Recommendations for Dynamic Allowance in Bridge Assessment

Eugene OBrien, Arturo Gonzalez

Daniel Cantero, Jason Dowling

University College Dublin

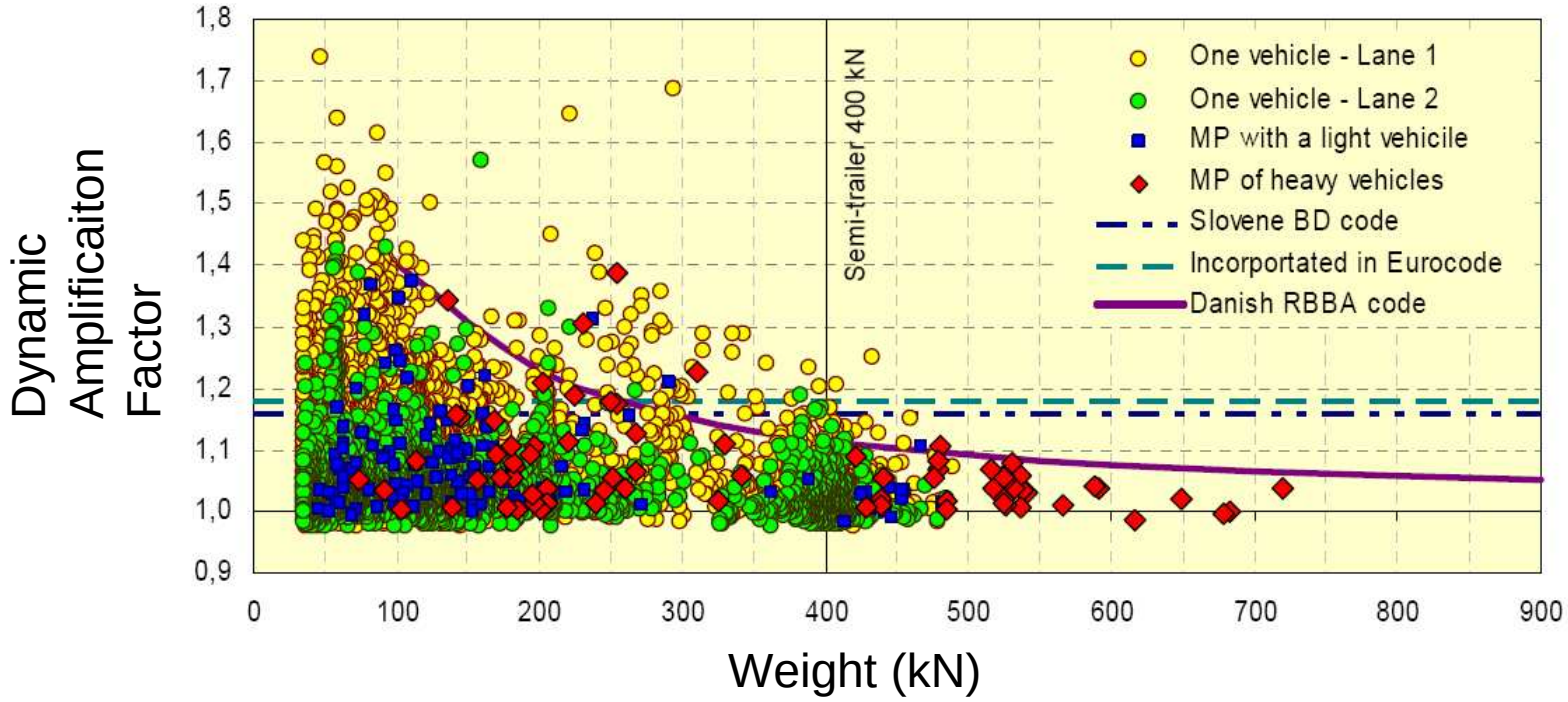
1. Introduction
2. Dynamic Allowance for All Bridges
3. Recommendations for Site-Specific Assessment of Dynamic Allowance
4. Conclusions

1. Finding Characteristic Static Load Effect, i.e., Load Effect with acceptably low probability
   - previous speaker (WIM measurements and computer simulations)

2. Or use a notional load model for assessment

3. Adding an allowance for dynamic amplification
   - this is what I will address

We have reason to believe that allowances for dynamics are quite conservative



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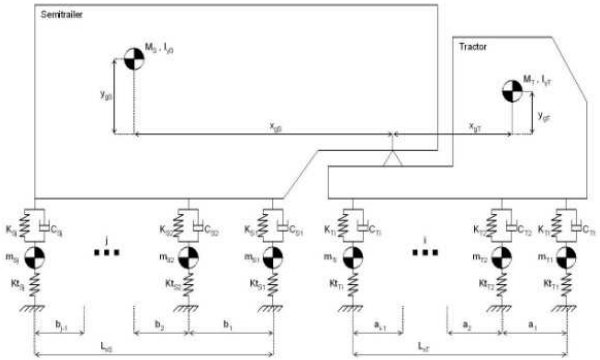
Previous studies considered dynamics for common trucks (2-axle or 5-axle)

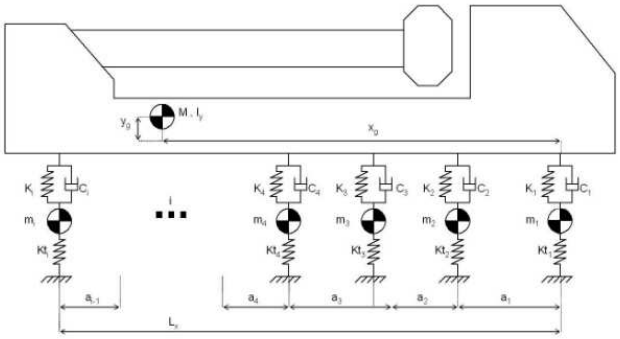
We found in ARCHES that critical loading events involve big cranes or low loaders

