WBI 2017

Safety assessment grass revetments on dikes

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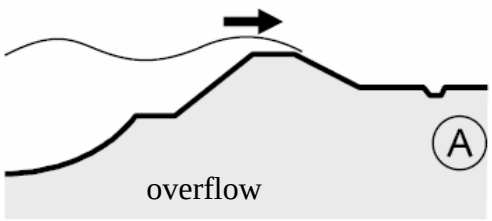
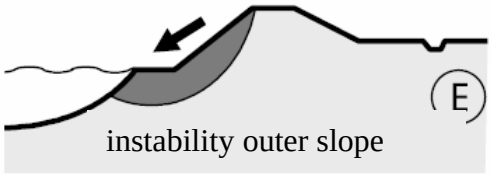
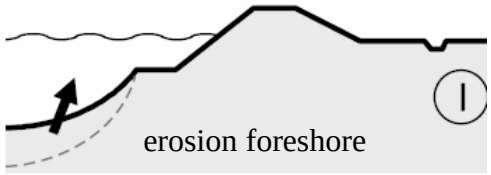
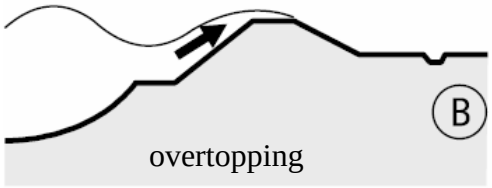
Dutch dike system

