ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018
The State of the Art and Science of Coastal Engineering

Effective Method of Beach Nourishment Placement

For low wave energy shores with limited sediment availability

Hyun Dong Kim, Nobuhisa Kobayashi, Aoki Shin-ichi

Susumu Onaka, Young Bok Lee, Kisu Kwak and Kyu Tae Shim

MIRAE OCEAN CORPORATION

Center for Applied Coastal Research
University of Delaware

CATHOLIC KWANDONG UNIVERSITY

OSAKA UNIVERSITY

NIPPON KOEI

CONTENTS

1. Introduction

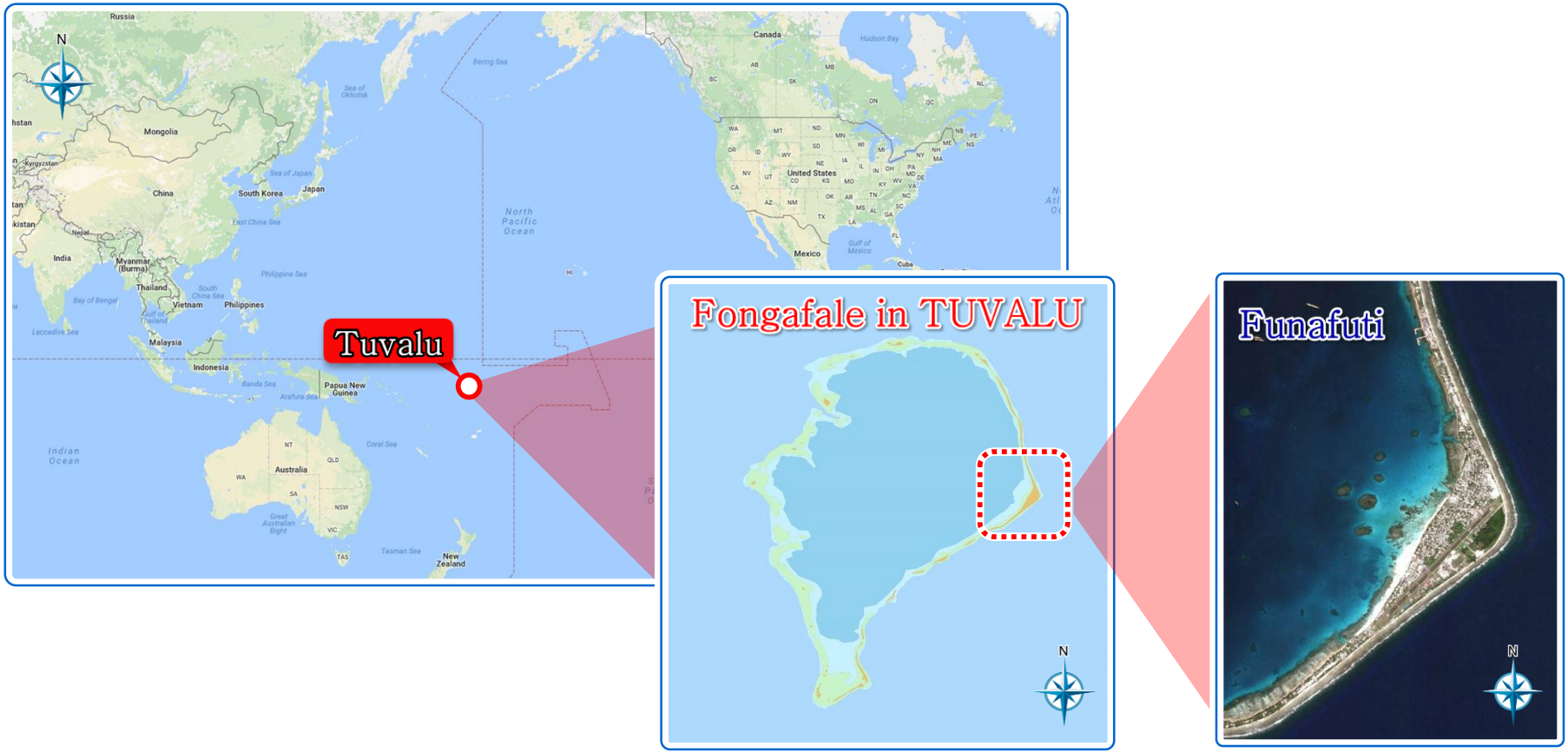
- Open-ocean sand beaches suffering from chronic beach erosion are maintained by periodic placement of a sufficient amount of sand

- This erosion mitigation measure is sustainable as long as suitable beachfill sediment is available nearby

- For sand-starved beaches in low wave energy environment, it is necessary to make the best use of locally available sediments of limited volumes

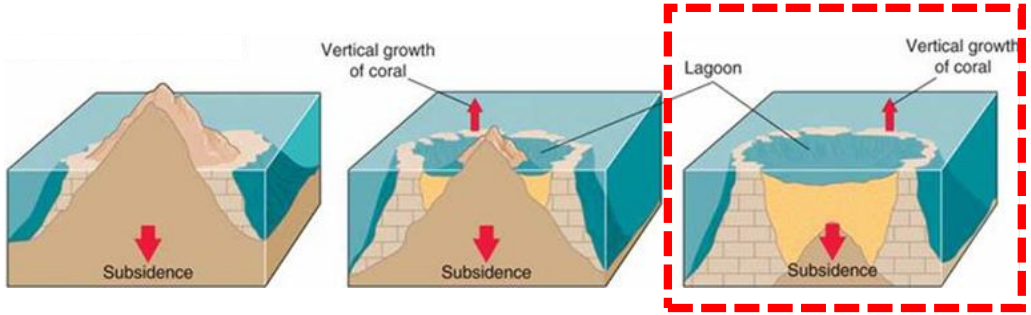
2. Field Example

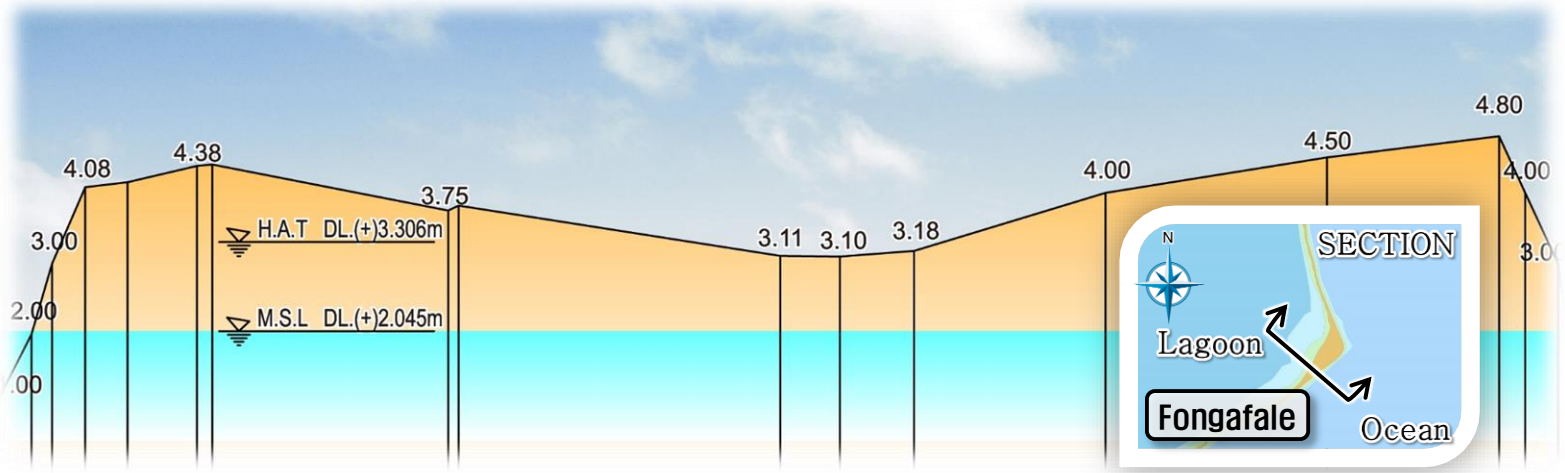
- The island is located in the middle of the Pacific Ocean (no sand source, relatively small storm tide)



