Report

2012 Annual WAMIT Consortium Meeting

October 4-5, 2012

Woods Hole, Massachusetts

Agenda for 2012 Annual WAMIT Meeting
Room 310, Marine Resource Center, Swope Center, Woods Hole, MA

October 4, 2012:

9:00AM: Welcome

9:15AM: "WAMIT Version V6.4S"
C.-H. Lee/X.M. Zhu, WAMIT Inc.

10:00 AM: "WAMIT V7 Updates"
C.-H. Lee, WAMIT Inc.

10:15 AM: "WAMIT for Linux"
K. Hendrickson, WAMIT Inc.

10:45 AM: Break

11:15 AM: "Optimization with WAMIT"
J. N. Newman, WAMIT Inc.

12:00PM: Lunch, Swope Center Dining Hall

1:30 PM: "Multi-body interactions using WAMIT"
Edgard Malta, USP

2:15PM: "Modeling Offshore Systems"
John Niedzwecki, OTRC

3:00 PM: Break

3:30 PM: "Technical discussion"

5:30PM: Mixer and Dinner, Swope Center Dining Hall

October 5, 2012

9:00AM: “Technical discussion”

10:30AM: Break

11:00AM: Business meeting

12:00AM: Lunch, Swope Center Dining Hall

WAMIT V6.4S

New features in V6.4S

1. Higher order method for the evaluation of complete 2nd -order solutions

The 2nd -order solutions are represented using B-splines. For efficiency, integration of forcing terms is treated in a piece-wise manner over exact body and free surfaces (Centroids of the subdivisions in parametric space are used as nodes of integration).

2. Improved computational results for the second-order wave elevation

Significant improvement is made over V6.1S and earlier versions, for the calculation of run-up and wave elevation close to structures.

3. Control surface method for quadratic forces and moments

4. 2nd-order solutions for bodies with internal tanks

This is a formal extension of the 2nd-order analysis to internal tanks. (The code is extended to solve the 2nd –order solution in the same manner as the external flow.)

1. Second-order potential force (Fp) on a bottom mounted Cylinder

draft/radius=1 infinite depth wave numbers (KR) =(1, 1) and (1,2)

	ILOWHI=1		ILOWHI=0	
N	(1,1)	(1,2)	(1,1)	(1,2)
4	1.663	2.712	1.658	2.807
6	1.682	2.686	1.658	2.736
8	1.686	2.677	1.656	2.708
4	1.649	2.702	1.659	2.785
6	1.676	2.682	1.659	2.727
8	1.683	2.675	1.657	2.703
4	1.639	2.712	1.656	2.780
6	1.638	2.675	1.657	2.724
8	1.638	2.666	1.655	2.701
	1.636	**2.661**	**1.636**	**2.661**

Last line: Newman (1996) and Kim & Yue (1989)

ILOWHI=1
N x N and N x 1.5N patches on a quadrant of the body and the free surface, between R and 3R. 4N subdivisions for forcing.

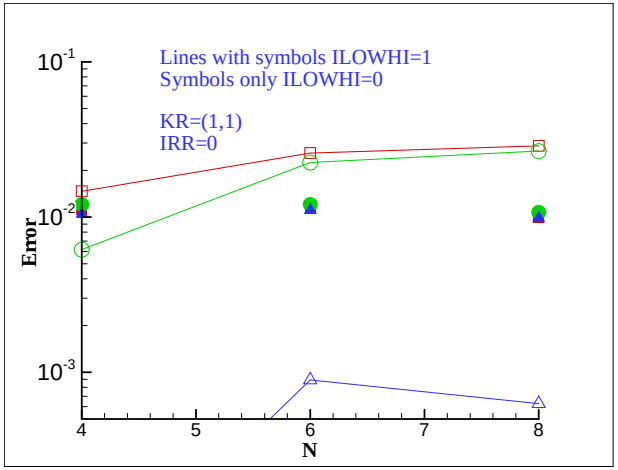
ILOWHI=0
4N x 4N and 4N x 6N panels

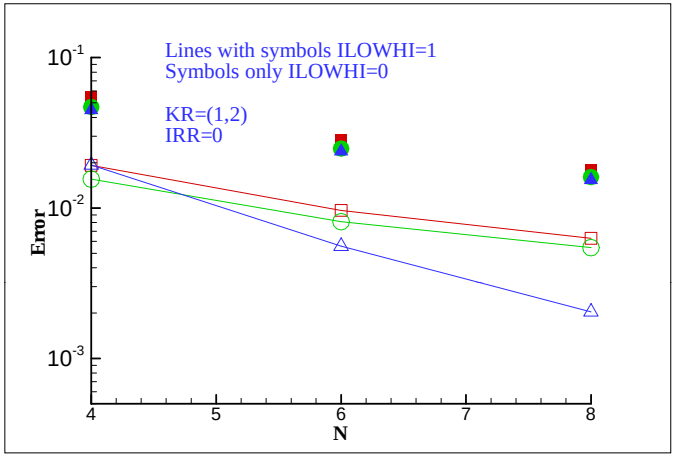
Red: uniform spacing on both surfaces

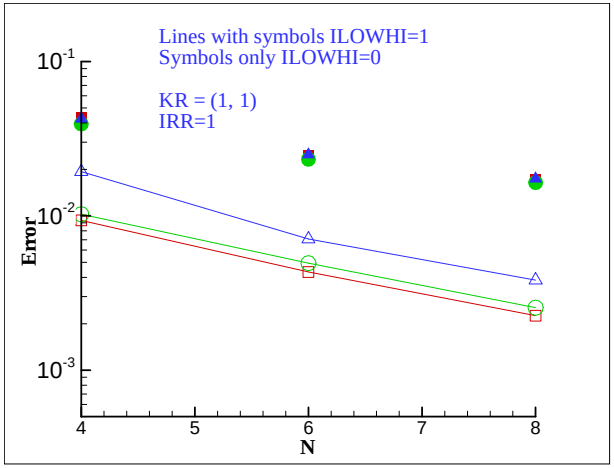
Green: cosine spacing on the free surface only

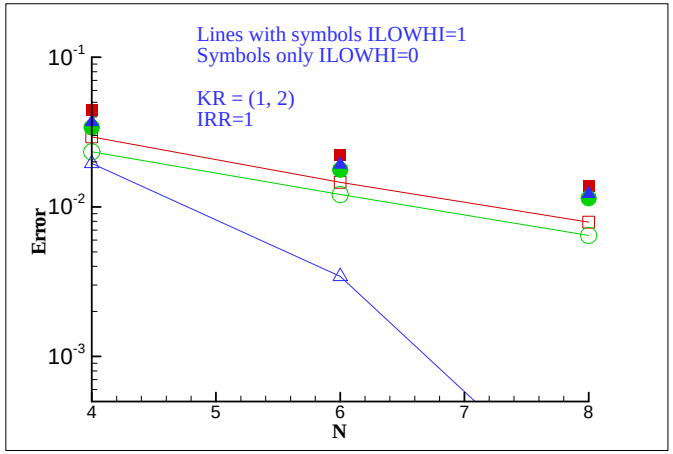
Blue: cosine spacing on both surfaces

First row: Relative error of the results shown in the previous slide
Second row: after using irregular frequency removal option







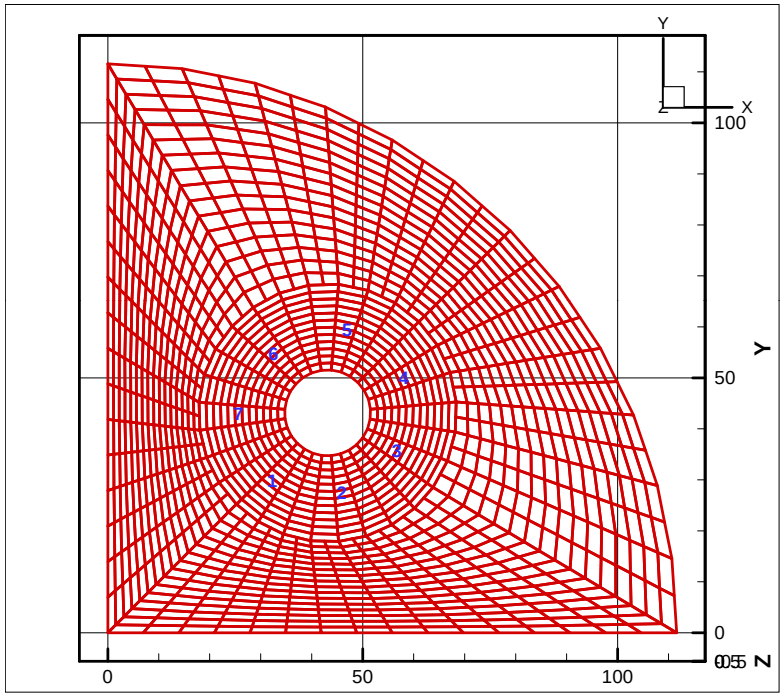


2.1
Wave elevation using ILOWHI=0 is improved over V6.1S for moving bodies

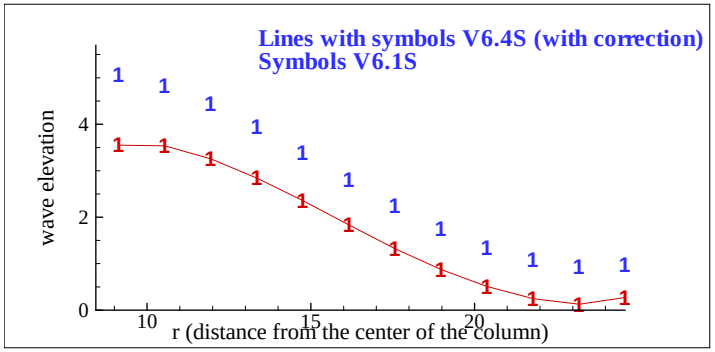
ISSC TLP

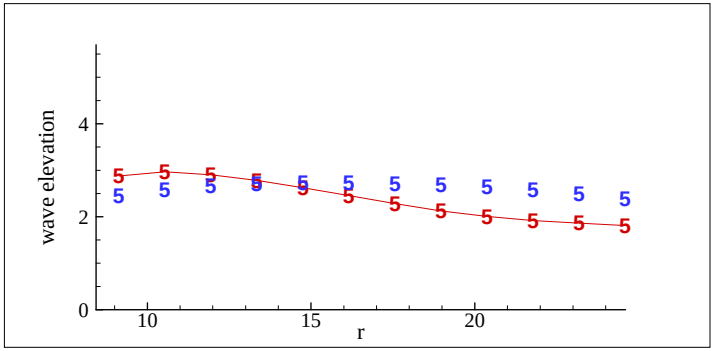
Wave period=8 second
Wave heading to the right
Surge RAO = 0.27

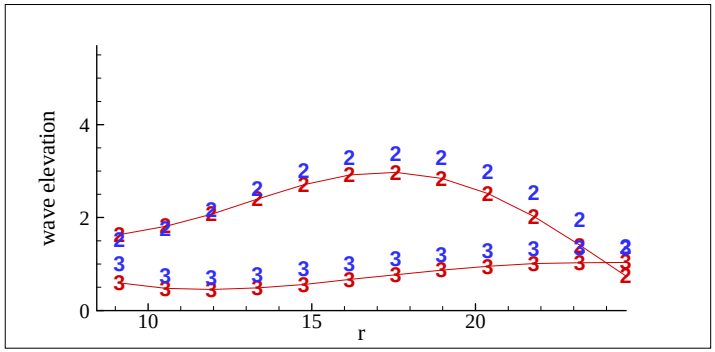
Body panels= 528
Free surface panels = 1232