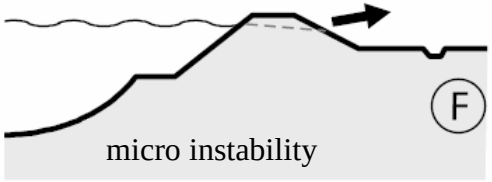
Failure mechanisms

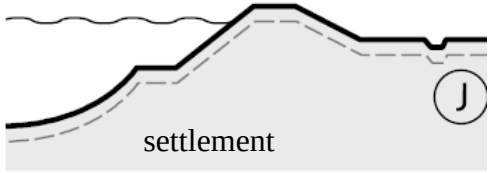


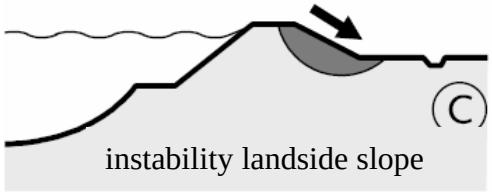


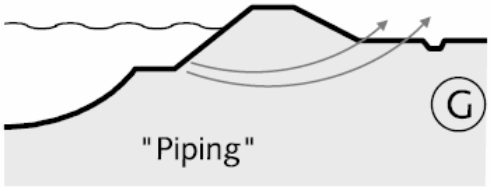


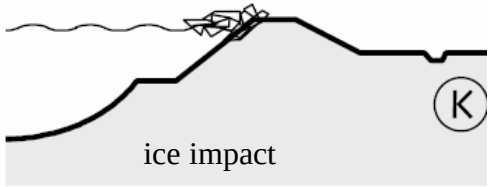


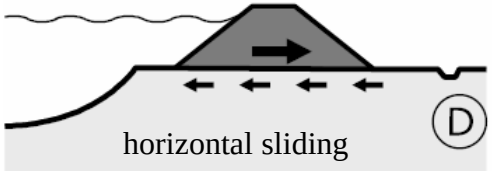


