

# Recycled Glass as Beach Nourishment Material: Grain Characterization

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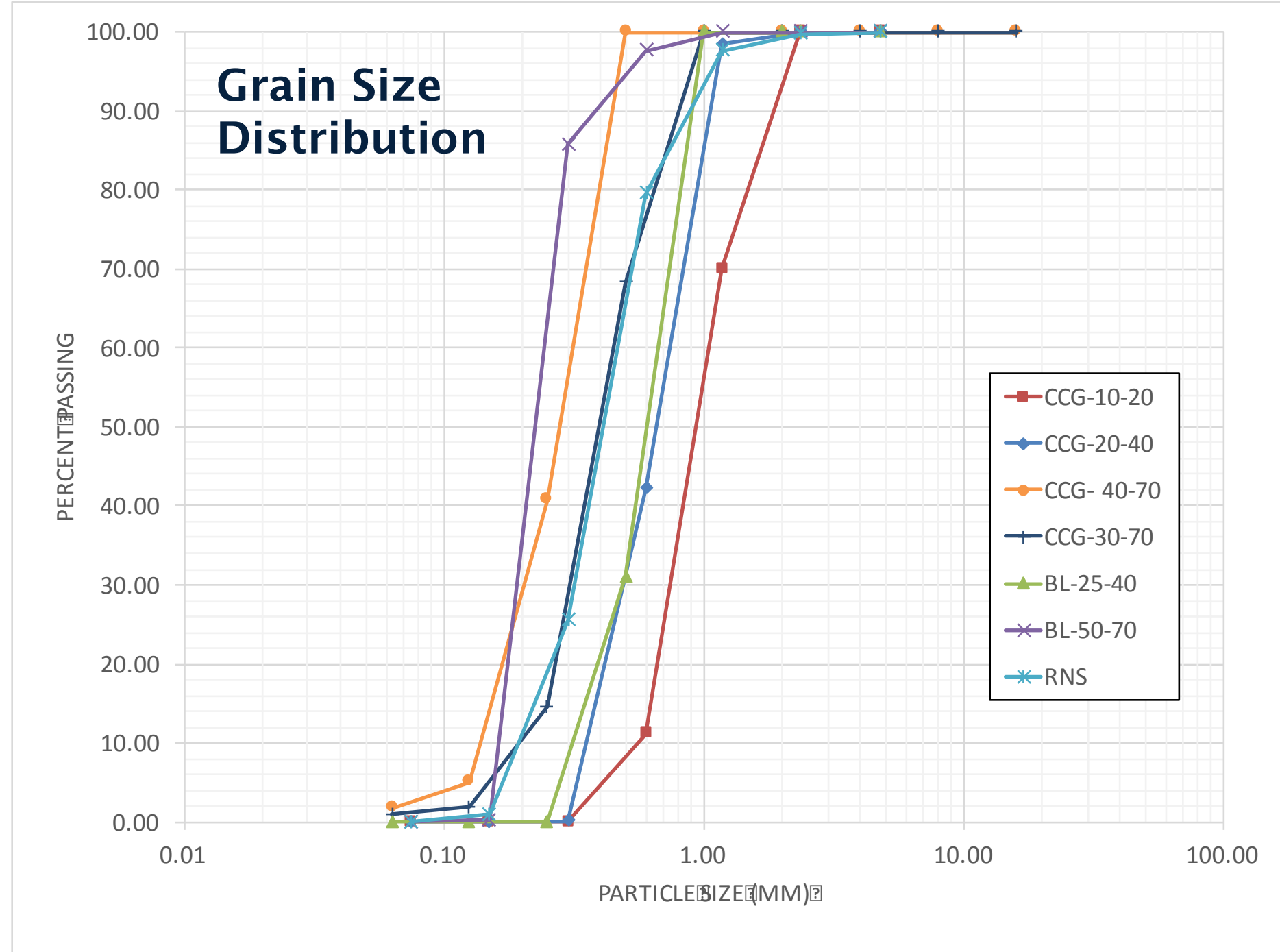
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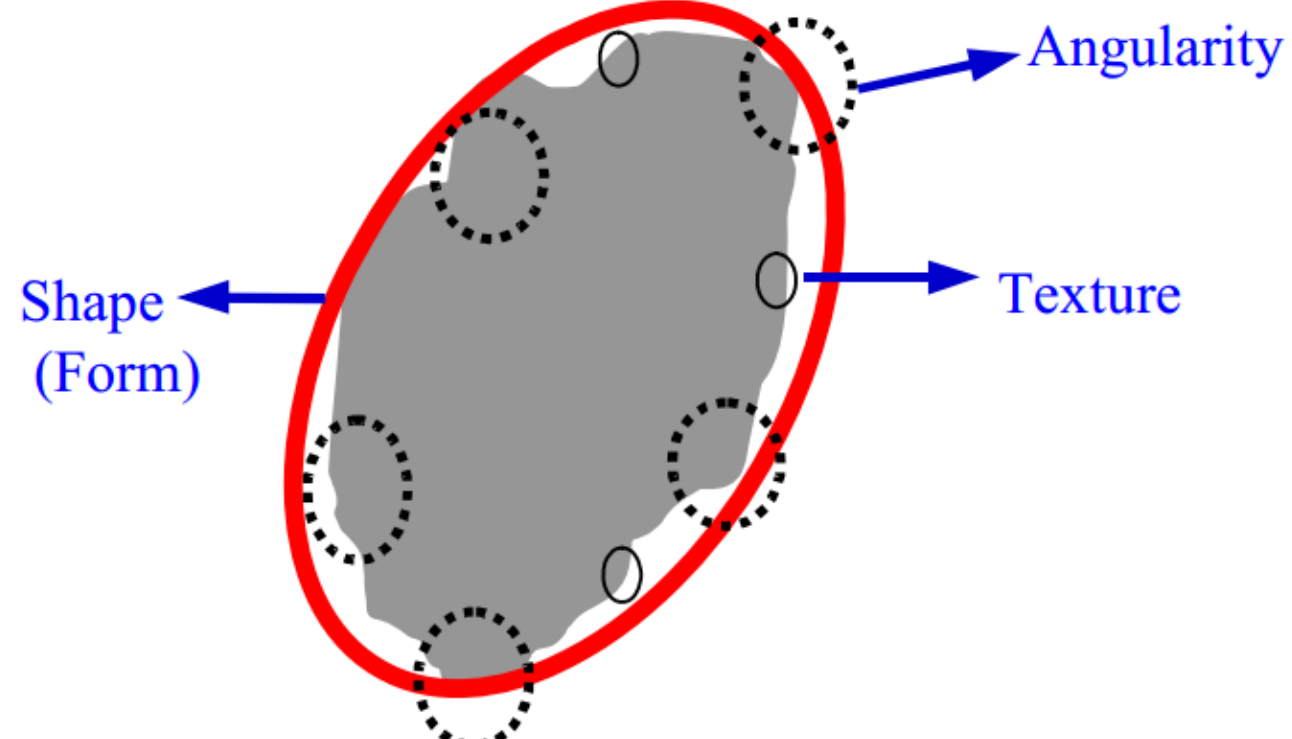
## Grain Types and Characteristics

