Meeting Minutes

IABMAS Technical Committee on Bridge Load Testing

Zoom Meeting ID: 880 257 05271 https://usfq.zoom.us/j/88025705271?from=addon

Wednesday April 16th 8:00 – 10:00 CDT, 15:00 – 17:00 CEDT

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	David Kosnik (TRB AKB40 liaison)
Jesse Grimson	**Daniele Losanno**
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	Hisatada Suganuma
Rolando Chacon	**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**
Ho-Kyung Kim	

Guests: Gianmarco Addonizio
Regrets: Sreenivas Alampalli

1. Administrative

1.1. Welcome and introduction

The meeting was called to order at 8:03 am by Eva Lantsoght. All attendees introduced themselves with name and affiliation.

1.2. Review and approval of agenda

The meeting agenda was reviewed without comments.

2. Strategic Planning and Discussion

2.1. Membership and committee leadership

There are no changes to the committee membership or leadership.

2.2. Website

On the IABMAS website, the committee information is updated.

3. Old business

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

The working group met on March 17th. Eva Lantsoght presented the current draft of the bulletin being developed in collaboration with fib (Fédération Internationale du Béton). As of April 9th, the document is progressing, with most of the content expected to be completed by the end of the year. Editorial processes are still pending. Chapters 11 and 12 focus on research needs and conclusions, respectively. Committee members will be involved in reviewing the text.

3.2. Collaboration with other IABMAS TCs

Eva Lantsoght presented preliminary results from a survey of bridge owners and managers. The slides of this presentation are attached to these minutes. Key insights included:

- Diverse interpretations of what constitutes a digital twin — from simple 3D models to fully integrated, real-time systems.
- Strong emphasis on cost-efficiency and the need for funding.
- Owners expressed a clear desire for practical solutions and better understanding of bridge performance through DTs.
- Responses included a wide range of data types, such as sensor data, SHM/NDT outputs, geospatial imagery, AI-based defect tracking, design documents, and traffic loads.

Stakeholders identified desired workshop outcomes, including:

- Clear definitions
- Input/output specifications
- Technology recommendations
- Real-world examples
- Best practices and roadmaps
- ROI discussion
- Standardization and alignment with broader industry efforts

Eva noted responses came from 19 countries. Joan Casas highlighted the value of knowing respondent profiles. Alok Bhowmick raised concerns over limited Asian representation. Dave Cousins questioned whether the committee is pushing toward a single definition of DT.Eva welcomed these reflections and emphasized openness. Sreenivas will present a related poster at the Missouri workshop in May.

Rolando Chacón introduced the status of the planned Digital Twin Workshop in collaboration with the SHM and Bridge Management committees. The slide of this presentation is attached to these minutes. Rolando Chacón continued with planning details:

- **Organizers**: Rolando Chacón, Necati Catbas, Basak Bektas, Rade Hajdin, Alfred Strauss
- **Tentative date**: July 6, 2026 (prior to IABMAS Conference)
- **Venue**: Under discussion
- **Output**: Still being defined
- **Participation**: 40–60 attendees in 10–15 person breakout groups
- **Scope**: Focus on existing bridges
- **Breakout Sessions**: Four are planned, addressing multi-scale perspectives

4. New Business

4.1. Technical presentations

Michal Venglar – Bridge Load Testing and Vibration Monitoring for the Design of Stabilisation and Protection of the Piers of the Railway Bridge

The slides of this presentation are attached to these minutes. Eva Lantsoght asked about the accuracy of the radar interferometry measurements and use of reflectors. Jesse Grimson mentioned the excellent accuracy of the measurements, considering these allow measuring from the bank. Joan Casas asked about the same value of deflections at the pier and the midspan, and the cause of this rather unexpected outcome. Pavel Ryjacek noted that this result could be due to the presence of horizontal components, and Piotr Olaszek recommended the use of two radar systems to reduce the uncertainties on the measurements.

Daniele Losanno - The influence of Proof Load Testing on I-type girder bridges

The slides of this presentation are attached to these minutes. Jesse Grimson asked about the risk of cracking, and shear cracking, and Dave Cousins asked about the insights that can be obtained with reliability analysis versus proof load testing, given that it is not a commonly adopted tool in engineering practice yet, and whether testing at a lower load level (for example, 90% of the proof load) could be achieved using the probabilistic tools.

4.2. Liaison updates

- TRB AKB40 Liaison update: Eva Lantsoght finished her maximum number of terms as secretary of TRB AKB40 Testing and Evaluation of Transportation Structures and is now chairing AKB40(1) Non-destructive Evaluation of Structures. The committees are preparing a webinar on NDE for roads, workshop for TRB 2026 (tentatively), and e-circular on NDE.
- fib TG 3.2 liaison update: Eva Lantsoght mentioned the ongoing collaborations with TG 3.2 on the bulletin on proof load testing.

4.3. Updates of ongoing research projects

The floor was opened for research updates. No specific projects were presented. Armin Mehrabi thanked Rolando Chacón for his work on the Digital Twin Seminar at FIU.

4.4. Upcoming conferences and events

The next IABMAS Conference will take place in Orlando, Florida, in 2026. Unfortunately, the dates coincide with EWSHM in France.

Participants were encouraged to share any additional events for dissemination

5. Adjournment

Eva Lantsoght thanked the presenters for their contributions. Jesse Grimson adjourned the meeting at 9:57 am CET. The next meeting will be held during Fall 2025, online. Eva Lantsoght will send a whenisgood poll in August to check availability.

Analysis of survey results

Eva O.L. Lantsoght

TU Delft

Overview of results

- 141 responses
- Informed consent: 125 responses
- Not empty & informed consent: 75 responses

- Report: updates in Qualtrics automatically
- Version stored in shared Dropbox

Bridge owner needs for digital twins

IABMAS Working Group Survey

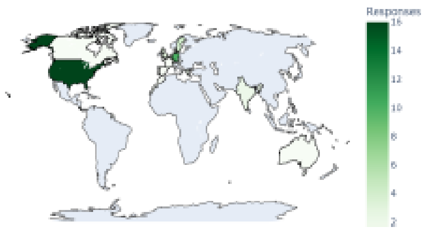
Eva Lantsoght and Sreenivas Alampalli – on behalf of the IABMAS Working Group on Digital Twins

Introduction

- **IABMAS Working Group on Digital Twins**: IABMAS Bridge TCs (Load Testing, BHM, and Bridge Management) identified Digital Twins as an important common topic of study for enhancing bridge safety and management. Conducted a survey to identify topics for a planned future workshop.
- Survey objective: map **needs of bridge owners** for bridge management and perception regarding digital twins

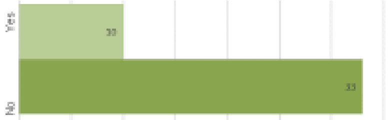
Methods

- Survey on Qualtrics platform
- Filtered responses: 55 bridge owners from 19 countries

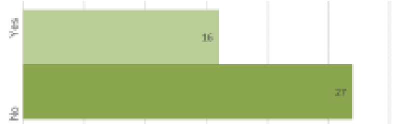


Results – Adoption of digital twins

Question: Are you **using BIM/BrIM** tools in your bridge management?



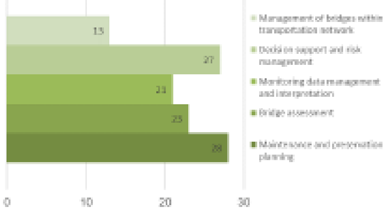
Question: Are you currently **using** any form of **digital twin** technology?



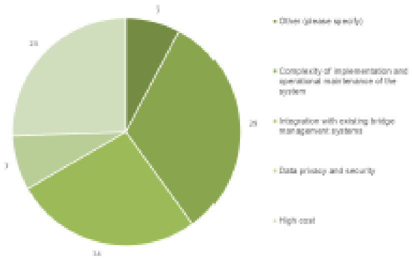
Question: Are you currently interested in **exploring digital twin technology** for bridge management at the asset level?

Results – Bridge owner needs

Question: What are your current **challenges** in bridge management?



Question: What are your biggest **concerns** about using digital twin technology?



Other concerns: resources and funding, gathering data to make model useful, data size, purging old data versus retaining data, different types necessary as function of different bridge types, use and value of data, human factor

Discussion

- Many different **definitions** and understanding of digital twins for bridge Management
- **Limited adoption**, mostly for new bridges, large interest from bridge owners
- Digital twins considered as **potential solution** for bridge management challenges, but owners have concerns
- Less interest for **network-level** approach

Conclusions

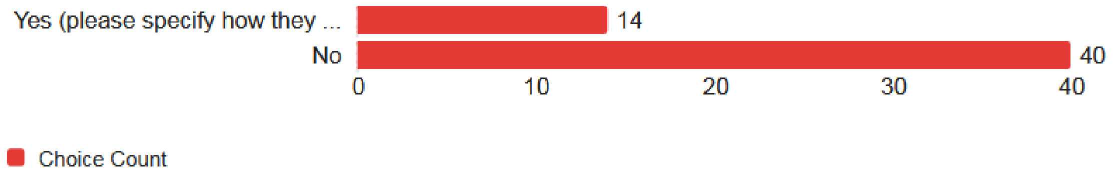
- Need for **uniform definitions** for digital twins in bridge management, and identifying inputs and outputs
- Owners interested in **case studies**
- IABMAS Working Group on digital twins to develop **white paper and workshop** at IABMAS 2026 (https://iabmas2026.org/)

IABMAS Working Group on Digital Twins

Use of BIM/BrIM

Q8 - Are you using Building/Bridge Information Modeling (BIM/BrIM) tools in your bridge management practices? - Selected Choice

54 Responses



Q8_1_TEXT - Yes (please specify how they are used) - Text

Yes (please specify how they are used) - Text

Some of the new bridges that are beeing bulit are discribed in BIM rather than in drawings. We are just getting started to use - bridges bulit in BIM - in bridge maintenance management

We are currently working on a research about the use and implementation of BrIM on the bridges of Costa Rica.

Prediction of future conditions, scenarios

Digital Twins for Bridge Inspection and Management

selected bridges for management/project delivery

Excel/Python based custom tools.

Starting this effort in the design phase not bridge management yet

we leverage the extensive storage capabilities of digital twins to host our inspection data, programming, LIDAR, smart sensor management, and even AI-based interpretation. These tools are used to enhance our performance in managing, planning, and maintaining structures. However, these initiatives remain exploratory and marginal within our bridge maintenance program.

Design

Collaboration in various systems owned by asset managers - e.g. Network Rail: CARRS/NEST

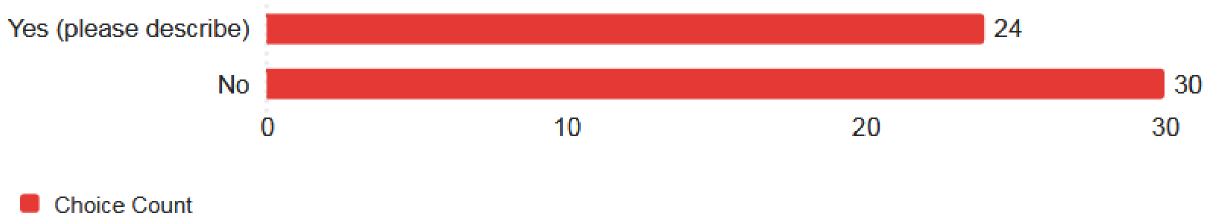
Inspection results are integrated

For research purposes

Current designs of new bridge and major bridge repairs are being carried out in 3Dmodels, and 3D models will be tranfserred over the as-built recorde for future management

Current use of DT

Q9 - Are you currently using any form of Digital Twin technology for bridges? - Selected Choice



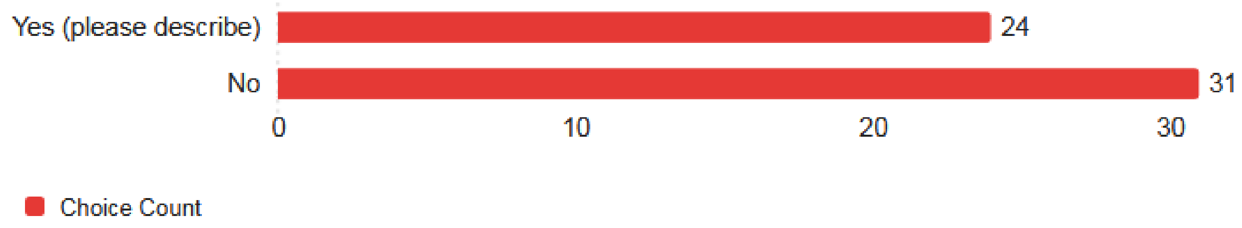
Q9_1_TEXT - Yes (please describe) - Text

Yes (please describe) - Text
Digital twin is a concept that can mean different depending who you speak to. We have a module that stipulates how heavy vehicles that need special pemission may pass the bridges.
In BATMAN we have described our bridges so we can calculate possibilities to allow over weight trucks
Finite Element models
The model updating of bridges that are continyousely monitored, based on their modal data are systematically identifoed
In some pilot projects, BIM is used for the planning and building phases, and trials are ongoing to build a "link" to the BIM-Model to get data back in the KUBA tool.
We are working on the implementation of digital twins for bridges and their integration with BIM and GIS.
Trying to develop a digital twin for a few structures to use for inspector calibration throughout the state.
We use a smart bearing to monitor the loads

Supplement inspection teams, historical records, and inspection documentation.
Itwin Capture and Itwin Experience
A few pilot 3D modeling bridge plans
Only in support of research projects
TxDOT is requiring digital models for new bridge designs. Our processes are not advanced enough to use these for bridge asset management yet.
drone-based plan for historic masonry repairs
Under development. Driven by our Office of Strategic Innovations/VTRC
early stages
Implementing the design model as the legal document then moving the model to construction to asset management; starting to evaluate the digital twin
we leverage the extensive storage capabilities of digital twins to host our inspection data, programming, LIDAR, smart sensor management, and even AI-based interpretation. These tools are used to enhance our performance in managing, planning, and maintaining structures. However, these initiatives remain explorator and marginal within our bridge maintenance program.
Digital twin for traffic at Seohae grand bridge
AIM Group 'M' Platform. Collecting live monitorign data from many bridges. Graphical displays. Automated alerts. Machine learning for anomaly detection.

Current use of monitoring

Q10 - Are you currently using digital method to monitor bridge or transportation network-level status? - Selected Choice



Q10_1_TEXT - Yes (please describe) - Text

Yes (please describe) - Text
only on specific bridges
On bridges with specific needs for monitoring it is used, For example bridges with damages that effect the load capacity.
As before
Traffic is monitored since over 20 years with approx. 10 Weigh-in-motion stations; the traffic load itself is monitored with traffic counters between every highway access point; monitoring solutions are used in distinct bridges with special problems, but not yet as a "netwide" application; however, a concept is ongoing to figure out a monitoring setup to equip at least one bridge in a section between two access points to cover the whole network and to cover all structure types.
SAEP. Geoportal of Lanamme, based on the visual inspection of the bridges
Not really sure what you mean by "using digital method". Health monitoring? We use multiple types of health monitoring systems.
We put sensors inside the bridge bearings to record load, and adjust the load.
Itwin Capture and Itwin Experience
Acoustic monitoring in one FRP repaired segmental bridge. Various instrumentation trialed in the Sunshine Skyway over Tampa Bay. 10 pilot bridge projects with scour monitoring
We are beginning to use BrM for asset management. Additionally, we have dashboards to monitor network-level performance of our bridge inventory.
AssetIntel InspectX
early stages
Traditional SHM, UAV, LiDAR (in tunnels), ROV, USV, Satellites (just testing)
In some cases - this appears to be more about traffic movement
Currently, there are no digital technologies in place to manage bridges at the network level, as our BIM initiatives are limited to a few pilot projects. However, the technology holds promise for the future, particularly for potential autonomous management of special permits (overweight loads) traveling on our network. The Ministry operates a mobile lab that conducts instrumentation and continuous monitoring of certain structures, mainly those with specific behavioral issues. The hosting of monitoring data will soon transition to digital twins.
We are currently using digital methods to monitor the status of our bridges. Several bridges in our network are equipped with sensors."
Monitoring system for Seohae grand bridge
YEs - it is exactly what Accolade do!
Networks are monitored

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DT definitions

- Broad range of definitions (1.5 pages of definitions):
  - From: 3D image of the bridge

Kopie des realen Bauwerks in der Planungsphase (3-D-Planung)

  - To: updated digital replica with forecasting abilities

A Digital Twin is a virtual representation of a bridge that integrates real-time data from sensors, inspections, and other monitoring systems. This digital replica allows for continuous monitoring, analysis, and simulation of the bridge's condition and performance over time. By using advanced algorithms and data analytics, a Digital Twin helps predict potential issues, and support decision-making for the bridge's lifecycle management.

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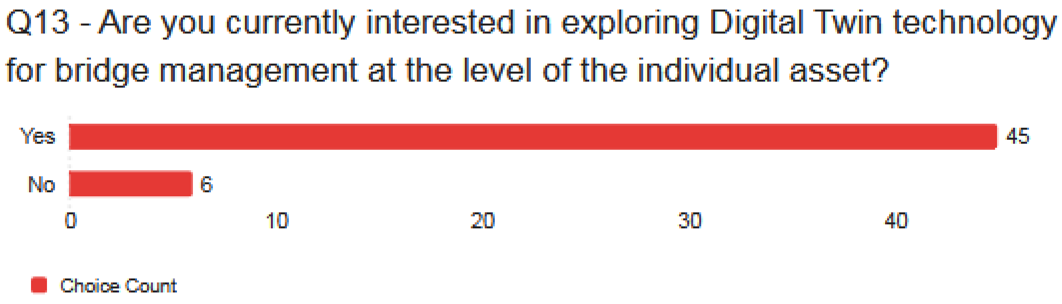
Interest in DTs



- Cited reasons for DT: better decision-making, integrate SHM, leverage design models, effectiveness, research experience, improved maintenance, LCA optimization, integration of data sources, valuable for complex assets
- Cited reasons for not: limited practical value, incomplete toolkits, complexity of integration, high cost, large number of assets

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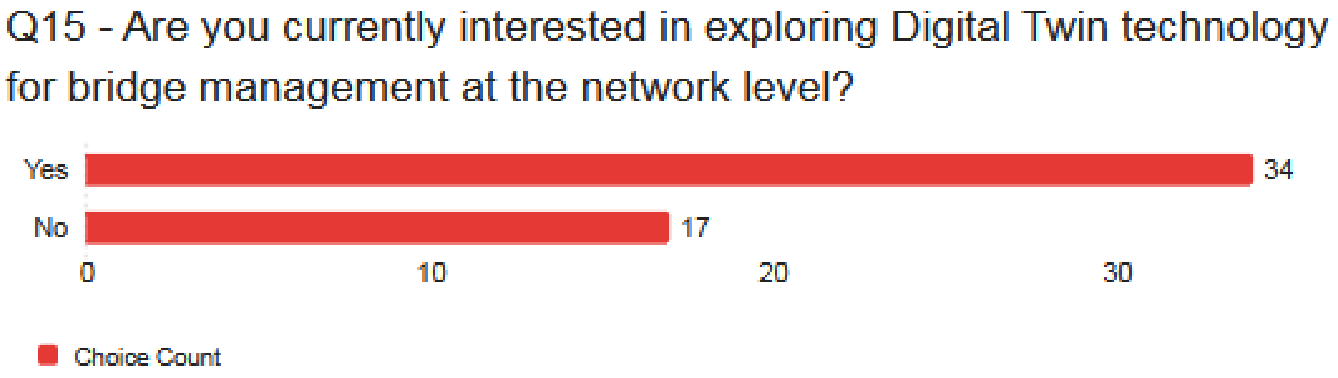
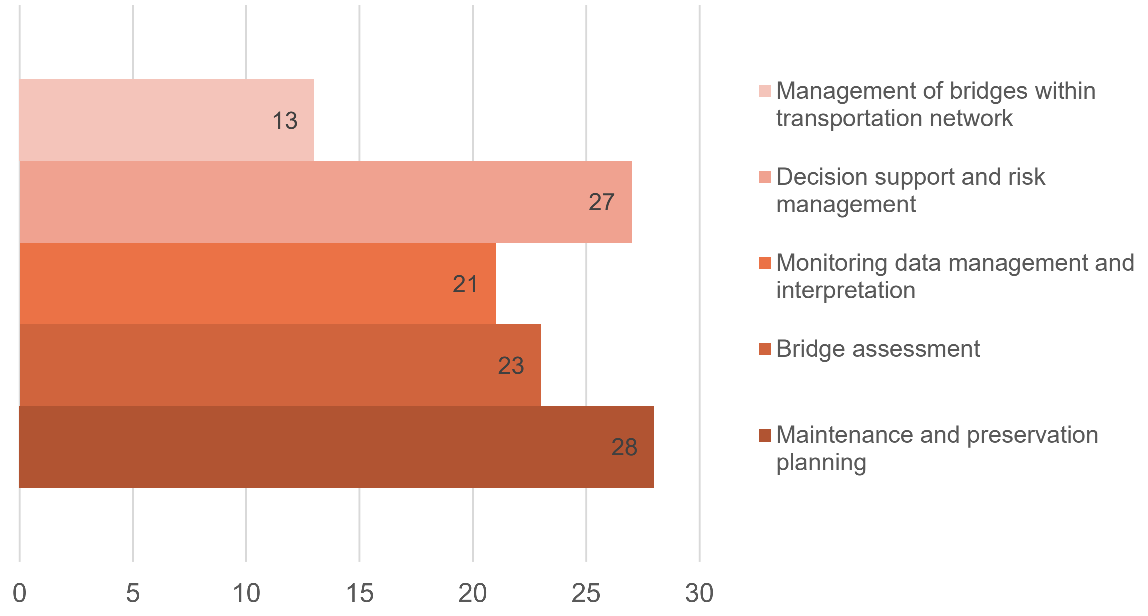
Interest for network-level



- Motivation: similar to individual asset, high representativeness, upscaling existing models, system-wide strategies for resilience
- But: perhaps not generally aplicable, network level involves even higher cost due to scale, limited practical examples, lack of Management tools

Bridge Management Challenges



Q17_6_TEXT - Other (please specify) - Text

Other (please specify) - Text
prioritizing innovations, optimizing continuous dealflow, flatten the curve in costs and demand on resources, optimizing supply and demand in circular use of bridge elements
Storage of and ownership of big-data, security and legals
Funding
Financial resources, traffic impacts
Scoping recommendations for clients
Climate change era is asking us to act differently.
Each of these areas are challenges. Developing a comprehensive data-driven statewide bridge management system
Resources and funding.
All of the above are challenges. The biggest challenge in Australia and New Zealand is to get the most out of ageing bridge stock with the levels of funding being provided from government.
R&D
All of the above to a certain degree. We have a well working process in place, but there is room for improvement in all directions.