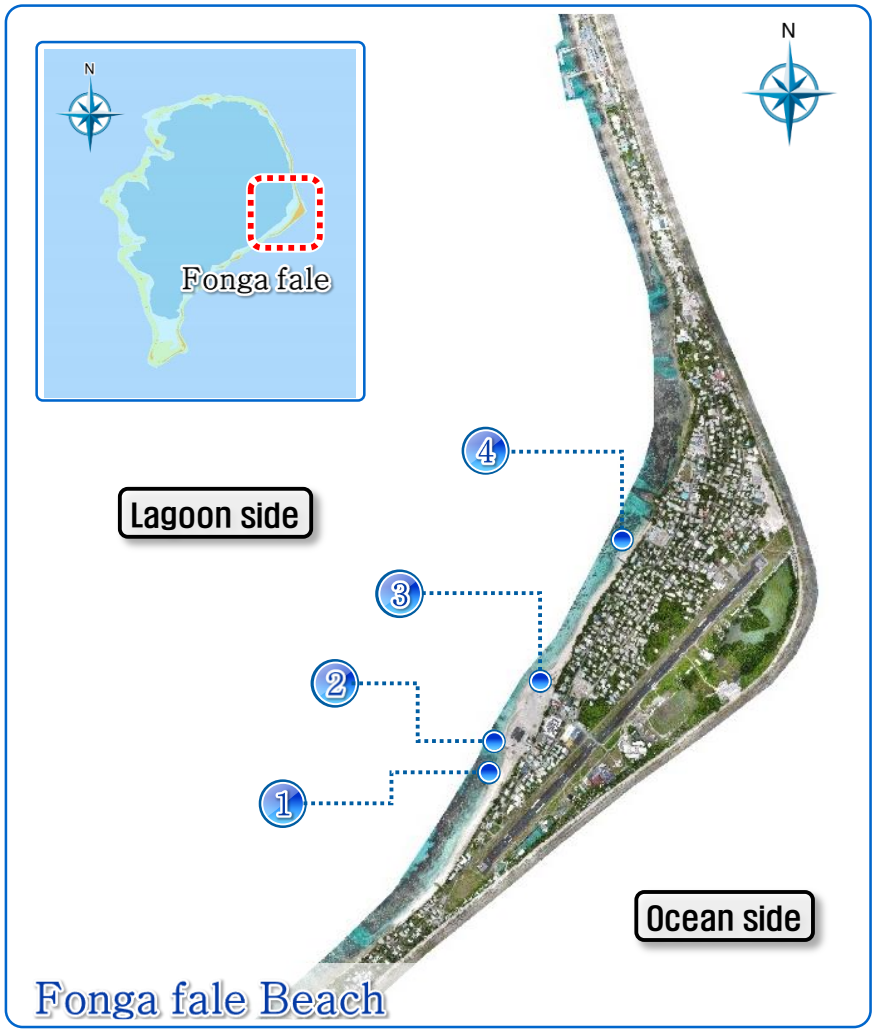
Field Example

- The island is a coral atoll (Very low-elevation and small land area)





Field Example




1. Beach in front of Government Building


2. Groin in front of Government Building


3. Coarse Gravel Area

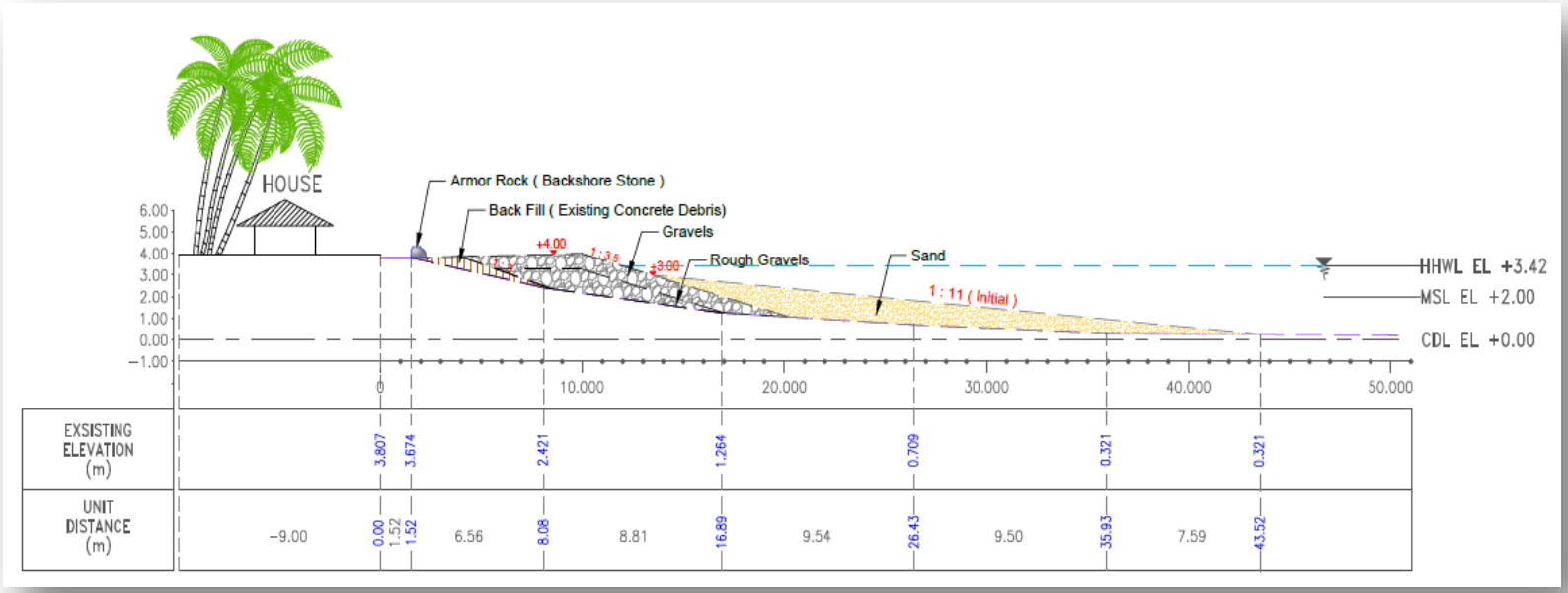

3. Gravel Nourishment Beach Area

- Nourishment site on the lagoon side (low wave energy). The open-ocean side appears to be protected by a seawall (more strongly)