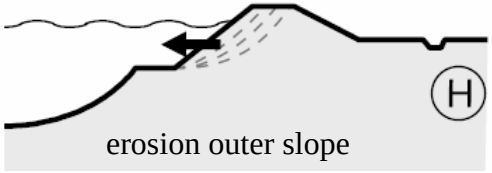


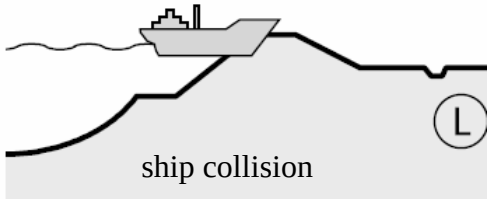






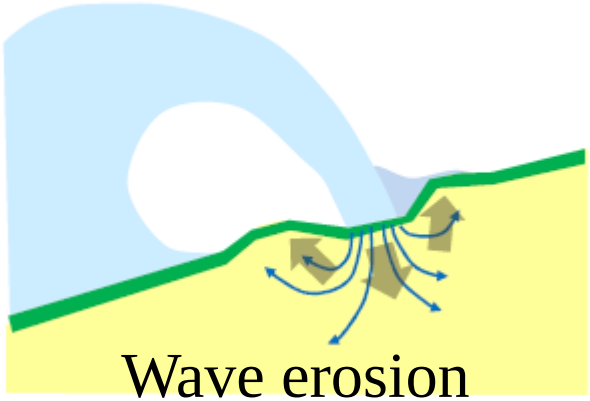






Grass revetment mechanisms

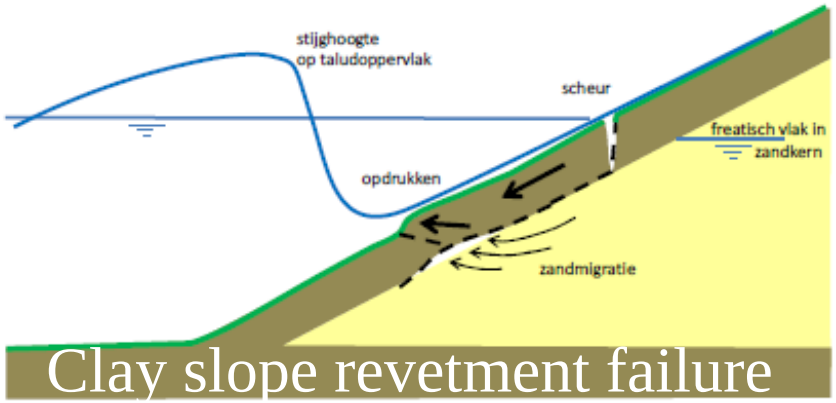
OUTER SLOPE



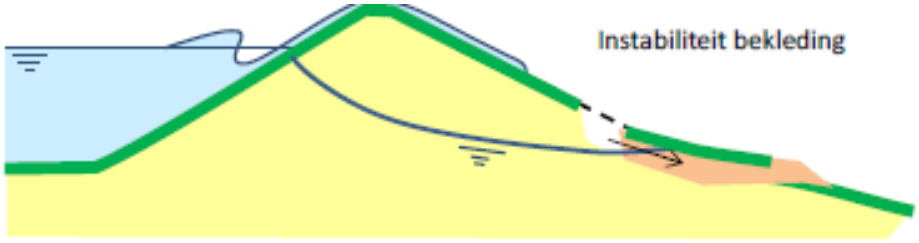