In ARCHES, we compared dynamic amplification for cranes & 5-axle trucks

5-axle truck



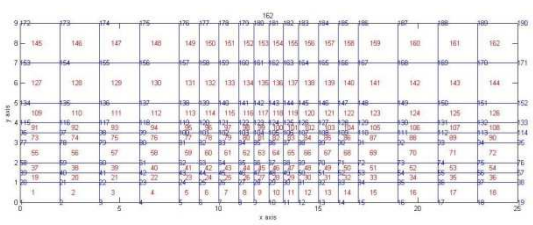
crane

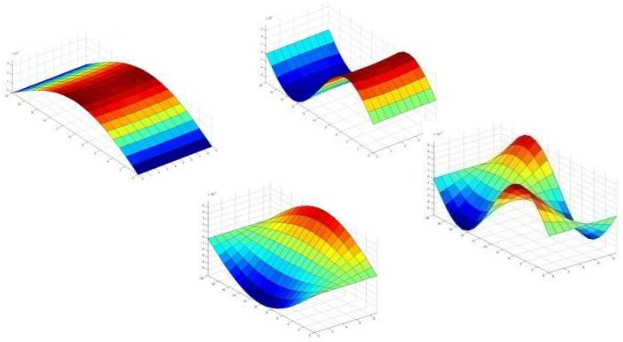


- Beam Model

- Euler-Bernoulli beam
- Inaccurate
- Conservative
- Faster calculations

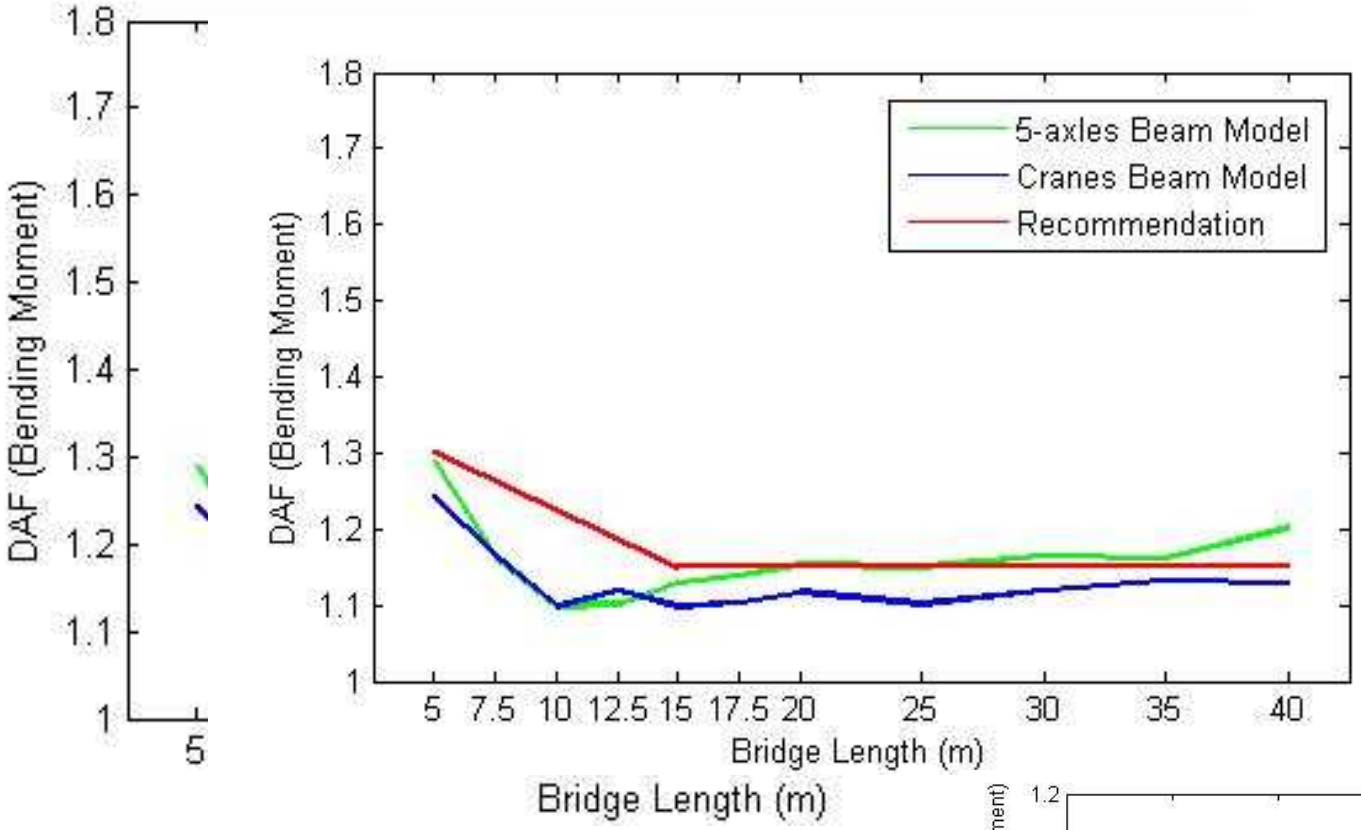
- Plate Model (FEM)





