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Enabling Delta Life

Erosion at transitions in landward slopes of dikes due to wave overtopping

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Wave overtopping test

- Erosion of the grass cover on the slope;
- Erosion at transitions from slope to a horizontal berm or at the toe;
- Erosion related to non-water retaining structures such as a concrete staircase in the slope, fences, trees and poles.

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Scour at transitions and obstacles

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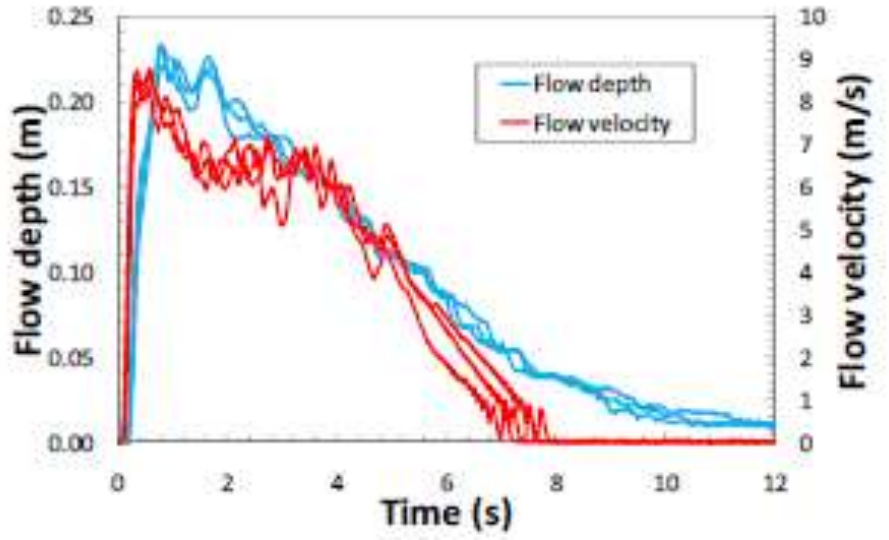
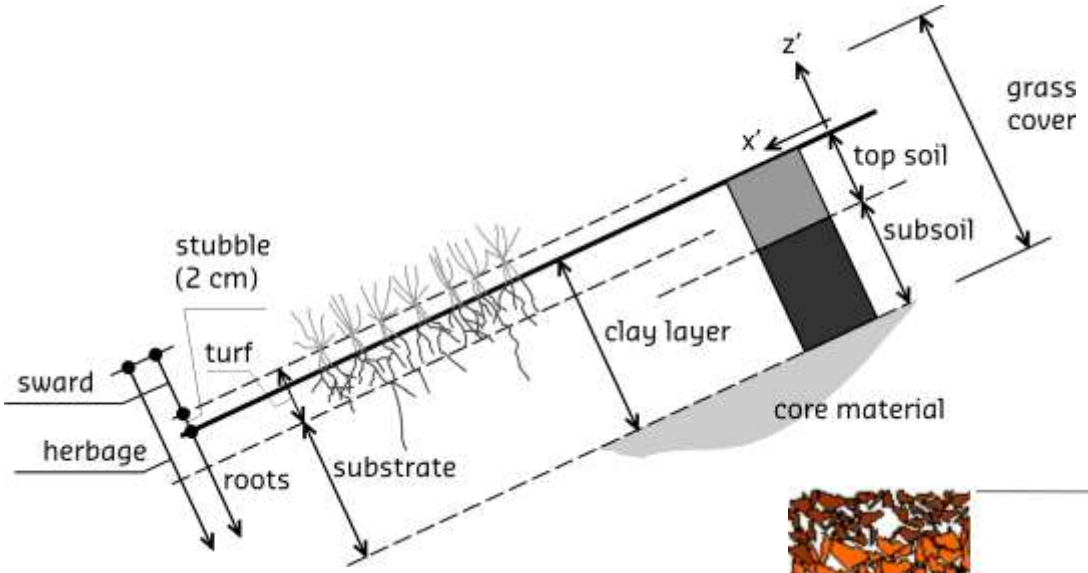
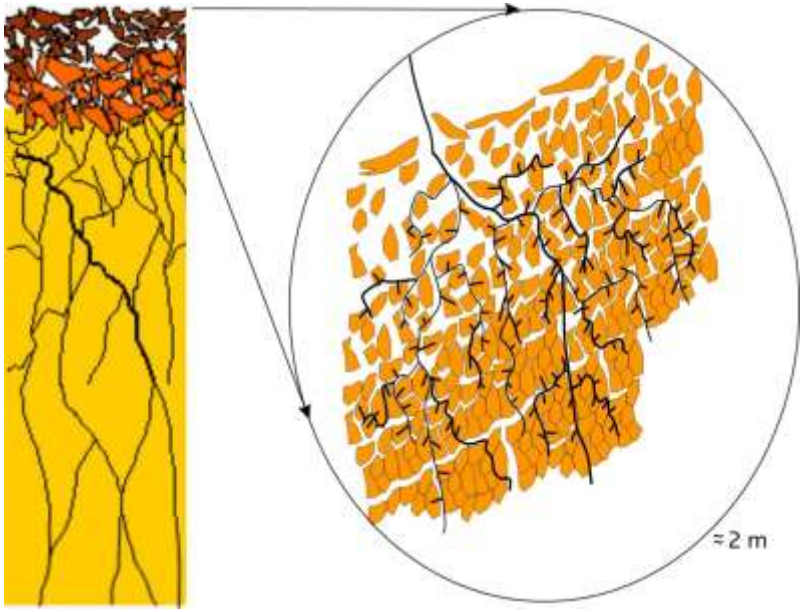
Scour at transitions and obstacles



