Reduction of wave overtopping by Vetiver Grass

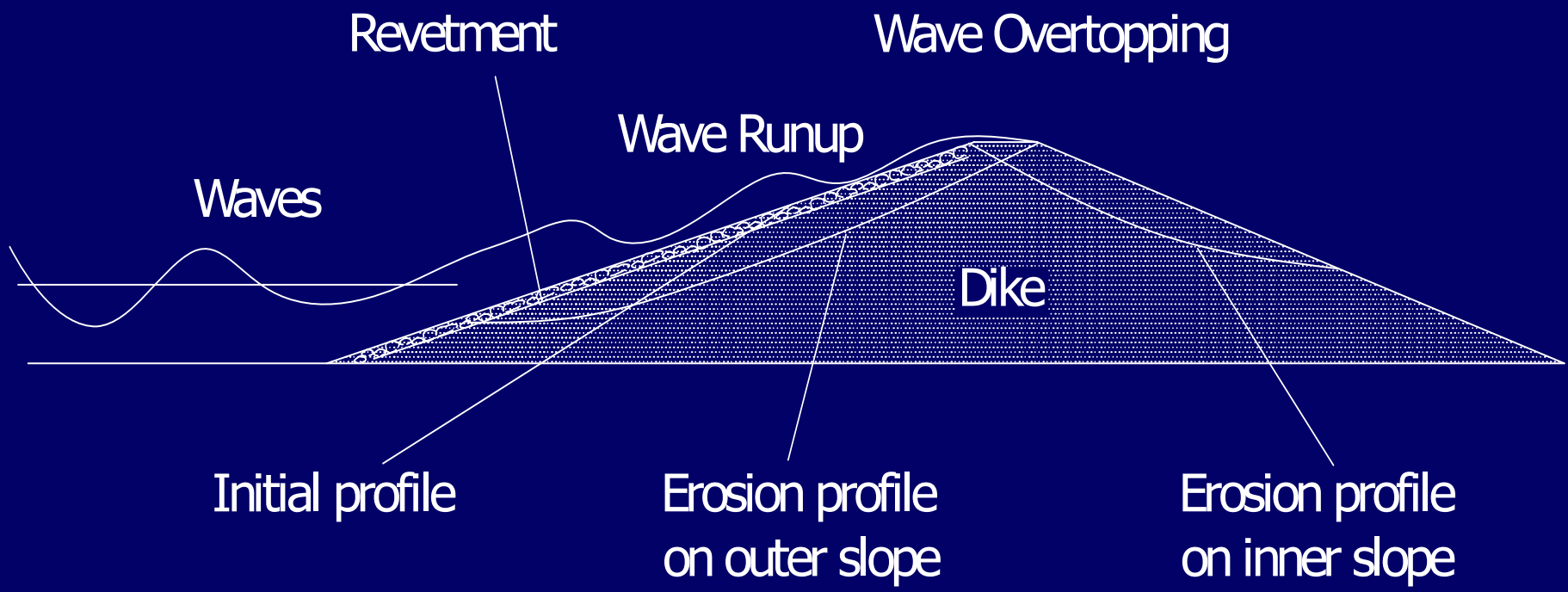
Presentation: Vu Minh Anh

Contents of presentation

- Introduction
- Physical model and model set-up
- Results and Case study
- Conclusions & Recommendations
- Questions and Discussion

Violent wave overtopping at the sea dikes

Wave overtopping at the sea dikes



Design Sea Dike

Reduce wave overtoppig

↓

Traditional method:

‘’Hard’’ revetments like concrete blocks, big rocks, glacial stones

‘’Hard’’ Revetments

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Design Sea Dike

Reduce wave
overtopping height

↓

Traditional method:

''Hard'' revetments like concrete blocks, big rock, glacial stone

Methods which are low-cost and readily available

↓

Combination between ''Hard'' revetments with Vegetations

or Bioengineering methods.

‘’Soft’’ Solutions

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Vetiver grass

In a number of tropical countries Vetiver grass is well-known bioengineering.

Vertiver grasses grow naturally in clump with thin, long, and erect leaves.

Vetiver grass

Vetiver grasses as sea dike revetments

- Lack of basic understanding for processes and properties
- Lack of quantitative and qualitative knowledge of the protection on the outer slope of the sea dike by Vetiver

