Structures of data `sd_contact`

Summary:

This document describes the contents of the object of the type `sd_contact` product by the order `DEFI_CONTACT` but also some objects used at the time of the resolution in the non-linear operators.

Contents

1 General information

Information describing the options of contact is stored in the structure of data (SD) sd_contact (operator DEFI_CONTACT).

This SD stores two types of information:

- The total options of the contact, which do not depend on the zones;
- The local options of the contact, definite zones by zone.

Certain options are common to all the methods, others are specific to each formulation.
The access to the SD is made *via* specific routines which encapsulate the definition of the objects JEVEUX. It is advisable to use them exclusively.

A zone of contact/friction comprises two surfaces which one seeks to prevent the interpenetration. There exist three formulations for the contact/friction (keyword FORMULATION) :

- The discrete formulation (DISCRETE)
- The formulation continues (CONTINUOUS including LAKE formulation)
- The formulation continues applied to XFEM (XFEM)

The formulation is gathered DISCRETE and the formulation CONTINUOUS in what one will call the formulations **with a grid**. method XFEM is not giftC not a formulation with a grid.

There exists a specific formulation in addition (LIAISON_UNIL), dedicated to the simple unilateral conditions (without pairing). This formulation, derived from the discrete methods, makes it possible to impose a unilateral condition on a degree of freedom. For example: $DX<4$ or $PRES<3$. One makes use of it particularly in THM, to impose the conditions known as of seepage.

In the case of formulations with a grid with pairing NODAL or MAIT_ESCL, there are two surfaces whose composition is given under the keywords GROUP_MA_MAIT/MAILLE_MAIT and GROUP_MA_ESCL/MAILLE_ESCL. In the case of the formulation LIAISON_UNIL, there is only one surfaces whose composition is given under the keywords GROUP_MA/MAILLE/GROUP_NO/NOEUD. In the case of the formulation XFEM, there is no grid and one gives the cracks XFEM to which will apply the conditions of contact/friction (*via* keywords FISS_MAIT).

2 Structure of definition of the contact

```
sd_contact (K8)       :: = record

/FORMULATION = all
    (O) '.CHME.MODEL.NOMO'  :    V       Long K8 = 1
    (O) '.CONTACT.PARACI'   :    V       I  length = ZPARI
    (O) '.CONTACT.PARACR'   :    V       R  length = ZPARR
    (O) '.TYPE'             :    V       Long K8 = 1

/FORMULATION = 'LIAISON_UNIL'
    (O) '.UNILATE.NDIMCU'   :    V       I  length = 2
    (O) '.UNILATE.CMPGCU'   :    V       Long K8 = NCMPG
    (O) '.UNILATE.COED'     :    V       Long K8 = NNOCU
    (O) '.UNILATE.COEG'     :    V       Long K8 = NCMPG
    (O) '.UNILATE.LISNOE'   :    V       I  length = NNOCU
    (O) '.UNILATE.POINOE'   :    V       I  length = NNOCU+1
    (O) '.UNILATE.COEFPE'   :    V       R  length = NNOCU

/FORMULATION = unilateral contact ('CONTINUOUS' 'DISCRETE' or or 'XFEM')
    (O) '.CONTACT.NDIMCO'   :    V       I  length = ZDIME

/FORMULATION = with a grid ('DISCRETE' or 'CONTINUES')
    (O) '.CONTACT.METHCO'   :    V       I  length = ZMETH*NZOCO
    (O) '.CONTACT.DIRAPP'   :    V       Long K8 = 3*NZOCO
    (O) '.CONTACT.DIRNOR'   :    V       Long K8 = ZDIRN*NZOCO
    (O) '.CONTACT.JFO1CO'   :    V       Long K8 = NZOCO
    (O) '.CONTACT.JFO2CO'   :    V       Long K8 = NZOCO
    (O) '.CONTACT.TOLECO'   :    V       R  length = ZTOLE*NZOCO

    (O) '.CONTACT.JEUCOQ'   :    V       R  length = NMACO
    (O) '.CONTACT.JEUPOU'   :    V       R  length = NMACO

    (O) '.CONTACT.PZONECO'  :    V       I  length = NZOCO+1
    (O) '.CONTACT.PSUMACO'  :    V       I  length = NSUCO+1
    (O) '.CONTACT.PSUNOCO'  :    V       I  length = NSUCO+1
    (O) '.CONTACT.MAILCO'   :    V       I  length = NMACO
    (O) '.CONTACT.NOEUCO'   :    V       I  length = NNOCO
    (O) '.CONTACT.MANOCO'   :    V       I  length = NMANO
    (O) '.CONTACT.PMANOCO'  :    V       I  length = 1+NNOCO
    (O) '.CONTACT.NOMACO'   :    V       I  length = NAMED
    (O) '.CONTACT.PNOMACO'  :    V       I  length = 1+NMACO

    (F) '.CONTACT.PSSNOCO'  :    V       I  length = 1+NZOCO
    (F) '.CONTACT.SSNOCO'   :    V       I  length = STOCNO

    (O) '.CONTACT.TYPENO'   :    V       I  length = ZTYPN*NNOCO
    (O) '.CONTACT.TYPEMA'   :    V       I  length = ZTYPM*NMACO
    (O) '.CONTACT.MAESCL'   :    V       I  length = ZMAES*NTMAE

/FORMULATION = 'DISCRETE'
    (O) '.CONTACT.CARADF'   :    V       R  length = ZCMDF*NZOCO
    (F) '.CHME'             :    V       sd_char_meca

/FORMULATION = 'CONTINUES'
    (O) '.CONTACT.CARACF'   :    V       R  length = ZCMCF*NZOCO
    (F) '.CONTACT.PSANOFR'  :    V       I  length = 1+NZOCO
    (F) '.CONTACT.SANOFR'   :    V       I  length = STOCNO
```

```
    (F) '.CONTACT.EXCLFR'   :    V       R  length = ZEXCL*NZOCO

    (O) '.CHME.LIGRE'       :    V       sd_ligrel

/FORMULATION = 'XFEM'
    (O) '.CONTACT.CARAXF'   :    V       R   length = ZCMXF*NZOCO
    (O) '.CONTACT.MODELX'   :    V       K8  length = 1
    (O) '.CONTACT.XFIMAI'   :    V       K8  length = NZOCO
    (O) '.CONTACT.XNRELL'   :    V       Long K24 = NFIS
    (O) '.CONTACT.MAESCX'   :    V       I   length = ZMESX*NTMAE
```

