

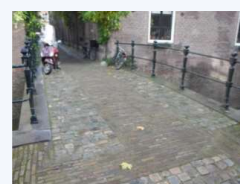
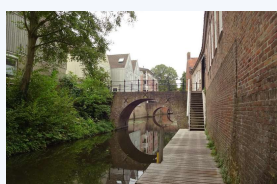


Content

1. Background
2. Masonry arch bridges: definitions and principles
3. Assessment cycle
 1. Survey
 2. Structural assessment
 1. Desk study
 2. Inspections & investigations
 - 3. Verification calculations**
 4. Measures & Advice
 5. Test load (example)
4. Questions

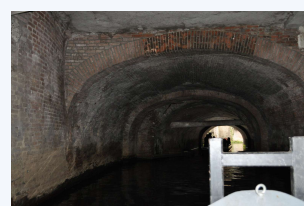
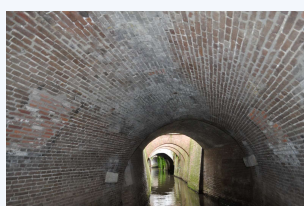
1. Background

- Masonry arch bridges: 35 in total
 - 25 road bridges
 - 10 bicycle- and pedestrian bridges
- Raamovereenkomst: assessment of structural safety



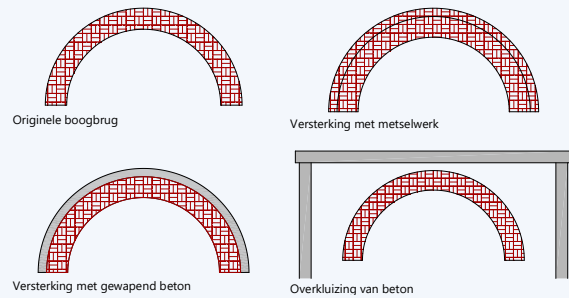
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1. Background



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1. Background



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1. Background



- Plan of approach:
 - . Fase 0: Preparations
 - . Fase 1: Inspections
 - . Fase 2: Preliminary research (calculation method)
 - . Fase 3: Preparations test load (prediction FEM)
 - . Fase 4: Test load (post-diction FEM)
 - . **Fase 5: Structural assessments (risk-driven)**
- Opstellen richtlijn 'Aanpak constructieve beoordeling metselwerk boogbruggen 's-Hertogenbosch'

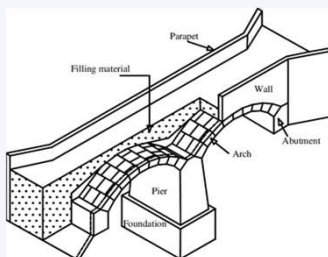
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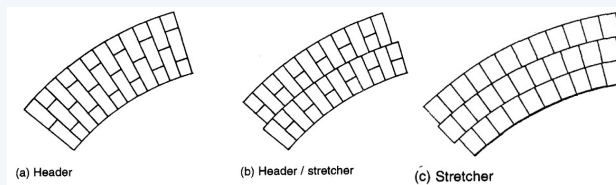
1. Background
2. **Masonry arch bridges: definitions and principles**

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2. Masonry arch bridges: definitions



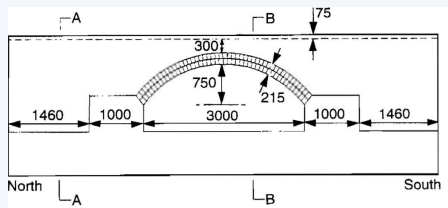
M. Rota et al. (2005)



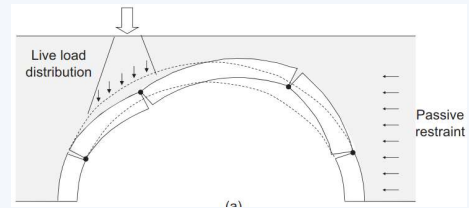
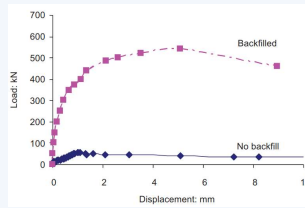
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2. Masonry arch bridges: definitions and principles