Wave erosion

INNER SLOPE

Overtopping erosion



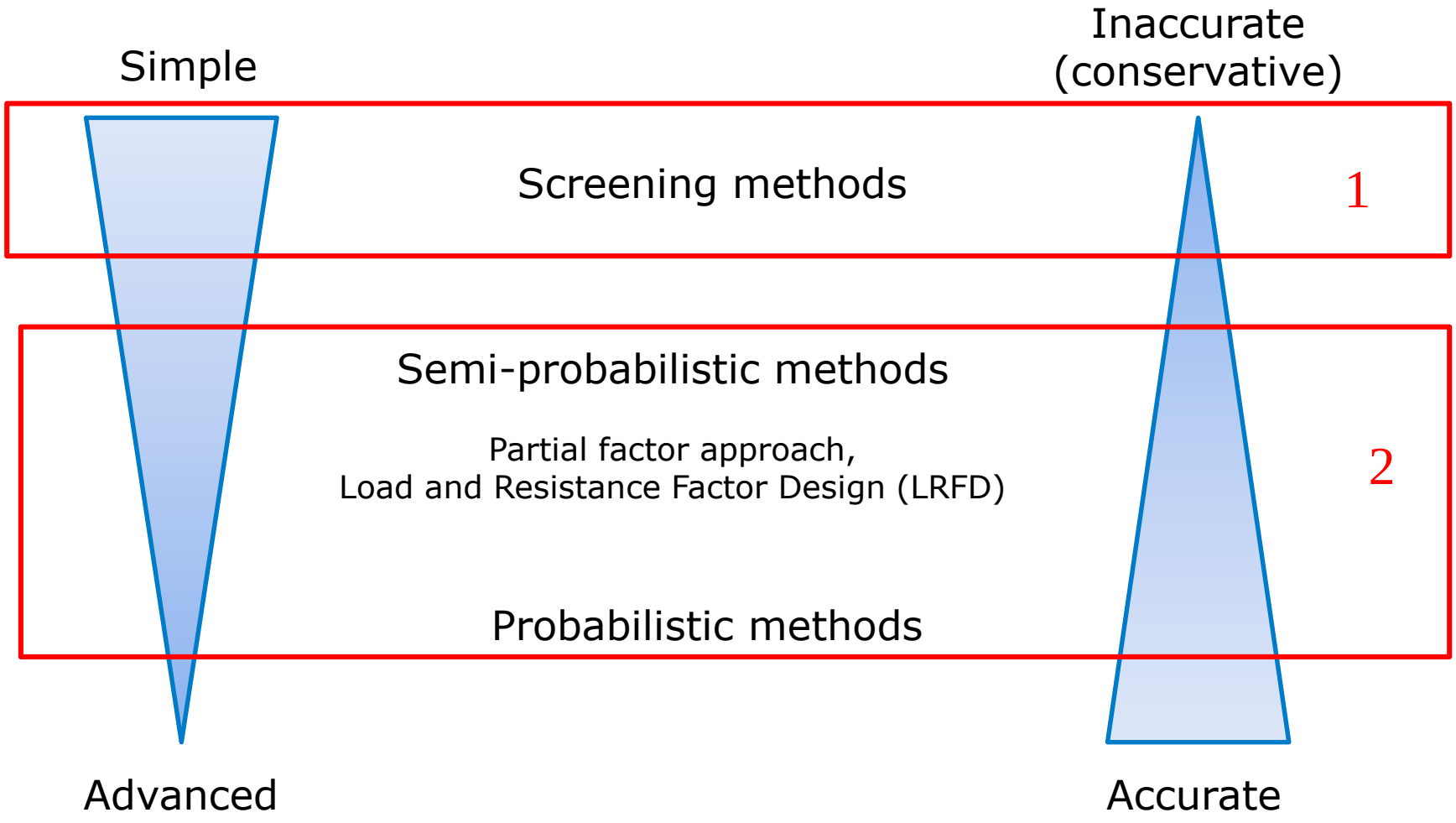
Clay slope revetment failure



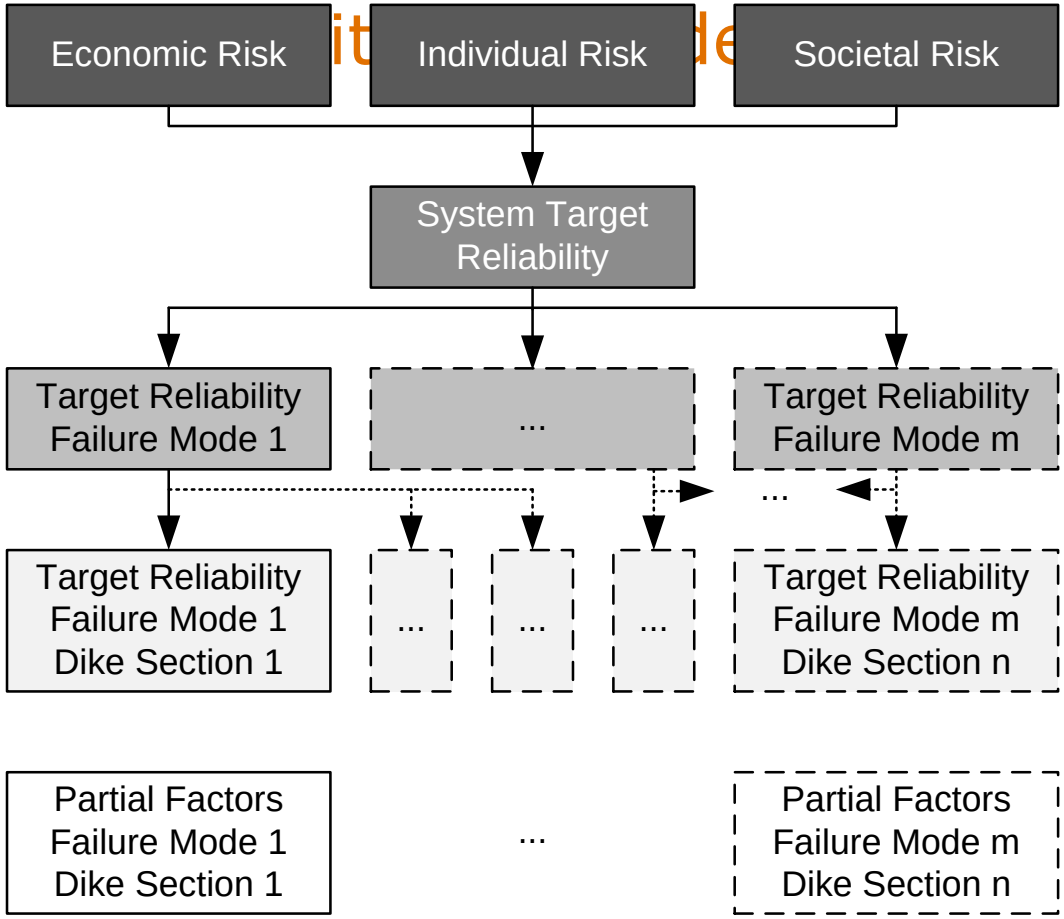
Inner slope revetment failure

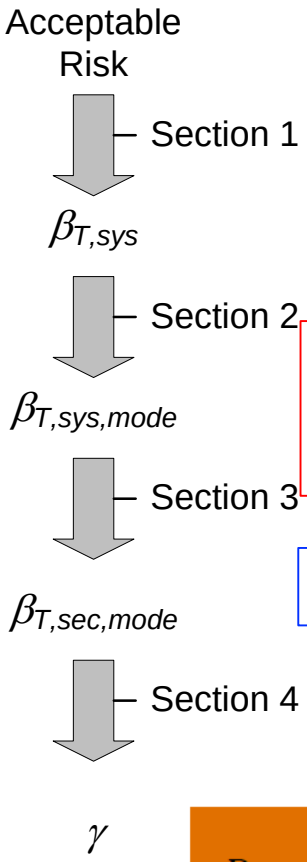
Grass revetments New Orleans (2005)