Field Example

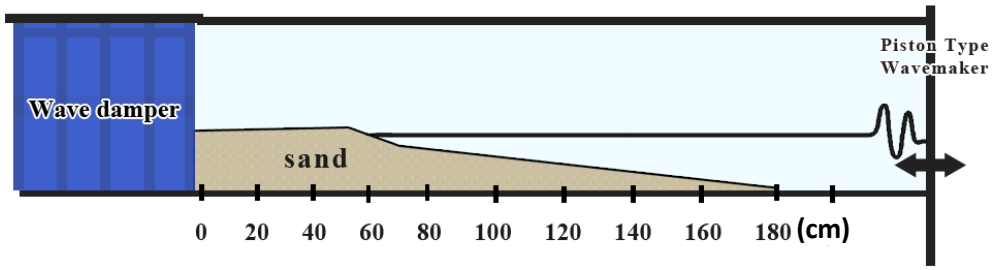
Cross—section and photo of gravel sand nourishment

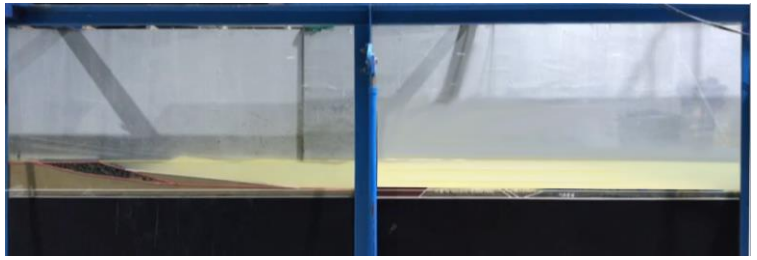


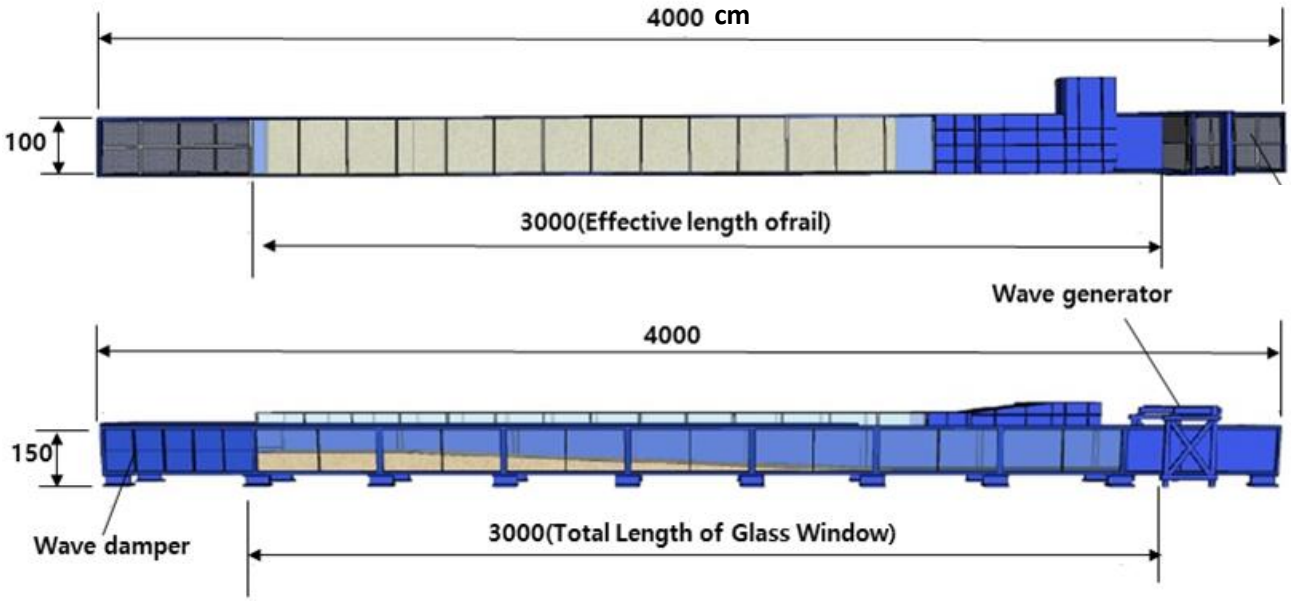



3. Small-Scale Experiment

Cross-section of Experimental Setup



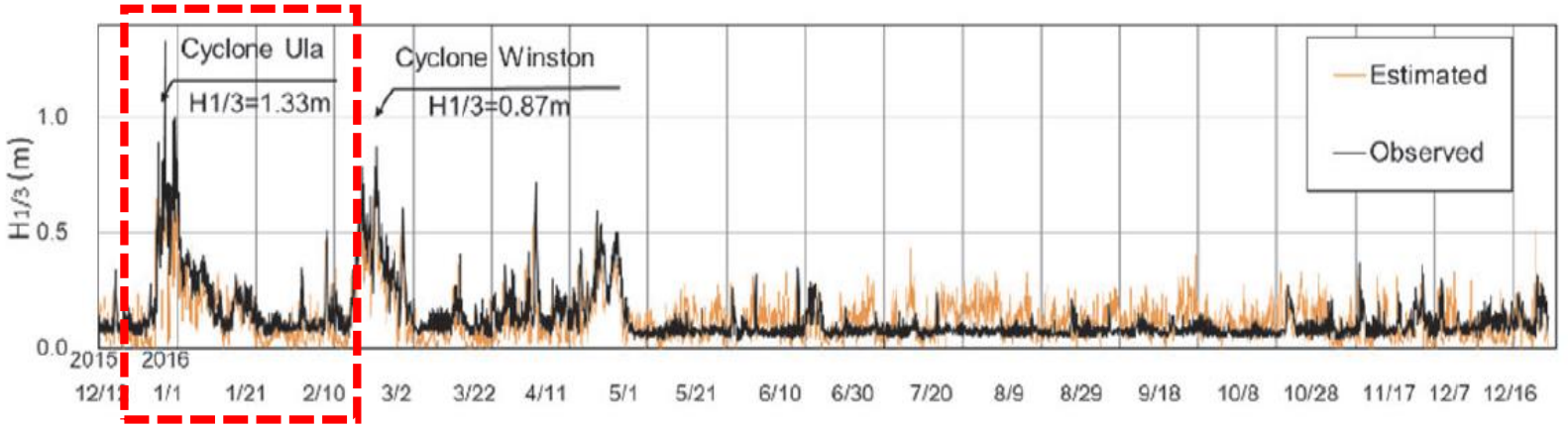




Top view

Side view

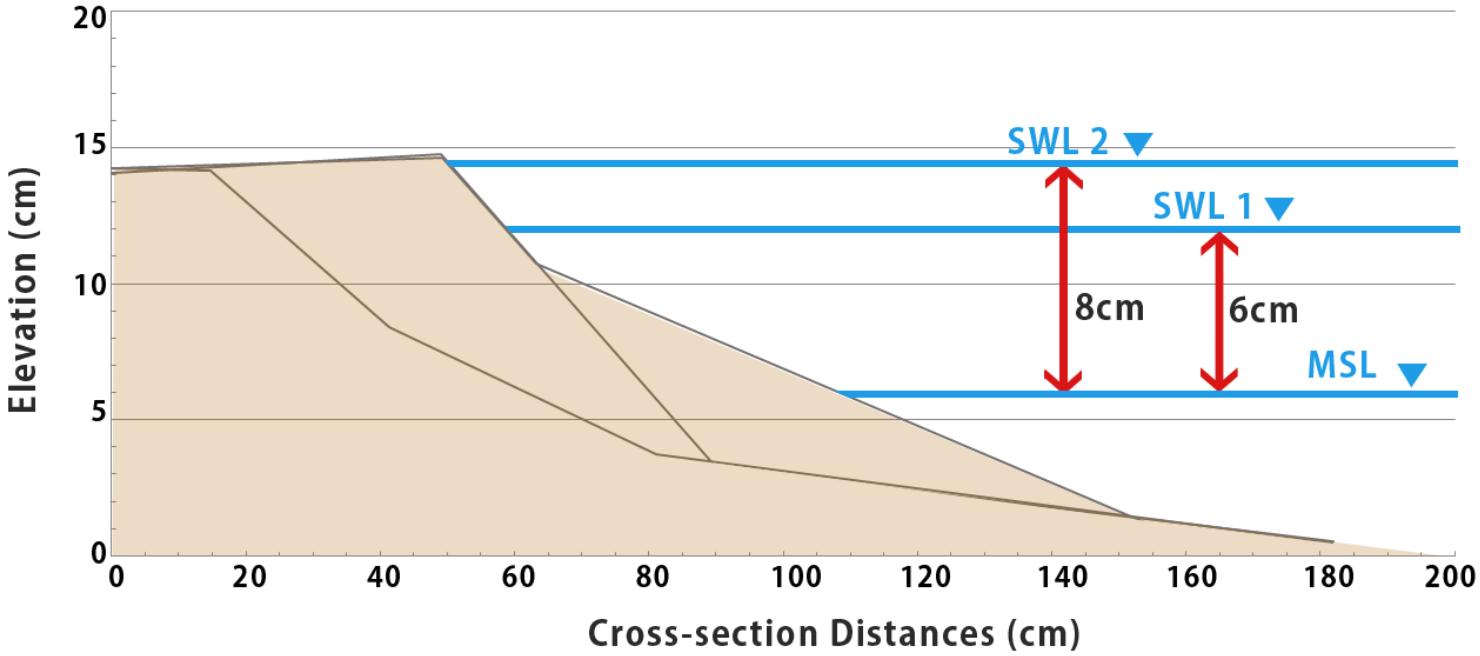
Small-Scale Experiment



Wave Height at the Lagoon Side During the Monitoring Period (Onaka et al., 2017)

- Design (10 year-return period) waves based on Froude Similitude of about 1/25 (model/ prototype)
- Significant wave height and period of 5.2 cm and 1.1 s for 2 hr duration

