EXTREME WAVE FORCE AND RUN-UP ON OFFSHORE WIND-TURBINE FOUNDATIONS

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From experimental work

WAVE RUNUP OF RANDOM WAVES ON A SMALL CIRCULAR PIER ON SLOPING SEABED

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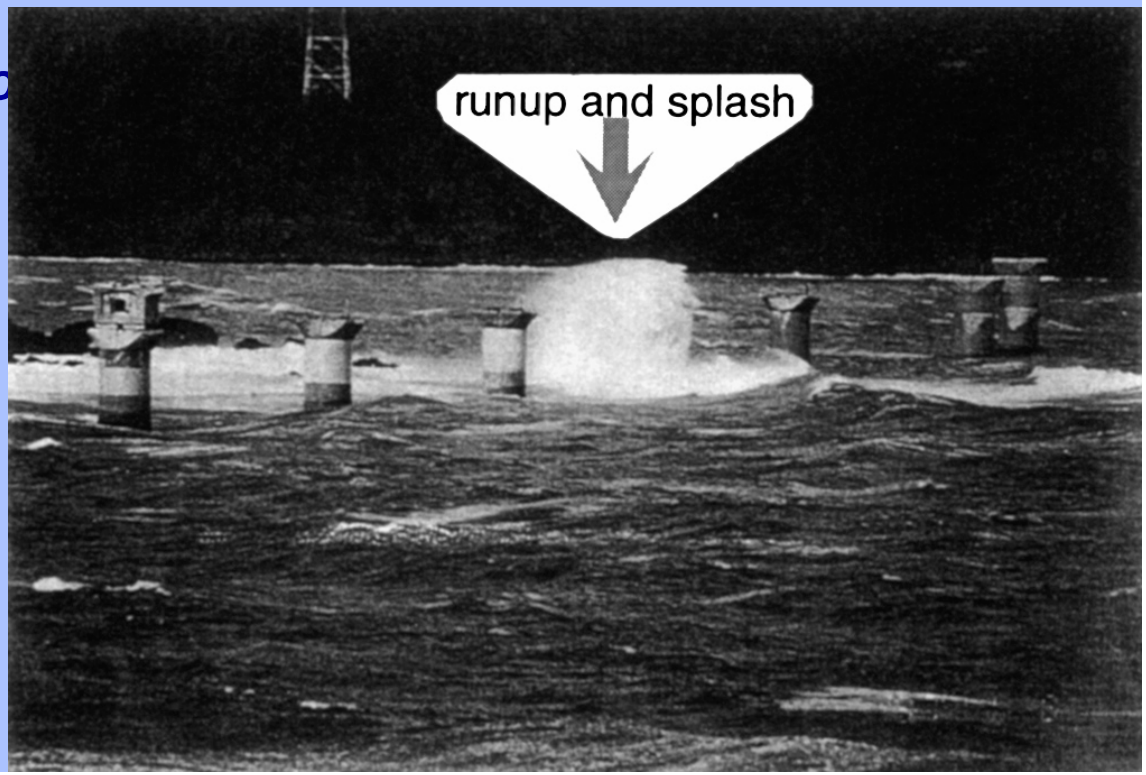
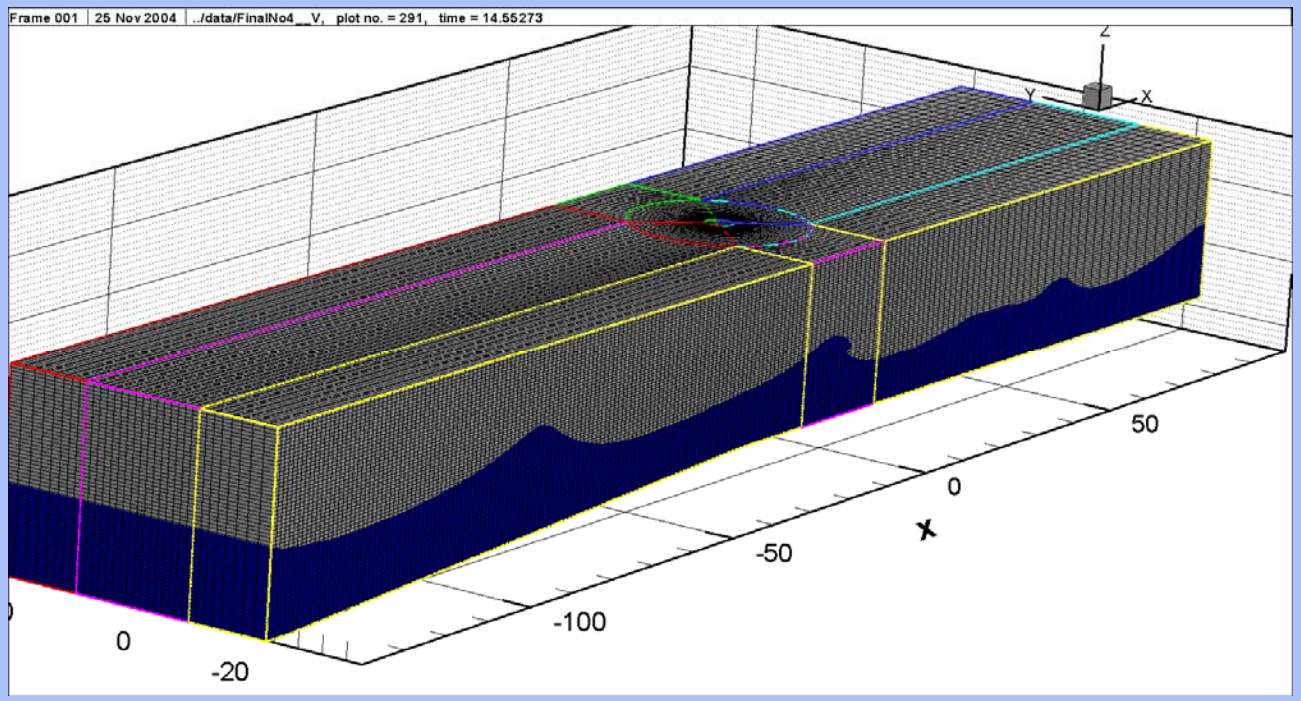


