SDLX105 – Impedances of ground under a cylindrical foundation dug in a double-layered medium

Summary:

This test takes part in the validation of the chaining *Code_Aster* - MISS3D. It represents a standard case of calculation of impedances of ground under a cylindrical foundation inserted in a medium Bi sleep. One considers the possibility of connection partial between the ground and the side wall of the foundation.

The impedances obtained by the chaining enters *Code_Aster* and MISS3D are compared with those given in the reference [bib2] making a synthesis between several digital methods. One obtains lower deviations than 15% on average in the case of rigid connection between the ground and the side wall of the foundation. In the case of partial connection, the maximum variations can be more important, about 30%.

1 Problem of reference

1.1 Geometry

Software *Code_Aster* - MISS3D uses the frequential method of coupling to take account of the interaction ground - structure. This method, based on the dynamic under-structuring, consists in cutting out the field of study in three under-fields:

- ground,
- the foundation,
- the structure.

Ground

The ground corresponds to a layer of 8 meters thickness semi-infinite homogeneous medium above an infinitely hard substrate.

The foundation

The foundation of the cylinder of ground is represented on [Figure 1.1-a] below. With the initial surface model of 64 elements representing the base of the foundation of ray $4\,m$, one adds 64 surface elements to represent the side walls of the depression of $4\,m$.

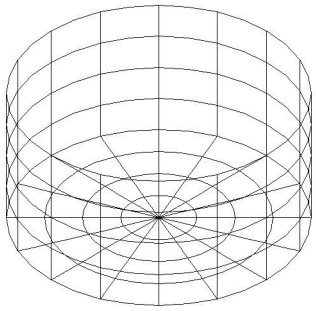

Figure 1.1-a: Surface grid of the foundation

The structure

The structure consists of solid elements representing a cylinder full with $4\,m$ of height and $4\,m$ of ray dug in the first homogeneous soil horizon.

1.2 Properties of materials

Ground

The mechanical characteristics of the layers of the elastic model of ground which were used are those indicated below which make it possible to obtain a speed of wave of shearing of $330\,m/s$ for the first soil horizon thickness $8\,m$ above an infinitely hard substrate.

E (N/m^2)	$580.8\,E6$
NU	0.3333
RHO (kg/m^3)	2000
AMOR_HYST	0.1

The foundation and the structure

The mechanical characteristics of the foundation and the structure which were used are the same ones as those of the ground described above.

1.3 Boundary conditions and loadings mechanical

To calculate the 6 static modes of rigid body of the foundation and the clean modes, one blocks the 6 degrees of freedom of translation and rotation of the central node of the foundation by imposing a solid relation of connection there.

2 Reference solution

2.1 Method of calculating used for the reference solution

The results of reference are the impedances of ground obtained starting from the fields of incidental displacements and the induced constraints calculated by the computation software of interaction ground-structure *Code_Aster* - MISS3D in various levels of depth of a laminated ground. The incidental field on the surface of the ground is considered unit in each direction of the space and for any frequency of request. Variation of this field in the depth of the ground, or déconvolution, is obtained starting from functions of Green. These functions constitute a base of elementary solutions in various receiving levels with unit requests in various levels sources of the ground [bib1].

2.2 Results of reference

For obtaining results of reference, one refers to the computation results of complex impedance obtained by the reference [bib2] and making the synthesis of several digital or semi-analytical studies carried out by various authors [bib3]. The values of impedance are given for each of the 6 directions of rigid body with a rigidity part reduced on static rigidity and reduced a damping part.

