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SeaFEM - Validation Case 5

Semisubmersible structure GVA 4000

SeaFEM

Version
15.1.0

Compass Ingeniería y Sistemas http://www.compassis.com
Tel.: +34 932 181 989 - Fax.: +34 933 969 746 - E: info@compassis.com - C/ Tuset 8, 7o 2a, Barcelona 08006 (Spain)

http://www.compassis.com
info@compassis.com
November 2018

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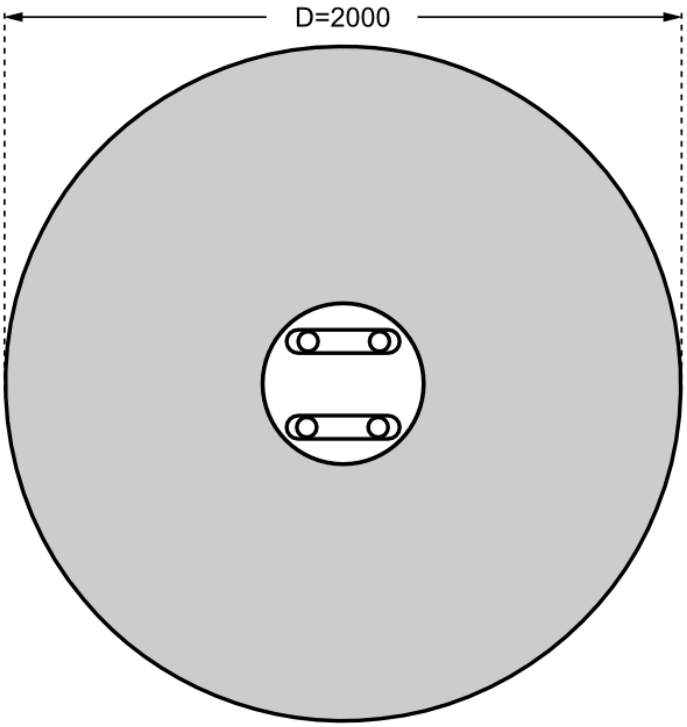
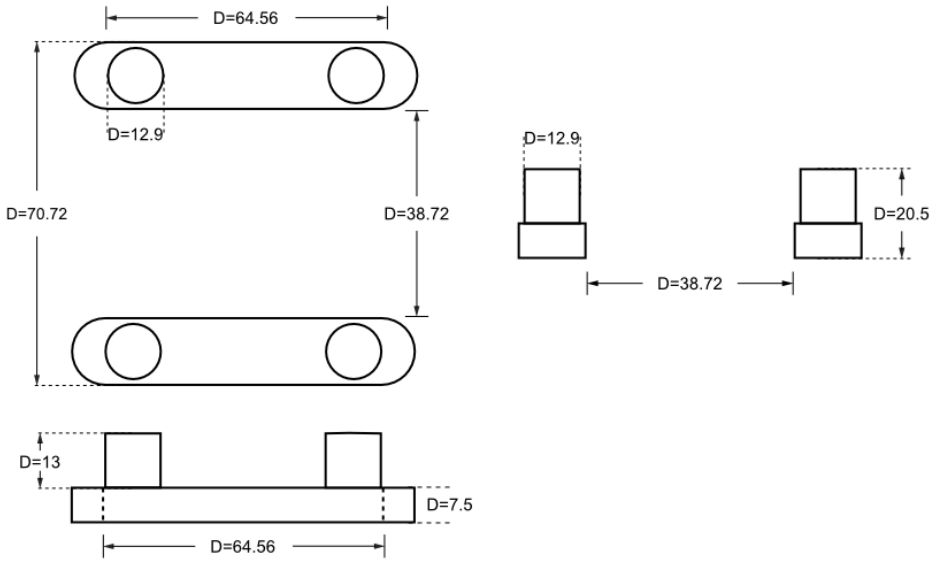
1 Validation Case 5 - Semisubmersible structure GVA 4000

The present test case analyzes the seakeeping behaviour of a freely floating semi-submersible structure subjected to the action of monochromatic waves while being pulled by an external force. The GiD geometry below shows the whole computational domain with the semi-submersible structure located at the center (all length units in meters). Next, details of the semisubmergible geometry are presented. This geometry was constructed based on that defined in reference [1].





The mass of the body is calculated internally in order to equal the mass of the water displaced by the structure. The gravity used is $g=9.80665 m/s^2$, the water density used is $\rho=1025 kg/m^3$, and water depth is H=120m.

The structure characteristics are given in the following table. We would like to thank Prof. Günther F. Clauss and Dr. Christian Schmittner for all the information they have provided concerning the geometric and dynamic characteristics of the semisubmersible structure under analysis.

Structure characteristics	
Characteristic length (m)	70
Heigth (m)	20
XG (m)	0
YG (m)	0
ZG (m)	0.85
$R_{xx} = (I_{xx}/M)^{1/2}$ (m)	30.40
$R_{yy} = (I_{yy}/M)^{1/2}$ (m)	31.06
$R_{zz} = (I_{zz}/M)^{1/2}$ (m)	37.54

In the present analysis we are interested to know how the body moves when excited by a regular wave. However, experiments in [1] were performed in such a way that surge movement of the structure was limited by the action of a spring. The influence of the spring was considered in our simulations by imposing an external pulling force with a linear elastic response characterized by a spring constant K = 1.0E5 N/m.

