Aged asphaltic revetments on (saturated) sand tested in a large Deltaflume

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- Analysis of test results
- Conclusions and recommendations

2. Physical model tests

- Delta Flume Deltares (300 m length; 9.5 m depth; 5 m width, irregular waves up to H_s = 2 m)
- Asphalt plates, from Lauwersmeer dike, age 50 years, (8 x 0.5 m^2) thickness 15 - 25 cm.
- On sand bed, with variable phreatic line.
- Wave loading in steps of 2 hours; two test series

Asphalt in series 1 had better quality and was less damaged than in series 2.

Density of sand bed in series 2 was typical for dike (proctor 90 -100); sand series 1 was less dense: proctor 85-90;

D50 sand = 240 µm.

8 asphalt plates cut from dike:
15 - 25 cm thick;
and area 8 x 0.5 m²

Test series 1 and 2

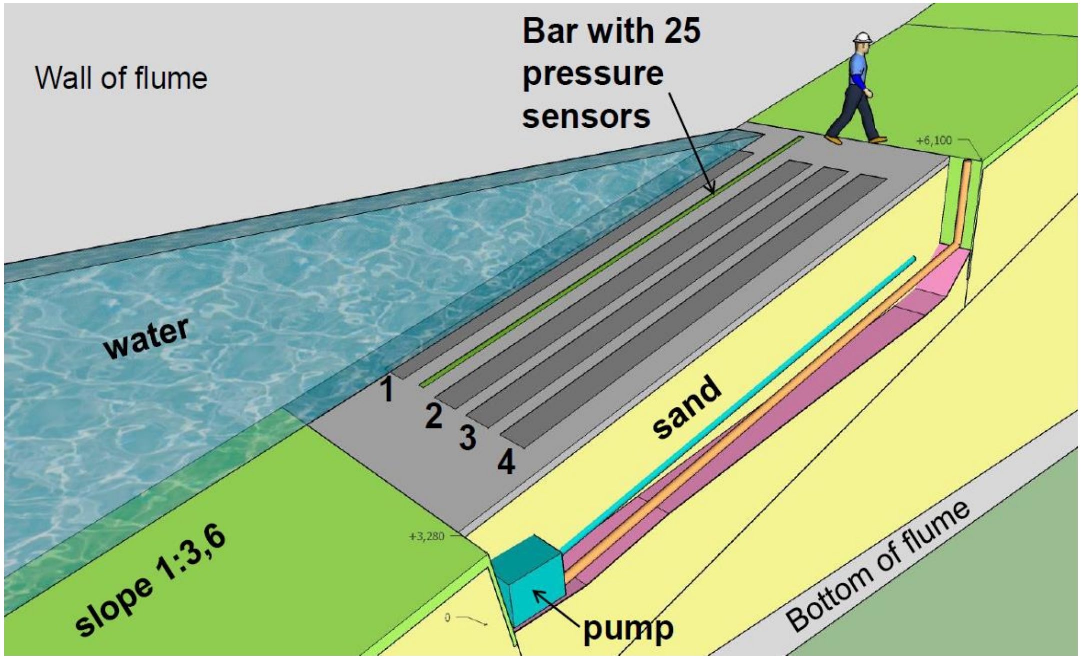
Low phreatic line (both test series):

- 3 short duration tests (H_{m0} = 1 m)
- 3 tests: H_{m0} = 1.6 m; 1.8 m and 2.0 m (2 hours each)
- A few large single waves

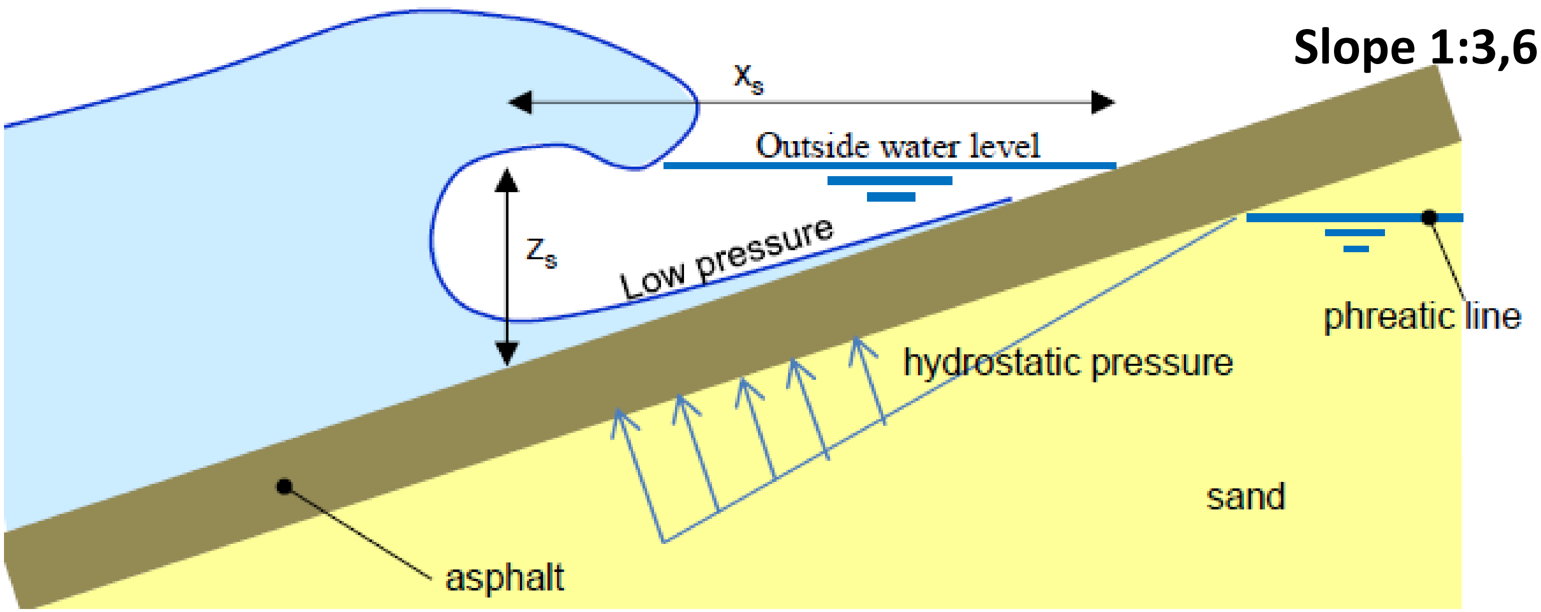
High phreatic line (h_f = level):

