Orcina Newsletter
www.orcina.com
April 2005

OrcaFlex v8.6 is Released

Welcome to the April 2005 Orcina Newsletter. Traditionally our newsletters have been linked to the release of OrcaFlex. However, for various reasons this newsletter is a couple of months behind the release of OrcaFlex version 8.6. Despite this there is still plenty of informative content here, which we hope you find useful....

The two main articles in this newsletter examine a validation issue and the 'long promised' nets article. The validation article deals with the transmission of axial stress waves. Using the robust explicit integrator in OrcaFlex is a good way of capturing and examining this effect, and comparisons with theoretical predictions are presented. The second article finally covers something we have promised for sometime now – namely the modelling of, and collision with, nets.

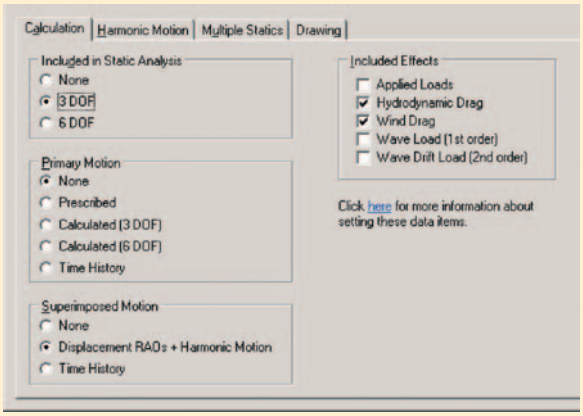
There is also the usual digest of news, hints and short articles on the main features in 8.6. We are already well advanced through the next development cycle where two of the developments herald a new era for OrcaFlex. The first of these is the addition of an implicit integrator to speed up OrcaFlex simulations, and the second is the advent of shaded (eg *Figure 2* on page 2) graphics for much greater realism - much more on these in the next newsletter, and some will be on display at this years OTC show, Booth#2758.

In This Months Newsletter

Changes to the Vessel Calculation Page

With the advent of wave frequency wave load calculations for Vessels in OrcaFlex, we have reorganised the layout and use of the data on the Calculation page of the Vessel data form. Here we explain how to use this new layout (shown below), where we have replaced drop down boxes with radio buttons, and added a box for selecting the Included Loads. The screen shot shows the default selection of options on this page. With this new layout, the options on the left of the page (Included in Static Analysis, Primary Motion and Superimposed Motion) tell OrcaFlex how to determine the vessel motions, and which degrees of freedom (DoF) to include. Then, for the selections you make on the left, the right hand box (Included Effects) indicates which loads are to be included in the analysis.

Included in Static Analysis: Lets the user exclude the vessel from statics, only calculate the horizontal motion, or determine all 6 DoF. For these last two options, the Included Effects can include Applied Loads, Hydrodynamic Drag, Wind Drag, and Wave Drift Load (giving the mean wave drift force). Although the wave drift load is strictly a dynamic effect, it is very often applied as a static load to find the steady offset of the vessel.



Primary Motion: Here's where the real change applies: Under this option the loads arising from checked Included Effects will only affect the vessel motion if the primary motion is set to one of the Calculated options. Otherwise the vessel motion is completely specified by prescribed motion or by the use of a time history file.

Superimposed Motion: Here the options available to the user have not changed with this new layout, other than being presented as radio buttons.

A point to note: With this new layout, all combinations of Primary and Superimposed Motion and the Included Effects are possible. Some combinations might not be that appropriate – for example you can set Primary Motion = Calculated 6 DOF, Superimposed Motion = Displacements RAOs…, and set Included Effect to include the 1st Order Wave load. This would add in the wave frequency effects twice. We have decided not to preclude the user from selecting such combinations – our experience in the past with other such decisions is that whilst we don't see the rationale for 'odd' combinations, our clients are quite likely to invent good reasons for wanting these available. However, we do offer a warning if the combinations selected are 'out of the ordinary' – a warning the user is free to ignore.

More Short Articles on Page 5

VIV Toolbox Developments

The OrcaFlex VIV Toolbox module has been receiving some technical attention lately, and is also gathering good commercial momentum. We have been involved in some major validation exercises recently and we have also reviewed and changed the commercial terms.

Commercially, the OrcaFlex VIV Toolbox started life as one module. Approximately 2 years ago we split the module in two: one part containing the interfaces to the 3rd party programs SHEAR7 and VIVA, and the other part holding the time domain VIV prediction tools. This situation became difficult to maintain. Because of this and other pressures, we have re-combined all the functionality and facilities offered back into one. However, we have also significantly altered the price structure of this module - please enquire for further details.