Small-Scale Experiment



Two water levels (SWL1 and SWL2) above the mean sea level (MSL) of 6 and 8 cm because of the sensitivity of erosion and flooding risk to the water level

Small-Scale Experiment

Sand and Gravel Characteristics

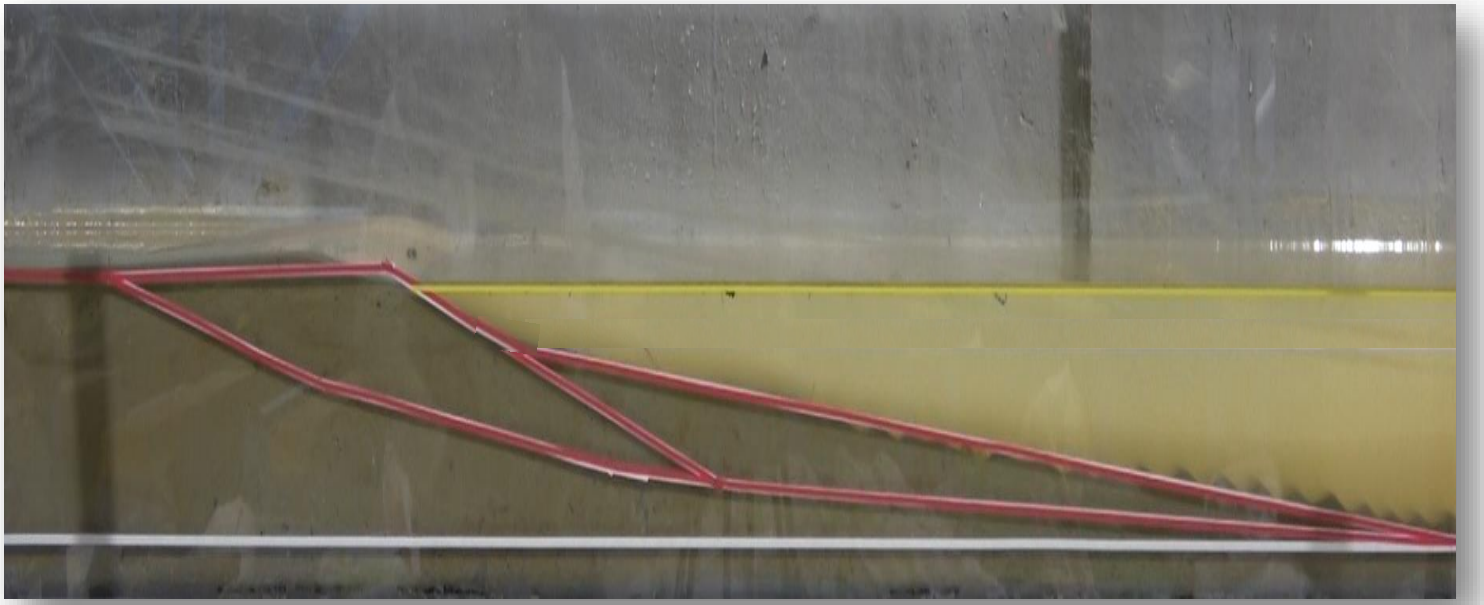
Sand : d_{50} = 0.16mm, density=2.50g/cm^3

Gravel : d_{50} = 5.00mm, density=2.68 g/cm^3

- Sand and gravel are not in similitude with prototype sand and gravel
- Sand particles moved onshore as bed load and offshore as suspended load (under breaking waves)
- Gravel particles moved onshore (photo) as bed load