2.3 Bibliographical references

1) D. CLOUTEAU: “Manual of reference of MISS3D – version 6.3 – Power station Searches SA”

2) J.G. SIEFFERT & F. CEVAER: “Calculation of the impedances of foundation – Nantes Power station – Ouest-France Editions”

3) J.L TASSOULAS: “Elements for the Numerical Analysis of Wave Motion in Layered Media – MIT – Research Reference mark. R 81-2”

3 Modeling A

3.1 Characteristics of modeling

The characteristics used and the grid are those deduced from the data of [§1]. One uses a range of frequencies of calculation enters 1 and $35\,Hz$ by step of $1\,Hz$ giving a value of adimensional parameter of frequency $a_0 = \omega R / Vs$ lower or equalizes to 5.

One use in CALC_MISS LE way of calculating automated of the parameters of MISS3D.

3.2 Characteristics of the grid

Grid provided to *Code_Aster* contains meshs of the types QUAD4, TRIA3 to model the foundation of the cylinder of ground modelled by DST elements. It is important to have directed the elements of surface of the foundation with normal returning in the ground. The meshs of the side walls representing the depression are generated by the same vertical generator as MISS3D requires it. One obtains in all 128 surface meshs for the foundation with a size of mesh of $1\,m$ approximately.

One distinguishes on the side wall from the foundation from the groups from meshs belonging to the interface ground-structure with orientation towards the ground and possibly from the groups of meshs of free ground with opposite orientation where there is not contact between the ground and the wall.

4 Results of modeling A

4.1 Values tested of rigidity

The values tested below correspond to [Figure 3.1-a] for the case with total connection between the ground and the foundation (rounds and mixed features, $d/D=1$) and of the values of $a0$ close relations of 2 and 3.

Identification	Value of reference	Type of reference	Tolerance
KH ($26\,Hz$)	0.43	'SOURCE_EXTERNE'	27%
KH ($35\,Hz$)	0.79	'SOURCE_EXTERNE'	3%