Addressing previous information: reduce wave overtopping by Vetiver grasses

Objectives

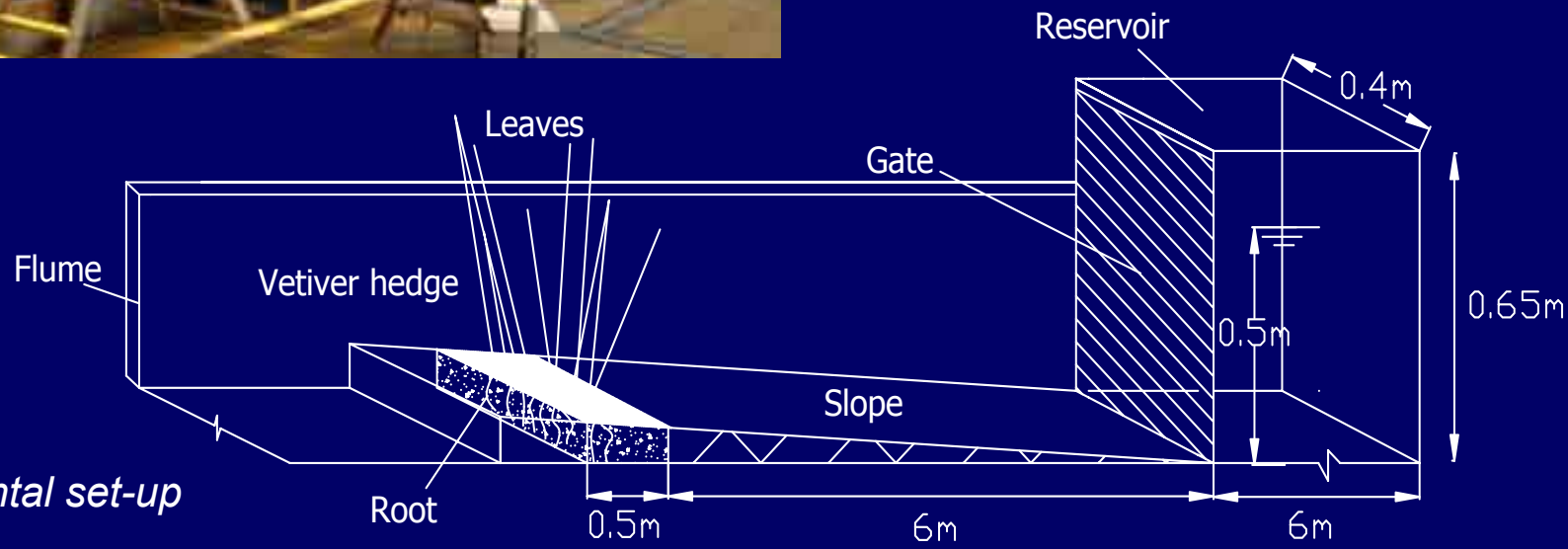
- The hydraulics of flow with Vetiver grass
- The interaction between flow velocity and flow depth in cases of Vetiver hedge in relation to the reduction of wave overtopping
- Improving the guidelines in designing sea dike dimensions

Model set-up

Full scale

- Vetiver grass
- Wave parameters in front of Vetiver hedge.

Model set-up



Overview of experimental set-up

Model set-up

Locations and instruments

- Wave Gauge Height Meter - GHM
- Electromagnetic Flow Velocity Meter - EMS

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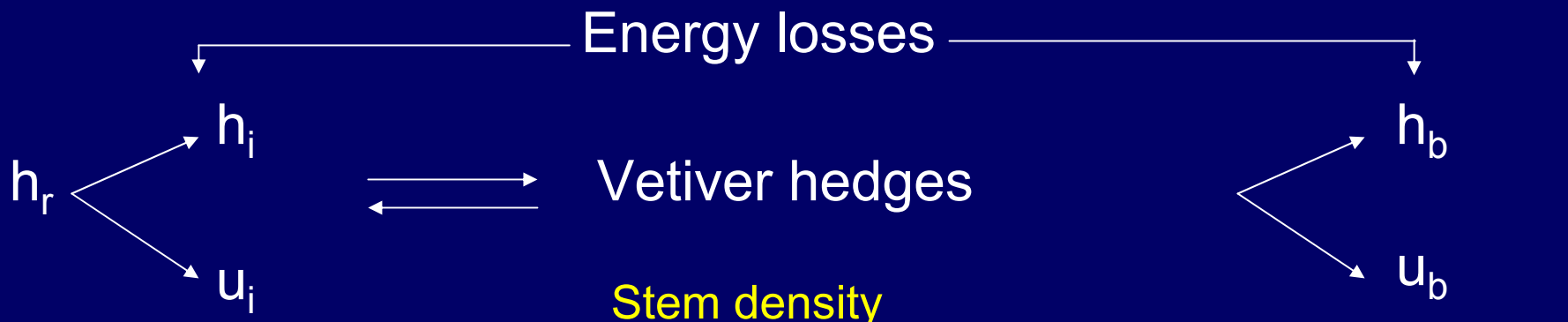
Model set-up

Case	Density of grass (Stem/m^2)	Water level inside reservoir h_r (cm)
Case 1	Without grass	50, 45, 40, 35
Case2	530	50, 45, 40, 35
Case 3	265	50, 45, 40, 35
Case 4	160	50, 45, 40, 35

The experiment scenarios

Results
The interactions



Results

- Flow through Vetiver hedges: Manning factor
- Overtopping discharge

Practical application: Nam Dinh-Vietnam

- Reduction of wave run-up
- Guideline for designing dams and reduction of the cost for upgrading of the present sea dike

Observations

Overview (film)