The length of the SD for the contact is stored in routine FORTRAN CFMMVD . The call is simple:
ZDIME = CFMMVD ('ZDIME')

For example, ZDIME give the length of the object DEFICO (1:16)/'.NDIMCO'. When the SD is multi-zones, the value ZLONG turned over by CFMMVD is a multiplier (the overall length of the object is worth then NZOCO*ZLONG with NZOCO the number of zones in contact). Any change length of the SD of contact must pass by this utility. One will take care to reflect the change simultaneously in sd_contact.py.

3 Common objects for all the formulations

```
(O) '.CHME.MODEL.NOMO'   :   V      Long K8 = 1
(O) '.CONTACT.PARACI'    :   V      I  length = ZPARI
(O) '.CONTACT.PARACR'    :   V      R  length = ZPARR
(O) '.TYPE'              :   V      Long K8 = 1
```

Here the description of the single objects (i.e. not depending on the zone of contact) for all the methods. There are three objects:
'.CHME.MODELE.NOMO' – give the name of MODEL
'.CONTACT. PARACI ' – various parameters of the whole type - single routine of access CFDISI
'.CONTACT.PARACR ' – various parameters of the real type - single routine of access CFDISR
'.TYPE' – type of the load ('MECA_RE')

For each element of the objects containing the parameters, one gives in the table below:
1. The index;
2. A description;
3. (S) the keyword (S) concerned (S) in DEFI_CONTACT ;
4. The question to pose in CFDISI or CFDISR ;
5. If information is relevant (O) or not (NR) for each FORMULATION (**D** : DISCRETE, **C** : CONTINUOUS, **X** : XFEM, **L** : LIAISON_UNIL)

