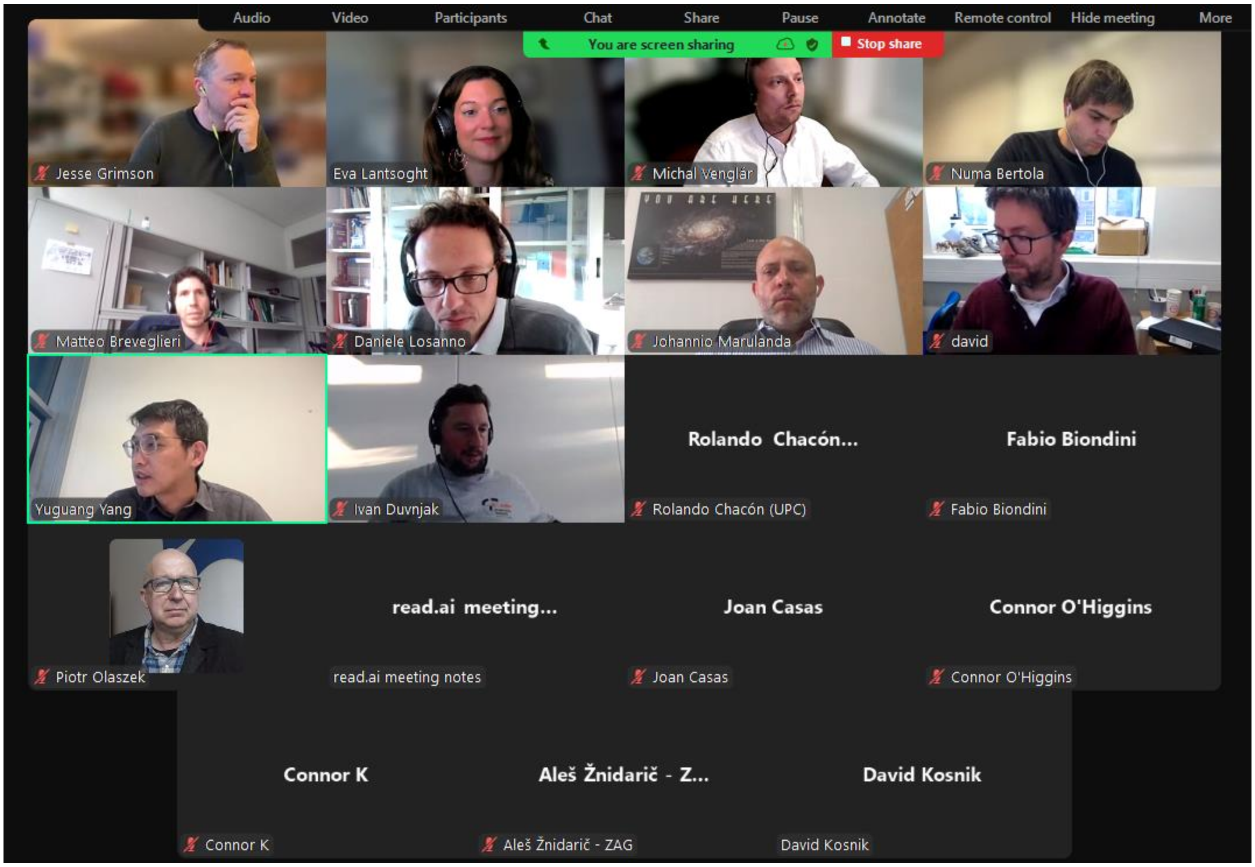
Eva Lantsoght – Chair	**Daniele Losanno**
Jesse Grimson – Vice Chair	Ho-Kyung Kim
Rolando Chacon - Secretary	**David Kosnik (TRB AKB40 liaison)**
Mitsuyoshi Akiyama	Marcelo Marquez
Sreenivas Alampalli	**Johannio Marulanda**
Numa Bertola	Armin Mehrabi
Fabio Biondini	**Piotr Olaszek**
Tulio Bittencourt	Pavel Ryjacek
Alok Bhowmick	Marek Salamak
Matteo Breveglieri	Gabriel Sas
Anders Carolin	Jacob Schmidt
Hermes Carvalho	Tomoki Shiotani
Joan Ramon Casas	Matias Valenzuela
Dave Cousins	**Michal Venglar**
Ivan Duvnjak	Esteban Villalobos Vega
Dan Frangopol	David Yang
Monique Head	**Yuguang Yang (fib TG 3.2 liaison)**
Robert Heywood	Gloria Zhang
Boulent Imam	**Ales Znidaric**
Alex Lazoglu	

Regrets: Anders Carolin, Esteban Villalobos, Sreenivas Alampalli, Boulent Imam, Jacob Schmidt, Monique Head
Visitors: Connor Kent, Connor O´Higgins, David Hester

1. Administrative

1.1. Welcome and introduction

These introductions will include name and affiliation. Introduction of new member: Ivan Duvnjak from the University of Zagreb. Eva mentioned a tight schedule, so no introduction round was conducted.



1.2. Review and approval of agenda

The agenda was approved without comments.

2. Strategic Planning and Discussion

2.1. Membership and committee leadership

One new member Ivan Duvnjak since October 2024. New addition to the committee leadership.

2.2. Website

On the IABMAS website, the committee information is updated. Leadership has been updated after this meeting. Rolando Chacón was designated as the Secretary. It was agreed that the status of the committee leadership needs to be uploaded on the website. Confirmed that the minutes of all past meetings are available for reference.

3. Old business

3.1. Development of joint bulletin of proof load testing of concrete structures with fib TG 3.2

Update on the current status of document and planning. Working group met on October 10th.

Status of chapters:

- chapter 3: first draft ready, meeting on 6/12, see if we can start distilling definitions to chapter 2
- chapter 4 status: first draft ready, Matias commented, in review with Jacob
- chapter 5: authors / new chapter lead Joan Casas; Eva has drafted sections
- chapter 6: authors and what we can write, Eva remains chapter lead; plan to write first sections early 2025
- chapter 7: with Yuguang, new outline, coordination of contents between chapters 3, 7 and 8, meeting planned for January 16th
- chapter 8: Dave has coordinated contents with chapter 7 (Yuguang), Dave will start drafting text end of the month
- chapter 9: authors and what we can write -> Numa as chapter lead, status: assigning sections with authors
- Yuguang Yang reported updates on fib TG 3.2: Most of the work has been completed. Proposed the idea of printing new chapters, but it does not make sense to share the present version yet. Focused discussions are on the middle portion of the chapter, led by Eva. Technical Comments
- Focus is on Chapters 3 to 9. Chapter 3: Load testing draft is ready and undergoing fine-tuning. Definitions are emphasized as key for the document, with an expectation of consistency throughout the bulletin.
- Chapter 7: Presented by Yuguang, highlighting participation from many contributors.
- Chapter 8: Will begin to be sparkled early next year, with Numa Bertola leading the effort.

3.2. Collaboration with other IABMAS TCs

IABMAS committees on SHM and Bridge Management. Plan for workshop at IABMAS 2026 on digital twins. Working group will meet December 19th. Established liaisons with fib COM 3, fib TG 3.1, IABSE, Eurostruct, PIARC. Bridge owners involved from Portugal, Spain, Germany, Japan, Denmark, Australia and Morocco.

For bridge owners: questionnaire at
https://usfqadmin.co1.qualtrics.com/jfe/form/SV_8B3yCVmKbFgPvca

Topic is a collaboration with other TCs, and a workshop is being planned for IABMAS 2026. Ad-hoc working group formed to coordinate the effort. Liaisons with other associations (e.g., bridge owners, Eurostruct, fib members) are active. Additional bridge owners are welcome, and Eva shared a link in the chat to add potential owners to the poll. Yuguang Yang reported TG3.2 activities related to digital twins: Includes computational aspects, measurements, interpretation, and cracks. Suggestion to forward relevant information to TG3.2 for further discussion. Goal is to develop digital twins as part of the system and connect those interested in the topic. Next week's meeting will focus on analyzing bridge owner responses and technical presentations.

4. New Business

4.1. Research updates

1. Presentation by Matteo Breveglieri and David Hester: Swiss Bridge Load Test Empa Reports: A Database from 1955 to 1996

During the meeting, Matteo Breveglieri presented a significant project involving Empa Reports, which encompass a database of bridge testing data collected between 1955 and 1996. Originally stored in 49 boxes containing 8–10 reports each, these documents were meticulously scanned by Connor, resulting in an 11 GB collection of PDFs. The database includes both static and dynamic test data, which were summarized by Renato Cantieni. The reports feature highly accurate plots that could be digitized for future use; however, the data, while shareable on a personal basis, is not open for general distribution. As part of the presentation, David highlighted the Glattbrücke in Opfikon as a case study, offering insight into historical testing approaches. The discussion shifted to a UK Universities collaboration project, which introduced the concept of Population-Based Structural Health Monitoring. This project draws analogies between the behavior of assets and humans, emphasizing the challenges of aligning existing assets with new constructions. Connor is actively grouping data and analyzing it at a population level, with processing efforts underway in the Rosehips Project based in Belfast. Eva raised questions about how instrumentation has evolved over time, citing examples such as changes in vehicle suspension systems and tanks, as well as the analysis of simple first natural frequencies. The debate also touched on data digitization, with Rolando inquiring about methods to digitize plots, tables, and text in German and Italian. Technologies like Captcha and crowdsourcing were suggested as potential solutions. Ivan raised concerns about the ranges of weights and the availability of historical drawings, while Jesse Grimson noted that the additional stiffness of bridges had historically confused owners, leading to discontinued measurements. Numa added that past distribution factors may have been inaccurate, further complicating historical data interpretation.

2. Presentation by Numa Bertola: Bridge load testing with continuous fiber optic sensing

The slides of this presentation are added to these minutes.

Grimson congratulated Bertola on the presentation. Duvnjak asked about the application to dynamic testing. Bertola commented that right now the system is limited to 20 Hz (and 10 Hz when two fibers are plugged in) and this topic will be addressed in research next year. Grimson clarified that the limitation comes from the interrogator and not the fibers themselves. Chacon commented on the discrepancy between the ending of load testing in Switzerland, and the ability to get much more data now using load testing, but also the need to clean and store the data. Casas asked about the spikes and if there are cracks at the locations indicated. Bertola clarified that these cracks follow the shape of the prestressing cable and not flexural cracks, and the cause of cracking is still under investigation. Casas commented that this ability to pick up the cracks is very interesting for monitoring. Yang commented on experiments using fiber optics and acoustic emissions, where the fibers can capture the preexisting cracks when load is applied. However, the peaks would be expected for vertical rather than longitudinal cracks. Bertola clarified that the drone model will be used to map the shape of the cracks, as they are not fully horizontal. Yang identified the peaks could also be related to the fiber installation, for example the effect of the glue. Yang also asked why the outside instead of inside position was selected, and Bertola clarified that this choice is practical, related to the scaffolding of the cantilevering part. Breveglieri asked about the sensor from Smartec used in the experiments.

4.2. Upcoming conferences and events

TRB Annual Meeting 2025, January 5th – 9th

IALCCE 2025 in Melbourne, July

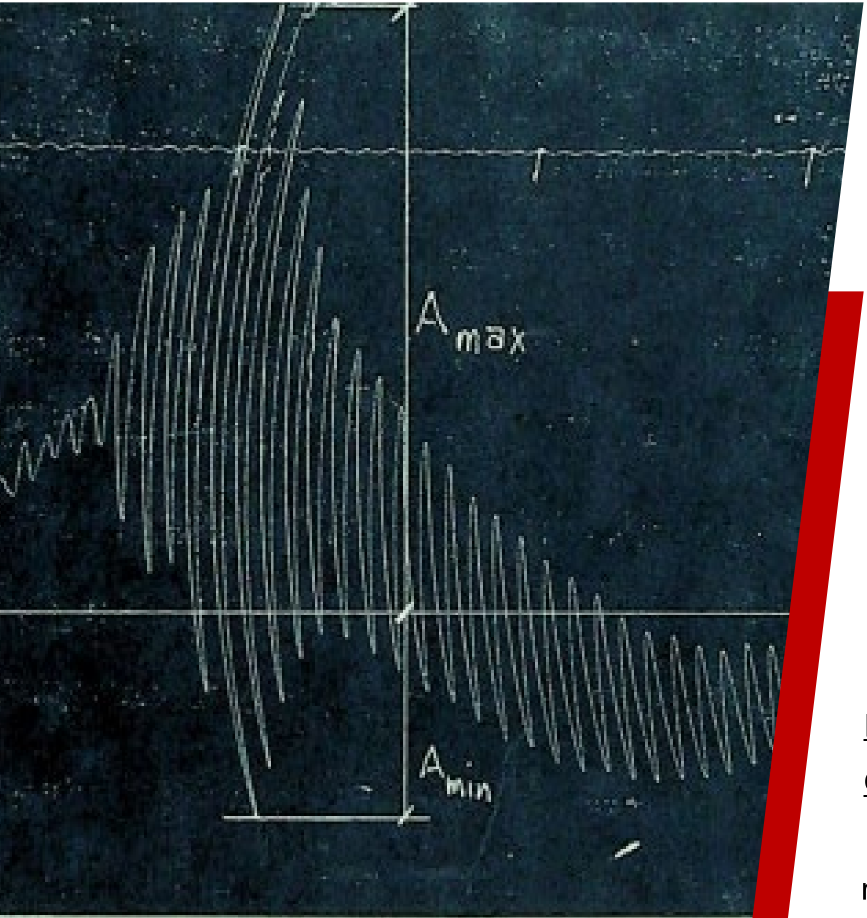
fib symposium in Antibes, France, June

ISHMII in Graz, Austria 2025, September – special session on model updating of bridges and digital twins: **https://www.tugraz.at/events/shmii-13/home**

5. Adjournment [5 min]

Next meeting – Spring 2025, online

The meeting was adjourned at 10:45 am EST.



