

2010 EUROPEAN HYPERWORKS TECHNOLOGY CONFERENCE

3D Numerical investigations of ship-induced waves in
restricted waterways
by Radioss-Altair software

S. JI (PH.D, UTC-Compiègne)

A. OUAHSINE (Prof UTC-Compiègne)

P. SERGENT (Ing. Chef Ponts Chaussées, HDR)

H. SHAKOURZADEH (PH.D ,ALTAIR)

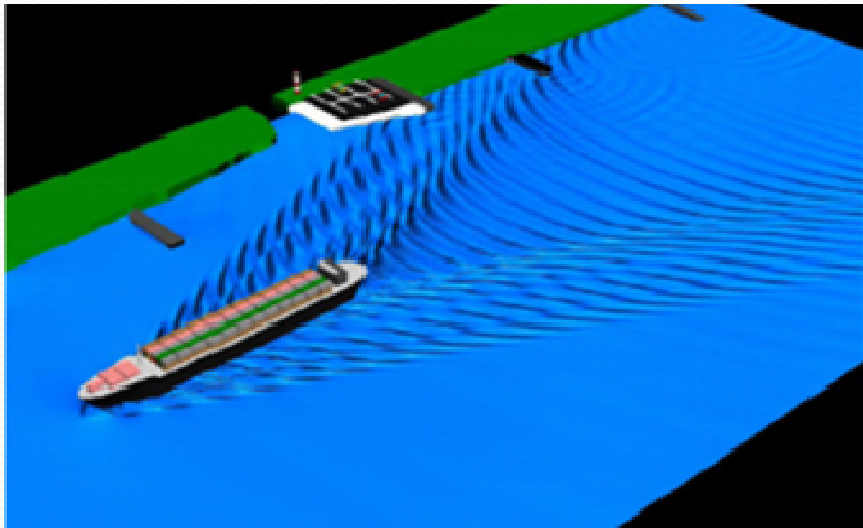


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- **Physical problem**
- **Formulation of the numerical Model**
- **Results and analysis**
- **Conclusions**

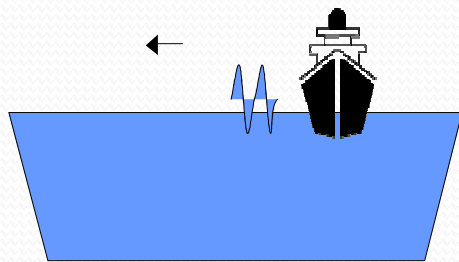
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Physical problem

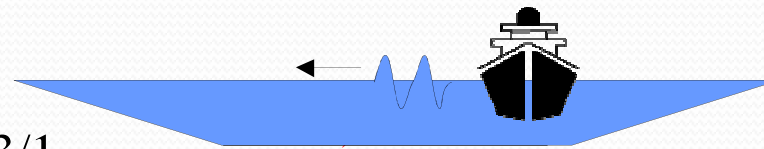


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Usual banc Profil

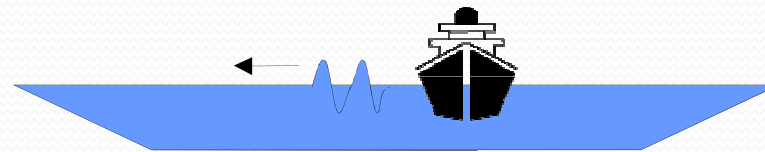


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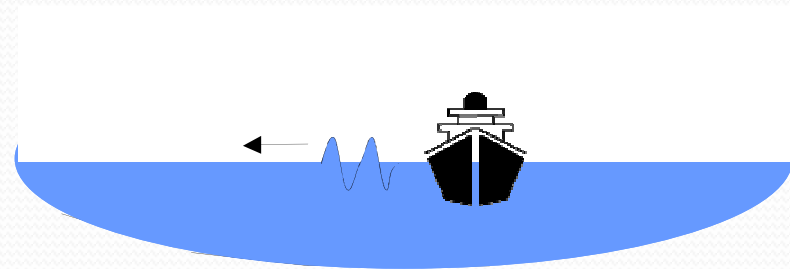


Profil allemand

2/1



Profil français



Profil hollandais

Formulation of the problem

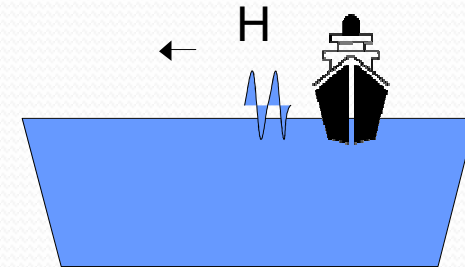
The maximum wave height (H) depends on:

Ship speed (V)

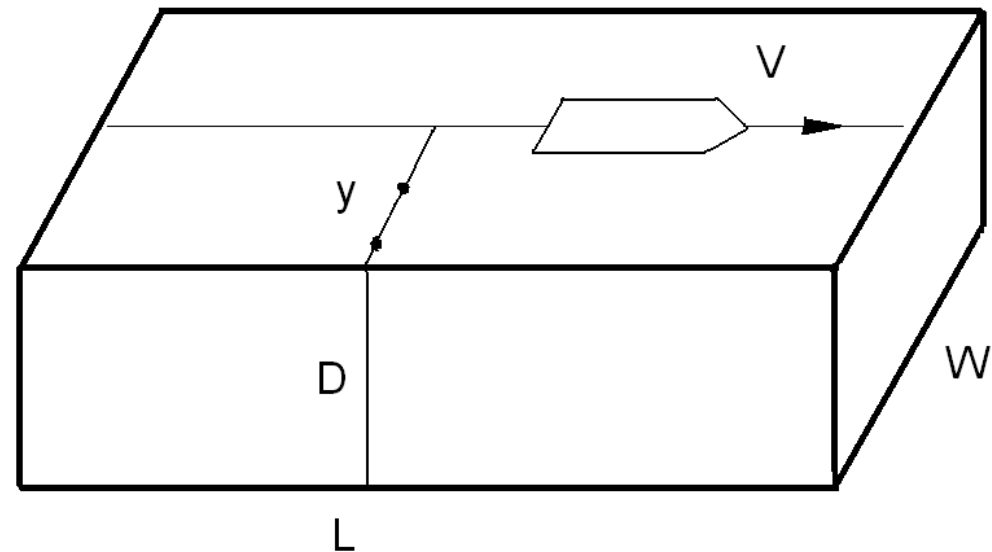
Distance from sailing line (y)

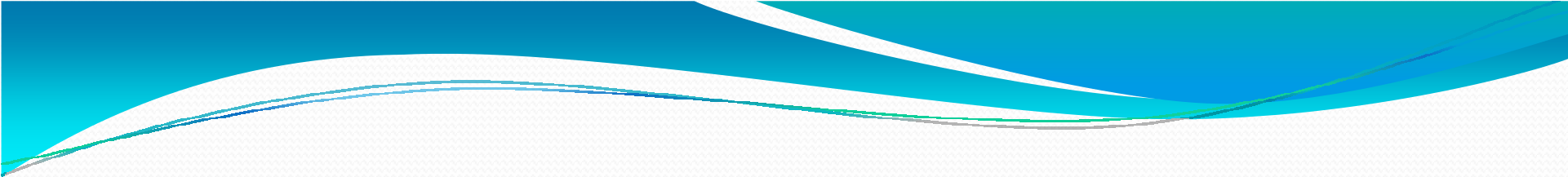
Water depth (D)

Hull form γ



$$\frac{D}{L} \ll 1 \quad \text{For Shallow Water}$$




$$H = \gamma \cdot y^n \quad n = -1/3 \quad \text{in Deep Water}$$

$$Fn = \frac{V}{\sqrt{gD}}$$



$Fn \leq 0.65$ Deep Water

$0.65 < Fn < 1.2$ intermediate Water

$Fn > 1.2$ Shallow Water

- **Model building**

Domain dimensions:

Domain Dimensions				
Domain	L(m)	w(m)	D(m)	
Water	7.00	3.00	0.350	
Air	7.00	3.00	0.150	
Main dimensions of Ship Model				
L(m)	B(m)	T(m)	C_B	Displ.[kg]
1.85	0.250	0.084	0.400	14.5

T is Draught

$$\frac{D}{L} = \frac{0.35}{7} = 0.05 \ll 1$$

for shallow water approximation.



- **Model building**

Two types depends on fluid model and contact type

Model 1:

Fluid model: N-S equations for Biphases (LAW₃₇)

Structure model: rigid body mouvement.