Single-span behaviour



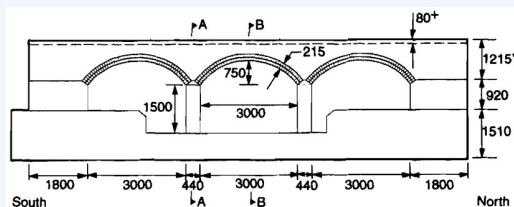
Melbourne and Gilbert (1995)



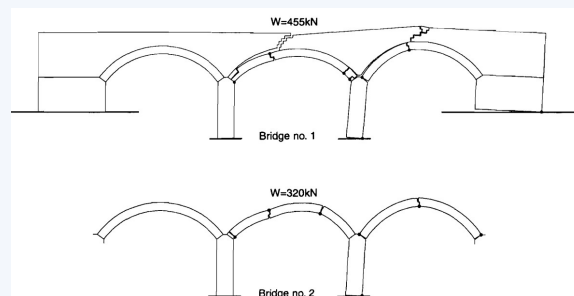
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2. Masonry arch bridges: definitions and principles

Multi-span behaviour



Melbourne and Gilbert (1997)



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1. Background
2. Masonry arch bridges: definitions and principles
3. **Assessment cycle**
 1. **Inventory**
 1. Archival research
 2. Re-assessment necessary?
 3. Clustering
 4. **Prioritization**

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3. Assessment cycle

1. Inventory
4. **Prioritization** o.b.o. MEXE-theorie (risk-driven)
 1. Span (l)
 2. Thickness (d)
 3. Thickness backfill (h)
 4. Weight backfill (s)
 5. Bow height (a)
 6. Compression strength (f)

Not conservative !!!



$$W = \frac{\left(\frac{256 f h d}{l} \right) + 128 \sigma l h \left(\frac{a}{28d} - \frac{1}{21} - \frac{h+d}{4a} \right)}{\left(\frac{25}{a} + \frac{42}{d} \right)}$$

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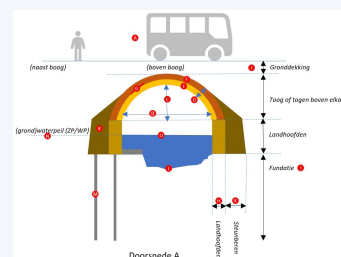
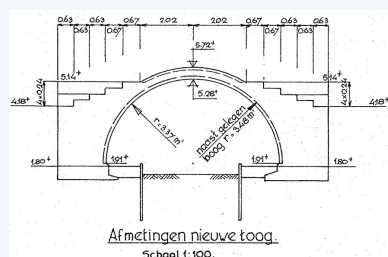
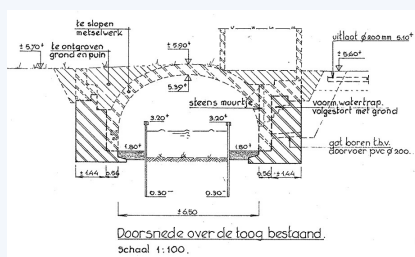
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 2. **Structural assessment**
 1. **Desk study**

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3. Assessment cycle

2. Structural assessment (desk study)



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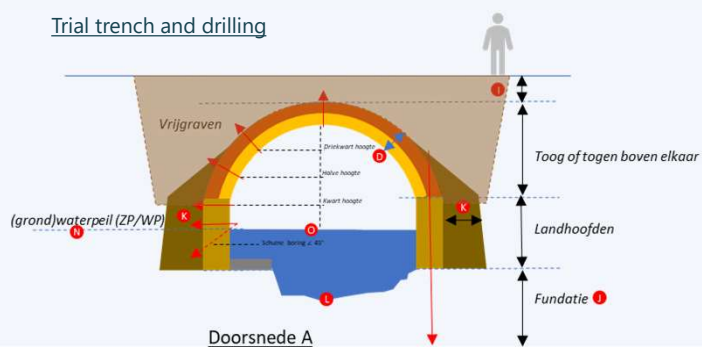
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 4. Measurements & Advice
 5. Test load (example)
4. Questions

