

3rd Workshop of ISOPE Numerical Wave Tank Group

Seattle, USA, May 28 - June 2, 2000

Benchmark test cases for diffraction force

FIRST ANNOUNCEMENT

The Numerical Wave Tank (NWT) group of the International Society of Offshore and Polar Engineers was established at the 5th ISOPE conference in The Hague (1995). This group is open freely to everybody interested in this topic.

At the 7th conference in Honolulu (1997), it was decided by the member of the group to begin series of informal workshop meeting where computational benchmark cases will be defined and their results discussed and commented in a special session during the forthcoming ISOPE conference. A free access data bank will be created and enriched with the numerical results of the participants; this data bank will be accessible freely and permanently in an ftp site via Internet (see below). Then everybody will be able to get data files and to perform his own analysis and comparison with any other participant. The files will contain not only numerical results, but also a short text section where the numerical technique will be summarized and related bibliographic references will be given.

The first and the second special NWT Workshop session were held in ISOPE-98 Montreal Conference and ISOPE-99 Brest Conference. The third NWT Workshop session will be held in ISOPE-2000 Seattle Conference. The results, gathered and analyzed, will be presented by the NWT group leader (currently Katsuji Tanizawa), then openly discussed by all the present participants (contributing or not).

2000 Benchmark series : the topic of the third workshop is the **diffraction force** computation by numerical wave tanks. In this test case, hydrodynamic wave force acts on a fixed Lewis form body is considered. Pressure computation on the body is the key point.

Sending your result files : result files must be sent to Katsuji Tanizawa (Ship Research Institute of Japan) via email or FTP. Data file structure and format are given in the sections below. From the filename by appending the test case number to your name (or to a pseudo for anonymous contributors). One data file per test case via FTP, or attached to an email at:

email : **tanizawa@srimot.go.jp** (max. size = 1Mbyte/mail)

FTP : **W3.srimot.go.jp**(userid=ftp, password=youremail, directory=//172.17.3.118/Upload)
If you use FTP, please send me also an email to inform me. If you want to contribute anonymously, inform me in the mail, replace you name in the file by a four digit number of your choice, and give any chain of characters instead of your email in the data files.

Please, **limit the size of each data file to 3 Mbyte** by skipping time step or boundary vertices, and/or by *gzing* the file.

Deadline : 15th March 2000

Loading files from NWT FTP site : After checking and analysis, your files will be put in a permanent data bank freely accessible to everybody on the SRI Web server at:

<http://www.srimot.go.jp/dyn/member/tanizawa/nwtws2000/index.htm>

Everybody will thus be able to read results files of any other participant, and perform his own analysis and comparisons.

Benchmark test of diffraction problem

Diffraction of regular waves by a fixed Lewis form body

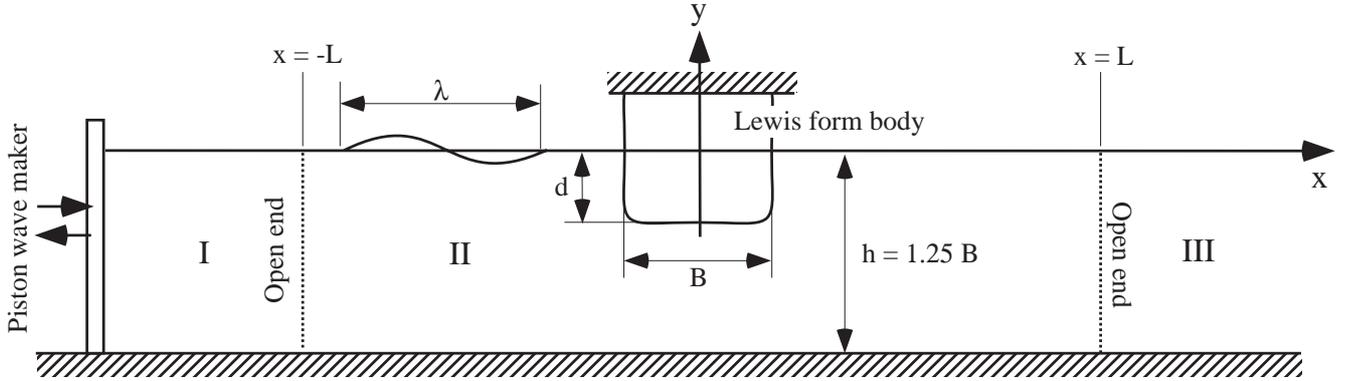


Figure 1

Description of benchmark test

- Depth of the body : $d = B/2$
- Lewis form parameter : $H_o = 1.0, \sigma = 1.0$ (See appendix)
- Depth of wave tank : $h = 1.25B$
- Motion of the wave maker : $X = A \sin \omega t$
- Amplitude of wave maker : $A/B = 0.01875, 0.03125, 0.04375$
- Wave frequencies ω , wave periods T and wave length λ