Methods for dike safety assessments



Reliability criteria cross-section



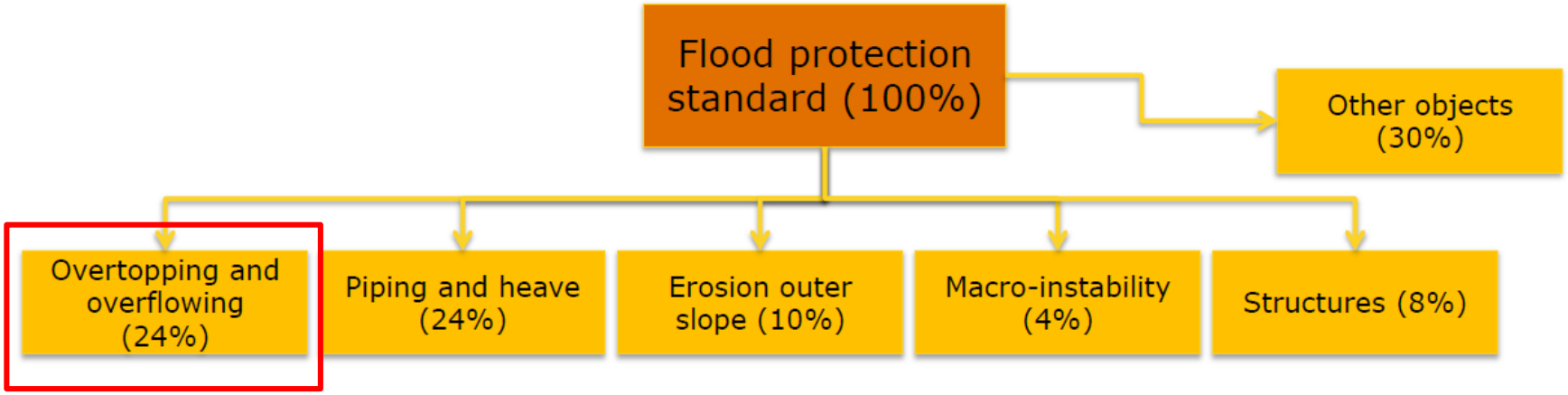


Failure mechanism ω

Length-effect

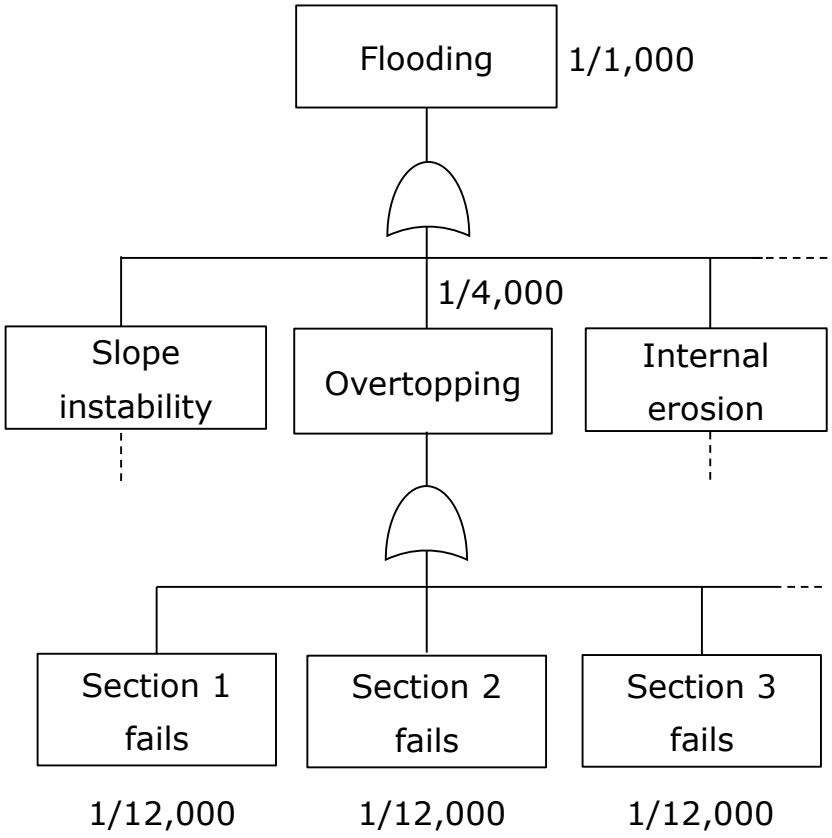
$$P_{cross-section} = \frac{P * \omega}{1 + \frac{a * L_{tr}}{b}}$$

Criteria for overtopping

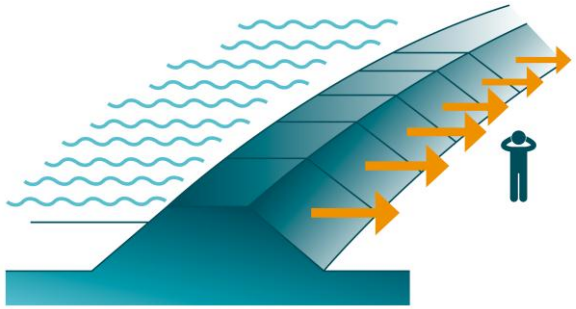


- The sum of the 'budget factors' (ω_i) is one (serial system). This way we ensure that given the **individual** failure modes meet the target reliability, also the **overall target reliability** is met for sure.
- **Changing** of budgets allowed

