Calculation of wave forces due to extreme events in the coastal region using REEF3D

Beregning av bølgebelastninger fra ekstrem vær i kyst områder med REEF3D

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MOTIVATION (I / II)

CONTENT

MAIN REASONS

1. Coastal regions are important economic areas

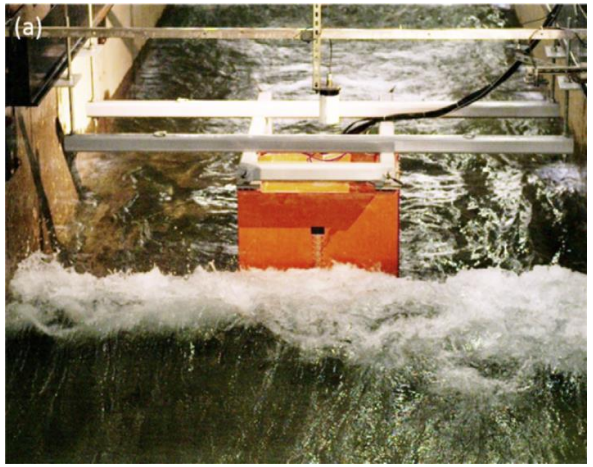
2. High vulnerable zones to natural disasters due to extreme weather or seismic events

MOTIVATION (II / II)

CONTENT

3. Climate change
   - → Increase SWL
   - → Increase the probability of occurrence of an extreme event

4 . Check if **CFD model REEF3D** can capture **structure-wave interaction**
   - → Short time
   - → Large magnitude



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CFD

Reynolds-Averaged Navier-Stokes Equations (RANS)

$$\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{1}{\rho}\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j}\left[\nu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\right] + g_i$$

Turbulence model → k-ω model

$$\frac{\partial k}{\partial t} + u_j \frac{\partial k}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] + P_k - \beta_k k\omega$$

$$\frac{\partial \omega}{\partial t} + u_j \frac{\partial \omega}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_\omega}\right)\frac{\partial \omega}{\partial x_j}\right] + \frac{\omega}{k}\alpha P_k - \beta\omega^2$$

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PROJECT

CONTENT

OBJECTIVES

1. Investigation of slamming loads on deck structures.
2. Evaluation of horizontal and vertical loads on an elevated structure due to extreme waves.

TASKS

- Literature review to obtain the state-of-the-art on extreme wave impact in the coastal region.
- The simulations of extreme wave interaction with structures using the open-source hydrodynamic model REEF3D evaluating the horizontal and vertical forces on coastal structures.
- The influence of the incident wave characteristics on the slamming loads will be studied.

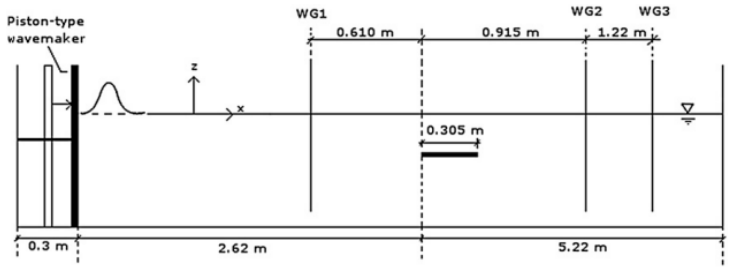
PRELIMINARY RESULTS (I / X)

