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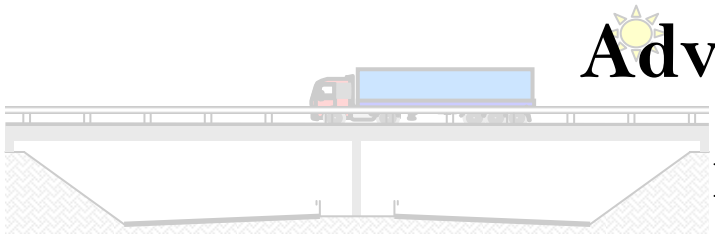
Advances in Structural Analysis



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Introduction

To address the topic:

1. Define the context, i.e., define Structural Engineering;
2. Identify structural analysis within Structural Engineering;
3. Examine the elements of structural analysis;
4. Discuss current state-of-the-art;
5. Locate areas for future progress.

Definition of Structural Engineering

***Institution of Structural Engineers*:**

"…the science and art of designing and making with economy and elegance buildings, bridges, frameworks and other similar structures so that they can safely resist the forces to which they may be subjected"

***Prof. Tom Collins, University of Toronto*:**

"…the art of moulding materials we do not really understand into shapes we cannot really analyze so as to withstand forces we cannot really assess in such a way that the public does not really suspect"

Taking Prof. Collins' key elements of structural engineering…

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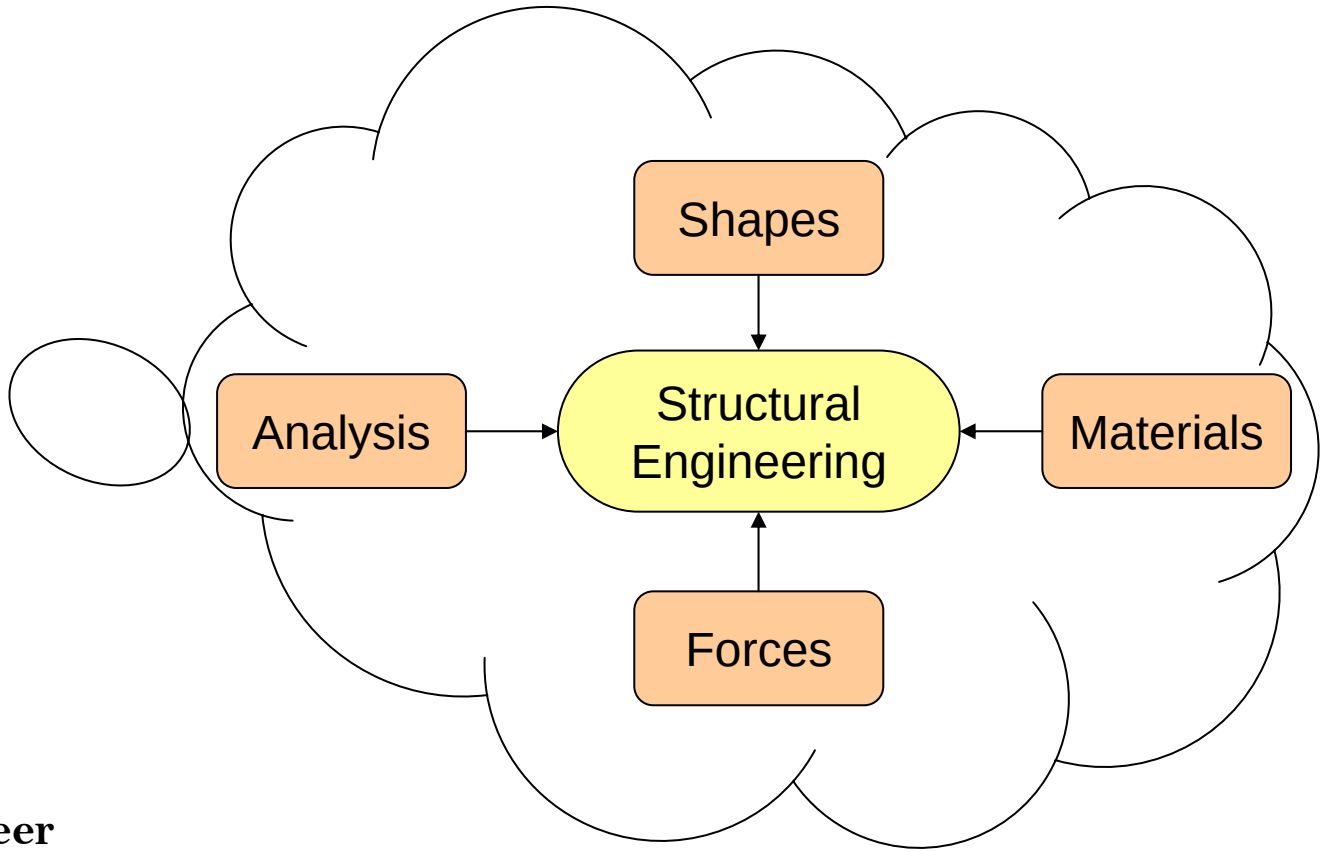
Key Elements