Examples of wave run-up and pressure



- The multiblock structure of the computational domain
- Finite volume method with VOF used to solve the Navier-stokes equations.

Test cases

- Two-dimensional regular waves
- Constant slope

$$R = f_r(H_0, T, L_0, g, \beta, h, D, v)$$

$$F = f_f(H_0, T, L_0, g, \beta, h, D, \rho, v)$$

- where H_0 is the deep water wave height
- T the wave period,
- L_0 the deep water wave length,
- g the gravitational acceleration,
- β the slope
- h the water depth, and
- D the diameter of the foundation cylinder.
- ❒ density of water
- ■ kinematic viscosity

Test Cases

- Dimension analyses give

$$R/h = f(H_0/h, T/\sqrt{h/g}, \xi_0, D/h, Re)$$

$$F/(\rho g h^3) = f(H_0/h, T/\sqrt{h/g}, \xi_0, D/h, Re)$$

•wave height,
•wave period,
•surf similarity parameter,
•diameter

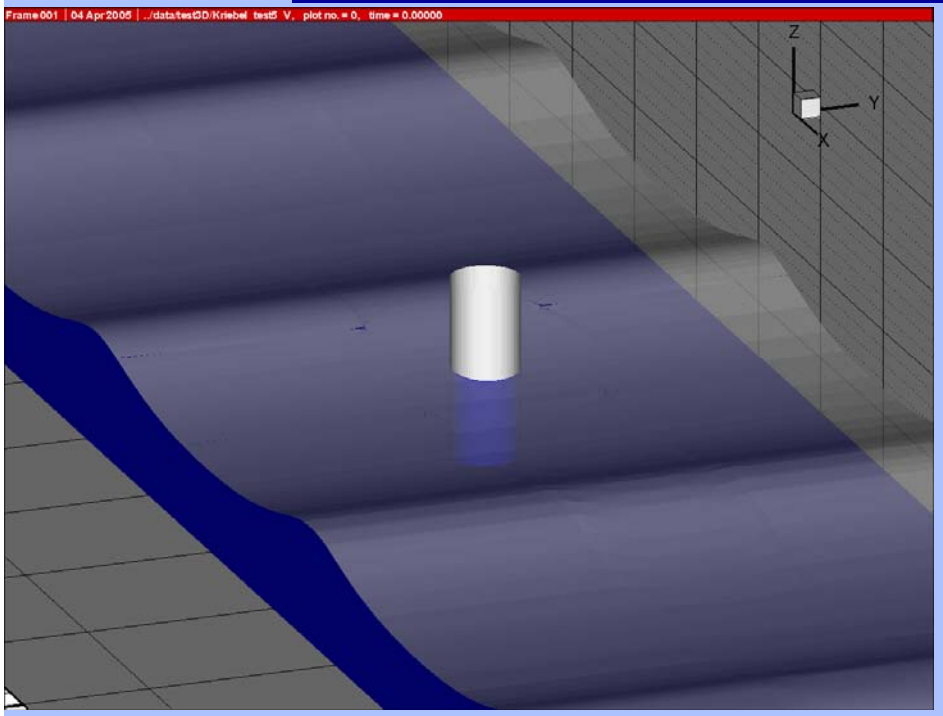
•Not included:
•The state of breaking
•full three-dimensional waves
•irregular waves
•general bed topography
•Reynolds effects

Validation for smaller waves

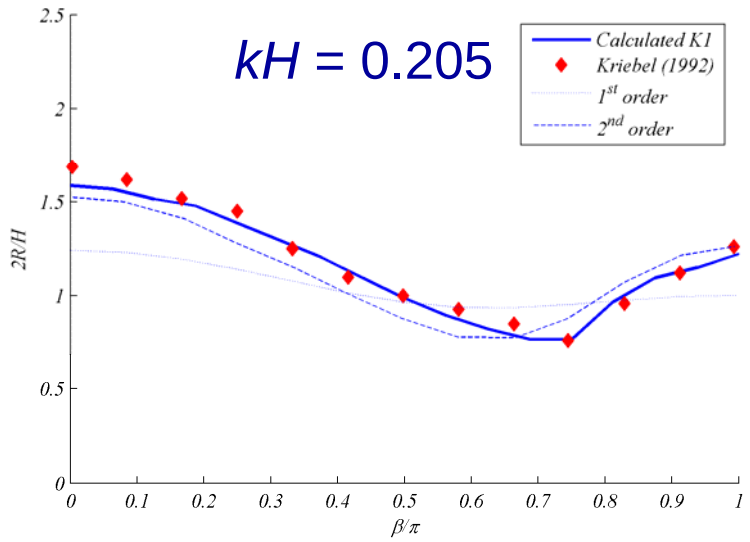
Test Cases for a cylinder on a horizontal plane bed compared to Kriebel (1992), which includes sensitivity of the run-up to the no of cells and time step