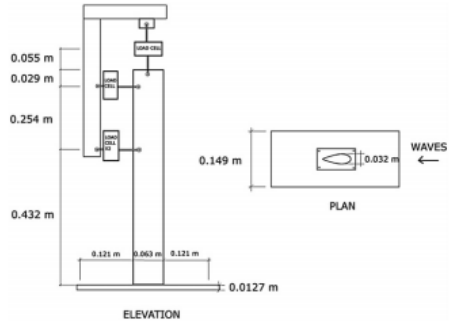
CONTENT

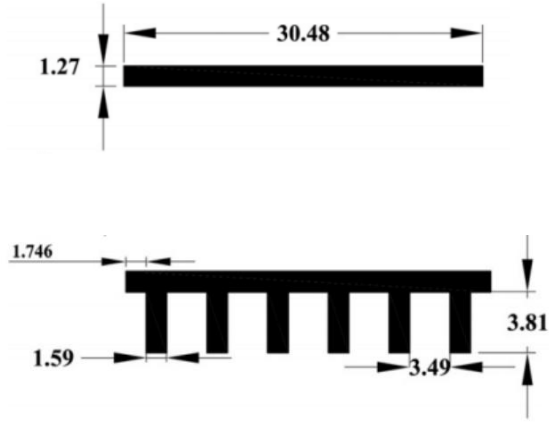
2D

"*Experiments and computations of solitary-wave forces on a coastal-bridge deck. Part I: Flat Plate*" – B. Seiffert et al. 2014

"Experiments and computations of solitary-wave forces on a coastal-bridge deck. Part II: Deck with girders" – M. Hayatdavoodi et al. 2014







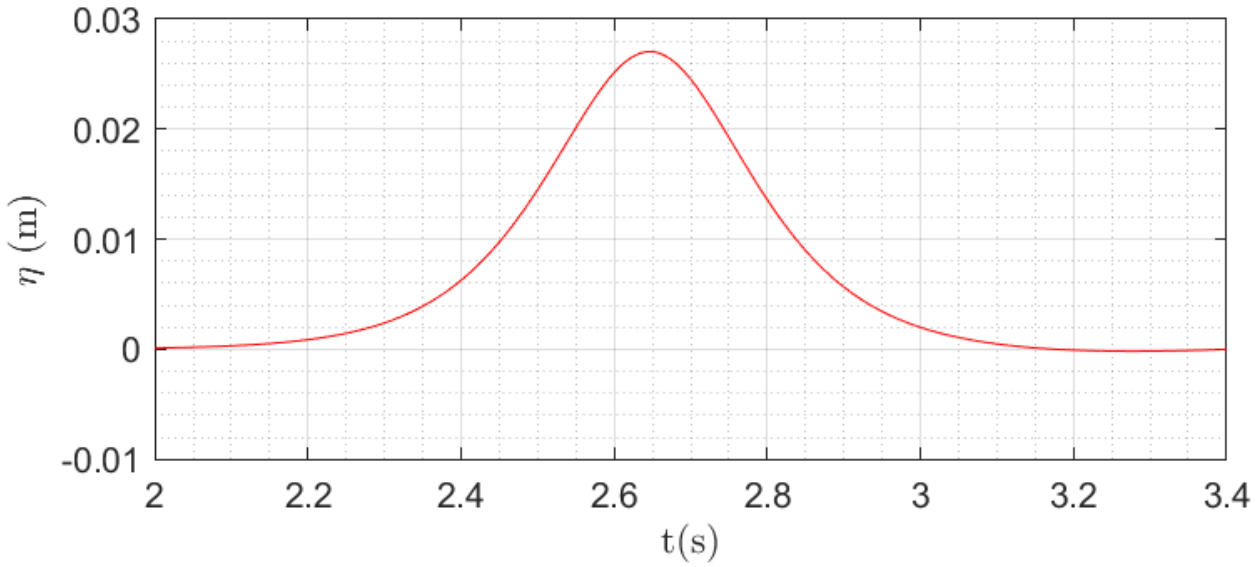
PRELIMINARY RESULTS (II / X)

CONTENT

WAVE THEORY - SOLITARY WAVE.

$$\eta = a\,\mathrm{sech}^2\sqrt{\frac{3}{4}\frac{a}{d^3}}x \qquad c = \sqrt{g(\eta + d)} \qquad L = \frac{2.12d}{\sqrt{\frac{a}{d}}}$$