Swiss Bridge Load Test Empa Reports: A Database from 1955 to 1996

Matteo Breveglieri, Glauco Feltrin, Empa

Connor Kent, Connor O'Higgins, David Hester, Queen's University Belfast

12.12.2024

matteo.breveglieri@empa.ch

Introduction

- In the past in Swizerland proof load tests were required for new bridges.

↓

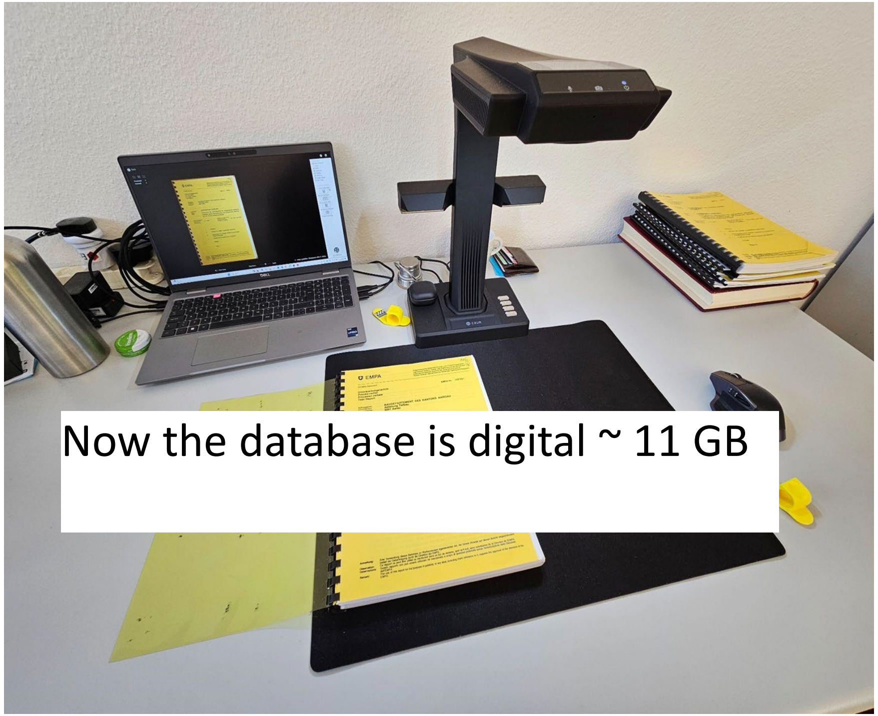
Design Validation

- The Swiss Federal Laboratories for Materials Science and Technology (Empa) has undertaken more than 200 bridge test between 1955 and 1996.
- Over 400 individual reports counted (>200 bridge).

Empa Report Nr.60’950 (1968)
Belastungsversuch am Viaduct de Guin, Fribourg-Luggiwil

Empa Test Database in 2024

- EMPA archive containing 49 boxes, approximately 8-10 reports in each.
- Over 400 individual reports counted ... *And there are more older ones... before 1955*



Now the database is digital ~ 11 GB

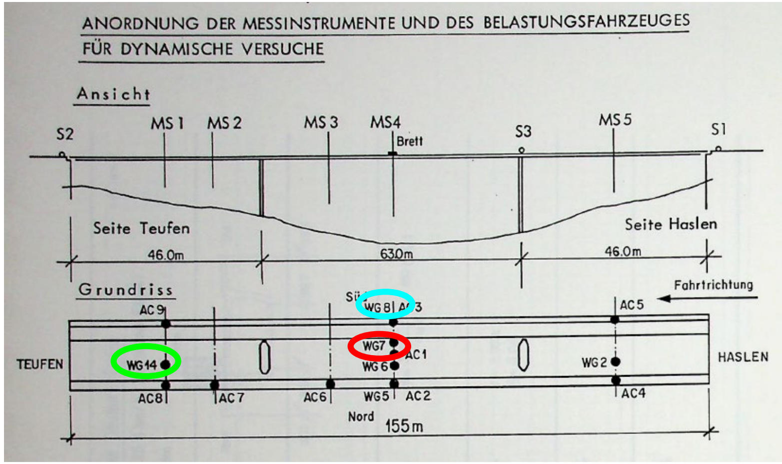
Scanner setup used by Connor K Queen's University Belfast *.while his stay at EMPA*

Empa Bridge Reports

Most of the reports contain:

- A test description
- Bridge drawings (no reinforcement)
- Testing arrangements
- Results
- Pictures from tests

- Static and/or dynamic test
- Language → German

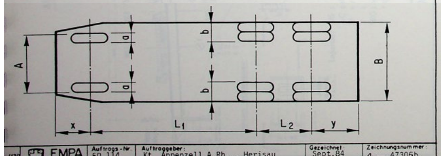


Bridge drawings and sensor layout

Beilage 4

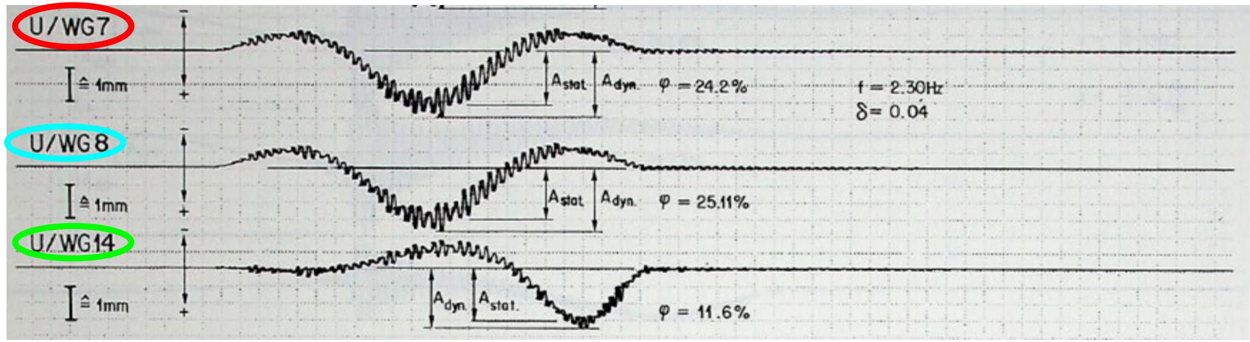
Tabelle der Wagendaten

Lastwagen		Abmessungen [m]								Statische Lasten [kN]		
Nr.	Ktr.Schild	L_1	L_2	x	y	A	a	B	b	vorne	hinten	total
1	AR 9290 Baldegger	3.00	1.32	1.76	1.50	2.30	0.25	2.30	0.55	63.0 61.0	187.0 190.5	250.0 251.5*
2	AR 7740 Kamm	3.00	1.32	1.76	1.50	2.30	0.25	2.32	0.58	63.0 63.5	187.0 191.0	250.0 254.5*
3	AR 403 Frischkn.H	3.00	1.33	1.76	1.33	2.30	0.26	2.30	0.54	63.0 65.0	187.0 191.5	250.0 250.5*
4	AR 24388 Frischkn.E	3.00	1.34	1.70	1.50	2.30	0.30	2.26	0.60	63.0 63.0	187.0 192.3	250.0 255.3*
5	AR 401 Frischkn.H	3.00	1.33	1.76	1.33	2.30	0.26	2.30	0.54	63.0 65.0	187.0 187.5	250.0 252.5*
6	AR 2881 Fitzi	3.00	1.32	1.76	1.45	2.30	0.30	2.30	0.61	63.0 65.0	187.0 195.0	250.0 260.0*
7	AR 900 Alder	3.00	1.30	1.60	1.50	2.25	0.28	2.30	0.60	63.0 63.0	187.0 195.0	250.0 258.0*
8	AR 3245 Schittli	3.00	1.32	1.76	1.50	2.32	0.308	2.33	0.62	63.0 63.0	187.0 188.5	250.0 251.5*
											Total	2000.0 2033.8*



Vehicle load information

Displacement, first natural frequencies, damping ratios.

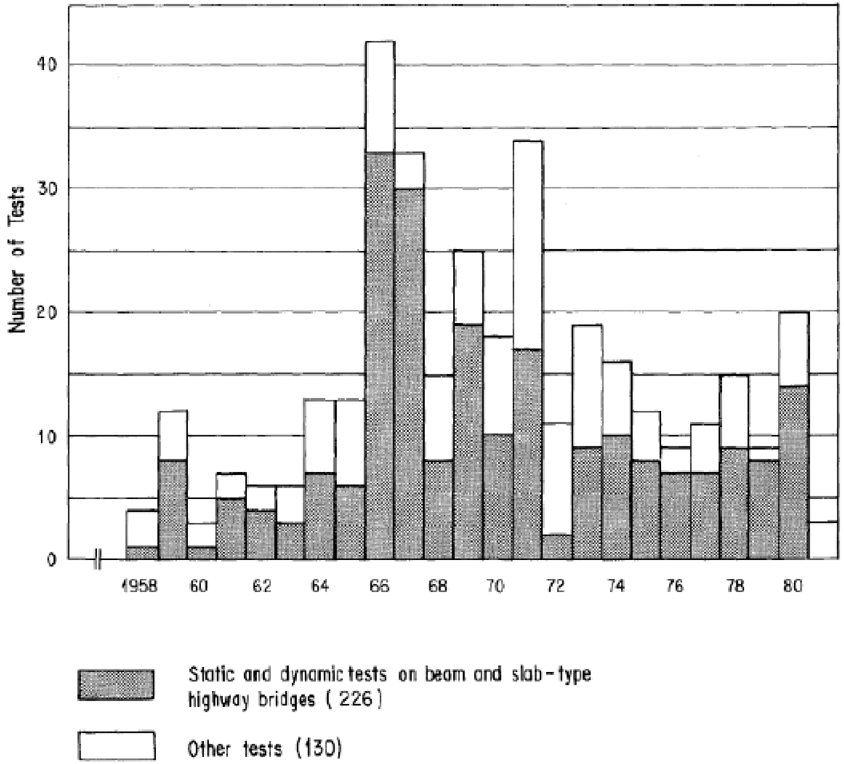


Vehicle used during testing

List of published works based on the Empa Database

- Cantieni, R. (1983). Dynamic Load Tests on Highway Bridges in Switzerland. 60 Years Experience of EMPA. Empa-Berichte: Vol. 211. Dübendorf: Empa.
- Cantieni, R. (1992). *Dynamic Behavior of Highway Bridges Under the Passage of Heavy Vehicles. Empa-Berichte: Vol. 220*. Dübendorf: Empa
- Cantieni R. (1988) Stossempfindlichkeit von Strassenbrücken unter rollendem Verkehr. (Shock sensitivity of road bridges under rolling traffic). ASTRA Forschungsauftrag Nr. 8/80.

Bridge type and location



- Between 1958 – 1981, EMPA performed load tests on 356 bridges.
- **226 of these are static and dynamic tests on beam and slab highway bridges**; 12 are static and dynamic on highway arch bridges.