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Observations

Wave Flow though the Vetiver hedge

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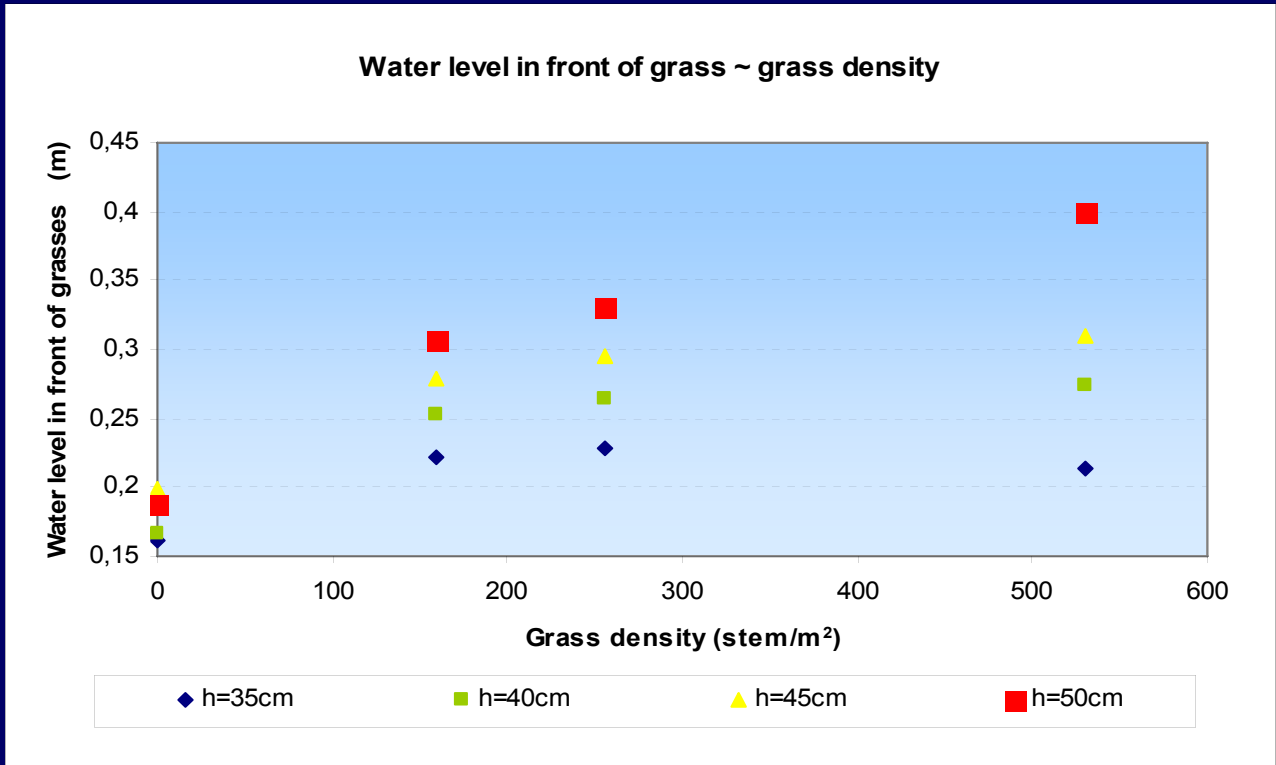
Results (1)

Flow through Vetiver hedge



Water level in front of Vetiver hedge and Grass density

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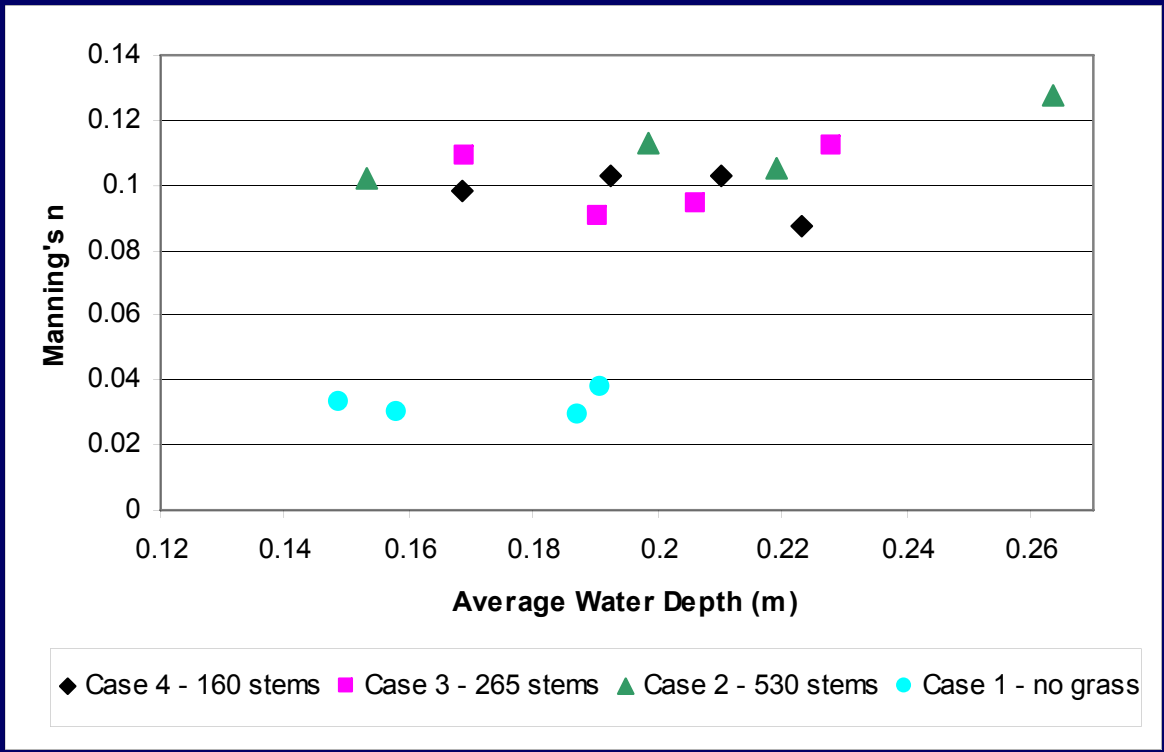
Results (1)