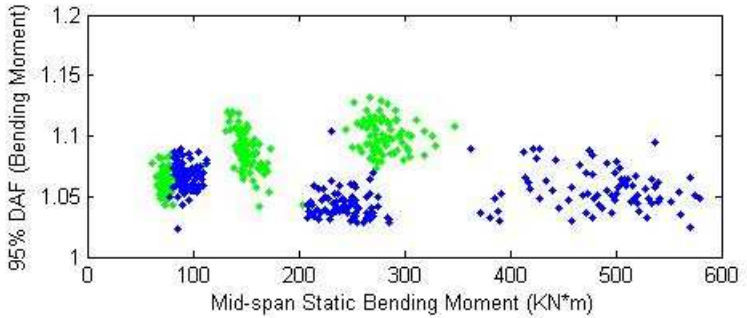
- Finite Element Plate
- More accurate
- Slower calculations

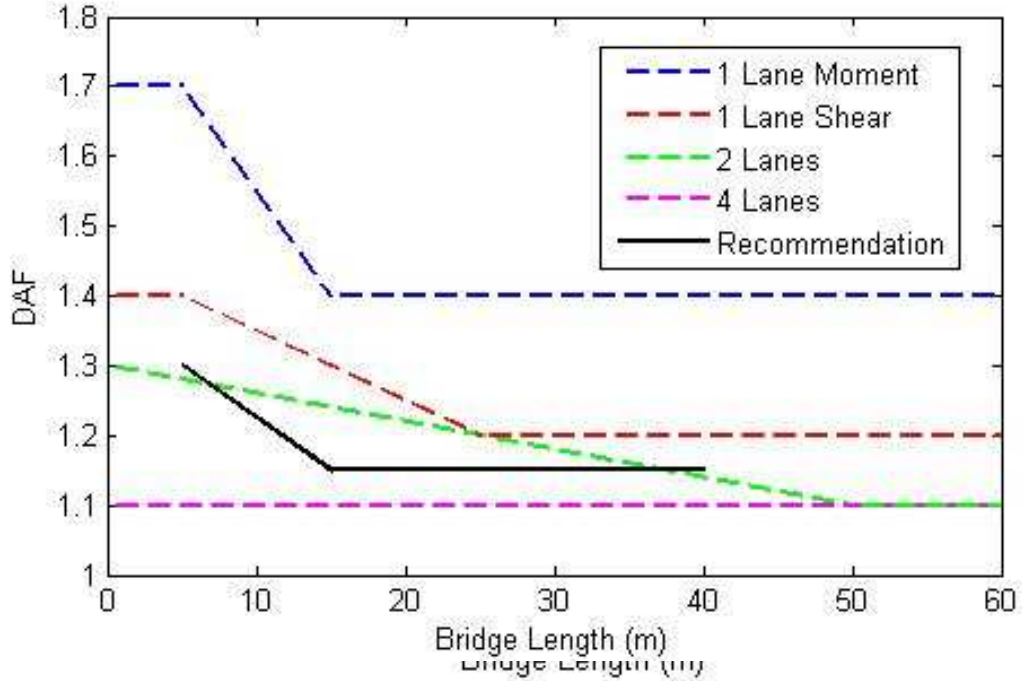
- Vehicle fleet
  - Woerden Weigh-In-Motion site (The Netherlands)
  - 77 daily maxima
  - 5-axle truck vs. Crane type vehicles
- Random variability (Monte Carlo scheme)
  - Road profiles, ISO Class A & B
  - Vehicle properties (Speed, suspension and tyre stiffness, …)
- Results
  - Over 300 000 Beam model simulations
  - Over 50 000 Plate model simulations
  - Class A and B profiles analyzed separately



Beam Model: Cranes and Recommendation

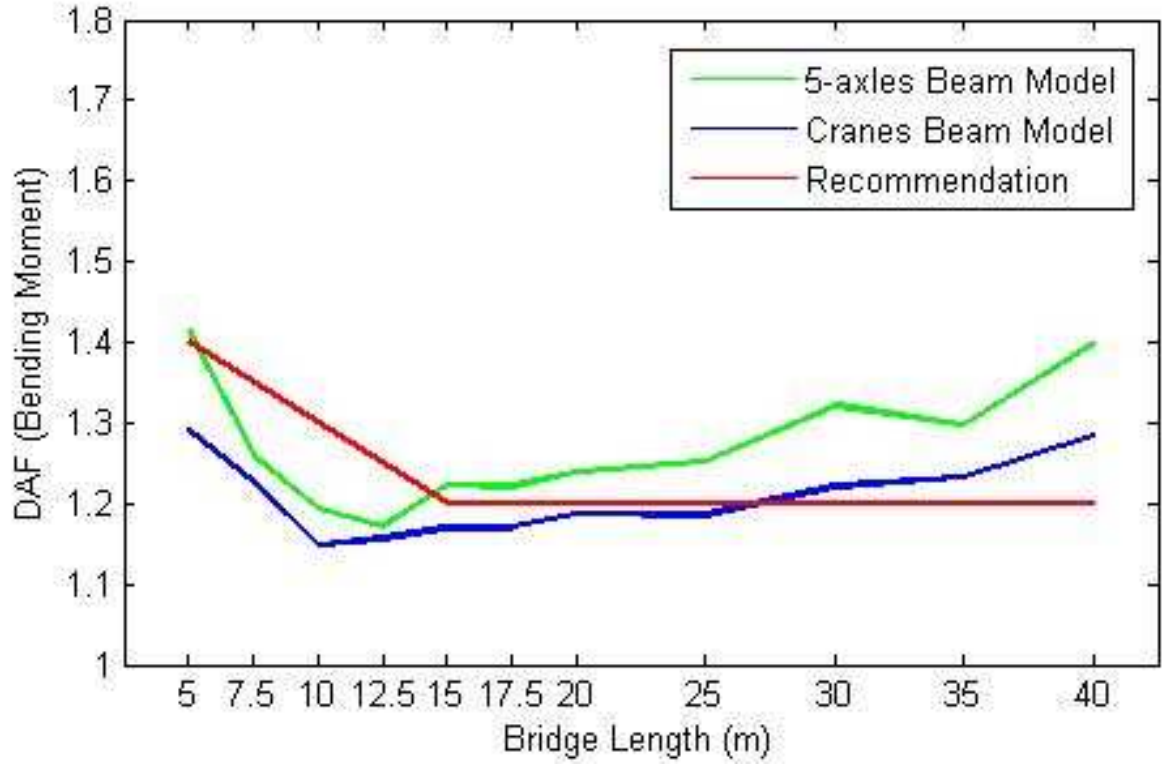
Same trend for 95% confidence interval for