3.1 Sand Berm and Beach (SBB)

- Cross section with SWL 1 at time = 0



- Berm slope of 1/3.5 and beach slope of 1/11

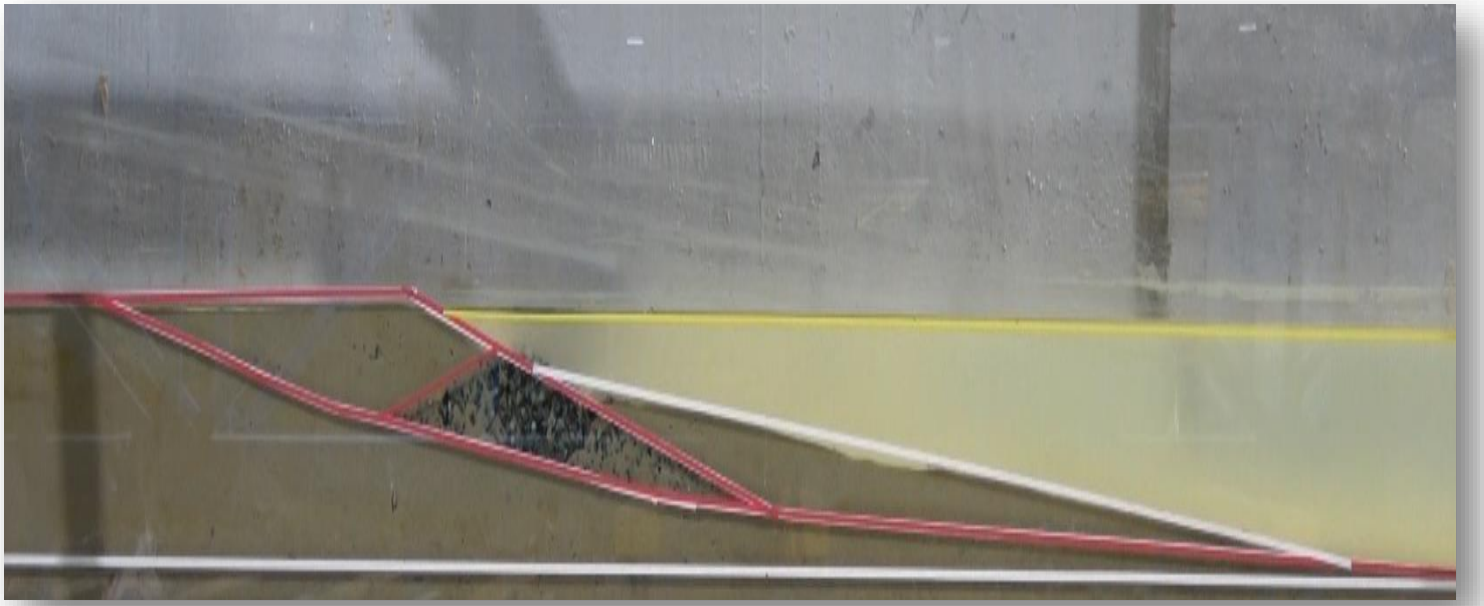
3.2 Gravel Berm and Sand Beach (GBS)

- Cross-section with SWL1 at t=0

- Gravel berm is expected to reduce berm erosion and wave overtopping of the berm
- Sand beach provides recreational comfort

3.3 Buried Gravel Sill (BGS)

- Cross-section with SWL1 at t=0



- Buried gravel sill may reduce the extent of berm erosion and does not spoil shore aesthetics

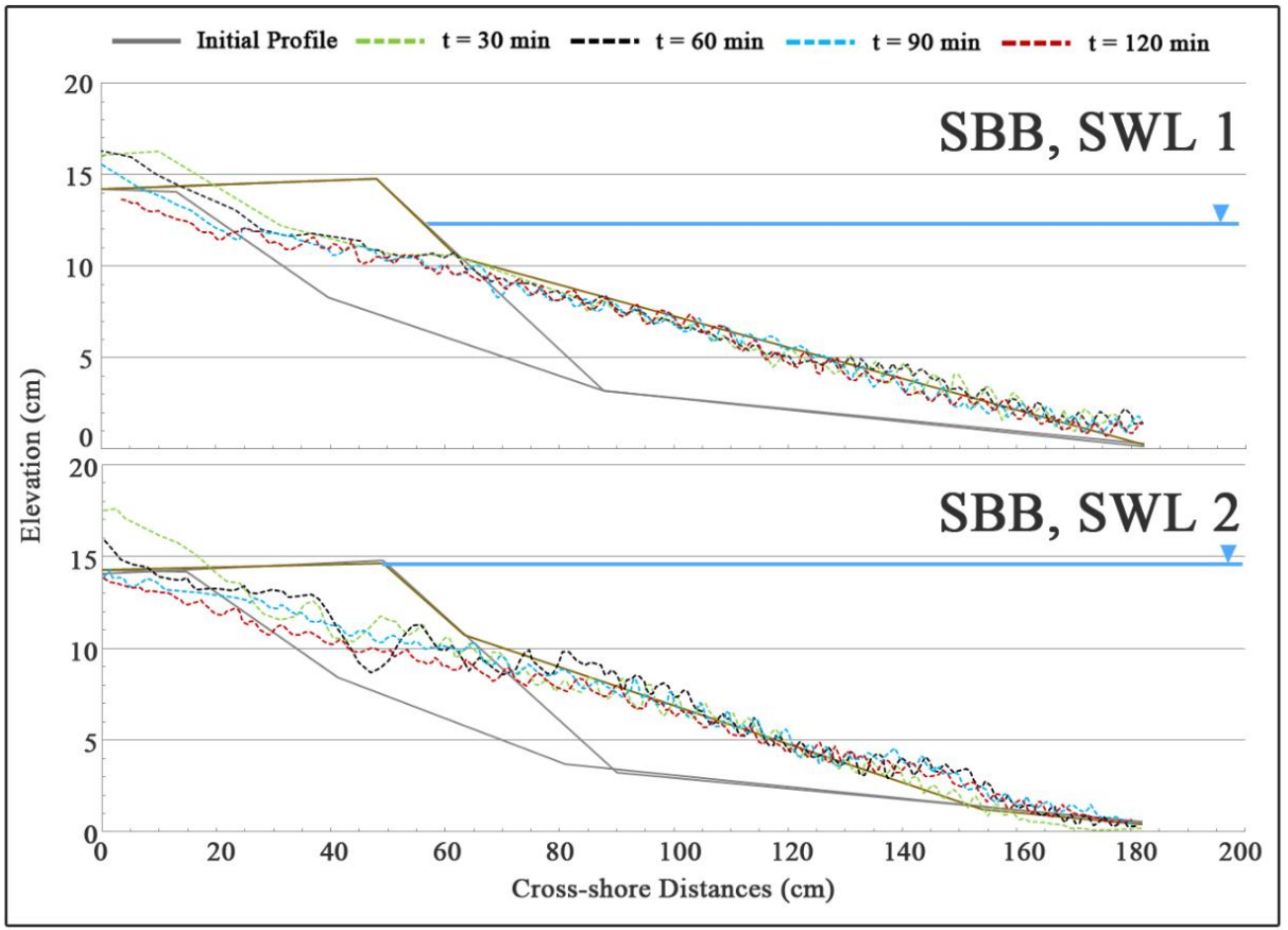
3.4 Buried Gravel Layer (BGL)

- Cross-section with SWL1 at t=0

- Buried gravel layer may prevent lowering of eroded sand berm and facilitate an equilibrium profile development

