Comparison of Sill and Revetment in Reducing Shore Erosion and Wave Overtopping

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CONTENTS

1. INTRODUCTION

Sills (low-crested rubble mounds) have been constructed to protect planted marshes in living shoreline projects. No method exists to design the sill geometry and its distance from an eroding shore.

Revetments have been used to protect eroding shores and reduce wave overtopping and damage to backshore areas. Revetment construction may result in loss of buffering wetlands.

Experiment is conducted to clarify the similarity and difference of a sill and a revetment consisting of the same stones.

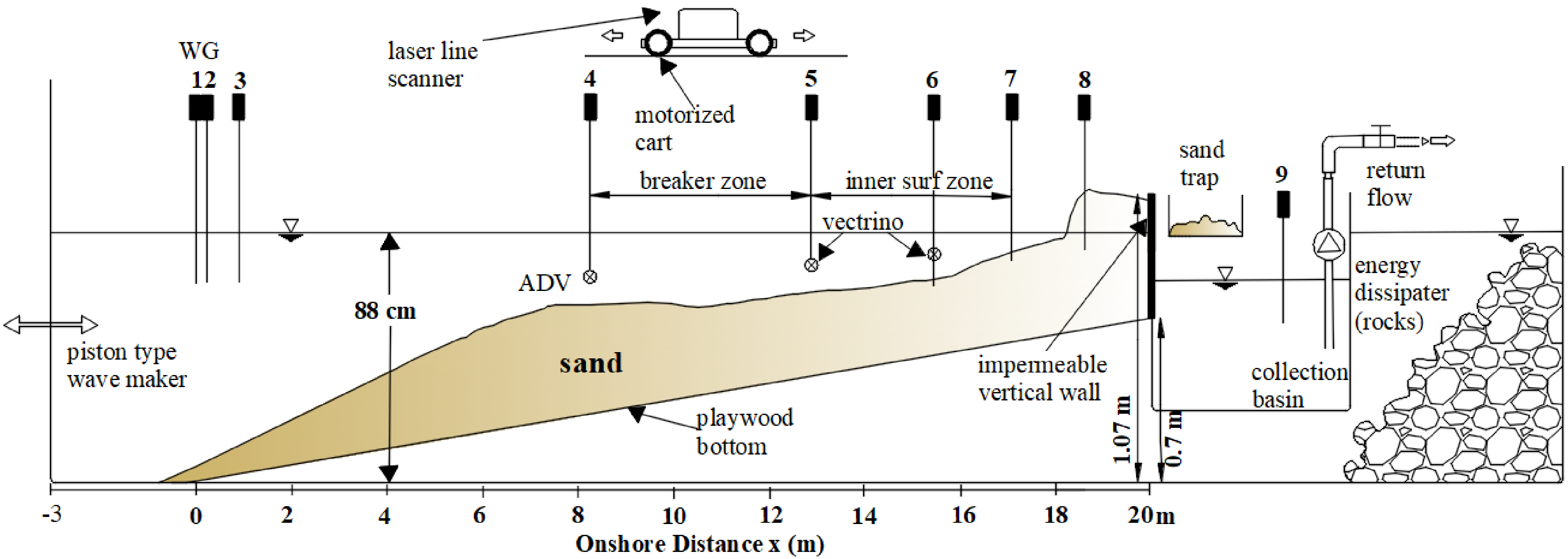
Typical Sill
Living shoreline engineering guidelines New Jersey Department of Environmental Protection, 2016

Revetment
Ventura rock revetment,
Ventura river ecosystem, 2017

2. EXPERIMENT

2.1 Wave flume setup

Experimental setup at start of test N with no structure

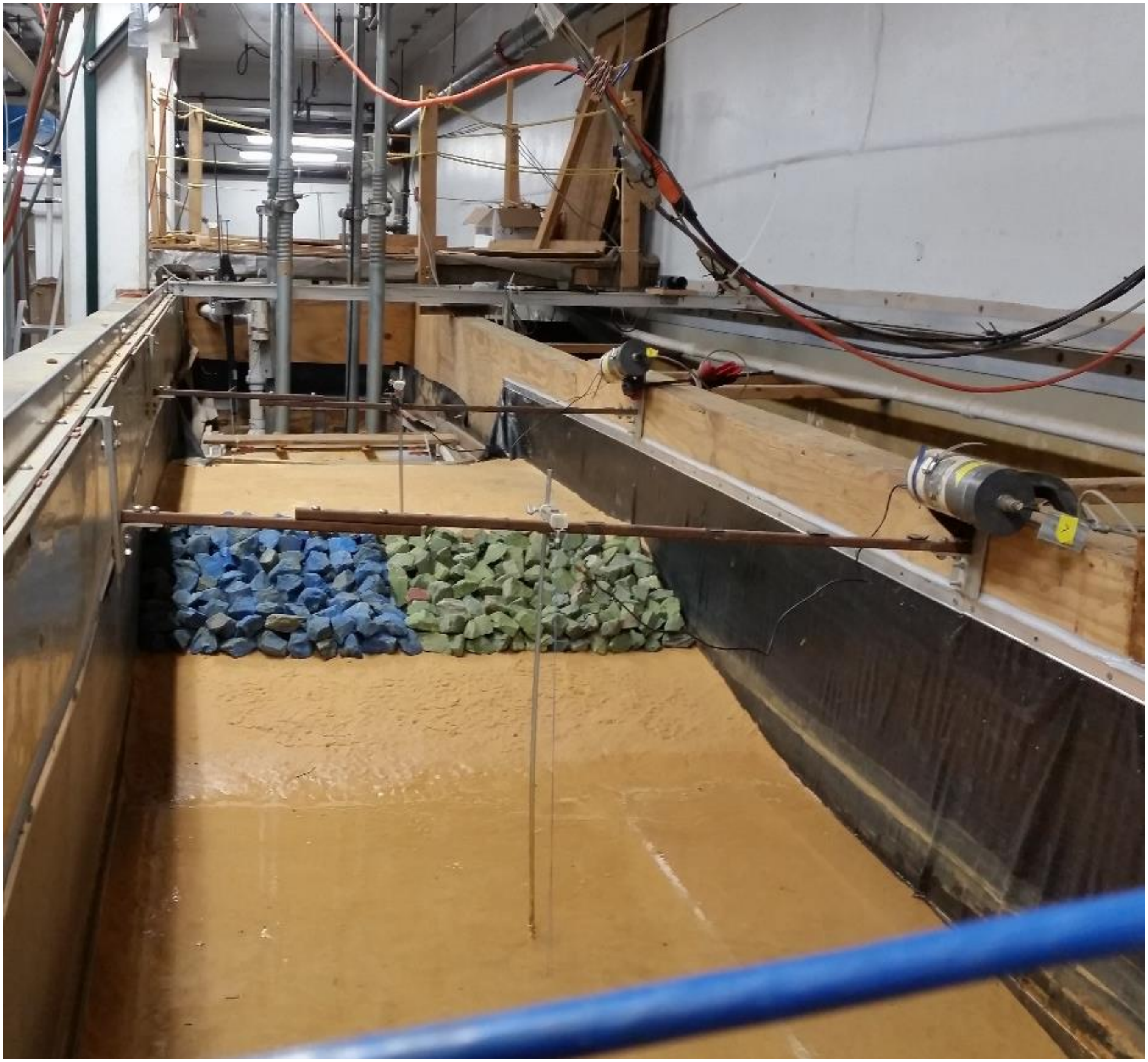


Incident waves at WG 1:

- Significant wave height, H_{mo} = 19 cm
- Peak period, T_p = 2.6 s
- Wave reflection coefficient less than 0.2

2.2 Three tests with the same initial sand profile

Berm in no protection test N

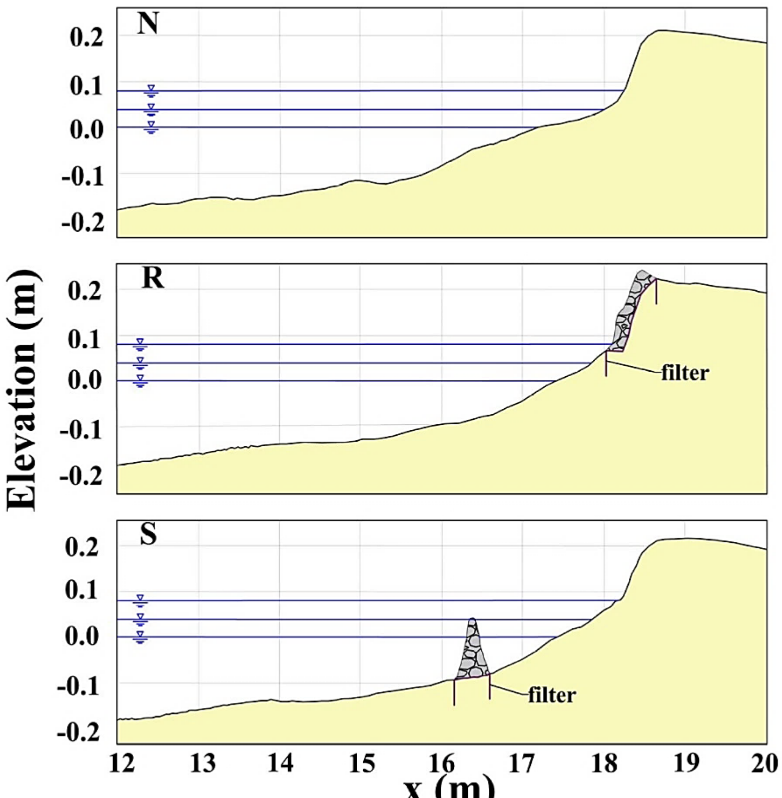


Berm protected by revetment in test R

Berm protected by sill in test S

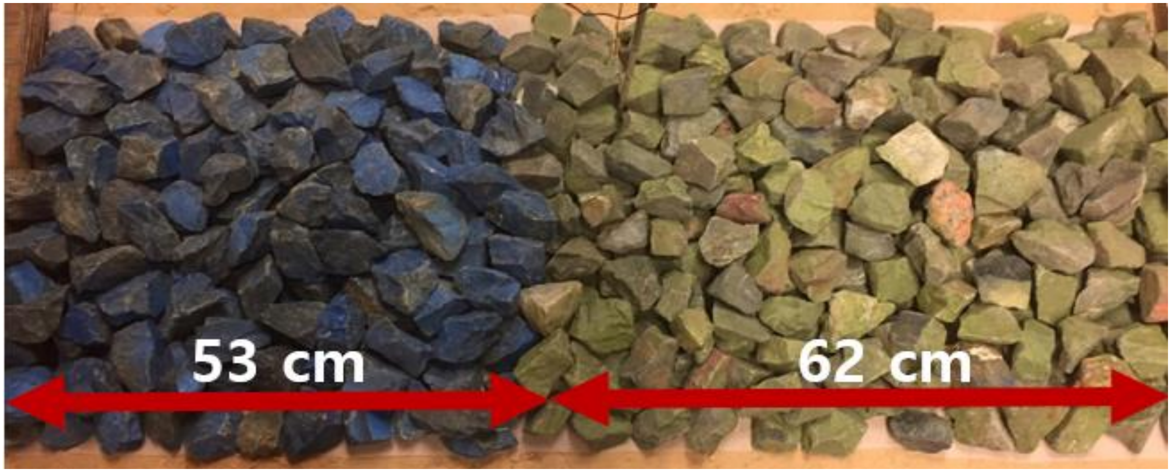
Series	Description	SWL (cm)	Duration (s)
N	No protection	0	0 – 4,000
		4	4,000 – 8,000
		8	8,000 – 12,000
R	Revetment	0	0 – 4,000
		4	4,000 – 8,000
		8	8,000 – 12,000
S	Sill	0	0 – 4,000
		4	4,000 – 8,000
		8	8,000 – 12,000
Later: t_0=0, t_1=4,000 s, t_2=8,000 s, t_3=12,0000 s			

Sequence of 3 tests with still water level increase of 4 cm after 10 runs (400-s duration for each run)