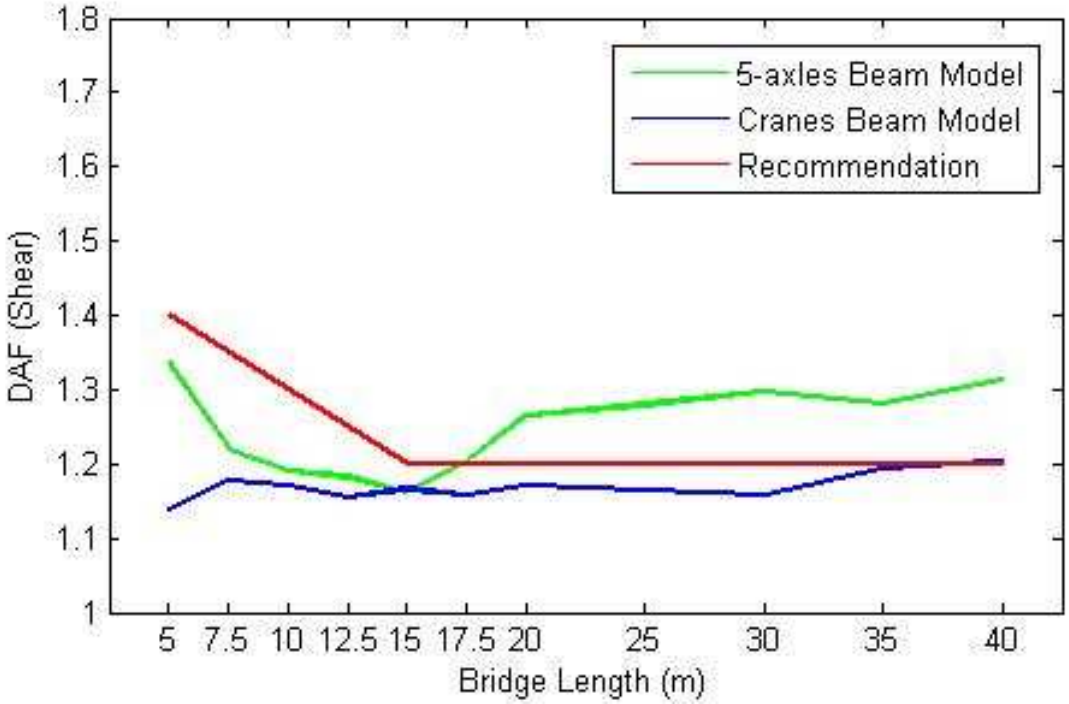


Class A Recommendation for

- 1 Lane Moment
- 1 Lane Shear
- 2 Lanes



Class B Bending Moment &
Recommendations



Class B Shear &
Recommendations

- This study was for1-Lane bridges
- (But would be conservative for 2-lane bridges)

Next Steps

- Study of 2-Lane scenario
  - Critical events (2 or more vehicles meeting on the bridge)
- Estimation of calculation time
  - Critical events using traffic model = 40 PC-days
  - Dynamic evaluation of events = Another 60 PC-days
- Expect reduced allowances for dynamics

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Site-specific measurement of Dynamic Amplification:

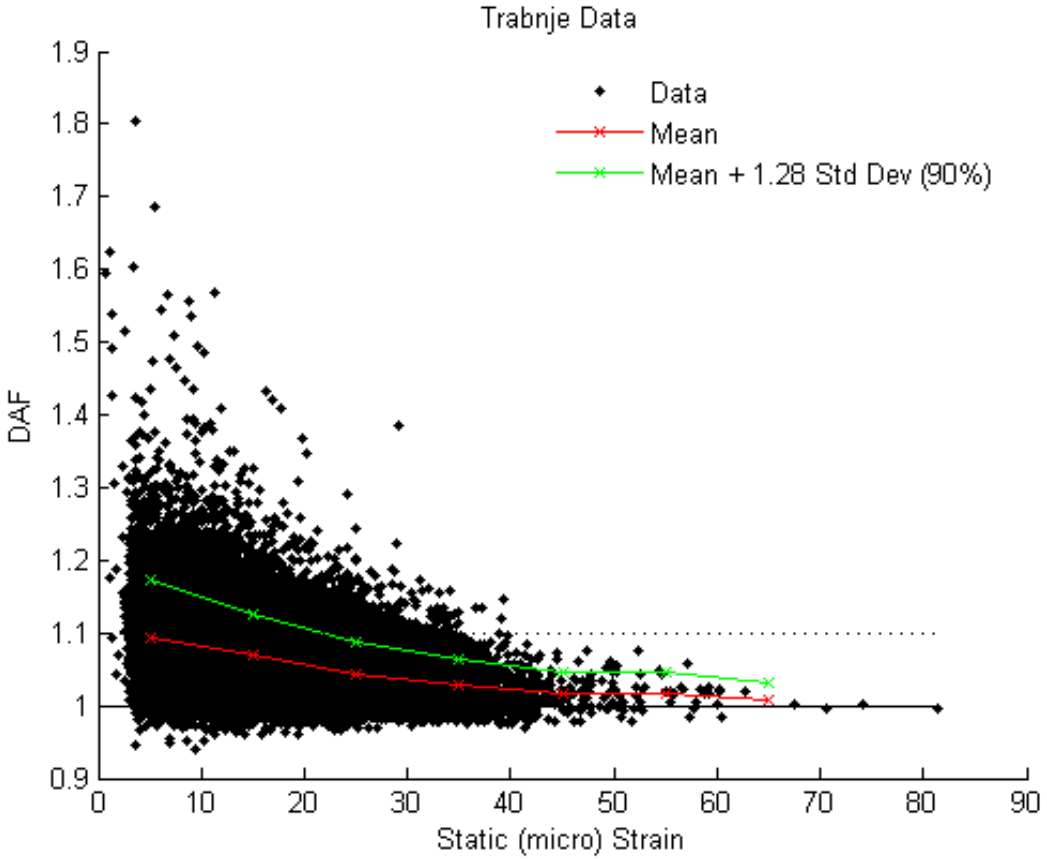
- Directly measure total strain
- Use Bridge WIM system to measure truck weight
- Hence estimate the static strain

