SDLL102 - Gantry subjected to electrodynamic forces

Summary:

This test is a three-dimensional problem of direct transitory dynamic calculation with forces distributed of electrodynamic origin applied to a gantry (bars on 3 insulating columns of a switchyard).

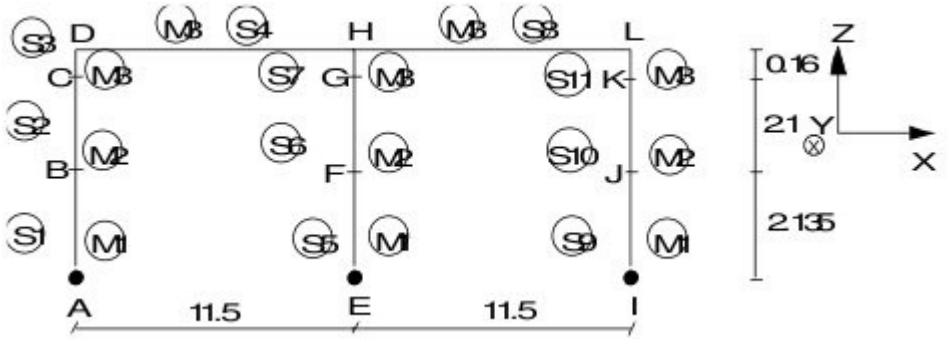
This test was provided by the Center of Studies of Transport network (EDF-DEPT). It was supplemented since by a benchmark international bench starting from experimental measurements (results of several foreign codes): test CIGRE-structure D.

It makes it possible to compare results of displacements compared to those obtained by other industrial codes using a method finite elements or finished differences.

This test contains a modeling with elements of the type SEG2.

1 Problem of reference

1.1 Geometry



Cross sections of beams:

- frame support

$S1$: $A = 1.2061\,10^{-2}\,m^2$ $I_z = 2.3681\,10^{-5}\,m^4$
$S5$: $A = 1.4621\,10^{-2}\,m^2$ $I_z = 2.8709\,10^{-5}\,m^4$
$S9$: $A = 1.5530\,10^{-2}\,m^2$ $I_z = 3.0493\,10^{-5}\,m^4$

- insulating columns

$S2$: $A = 3.1428\,10^{-2}\,m^2$ $I_z = 4.5070\,10^{-5}\,m^4$
$S6$: $A = 3.2592\,10^{-2}\,m^2$ $I_z = 4.6738\,10^{-5}\,m^4$
$S10$: $A = 3.3416\,10^{-2}\,m^2$ $I_z = 4.7927\,10^{-5}\,m^4$

- connections

$S3, S11$: $A = 3.1944\,10^{-2}\,m^2$ $I_z = 1.15\,10^{-5}\,m^4$
$S7$: $A = 4.2130\,10^{-2}\,m^2$ $I_z = 1.15\,10^{-5}\,m^4$

- drivers

$S4, S8$: circular $R = 6.055\,10^{-2}\,m$ $e = 6.2\,10^{-3}\,m$

1.2 Material properties

$M1$: $E = 2.10^{11}\,Pa$ $\rho = 8000\,kg/m^3$ (frame support)
$M2$: $E = 5.10^{10}\,Pa$ $\rho = 2500\,kg/m^3$ (insulating column)
$M3$: $E = 7.10^{10}\,Pa$ $\rho = 2700\,kg/m^3$ (connection and conducting aluminium)

1.3 Boundary conditions and loadings

Points A , E , I : embedding
Points D , L : not-continuity of u_x , θ_y , θ_z
Forces of Laplace on the drivers DH , HL ;

- two-phase current $\phi=\omega=100\,m$
- infinite drivers separated from $1\,m$

$$I=I_{eff}\sqrt{2}(\cos(\omega t+\phi)-e^{-t/\tau}\cos\phi)$$

I_{eff} effective intensity of the current
τ time-constant

- two short-circuit with reset

t	$0<t\leq 0.135$	$0.135<t<0.580$	$0.580\leq t\leq 0.885$
I_{eff}	$15.6\,kA$	0	$15.6\,kA$
τ	$0.066\,s$	-	$0.062\,s$

1.4 Initial conditions

$t=0$, speed and zero acceleration.