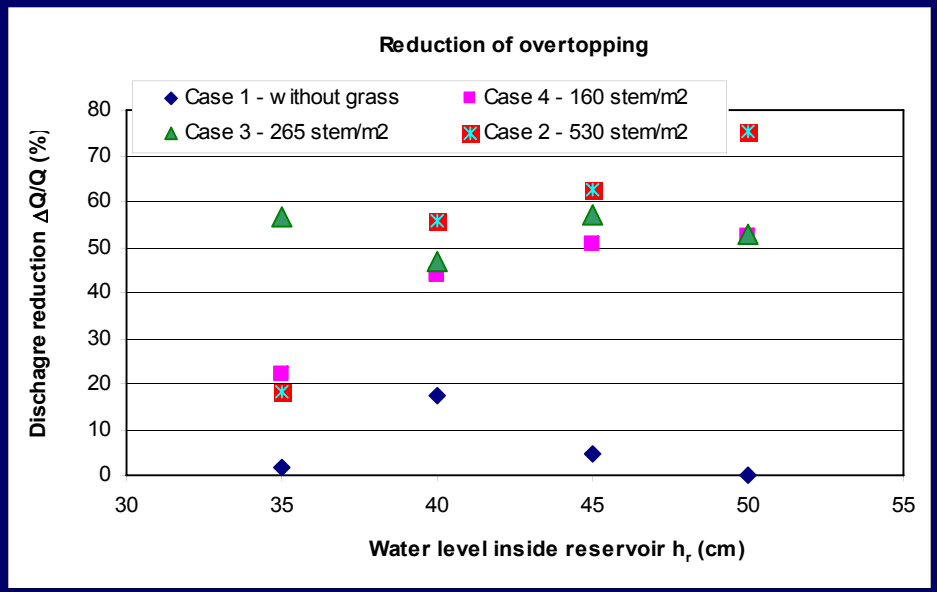
Flow through Vetiver hedge

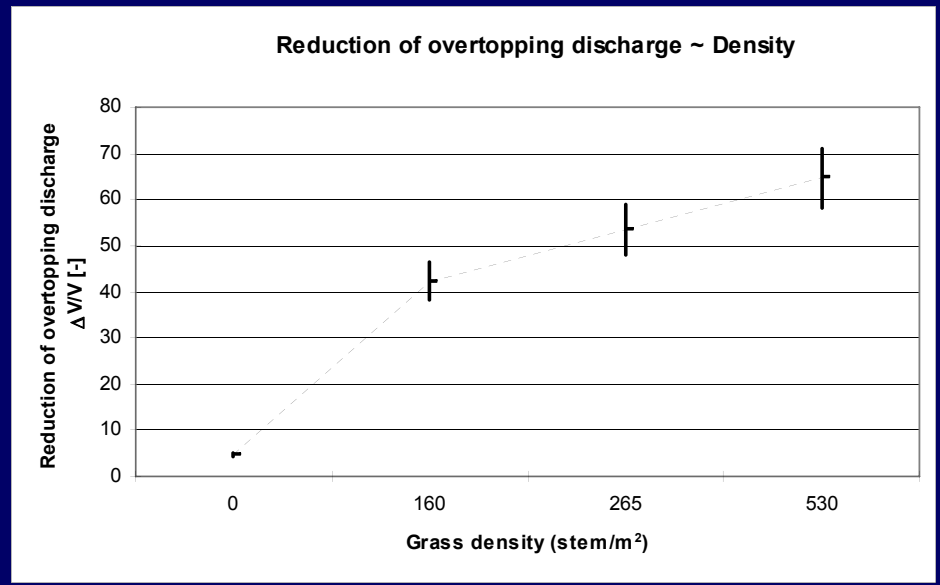


$$n = \frac{1}{u_1} . \sqrt{S_f} . h^{\frac{2}{3}}$$

Variation of roughness coefficient with flow depth through Vetiver hedge

Results (2)
Overtopping Discharge





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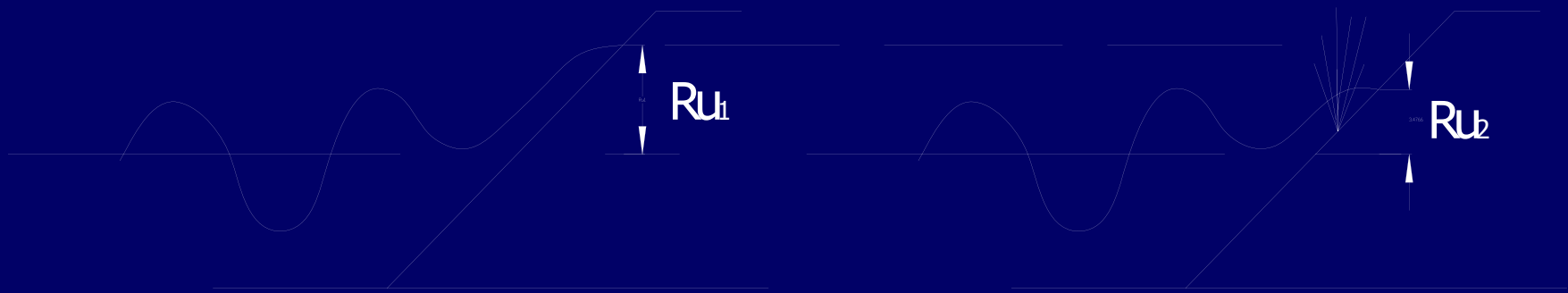
Practical Application

The reduction of wave run-up



- Calculate wave run-up on the outer slope.