Ticino	71	Luzern	11	Thurgau	3
Aargau	62	Basel-Stadt	11	Vaud	3
Bern	36	Appenzell AR	10	Schaffhausen	2
Zürich	32	Genève	9	Wallis	2
Uri	21	St.Gallen	7	Neuchâtel	–
Fribourg	16	Nidwalden	6	Obwalden	–
Solothurn	15	Schwyz	6	Jura	–
Zug	13	Glarus	5	Appenzell-IR	–
Graubünden	11	Basel-Land	4	Total	356
				Yearly av.	~15

Figure 1 – Bridge load tests performed by the EMPA between 1958 and 1981.

From: Cantieni, R. (1983)

Test conditions

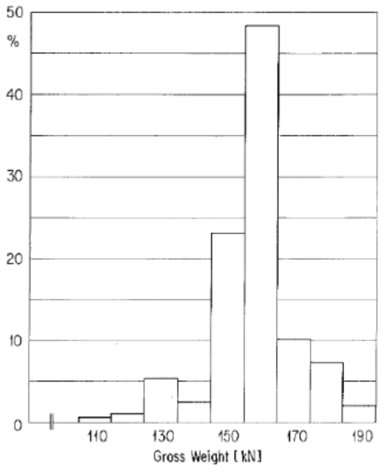


Figure 7 – Gross weight distribution of 207 vehicles used

4.31 *Bridge Systems*

a) Building Material

- prestressed concrete 90.7%
- reinforced concrete 2.2%
- composite (steel/concrete) 6.2%
- steel .0%
- prestressed lightweight concrete .9%

b) Type of the Longitudinal Bridge System

- simply supported beam 12.4%
- continuous beam 71.7%
- cantilever beam (Gerber-type) 4.9%
- one-span frame 1.3%
- multiple-span frame .0%
- slant-legged frame 8.4%
- arch .0%
- one-span plate girder .4%
- multiple-span plate girder .9%

Figure 8 – Examples of the categorisation of bridge data

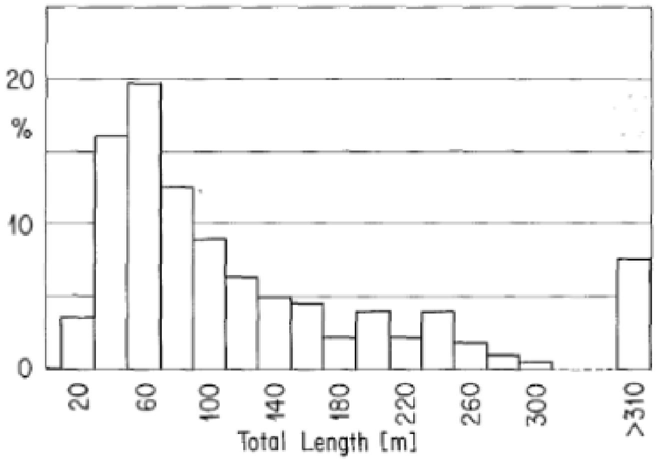


Figure 9 – Lengths of bridges

From: Cantieni, R. (1983)

Standardised test

- Discuss that several factors can affect practical tests, but that dynamic load tests have largely been able to be standardised during the years of records.
- Test loading achieved by:
  - Passage of a fully loaded, two-axle truck (fig. 2) at constant speed (determined by contact threshold of measurement cross-section).
  - Initial speed of 5 km/h, increasing by 5km/h each run until maximum speed achieved.
  - Load unevenness accounted for by including a wooden plank placed at main measurement cross section.
  - Comparability improvements made in 1976:
    - Marked driving lanes
    - Speed control wheel added (see fig 3)
    - Tire pressure monitoring
  - No EMPA test vehicle, but same army vehicles used.

Figure 2 – Load test vehicle

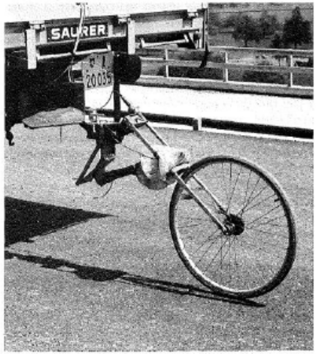


Figure 3 – Speed control wheel

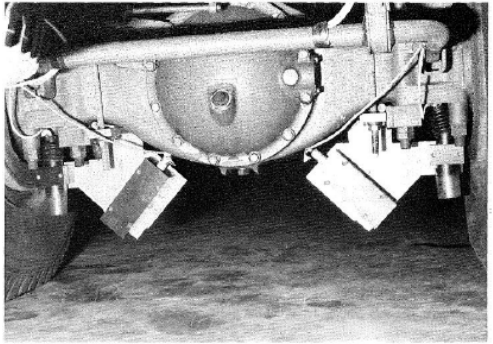


Figure 4 – Opto-electronic systems measuring the dynamic wheel loads

From: Cantieni, R. (1983)

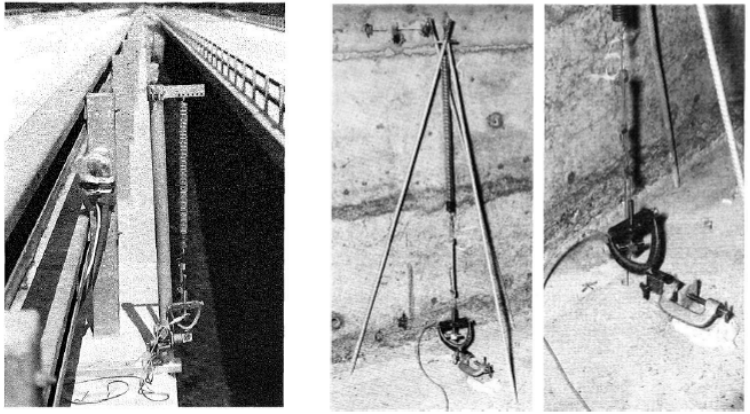
Data measurements

- Displacement
  - Mechanical vibration recorded until 1964 (40 years use)
  - Replaced by inductive displacement transducers (fig. 5)
- Strain
  - Mechanical recorders or inductive transducers
  - Limited use of electrical resistance gauges
- Position of measurement location
  - An abnormal test result prompted in greater effort to locate directly in region of influence

- Deflection recorded normally at midpoint of largest span. If not possible, strain measurements are substituted.

- Data recording achieved by:
  - Mechanical vibration recorders
  - Electrical paper-strip recorders (fig. 6)
  - Magnetic tape

- Data processing of dynamic load tests yielded:
  - Frequency of one or more modes
  - Damping of the dominant natural vibration(s) in free decay
  - Dynamic increment of one or more measurement signals as a function of vehicle speed



(a) (b)

Figure 5 – (a) inductive displacement transducers, (b) mounting of transducer

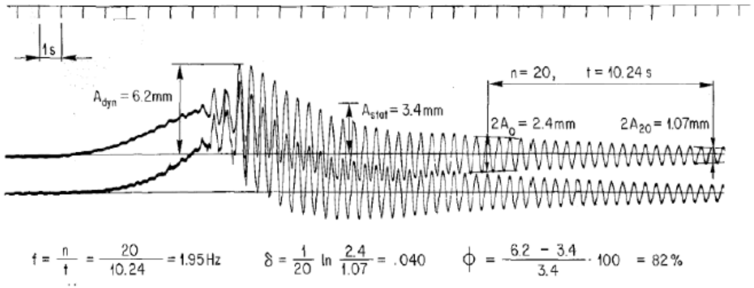


Figure 6 – Displacement and strain recorded by photographic galvanometer oscillograph

Output of the Report 211 (Cantieni 1983

- Natural frequency results
  - 202 bridges represented in the natural frequency histogram (fig. 10) also have deflection and strain measurements at mid-span.
  - Using the data collected, Cantieni estimated the fundamental frequency and the maximum span of the bridge (fig. 11)
  - There are several examples of this relationship, but the one presented eliminates some extreme factors.
- Other results presented:
  - Spring constants
  - Damping
  - Dynamic increments

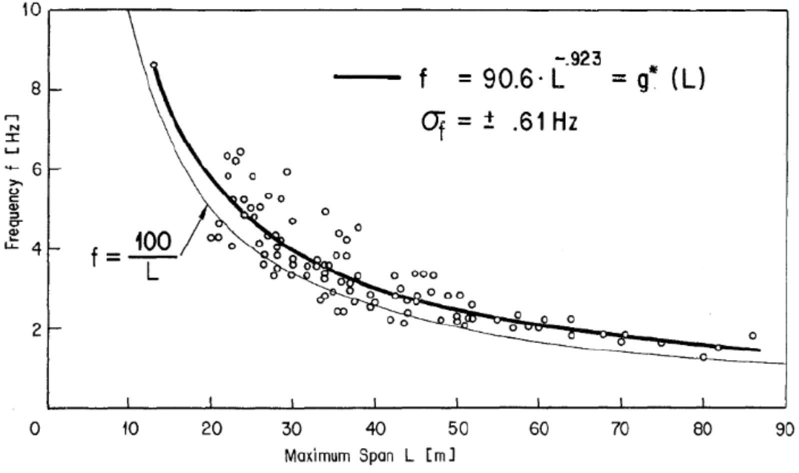


Fig. 30 Fundamental frequency *f* of the bridges as a function of the maximum span *L*. 100 values, selected from the total of 224 by eliminat-

Figure 11 – Relationship between fundamental frequency and maximum span

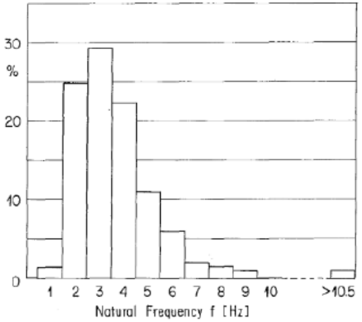


Figure 10 – Fundamental frequency for 202 bridges

In the last section of the report there are a few examples

Following this are four examples of dynamic tests conducted on highways bridges in order to demonstrate the prototype of the research, common issues encountered, etc.

Tests on the „Glattbrige" in Opfikon

EIDGENÖSSISCHE MATERIALPRÜFUNGS- UND VERSUCHSANSTALT
FÜR INDUSTRIE, BAUWESEN UND GEWERBE, DÜBENDORF

LABORATOIRE FÉDÉRAL D'ESSAI DES MATÉRIAUX ET INSTITUT DE
RECHERCHES-INDUSTRIE, GÉNIE CIVIL, ARTS ET MÉTIERS, DUBENDORF

Bericht Nr. 192

Die Versuche an der Glattbrücke in Opfikon

von

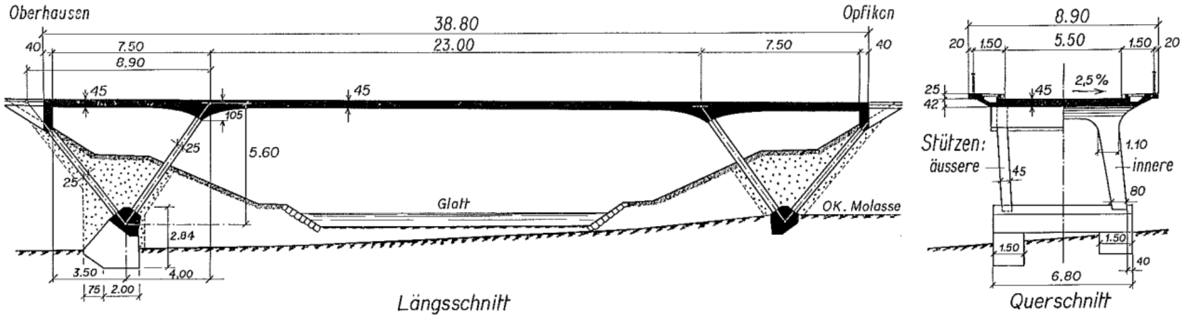
Dr. A. Rösli, dipl. Ing. ETH

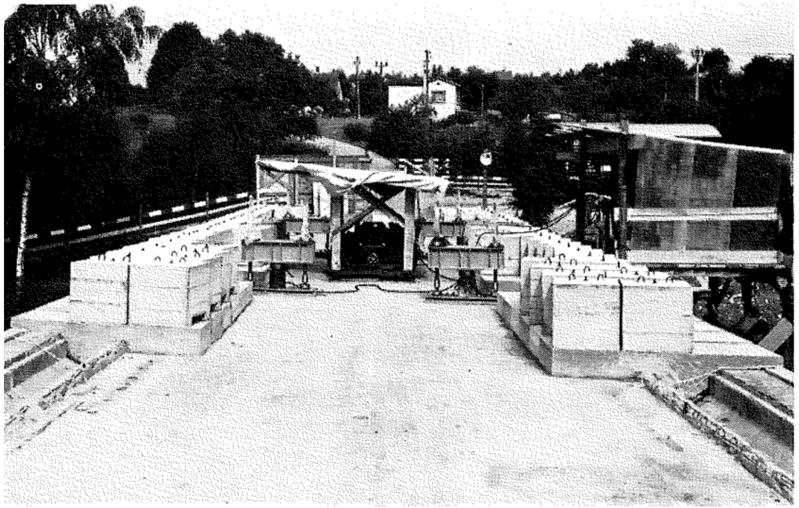
unter Mitarbeit von

Dr.-Ing. R. Kowalczyk, dipl. Ing. H. Hofacker

und *dipl. Ing. R. Sagelsdorff*

Dübendorf, Dezember 1963





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EPSRC PROGRAMME GRANT

ROSEHIPS: Revolutionising Operational Safety and Economy for High-value Infrastructure using Population-based SHM

Healthy infrastructure is critical in ensuring the continued health of UK society and the economy.