Contact: Interface 18

Model 2:

Fluid model: LES model (LAW 46)

Structure model: rigid body mouvement

Contact: Interface 9



- **Model building**

Model 1:

Fluid meshes : Hexahedron meshes for domain

Dimensions: x: 0.05m
 y:0.05m
 z:0.02m~0.15m

Ship meshes: Shell boat

Dimensions: x,y,z: 0.055m

- **Model building**

Model 2:

Fluid meshes : Hexahedron

[meshes for water](#)

Dimensions: x: 0.05m

y:0.05m

z:0.025m

Ship meshes: Hexahedron

[boat](#)

Dimensions: x,y,z: 0.053m



- **Model building**

Parameters for type one:

Water:

Density: 1000kg/m^3

bulk modulus: 2.089GPa

Shear kinematic viscosity: $10^{-6}\text{m}^2/\text{s}$

Bulk kinematic viscosity: $10^{-20}\text{m}^2/\text{s}$

Air:

Density: 1.22kg/m^3

Perfect gas constant: 1.4

Initial pressure: 10^5Pa

Shear kinematic viscosity: $1.461\text{E}-10^{-5}\text{m}^2/\text{s}$

Bulk kinematic viscosity: 0



- **Model building**

Interface 18:

Gap: 0.05m

STFAC: 350

Multimp: 4

The others are set by defaults

The quality of the results using this interface 18 depends strongly on the interface parameters and especially on the stiffness of the interface(STFAC)

Results with different parameters for comparison at [Measure point A](#).

Time step: 0.021s or steps initial (10^{-5} s).

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- **Model building**

Parameters for type two:

Water:

Density: 1000kg/m³

Speed of sound: 50m/s

Molecular kinematic viscosity: 5.45E-10⁻⁵ m²/s

Sub-grid scale model: no

The others are set by defaults.



- **Model building**

Interface 9:

Coulomb friction: 0

Gap: 0.003m

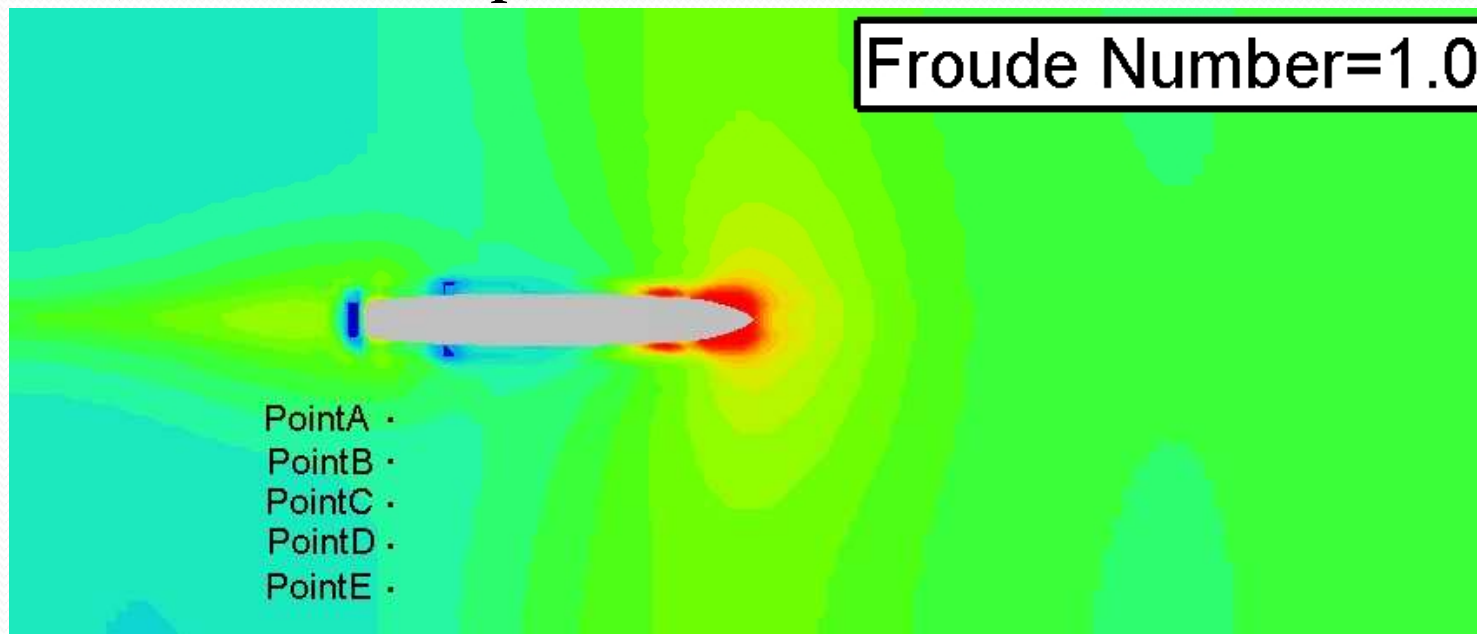
Full upwind for free surface normal computation

