DAMPING OF TSUNAMI AND STORM WAVES BY COASTAL FORESTS – PARAMETERIZATION AND HYDRAULIC MODEL TESTS

S. Reimann
S. Husrin
A. Strusińska
H. Oumeraci

Leichtweiß-Institute für Wasserbau (LWI)
Abteilung Hydromechanik und Küsteningenieurwesen
Technische Universität Braunschweig

FZK Kolloquium, Hannover, 26. March 2009
1. Motivation and objectives

2. Parameterization of mangroves

3. Laboratory experiments on hydrodynamic performance of mangrove forest

4. Outlook
1. Motivation and objectives

MULTI DEFENCE LINE STRATEGY (Oumeraci, 2006)

- Damping performance of forest
- Structural integrity of single tree
OBJECTIVES

- Generate knowledge base for better insight into physical processes involved in interaction of tsunami/storm waves with coastal forests, incl. subsequent energy attenuation

- Develop generic methodology for coastal forest parameterization based on easily measurable/observable parameters

- Develop and validate/verify prediction models (analytical/numerical, semi-empirical) for hydraulic performance of coastal forests as a protection against tsunami/storm waves.
1. Motivation and objectives

2. Parameterization of mangroves

3. Laboratory experiments on hydrodynamic performance of mangrove forest

4. Outlook
Rhizophora sp.

- $b_B = 3.0 - 3.2 \text{ m}$
- $h_B = 3.5 - 4.0 \text{ m}$
- $h_M = 5.0 - 5.5 \text{ m}$
- $h_{TR} = 0.5 - 1.0 \text{ m}$
- $h_R = 1.3 - 1.5 \text{ m}$
- $\varnothing \text{ branch} = 5 - 6 \text{ cm}$
- $\varnothing \text{ trunk} = 12 - 18 \text{ cm}$
- $\varnothing \text{ root} = 4 - 6 \text{ cm}$
- density of trunks = 0.8 - 1.0 trunks/m²
- number of prop roots = 72 - 152 roots/trunk

after Dinar et al. (2004)
2. Parameterization of mangroves

Model Scale 1 : 20

- **Reference Model**
  - Model A
  - Cross section
  - Top view

- **Parameterised Models**
  - **Model B** (1st Parameterised Model)
  - Cross section
  - Top view
  - **Model C** (2nd Parameterised Model)
  - Cross section
  - Top view

Graph:
- **Model A&B**
- **Model C**
- N. Gawa (Mazda, 1997)
- C. Creek (Mazda, 1997)

**Parameterization of Mangrove Tree**

FZK Kolloquium, Hannover, 26. March 2009
S. Reimann
SELECTED RESULTS OF PARAMETERIZATION TESTS

2. Parameterization of mangroves

FZK Kolloquium, Hannover, 26. March 2009
S. Reimann
1. Motivation and objectives

2. Parameterization of mangroves

3. Laboratory experiments on hydrodynamic performance of mangrove forest

4. Outlook
EXEMPLARY MODEL SET-UP FOR FOREST WIDTH B=0.75m (1)

3. Laboratory experiments on hydrodynamic performance of mangrove forest

FZK Kolloquium, Hannover, 26. March 2009
S. Reimann
TREE NUMBER: N=62
SIZE OF SINGLE TREE MODEL: 15x15cm
FOREST WIDTH: B=0.75m

Measuring devices:
- WG Wave gauge
- P Propeller
- ADV Acoustic Doppler Velocimeter (ADV)
- PT Pressure Transducer
- FTS Force Transducer for single tree
EXEMPLARY MODEL SET-UP FOR FOREST WIDTH B=0.75m (2)
1. STAGE: Mangrove Forest

2. STAGE: Pine Forest

- **MODEL SCALE**: 1:25
- **MODEL STIFFNESS**: MANGROVE FOREST - stiff tree models (submergence depth up to canopy)
  MANGROVE & PINE FOREST - stiff/flexible tree models (submergence depth up to canopy)
- **FOREST WIDTH**: B=0.0, 0.75, 1.5, 2.25, 3.0 ... m
- **WATER DEPTH**: h=0.415, 0.465, 0.515, 0.565, 0.615m
- **WAVE TYPES**: storm waves (regular and irregular waves), tsunami (solitary waves and bore)
- **WAVE PARAMETERS**: wave height H=0.04-0.20m; wave period T=1.0-6.0s
REGULAR WAVES:
\[ h = 0.565 \text{m}, \quad H = 0.04 \text{m}, \quad T = 1.0 \text{s} \]

FTS1 (in front of forest)

FTS2 (in the middle of forest)
 Graves (2008) used regular waves of amplitude H = 0.04 m and wavelength λ = 0.7 m to test the hydrodynamic performance of mangrove forests.

h = 0.565 m, H = 0.04 m, T = 1.0 s
MEASUREMENTS OF WAVE GAUGES (WG)

REGULAR WAVES:

h=0.565m, H=0.04m, T=1.0s

WG12 (in front of forest)
WG19 (behind forest)

3. Laboratory experiments on hydrodynamic performance of mangrove forest
1. Motivation and objectives

2. Parameterization of mangroves

3. Laboratory experiments on hydrodynamic performance of mangrove forest

4. Outlook
Preparation of equipments required for performance of the experiments (e.g. coastal pine models, gate for a bore generation in twin wave flumes)

- performance of laboratory experiments on mangrove effectiveness on wave energy reduction for varying water depths and wave conditions
- performance of laboratory experiments on Casuarina effectiveness on wave energy reduction for varying water depths and wave conditions
- determination of hydraulic performance of both types of forest (wave transmission, reflection and energy dissipation)
- Use of experimental results for the development of numerical model
THANK YOU FOR YOUR ATTENTION!