4. Measured Profile Changes

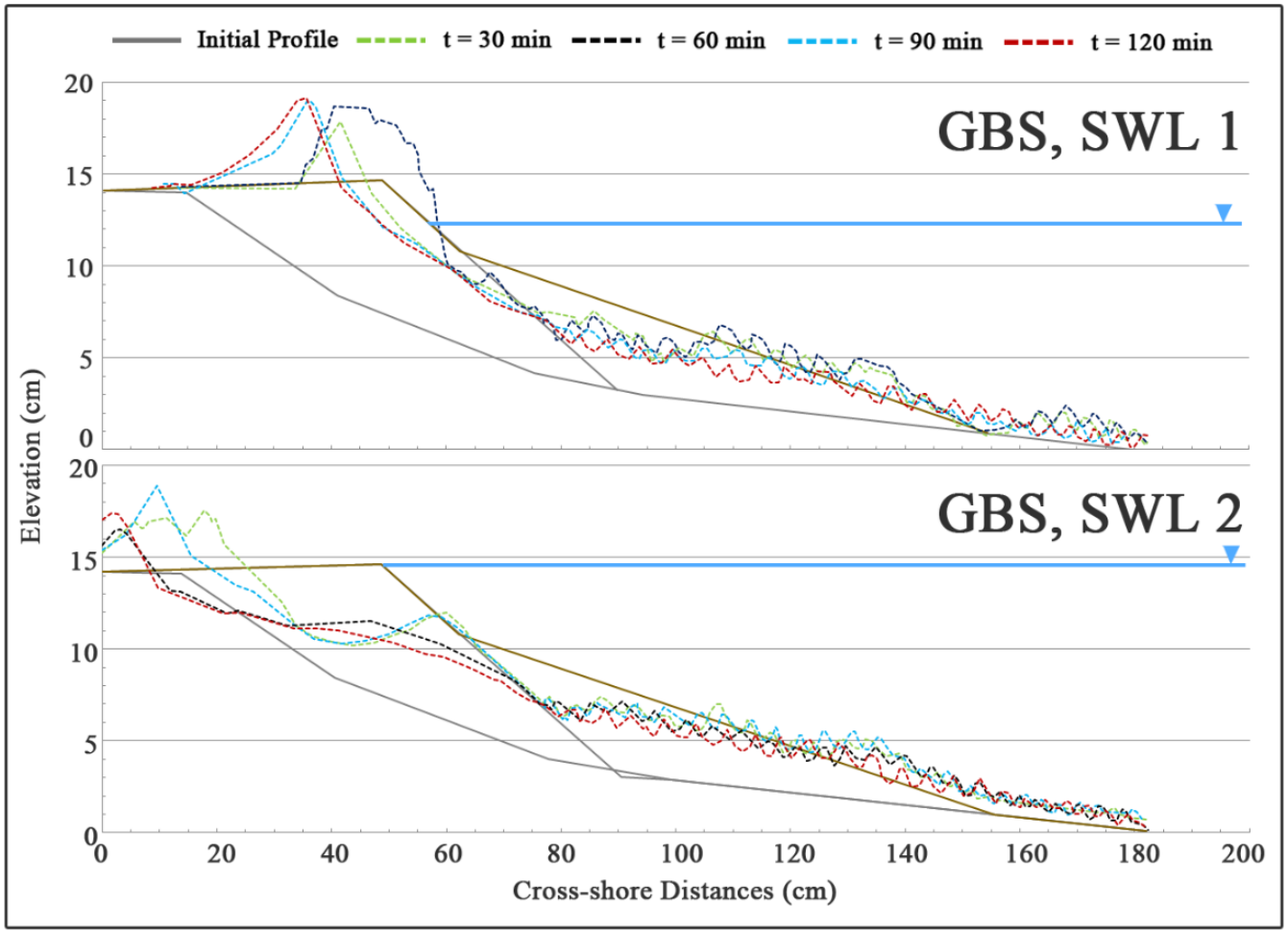
Sand Berm and Beach (SBB): SWL1 and SWL2



- Final profiles for SWL1 and SWL2 are similar (less sensitive to SWL)

Measured Profile Changes

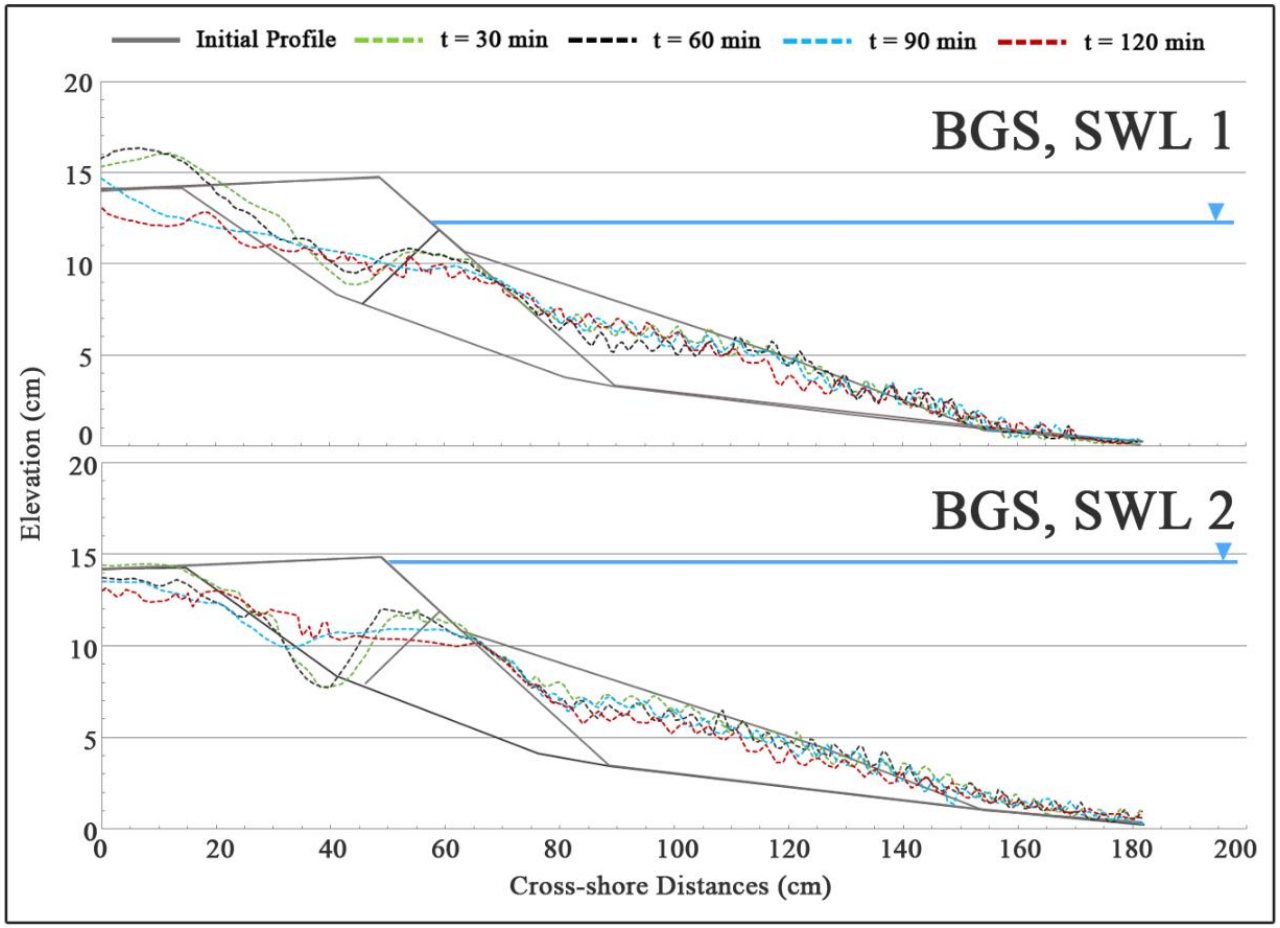
Gravel Berm and Sand Beach (GBS): SWL1 and SWL2