- **First series (better than average asphalt quality)**
  - h_f = SWL, H_{m0} = 1.6 m (large damage after 1 hour)
- **Second series (less than average asphalt quality)**
  - $h_f = SWL - 0.6 \cdot H_{m0}$, H_{m0} = 2.0 m
  - $h_f = SWL - 0.2 \cdot H_{m0}$, H_{m0} = 2.0 m
  - h_f = SWL , H_{m0} = 2.0 m (large damage after 16 min.)

Failure at high phreatic line

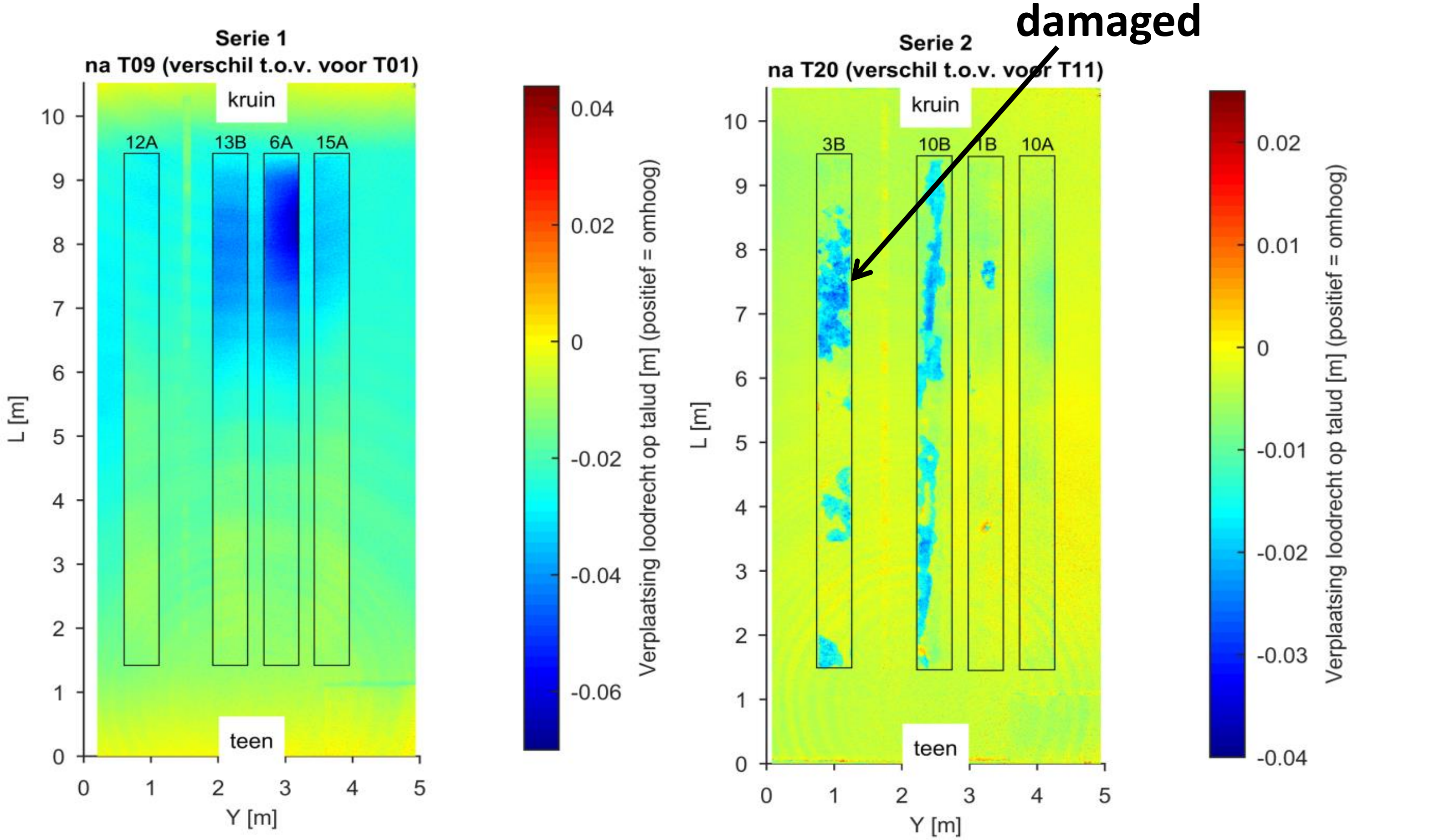


After test T10A



Low phreatic line; laser images

Only surface coating was damaged



- **Small deformation after 6 hours of wave action; no major damage.**
