A METHOD TO DETERMINE WAVE DESIGN CRITERIA WITH HIGHER ACCURACY

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ABSTRACT
The biggest concern on coastal constructions is lower the risk of failure against environmental pressures, like waves. The effect of waves on the structures is considered in the equations raising the power of significant height (H_s) of 2 to 4. However, designing a project considering a wave height that is too conservative can significantly increase its cost and make it economically unfeasible. On the other hand, underestimating the wave height can result in a project's catastrophic failure or significant maintenance costs. This study proposes a new method to assess the wave heights for design criteria more accurately.

INTRODUCTION
Knowledge of the wave climate is essential to determine areas sensitive to wave amplification. The study of wave propagation is of great importance since the waves can reach the coast amplified and thus, often cause accidents. Spectral models are used for general characterization, showing the sea state. However, in the engineering design criteria application, it is necessary to consider a single case, the worst possible. For this, we isolate the sea state in characteristic waves for monochromatic propagation. However, this "worst wave" comes from spectral models and follows a classification that considers only certain angles (every 30°) and periods (swell). The preliminary results of Figure 1 show a wave with the same incidence angle, when the period varies only 1 second, it changes the path entirely, and it is the difference between striking the structure or not.

METHODS
The model used was SisBaHiA® which wave propagation module is based on REF/DIF, version 3.0.
In the proposed "disturbance range", the incident direction varies at 1° and the period in 1 second. The disturbance range used a "unit" wave of 1 meter to have the results in terms of "amplification factor" for the design criteria, and later this shall be applied to real wave heights.
Two places were determined as case studies:

a) Itaorna inlet - Breakwater protecting the cooling structures of a nuclear plant, which failure would have a great consequence. The region has a complex bathymetry that greatly influences the refraction of waves.
b) Tim Maia bike path - Coastal bike path that collapsed in 2016 due to an "unforeseen" wave on the structure.

RESULTS
Hudson's formula uses H_s^3 for the rock weight calculation for a breakwater. For typical waves of S, 180° and 13s, the amplification factor on the breakwater is 0.8. However, the maximum wave amplification of 13s was from the 183° direction with a result of 1.55, 92% more than the first estimation. However, after applying H_s^3 to the height $H_s90\%$ = 3.5 m, they present respective values of 21.95 and 157.46, with the value of the second being 617% more.
Figure 2 shows that for the 13 s wave the amplification factor varies from 0.1 to 1.6, in only 6 degrees of variation in the entrance angle, and the angle with greater amplification is 183°, an angle never included in classic simulations.

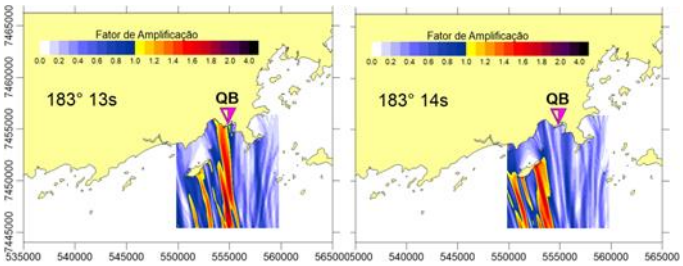

Figure 1 - Isolines of wave height amplification factors (H/H_0). Differences in effects varying only the periods.

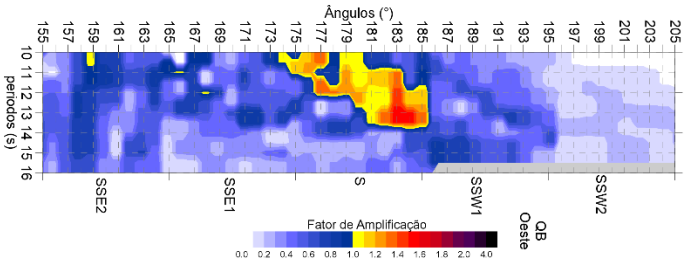

Figure 2 - Example of a result summarized, a matrix combining incident angles and periods.

CONCLUSION
When the incident direction differed by just 1°, the results demonstrated a significant change in H_s amplification, of about 60%. Even more, the conventionally used angles of storm waves for the region of study do not amplify the H_s, so its effect would be underestimated, and it was concluded to be one of the causes for the collapse of the bike path in 2016. When the period differed by just 1 second, the results demonstrated an abrupt change in H_s amplification, of about 92%. In addition, the increase in period does not necessarily imply an increase in the amplification factor. In conclusion, the proposed methodology effectively improves the accuracy of H_s estimation for wave design criteria, with variations in incident parameters, T_p e D_p.

REFERENCES
Soares (2016): Methodological discussion about sensitivity of incident waves parameters to define project conditions (in Portuguese), UFRJ/COPPE.
Rosman (2019): Technical Reference of SisBaHiA (in Portuguese), UFRJ/COPPETEC.