We have also extended the technical capability within the VIV Toolbox. With the VIV Toolbox module enabled, the user has for sometime been able to export the SHEAR7 mode shape file from the modal analysis form. To complement this, you can now also export the structural data for use with SHEAR7. This export facility appears on the VIV tab of the Line Data Form, and produces a datafile fully consistent with SHEAR7.

Orcina

How to Model Underwater Nets and Net Collisions

OrcaFlex has occasionally been used to model impact protection nets, for fixed jackets or for port/harbour security barriers. Indeed, we have also been asked if we can model fish nets! The answer is of course yes. However, it used to be very tedious to set the model up, but with the onset of the Model Browser grouping facilities in OrcaFlex it has become relatively easy.

This article explains how to set up net models in OrcaFlex, and shows how collisions can be analysed.

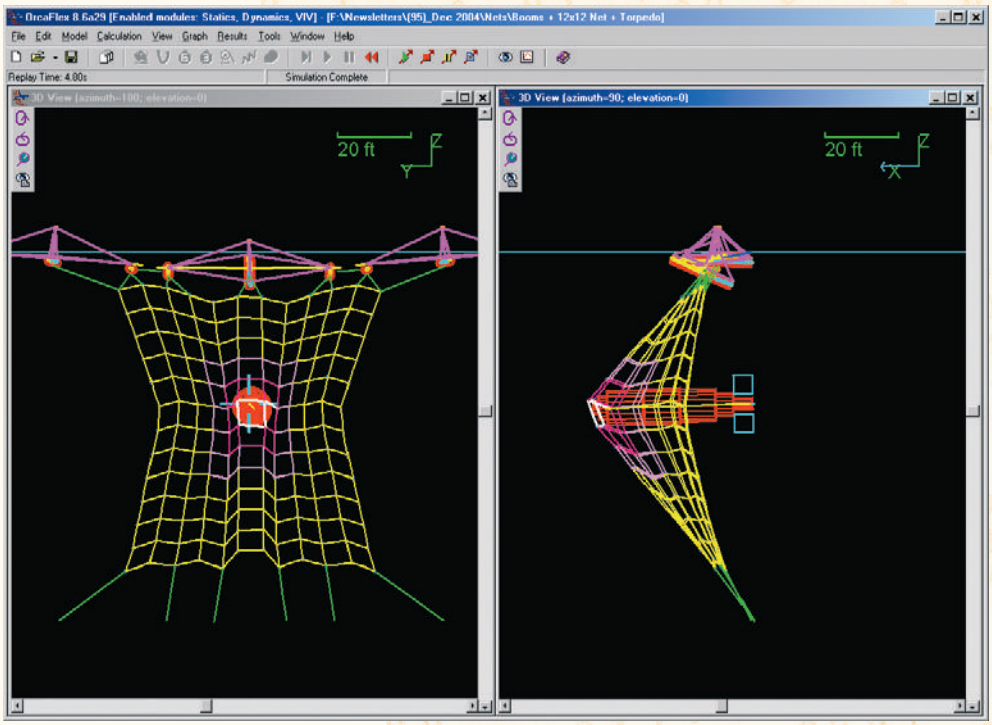


Figure 1 - Screenshot showing the Boom, Net and Torpedo Modelling Objects.

