COST TU1402: Quantifying the Value of Structural Health Monitoring

Short Term Scientific Mission Report

Application of Bridge Weigh-in-Motion measurements in assessment of existing road bridges.

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General Information

STSM Title: Application of Bridge Weigh-in-Motion measurements in assessment of existing road bridges.

STSM Duration : 09-05-2016 to 27-05-2016

Location: Slovenian National Building and Civil Engineering Institute (ZAG), Ljubljana, Slovenia

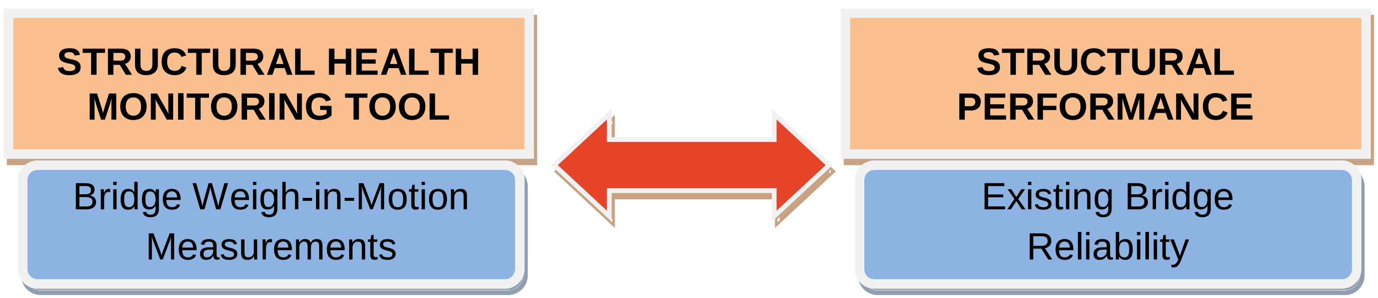
Host: Mr. Aleš Žnidarič, Head of Section for Bridges and Other Civil Engineering Structures, Slovenian National Building and Civil Engineering Institute

STSM Participant: Dominik Skokandić, Department of Structures, Faculty of Civil Engineering, University of Zagreb, Croatia

Purpose of the STSM

Main purpose: To study and analyse application of B-WIM measurements, as a part of SHM, in load carrying capacity assessment of existing bridges.

Long term outcome: To create a valuable link between a certain monitoring tool and corresponding structural performance of interest.



Main focus during STSM: To relate B-WIM data with theoretical bridge models, developed in *Sofistik* software, in order to upgrade them and to obtain more realistic assessment results.

Background and Motivation

- Development of Multi – Level method for assessment of existing road bridges.
- Age of existing bridges in Croatia and region.
- Conservative assumptions in current European standards for design of new bridges.
- Opportunity to work and learn with world leading experts in WIM technology in Ljubljana.
- Opportunity to observe field measurements on existing bridges carried on by professional personnel.

Background and Motivation

- Weigh-in-Motion (WIM) – method of measuring vehicles as they drive over measurement sites, without slowing down or stopping.
- Data provided:
  - Vehicle gross weight
  - Axle weights
  - Axle number
  - Axle spacing
  - Vehicle speed
  - Time stamps

- Bridge Weigh-in-Motion (B-WIM) – WIM method that uses existing bridges as weighing scales – minimum traffic interruption.
- B-WIM data can be used to site – specific load models for certain time periods.
- Additional structural parameters:
  - Realistic influence lines
  - Dynamic amplification factor
  - Transverse load distribution etc.