DT to address these challenges?

- **Summary of text answers:**
- Better use of information, data integration
- Cost reduction for assessments if one DT is used for all activities
- Forecasting, analysis of scenarios, planning maintenance Works
- Visualization and communication facilitation

- Not a solution
- Data collection is still expensive
- Need for further research and pilot projects

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Necessary DT inputs

- **Summary of text answers:**
- Sensor data
- SHM output
- NDT results
- DT results
- Geospatial data
- Images (including cloud point data, UAV-collected data)
- Use AI for tracking defects
- Assessed capacities
- Design information
- Traffic loading
- Data storage considerations
- Depends on the purpose of the DT

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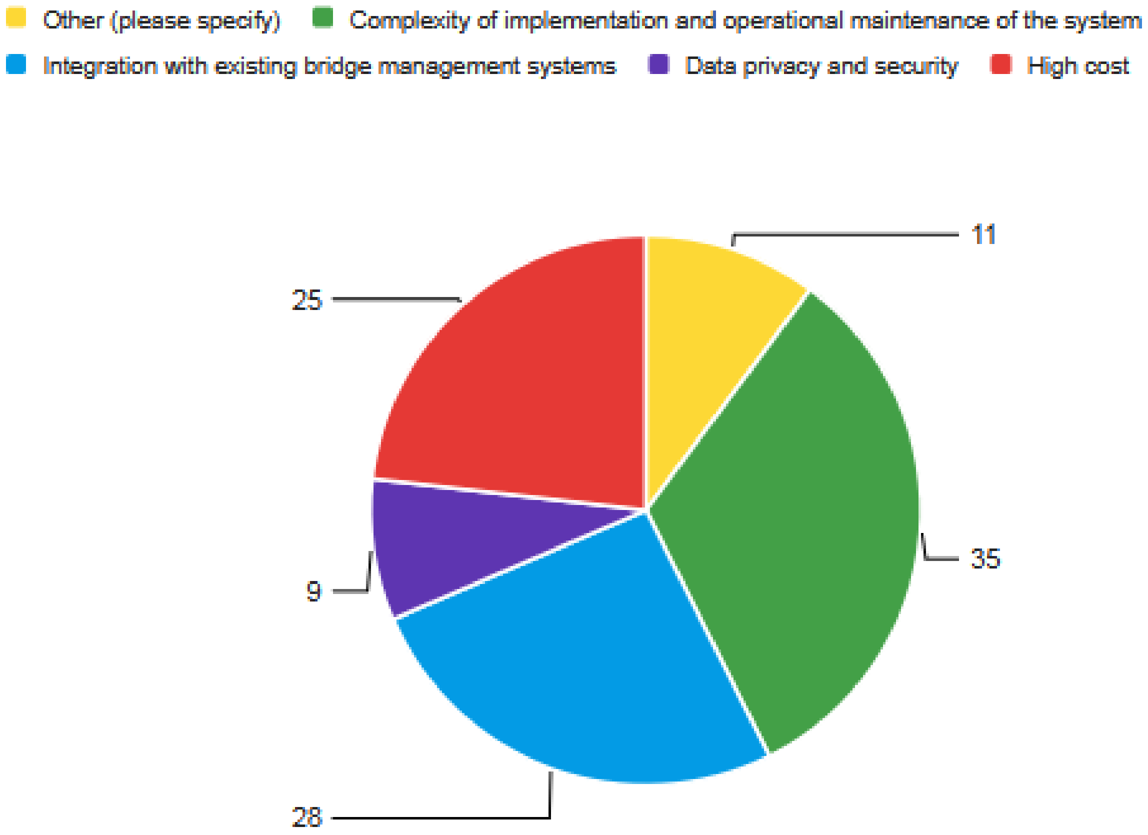
Concerns



the human factor

(Additional) ressources

Use and value of data provided.

Storage of these very large data files.

Owner acceptance.

Willingness of clients to allow/support use

Due to different type of bridges , we may have to have different types of prototypes to suite to the field conditions.

data size, purging old data that has been subject to repair but balancing with the benefit of retaining data of significance for deterioration understanding

Gathering all of the data required to make the model useful.

Resources and funding.

It's unlikely to deliver the wholistic benefits described.

Topics for the workshop

The value of Digital Twins in improving bridge performance understanding	28
Real-world case studies from other industries	28
Standardization and data formats for Digital Twins	26
Defining inputs and outputs of Digital Twin models	26
Potential for implementing Digital Twins into bridge management systems	22
Technological requirements and solutions for Digital Twin integration	22
Methodologies and frequencies for updating Digital Twin models	20
Connection to transportation network level	8
Other (please specify)	3

I'd like to hear from other asset owners that operate and maintain a digital twin.

Overcoming the marketing from certain companies - i.e. describing a static 3D laser scan or 3D model as BIM/Digital twin.a

The key aspect from an Australian and New Zealand standpoint is to demonstrate the benefits/return on investment from the implementation of a Digital Twin.

Outcomes for workshop

- **Summary of text answers:**
- Firm definitions, common and accepted view of usage of DT technology for bridges
- Defining input and outputs, including data formats and standardization
- Technology recommendations
- Best practices
- Examples
- Benefits/return on investment, efficiency and effectiveness
- Reports reflecting the topics
- Roadmap for implementation
- Industry standards

Additional input

- Consider future scenarios (many assets, limited resources) + politics, climate change, electrification of transport, economic growth/decline
- Start Digital Road Twin Forum International for organized and periodical Exchange
- Include BIM & AI in DTs
- Development of user-friendly tools
- Include SHM community for integrated approach
- Keep it practical: most owners do not have the time, manpower nor resources to digitize their assets

Eva Lantsoght

Bridging the Twins or Twinning the Bridges? **Workshop. IABMAS 2026. Orlando, Florida**

- **Who is involved?** Rolando Chacón, Necati Catbas, Basak Bektas, Rade Hajdin, Alfred Strauss
- **When?** Tentatively scheduled for July 6th, just before the conference
- **Venue:** IABMAS 2026 is assessing venue options with attention to pricing, availability, and room configuration
- **Output:** We're still shaping the core focus—what's valuable, what's interesting? This is already sparking rich debate among us.
- **Logistics:** Estimated participation is 40–60 attendees, ideally 10–15 per breakout group for active engagement
- **Breakout Sessions:** Agreed to include four of them, though we'll keep themes under wraps for now. Intended to cover a multi-scale perspective (from material to large stocks of bridges)
- **Scope:** We've agreed to focus specifically on existing bridge structures

Slovak University of Technology in Bratislava
Faculty of Civil Engineering
Department of Structural Mechanics

Bridge Load Testing and Vibration Monitoring for the Design of Stabilisation and Protection of the Piers of the Railway Bridge

Assoc. prof., M. Eng. Michal VENGLAR, PhD.

Agenda

+ Subject of the campaign
+ Brief description of the bridge
+ Measurement of accelerations
    Operational modal analysis
    Analysis of response of piers
+ Measurement of dynamic displacements
+ Conclusion

SLOVENSKÁ TECHNICKÁ
UNIVERZITA V BRATISLAVE
STAVEBNÁ FAKULTA

Subject of the campaign

To prepare background documents for the design of stabilisation and protection of the piers founded in the river

+ Measurement of accelerations

  Provides data on the dynamic properties of the bridge

+ Ambient Vibration

  Monitoring of ambient vibrations of the bridge

+ Radar Displacement Measurement

  Accurate tracking of movements and deformations during the train passage

Location and total length of the bridge

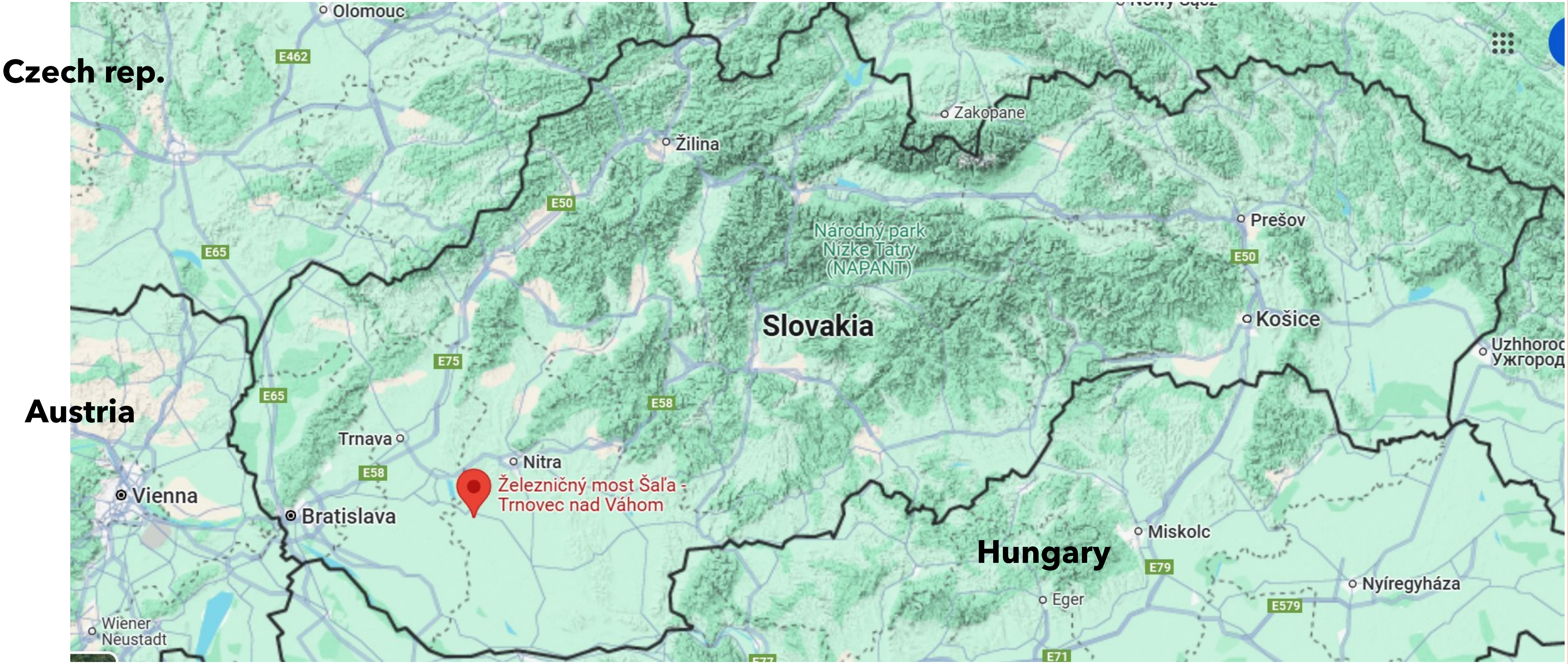
+ Location of the bridge

  Station 117.748 km of track no. 130

+ Bridging:

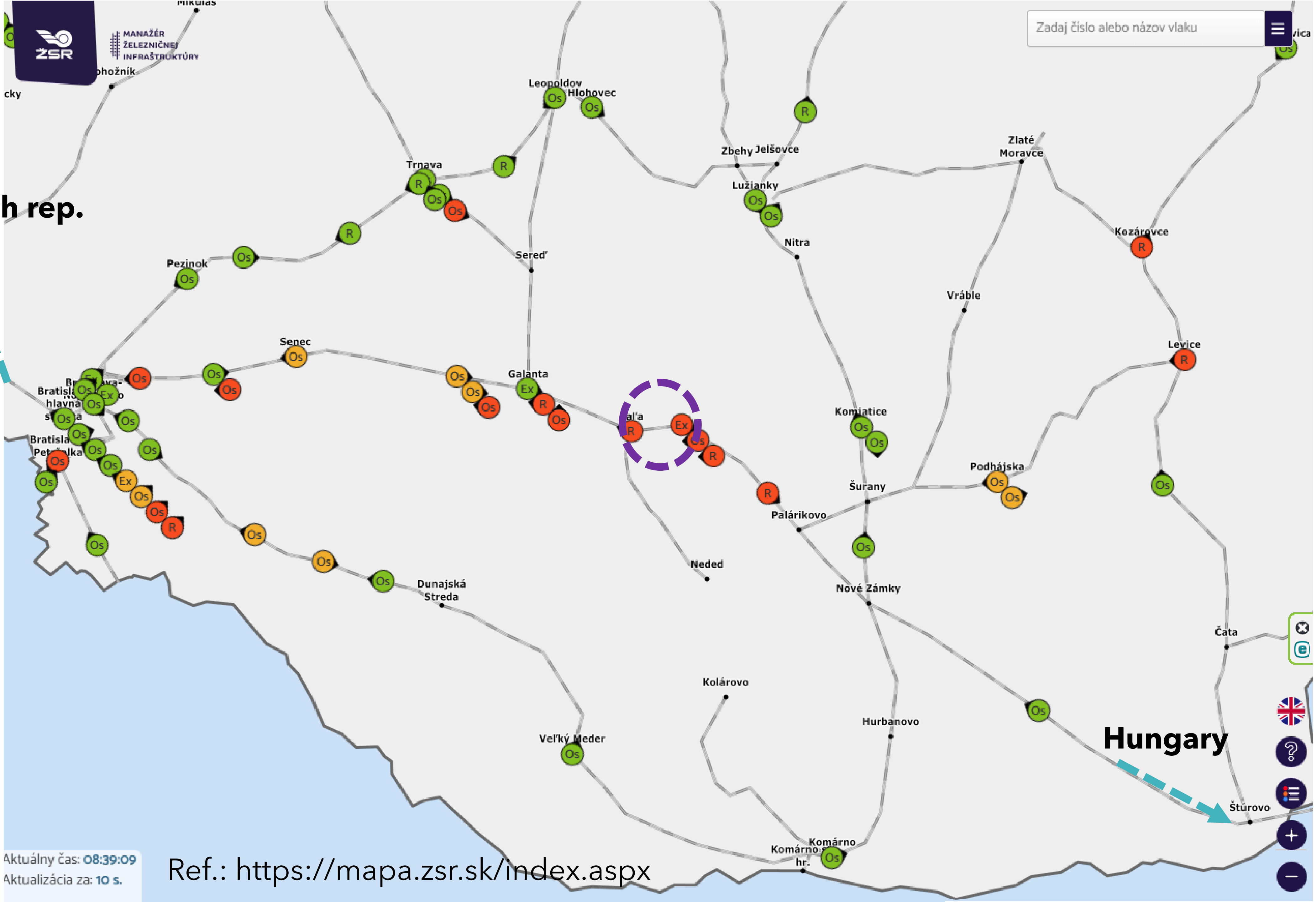
  Field road, Váh River, inundation area, utility road

  Total length 455.75 m



Ref.: https://maps.google.com

Czech rep.



Hungary

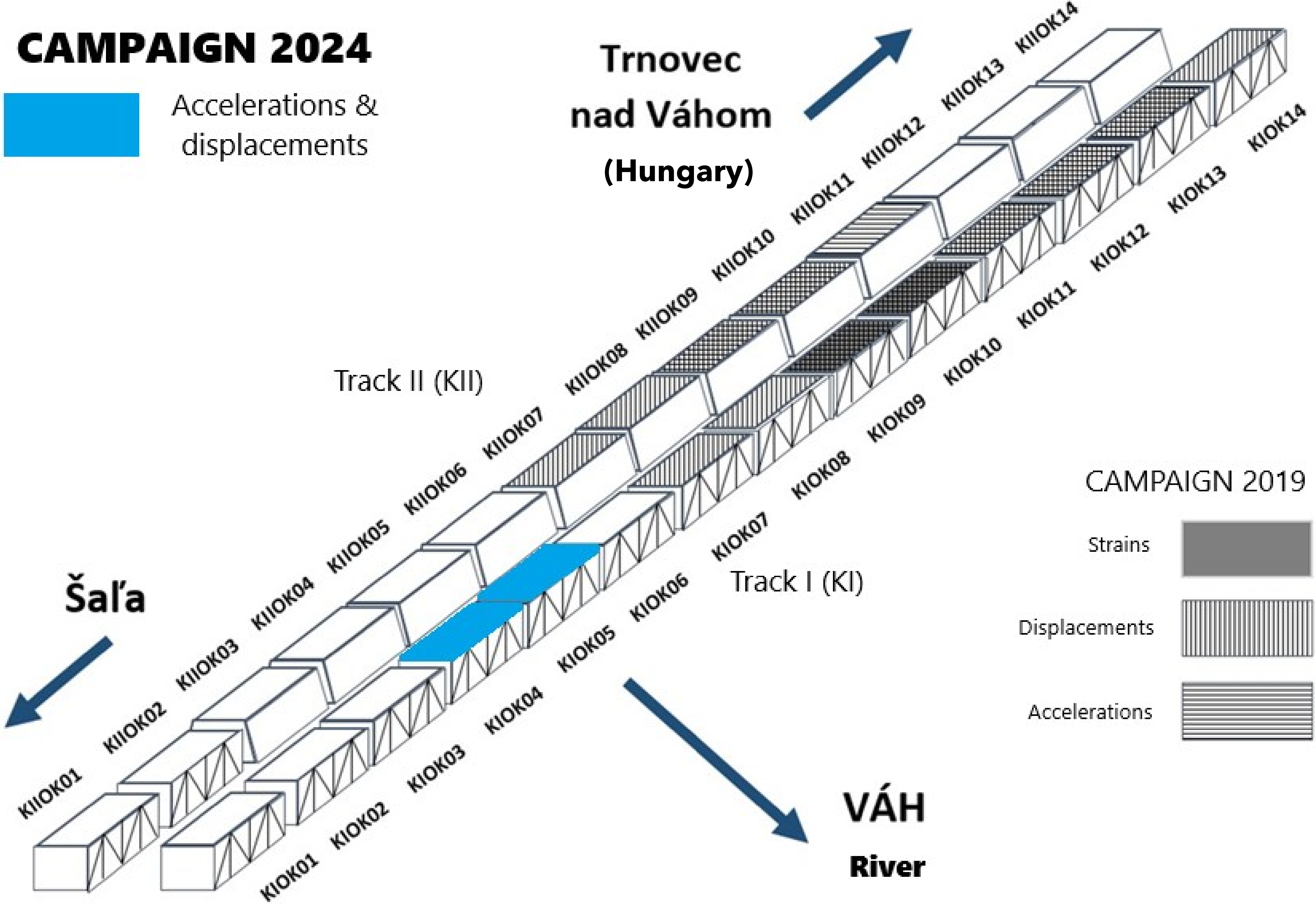
Ref.: https://mapa.zsr.sk/index.aspx

SLOVENSKÁ TECHNICKÁ UNIVERZITA V BRATISLAVE
STAVEBNÁ FAKULTA
STU SvF

Scheme of steel bridge structures

SLOVENSKÁ TECHNICKÁ
UNIVERZITA V BRATISLAVE
STAVEBNÁ FAKULTA

STU
SvF



CAMPAIGN 2024
Accelerations & displacements
Trnovec nad Váhom (Hungary)
Track II (KII)
KIIOK01
KIIOK02
KIIOK03
KIIOK04
KIIOK05
KIIOK06
KIIOK07
KIIOK08
KIIOK09
KIIOK10
KIIOK11
KIIOK12
KIIOK13
KIIOK14
Šaľa
Track I (KI)
KIOK01
KIOK02
KIOK03
KIOK04
KIOK05
KIOK06
KIOK07
KIOK08
KIOK09
KIOK10
KIOK11
KIOK12
KIOK13
KIOK14
CAMPAIGN 2019
Strains
Displacements
Accelerations
VÁH
River

