ISWIM Webinar Unlocking the Potential of WIM Data for Bridges
Thursday 16 May 2024

Fatigue – a client's perspective on the use of Bridge WIM data for remaining life prediction

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About the author

Bridge engineering experience

- bridge designer, 1997-2004
- National Transport Agency (FTIA) – bridge expert/authority /client/owner, 2004-2023
- Private consultant, 2023 →

Experience in standardization

- Eurocode National Annexes for bridges – Finland, 2007…2010 (+updates)
- Eurocode-compatible design guides for bridges, 2009-2016 (+ updates)
- Standard drafting in CEN/TC250, 2015 - ongoing
- 2nd generation Eurocode National Annexes (EN1991-2 / EN1990), 2023 - ongoing

Relevant bWIM-experience

- Several conference papers about bWIM/Fatigue
- Code calibration "exercises" with bWIM
- Co-Chair of IABSE TG1.10 - Utilization of traffic data in research, design, and assessment of bridges

Private consultancy

- Support for Standard implementation, bridge projects, R&D projects, monitoring of bridges, etc.
- 2023 - ongoing

Content

1. Examples of fatigue studies

(done due to changes in regulations 2013 – heavier vehicles allowed)

1a - Composite steel-concrete bridge, main span 120m

1b - Orthotropic steel plate for moveable bridge

2. Code calibration – why is it so difficult?

3. Hidden safety in the design codes?

4. What do (bridge) clients want?

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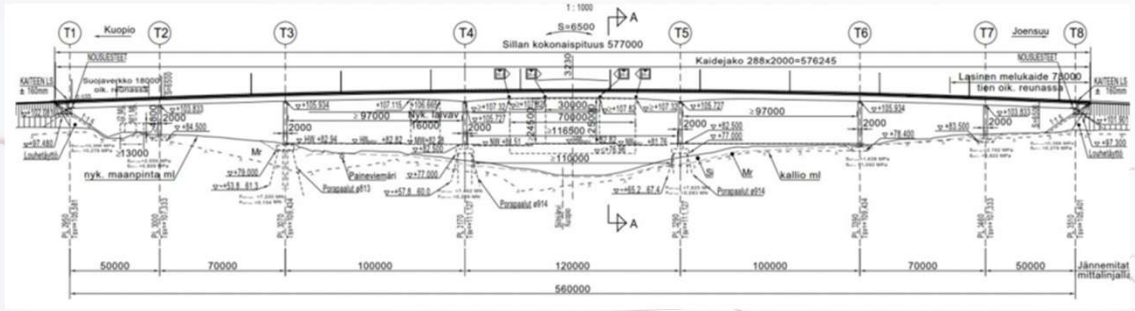
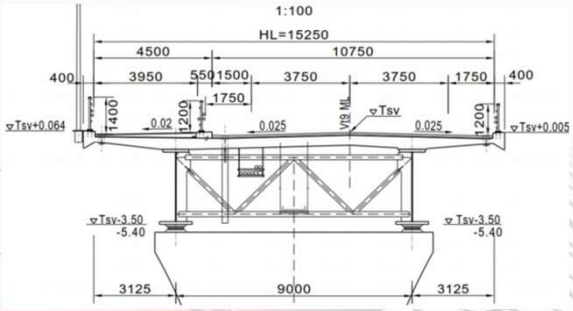
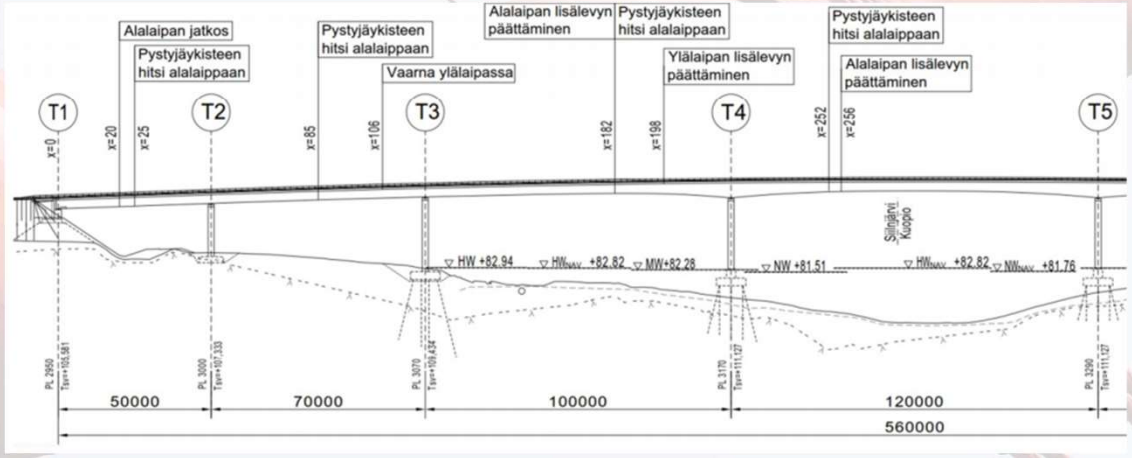
1. Examples of fatigue studies

