Damping in response-spectrum analysis

Within the Response Spectrum Function Definition menu, shown in Figure 1, the function damping ratio represents the damping ratio for which the response spectrum was generated.

The modal damping ratio of the structure must also be specified in the response-spectrum analysis case definition, which is shown in Figure 2:
During analysis, the response-spectrum curve will automatically adjust from the function damping value to that of the actual damping present in the model. The velocity formula (Newmark and Hall, 1982) used for computation is as follows:

\[ A_2 = A_1 \cdot \frac{(2.31 - 0.41 \cdot \log D_2)}{(2.31 - 0.41 \cdot \log D_1)} \]

where:

- \( A_1 \) = acceleration corresponding to damping ratio \( D_1 \)
- \( A_2 \) = acceleration corresponding to damping ratio \( D_2 \)
- \( 0 < D_1 < 100 \) (percentage)
- \( 0 < D_2 < 100 \) (percentage)
- \( \log \) = natural log (base \( e \))
For example, given an input acceleration \( A_1 = 0.4 \) at a particular period and function damping ratio \( D_1 = 0.05 \), the acceleration \( A_2 \) which correlates with the modal damping ratio \( D_2 = 0.08 \) would be computed as:

\[
A_2 = 0.4 \cdot \frac{(2.31 - 0.41 \cdot \log 8)}{(2.31 - 0.41 \cdot \log 5)} = 0.4 \cdot \frac{1.457}{1.650} = 0.353
\]

Here, \( D_1 \) is the damping value (percentage) used to generate the response spectrum curve. In the curve definition, this is denoted as the function damping ratio. \( D_2 \) represents the modal damping (percentage) of the structure, and is obtained through summation of damping sources which include the following:

1. Modal damping specified in the analysis case
2. Composite modal damping from materials
3. Effective damping from link/support elements

If \( D_1 \) is not equal to \( D_2 \) (and \( D_1 > 0 \)), then the response-spectrum curve will be adjusted according to the velocity formula (Newmark and Hall 1982). If the function damping ratio is specified as zero, no adjustments are made to the response spectrum curve, and the values are used as-is.

References