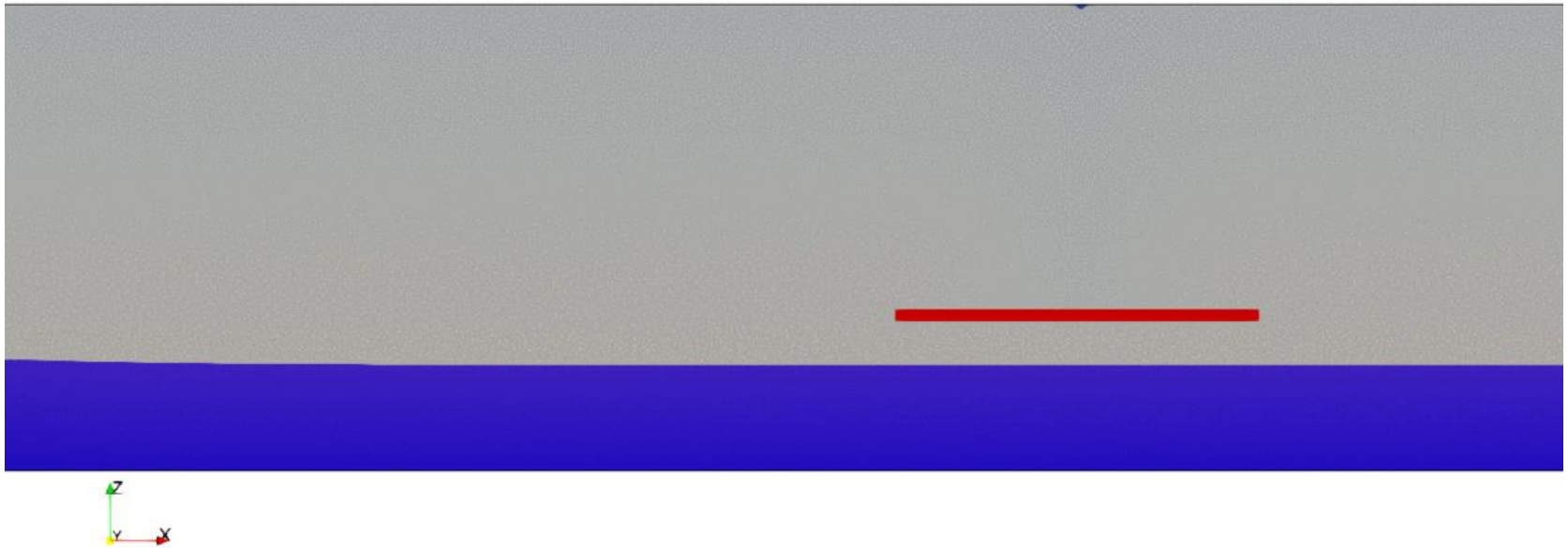
*Length over which 95% of the volumen under the crest is contained



PRELIMINARY RESULTS (III / X)

