Effect of floating or near-surface structures on sandy bed mobility under incoming waves in deep water conditions

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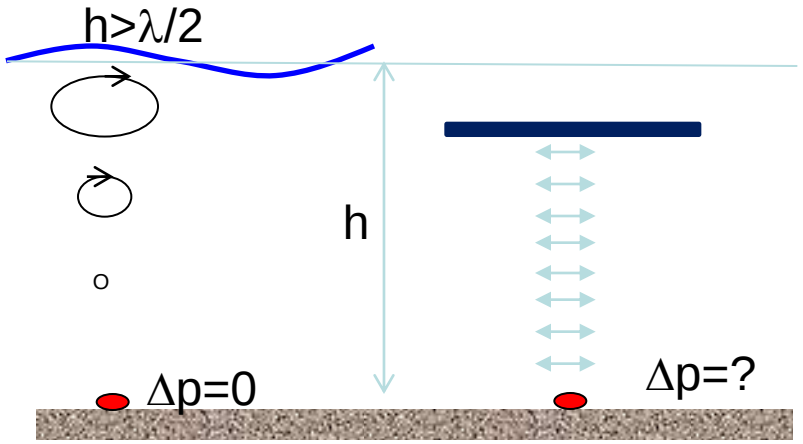
Aim of the study

Bottom induced dynamics under deep water incoming wave action:
effect of an near surface obstacle
- Bottom induced pressure
- Bottom induced velocities and sandy bed mobility

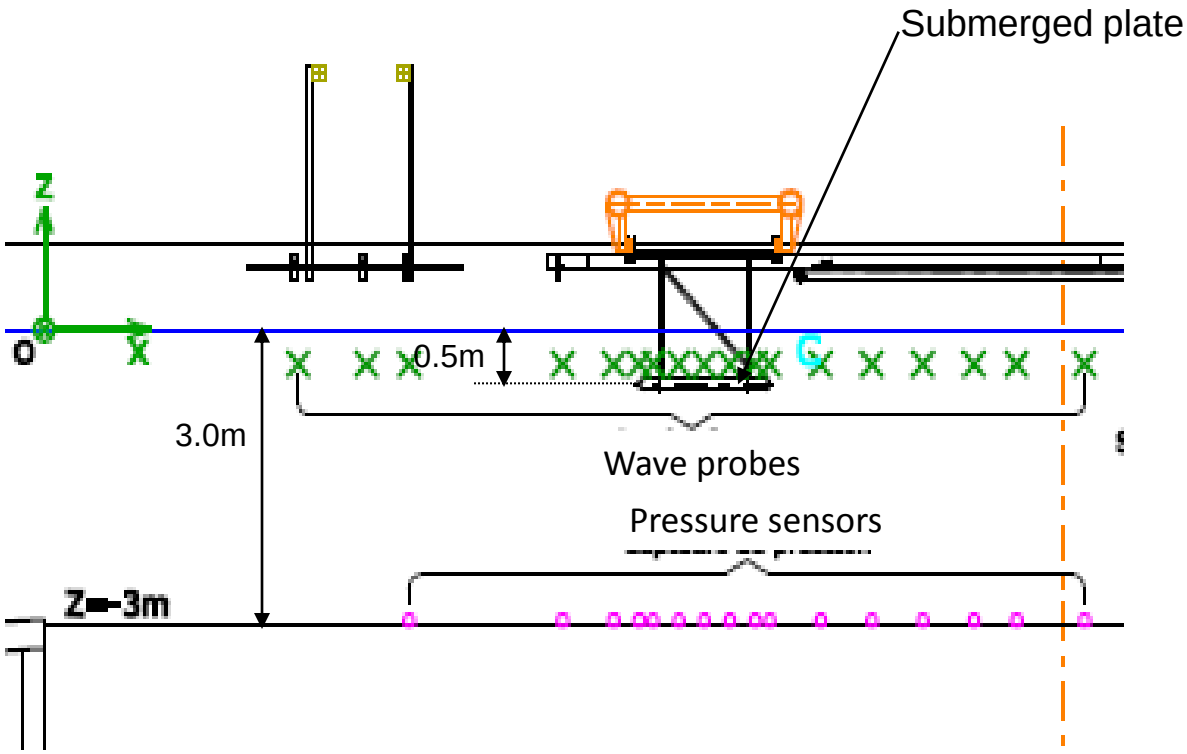
L=24m, l=16m, H=3m



Experiments carried out in the Ocean Basin BGO FIRST,
La Seyne/Mer, France
In the framework of the GIS HYDRO

Experimental set-up

Submerged plate induced « local » dynamics



Wave conditions:

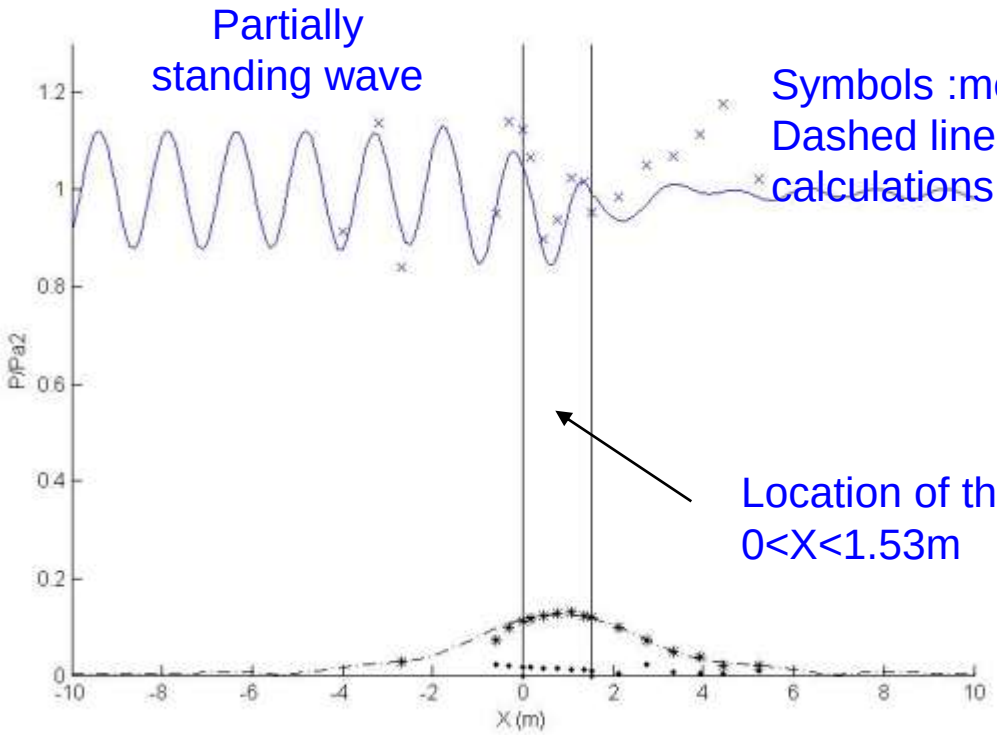
Regular waves
T=1.4s (λ=3m)
a=44, 54 and 65mm

Irregular waves:
Tp=1.4s, γ=3.3

→ « Deep water conditions »