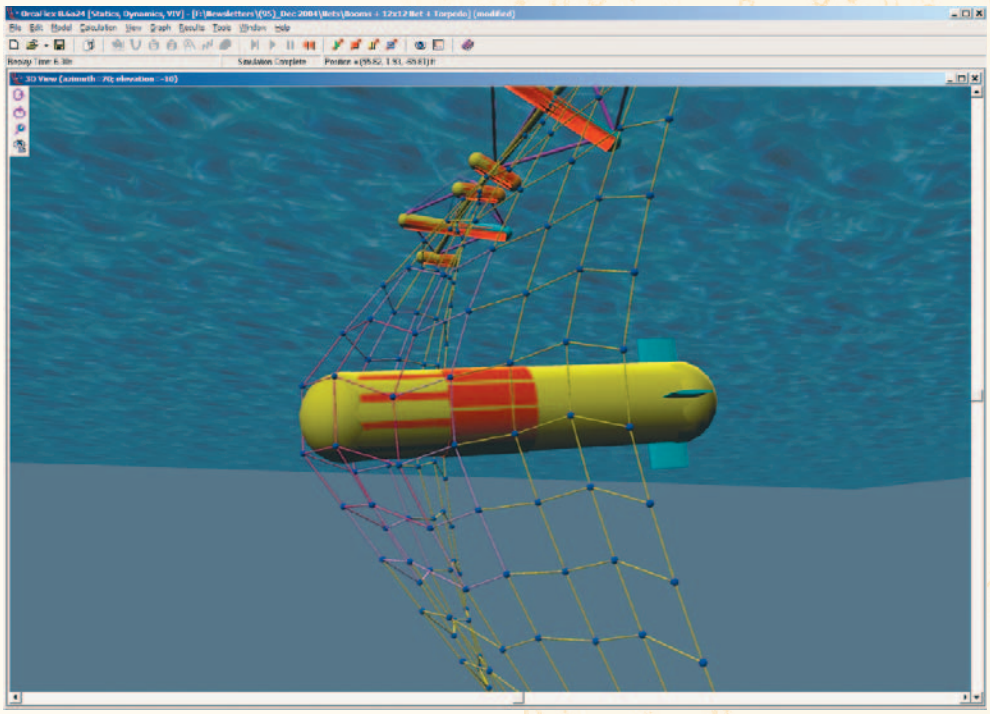


Figure 2 - Using the forthcoming OrcaFlex Shaded Graphics Option gives a visually more meaningful result.

Setting up the OrcaFlex model:
There are, in-fact, three elements to setting up a model showing a collision with an impact protection net: the net itself, the floating booms supporting the net, and the torpedo object.

Each of these elements can be seen in *Figure 1*, and we outline below the method for setting these up. We must also allow for any environment we might wish to consider, but this is straightforwardly covered by the facilities already in OrcaFlex.

1. Modelling the Supporting Booms
The supporting booms are simply set up through a combination of buoys for the pontoons, and single segment lines for the superstructure. Model geometry is straightforward, and we attach some 'dummy' lines (ie, lines with no physical properties, except geometry for contact) to the pontoons in case impact between the torpedo and boom structure is likely.

Simple linear tether elements are used to connect the net to the undersides of the booms, and to inter-connect boom units. The boom mooring is normally to a port structure or seabed contour, but can also be fixed at any arbitrary position.

2. Modelling the Net
For the net, 'knots' connect the lines, and lines join the knots together. In OrcaFlex, 3D Buoys with negligible properties are used as knots (they are only needed as a convenient object to connect the lines).

The lines are modelled as single segment lines. Consequently, an 8 x 8 mesh has 64 3D Buoys and 128 Lines - hence the number of objects in a net model can rapidly escalate. Handling this data in a sensible and consistent fashion is the biggest task facing the modeller, and is one reason why modelling net dynamics is not routine.

However, the new Model Browser grouping facilities allow the net to be built in a hierarchy of groups, thereby more effectively managing the data. Notwithstanding, this can still be time consuming for large meshes. Then effort spent writing a short piece of code is well spent - we used Visual Basic in Excel to produce some OrcaFlex batch script commands to automatically create and modify objects in the numerical model. This approach allows the flexibility to change the mesh density and the net aspect ratio to be built in.

The net boundary conditions can be any combination of: one edge fixed in space, knots tied down at corners and intermediate points, or freely suspended (eg, from surface following boom structures). The boundary conditions depend on

the application and are in any case easy to change.

The initial net shape arises by placing the knots at pre-defined points decided on at the mesh building stage – the example here shows a grid in a plane. Some fish cage nets are built up from 4 'planes', but more thought on the geometric set-up is required if they are to be in a non-planar configuration. The 3D Buoys making up the knots are excluded from OrcaFlex Statics. But as long as the geometry has been set up correctly, the net will find its equilibrium position very quickly once dynamics is run.

3. How to Model the Torpedo and Collisions

In order to model a collision, the OrcaFlex Line clashing algorithm is used - here it's switched on for the Line elements used to model the net. Then we devise a torpedo with a 'dummy' line, also with clashing turned on.

The torpedo is represented as a free-moving rigid body, ie an OrcaFlex 6D Buoy set as a Towfish. Attached to this is a large OD single element Line with clashing turned on. The OrcaFlex clashing algorithm attributes a hemispherical volume to each end of the Line, conveniently representing the nose of our torpedo. The torpedo is 'flown' into the net by releasing it midwater at the start of dynamics, and applying a thrust force along the appropriate body axis.

Some Observations

- *Figures 1 and 2* show the deformation of the restrained net caused by the incoming torpedo. Although here the net repulses the torpedo, this isn't always the case!

- It isn't always essential to model every mesh of a net: you just need a mesh density that doesn't let the object through. Using a single model mesh to represent a 4x4 real mesh, means the line axial stiffness and drag should be increased in proportion.

- The mid-part of the net (coloured purple) is the only part of the net with the line clashing algorithm switched on. This initially repels the torpedo. But the torpedo thrust keeps it coming, and eventually the torpedo slips 'though' the yellow part of the net (the part without clashing turned on).