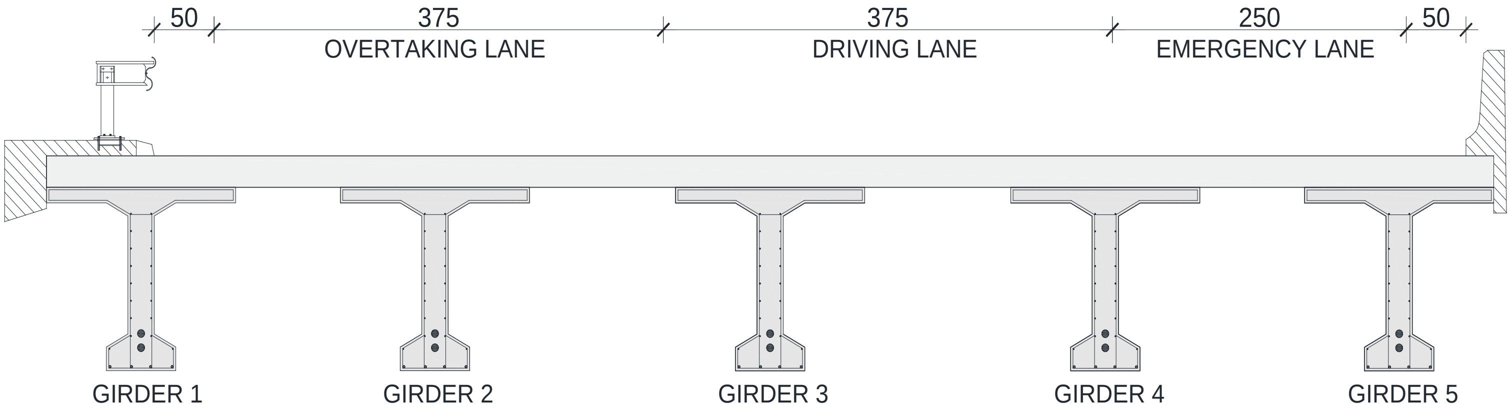
STSM Work Plan

- Multi level assessment of Case Study Bridge:

1. Load carrying capacity assessment according to standards for design of new bridges, and based on theoretical bridge model.
2. Modified bridge model based on realistic influence lines, obtained from B-WIM measurements.
3. Bridge model from previous level is additionally modified with transverse load distribution factors to take into account eventual cracks and stiffness reductions.
4. Site specific load effects, obtained from B-WIM measurement and post-processing, are applied in load carrying capacity assessment.

Case Study Bridge

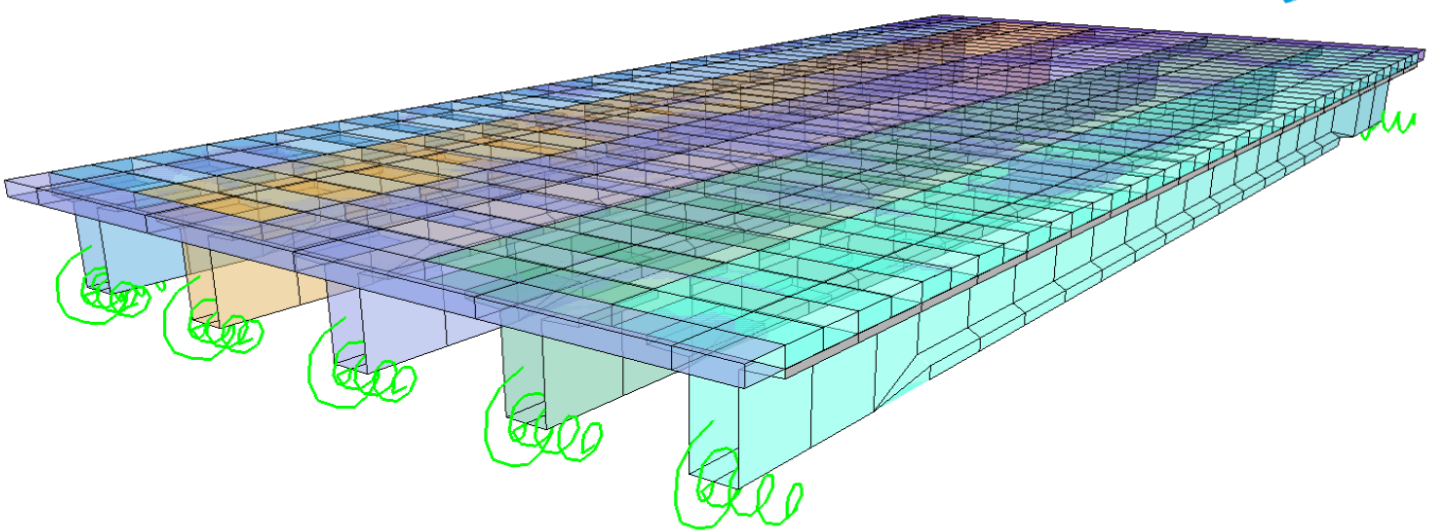
Bridge description:



- Simply supported highway bridge.
- Single span of 24,8 meters.
- Original design plans were available from archives.
- B-WIM data available.
- Cross section resistance to bending is calculated using built in reinforcement.

Case Study Bridge

Bridge model:



- 3D model developed in *Sofistik* software.
- Grillage method – transverse load distribution.
- Additional rotational springs on supports.
- Only permanent actions and traffic loads taken into account in load carrying capacity assessment.

Assessment of Case Study Bridge:

1

Initial level:

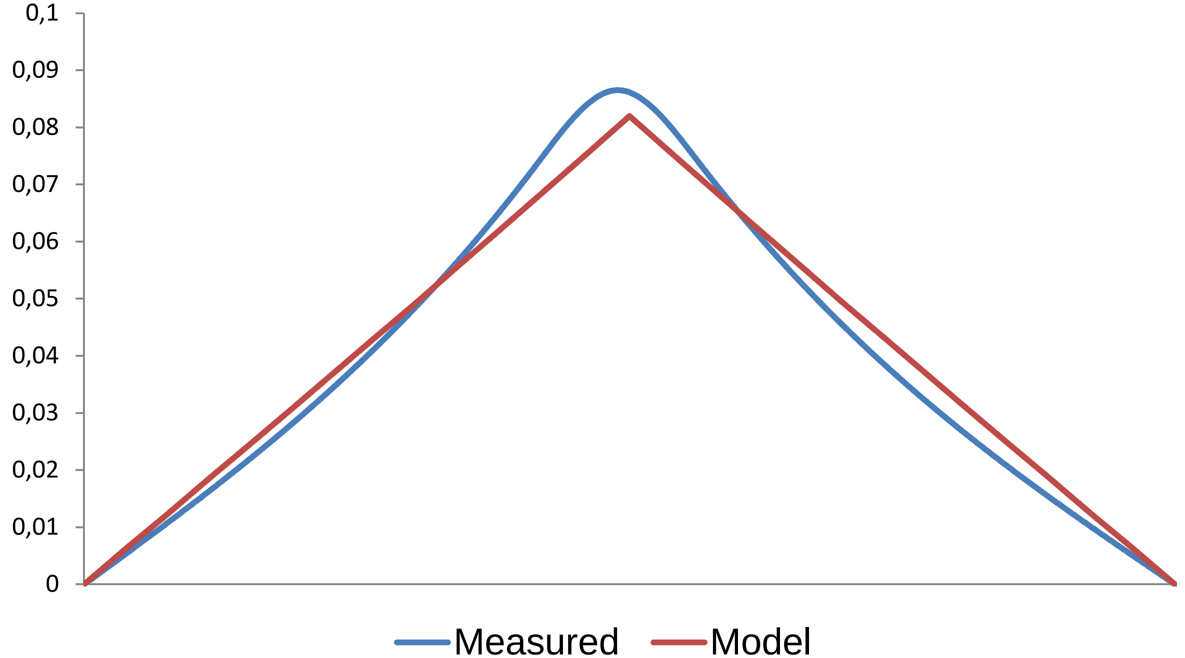
- Partial factors for materials and loads according to standards for design of new bridges.
- Theoretical influence line and transverse load distribution.
- Permanent action (self-weight, fixed equipment and road – surfacing) calculated based on original plans.
- Traffic loads according to Eurocode Load Model 1.
- Linear analysis in *Sofistik* software.