We have:

The Structural Engineer



The Design Process

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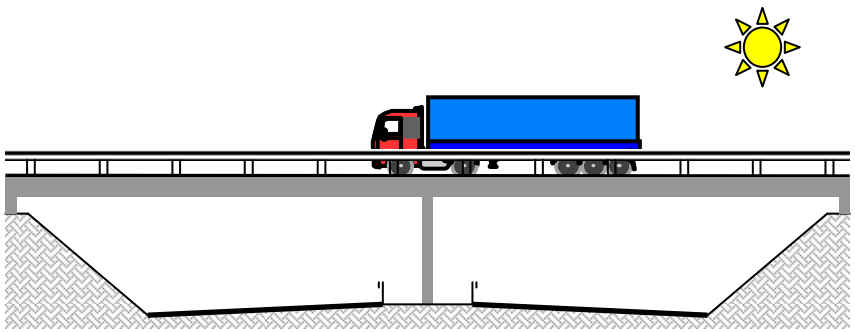
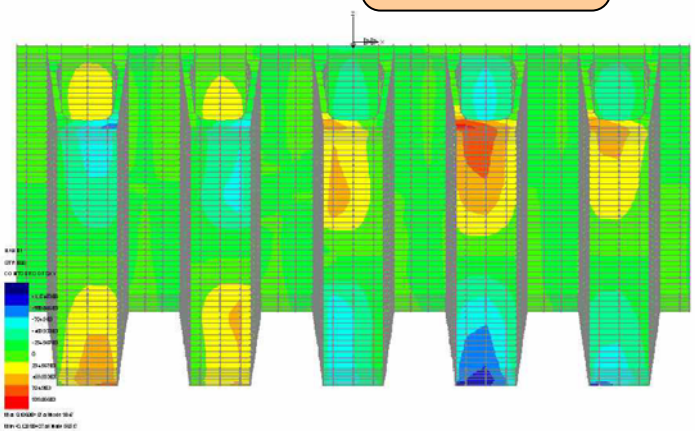
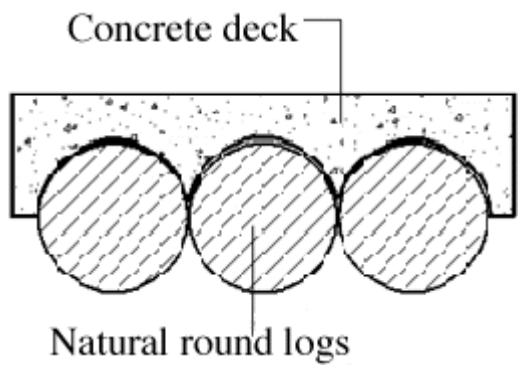
Analysis Process

The Structural Analysis process is:







Shapes

Loads

Structural Analysis

Materials

Stress Resultants

Design for Analysis

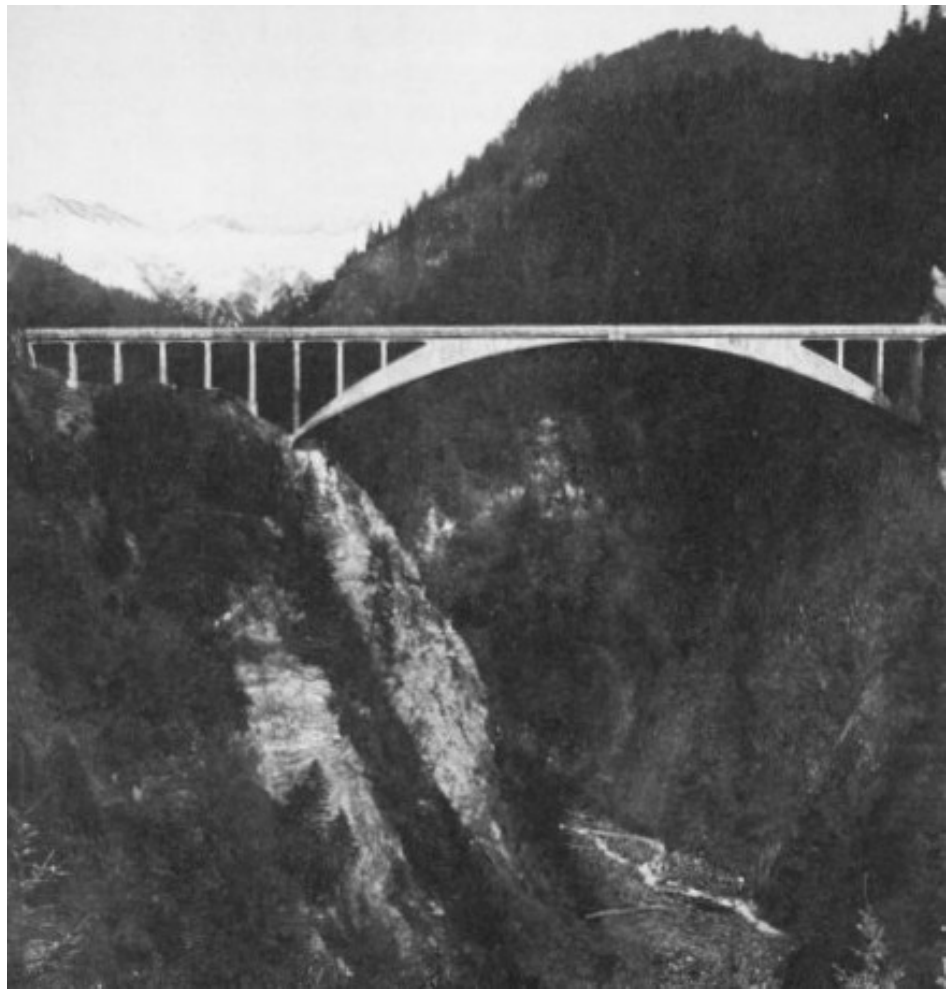
Note that Structural Analysis requires:

- A structural form (shape);
- A choice of material;

These choices form the art involved in structural engineering.

In contrast:

- loads are stipulated;
- the analysis method should make little difference.



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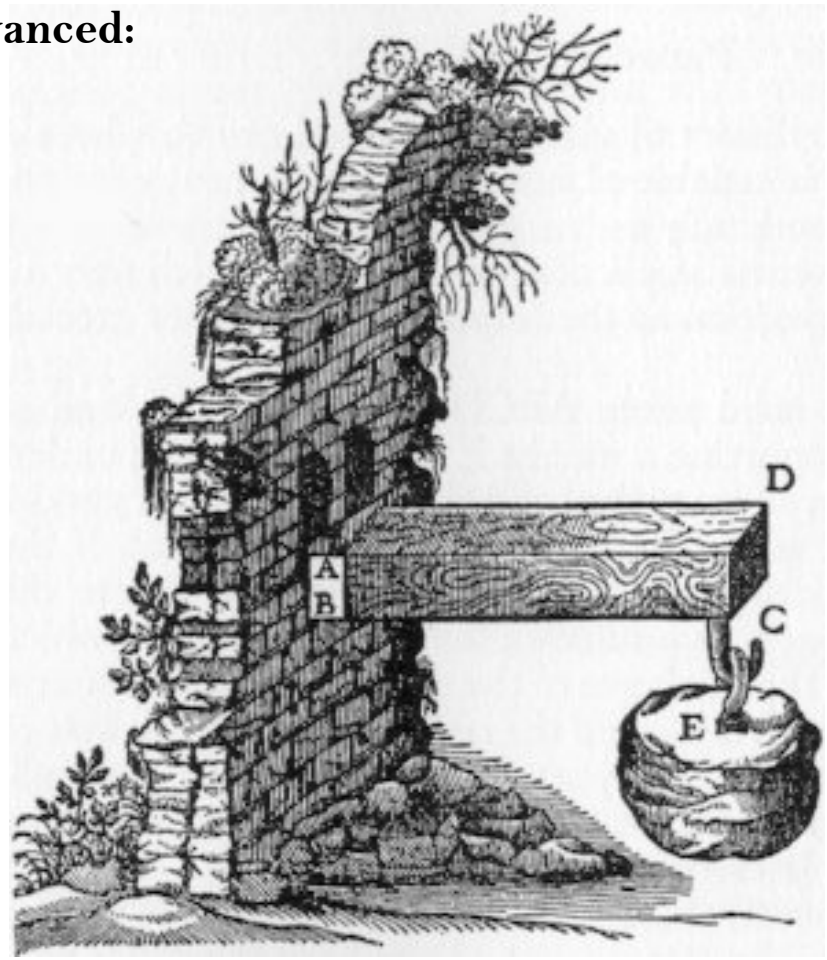
Analysis Methods