Since the computational method used herein solves the problem in the time domain, initial conditions will be important. In order to attain faster the harmonic steady state, the incident potential is introduced smoothly by means of a cosine function along an initialization time. Moreover, the body is supposed to be initially at the equilibrium position with zero velocity. During the initialization period a dissipation term proportional to the body velocity is introduced. This dissipation term is smoothly decreased down to zero so that it disappears after the initialization period.

Finally, external forces and moments are applied to the body to somehow simulate the action of an external mooring system. In this case, the force and moment simply represent the action of an elastic spring. The expresions to be entered within the external forces and moments fields of the corresponding body are as follows:

External force X:

-0.5E5*dx[-40.28,27.36,-17.55]-0.5E5*dx[-40.28,-27.36,-17.55]

External moment Y:

0.5E5*(ZG+16.7)*dx[-40.28,27.36,-17.55]+0.5E5*(ZG+16.7)*dx[-40.28,-27.36,-17.55]

Problem description

- Geometry

Semi-submergible structure with a characteristic length about 70 meters.

- Domain

Seakeeping analysis dealing with an spectrum waves of period ranging from 8 to 28 seconds.

- Fluid Properties

Seakeeping analysis undertaken using SeaFEM always consider that the fluid medium is sea water. Nevertheless, water density can be adjusted to match the actual fluid properties variation. For the present analsyis, water density was taken to be $\rho = 1025\ kg/m^3$.

- Fluid Models

Seakeeping analysis undertaken using SeaFEM always deal with incompressible fluids.

- Boundary Conditions and seakeeping environment

Wave spectrum type: white noise

Wave amplitude: 1.0 m

Shortest period: 8 s

Largest period: 28 s

Number of waves periods: 11

Wave direction: 0.0 deg

External force: linear elastic recovery spring with K = 1.0E5 N/m

- Time data and solver parameters

Time step: 0.3 s

Simulation time: 600 s

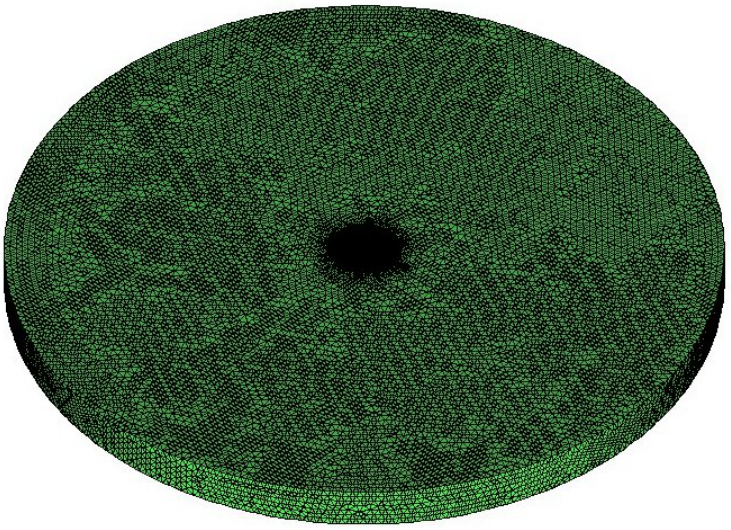
Symmetric solver: Deflated conjugate gradient (tolerance = 1.0E-7) with an ILU preconditioner

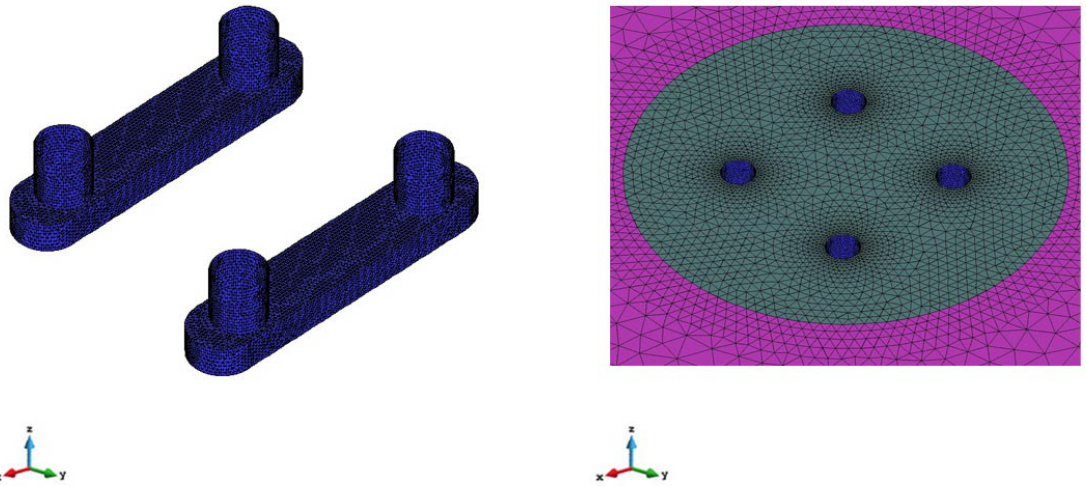
Mesh

Mesh properties for the present analysis are summarized in the following table:

Mesh properties	
Min. element size	1
Max element size	20
Mesh size transition	0.3
Number of elements	955,093
Number of nodes	158,003

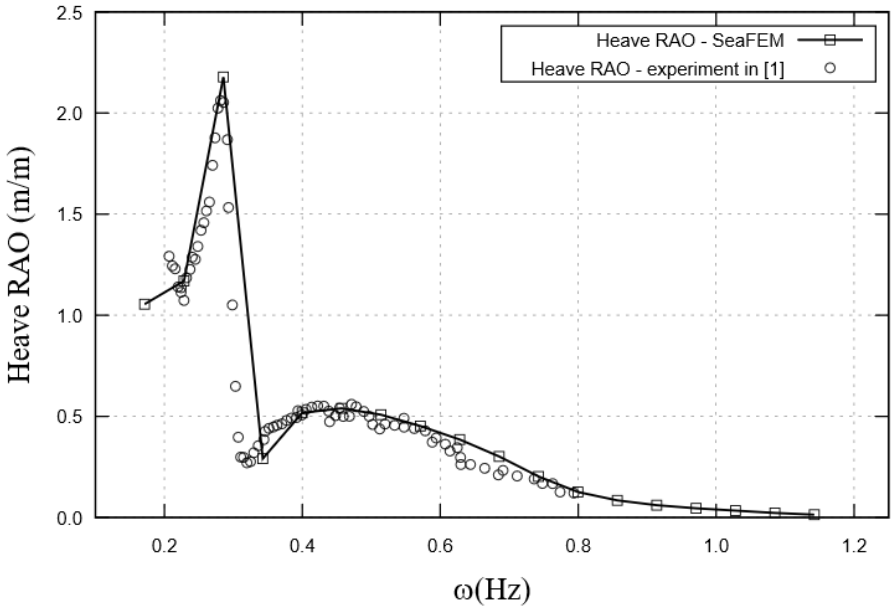
The following figures show the mesh used for the present analysis. First a global view is presented. Next, details of the semisubmergible structre mesh are shown as well as the free surface mesh close to the structure location.

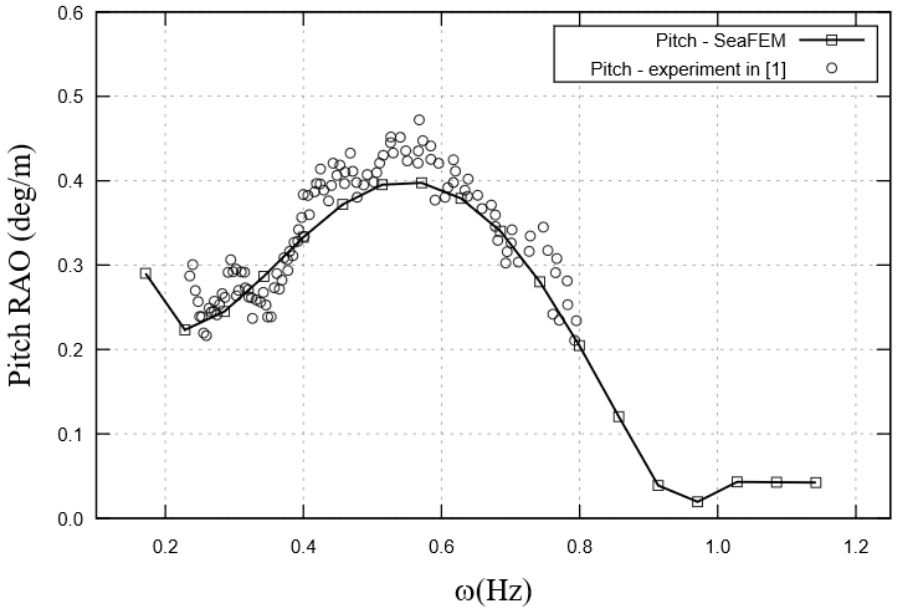




Results

In the present SeaFEM simulations the RAOs are calculated using a white noise spectrum. Using this type of spectrum, a number of waves is introduced with periods uniformly distributed across a given interval but with the same amplitude and direction. In the present case, periods range between 8 and 28 seconds. Figures below compare the response amplitude operators (RAOs) obtained by the present SeaFEM model and experimental RAOs reported in [1].




Pitch - SeaFEM
Pitch - experiment in [1]
Pitch RAO (deg/m)
ω(Hz)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.2
0.4
0.6
0.8
1.0
1.2

Validation Summary

CompassFEM version	15.1.0
Tdyn solver version	15.1.0
RamSeries solver version	15.1.0
Benchmark status	Successfull
Last validation date	27/11/2018

References

[1] Clauss G.F., Schmittner C. and Stutz K., Time-domain investigation of a semisubmergible in rogue waves. Proceedings of OMAE'02, 21st International Conference on Offshore Mechanics and Arctic Engineering. June 2002.