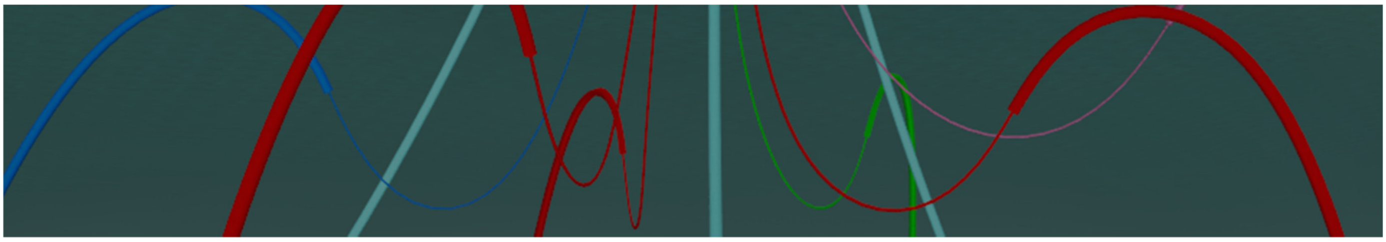
Orcina

Professional Software for Professional Engineers

OrcaFlex Newsletter

Version 10.1 (released Oct-16)



Editorial

The long oil price downturn continues, although there has been some relief of late. We're disappointed for all our colleagues in the industry who have been affected and hope that, at the very least, the decline is at an end.

Despite the turmoil, OrcaFlex version 10.1 was released in October 2016 and will have reached clients shortly afterwards. This release contains many good things and the major ones are described herein. But an honourable mention must be given to the **Constraints** feature which marks a major step change in capability.

In this Newsletter

In the last newsletter we mentioned the advent of our **LinkedIn page** which can be found at linkedin.com/company/orcina-ltd. This has proved a successful channel for more timely and regular communications with clients. We're giving it one more shout-out here before it becomes 'normal'!

As most readers will know, OrcaFlex is mainly used for risers, moorings, installation, etc. But it's not generally known that OrcaFlex gets used for a wide range of other **less common applications**. These include, but are not limited to, aquaculture, cable-stayed structures, floatover / decommissioning, jacket launch, floating bridges, jack-ups / liftboats, jetty moorings, compliant renewable systems,…. If you're interested please see our more detailed blog article at orcina.com/blog/less-common-applications-for-orcaflex and / or contact us directly.

In the meantime we hope that this roundup of v10.1 functionality is useful…..

Constraints

To fix or not to fix (DoFs) – now infinitely easier…

Summary

For those in a rush, here's the quick take: Constraints are a new object in OrcaFlex which connect other OrcaFlex objects (Lines, Buoys, etc.). But at the same time, Constraints allow the individual degrees of freedom (DoF) of the connections to be either individually fixed or to have displacements imposed on them.

This is very powerful functionality, applicable in a wide range of ways. For example, Constraints are now the right way to simulate hinges (pivots), articulations, telescoping joints (including general sliding mechanisms), crane operations, etc., etc.

Why Constraints?

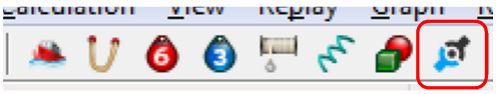
In previous versions of OrcaFlex there was limited control over the mix of DoFs that could be included in an OrcaFlex analysis. Prior to 10.1, we had some control over which Buoy DoFs were included in statics, although once dynamics started all available DoFs were included. And for vessels we could limit statics and *calculated* dynamics to the horizontal plane or have all 6 DoFs included (vessel statics could also exclude the Vessel from the solve).

But for many years, off and on, we've been asked if OrcaFlex can provide greater flexibility over which DoFs are included in the analysis. And not just for Buoys and Vessels, for Lines also. However, despite being sensitive to these requests, some deep internal assumptions in OrcaFlex meant that this was not an easy task.

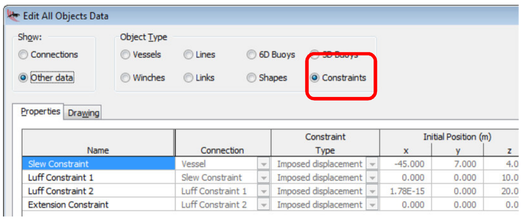
But, for the last three years or so, we've been working on these deep internals. The aim was to free up many of the unintended limitations inherent in OrcaFlex from the start, and which were curbing our ability to develop required functionality. As a result of this work we've already delivered unification of explicit and implicit codebases, frequency domain analysis, direct line-to-line connectivity and chained connections. And the final piece in this long-term jigsaw is, in v10.1, the delivery of Constraints – the ability to generalise connectivity between objects, to constrain individual DoFs and to impose displacements on individual DoFs.