Since Galileo used Hooke's Law, we have advanced:

- **Euler-Bernoulli beam theory;**
- **Coulomb's analysis of arches;**
- **Clapeyron's theorem of *3* moments;**
- **Mohr's thereoms;**
- **Theory of Elasticity;**
- **Moment Distribution;**
- **Plastic Analysis;**
- **Computer methods of structural analysis.**

…all leading to: The Finite Element Method



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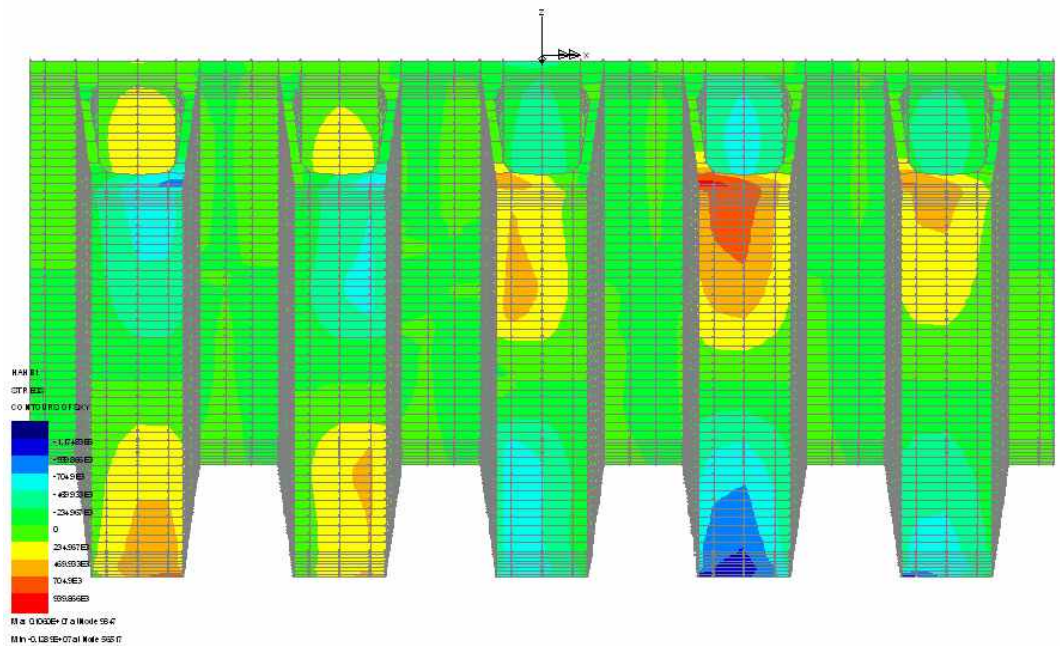
Analysis of Structures – State of the Art

Given:

- **arbitrary geometry;**
- **stipulated loading, and;**
- **boundary conditions,**

finite element analysis:

allows us to solve for all stress resultants to any desired degree of accuracy.



Has the methods of analysis essentially reached their peak?

Are advances in such areas as mesh generation, new elements, and material models more refinement than innovation?

What about loading?

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Loading

Institution of Structural Engineers:

> ***"Structures…must safely resist the forces to which they may be subject."***

But what forces does nature impart to our structures?