| Designation | CCG-10-20 | CCG-20-40 | CCG-30-70 | CCG-40-70 | BL-25-40 | BL-50-70 | RNS  |
|-------------|-----------|-----------|-----------|-----------|----------|----------|------|
| Appearance  |           |           |           |           |          |          |      |
| D50 (mm)    | 0.98      | 0.68      | 0.41      | 0.29      | 0.64     | 0.24     | 0.44 |

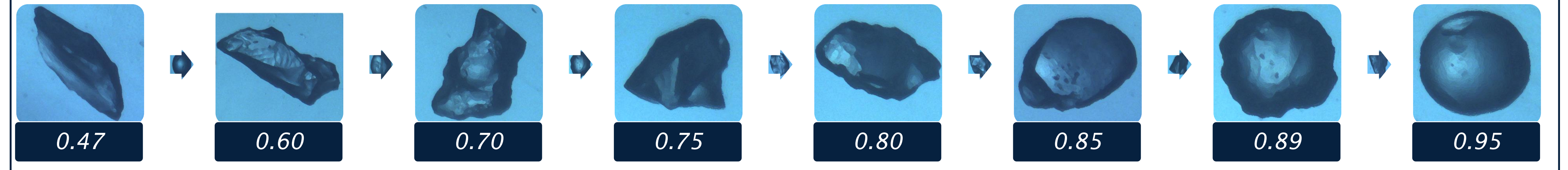


## CAY CLEAN GLASS PLANT

Sampling of sand was carried out at Rincon's Public beach, while crushed glass was acquired from Cay Clean Glass Plant.