Constraints - a New Object

So what's with the new object? After all, the number of OrcaFlex objects has been the same (seven) since the first windows version of OrcaFlex was released 20 years ago! The highlight in the screenshot below shows the latest addition to the OrcaFlex toolbar:



And, of course, like any good object in OrcaFlex, Constraints also feature in the All Objects Data form:



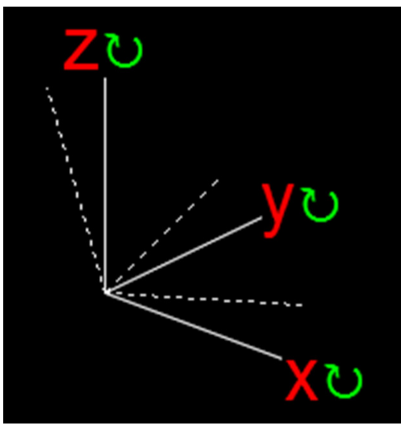
In what follows we outline in more detail some further aspects of Constraints and give some examples of where they can be used.

Frames of Reference

Before exploring more, we should just say:

- Unlike the other modelling objects, Constraints do not have a physical presence in an OrcaFlex model via mass, buoyancy, etc. Rather they represent a way to connect objects and have separate control over each of the connection DoFs – eg., you could fix all DoFs except rotation about z to allow a hinge.
- Constraints are very detailed objects and we won't explore all this here. But of course the OrcaFlex help file contains all you need to know, and the 2016 UGM materials also give some further background.

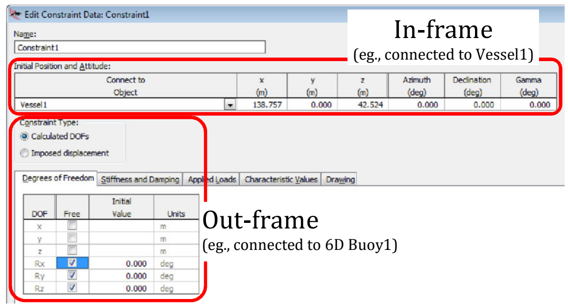
But now digging in a little more detail…. Constraints are made up of two frames of reference – in OrcaFlex these are called the **in-frame** and the **out-frame** and are shown in the screenshot below.



The various drawing parameters can all be user-defined, but by default the in-frame is shown as a solid white line and the out-frame as a dashed white line.

The axes are labelled with X, Y and Z, and ↻ indicates rotations about these axes. In the default colour scheme, any fixed DoFs are shown in red and any free DoFs in green. So in the case shown in the screenshot, all the translations are fixed (so the origins of the out- and in-frames remain coincident) but the rotations are all free, hence the rotated out-frame.

OK, but what do these reference frames mean? To explain let's first have a look at the Constraints data form:



In *Initial Position and Attitude* you'll see that Constraint1 is connected to Vessel1 using the familiar connection coordinates and / or rotations. But, more specifically, it's the Constraint's **in-frame** which has been connected to Vessel1. Vessel1 then becomes the 'master object'. In this way the in-frame is rigidly connected to the master object and so will rigidly translate and rotate with it.

Then we are at liberty to connect other objects to that constraint. In this example we have, via its own data form, connected a 6D Buoy to Constraint1. But, again more specifically, the 6D Buoy has been connected to the Constraint's **out-frame**. Consequently the 6D Buoy becomes the 'Slave' object. Then the data contained in the second highlight in the above screenshot, gives control over the kind of constraint we wish to impose between the two connected objects. We discuss these in the next section.

Constraint Types

There are two Constraint Types available, each offer different control over the connection behaviour between objects.

Calculated DoFs is the default and is as shown above. Here loads from connecting objects are calculated and applied to the out-frame. The out-frame is free to respond to these loads, but only where one or more DoFs are set, via the check-boxes, to be 'Free'. Any DoF not marked as Free remains fixed to the in-frame.