Assessment of Case Study Bridge:

2

Second level:

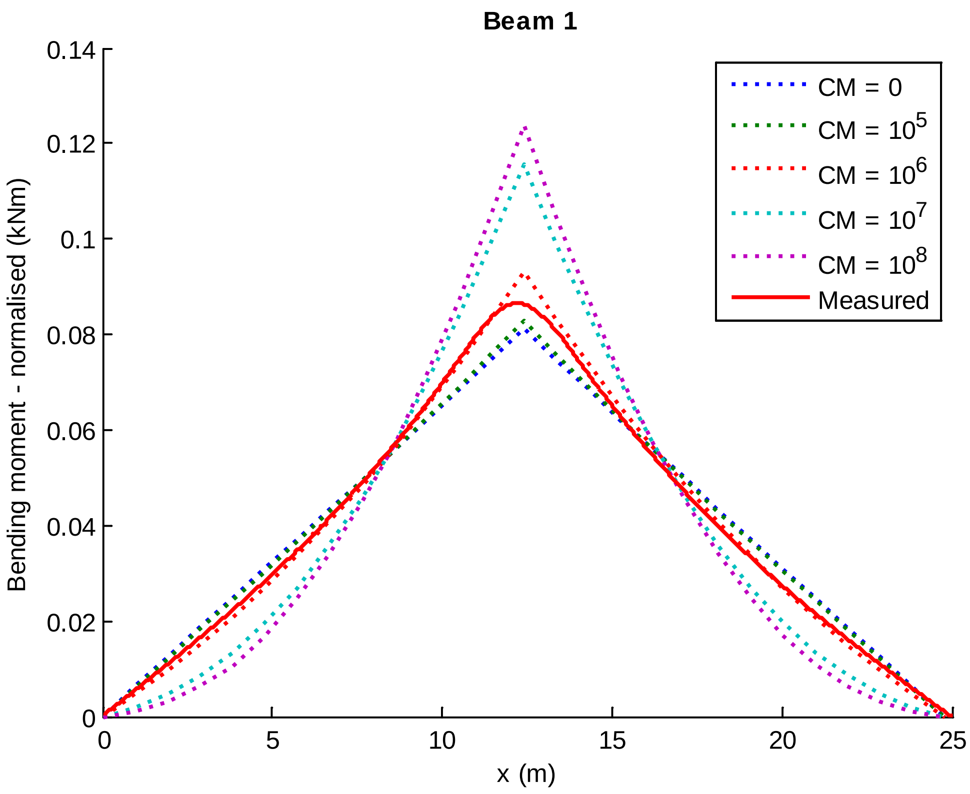
- Comparison between measured and theoretical influence line:



- Realistic bridge behaviour is not simply supported.
- Modification of bridge model with additional rotational stiffness.

Assessment of Case Study Bridge:

2 Second level:



- Modification of influence line → Reduced bending moments.

