ZZZZ200 - Test of `RIGI_PARASOL` and `RIGI_MISS_3D`

Summary:

This test makes it possible to model in modal analysis an industrial structure: that of test SDLL109[1] (discrete elements and beams) supplemented at its base of voluminal and surface elements.

Its interest is to test the options of *Code_Aster* specific to the assignment of characteristics representative of rigidities of ground under the foundation of the structure.

This test understands for that 4 modelings. The three first evaluate the 2 options of `AFFE_CARA_ELEM` fulfilling this function: `RIGI_PARASOL` (where one affects the 6 values of total rigidity of the ground corresponding each one to a degree of freedom of body solid and divided into each node of the foundation) and `RIGI_MISS_3D` (where one affects in each degree of freedom of the foundation the terms of the matrix of impedance of ground calculated as a preliminary by the software of interaction ground-structure MISS3D). The fourth modeling tests the macro-order `POST_DECOLLEMENT` by applying a significant seismic loading for separation.

The first modeling checks too autocorrection of the negative or worthless damping coefficients being able to be generated by the operator `CALC_AMOR_MODAL`.

1 This test is not accessible to the public.

1 Problem of reference

1.1 Geometry

One uses a model skewer for the building with 136 voluminal meshs PENTA6 to represent the foundation raft and one assigns 6 degrees of freedom to his lower face made up by surface meshs TRIA3.

Modeling presented is a simplified modeling for which the building is represented by a plane structure. Four substructures are represented by four nonheavy vertical beams, of inertia of variable and bearing inflection of the masses and nodal inertias representing the civil engineer and the equipment. Discrete elastic connections connect these beams at various levels. The four beams are embedded on a foundation raft general of great inertia of inflection.

1.2 Material properties

$E=4.0\,10^{10}\,Pa$

$\rho=2500\,kg/m^3$ (heavy elements only)

$\nu=0.149425$

+ characteristic of specific masses ('M_TR_D_N') and of connections node-node ('K_TR_D_L').
The characteristics of ground depend on modelings described hereafter. They correspond to the same ground with the 2 respective assumptions of rigid foundation and flexible foundation.

1.3 Description of modelings

One implements 3 modelings corresponding to 2 options of the operator AFFE_CARA_ELEM :

- An option RIGI_PARASOL where one affects the 6 values of total rigidity of the ground corresponding each one to a degree of freedom of body solid and divided into each node of the foundation,
- An option RIGI_MISS_3D where one affects in each degree of freedom of the foundation the terms of the matrix of impedance of ground calculated as a preliminary by the software of interaction ground-structure MISS3D [bib1].

1.4 Boundary conditions and loadings

The limiting conditions depend on modeling. In all the cases, one imposes a solid connection on the higher face of the foundation raft (LIAISON_SOLIDE on the group of nodes $HRADIER$).
For modeling A, one imposes:

- Solid connection on the lower face of the foundation raft (LIAISON_SOLIDE on the group of nodes $SRADIER$)

For modeling B, one imposes initially:

- Blocking of the degrees of freedom of the nodes of the lower face of the foundation raft (group of nodes $SRADIER$) to calculate the constrained static modes,

Then one removes this condition to affect the terms of the matrix of impedance of ground calculated by MISS3D.

2 Reference solution

2.1 Method of calculating used for the reference solution

Modal analysis by the method of the subspaces.

2.2 Results of reference

the first 5 Eigen frequencies corresponding to dominating modes in the horizontal directions. Results got by *Code_Aster* values of nonregression constitute.

2.3 Uncertainty on the solution

Digital solution.

2.4 Bibliographical references

1. And reference instruction manual of MISS3D - (version 6.3) (D. CLOUTEAU - Laboratory MSSM-ECP) - 2003

3 Modeling A

3.1 Characteristics of modeling

25 elements of beam POU_D_T,
5 connection elements node-node (DIS_TR_L),
26 elements POI1 of specific mass (DIS_TR_N),
136 voluminal elements (modeling '3D') for the foundation raft and 272 elements DST for its lower face.
The 6 components of total rigidity of the ground are worth respectively:
$KX = KY = 6{,}295\text{E}11\ N/m$, $KZ = 6{,}864\text{E}11\ N/m$, $KRX = KRY = 3{,}188\text{E}14\ N.m$, $KRZ = 3{,}2\ N.m$

Modal analysis: calculation of the first 10 Eigen frequencies.

