ZZZZ108 - Test of Summarized *the Code_Aster-MISS3D*

interface:

This test makes it possible to model in harmonic linear dynamics and transient 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 commands of *the Code_Aster* specific to the interaction soil-structure for the interfacing with software MISS3D (ECP-LMSSM).

One can thus treat with only one and even resolution in MISS3D several results transitory or harmonic restored on physical base by *the Code_Aster*.

In this test, one also tests another possibility of resolution, only by *the Code_Aster*, by means of the harmonic operator of resolution after having recovered MISS3D the impedances of soil and the variable seismic forces according to the frequency.

One also introduces the test in postprocessing of displacements into cubes check-points located into the soil and additions at the modelization of structure by *Code_Aster*.
A modelization with such check-points also makes it possible to test the induced incidental fields on various in-depth levels of the soil by one plane wave described as with tilted incidence.

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 surface TRIA3 to represent to erase it and assign 6 d.o.f. to its lower face.

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").

1.3 Solid boundary conditions and

loadings Connections on the sides higher and lower of basemat (LIAISON_SOLIDE on the nodes groups $HRADIER$ and $SRADIER$).

- •Blocking of the central node ($N98$) of the lower face (6 degrees of freedom) to compute: modes of rigid body,
- •nodal Force of $10^4\,Newtons$ applied to the node $N1500$,
- •Or transitory acceleration Euro spectrum in the direction X of amplitude $0.25\,g$,
- •Or unit harmonic acceleration in the directions X and Y

1.4 Initial conditions

Displacements, velocities and zero acceleration.

2 Reference solution

2.1 Method of calculating used for the reference solution

Resolution in modal base of projection (constituted by eigen modes with blocked interface and of the constrained static modes calculated by *the Code_Aster*) carried out by MISS3D in the field of the frequencies on the finite elements of border.
There is also the possibility of proceeding to this resolution by *the Code_Aster* by means of the operator of harmonic resolution after having recovered MISS3D the impedances of soil and the variable seismic forces according to the frequency

Return in time post-treaty by MISS3D by transformation of opposite Fourier.

Return on the basis of the harmonic or transitory evolution physical base result of *the Code_Aster*.

2.2 Results of reference

harmonic Responses to the nodes higher (N800, N1500 and N2700) than frequencies close to resonances (cf test SDLL109 [V2.02.109]).

Maximum transitory accelerations in these same points for an Euro spectrum of $0.25\,g$.

2.3 Uncertainty on the numerical

solution Solution.

2.4 Bibliographical references

•and reference Instruction manual of MISS3D - (version 5.6) (D. CLOUTEAU - Laboratory MSSM-ECP).

•Interface Aster-MISS3D: principle and use (G. DEVESA - Note Technical HP - 62/95/038/B.

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),
2 elements POI1 of point mass null (DIS_T) for modelling check-points in the soil with post-treating,

136 elements voluminal (modelization "3D") for erasing it and 136 elements DST for its lower face.

the 1st harmonic computation: in the interval $(0,10\,Hz)$ by step of $0.1\,Hz$,
the 2nd harmonic computation: in the interval $(0,10\,Hz)$ by step of $0.1\,Hz$,

the 3rd transient computation: in the interval $(0,10\,s)$ by step of $10^{-2}\,s$.

3.2 Characteristics of the mesh

Many nodes: 190

Number of meshes and type: 136 PENTA6, 136 TRIA3, 30 SEG2, 28 POI1

3.3 Quantities tested and Values

3.4 results tested

harmonic Computation (complex): resolution by MISS3D or *Code_Aster*

Identification	*Aster*
Displacement UX , Node 1500 , Fréq. : $3.9\,Hz$	$(9.871\,E-7,-5.369\,E-6)\,m$
Displacement UX , Node 800 , Fréq. : $3.9\,Hz$	$(-5.724\,E-7,-3.946\,E-6)\,m$
Displacement UX , Node 800 , Fréq. : $4.8\,Hz$	$(-8.385\,E-7,2.540\,E-6)\,m$
Displacement UX , Node 2700 , Fréq. : $3.9\,Hz$	$(1.033\,E-7,-2.244\,E-6)\,m$
Displacement UX , Node 2700 , Fréq. : $7.5\,Hz$	$(-8.612\,E-8,1.151\,E-6)\,m$