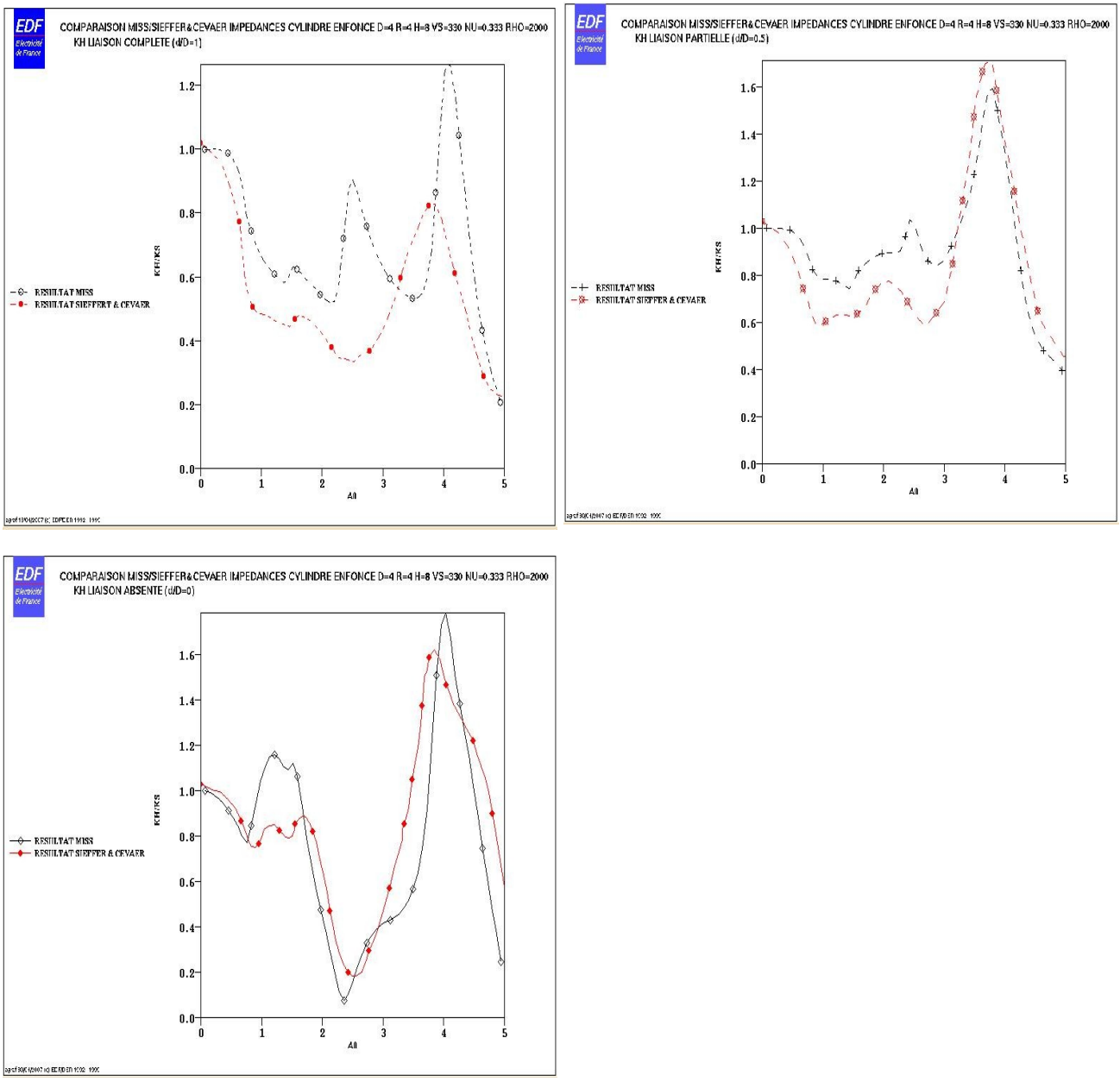

Figure 3.1-a: Evolutions of the impedances of horizontal adjustment

The values tested below correspond to [Figure 3.1-b] for the case with total connection between the ground and the foundation (rounds and mixed features, $d/D=1$) and of the values of $a0$ close relations of 2 and 3.

Identification	Value of reference	Type of reference	Tolerance
$KV\ (26\,Hz)$	0,28	'SOURCE_EXTERNE'	17%
$KV\ (35\,Hz)$	-	'NON_REGRESSION'	-