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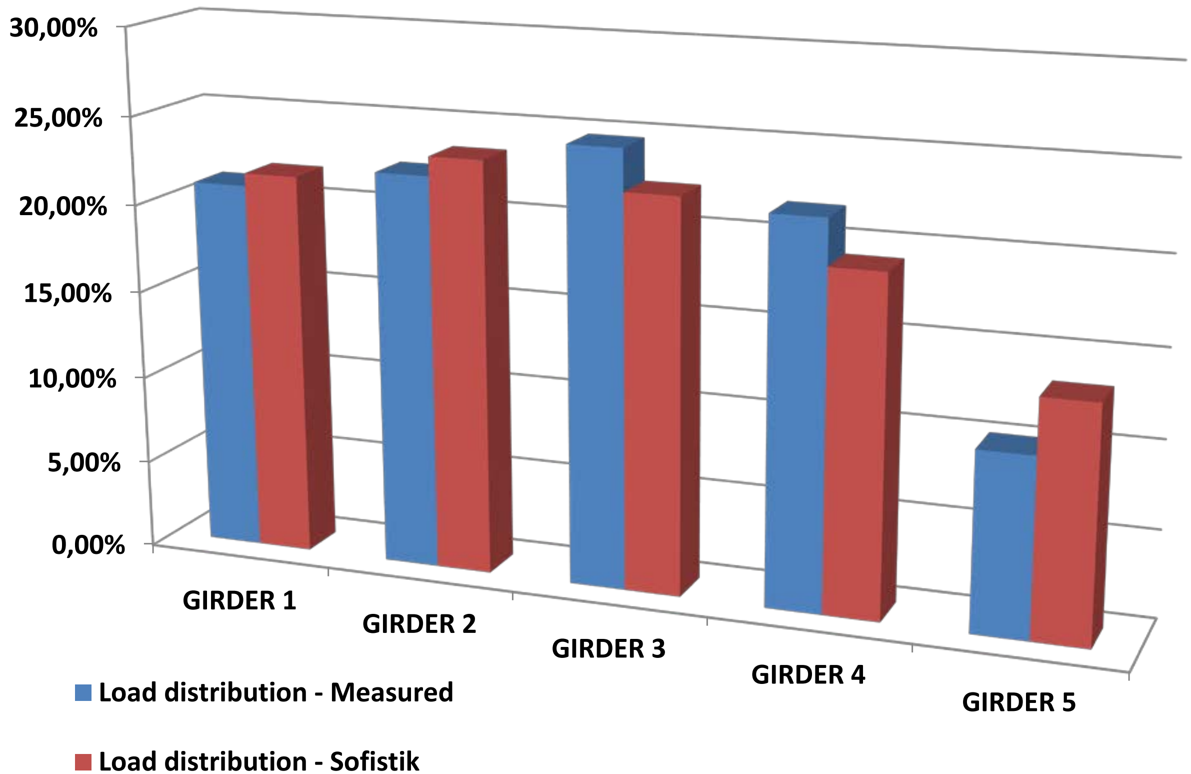
Assessment of Case Study Bridge:

3

Third level:

- Comparison of measured and theoretical transverse load distribution.
- Useful to discover any type of degradation (cracks, stiffness reduction etc.).