What's On

IMAC-XLIII – 42nd IMAC: A Conference and Exposition on Structural Dynamics – Orlando, Florida, USA – 10th-13th February 2025

DTE & AICOMAS 2025 – 3rd IACM Digital Twins in Engineering Conference & 1st ECCOMAS Artificial Intelligence and Computational Methods in Applied Science – Paris, France – 17th-21st February 2025

CSE25 – SIAM Conference on Computational Science and Engineering – Fort Worth, Texas, USA – 3rd-7th March 2025

DRMS 2025 – 2nd International Conference on Durability, Repair and Maintenance of Structures – Porto, Portugal – 13th-14th March 2025

Consortium

University of Sheffield

QUEEN'S UNIVERSITY BELFAST

UNIVERSITY OF CAMBRIDGE

University of Exeter

Principal Investigator
Management Committee

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Management Committe
Co-Investigator
David Hester <d.hester@qub.ac.uk>

Bridge load testing with continuous fiber optic sensing

Numa Bertola
Francesco Fabbricatore

12.12.2024

Ferpècle Bridge presentation

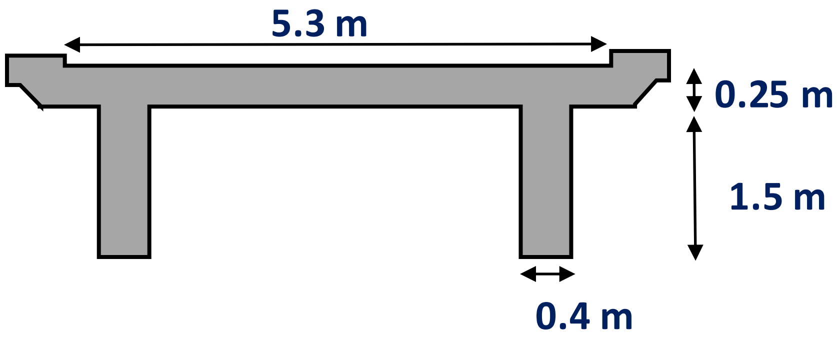
Built in 1958

Located in Swiss Alps

TT cross-section in
pre-stressed concrete

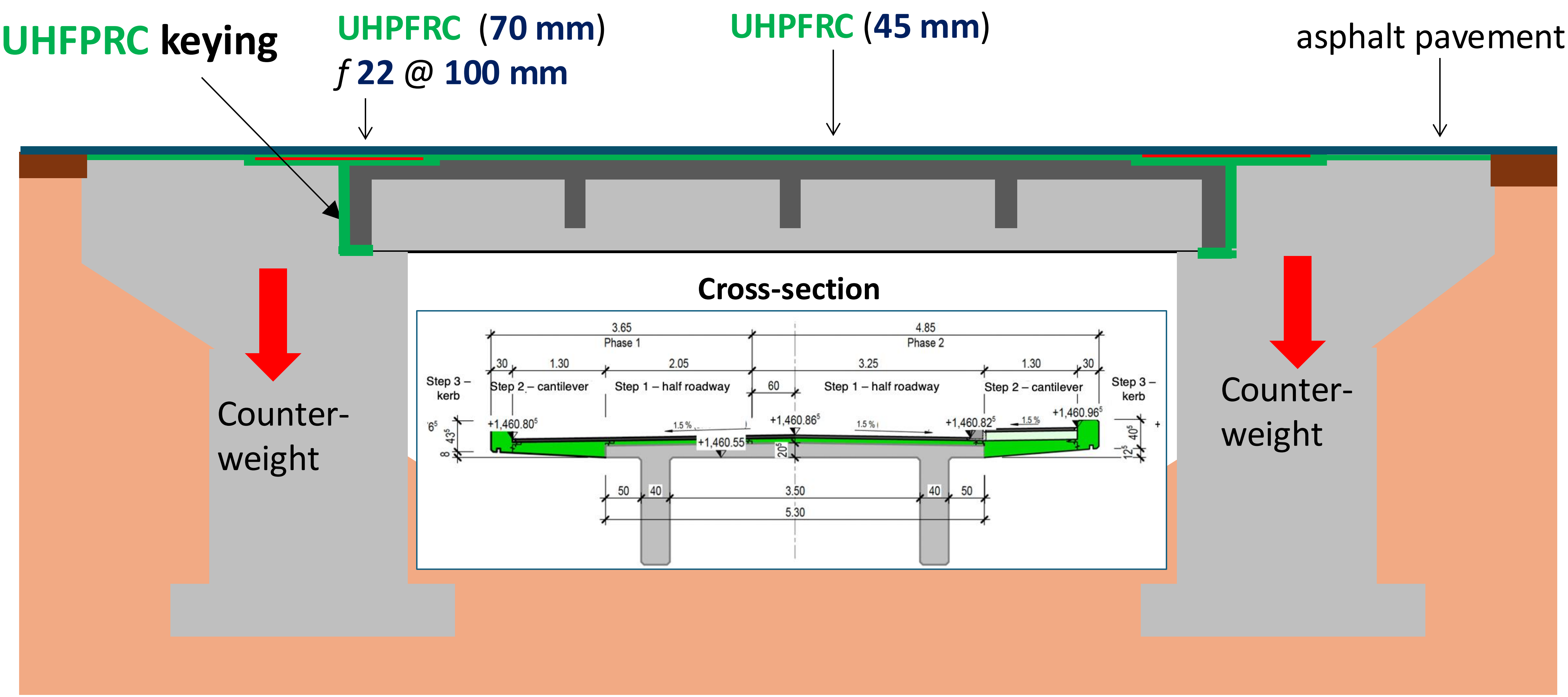
Span of 34.5 m
Width of 5.3 m

Widening project to 7.9 m



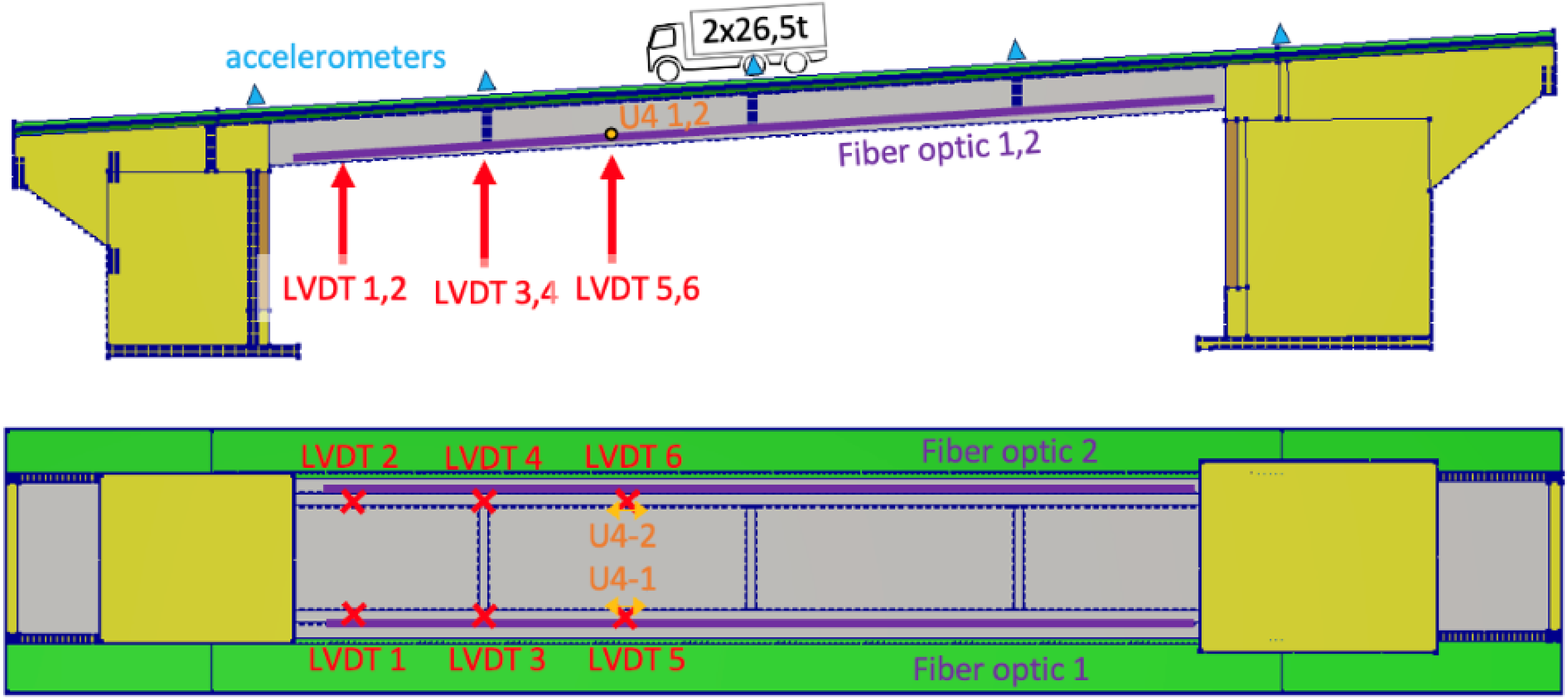
Intervention design

Creation of a monolithic and hyperstatic structure with UHPFRC (UB)

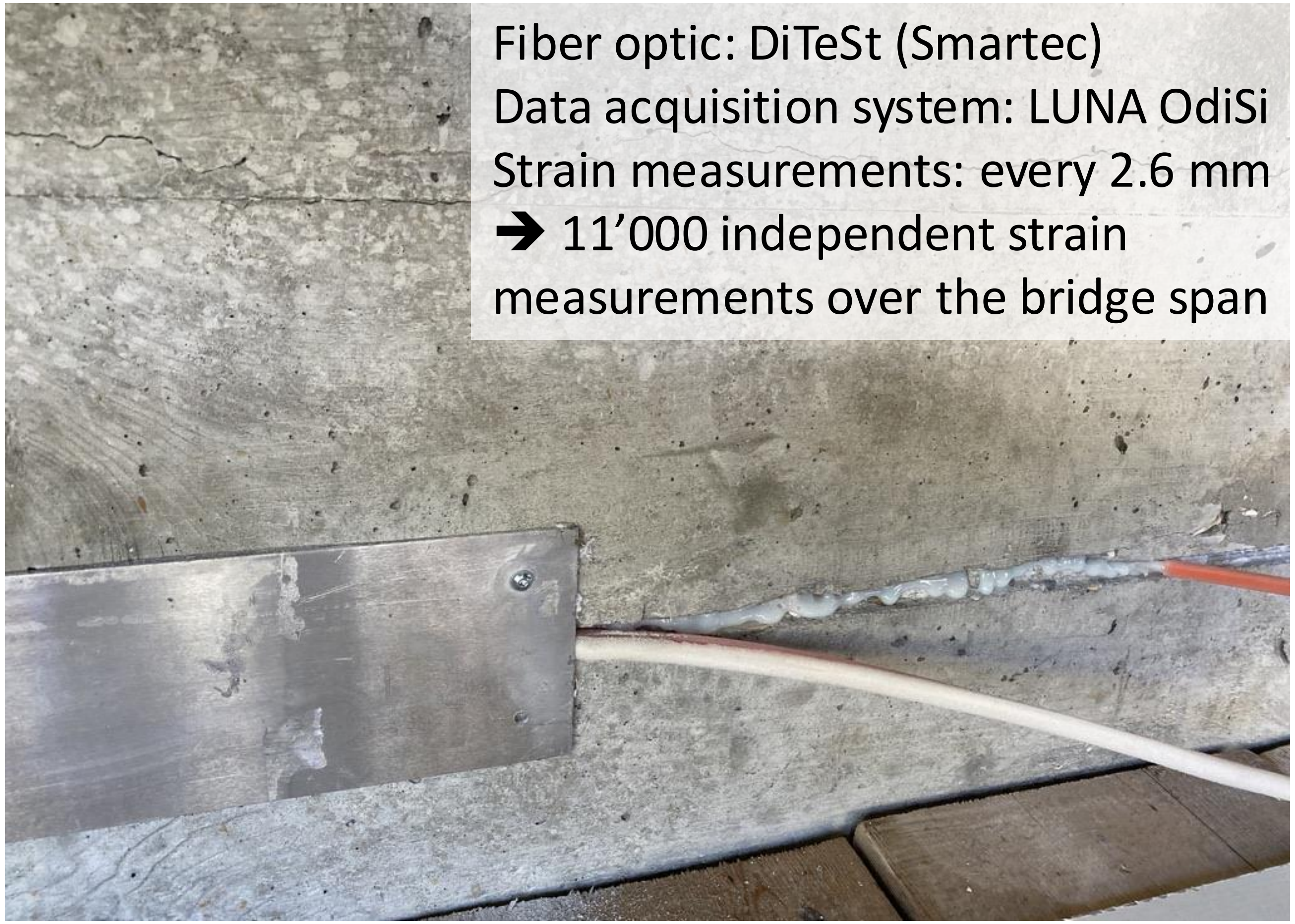


Bertola, N., Brühwiler E. (2024) Transforming The Static System of Prestressed Concrete Bridges Using UHPFRC. Journal of Bridge Engineering, Under review

