Effective coastal vegetation landscaping to resist tsunami : Points for mitigation and future reconstruction

Introduction

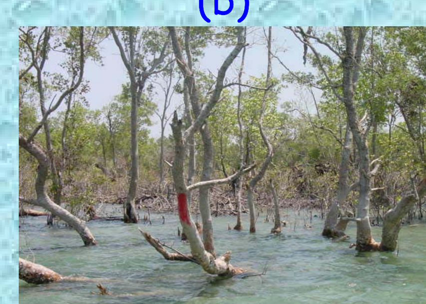
- The damage caused by the Indian Tsunami (December 26, 2004) emphasized the importance of developing methodologies to minimize the impacts from future tsunami.
- Post Tsunami field investigations revealed the significant role of coastal vegetation to retardate the severity of tsunami energy.
- Field investigation covered about 250km on the southern coast of Sri Lanka from Negambo to Kalmunai and about 200km on the Andaman coast of Thailand from Pucket to Ranong in Yr 2005 and 2006 respectively.
- The representative coastal vegetation can be classified into six types , according to their habitat and the stand structures of the trees.

Reconnaissance

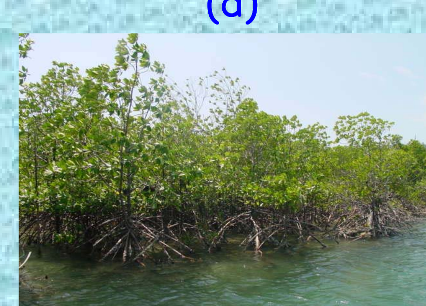

(a)


(b)


(c)


(d)


(e)


(f)

Representative coastal vegetation in the observed area

(a) *Casuarina equisetifolia* (vegetation in sand beach)

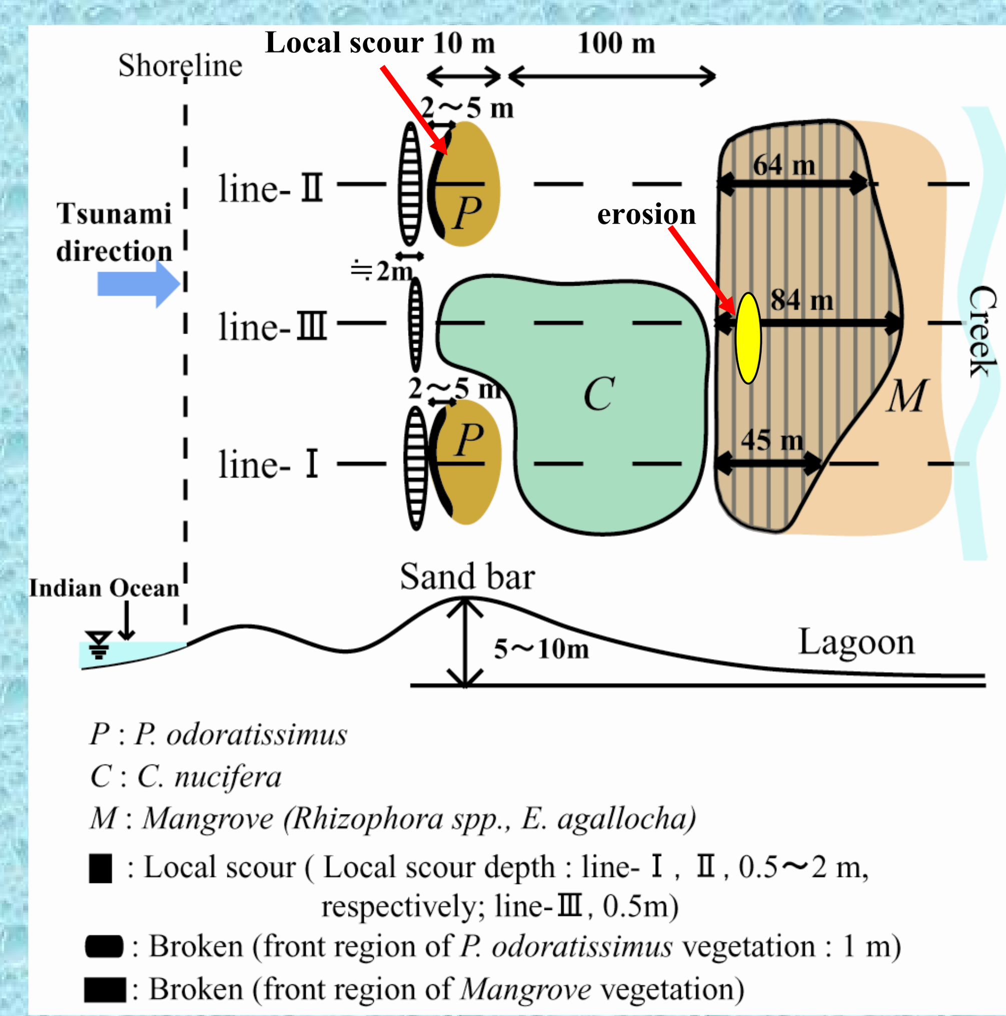
(b) *Anacardium occidentale* (plantation species in coastal zone)

(c) *Cocos nucifera* (plantation species in coastal zone)

(d) *Avicennia alba* or *Avicennia marina* (mangrove species in small tidal zone)

(e) *Pandanus odoratissimus* (vegetation in sand beach)

(f) *Rhizophora apiculata* or *R. mucronata* (mangrove species in large tidal zone)



Field survey at Medilla (Sri Lanka)

1) Pandanus effect
2) Mangrove effect

The length of the damaged mangrove forest was maximum at *Cocos* line.