- Gravel deposition and landward migration were sensitive to SWL because wave runup on gravel is sensitive to SWL

Measured Profile Changes

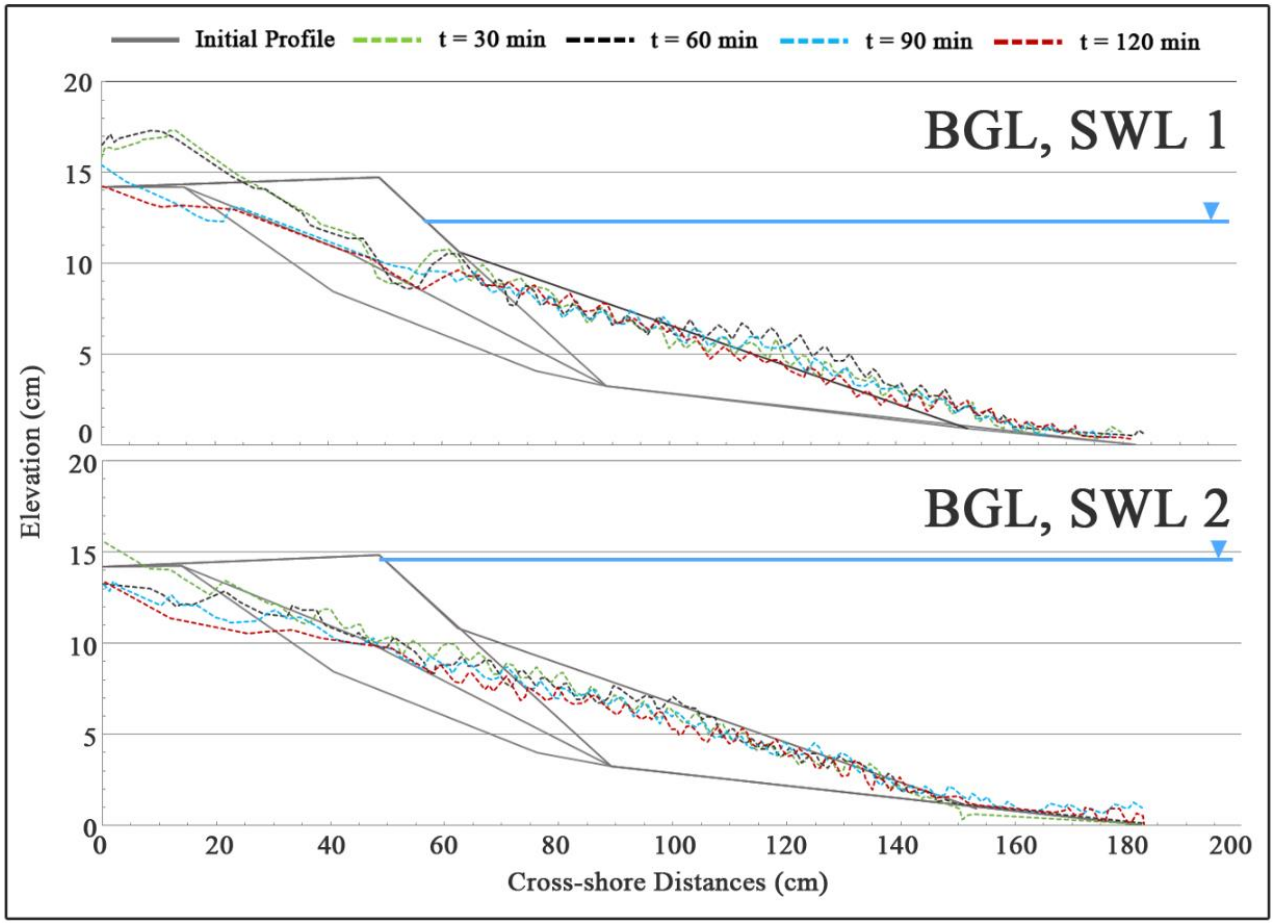
Buried Gravel Sill (BGS): SWL1 and SWL2



- The sill's effect became noticeable only after the sill's crest was exposed but wave breaking over the exposed crest created a scour hole landward of the sill

Measured Profile Changes

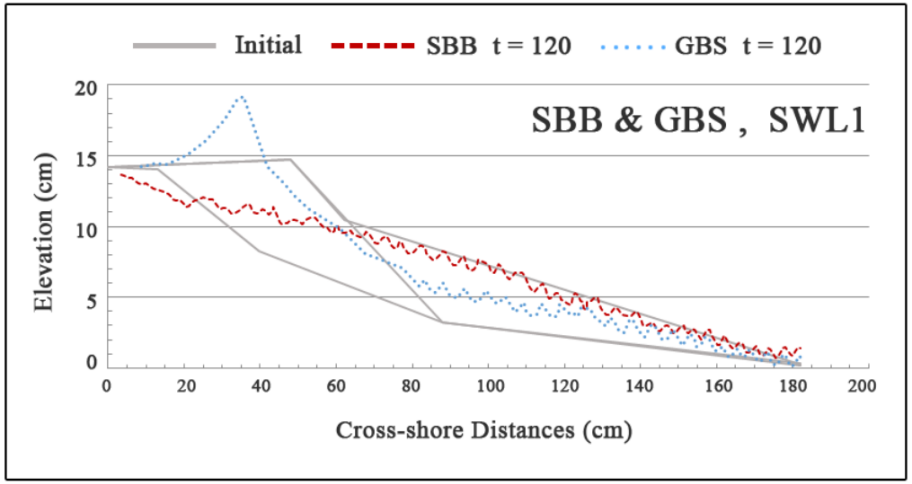
Buried Gravel Layer (BGL): SWL1 and SWL2



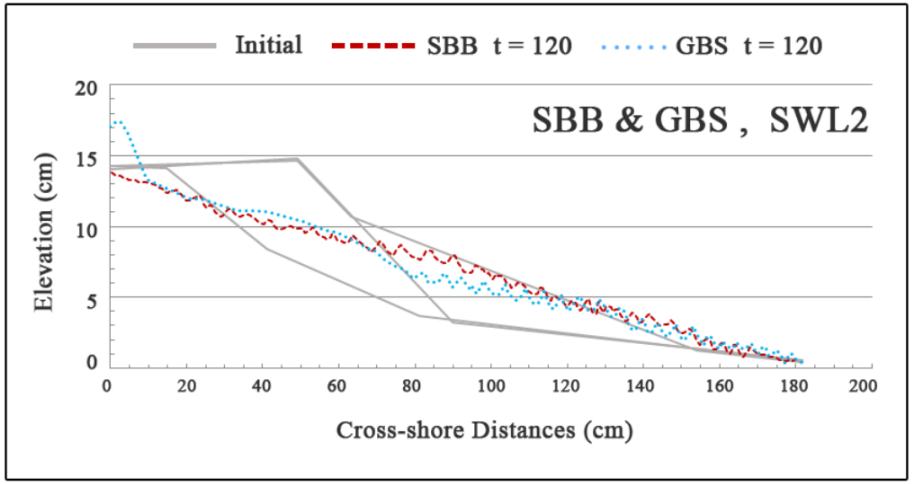
- The landward edge of the gravel layer was eroded after the berm erosion progressed landward and the thin layer of gravel did not protect sand below the gravel layer