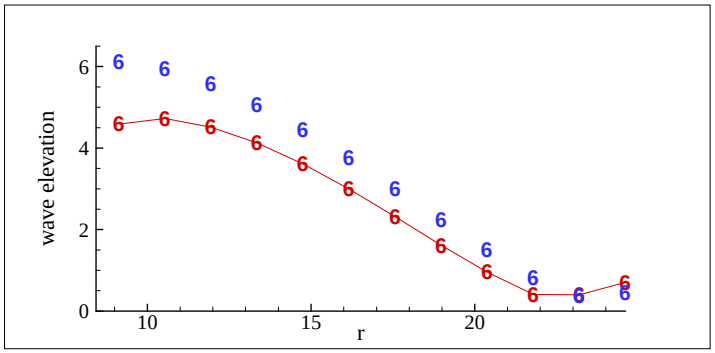


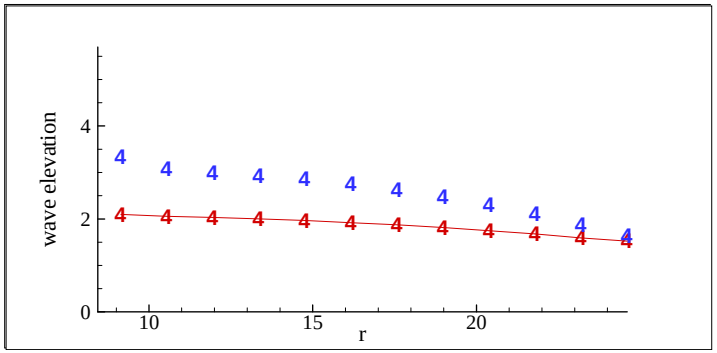
Wave elevation near the right column (ILOWHI=0)

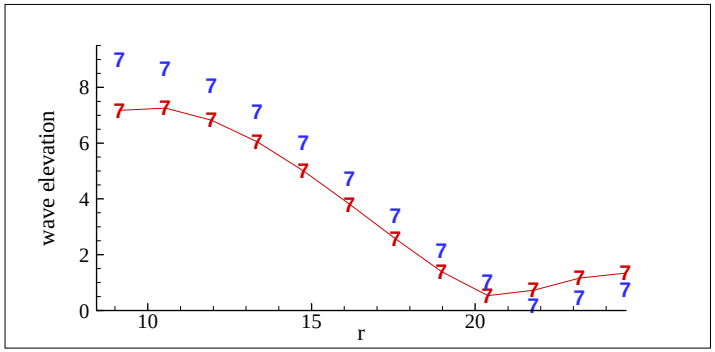




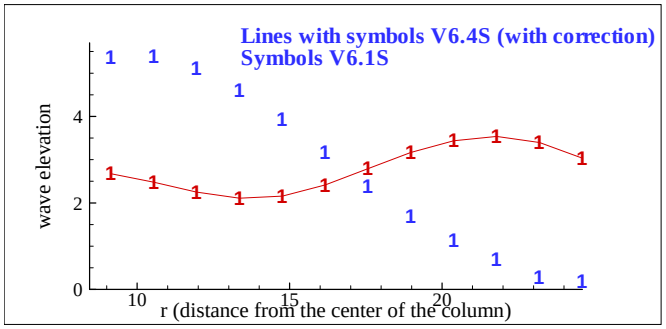


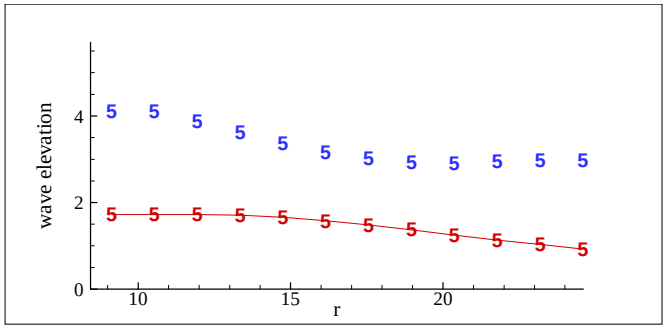


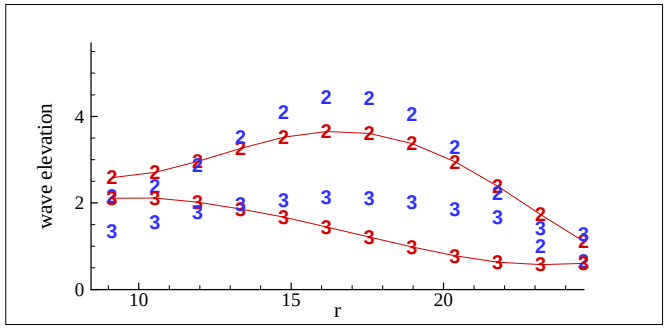


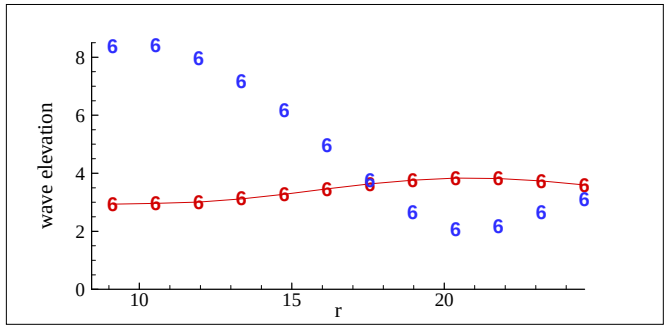


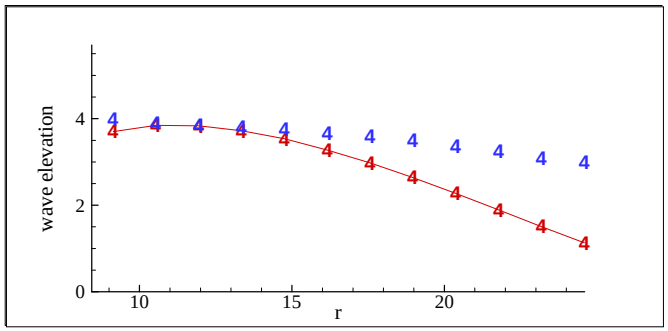
Wave elevation near the left column (ILOWHI=0)

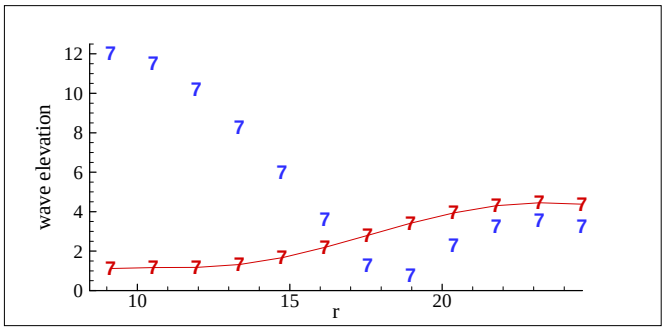




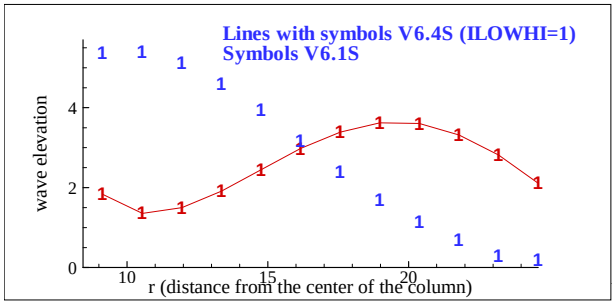


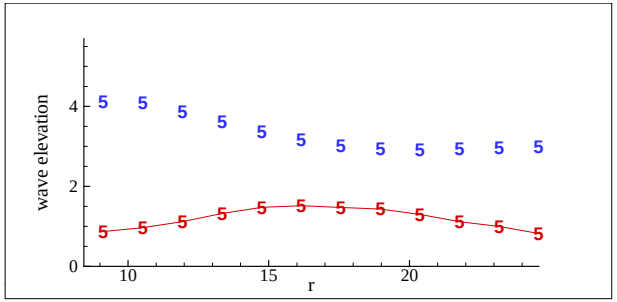


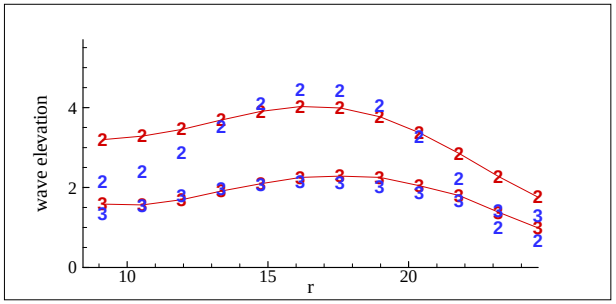


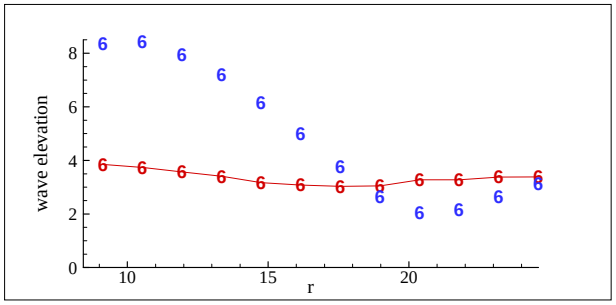


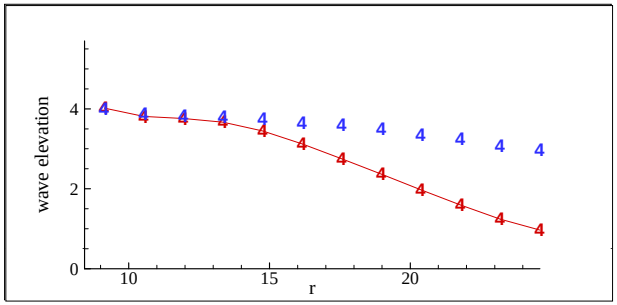
Wave elevation near the left column
(ILOWHI=1 V6.4S, ILOWHI=0 V6.1S)