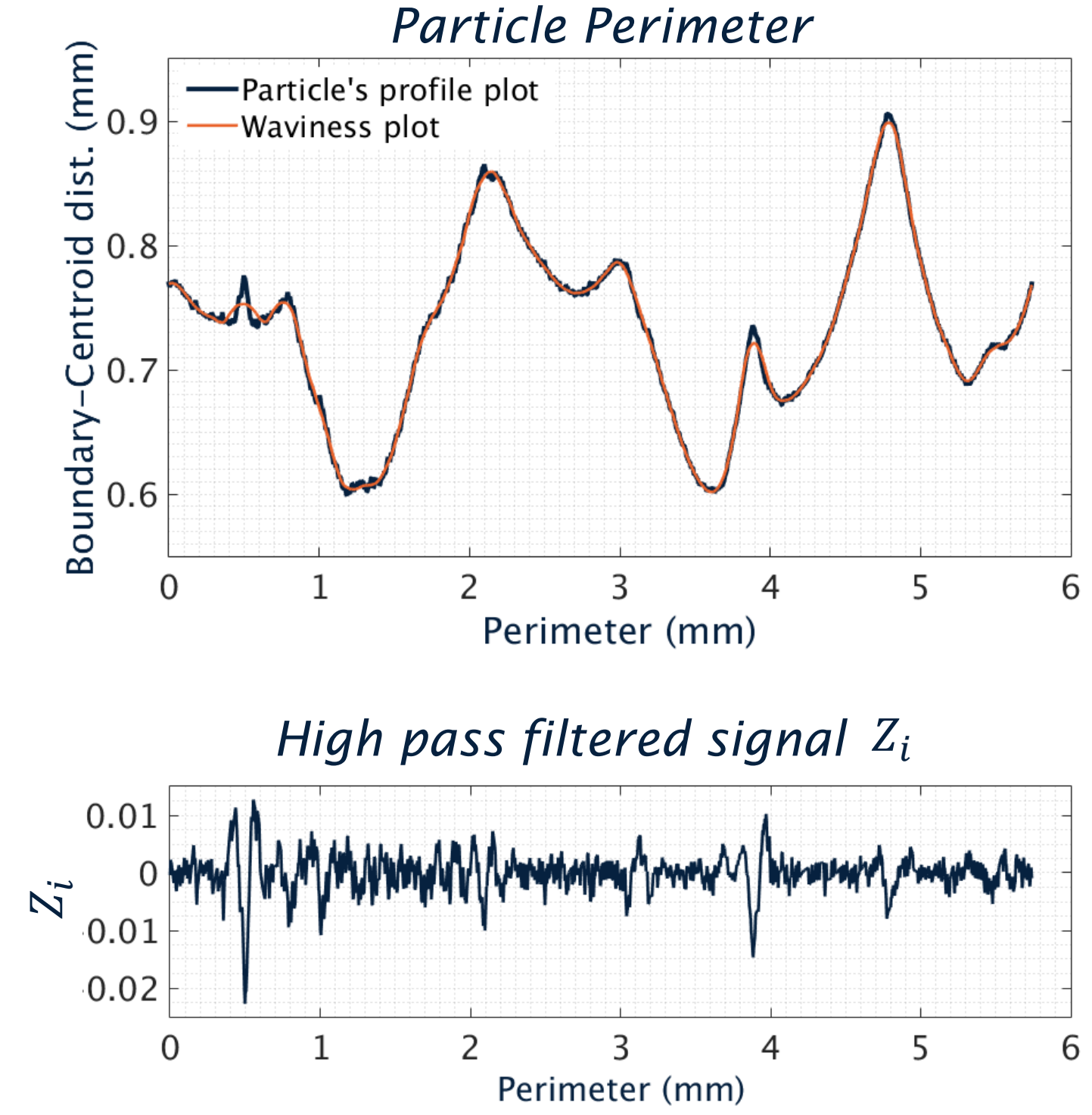


## Shape Factor examples:



## Particle boundary:

The particle's boundary is determined through edge detection algorithms. It provides a perimeter estimate from which characteristics such as texture and roughness can be computed.