- **6 hours is the typical duration of wave attack on the Lauwersmeer dike.**

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Modeling (phreatic line is low):

Single wave impact:

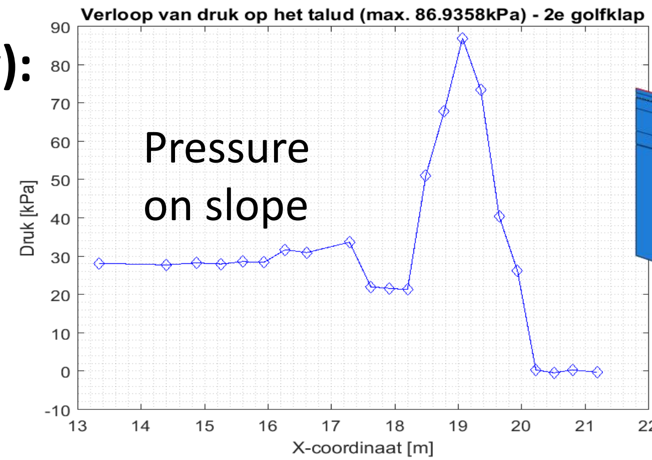
1. Abaqus

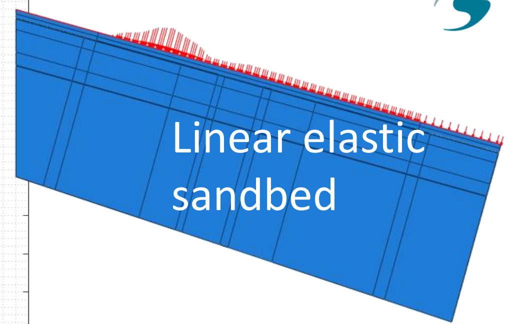
2. Analytical formula's

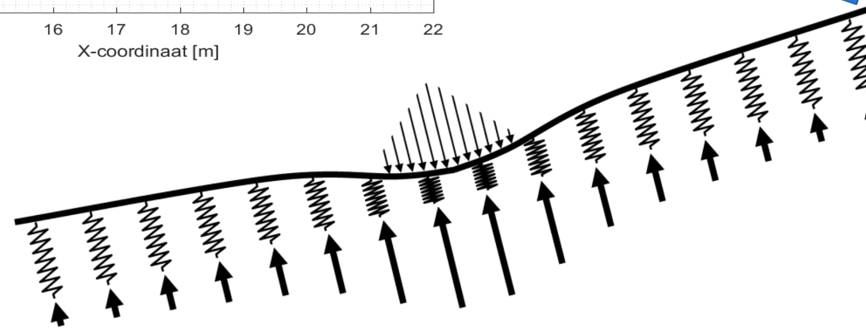
Fatigue under storm conditions:

3. Model Wave impact

(de Looff, A.K., et al., 2006. Proceedings ICCE 2006. San Diego, CA.)







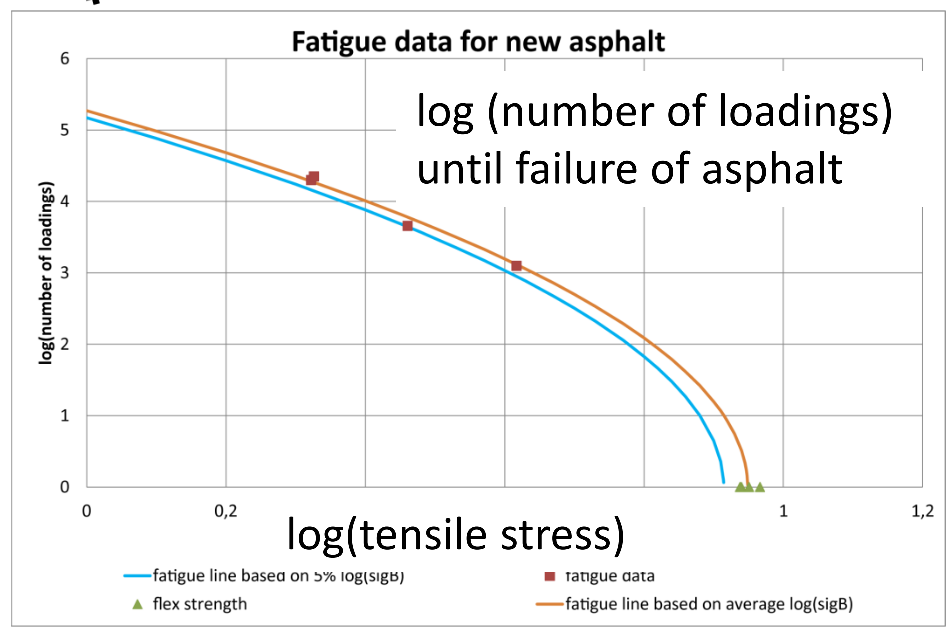
Input 2 and 3:

Asphalt: thickness, E modulus, Poisson's ratio, fatigue line; subsoil: modulus of subgrade reaction

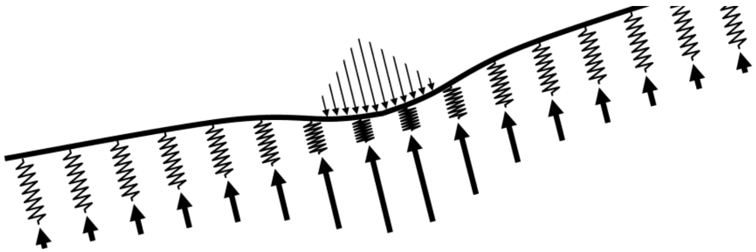
(de Looff, A. K., et al., 2011. Proceedings of the Coastal Structures 2011 conference. Yokohama.)

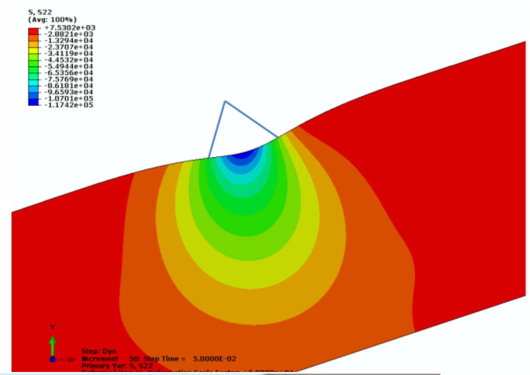
Wave action: slope angle, triangular load, statistical distributions of factor of impact, width and impact position

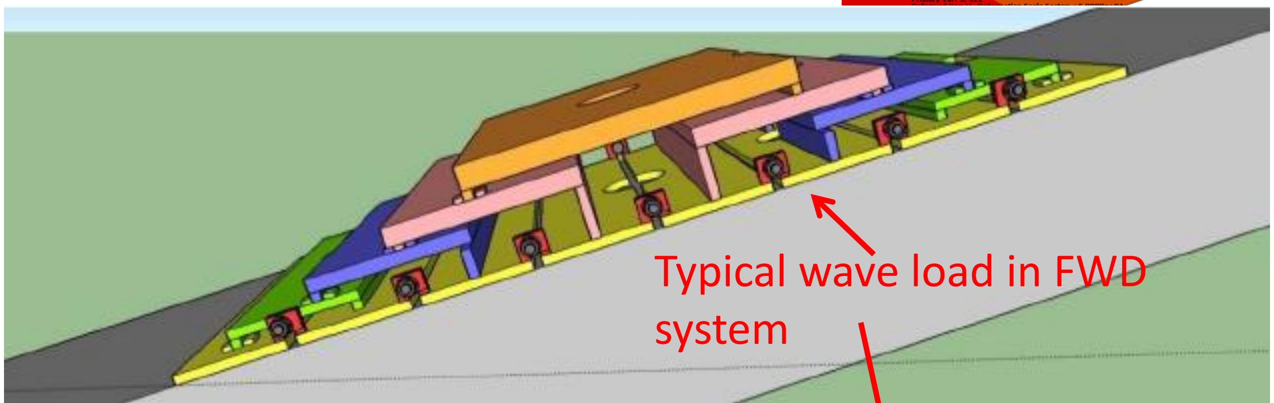
Main features input 1: pressure distribution as measured; linear elastic sand bed