3.1 Parameters of the whole type PARACI

```
(O) '.CONTACT.PARACI'    :   V      I  length = ZPARI
```

Index	Description	DEFI_CONTACT	Question CFDISI	D	C	X	U
1	Geometrical type of reactualization 0 – WITHOUT -1 – AUTOMATIC X – CONTROL with x= NB_ ITER _GEOM	REAC_GEOM NB_ITER_GEOM	NB_ITER_GEOM	O	O	O	NR
2	Stop on singular matrix of contact 0 – YES 1 – NOT	STOP_SINGULIER	STOP_SINGULIER	O	NR	NR	O
3	Many second simultaneous members during the construction of the complement of Schur	NB_RESOL	NB_RESOL	O	NR	NR	O
4	Type of formulation 1 – DISCRETE 2 – CONTINUOUS 3 – XFEM 4 – LIAISON_UNIL	FORMULATION	FORMULATION	O	O	O	O
5	Multiplying number of iterations of contact X – ITER_CONT_TYPE=' MULT' with x= ITER_CONT_MULT -1 – ITER_CONT_TYPE=' MAXI'	ITER_CONT_TYPE ITER_CONT_MULT	ITER_CONT_MULT	O	O	O	NR
6	Maximum number of geometrical iterations	ITER_GEOM_MAXI	ITER_GEOM_MAXI	O	O	O	NR
7	Maximum number of iterations of friction	ITER_FROT_MAXI	ITER_FROT_MAXI	NR	O	O	NR

8	Zones all in mode without calculation
	`0 – NOT`
	`1 – YES`
		`RESOLUTION`	`ALL_VERIF`	O	O	NR	NR

9	Type of algorithm for the geometry
	`0 – POINT_FIXE`
	`1 – NEWTON`
		`ALGO_RESO_GEOM`	`ALGO_RESO_GEOM`	O	O	O	NR

10	Maximum number iterations of contact
	`X – ITER_CONT_TYPE=' MAXI'`
	with `x= ITER_CONT_MAXI`
	`-1 – ITER_CONT_TYPE=' MULT'`
		`ITER_CONT_TYPE`
		`ITER_CONT_MAXI`
			`ITER_CONT_MAXI`	NR	O	O	NR

11	Zones all in initial contact (‘ `INTERPENETRATE` ‘)
	`0 – NOT`
	`1 – YES`
		`CONTACT_INIT`	`ALL_INTERPENETRE`	NR	O	NR	NR

12	Iteration count of the GCP	`ITER_GCP_MAXI`	`ITER_GCP_MAXI`	O	NR	NR	NR

13	Type of preconditionnor of the GCP
	`0 – WITHOUT`
	`1 – DIRICHLET`
		`PRE_COND`	`PRE_COND`	O	NR	NR	NR

14	Iteration count of the preconditionnor of the GCP	`ITER_PRE_MAXI`	`ITER_PRE_MAXI`	O	NR	NR	NR

15	Linear type of Research for `GCP`
	`0 – ACCEPTABLE`
	`1 – NON_ADMISSIBLE`
		`RECH_LINEAIRE`	`RECH_LINEAIRE`	O	NR	NR	NR

16	Axisymmetric model
	`0 – NOT`
	`1 – YES`
		In `AFFE_MODELE`	`AXISYMMETRIC`	NR	O	NR	NR

17	Method for the contact - `DISCRETE`
	`1 – CONSTRAINT`
	`2 – GCP`
	`4 – PENALIZATION`
		`ALGO_CONT`	`ALGO_CONT`	O	NR	NR	NR

	Method for the contact - `CONTINUOUS` `6 – YES`	*nothing*	`ALGO_CONT`	NR	O	NR	NR
	Method for the contact - `XFEM` `7 – YES`	*nothing*	`ALGO_CONT`	NR	NR	O	NR
18	Method for friction - `DISCRETE` `0 –` *pas de friction* `1 – PENALIZATION`	`FRICTION` `ALGO_FROT`	`ALGO_FROT`	O	NR	NR	NR
	Method for friction - `CONTINUOUS` `6 – YES`	`FRICTION`	`ALGO_FROT`	NR	O	NR	NR
	Method for friction - `XFEM` `7 – YES`	`FRICTION`	`ALGO_FROT`	NR	NR	O	NR