1a - Composite steel-concrete bridge, 560m - main span 120m







Final Thesis (Tarmo Yli-Junno 2017)

Fatigue study for bWIM-data

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Comparison to Eurocode fatigue load models

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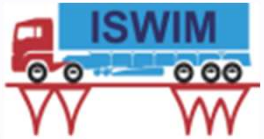
1. Examples of fatigue studies

1a - Composite steel-concrete bridge, main span 120m

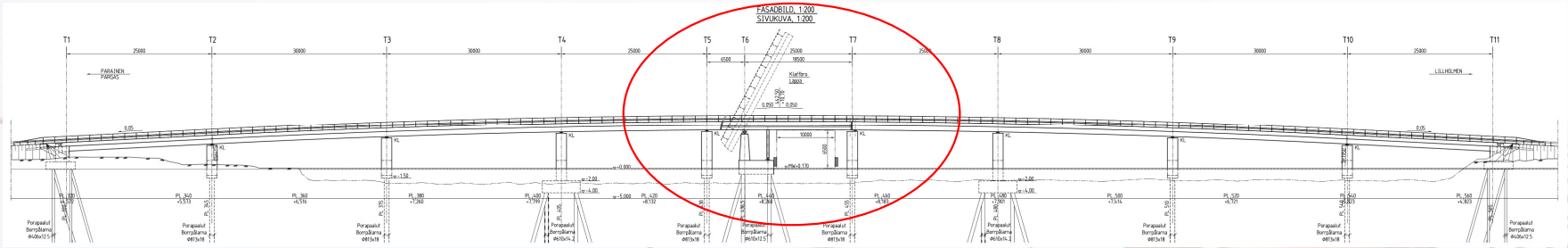
Main Conclusions:

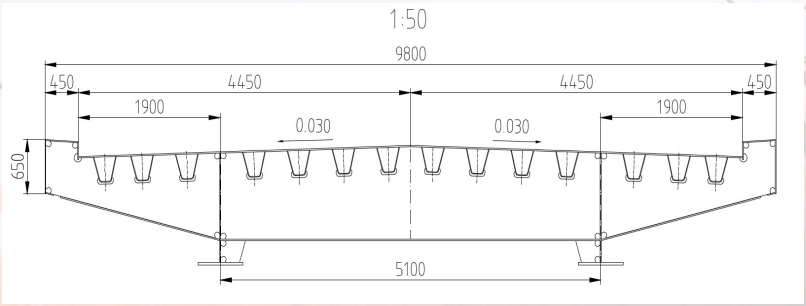
- The study was made with bWIM-traffic recorded yearly between 2013…2018
- FLM4 was found to be unreliable – default weights (in Eurocode) are not sufficient for Finnish Traffic (heaviest in Europe, legal limit 76 tons)
- FLM3 was found to be conservative for shorter spans (50m, 70m) and unconservative for longer spans (100m, 120m) – however, fatigue was not a decisive load situation
- FLM2 was not studied (clearly unconservative for Finnish traffic), FLM1 was not studied (too conservative)
- Special transportations (<0,5% of vehicles) cause >50% of the fatigue
- Fatigue accumulation is very, very site-specific
- Good detailing is important, weld improvement methods can save the day…
- Fatigue accumulation increased ~30% for some details after the regulation change

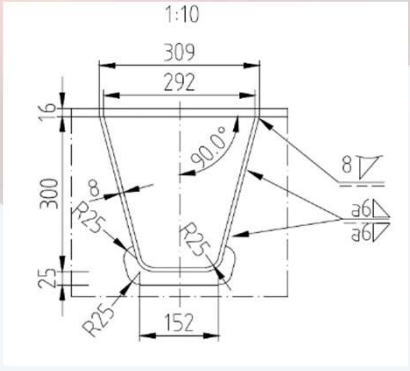


1. Examples of fatigue studies

1b - Orthotropic steel plate







Final Thesis (Jami Qvisen 2020)

Standardized Bridge Weigh-in-Motion Data and Its Applications in Bridge Engineering

