

## Operator GENE\_MATR\_ALEA

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### 1 Goal

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To generate achievements of generalized matrices considered as random for structures or substructures. The law of probability of the matrices is built according to the principle of the maximum of entropy by considering information available (average and coefficient of variation) and their algebraic properties (definite symmetry positivity) [R4.03.05].

Product a structure of data `matr_asse_gene_R` or `macr_elem_dyna` according to the type of data input.

## 2 Syntax

```
[ macr_elem_dyna ] / [ matr_asse_gene_R ] = GENE_MATR_ALEA

( ♦ / ♦ MATR_MOYEN = average [matr_asse_gene_R]
  ♦ COEF_VAR = / delta [R]
  / 0.1 [DEFECT]

/ ♦ MATR_MOYEN = average [macr_elem_dyna]
  ♦ COEF_VAR_RIGI = / delta_R [R]
  / 0.1 [DEFECT]

  ♦ COEF_VAR_MASS = / delta_M [R]
  / 0. [DEFECT]

  ♦ COEF_VAR_AMOR = / delta_C [R]
  / 0. [DEFECT]

  ♦ INIT_ALEA = nor [I]
)

If average = [matr_asse_gene_R] then [matr_asse_gene_R] = GENE_MATR_ALEA
If average = [macr_elem_dyna] then [macr_elem_dyna] = GENE_MATR_ALEA
```

## 3 Operands

With or without under-structuring, this operator in fine consists in generating achievements of one or more noted random matrices in a generic way  $[A]$ .  $[A]$  is a random variable with value in the whole of the positive definite real matrices of dimension  $(n, n)$  whose law is parameterized by its median value  $[A]$  and its scatter coefficient [R4.03.05].

### 3.1 Keyword MATR\_MOYEN

- ♦ MATR\_MOYEN = average

average indicate the average matrix  $[A]$  random matrix  $[A]$ .

If average is of type [matr\_asse\_gene\_R], then  $[A]$  is obtained by projection of an average assembled matrix of the average model to the finite elements on a given number of clean modes of the dynamic system (operator PROJ\_BASE for example  $[A]$ ). Achievements of  $[A]$  generated by GENE\_MATR\_ALEA can thus be matrices of masses, stiffness or damping generalized.

#### Caution:

The matrix average  $[A]$  must be stored in mode of full storage (operator NUME\_DDL\_GENE, keyword STOCKAGE=' PLEIN' or operator PROJ\_BASE, keyword PROFIL=' PLEIN' ).

If average is of type [macr\_elem\_dyna] (under-structuring), then  $[A]$  is a concept containing the matrices of rigidity, mass and possibly of damping projected on the basis of modal substructure supplemented by the matrices of connection of the interfaces, the average model.

### 3.2 Keyword COEF\_VAR

- COEF\_VAR = /delta  
/ 0.1 [DEFECT]

This keyword informs the parameter  $\delta$  of control of the dispersion of the random generalized matrix  $[A]$  who can be of mass, stiffness or dissipation. This coefficient of variation  $\delta$  is defined by:

$$\delta = \sqrt{\frac{(n+1) \cdot \|A\|_F^2}{\text{tr}(A)^2 + \text{tr}(A^2)}}} \times \sqrt{\frac{E(\|[\mathbf{A}] - [A]\|_F^2)^{1/2}}{\|A\|_F^2}}$$

with:

- 1)  $\|A\|_F = (\text{tr}([A][A]^T))^{1/2}$
- 2)  $n$  the dimension of  $[A]$
- 3)  $\sqrt{\frac{E(\|[\mathbf{A}] - [A]\|_F^2)^{1/2}}{\|A\|_F^2}}$  the scatter coefficient of the matrix  $[A]$

$\delta$  can also be written:

$$\delta = \left( \frac{E \| [\mathbf{G}_A] - [\mathbf{G}_A] \|_F^2}{\| [\mathbf{G}_A] \|_F^2} \right)$$

with  $[\mathbf{L}_A]$  the lower triangular matrix resulting from the factorization of Cholesky  $[\mathbf{A}] = [\mathbf{L}_A]^T [\mathbf{G}_A] [\mathbf{L}_A]$  average matrix  $E\{[\mathbf{A}]\} = [\mathbf{A}]$ .