CONTENT

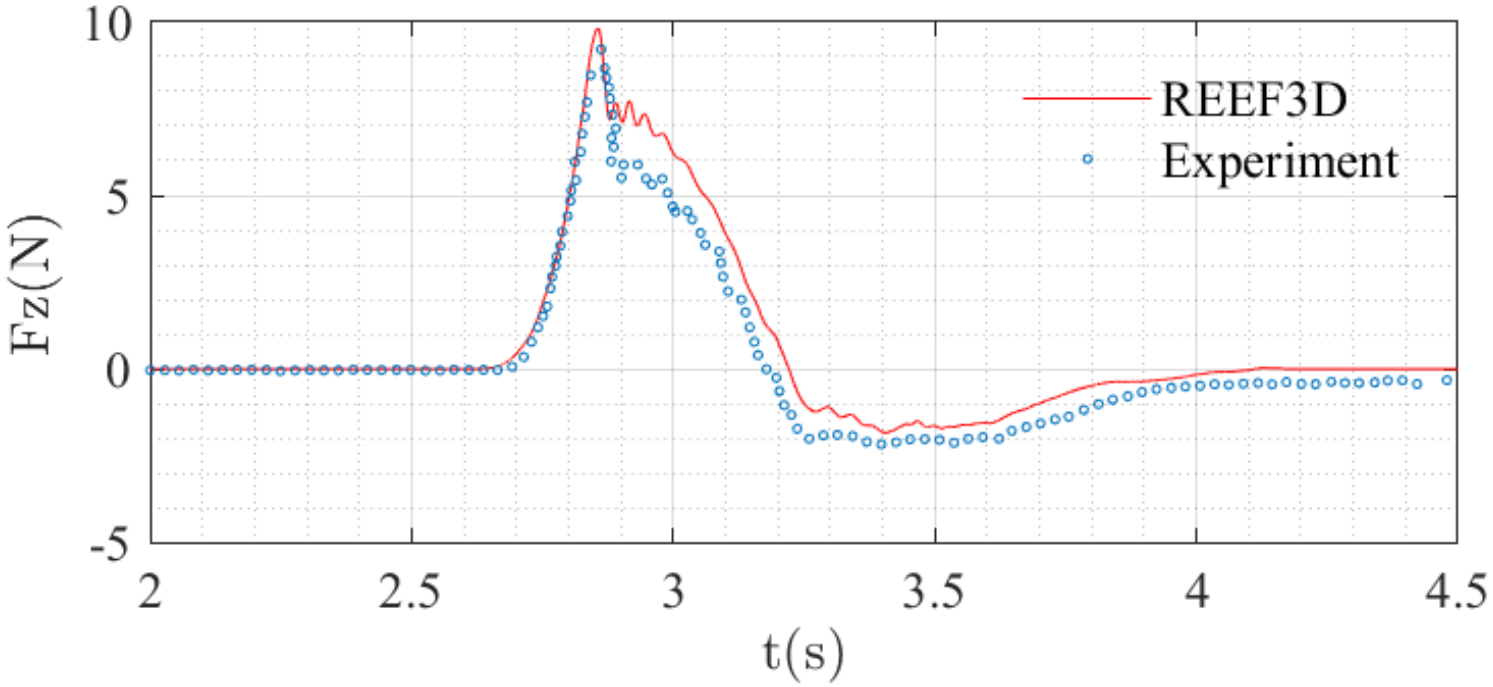
ELEVATED FLAT PLATE



PRELIMINARY RESULTS (IV / X)

CONTENT

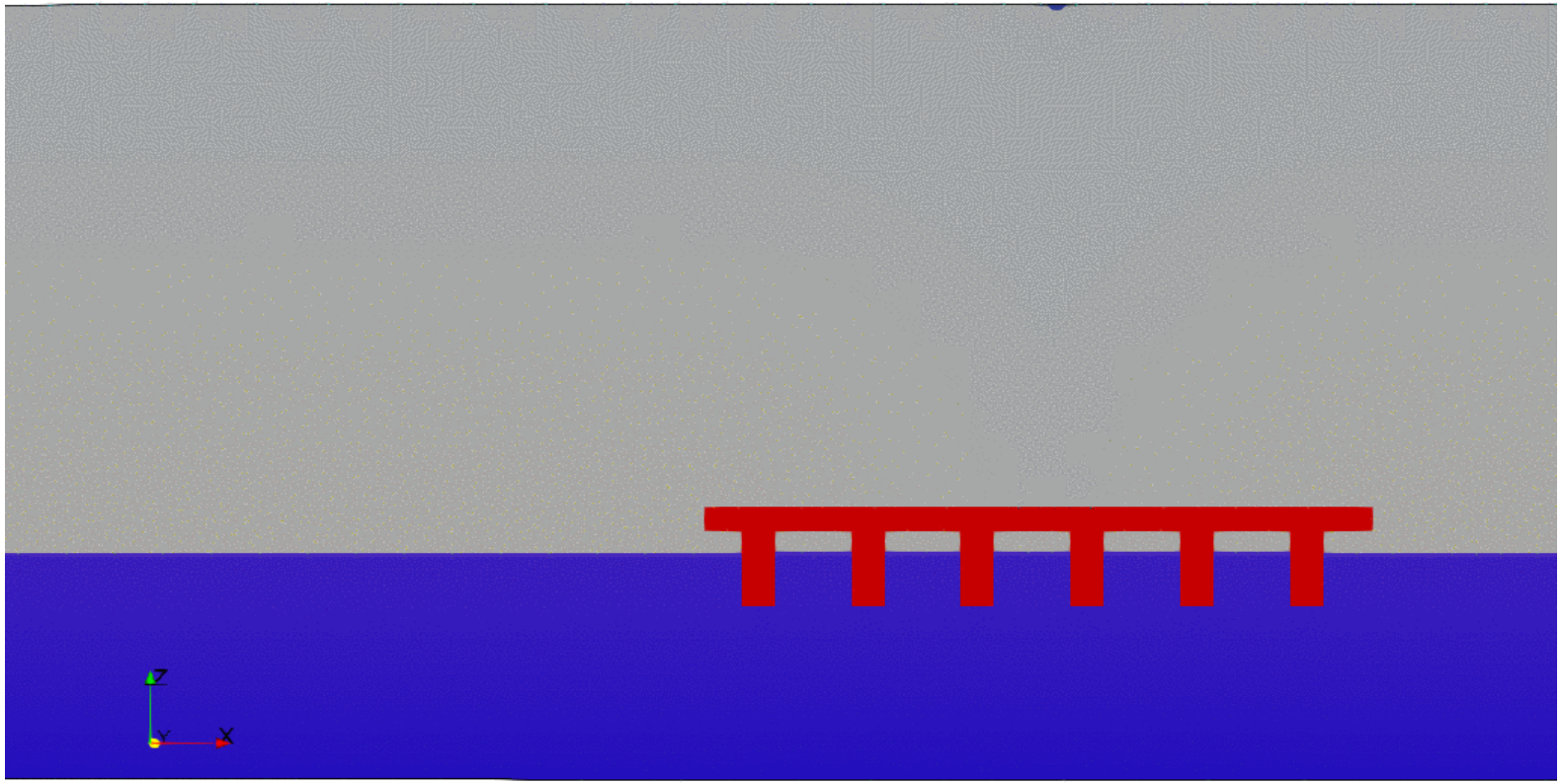
WAVE THEORY.