Harmonic computation: resolution by MISS3D and postprocessing at the check-points

Identification	*Aster*
Acceleration AX , Not $NC1$ $(75,0,-6.05)$, Fréq. : $3.9\,Hz$	$(9.584\,E-1,-5.455\,E-2)\,m/s^2$
Acceleration AX , Not $NC2$ $(50,0,-6.05)$, Fréq. : $3.9\,Hz$	$(9.662\,E-1,-1.136\,E-1)\,m/s^2$
Acceleration AY , Not $NC1$ $(75,0,-6.05)$, Fréq. : $3.9\,Hz$	$(9.561\,E-1,-4.853\,E-2)\,m/s^2$
Acceleration AY , Not $NC2$ $(50,0,-6.05)$, Fréq. : $3.9\,Hz$	$(9.578\,E-1,-9.910\,E-2)\,m/s^2$
Acceleration AX , Not $NC1$ $(75,0,-6.05)$, Fréq. : $4.8\,Hz$	$(9.893\,E-1,4.942\,E-3)\,m/s^2$
Acceleration AX , Not $NC2$ $(50,0,-6.05)$, Fréq. :	$(9.799\,E-1,-1.616\,E-3)\,m/s^2$

$4.8\,Hz$	
Acceleration AY , Not $NC1$ $(75,0,-6.05)$, Fréq. : $4.8\,Hz$	$(9.876\,E-1, 6.045\,E-3)\,m/s^2$
Acceleration AY , Not $NC2$ $(50,0,-6.05)$, Fréq. : $4.8\,Hz$	$(9.767\,E-1, 6.007\,E-4)\,m/s^2$

Transient computation (real)

Identification	*Aster*
Acceleration AX , Node 1500 , $t=3.15\,s$	$10.108\,m/s^2$
Acceleration AX , Node 800 , $t=3.15\,s$	$9.228\,m/s^2$
Acceleration AX , Node 2700 , $t=1.35\,s$	$10.841\,m/s^2$
Acceleration AX , Node 98 , $t=3.10\,s$	$2.682\,m/s^2$

3.5 Summary of the results of the modelization A

the got results illustrate the possibility of obtaining a harmonic evolution and a transitory evolution starting from the same computation in MISS3D. They constitute values of test of non regression.

One can only note, as comparison, that the peaks of the harmonic responses correspond to the resonance frequencies of test SDLL109 obtained with a model of springs of equivalent soil.

In addition, for the resolution in the field of the frequencies of the harmonic problem project on a modal base consisted eigen modes with blocked interface and of the constrained static modes, one gets the same results by *Code_Aster* and MISS3D.

4 Modelization B

4.1 Characteristic of the modelization

This modelization is characterized by the presence of check-points in the soil in order to model the déconvolution of a vertical sinusoidal signal imposed on the surface of the soil.

3 elements `POI1` of point mass null (`DIS_T`) are thus introduced in order to model check-points in the soil with post-treating.

They correspond to 3 in-depth levels of a homogeneous soil: on the surface and shifted respectively quarter and of a half-length of plane wave of pressure to incidence vertical but treated as cas particulier of incidence inclined by the key word `DIRE_ONDE` in factor key word `the PARAMETRE` of operator `MACRO_MISS_3D` in order to test this functionality by this modelization.

This soil is a homogeneous soil whose characteristics are summarized in the table hereafter:

Lay down	Thickness (m)	ρ (kg/m^3)	ν	E (MPa)	
Layer 1	35	2400	0.4	70.0.1	

Table 6.1-1: Soil mechanics characteristics homogeneous

These values induce a wave velocity of pressure $V_P=250\,m/s$, which gives one wave length of pressure of 50 meters for an excitation frequency of $5\,Hz$. The second and the third check-points are thus inserted of respectively $12.5\,m$ and $25\,m$ in the vertical direction.

One carries out a transient computation in the interval $(0,4\,s)$ by step of $10^{-2}\,s$ with a sinusoidal acceleration of frequency $5\,Hz$ imposed on the surface of the soil in the vertical direction Z .