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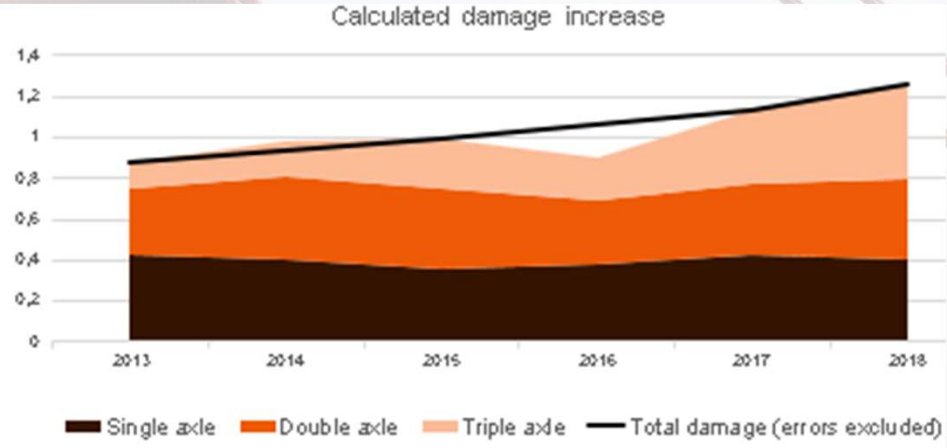
1. Examples of fatigue studies

1b - Orthotropic steel plate

Main Conclusions:

- A standardized method for B-WIM data presentation was proposed in this study.
  - an efficient way to compare and analyse multiple different B-WIM measurements
- Eurocodes Fatigue load model 4 cannot accurately calculate fatigue for orthotopic decks and might, in special cases, underestimate the fatigue damages for bridges in Finland
  - (information about tyres naturally needed, not gained from the WIM)
- Depending on the site, the fatigue accumulation increased considerably after the regulation change

New traffic regulations were set in 2013, which increased the total weights and axle weights of heavy vehicles.



2. Code calibration – why is it so difficult?

- **It is impossible to develop an easy-to-use load model, that achieves uniform reliability level for all kinds of bridges**
- **The span length is very important (e.g. the sweet spot (= lowest reliability) for positive bending seems to be somewhere in span lengths 30….50 meters for flowing traffic)**
- **The type of the bridge is another important factor (how the bridge distributes the load transversally)**

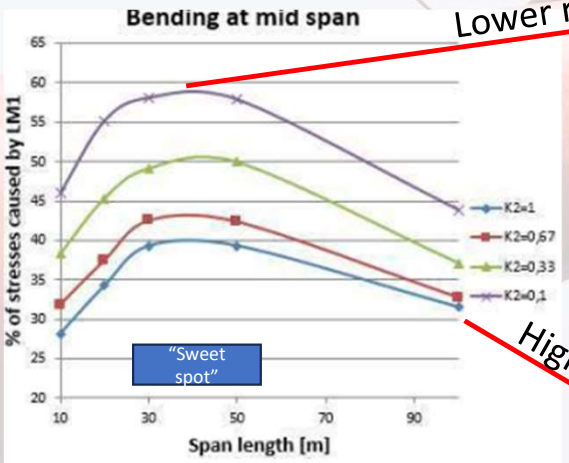


Figure 2. The maximum equivalent bending at mid span.

Lower reliability

Higher reliability

The graph tells the proportion (%) of the Eurocode design load model that the actual (WIM) traffic corresponds to (assuming 2 million load situations)

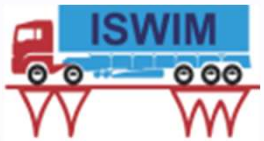
→ for very long spans, reliability increases (hidden safety), also certain types of bridges have hidden safety

3. Hidden safety in the design codes?

- **The design codes are often (for a reason) well safe sided; on rare occasions, they can also be unconservative**
- **There is perhaps no reason to ease the load models in the Ultimate Limit State for new bridges (apart from very long/wide spans), but the hidden safety can be dug out and used for fatigue and serviceability checks.**
- **For existing bridges, this hidden safety is "taken into use" (when allowed) by using lower safety factors for materials (after testing) and loads**
- **The characteristic load models in current design codes (meant for new bridges) are too conservative for bridges designed with old codes. If the wrong models are used, it will easily get very expensive. → safe (but realistic) load models for assessment needed**
- **WIM (and traffic simulations based on WIM data) seems sufficient to deal with this problem, accompanied by appropriate reliability analysis.**
  - **However, transparent methods are needed so that the relevant Authorities can trust them….**

4. What do (bridge) clients want?

- Clients do not want black boxes, transparency needed
- Often, bridge clients are interested in totally different aspects than other clients
- Give out clear statistics of the vehicles so that they can be used in the simulations for existing bridges
- Measurements with only a huge amount of data are not enough; some level of expert data analysis is needed to give the Client ready-made tools to utilize the data to the fullest
- In the age of AI, data will be used anyway (in the near future?). Shouldn't we show the way (so that we are not completely unaware of what AI is doing…)?



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IABSE

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Task Group 1.10

Mission Statement/Objectives

The main objective of the project is to provide a platform to exchange knowledge and provoke understanding of the benefits of using road traffic data in research, design, and assessment of bridges.

Thank you for your attention

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