Brief description of the bridge

- The track KI consists of 14 truss single-span bridge structures

  The span of the bridge structures is 31.3 m

  Each bridge structure is divided into 10 trusses
- The cross-sectional dimensions of all elements are unchanged

  The structures have a recessed bridge deck with a flat bearing of the bridge decks
- Main beams

  Both main beams are the same

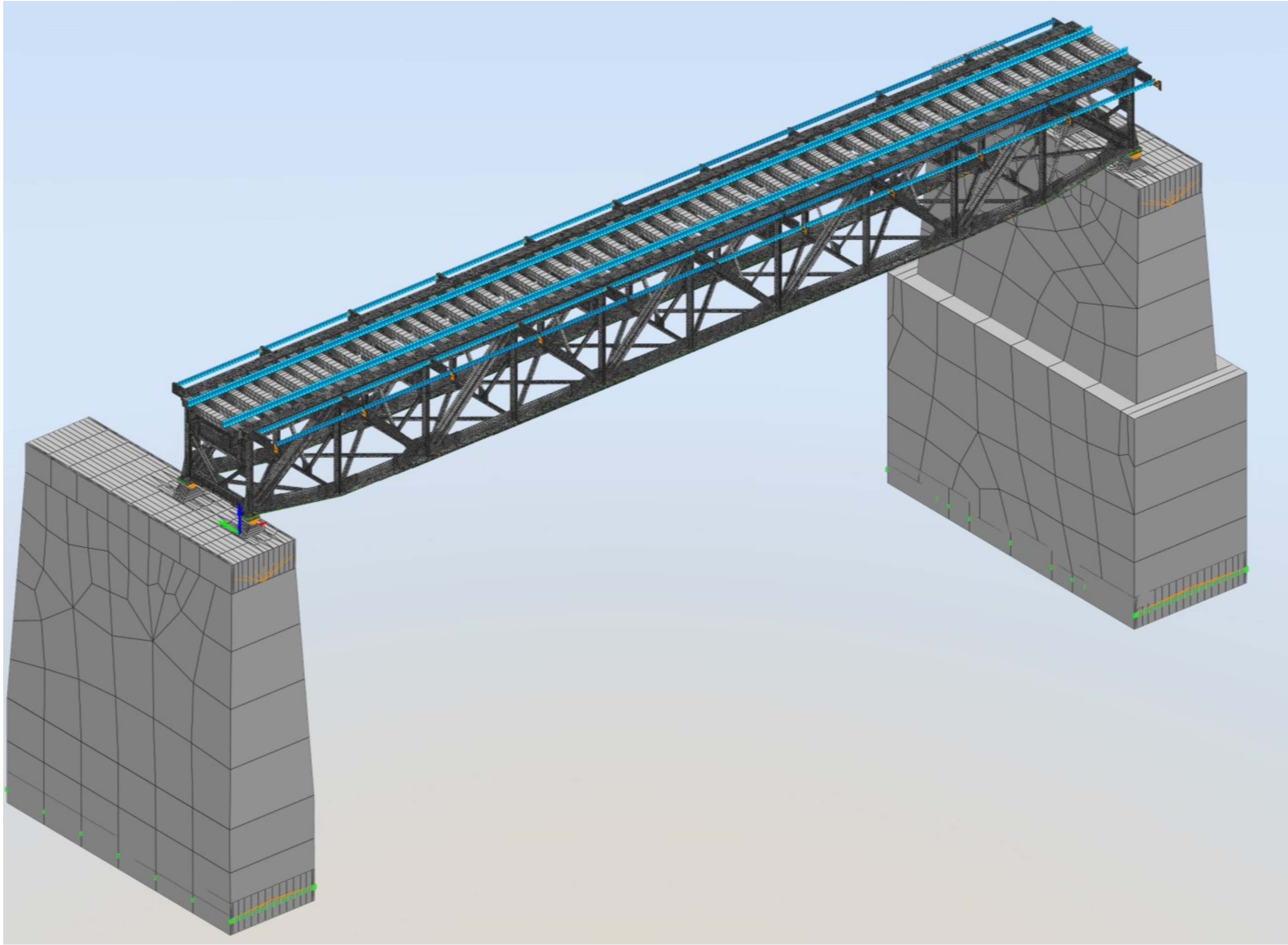
  They consist of ten lattice fields

  The axial distance of the main beams is 2.6 m

  The axial distance between the bottom and upper chord is 3.18 m

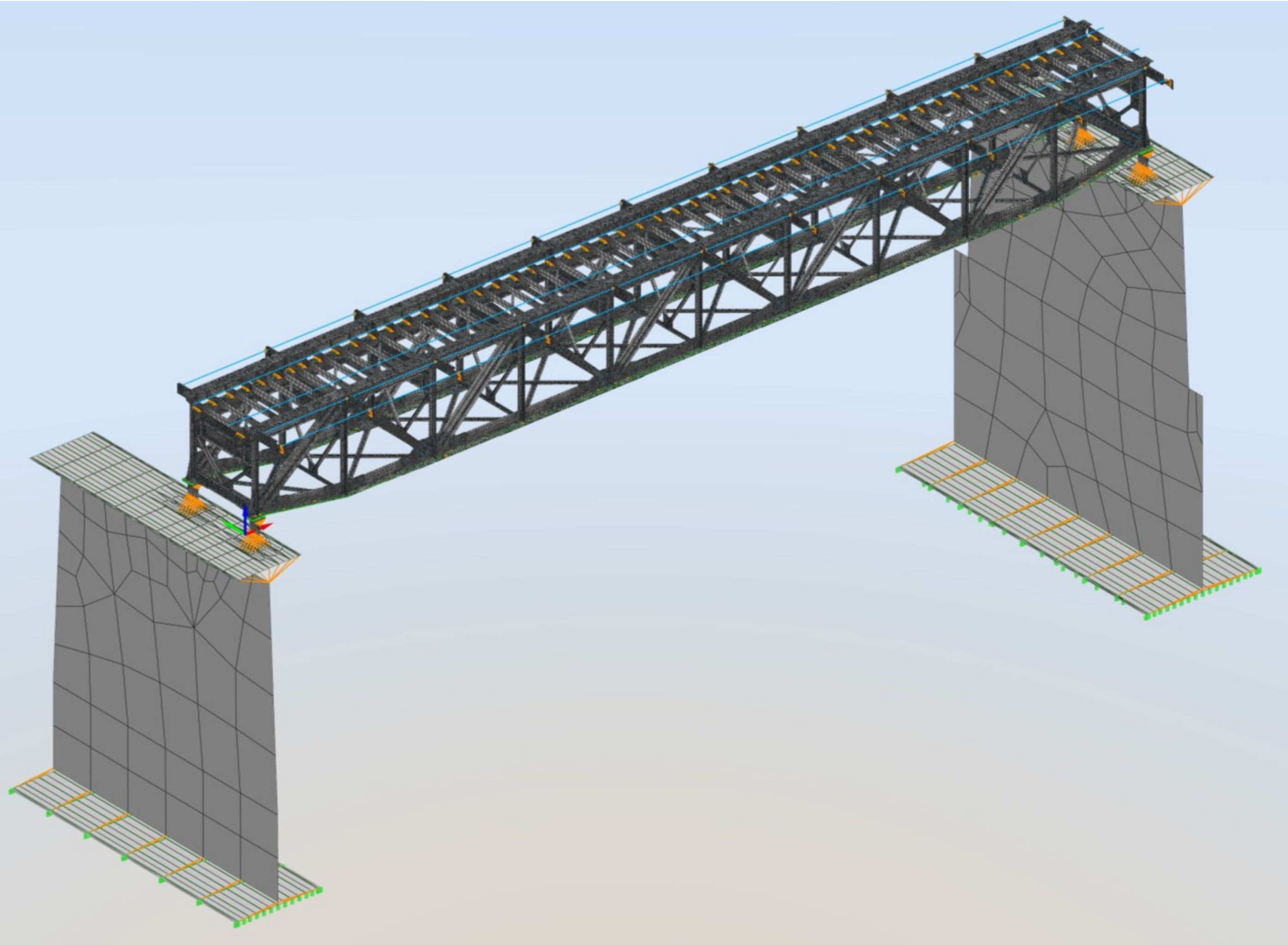
FEM model

+ Rendered model of the one structure on the track KI
+ Very detailed
+ Piers were also modelled



FEM model

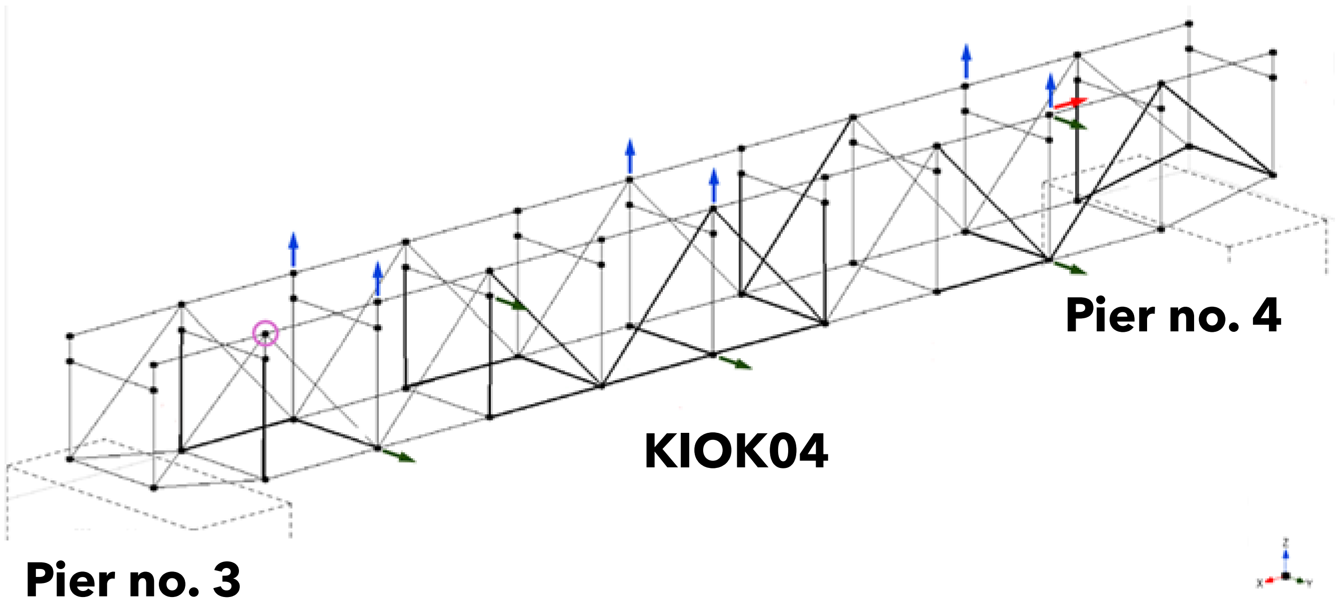
+ Analytical view
+ Modal analysis were done
+ It was not used as a base for measurements



Measurement of accelerations

+ Placement of acceleration sensors

  Totally, 32 sensors for **KIOK04**, KIOK05 , Pier no. 2 and Pier no. 4



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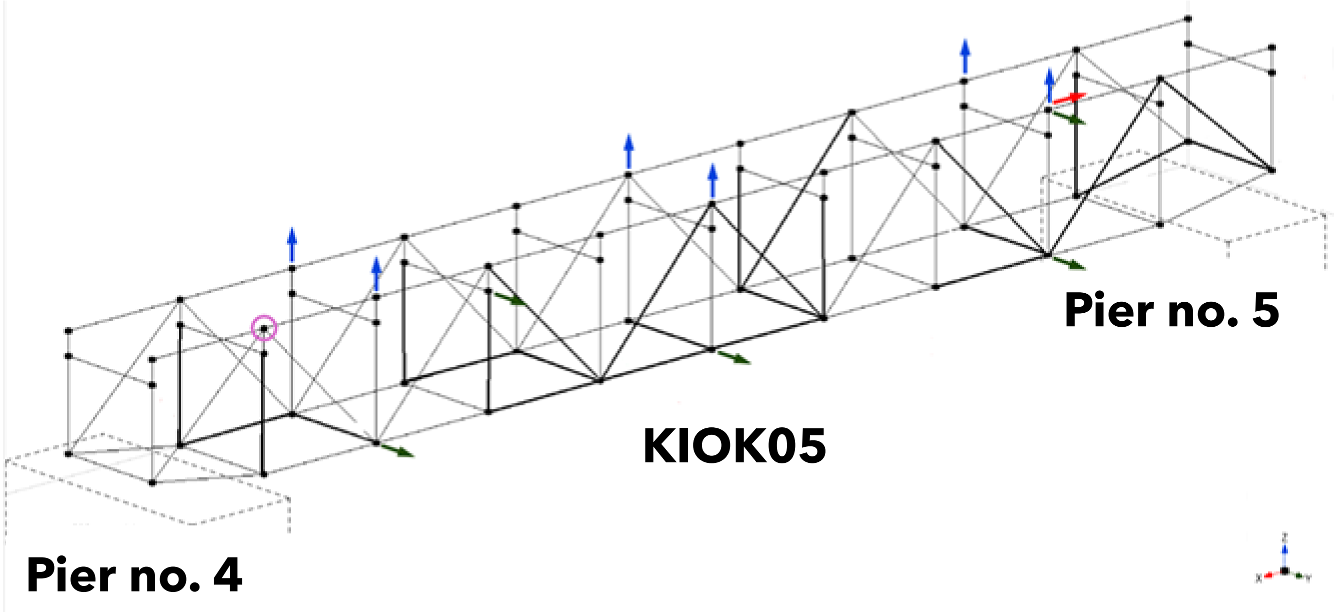
Measurement of accelerations

+ Placement of acceleration sensors

  Totally, 32 sensors for KIOK04, **KIOK05**, Pier no. 2 and Pier no. 4



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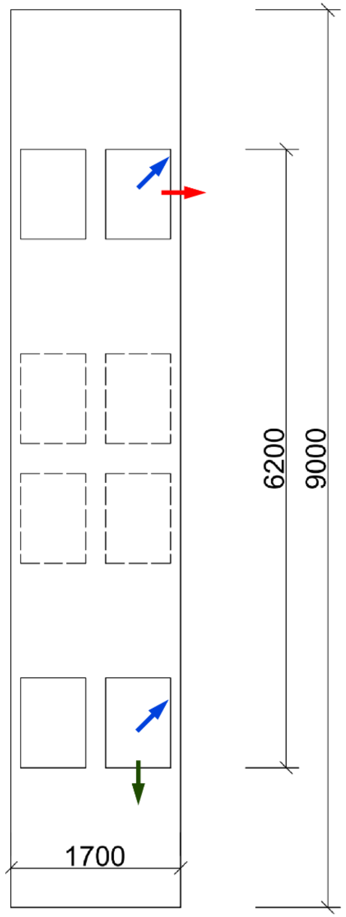
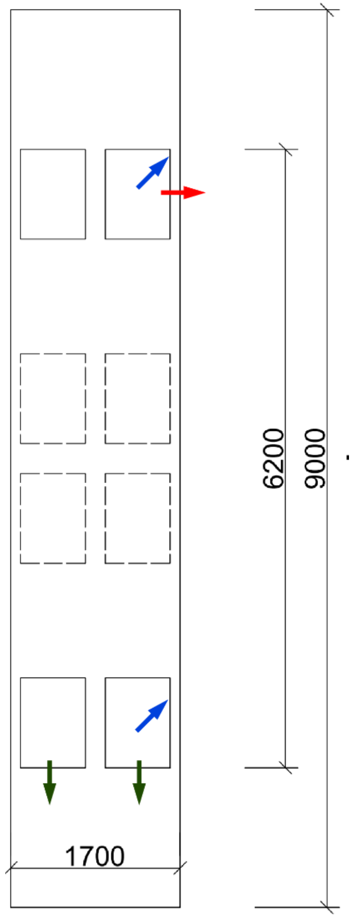
Measurement of accelerations