PRELIMINARY RESULTS (V / X)

ELEVATED DECK WITH GIRDERS

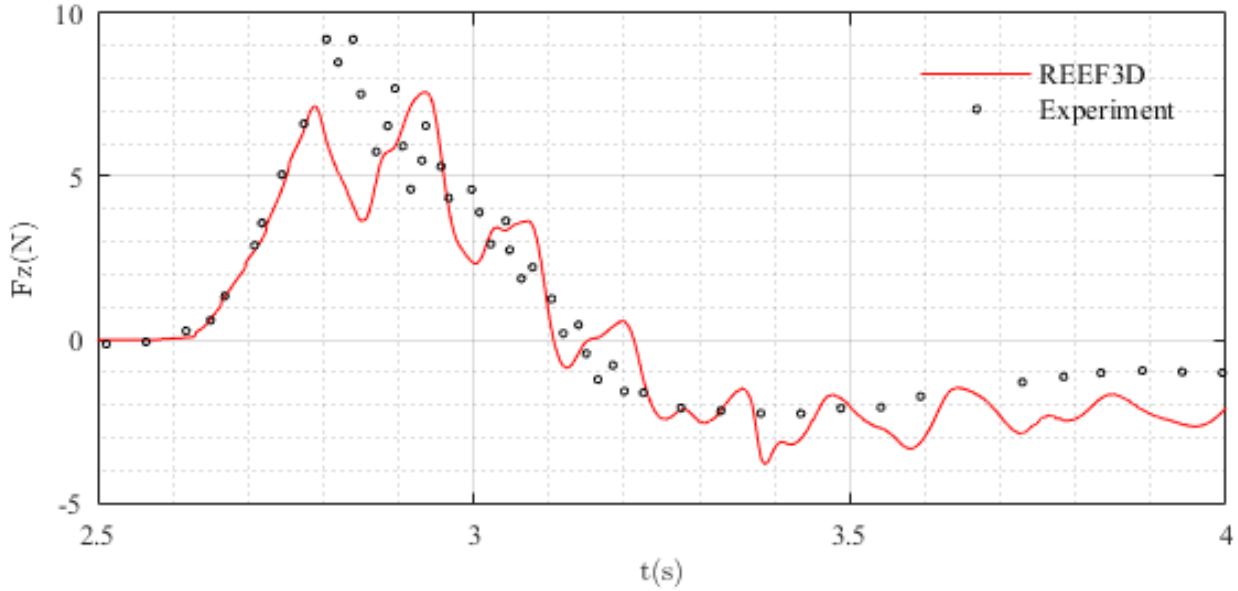
CONTENT



PRELIMINARY RESULTS (VI / X)