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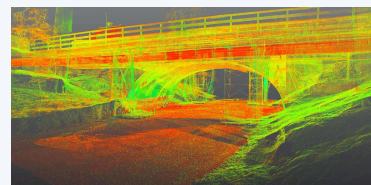
3. Assessment cycle

2. Structural assessment (inspections and investigations)

Trial trench and drilling



DTM



<https://www.rps.nl>

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3. Assessment cycle

2. Structural assessment (inspections and investigations)

Drilling



Inspections



Trial Trench

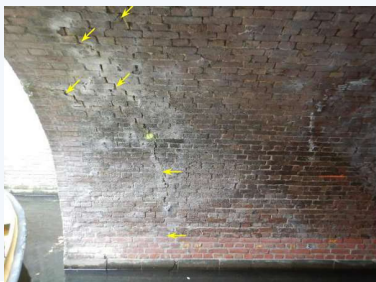


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3. Assessment cycle

2. Structural assessment (inspections and investigations)

Cracks



Repairs



Quality

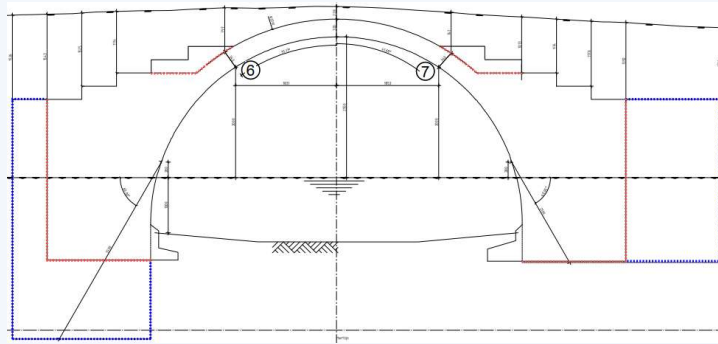


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3. Assessment cycle

2. Structural assessment (inspections and investigations)

Combining data:



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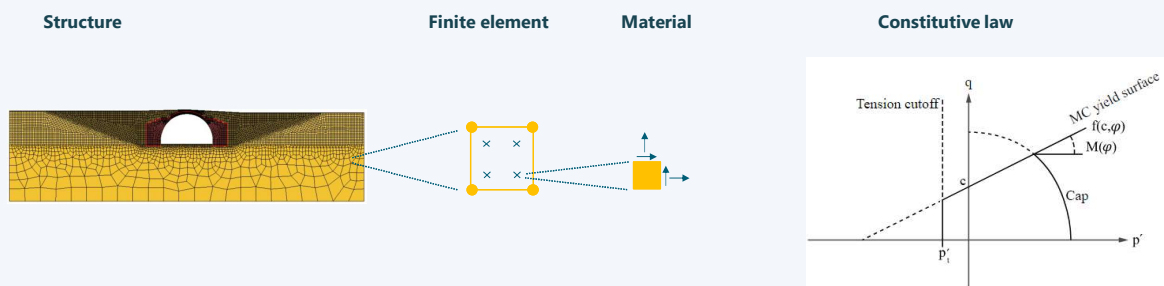
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3. Assessment cycle

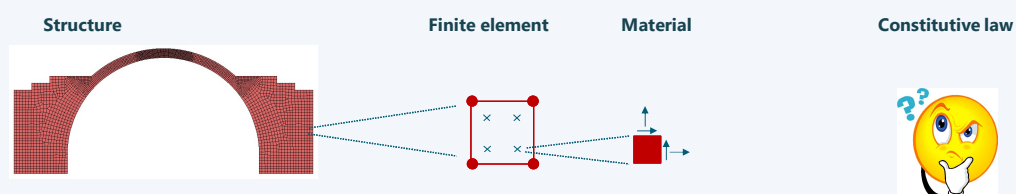
3. Structural assessment (verification calculations)