Surface tension: 0

Time step: initial

- **Results and analysis.**

Model 1 :(initial time step)



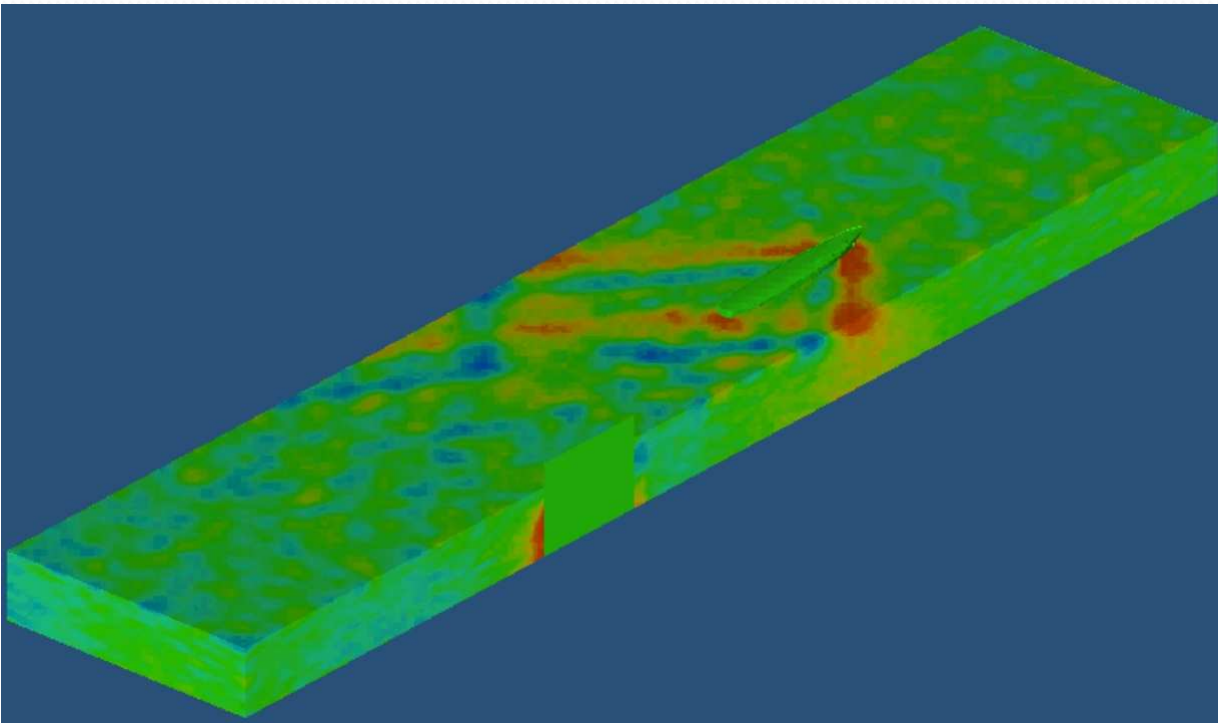
Pressure distribution at $Fn=1.0$

Model 2: velocity distribution contour velocity distribution vector

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- **Results and analysis.**

Model 1:(time step: 0.0211s)