In Conclusion

OrcaFlex is fully capable of modelling both nets and the effect of an impacting object. This allows the adequacy of port and installation security systems and riser protection nets to be assessed under both environmental and 'occasional' loads.

The ease of setting up a net has improved considerably with the advent of Grouping in the Model Browser, making this type of analysis a routine possibility. In the future we might be able to automate the net-building process still further, if there were sufficient client demand. Let us know!

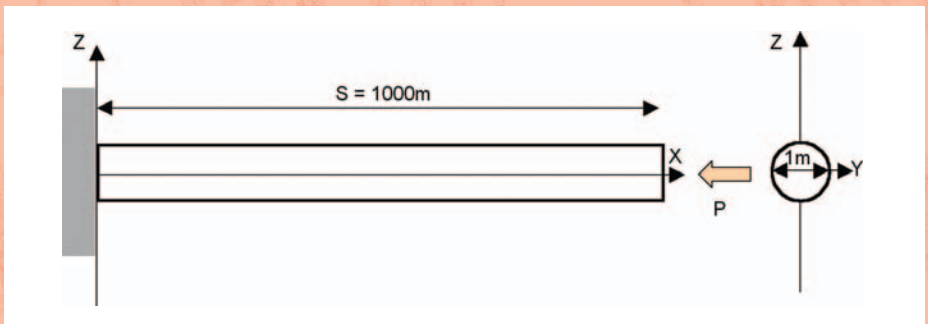
Transmission of Axial Stress Waves

We are occasionally interested in examining the transmission of axial effects along a line. This is particularly the case where shock loads in one part of the system have important effects on another part of the system, and the means of transmission are via a line, or where peak loads are being generated by an excitation of a particular resonance in a line. In either case sufficient accuracy of modelling, both spatially and temporally, are required to resolve accurately the resulting loads. This article looks at the idealised case of axial stress wave transmission for an undamped cantilever beam, subjected to a sudden load at the free end. The numerical results for the speed of axial wave transmission are compared to the theoretical result for wave propagation. These comparisons are made for a range of segment length, axial stiffness and time step.

OrcaFlex Model

For this investigation we set up a neutrally buoyant cantilevered beam in OrcaFlex. The length of the beam is 1000m, the outer diameter is 1m and the mass per unit length is 6.17te/m. The beam is fully encastre at the left end and free at the right. We introduce an impulsive compressive load (P) via a dummy buoy attached at the right hand end specified with a time varying Applied Load in the Global X axis. The basic setup is shown in the figure below.

Actually, having completed this investigation, it became apparent that there is a slightly better way of modelling this scenario. This would be to lay the line out on the seabed and set a zero seabed friction coefficient. Then dispense with the dummy 6D buoy and simply apply the impulse via a winch attached to the right hand end. Not having the dummy buoy at the free end means that the line does not have to include torsion resulting in slightly faster simulations. Also, lying on the seabed means we don't have to spend time making the line neutrally buoyant. Ho hum – but at least the results are the same which ever method used!



Results

The numerical results from OrcaFlex are compared with the equation for wave propagation speed in undamped materials (see, for example, Timoshenko and Goodier, page 439)

$$C^2 = \frac{EA}{(mass/unit\ length)}$$

To compare with the above, the following OrcaFlex simulations have been run:

- For each segment length considered (10m, 20m 40m), vary EA = from 10e6kN to 100e6kN in 10e6kN increments:

- For segment length of 10m and EA = 60e6kN, vary the time step from 1e-5s to 1e-3s

The results are shown in *Figures 1* and *2*.

Discussion

There are several interesting features arising from this analysis, both in running and extracting the results and in the results themselves:

a) For the largest axial stiffness value and smallest element size, the OrcaFlex Inner Time step is set using the default OrcaFlex convention (1/20th the shortest nodal period). This value has been used for all simulations. The target Sample Logging interval has also been set to this value. This results in very large simulation files, but is necessary to accurately capture the nature of the problem.

b) We manually obtain results for the time of peak direct tensile stress at each end of the line. The difference in these times is the time taken for the wave to transit the line.

c) The times are measured using an instantaneous range graph of direct tensile stress to note the peak occurrence of this stress at each end. The replay interval must be set low (0.0001s) in order to accurately capture the time of the peaks.

d) *Figure 1* shows that for a given segmentation, the error is not significantly dependent on the value of axial stiffness. However, the level of segmentation can have a serious impact on the magnitude of the error.

e) *Figure 2* shows that as we increase the size of the time step, the magnitude of the error gradually increases (although in a non-uniform manner). It is clear that the magnitude of the error will generally increase with increasing time step size.

f) *Figure 2* also shows the following important point: Not only should we undertake sensitivity studies on the influence of mesh size on the accuracy of results, but we should also be checking that the temporal 'discretisation' is sufficient for required accuracy.

