3rd DualSPHysics Users Workshop
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COUPLING BETWEEN DUALSPHYSICS AND SWASH MODELS AND LATEST APPLICATIONS TO COASTAL ENGINEERING PROBLEMS

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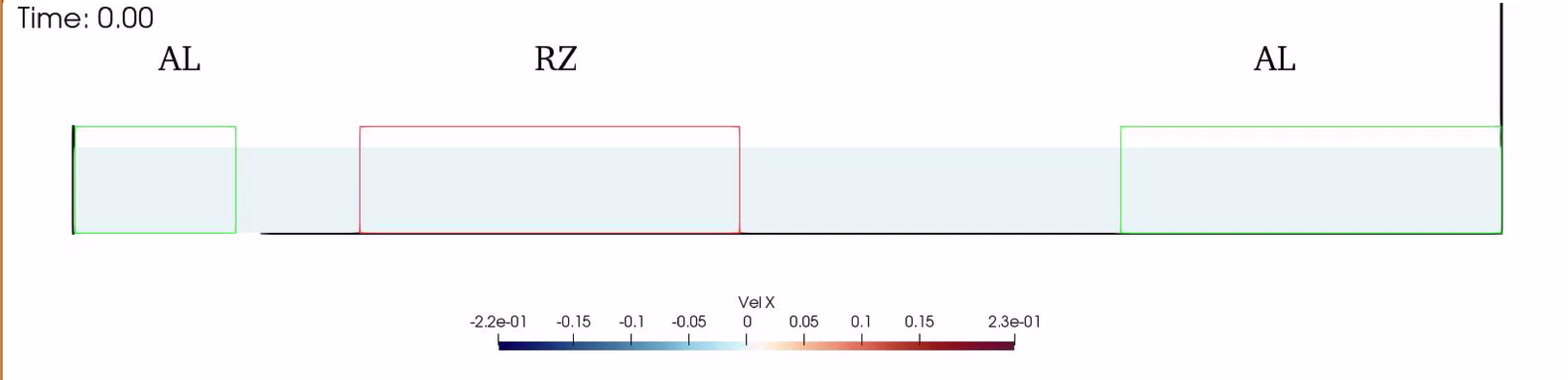
INTRODUCTION

User: I’d like to generate (water) waves!
Corrado: We’ve got a RZ!
User: How can I use that?
Corrado: Well…
Simplicio: That won’t work…

INTRODUCTION



Design the Relaxation zone means fixing:

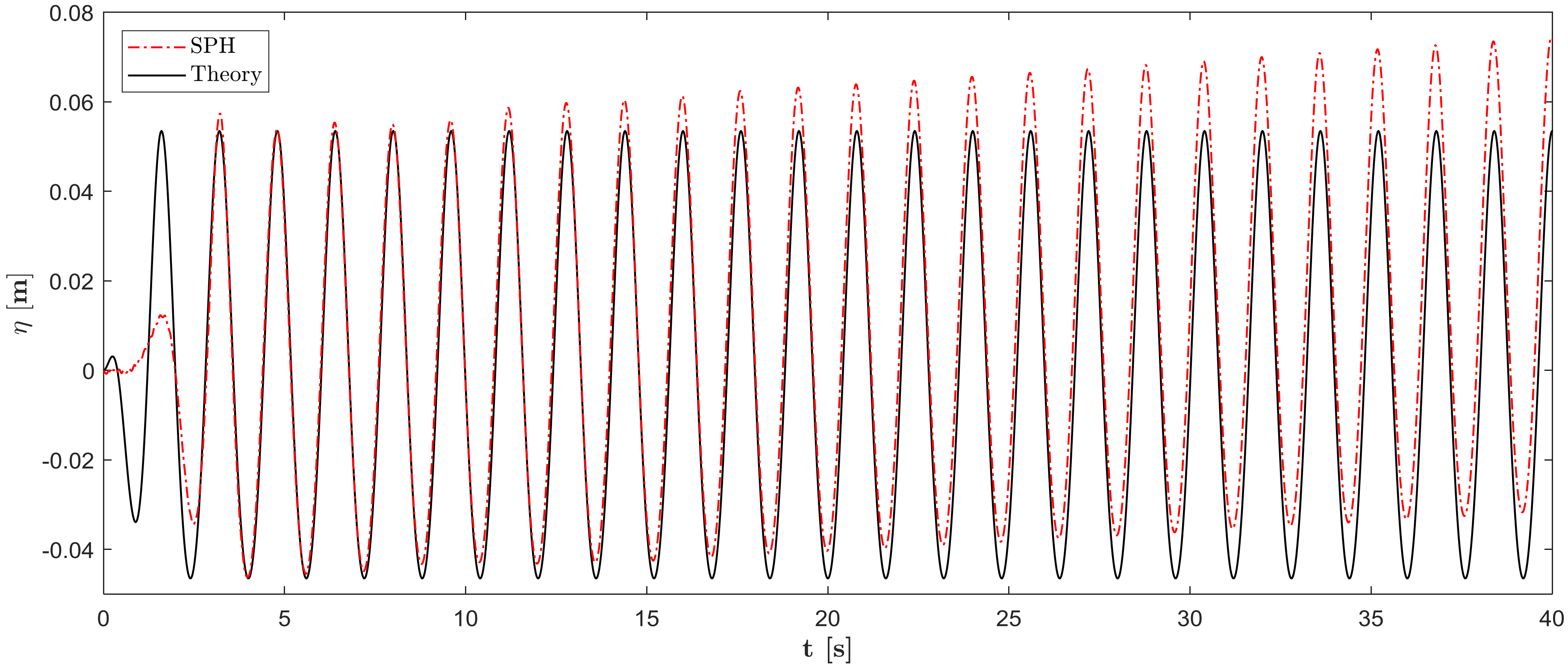
W_{RZ} width of RZ

α, β C-function parameters

INTRODUCTION

0. Wave generation using Relaxation Zone tool in DualSPHysics

mass drift!