2.3 Sand and stone characteristics

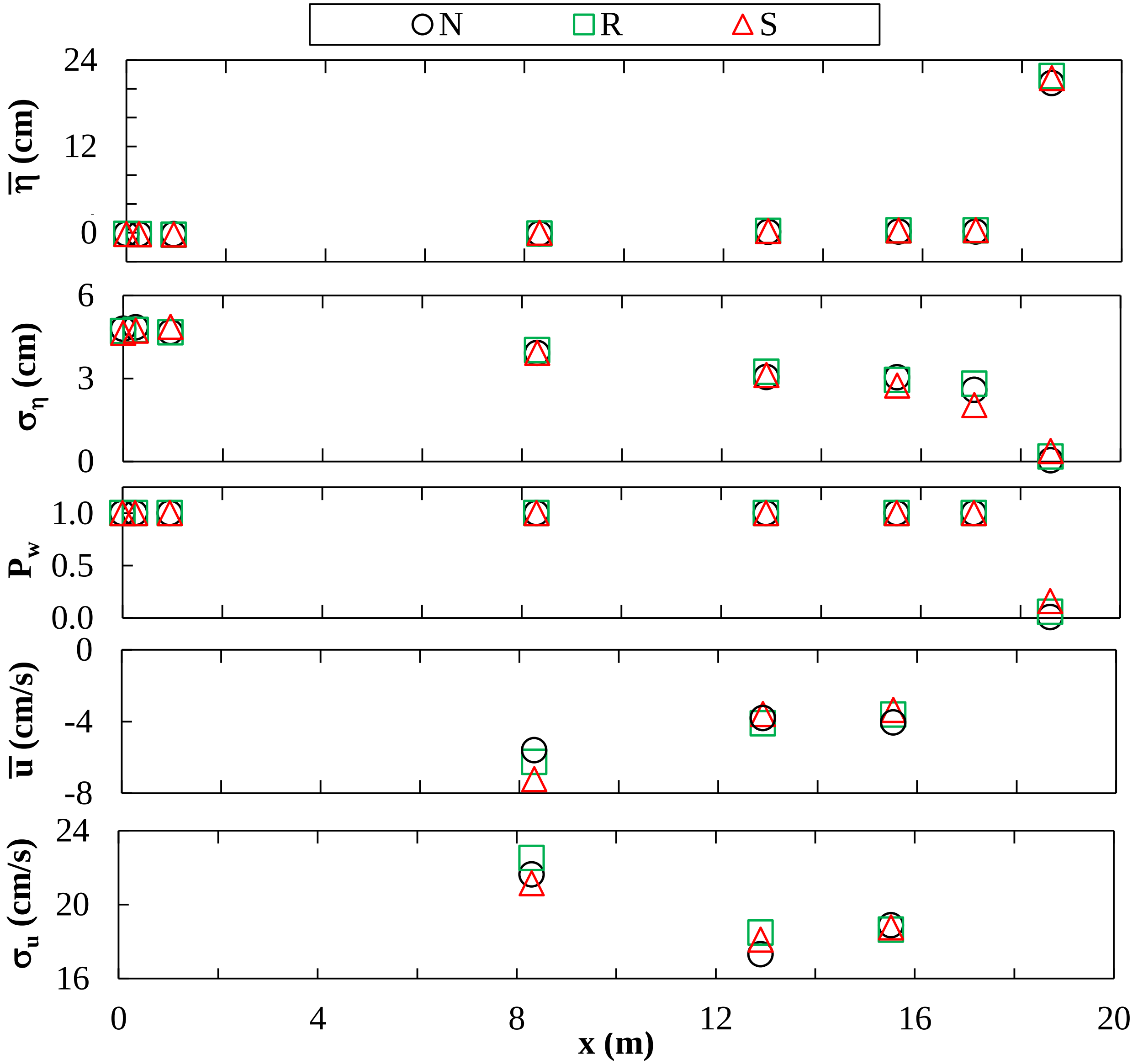
Parameter	Sand	Blue Stone	Green Stone
Diameter (cm)	0.018	3.81	3.52
Density (g/cm^3)	2.60	3.06	2.94
Porosity	0.40	0.44	0.44
Width (cm)	115	53	62



Stones used in tests R and S

3. Measured Hydrodynamics

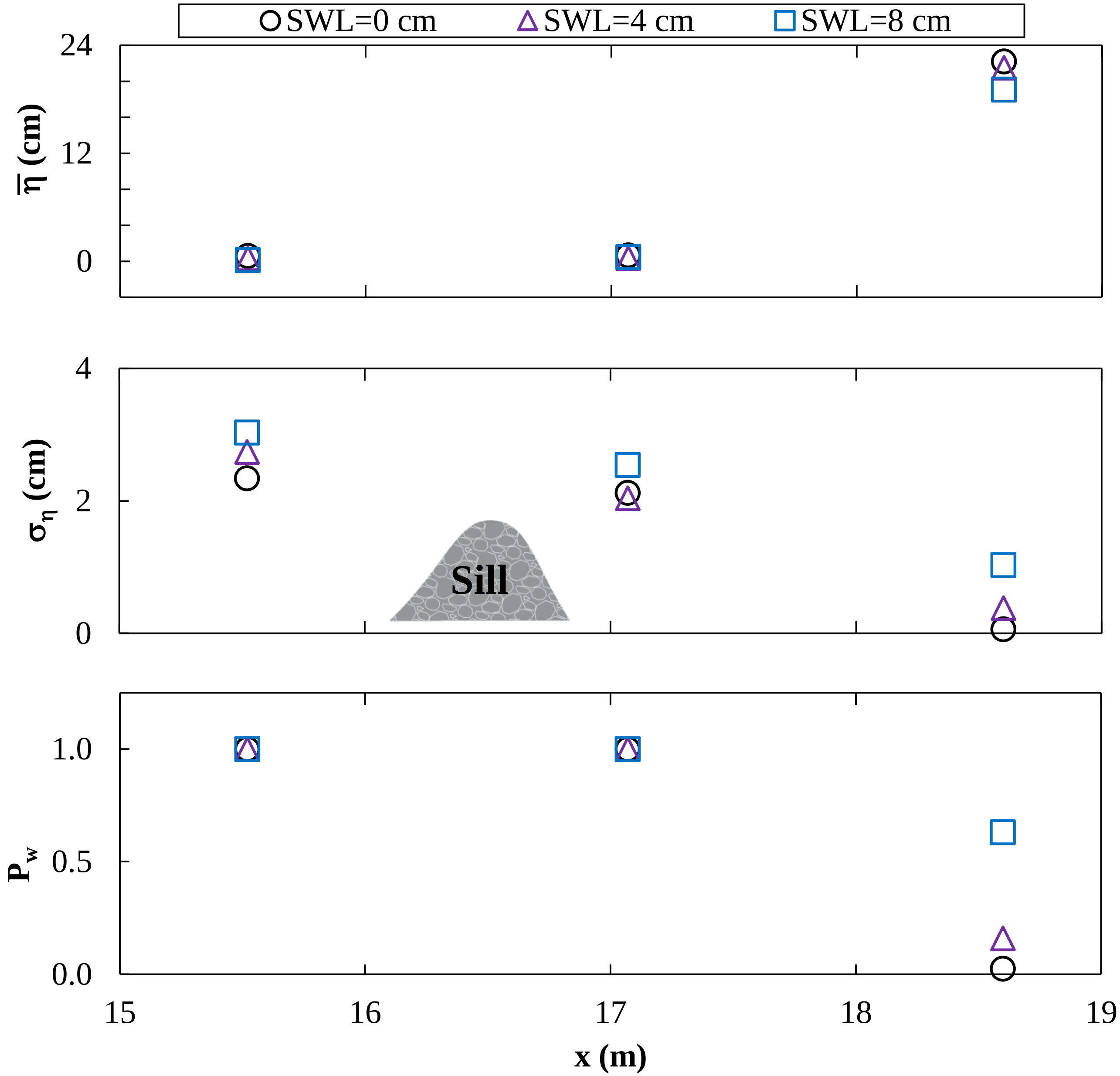
3.1 Cross-shore wave transformation



Average values of mean and standard deviation of free surface elevation η and horizontal velocity u together with wet probability P_w for 10 runs during time t =4,000 – 8,000 s for tests **N**, **R** and **S**.