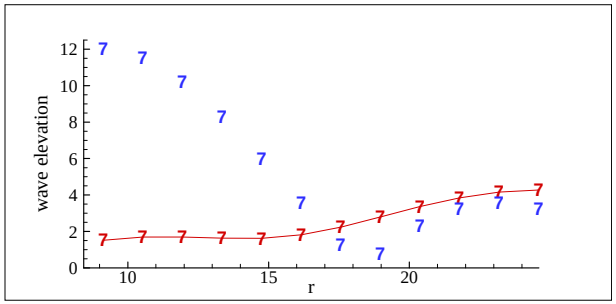










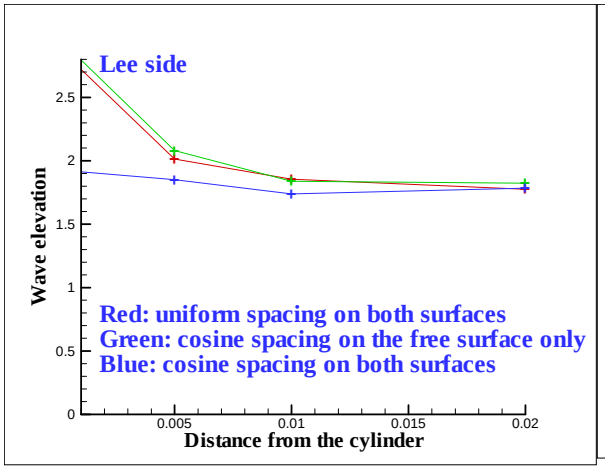


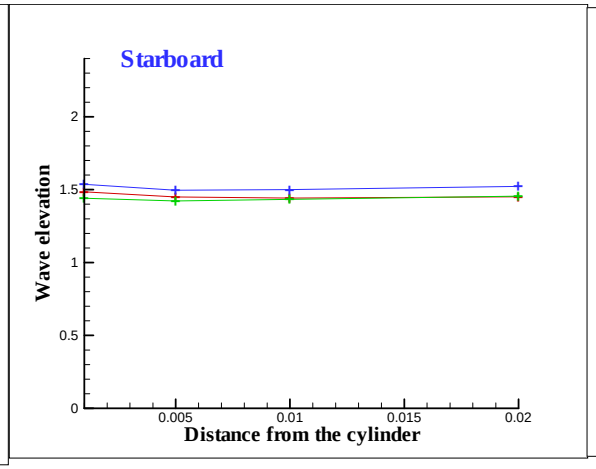
2.2
Wave elevation near a bottom mounted cylinder using higher order method

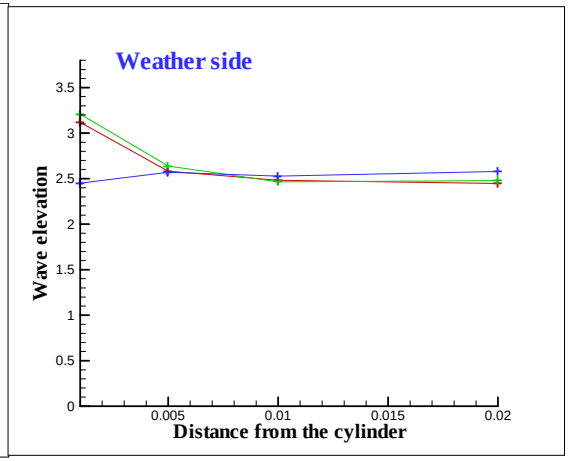
Depth/Radius=1
Infinite depth wave numbers (1,2)

The field point may not be arbitrarily close to the body because of piecewise integration of the forcings on the body. But using nonuniform mapping, the point can be approached closer to the body.

The results are obtained using 64 higher-order panels on one quadrant of the body and 92 panels on the free surface of the first quadrant of an annulus between radial distance 1 and 3.





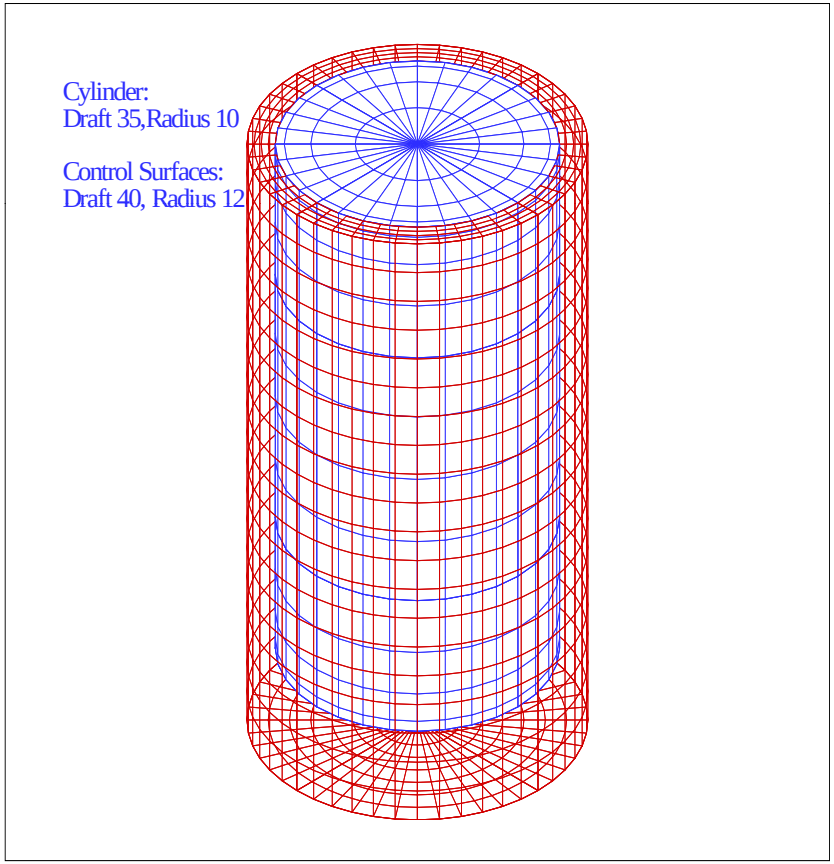


3. Control Surface Method for evaluation of quadratic forces

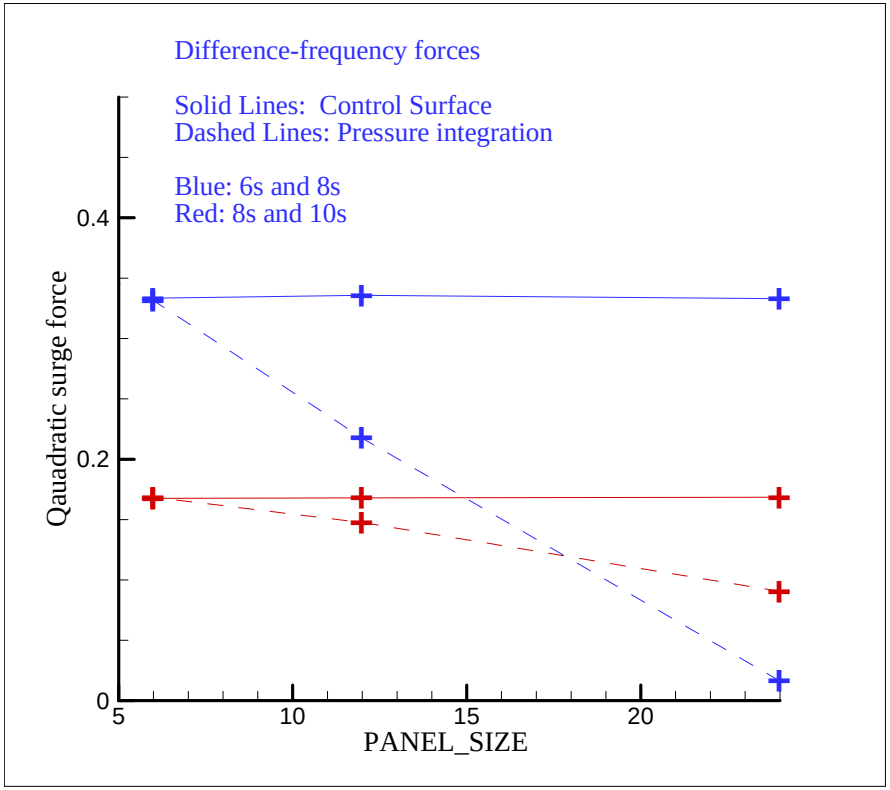
- Control surface method for the mean drift forces and moments in V6.4 is extended for the 2nd-order sum- and difference frequency quadratic forces

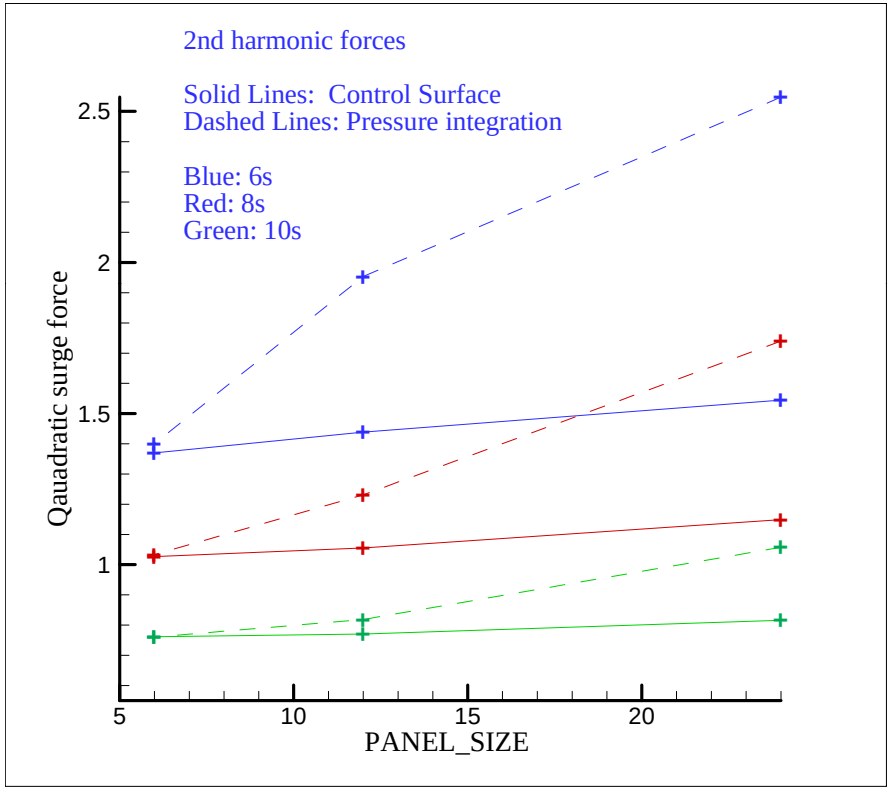
- It is more efficient and accurate than using quadratic pressure on the body only, especially for the bodies with corners.

- Evaluation of a part of the quadratic pressure is transferred to the control surfaces surrounding each body. Unlike mean drift forces, the other part of the pressure needs to be integrated over the body and it may not be as much efficient and accurate as for the mean drift force especially for the sum-frequency forces.