One must have (cf [R4.03.05]):

$$0 < \delta_A < \sqrt{\frac{n_0 + 1}{n_0 + 5}},$$

where  $n_0 \in \mathbb{N}$  is a constant of the probabilistic model selected so that  $n_0 < n$ .

- COEF\_VAR\_RIGI = / delta\_R [R]  
/ 0.1 [DEFECT]

This keyword informs the parameter  $\delta_R$  of control of the dispersion of the random matrix of rigidity of a substructure. This coefficient of variation is defined in a way identical to the definition given for the keyword COEF\_VAR.

- COEFF\_VAR\_MASS = / delta\_M [R]  
/ 0. [DEFECT]

This keyword informs the parameter  $\delta_M$  of control of the dispersion of the random matrix of mass of a substructure. This coefficient of variation is defined in a way identical to the definition given for the keyword COEF\_VAR.

- COEFF\_VAR\_AMOR = / delta\_C [R]  
/ 0. [DEFECT]

This keyword informs the parameter  $\delta_C$  of control of the dispersion of the random matrix of dissipation of a substructure. This coefficient of variation is defined in a way identical to the definition given for the keyword COEF\_VAR.

### 3.3 Operand INIT\_ALEA

- ◇ INIT\_ALEA = nor [I]

Cause initialization with sound  $ni$ -ième term of the continuation of pseudo-random numbers used for the generation of the matrices.

If the keyword INIT\_ALEA is absent, the terms used of the continuation are those immediately consecutive with those already used. If no term were still used, the continuation is initialized in its first term.

#### Recommendation:

*With less than one particular use, it is advised not to inform the keyword INIT\_ALEA in the operators according to: GENE\_FONC\_ALEA, GENE\_VARI\_ALEA and GENE\_MATR\_ALEA. In this case, with the first call to the one of these operators, the continuation of pseudo-random numbers is initialized in its first term. The omission of the keyword INIT\_ALEA to each call of these operators in the command file the statistical independence of the pseudo-random numbers used guarantees.*

**Note:**

The germ of the continuation remains identical of one execution to the other of Code\_Aster; the results thus remain rigorously identical (one can thus test to it not regression of not converged statistical results). If one wishes to generate results statistically independent from one execution to another, then the keyword should be used `INIT_ALEA` with values raising the number of terms used in the former executions.

**Caution:**

The generator of random variable used is that of the module "random" of Python. It depends on the version of Python exploited by Code\_Aster. Not statistically converged results can thus vary from one version to another of Code\_Aster or platform to another, if the version of Python is not the same one and that between the two versions the module random evolved (case between Python 2.1 and 2.3).

**Note:**

In version Python 2.3, the period of the generator is of  $2^{19937} - 1$ .

## 4 Example

By call, the order generates only one realization of the random matrix to simulate. To generate several achievements of the same random matrix, it is necessary to repeat the order without changing its parameters or placing the order in a loop of the process control language of Code\_Aster - the language python.

In the following example, one generates *ns* achievements of a random matrix of median value `MATR_MOYEN` with one  $\delta = 0.1$ . These achievements are then used as values of matrix of mass.

```
ns=100

for K in arranges (1, ns+1):

# Generation
  MAT_ALEA=GENE_MATR_ALEA (
                                MATR_MOYEN=MATR_MOY,
                                COEF_VAR=0.1,
                                )

  DYN=DYNA_TRAN_MODAL (
                        ... MASS_GENE= MAT_ALEA,
                        )
# Here for example, statistical processing of DYN

  TO DESTROY (CONCEPT=_F (NOM= (DYN, MAT_ALEA)))

# End of the loop (indentation)
```

For more complete examples, to consult the cases test SDNS01 [V5.06.001], SDNL105d [V5.02.105] and SHLS200a [V2.06.200], like [U2.08.05].