SHLS200 - Model probabilistic nonparametric: Harmonic response of a under-structured plate

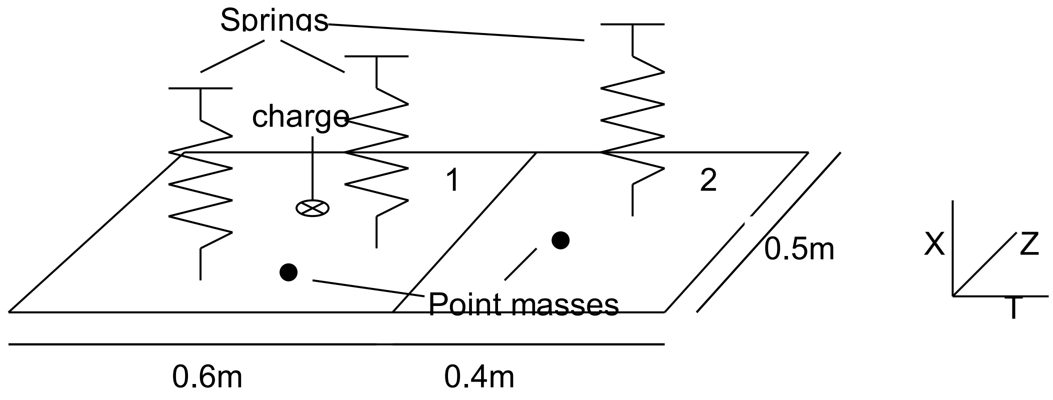
Summarized:

This benchmark treats taking into account of random uncertainties for the computation of a harmonic response per substructuring of the type Craig Bampton. We take again here an example of the literature made up of a plate supported at its ends.

The functionality of operator GENE_MATR_ALEA `consisting in` is tested taking for entering concept a concept `macr_elem_dyna` of substructure given and producing `a random` macr_elem_dyna (mass, stiffness and damping). The concepts `macr_elem_dyna` random products then make it possible to calculate for example the field of confidence of the harmonic response of the plate.

1 Problem of reference

1.1 Geometry



is there a thin plate of separate $0.4\,10^{-3}\,m$ rectangular thickness in two substructures including each one a lumped mass.

1.2 Material properties

the materials is homogeneous and isotropic.

Mass density: $7800\,kg/m^3$,
Young Modulus: $2.1\,10^{11}\,N/m^2$

Concentrated stiffness: $2.388\,10^7\,N/m$,
Coordinated stiffness concentrate: $(0.28, 0.22)$, $(0.54, 0.33)$ and $(0.83, 0.44)$,

Lumped mass: $3\,kg$ for substructure the 1 and $4\,kg$ substructure 2,
Coordinated masses concentrate: $(0.4, 0.2)$ and $(0.75, 0.35)$.

Damping
the damping matrix $[\underline{D}]$ is defined as being a linear combination of the average matrixes of mass $[\underline{M}]$ and stiffness $[\underline{K}]$:

$$[\underline{D}]=a[\underline{M}]+b[\underline{K}] \quad \text{with} \quad a=\frac{2\xi\Omega_{max}\Omega_{min}}{\Omega_{max}+\Omega_{min}} \quad \text{and} \quad b=\frac{2\xi}{\Omega_{max}+\Omega_{min}}$$

where $\xi=0.04$, $\Omega_{min}=5.2\pi\,rad/s$ and $\Omega_{max}=212.8\pi\,rad/s$.

1.3 Boundary conditions and loadings

the flexbeam is out of simple bearing on its four edges.

Substructure the 1 is subjected to an external force at the point $(0.24, 0.24)$ equal to $1\mathrm{N}$ on the tape of analysis $[0, 2\pi.100]\,rad/s$ according to the direction z and null on the other degrees of freedom and for the other frequencies.

1.4 Initial conditions

the dynamic system is initially at rest.