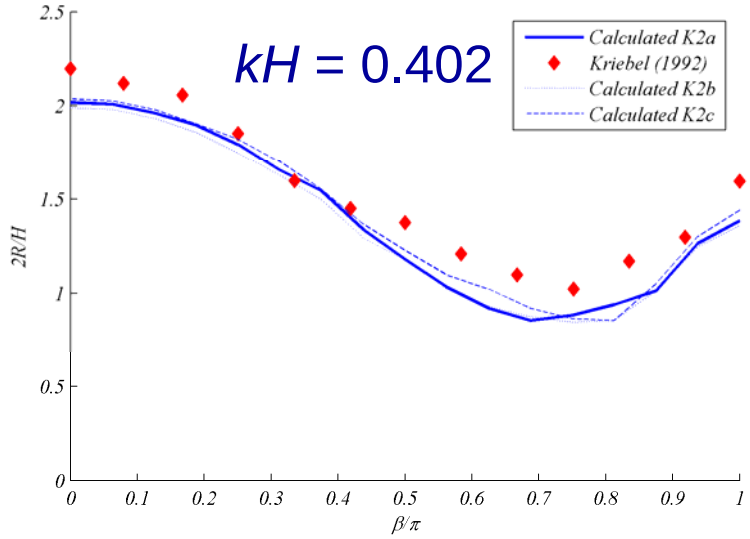
Test no.	kD/2	kh	kH	D (m)	H (m)	h (m)	L (m)	Δt (s)	No. Cells
K1	0.374	1.036	0.205	4	1.096	5.54	33.6	0.01	299008
K2a	0.374	1.026	0.402	4	2.19	5.54	33.6	0.01	299008
K2b	0.374	1.026	0.402	4	2.19	5.54	33.6	0.005	299008
K2c	0.374	1.026	0.402	4	2.19	5.54	33.6	0.01	503808

Comparison to Kriebel (1992)

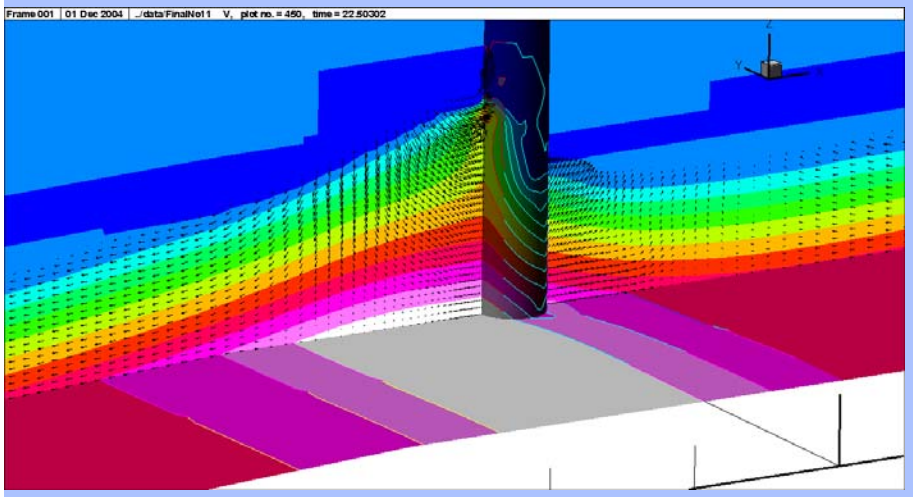


kH = 0.205 and *kh* = 1.036





Wave forces on a vertical cylinder



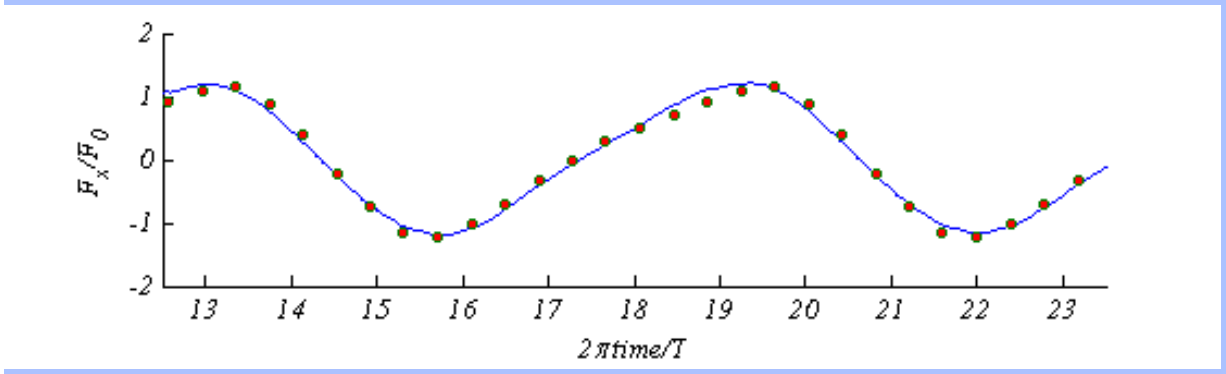
Test case: Kriebel (1998)