- Re-calculate wave run-up in case of Vetiver grass are planted on the outer slope.
- Find the reduction of wave run-up.
- Define the influence factor for roughness of Vetiver grasses.

Practical Application - Results (4)

The reduction of wave run-up

The coastal line of Hai Hau District
Nam Dinh Province - Viet Nam

Nam Dinh province

- Location
- 72km length of coastal line

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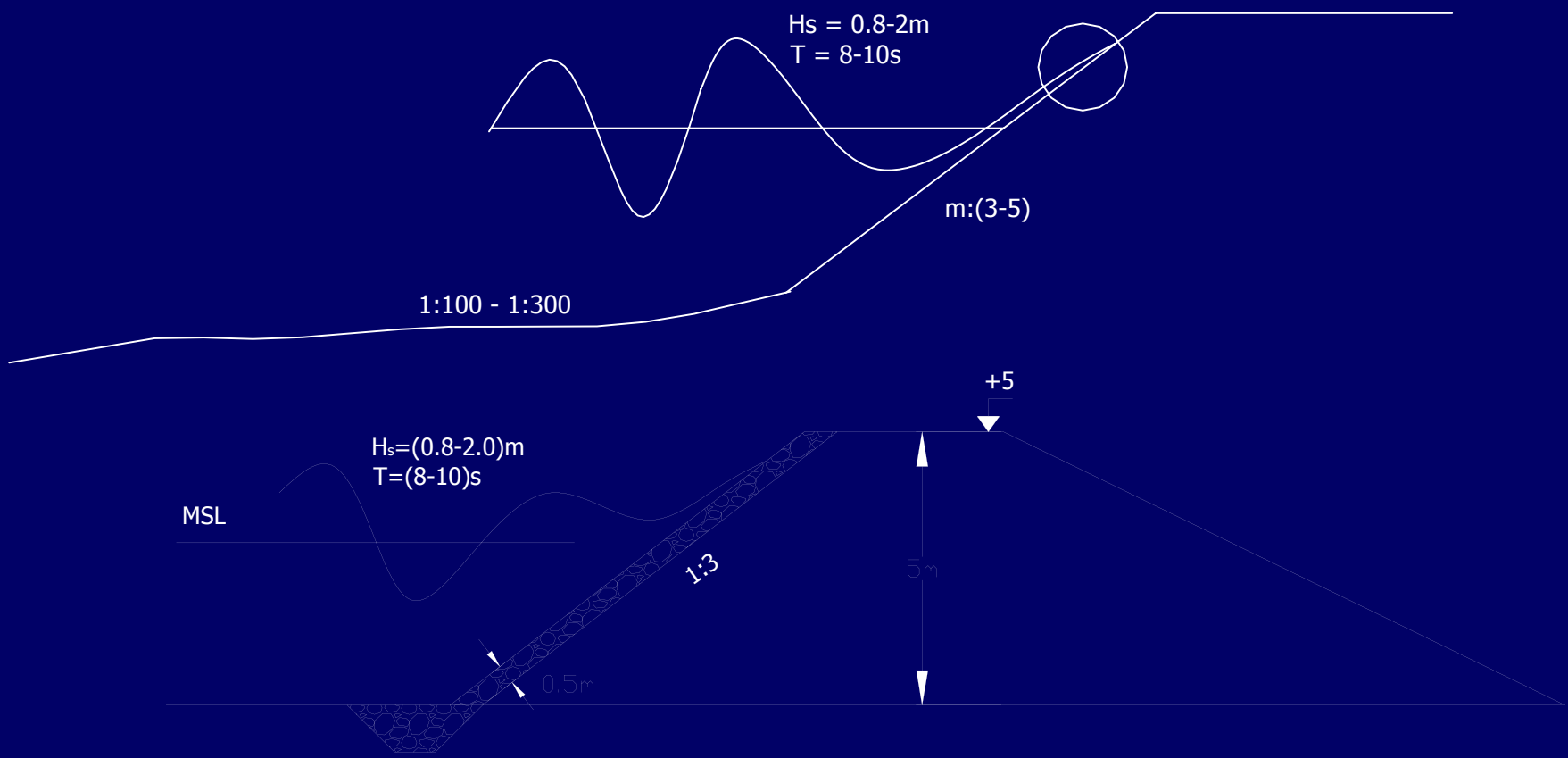
Practical Application - Results (4)