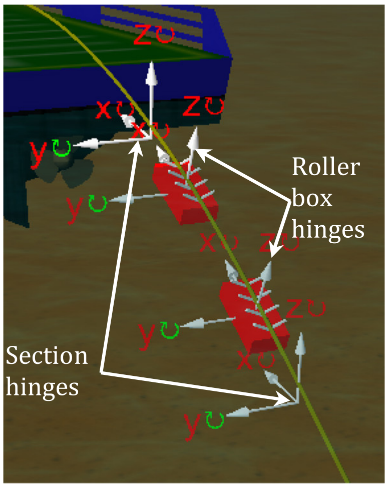
Calculated constraints can also include user-specified, linear or nonlinear, stiffness and damping. These can be used to resist the displacement and velocity, respectively, of the out-frame relative to the in-frame. It's also possible to have Applied Loads act directly on the out-frame. The way Constraint Applied Loads are specified is the same as has been available for Vessels and 6D Buoys for many years, ie., loads can be constant, time varying, or externally calculated.

When the **Imposed displacement** Constraint Type is used, the displacement of the out-frame relative to the in-frame, is specified by time history. None, some or all DoFs can be varied, although it is perfectly possible to vary just a single degree of freedom, if that is required.

Some Applications

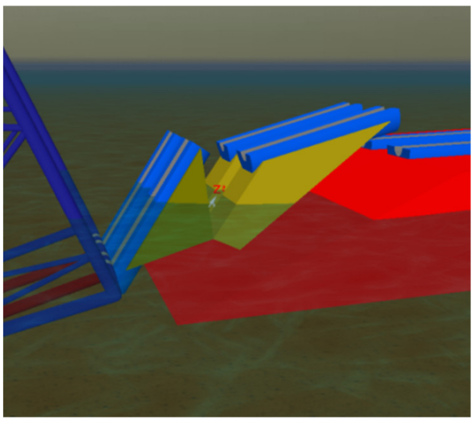
Constraints are immediately applicable to a wide-range of modelling applications. Here we briefly mention some to whet the appetite. But this list is not exhaustive, and we fully expect our users to happily apply Constraints in lots of areas we've not thought of!

Pipelay models are perfect for Constraints. This example shows Constraints used to model the dynamics of pipelay. Here we've used Constraints in two ways (but both using the Calculated option). Firstly, they model the rotations between different sections of the stinger, and secondly they model the pivots on the roller boxes. Note from the screenshot that the only DoFs which are free are rotations about Y – hence they are drawn in green.

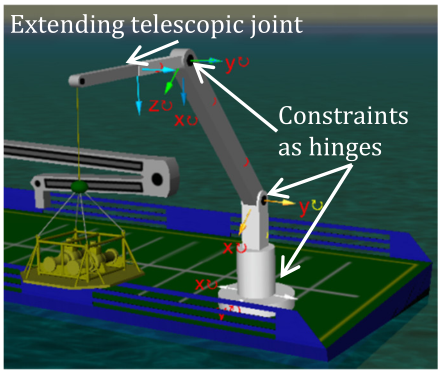


In fact this is a rather clever way to use Constraints – each roller box constraint is directly connected to (and offset from) the relevant constraint between stinger sections. In other words the roller box pivot is connected to the relevant stinger section at the appropriate offset from the hinge!

Rocker Arms: This screenshot shows the rocker arms on the stern of a barge being used for the launch of a jacket. Again, a simple example of Calculated Constraints with one free rotation to model the pivot.

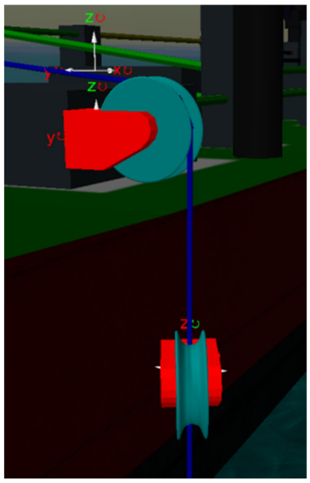


Crane modelling is also ready-made for Constraints. We did have workarounds for this application, but, well, let's just say they had 'issues'! But Constraints now gives us exactly the right mechanisms:



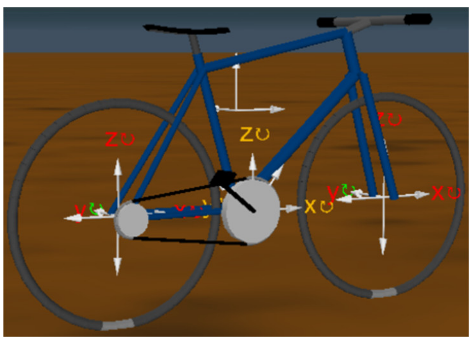
The screenshot shows four Constraints at work, all using Imposed displacement as the Constraint Type, so their displacements are handled by a time history file. Three are time histories of single rotations which control the slewing and luffing. But the fourth Constraint is a time history of displacement along one axis (z as it happens), and this creates the extending top arm of the crane.