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3. Assessment cycle

3. Structural assessment (verification calculations)

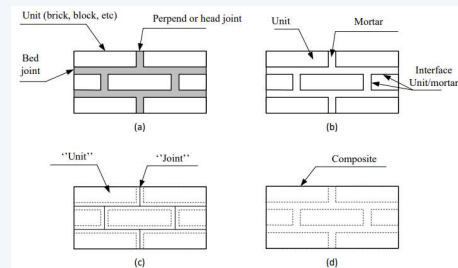


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3. Assessment cycle

3. Structural assessment (verification calculations)

- Detailed micro modelling (b)
- Simplified micro modelling (c)
- Macro modelling (d)

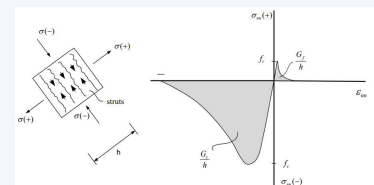
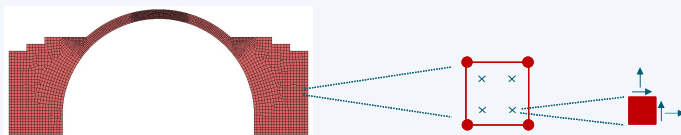


Lourenco (1996)

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3. Assessment cycle

3. Structural assessment (verification calculations)



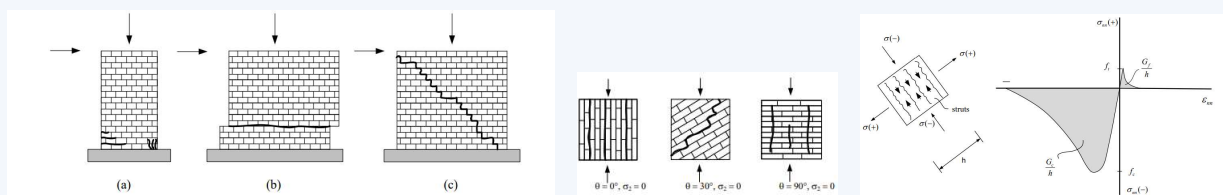
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3. Assessment cycle

3. Structural assessment (verification calculations)

Total strain-based crack model

- Tensile strength?
- Influence of orientation?



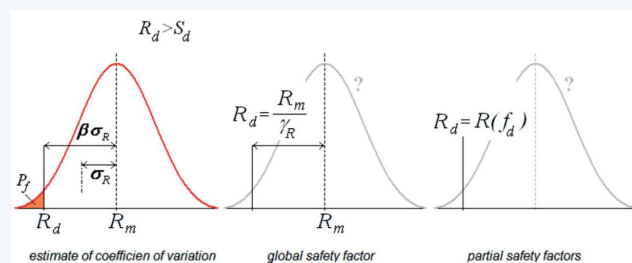
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3. Assessment cycle

3. Structural assessment (verification calculations)

Safety philosophy Ultimate Limit State

- Partial factor method (PF)
- Global resistance factor method (GRF)
- Estimate of coefficient of variation (ECOV)



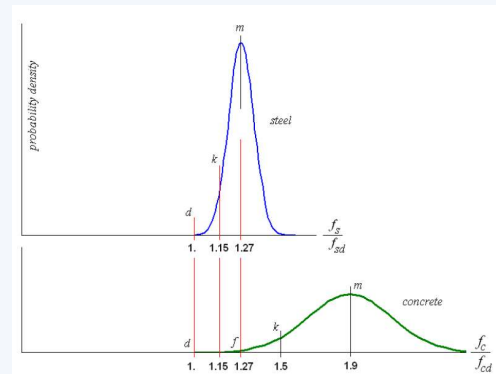
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3. Assessment cycle