INTRODUCTION

0. Wave generation using Relaxation Zone tool in DualSPHysics

According to the Stokes' equations,

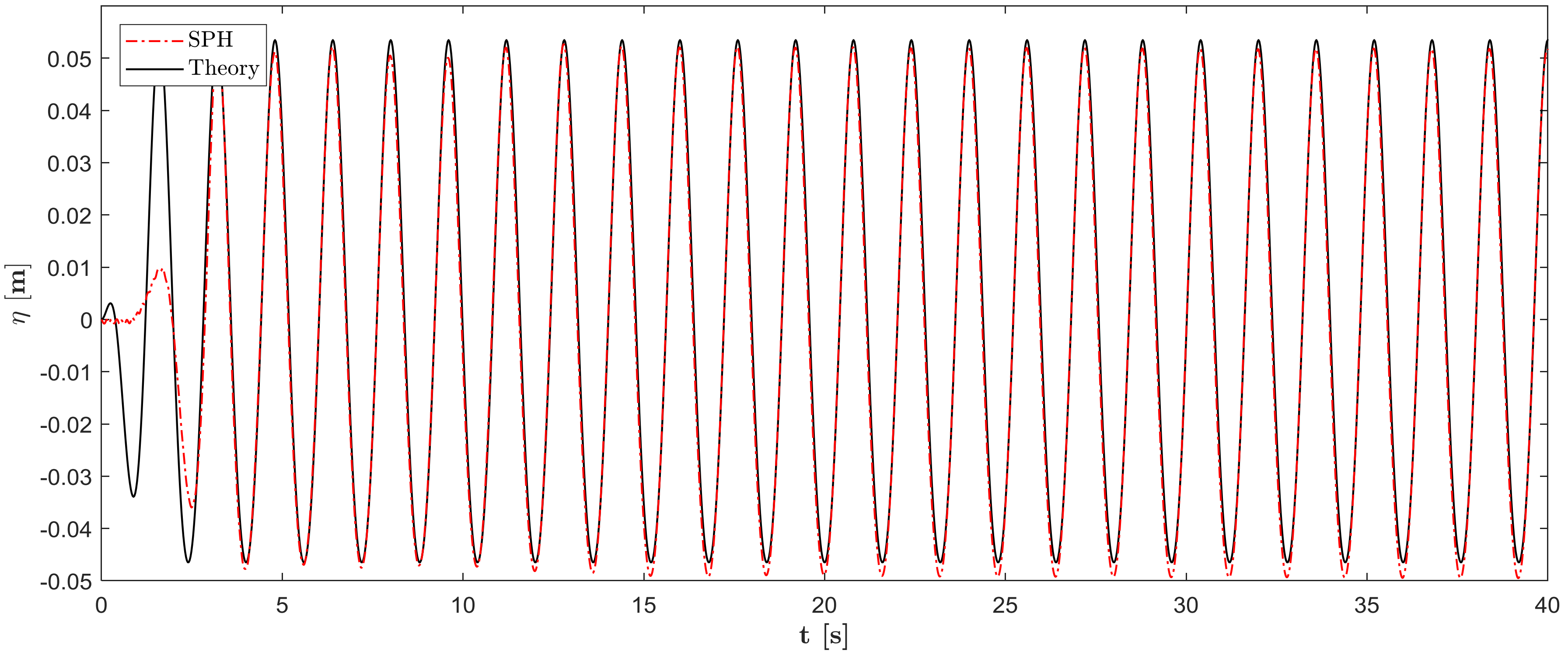
$$\overline{U}(z) = \frac{\xi(\tilde{x}, \mathrm{z}, \mathrm{T}) - \xi(\tilde{x}, z, 0)}{T} = (\frac{\pi H}{L})^2 \, \frac{C}{2} \frac{\cosh\left[\frac{4\pi(z+d)}{L}\right]}{sinh^2\left(\frac{2\pi d}{L}\right)}$$