On a more general point, some 'traditional' finite element packages distinguish between their 'implicit' and 'explicit' solvers. Generally speaking implicit solvers allow solutions to be determined efficiently. However, explicit solvers are used in preference for contact and high speed transient phenomena, such as examined in this article.

Instantaneous range graphs also show an interesting point relating to the reflection of axial waves at different boundary conditions. In our example a compressive impulse is set at the free end of the line, giving a positive stress wave travelling towards the fixed end. *Figure 3* tries to capture statically the salient features from the instantaneous range graph.

Theory of Elasticity, Timoshenko and Goodier, page 443, gives a nice explanation of what happens to this wave on reflection:

Reflection at a fixed end is equivalent to what happens when the wave meets an opposite-direction, same-shape, same-sign (ie, both compressive or both tensile) wave. At the crossing point the strains from the two waves cancel, since they are in opposite directions, so the crossing point does not move, which is equivalent to it being fixed. So at a fixed end the wave is reflected in direction, but has no sign change.

Now the still-positive stress wave is travelling back towards the free end. At a free end reflection is equivalent to what happens when the wave meets an opposite-direction, same-shape, opposite-sign (ie compressive where the incident wave is tensile, and vice versa) wave. At the crossing point the strains from the two waves reinforce (since the waves are opposite direction but also opposite sign). But the stresses from the two waves cancel out, since one is tensile and the other compressive, and the sign of stress does not depend on the direction of travel of the wave. So the crossing point has zero stress, which is equivalent to it being free. Therefore at a free end a wave is reflected in direction and changed in sign.

In Conclusion

As a final word, by far the most important point to draw from this short study is that spatial and temporal sensitivity studies are essential when numerically modelling high speed phenomena. Final results are heavily dependant on selected mesh/time step values, and use of inappropriate values may give mis-leading results.

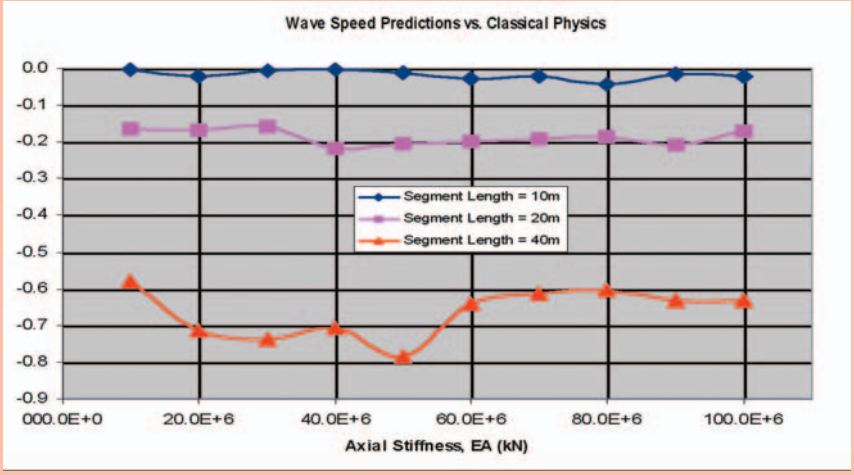


Figure 1 – Error as a Function of EA and Segment Length.

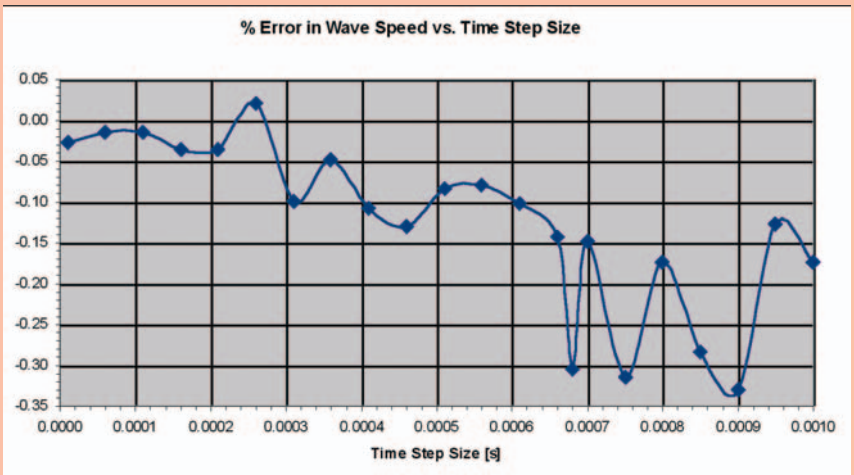


Figure 2 – Error as a Function of Time Step.