Quadratic forces on a truncated cylinder



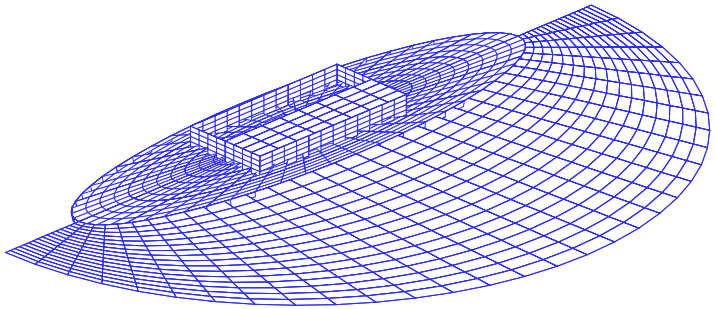


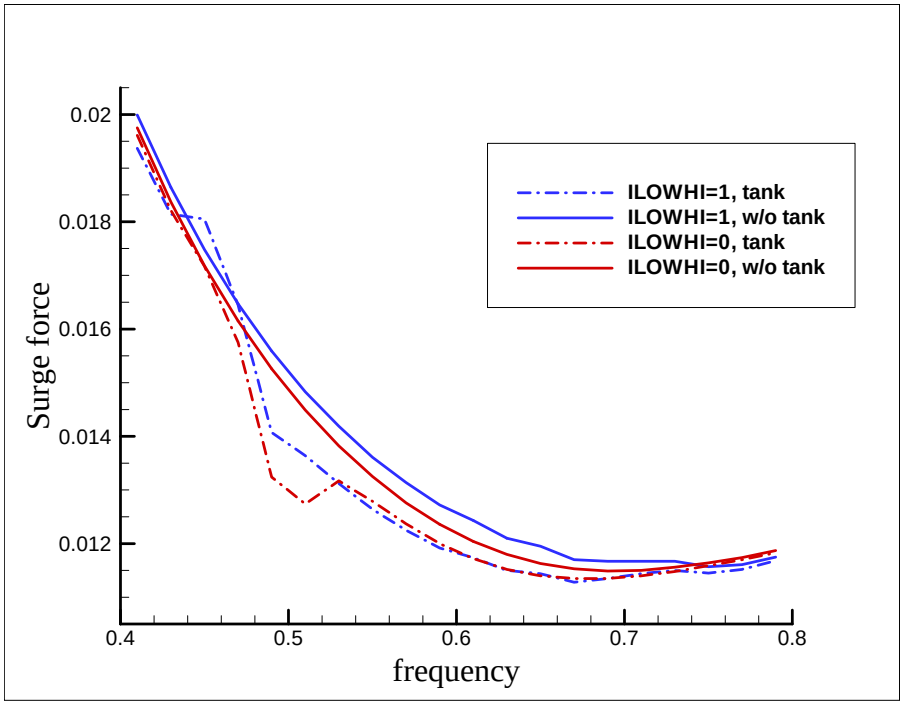
4. Internal tanks

A computational example of a vessel with an internal tank (preliminary results).

Difference frequency (0.02 sec) 2nd-order potential force on:
Ellipsoid with semi-axis: 75m, 30m and 20m
Tank: 50m, 24m, 10m
ILOWHI=1, Body 64 patches, Free surface 34
ILOWHI=0 , Body 1024 panels, Free surface 544

Wave heading 30 deg





Summary

- New features of V6.4S are reviewed in previous sides

In addition :

- An automatic free surface discretization method is implemented for ILOWHI=1

- For ILOWHI=0, when wave-elevation is computed, the input field points are automatically shifted toward the panel centroids, if they fall on the boundary of the free surface panel. (In V6.1S, the program was aborted.)

- Various minor refinements.

WAMIT V7 Updates

- V7 (11/14/11)

- V7.01 (12/2/12)
  * (IFORCE=2) + (NCPU=1 or NPER=1) option corrected
  * Header displayed before warning message to overwrite the .p2f or .out files

- V7.011 (1/16/12)
  * NPER=0 option corrected
  * **IPOTEN=0 + IFORCE=2 is not allowed**

- V7.02 (2/24/12)
  * **Revised defintion of input parameter IOPTN(7) in the .frc file**
    IOPTN(7)=1 Unidirectional
    IOPTN(7)=2 Bidirectional
  * **New input parameter IALTCSF in the .cfg file (or config.wam)**
    Alternative 1 or 2 of control surfaces method
    (Section 15.9 of User Manual)

- V7.021 (2/27/12)
  * Output options (IOPTN(n), n >=4) for force motion (IRAD > -1 and IDIFF=-1) is corrected

- V7.022 (3/15/12)
  * Field quantities (IOPTN(6)>0) for infinite frequency (PER=0) are corrected

- V7.023 (3/21/12)
  * Field quantities for forced motion (NBETA=0 and IDIFF=-1) is corrected

- V7.03 (5/24/12)
  * Pressure mean drift forces (IOPTN(9) > 0) on fixed bodies (IRAD= -1) are corrected

Corrections of errors listed above are made in the updates and extensions made in V7 from earlier version. These errors are not relevant to V6.4 or earlier versions.

USER MANUAL – WAMIT Version 7.0

List of Updates and Revisions

This document lists updates in the WAMIT User Manual, with brief explanations. It is intended to assist users by calling attention to updates, and indicating when it is appropriate to download the latest edition of the complete manual, or separate chapters thereof.

Changes in the Manual are listed below, preceded by three integers (Chapter, Section, Page). Note that page numbers may change from previous editions.

Updated 18 April 2012

2	1	2	added information regarding USERID_PATH and `readme.txt` file
4	7	35	added restrictions regarding USERID_PATH

Updated 22 March 2012

3	7	8	Factor KL added to definition of V_j
13	-	-	Chapter describing F2T revised
References	-	3	References 29-30 added

Updated 7-8 March 2012

9	5	10	reference to IALTPOT=1 and 'with IALTPOT=2' are removed
9	5	11	words including 'IALTPOT=1' are removed
12	1	4	modified last paragraph to explain tank hydrostatics
13	2	2	IPERIO=2 replaced by IPERIN=2
A	5	17	reference to ICTRSURF removed, Chapter 14 corrected to Chapter 11

A	13	47	reference to IALTPOT=2 removed
A	13	47	reference to ICTRSURF removed, Chapter 14 corrected to Chapter 11
A	14	56	IALTPOT and MAXSCR removed from the input file `test14a.cfg`
A	17	73	IALTPOT=2 removed from the input file `test17c.cfg`

First issued 1 March 2012

0	-	2	The date of the revised Manual is shown on page 0-2.
4	3	14	The value of IOPTN(7) is used in the same manner as Options 8 and 9, to control which combinations of wave periods are included in the evaluations of the drift force and moment.
4	7	25	The new parameter IALTCSF is added to the configuration file input list.
4	7	26	The value of IALTCSF designates Alternative 1 or 2 for evaluating the drift force and moment from a control surface.
4	7	31	Description of ISOR changed for Options 6 and 7.
4	7	36	The new parameter IALTCSF is added to the configuration file input list.
5	1	2	Second line under OPTN.9 is added under OPTN.7 (drift moment about moving origin)
5	2	4	Reference to Figure 12-2 replaced by Figure 15-2.
11	-	1-2	Alternatives 1 and 2 explained using new configuration parameter IALTCSF
15	9	14	IOPTN(7) replaced by IALTCSF

- List of Updates and Revision of User Manual is available at
  http://www.wamit.com/manualV7.0/UpdateList.pdf

WAMIT for Linux

Status Update

- WAMIT v7 for Linux completed March 2012
- Built for 64-bit systems running at least kernel 2.6.32 and glibc 2.3
- Tested on
  - Centos6 (Red Hat Enterprise Linux 6)
  - OpenSUSE 11
  - Ubuntu 11.10
- Linux demonstration program available for download

Little Lessons Learned

- The direction of the slash (currently) doesn't matter
  - Linux uses /
  - DOS uses \
  - However, DOS accepts /, so no code changes required
- Linux is case sensitive, DOS doesn't care
  - Code references to files such as 'userid.wam' changed to lower case
  - Users reminded of case sensitivity in documentation

Compiling WAMIT for Linux
Intel Fortran

- Basic compile flags: -O3 –openmp
  - Basic optimization and process openmp directives
- Shared Libraries (.so files aka Linux DLLs)
  - Basic compile flags plus:
    - -FPIC: compiler produces object files
    - -shared: compiler produces .so file from object files instead of executable

Timings

- Testing in virtualized* and non-virtualized systems

TEST14A	Linux (V)[1]		Linux (NV)[2]	Windows
		After reboot		
1 Core	106.0 s	35.3 s	39.4 s	30 s
2 Core	60.2 s	19.1 s	22.2 s	17 s
4 Core	40.0 s	11.6 s	21.4 s[2]	11 s

*virtualized timings very sensitive to virtualization setup, virus scan and Windows reboot

[1]virtualized 2 dual core CPUs run on Intel Core i7-2720QM @2.2GHz

[2]Intel Core2 Duo CPU T7500 @2.2GHz

Linux Distribution Notes

- General Site user distributions
  - Linux specific instructions
  - Installation scripts
  - *.so files and Intel redistributable libraries
- Consortium user distributions
  - Above plus generalized makefile

Optimization with WAMIT

by J. N. Newman

WAMIT Consortium Meeting

October 2012

(following from work described last year on scattering by a bottom-mounted cylinder with variable bathymetry)

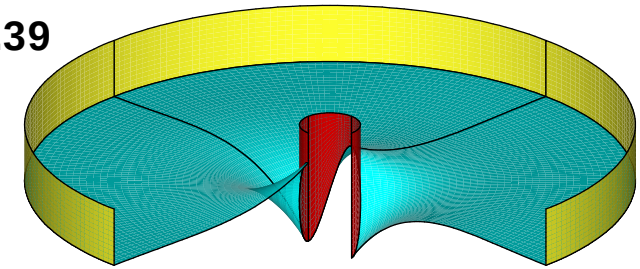
Beds shown last year -- optimized for `cloaking'

(2,2), (2,4), (4,4), (4,8) (Fourier,Chebyshev) modes

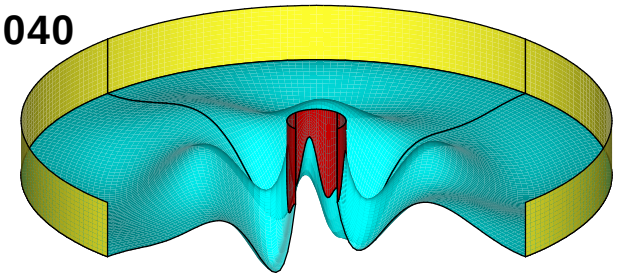
M=total number of optimized `modes'

E=scattered energy, Ecyl=cylinder alone

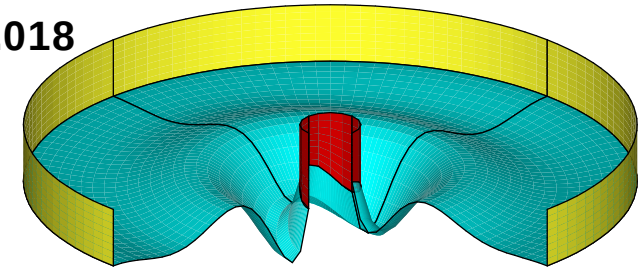
M=4 E=0.0353
E/Ecyl=0.39



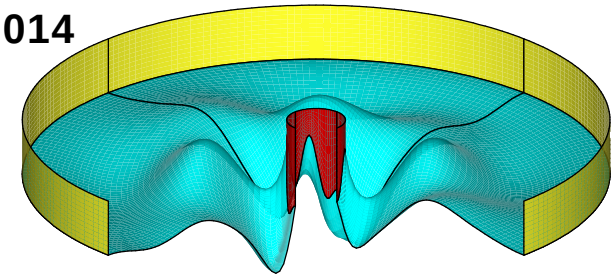
M=16 E=0.00036
E/Ecyl=0.0040



M=8 E=0.00164
E/Ecyl=0.018



M=32 E=0.00013
E/Ecyl=0.0014

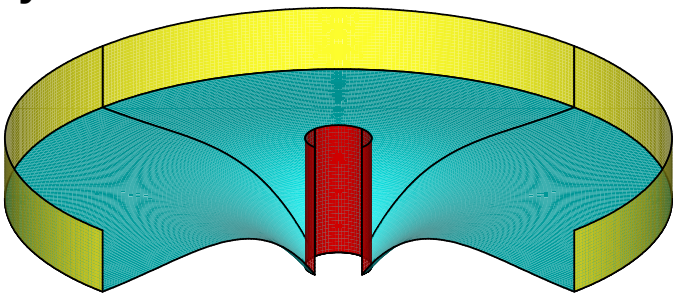


WAMIT is modified with solutions in two domains matched on the yellow cylinder

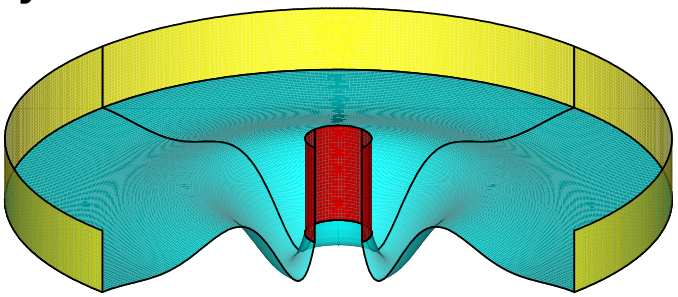
Later discovery: axisymmetric structures