Sheaves, as shown below, also readily lend themselves to Constraints. The top sheave is set to displace only vertically. The in-frame is clearly shown at the top; the displaced out-frame is slightly obscured by the sheave drawing.

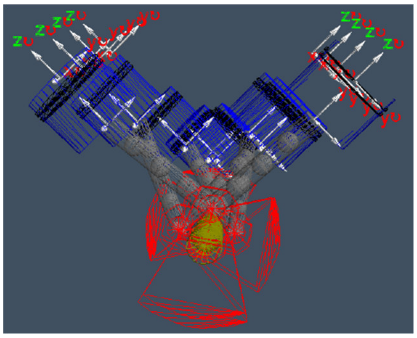


The bottom sheave is allowed only to rotate around its vertical axis. So in a dynamic replay which has the vessel heaving in waves, the top sheave simply slides up and down, while the lower sheave rotates on its hinge.

And what else have we used Constraints for? Well lots - a fuller list of applications can be seen by following the OrcaFlex 2016 UGM link given earlier in this article. But those clever folks at Orcina don't spend all their time at work. Sometimes they are to be found on their bikes:



And of course when the going gets tough for the legs, you can always revert to a little V8 engine power:



More with Constraints on the way…

So enthused have we become with Constraints that we've added a couple of new features which will be available in the next release of OrcaFlex. More details then, but in summary:

- The Constraint out-frame can be disconnected from the Constraint in-frame at the start of any simulation stage (in the same manner as we've always done with Lines, Winches, etc.).
- New *Curvilinear Constraints* can model motion along arbitrary curves and surfaces, include a mix of calculated and imposed motion, and dynamically release the out-frame based on some user-specified criteria!

Conclusion

Constraints just make it so easy to connect various objects with extensive control over the connection DoFs. This makes modelling of a range of OrcaFlex models very much more straightforward – we hope you enjoy.

Frequency Domain – Addition of Low Frequency

Further extending the Frequency Domain toolkit…

In version 10.0 (Oct-15) we introduced wave frequency, frequency domain (FD) analysis into OrcaFlex. This was ground-breaking because until that point OrcaFlex dynamics were always in the time domain. If you missed any of this, the 2015 UGM carried extensive information on the frequency domain development (see orcina.com/Support/UserGroup/2015), and there is a summary in the accompanying v10.0 newsletter (see orcina.com/Resources).

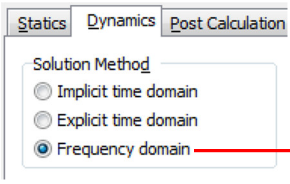
We pointed out at the time that there were several omissions in this work – obviously some features are inherently time domain concepts and so can't be included in the frequency domain. But there were also some features we didn't have time to adapt to frequency domain, probably the most significant of which were calculated vessels. Here we discuss how OrcaFlex has changed to include calculated vessels in frequency domain.

Whilst including calculated vessels in wave frequency FD didn't present too many challenges, including them in a low frequency FD analysis created a number of issues to think about. In considering these we've made a number of changes to the UI for both the existing wave frequency FD and the new low frequency FD. These are briefly introduced below.

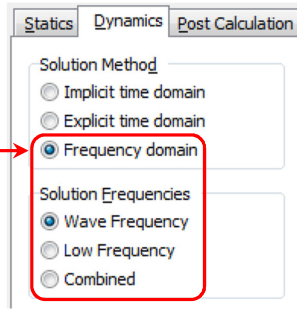
Now Choose which Solution Frequencies

First up are changes on the General Data form as shown below – with *Frequency domain* selected, v10.1 now asks which *Solution Frequencies* we want to solve for:

Version 10.0



Version 10.1



With *Wave Frequency* selected we're essentially using the same solver as presented in v10.0, ie., this performs linearised wave frequency FD analysis.

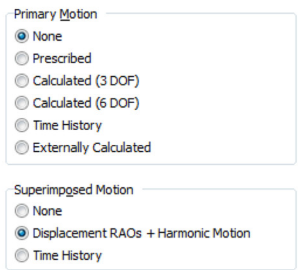
When *Low Frequency* is selected, we are performing a Frequency Domain analysis which includes vessel wave drift effects and wind component frequencies.

And when *Combined* is selected, there is an initial wave frequency solve followed immediately by a low frequency solve. The results from the first solve are not made available, but allow us to capture, in the low frequency analysis, the increase in drag on lines due to the presence of wave frequency motion.