- Estimate of DAF = Total/(Est. of Static)

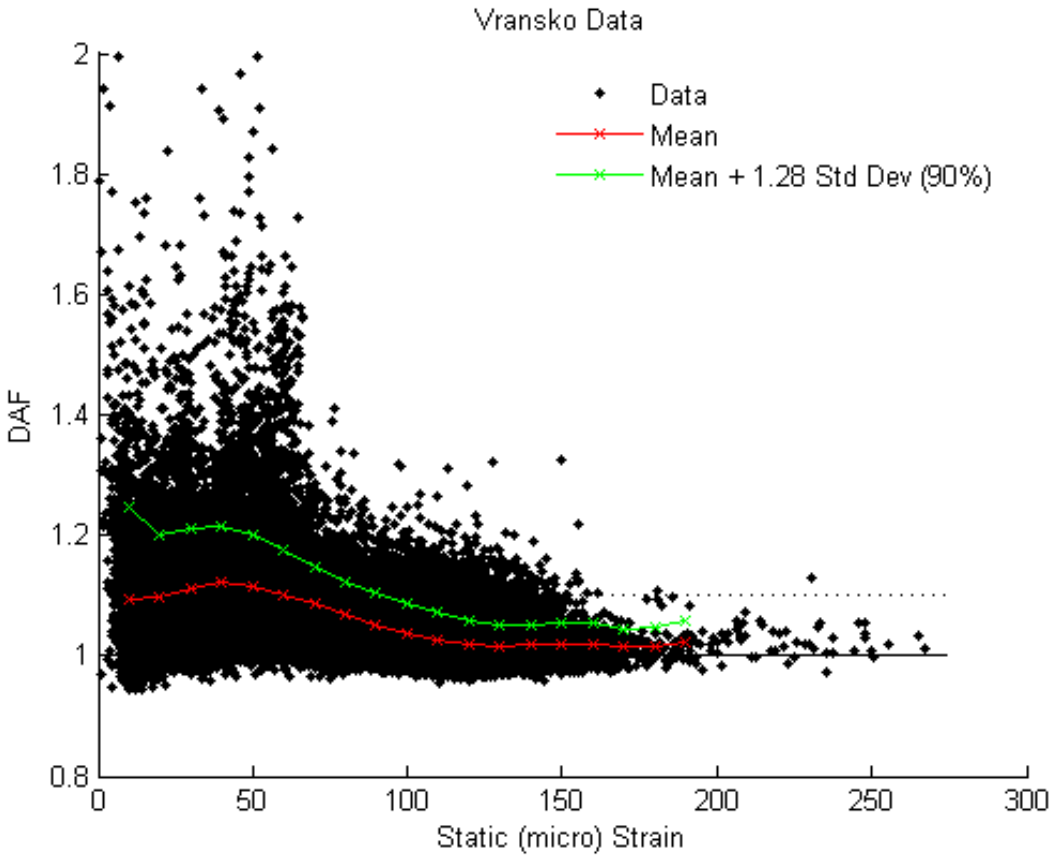
Bridge Weigh-In-Motion Data was analysed from 4 locations:

- Trebnje	8m 50 937 events (34 days)
- Vransko	24.8m 112 339 events (58 days)
- Blagovica	12m 50 770 events (33 days)
- The Netherlands	7.3m 52 694 events (15 days)