3.2 Characteristics of the grid

Many nodes: 187

Number of meshs and type: 136 PENTA6, 272 TRIA3, 30 SEG2, 26 POI1

4 Results of modeling A

4.1 Values tested

Modal analysis

Identification	Reference
Frequency No 1	3.9577 Hz
Frequency No 2	3.9657 Hz
Frequency NO3	4.7815 Hz
Frequency No 4	4.7830 Hz
Frequency NO5	7.0765 Hz
Frequency No 6	7.5462 Hz
Frequency No 7	10.050 Hz
Frequency No 8	11.803 Hz
Frequency No 9	12.069 Hz
Frequency No 10	13.367 Hz

One also adds in this test the validation of the autocorrection of the negative or worthless damping coefficients which can be generated by the operator CALC_AMOR_MODAL. For that, one modifies the data provided inputS with two new calls to CALC_AMOR_MODAL so DE to voluntarily generate negative values damping coefficients. One checks the emission of the message of alarm for the case CORR_AMOR_NEGATIF=' IGNORE'. Lastly, one checks also the correction for the case CORR_AMOR_NEGATIF=' OUI'.

5 Modeling B

5.1 Characteristics of modeling

241 elements of beam POU_D_T,
5 connection elements node-node (DIS_TR_L),
26 elements POI1 of specific mass (DIS_TR_N),
136 voluminal elements (modeling '3D') for the foundation raft,
107 elements POI1 of specific rigidity (DIS_T_N) in each node under the foundation raft,
The characteristics of the ground under the foundation are those of test ZZZZ108.

Modal analysis: calculation of the first 10 Eigen frequencies.

5.2 Characteristics of the grid

Many nodes: 187

Number of meshs and type: 136 PENTA6, 272 TRIA3, 246 SEG2, 107 POI1

6 Results of modeling B

6.1 Values tested

Modal analysis

Identification	Reference
Frequency No 1	3.84932 Hz
Frequency No 2	3.85690 Hz
Frequency NO3	4.77883 Hz
Frequency No 4	4.78053 Hz
Frequency NO5	7.12096 Hz

7 Modeling C

7.1 Characteristics of modeling

One takes as a starting point the modeling A by replacing the elements DST lower face of the foundation raft by elements of the type COQUE_3D. Initial grid comprising of the classical quadratic elements, the use of COQUE_3D oblige as a preliminary to add the nodes mediums for these elements (passages TRIA6_7 and QUAD8_9 with CREA_MAILLAGE option MODI_MAILLE).

One modifies also the solvor used in CALC_MODES by choosing MUMPS here.

Lastly, to limit time CPU, one calculates nothing any more but the first 6 Eigen frequencies instead of the 10 of modeling A.

The Eigen frequencies obtained are compared with those calculated with modeling A.

7.2 Characteristics of the grid

Many nodes: 987

Number of meshs and type: 216 QUAD9, 24 TRIA7, 41 SEG2, 28 POI1

8 Results of modeling C

8.1 Values tested

Modal analysis

Identification	Reference
Frequency No 1	3.9577 Hz
Frequency No 2	3.9657 Hz
Frequency NO3	4.7815 Hz
Frequency No 4	4.7830 Hz
Frequency NO5	7.07653 Hz
Frequency No 6	7.5462 Hz

9 Modeling D

9.1 Characteristics of modeling

Modeling D presents a nonlinear dynamic calculation with seismic loading for separation, with:

- material shock creation and assignment for $PRADIER$, then orientation of these materials,
- horizontal gravity instead of CALC_CHAR_SEISME,
- amplitude of the loading with $0{,}25\,G$

The elements of this model are:
25 elements of beam POU_D_T,
5 connection elements node-node (DIS_TR_L),
26 elements POI1 of specific mass (DIS_TR_N),
136 voluminal elements (modeling '3D') for the foundation raft,
81 elements POI1 of specific rigidity (DIS_T_N) in each node under the foundation raft.

The characteristics of the ground under the foundation are those of test ZZZZ108.

9.2 Characteristics of the grid

Many nodes: 187

Number of meshs and type: 136 PENTA6, 272 TRIA3, 30 SEG2, 26 POI1

10 Results of modeling D

10.1 Values tested

INST	%DECOL (Reference)
3,130	0,00000
3,135	0,61111
3,150	2,40852
3,165	0,61111
3,170	0,00000

11 Summary of the results

The got results constitute values of test of nonregression. The light differences of the values of frequencies between the first 2 modelings correspond to the differences in representation of the foundation: rigid assumption with the modes of rigid body for modeling A and flexible assumption with all the constrained modes for modeling B.

One can however note, as comparison, that there is general correspondence between the frequencies of resonance of tests SDLL109[2] and ZZZZ200 obtained with a model of springs of equivalent ground and peaks towards $3{,}9$, $4{,}8$ and $7{,}1\,Hz$ harmonic answers obtained starting from the complete calculation of interaction ground-structure, by frequential method of coupling, in MISS3D launched by test ZZZZ108.

Modeling C gives results very close to the A, the variations being lower than 0,1%.

One notes that for modeling D, an amplitude of loading with $0{,}25\,G$ is sufficient to make take off them $2.4\,\%$ foundation raft compared to the ground.

2 This test is not accessible to the public.