19	Smoothing of the normals
	`0 – NOT`
	`1 – YES`
		`SMOOTHING`	`SMOOTHING`	O	O	NR	NR

20	Adaptation of the coefficients of increase
	`0 – NOT`
	`1 – YES`
		`ADAPT_COEF`	`ADAPT_COEF`	NR	O	NR	NR

21	At least a zone into cohesive
	`0 – NOT`
	`1 – YES`
		`ALGO_CONT`	`EXIS_XFM_CZM`	NR	NR	O	NR

22	At least a zone in penalization
	`0 – NOT`
	`1 – YES`
		`ALGO_CONT`
		`ALGO_FROT`
			`EXIS_PENA`	NR	O	O	NR

23	At least a zone in mode without calculation
	`0 – NOT`
	`1 – YES`
		`RESOLUTION`	`EXIS_VERIF`	O	O	NR	NR

24	All zones in nodal integration
	`0 – NOT`
	`1 – YES`
		`INTEGRATION`	`ALL_INTEG_NOEUD`	NR	O	NR	NR

25	Stop if interpenetration in mode without calculation
	`0 – NOT`
	`1 – YES`
		`STOP_INTERP`	`STOP_INTERP`	O	O	NR	NR

26	At least a zone in bilateral contact
	`0 – NOT`
	`1 – YES`
		`SLIDE`	`EXIS_GLISSIERE`	O	O	O	NR

27	Type of algorithm for the contact
	`0 – POINT_FIXE`
	`1 – NEWTON`
		`ALGO_RESO_CONT`	`ALGO_RESO_CONT`	NR	O	NR	NR

28	Type of algorithm for friction
	`0 – POINT_FIXE`
	`1 – NEWTON`
		`ALGO_RESO_FROT`	`ALGO_RESO_FROT`	NR	O	NR	NR

3.2 Parameters of the whole type `PARACR`

```
(O) '.CONTACT.PARACR'   :   V      R  length = ZPARR
```

Index	Description	**`DEFI_CONTACT`**	Question CFDISR	D	C	X	U
1	Threshold for geometrical reactualization `X – RESI _GEOM`	`RESI_GEOM`	`RESI_GEOM`	O	O	O	NR
2	Threshold for reactualization of friction `X – RESI _ FROT`	`RESI_FROT`	`RESI_FROT`	NR	O	O	NR
3	Tolerance interpenetration in mode without calculation `X – TOLE_INTERP`	`TOLE_INTERP`	`TOLE_INTERP`	O	O	NR	NR
4	Residue GCP `X – RESI_ABSO`	`RESI_ABSO`	`RESI_ABSO`	O	NR	NR	NR
5	Residue of preconditionnor GCP `X – COEF_RESI`	`COEF_RESI`	`COEF_RESI`	O	NR	NR	NR

4 Common object for the unilateral contact

4.1 Object NDIMCO

This object is common to all the formulations of the unilateral contact, it thus does not exist in the case of the formulation LIAISON_UNIL.

```
(O) '.CONTACT.NDIMCO'   :    V       I  length = ZDIME
```

Index	Description	Question CFDISI
1	Dimension of space	NDIM
2	Many zones of contact	NZOCO
3	Many surfaces of contact	NSUCO
4	Many meshs of contact	NMACO
5	Many nodes of contact	NNOCO
6	*Not used*	
7	*Not used*	
8	Full number of nodes slaves	NTNOE
9	Full number of meshs slaves	NTMAE
10	Full number of main nodes	NTNOM
11	Full number of meshs Masters	NTMAM
12	Full number of nodes slaves indeed in contact	NTNOEC
13	Full number of meshs slaves indeed in contact	NTMAEC
14	Full number of main nodes indeed in contact	NTNOMC
15	Full number of meshs Masters indeed in contact	NTMAMC
16	Full number of points	NTPT
17	Full number of points indeed in contact	NTPC
18	Dimension of the table of connectivity mailles→nœuds	NTMANO

Note:
* The number of points has direction only in the formulation CONTINUOUS (it depends then on the diagram of integration). For the discrete methods, it is equal to the number of nodes slaves;
* The term "indeed in contact" corresponds if the quantities are related to a resolution of calculation (RESOLUTION=' OUI' in DEFI_CONTACT). For example, for the nodes slaves:
  * NTNOE : full number of nodes slaves;
  * NTNOEC : many nodes slaves on which one will calculate;
  * NTNOEV=NTNOE-NTNOEC : many nodes slaves on which one will make only pairing;

5 Objects common to all the formulations with a grid

Here the description of the objects depending on the zone on contact dedicated to the formulations with a grid (method CONTINUOUS and DISCRETE).

5.1 Options of pairing per zone

These objects correspond to the variable options of pairing of a zone of contact to the other. For each element of the objects containing the parameters one gives in the tables below:

1. The index;
2. A description;
3. (S) the keyword (S) concerned (S) in DEFI_CONTACT ;
4. The question to pose in MMINF* ;