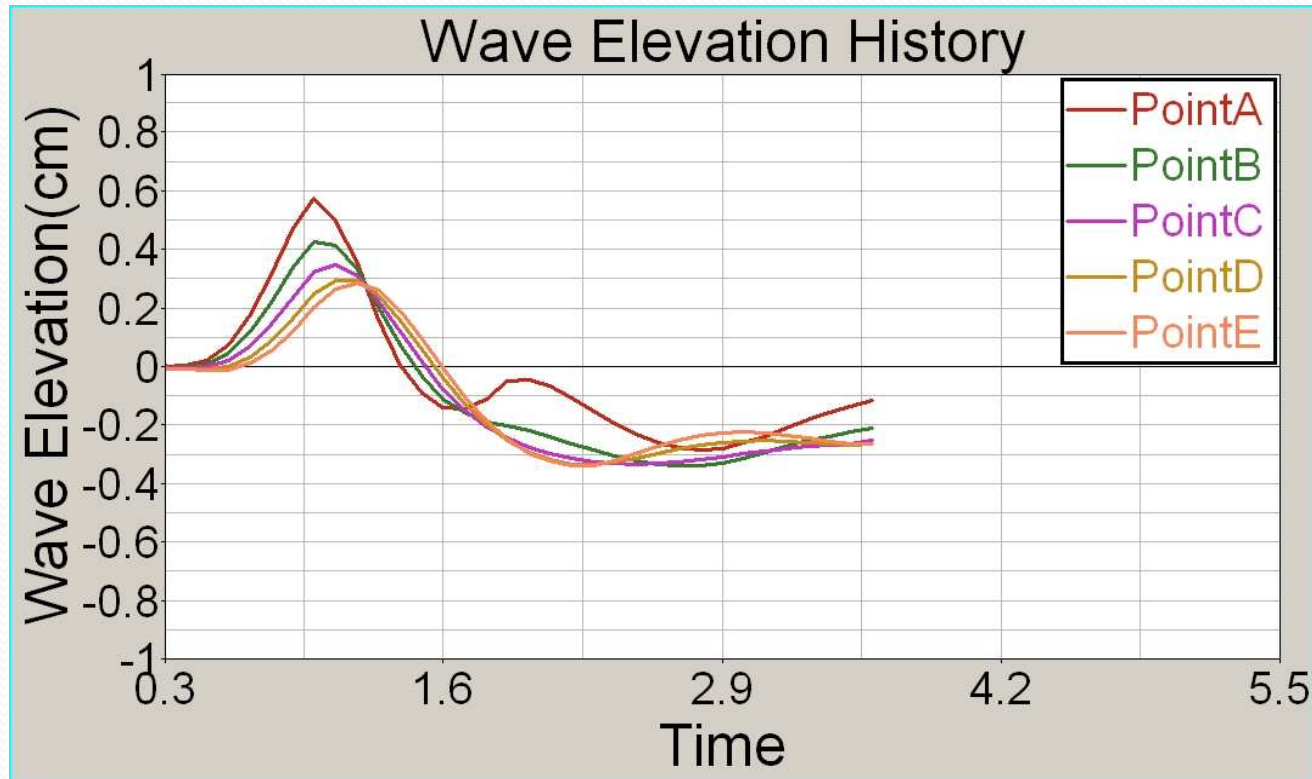


1. Very large added mass(10^7kg)
2. Very small fluid velocity ($10^{-6}\text{--}10^{-7}\text{m/s}$)

Pressure distribution at $Fn=1.0$

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