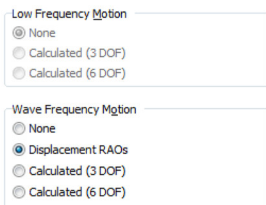
New-style Vessel Calculation form

With *Frequency domain* selected as the Solution Method on the General Data form (as shown above), the presentation of the Vessel *Calculation* options change:

Version 10.0



Version 10.1



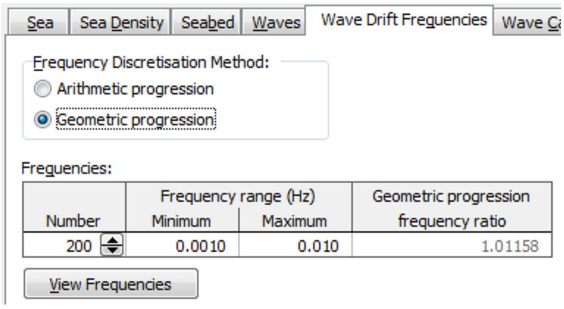
However, if either of the time domain solution options is selected, the vessel calculation options remain as the familiar Primary Motion and Superimposed Motion.

Note also that the options for Low Frequency Motion in the above screenshot are greyed out. These are unavailable because on the General Data form only Wave Frequency Solution Frequencies has been selected. If Low Frequency had been asked for, then the vessel calculation options above would allow Low Frequency Motion to be set, but not Wave Frequency Motion. And finally, with Solution Frequencies = Combined, then both

Low- and Wave-Frequency Motion options would be available.

Wave Drift Frequencies

With either Low Frequency or Combined set as the solution frequencies, we get, on the Environment Data form, a new tab:



The correct selection of the wave drift frequencies is very important for Low Frequency analysis – all the important response frequencies must be covered, and the frequency discretisation must be robust. But of course, as ever, there is a trade-off between accuracy and performance - using more frequencies is more accurate, but makes the analysis more time consuming.

Accuracy & Performance

In the FD development work so far we have chosen to favour accuracy over performance. We may in the future include simpler methods that will be faster, but potentially at the expense of accuracy. When we say that we "favour accuracy over performance", we mean that we:

- rigorously include coupling between independent wave elevation processes (ie., multiple wave trains or spread waves).
- accurately capture the correlation in the second order loading between vessel DoFs, eg., surge vs sway load.
- accurately capture the correlation in the second order loading between multiple vessels, eg., vessel1 surge vs. vessel2 surge, vessel1 surge vs. vessel2 sway, etc.
- include WF motion on the mooring drag linearisation when the combined solution frequencies is selected.

Conclusion

We have implemented a powerful and rigorous frequency domain calculation engine which is ready to use right out of the box. We hope you are finding this capability useful.

But in our minds we can build on this, particularly in the case of frequency domain mooring analysis. So we plan to look at the following issues:

- Improve the workflow for mooring analysis.
- Improve results presentation for mooring analysis.
- Possibility of including simpler but faster methods (potentially at the expense of accuracy).

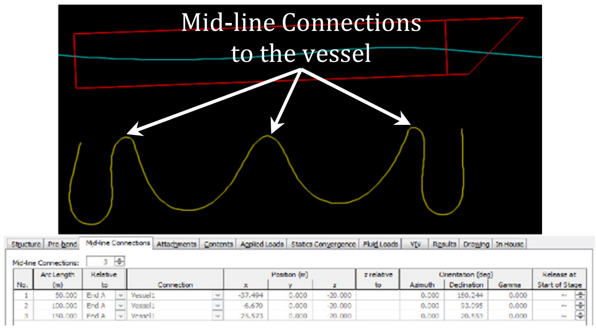
To this end, we'd really appreciate your feedback on how you are currently performing your mooring analysis, with particular emphasis on which approaches are being used.

Mid-Line Connections

At last, connections for mid-nodes on a line...

As mentioned previously, we've been working hard on the internals of OrcaFlex over the last few releases, resulting in much greater connection control. But one omission was the ability to connect Line nodes, away from their ends (ie., mid-line nodes), to other objects.

Well, that's now in the bag – see the abstract case below:



So, why add this functionality? Mainly so Constraints can be connected in the middle of a Line, thereby permitting all the functionality that Constraints give to Line ends, to also apply to nodes in the middle of a line.

