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RamSeries - Validation Case 42

Structure subjected to wave loads

RamSeries

Version
14.0.0

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1 Validation Case 42 - Wave loads comparison

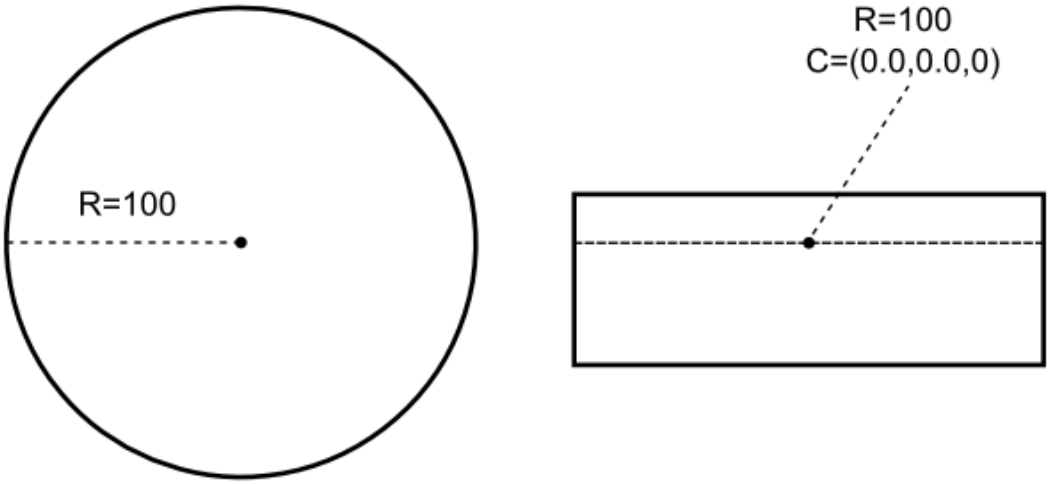
Model description

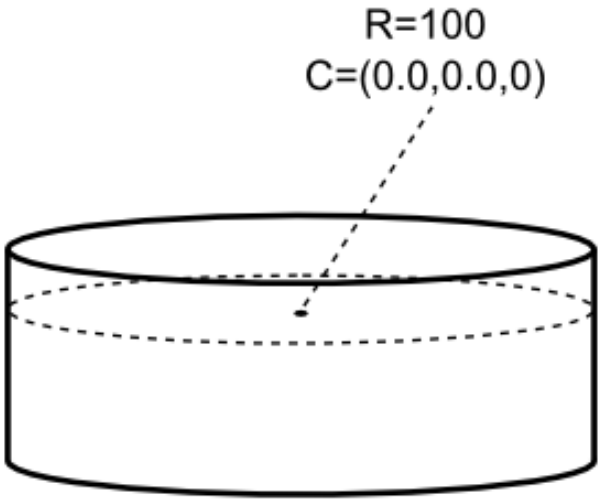
This verification case is an analysis based on Validation Case 14, in order to test RamSeries wave load. This load should be able to reproduce the effect of a wave pressure load coming from a previously run SeaFEM simulation in which diffraction/radiation effects have been neglected. In this case current velocity has been included.

Test model has a simple geometry, consisting on a shells cylinder with the following dimensions:

R_{cyl} = 1.0 m

h_{cyl} = 0.7 m





RamSeries model:

First, the hidrostatic equilibrium for the initial configuration is stablished by checking de displacement calculated in SeaFEM, and adjusting the specific weight (ρ) in RamSeries, so the cylinder has its floating line in z = 0 (this means a depth of d=0.5 m).

Displacement (SeaFEM): Δ_{SF} = 15757.91 N

Cylinder volume: V_{cyl} = 1.56873 m^3

The cylinder is assigned with a material of the following properties (the material is assumed to be linear elastic):

E = 2.1e11 N/m2

μ = 0.3

ρ_{cyl} = 20821 N/m3

t_{cyl} = 0.1 m

- Loads:
  Both linear and non-linear models are loaded with dynamic wave pressures coming either from the SeaFEM analysis results or from the internal RamSeries wave loads, plus the standard hydrostatic pressure load, and the self-weight. Dynamic wave load pressures are applied to the geometry below the floating line, while hydrostatic pressures are also applied above the waterline, to account for its variation,

  The self-weight load is applied to the whole model.

  The internal wave pressure load in RamSeries includes also the initialization (10 seconds) used in the SeaFEM simulation.