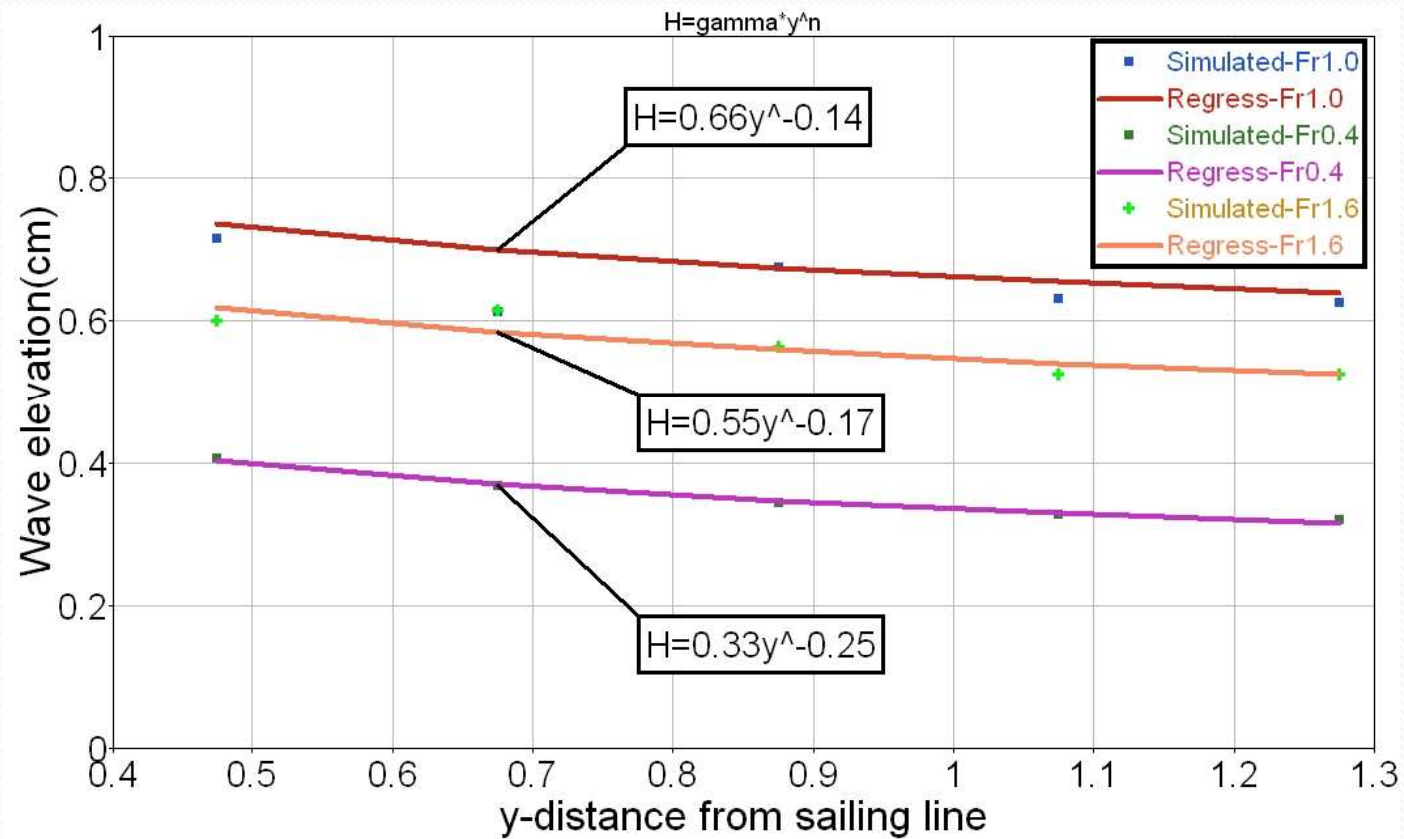
- **Results and analysis.**



Wave elevation histories of points A-E

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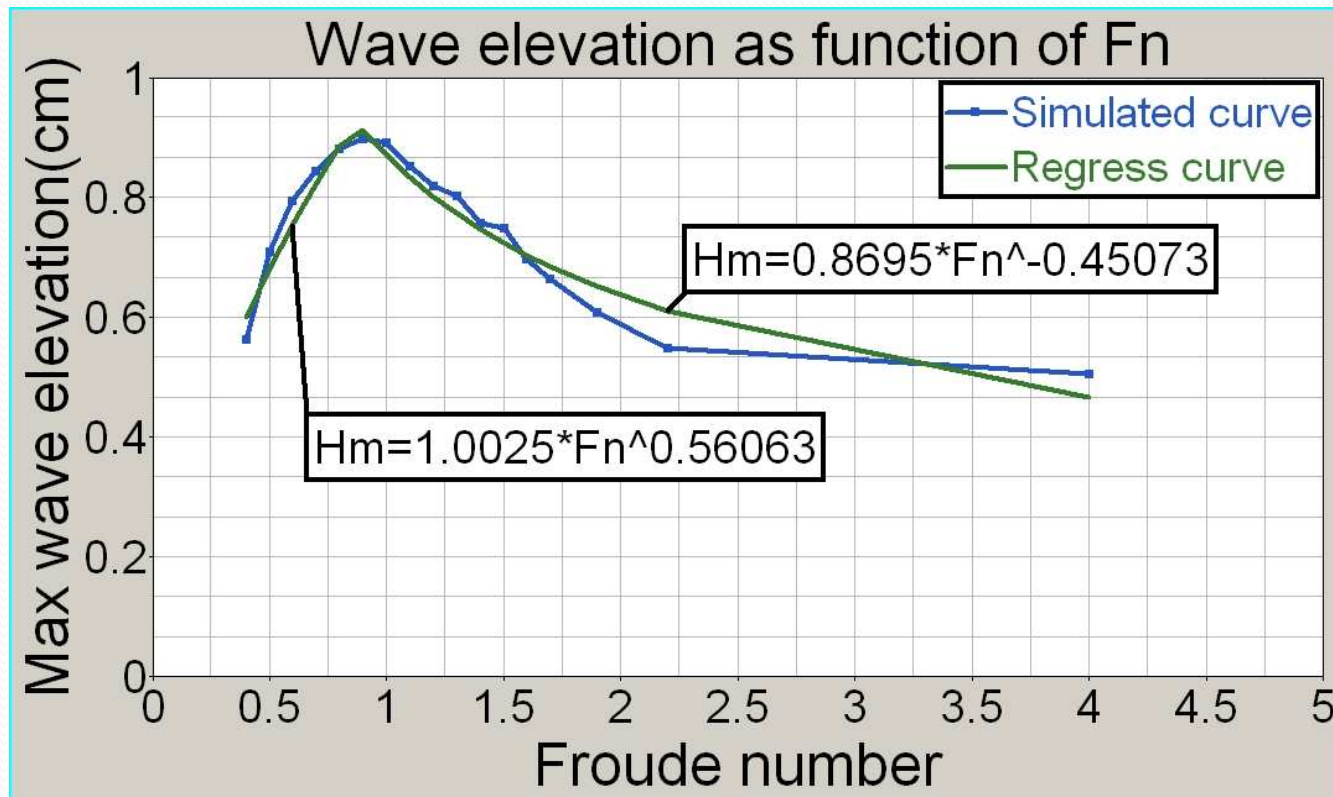
• Results and analysis