The reduction of wave run-up



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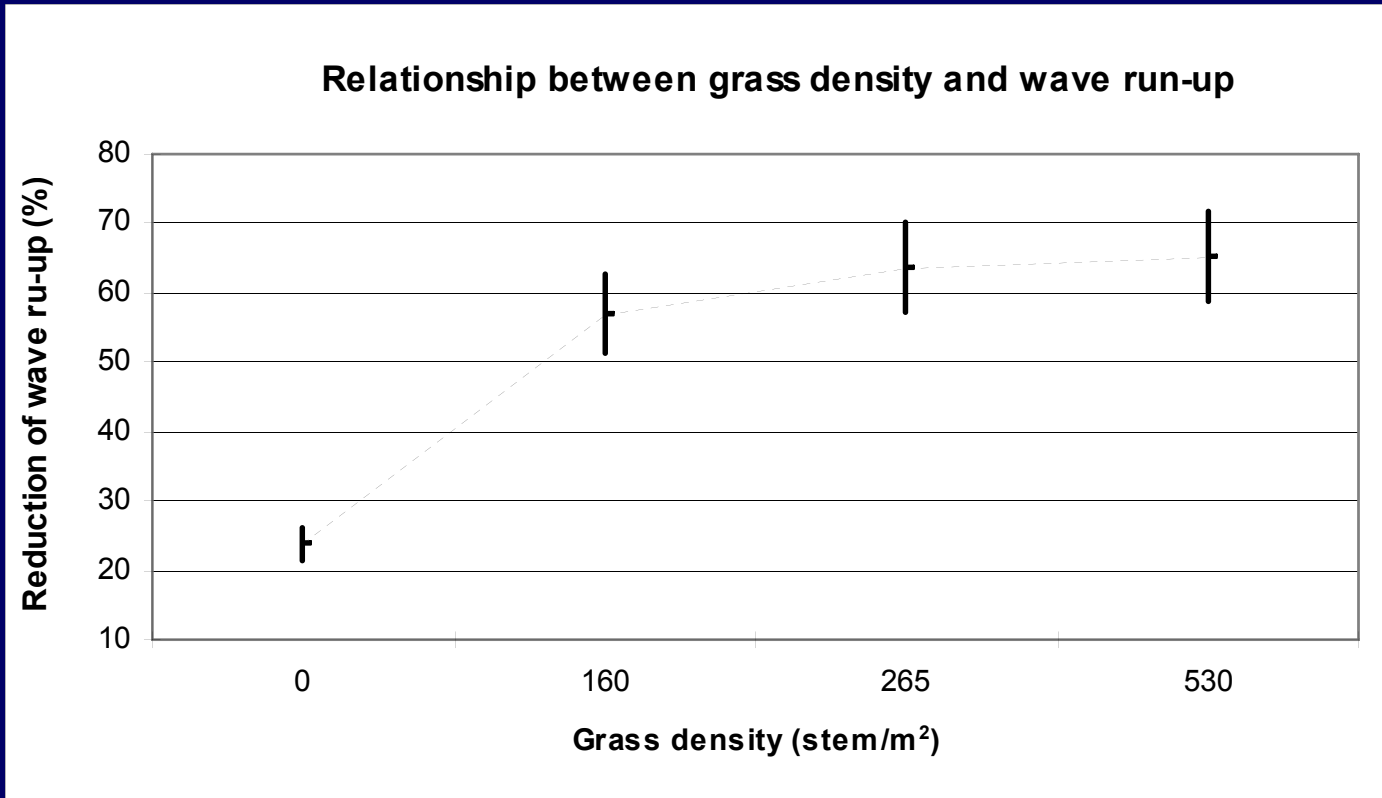
Practical Application