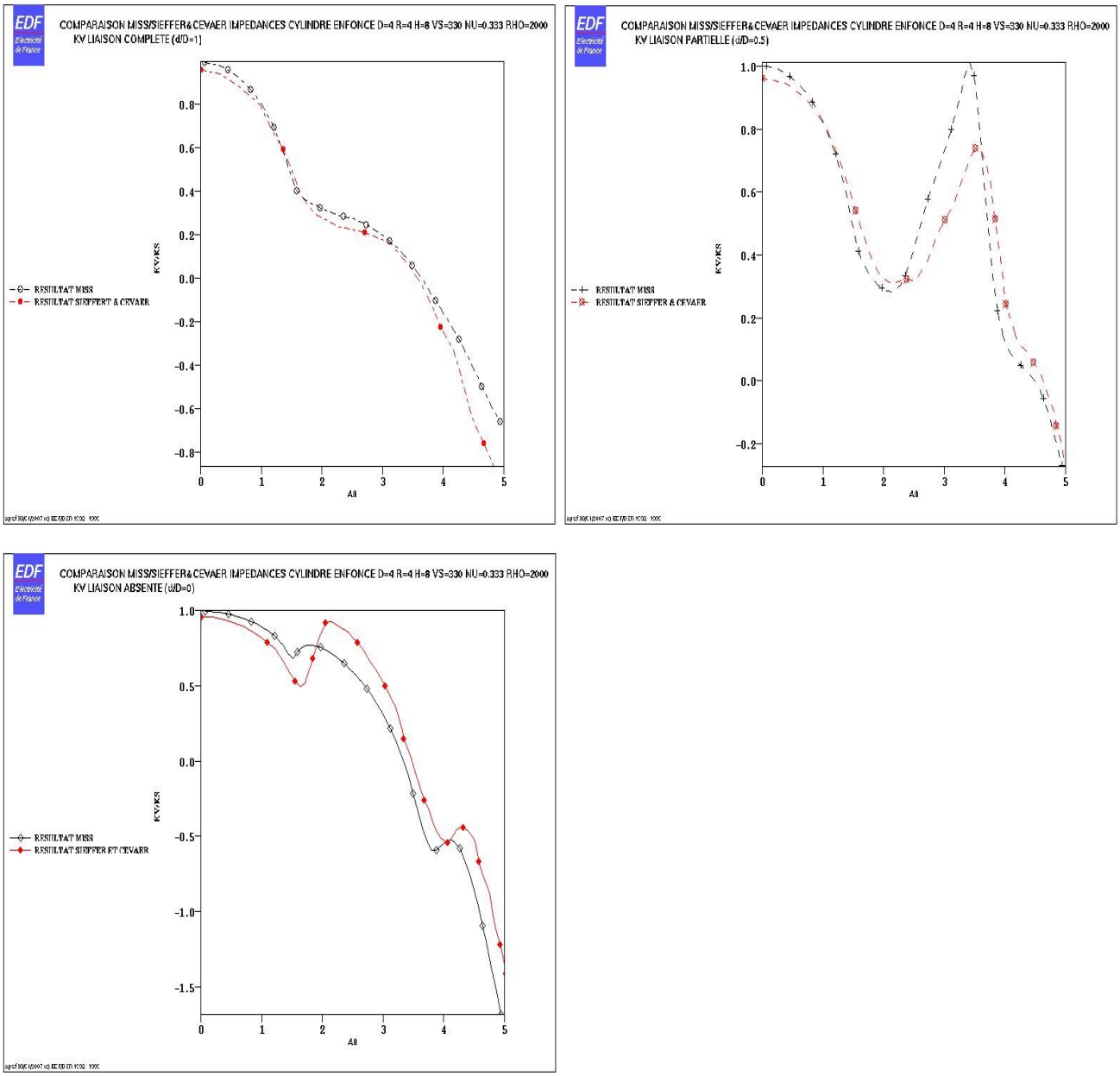

Figure 3.1-b: Evolutions of the impedances of vertical adjustment

The values tested below correspond to [Figure 3.1-c] for the case with total connection between the ground and the foundation (rounds and mixed features, $d/D=1$) and of the values of $a0$ close relations of 2 and 3.

Identification	Value of reference	Type of reference	Tolerance
$KR\ (26\,Hz)$	0,63	'SOURCE_EXTERNE'	5%
$KR\ (35\,Hz)$	-	'NON_REGRESSION'	-