CONTENT

ELEVATED DECK WITH GIRDERS

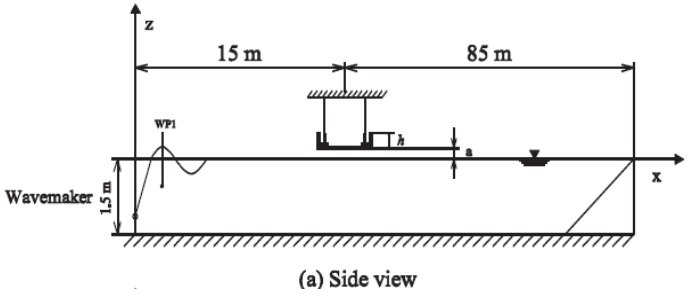


PRELIMINARY RESULTS (VII / X)

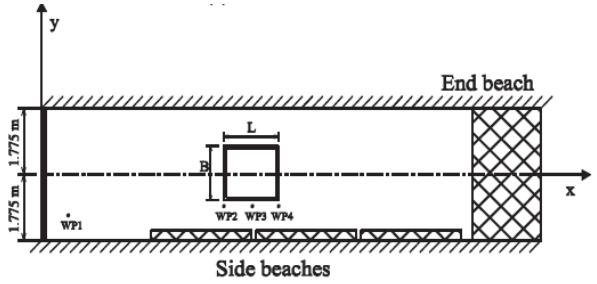
CONTENT

3D

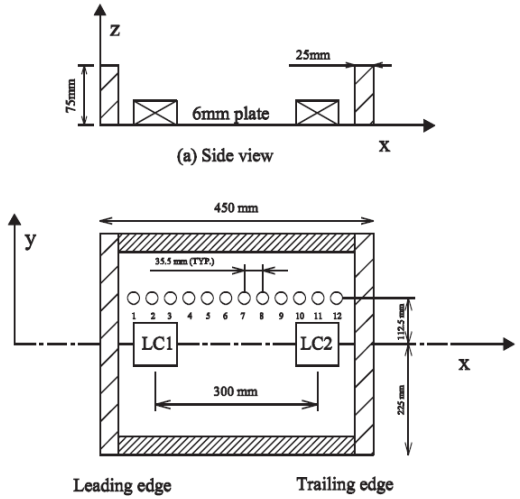
"Vertical Wave-in-Deck Loading and Pressure Distribution on Fixed Horizontal Decks of Offshore Platforms" – N. Abdussamie et al. 2014



(a) Side view



(b) Plan view



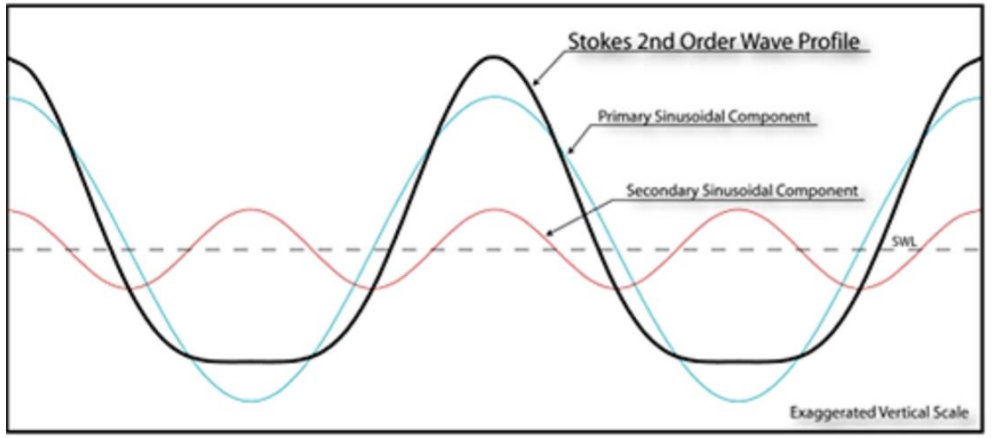
PRELIMINARY RESULTS (VIII / X)

CONTENT

WAVE THEORY -2ND ORDER STOKES.

