SDLS119 - Plate on bearings subjected to an acceleration of Ricker (method TEMPS-frequency)

Summarized:

This test of non regression met of work processing of the nonlinear problem of separation of a flexible plate modelled by finite elements of shells and posed on springs of contact. These springs support the inertia loading of the plate and the compressions generated by the rotation and the vertical motion of the plate. Separations are taken into account and treaties by penalization.

The requests imposed in the form of horizontal driving acceleration are of the impulses of the Ricker type. In this modelization, the resolution of the dynamic problem takes place in a loop of linear computations where one each time recomputes on all the temporal beach the complement of nodal forces due to nonthe linearity of separation. One uses, either a harmonic computation with a frequential evolution and return in time by transform of Fourier in the classical method TEMPS-frequency, or a transient computation on physical base in a method strictly temporal alternative.

This case test makes it possible to test, on a strictly linear computation, operator `REST_SPEC_TEMP` of return in time by opposite transform of Fourier of all the harmonic evolution while comparing its result with the transitory evolution obtained directly by transient computation.

The modelization B realizes an identical computation on modal base. The parameters of computation are different (in particular the step and the tape of computing time). This benchmark makes it possible to test option EXCIT_RESU in a transient computation on modal base, and the option of projection RESU_GENE of a structure dyna_trans in PROJ_BASE.

1 Problem of reference

1.1 Geometry

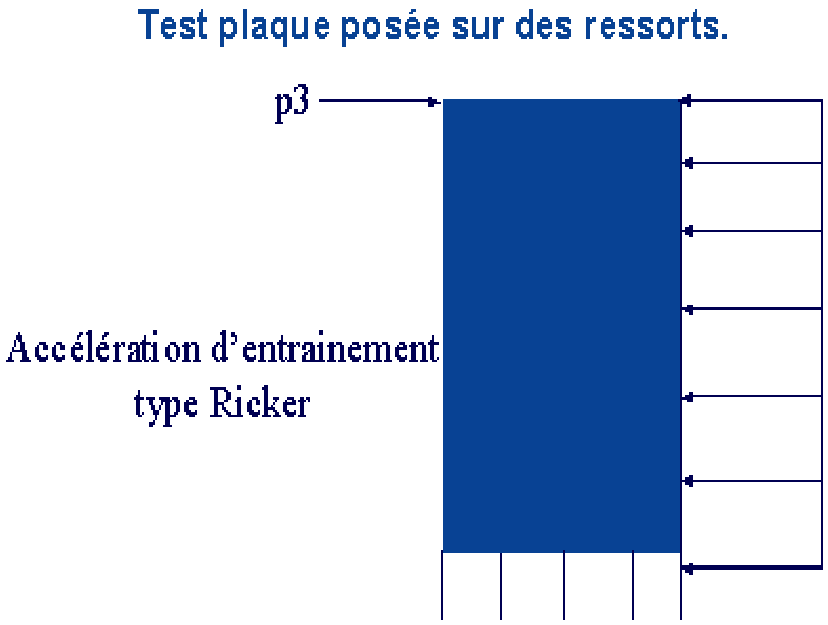


Figure 1: plate on bearings springs subjected to an imposed acceleration

the plate has a width of $4\,m$ (direction X), a height of $8\,m$ (direction Y) and a thickness of $1\,m$ in the normal Z direction to its plane.

One assigns a double series of springs to lower edge of the plate. A first series of 5 springs to represent the bearing of the plate and a second series of 5 springs intercalated between the first and lower edge of the plate to represent springs of contact by penalization.

1.2 Properties of the materials

For the material of the plate, one a:

$$E=1.4\times10^{8}\,Pa \qquad \nu=0.3 \qquad \rho=2.5\times10^{3}\,kg/m^{3}$$

Proportional damping (RAYLEIGH):

$C=\alpha K+\beta M$ with $\alpha=5.0\times10^{-3}\,s$ and $\beta=0.1\,s^{-1}$.

The first series of springs to represent the bearing of the plate has characteristics of stiffness of $1.0\times10^{8}\,N.m$ in the horizontal Y direction. The other characteristics of stiffness in the other directions as those within the competences of contact by penalization are worth $1.0\times10^{15}\,N.m$.

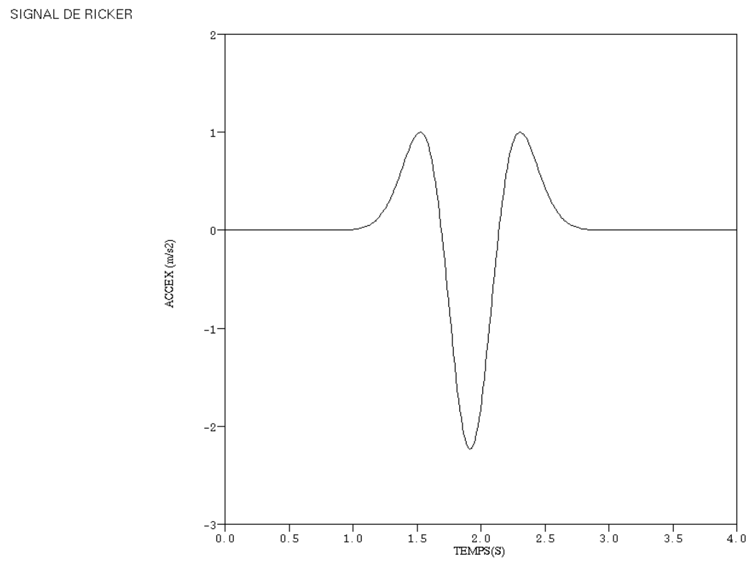
1.3 Boundary conditions and loadings

On all structure one imposes $DZ=DRY=0$.