5.1.1 Object METHCO

```
(O) '.CONTACT.METHCO'   :   V      I  length = ZMETH*NZOCO
```

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Type of pairing 0 – NODAL 1 – MAIT_ESCL	PAIRING	MMINFI	PAIRING
2	Presence of the keyword DIST_POUTRE	DIST_POUTRE	MMINFL	DIST_POUTRE
3	Presence of the keyword DIST_ HULL	DIST_COQUE	MMINFL	DIST_COQUE
4	Type of normal 0 – MAIT 1 – MAIT_ESCL 2 – ESCL	NORMAL	MMINFI	NORMAL
			MMINFL	MAIT ESCL MAIT_ESCL
5	Type of the vector carried by the mesh Master 0 – CAR 1 – FIXED 2 – VECT_Y	VECT_MAIT MAIT_FIXE MAIT_VECT_Y	MMINFI	VECT_MAIT
			MMINFR	VECT_MAIT_DIRX [1] VECT_MAIT_DIRY VECT_MAIT_DIRZ
6	Type of the vector carried by the mesh slave 0 – CAR 1 – FIXED 2 – VECT_Y	VECT_ESCL ESCL_FIXE ESCL_VECT_Y	MMINFI	VECT_ESCL
			MMINFR	VECT_ESCL_DIRX [2] VECT_ESCL_DIRY VECT_ESCL_DIRZ
7	Type of search for pairing 0 – CAR 1 – FIXED	TYPE_APPA DIRE_APPA	MMINFI	TYPE_APPA
			MMINFR	TYPE_APPA_DIRX [3] TYPE_APPA_DIRY TYPE_APPA_DIRZ
			MMINFL	TYPE_APPA_FIXE
8	Many meshs slaves on the zone		MMINFI	NBMAE
9	Many nodes slaves on the zone		MMINFI	NBNOE

1 Access object '.CONTACT.DIRNOR'
2 Access object '.CONTACT.DIRNOR'
3 Access object '.CONTACT.DIRAPP'

10	Many meshs Masters on the zone		MMINFI	NBMAM
11	Many main nodes on the zone		MMINFI	NBNOM
12	Many meshs slaves in effective contact on the zone		MMINFI	NBMAEC
13	Many nodes slaves in effective contact on the zone		MMINFI	NBNOEC
14	Many meshs Masters in effective contact on the zone		MMINFI	NBMAMC
15	Many main nodes in effective contact on the zone		MMINFI	NBNOMC
16	Shift in the vectors for the meshs slaves		MMINFI	JDECME
17	Shift in the vectors for the meshs Masters		MMINFI	JDECMM
18	Shift in the vectors for the nodes slaves		MMINFI	JDECNE
19	Shift in the vectors for the main nodes		MMINFI	JDECNM
20	Many points		MMINFI	NTPT
21	Points number indeed in contact		MMINFI	NTPC
22	Zone in mode without calculation 0 – NOT (RESOLUTION=' NON') 1 – YES (RESOLUTION=' OUI')	RESOLUTION	MMINFL	VERIF CALCULATION

5.1.2 Object DIRAPP

```
(O) '.CONTACT.DIRAPP'   :   V      Long K8 = 3*NZOCO
```

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Direction of search for pairing following X	DIRE_APPA	MMINFR	DIRE_APPA_DIRX
2	Direction of search for pairing following Y	DIRE_APPA	MMINFR	DIRE_APPA_DIRY
3	Direction of search for pairing following Z	DIRE_APPA	MMINFR	DIRE_APPA_DIRZ

5.1.3 Object DIRNOR

```
(O) '.CONTACT.DIRNOR'   :   V      Long K8 = ZDIRN*NZOCO
```

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Normal Master according to X	MAIT_FIXE MAIT_VECT_Y	MMINFR	VECT_MAIT_DIRX
2	Normal Master according to Y	MAIT_FIXE MAIT_VECT_Y	MMINFR	VECT_MAIT_DIRY
3	Normal Master according to Z	MAIT_FIXE MAIT_VECT_Y	MMINFR	VECT_MAIT_DIRZ
4	Normal slave according to X	ESCL_FIXE ESCL_VECT_Y	MMINFR	VECT_ESCL_DIRX
5	Normal slave according to Y	ESCL_FIXE ESCL_VECT_Y	MMINFR	VECT_ESCL_DIRY
6	Normal slave according to Z	ESCL_FIXE ESCL_VECT_Y	MMINFR	VECT_ESCL_DIRZ

5.1.4 Objects JFO1CO and JFOCO2

```
(O) '.CONTACT.JFO1CO'   :    V       Long K8 = NZOCO
(O) '.CONTACT.JFO2CO'   :    V       Long K8 = NZOCO
```

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Additional game on mesh Master *Name of the function*	DIST_MAIT	MMINFL	DIST_MAIT

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Additional game on mesh slave *Name of the function*	DIST_ESCL	MMINFL	DIST_ESCL