The reduction of wave run-up

	Unit	Real value	Case 1	Case 4	Case 3	Case 2
Grass density	stem/m^2	-	**0**	**160**	**256**	**530**
Ration of wave height	-	-	0.886	0.501	0.422	0.406
$R_{u2\%}$	m	3.26	2.49	1.41	1.19	1.14
Reduction of wave run-up	%	-	23.73	56.85	63.64	65.1
γ_f	-	**0.95**	**0.75**	**0.410**	**0.345**	**0.332**

Practical Application

The reduction of wave run-up



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Practical Application - Case Study

- Use the previous influence factor for roughness of Vetiver grasses (Result 4)
- Allowed discharge of overtopping q=0.0001m²/s

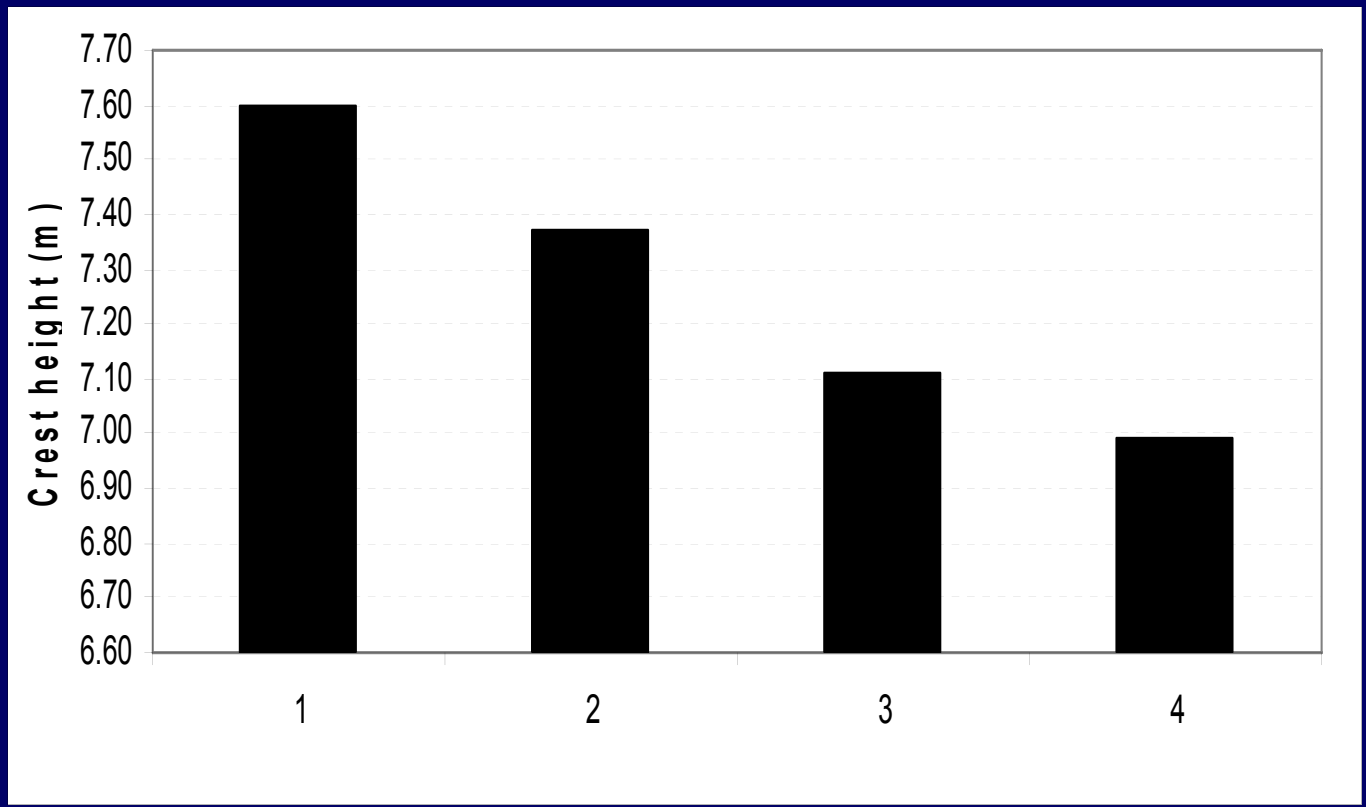
  (Dutch Guideline for the design dam)
- Use Van der Meer formula (2001)

$$\frac{Q}{\sqrt{g.H_{m0}^3}} = \frac{0,06}{\sqrt{\tan\alpha}}.\gamma_b.\xi_0.\exp\left(-4,7.\frac{R_c}{H_{m0}}.\frac{1}{\xi_0.\gamma_b.\gamma_f.\gamma_\beta}\right)$$