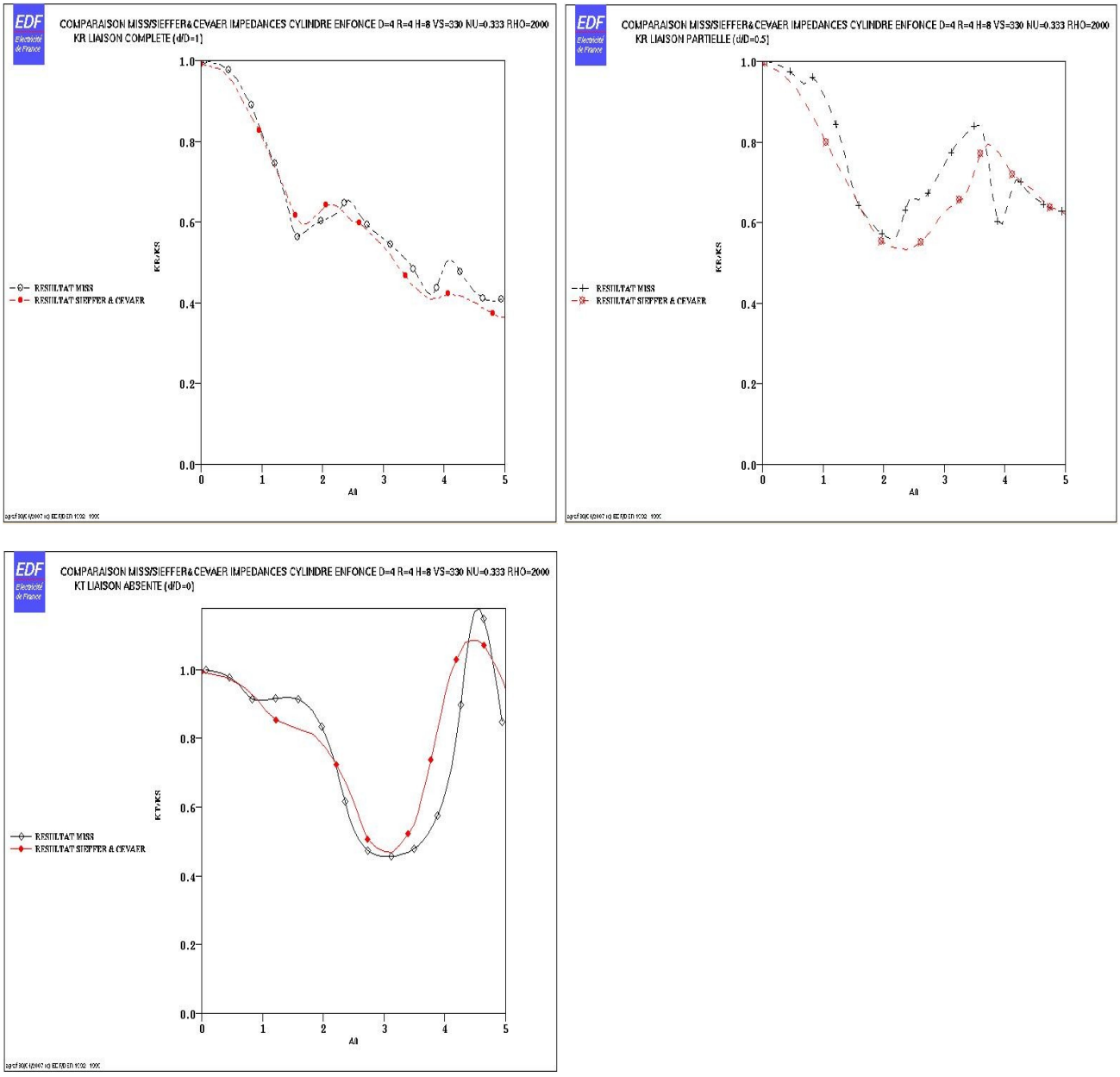

Figure 3.1-c: Evolutions of the impedances of swinging

The values tested below correspond to [Figure 3.1-d] for the case with total connection between the ground and the foundation (rounds and mixed features, $d/D=1$) and of the values of $a0$ close relations of 2 and 3.

Identification	Value of reference	Type of reference	Tolerance
$KT\ (26\,Hz)$	0,624	'SOURCE_EXTERNE'	15%
$KT\ (35\,Hz)$	-	'NON_REGRESSION'	-