5.1.5 Object TOLECO

```
(O) '.CONTACT.TOLECO'   :    V       R  length = ZTOLE*NZOCO
```

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Parameter projection out-mesh	TOLE_PROJ_EXT	MMINFR	TOLE_PROJ_EXT
2	Parameter tolerance outdistances pairing	TOLE_APPA	MMINFR	TOLE_APPA
3	Parameter tolerance interpenetration in mode without calculation	TOLE_INTERP	MMINFR	TOLE_INTERP

5.2 Options of pairing per mesh (slave)

5.2.1 Objects JEUPOU / JEUCOQ

```
(O) '.CONTACT.JEUPOU'   :    V        R  length = NMACO
(O) '.CONTACT.JEUCOQ'   :    V        R  length = NMACO
```

These objects contain the additional game by mesh slave when one uses beams (keyword DIST_POUTRE) or of the hulls (keyword DIST_COQUE). Information (thickness of the hull or ray of the beam is read directly in the SD cara_elem data in **DEFI_CONTACT**).

Object indexed by the number of the mesh slave in MAILCO (POSMAE).

Index on the mesh slave	Description	DEFI_CONTACT
1	Additional game on mesh slave of beam	DIST_ BEAM CARA_ELEM

Index on the mesh slave	Description	DEFI_CONTACT
1	Additional game on mesh slave of hull	DIST_ HULL CARA_ELEM

5.3 Description of the zones of contact

The system of contact is composed of several zones, themselves divided into two surfaces made up of meshs, container of the nodes. Surfaces of contact are located by their absolute number i in the list of all surfaces of contact, all confused zones.
Only tables MAILCO, NOEUCO and SANSNO index the nodes and the meshs by their absolute number in the grid; all the other tables use the index in MAILCO and NOEUCO to indicate a mesh or a node. This index often is called position and noted POSMA/POSNO in the routines (whereas the absolute number of the mesh or node are rather indicated by NUMMA/NUMNO).

5.3.1 Object PZONECO

```
(O) '.CONTACT.PZONECO'  :    V        I  length = NZOCO+1
```

Pointer of access towards surfaces for each zone of contact.

Number ISURF1 the first surface (Master) for the zone IZONE:
ISURF1 = ZI (JZONE+IZONE-1) +1

Number ISURF2 the second surface (slave) for the zone IZONE:
ISURF2 = ZI (JZONE+IZONE)

Routine of direct access (to be privileged):

```
SUBROUTINE CFZONE (DEFICO, IZONE, TYPSUR, ISURF)
    IN  DEFICO: SD OF DEFINITION OF THE CONTACT
    IN  IZONE  : NUMBER OF THE ZONE OF CONTACT
    IN  TYPSUR: TYPE OF SURFACE
                 'MAIT'
                 'ESCL'
    OUT ISURF  : NUMBER IN SURFACE FOR ACCESS PSUNOCO/PSUMACO
```

5.3.2 Objects PSUMACO/PSUNOCO

```
(O) '.CONTACT.PSUMACO'   :    V       I  length = NSUCO+1
(O) '.CONTACT.PSUNOCO'   :    V       I  length = NSUCO+1
```

Pointer of access towards the meshs/nodes of each surface of contact. One points towards the objects MAILCO and NOEUCO.

Shift JDECMA in MAILCO for the first mesh of surface ISURF :
JDECMA = ZI (JSUMA+ISURF-1)

Shift JDECNO in NOEUCO for first node of surface ISURF :
JDECNO = ZI (JSUNO+ISURF-1)

Number NBMA meshs for surface ISURF:
NBMA = ZI (JSUMA+ISURF) – ZI (JSUMA+ISURF-1)

Number NBNO nodes for surface ISURF:
NBNO = ZI (JSUNO+ISURF) – ZI (JSUNO+ISURF-1)

To reach a node or a mesh, one uses the shifts given in PSUMACO/PSUNOCO to traverse MAILCO and NOEUCO. Entireties (often noted POSMA in the code) contents in PSUMACO vary between 1 and NMACO. Entireties (often noted POSNO in the code) contents in PSUNOCO vary between 1 and NNOCO.

