Experiment 5: "Wave shoaling and breaking"

1. Background theory

The wave shoaling coefficient can be estimated by the conservation of energy flux equation. In general, this coefficient increases as the wave propagates in shallow water and the conservation of energy flux equations predicts that it goes to infinite as the water depth *h* approaches to 0. However, in nature this condition does not occur owing to wave breaking. As the water waves propagate on a water depth similar to its wave height, it becomes unstable due to the mismatch of the wave celerity and water particle velocity near the crest. The wave breaking type depends on the beach slope and wave characteristics. For instance, for mild slopes spilling breaking, characterized by a wide surf zone, is more common. On the other hand, plunging breakers often happen when the beach slope is steep and it is characterized by the impinging jet on the wave trough. Collapsing breakers require a very steep beach and consist of narrow or inexistent surf zone (Dean & Dalrymple, 1991).

Beach slope and wave steepness are related through the *surf similarity parameter* (Battjes, 1974) or Iribarren (Iribarren and Nogales, 1949) number given by:

$$\varepsilon_0 = \frac{\tan\beta}{\sqrt{H_0/L_0}} \quad \text{or} \quad \varepsilon_b = \frac{\tan\beta}{\sqrt{H_b/L_0}}$$

where $\tan\beta$ is the beach slope, H is the wave height, and L is the wave length, and subscripts b and 0 denotes breaking or deep-water conditions, respectively. The different breaking types (Figure 1) can be determined by the Iribarren number (Table 1).

Tabla 1. Breaking types according to the *surf similarity parameter* (Battjes, 1974) given by deep water or breaking wave conditions.

Breaking type	ξ_0	ξ_b
Surging or collapsing	$\xi_0 > 3.3$	$\xi_b > 2.0$
Plunging	$0.5 < \xi_0 < 3.3$	$0.4 < \xi_b < 2.0$
Spilling	$\xi_0 < 0.5$	$\xi_b < 0.4$

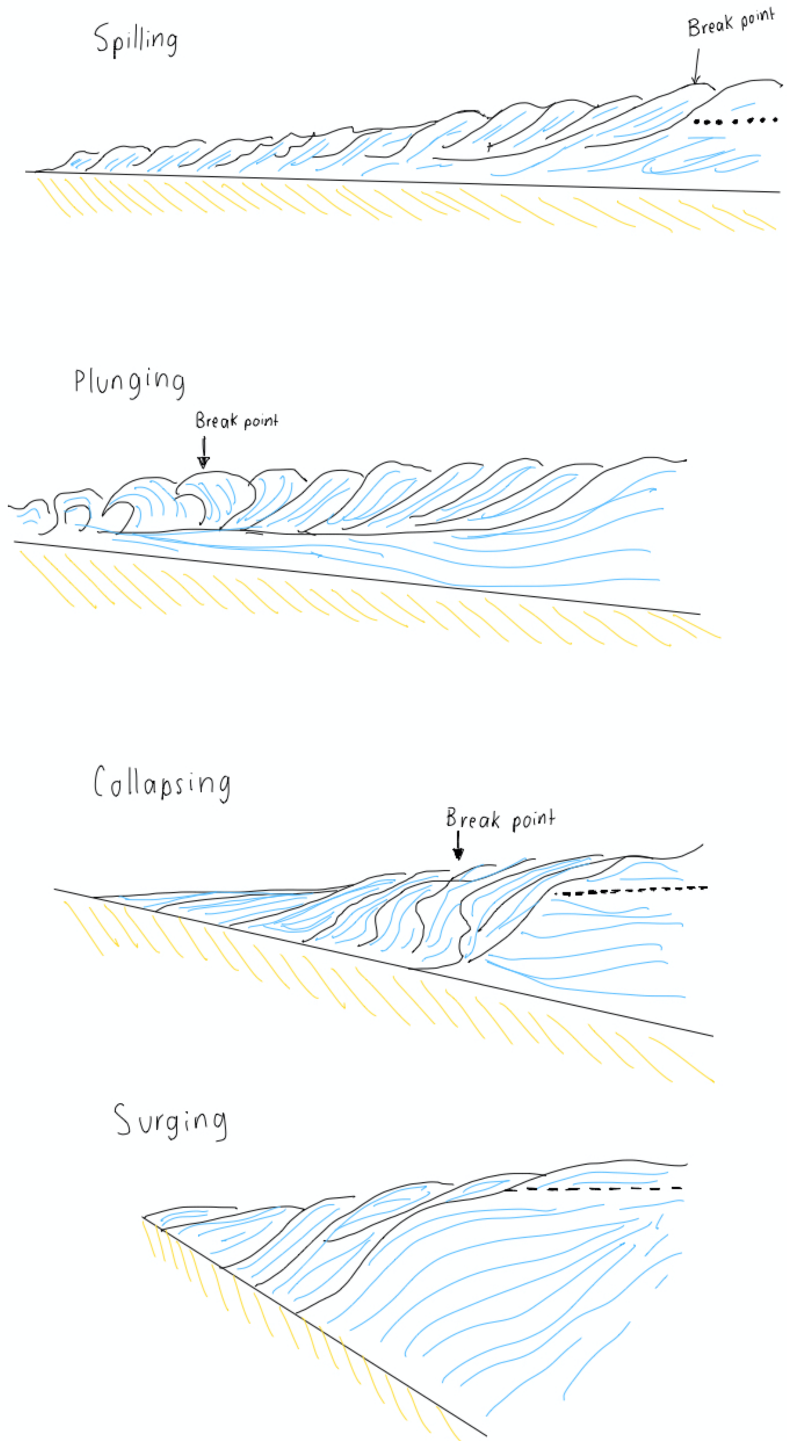

Figure 1. Wave breaking type according to beach slope: *Spilling*, *Plunging*, *Collapsing*, and *Surging*.