Significant wave height $H_{mo}=4\sigma_\eta$

3.2 Sill effect on breaking wave height reduction

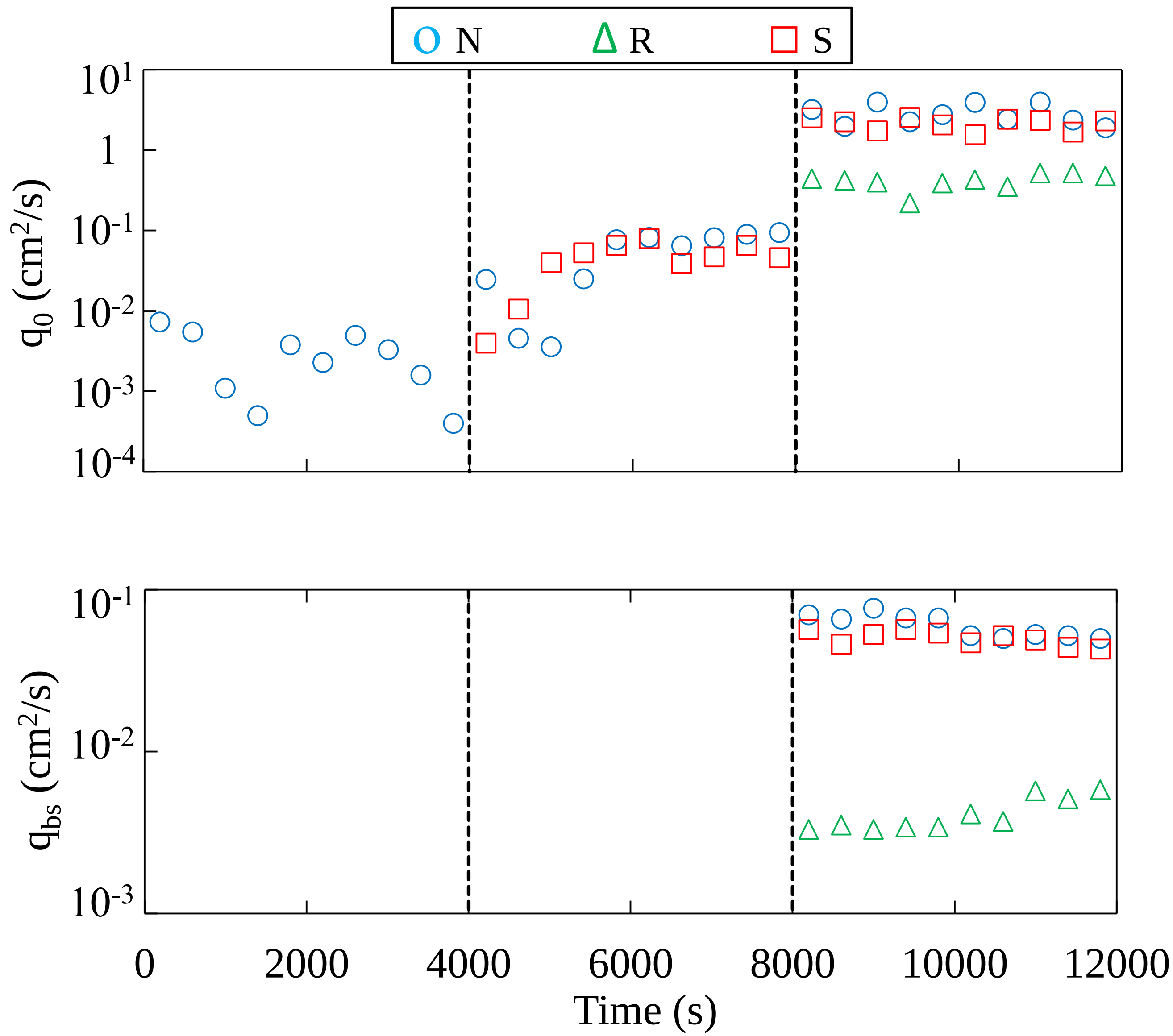


Average values of mean and standard deviation of free surface elevation η and wet probability P_w for 10 runs with SWL=0, 4 and 8 cm in test **S**.

Increase of SWL increases wave height at sill located inside surf zone.

Wave gauge 8 at x=18.6 m on berm crest became wetter as SWL increased and foreshore was eroded.

3.3 Wave overtopping and overwash rates



No wave overtopping for

t = 0 -8,000 s in test **R** and

t = 0 – 4,000 s in test **S**.

Overwashed sand was

deposited on 1.5 m wide

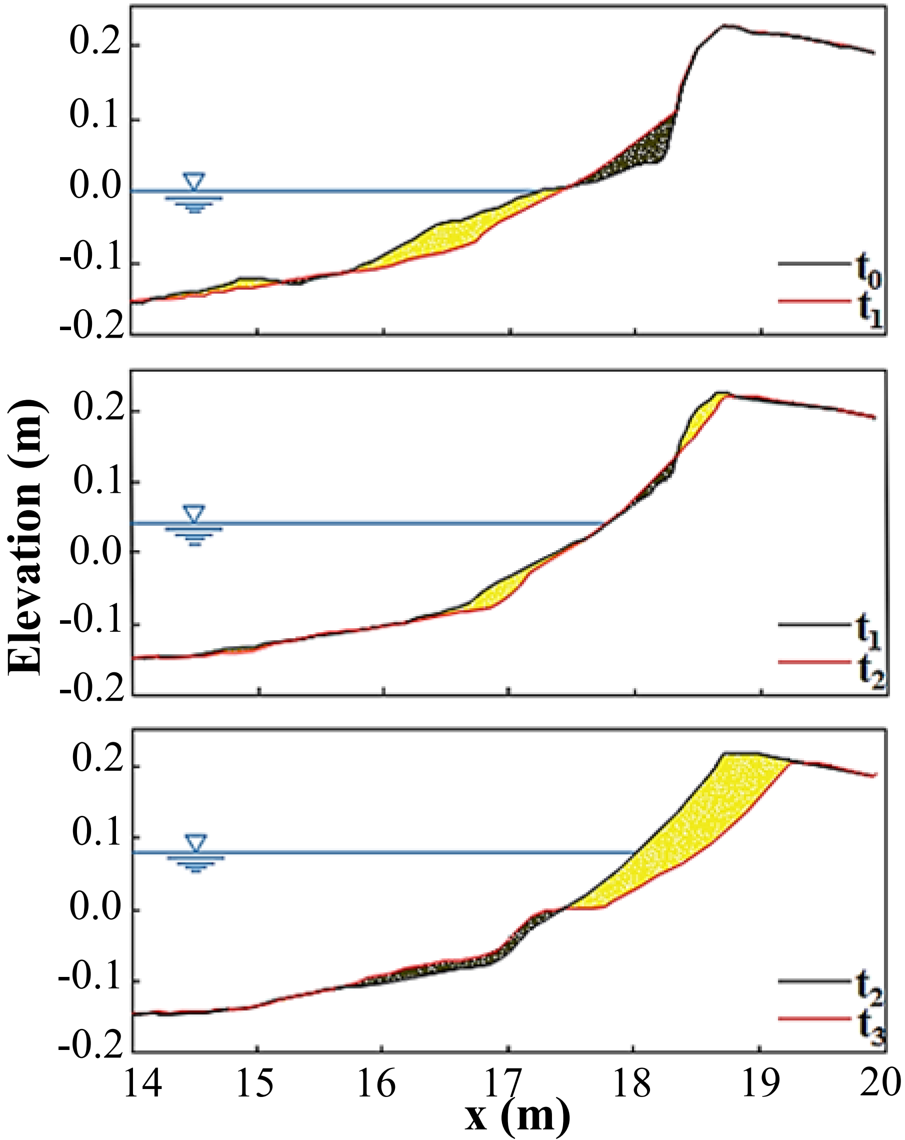
berm crest during

t = 0 -8,000 s in test **N** and

t = 4,000 – 8,000 s in test **S**.