+ Placement of acceleration sensors

  Totally, 32 sensors for KIOK04, KIOK05 , **Pier no. 2** and **Pier no. 4**

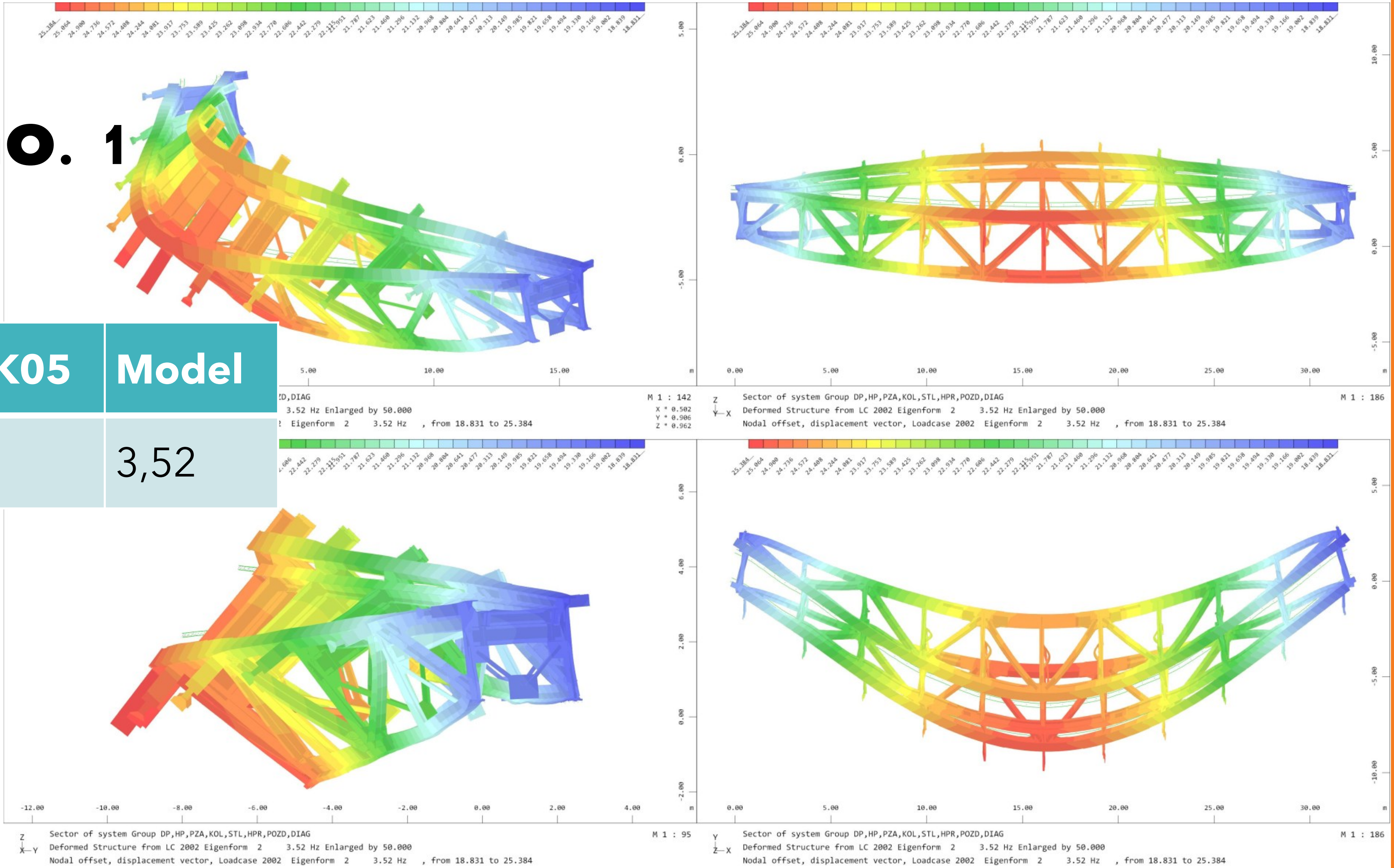


Pier no. 2



Pier no. 4

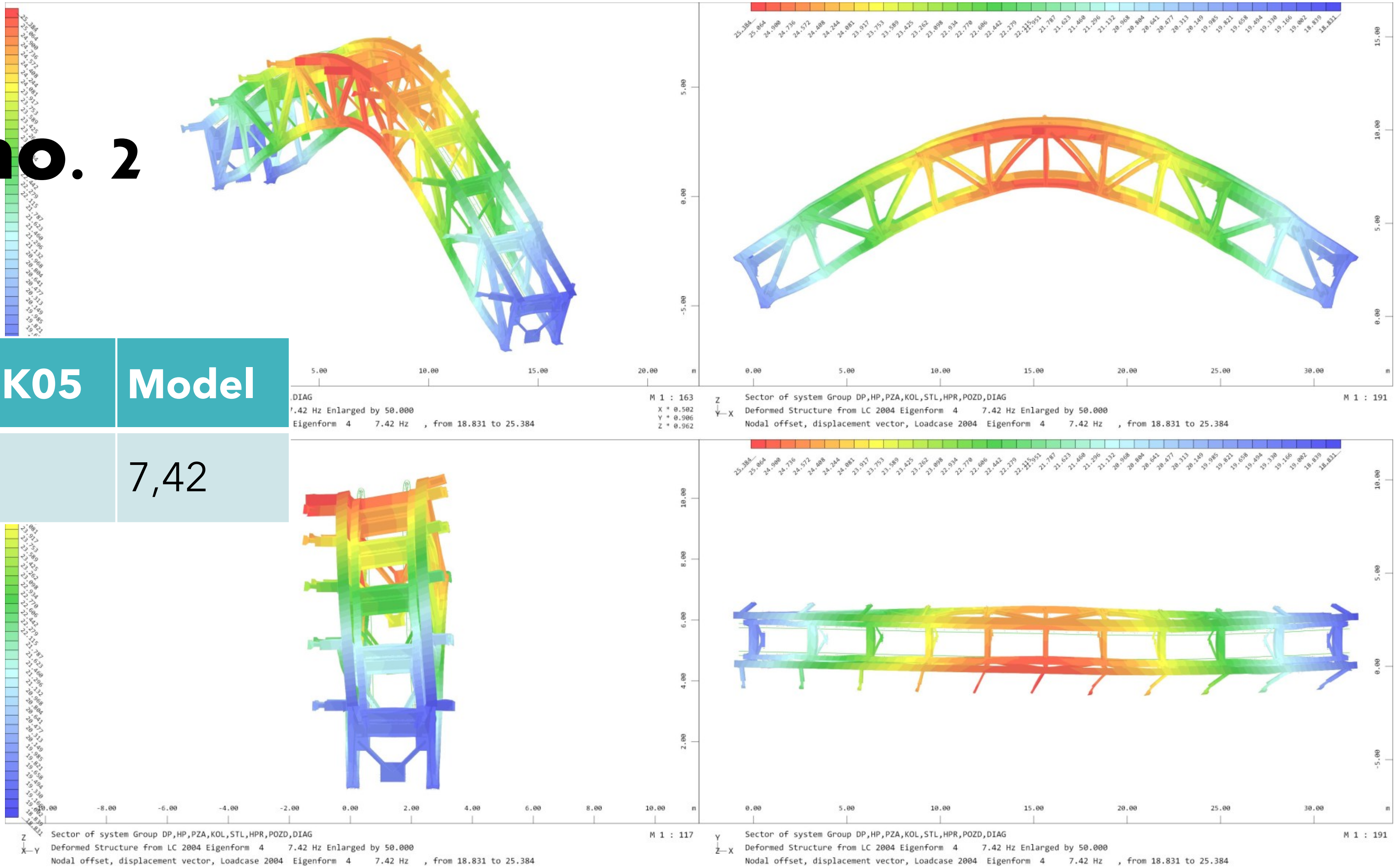
Mode shape no. 1



	KIOK04	KIOK05	Model
f_i [Hz]	3,36	3,43	3,52

Horizontal vibration

Mode shape no. 2

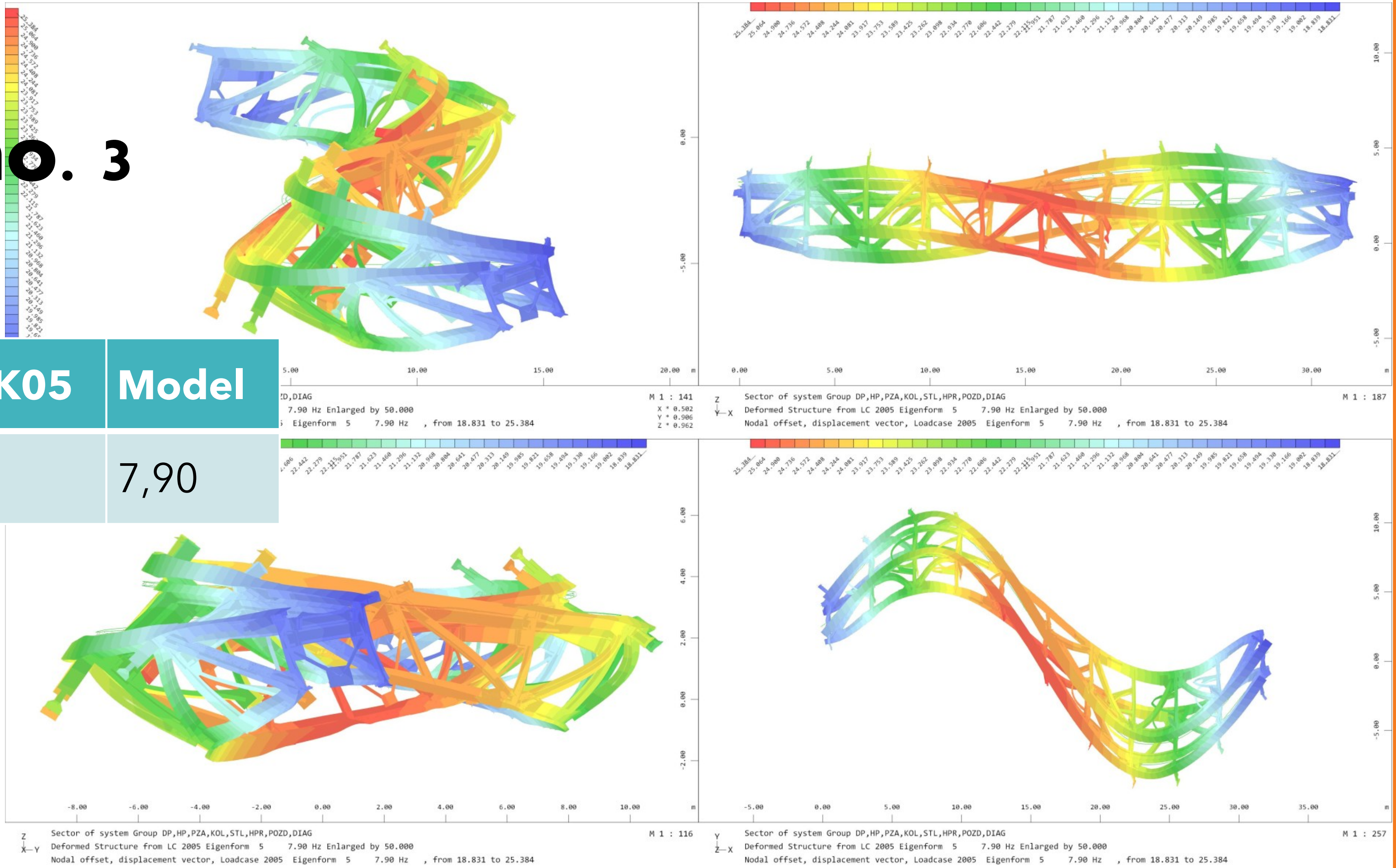


	KIOK04	KIOK05	Model
f_i [Hz]	7,42	7,51	7,42

Vertical vibration

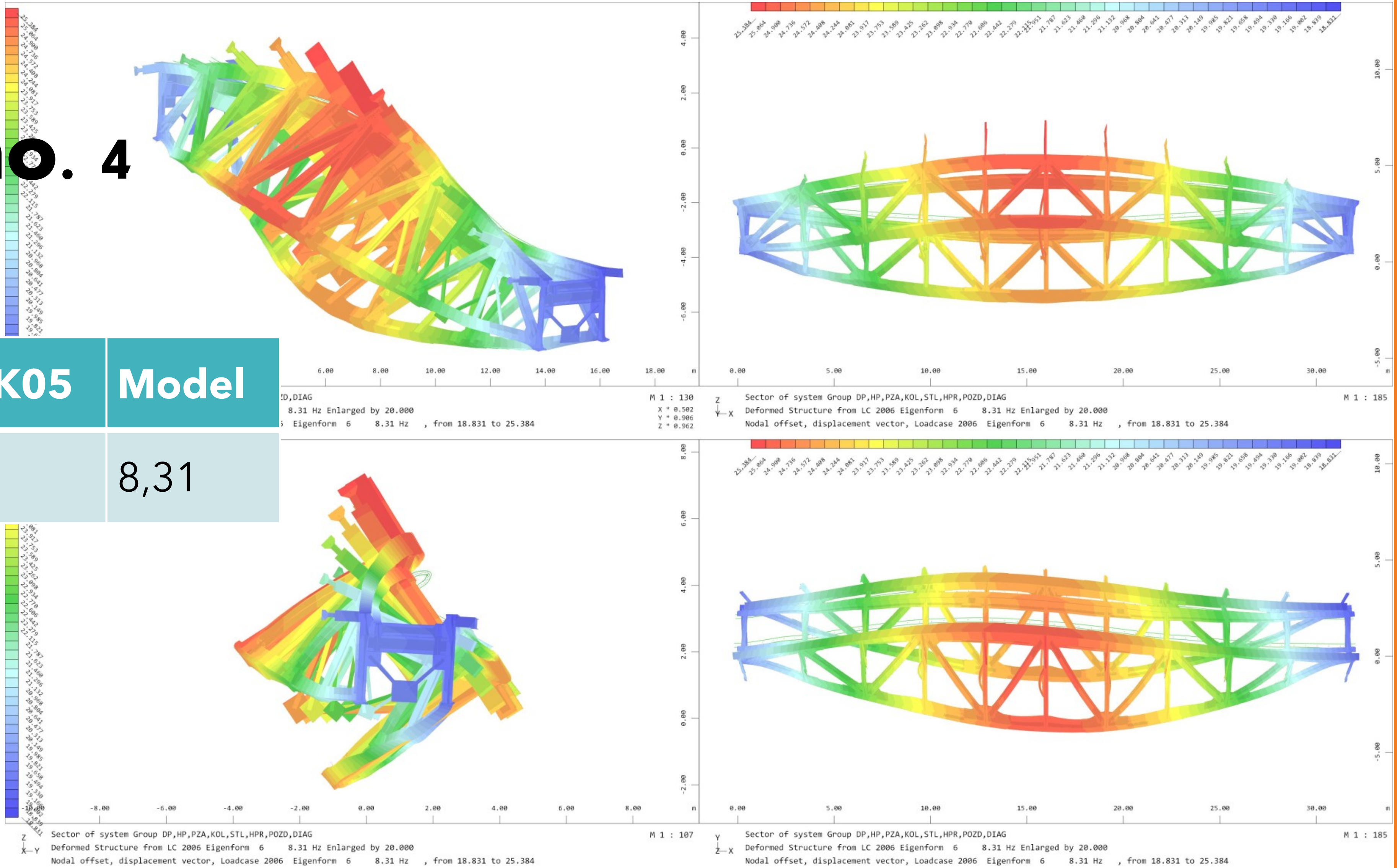
Mode shape no. 3

	KIOK04	KIOK05	Model
f_i [Hz]	8,50	8,27	7,90



Horizontal vibration

Mode shape no. 4

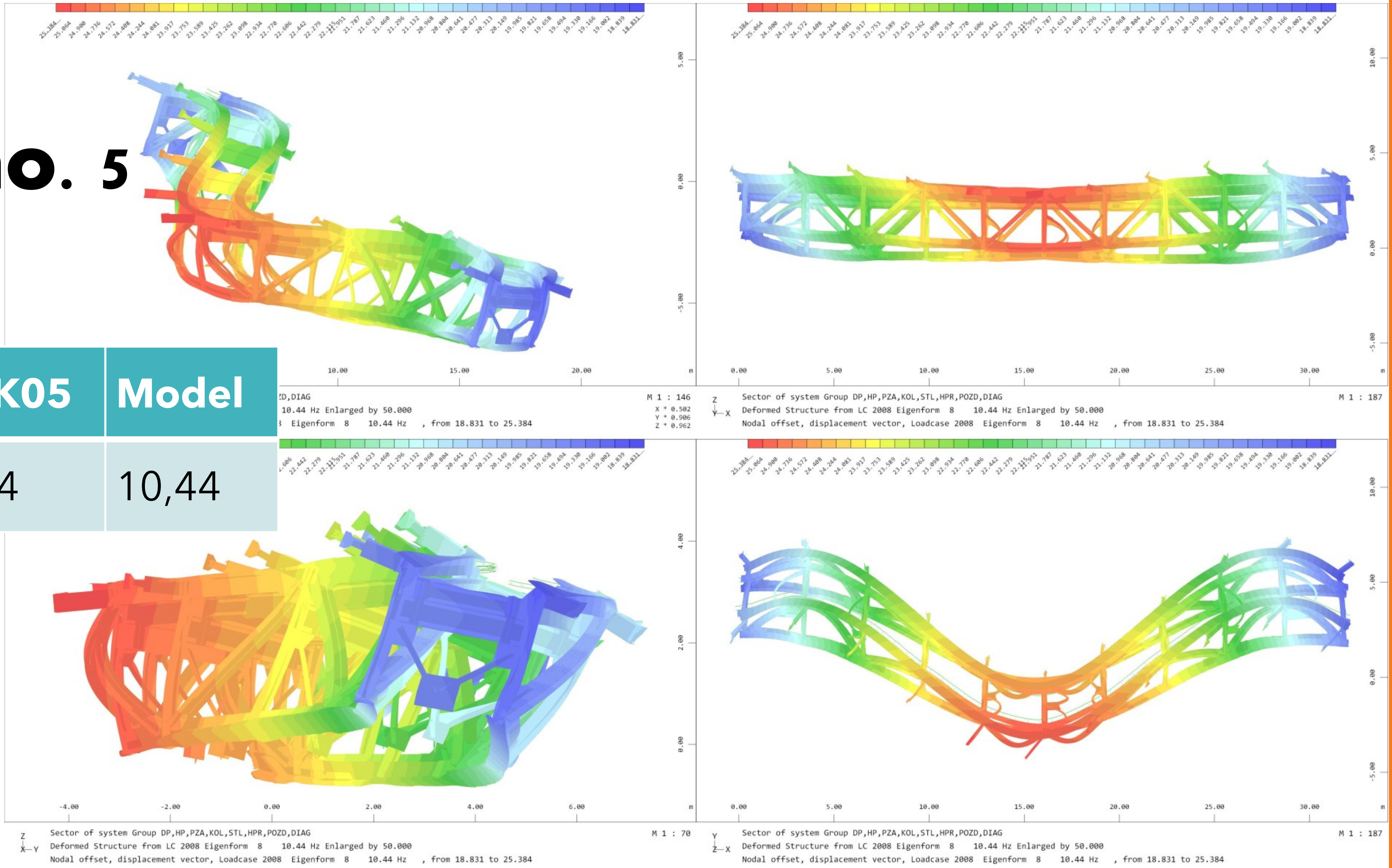


	KIOK04	KIOK05	Model
f_i [Hz]	9,17	9,06	8,31

Torsional vibration

Mode shape no. 5

	KIOK04	KIOK05	Model
f_i [Hz]	12,93	12,94	10,44



Horizontal vibration

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Comparison of identified eigenfrequencies f_i [Hz] for the structures (on track KI) from measurements in 2024 and 2019

MODE SHAPE NO.	2024		2019				
i	KIOK 04	KIOK 05	KIOK 09	KIOK 10	KIOK 11	KIOK 12	KIOK 13
1	3,4	3,4	3,6	3,6	3,3	3,6	3,5
2	7,4	7,5	7,8	7,8	7,7	7,7	7,8
3	8,5	8,3	8,7	8,4	8,1	8,4	8,4
4	9,2	9,1	9,5	9,5	9,2	9,3	9,4
5	12,9	12,9	13,6	13,9	13,1	13,6	13,4

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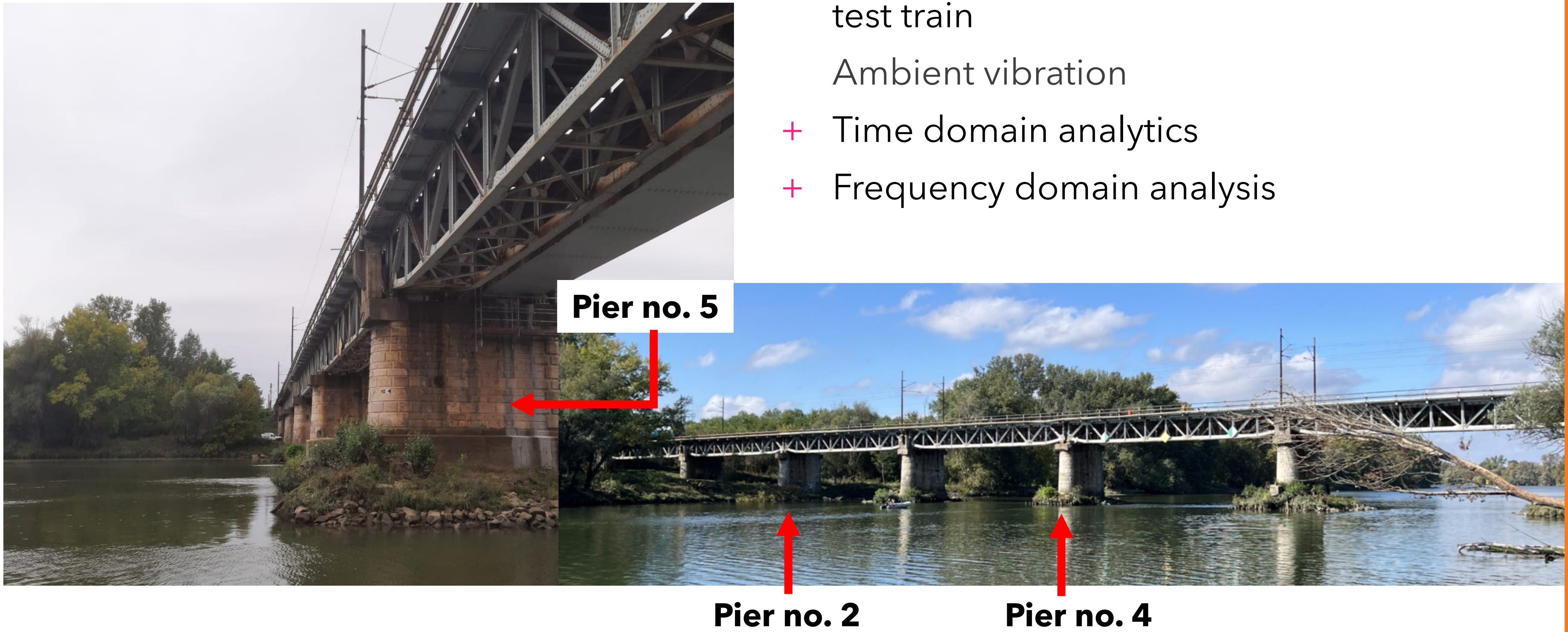
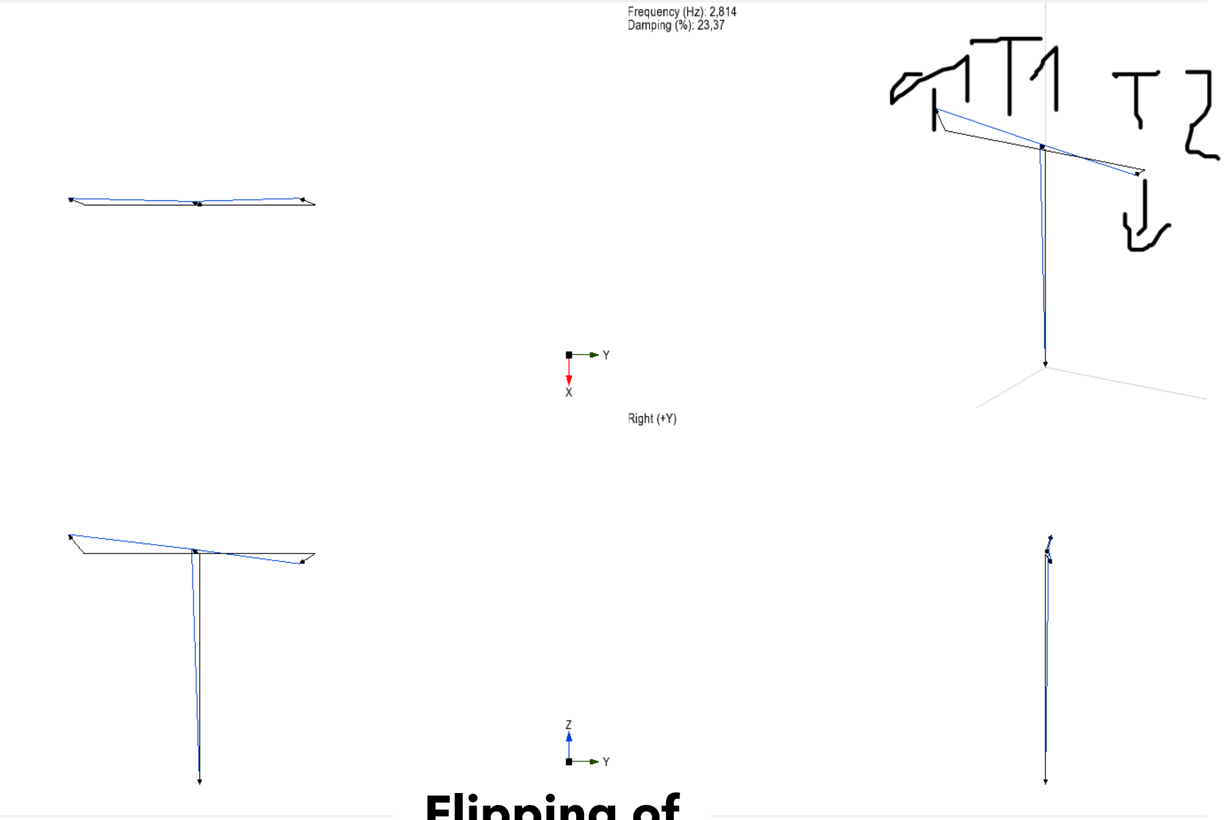
Piers