The maximum wave height as function of y

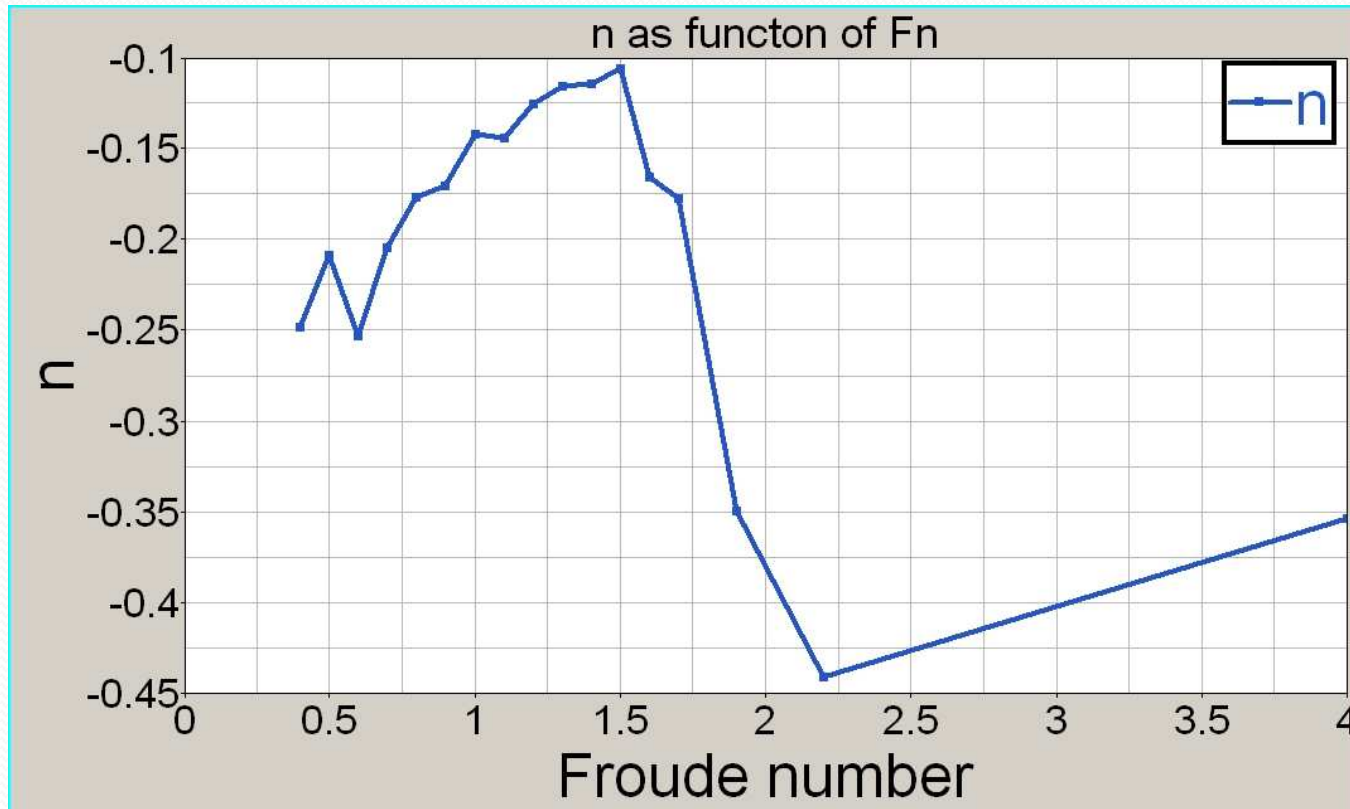
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- **3.Results and analysis.**