4. Measured Beach Profiles

4.1 Profile changes for test **N** with 4 cm SWL increase at $t=t_1$ and t_2



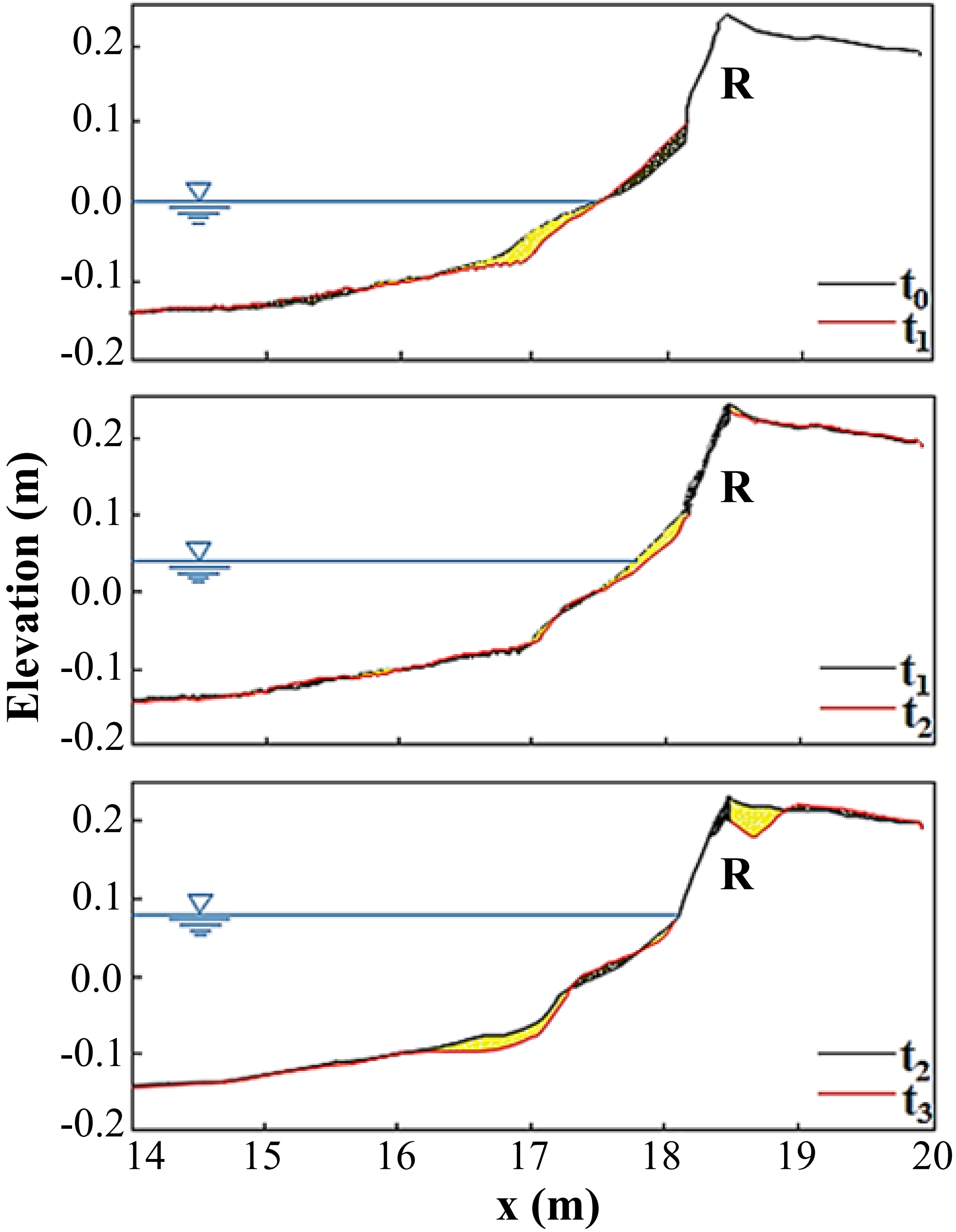
Onshore sand transport and foreshore accretion.

Erosion on upper foreshore.

Accretion on lower foreshore.

Severe foreshore erosion due to wave overtopping.