One imposes the condition of fixed support in bottom of the first series of springs in order to represent the bearing of the plate: $DX=DY=DZ=0$.

One applies gravity in the vertical direction Y .

One also applies an imposed acceleration mono-bearing in the horizontal direction X in the form of signal of Ricker of amplitude $0.23\,g$.



1.4 Initial conditions

the structure is initially at rest.

2 Reference solution: modelization A

2.1 Méthode de calcul used for the reference solution

the method used here is the method known as TEMPS-frequency [bib1] where after a first linear stage solved into frequential after transformation of Fourier of the transitory excitations then general return in time of all result obtained by transformation of Fourier reverses, one estimates the complement of internal forces nodal due to nonthe linearity of the separation calculated on all the temporal beach. One proceeds then in a new stage to a new linear resolution into frequential after transformation of Fourier of this complement added to the initial transitory excitations. The solution obtained generates a new complement of nonlinear internal nodal forces and so on. The iterative process is stopped when a norm on the temporal window of the difference of displacements between 2 successive stages becomes lower than a value of criterion user.
There exists also a purely transitory alternative of this method [bib2] where one solves only out of transient without return into frequential of the complement of nonlinear internal nodal forces.

2.2 Results of reference

One retains like results of reference maximum horizontal displacements and vertical statements during 2 stages of dynamic computation at the left end higher of the plate than the point $P3$ (cf figure1).

2.3 Validation complementary to `REST_SPEC_TEMP`

operator REST_SPEC_TEMP is based on a version FORTRAN of the algorithm of FFT. It is relevant to check that one finds well the same one result with the FFT (python) of CALC_FONCTION. For that, one will compare the evolution of following displacement X and Y the point $P3$. The absolute deviation between the two methods must be negligible (about the numerical accuracy).

3 Reference solution: modelization B

3.1 Méthode de calcul used for the reference solution

The computation carried out here is identical to that of the modelization A, on modal base. This computation makes it possible to validate commands

- PROJ_BASE option RESU_GENE : projection of a temporal evolution (dyna_trans) on a basis of modes,
- DYNA_VIBRA, into temporal (TYPE_CALCUL=' TRAN') and on modal base (BASE_CALCUL=' GENE') with an excitation defined by option EXCIT_RESU.

3.2 Results of reference

the results tested in the frame of the modelization B are the same ones as for modelization A. the values of reference are different, because the values of the tapes and time step of computation are different. The sampling rate chosen for temporal computations is of 1000 Hz.

4 Bibliographical references

1.N. GREFFET: Project OMERSI - Assessment on the method TEMPS-frequency in ISS. CR-AMA-06.219

2.G. DEVESA: Application of a method of modal dynamic condensation in *Code_Aster* under investigation in ISS of the joint resumption of the method TEMPS-Frequency and of a strictly temporal alternative method. CR-AMA-08.164

5 Modelization A

5.1 Characteristic of the modelization

In this modelization, the resolution of the dynamic problem take place in a loop of linear computations where one recomputes with each time on all the temporal beach the complement of nodal forces due to nonthe linearity of separation. One uses, either a harmonic computation with a frequential evolution and return in time by transform of Fourier in the classical method TEMPS-frequency, or a transient computation on physical base with a method strictly temporal alternative.

5.2 Characteristics of the mesh

The model is composed of 55 nodes (285 ddls), 42 elements (32 elements plates DKT and 10 discrete elements DIS_T).

5.3 Parameters of computation

Each transient dynamic computation is carried out on an interval from $5s$ time step of $0.005s$ filed all the 2 steps. Each harmonic computation is carried out with a step of $1/20.48\,Hz$ which makes it possible to restore a temporal window of $20.48\,s$ sufficient for calculating well the FFT of the force of constant gravity in time; the maximum frequency of computation is worth $25\,Hz$ and that prolonged is $50\,Hz$ in order to time step to obtain one $0.01\,s$ in the temporal window restored by FFT.

5.4 Quantities tested and Transitory

Identification	results	Harmonic	Difference
$P3 - DX$ (2.33 S) iter=1	-4.58502E-2	-4.58588E-2	0.019%
$P3 - DY$ (2.33 S) iter=1	5.67299E-3	5.67541E-3	0.043%
$P3 - DX$ (2.34 S) iter=2	-4.82202E-2	-4.82436E-2	0.048%
$P3 - DY$ (2.34 S) iter=2	6.55566E-3	6.54736E-3	0.127%

Comparison of FFT FORTRAN (REST_SPEC_TEMP) and the FFT python (CALC_FONCTION):

Identification	REST_SPEC_TEMP	CALC_FONCTION	absolute Deviation
$P3 - DX$ (2.34 S) iter=2	-4.82202E-2	-4.82202E-2	2.5673907444E-16
$P3 - DY$ (2.34 S) iter=2	6.55566E-3	6.55566E-3	-7.4593109467E-17

6 Summary of the results

One can consider that the implementation of this case test is a good application of the method TEMPS-frequency and that it at the same time makes it possible to test, on a strictly linear computation, operator `REST_SPEC_TEMP` of return in time by opposite transform of Fourier of all the harmonic evolution while comparing its result with the transitory evolution obtained directly by a transient computation on physical base.