Local scour was larger in front of the *Pandanus* forest.

About 10 m thickness and dense ***Pandanus* forest has a role to reduce the velocity, although part of the species were broken at the main stem** (1-2 m in height).

Mathematical background behind tsunami flow through the vegetation (1-D Case)

Governing equations derived by Nandasena & Tanaka (2007)

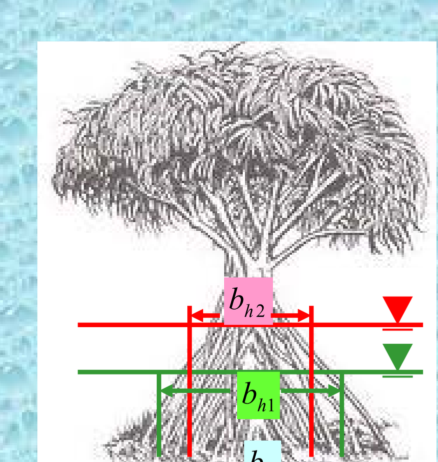
Continuity equation
$$\sqrt{\theta_h}\frac{\partial h}{\partial t}+\frac{\partial (Uh)}{\partial x}=0$$

Momentum equation
$$\sqrt{\theta_h}\frac{\partial (hU)}{\partial t}+\frac{\partial (hU^2)}{\partial x}+gh\frac{\partial h}{\partial x}+\sqrt{\theta_h}gh\frac{\partial z}{\partial x}+\frac{\theta_b}{\rho\sqrt{\theta_h}}\tau_b+\frac{\sqrt{\theta_h}}{\rho}\sum_{i=1}^{k}\tau_x+\frac{\sqrt{\theta_h}}{\rho}\sum_{i=1}^{k}f_x=0$$

Porosity due to vegetation

Bed aerial porosity
$$\theta_b=1-n\pi\frac{b_b^2}{4} \qquad 0\le\theta_h,\theta_b\le 1$$

Depth averaged aerial porosity
$$\theta_h=1-n\pi\frac{b_h^2}{4}$$



Where,

b_b is tree diameter on ground, is constant irrespective of water depth

b_h is depth averaged tree diameter (above ground), is depend on water depth

U - Depth averaged flow velocity in X- direction

h - Water depth on bed

z - Land elevation measured from datum

n - Density of vegetation (no of tree per unit area)