(motivated by discussion at IWWWFB27)

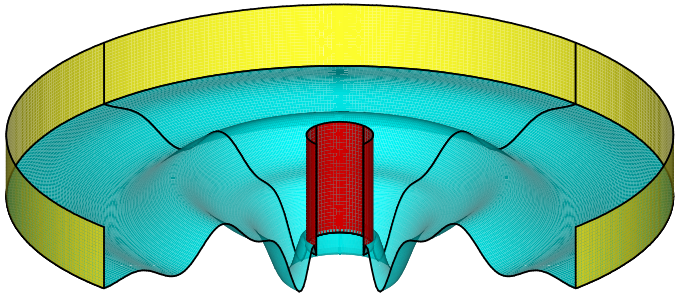
M=2 E=0.04016
E/Ecyl=0.4443



M=4 E=0.00222
E/Ecyl=0.0246



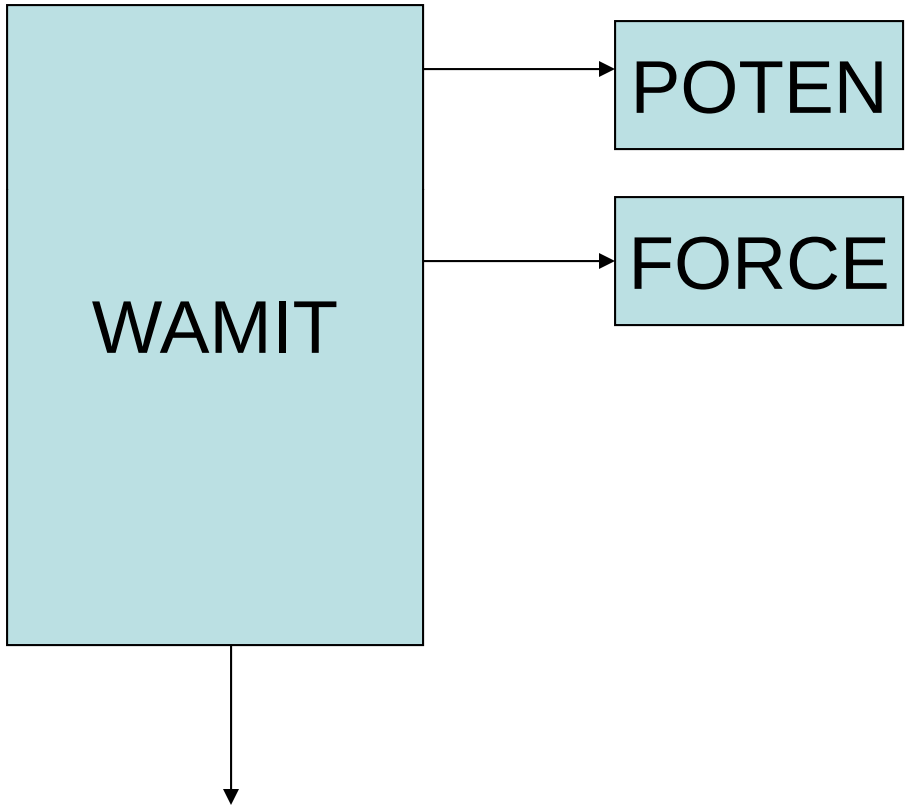
M=8 E=0.000114
E/Ecyl=0.0013



Development of a more useful code

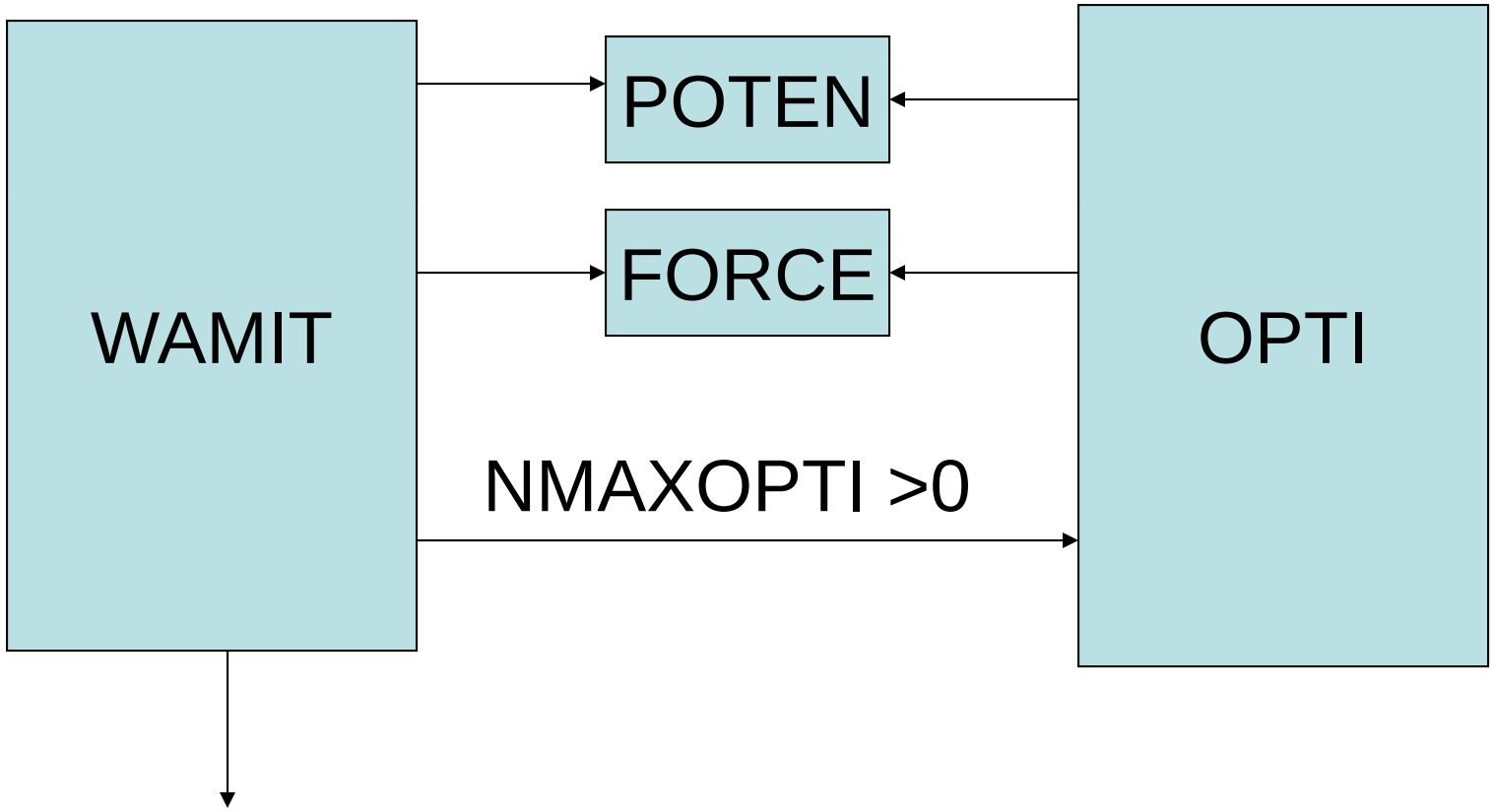
- Application to structures in constant or infinite depth
- No domain decomposition
- Optimizer is called as subroutine from WAMIT
- Can optimize any standard outputs (or modify source code for special outputs)

Conventional WAMIT flowchart
(no optimization option)



Modified flowchart

(option to optimize if NMAXOPTI>0)



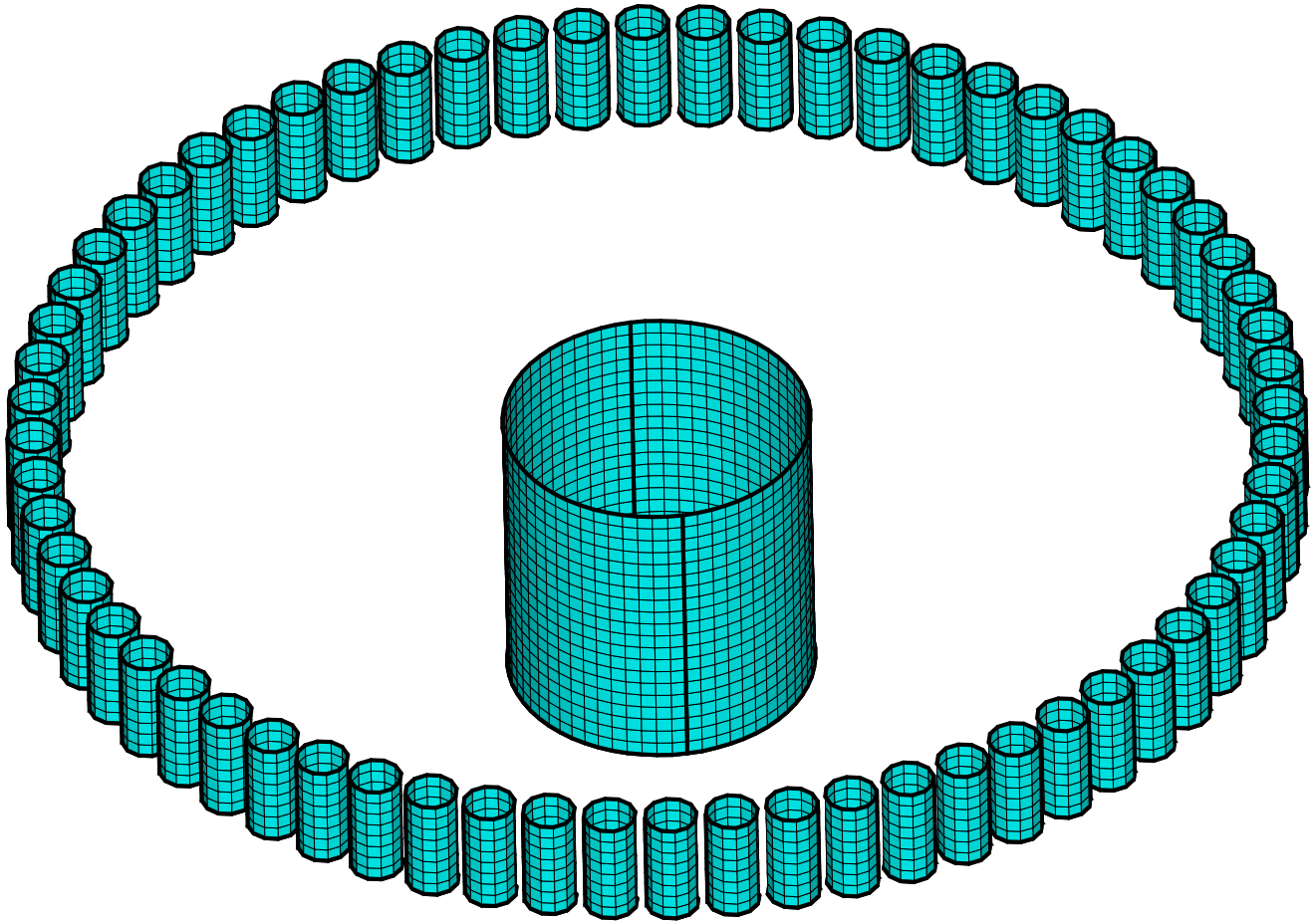
Results with new code

Bodies in infinite depth surrounded by outer structures optimized to minimize the scattered energy and mean drift force