Target failure per mechanism/section



A flood defense is a series system



Probabilistic assessment

1. Specify limit state (Z) function

   Z < 0 implies failure

$$Z = g(X)$$

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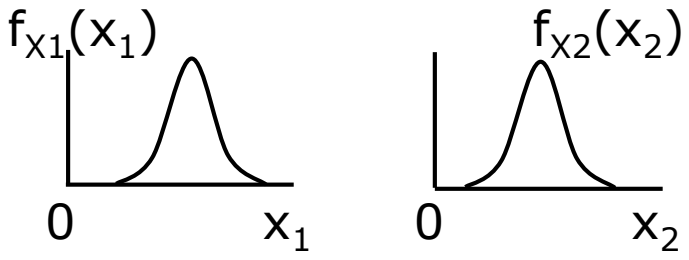
2. Specify inputs of limit state function



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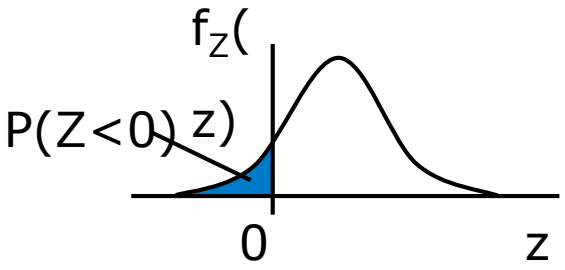
3. Calculate probability of failure



Semi-probabilistic assessment

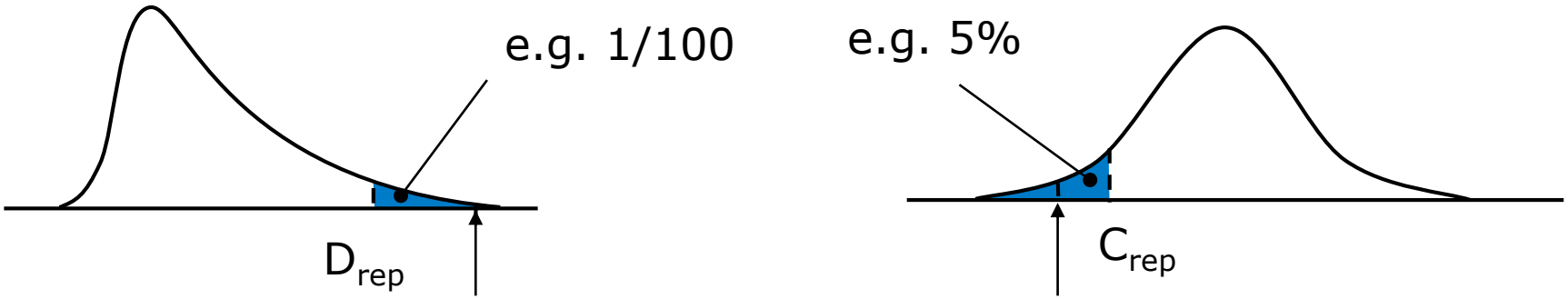
Demand (Load)

Design value = Representative value x partial factor

Capacity (Strength)