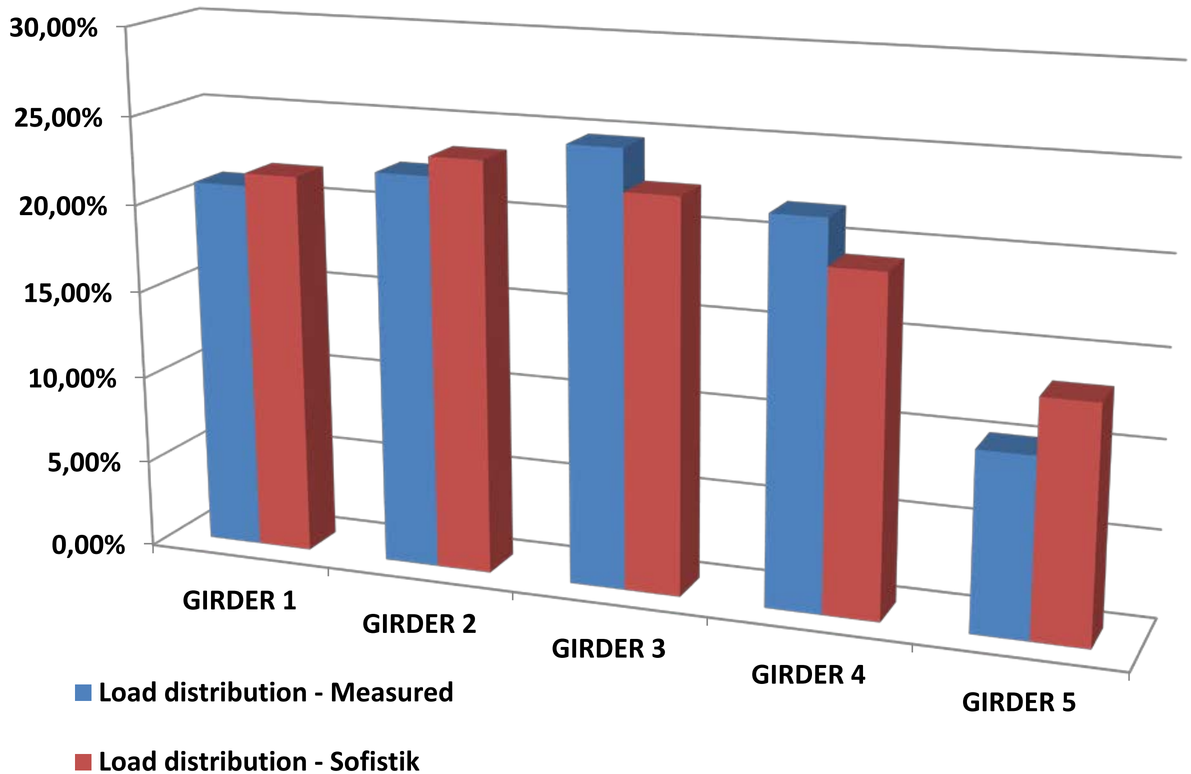


Assessment of Case Study Bridge:

3

Third level:

- No significant difference – results as in level before (expected due to no visible signs of degradation).