4.1 Profile changes for test **R** with 4 cm SWL increase at $t=t_1$ and t_2



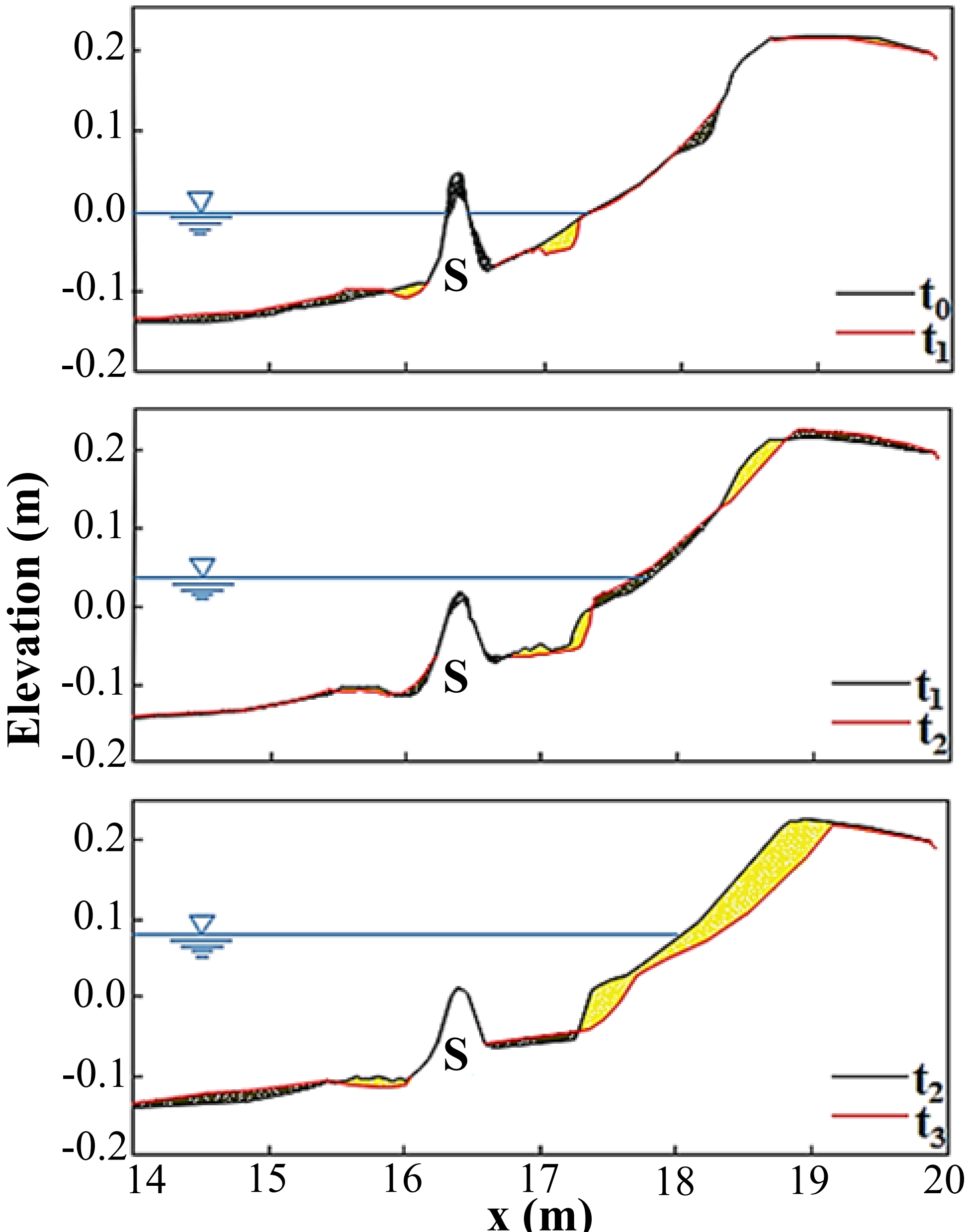
Reduced onshore sand transport relative to test N and toe accretion.

Stone surface settlement.

Minor erosion at toe and crest of revetment.

Revetment crest damage and landward erosion due to wave overtopping.

4.1 Profile changes for test **S** with 4 cm SWL increase at $t=t_1$ and t_2



Reduced onshore sand transport in comparison to test N.

Displacement of loosely piled stones on sill crest.

Reduced onshore sand transport and sand accretion on berm crest.

Stabilized sill crest.

Foreshore erosion due to wave overtopping less than test N .

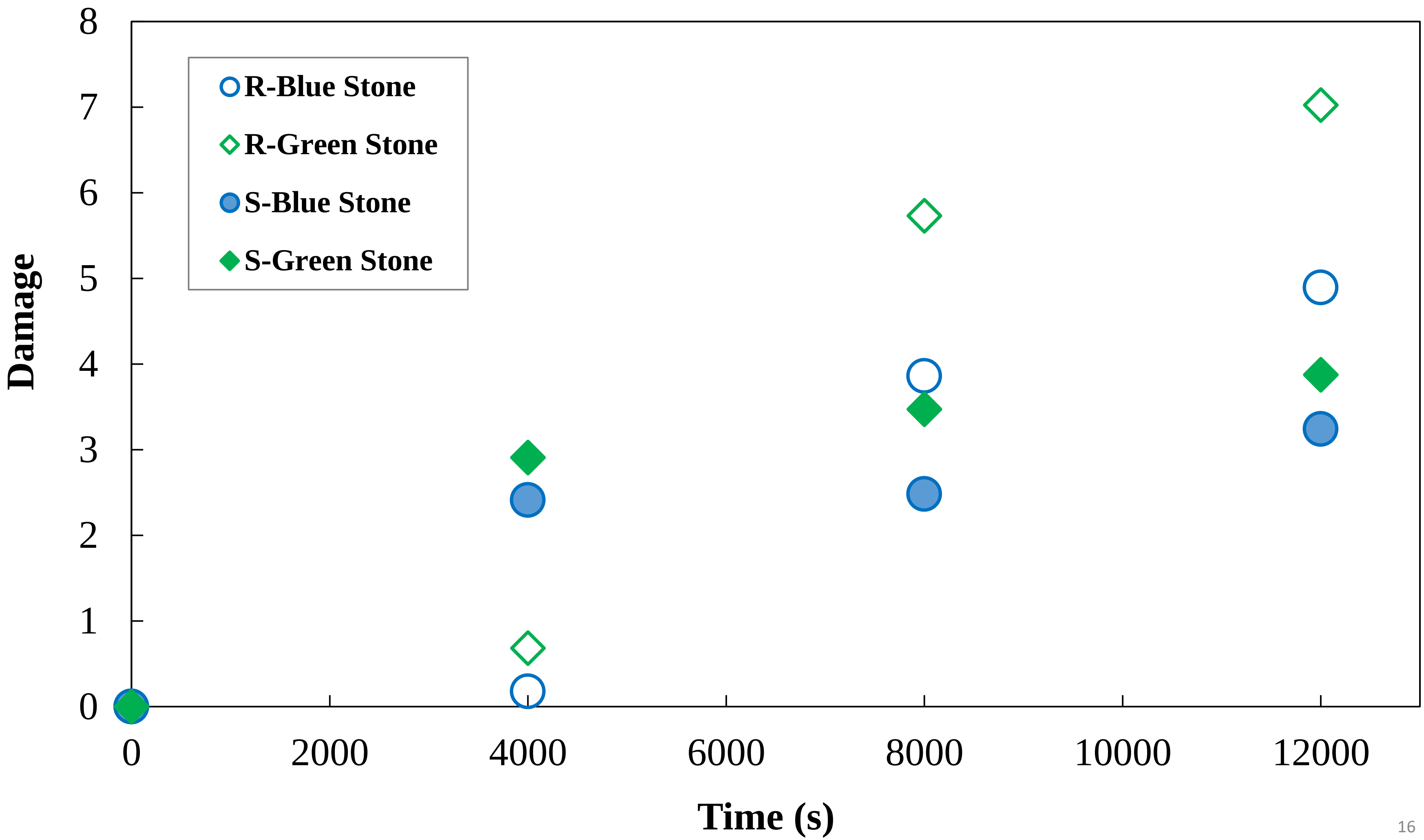
Minor erosion at toe of submerged sill.

