Revetment Design

Revetments are structures designed to prevent erosion.

Step 1: Determine what type of structure is best suited for the site and the goal of the structure (i.e. erosion control, access, etc).

Today’s example is a revetment structure using armor stone.

Step 2: Calculate the weight and size of the armor stone units (rock) needed to resist the uplift forces of the waves.

How: Coastal Engineers use Hudson’s Equation to calculate the median weight of a rock needed to resist a given wave height.

Why: Hudson’s Equation is used to design sloped rock revetments and breakwaters.

Step 3: Additional Considerations:

- How does required stone size change with the specific gravity of material and material type?
- Why is concrete rubble not effective?
- What other factors should be considered that aren’t included in the equation including 1.) armor stone cracking, 2.) severe weather events, 3.) poor construction?
- What should be the factor of safety?
Hudson’s Equation

\[ W_{50} = \frac{\gamma_r H^3}{K_D (S_r - 1)^3 \cot \theta} \]

Where:

- \( W_{50} \) is the 50th percentile (median) weight of the stone (lbs)
- \( \gamma_r \) is the unit mass of the stone (lb/ft\(^3\)); limestone typically is 160-165 lb/ft\(^3\)
- \( H \) is the design wave height (ft) at the toe of the structure
- \( S_r = \frac{\gamma_r}{\gamma_w} \); (\( \gamma_w = 62.4 \) lb/ft\(^3\))
- \( K_D \) is the stability coefficient, an empirical value based on physical testing. For randomly placed, angular stone \( K_D = 2.0 \)
- \( \cot \theta \) is the design slope of the revetment. For a 2:1 slope, \( \cot \theta = 2 \)

Hudson’s Equation is “empirical.”

- Empirical means the equation is based on testing in the real world.
- Empirical equations usually have a “K” factor to allow the test data to fit different types of conditions.
- “\( K_D \)” is a constant value based on the type of rock and arrangement in the structure.
Revetment Design

It’s your turn! Calculate the weight of rock needed to resist the uplift forces of waves.

Hudson’s Equation:

\[ W_{50} = \frac{\gamma_r H^3}{K_D (S_r - 1)^3 \cot \theta} \]

We know:
The height of the wave (H): _____ in feet
The slope of the structure (cotangent θ): 1.5 feet per foot (rise over run)
The unit weight of the rock (\( \gamma_r \)): 165 pounds per cubic foot
The unit weight of water (\( \gamma_w \)): 62.4 pounds per cubic foot
Stability Coefficient (K_D): 2 for rough stone on a slope

We calculate: \( (W_{50}) \): the median weight of rock in pounds

<table>
<thead>
<tr>
<th>Wave H (H)</th>
<th>Slope</th>
<th>( W_{50} )</th>
<th>( W_{50} ) Volume</th>
<th>Diameter</th>
<th>Comparable to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Feet/Foot</td>
<td>Pounds</td>
<td>Tons</td>
<td>Feet(^3)</td>
<td>Feet</td>
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<tr>
<td>1</td>
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<td>0.01</td>
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<td>3.17</td>
<td>38.39</td>
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</tbody>
</table>

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