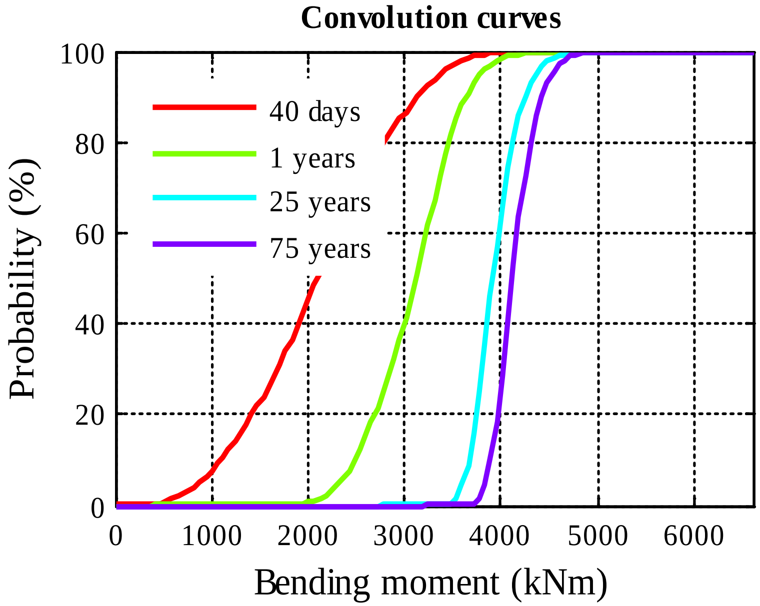


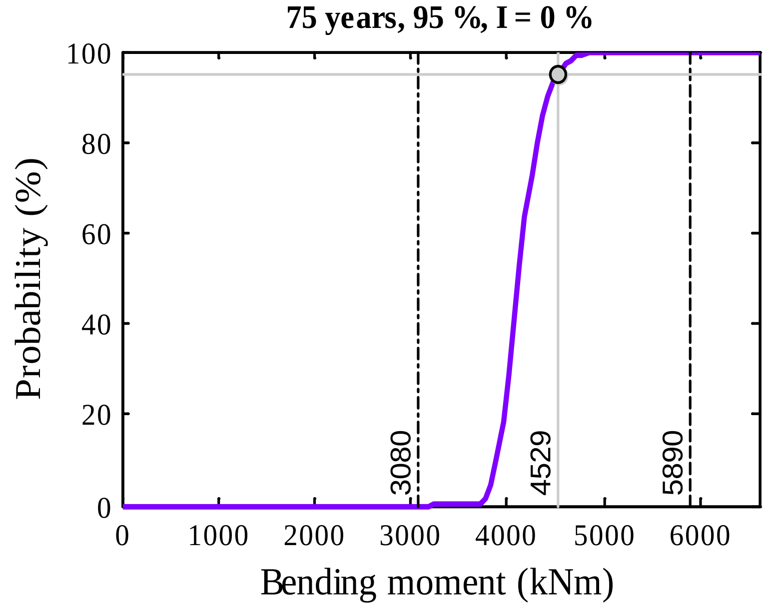
Assessment of Case Study Bridge:

4

Final level:

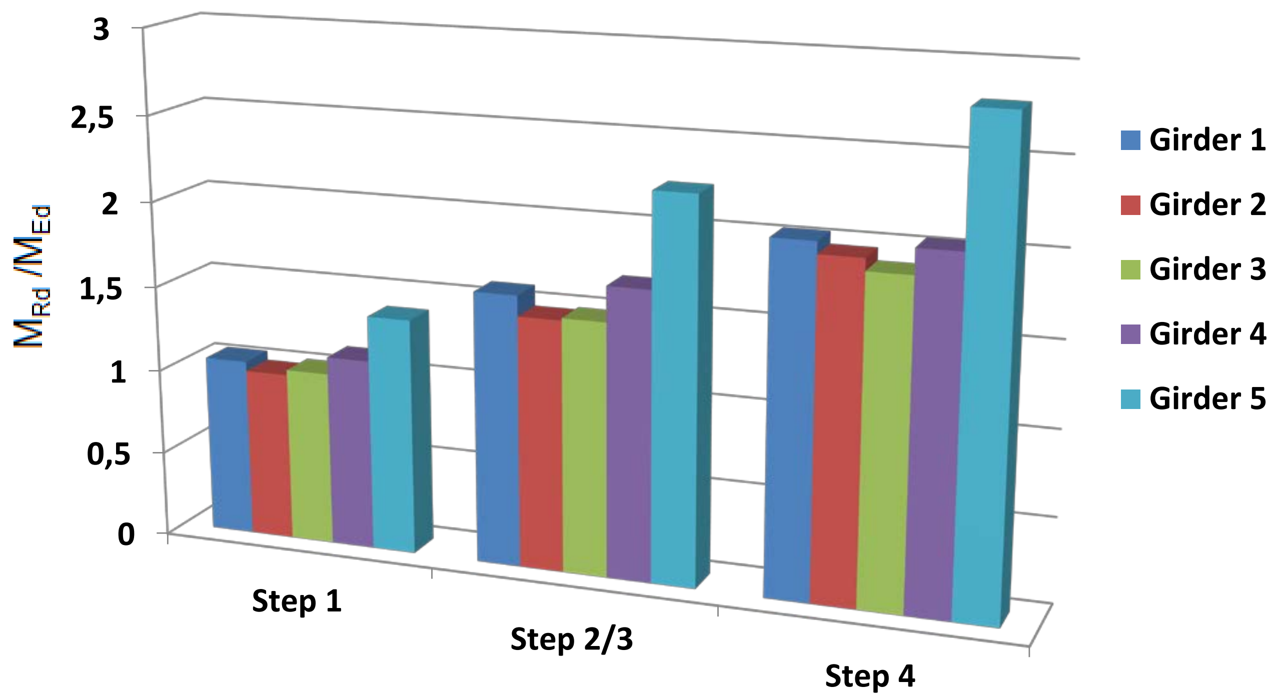
- Traffic load effects obtained from B-WIM measurements.
- Extrapolated for a period of 75 years – using extreme value theory.
- Partial factors as in previous levels.