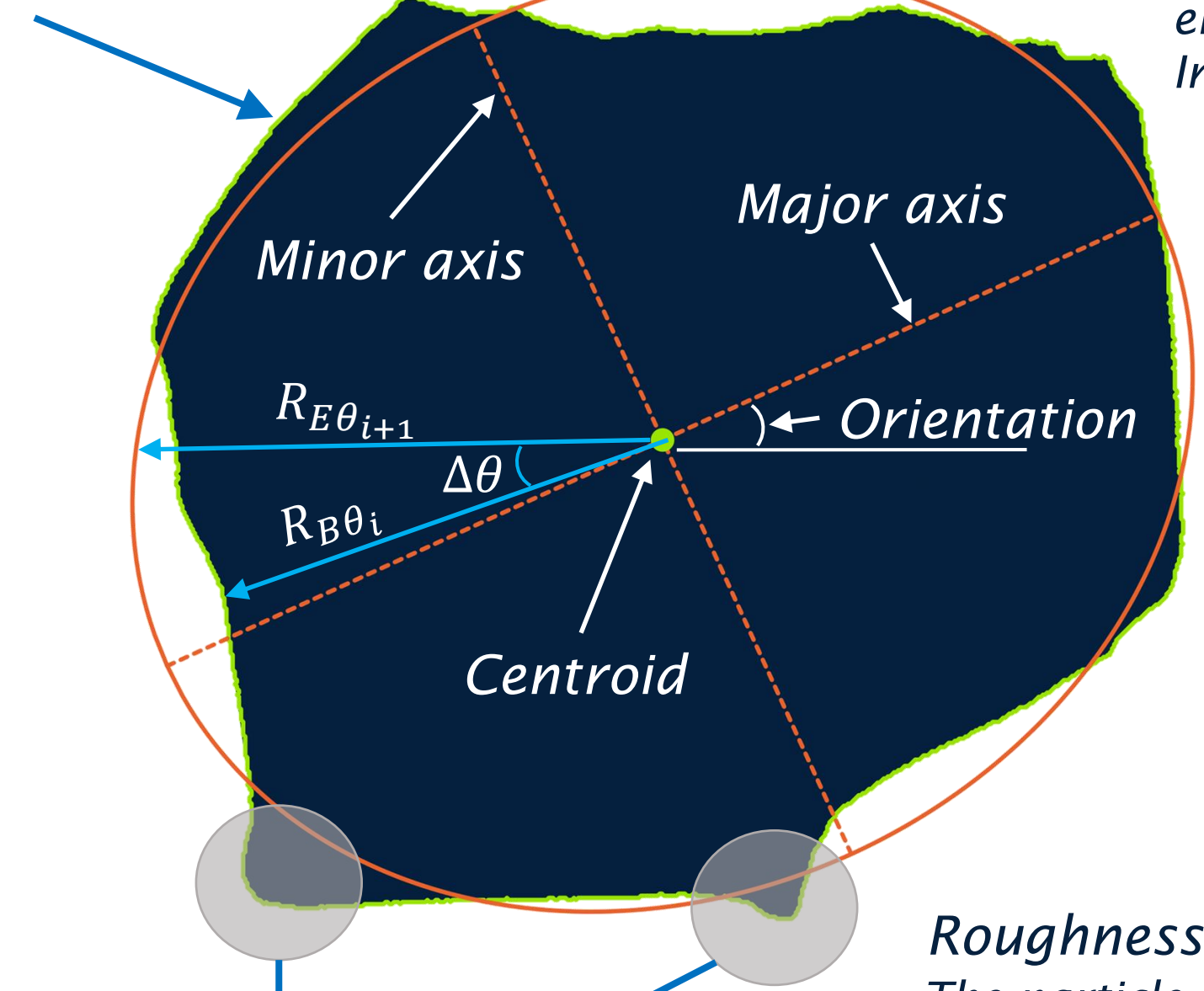
## Equivalent ellipse:

This parameter indicates how spherical a particle is. It is parameterized through the Shape Factor (SF); whose value ranges from 0-1, with 1 being a perfect circle. The equivalent ellipse also provides information to determine the Angularity Index (AI).

$$SF = \frac{4 \pi \text{Area}}{\text{Perimeter}^2} \quad AI = \sum_{\theta=0}^{\theta=360^\circ-\Delta\theta} \frac{|R_{B\theta} - R_{E\theta}|}{R_{E\theta}}$$

Properties resolved by image analysis: A = Area, P = perimeter (P), SF = Shape Factor, and AI = Angularity Index. The values on the right indicate the particle tends to be rounded and weakly angular.

A = 1.65 mm<sup>2</sup>  
 P = 5.09 mm  
 SF = 0.80  
 AI = 5.94



## Roughness calculation:

The particle roughness was determined by computing the RMS (R<sub>RMS</sub>) signal of the high-pass filtered particle perimeter.

