17 Wave Breaking

The process of wave breaking can be thought of as the release of energy, derived from the wind, along the narrow coastal zone. It leads to geomorphic work done by wind, really, which is translated through medium of water. Wave breaking is responsible for the processes which control beach morphology: (1) nearshore current generation, and (2) sediment transport. This topic is covered in the Davidson-Arnott textbook in Sec. 5.4, pp. 92-102.

17.1 Condition for Wave Breaking

As waves shoal into shallow water, the wave height $H$ increases and the wave length $L$ decreases, dramatically increasing the steepness $H/L$. This cannot continue indefinitely – something has to give.

Common misconception: "breaking is a result of waves dragging on the bottom, then tripping forward due to friction" - not true.

In reality, friction plays a very small role in the dissipation of wave energy. Computer simulations that completely neglect friction still produce breaking waves.

* A wave breaks when it becomes overly steep, because the velocity of water particles in the wave crest exceeds the velocity of the wave form itself.
17.2 Breaker Types

The three (or four) main breaker types are:

1. Spilling Breakers – display a cascading face of bubbles and foam after peaking and initiating the breaking process.

2. Plunging Breakers – abrupt pattern of peaking to a vertical face, overcurling, and plunging downward and forward to unload energy in a very concentrated portion of beach

3. Surging Breakers – during the peaking process, the base of the wave destabilizes and surges forward, causing the wave top to implode/collapse

4. Collapsing Breakers – not often witnessed and difficult to identify, this wave breaking type is thought to be intermediate between Plunging and Surging.

17.3 Iribarren Number / Surf Similarity Parameter

In reality, breaker types transition from one to the next through a continuum, but in general the type of breaking style correlates well with the ratio of beach slope to wave steepness. This concept was explored by Battjes (1974), and in so doing, he introduced deep-water and shallow-water forms of the Iribarren Number ($\xi_\infty$ and $\xi_b$, respectively), which has/have since been referred to as the Surf Similarity Parameter

$$\xi_\infty = \frac{S}{(H_\infty/L_\infty)^{1/2}} \quad (1)$$

$$\xi_b = \frac{S}{(H_b/L_\infty)^{1/2}} \quad (2)$$

**Spilling** breakers tend to occur on gently sloped beaches with waves of high steepness ($\xi_\infty < 0.5, \xi_b < 0.4$)

**Plunging** breakers tend to occur on intermediate beaches with waves of intermediate steepness ($0.5 < \xi_\infty < 3.3, 0.4 < \xi_b < 2.0$)
**Surging/Collapsing** breakers tend to occur on high gradient beaches with waves of low steepness ($3.3 < \xi_\infty$, $2.0 < \xi_b$)

### 17.4 Breaker Height Relationship

It is convenient to identify a critical condition at which waves break – attempts at this have resulted in the following ratio which relates breaking wave height $H_b$ to the breaking wave depth $h_b$.

$$\gamma_b = \frac{H_b}{h_b}$$  \hspace{1cm} (3)

Laboratory experiments have revealed that this value is not a constant, but varies considerably with wave steepness, $H_b/gT^2$, and beach slope, $S$. This behavior is illustrated in Komar’s Fig. 6-8. For a given wave steepness, higher beach slopes yield higher $\gamma_b$ values. Logically, this observation has led to an attempt to link $\gamma_b$ to the deep-water Iribarren number

$$\gamma_b = 1.2\xi_\infty^{0.27}$$  \hspace{1cm} (4)

Several breaker height prediction relationships have been generated based on deep-water wave conditions including:

$$\frac{H_b}{H_\infty} = \frac{1}{3.3(H_\infty/L_\infty)^{1/3}}$$  \hspace{1cm} (5)

$$\frac{H_b}{H_\infty} = \frac{0.563}{(H_\infty/L_\infty)^{1/5}}$$ \hspace{1cm} (6)

$$\frac{H_b}{H_\infty} = \frac{0.46}{(H_\infty/L_\infty)^{0.28}}$$ \hspace{1cm} (7)

These various forms of the breaker height prediction relationship are plotted in Komar’s Fig. 6-9.
Rearranging Eqn. 6, derived by Komar and Gaughan (1972), we can obtain a relationship for breaking wave height as a function of deep-water height and period

\[ H_b = 0.39g^{1/5}(TH_\infty^2)^{2/5} \]  

This relationship is plotted and compared to 3 data sets in Komar’s Fig. 6-10. The data span 3 orders of magnitude of breaker heights and are remarkably well-behaved.

17.5 Plunge Distance

As shown in Komar’s Fig. 6-11, the ratio of plunge distance to breaking wave height tends to decrease with increasing beach slope.

References