Wave elevation histories of points A

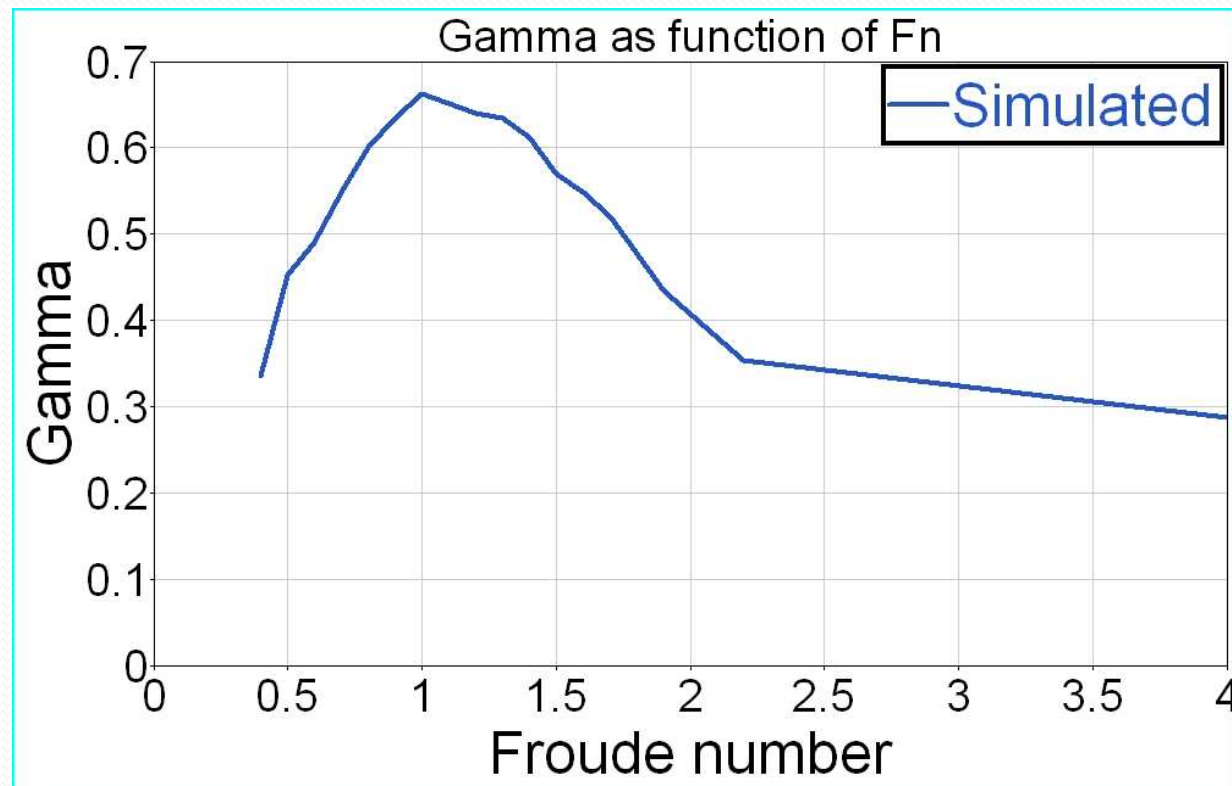
$$H = \gamma \cdot y^n$$



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- Results and analysis.

$$H = \gamma \cdot y^n$$



The coefficient γ which could stand for the hull's shape effects

• Conclusions

1. The max wave elevation varies significantly depending on the Froude number, The peak occurs at Froude number= 0.9.
2. Because of the bottom's influence, the wave decay coefficient n changes from -0.11 to -0.44 as function of Froude number. While in deep water, it keeps constant
3. By using the fluid model LAW37 , the solver Radioss performs well the interaction between fluid and structure with the interface 18 for contact by explicit scheme.
But it is time consumed with time step about 10^{-5} s.



Thank you for your attentions.

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