Routine of direct access (to be privileged):

```
SUBROUTINE CFNBSF (DEFICO, ISURF, TYPIFY, NBENT, JDEC  )
   IN  DEFICO: SD OF DEFINITION OF THE CONTACT
   IN  TYPIFY: TYPE OF ENTITY
               'NOEU'  ACCESS TO THE NODES FASTENERS ON THE SURFACE
               'E-MAIL'  ACCESS TO MESHS ATTACHEES ON THE SURFACE
   IN  ISURF  : NUMBER OF SURFACE
   OUT NBENT  : MANY ENTITIES
   OUT JDEC   : SHIFT IN THE VECTORS FOR THE FIRST OF SURFACE
```

5.3.3 Objects MAILCO/NOEUCO

```
(O) '.CONTACT.MAILCO'    :    V       I  length = NMACO
(O) '.CONTACT.NOEUCO'    :    V       I  length = NNOCO
```

Give the absolute number of the meshs/nodes of contact. One points towards the objects of the SD grid.
One reaches these objects thanks to the pointers PSUMACO / PSUNOCO .

Absolute number NUMMA I - ème mesh of the surface of number ISURF :
NUMMA = ZI (JMACO+JDECMA-1+ISURF)

Absolute number NUMNO I - ème node of the surface of number ISURF :
NUMNO = ZI (JNOCO+JDECNO-1+ISURF)

Entireties (often noted NUMMA in the code) contents in MAILCO vary between 1 and the full number of meshs in the grid. Entireties (often noted NUMNO in the code) contents in NOEUCO vary between 1 and the full number of nodes in the grid.

Routines of direct access (to be privileged):

```
SUBROUTINE CFNUMM (DEFICO, NMA   , POSNMA, NUMNMA)
   IN  DEFICO: SD OF CONTACT (DEFINITION)
```

```
    IN  NMA    : MANY MESHS
    IN  POSNMA: INDICES IN MAILCO OF THE MESHS
    OUT NUMNMA: ABSOLUTE NUMBERS OF THE MESHS IN THE GRID

SUBROUTINE CFNUMN (DEFICO, NO   , POSNNO, NUMNNO)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  NO    : MANY NODES
    IN  POSNNO: INDICES IN NOEUCO OF THE NODES
    OUT NUMNNO: ABSOLUTE NUMBERS OF THE NODES IN THE GRID

SUBROUTINE CFPOSN (DEFICO, POSMAI, POSNNO, NAMED)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  POSMAI: INDEX OF THE MESH (IN SD CONTACT)
    OUT POSNNO: INDICES IN NOEUCO OF THE NODES
    OUT NAMED: MANY NODES OF THE MESH (IN THE SD OF CONTACT)

SUBROUTINE CFNOMM (NAMED  , DEFICO, TYPIFY, POSE, NAME)
    IN  NAMED   : NAME OF THE GRID
    IN  DEFICO: SD OF DEFINITION OF THE CONTACT
    IN  POSE: POSITION OF THE ENTITY IN THE SD CONTACT
    IN  TYPIFY: TYPE OF ENTITY
                  <MAIL>  MESH
                  <NOEU>  NODE
    OUT NAME: NAME OF THE ENTITY
```

5.3.4 Objects MANOCO/PMANOCO

```
(O) '.CONTACT.PMANOCO'  :    V       I  length = NNOCO+1
(O) '.CONTACT.MANOCO'   :    V       I  length = NMANO
```

One reaches connectivity opposite *via* objects MANOCO / PMANOCO . Connectivity opposite turn over for a node given the meshs which are attached there.
The object PMANOCO is indexed by the number of the node of contact in NOEUCO (number given by PSUNOCO and often noted POSNO in the code). Values contained in PMANOCO point towards MANOCO, they vary between 1 and NMANO. Entireties (often noted POSMA in the code) contents in MANOCO vary between 1 and NMACO (they point towards MAILCO).

Shift JDEC in MANOCO first mesh attached to the node of number POSNO in CONTNO :
`JDEC   = ZI (JPOMA+POSNO-1)`

Number NBMANO meshs attached to the node of number POSNO in CONTNO :
`NBMANO = ZI (JPOMA+POSNO) – ZI (JPOMA+POSNO-1)`

Number POSMA in MAILCO I- ème attached mesh with the node of number POSNO in CONTNO :
`POSMA  = ZI (JMANO+JDEC-1+I)`