Now we subtract this term from the theoretical velocity field

INTRODUCTION

0. Wave generation using Relaxation Zone tool in DualSPHysics

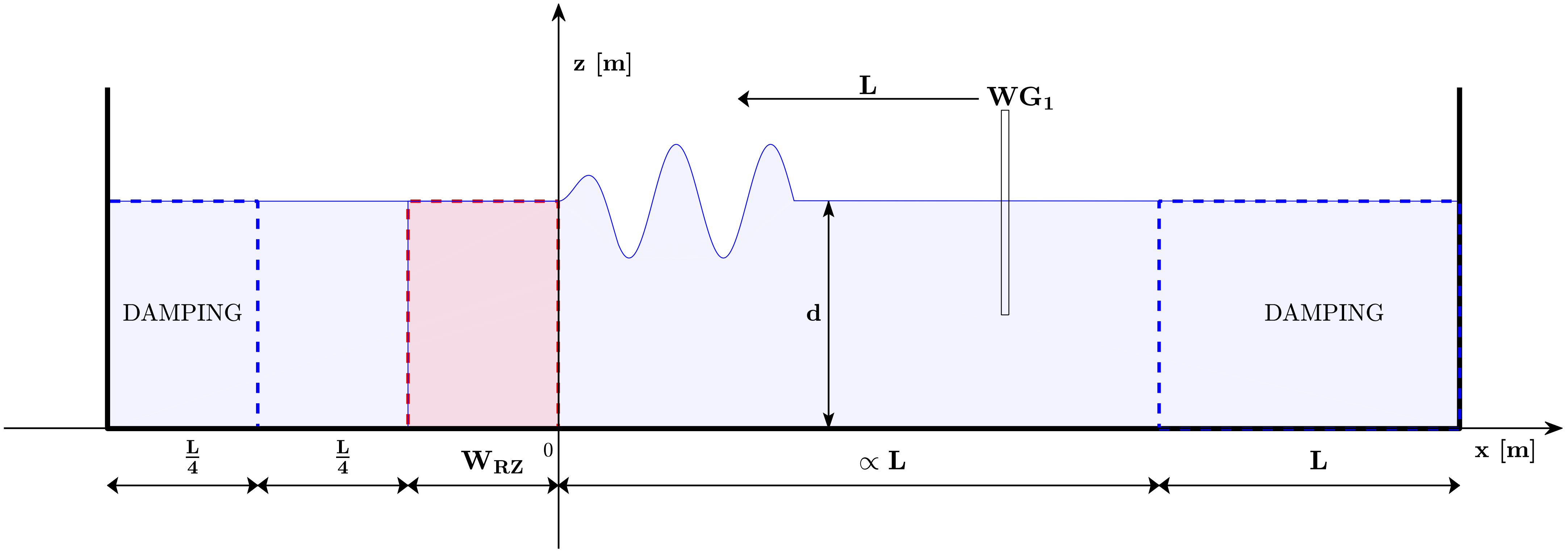
drift correction=ON



1) VALIDATION OF WAVE GENERATION

VALIDATION OF WAVE GENERATION

1. Model setting



VALIDATION OF WAVE GENERATION

2. Definition of Effective Width - W_{eff}

$$W_{eff} = (\chi_2 - \chi_1) \cdot W_{RZ} \; [m]$$

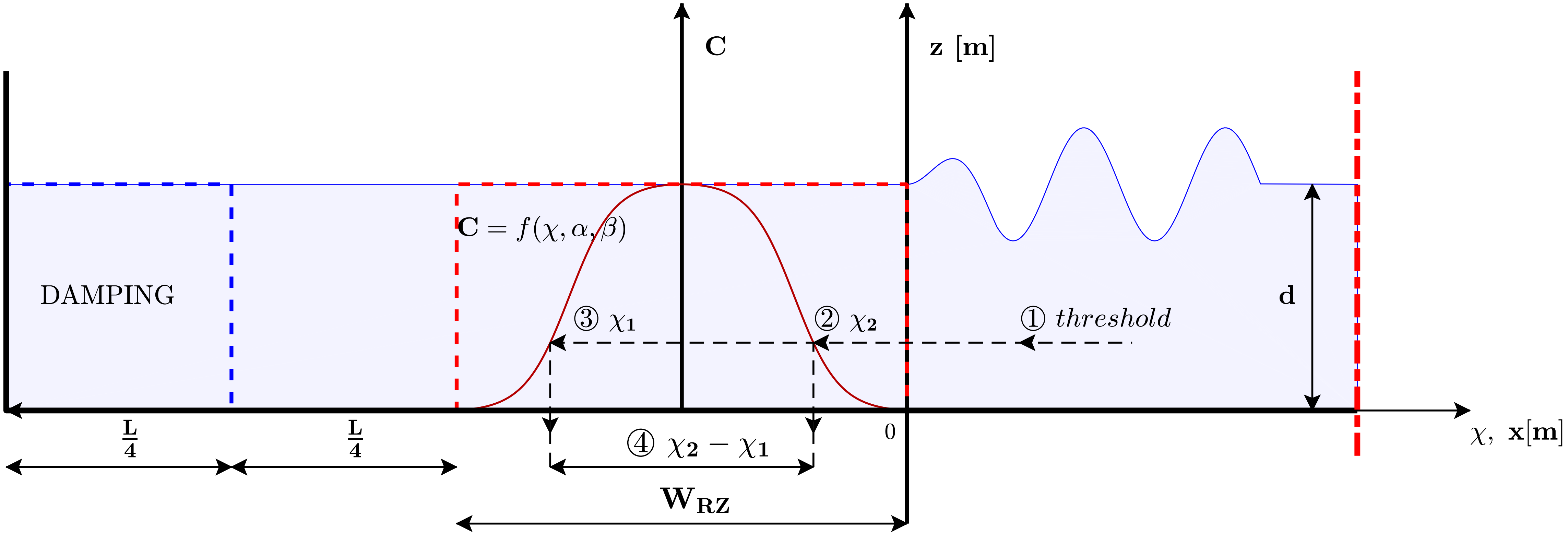
where

$$\chi_1 \;\; \| \; C(\chi, \alpha, \beta) = threshold \cup \chi \ni [-1, 0]$$

$$\chi_2 \;\; \| \; C(\chi, \alpha, \beta) = threshold \cup \chi \ni [0,1]$$

VALIDATION OF WAVE GENERATION

2. Definition of Effective Width - W_{eff}



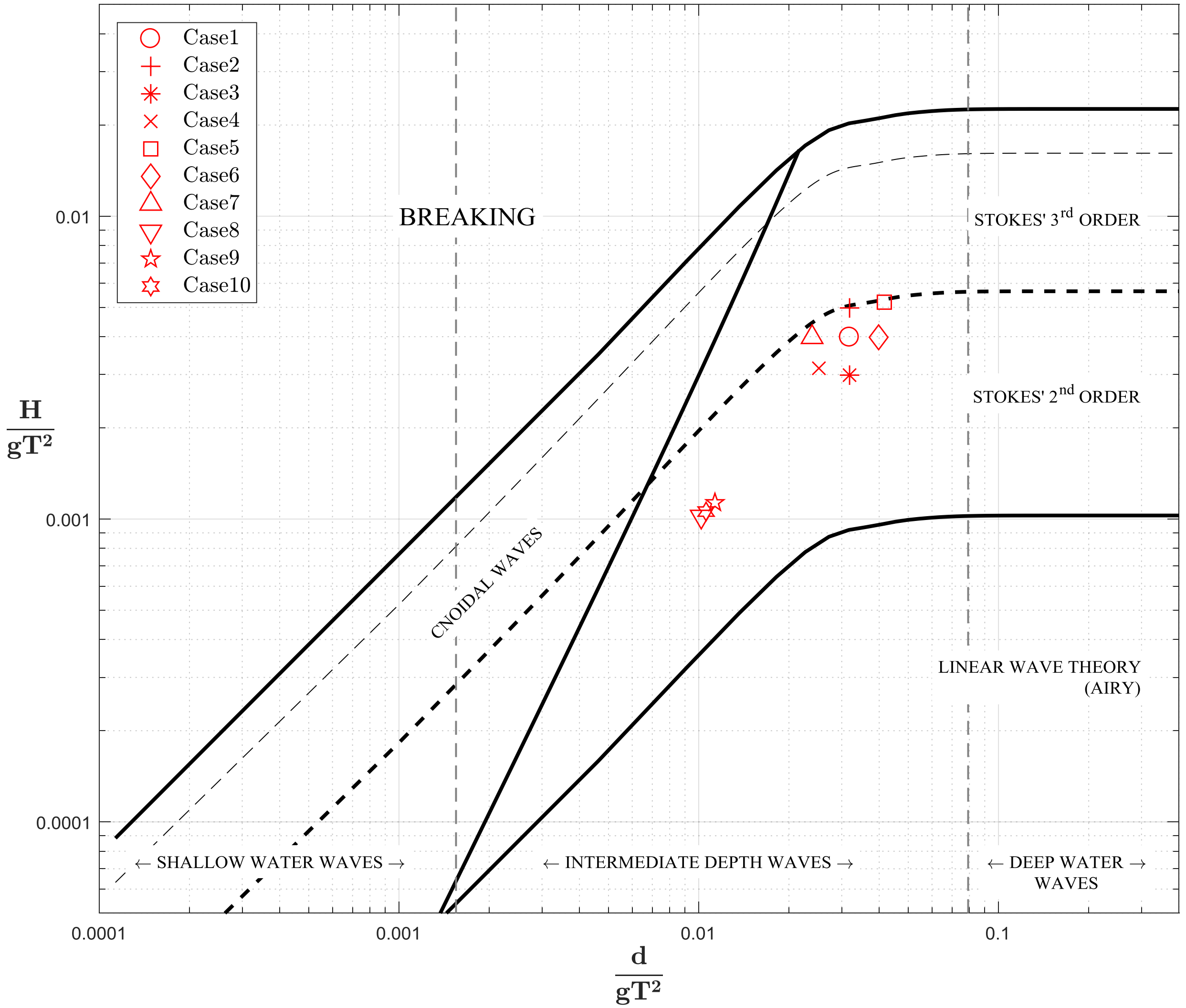
VALIDATION OF WAVE GENERATION

3. Definition of benchmark tests – Wave conditions

Case	Height [m]	Period [s]	Depth [m]	Length [m]	Steepness [%]
1	0.100	1.60	0.80	3.55	**2.82**
2	0.125	1.60	0.80	3.55	**3.52**
3	0.075	1.60	0.80	3.52	**2.11**
4	0.100	1.80	0.80	4.22	**2.38**
5	0.100	1.40	0.80	2.88	**3.47**
6	0.100	1.60	1.00	3.73	**2.68**
7	0.100	1.60	0.60	3.27	**3.06**
8	0.040	2.00	0.40	3.69	**1.08**
9	0.100	3.00	1.00	8.69	**1.15**
10	**0.030**	**1.70**	**0.30**	**2.71**	**1.11**

VALIDATION OF WAVE GENERATION

3. Definition of benchmark tests – Wave conditions (defined according Le Mehaute 1968)



VALIDATION OF WAVE GENERATION

3. Definition of benchmark tests – Numerical setting

For each case, the simulations have been repeated using

$$W_{RZ} = [\frac{1}{4}, \frac{1}{6}, \frac{1}{8}, \frac{1}{10}, \frac{1}{12}] \cdot L$$

$$\alpha = [\,0.1, 0.2, 0.3, 0.4, 0.5, 0.7]$$

$$\beta = [5, 7, 9]$$

Total=900 simulations

VALIDATION OF WAVE GENERATION

4. Analysis – Error estimation

Error in wave height

$$\epsilon = \left(mean^{40s} \frac{|H_{SPH} - H_{Th}|}{H_{Th}} \right) \cdot 100\ [\%]$$

Error in wave height in term of initial interparticle distance

$$\epsilon_h = \left(mean^{40s} \frac{|H_{SPH} - H_{Th}|}{h_{SPH}} \right) \cdot 100\ [\%]$$

where:

H_{SPH} is the numerical wave height

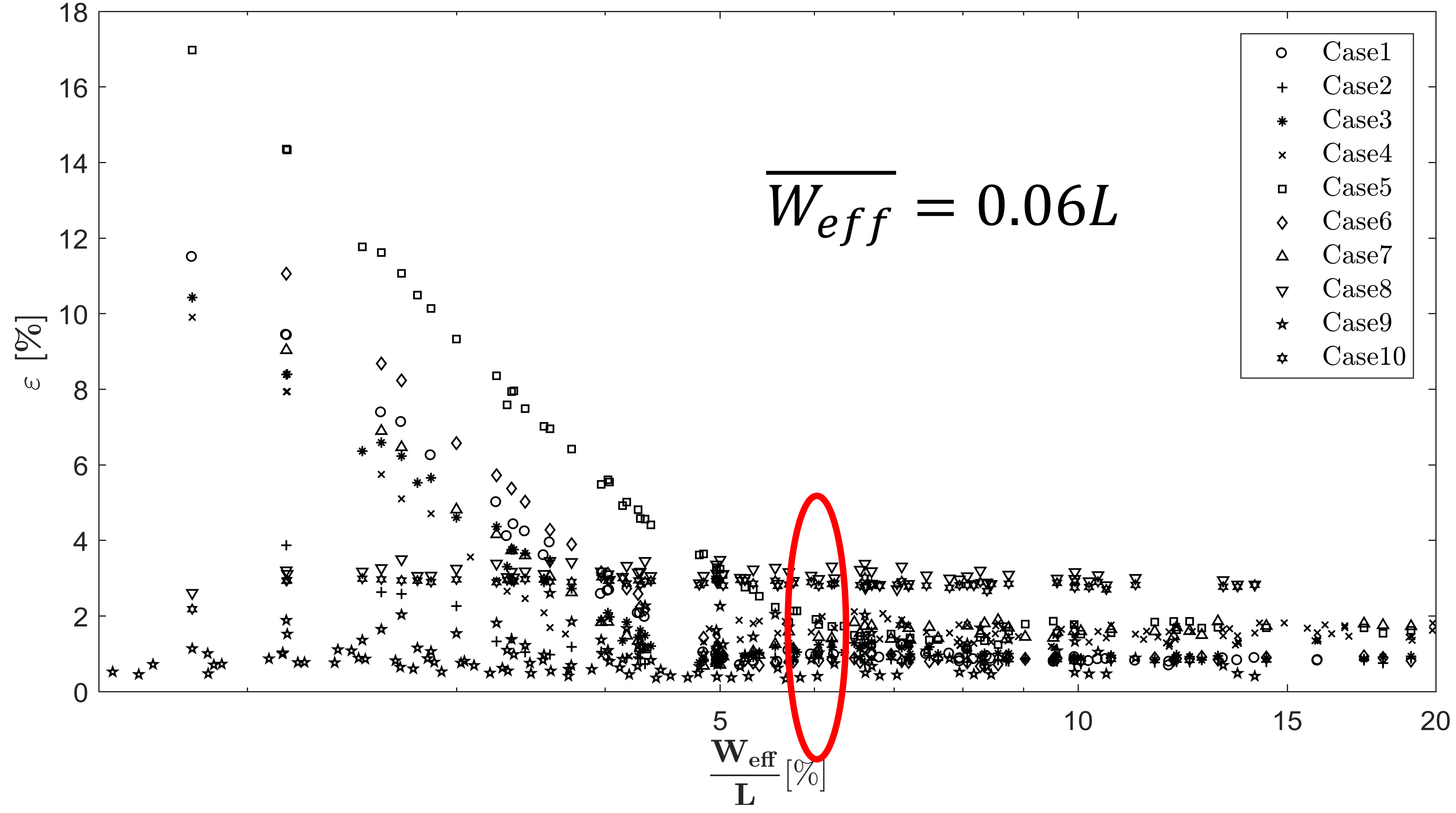
H_{th} is the target theoretical wave height

h_{SPH} is the smoothing length

VALIDATION OF WAVE GENERATION

5. Results – Error in wave height

$$threshold = 0.15$$



VALIDATION OF WAVE GENERATION

6. Design of Relaxation Zone

In principle, we have two unknowns (α and β) varying with χ.

Fixed the value of the $threshold = 0.15$, we can calculate the

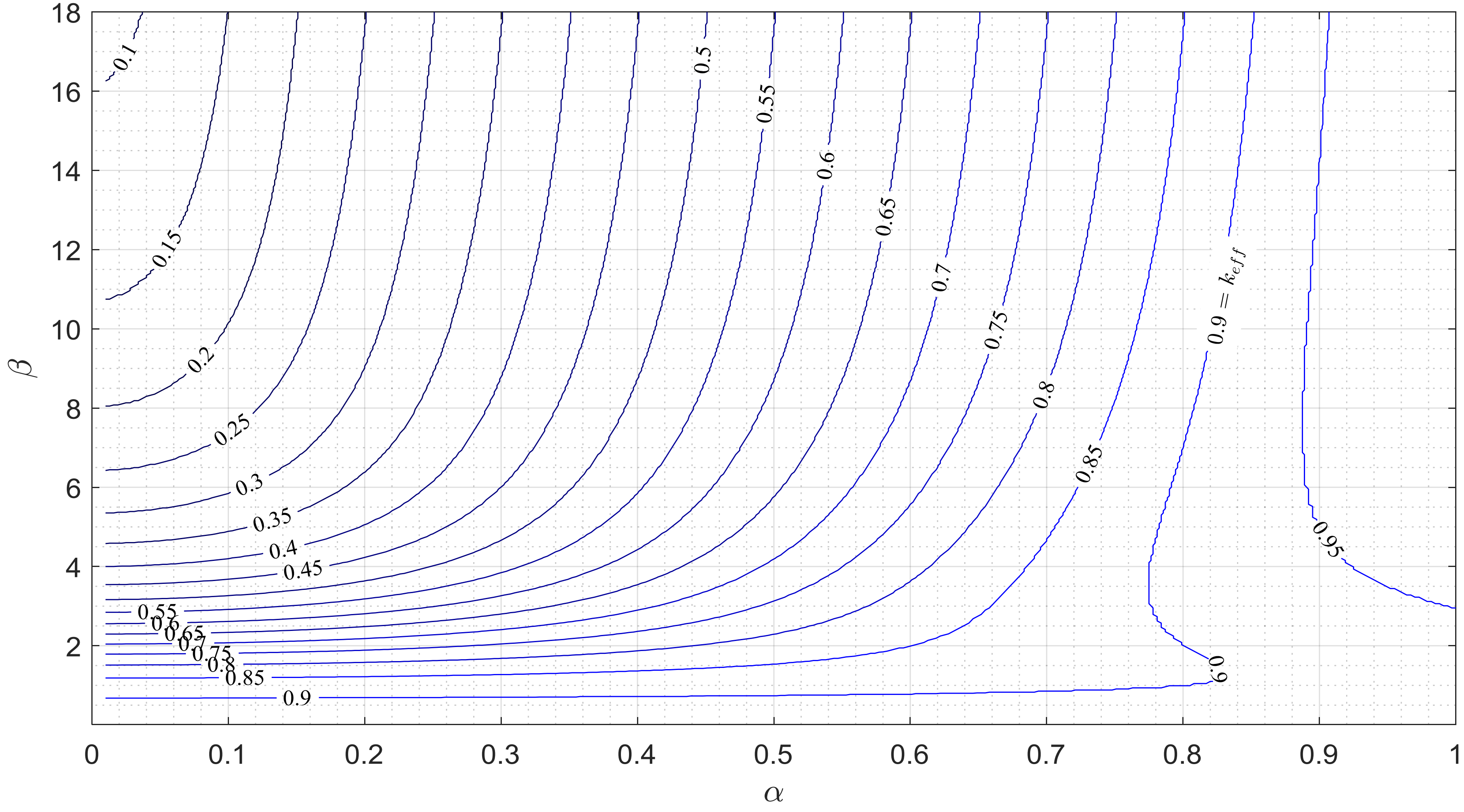
$z = f(\alpha, \beta)$, surface in $\mathbb{R}^3$, in which

$$z = \chi \,||\, C(\chi, \alpha, \beta) = threshold$$
$$\forall\, \alpha \in [0,2], \beta \in [0,18] \cup \chi > 0$$

We can visualize the solution plotting the χ isolines in the α-β grid

VALIDATION OF WAVE GENERATION

6. Design of Relaxation Zone



VALIDATION OF WAVE GENERATION

6. Design of Relaxation Zone - how to use the proposed abacus

- From our analyses, it has been fixed $\overline{W_{eff}}$ (e.g. 6% of L)
- Choose a χ isoline ($k_{eff} = 0.80$ could be appropriate)
- $W_{RZ} = \frac{\overline{W_{eff}}}{k_{eff}}$
- According to the choice of k_{eff}, the value of α, β to be use for regular wave generation are taken.