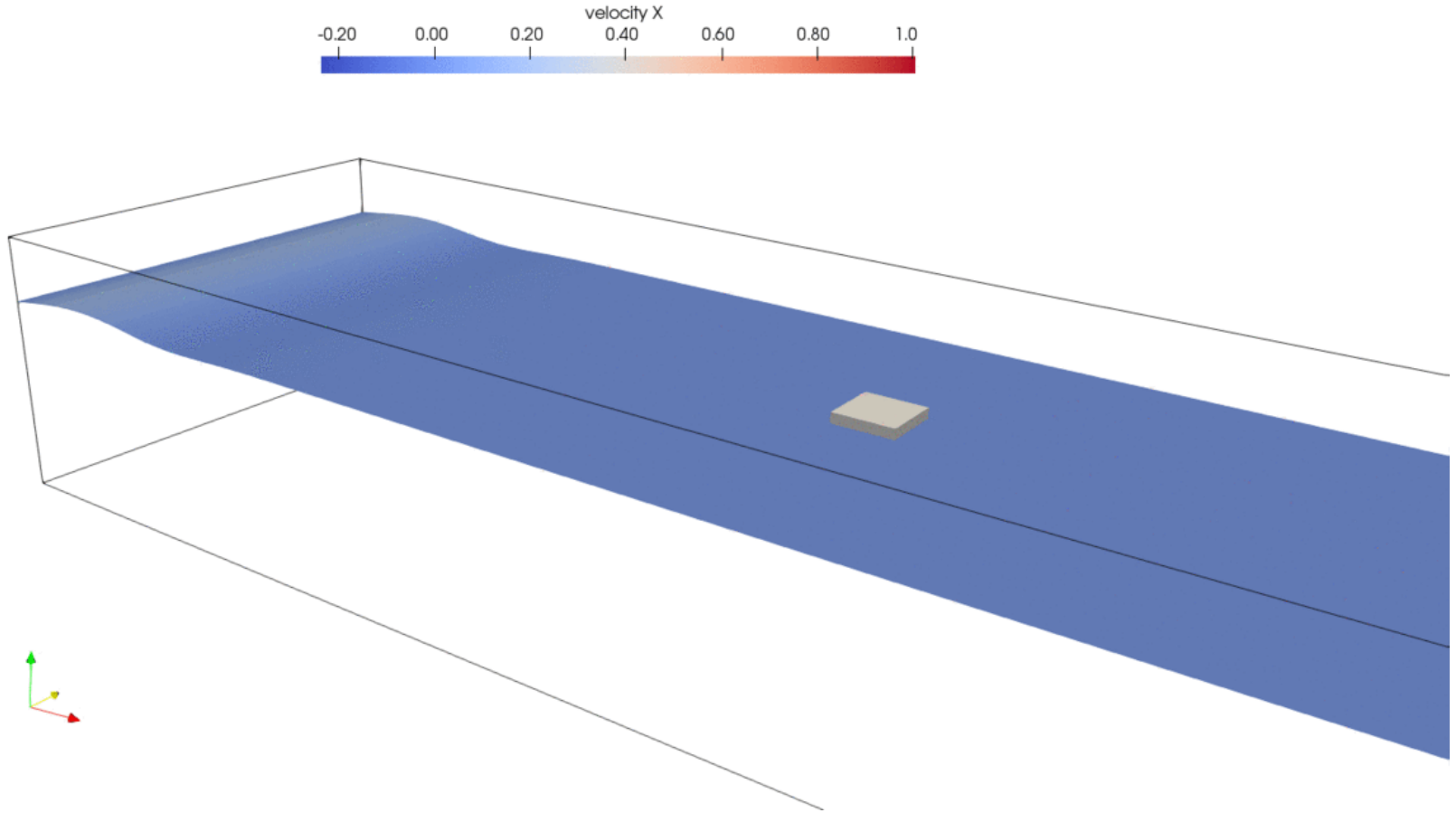
$$\eta(x,t) = a\cos(\omega t - kx) + ka^2 \frac{\cosh(kd)}{4\sinh^3(kd)}[2+\cosh(2kd)]\cos[2(\omega t - kx)]$$

