ZZZZ200 - Test of RIGI_PARASOL and RIGI_MISS_3D

Summarized:

This test makes it possible to model in modal analysis an industrial structure: that of test SDLL109 (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 the stiffness of soil under the foundation of structure.

This test understands for that 4 modelizations. The three first evaluate the 2 options of AFFE_CARA_ELEM fulfilling this function: RIGI_PARASOL (where one affects the 6 values of total stiffness of the soil corresponding each one to a degree of freedom of solid body 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 soil calculated as a preliminary by the software of interaction soil-structure MISS3D). The fourth modelization tests macro-command POST_DECOLLEMENT by applying a significant seismic loading for separation.

1 Problem of reference

1.1 Geometry

One takes again the model test SDLL109 [V2.02.109] (Civaux - N4) except for the lower mesh of type SEG2 enters $-3.00\,m$ and $-6.05\,m$ replaced by a layer of 136 meshes voluminal PENTA6 to represent to meshes erase it and assign 6 degrees of freedom to its lower face made up by surface TRIA3.

The modelization presented is a simplified modelization for which the building is represented by a plane structure. Four substructures (representing the external enclosure, the internal enclosure, internal structures and the well of tank) are represented by four nonheavy vertical beams, of inertia of variable and bearing bending 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 main floor of great inertia of bending.

1.2 Material properties

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

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

$\nu=0.149425$

+ characteristic of point masses ("M_TR_D_N") and of connections node-node ("K_TR_D_L").
The characteristics of soil depend on the modelizations described hereafter. They correspond to the same soil with the 2 respective assumptions of rigid foundation and flexible foundation.

1.3 Description of the modelizations

One implements 3 modelizations corresponding to 2 options of operator AFFE_CARA_ELEM :

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

1.4 Boundary conditions and loadings

the limiting conditions depend on the modelization. In all the cases, one imposes a solid connection on the upper face of basemat (LIAISON_SOLIDE on the nodes group $HRADIER$).
For the modelization A, one imposes:

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

For the modelization B, one imposes initially:

- Blocking of the degrees of freedom of the nodes of the lower face of the basemat (nodes group $SRADIER$) to compute: constrained static modes,

Then one removes this condition to affect the terms of the matrix of impedance of soil 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 eigenfrequencies corresponding to dominating modes in the horizontal directions. The results got by *Code_Aster* constitute values of non regression.

2.3 Uncertainty on the numerical

solution Solution.

2.4 Bibliographical references

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

3 Modelization A

3.1 Characteristic of the modelization

25 beam elements POU_D_T,
5 connection elements node-node (DIS_TR_L),
26 elements POI1 of point mass (DIS_TR_N),
136 element voluminal (modelization "3D") for erasing it and 272 element DST for its lower face.
The 6 components of total stiffness of the soil 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: computation of the first 10 eigenfrequencies.

3.2 Characteristics of the mesh

Many nodes: 187

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

4 Results of the modelization 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

5 Modelization B

5.1 Characteristic of the modelization

241 beam elements POU_D_T,
5 connection elements node-node (DIS_TR_L),
26 elements POI1 of point mass (DIS_TR_N),
136 elements voluminal (modelization "3D") for erasing it,
107 elements POI1 of specific stiffness (DIS_T_N) in each node under the basemat,
the characteristics of the soil under the foundation are those of test ZZZZ108.

Modal analysis: computation of the first 10 eigenfrequencies.

5.2 Characteristics of the mesh

Many nodes: 187

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

6 Results of the modelization 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 Modelization C

7.1 Characteristic of the modelization

One takes as a starting point the modelization A by replacing elements DST by the lower face by the basemat by elements of the type COQUE_3D. The mesh initial comprising classical quadratic elements, the use of COQUE_3D obliges as a preliminary to add the nodes mediums for these elements (transitions TRIA6_7 and QUAD8_9 with CREA_MAILLAGE option MODI_MAILLE).

One modifies also the solver used in MODE_ITER_SIMULT by choosing MUMPS here.

Lastly, to limit the TEMPS CPU, it is not calculated any more that the first 6 eigenfrequencies instead of the 10 of modelization A.

the eigenfrequencies obtained are compared with those calculated with modelization A.

7.2 Caractéristiques of the mesh

Many nodes: 987

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

8 Results of the modelization 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 Modelization D

9.1 Characteristic of the modelization

The modelization D presents a nonlinear dynamic computation with seismic loading for separation, with:
–creation and assignment of material shock for $PRADIER$, then directional sense of these materials,
–horizontal gravity instead of CALC_CHAR_SEISME,
–amplitude of the loading to $0.25\,G$

the elements of this model are:
25 beam elements POU_D_T,
5 connection elements node-node (DIS_TR_L),
26 elements POI1 of point mass (DIS_TR_N),
136 elements voluminal (modelization "3D") for erasing it,
81 elements POI1 of specific stiffness (DIS_T_N) in each node under erasing it.

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

9.2 Characteristics of the mesh

Many nodes: 187

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

10 Results of the modelization 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 non regression. The light differences of the values of frequencies between the first 2 modelizations correspond to the differences in representation of the foundation: rigid assumption with the modes of rigid body for the modelization A and flexible assumption with all the constrained modes for the modelization B.

One can however note, as comparison, that there is general correspondence between the resonance frequencies of tests SDLL109 and ZZZZ200 obtained with a model of springs of soil are equivalent and the peaks towards 3.9 , 4.8 and $7.1\,Hz$ of the harmonic responses obtained starting from the complete computation of interaction soil-structure, by frequential method of coupling, in MISS3D launched by test ZZZZ108.

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

It is noted that for the modelization D, an amplitude of loading with $0.25\,G$ is sufficient to make take off $2.4\,\%$ basemat compared to the soil.