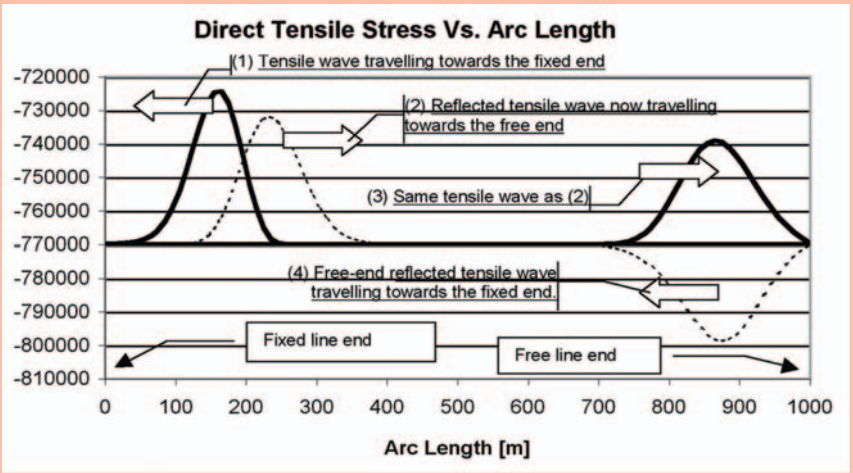


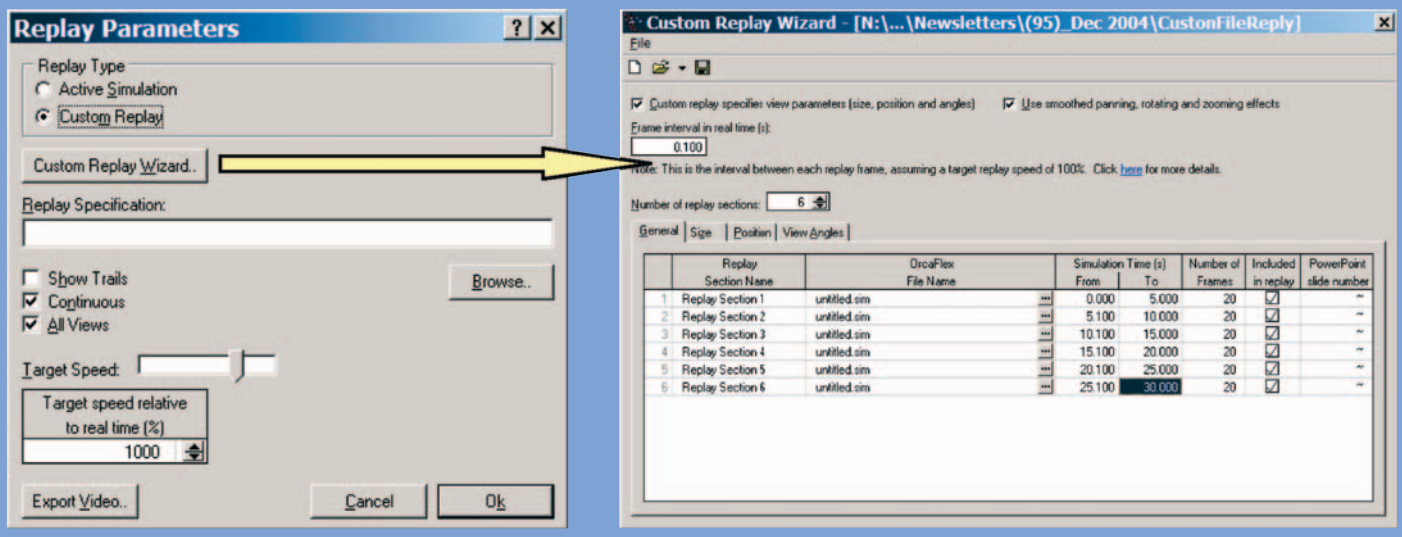
Figure 3 – Modification of Wave Profile on Reflection at Line Ends

Short Articles

Continued from page 1

Custom Replay Wizard

For a long time OrcaFlex has had the facility to allow the user when in Replay mode to 'fly' around the 3D view by zooming and panning. Until recently this has not been the easiest to use. In fact it is probably true to say that this has hardly been used outside of Orcina because of the hassle in setting up the replay files. Now, however, we have the Custom Replay Wizard