$\omega^2 B/g$	0.5	1.0	1.5	2.0	2.5	3.0
$T/\sqrt{B/g}$	0.9067	0.6411	0.5235	0.4534	0.4055	0.3702
λ/B	8.896	5.575	4.023	3.102	2.504	2.092

- Left end ($x = -L$) and right end ($x = L$) are supposed to be open
- Length of effective wave tank : $2L \geq 4\lambda$

The numerical simulation is started from the calm condition at time $t = 0$, and should be continued until the wave field converges to the periodically steady state. Any type of gradual start sequence of wave maker and any type of numerical wave absorption method can be used at outside of open ends (region I and III). The absorption of transmitted wave will begin at $x \geq L$ and may extended beyond this limit. If a numerical beach is used, it must be located in region III. The absorption of reflected wave will begin at $x \leq -L$. If an absorbing wave maker is used, the wave maker can be located at $x = -L$ and region I is not necessary. If a numerical beach is used, it must be located in region I. If no absorption is applied for reflected wave, distance between wave maker and fixed body should be taken long enough so that the simulated hydrodynamic forces do not affected by reflected wave before wave field around the body converges to the periodically steady state.

All the variables are nondimensionalized by breadth of body: B , gravitational acceleration: g and density of fluid: ρ . Units of variables are given in the following table.

length	B	acceleration	g	fluid density	ρ
time	$\sqrt{B/g}$	frequency	$\sqrt{g/B}$	velocity	\sqrt{Bg}
pressure	$\rho g B$	force/unit width	$\rho g B^2$	potential	$B\sqrt{Bg}$

Benchmark test number

$\omega^2 B/g$	0.5	1.0	1.5	2.0	2.5	3.0
$A/B = 0.01875$	①	[10]	②	[11]	③	[12]
$A/B = 0.03125$	④	[13]	⑤	[14]	⑥	[15]
$A/B = 0.04375$	⑦	[16]	⑧	[17]	⑨	[18]

①~⑨ : Benchmark test cases, [10]~[18] : Options

Result file structure (ASCII character set, possibly compressed by *gzip*.)

```
c Your name, e-mail address and benchmark number
  write(*,*) your.name
  write(*,*) your@email
  write(*,*) benchmark.test.number
c(1st block) Simulated diffraction forces on the body and wave elevations
  write(*,*) Ntime
  begin time loop from 1 to Ntime
    write(*,*) time,SF,HF,RM,W1,W2,W3
  end time loop
c(2nd block) Boundary values for one period of
c           the periodically steady state
  write(*,*) Mtime,Nfreesurf,Nbodysurf
  begin time loop from 1 to Mtime
    write(*,*) time
    begin free-surface nodes loop from 1 to Nfreesurf
      write(*,*) X(i),Y(i),U(i),V(i),[\phi(i),\phi_t(i)]
    end free-surface nodes loop
    begin body surface nodes loop from 1 to Nbodysurf
      write(*,*) X(i),Y(i),U(i),V(i),P(i),[\phi(i),\phi_t(i)]
    end body surface nodes loop
  end time loop
c(3rd block) Information of your simulation method
  write(*,*) the first line - 80 characters max.
  .....(as many comment lines as necessary)
  write(*,*) the last line - 80 characters max.
```

Comments

1st block : Time histories of fluid force will be given from the beginning to the end of the simulation. At the end of simulation, the wave field must have converged to the periodically steady state.

Ntime : number of time record of 1st block
time : nondimensional time (nondim. by $\sqrt{B/g}$)
SF : sway force acts on the body (nondim. by $\rho g B^2$)
HF : heave force acts on the body (nondim. by $\rho g B^2$)
RM : roll moment acts on the body (nondim. by $\rho g B^3$)
W1,W2,W3 : wave elevation at $x = -1.25\lambda, -\lambda$ and λ respectively (nondim. by B)

2nd block : Boundary values are given in the 2nd block. Please select one period to fill 2nd block after simulated wave field converged to the periodically steady state. Boundary values for $|x| > 2\lambda$ are not necessary.

Mtime : number of time record of 2nd block
Nfreesurf : number of nodes on the free-surface
Nbodysurf : number of nodes on the body surface
X(i),Y(i) : coordinates of node #i, $-2\lambda \leq X(i) \leq 2\lambda$, (nondim. by B)
U(i),V(i) : horizontal and vertical components of fluid velocity at node #i
(nondim. by \sqrt{Bg})
P(i) : pressure at the node #i (nondim. by $\rho g B$)
 $\phi(i)$: velocity potential at node #i (nondim. by $B\sqrt{Bg}$)
 $\phi_t(i)$: time derivative of velocity potential at node #i (nondim. by Bg)
[$\phi(i), \phi_t(i)$] are for potential flow participants

3rd block : After the numerical data, participants are requested to append to the file any relevant matters such as : type of simulation method, the wave absorption technique at open end, velocity calculation method at the intersection point of body and free-surface and references about simulation codes. In particular, potential flow participants are requested to mention the method to compute ϕ_t .

