# SDLL102 - Gantry subjected to electrodynamic forces

**Summarized:**

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

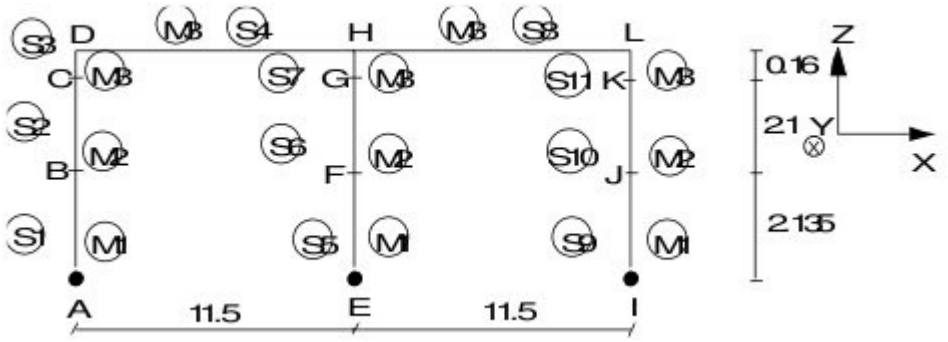
This test was provided by the Center of Studies of Transport network (EDF-DEPT). It was supplemented since by a benchmark international bench from experimental measurements (results of several foreign codes): test CIGRE-structure D.

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

This test contains a modelization 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 aluminum)

## 1.3 Boundary conditions and loadings

Points $A$ $E$ $I$ : fixed support
Points $D$ $L$ : NON-continuity of $u_x$ $\theta_y$, $\theta_z$
Forces of Laplace on the drivers $DH$ $HL$ ;

- two-phase flow $\phi=\omega=100\,m$
- 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 flow
$\tau$ 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 | $15.6\,kA$ |
| $\tau$ | $0.066\,s$ | - | $0.062\,s$ |

## 1.4 Initial conditions

$t=0$ , velocity and zero acceleration.

# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

- experimental measurements,
- numerical methods Finite 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 $10\%$.

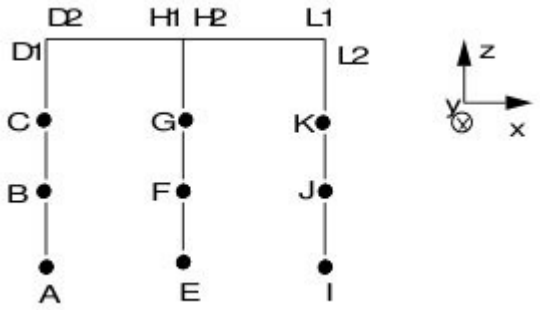
## 2.3 Bibliographical references

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

# 3 Modelization A

## 3.1 Characteristic of the modelization

Modelization POU_D_E




Discretization:

- elements $AB \quad EF \quad IJ$ : 10 meshes: SEG2
- elements $BC \quad FG \quad JK$ : 10 meshes: SEG2
- elements $CD1 \quad GH1 \quad KL1$ : 1 mesh: SEG2
- elements $D2H1 \quad H2L1$ : 30 meshes: Dynamic

SEG2 Evolution on $1\mathrm{s}$ discretized in time step of $5.10^{-4}s$ with the algorithm of NEWMARK $(a=0.25\,,d=0.5)$.

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

## 3.2 Characteristics of the mesh

Many nodes: 126
Number of meshes and types: 123 meshes SEG2

## 3.3 Quantities tested and results

| Identification | Reference test |
|---|---|
| $t=0.12\,s$ | |
| $u_y$ in $C2$ | |
| $M_x$ of $S1$ | – 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 $C2$ | |
| $M_x$ of $S1$ | – 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 tests-CALCUL).

## 3.4 Remarks

the 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 forces in the elements at times $t=0.12\,s$ $t=0.27\,s$ $t=0.70\,s$.

# 4 Modelization B

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

## 4.1 Quantities tested and results

| | Reference test | References of NON-regression | % toléranceessais /non 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 of results locate values produced by Code_Aster in good core among ten of other software.