- Pier no. 2 & Pier no. 4
- Records during the passages of the test train

  Ambient vibration
- Time domain analytics
- Frequency domain analysis

Piers



Flipping of the pier

+ Greater amplitudes at Pier no. 4

  Extra Frequency around 2.8 Hz

+ Vibration on Pier 2

  Identified frequency together with the upper structure above 3.2 Hz

+ Comparison of the vibration of KIOK05 and Pier no. 4

  Frequency around 2.8 Hz: vibration of the KIOK05 and Pier no. 4 together

  First natural frequency of 3.4 Hz: vibration of the KIOK05 only

  At 3.4 Hz, there was no flipping Pillar4

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Measurement of displacements

+ Use of the IBIS-S interferometric radar

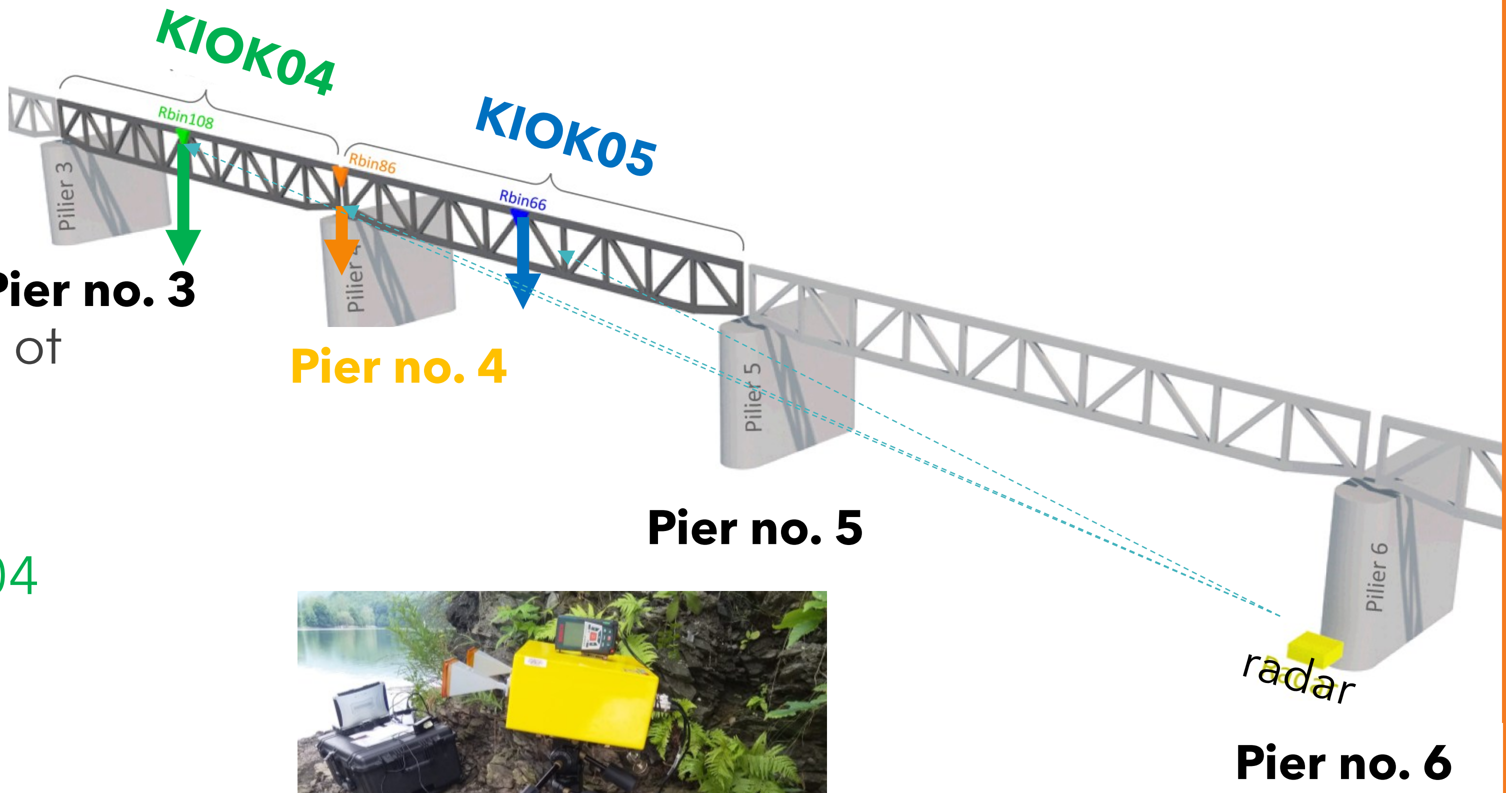
  Comparing the phase shift of electromagnetic waves

+ Device Placement

  At Pillar 6, aiming at KIOK04 (Span no. 4) and KIOK05 (Span no. 5) and Pier no. 4

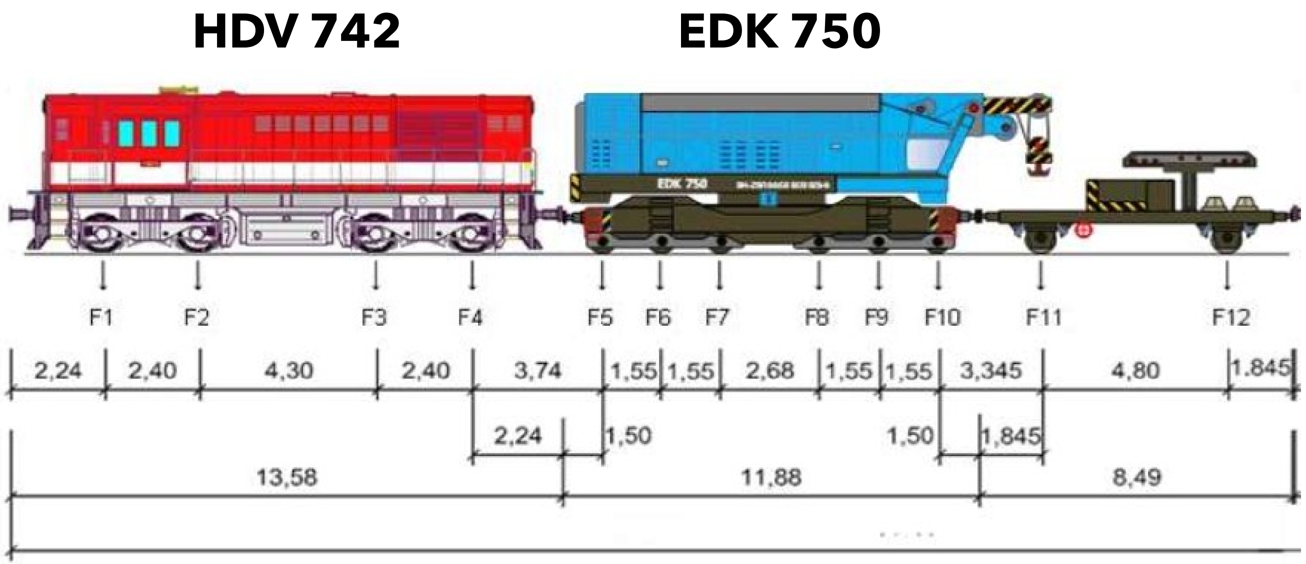
+ Dynamic Mode

  Sampling rate 200 Hz



Description of test train „TT"

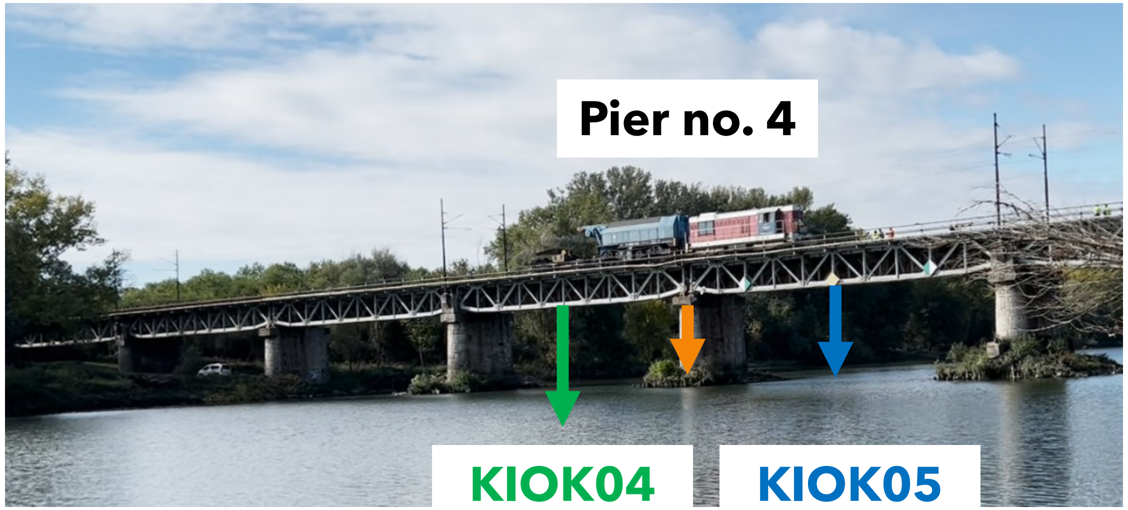
+ Test train „TT"
  - Locomotive HDV 742
  - Crane EDK 750
+ Total weight
  - 216 tons (64 tons + 152 tons)



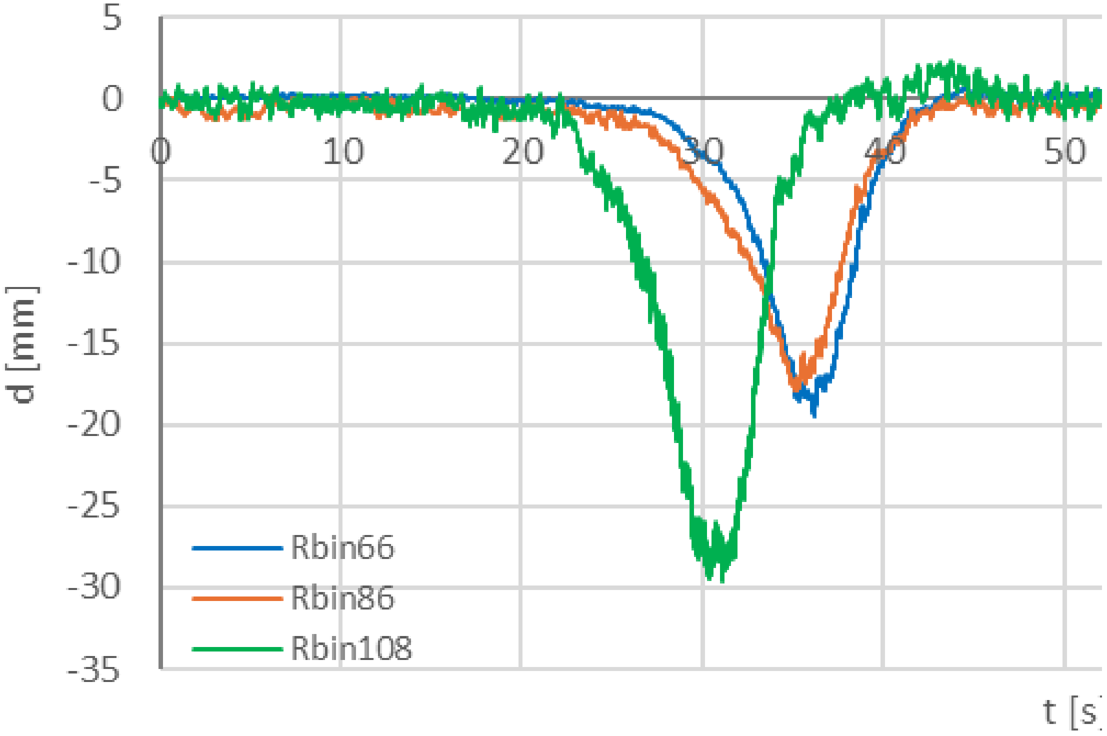
Test Train Passages

Number	Expected Speed [km/h]	Direction	Real speed [km/h]
TT01	10	Š→T	12,5
TT02	10	T→Š	11,3
TT03	20	Š→T	20,9
TT04	30	T→Š	30,1
TT05	30 + braking	Š→T	-
TT06	30 + braking	T→Š	-

Displacements from test train passages



ŠAĽA Train passage TT03 TRNOVEC



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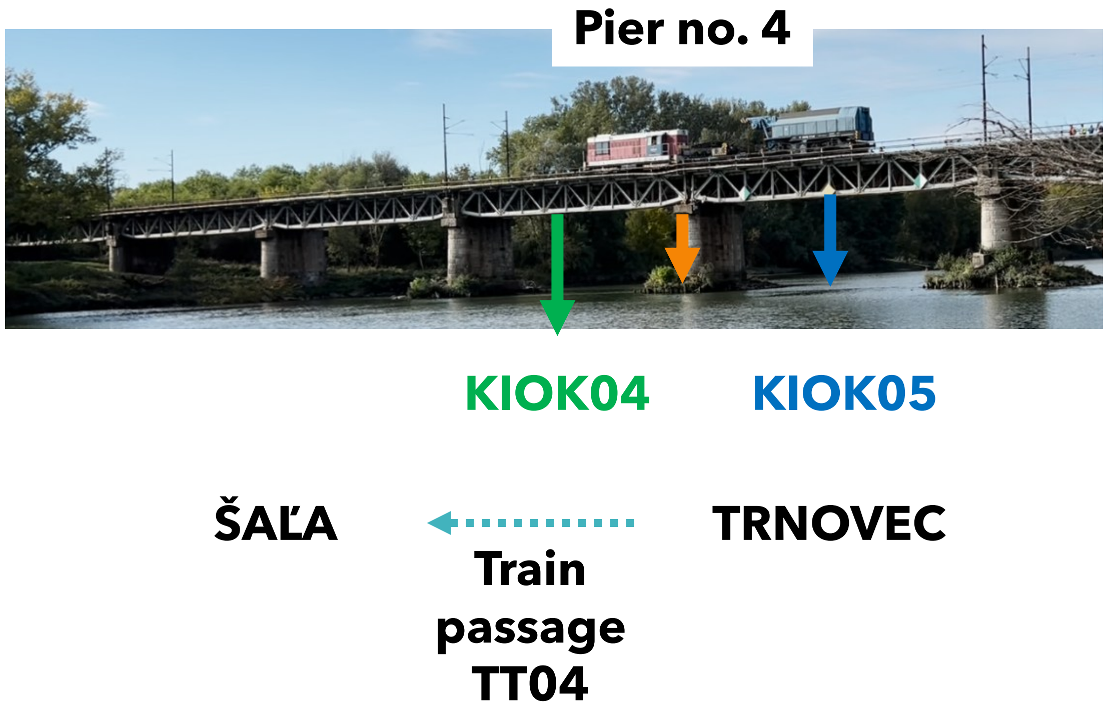
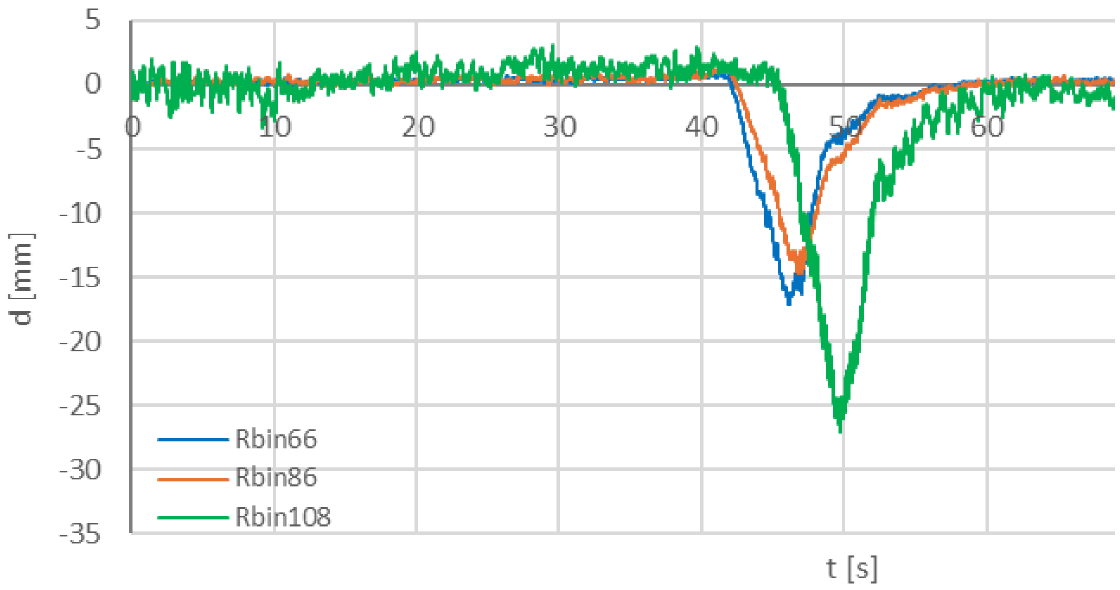
Displacements from test train passages





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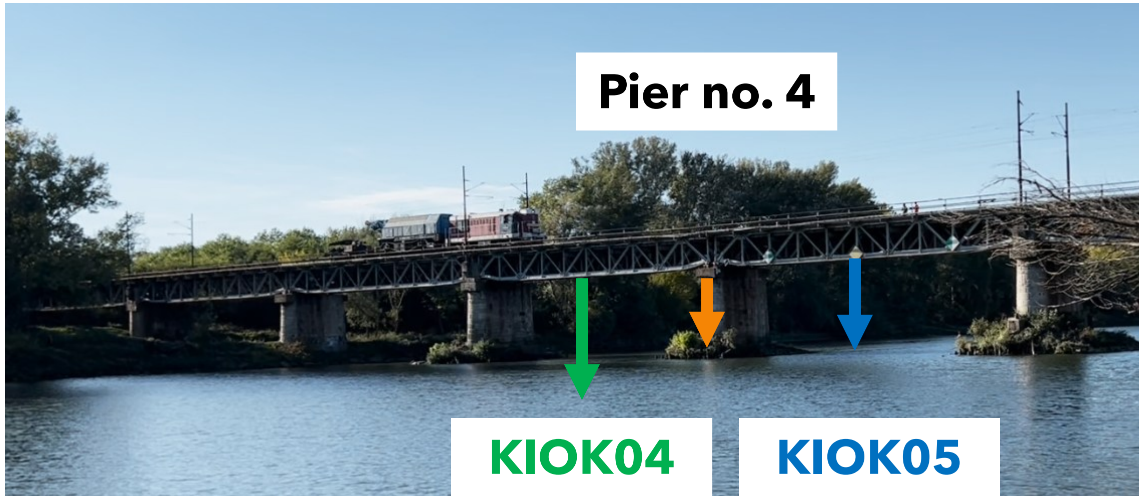
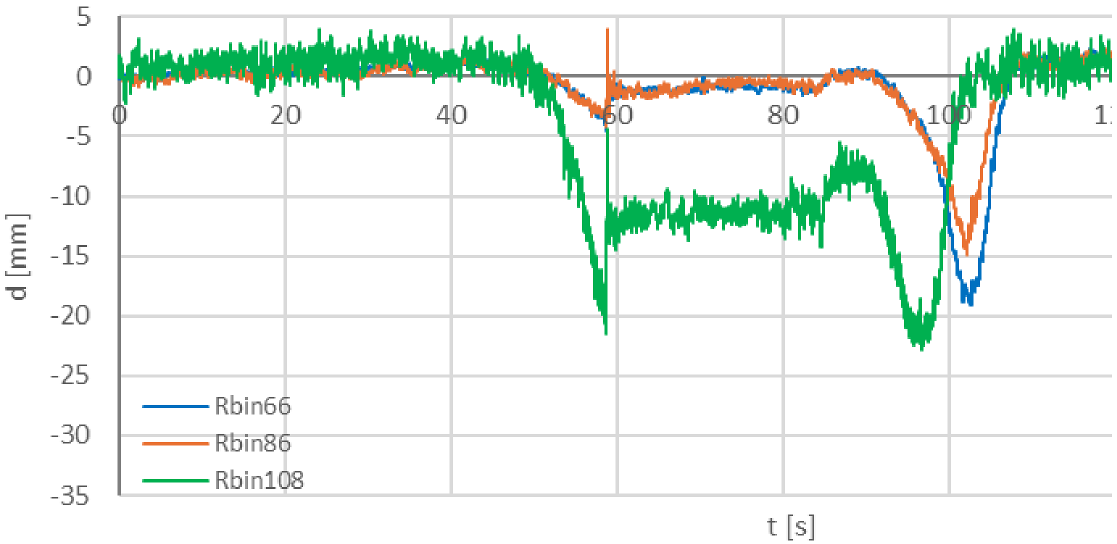
STU SvF