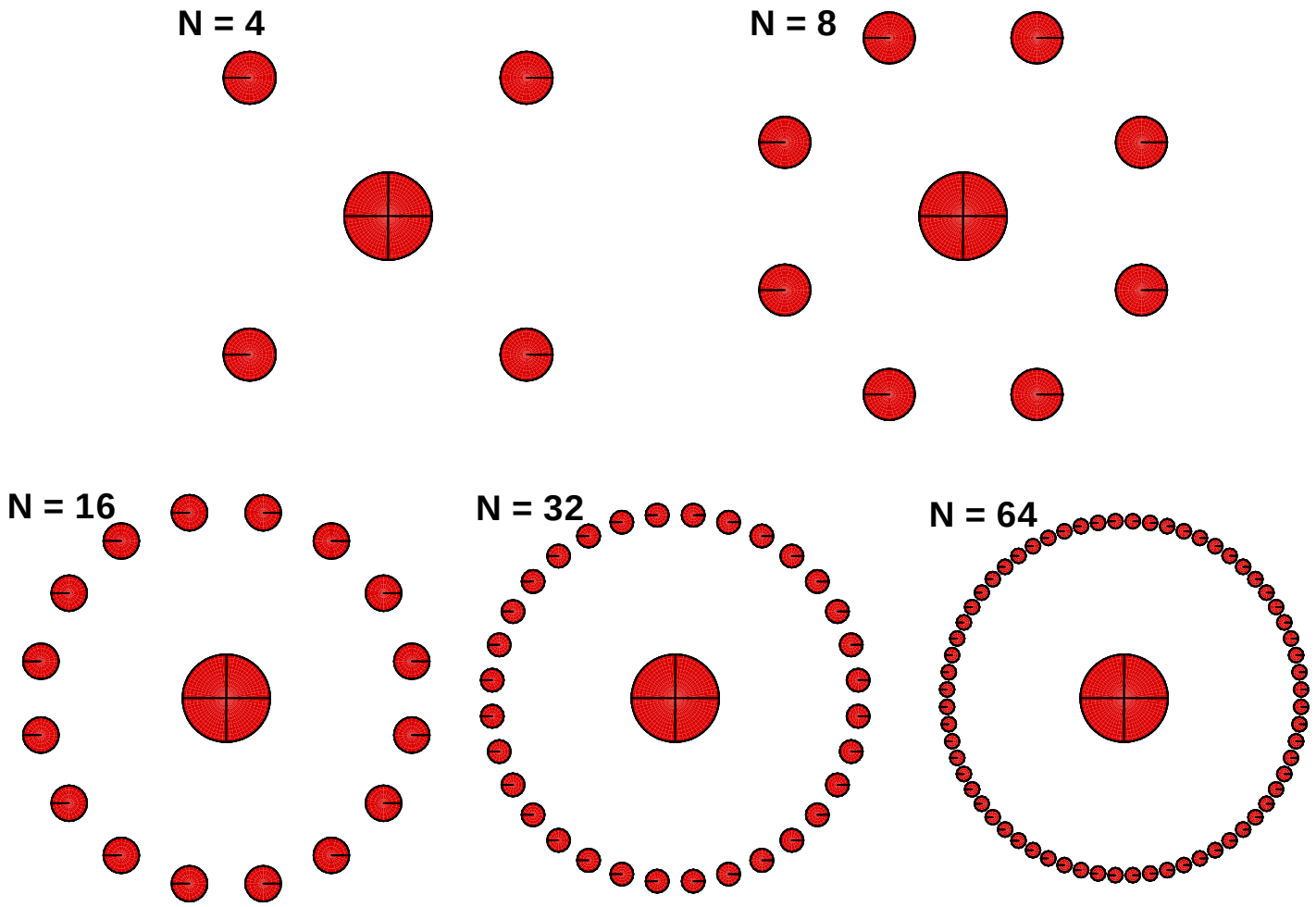
- all structures are fixed
- all optimizations at wavenumber K=1 (except as noted)

Circular cylinder of finite draft, surrounded by a ring of N uniformly-spaced cylinders

N=64:



Plan view, N = 4,8,16,32,64



Inner cylinder fixed: diameter=draft=1

E=scattered energy, Ecyl=cylinder alone

Optimized parameters:

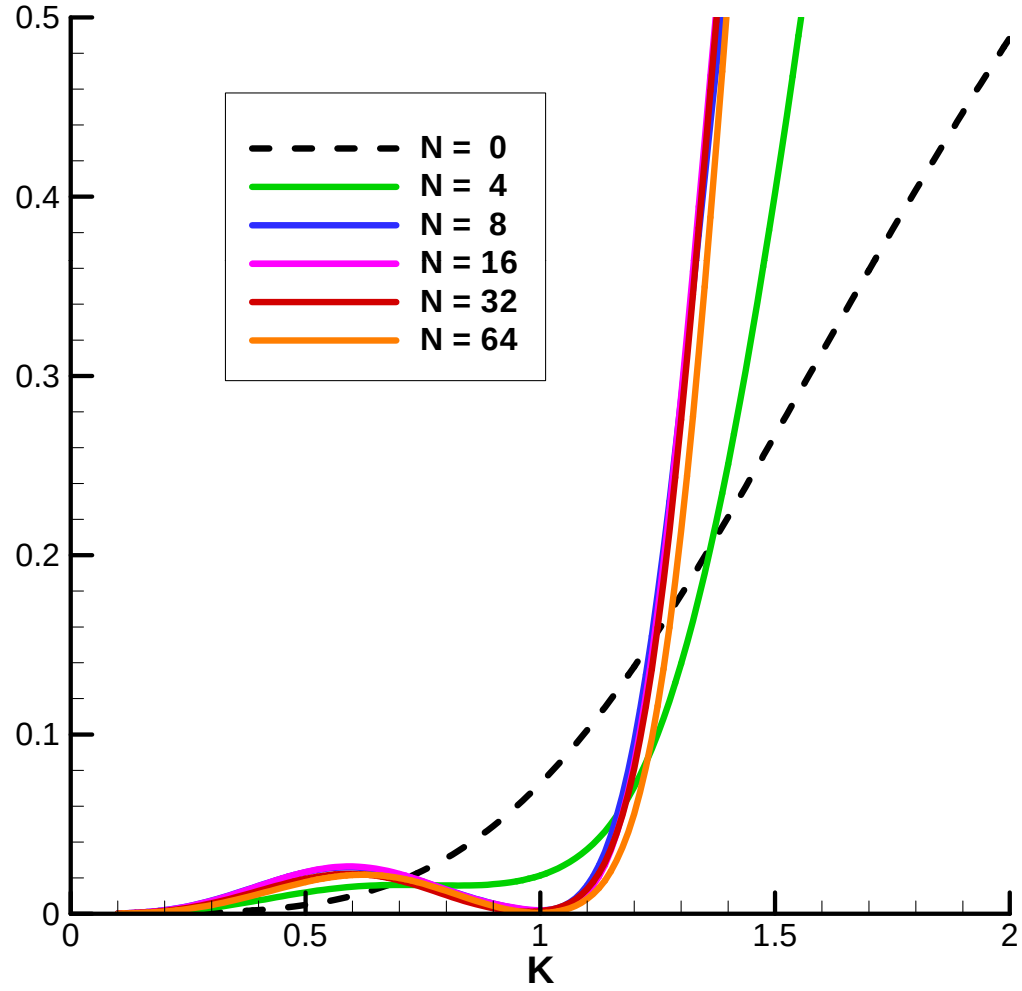
r,d = radius,draft of outer cylinders

R= radius of their axes

N	r	d	R	E	E/E_{cyl}
4	0.299268	0.343463	2.20706	0.02137	0.2939
8	0.293323	0.474505	2.20311	0.00184	0.0253
16	0.196341	0.478542	2.15920	0.00143	0.0197
32	0.130926	0.450723	2.10031	0.00091	0.0125
64	0.084790	0.360602	2.01702	0.00051	0.0071

Scattered energy vs wavenumber K

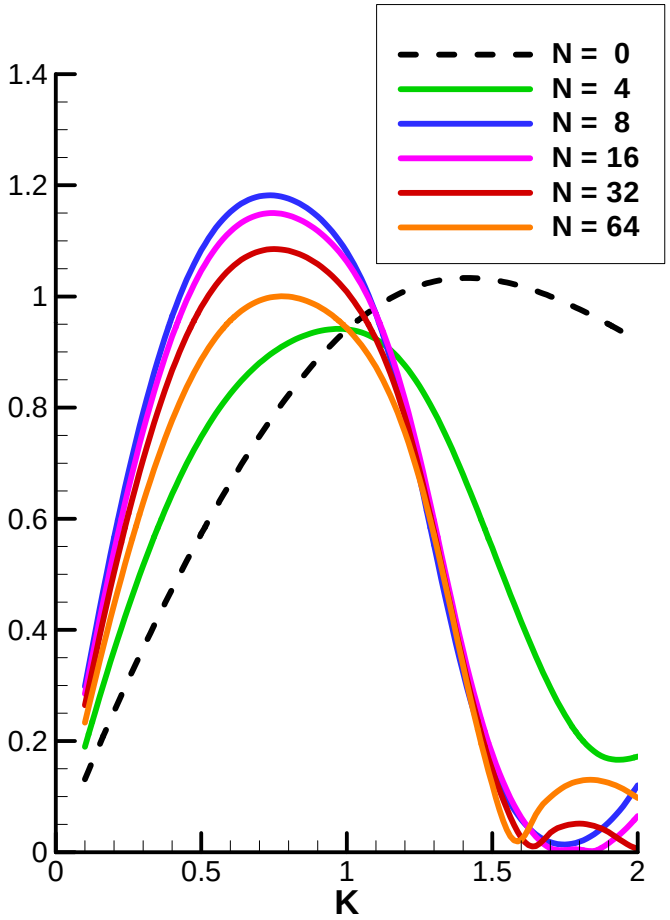
black dashed line (N=0): inner cylinder only



