# SDLS119 - Plate on supports subjected to an acceleration of Ricker (method time-frequency)

**Summary:**

This test of nonregression implements the treatment of the nonlinear problem of separation of a flexible plate modelled by finite elements of hulls and posed on springs of contact. These springs support the actual weight of the plate and the compressions generated by the rotation and the vertical movement of the plate. Separations are taken into account and treaties by penalization.

The requests imposed in the form of horizontal acceleration of training are of the impulses of the Ricker type. In this modeling, the resolution of the dynamic problem takes place in a loop of linear calculations 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 calculation with a frequential evolution and return in time by transform of Fourier in the classical method time-frequency, or a transitory calculation on physical basis in a method strictly temporal alternative.

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

Modeling B carries out an identical calculation on modal basis. The parameters of calculation are different (in particular the step and the band of computing time). This CAS-test makes it possible to test the option EXCIT_RESU in a transitory calculation on modal basis, and the option of projection RESU_GENE of a structure dyna_trans in PROJ_BASE .

# 1 Problem of reference

## 1.1 Geometry

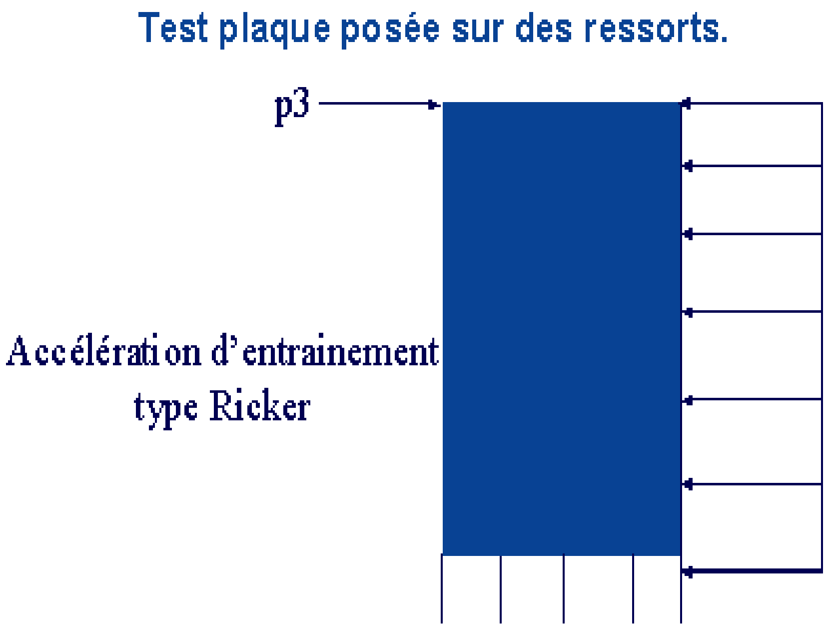



Figure 1: plate on supports springs subjected to an imposed acceleration

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 direction $Z$ normal with its plan.

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

## 1.2 Properties of materials

For material of the plate, one a:

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

Damping proportional (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 support of the plate has characteristics of rigidity of $1.0\times10^{8}\,N.m$ in the direction $Y$ horizontal. The other characteristics of rigidity in the other directions as those within the competences of contact by penalization are worth $1.0\times10^{15}\,N.m$ .

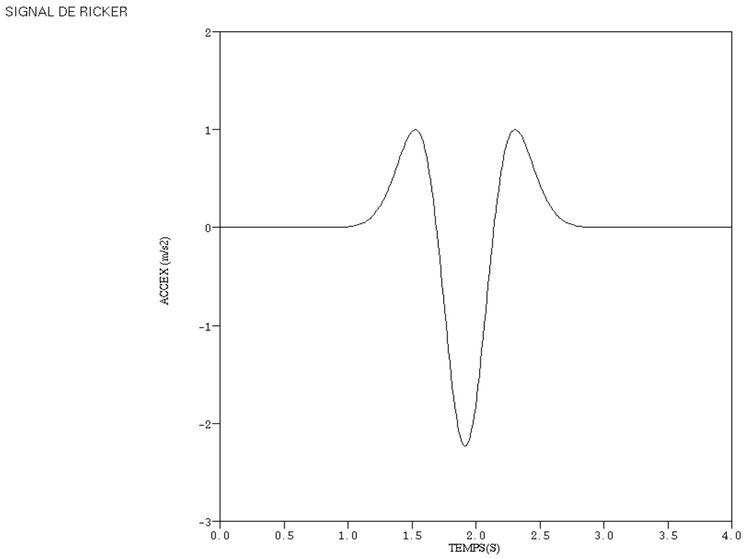
## 1.3 Boundary conditions and loadings

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

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

One applies gravity in the vertical direction $Y$ .

One also applies an imposed acceleration mono-support 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: modeling A

## 2.1 Method of calculating used for the reference solution

The method used here is the method known as time-frequency [bib1] where after a first linear stage solved into frequential after transformation of Fourier of the transitory excitations then return general in times of all the result got 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 standard 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 in 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 calculation at the left end higher of the plate than the point $P3$ (cf figure1).

## 2.3 Validation complementary to `REST_SPEC_TEMP`

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

# 3 Reference solution: modeling B

## 3.1 Method of calculating used for the reference solution

Calculation carried out here is identical to that of modeling A, on modal basis. This calculation makes it possible to validate the orders

- 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 basis (BASE_CALCUL=' GENE') with an excitation defined by the option EXCIT_RESU.

## 3.2 Results of reference

The results tested within the framework of modeling B are the same ones as for modeling A. the values of reference are different, because the values of the bands and not of computing time are different. The sampling rate chosen for temporal calculations is of 1000 Hz.

# 4 Bibliographical references

1. NR. GREFFET: Project OMERSI - Assessment on the method time-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 Time-Frequency and a strictly temporal alternative method. CR-AMA-08.164

# 5 Modeling A

## 5.1 Characteristics of modeling

In this modeling, the resolution of the dynamic problem takes place in a loop of linear calculations 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 calculation with a frequential evolution and return in time by transform of Fourier in the classical method time-frequency, or a transitory calculation on physical basis with a method strictly temporal alternative.

## 5.2 Characteristics of the grid

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 calculation

Each transitory dynamic calculation is carried out on an interval of $5 s$ by step of time of $0.005 s$ filed all harmonic 2 pas. Chaque calculation is carried out with a step of $1/20.48 Hz$ who allows to restore a temporal window of $20.48 s$ sufficient for calculating well FFT of the force of constant gravity in time; the maximum frequency of calculation is worth $25 Hz$ and that prolonged is of $50 Hz$ in order to obtain a step of time of $0.01 s$ in the temporal window restored by FFT.

## 5.4 Sizes tested and results

| Identification | Transient | 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 of 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 time-frequency and that it at the same time makes it possible to test, on a strictly linear calculation, the operator REST_SPEC_TEMP of return in time by transform of Fourier reverses of all the harmonic evolution by comparing its result with the transitory evolution obtained directly by a transitory calculation on physical basis.