SDLD29 - Transient masses spring with 8 degrees of freedom and viscous damping nonproportional

Summary:

This problem corresponds to a transitory analysis by modal recombination of a linear discrete system made up by 8 degrees of freedom. This system has a damping not proportional. A transitory force of standard crenel is applied into 1 degree of freedom.

In this problem the elements are tested DISCRETE with modal masses (M_T_D_N), matrices of rigidity (K_T_D_L) and matrices of damping (A_T_D_L) in a modeling.

The problem has a reference solution suggested by commission VPCS. Variations with Code_Aster do not exceed 1.8%.
1 Problem of reference

1.1 Geometry

![Diagram of spring system with nodes and forces]

Specific masses:
\[ m_{P_1} = m_{P_2} = m_{P_3} = \ldots = m_{P_8} = m \]

Stiffnesses of connection:
\[ k_{AP_1} = k_{P_1P_2} = k_{P_2P_3} = \ldots = k_{P_8B} = k \]

Viscous damping:
\[ C_{P_1P_2} = C_{P_2P_3} = \ldots = C_{P_7P_8} = c \]
\[ C_{AP_1} = cc \]
\[ C_{P_8B} = cd \]

1.2 Material properties

Spring of elastic translation linear
\[ k = 10^5 \text{ N/m} \]

Specific mass
\[ m = 10 \text{ kg} \]

Damping of connection
\[ c = 50 \text{ N/(m/s)} \]
\[ cc = 250 \text{ N/(m/s)} \]
\[ cd = 25 \text{ N/(m/s)} \]

1.3 Boundary conditions and loadings

Points A and B embedded: \( u = 0 \)

Loading: Concentrated force not periodical at the point \( P_4 \)

\[ F_x(t) = \begin{cases} 1 \text{ N} & \text{for } 0 \leq t \leq 1 \text{s} \\ 0 & \text{for } t > 1 \text{s} \end{cases} \]

1.4 Initial conditions

For \( t = 0 \), in any point \( P_i \): \( u = 0 \), \( \frac{du}{dt} = 0 \).

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2 Reference solution

2.1 Method of calculating used for the reference solution

Digital integration (approximate) by the direct method using a digital diagram of integration by finished differences, the step of time used must be sufficiently small to obtain a sufficiently precise solution. With one of the diagrams used (Newmark method improved), the step of appointed time was of 0.001s.

Method of Newmark improved (NEWMARK NR. Mr., “with method of computation for structural dynamics” proceeding ASCE J. Eng. Mech. Div E-3, July 1959, pp 67-94) use the diagram of integration according to:

\[
\frac{1}{\Delta t^2}[M] + \frac{1}{2\Delta t}[C] + \frac{1}{3}[K]\left[u_{n+2}\right] = \frac{1}{3}\left([P_{n+2}] + [P_{n+1}] + [P_n]\right) + \frac{2}{\Delta t^2}[M] - \frac{1}{3}[K]\left[u_{n+1}\right] + \frac{1}{\Delta t^2}[M] - \frac{1}{2\Delta t}[C] - \frac{1}{3}[K]\left[u_{n}\right]
\]

Indices \(n\), \(n+1\), \(n+2\) the calculations carried out at time indicate respectively \(t_n\), \(t_{n+1} = t_n + \Delta t\) and \(t_{n+2} = t_n + 2\Delta t\), where \(\Delta t\) is the increment of appointed time. \([M]\), \([C]\) and \([K]\) are respectively the matrices masses, damping and stiffness, \([u]\) is the vector displacement and \([P]\) the vector forces associated.

![Graph showing displacement according to time](image)

Point 4: displacement according to time

2.2 Results of reference

Displacement at the point \(P4\) according to time, confer graph above.

2.3 Uncertainty on the solution

- position of the extremas: \(\Delta t < 0.015\)
- maximum amplitude: \(\Delta u/u < 0.5\%\)

2.4 Bibliographical references

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1. Card SDLD29/90 of commission VPCS
3 Modeling A

3.1 Characteristics of modeling

Discrete element of rigidity in translation

\[
\begin{array}{cccccccc}
A & P_1 & P_2 & P_3 & P_4 & P_5 & P_6 & P_8 & B \\
\end{array}
\]

Characteristics of the elements

DISCRETE: with nodal masses \( M_{T,D,N} \)
and matrices of rigidity \( K_{T,D,L} \)
and matrices of damping \( A_{T,D,L} \)

Limiting conditions:
in all the nodes \( DDL_{IMPO} = F \) (TOUT='OUI' \( \text{DY}=0. \), \( \text{DZ}=0. \))
with the nodes ends \( \text{GROUP_NO} = AB \) \( \text{DX}=0. \)

Names of the nodes:

Not \( A = N1 \) \( P_1 = N2 \)
Not \( B = N10 \) \( P_2 = N3 \)
\( P_8 = N9 \)

Modal recombination with all the modes (8) \( \text{pas de time used} \)
diagram of EULER \( dt=1.E-3 \ s \)

3.2 Characteristics of the grid

Many nodes: 10
Many meshes and types: 9 SEG2

3.3 Sizes tested and results

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<th>Time (s)</th>
<th>Reference</th>
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3.4 Remarks

Contents of the file results: displacements.

4 Summary of the results

One obtains a relatively good agreement between the calculated solution and solution VPCS (<0.7%) except at moment 0.91 (2.4%). The differences are primarily due to the fact that the moments of test are given only with 2 significant figures, which does not make it possible to seize sufficiently well the moment of the extremum.