As an example, consider a line extending over a mid-water arch. Previously it was common to split the line in two and effect the appropriate connections at the arch. Now one line can be used throughout, with a mid-line connection at the arch using Constraints. This also has the very happy consequence that results need only be generated for one line, rather than for two as previously.

Another obvious application for Mid-line Connections (though there'll be many others), is the classic problem of finding clearances between a dynamic line and seabed furniture (eg., between a mooring line and a pipeline). In the past we had some unsatisfactory workarounds for this problem. But now, simply connect *all* the pipeline nodes at the surveyed x,y,z coordinates. Then the clearances between the mooring line and the pipeline are found from the normal clearance facilities in OrcaFlex ☺.

This 'clearance concept' can also be used for clearances between adjacent vessels. Connect all nodes of one 'clearance' line to one vessel, and do the same for a second line to a second vessel. Then use the standard clearance facilities as before (for a simple example see the v10.1 OrcaFlex release video at orcina.com/SoftwareProducts/OrcaFlex/Videos/). More care is needed in this case to ensure the 'clearance meshing' is appropriate – we'll blog more about this in due course.

We're also working on an extension to clearance results to allow the identification of horizontal and vertical clearances. This will more readily allow OrcaFlex clearance results to be used with the traditional DNV and API mooring codes – more on this in v10.2.

In the meantime we hope you find Mid-line Connections useful.

Many Other Developments

Some other v10.1 developments are listed below...

Multi-Threading Performance

Since 2008 OrcaFlex has employed multi-threading for no extra charge – a commercial feature which still sets us apart from our peers! However, hardware advances in the intervening years have created some complications:

- Traditional applications need to be adapted to take advantage of more than 64 processors.
- Shared memory access on large machines becomes difficult to manage efficiently.

Consequently OrcaFlex and Distributed OrcaFlex were struggling to take advantage of more than 64 processors and to efficiently share memory on these large machines.

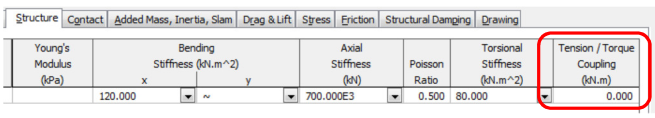
In light of this OrcaFlex v10.1 is changed so that batch processing scales much better on large machines.

Distributed OrcaFlex also faced the same issues. But here, rather than use the multi-threading of the batch processor, we're improving scalability by using multiple processes. This will be particularly useful where external functions or Post Calculation Actions are being used.

Tension-Torque Coupling

Way back (last century in fact!) we had tension-torque coupling in OrcaFlex. But the advent of the implicit integrator in 2006 highlighted that we had, inadvertently, implemented a non-conservative model. By this we mean that the model allowed tension to induce torque, but not the other way around – ie., torque *did not* induce tension! So what to do? Well at the time the simplest and easiest option was to remove this feature entirely! We did this in v9.1, but with a plan to revisit the model as soon as we could and re-work it to be conservative.

Err, well, 'revisiting' has taken rather longer than we'd hoped! But we've now done this, and have re-implemented tension-torque coupling in v10.1:



But, of course, we've not simply 're-implemented' the old feature, rather we've derived a symmetric (ie., conservative) model. Now tension creates torque and torque creates tension – and that should keep us all happy ☺.

Line Added Mass as a function of Height above Seabed

Back in v9.0 we added the facility to have line lift and drag vary with height above seabed. This was primarily added to assess the hydrodynamic stability of lines on the seabed. In most such cases, having a line that moved would not normally be allowed, so understanding *how* it moved was not so important.

But of course we then, not unreasonably, received a steady stream of requests to also allow line added mass to vary in the same way.

Until recently we didn't have a program architecture which would easily allow us to develop such a feature. But the advent of variable added mass coefficient for water surface slamming calculations created just such an internal program structure. Building on this we've now enabled line added mass to vary with height above seabed! Enjoy ☺.

Vertical Current Stretching

A new option is added which allows the current profile at the Seabed Origin to be scaled to fit water depths away from the seabed origin:

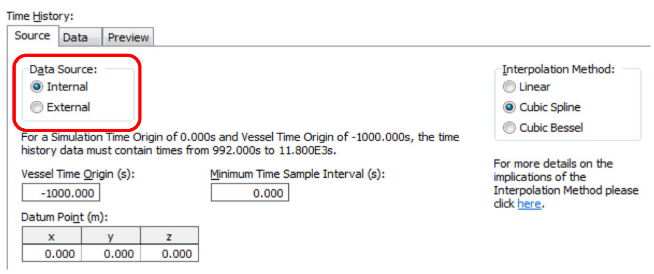
Specifically, the stretching model is set up such that the current speed at the mean water level, the mid-depth and at the seabed are the same at all horizontal locations in the model.