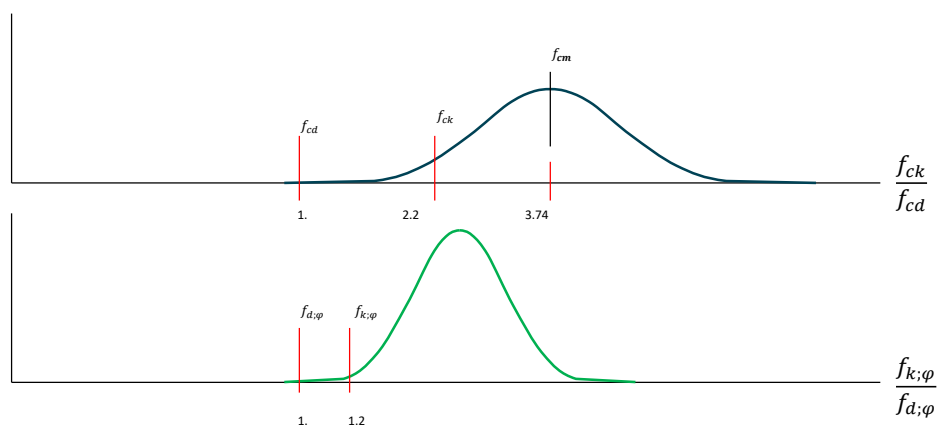
3. Structural assessment (verification calculations)

Safety philosophy Ultimate Limit State

- Partial factor method (PF)
- **Global resistance factor method (GRF)**
- Estimate of coefficient of variation (ECOV)

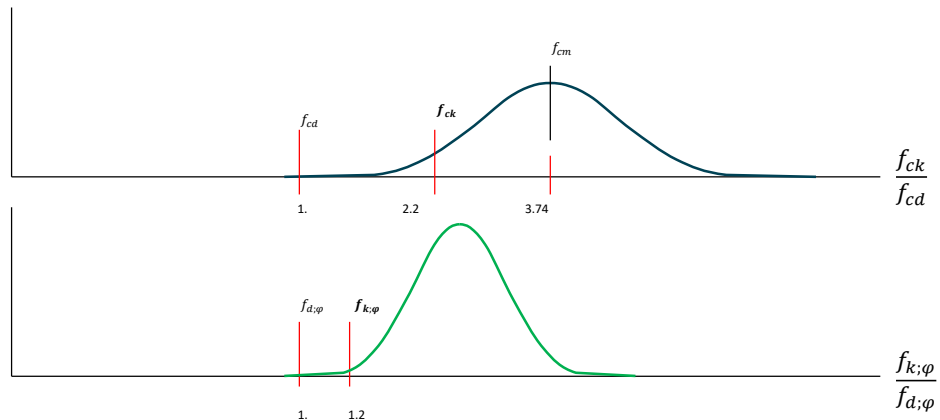


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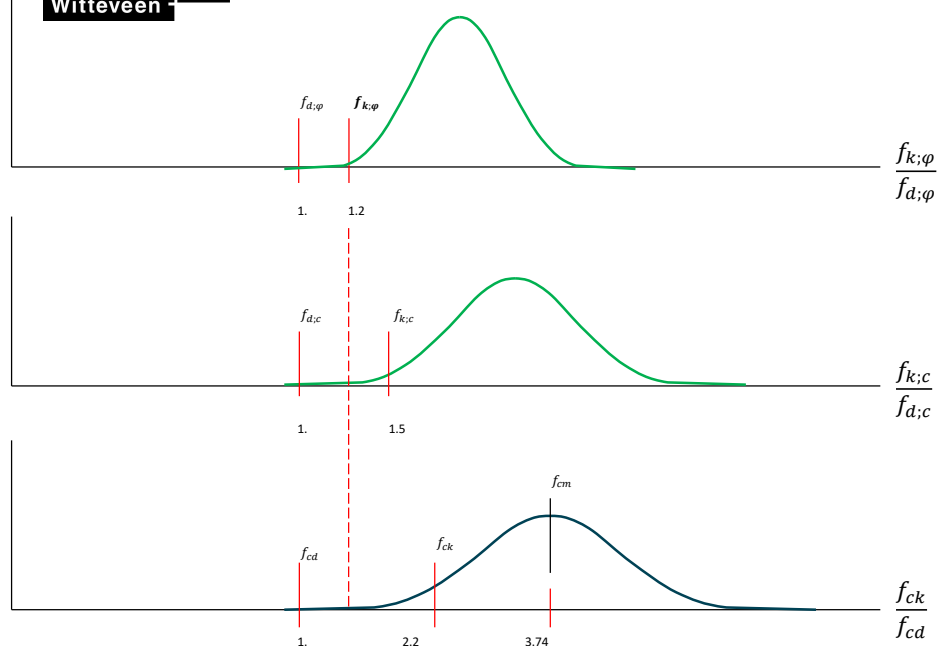
Witteveen + Bos