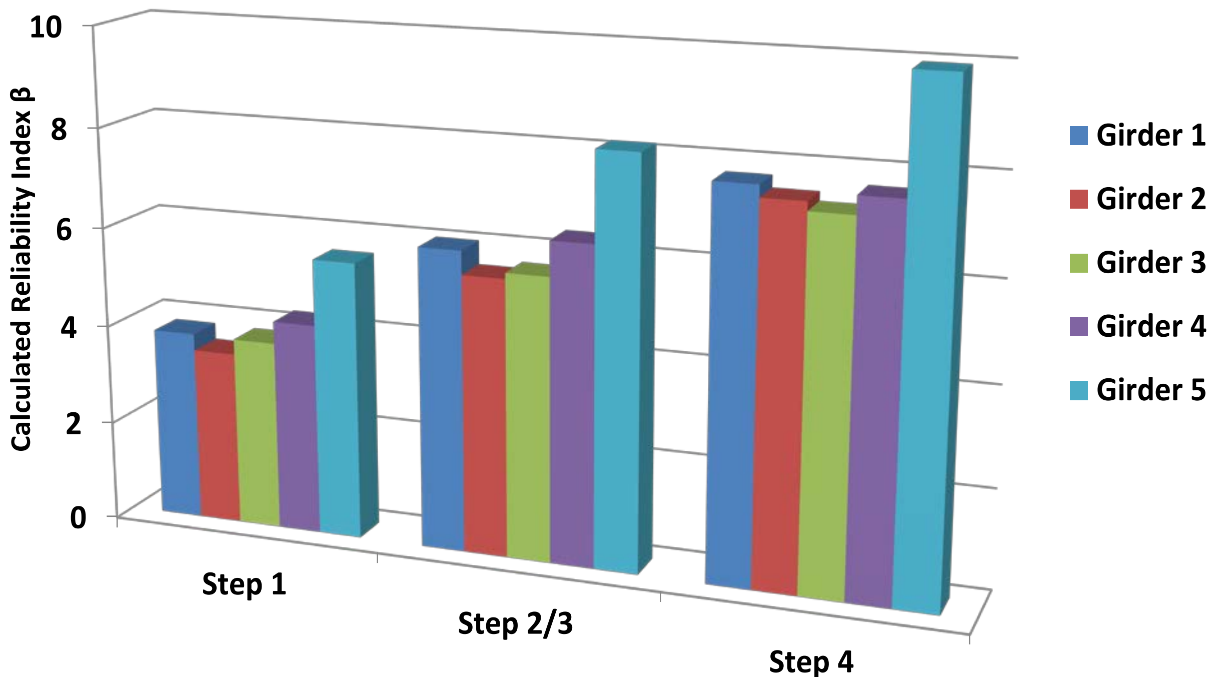
Assessment results (deterministic):

	G1	G2	G3	G4	G5
M_{Ed} [kNm] – Step 1	7553,63	7968,83	7728,16	7030,85	5686,29
M_{Ed} [kNm] – Step 2/3	4963,38	5367,21	5317,27	4668,96	3522,73
M_{Ed} [kNm] – Step 4	3881,22	4021,17	4171,04	3870,53	2824,62
M_{Rd} [kNm]	7901,76				



Assessment results (probabilistic):

	G1	G2	G3	G4	G5
β – Step 1	3,82	3,49	3,81	4,25	5,58
β – Step 2/3	6,02	5,55	5,67	6,37	8,16
β – Step 4	7,73	7,49	7,31	7,67	9,96
β_{target}	3,8 – for design of new bridges				
	3,7 – for existing bridges of similar age [Kotes and Vican, 2013]				



Conclusions

- **Existing bridges**: Results clearly show the quantification of WIM measurements as a part of SHM tools for load carrying capacity assessment.

- **Economic aspect**:

- **Bridge Management:** WIM data can be used for early discovery of non-visible degradation of bridge elements (as described in step 3 of assessment procedure).

Thank you for your attention!

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