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Modeling tuned mass dampers (TMD) in Autodesk Robot Structural Analysis Professional
Description of example

1. Simply supported beam divided in 20 parts
2. Mass corresponding to self-weight
3. Excitation defined as 0.7kN load applied in central node of the beam (node 12),
4. Modal analysis defined and run to check basic properties like frequency and pulsation for the 1st mode, modal mass for this mode
5. Compatible node 22 defined for node 12 to model tuned mass damper (TMD):
6. Properties calculated and defined in relation to tuned mass damper:
   a. fundamental frequency of the structure f0 = 2.6986 Hz corresponding to pulsation w0 = 16.9557 rad/s
   b. stiffness of the structure calculated basing on forces and displacements of load case 3
      UZ=-2,5577784 mm
      FZ=-0.7 kN
      K = 273675 N/m
   c. modal mass for mode 1 M=966 kg
   d. mass m of TMD 5% of M so m = 0.05 * 966 = 48.3 kg
   e. Other properties of TMD according to Den Hartog's formulas for m=0.05*M:
      optimum stiffness
      k = 1/(1+0.05)*0.05*K = 0.047619*K = 13032.143 N/m
      optimum relative damping
      e = SQRT(3*0.05/8/(1+0.5)) = 0.1336306
      (for different version of above formula it can be e = SQRT(3*0.05/8/(1+0.5)^3) = 0.1272672 - not used in this example)
   f. absolute damping of TMD resulting from above relative damping
      a = 2*m*wt*e
      where wt pulsation of vibrations related to damper wt = SQRT(k/m) = SQRT(13032.143/48.3) = 16.4261 rad/s
      so a = 2*48.3*16.4261*0.1336306 = 212.04 N*s/m
7. Damping a and stiffness k defined in properties of compatible node
8. Defining a series of time history analysis using Newmark method (acceleration)
   a. with various frequencies of sinusoidal harmonic excitation and using the load defined in step 3/
   b. with structural Rayleigh damping corresponding to 0.02 (2%) relative damping - calculated for pulsations w0 and wt
   c. with the time length sufficient to dissipate transient effects resulting from starting conditions – analyzing results for steady state vibrations
9. Splitting the range of frequencies in separate models to avoid limits related to the number of time steps within one model
10. Saving and running models with or without added mass m defined in node 22 to activate or not tuned mass damper between this node and node 12 (models with and without TMD). When there is no mass m TMD is not working - models without TMD
11. Results from all these models used in the MS Excel spreadsheet. It contains maximum vertical displacements of node 12 for steady state vibrations with various frequencies of excitation with and without tuned mass damper. In the generated diagram it can be noticed that using TMD results in significant reduction of maximum vertical displacements in the middle of the beam in case of harmonic excitement with frequency close to the 1st fundamental mode.