Grass cover





$$U_c = \alpha_{grass,U} r_0^{-1} \sqrt{\Psi_c \sigma_{grass,c}(0) / \rho}$$

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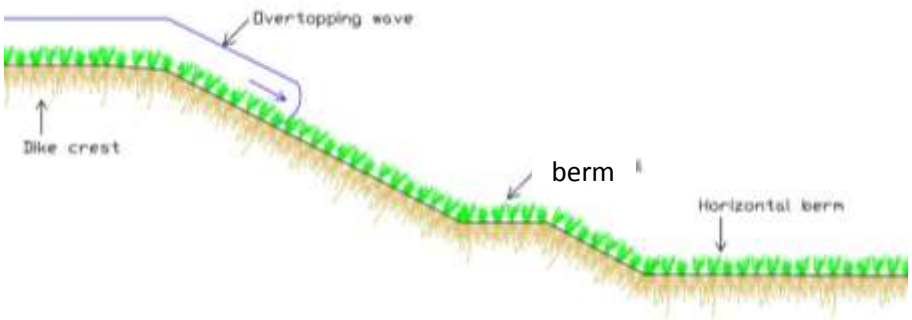
Approach at transitions

Cumulative effective load model : $\sum_{i=1}^{N}\left(U^2 - U_c^2\right) = D$

$$D = \sum_{i=1}^{N}\left(\left(\alpha_m U\right)^2 - U_c^2\right)$$



damage at various locations $500\ \mathrm{m^2/s^2} < \sum_{i=1}^{i=N_1}\left(U_{m,i}^2 - U_c^2\right) < 1500\ \mathrm{m^2/s^2}$

failure of dike slope $\sum_{i=1}^{i=N_1}\left(U_{m,i}^2 - U_c^2\right) > 3500\ \mathrm{m^2/s^2}$

- Theoretical approach: α_m from jet theory
- Practical approach: α_m from overtopping tests

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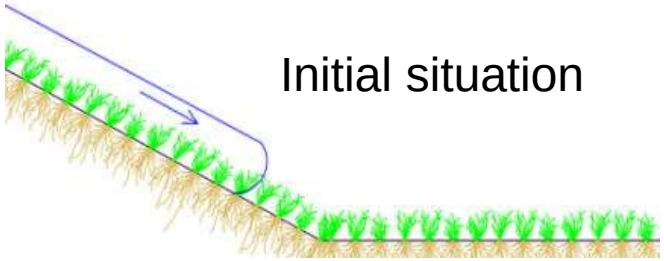
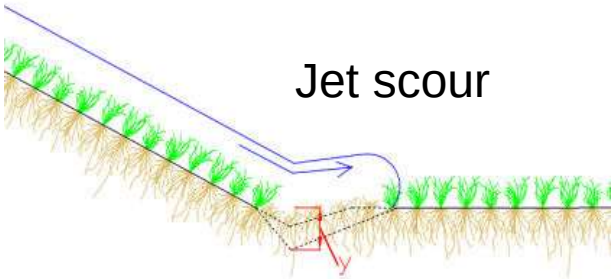
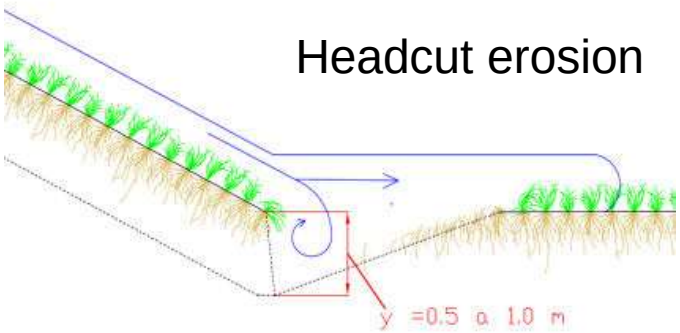
Theory: jet scour approach