Design value = Representative value / partial factor

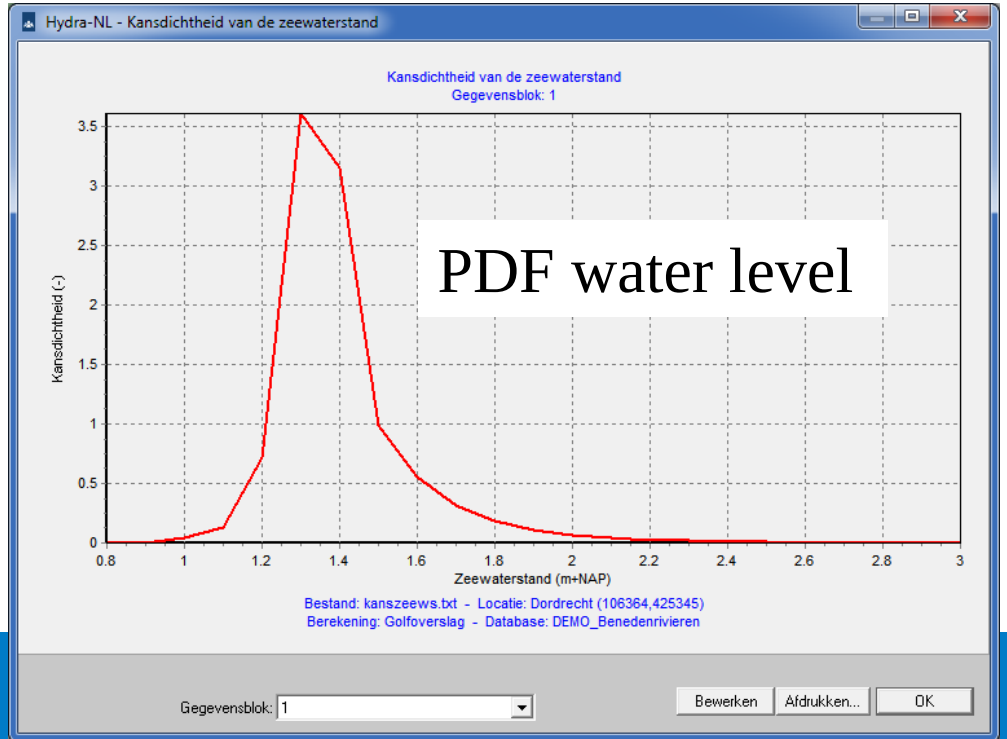
Load (D_d) **<** **Strenght (C_d)**

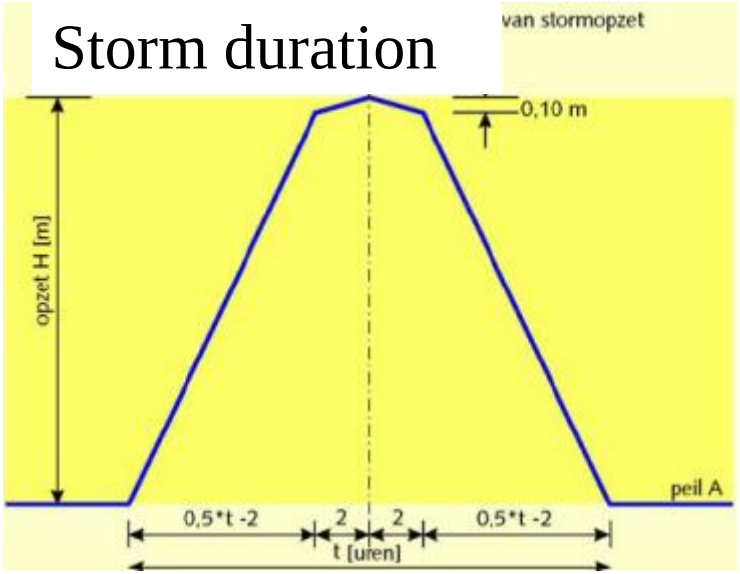


Overtopping erosion

Loads

- Joint probability density functions of water level and waves
- Consideration of full flood wave
- Load mainly determined by cumulative effect of largest volumes