Résults

Free surface deformation and bottom pressure amplitudes, T=1.4s, a=54mm

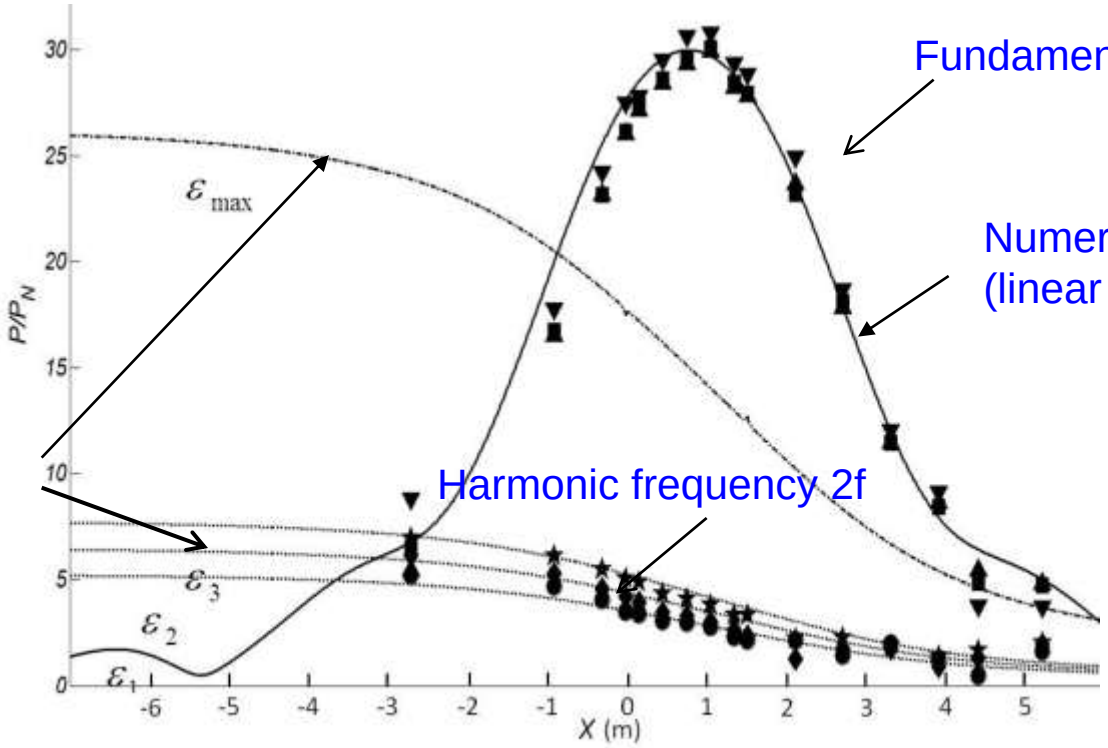


→ Pressure increase under and on both sides of the plate

Résults

Bottom pressure amplitudes (at frequencies f and 2f), T=1.4s, a=44, 54 and 65 mm

$$P_N = \frac{\rho g a_i}{\cosh(kh)}$$



Numerical results at frequency 2f, solution forced by the solution at order 1 (frequency f)

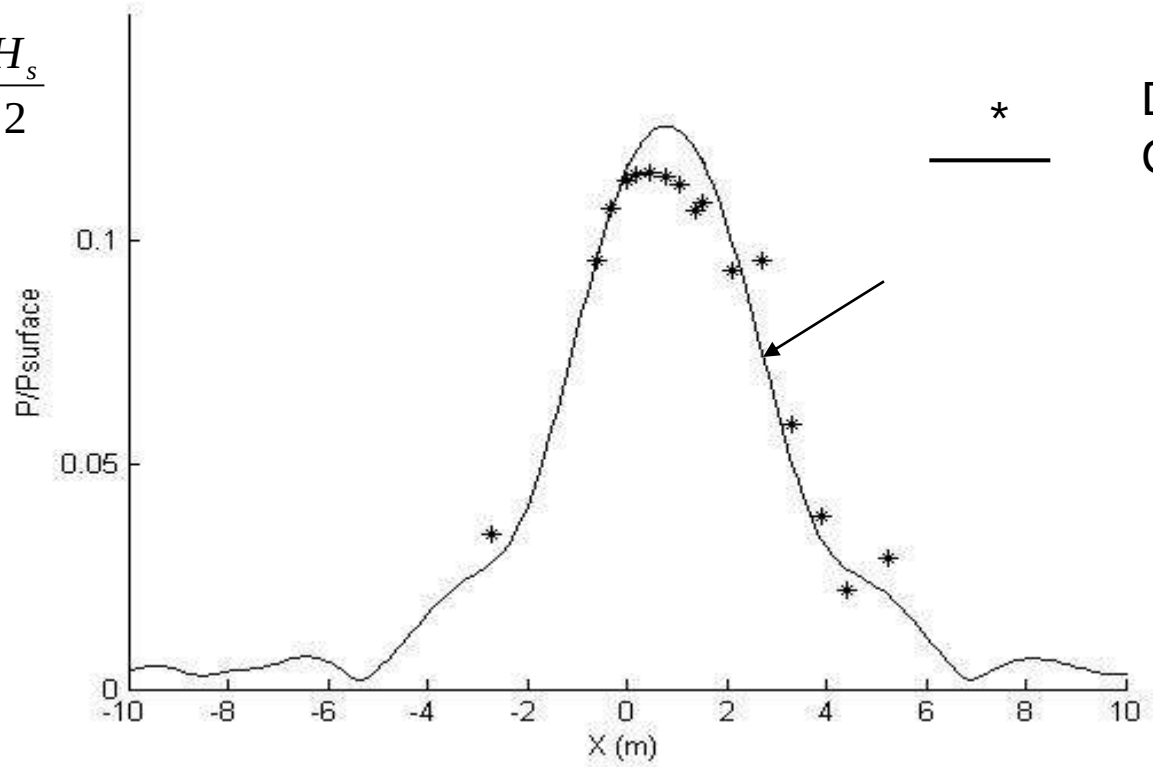
Touboul and Rey, JFM 2012

→ 1st order bottom pressure amplitude (frequency f) 30 times the bottom pressure due to the incoming wave « Longuet-Higgins effect » at order 2