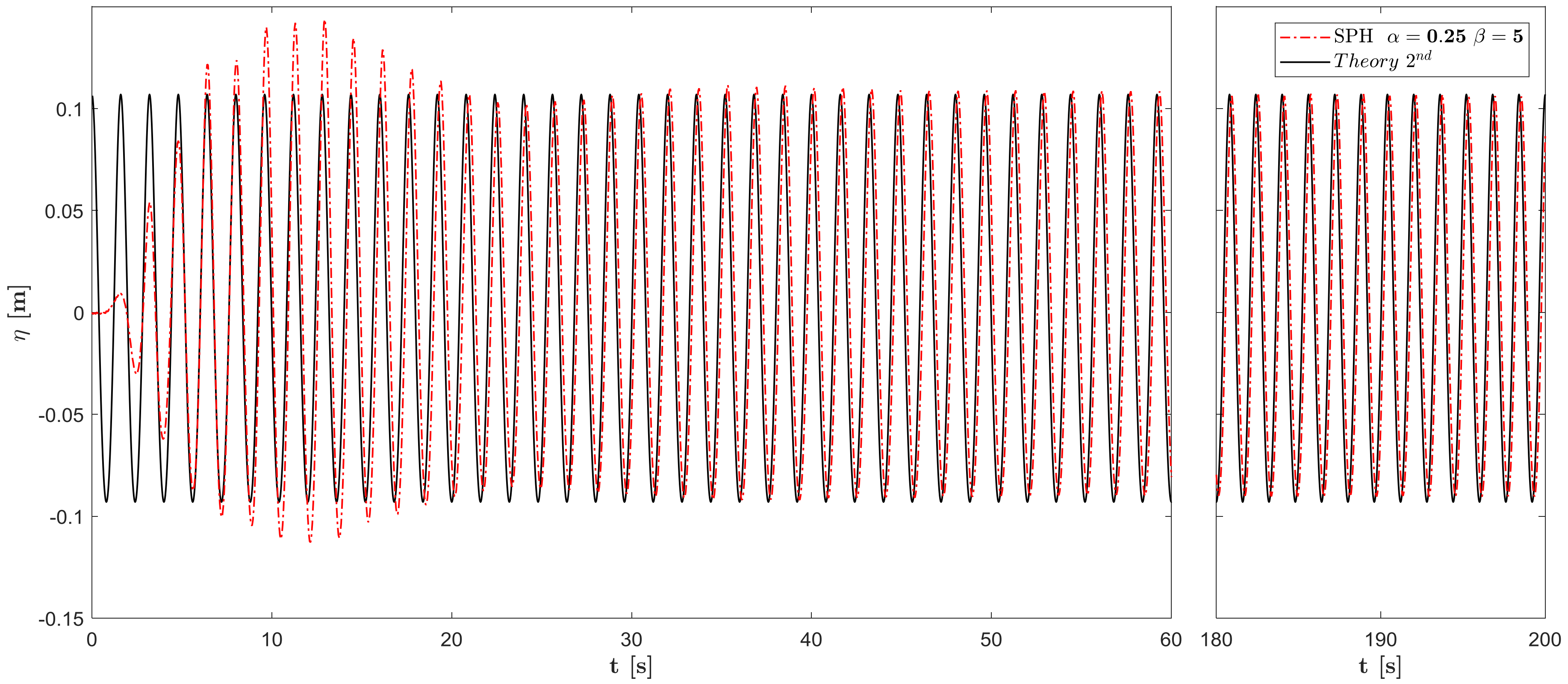
Simplicio: It seems to be working... Ummm
User: And for higly reflective condition?
Corrado: Well you...
Simplicio: It can’t work!

2) VALIDATION OF WAVE REFLECTION

VALIDATION OF WAVE REFLECTION

0. About reflection – General behaviour

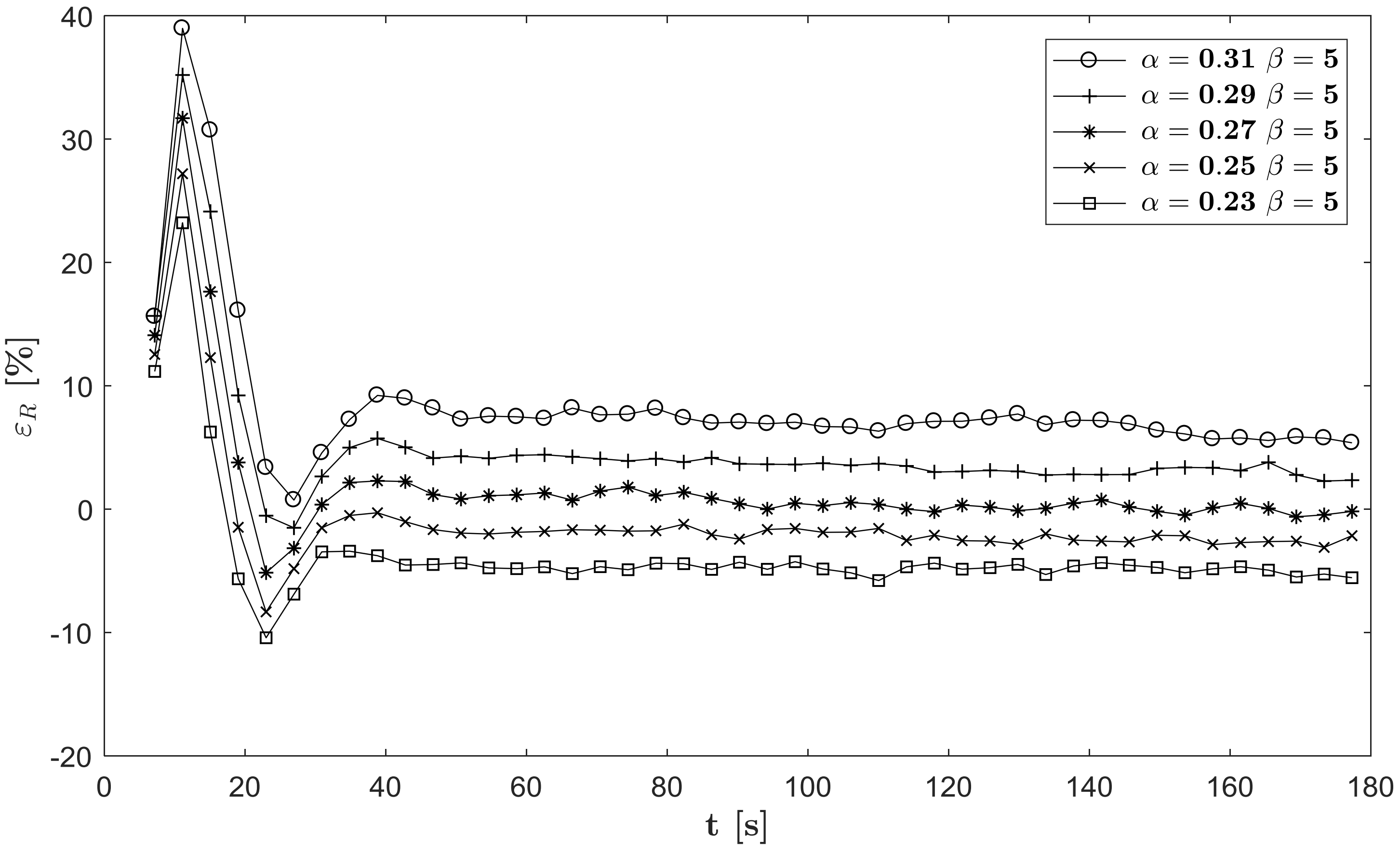
CASE 1 – Wave profile at antinode ($x = L$)