Overtopping erosion

- Resistance function of grass quality

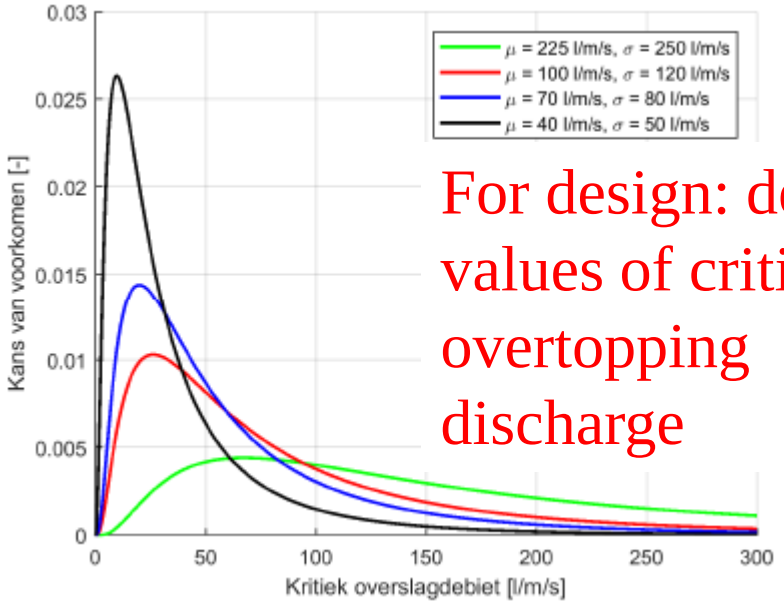
Open

Closed

fragmented

Overtopping erosion

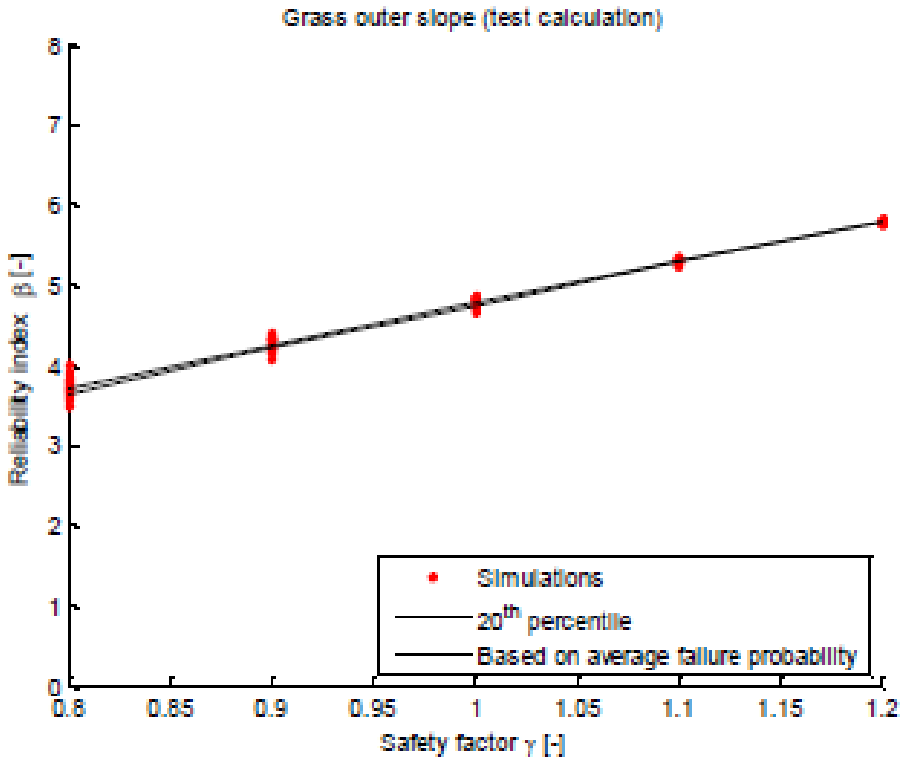
- High uncertainty in overtopping resistance
- Distribution depends on
  - Wave class (discharge q_{crit} vs overload model U_c)
  - Grass quality



For design: design values of critical overtopping discharge

Source:Van der Meer Consulting

Grass erosion (outer) code calibration



Challenges

1. Reduction uncertainties
2. Transitions

3. Residual strength / failure definitions

Concluding remarks

1. The WBI framework allows to assess whether flood defense structures comply with legal safety standards for various failure mechanisms

2. Semi-probabilistic and probabilistic assessments are both possible

3. The WBI-code calibration procedure has been applied successfully to a range of failure mechanisms:
   - Slope instability
   - Internal erosion (uplift, heave and piping)
   - Block revetment failure
   - Asphalt revetment failure
   - **Grass revetment failure**
   - Structural failure

References

Slomp, R., H. Knoeff, A. Bizzarri, M. Bottema and W. de Vries (2016). *Probabilistic Flood Defence Assessment Tools*. Proceedings FloodRisk 2016.

Jongejan, R.B. (2016). WBI2017 Code Calibration - Reliability-based code calibration and semi-probabilistic assessment rules for the WBI2017. Rijkswaterstaat report 24-06-2017.

Kanning. W. et al. (2016). Derivation of the semi-probabilistic safety assessment rule for inner slope stability. Deltares report 1230086-009.

For more, see:

https://www.helpdeskwater.nl/onderwerpen/waterveiligheid/primaire/beoordelen-(wbi)/producten-wbi/