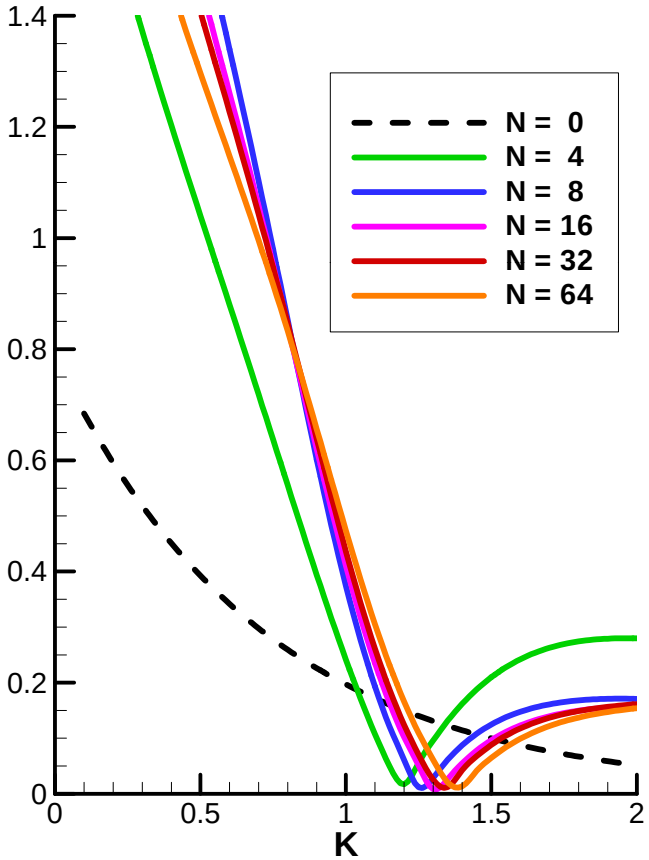
A practical question

- How does this affect the forces (including both the 1st-order exciting forces and the 2nd-order horizontal drift force)?

Exciting forces (on complete structure)



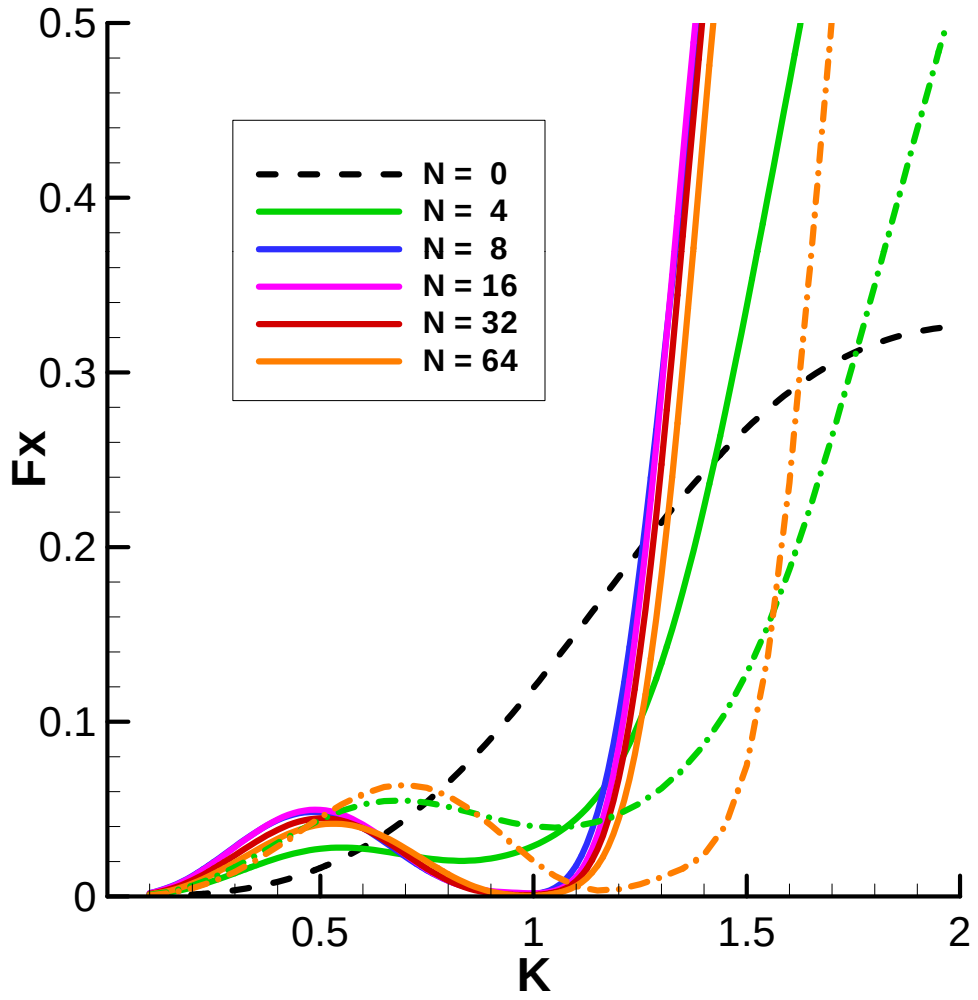
Surge



Heave

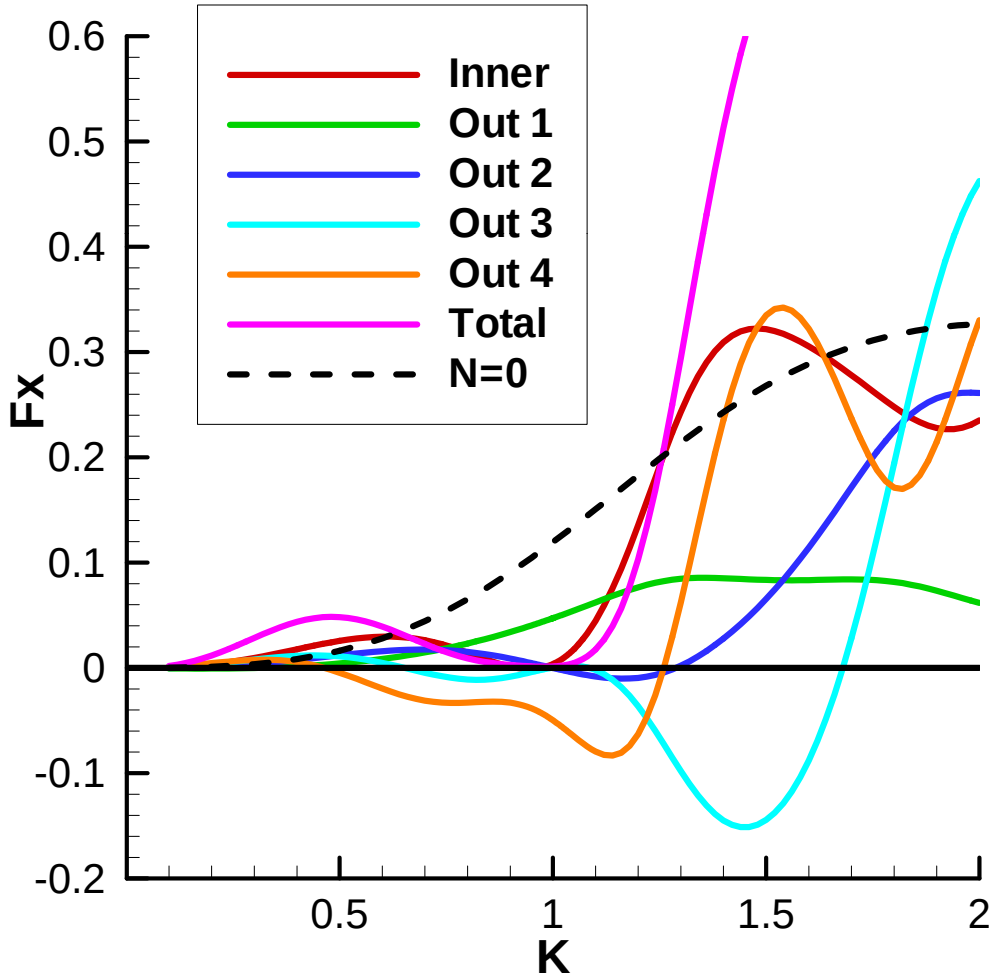
Drift force on the complete structure

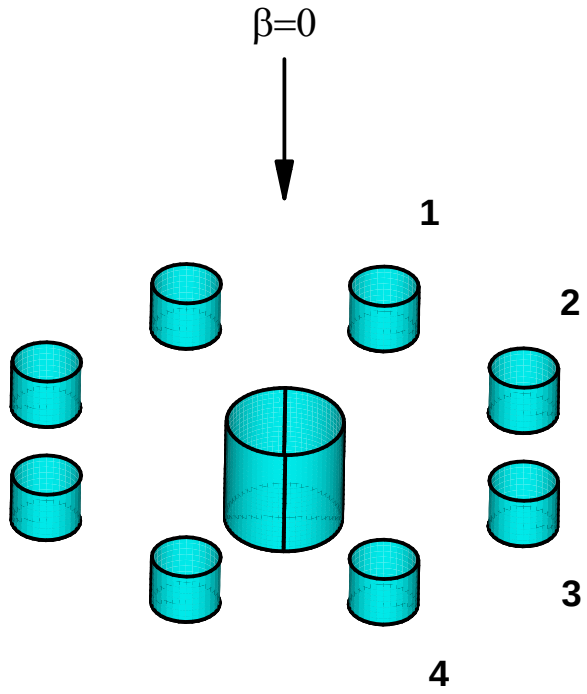
dash-dot lines: optimized for (0.8<K<1.4)



Drift force on each component (N=8)

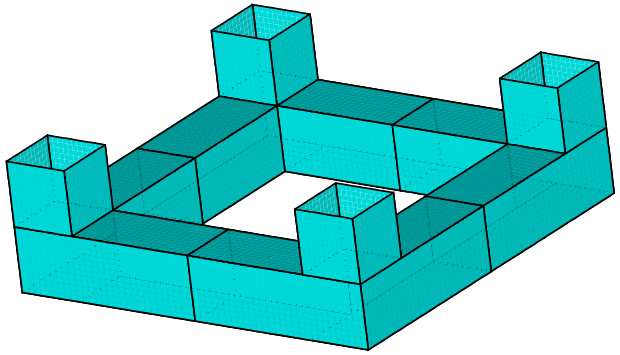
(Forces on outer cylinders y>0,y<0 are combined)



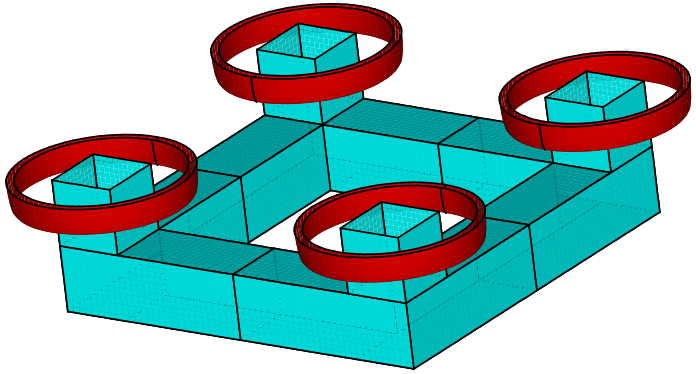


Another practical question

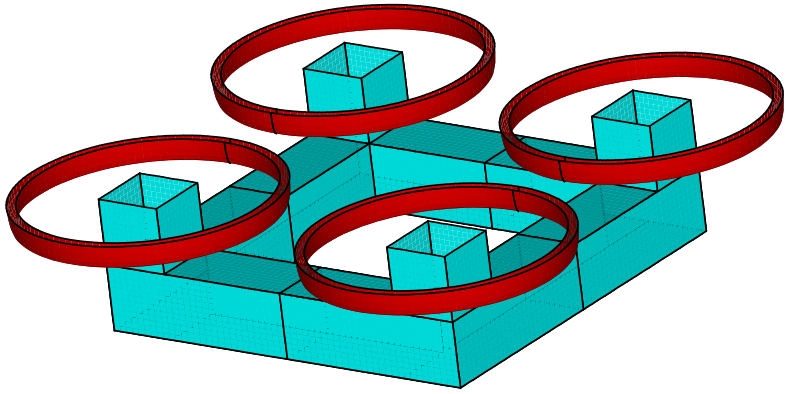
- Does this work for other structures?