Displacements from test train passages



ŠAĽA → **TRNOVEC**

Train passage TT05



Dynamic Amplification Factor (DAF)

+ Dependence of DAF on the speed of the passage

Number	Direction	Speed [km/h]	KIOK05 Rbin66	Pier no. 4 Rbin86	KIOK04 Rbin108
TT01	Š→T	12,5	1,04	1,03	1,05
TT02	T→Š	11,3	1,02	1,02	1,03
TT03	Š→T	20,9	1,08	1,05	1,06
TT04	T→Š	30,1	1,07	1,06	1,10

Conclusion

- Not recommended an increase in the maximum speed of trains

  Increased DAF at higher speeds

  Negative impact on the behaviour of the structure of the Pier no. 4

- **Further measurements after the KII track is put into operation**

  Occurrence of two trains over Pier no. 3 or Pier no. 4

Thank you for your attention

+ Main responsibility and acceleration measurements: **Michal Venglar**, STUBA, FCE, DSM
+ Numerical modelling: **Kamil Laco**, Con-IS s.r.o., STUBA, FCE, DCSB
+ Displacement measurements: **Katarina Lamperova**, STUBA, FCE, DSM
+ Analysis of piers: **Marian Sykora** & **Daniel Beutelhauser**, STUBA, FCE, DSM

+ If you have any questions, please do not hesitate to contact us

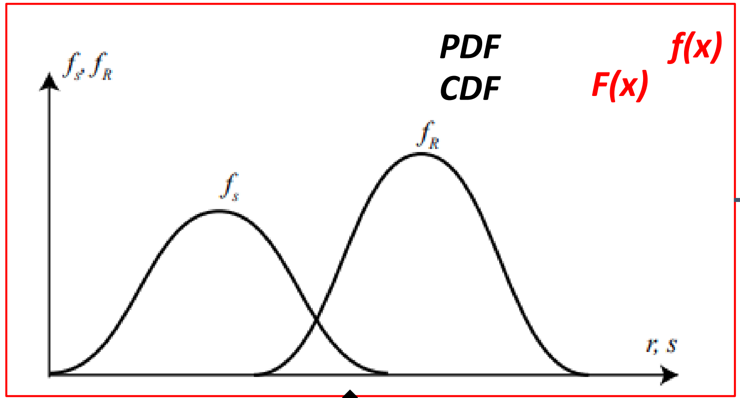
PROOF LOAD TESTING
OF PRESTRESSED CONCRETE (PC) I-GIRDER DECK BRIDGES

Gianmarco Addonizio, **Daniele Losanno**, *Eva O.L. Lantsoght, Joan R. Casas*

16 April 2025

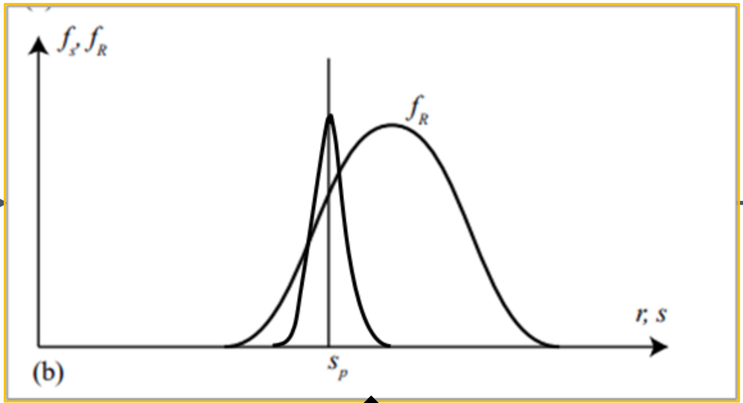
*SIMPLIFIED MODEL R-S: Conditioning of the residual capacity distribution**

Prior



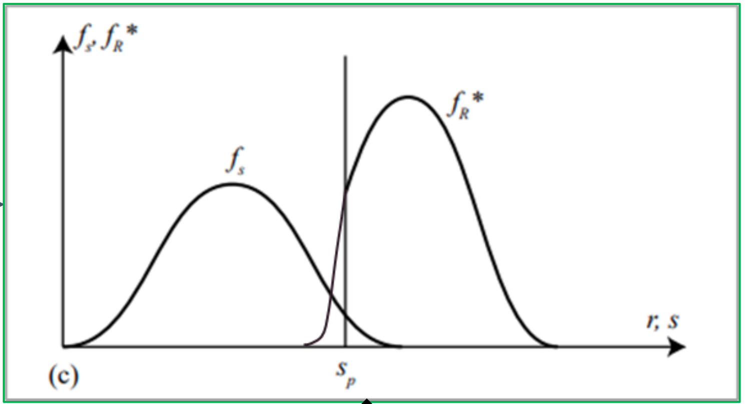
$P_{f,\xi,before} \quad (\Delta t = 1yr)$
$= P\left[\boldsymbol{\theta_R} \cdot \boldsymbol{R_\xi} - \boldsymbol{\theta_E} \cdot \left(\boldsymbol{D} + \boldsymbol{TL_{1yr}}\right) \leq 0\right]$

During proof load test



$\boldsymbol{P_{f\_during}} = \boldsymbol{P_f}(\mathbf{R} - \mathbf{s_p} < \mathbf{0})$

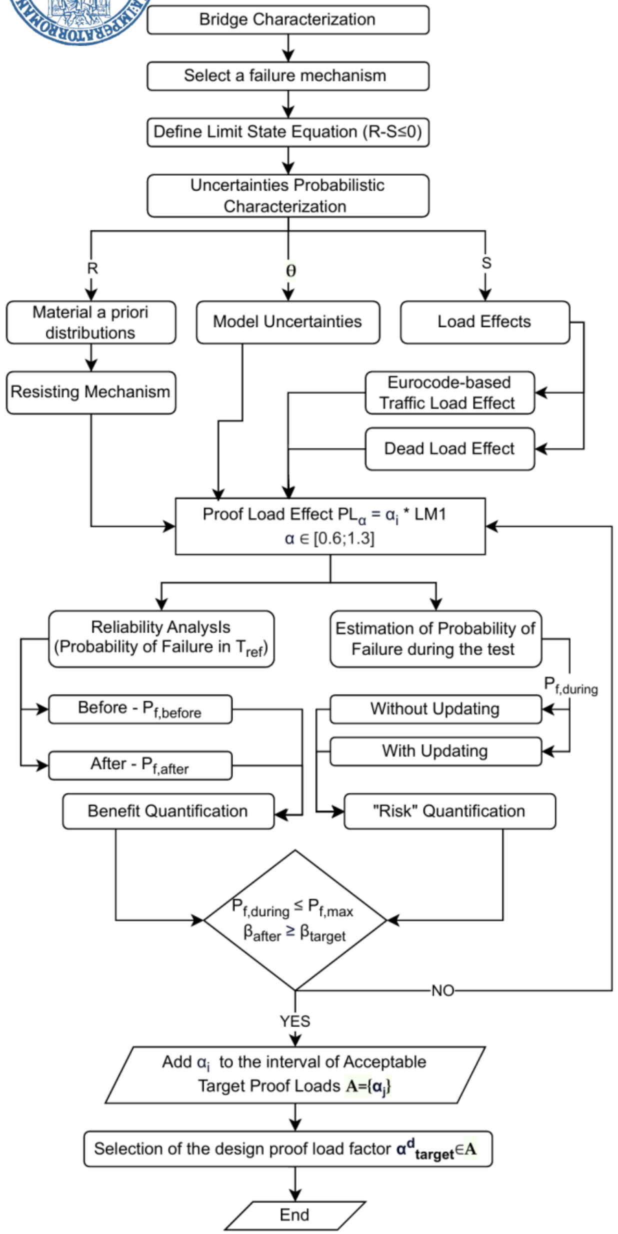
Posterior



$P_{f,\xi,after_{PL_i}}(\Delta t = 1yr)$
$= P\left[\boldsymbol{\theta_R} \cdot \boldsymbol{R_\xi} - \boldsymbol{\theta_E} \cdot \left(\boldsymbol{D} + \boldsymbol{TL_{1yr}}\right) \leq 0 \,\middle|\, \boldsymbol{\theta_R} \cdot \boldsymbol{R_\xi} - \boldsymbol{\theta_E} \cdot \boldsymbol{D} > \boldsymbol{\theta_E} \cdot \boldsymbol{PL_i}\right]$

**NB*: In the case of an existing bridge, the residual capacity R is already lower-bounded by a value determined by the highest load applied during its service life - including exceptional loads, acceptance test after the realization and any subsequent load tests.

METHODOLOGY



Safety *before* and *after* PLT

$$LS_{j,0} = \theta_R R_j - \theta_E G - TL(\Delta t)$$

$$P_{f,\boldsymbol{before}}\left(LS_{j,0}, \Delta t\right) = P\left[LS_{j,0} \le 0\right]$$

$$P_{f,\boldsymbol{after}}\left(LS_j, \Delta t, PL_\alpha\right) = P\left[LS_{j,0} \le 0 \mid LS_{PL_\alpha} > 0\right]$$

$$P_f = \Phi(-\beta) \quad \rightarrow \quad \beta_{after} > \beta_{before}$$

Consequence Class	β_{up}	β_0
CC1	3.3 − 0.5 = 2.8	3.3 − 1.5 = 1.8
CC2	3.8 − 0.5 = 3.3	3.8 − 1.5 = 2.3
CC3	4.3 − 0.5 = 3.8	4.3 − 1.5 = 2.8

Table 1 – ULS target reliability indexes (fib Bulletin 80,2016)

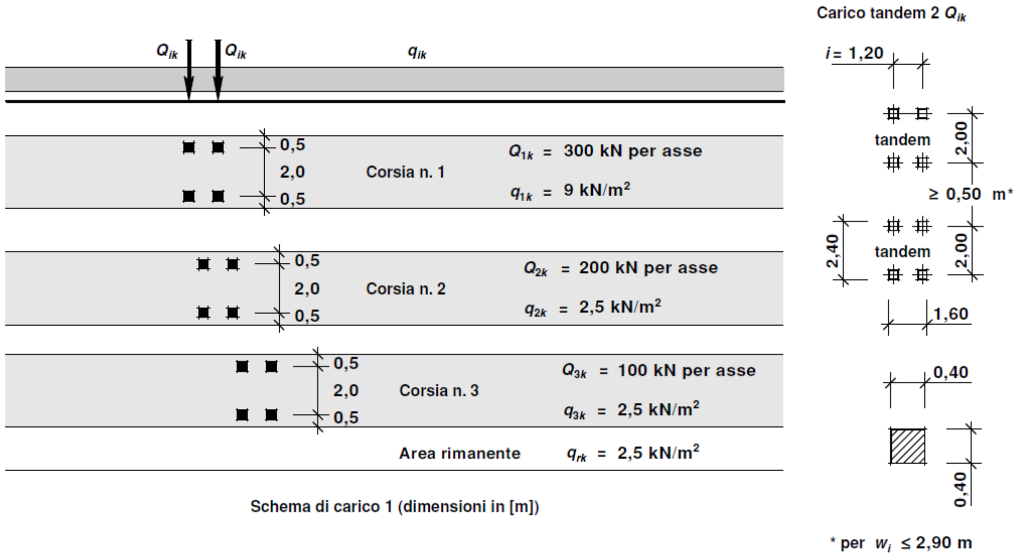
Safety *during* PLT

$$P^{u}_{f,\boldsymbol{during}}\left(LS_j, PL_\alpha\right) = P\left[LS_{PL_\alpha} \le 0\right]$$

$$P^{c}_{f\,i,\boldsymbol{during}}\left(LS_j, PL_\alpha, i\right) = P\left[LS_{PL_i} \le 0 \mid LS_{PL_{i-1}} > 0\right]$$

$$PL_\alpha = \boldsymbol{\alpha} \cdot LM1$$

Load Model 1 (LM1) of EC1991-2

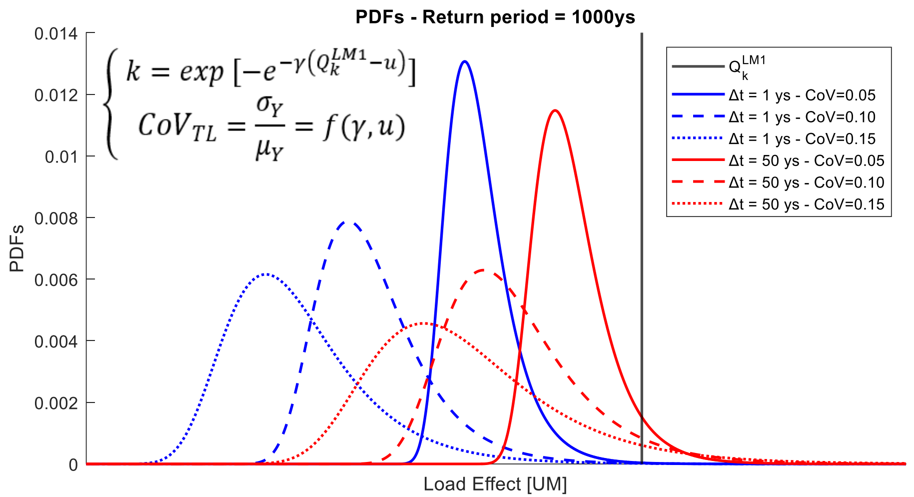


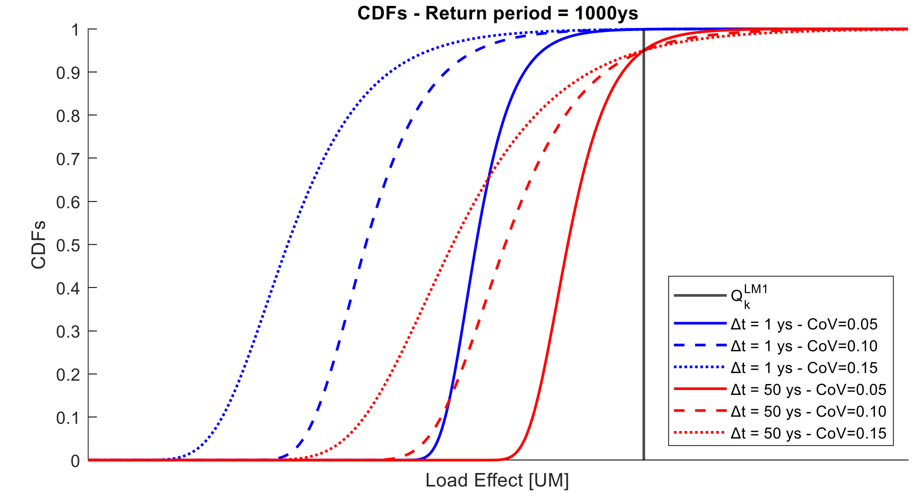
Tab. 5.1.II - *Intensità dei carichi Q_{ik} e q_{ik} per le diverse corsie*

Posizione	Carico asse Q_{ik} [kN]	q_{ik} [kN/m²]
Corsia Numero 1	300	9,00
Corsia Numero 2	200	2,50
Corsia Numero 3	100	2,50
Altre corsie	0,00	2,50

$$PL_\alpha = \alpha \cdot LM1$$

Distributions of maximum traffic load effects calibrated on LM1





CAPACITY MODELS

Flexure (ULS)

$$\boldsymbol{M_R = 0.9d_s \cdot A_s \cdot f_y + 0.9d_{sp} \cdot A_{sp} \cdot f_{p,01}}$$

Shear (ULS)

1) $V_{R,U} = \frac{I}{S} b_w \sqrt{f_{ct}^2 + \boldsymbol{f_{ct} \cdot \sigma_{cp}}}$

2) $V_{R,T} = \min(V_{rs}; V_{rc})$

$$\begin{cases} V_{R,S} = \frac{A_{sw}}{s} z \cdot f_{yw} \cdot \cot(\theta) \\ V_{R,C} = 0.5 b_w z \cdot \alpha_{cw} \cdot f_c \cdot \frac{1}{\cot(\theta) + \tan(\theta)} \end{cases}$$

3) $V_{R,WS} = \left[\frac{0.18}{\gamma_c} \cdot k \cdot (100\rho \cdot f_{ck})^{1/3} + k_1 \cdot \sigma_{cp}\right] b_w d$

$$\boldsymbol{V_R = max(V_{R,U}; V_{R,T}; V_{R,WS})}$$

Cracking (SLS)

$$\boldsymbol{M_{CR}} = \frac{I_m}{y_m^c} \cdot \left[f_{ct} + \sum_{i=1}^{m} \left[\frac{P_i(x)}{A_i} + \frac{P_i(x) e_i(x) - M_{G,i}(x)}{I_i} y_i^c\right]\right]$$

Safety Checks with Partial Safety Factor (PSF)

$$CDR = \frac{R_d}{S_d}$$

$$CDR\,(\xi) = \xi \frac{R_d}{S_d}$$

Symbol	Value	Object
γ_S	1.15	Steel
γ_C	1.50	Concrete
γ_G	1.35	Dead Load
γ_{TL}	1.35	Traffic Load
γ_p	1.00	Prestressing