Periodic plane wave

$kH = 0.286$

$kh = 1.036$

$F_0 = ½ \rho g D H h (\tanh(kh)/kh)$



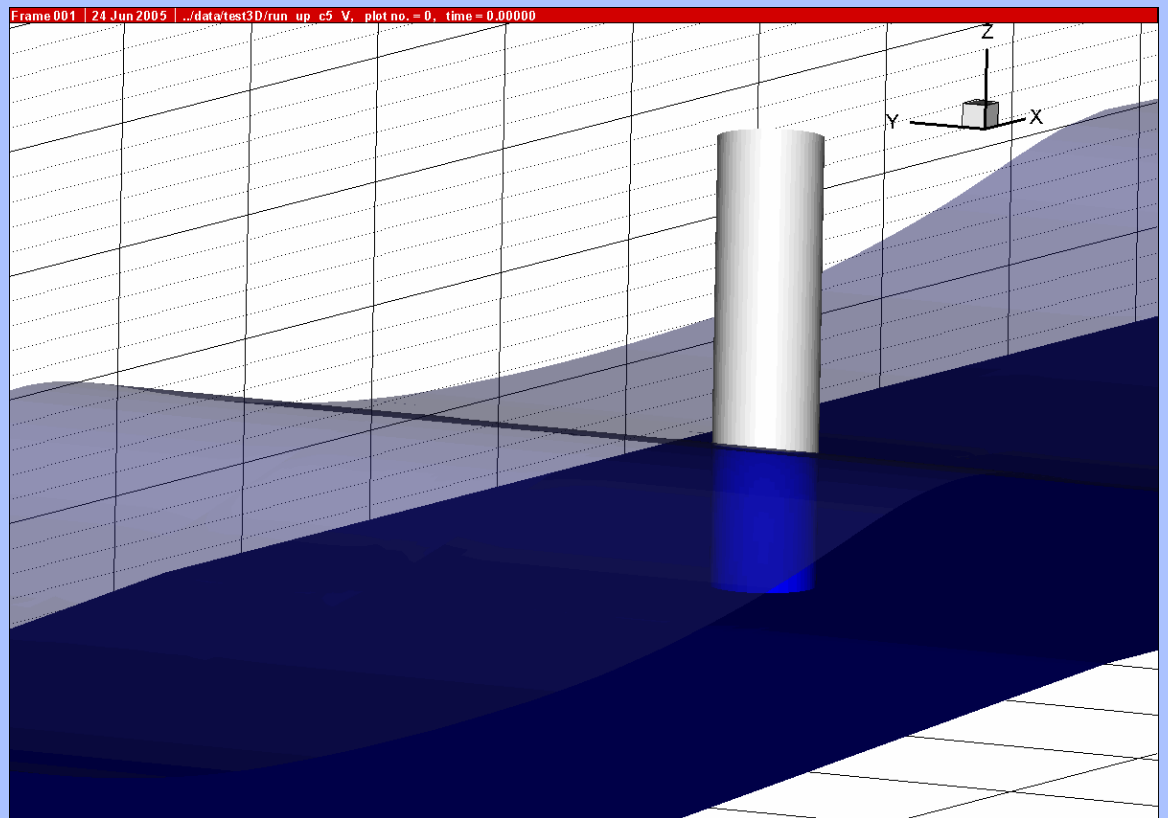
Equivalent to:

D = 4.00 m
h = 5.54 m
H = 1.53 m
T = 5.30 s

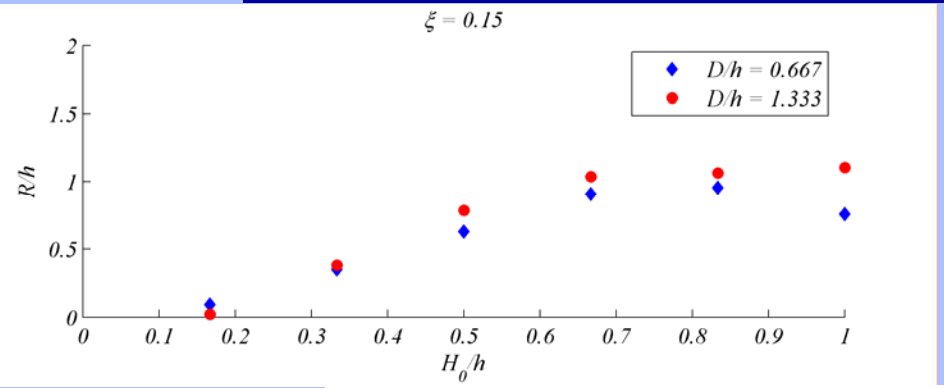
Example from an extreme case

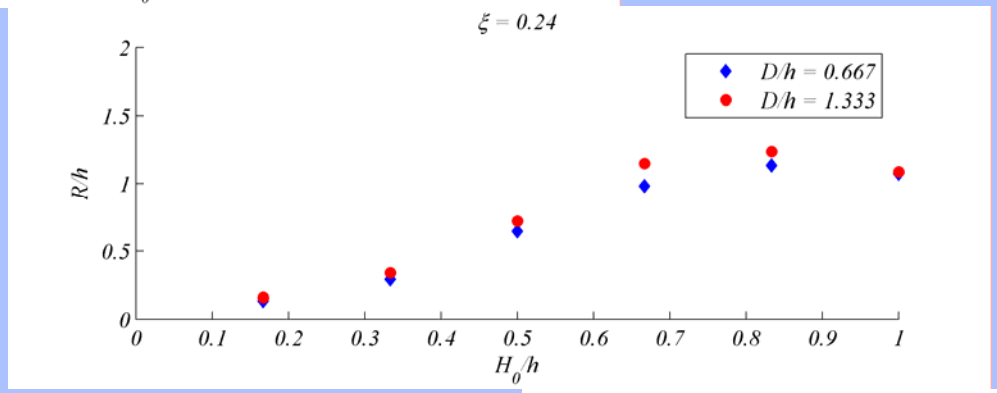
H_0 = 5.0 m, T = 8.65 s, h = 6 m,
slope 1:20, Dia = 4.0 m =>

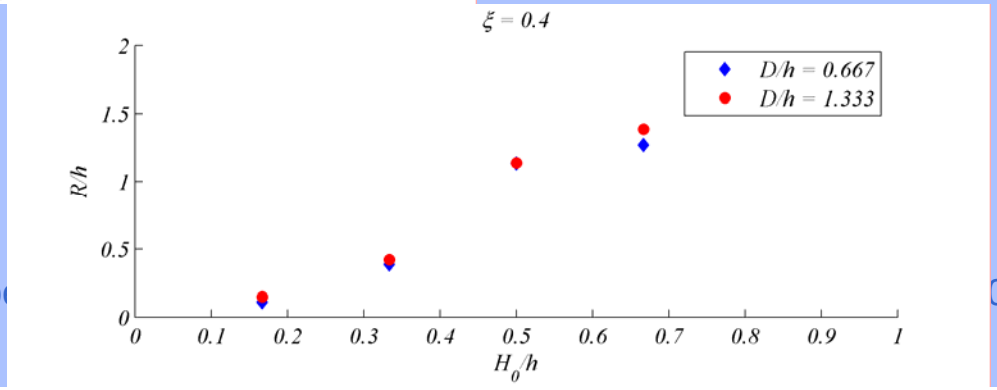
H0/h =0.83, T =11, ⊠$_0$ =0.24*
and D/h = 0.667