2 Reference solution

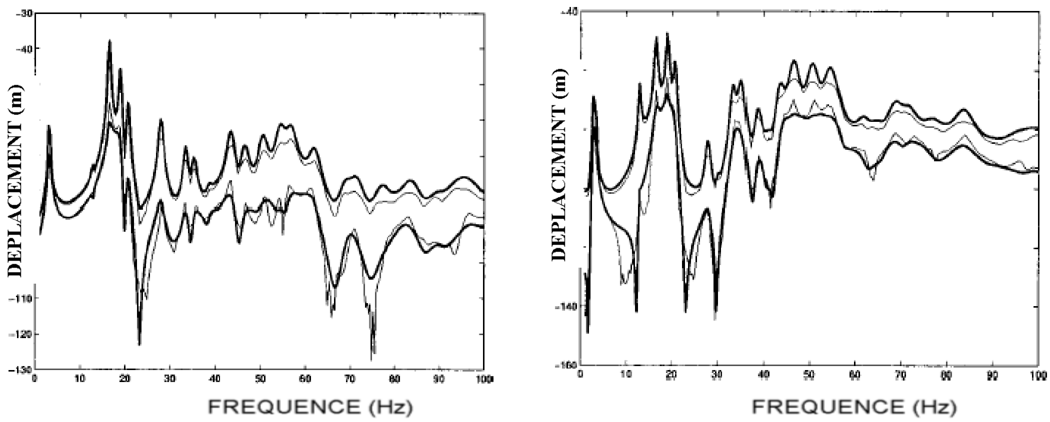
2.1 Method of calculating used for the reference solution

the method used is the method published in particular in [bib1] (cf [§2.3]). Random uncertainties of the dynamic system are modelled by means of the model probabilistic known as not parametric uncertainties due to Soize (cf [bib1]). The statistics on the harmonic response of the linear dynamic system are obtained by the method of Monte Carlo. The procedure is identical to that presented to [§ 3.3], but developed under Matlab.
In the standard commodity, 500 pullings are carried out and the envelopes lower and higher of these 500 pullings are presented.

2.2 Results of reference

the degrees of freedom of observation correspond to the direction DZ of the node of coordinates $(0.39, 0.31)$ for the first substructure and of the node of coordinates $(0.79, 0.24)$ for the second substructure.
The results of reference are given in the form of the graphs below drawn from [bib1].

Node $(0.39, 0.31)$, DZ Node $(0.79, 0.24)$, DZ



inter-quantiles Fields (milked thin) of displacements to the degrees of freedom of observation
Results of reference
(the fatty features are approximations, not used here for the comparison)

2.3 Bibliographical reference

1) C. SOIZE and H. CHEBLI: "Random Uncertainties Model in Dynamic Substructuring Using has Nonparametric Probabilistic Model, ASCE Newspaper of Engineering Mechanics, 0733 - 9399(2003) 129: 4(449).

3 Modelization A

3.1 Characteristic of the modelization

Modelization: DKT

The model average with the finite elements of the plate consists of a regular rectangular mesh whose step is constant and is worth $0.01\mathrm{m}$ in the directions X_1 and X_2. Consequently, all the finite elements are identical and each one is an element plates with 4 nodes.

Modelization: DIS_T

the lumped masses and the concentrated stiffness are modelled by elements DIST_T.

3.2 Characteristics of the average

mesh The model finite elements comprises 14849 active degrees of freedom, including 8840 for under - structure, 1,5860 for substructure the 2 and 149 for the interface.

Many degrees of freedom: 8840+5860+149
Many finite elements: 6000 QUA4 et3 DIS_T

3.3 Méthode de calcul

Model reduced

As for the reference, we take for each substructure 20 modes in order to have a good convergence of the calculated response with respect to the number of modes.

Achievements of the random matrixes of the nonparametric probabilistic model by under structure

For each under structures, the reduced matrixes of masses, stiffness and dissipation of the model layers are replaced by achievements of the random matrixes of mass, stiffness and of nonparametric dissipation following the model probabilistic. For that, we use the generator of random matrixes GENE_MATR_ALEA which generates a concept macr_elem_dyna from an average macr_elem_dyna.

One can thus allot to a each substructure level of uncertainty by fixing the parameters of dispersion for each substructure. We fixed them at 0.1 for each mass matrix, of stiffness and generalized damping and for each substructure.

Resolution of the probabilistic linear dynamic system.

The harmonic operator of computation is used to build the harmonic response of the plate for each random realization of the matrixes of mass, stiffness and dissipation.

The frequential interval of the study is $B=[0,100]\,Hz$, with a step of $0.5\,Hz$.

Construction of the statistical estimates.