4.2 Reference solution

For a sinusoidal request of frequency f in a soil wave velocity C and hysteretic damping β, one obtains analytically like crest factor to the depth Z :

$$Az=sh(\beta\pi f\,Z/C)\sin(2\,\pi f\,Z/C)+ch(\beta\pi f\,Z/C)\sin(2\,\pi f\,Z/C)$$

4.3 Quantities tested and Transient computation

results (real) resolution by MISS3D and postprocessing at the check-points

Identification	Reference
Acceleration AZ , Not $NC1$ $(50,0,0)$, $T=0.05\mathrm{s}$	$1.0\,m/s^2$
Acceleration AZ , Not $NC2$ $(50,0,-12.5)$, $T=0.20\mathrm{s}$	$0.0782\,m/s^2$
Acceleration AZ, Not $NC3$ $(50,0,-25.0)$, $T=0.05\mathrm{s}$	$-1.01236\,m/s^2$

4.4 Summary of the results of the modelization B

the new modelization with the check-points makes it possible to find the analytical values of amplitudes of induced incidental fields on various in-depth levels of the soil, corresponding to surface and respectively a quarter and a half-length of vertical plane wave described as to tilted incidence. That makes it possible to test key word `DIRE_ONDE` in factor key word `the PARAMETRE` of operator `MACRO_MISS_3D`.

5 Modelization C

5.1 Characteristic of the modelization

This modelization takes again the characteristics of the modelization B. The computation is carried out with `CALC_MISS` and without tilted waves.

5.2 Reference solution

the reference solution is obtained by *degrading* the modelization B (suppression of the tilted waves).

5.3 Quantities tested and results

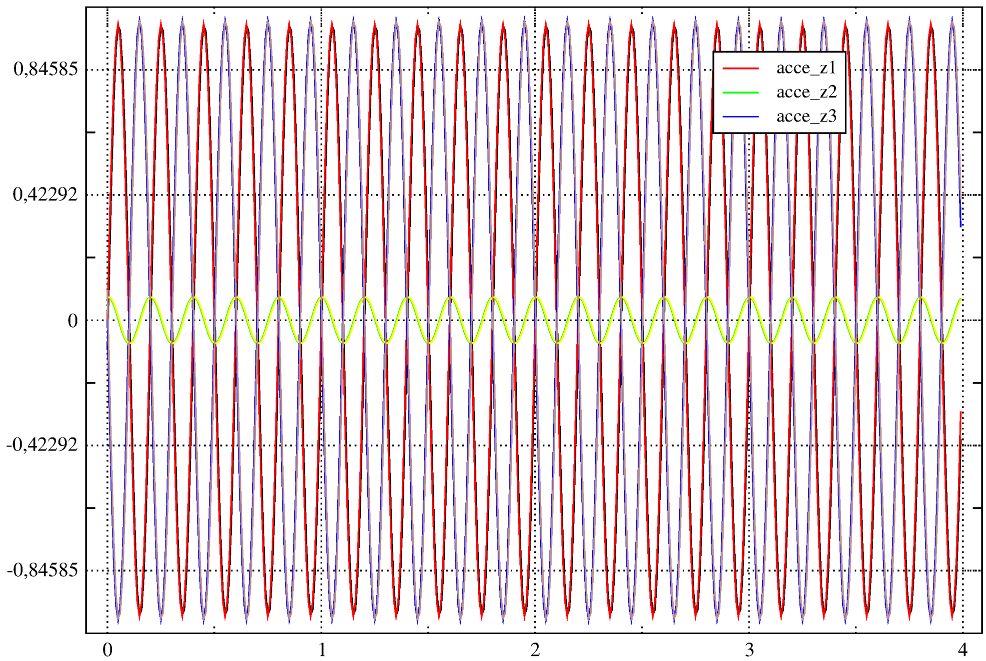
They is the values actually obtained by the modelization B degraded

Identification	*Reference*
Acceleration AZ, Not $NC1$ $(50,0,0)$, $T=0.05\text{s}$	$1.0\,m/s^2$
Acceleration AZ, Not $NC2$ $(50,0,-12.5)$, $T=0.20\text{s}$	$0.0781346\,m/s^2$
Acceleration AZ, Not $NC3$ $(50,0,-25.0)$, $T=0.05\text{s}$	$-1.0124\,m/s^2$

tests of non regression are carried out on the transfer transfer functions resulting from Miss3D.

5.4 Summary of the results of the modelization C

the results are very close (cf superposition of the curves). There is a very light phase shift.
The amplitudes are very close, by recording the values at times given, the variation is about 1 %.



Comparison with the modelization B degraded