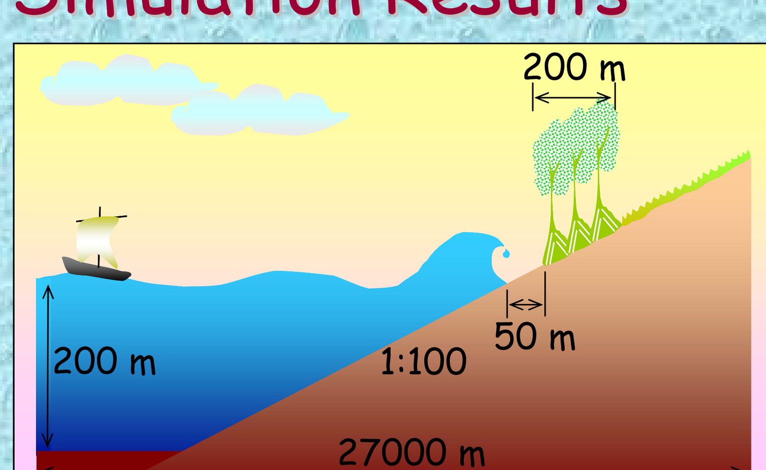
ρ - Density of fluid

τ_b - Bed roughness

τ_x - Resistance due to other effects

f_x - Resistance due to vegetation

Simulation Results



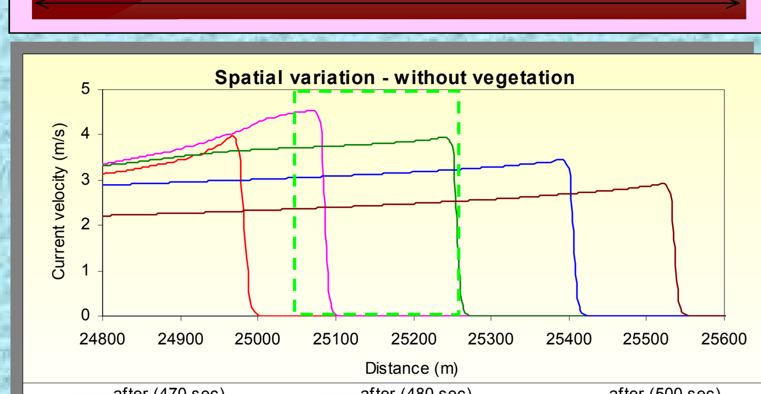
Simulation conditions

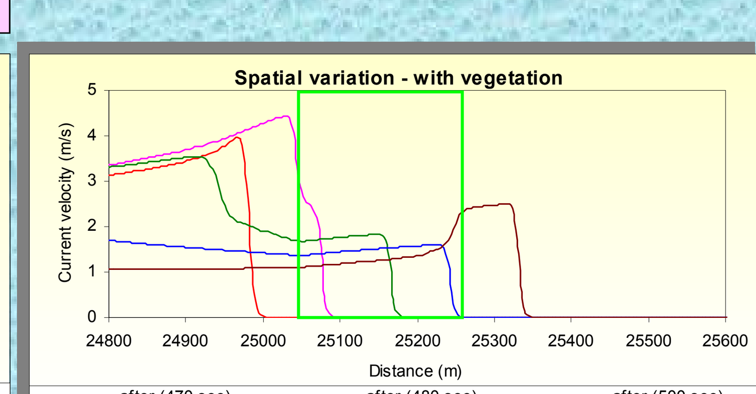
Tsunami characteristics in deep sea at 200 m water depth

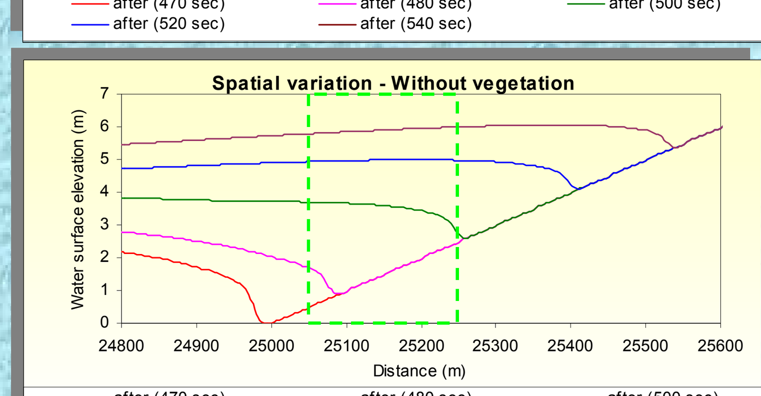
Effective wave height (H_s) - 4 m

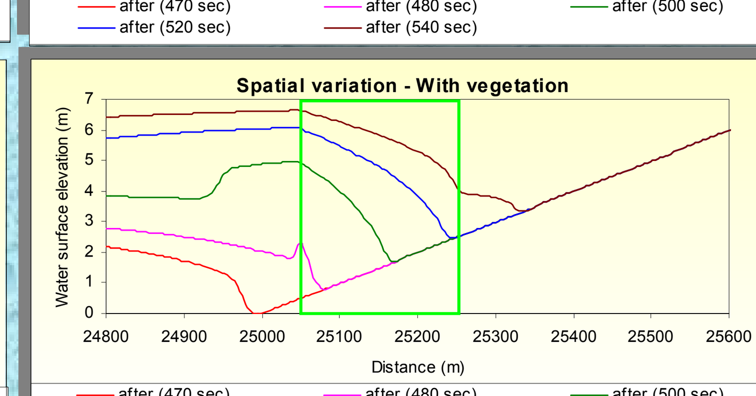
Wave period (T_p) - 20 min

Vegetation type-*Pandanus Odoratissimus*

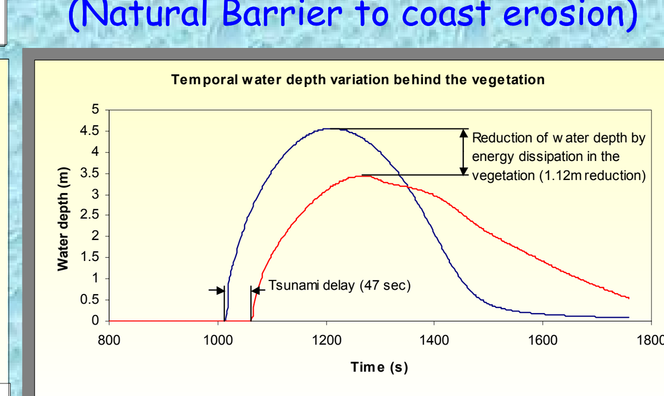








Densely grown Pandanus sp., in Kalutara Beach, Sri Lanka (Natural Barrier to coast erosion)



Fruitful steps towards Coastal Vegetation landscapes for Mitigating of Future Tsunami Events

A combined research commenced by Universities of Peradeniya and Moratuwa, Sri Lanka with the collaboration of Saitama University, Japan to investigate the green belt effect on future tsunami mitigation in Matara Sri Lanka on 26 Dec., 06.

Effective coastal vegetation: Landscaping to resist tsunami

Combined research reveals