Flume experiments on high-water channel erosion and revetment failure during flood

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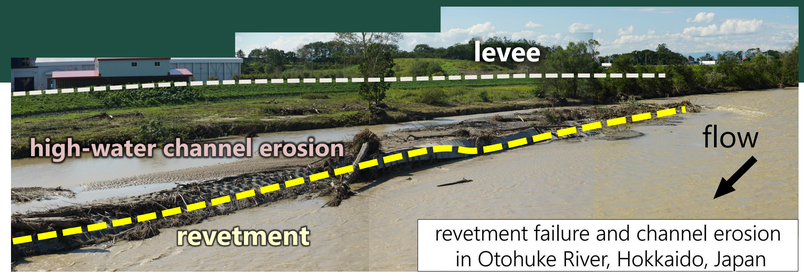


revetment failure and channel erosion in Otohuke River, Hokkaido, Japan

BACKGROUND

To protect banks and levees from river flow's lateral erosion, a revetment is installed on levee and bank slope, especially at an outer bend of a meandering channel.

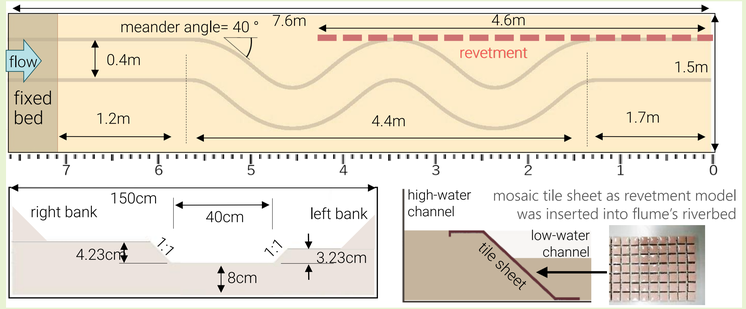
In a flood event of eastern Hokkaido in August 2016, one of noticing points was that many of revetment failures were with **high-water channel erosion behind revetments** and without damages to revetment's foundation, as in Otohuke River, eastern Hokkaido.

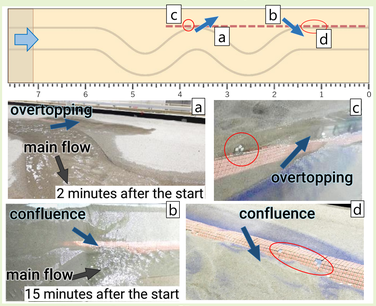
PURPOSE

As there are various factors in revetment failures, a detailed explanation about revetment failures remains unclear. In this study we focused on high-water channel erosion behind a revetment during flood. By means of flume experiments and a numerical simulation, we investigate the mechanism of the high-water channel erosion behind revetments.

FLUME EXPERIMENTS

First, to replicate the erosion and revetment failure, we conducted a flume experiment which had a meandering channel with a revetment model. The flume experiment showed characteristic high-water channel erosion along revetment's top.

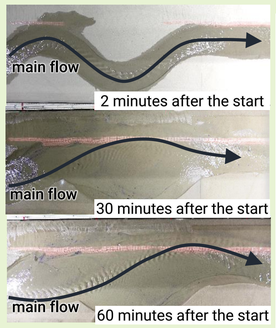




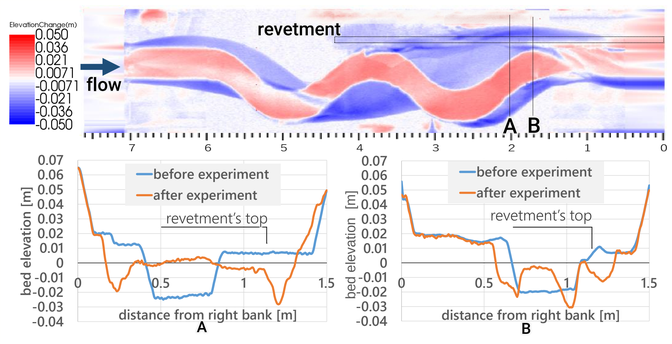
overtopping & confluence over revetment

a : overtopping happened at left outer bend of meandering.
b : the flow joined at downstream area
c, d : some tiles of revetment model came off

conditions
bed slope: 1/120, bed material: silica sand (d=0.765mm), discharge: 0.005m³/s,
sediment supply: 2.5*10⁻⁶m³/s, experimental period: 73 minutes

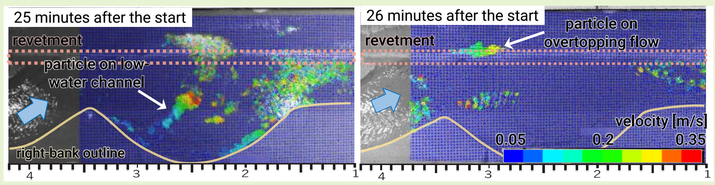


channel transformation
the meandering channel gradually migrated downstream and meandering angle decreased.