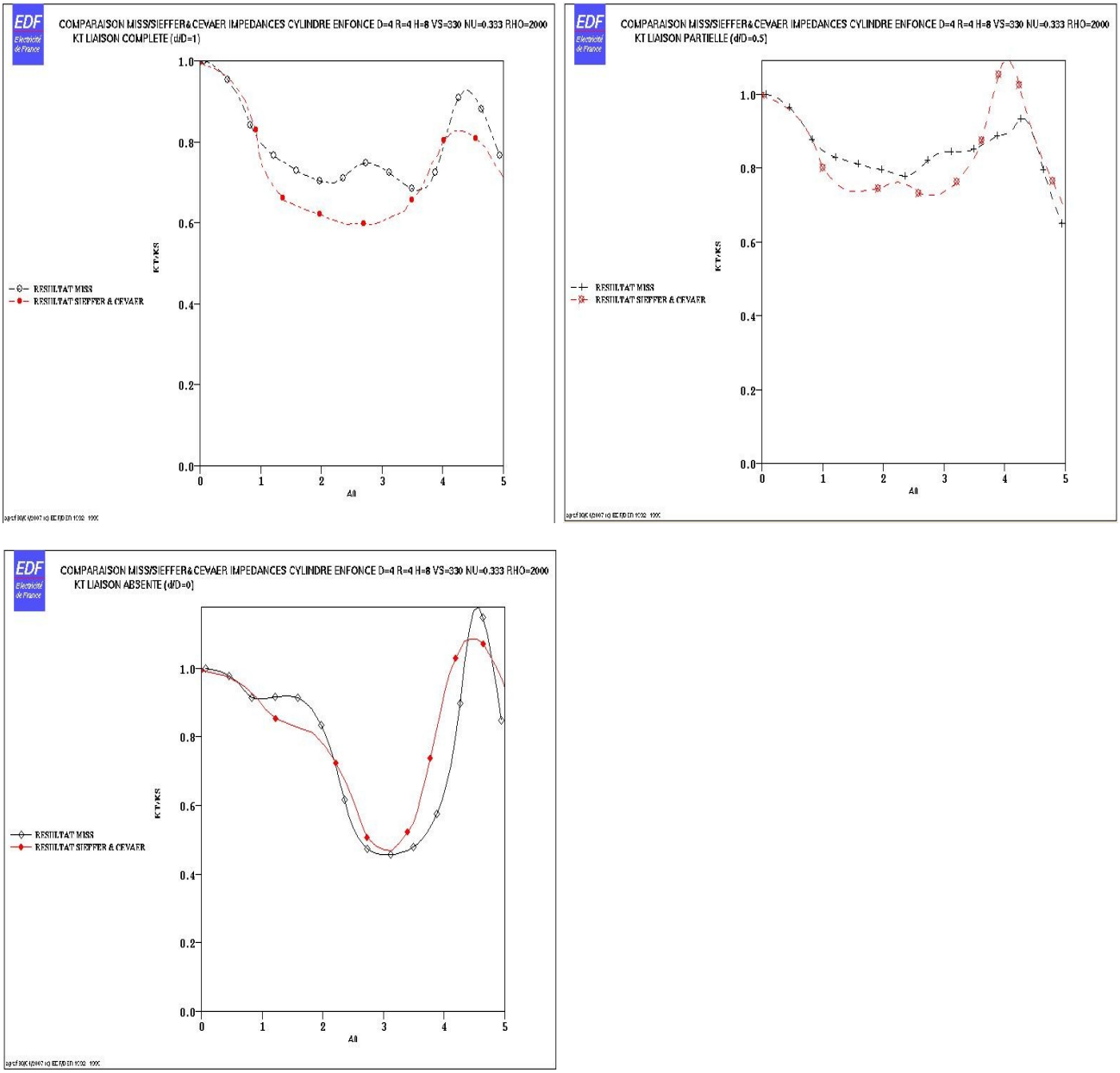

Figure 3.1-d: Evolutions of the impedances of torsion

5 Summary of the results

The agreement enters the impedances obtained by the chaining enters *Code_Aster* and MISS3D and those given in the reference [bib2] are satisfactory, with variations of about a 15% on average, especially in the case of connection rigid between the ground and the side wall of the foundation where this reference is a synthesis between several authors. In the case of partial connection (case $d/D=0$, curves in full features), the variations can be more important, about 30% on average, but one does not have any more whereas only one author of reference [bib3] also using a digital method difficult to decide between compared to the digital method used in MISS3D.