4.2 Stone damage and settlement

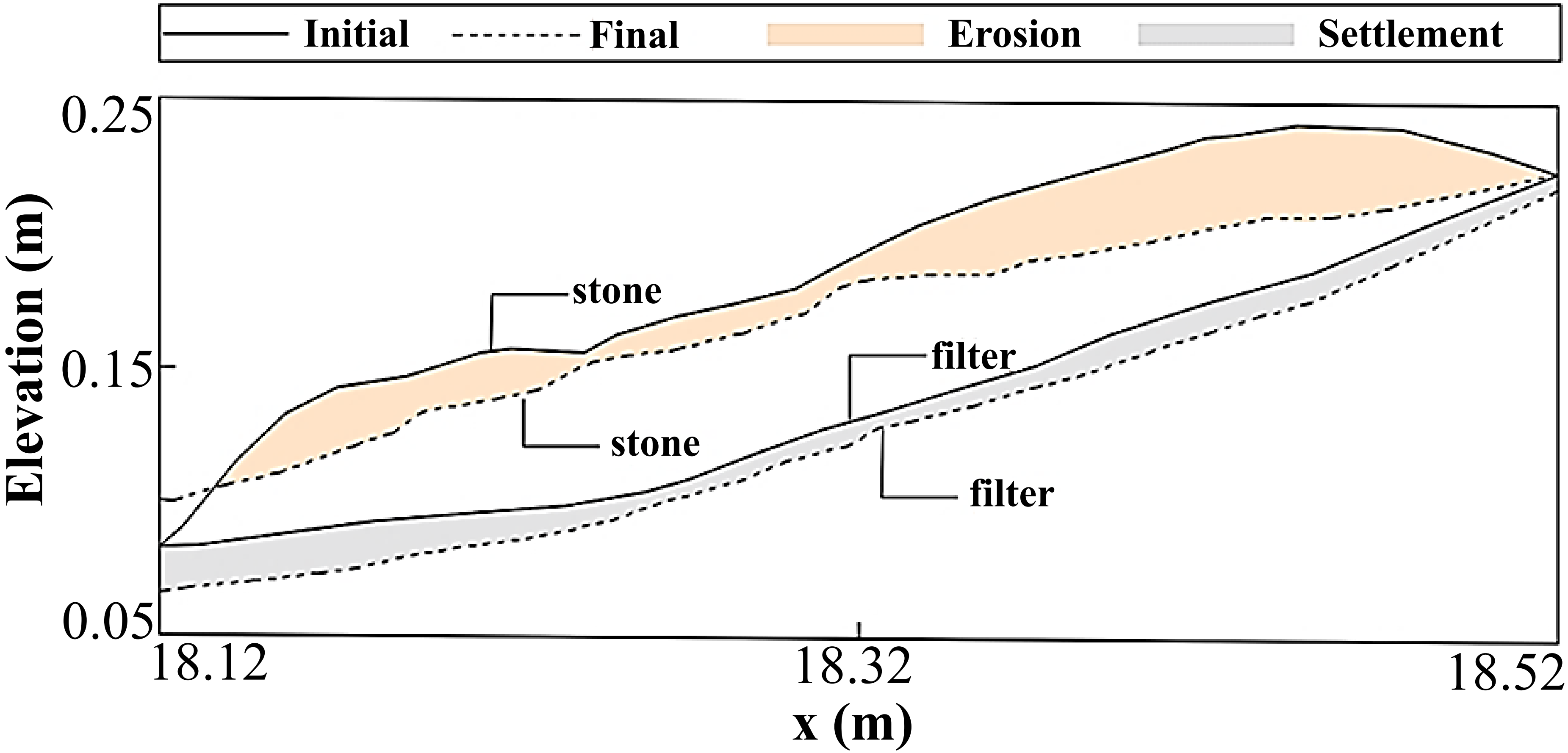
Damage = (eroded area in stone zone) / (nominal diameter)^2

Damage progression of blue and green stones in tests **R** and **S**.

More damage for slightly smaller **green** stones.

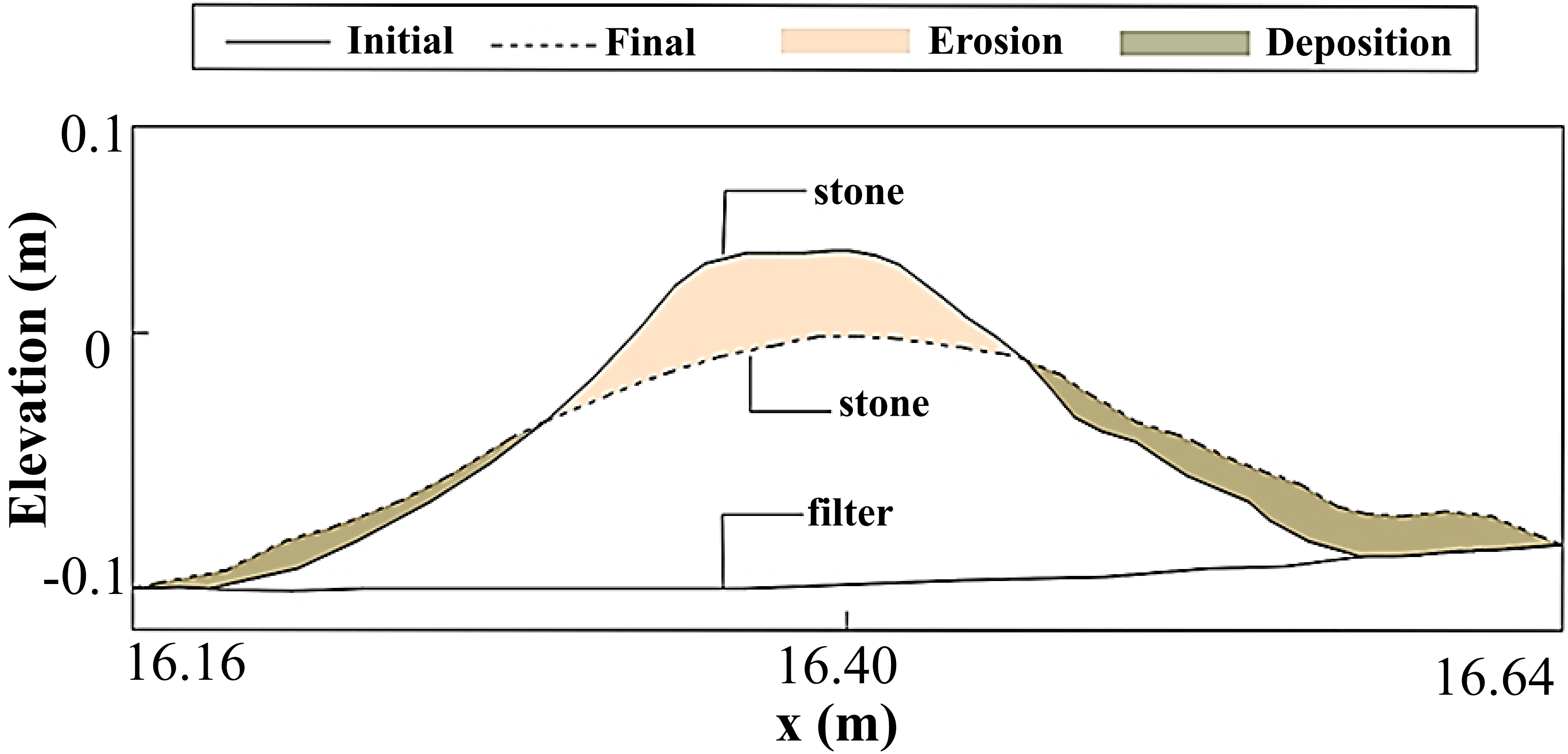


Measured stone surface and filter elevations before and after test R



Revetment damage was caused by filter settlement and onshore stone displacement on its crest due to wave overtopping.