- Constraints:
  The model has its displacement restrained in the direction transversal to the advancing direction of the wave system (Y axis), and the rotation restrained in the pitch axis (θ_y). This condition is applied to the points A(0.0,-1.0,-0.5) and B(0.0,1.0,-0.5).

  It also has displacement restrained in the direction transversal to the advancing direction of the wave system (Y axis), and the rotation restrained in the roll axis (θ_x). This condition is applied to the points C(-1.0,0.0,-0.5) and D(-1.0,0.0,-0.5), to avoid the rotation in the yaw axis (Z).

  Also, an elastic constraint has been applied at the point P(-1.0,0.0,-0.5). The stiffness value is K=100 N/m. This condition is also applied in the SeaFEM model as a external load, to make them equivalent.

- The dynamic analysis parameters are the following:

Δt = 0.1 s

Num. Steps: 400

Integration Method (non-linear): Energy Conserving/Decaying

$\alpha_{E\text{-}C/D}$ = 0.0 (High frequency dissipation parameter)

Integration Method (linear): Bossak-Newmark

$\alpha_{B\text{-}N}$ = -0.1

Matrix storage: Consistent

Initial conditions: None

Damping (Rayleigh):

α_M = 0.4426

α_K = 0.0

The damping coefficient, α_M, has been defined to be the 5% of the critical damping for the heave motion. The calculation procedure is showed next:

$\xi = C/C_c = 1$

with:

$C = M \cdot \alpha'_M$

$C_c = 2 \cdot M \cdot \omega_c$

So:

$\alpha'_M = 2 \cdot \omega_c$

The natural frequency of the heave motion is calculated as:

$\omega_c = (K_{33}/M)^{1/2} = 4.415\ s^{-1}$

with:

$K_{33} = \rho \cdot g \cdot A_{flot} = 31557.3$ N/m

and being M, the total mass of the floater. And finally,

$\alpha_M = 0.05 \cdot (2 \cdot \omega_c) = 0.05 \cdot \alpha'_M = 0.4426$

SeaFEM model:

The geometry of the model for SeaFEM is the same, but for the part of the cylinder over the free surface (Z= 0), which is neglected (not necessary for SeaFEM analyses). Details of the generation of this model are described in the SeaFEM Manual.

- Enviroment data.
  The simulation is performed for monochromatic wave system advancing along the positive X axis direction (0.0 deg). Also a current has been included:

  A_{wave} = 0.1 m

  T_{wave} = 6.0 s

- Body data:
  The body data corresponds to the geometric properties of the cylinder, which have been obtained with RamSeries tools:

```
Center of Gravity
(xG,yG,zG) = (-9.33527e-006,-3.20587e-011,-0.295571) [L]

Total weight = 15662.4 [N]

Radii of gyration respect to ortogonal axis passing through the Center of
Gravityn
(rxg,ryg,rzg) = (0.6734,0.6734,0.892) [F*L^2]
```

Center of gravity: CDG=(0.0,0.0,-0.295571).

Radii of gyration:

$R_{xx} = R_{yy}$ = 0.6734

R_{zz} = 0.892

Three degrees of movement are free: surge, heave and pitch.

External forces have been added:

1 .Elastic spring (same as in RamSeries):
F_x = -100*dx[-1.0,0.0,-0.5]

2 .Compensating moment:
This moment is applied so it compensates the moment which will appear in RamSeries due to the elastic restriction.

M_y = -100*dx[-1.0,0.0,-0.5]*(0.5-0.15)

- Irregular frequency removal = 0.05.
  A 5% of the critical damping factor has been considered here, in order to make the analysis equivalent to RamSeries simulation.

Results

For the sake of validation, a simulation was run using the properties, loads and problem conditions described in the previous chapter.

Mesh:

An unstructured mesh of linear triangles has been used in RamSeries:

Number of elements: 610

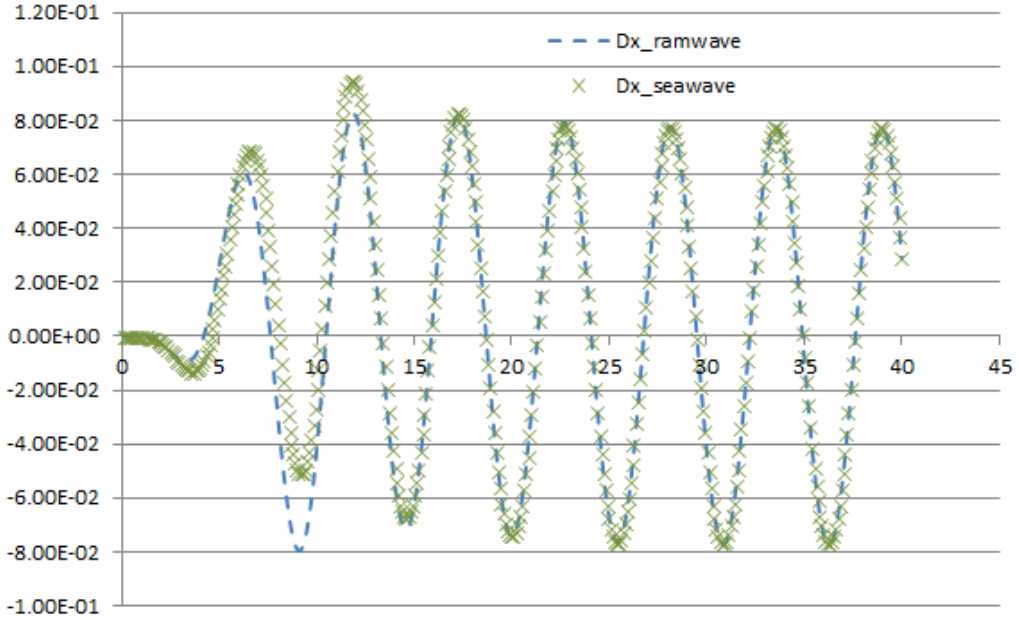
Number of nodes: 326

Displacements results:

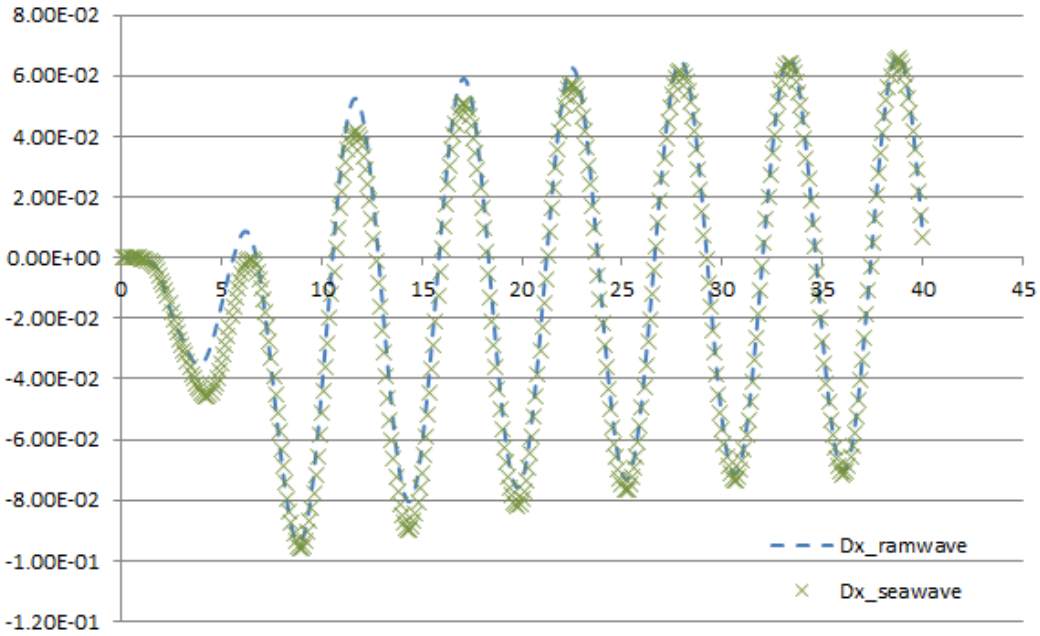
The main goal of this test is to validate that the dynamic response solution given by RamSeries is equivalent when wave loads come either from a SeaFEM result (with radiation/diffraction neglected), or from the internal wave loads of RamSeries.

The following images show the comparison of both loads' solution for the main movements (heave, and surge).