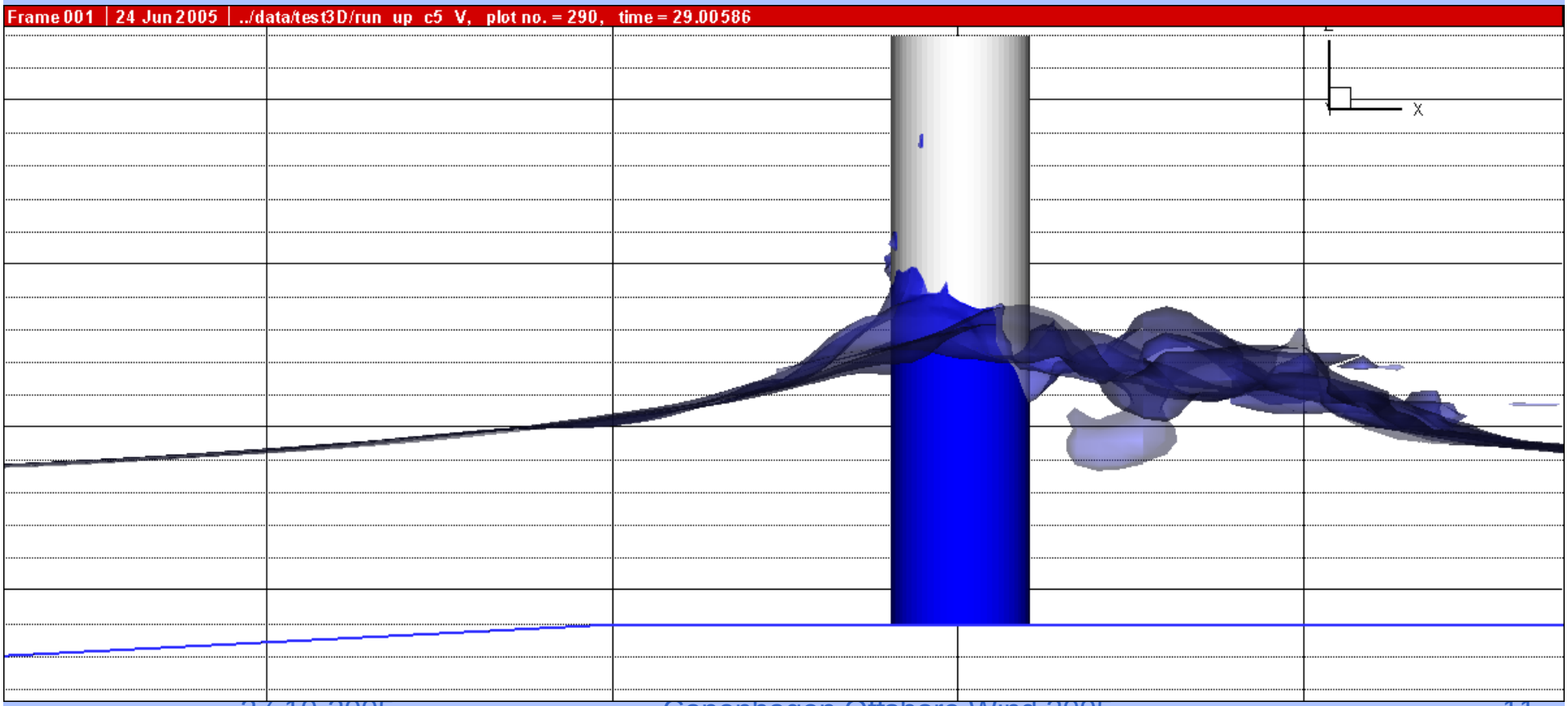
Dimensionless run-up



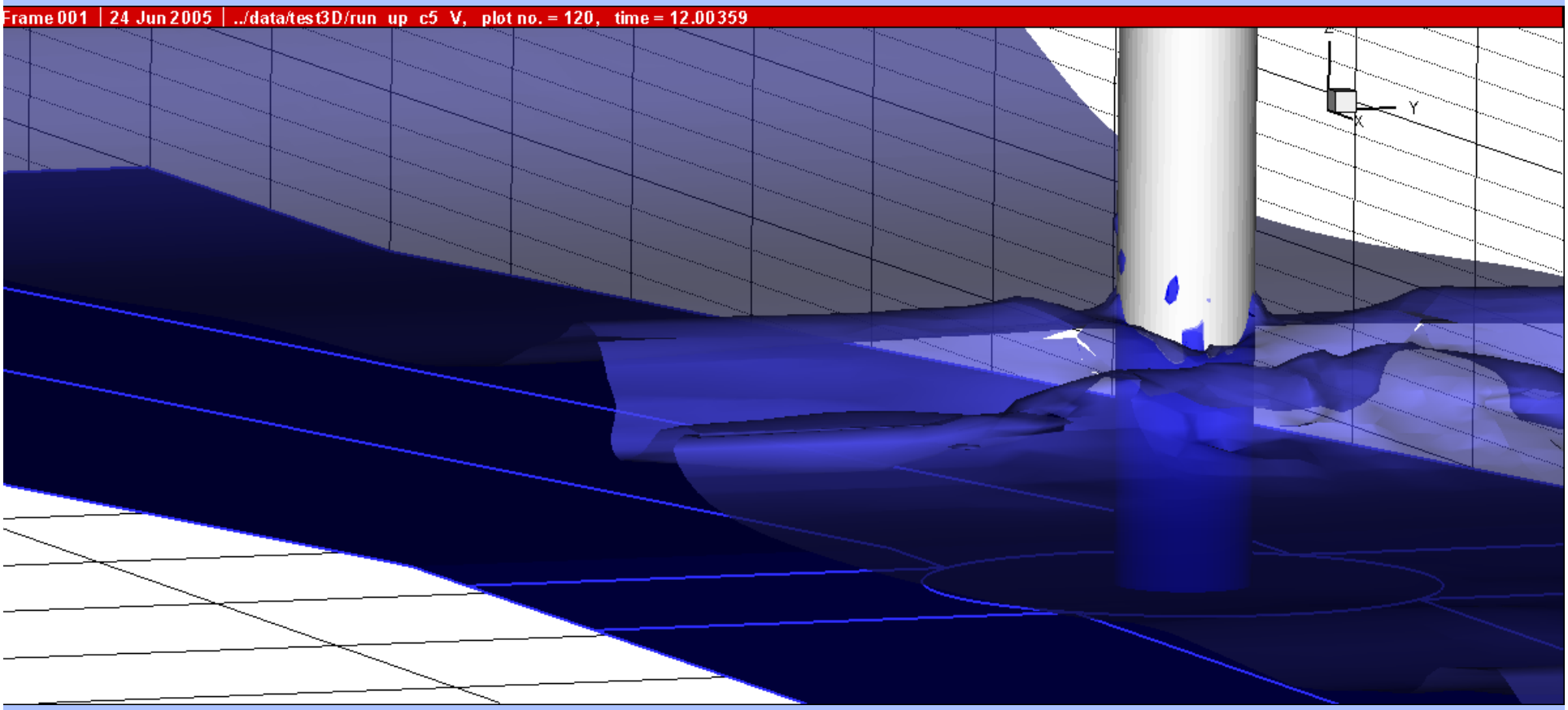




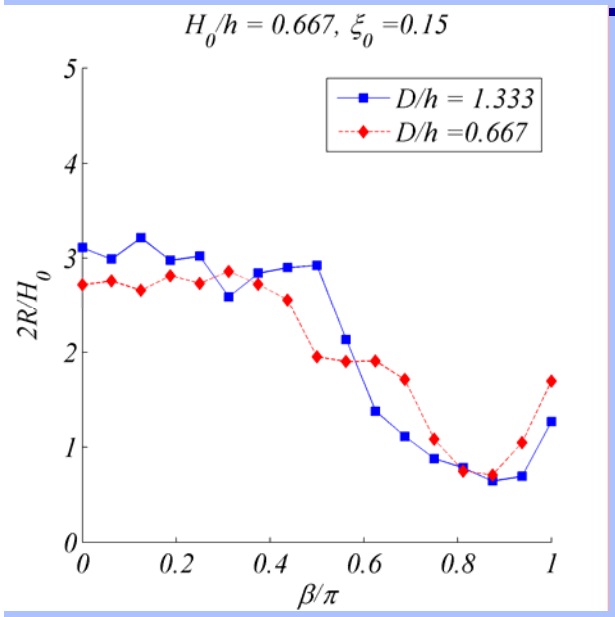
Effect of the stage of breaking

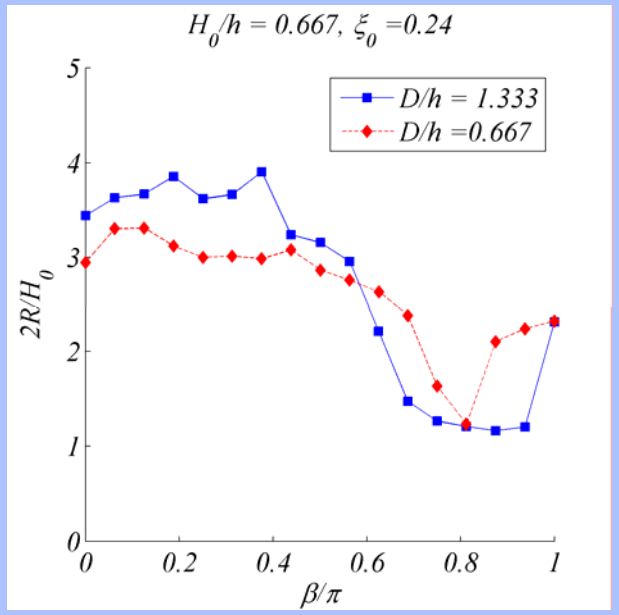


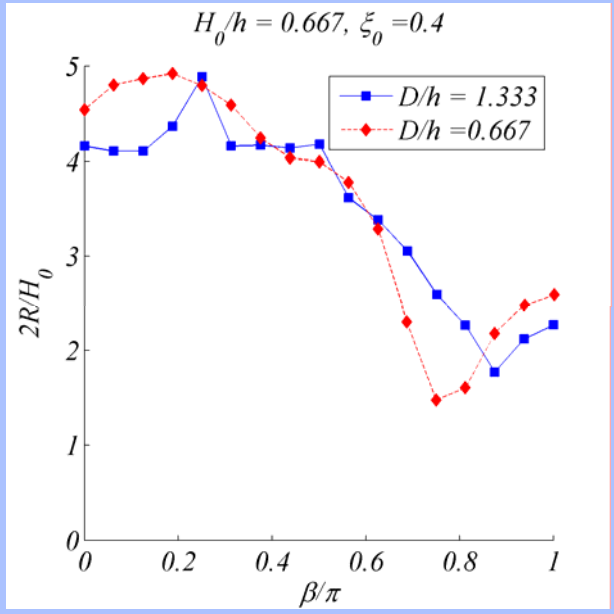
Run up around the cylinder



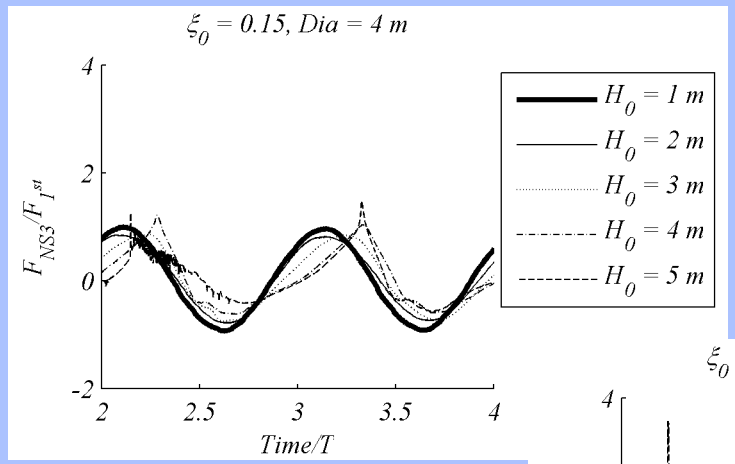
Wave run-up on a cylinder

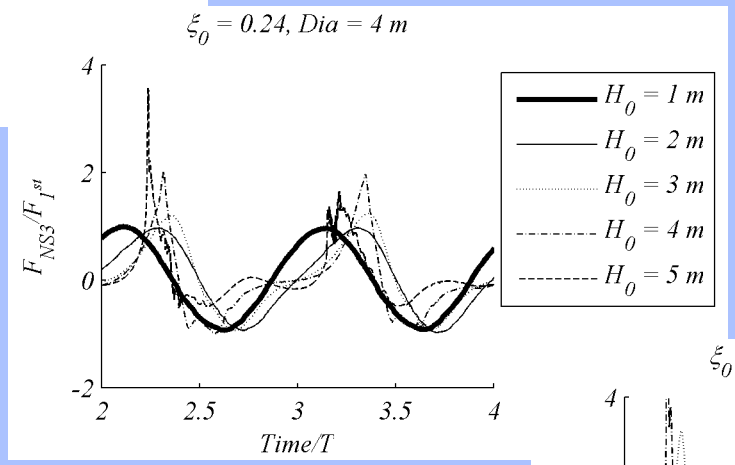


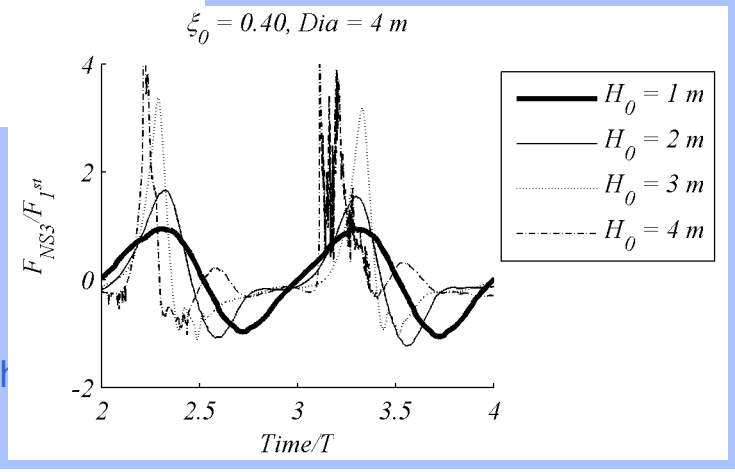