1. Bound second harmonic; dispersion relationship remains the same
2. Horizontally symmetric; vertically asymmetric; flatter trough; sharper crest



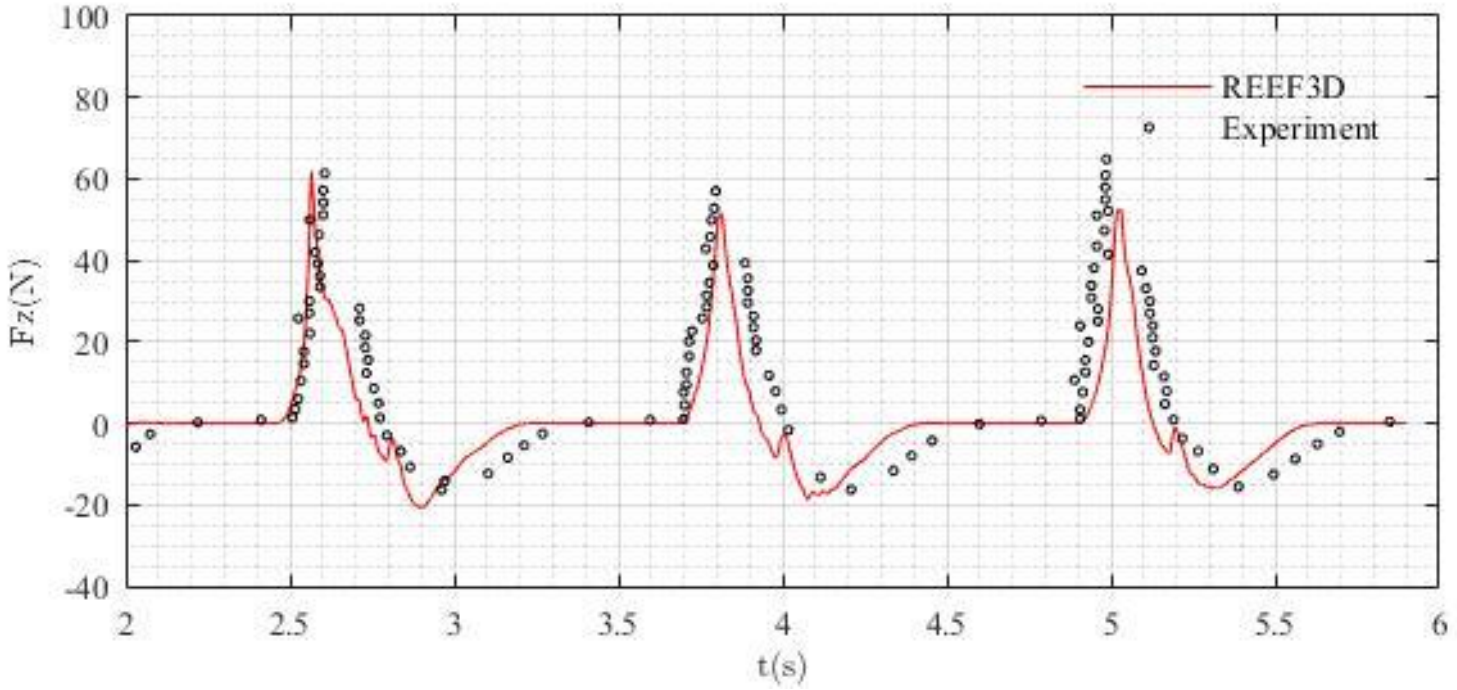
PRELIMINARY RESULTS (IX / X)

CONTENT



PRELIMINARY RESULTS (X / X)

CONTENT



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SUMMARY

CONTENT

WHY?

- Important economic areas
- Vulnerable zones
- Climate change

WHAT WILL I DO?

- State-of-the-art on extreme wave impact in the coastal region.
- The simulations of extreme wave interaction with structures using the open-source hydrodynamic model REEF3D
- The inundation of the coastal region under an extreme wave event.