- Calculation the total cost for upgrading the present sea dike

Case Study

Crest height of sea dike



No Hedge One Hedge Two Hedges Three Hedges

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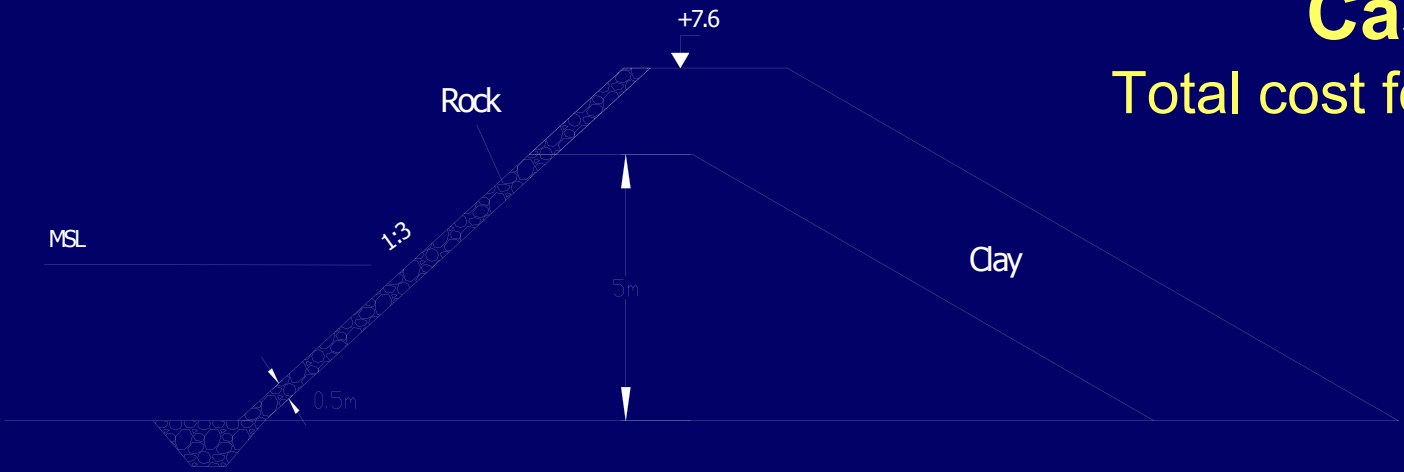
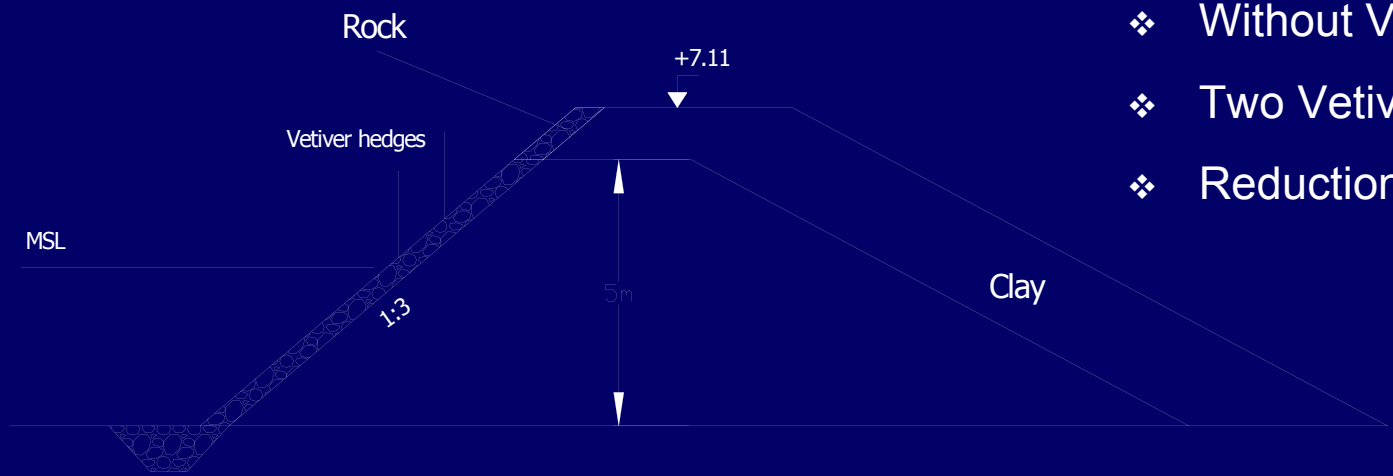
Case Study

Total cost for one meter length





- Without Vetiver grass: $147,5
- Two Vetiver hedges: $128,96
- Reduction 12,6% total costs

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Conclusions

- The resistance of the slope with Vetiver grass is 2.5 times larger in comparison with the slope without grass.
- The Vetiver hedges have ability to withstand flow which reaches depths up to 40cm.

Conclusions

- The wave overtopping reduces with 45% in case of 200 stem/$m^{2.}$
- The influence factor for roughness of Vetiver grass varies from 0.33 to 0.41.
- For upgrading sea dikes, the crest level would reduce 0.49m, and the total costs 12.6% if two Vetiver hedges are planted.

Recommendations

- The influence factor of berm and angle of wave attack
  → Further research which includes these factors.
- The accurate velocities in the middle of grass need more studies and investigations.
- The living condition of Vetiver on the outer slope under saline condition.
- A problem could appear because of grass's roots.


Thanks for your attention