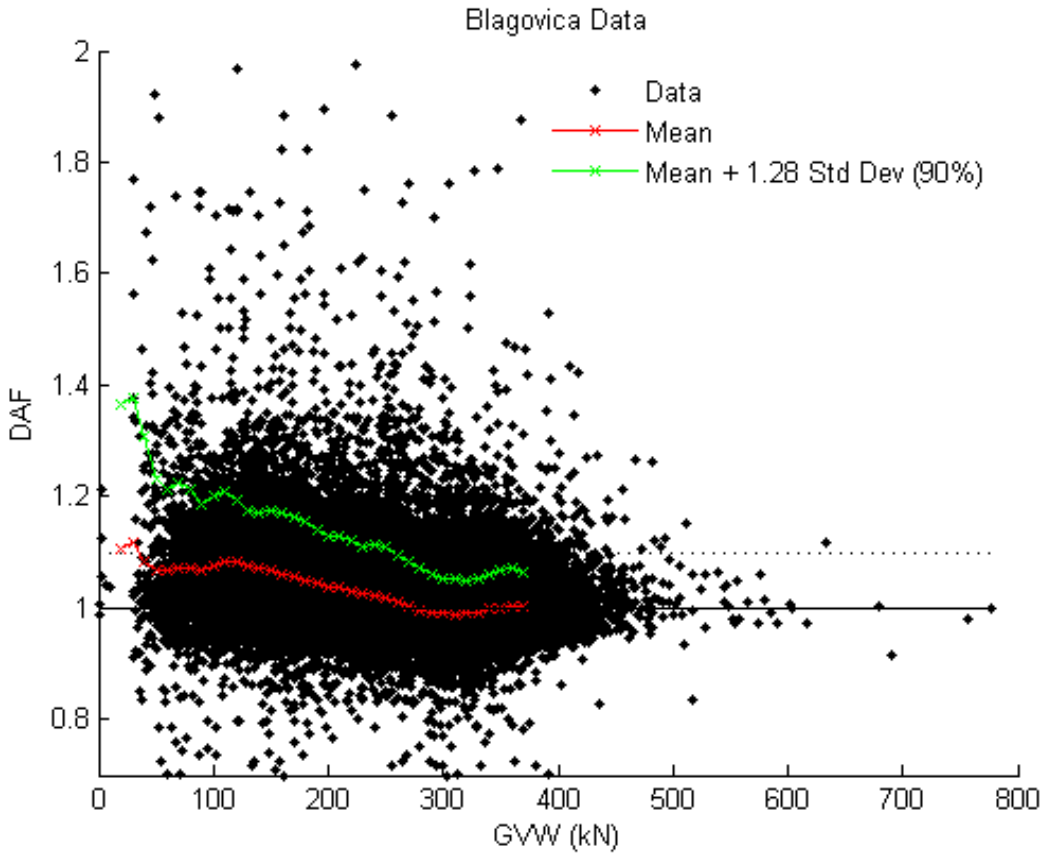
Trebnje


Trabnje Data
Data
Mean
Mean + 1.28 Std Dev (90%)
DAF
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0
10
20
30
40
50
60
70
80
90
Static (micro) Strain

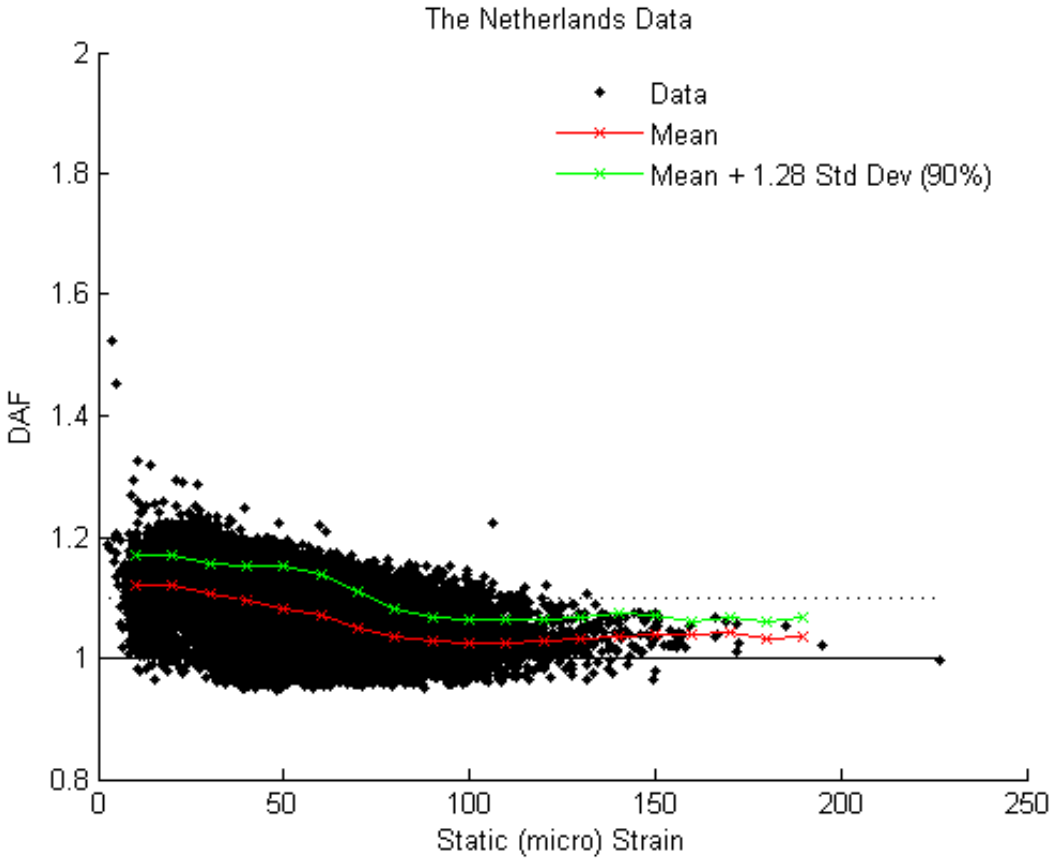
Vransko


Vransko Data
Data
Mean
Mean + 1.28 Std Dev (90%)
DAF
Static (micro) Strain
2
1.8
1.6
1.4
1.2
1
0.8
0
50
100
150
200
250
300

Blagovica


Blagovica Data
Data
Mean
Mean + 1.28 Std Dev (90%)
DAF
GVW (kN)
2
1.8
1.6
1.4
1.2
1
0.8
0
100
200
300
400
500
600
700
800

The Netherlands



Definition of Dynamic Amplification Factor (DAF):

