Breakwater Gap Wave Diffraction

CEE 514: Coastal Engineering
By Nick Dosch
Motivation
Motivation

- Harbors protect boats from waves
  - Need gaps
  - Waves enter gaps

- How can wave size be minimized inside harbor while still having gaps in breakwater
Wave train hits barrier

Lateral transfer of wave energy

Wave continues on lee of barrier
• Wave height in shadow region compared to incident wave height
  • $H_d$ is diffracted height
  • $H_i$ is incident height
• $K_d$ is the Refraction coefficient $K_d = \frac{H_d}{H_i}$
Test Objectives

- Compare Refraction Patterns
  - Breakwater Thickness
  - Gap Width
- Determine Resulting Coefficient of Refraction ($K_d$)
Testing Facilities
Materials

- Styrofoam?
- Wood?
- Structural Foam
Structural Foam
Installation
Breakwater Thickness Test

- Three Breakwaters, 1-3 inches thick
- Increasing increments of 1 inch
- Gap width constant
Breakwater Thickness Test

- Study Diffraction Patterns on lee side
- Determine wavelength (L) on lee side
- Determine $K_d$
Width Increase – Width Test

- Thickness remains constant (3 in)
- Increase gap thickness from 3.5 in to 5 in

4 Total Tests
Dimensions

\[ \theta \approx 90 \]
1 Inch Thickness

Average $L \approx 1.75$ inches
Close up View of 2in
3 Inch Thickness

Average \( L \approx 0.75 \) inches
• Thickness remains constant (3 in)

• Increase gap thickness from 3.5 in to 5 in
Width Test

5 in
Average $L \approx 2.0$ inches
Results
# Diffraction Coefficient Table

<table>
<thead>
<tr>
<th>β (Degrees)</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>105</th>
<th>120</th>
<th>135</th>
<th>150</th>
<th>165</th>
<th>180</th>
</tr>
</thead>
<tbody>
<tr>
<td>r/L</td>
<td>0.5</td>
<td>0.31</td>
<td>0.31</td>
<td>0.33</td>
<td>0.36</td>
<td>0.41</td>
<td>0.49</td>
<td>0.59</td>
<td>0.71</td>
<td>0.85</td>
<td>0.96</td>
<td>1.03</td>
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<td></td>
<td>1</td>
<td>0.22</td>
<td>0.23</td>
<td>0.24</td>
<td>0.28</td>
<td>0.33</td>
<td>0.42</td>
<td>0.56</td>
<td>0.75</td>
<td>0.96</td>
<td>1.07</td>
<td>1.05</td>
<td>0.99</td>
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<td></td>
<td>2</td>
<td>0.16</td>
<td>0.16</td>
<td>0.18</td>
<td>0.2</td>
<td>0.26</td>
<td>0.35</td>
<td>0.54</td>
<td>0.69</td>
<td>1.08</td>
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<tr>
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Add individual $K_d$ Values together to determine appropriate gap coefficient

$\beta_1 = 45^\circ$  \hspace{1cm}  $\beta_2 = 160^\circ$

$r_1 = 2.28 \text{ in}$  \hspace{1cm}  $r_2 = 5.85 \text{ in}$

$L$ is known from experiments

$\theta = 90^\circ$
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<tr>
<td>β (Degrees)</td>
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<td>1.01</td>
<td>1</td>
</tr>
</tbody>
</table>
# Results

## Thickness Test Series

<table>
<thead>
<tr>
<th>Test</th>
<th>Test 1 (1 inch thickness)</th>
<th>Test 2 (2 inch Thickness)</th>
<th>Test 3 (3 inch Thickness)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β = 20°</td>
<td>β = 160°</td>
<td>β = 20°</td>
</tr>
<tr>
<td>r (in)</td>
<td>2.28</td>
<td>5.85</td>
<td>2.82</td>
</tr>
<tr>
<td>L (in)</td>
<td>1.75</td>
<td>1.75</td>
<td>1.0</td>
</tr>
<tr>
<td>r/L</td>
<td>1.6</td>
<td>3.3</td>
<td>2.85</td>
</tr>
<tr>
<td>Kd</td>
<td>0.24</td>
<td>0.99</td>
<td>0.18</td>
</tr>
<tr>
<td>Total Kd</td>
<td><strong>1.23</strong></td>
<td><strong>1.17</strong></td>
<td></td>
</tr>
</tbody>
</table>

## Width Test Series

<table>
<thead>
<tr>
<th>Test</th>
<th>Test 3 (3.5 inch Gap)</th>
<th>Test 4 (5 inch gap)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β = 20°</td>
<td>β = 160°</td>
</tr>
<tr>
<td>r</td>
<td>2.82</td>
<td>5.85</td>
</tr>
<tr>
<td>L</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>r/L</td>
<td>3.75</td>
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<tr>
<td>Kd</td>
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</tr>
<tr>
<td>Total Kd</td>
<td><strong>1.14</strong></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- Thicker Barrier leads to lower $K_d$
- Smaller Gap Size minimizes refracted wave height
Conclusions

• Sources of error
  • Not an infinite barrier
  • Incident waves idealized as linear
  • Wave reflection
  • Basin Size

• Need Additional Testing to verify results
References