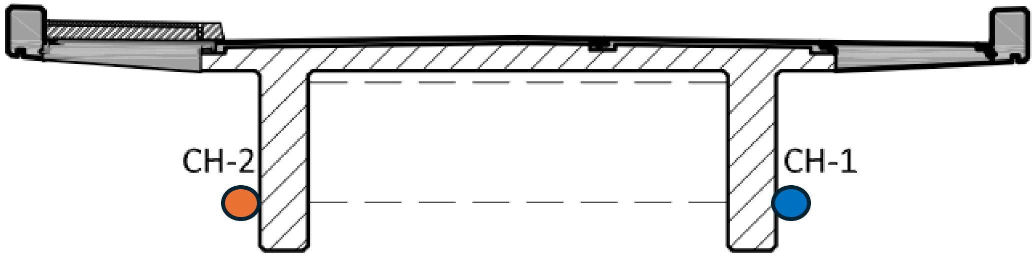
Monitoring system for intervention validation



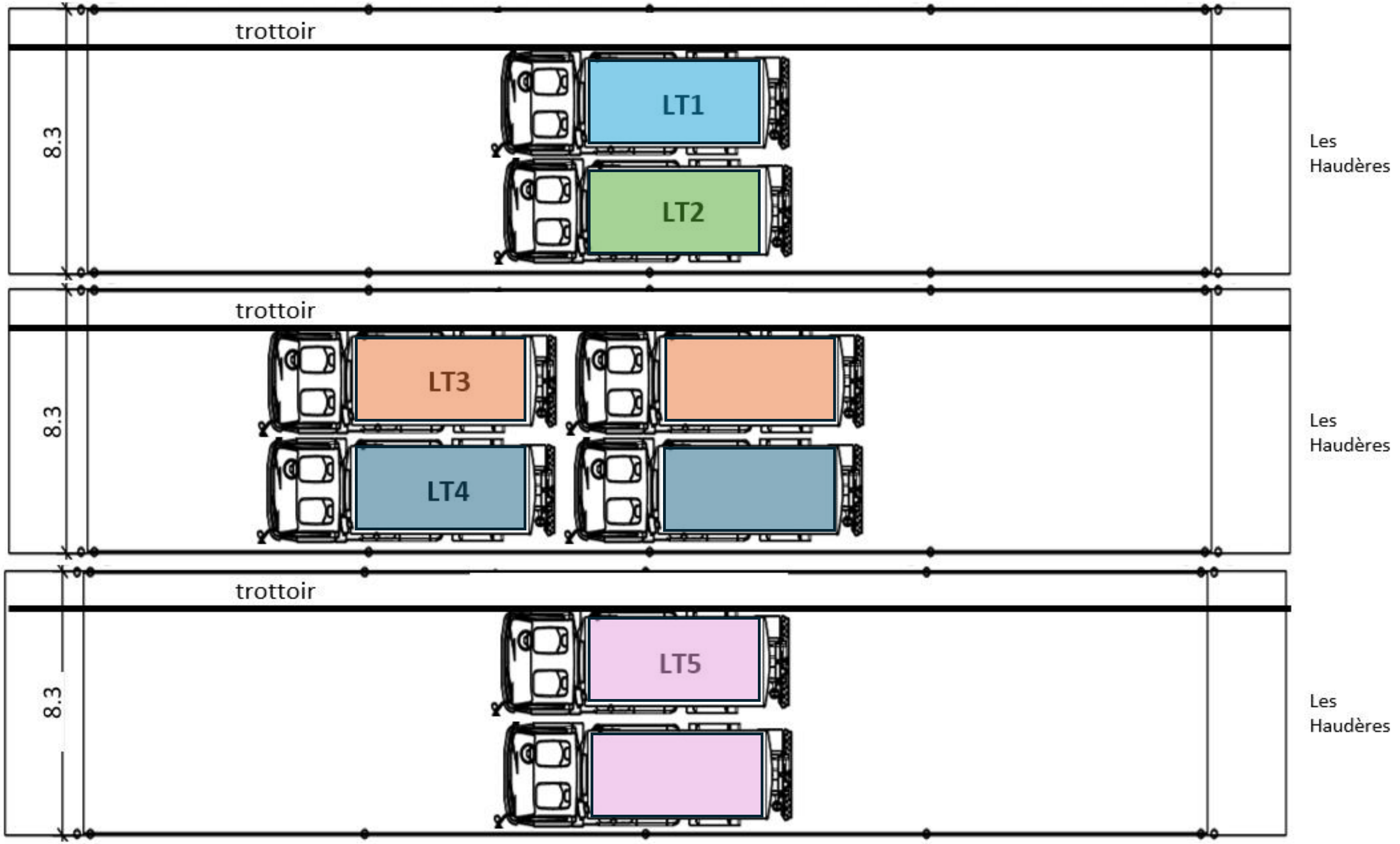
Fiber optic installation



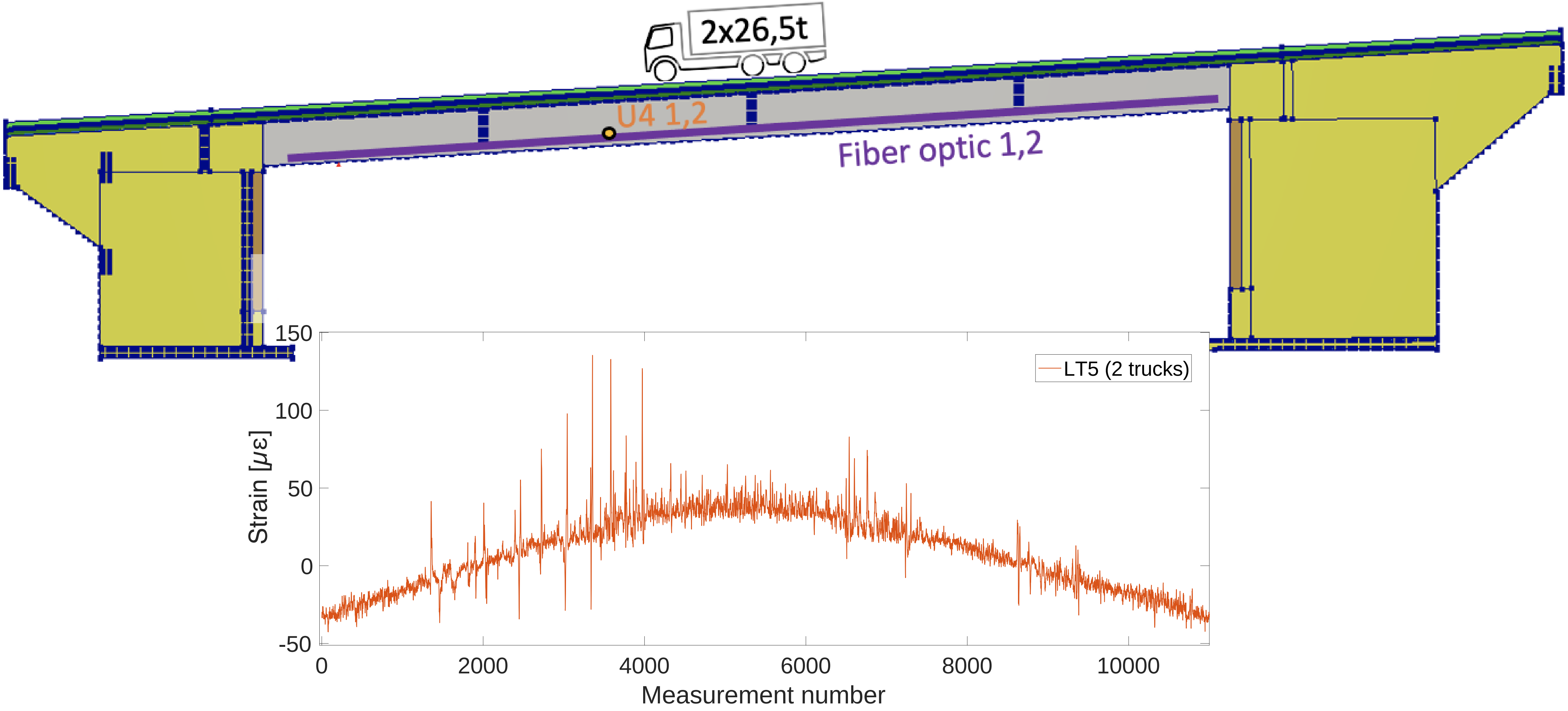
Fiber optic: DiTeSt (Smartec)
Data acquisition system: LUNA OdiSi
Strain measurements: every 2.6 mm
➔ 11’000 independent strain measurements over the bridge span



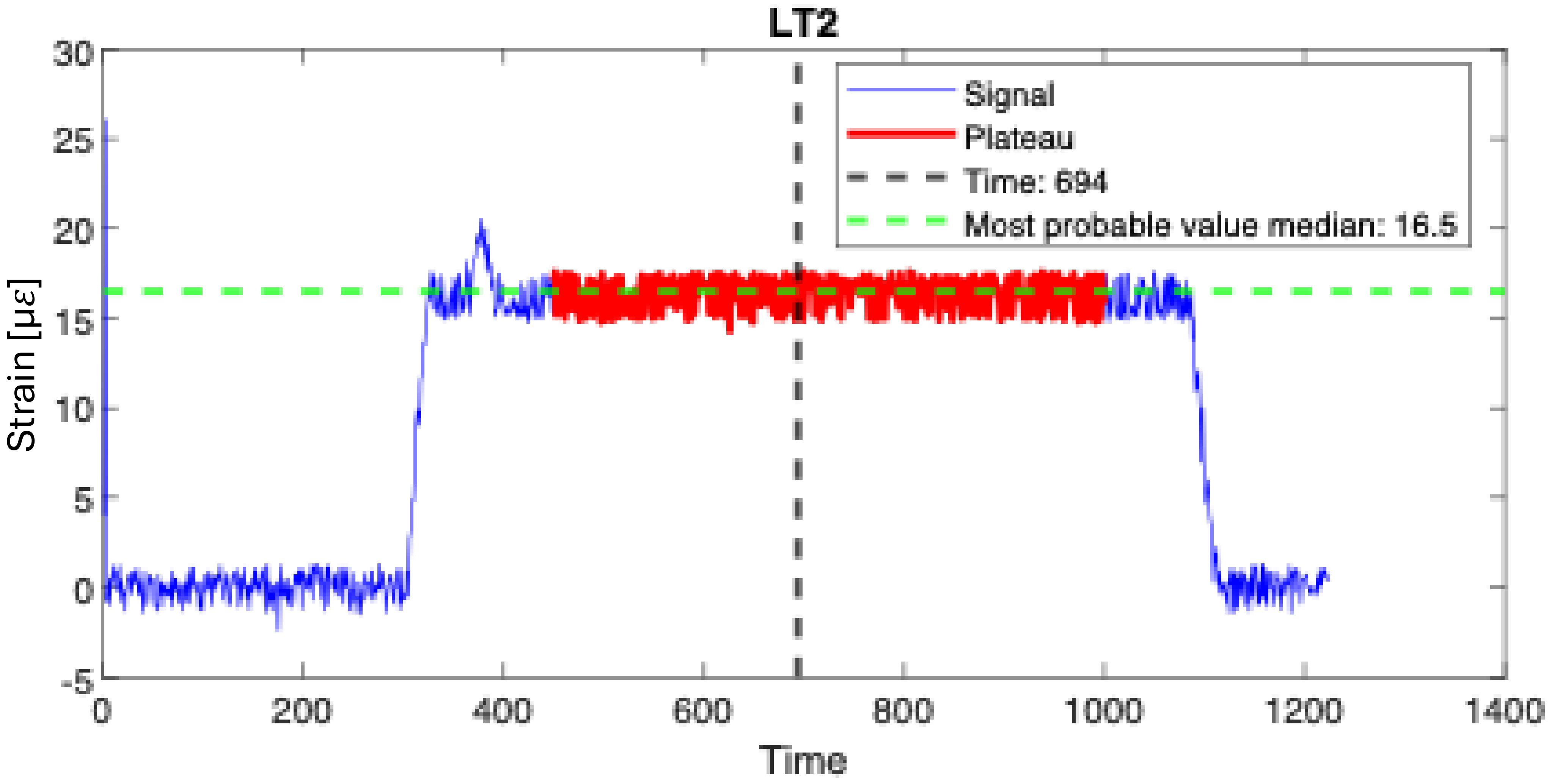
Load tests


trottoir
8.3
LT1
LT2
Les Haudères
trottoir
8.3
LT3
LT4
Les Haudères
trottoir
8.3
LT5
Les Haudères