bed elevation change
A: deepest scoring point
B: confluence point

- there was a remarkable erosion along back of revetment around 2m from downstream end
- the erosion on high-water channel was 40mm at most, almost same depth as low-water channel



flow velocity measurement by Particle Image Velocimetry
we used this measured velocity data to check its reproducibility

CONCLUSION

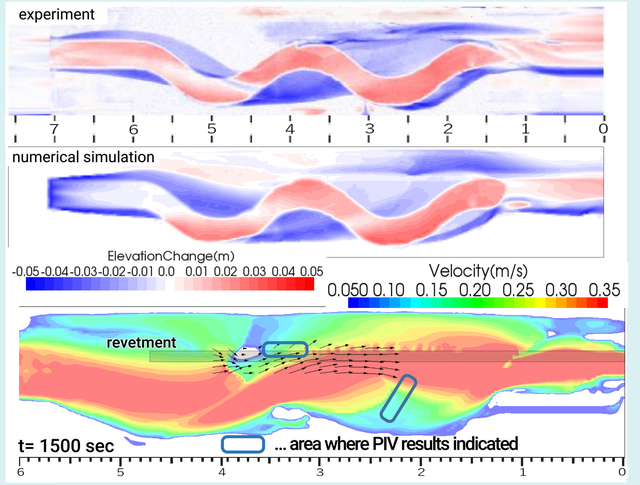
- Overtopping, confluence across revetment and large erosion that would cause revetment failure were observed in the flume experiment.
- From the result of numerical simulation, it was found that in a meandering channel there is a tendency of fluctuation of bedload and local bedload imbalance on high-water channel.
- This tendency would lead to high-water channel erosion along revetment as observed in Otohuke River.

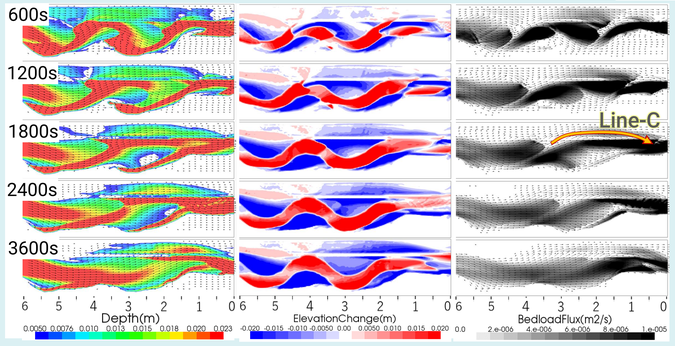
NUMERICAL SIMULATION

Next, we conducted reproduction computation by iRIC-Software's Nays2DH and checked its reproducibility with experiment's data; bed elevation change and flow velocity. From the computation, we investigated factors in high-water channel erosion.

computational conditions
model: Nays2DH (model for unsteady horizontal 2D-flow, sediment transport and bedform changes)
cell size: 15mm × 12.5mm
Manning's roughness: 0.022 for riverbed
0.014 for revetment
other conditions were same as in the experiment
revetment model in this computation
cells for revetment in the flume were regarded as fixed bed

checking reproducibility
Comparing elevation change and velocity distribution in computation with experiment's result, they had enough consistency to examine details of high-water channel erosion.

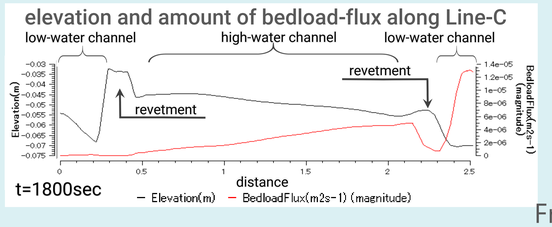




investigating high-water channel erosion

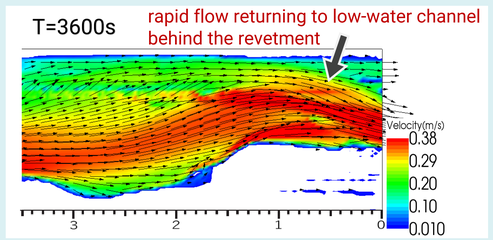
- process of the erosion development

t=600~1200sec: Overtopping flow spread on high-water channel and local scouring happened
t=1800~2400sec: The scouring propagated toward upstream
t=3600sec: By the meandering channel's migration, main flow concentrated into the scouring area, resulting in a large erosion along revetment's back



As shown in a graph, bedload flux increased toward downstream and this condition had continued until the computation ended.

➢ We considered that this tendency was a factor of large-scale high-water channel erosion



From flow velocity distribution in left figure, on high-water channel,

- the overtopping's velocity was relatively low, though the large-scale erosion was developing there
- the maximum velocity was observed where flow returned to low-water channel behind the revetment

➢ This would cause the revetment failure as in the photo of Otohuke River above.