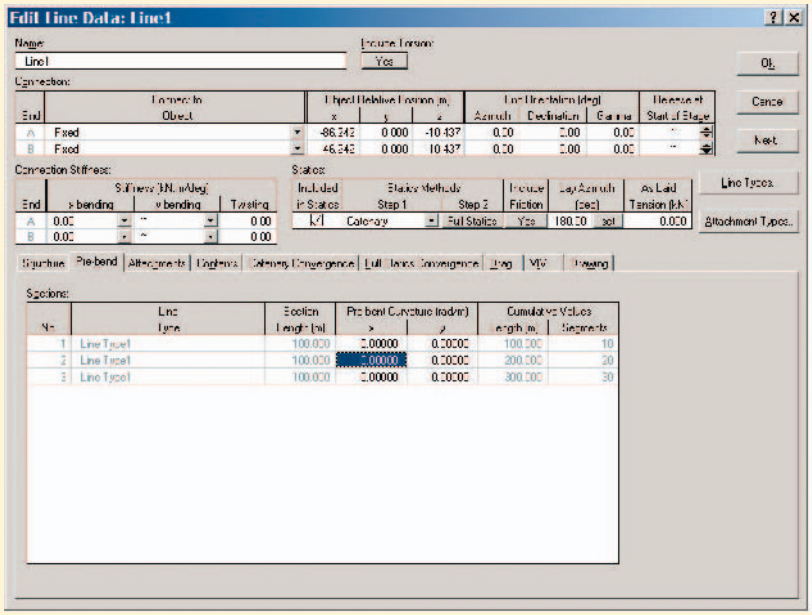


This super facility is available through the Replay Parameters form, when you select the Custom Replay option. It allows you easily to specify multiple sections of the same file and / or different simulation files. For each of these Replay Sections the parameters describing the 3D view can be linearly varied across the user defined simulation time within that file. Clear as mud? Probably. But have a go. It's a great way to demonstrate to clients your modelling prowess – this approach forms the basis of nearly all our exhibition presentations.

However, it's also very useful in the case where you need to repeatedly change the 3D view in the same manner to inspect different parts of your model. But, of course we need to remember that the real engineering requirement driving this development is the desire to view multiple static snapshots representating extended installation sequences. This new facility makes this much more straight forward.

Pre-Bend

It's now possible to have a section of a Line set up with pre-bend defined. This is provided for modelling lines which are not straight when unstressed, eg spool pieces. The pre-bend is defined for each section by specifying the pre-bent curvature (in radians per unit length) of the section – see the screenshot. The pre-bent curvature is the curvature of the pipe in its unstressed state. For lines which are straight when unstressed then pre-bend should be specified to be zero - which is the default setting.



Pre-bend can be specified in both the line local x and y directions. However, to simplify data preparation and interpretation of results we recommend that you arrange the line's local axes such that the pre-bend is entirely in either the local x or local y direction. Note that Pre-bend is only available when torsion is modelled. When this is used, curvature results are reported relative to the pre-bent curvature.

Instantaneous Range Graphs

Range graphs in OrcaFlex show how the value of a particular line variable changes with distance along the line. By default, for the selected simulation period, a range graph shows at each position along the line the maximum, minimum and mean value (you can also add the +/- *n* standard deviations curves from the Graph Properties dialog).

Newly added to the Results form is the ability to plot a Range Graph for a period called 'Instantaneous Values'. This range graph shows a single curve plotting the variable against arc length. However, this curve updates itself as a simulation progresses, giving you a time varying range graph. This is an excellent way to spot sudden loads within a line, such as caused by snatching, and it's a superb way to visualise variables like tension, stress, etc. that aren't obviously visual things.

During the last round of user group meetings we showed how the instantaneous range graph can show the compressive waves which can be formed in lines – you can watch these travelling and reflecting within a line. The article in this newsletter covering transmission of axial stress waves also utilises this feature very effectively.

In the Next Orcina Newsletter

- Simulation speed-up – the addition of an implicit integrator is a major enhancement to OrcaFlex.
- Shaded Graphics – much greater visual realism of your models, with hidden line removal, perspective and solid shading.

News in *Short...*

Further VIV Comparisons
Professor John Chaplin of Southampton University has recently published (FIV2004) an account of numerical and experimental comparisons for the predictions of Vortex Induced Vibration.

Orcina supplied blind results to this comparison effort using all 6 of the tools available through the OrcaFlex VIV Toolbox. The results offer one of the clearest insights as to the present state-of-the-art of numerical VIV predictions. The results can be viewed at: www.civil.soton.ac.uk/hydraulics/frames.htm, following the link (Vortex-induced vibrations of tension risers) at the bottom right hand side of the page.