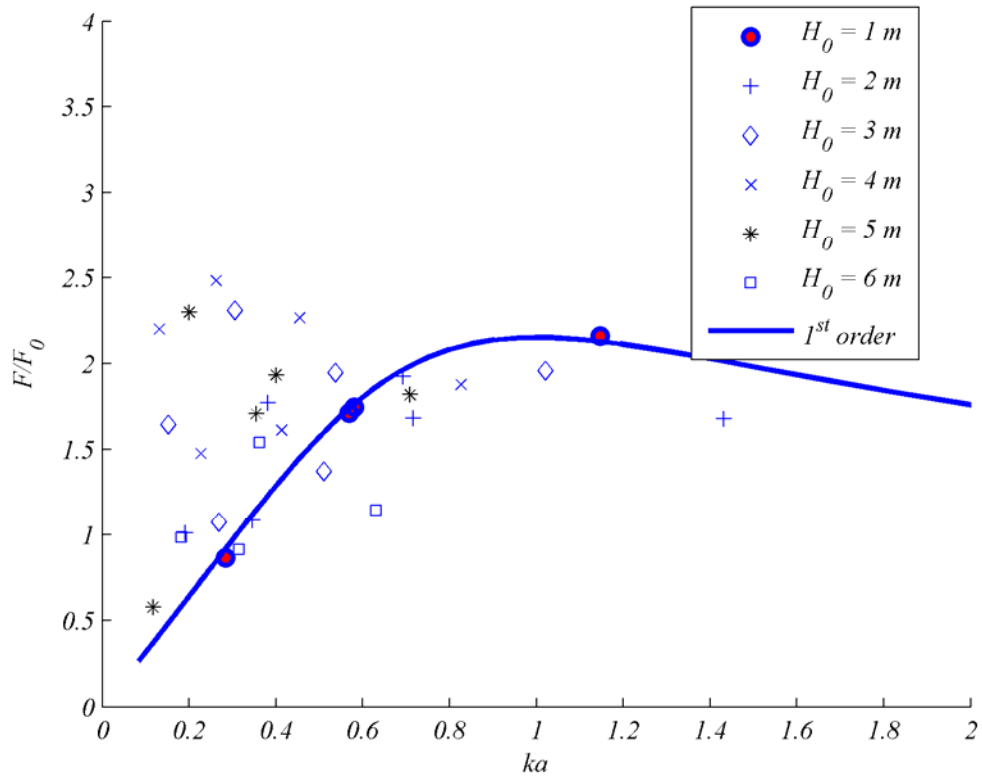
Peak force and breaker type







Maximum horizontal force, all 30 cases



a: radius

k: wave number

F_0 = ½□gDHh(tanh(kh)/kh)

The full blue line is the maximum 1st order diffraction force

Summary and conclusions

- Comparison of the modelled results to Kriebel (1992) shows a good agreement for run-up and horizontal force.
- For very high waves => slight underestimation of the run-up, which can be improved with a finer grid-resolution
- The breaking of waves have a major impact on the run-up
- The run-up is largest when the wave is just about to break.
- The peak force increase when the breaker type goes from spilling to plunging.
- The maximum peak force is at least up three times larger than the reference diffraction force
- A full three-dimensional sea might create unstable waves, even without a sloping bed.