- (1) Finite difference method
- (2) From the solution of the B.V.P. on ϕ_t
(please describe the boundary condition on body surface)
- (3) Others (Please describe in detail)

Technical computational details as: type of computer, operation system, programming language, program size, cpu time are also welcome. For this final part of the file, use as many lines of 80 character (max.) as necessary, within the limit of 3 Mbyte/whole_file. Please use a “Keyword” writing style to save space.

Appendix : Lewis form

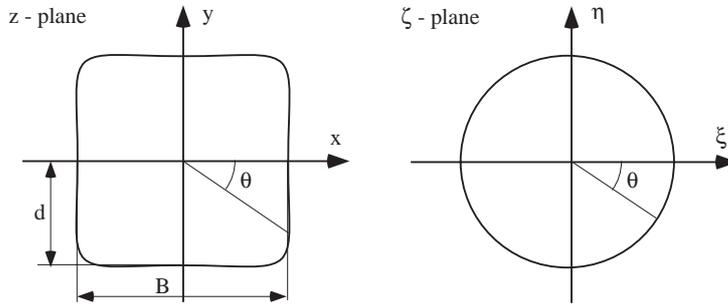


Figure 2

Lewis form body shape shown in z-plane is obtained by conformal mapping of unit circle shown in ζ plane. The mapping function is

$$\frac{z}{M} = \zeta + \frac{a_1}{\zeta} + \frac{a_3}{\zeta^3}$$

Using this mapping, Lewis form is given as

$$\begin{aligned} x &= M \{ (1 + a_1) \sin \theta - a_3 \sin 3\theta \} \\ y &= M \{ (1 - a_1) \cos \theta - a_3 \cos 3\theta \} \end{aligned}$$

Where M is scaling factor and Lewis form parameters are defined as

$$\begin{aligned} M &= B/2(1 + a_1 + a_3) \\ H_o &= B/2d = (1 + a_1 + a_3)/(1 - a_1 + a_3) \\ \sigma &= \frac{\pi}{4} H_o \frac{1 - a_1^2 + 3a_3^2}{(1 + a_1 + a_3)^2} \end{aligned}$$

When $H_o = \sigma = 1.0$, $M = 1.16328019417857$, a_1 and a_3 are determined as 0. and -0.140361879275243 respectively. Following table is a sample of (x,y) as a function of θ .

Table : A sample of Lewis form shape

θ	x	y
0.0000000E+00	0.1000000E+01	0.0000000E+00
0.8726646E-01	0.1001137E+01	-0.1436466E+00
0.1745329E+00	0.1004203E+01	-0.2836416E+00
0.2617994E+00	0.1008186E+01	-0.4165356E+00
0.3490659E+00	0.1011486E+01	-0.5392701E+00
0.4363323E+00	0.1012030E+01	-0.6493400E+00
0.5235988E+00	0.1007430E+01	-0.7449203E+00
0.6108652E+00	0.9951634E+00	-0.8249467E+00
0.6981317E+00	0.9727644E+00	-0.8891469E+00
0.7853982E+00	0.9380198E+00	-0.9380198E+00
0.8726646E+00	0.8891469E+00	-0.9727644E+00
0.9599311E+00	0.8249467E+00	-0.9951634E+00
0.1047198E+01	0.7449203E+00	-0.1007430E+01
0.1134464E+01	0.6493400E+00	-0.1012030E+01
0.1221730E+01	0.5392701E+00	-0.1011486E+01
0.1308997E+01	0.4165356E+00	-0.1008186E+01
0.1396263E+01	0.2836416E+00	-0.1004203E+01
0.1483530E+01	0.1436466E+00	-0.1001137E+01
0.1570796E+01	0.0000000E+00	-0.1000000E+01
0.1658063E+01	-0.1436466E+00	-0.1001137E+01
0.1745329E+01	-0.2836416E+00	-0.1004203E+01
0.1832596E+01	-0.4165356E+00	-0.1008186E+01
0.1919862E+01	-0.5392701E+00	-0.1011486E+01
0.2007129E+01	-0.6493400E+00	-0.1012030E+01
0.2094395E+01	-0.7449203E+00	-0.1007430E+01
0.2181662E+01	-0.8249467E+00	-0.9951634E+00
0.2268928E+01	-0.8891469E+00	-0.9727644E+00
0.2356194E+01	-0.9380198E+00	-0.9380198E+00
0.2443461E+01	-0.9727644E+00	-0.8891469E+00
0.2530727E+01	-0.9951634E+00	-0.8249467E+00
0.2617994E+01	-0.1007430E+01	-0.7449203E+00
0.2705260E+01	-0.1012030E+01	-0.6493400E+00
0.2792527E+01	-0.1011486E+01	-0.5392701E+00
0.2879793E+01	-0.1008186E+01	-0.4165356E+00
0.2967060E+01	-0.1004203E+01	-0.2836416E+00
0.3054326E+01	-0.1001137E+01	-0.1436466E+00
0.3141593E+01	-0.1000000E+01	0.0000000E+00