We can identify the types:

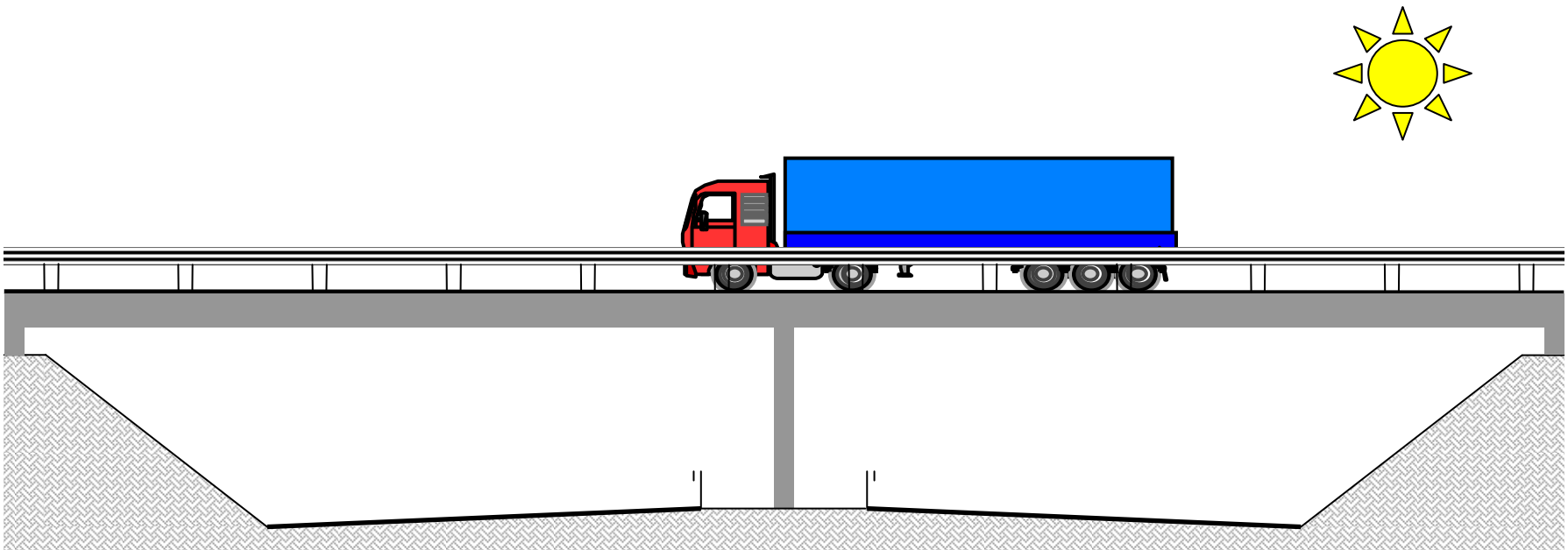
- **Environmental loads (wind, snow, temperature, etc.);**
- **Imposed loads (people, traffic, furnishings etc.);**
- **Dead loads (self weight, superimposed dead loads etc.).**

But what about the actual values?

- **Currently a mix of measurement, statistics and tradition.**

Loading – Example

The bridge structure below must be designed for many forms of force.



Examine bridge traffic loading as an example

Initial Measurement

In bridge traffic loading:

Weigh-in-Motion is used to collect truck data, such as:

- Gross Vehicle Weight;
- Configuration, axle-weights and spacings;
- Speed and headway or gap to vehicle-in-front.

Using influence lines, 'measured' load effects can then be determined.

