INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY HYDERABAD

R&D SHOWCASE 2021

Technology, Social Impact

# A Comparative Study of Absorbing Layer Methods for Radiating Boundary Conditions

## INTRODUCTION

- Absorbing Layer methods are increasingly popular due to their efficiency in absorbing outward propagation waves energy.
- Perfectly Matched Layers (PML) and Absorbing Layers by Increasing Damping (ALID) are the popular methods.
- In this study PML, ALID and ALID+VABC are compared to verify the efficiency in absorbing the wave propagating energy at various loading frequencies

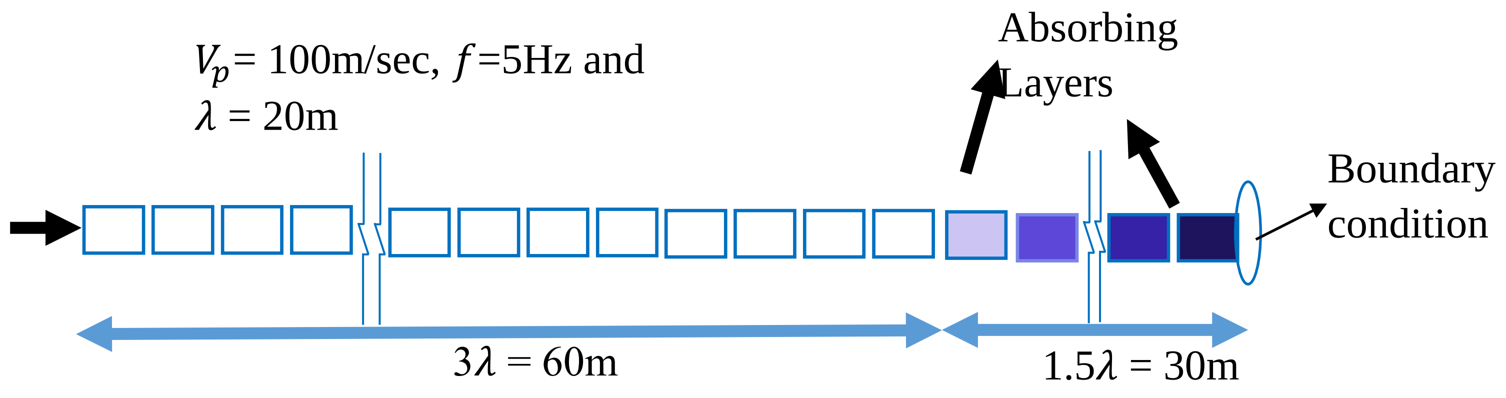
## MATHEMATICAL FORMULATIONS

$\sigma = a.\rho.V_p.\dot{u} + 0.5a.\rho.V_p.\alpha.u$

$\tau = b.\rho.V_s.\dot{v} + 0.5b.\rho.V_s.\alpha.v$

The artificial boundary condition includes a dashpot with coefficient and a spring with coefficient.

## NUMERICAL MODELLING – 1D WAVE PROPOGATION




**Loading:**

$$F(0,t) = A_f\left[1 - 2\pi^2 f_p^2 (t - t_s)^2\right] e^{-\pi^2 f_p^2 (t-t_s)^2}$$