Fiber optic results during load test



Time selection



Data consistency

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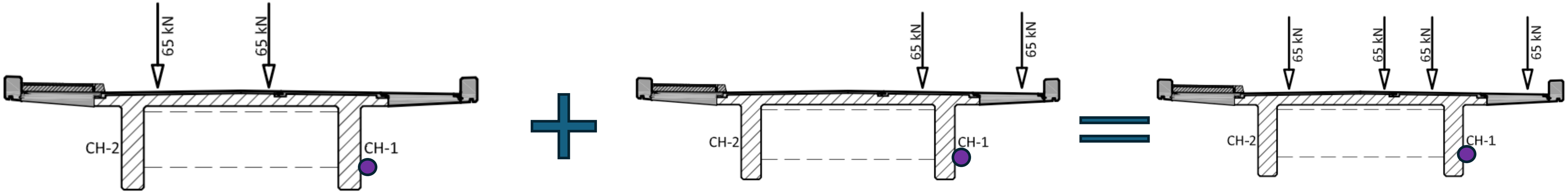
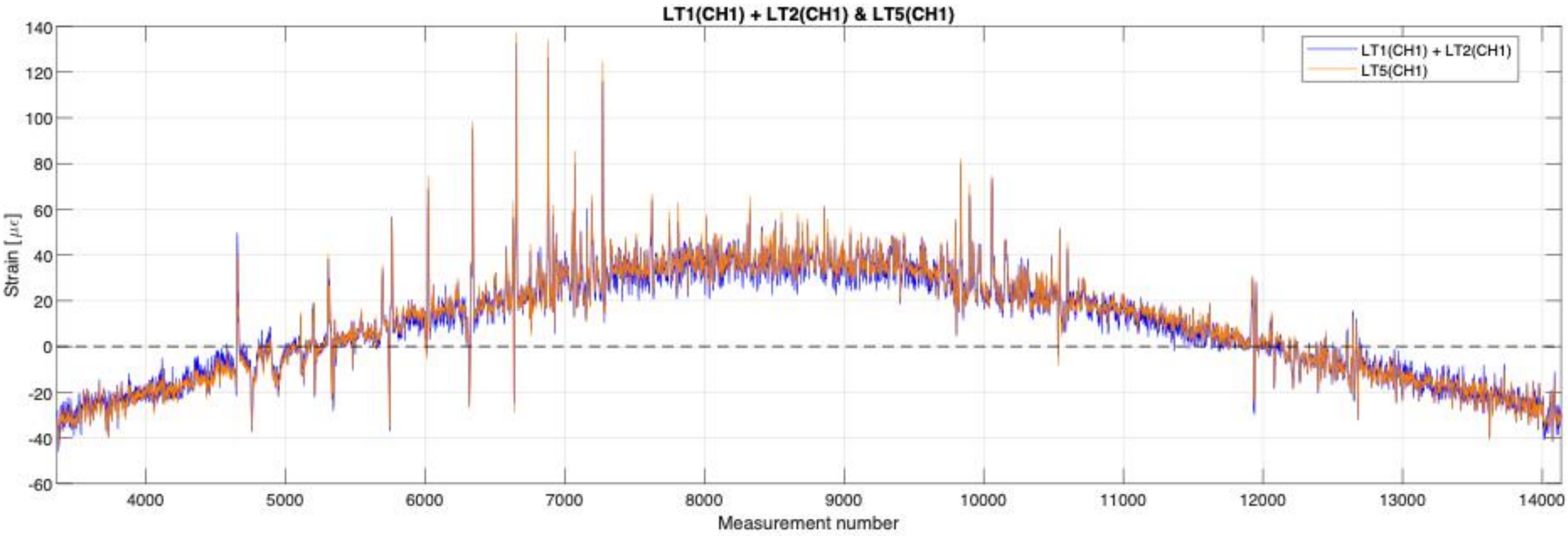
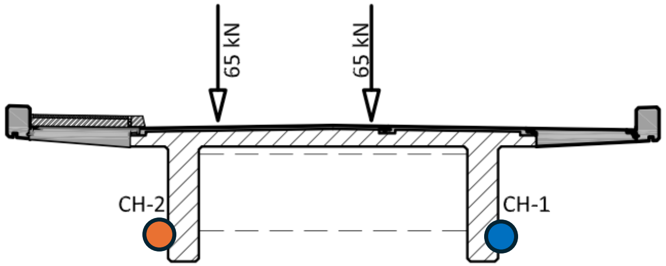
LT1 (one truck) **LT2 (one truck)** **LT5 (two trucks)**

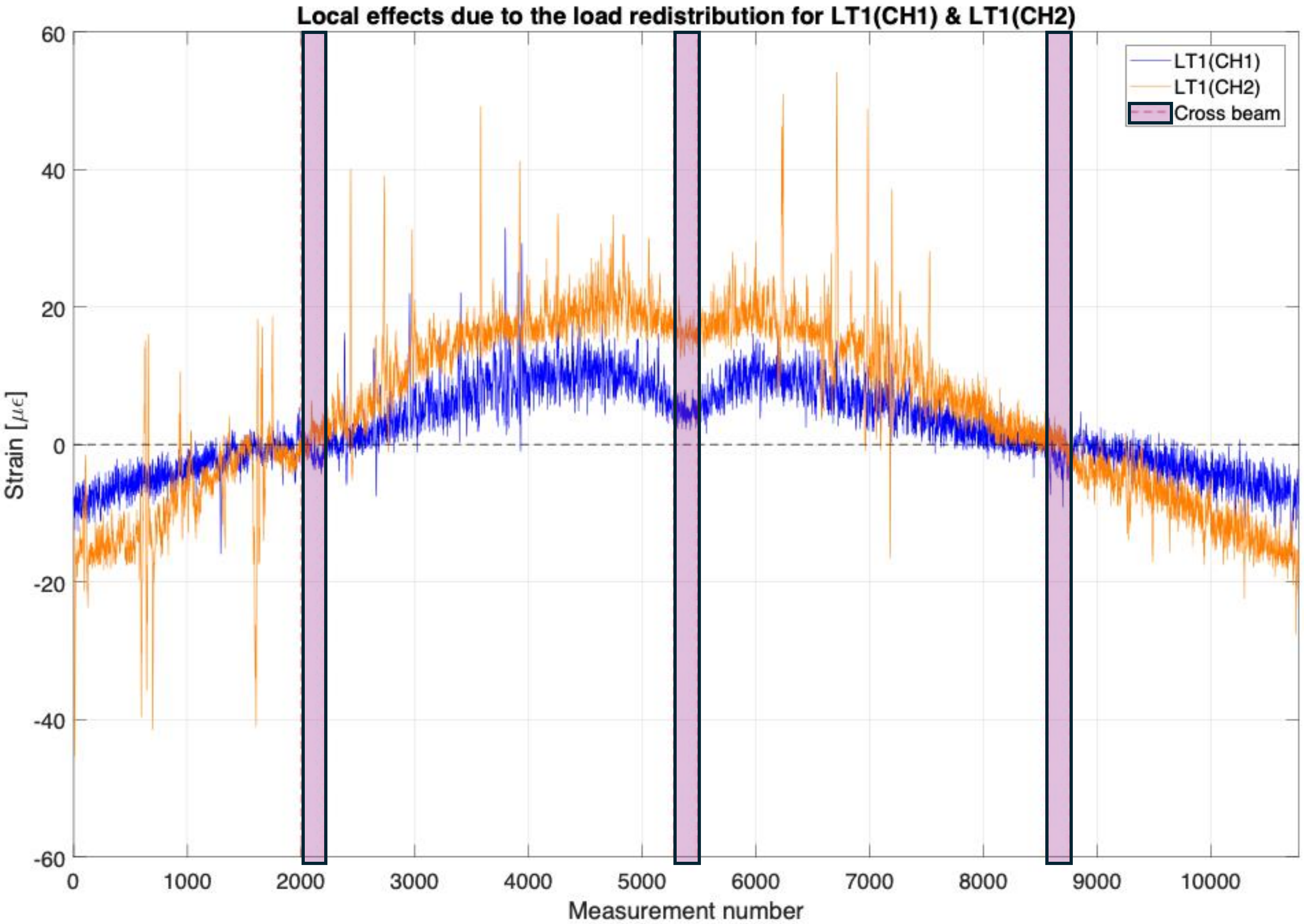




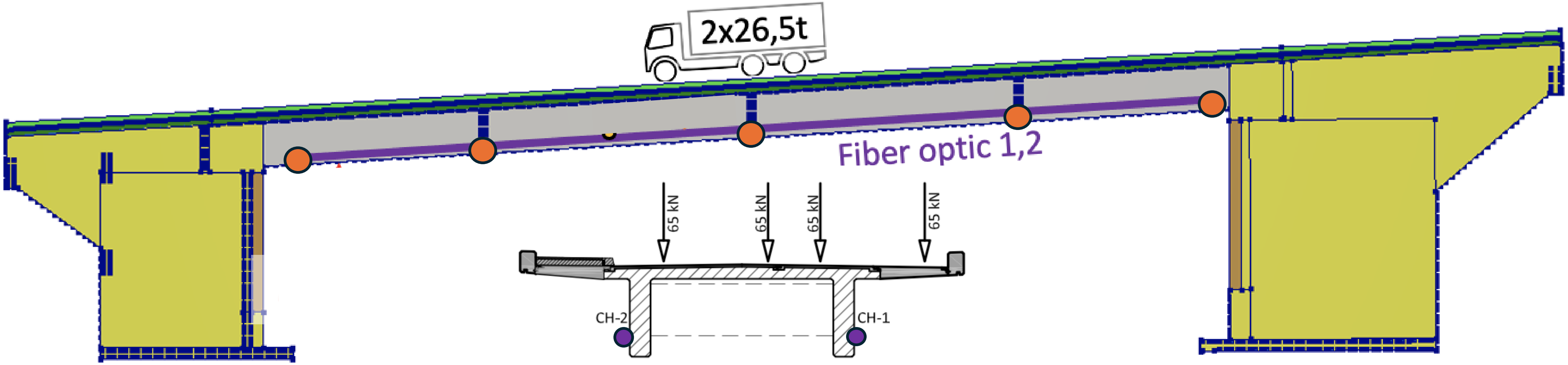
Local effects

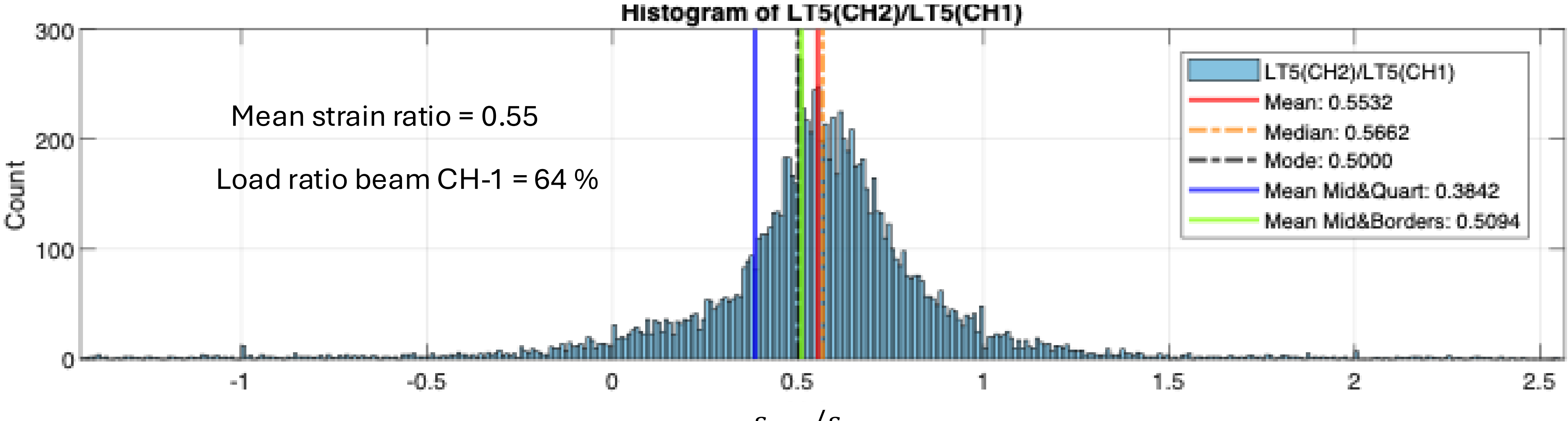
LT1 (one truck)