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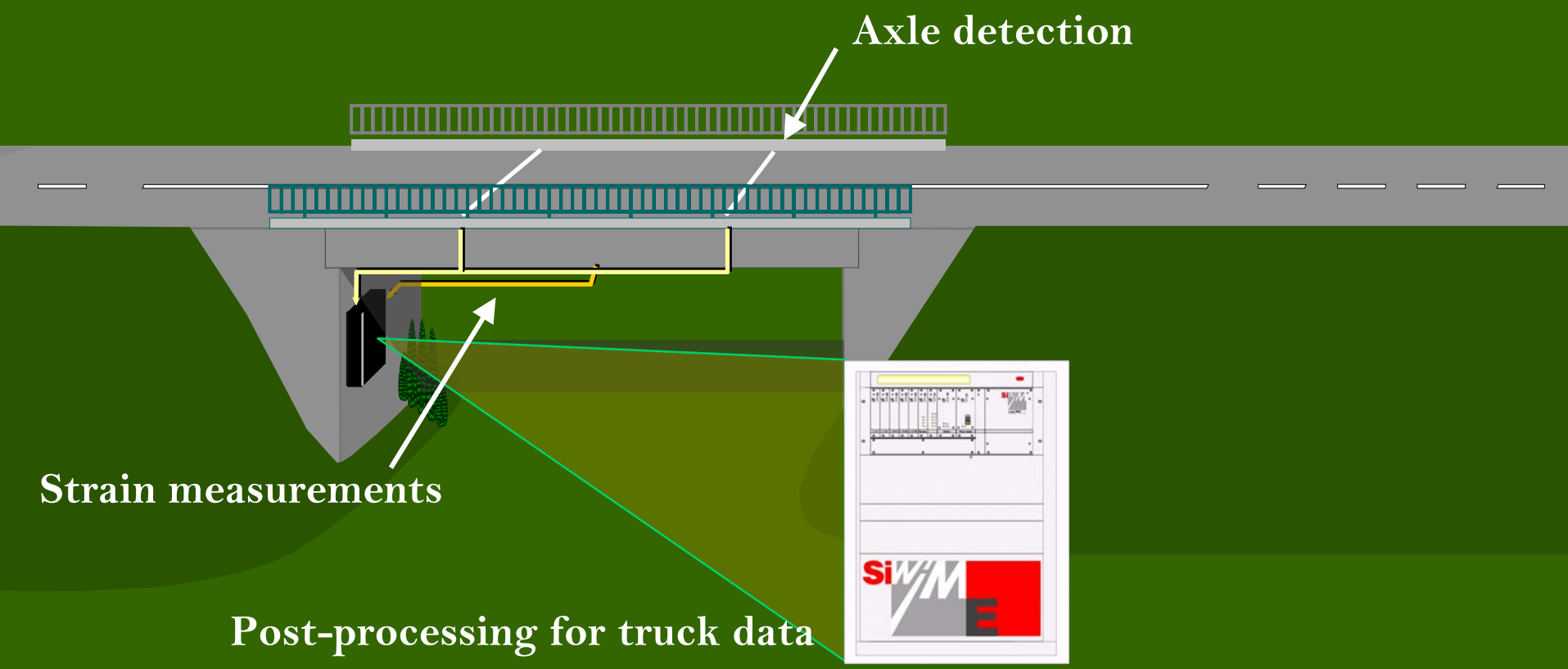
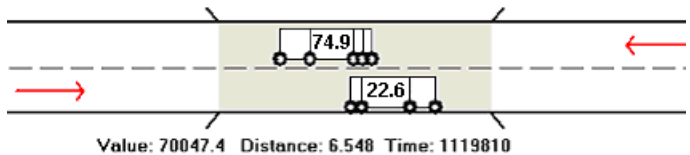
Weigh-In-Motion



Loading Theory

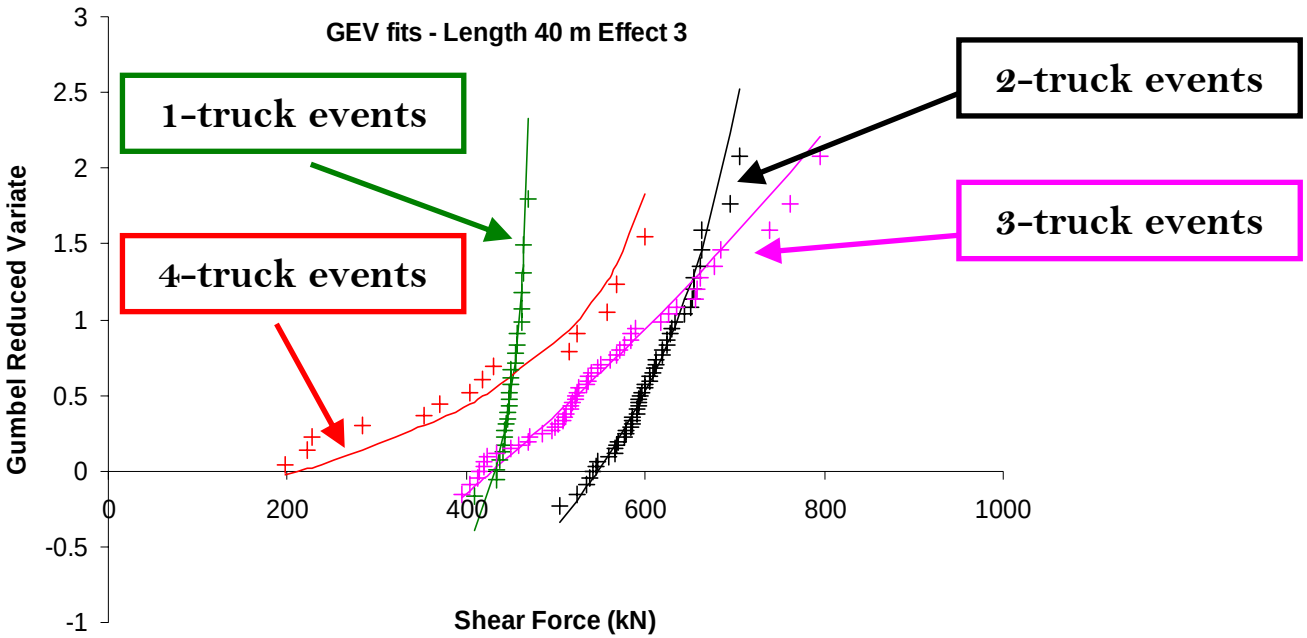
In bridge traffic loading:

Different forms of loading event exist:



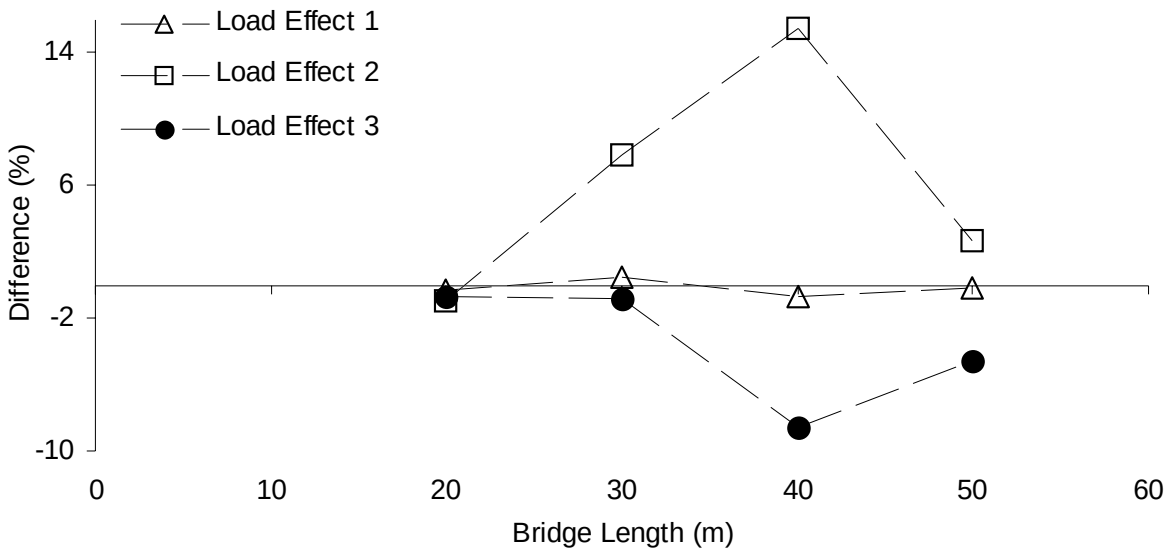
The statistical analysis takes account of this:

2-truck event



Impact of New Theory

Effect of latest theory:



Changes in loading of up to 14%

Conclusions

- Current methods of strutural analysis are briefly examined;
- Bridge traffic loading is used as a pertinent example;
- Better analysis of bridge loading changes stress resultants by 14%
- This is considerably more than might be expected from:
    - Better mesh generation;
    - Improved material models, etc.

Therefore:

Future advances in structural analysis are more likely in the analysis of loading than in the numerical calculations.

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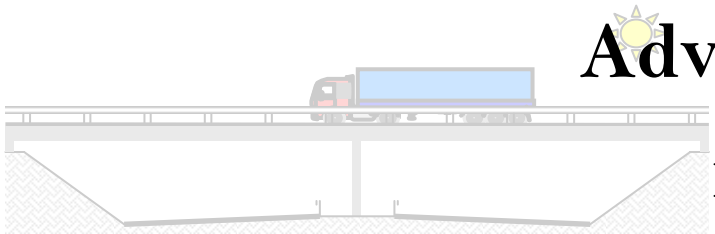

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