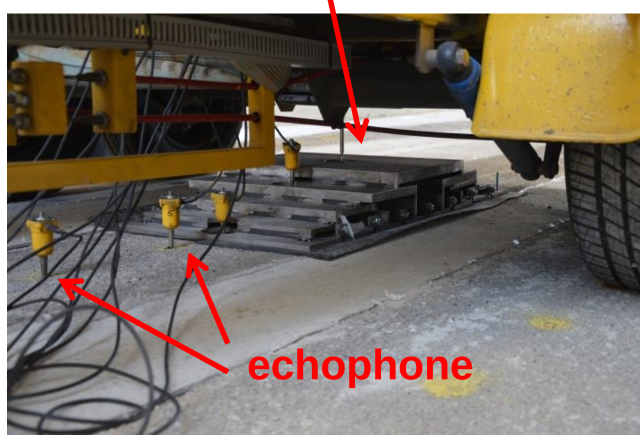


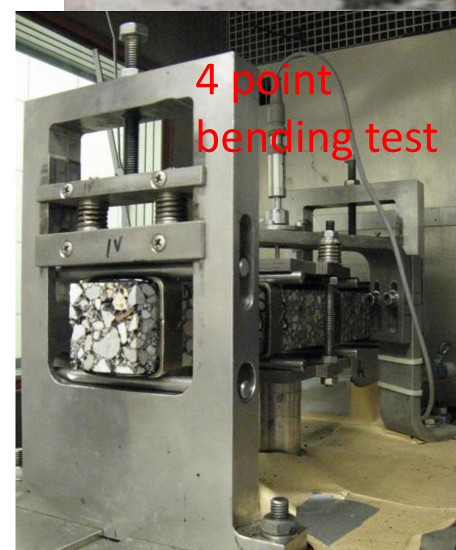
Input modelling











Instrumentation

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