Explicit Structural Damping

The OrcaFlex data item **Line target damping** (found on the Numerical damping page of the general data form and only visible when 'Explicit time domain' is selected on the 'Dynamics' page) specifies the level of damping for all lines. This note gives details of the relationship between the **Line target damping** specified and the percentage critical damping that will result for a given mode.

It is important to note two things about the damping implemented in OrcaFlex using the **Line target damping** data item.

- It is **viscous** damping, not **hysteretic** damping (see 'Dynamics of Fixed Marine Structures', Barltrop NDP, Adams, AJ, 1991, page 28). As a result the energy loss per cycle is frequency-dependent, and the effective % critical damping is not the same for all frequencies.
- Line target damping is specified as a percentage of the critical damping of the highest natural mode of the discretised model. This is the mode where a single node oscillates (axially, laterally or torsionally) on the segment springs each side of it, the neighbouring nodes being held fixed.

In other words, in OrcaFlex the user specifies the % critical damping for a high frequency natural mode of the discretised model. The effective percentage critical damping for other periods, e.g. the excitation period, will typically be a lot less than that specified, by a factor that depends on the level of discretisation used in the OrcaFlex model.

Effective % Critical Damping

As explained above, the effective % critical damping that OrcaFlex will give is frequency dependent. The % effective critical damping for an oscillation of period T is given by:

Effective % critical damping for period T = $(T_s / T) \times$ (Specified % Target Damping)

where Specified % Target Damping = value specified on the OrcaFlex General Data form

and T_s = shortest natural period of that section in the discretised model, for the appropriate degree of freedom (axial, bending or torsion).

These shortest natural periods are reported in the OrcaFlex statics results table for the line. The overall shortest natural period for the line is reported near the top of the table, and the shortest natural periods for each section are reported near the bottom. (The shortest torsion periods are only reported if torsion is included for that line.) For simple cases the axial damping can be calculated using the formula given in the Axial Damping section below.

The user can therefore achieve, for a given oscillation period T, a desired effective % critical damping by specifying to OrcaFlex as follows:

Specified % Target Damping = $(T / T_s) \times$ (Desired % critical damping for period T)

Here T will usually be the expected dominant response period.

Time Steps

Note that the above approach may lead to specifying very high percentages for the Target Damping data in OrcaFlex.

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If the percentage specified is very high (e.g. >100 for axial damping, typically higher still for bending and torsional damping) then you may find that you need to use a shorter inner time step for the simulation to remain stable.

It will normally be obvious if the time step does need to be reduced, since the simulation will very quickly report instability. In this case reduce the inner time step and try again.

Axial Damping

For a given section of a line, the shortest axial period of the model for that section is

$$T_s = 2\pi L_0 \sqrt{M/(2K)}$$

where L_0 = segment unstretched length, M = mass per unit length (including contents), and K = axial stiffness = EA. This formula can be useful to help calculate the adjustment factor (T/T_s) described above, for axial structural damping.

Warning: The values in the above formula must be given in inertial units. That is, units for which a unit force applied to a unit mass would give a unit acceleration.

We hope that the information in this article is useful, but do contact us if you have any comments or questions.

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