VALIDATION OF WAVE REFLECTION

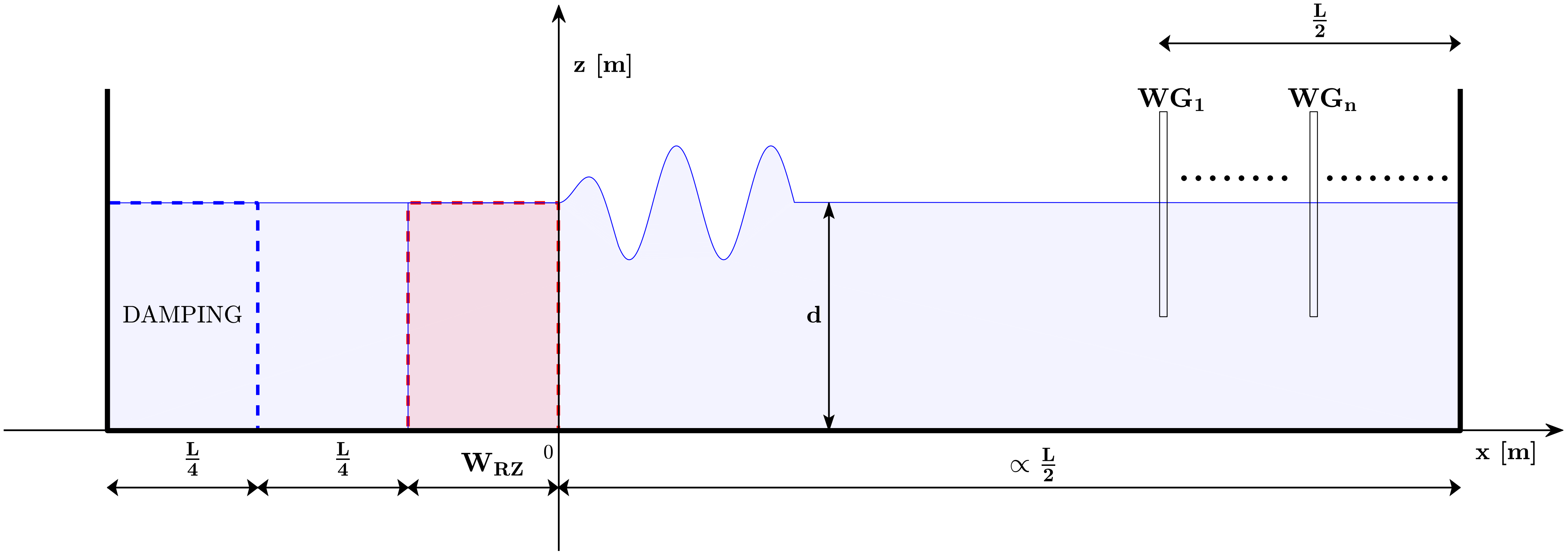
0. About reflection – General behaviour

CASE 1 – Accuracy of wave reflection



VALIDATION OF WAVE REFLECTION

1. Model setting



VALIDATION OF WAVE REFLECTION

2. Definition of Effective Width in reflection - $W_{eff.R}$

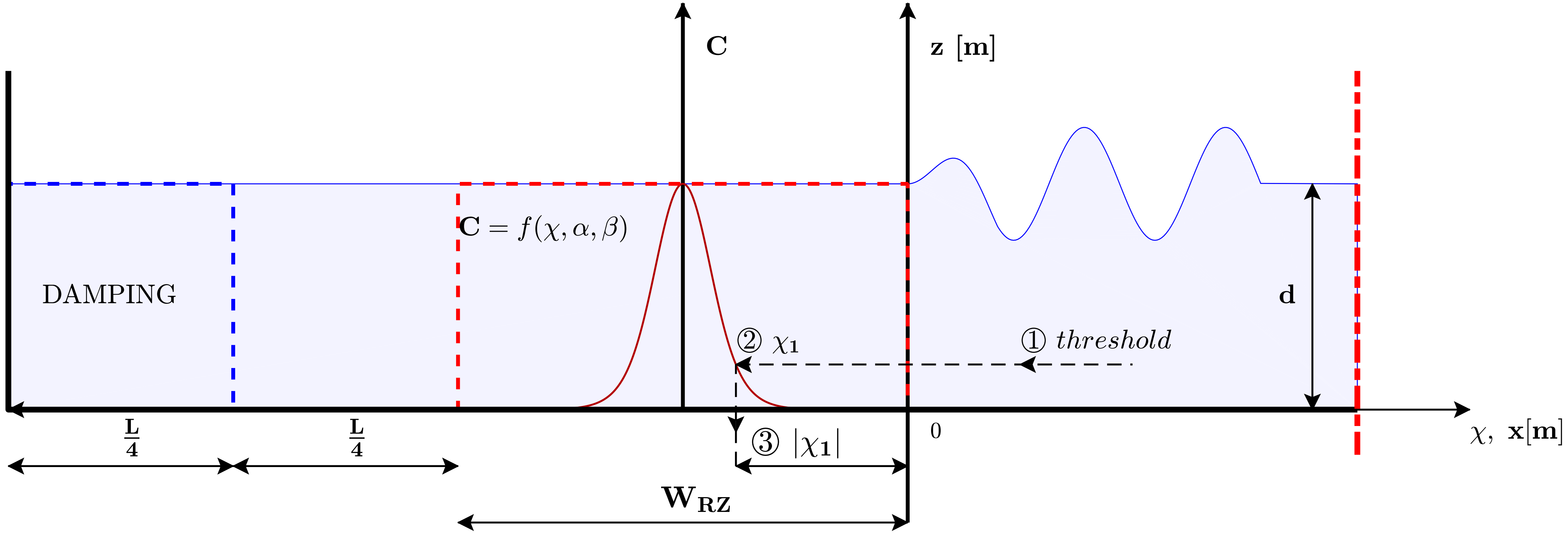
$$W_{eff.R} = |\chi_1| \cdot W_{RZ}$$

Where

$\chi_1 \parallel C(\chi, \alpha, \beta) = threshold \cup \ \chi \ni [0,1]$

VALIDATION OF WAVE REFLECTION

2. Definition of Effective Width - $W_{eff.R}$



VALIDATION OF WAVE REFLECTION

3. Definition of benchmark tests – Numerical setting

For each case, the simulations have been repeated using

$$W_{RZ} = [1, \frac{1}{2}] \cdot L$$

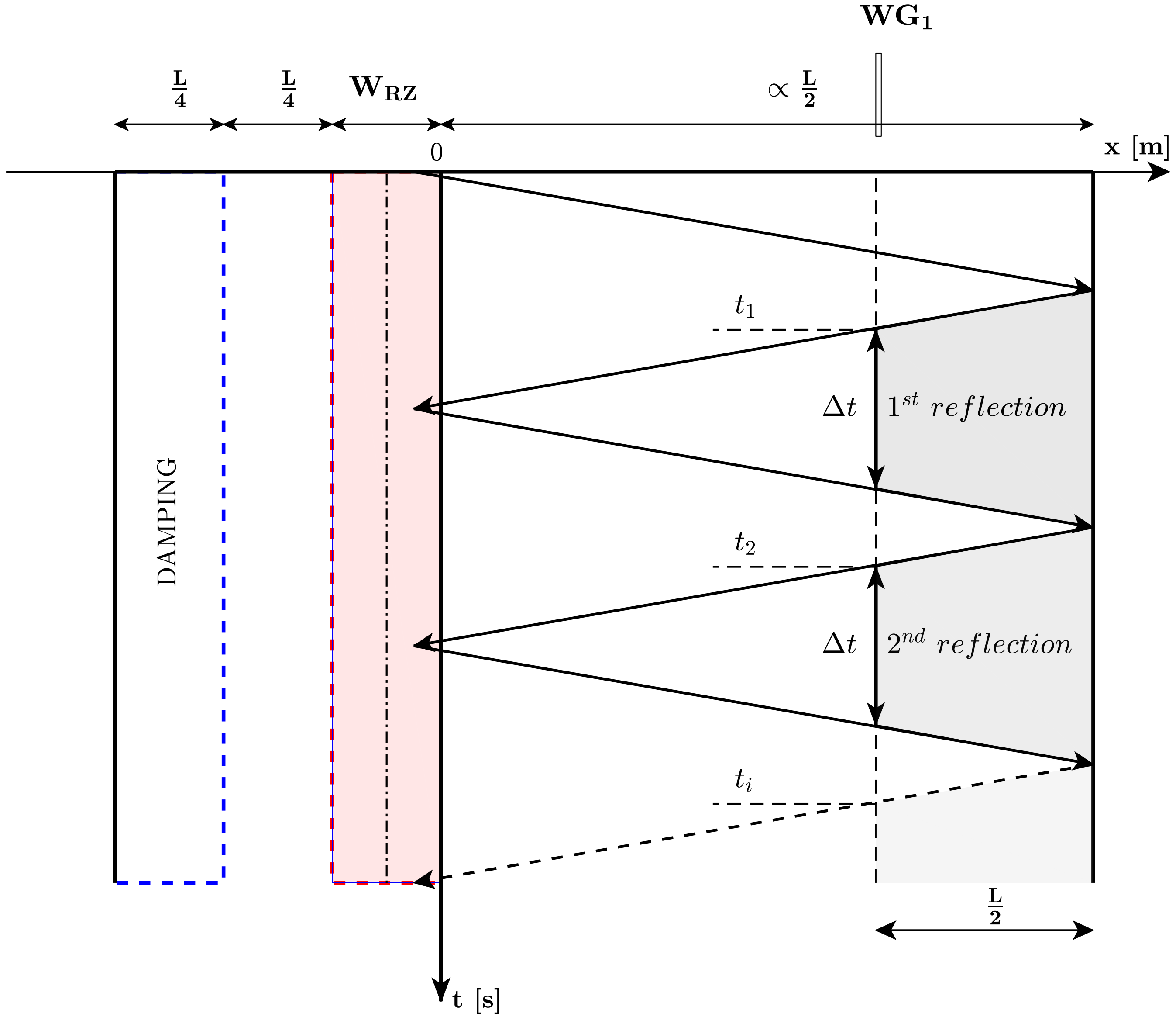
$$\alpha = [\ 0.05, 0.08, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.50\ ]$$

