GLOBAL SOLUTIONS IN ENGINEERING

How to Analyze More Thoroughly the Results Generated from the Wave Propagation Models Near Marine Infrastructures


Alain Drouin, Eng. M.Sc., PWGSC

2014-01-29
Presentation Outline

• Context
• Case study for evaluating bank erosion potential
• Surveys
• Numerical models
  • Wave generation
  • Wave propagation
• Notions on the solution-space domain
• Results
• Conclusions
Context

- Marine infrastructures are costly to build or rehabilitate
- Steps required to obtain the final design
  - Input data
  - Stress analyses for design
  - Numerical and physical modeling
  - Design & sizing of the infrastructure
- Impact of the Infrastructure on the surroundings
  - Computational power now allows for more detailed analyses
  - Tools required to summarize and synthesize the results
  - Case study for bank erosion potential in a cove
Case Study - 1

Transport Canada’s Maritime Infrastructure to Rehabilitate

- Problematics
  - Initial conditions following construction
  - Current conditions
  - Future conditions
    - Impact of the infrastructure on the wave pattern inside the cove
    - Impact on the bank erosion conditions in the cove
- Innovative approach to meet this demand
Case Study - II

Transport Canada

Fisheries and Oceans Canada
Issue: Bank Erosion
Impacts of the Rehabilitation Work?

Elevation = +3.9 m CD
Elevation = +5.3 m CD
Required Data

- Bathymetry
  - Canadian Hydrographic Service (CHS)
  - Recent multibeam surveys (PWGSC)
- Embankment profiles in 2013 (PWGSC)
- Water levels (Fisheries & Oceans Canada)
- Waves and currents (Fisheries & Oceans Canada)
  - Wave measurements scarce in Eastern Canada
    - Mont-Louis buoy 30 km north of the site
  - Wave generation models used:
    - MSC50, Aquawave
- Required verifications and validations
Bathymetry – Surveys
Survey Areas
Area for the SWAN Model
Offshore → Near Shore – "Phase Averaged"

Deep Water

Intermediate Water Depth
SWAN Generated Results
Proximal Area

Wave propagation near marine infrastructures

Public Works and Government Services Canada

WSP

03-Aug-2013 09:00:00
CGWAVE Model (Phase Resolved)
Discretization of the Domain, Mesh
Area for the CGWAVE model
Bathymetric representation within model
Scenarios Considered

13 scenarios analyzed

Mooring dolphin and sheet pile cells razed
Elev. = -4.00 m CD

Elev. = +4.50 m CD
Elev. = +7.90 m CD
Elev. = +6.00 m CD

Elev. = +8.00 m CD

Wave propagation near marine infrastructures

2014-01-29
Water Level
Recreation of the Tidal signal at the Site
Wave Climates
Measured Waves, MSC50, AquaWave, 1997

Wave propagation near marine infrastructures
Data Analysis – Measured vs Generated Measured Waves, MSC50, Aquawave, 2007

Wave height (m)

Wave propagation near marine infrastructures 2014-01-29
Wave stress on bank
Minimum & Maximum Erosion Resistance

Parameters:
- Wave height at breaking
- Water depth at breaking
- Water level, elevation of bank toe

Wave propagation near marine infrastructures
Shore Erosion Potential
Discretization of the Shore
Concept of solution-space
2 D solution-space - Basic example

Solution Space
8 and 12 cases
Concept of Solution Space
4-D Space domain

Solution Space 186 cases

Water Level (3)
Direction (9)
Period (6, 8, 10 s)
Wave Height

Wave propagation near marine infrastructures
Simulation Results
Wave Amplitude

Wave propagation near marine infrastructures 2014-01-29
Simulation Results
Phase (Direction of the Wave Trains)
Result from Another Simulation
Amplitude, Other Simulation
Projection onto Bank Profiles
186 Simulations x 60 Profiles
Creating a Time Series for a Profile with Hourly Time Steps

Wave conditions:

<table>
<thead>
<tr>
<th>Niveau</th>
<th>Azimuth</th>
<th>To</th>
<th>Ho</th>
<th>Kr</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.42</td>
<td>360</td>
<td>6</td>
<td>2</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Lower | Upper
---|---
2.42 | 3.42
337.5 | 360
6 | 8
Ho | variable variable

Water level

<table>
<thead>
<tr>
<th>Kr Value</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Interpolation weight</th>
</tr>
</thead>
</table>

Wave propagation near marine infrastructures

2014-01-29
Summary of Results – I
Number of Hours the Bank Was Under Wave Attack

Number of Hours Where Waves Reached an Elevation Exceeding the Bank Toe for the 1991-2012 Period, Excluding Winter Months

Profile ID N°(N°x 30 - 30 to get chaining from East wharf)

Scenario 1: Conditions Initiales.
Scenario 6: Modifications au scénario 3. Remblai de consolidation à 45 degrés.
Scenario 7: Modifications au scénario 3. Remblai de consolidation à 90 degrés.
Scenario 8: Modifications au scénario 6. Remblai de consolidation à 45 degrés.
Scenario 9: Modifications aux scénarios 4 et 5. Longueur de 360 m et mursoir.

Elevation of bank toe

Wave propagation near marine infrastructures
Summary of Results – II
Cumulative Energy Reaching the Bank

Cumulative Energy Reaching an Elevation Exceeding the Bank Toe for the 1991-2012 Period, Excluding Winter Months

Profile ID N°

- Scenario 1
- Scenario 6
- Scenario 7
- Scenario 8
- Scenario 9

Elevation of bank toe
Summary of the Results – III
Energy of the Top Third Energetic Events (Hourly Values)

Cumulative Energy for the Top Third Energetic Events Reaching an Elevation Exceeding the Bank Toe for the 1991-2012 Period, Excluding Winter Months

Profile ID N°

Energy (kWh)

Elevation CD (m)

Scenario 1: Conditions initiales
Scenario 6: Modifications au scenario 3. Pente de consolidation à 45 degrés.
Scenario 7: Modifications au scenario 3. Pente de consolidation à 90 degrés.
Scenario 8: Modifications au scenario 6. Pente de consolidation à 45 degrés.
Scenario 9: Modifications aux scenarios 4 et 5. Longueur de 500 m et masse armée.

Elevation of bank toe

Wave propagation near marine infrastructures

2014-01-29
CONCLUSION - 1

• Rehabilitation or construction project
  • Importance of involving all stakeholders
    – Interaction with client throughout the project
    – Population
  • Interest for the project
    – Presenting the results using simple figures to facilitate communication, understanding and validation.
→ Solution space concept helps reach this goal
  • Shows that everything was done to identify any potential impacts
  • Produces results on an hourly basis at specific locations within the domain
  • Produces summaries of results that facilitate the comparison of scenarios
  • Enables the shore stress analysis
  • Can allow for wave agitation analyses inside harbours
  • Results of the most recent, sophisticated models are used to create these solutions spaces
CONCLUSION - III

- Requires the development of sophisticated, but accessible post-treatment modules.
- Applies to other modules if their output data format is known
- Requires quality data as input
  - Importance of on-site measurements
  - Help validate the model-generated results
- Emphasize taking measurements to validate results or improve the models used for simulations
Acknowledgements

- Transport Canada
  - Provided financing to perform surveys
  - Provided financing to perform the study

- Public Works and Government Services Canada
  - Provided study supervision
  - Involvement at the scientific level
Questions?

Thank you for your attention!