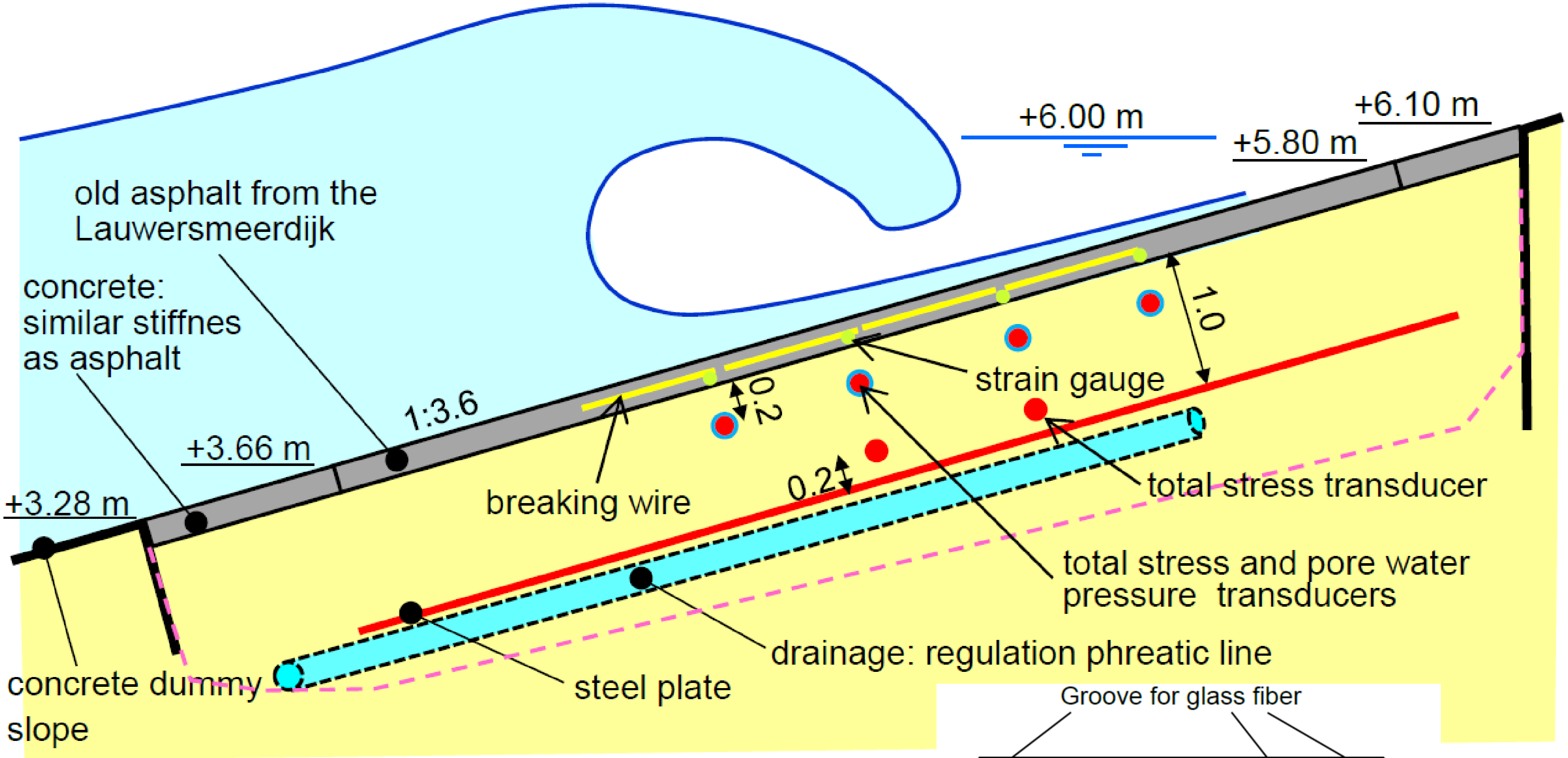
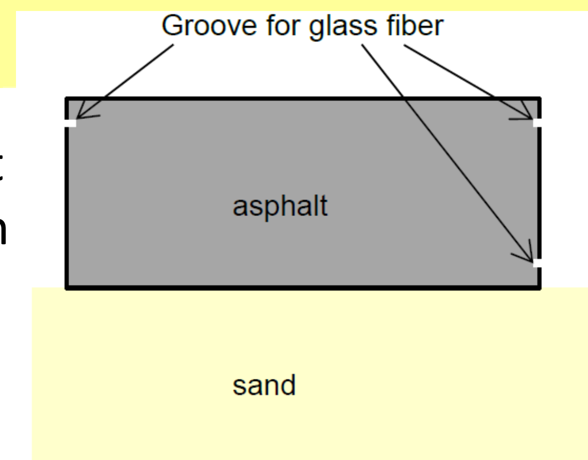
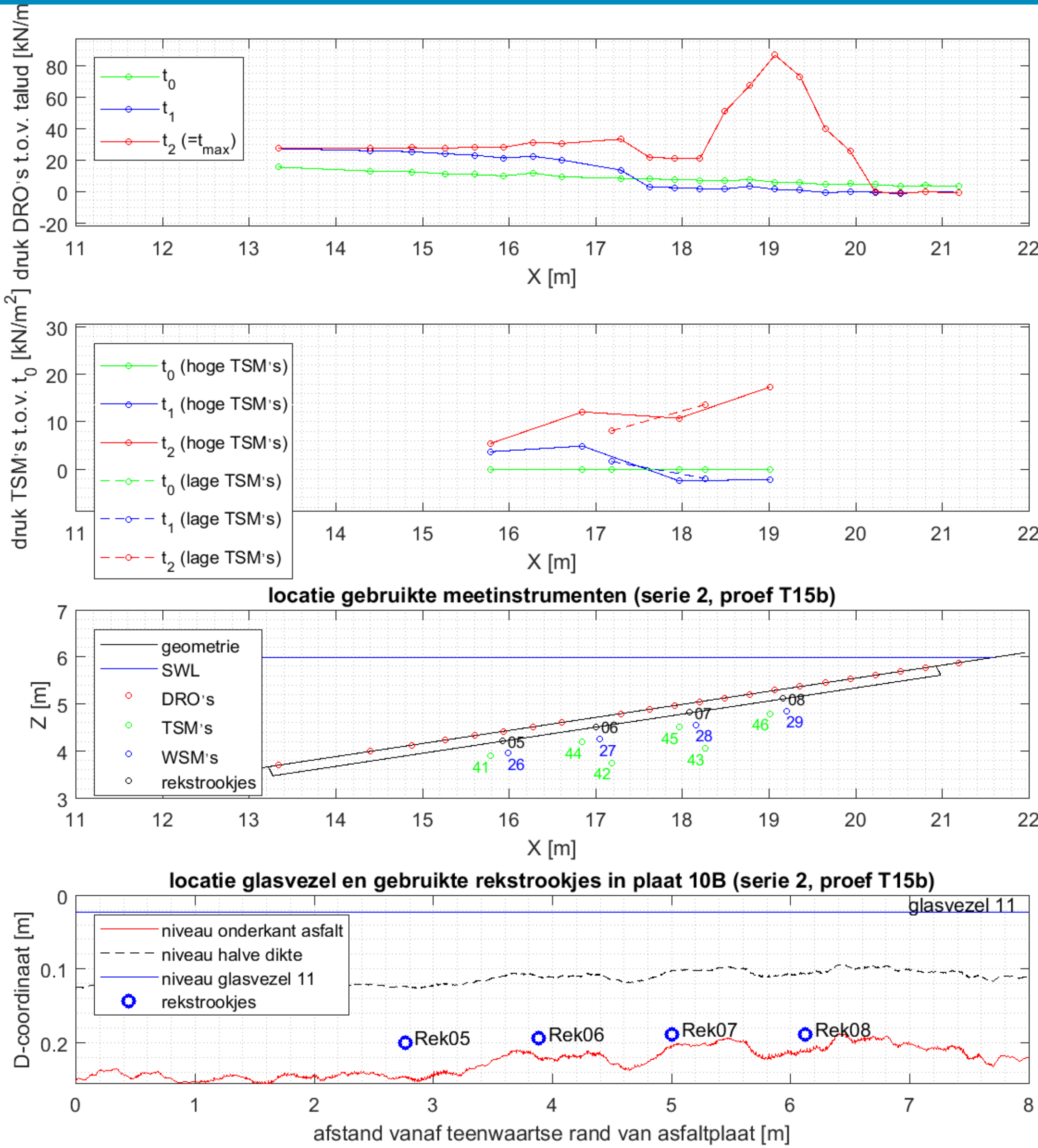


Glass fibers measure asphalt strain at distances of 2.6 mm over 8 m length.