5. Gravel Effects on Berm and Beach Erosion

Gravel Berm Effect on Final Profiles



2 lines for SBB and GBS at time = 120 min for SWL 1

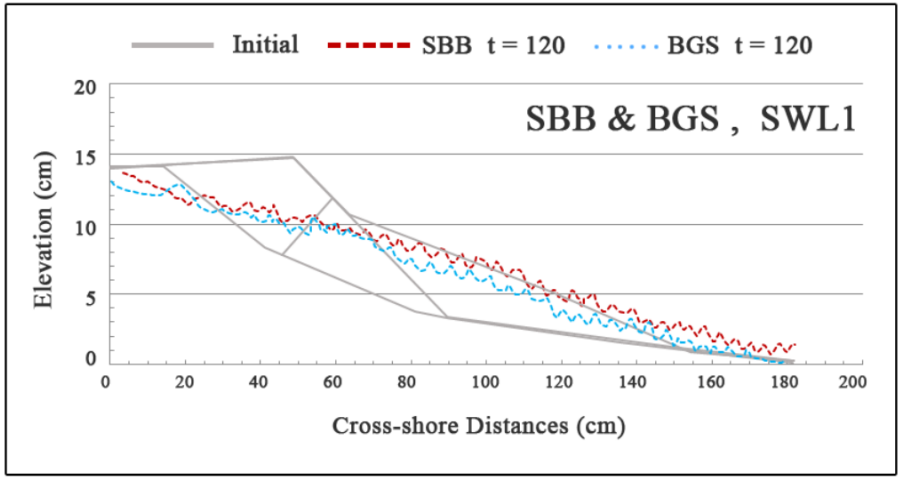


2 lines for SBB and GBS at time = 120 min for SWL 2

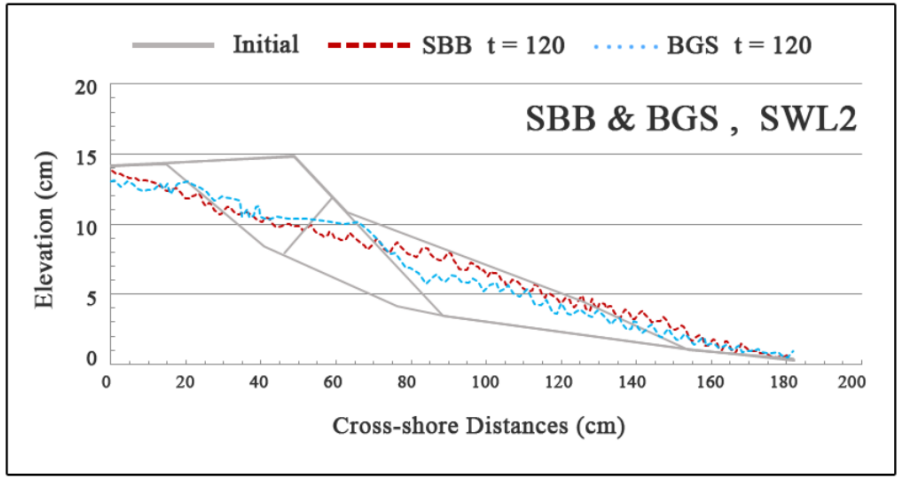
The gravel berm was effective in reducing berm erosion and wave overtopping (visually observed but not measured) but increased sand beach erosion because of less sand supply from the gravel berm filled with wet sand

Gravel Effects on Berm and Beach Erosion

Gravel Sill Effect on Final Profiles



2 lines for SBB and BGS at time = 120 min for SWL 1

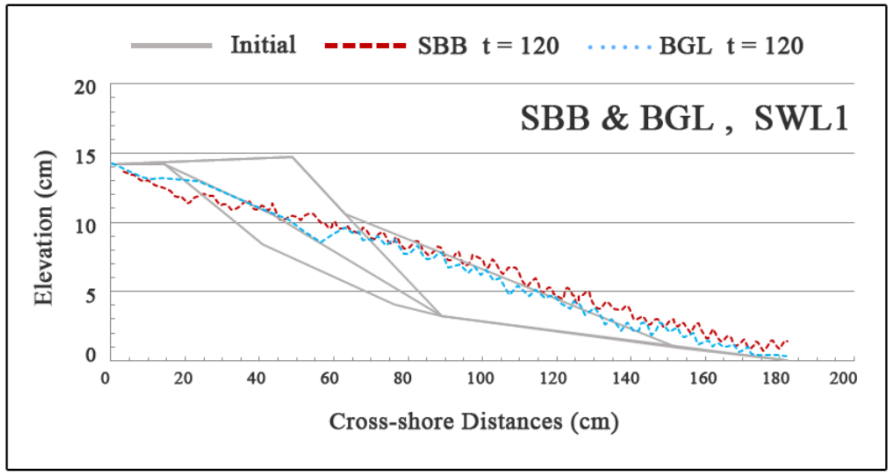


2 lines for SBB and BGS at time = 120 min for SWL 2

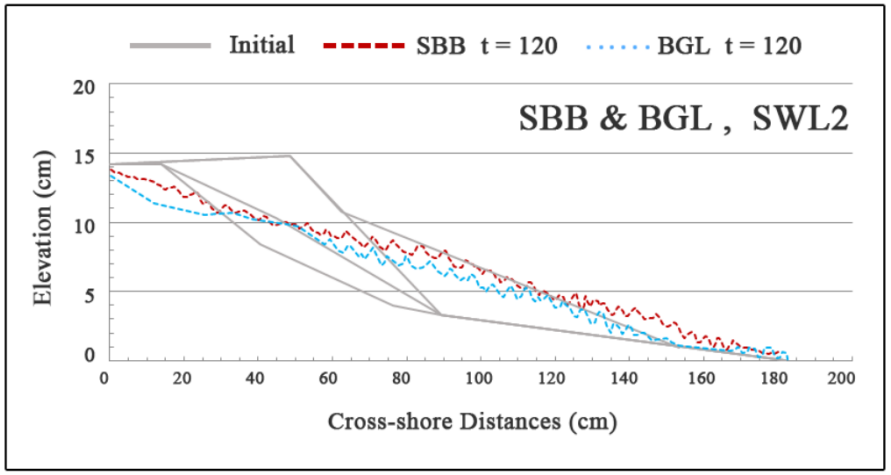
Buried gravel sill did not reduce sand berm erosion and increased sand beach erosion because of less sand supply from the gravel sill filled with wet sand

Gravel Effects on Berm and Beach Erosion

Gravel Layer Effect on Final Profiles



2 lines for SBB and BGL at time = 120 min for SWL 1



2 lines for SBB and BGL at time = 120 min for SWL 2

Buried gravel layer had little effect on the berm and beach erosion because the thin layer was damaged easily by wave action

6. Conclusions

- Use of gravel was investigated experimentally to reinforce nourished sand beaches for low wave energy shores with limited sediment availability
- Buried gravel sill and layer were not effective in reducing the berm erosion
- Porous gravel berm interacted with wave action in the swash zone and reduced wave overtopping and berm erosion
- Need to measure wave overtopping and overwash of sand and gravel over the landward wall.
- Large-scale experiment will be necessary to quantify the scale effects on sand and gravel transport
- A numerical model needs to be developed for practical design under various local conditions