After each call to the harmonic operator of computation, we have a realization of the fields of displacement. A each pulling (iteration of Monte Carlo) we build the statistical estimates with the assistance only of operator CALC_FONCTION and key words ENVELOPPE, PUISSANCE and COMB.

3.4 Features tested

the functionality tested of `GENE_MATR_ALEA` is the possibility of producing a concept of the macr_elem_dyna `type` from another concept of the macr_elem_dyna `type`.

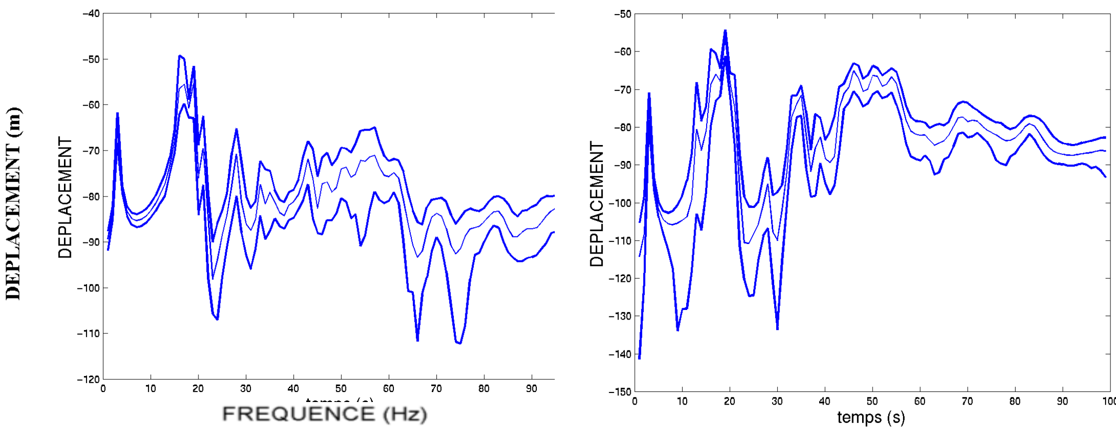
3.5 Quantities tested and results

the initial validity of the case test was established by graphic comparison with bibliographical reference given in [§2.2]. The responses are calculated into 1 point for each substructure; these points have as coordinates: $(0.39, 0.31)$ and $(0.79, 0.24)$.

As for the reference, the envelopes lower and higher of 500 pullings are calculated. For each frequency, the inter-quantile field corresponding corresponds, for example with a degree of confidence β of 0.95, with a probability of 0.994 for the maximum value and 0.006 for the minimal value.

The results obtained with *Code_Aster* are represented on the curves below:

Node $(0.39, 0.31)$, DZ Node $(0.79, 0.24)$, DZ



fatty Features: inter-quantiles fields of displacements to the ddls of observation
(milked thin: average)
Code_Aster *Results*

One tests the following values into non regression (cf comments):

Statistics on the values in displacement with 30Hz with the d.o.f. of observation of the first substructure

Parameters	References	*Aster*	% Difference
substructure Wraps	higher	6.7338296870618D-05	6.7338296870618 D-05
0 Envelope	lower	5.1116761251425D-05	5.1116761251425 D-05
0 Estimate of	the average	6.0802671417375D-05	6.0802671417375 D-05
0 Estimate of the moment of order	2	3.7457833680156D-09	3.7457833680156 D-09

0 Statistics on the values in displacement than 30Hz than the d.o.f. of observation of the second

Parameters	References	*Aster*	% Difference
Wraps higher	4.3459496115461D-04	4.3459496115461D-04	0
Envelope lower	2.8511128677169D-04	2.8511128677169D-04	0
Estimate of the average	3.5186242151806D-04	3.5186242151806D-04	0
Estimate of the moment of order 2	1.2765909447885D-07	1.2765909447885D-07	0

3.6 Comments

the various statistical estimates are not converged here. Only 3 simulations of Assembles - Carlo were made to reduce drastically the TEMPS CPU of the case test. Convergences having been validated on the complete study (after convergence, the statistical estimates calculated from *Code_Aster* correspond to the results given by the cf graphs, standard commodity), the case test is satisfied with the non regression one.

4 Summary of the results

the got results are completely in conformity with those of bibliographical reference [§2.2] entirely obtained in Matlab.