Internal Time History Files

Various built-in models are used by OrcaFlex to determine the displacements of vessels and the elevation of waves. But the user can optionally over-ride these built-in models and specify vessel motion, wave elevation, and wind speed and direction with externally supplied time history files. The mechanics of using external files works well, except in the following situations:

- When moving (or emailing) an OrcaFlex file and forgetting the external time history file!
- Using automation with external time history files can be awkward.
- Sometimes we just want to impose simple displacements – external files can then be unwieldy.

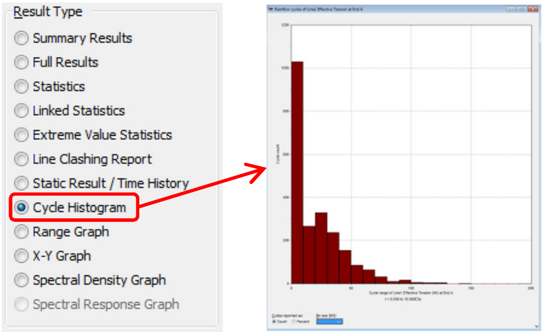
So, now in v10.1, whilst we retain the ability for time history files to be specified externally, we can now also store the time history data internally, eg:



We hope that this extra bit of functionality proves useful – it's already dug this author out of a hole ☺.

Time History Histograms

We've been asked for many years to provide time history cycle histograms in OrcaFlex. Well now it's available via a new result type:



In the usual way, these histograms can be extracted using OrcaFlex's post-processing tools, including the Excel spreadsheet.

We think that there is more to do here. Specifically we can see that it would be useful to provide a mechanism to apply cycle histograms to data that are collated from multiple simulations.

Profiled Inner Diameter

Profiled Outer Diameters came in v9.2 (2008) for tapered stress joints and bend stiffener modelling. Since then we've had a small number of users asking for the ID to be profiled.

This hasn't been a priority for us, but we've now got around to it. Profiled inner diameters are implemented in exactly the same way as profiled outer diameters – hope this is useful!

Logging

OrcaFlex tries to keep the size of its simulation files to a minimum and to that end uses the following strategies:

- By default OrcaFlex logs results at single precision, although the calculation itself is performed to double precision. The user can elect to log at double precision if needed.
- The minimum number of variables are logged, with user-requested results derived from these during post-processing.
- Logging can be suppressed for specified lines.

Notwithstanding, some files can end up being large - sometimes very large. To further help on this front we've added a new data item to the General Data form – Logging Start Time:

Logging:

Precision	Target Sample Interval (s)	Actual Sample Interval (s)	Start Time (s)
Single	0.1000	0.1000	~

We think that this will be of most use with regular wave analysis where usually results are only needed for the last complete wave cycle – ie., when the model has dynamically settled. And Start Time means that you can now choose to log only the last part of the simulation. But this does mean that replays and results will not be available before Start Time. In this case it might be hard to check that the system response has dynamically settled - but it is still the user's responsibility to check this!

Line Payout

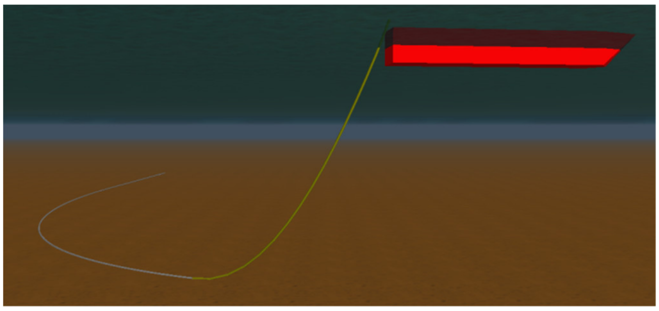
Yes, really! Here's a taste of something to come...

OK, first thing to say – this is *not* on public release yet! But, barring unforeseen circumstance, it can be expected in v10.2(cOct-17). However, we're pretty excited about it, so couldn't resist giving it a mention here…

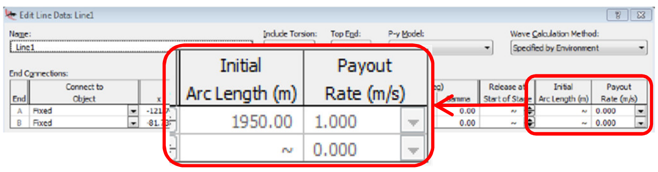
For those very, very few ☺ who do not know what this is: for many years we've been asked to allow an OrcaFlex Line to change its unstretched length (L_0) during a simulation. Of course a Line will stretch during a simulation, but L_0 remains unchanged.