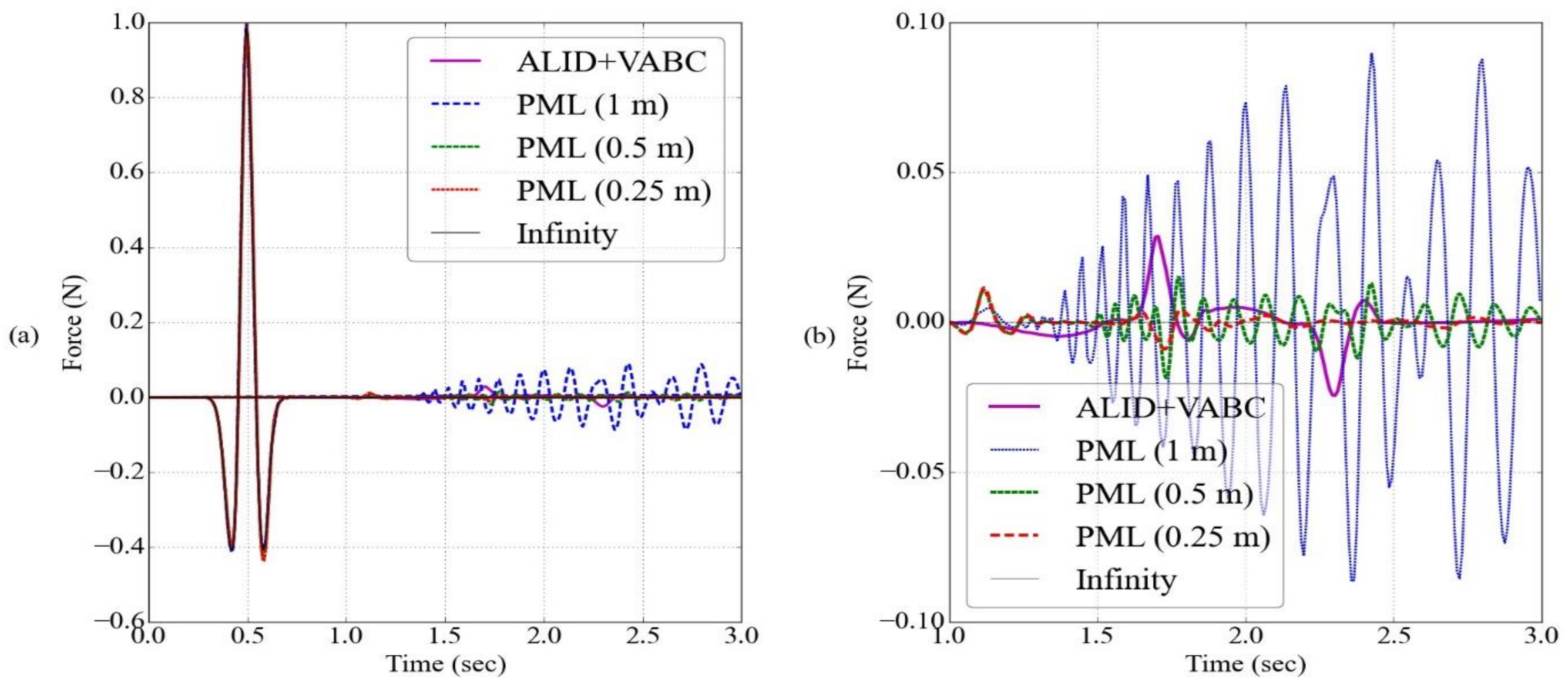
1. Ricker Wavelet with predominant frequency 5Hz
2. Wave propagation speed and wave length is 100 m/sec and 20m
3. Element size is fixed as 1m

## Numerical Results – Time Step Computation

| S.No | Boundary Condition Type | Element Length (m) | Time Step (sec) | Reduction in Time Step (%) |
|---|---|---|---|---|
| 1 | ALID+VABC | 1.00 | 8.5285E-03 | 0.00 |
| 2 | PML | 1.00 | 8.4813E-03 | 0.55 |
| 3 | PML | 0.50 | 4.2407E-03 | 50.28 |
| 4 | PML | 0.25 | 2.1203E-03 | 75.14 |
| 5 | Infinite | 1.00 | 8.5285E-03 | -- |

## Numerical Results –Number of Elements vs. Efficiency

| S.No | Element Length (m) | ALID | PML | | | |
|---|---|---|---|---|---|---|
| | | 30 elements | 30 elements | 15 elements | 10 elements | 5 elements |
| 1 | 1.00 | 2.8 | 8.77 | 8.77 | 8.77 | 10.25 |
| 2 | 0.50 | | 1.83 | 1.50 | 1.26 | 2.61 |
| 3 | 0.25 | | 1.13 | 1.06 | 1.19 | 2.47 |




## CONCLUSIONS

1. PML requires smaller element size and smaller computation time for a given loading frequency. Therefore, PML is computationally expensive.
2. ALID+VABC requires a large number of elements compared to the PML. The number of degrees of freedom is high in 3D wave propagation problem.
3. PML equations are complex and are not available in most of the existing commercial FE codes. The implementation cost is high. However, ALID+VABC method is readily available in almost all the FE codes.


*Ravi Shankar Badry, Pradeep Kumar Ramancharla*

*Earthquake Engineering Research Centre*