Semi-sub
60 x 60 x 20 m



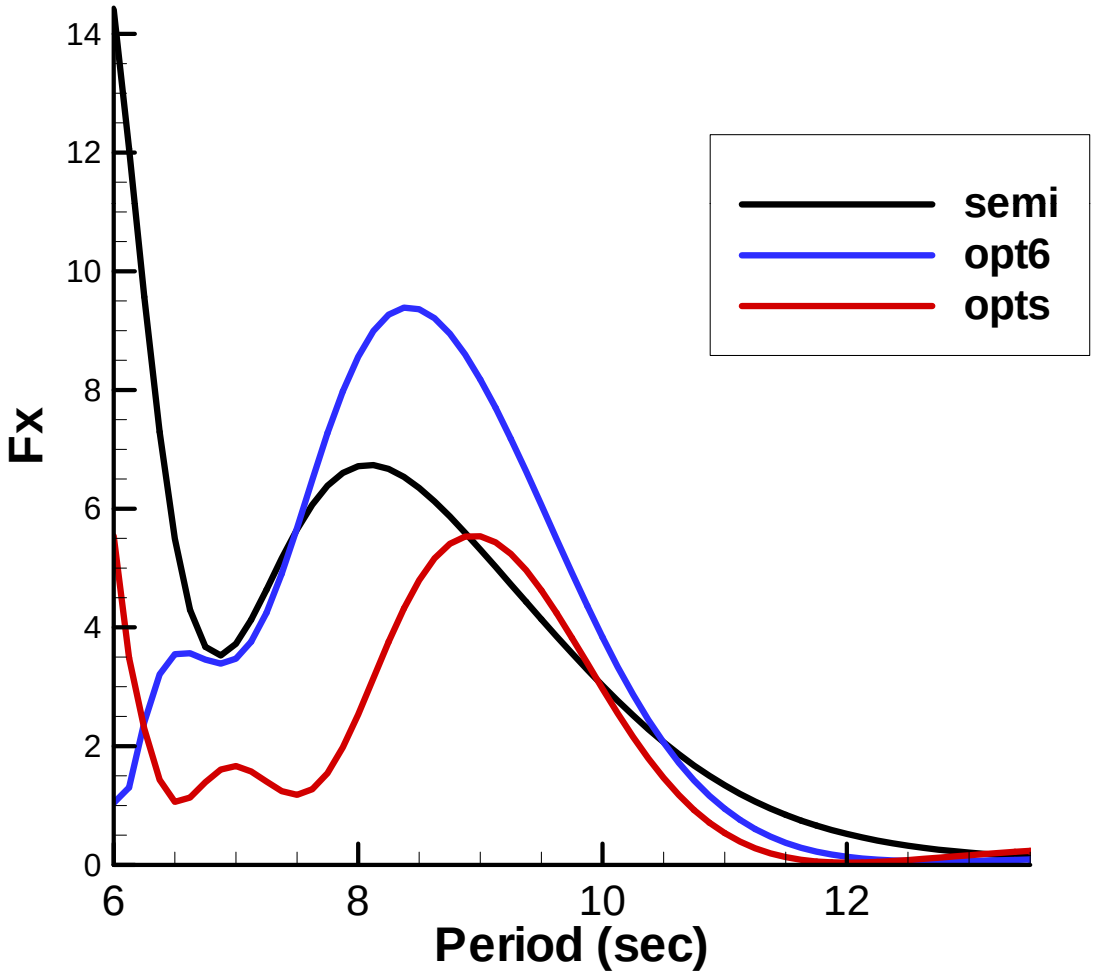
Optimized
Fx at 6 sec



Optimized
at 6-9.5 sec

Comparison of drift forces

semi: original (no rings), opt6: optimized at 6sec,
opts: optimized at 8 periods 6(0.5)9.5 sec



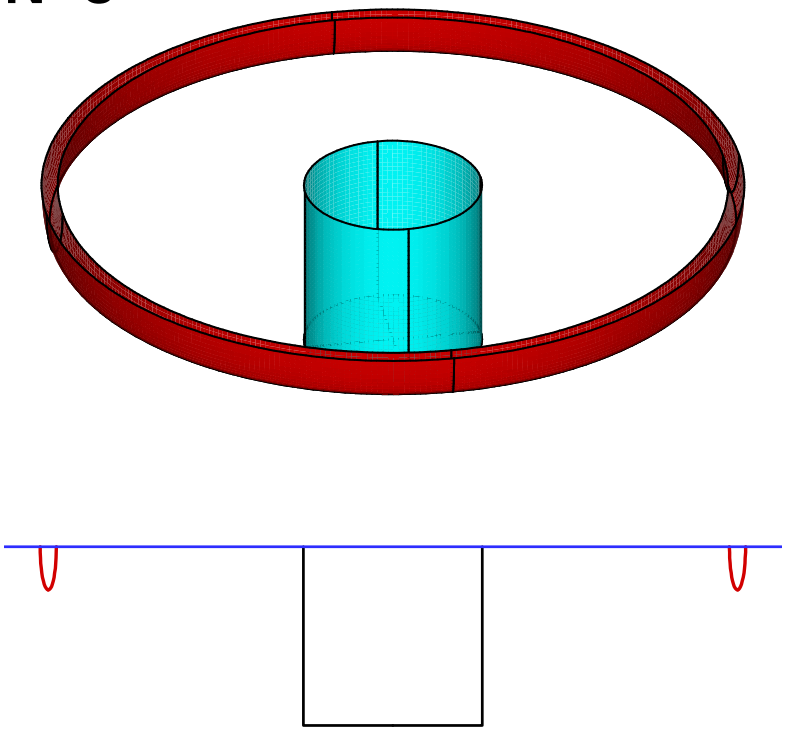
A scientific question

- Is complete cloaking possible (E=0)?

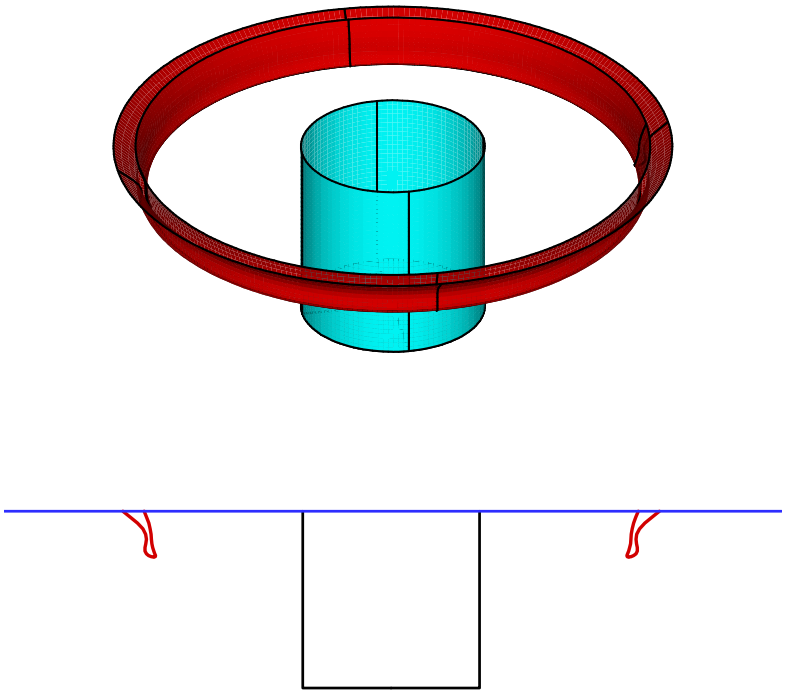
Toroidal rings with sections defined by Fourier series (N=3 is elliptical)

N=number of optimization parameters

N=3

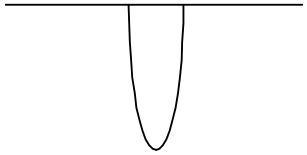


N=16

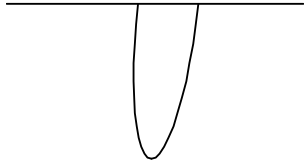


Reduction of scattering energy as N increases

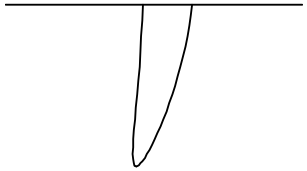
N=3 E=0.000222
E/Ecyl=0.00305



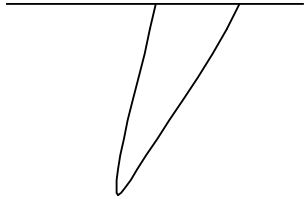
N=4 E=0.000128
E/Ecyl=0.00176



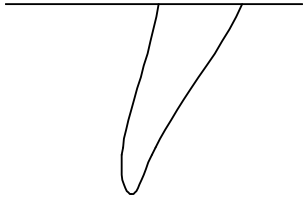
N=6 E=0.000087
E/Ecyl=0.00120



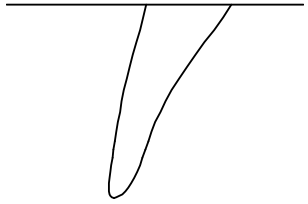
N=8 E=0.000017
E/Ecyl=0.00023



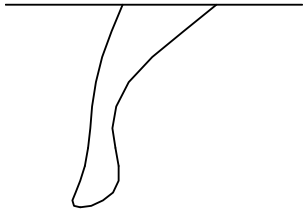
N=10 E=0.000018
E/Ecyl=0.00025



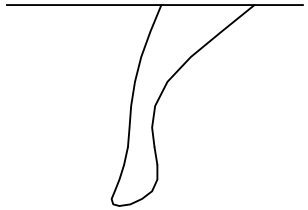
N=12 E=0.000015
E/Ecyl=0.00021



N=14 E=0.000008
E/Ecyl=0.00011



N=16 E=0.000008
E/Ecyl=0.00012



Caveats

- Code must be used with the higher-order method and geomxact subroutines
- Requires a large number of iterations (typically ~ 1000) with trial-and-error inputs to overcome false convergence
- Usually necessary to impose physical limits which may be restrictive

Conclusions

- Optimization can be used to reduce the drift force (quite dramatically, within a narrow bandwidth)
- Other applications of optimization using WAMIT?
- Experimental confirmation would be valuable!

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