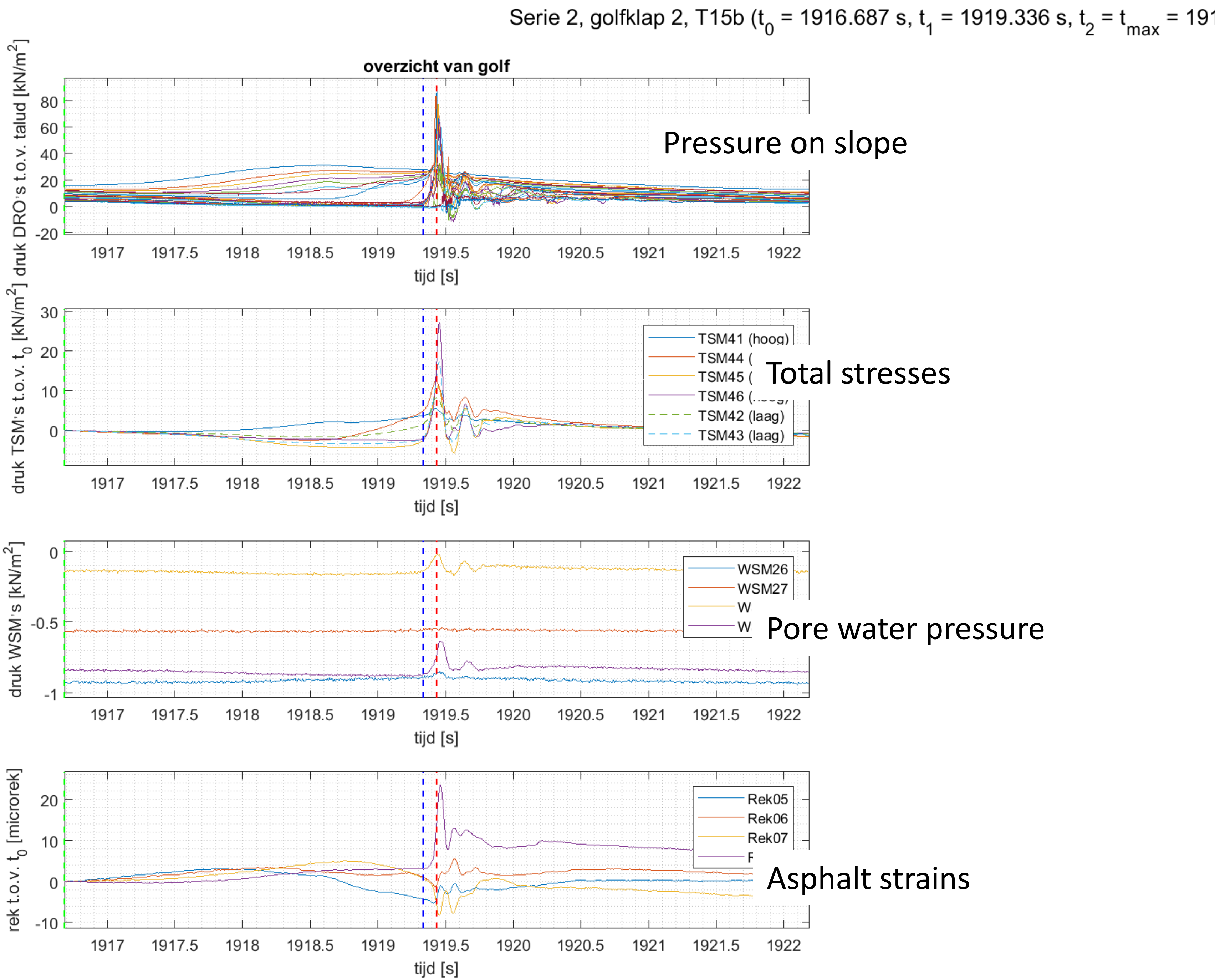


Typical wave attack with phreatic line low



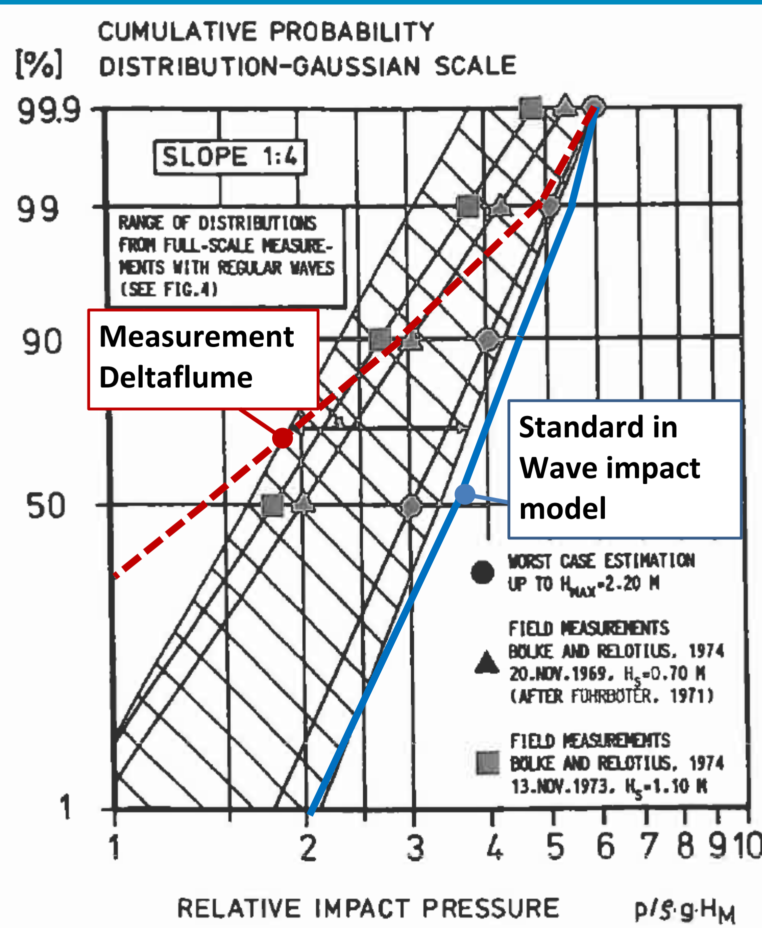
Pressure distribution on slope

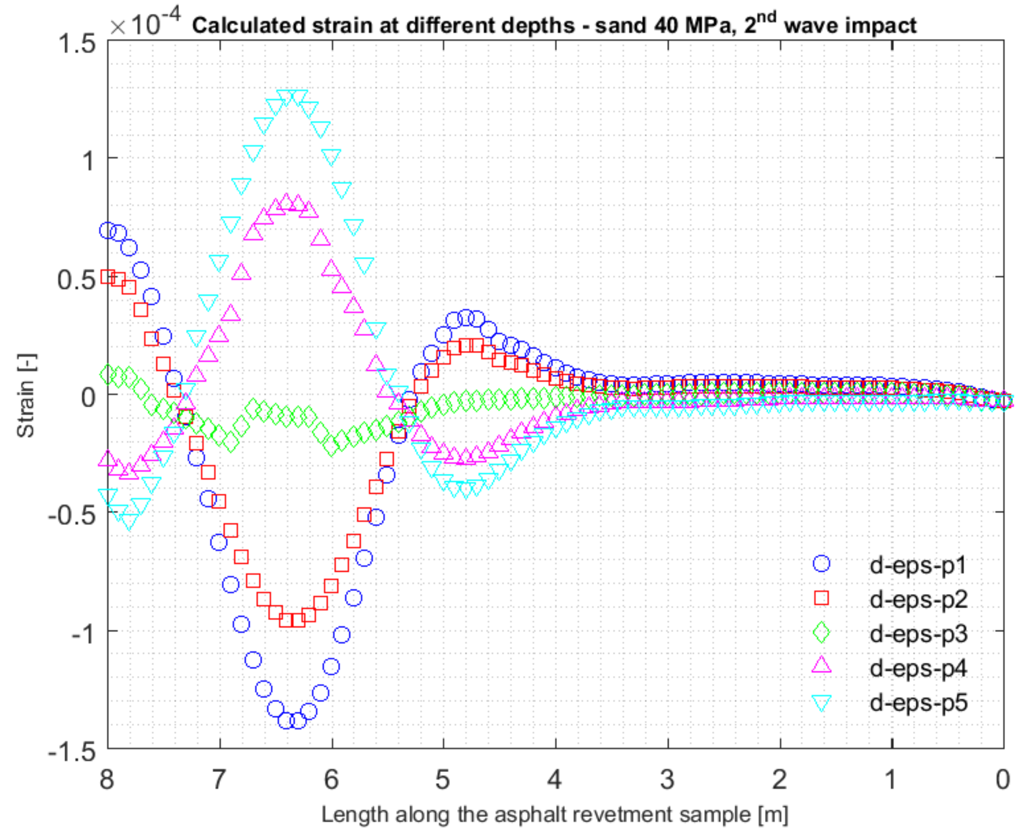
Total stresses in sand



Time period = 6 seconds

Results





Series 2 Strains [µm/m]	**Measurement** at bottom (in strain gauge)	**Abaqus** at bottom under strain gauge	**Abaqus** maximum strain at bottom	**Analytical** maximum strain at bottom
Impact 1	14 (12)	47	120	159
Impact 2	24 (20)	120	125	140

Conclusions and recommendations

- Factor of impact mostly lower than in standard model

High phreatic line:

Failure within 1 hour of wave attack, mechanism uplift, no liquefaction

Low Phreatic line:

- Asphalt strains are up to factor 1 to 5 smaller than expected from Abaqus modeling
- Dynamic effects play a role: a shorter impact duration has less effect.
- In total: gain of an order of magnitude in time till failure (Miner’s sum) might be possible.
- Further modelling is foreseen:
  - dynamics
  - visco-elastic asphalt

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Thank you for your attention

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