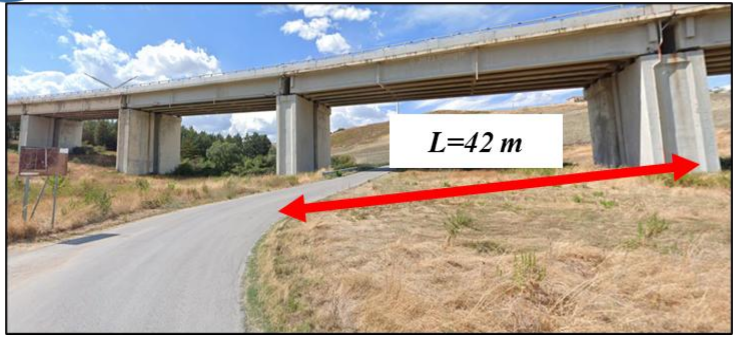
Table 1 – Partial Safety Factors

$$CDR\,(\xi_F) = \frac{M_{Rd}}{M_{Sd}} = \frac{\xi_F \cdot \left[0.9 d_s A_s \cdot \frac{f_{y,k}}{\gamma_s} + 0.9 d_{sp} A_{sp} \cdot \frac{f_{p,01,k}}{\gamma_s}\right]}{\gamma_G M_{G,k} + \gamma_{TL} M_{TL,k}}$$

$$CDR\,(\xi_V) = \frac{V_{Rd}}{V_{Sd}} = \frac{\xi_V \cdot V_R(\gamma_C; \gamma_S)}{\gamma_G V_{G,k} + \gamma_{TL} V_{TL,k} - \gamma_P V_P}$$

$$CDR\,(\xi_{CR}) = \frac{\xi_{CR} \cdot M_{CR}}{M_{TL,f}}$$

CASE STUDY

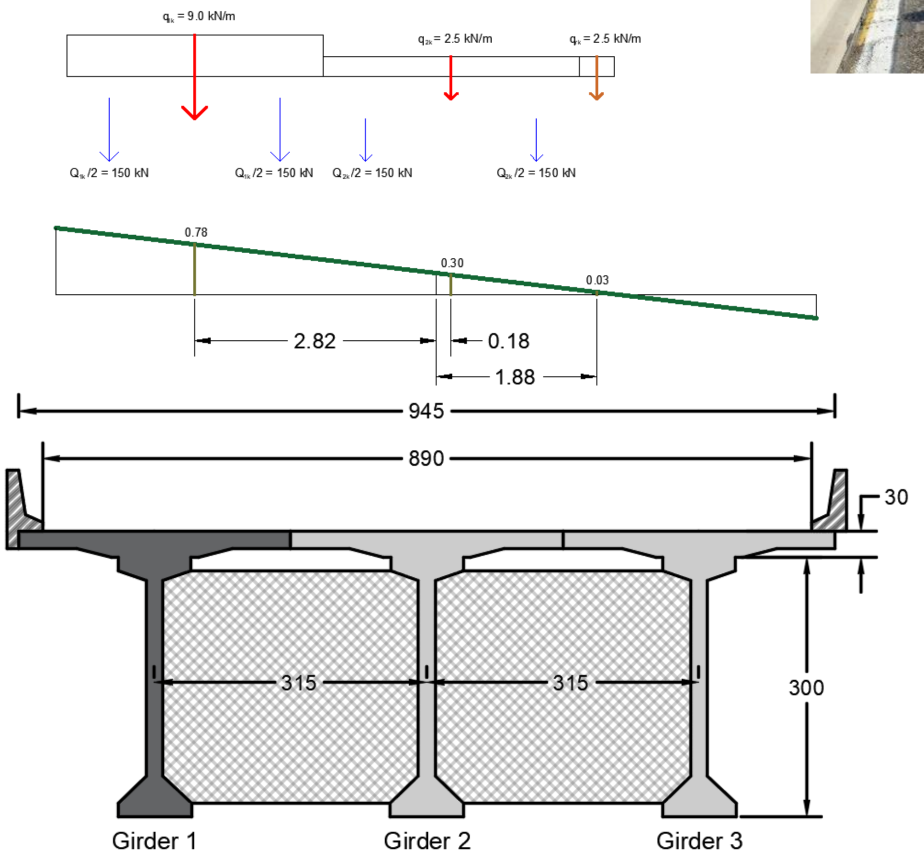


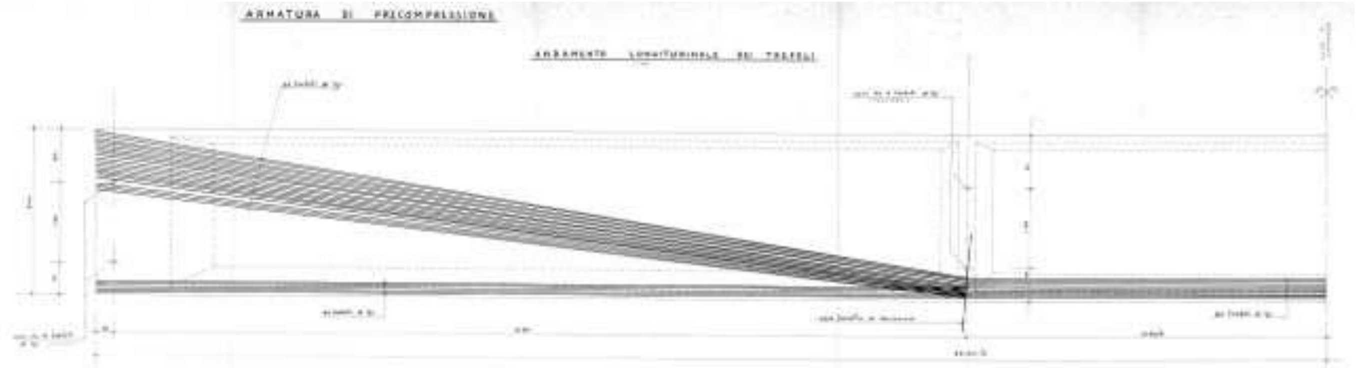
Input data:

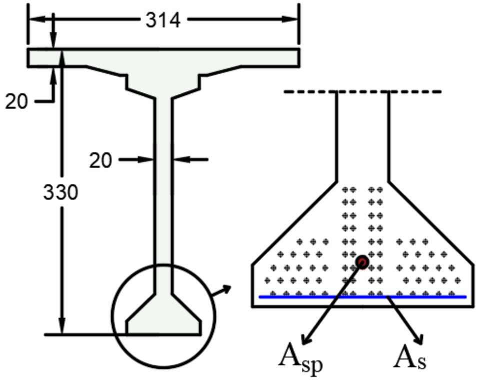
- Simply supported existing bridge with prestressed I-type girders (21 spans with 6 beams each)
- Proof load test after maintenance works (LM1)
- Proof load test without traffic flow performed successfully

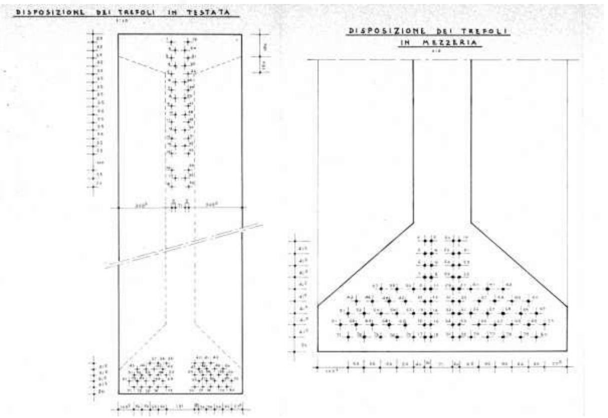
Hp:

- Sectional analysis of edge girder
- Time-invariant analysis









CASE STUDY

Geometry

Geometrical property	Symbol	Unit	Value	Notes
Span Length	L	m	42	Simply supported beam
Carriageway Width	w	m	8.9	
Total Deck Height	H	m	3.3	Beam + Slab
Effective Depth of Reinforcing Steel	d_s	mm	3260	$H - c_s$
Effective Depth of Prestressing Steel	d_{sp}	mm	3135	$H - c_{sp}$
Design Prestressing Steel Area	A_{sp}	mm^2	7740	80 strands of 7 wires 1/2"
ETD† from the Bottom at Mid-Span	c_{sp}	mm	165	
ETD† from the Bottom at the Shear-Critical Section	c_{spc}	mm	1100	At $d = H$ from the support
Equivalent Strand Inclination at Support	ψ	°	3.8	
Undamaged (Design) Reinforcing Steel Area	A_s	mm^2	2670	6Φ10+7Φ20
Mid-Span Centroid Cover of Reinforcing Steel	c_s	mm	40	
Stirrups Area	A_{sw}	mm^2	100	2x1Φ8
Stirrups Distance	s	mm	290	

† Equivalent Strand Distance

Table 1 - Geometrical properties

Mechanical Random Variables

Material	Variables	Symbol	Unit	Mean	CoV	RV Model
PS	Conventional Yielding Strength	$f_{p,01}$	MPa	1645 [a,b,c]	2.5% [b,c]	Normal [b]
PS	Initial Stress	σ_{0p}	MPa	1355 [a]	3.0%	Normal
PS	Percentage of Prestressing Losses (t=∞)	Δl	-	0.25 [a]	10.0%	Normal
RS	Yield Strength	f_y	MPa	500 [a,b]	6.0% [b]	Normal [b]
C	Compressive Strength	f_c	MPa	35.6 [d]	20%	LogNormal
C	Tensile Strength	f_{ct}	MPa	2.7 [e]	20%	LogNormal

Table 1 – Mechanical random variables

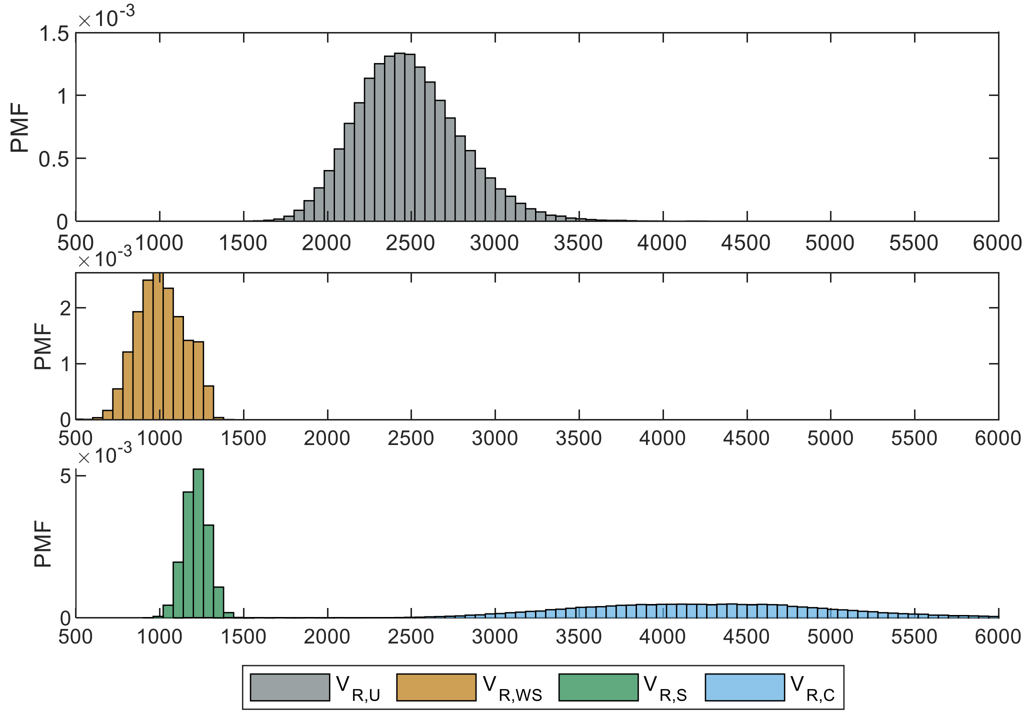
a - Original plans
b - (Joint Committee on Structural Safety, 2000)
c - (Federation Internationale de la Prècontrainte, 1976)
d - Laboratory experimental tests
e - Analytical relationships with f_{cm} based on (Italian Ministry of Infrastructures and Transportation, 2018) and (EN 1991-1-1 - Comité Européen de Normalisation, 2004)

Model uncertainties

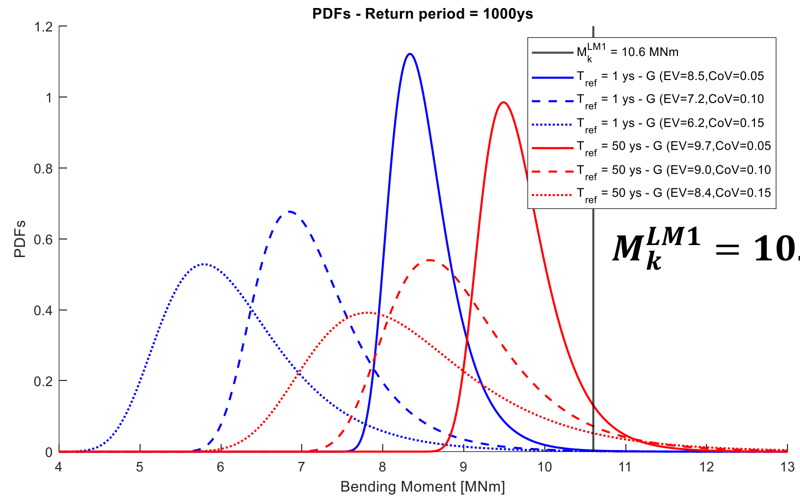
Random Variables	Symbol	Unit	Mean	CoV	RV Model
Flexural Resistance Model Uncertainty	$\theta_{R,F}$	-	1.00	5%	LogNormal
Shear Resistance Model Uncertainty	$\theta_{R,S}$	-	1.00	10%	LogNormal
Load Effect Uncertainty	θ_E	-	1.00	10%	LogNormal
Proof Load Model Uncertainty	θ_{PL}	-	1.00	5%	LogNormal

Table 1 – Model Uncertainties

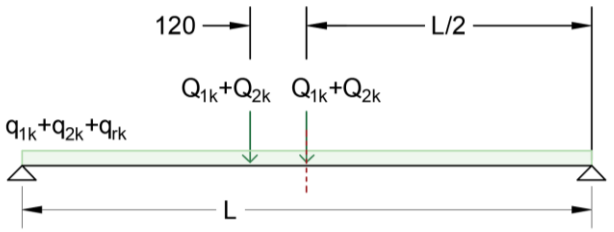
Shear Capacity

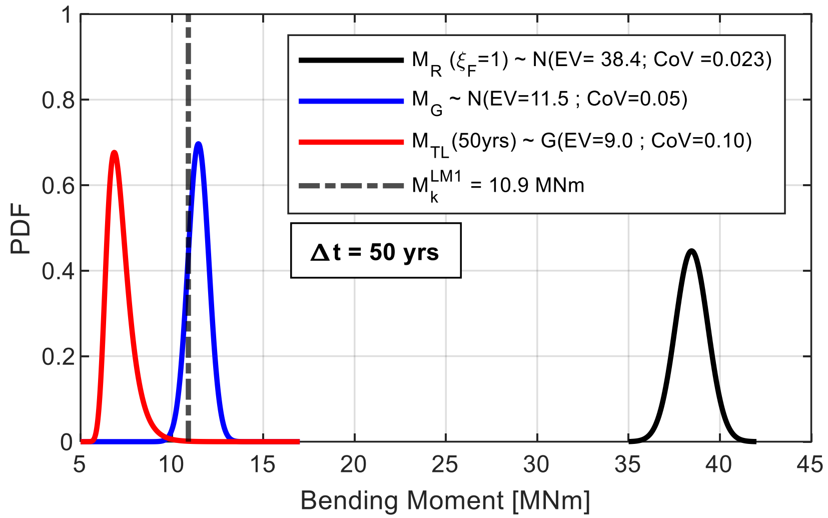


FLEXURE (ULS)

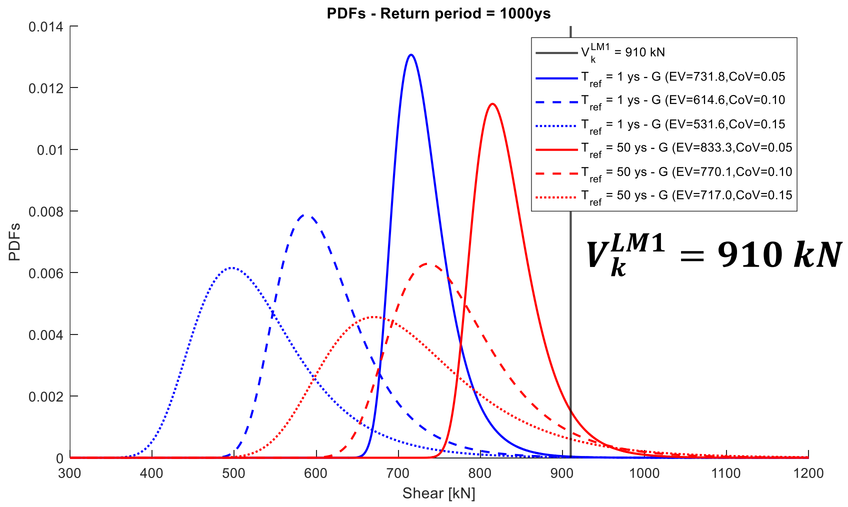


$$M_k^{LM1} = 10.6\ MNm$$

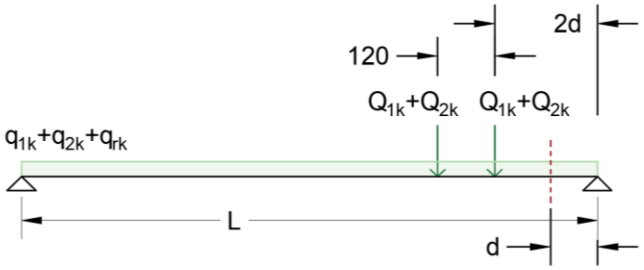


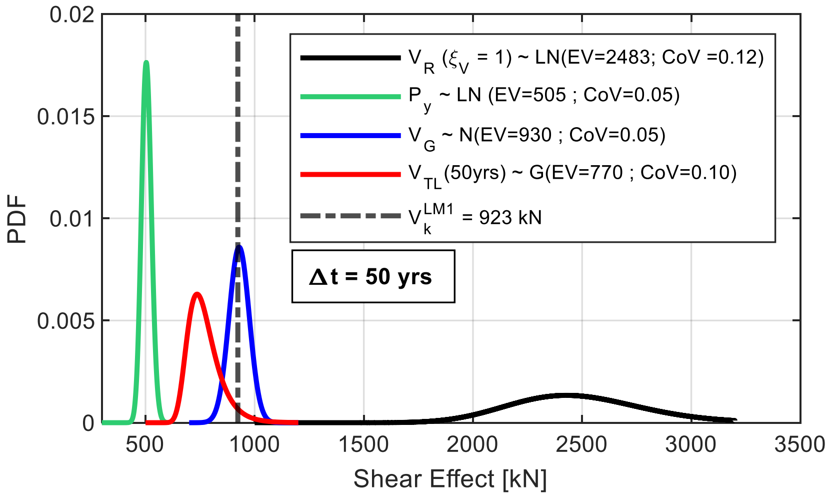


SHEAR (ULS)



$$V_k^{LM1} = 910\ kN$$

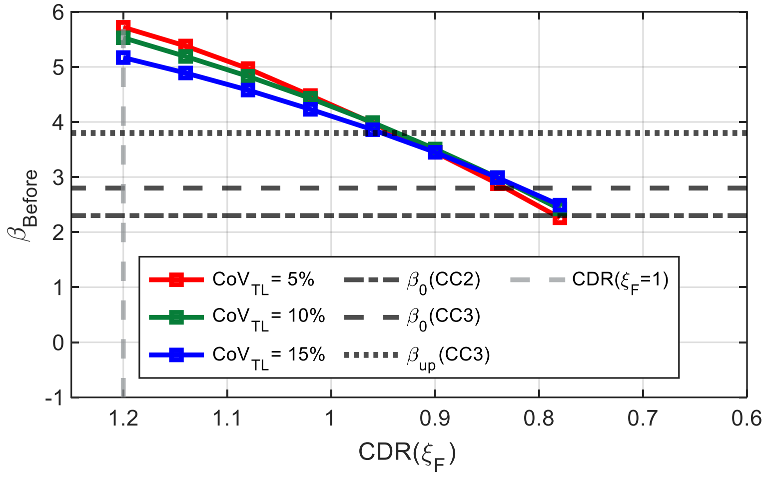




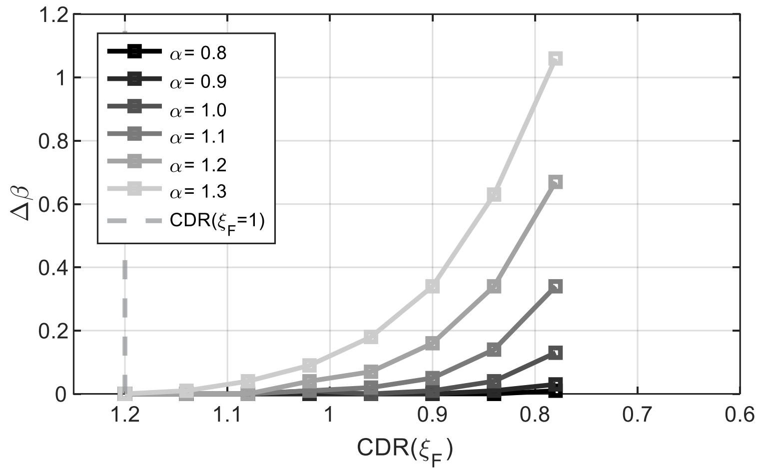
FLEXURE (ULS)

ξ_F	1.00	0.95	0.90	0.85	0.80	0.75	0.70	0.65
$CDR\,(\xi_F)$	1.20	1.14	1.08	1.02	0.96	0.90	0.84	0.78