2 Reference solution

2.1 Method of calculating used for the reference solution

- experimental measurements,
- digital methods Finished Differences or Finite elements.

$$I=I_{eff}\sqrt{2}(\cos(\omega t+\phi)-e^{-t/\tau}\cos\phi)$$

2.2 Uncertainty on the solution

The dispersion of the computed values is regarded as understood enters 5% and 10% .

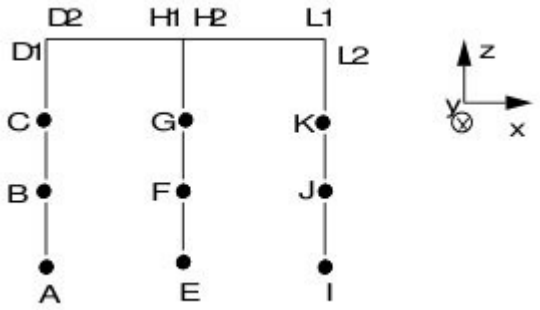
2.3 Bibliographical references

1) G. DEVESA: “Calculation of the electrodynamic strains on structures of drivers rigid of the electric stations: establishment in the mechanical computer code *Aster* and Validation”. Note HM-72/5904

3 Modeling A

3.1 Characteristics of modeling

Modeling POU_D_E



Discretization:

- elements AB , EF , IJ : 10 meshs: SEG2
- elements BC , FG , JK : 10 meshs: SEG2
- elements $CD1$, $GH1$, $KL1$: 1 mesh: SEG2
- elements $D2H1$, $H2L1$: 30 meshs: SEG2

Dynamic evolution on $1\mathrm{s}$ discretized in step of time of $5.10^{-4}s$ with the algorithm of NEWMARK $(a=0.25\,,d=0.5)$.

Storage of the results all 20 pas de time is $10^{-2}s$.

3.2 Characteristics of the grid

Many nodes: 126
Many meshs and types: 123 meshs SEG2

3.3 Sizes tested and results

Identification	Reference test
$t=0.12\,s$	
u_y in $C2$	
M_x in $S1$	– 3140. Nm
M_x in $S2$	– 10150. Nm
M_x in $S3$	– 3130. Nm
M_z in $C2$	1431. Nm
$t=0.70\,s$	
u_y in $C2$	
M_x in $S1$	– 6080. Nm
M_x in $S2$	– 19670. Nm
M_x in $S3$	– 6060. Nm
M_z in $C2$	2746. Nm

Maximum obtained with $t=0.12\,s$ (1st short-circuit) or $t=0.70\,s$ (2nd short-circuit) or reset (conformity test-calculation).

3.4 Remarks

Results got by Code_aster are satisfactory compared to the other codes. They are almost always lower than measurements (effects of the frames AB, EF, IJ overestimated). The maximum ones are chopped because of periodic storage.

Contents of the file results:

Displacements all them $10^{-2}\,s$ and efforts in the elements at times $t=0.12\,s$, $t=0.27\,s$, $t=0.70\,s$.

4 Modeling B

A modeling B was added to test the elements of beam with warping POU_D_TG.
The additional coefficients were arbitrarily selected:
$AY = AZ = 1.0$
$EY = EZ = JG = 0.0$

4.1 Sizes tested and results

	Reference test	References of not-regression	% tolerance tests/not regression
$t = 0.12\ s$			
u_y in $C2$		60.5 mm	N.A./0.2
M_x in $S1$	– 3140. Nm	– 3108. Nm	2.0/0.1
M_x in $S2$	– 10150. Nm	– 9255. Nm	9.0/0.1
M_x in $S3$	– 3130. Nm	– 2948. Nm	3.0/0.1
M_z in $C2$	1431. Nm	1304. Nm	9.0/0.1
$t = 0.70\ s$			
u_y in $C2$		118.9 mm	N.A/0.1
M_x in $S1$	– 6080. Nm	– 6150. Nm	2.0/0.1
M_x in $S2$	– 19670. Nm	– 18523. Nm	6.0/0.1
M_x in $S3$	– 6060. Nm	– 5928. Nm	3.0/0.1
M_z in $C2$	2746. Nm	2602. Nm	6.0/0.1

5 Summary of the results

The results are acceptable compared to the test results and locate values produced by Code_Aster in good place among ten results of other software.