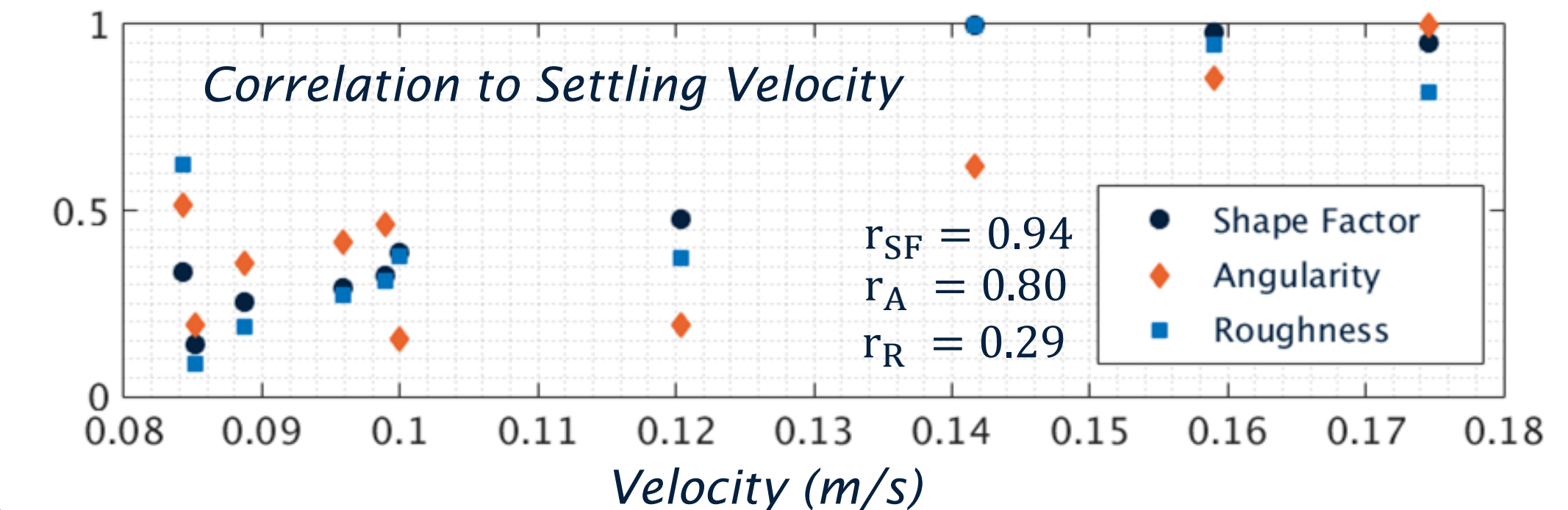
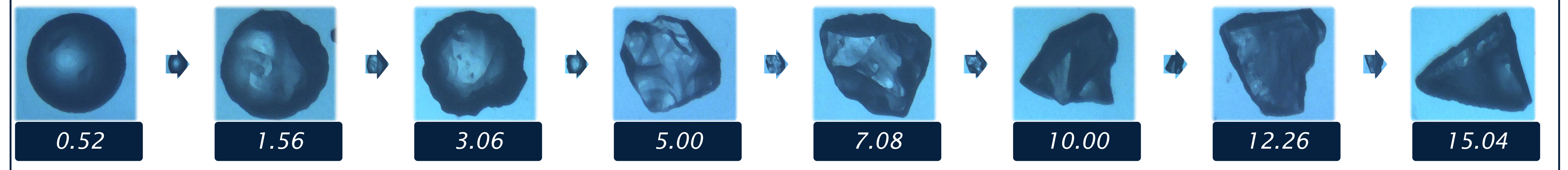
$$R_{RMS} = \sqrt{\frac{\sum_{i=1}^N (Z_i)^2}{N}}$$

## Angular regions:

These features contribute to the angularity value; when a particle has many angular regions, it is said to be very angular.

Perimeter = Low freq. signal + High freq. signal Zi

## Angularity examples:



## Conclusions:

- So far, particles CCG-10-20, CCG-20-40, BL-25-40, BL-50-70 have been characterized. It has been determined that the shape factor is the grain characteristic that affects the settling velocity the most (r = 0.94), while grain roughness has very little impact (r = 0.29).
- In general, the materials that are closest to RNS in angularity and SF values are CCG-10-20 and BL-25-40.



This research is one of the three parts of the project titled: "Recycled glass as beach nourishment material to mitigate Puerto Rico erosion problems. An integrated effort between scientists, engineers and citizens", and has the objective of characterizing the angularity, shape and roughness of crushed glass with the purpose of relating it to its settling velocity. In this way we aim at finding the optimal characteristics that replicate the hydrodynamic behavior of sand particles.