$$\beta = [2, 3, 4, 5, 7, 9]$$

Total=1200 simulations

VALIDATION OF WAVE REFLECTION

4. Analysis – Error estimation



VALIDATION OF WAVE REFLECTION

4. Analysis – Error estimation

Error in reflected wave height

$$\overline{\epsilon_R} = \frac{\sum_{i=10}^{end}\left(\epsilon_{R,t_i+\Delta t}\right)}{end - 10}$$

Where

t_i is the initial time of each *i-th* reflection time window

Δt reflection time window

$$\epsilon_{R,t_i+\Delta t} = \left(\frac{H_{SPH(t_i+\Delta t)} - \gamma H_{Th}}{\gamma H_{Th}}\right) \cdot 100\ [\%]$$

γ scalar for reflection conditions

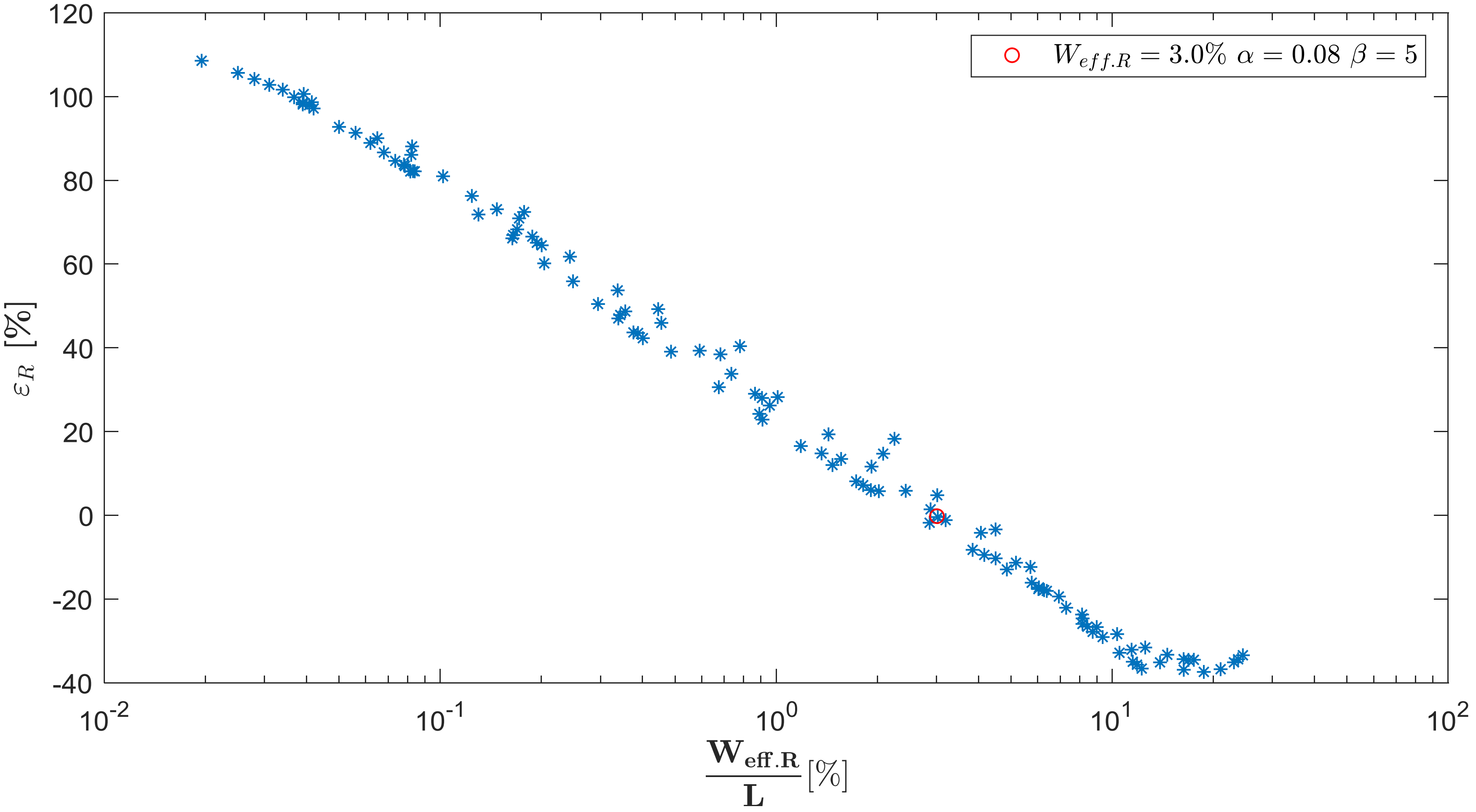
Implicitly, we've assumed that the correct reflection starts from the 10th cycle (empirical assumption).

VALIDATION OF WAVE REFLECTION

5. Results – Error in reflected wave height

CASE 1

$$working\ hypothesis: \gamma = 2$$
$$threshold = 0.005$$



VALIDATION OF WAVE REFLECTION

5. Results – Specific wave energy flux

Specific wave energy flux

$$\overline{e} = \frac{\overline{E}}{d} = \frac{1}{d}\frac{E}{L}\ [\frac{J}{m \cdot m}]$$

where:

$E = \frac{\rho g H^2 L}{8}$ total wave energy

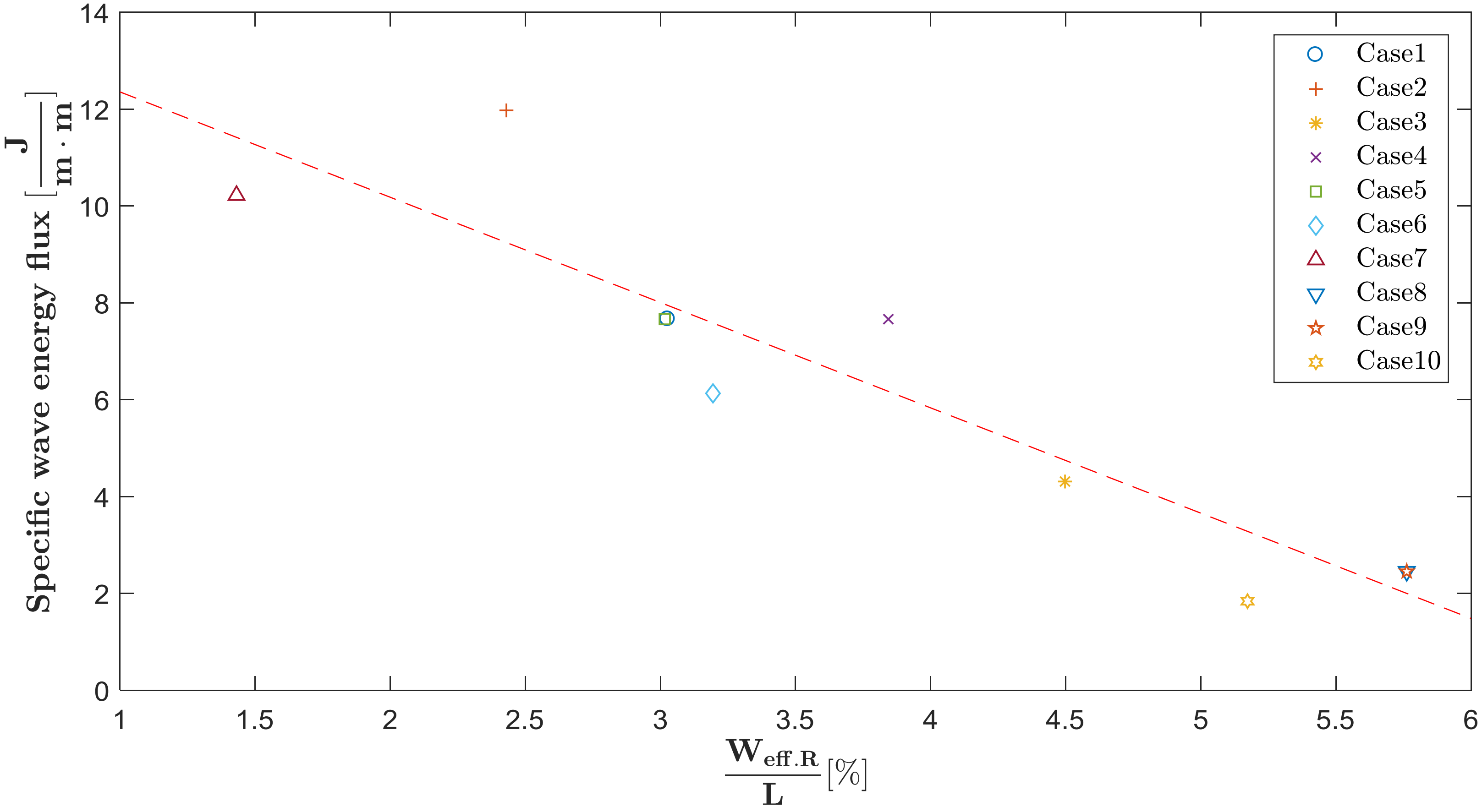
L is the wave length

d is the depth

H is the wave height of incident wave

VALIDATION OF WAVE REFLECTION

5. Results – Error in reflected wave height



VALIDATION OF WAVE REFLECTION

6. Different structural slope angles

We define

$$CR_{theoretical} = \frac{\mu^2}{5.5 + \mu^2}$$

and

$$CR_{numerical} = \frac{H_a - H_n}{H_a + H_n}$$

where:

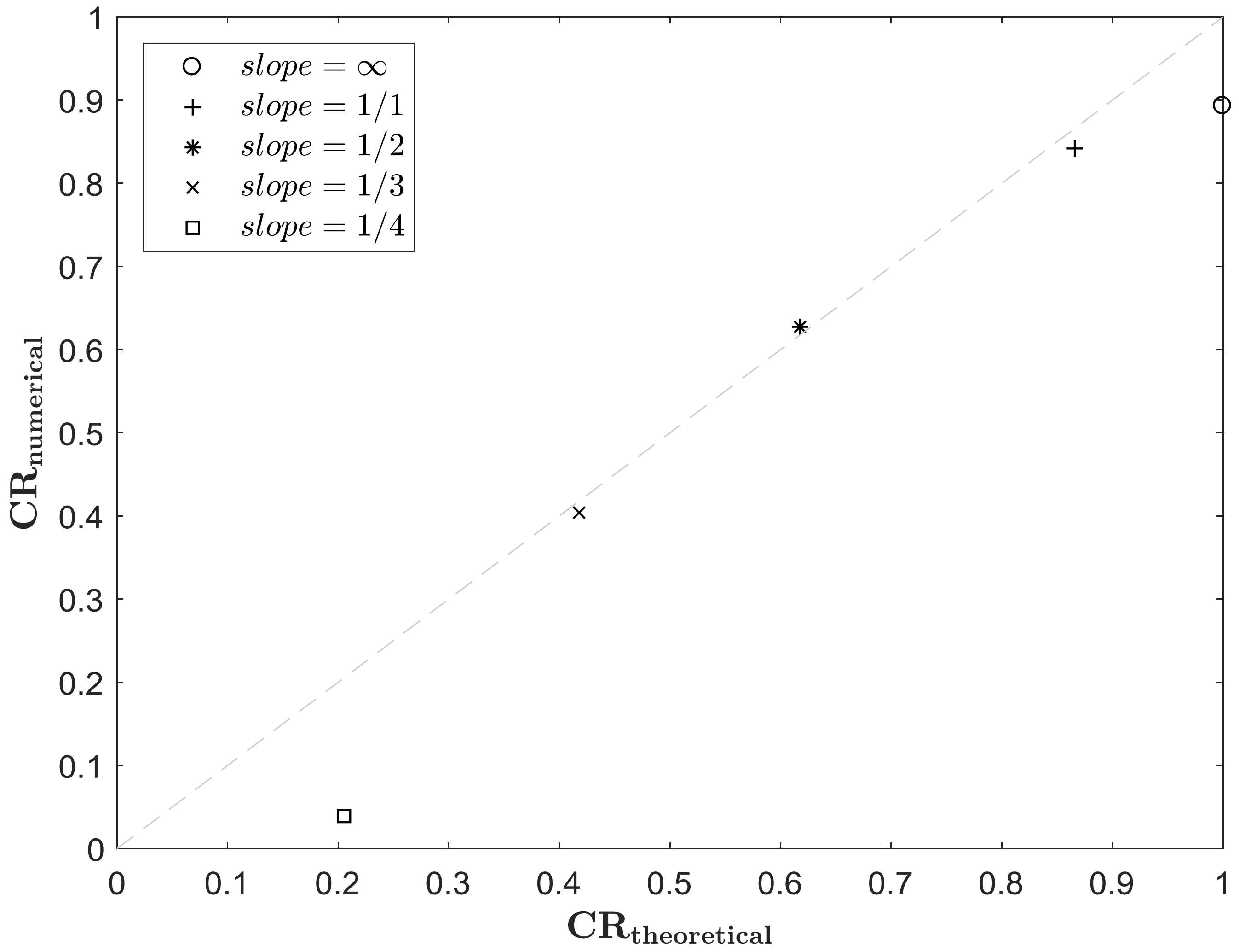
$\mu = beach_{slope}/\sqrt{H/L}$

H_a mean wave height at antinode

H_n mean wave height at node

VALIDATION OF WAVE REFLECTION

6. Different structural slope angles



Concluding remarks

- The relaxation criterion proposed by the authors is tested among different C function shape coefficients α and β

- We propose an abaqus for the design of the relaxation zone for wave generation

- A test case for the reflecting analysis is presented, showing a satisfactory agreement with the theoretical reflection coefficient.

Thank you for your attention