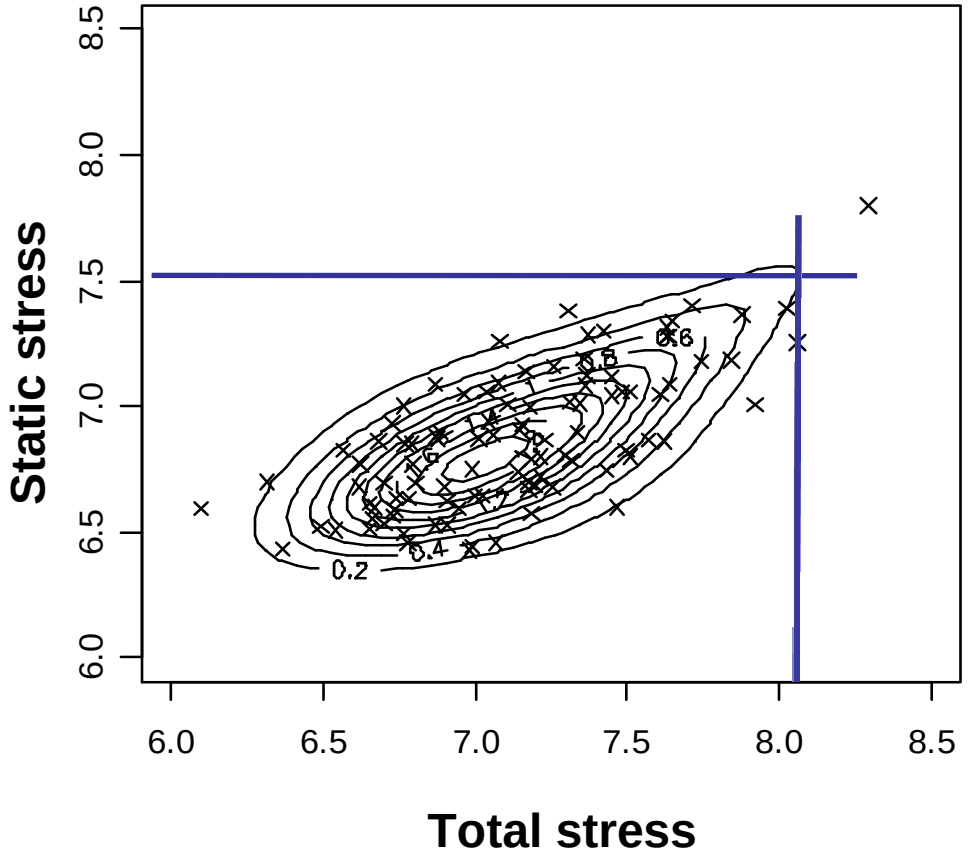
$$DAF = \frac{\text{Dynamic stress}}{\text{Static stress}}$$

for a given loading scenario

We have developed a new factor for dynamics, Assessment Dynamic Ratio (ADR):

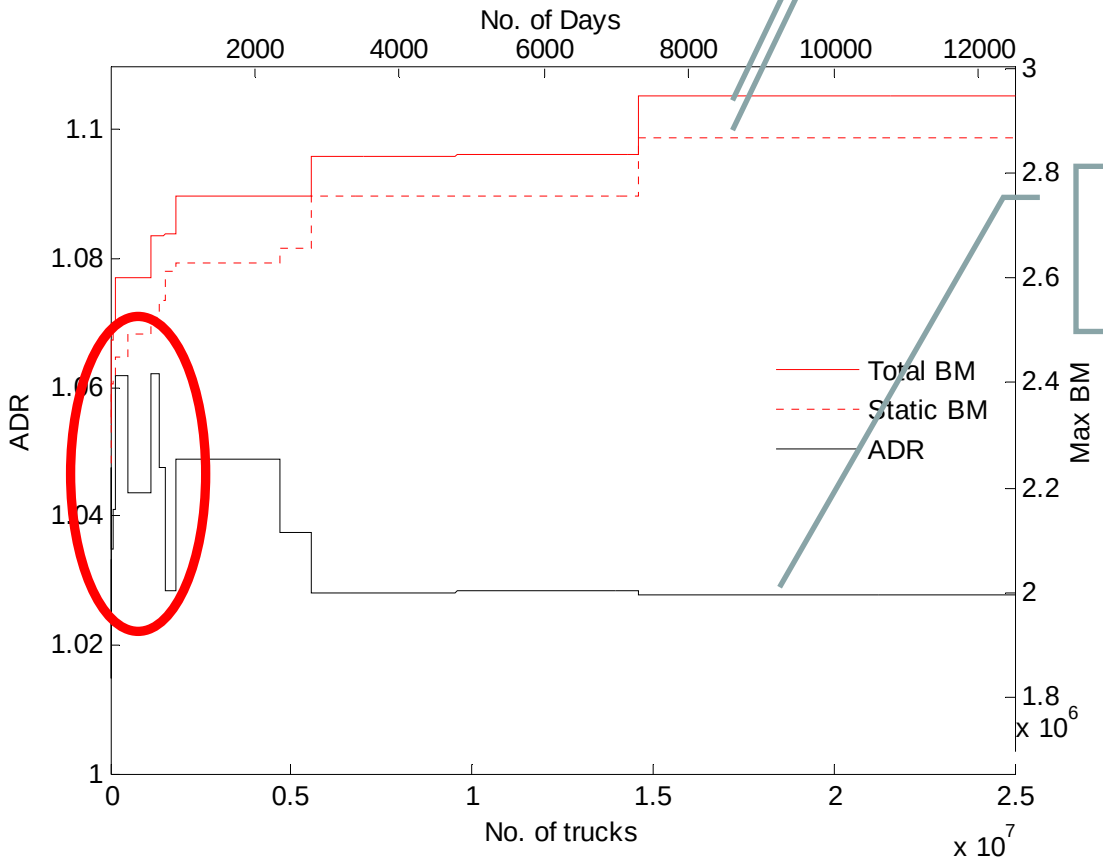
$$ADR = \frac{\text{What we want to know}}{\text{What we already know}}$$

$$ADR = \frac{\text{Characteristic total stress (all scenarios)}}{\text{Characteristic static stress (all scenarios)}}$$