Initial situation



Jet scour



Headcut erosion

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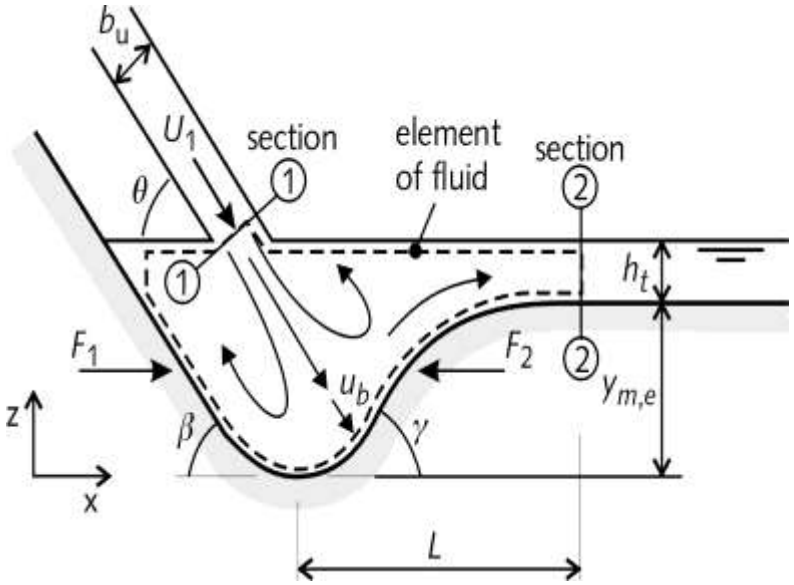
Theory: jet scour approach

2D-H $$z_{m,e} = z_{2H} = c_{2H}\sqrt{\frac{qU}{g}} \quad \text{with} \quad c_{2H} = 20\left(D_{90*}\right)^{-1/2}$$

2D-V $$z_{m,e} + h_t = c_{2v}\sqrt{\frac{qU\sin\theta}{g}} \quad \text{with} \quad c_{2v} = \frac{23}{\left(U_c\left(\Delta/(\nu g)\right)^{1/3}\right)^{1/2}}$$



$$\alpha_M = \sqrt{\frac{z_{2V}}{z_{2H}}}$$

$$\alpha_M = \sqrt{\frac{c_{2V}}{c_{2H}}\sqrt{\sin\beta}}$$

$\alpha_m = 1.2$

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Results experimental approach

Test location	Characterisation of transition	Quality of grass cover and soil	Observed scour	Predicted scour
Kattendijke	Minestone road on a sand bed	Good grass on clay, but many mole holes	1.0m	0.7 to 1.3m (U_c = 2 to 4 m/s)
Afsluitdijk	Brick road	Average grass on good clay	0.3m	0.3 to 0.5m (U_c = 6.3 m/s)
Vecht	Road consisting of concrete blocks	Good grass on sand	0.5m - 1.0m	0.6 to 0.8m (U_c = 4 m/s)

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conclusions

Transition:

- Theoretical approach: $\alpha_M = 1.2$
- Practical approach: $\alpha_M = 1.05$ to 1.21

Afsluitdijk:
Initial damage slope D = 2878 m^2/s^2
initial damage toe D = 1808 m^2/s^2

St Philipsland:
Initial damage slope D = 1855 m^2/s^2
Initial damage toe D = 990 m^2/s^2

- Tree: amplification factor α_m is about 1.2.

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Thank you for your attention

More information

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