We do, of course, have the OrcaFlex Winch - a superb object specifically designed to change its length during a simulation. But a Winch doesn't have mass, nor does it attract hydrodynamic loads or bend! And these shortcomings can be limiting. Frustratingly in contrast, the OrcaFlex Line has mass, sees fluid loads and can bend. What is needed is the best of both objects.

So, after much work, we now have an internal version of OrcaFlex where L_0 changes with time - the screenshot shows L_0 increasing during a pipelay simulation.



Two new data items on the Line Data form create changes to L_0:



The development work to effect a changing L_0 was not that great. What has been much more challenging has been to re-work lots of other OrcaFlex functionality which, for 30 years, have been based on the assumption that L_0 would remain constant during a simulation!

But a caveat – this is clearly an exciting development and shows great promise. But it is still a work in progress and there are many issues yet to solve, with a couple in particular proving tough to crack. Notwithstanding we're fairly confident there'll be something available in 10.2.

The 'Back Page'

News

Our company **LinkedIn** page has been running for about 18 months. We've gained a large number of followers and we hope that the content and frequency of posting is about right – feedback always welcome! In case you've not followed us yet and want to we're at linkedin.com/company/orcina-ltd.

As you might expect in the current climate, the demand for **OrcaFlex Training courses** has reduced, though gratifyingly, not to zero! However, our relatively new training rooms are looking a little underused. So if you need a brush-up, an advanced day or two, some instruction on automating OrcaFlex with Python, or just the standard introduction to OrcaFlex, then don't hesitate to contact us. Planned training courses, as well as other events, can be found at orcina.com/UpcomingEvents. This is regularly updated, but we'll post on LinkedIn too.

OrcaFlex Blog

Recent blog posts which might be of interest include:

- Less Common OrcaFlex Applications (07-Feb-17).
- Bugs in Python 2.7.11 and 2.7.13 that directly affect OrcaFlex (14-Jan-17).
- OrcaFlex 10.1 release blog (20-Oct-16).
- An Introduction to the Python Interface to OrcaFlex (29-Sept-16)
- 3D Bathymetry and Mooring Design (22-Aug-16).

New blog postings also get posted on LinkedIn page.

Out and About

As well as the usual mix of training courses and UGMs, 2016 saw us exhibit at: Subsea Expo, OPT, Oceanology (London), Subsea Tieback Forum, OTC (Houston), OMAE, Oceanology (China) and Subsea Lifting.

For 2017 we're exhibiting at: Subsea Expo, Oceanology (US), OPT, the Subsea Tieback Forum, Ocean Business, OTC (Houston), OMAE (Trondheim), Offshore Europe, Oceans (Anchorage), Oceanology (China) and Subsea Lifting. UGMs will also run between September and December – see orcina.com/UpcomingEvents for details and we'll post on LinkedIn too.

OrcaFlex User Group Meetings

The 2016 UGMs were a great success, with the number of attendees only slightly down on the record attendance from the previous year. We'd really like to thank all who attended and thereby continue to make these events so successful. We again hosted 11 meetings in China, Houston(x2), Perth, Kuala Lumpur, Singapore, London, Aberdeen, Amsterdam, Stavanger and Rio.

Past UGM content and a pointer to 2017 event info can be found at orcina.com/Support/UserGroup – keep an eye on this for updates and we'll post on LinkedIn too.

Future OrcaFlex Features (v10.2+)

Our development list depends largely on client feedback. This comes throughout the year, but a major input comes from the feature feedback notes you give us at the UGMs – so a big thank you to all who kindly take the time to do this. But suggestions are welcome at any time, and are especially useful if you can explain why a suggested feature is important. A review of all feedback has resulted in the following development plans:

- Workflow features related to mooring analysis.
- Line results at nodes in addition to mid-segments.
- Line Payout.
- Restarts.
- Improved lateral seabed modelling.
- Additional vertical and horizontal clearance results.
- Spatial wind specification.
- Software-based licencing (ie., without dongles).

These are features which we're either working on or are currently considering for the next couple of releases. But, as ever, this is not a definite commitment to add these features – some may take longer to implement, and some might not be technically possible. And the list above contains just the headline features – we add many other improvements in each development cycle.

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