GRF-1



Witteveen + Bos

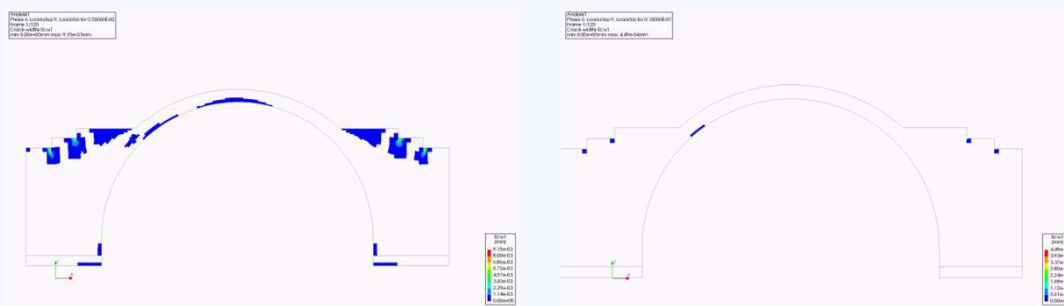
GRF-2



3. Assessment cycle

3. Structural assessment (verification calculations)

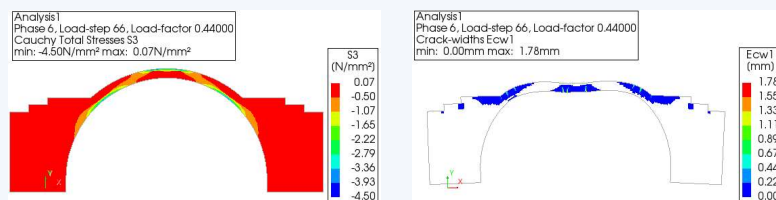
Detection of failure mode (e.g. influence of tensile strength):



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3. Assessment cycle

3. Structural assessment (verification calculations)



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3. Assessment cycle

4. Measures and advice

- ☐ 35 masonry arch bridges are prioritized in function of an estimated load capacity (o.b.v. MEXE);
- ☐ 8 masonry arch bridges have been analyzed by means of FEM;
- ☐ 2 masonry arch bridges do not satisfy the requirements;

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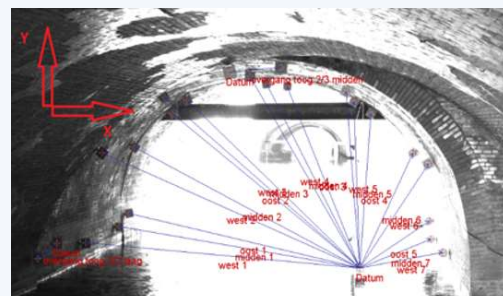
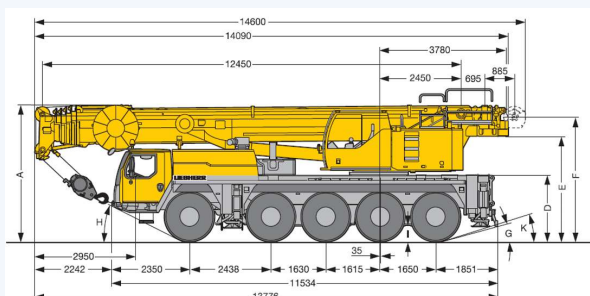
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 5. **Test load (example)**
4. Questions