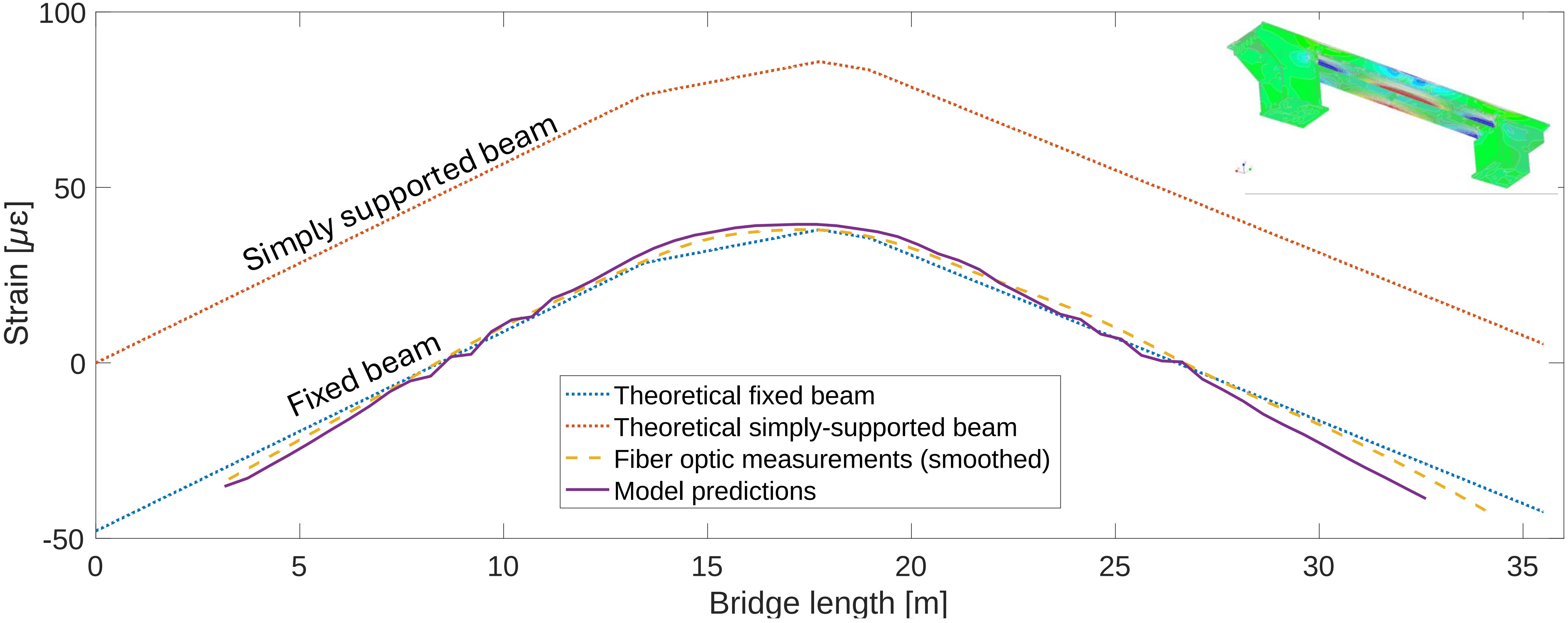


Load distribution between the girders



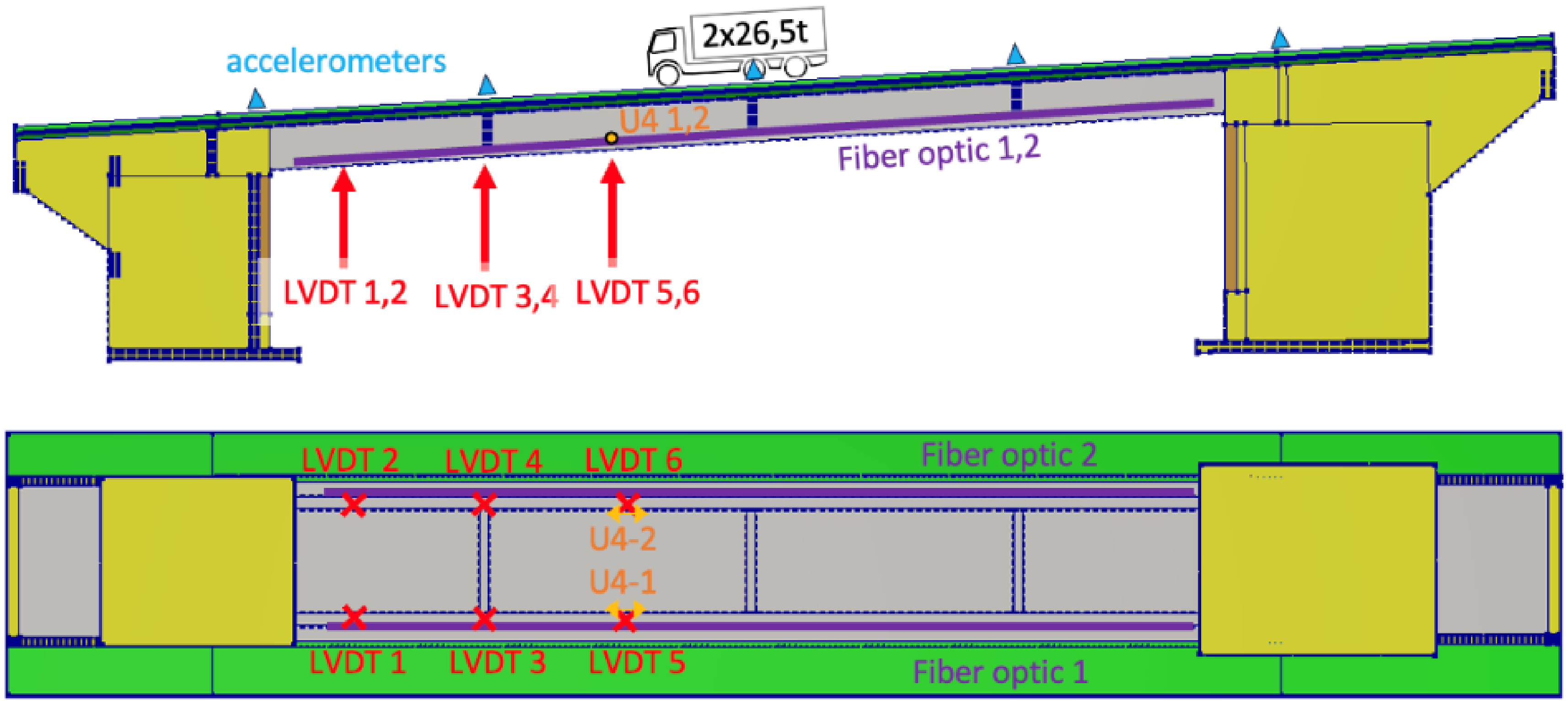


Identification of boundary condition



➔ **The bridge behaves like a fixed beam (mean FE model prediction errors 6 %)**

LVDT measurements



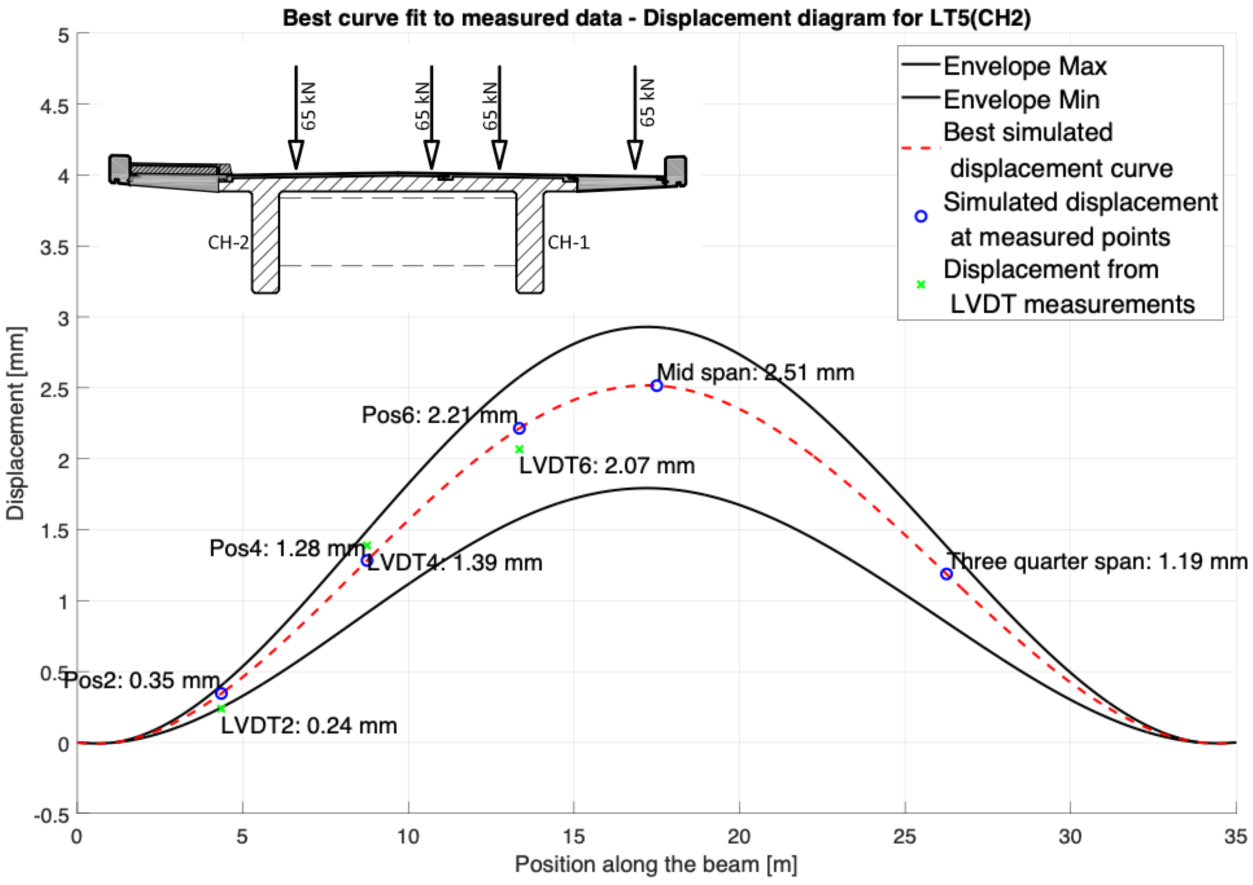
Deflection calculation

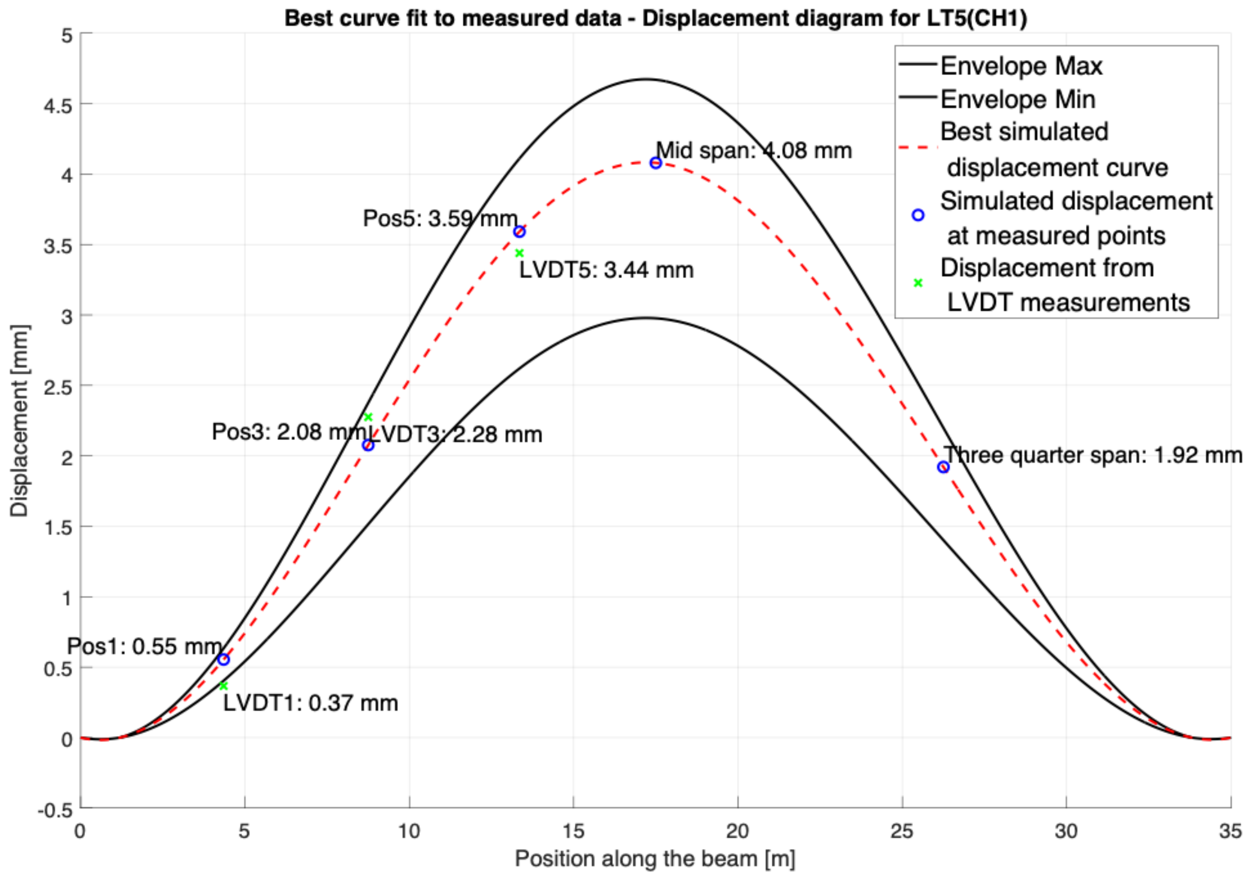
Use load distribution and boundary conditions results ➔ Deflection estimations

➔ Comparison with LVDT measurements

➔ Uncertainty on the rigidity (elastic modulus, inertia), load distribution,... ➔ work with distributions

Average error of best fit (all load tests) = 0.105 mm, max error (all LT)= 0.30 mm

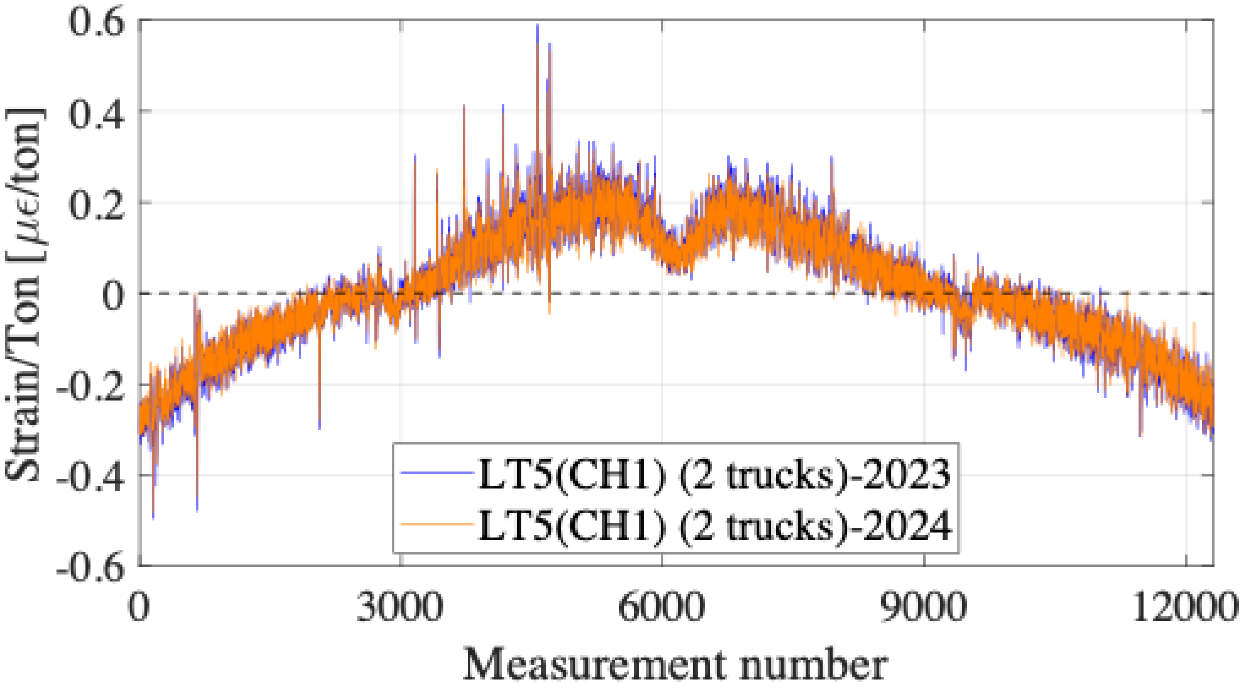


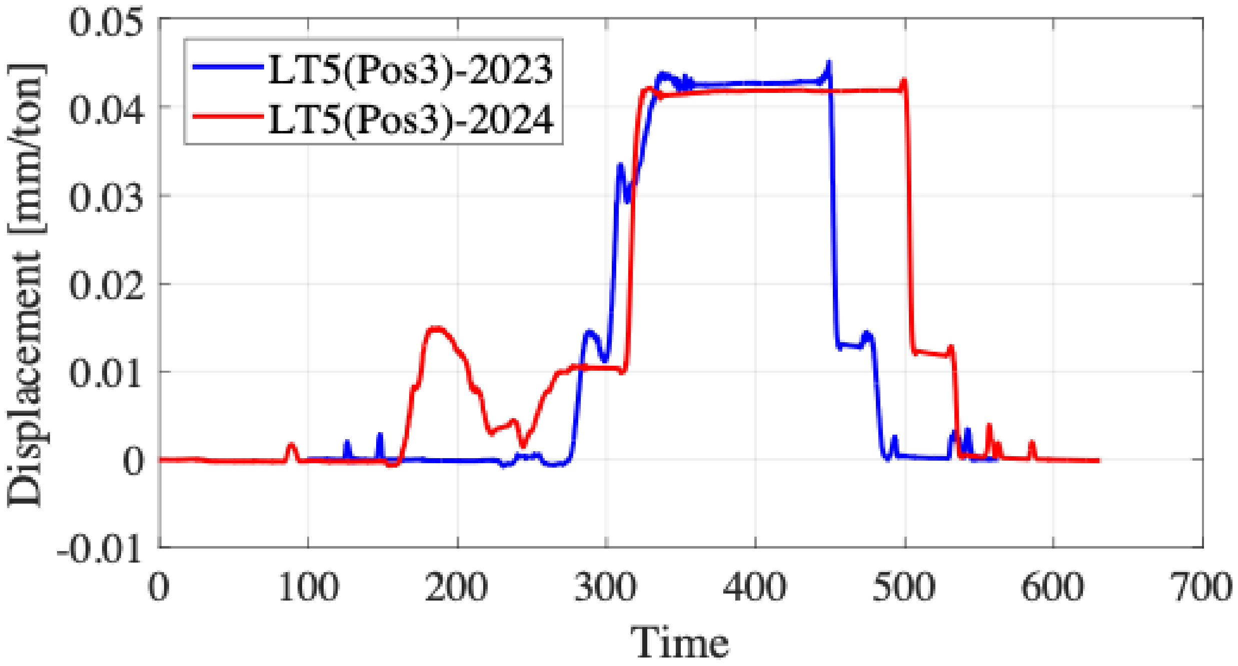