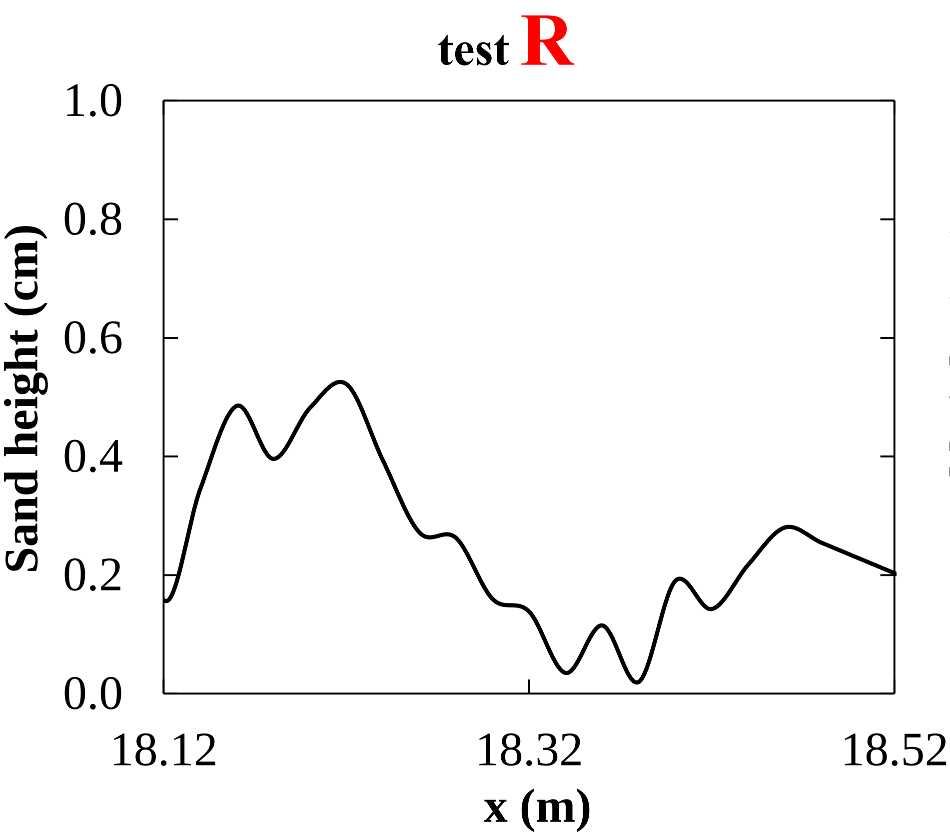
Measured stone surface and filter elevations before and after test **S**

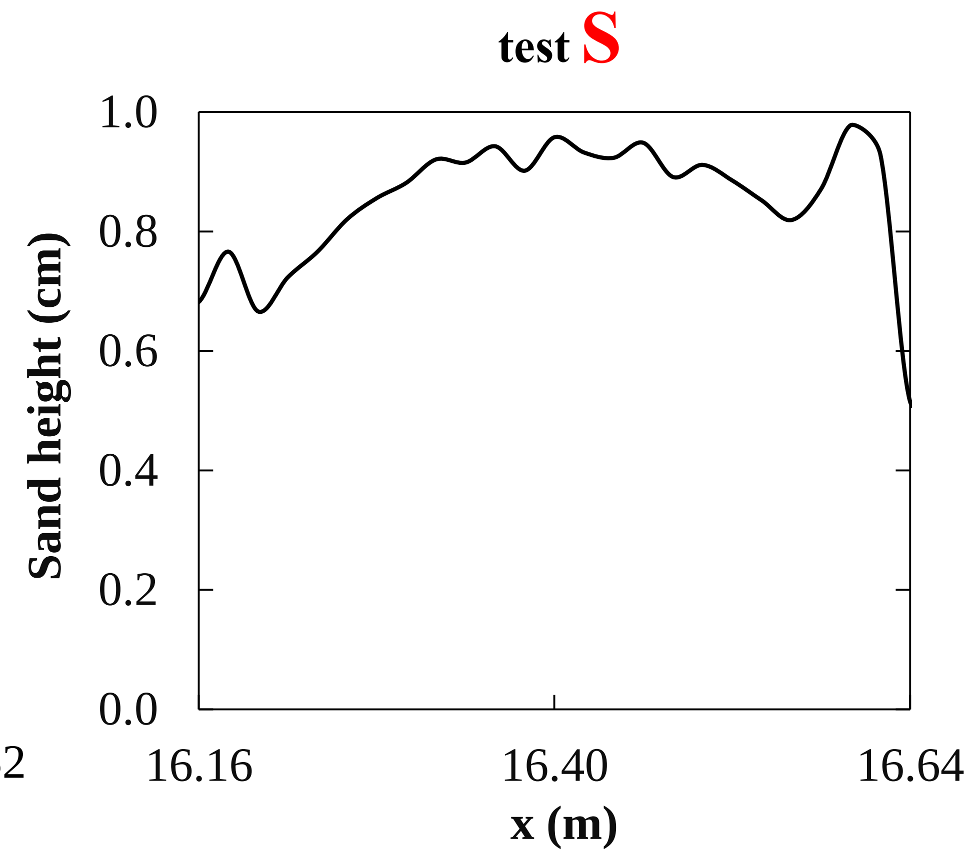


Sill damage was caused by landward and seaward displacement of piled stones on its crest.

4.3 Sand deposition in porous structures

Deposited height of sand with porosity of 0.4 in stone zone .





More deposition near revetment toe on foreshore slope of 0.4 (vertical/horizontal).

More uniform and larger deposition inside sill in surf zone.

5. Conclusions

- **R**evetment was effective in protecting foreshore sand slope of 0.4 and eliminating wave overtopping.
- **R**evetment crest was damaged when wave overtopping rate became about 0.4 cm^2/s (0.04 liter/s/m).
- **S**ill reduced foreshore erosion and accretion in comparison to foreshore with no sill, but large foreshore erosion occurred when sill crest was sufficiently submerged.
- Piled stones on sill crest were displaced, but the lowered and wider crest became stable.
- Additional tests are required to develop a design method for various conditions.