Résults

Bottom pressure significant amplitudes, Tp=1.4s, γ=3.3

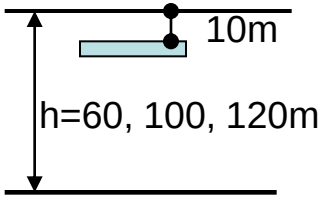
$$P_{Surface} = \rho g \frac{H_s}{2}$$

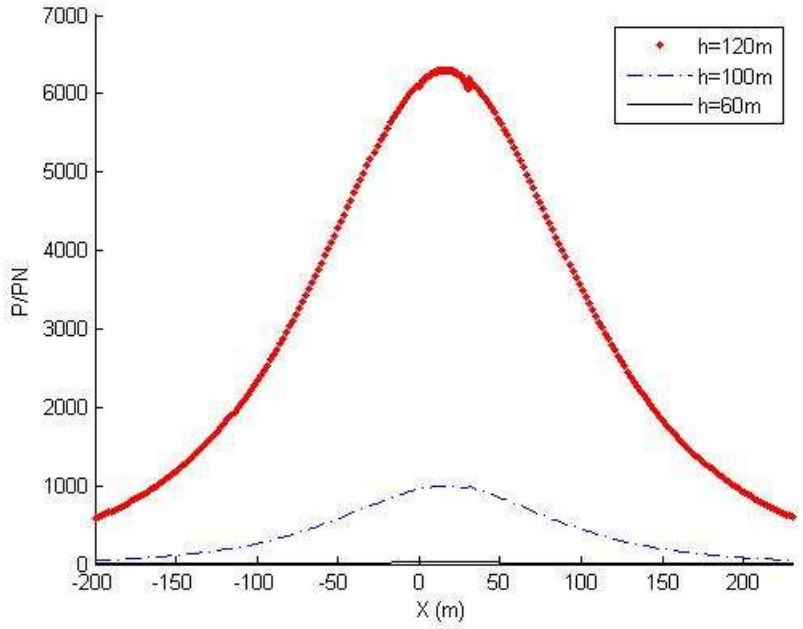


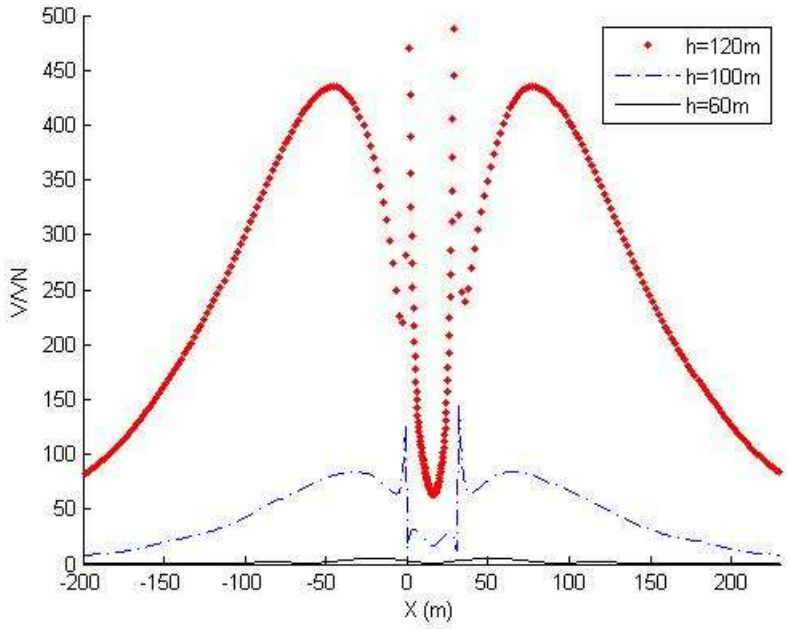
As for regular waves, 1st order bottom pressure amplitude (frequency f)
30 times the bottom pressure due to the incoming wave

Discussion on the wave induced dynamics

Bottom pressure significant amplitudes and velocities:
Influence of the water depth h







→ Strong relative amplitude of both pressure and velocity
Maximum amplitude of velocity on both sides of the plate location

Impact on sandy bed mobility

Mobility number and sediment motion

Mobility number $\Psi = \dfrac{\rho U_m^2}{(\rho_s - \rho) g D}$

Example:
Wave height Hs=6m, Tp=6.26s, water depth h=60m.

Bottom excursion of about 0.135m
Bottom velocity amplitude of about 0.10m/s.

→ Mobility number of 12.5 for a sand particle of diameter 0.05mm, big enough to move the particles

Conclusion

- Experimental evidence of near bottom pressure oscillation at the wave frequency even in “deep water” conditions, with a maximum of intensity under the plate
- Calculation of the induced velocities through a classical linear model, with a maximum of intensity on both sides of the plate
- The bottom dynamics are due to both the fluid horizontal oscillation under the plate and to the evanescent modes : such a phenomenon may also be observed under surface floating or fixed bodies
- Data analyses for the presented experimental set-up are in progress for regular and irregular waves under combined waves and current conditions