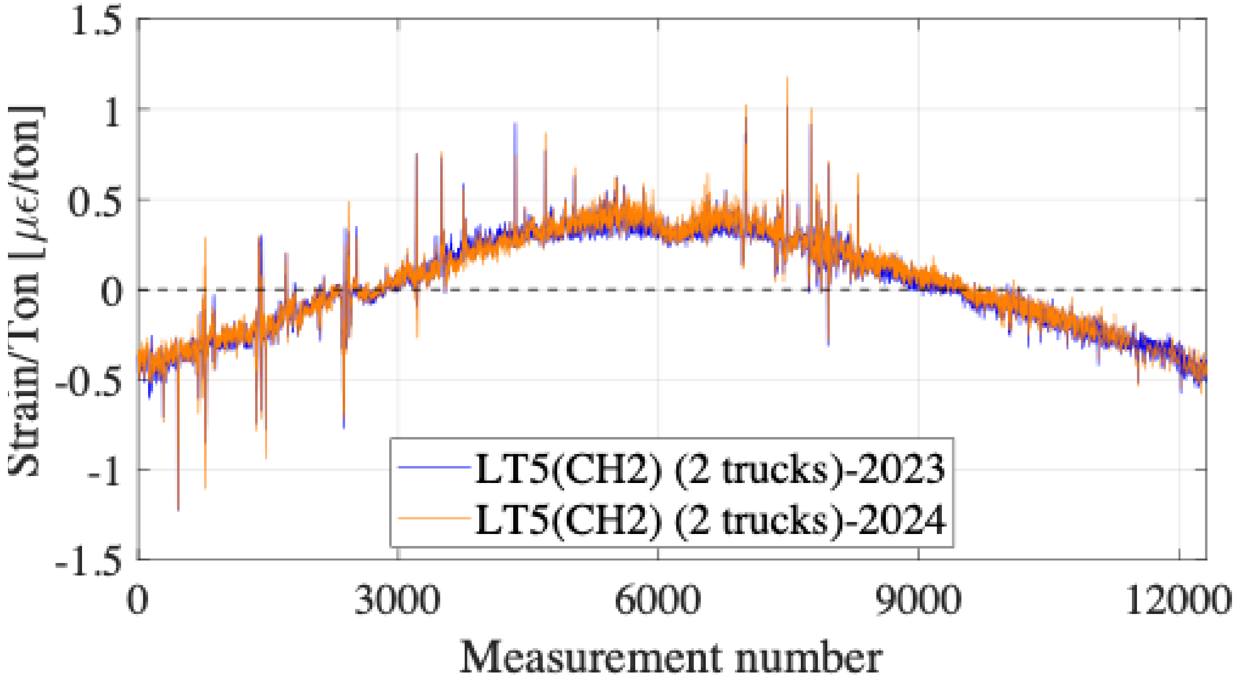
2023 vs 2024 measurements

Repetition of load tests in 2024

Small difference in total loads
(27 instead of 26 tons per truck)







Conclusions

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The distributed fiber-optic sensing (**DFOS**) allows for **spatially-continuous** monitoring during load testing with **millimeter precision**

DFOS enables **identifying local (**crack, secondary-beam effects) **effects** as well as **global bridge behavior**

DFOS datasets can lead to the **identification of bridge behavior** (boundary conditions, load distributions between girders) as well as **extrapolating deflection** with a precision of 0.1 mm

EPFL ETH zürich SWISS INSPECT irmos

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