Static stress
Total stress
6.0
6.5
7.0
7.5
8.0
8.5
0.2
0.4
0.6
0.8

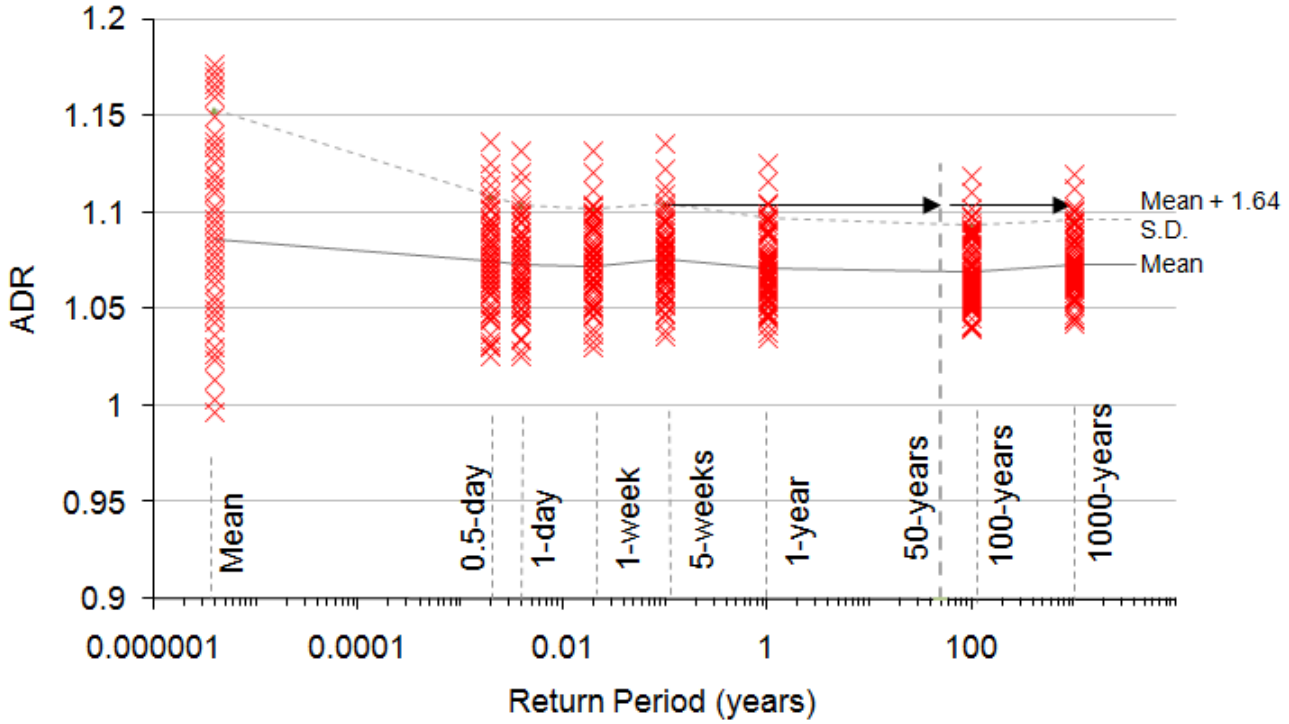
50 years...

Estimate of Max Static Bending Moment



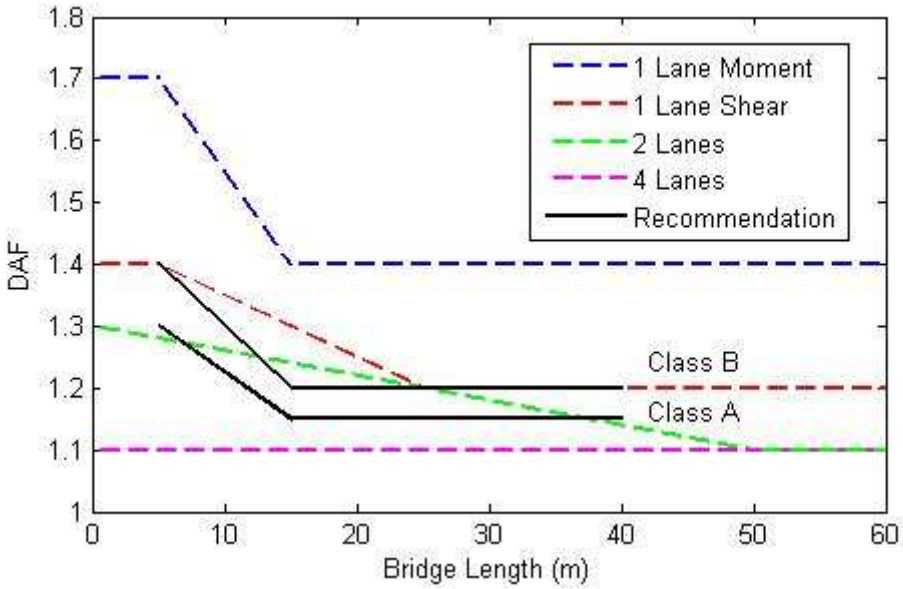
Assessment Dynamic Ratio (ADR)

Recommendation – we need about 3 months of data to predict the ADR for a 50-year return period



Conclusions

- There is a great deal of conservatism in the general EC1 allowances for dynamic amplification
- Recommendations for single vehicle events (1-lane bridges):



Conclusions (continued)

- For particular bridges, it is often possible to prove that allowances are much too conservative

- Recommend using Bridge WIM to estimate static
- And measure total strain directly
- 3 months of data enough for good estimate of Assessment Dynamic Ratio