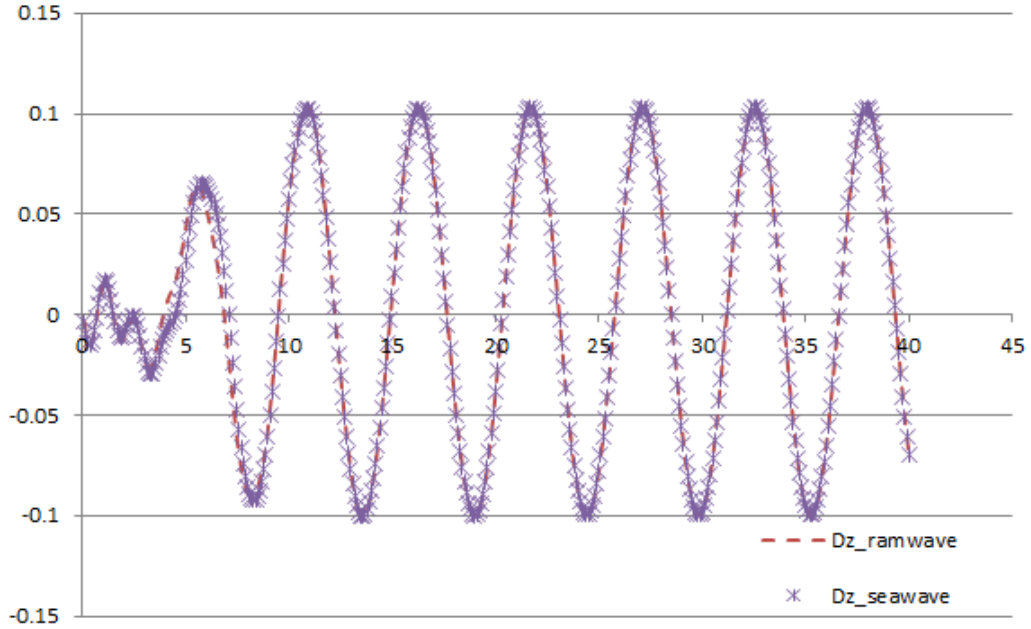
- Surge movement of the Center of Gravity (linear solution):



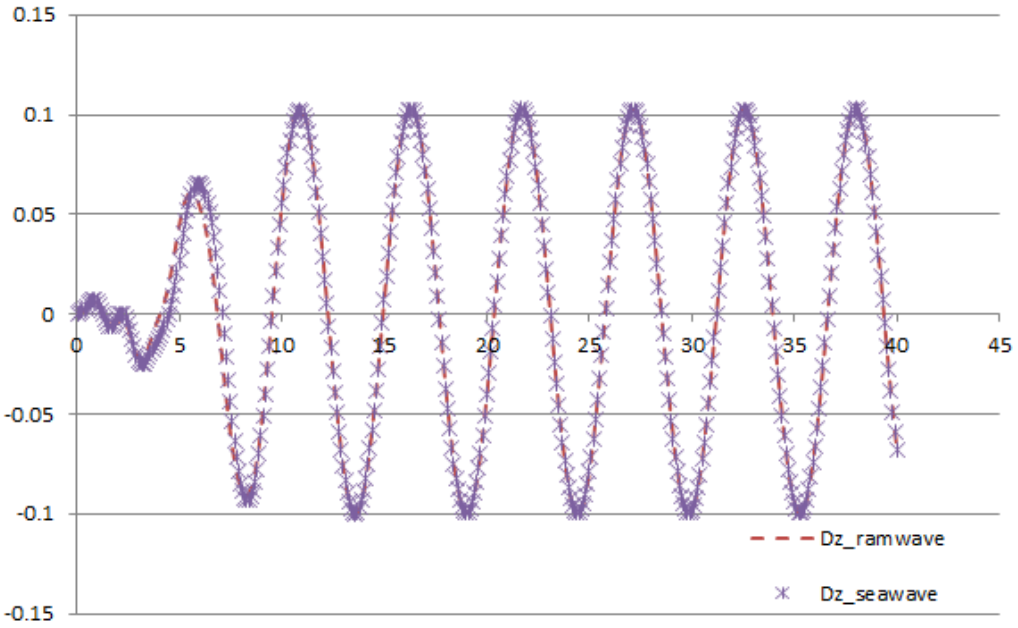
- Surge movement of the Center of Gravity (non-linear solution):



- Heave movement of the Center of Gravity (linear solution):



- Heave movement of the Center of Gravity (non-linear solution):



References

[1] B. Serván. SeaFEM Manual. CompassIS (2012).

Validation summary

CompassFEM version	14.0.0
Tdyn solver version	14.0.0
RamSeries solver version	14.0.0
Benchmark status	Successfull
Last validation date	09/06/2017