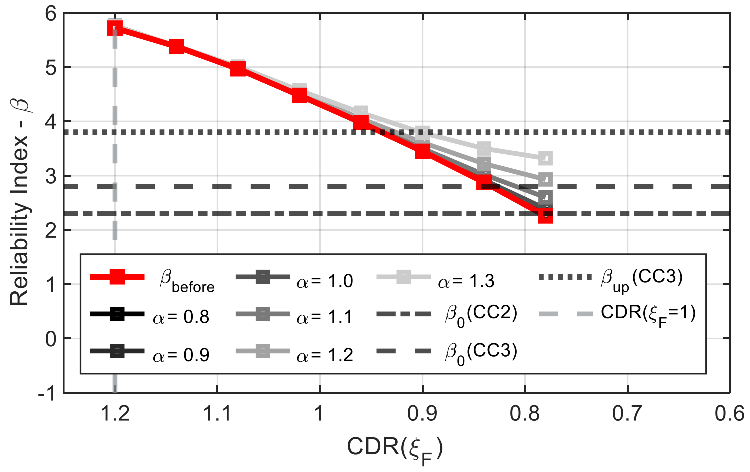
BEFORE PLT



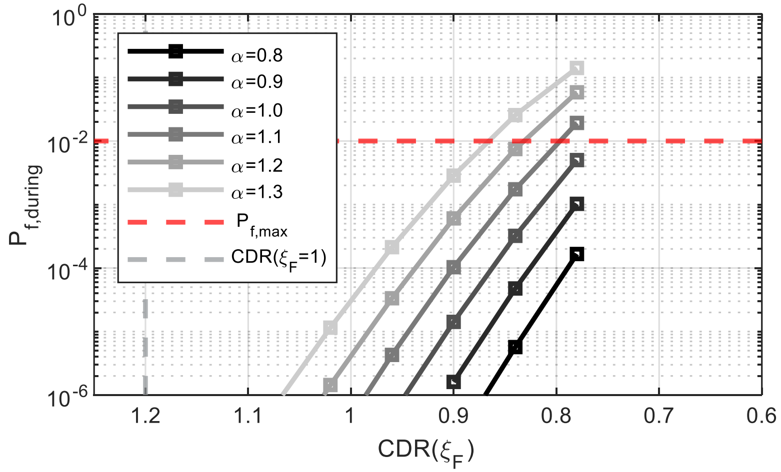
BENEFIT



AFTER PLT



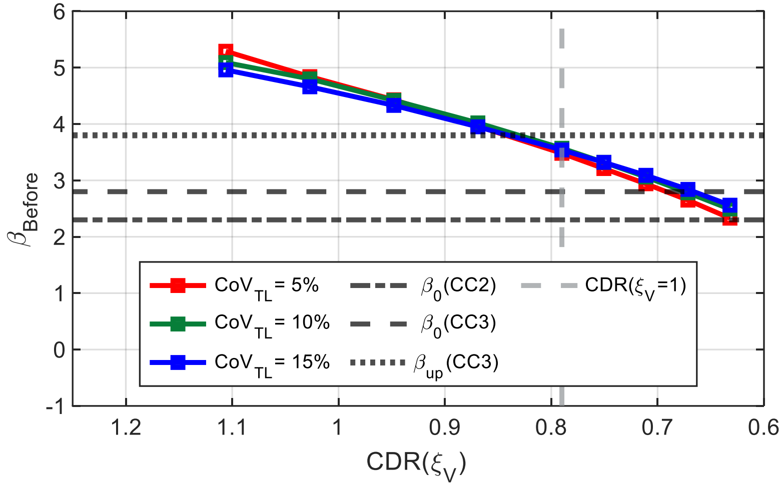
COLLAPSE DURING



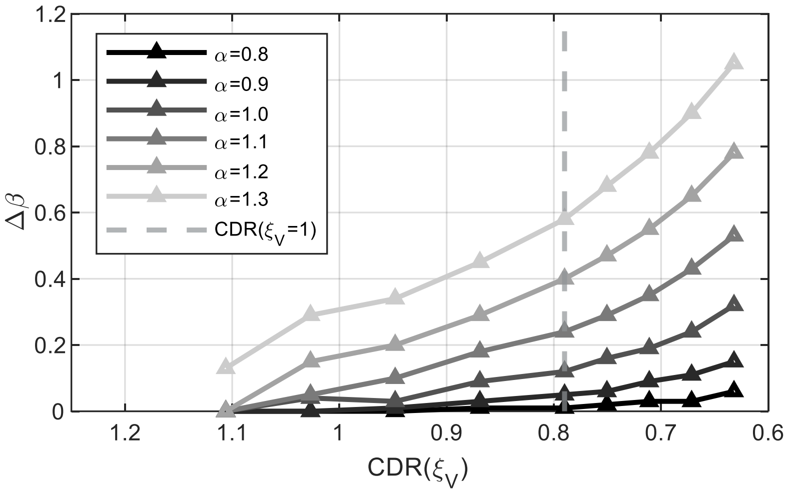
SHEAR (ULS)

ξ_V	1.40	1.30	1.20	1.10	**1.00**	0.95	0.90	0.85	0.80
$CDR\,(\xi_V)$	1.10	1.03	0.95	0.87	**0.79**	0.75	0.71	0.67	0.63

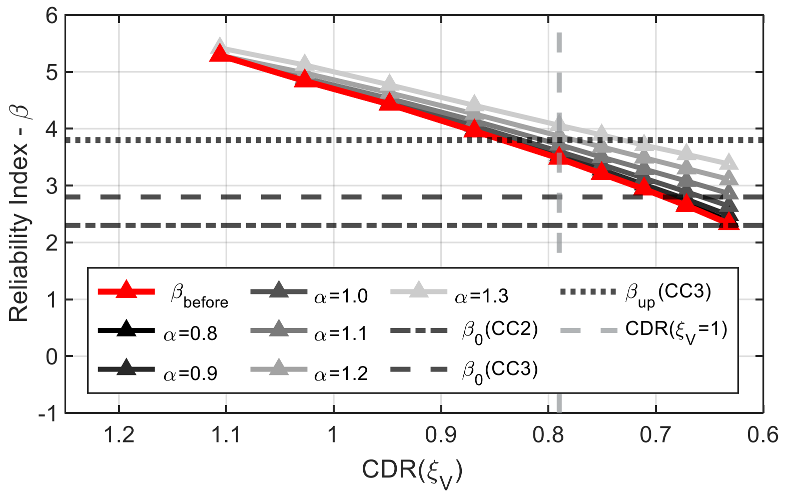
BEFORE PLT



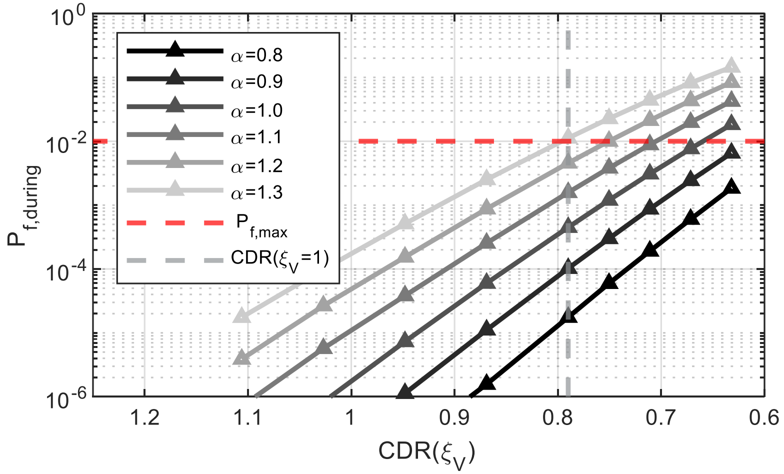
BENEFIT



AFTER PLT

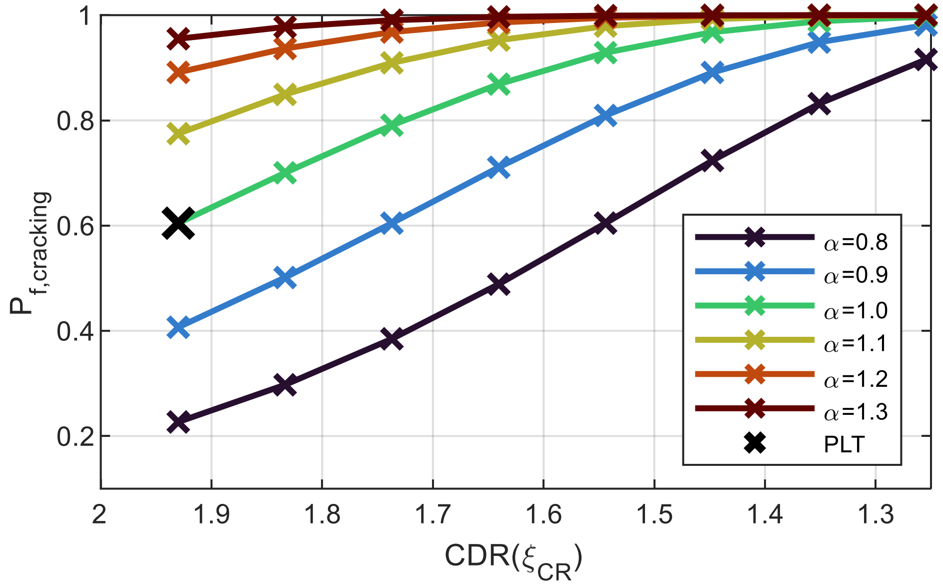


COLLAPSE DURING

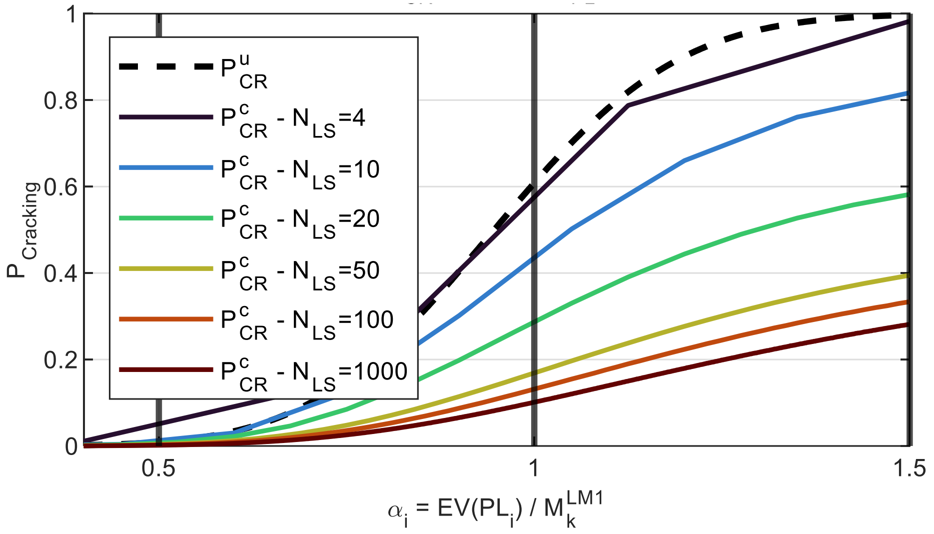


RISK DURING PLT

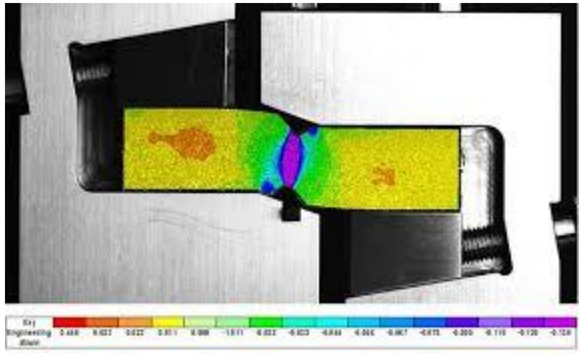
CRACKING



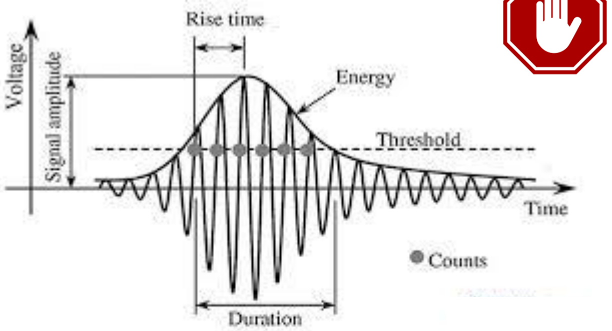
BENEFIT OF INCREMENTAL LOADING PROTOCOL



STRUCTURAL MONITORING DURING THE TEST

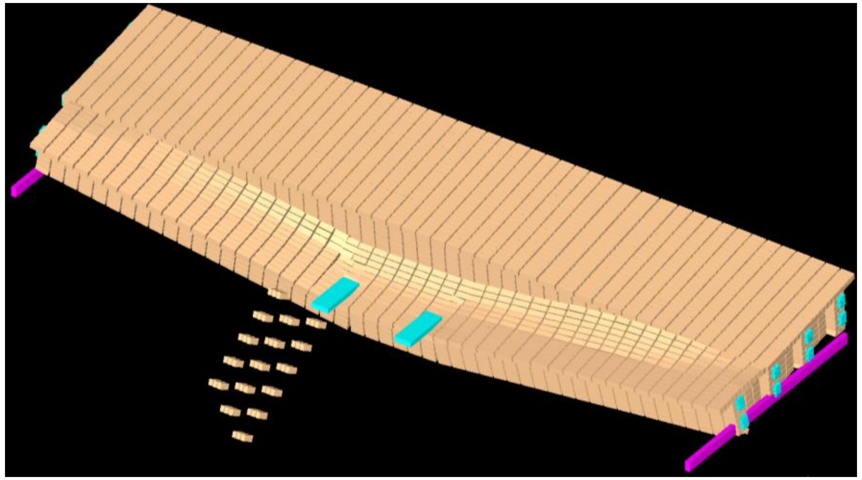


Digital Image Correlation (DIC)



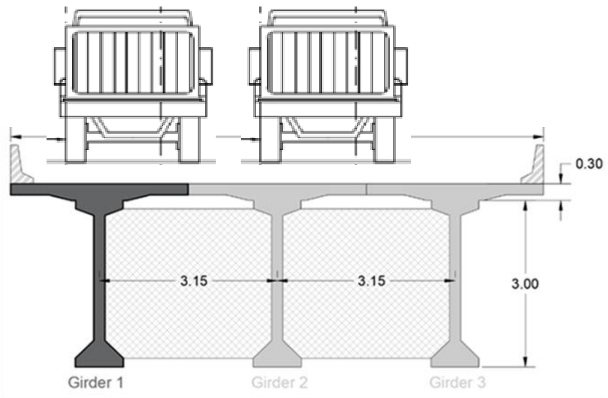
Acoustic Emissions (AE)

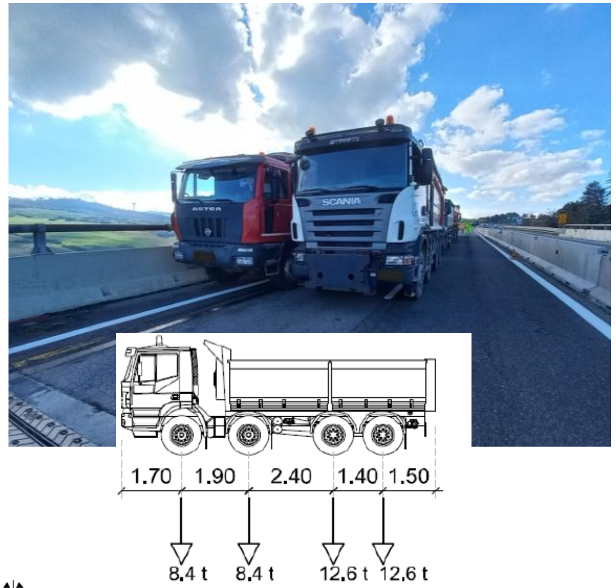
RESIDUAL CAPACITY AND STRUCTURAL ROBUSTNESS

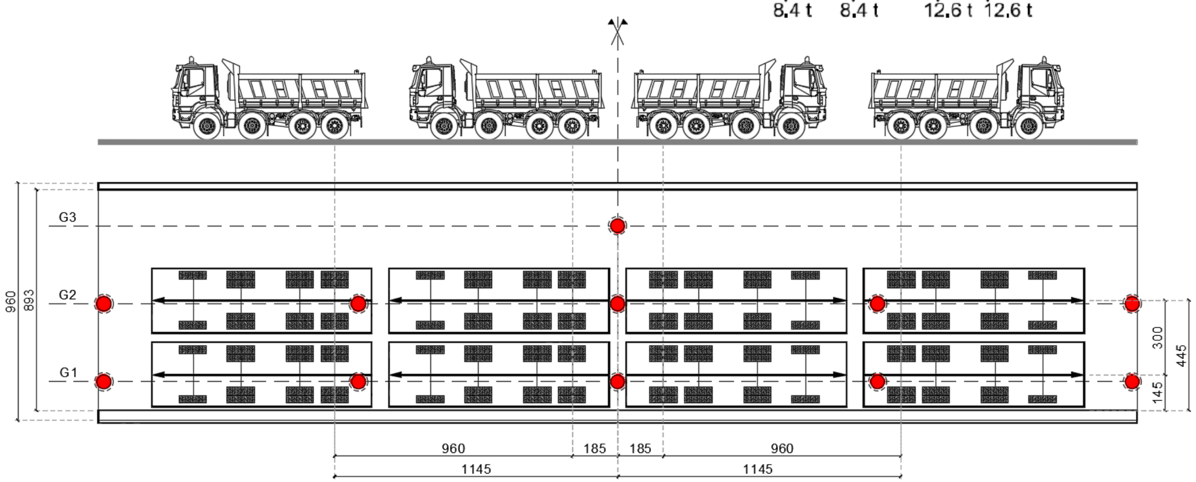


BENEFIT DURING PLT

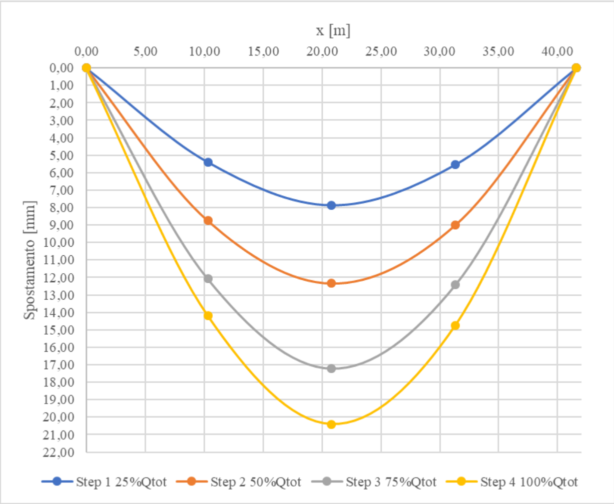
$$PL_\alpha = \mathbf{1,0} \cdot LM1$$

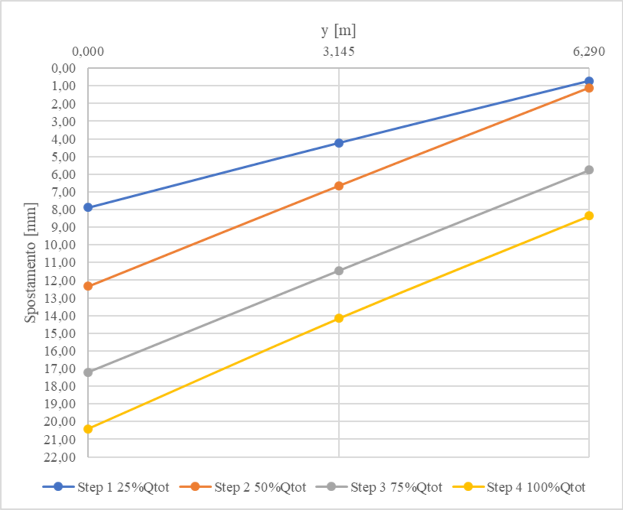






APPLIED LOAD vs LONGITUDINAL AND TRASNVERSAL DISPLACEMENTS





RELIABILITY AFTER THE TEST

MECHANISM	*CDR* ($\xi_i = 1$)	CoV_{TL}	β_{before}	β_{after} (α=1)	$\frac{\Delta\beta}{\beta_{before}}$ [%]	$P_{f,during}$ (α=1)
SHEAR	0.79	5%	3.48	3.60	**3%**	$4 * 10^{-4}$
		10%	3.57	3.67	**3%**	
		15%	3.54	3.60	**2%**	
CRACKING	1.15	5%	0.86	3.03	**250%**	$5.5 * 10^{-1}$
		10%	1.46	3.28	**125%**	
		15%	1.82	3.30	**81%**	

COMMENTS

1. **PLT proves effective bridge resistance**, especially where conventional methods underestimate structural resistance, as shown in the case study which achieved adequate shear resistance levels through PLT;
2. **In some cases, reliability-based structural analysis** may provide satisfactory safety levels ($\beta_{before} > \beta_{target}$), making PLT appear unnecessary. However, this would ignore practical constraints like budget, time and tool availability necessary for PLT;
3. **The risk of failure can be mitigated** using progressive, step-by-step loading combined with conditional probability updating, reducing the risk of cracking during the test;
4. **Uncertainties of PC I-girder bridges material and geometrical properties are limited**, i.e. PLT is less effective

Addonizio G, **Losanno D**, Lantsoght EOL, Casas JR (2025). *Value of proof load testing for prestressed concrete I-girder bridges in accordance with Eurocode-based safety levels.* Submitted to *Engineering Structures*

ON-GOING AND FUTURE STUDIES

1. WITHOUT ANY PRIOR INFORMATION ON RESISTANCE
2. EXPECTED LOSS ANALYSIS
3. OTHER CASE STUDIES AND IN-SITU TESTS