Field and laboratory observations show that the breaking wave height is proportional to the local water depth. There are different parametric wave breaking criteria and models reported in the literature (e.g., McCowan,1894; Dally et al., 1993). The simplest model was proposed by McCowan (1894) who determined that waves break when the wave height is a fraction of the water depth,

$$H_b = \kappa h_b$$

where κ = 0.78 for a solitary wave and the subindex *b* denotes breaking values. Therefore, when this criterion is exceeded, wave breaking occurs. Previous laboratory studies employing different beach slopes show a large scatter in the data (see Figure 2), suggesting there is no universal value for κ.

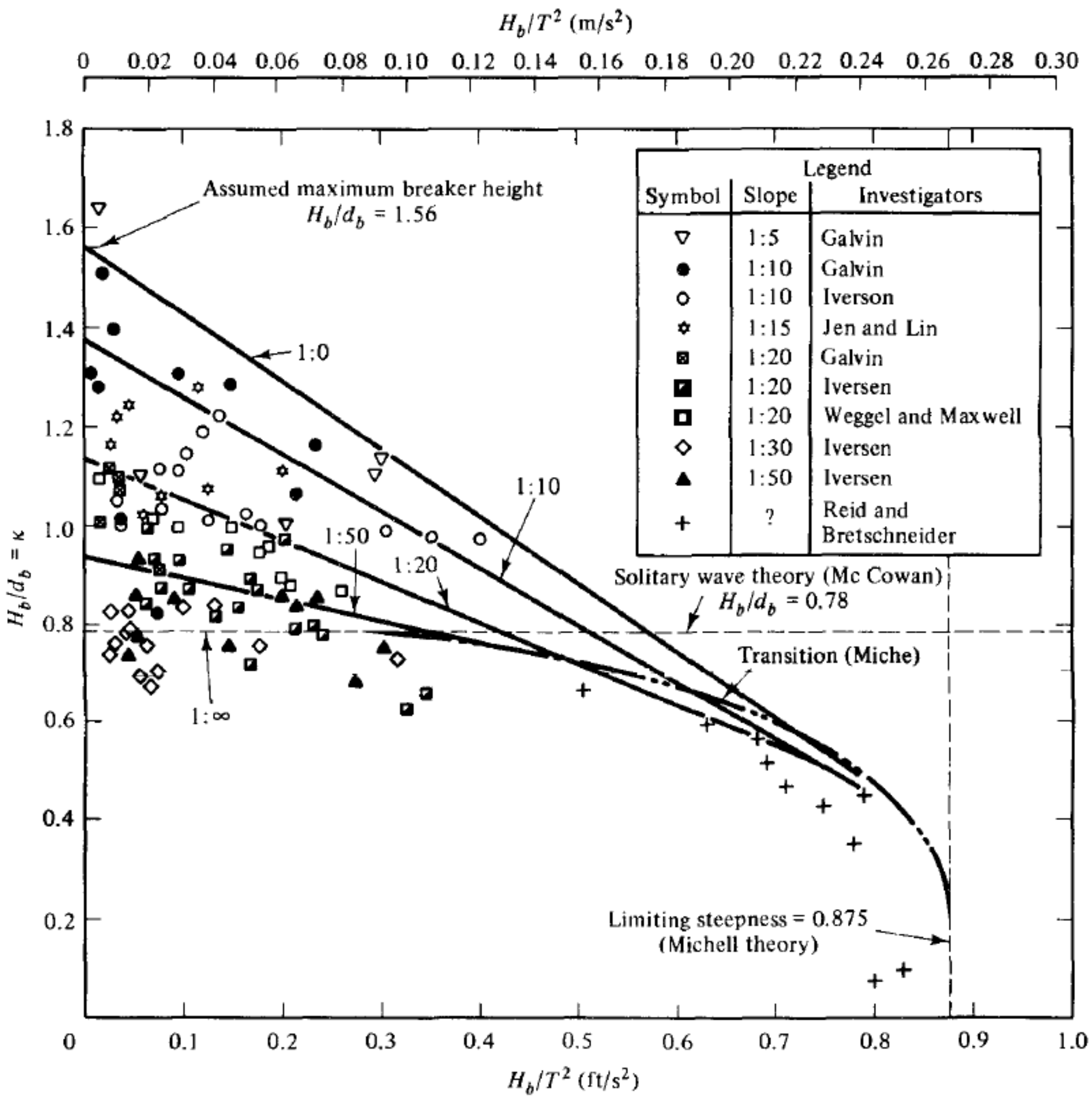

Figure 2. Experimental observations d_b/H_b with respect to H_b/T^2 (Weggel, 1972). Taken from Dean & Dalrymple, 1991.

2. Objective

To investigate progressive wave shoaling and breaking for monochromatic waves and to compare with linear wave theory.

3. Instructions

Employ the virtual wave flume using, three different wave conditions ($T = 2, 4, 6$ s), to:

- o Observe the wave transformation and identify visually the breaking point location for each Test.
- o Deploy wave gauge sensors along the flume with more resolution inside the surf zone to measure free surface elevation time series over 60 s. Export the data for further analysis.
- o Calculate the wave height H from the free-surface elevation time series by means of the zero-down crossing method.
- o Plot h vs H for each test.

4. Assignment

Using the virtual wave flume results identify H_b and h_b and estimate the breaking wave index κ. Compare the virtual wave data results with respect to the value found by McCowan. For each case, estimate the *Surf Similarity Parameter* to classify the breaking wave type and compare with visual observations in the wave flume.

<u>References</u>:

Battjes, J.A., 1974. Surf Similarity, *Proc. 14th Intl. Conf. Coastal Eng.,* ASCE, Copenhagen, 466-480.

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