OrcaFlex training courses
During 2004, and now established as a regular for us, we ran a number of Open OrcaFlex training courses. Our normal training mode in the past would have us attend your office and train a number of company employees. By contrast the open courses are set as fixed dates and venues throughout the year, and are open to people from any company to attend. This has proved a very successful training model, and we have increased the number of events for 2005.

We have also added a 1-day Advanced Training course based on the same model as the open training. On the basis of client needs, we selected two topics likely to be of interest – VIV Analysis and Fatigue Analysis, and devoted a full day to covering this subject matter. All details of software training courses can be found at www.orcina.com/SoftwareTraining.htm.

Report on 2004 UGMs
Our now annual round of User Group Meetings were held during the Autumn of 2004, in Aberdeen, Houston and Stavanger. We had excellent attendance at each of these meetings, and we would like to express our thanks to those who made them such a success. A digest of these meetings can be found at www.orcina.com/OrcaFlex/OrcaFlexUserGroup2004.htm.

New staff - Graham Christian and Yvonne Morgan
Continued and growing demand for our products and services has led to an active recruitment drive, resulting in the appointment of 2 new members of staff:

Graham Christian joined Orcina's software development team in January 2005. After a degree in Mechanical Engineering from Birmingham University, Graham worked in the water industry, mainly on operational efficiency problems. He then spent 6 years at the Royal Botanic Gardens, Kew as a software engineer, working on search servers and user interfaces for taxonomic databases. Graham gained an MSc in Computer Science during his time at Kew.

Yvonne Morgan joined Orcina as Office Administrator in March 2005. After a degree in Modern Languages and International Marketing from Aston University, Yvonne held positions as Marketing Manager and Customer Service Manager within the holography industry. With her commercial and organisational skills, Yvonne will be responsible for the administration of all software requirements for new and existing customers.

Orcina - Out and About

For all these events please see the Orcina website (www.orcina.com) for the most up to date information. During 2005, Orcina will be present at the following Conferences/Exhibitions:

- **OTC, Houston, 3rd to 6th May 2005 (Booth Number 2758)**
- **Offshore Europe, Aberdeen, 6th to 9th September 2005 (Stand Number 500)**

We will also be holding the OrcaFlex User Group Meetings during the Autumn of 2005:
- **OrcaFlex User Group Meeting (Aberdeen, September'05)**
- **OrcaFlex User Group Meeting (Houston, October'05)**
- **OrcaFlex User Group Meeting (Paris, November'05)**

Our OrcaFlex training course schedule for 2005 looks like this:
- **OrcaFlex Advanced Training Course (Houston, February 2005)**
- **OrcaFlex Open Training Course (Cumbria, UK, February 2005)**
- **OrcaFlex Open Training Course (Houston, April 2005)**
- **OrcaFlex Advanced Training Course (Cumbria, UK, June 2005)**

Please note that we are also planning to hold 2 day open training courses immediately after each of the User Group Meetings during 2005.
We will update these details in the next Newsletter, but for the latest information please look on our website.
However, please do not hesitate to contact us if you just want to ask directly.

Did You *Know...*

...Line attachment z position was always previously relative to End A. This can now optionally be End A or End B. This capability also applies to Links, Winches and 6D Buoy connections. The reason for adding this feature relates to the introduction of the Line Setup Wizard. One mode of this wizard acts to change the length of a line by varying the length of the first section of the line until a desired target top tension or declination is met. This clearly changes the z-position of any attachments as they could only previously be measured from End A. Setting attachments and connections relative to End B saves this trouble.

...Object names in OrcaFlex are no longer case sensitive. So, for example, Riser, riser and RISER would all refer to the same object. This brings the behaviour of OrcaFlex to be consistent with that of Windows filenames.

...If, in attempting to export values of a graph to a spreadsheet, there are to many data for the available number of rows in the spreadsheet then OrcaFlex now offers the user the option of exporting the values to a text file.

...that the drawing of Line Node axes can be switched on and off independently of the local axes. The shortcut key is CTRL+ALT+Y.

...'Pre-Tension' on Line data form has been re-named 'As Laid Tension'. This was done to remove the confusion for mooring designers for whom pre-tension has a very specific meaning.

...that the Modal analysis table and view pages now display mode type and inline, axial and transverse component percentages. Previously this was only available with the optional VIV Toolbox enabled.

...that a new set of Line acceleration results including *g* have been added. These are useful for doing comparisons with accelerometer readings from experimental scale, or full-scale, measurements.

...you can now alter the grid density drawing data for both seabed and plane shapes.

...that an extension of the Batch Script language allows the creation and deletion of objects (permitting model building and alteration through batch script), and the export of SHEAR7 mode shape and data files.

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