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3. Assessment cycle

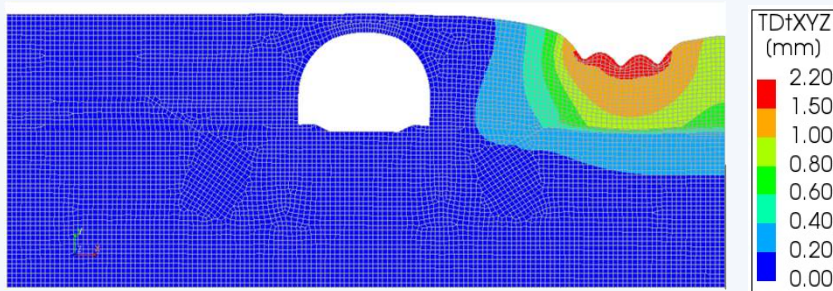
5. Test Load



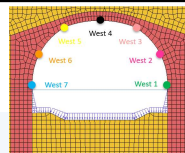
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3. Assessment cycle

5. Test Load

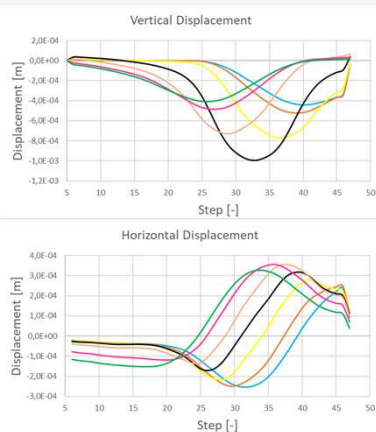


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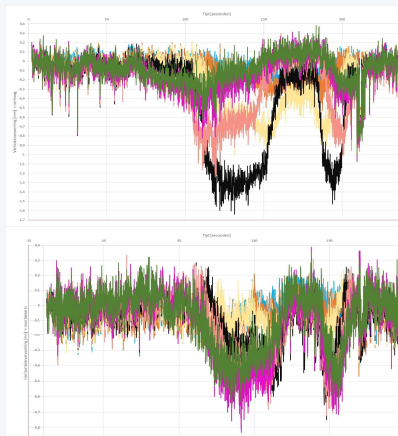
West 7 West 6 West 5 West 4 West 3 West 2 West 1

DIANA FEA



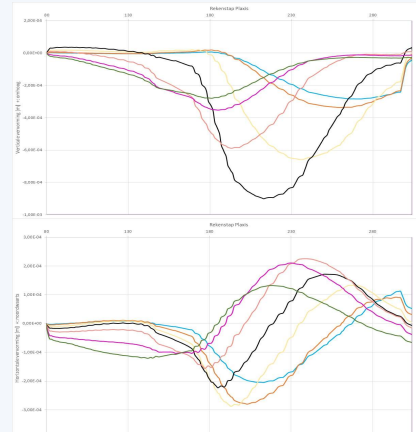
Landhoofd Noord (West 1)	Hor: 0,32mm, -0,15mm	Ver: -0,41mm
As (West 4)	Hor: 0,32mm, -0,17mm	Ver: -0,99mm
Landhoofd Zuid (West 7)	Hor: 0,24mm, -0,25mm	Ver: -0,44mm

Test Load



Landhoofd Noord (West 1)	Hor: -0,40mm	Ver: -0,25mm
As (West 4)	Hor: -0,45mm	Ver: -1,25mm
Landhoofd Zuid (West 7)	Hor: -0,15mm	Ver: -0,15mm

PLAXIS



Landhoofd Noord (West 1)	Hor: 0,13mm, -0,12mm	Ver: -0,27mm
As (West 4)	Hor: 0,17mm, -0,22mm	Ver: -0,90mm
Landhoofd Zuid (West 7)	Hor: 0,12mm, -0,20mm	Ver: -0,29mm

4. Questions