Routines of direct access (to be privileged):

```
SUBROUTINE CFNBEN (DEFICO, POSE, TYPIFY, NBENT, JDECEN)
    IN  DEFICO: SD OF DEFINITION OF THE CONTACT
    IN  POSE: POSITION OF THE ENTITY IN THE SD CONTACT
    IN  TYPIFY: TYPE OF ENTITY
                 'CONINV' POSE IS A NODE
                 - > ONE REACHES MESHS ATTACHEES THIS NODE
                 (CONNECTIVITY REVERSES)
                 'CONNEX' POSE IS A MESH
                 - > ONE REACHES THE NODES FASTENERS WITH THIS MESH
                 (DIRECT CONNECTIVITY)
```

```
    OUT NBENT  : MANY ENTITIES FASTENERS
    OUT JDECEN: SHIFT FOR TABLE

SUBROUTINE CFINVM (DEFICO, JDECIV, IMA   , POSMA)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  IMA    : NUMBER ORDER OF THE MESH IN SD IDIOT. OPPOSITE.
    IN  JDECIV: SHIFT FOR READING IN SD IDIOT. OPPOSITE.
    OUT POSMA  : POSITION OF THE MESH
```

5.3.5 Objects NOMACO/PNOMACO

```
(O) '.CONTACT.PNOMACO'  :    V       I  length = NMACO+1
(O) '.CONTACT.NOMACO'   :    V       I  length = NAMED
```

One reaches the connectivity of the meshs via a dedicated object and not *via* usual objects of sd_maillage (like CONNEX). There is indeed a difference because of QUAD8 which one excludes the nodes mediums from the contact (the mesh of contact QUAD8 thus qu does not containE 4 nodes). Moreover connectivity was reduced to the meshs of contact, which allows a faster access.
The object PNOMACO is indexed by the number of the mesh of contact in MAILCO (number given by PSUMACO and often noted POSMA in the code). Values contained in PNOMACO point towards NOMACO , they vary between 1 and NAMED . Entireties (often noted POSNO in the code) contents in NOMACO vary between 1 and NNOCO (they point towards NOEUCO).

Shift JDEC in NOMACO first node of the mesh of number POSMA in MAILCO :
JDEC   = ZI (JPONO+POSMA-1)

Number NBNOMA nodes for the mesh of number POSMA in MAILCO :
NBNOMA = ZI (JPONO+POSMA) - ZI (JPONO+POSMA-1)

Number POSNO in NOEUCO I- ème node of the mesh of number POSMA in MAILCO :
POSNO = ZI (JNOMA+JDEC-1+I)

Routines of direct access (to be privileged):

```
SUBROUTINE CFNBEN (DEFICO, POSE, TYPIFY, NBENT, JDECEN)
    IN  DEFICO: SD OF DEFINITION OF THE CONTACT
    IN  POSE: POSITION OF THE ENTITY IN THE SD CONTACT
    IN  TYPIFY: TYPE OF ENTITY
                'CONINV' POSE IS A NODE
                - > ONE REACHES MESHS ATTACHEES THIS NODE
                (CONNECTIVITY REVERSES)
                'CONNEX' POSE IS A MESH
                - > ONE REACHES THE NODES FASTENERS WITH THIS MESH
                (DIRECT CONNECTIVITY)
    OUT NBENT  : MANY ENTITIES FASTENERS
    OUT JDECEN: SHIFT FOR TABLE

SUBROUTINE CFCONN (DEFICO, JDECNO, INO   , POSNO)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  INO    : NUMBER ORDER OF THE NODE IN SD IDIOT.
    IN  JDECNO: SHIFT FOR READING IN SD IDIOT.
    OUT POSNO  : POSITION OF THE NODE
```

5.4 Exclusion of the nodes/meshs

5.4.1 Objects PSSNOCO / SSNOCO

```
(F) '.CONTACT.PSSNOCO'  :    V        I  length = NZOCO+1
(F) '.CONTACT.SSNOCO'   :    V        I  length = STOCNO
```

Objects used to exclude from the nodes given by SANS_GROUP_NO/SANS_NO or SANS_GROUP_MA/SANS_MAILLE and valid for the formulations DISCRETE and CONTINUOUS. PSSNOCO is a pointer of indirection towards SSNOCO.

Shift JDEC in SSNOCO first node excluded for the zone IZONE :
JDEC = ZI (JPSANS+IZONE-1)

Number NBEXNO nodes excluded for the zone IZONE :
NBEXNO = ZI (JPSANS+IZONE) – ZI (JPSANS+IZONE-1)

absolute number node in the grid is stored in SSNOCO with the index given by PSSNOCO.

5.5 Information on the meshs and the nodes

5.5.1 Object TYPENO

```
(O) '.CONTACT.TYPENO'   :    V        I  length = ZTYPN*NNOCO
```

The object '.CONTACT.TYPENO' is indexed by the number of the node of in NOEUCO (number given by PSUNOCO and often noted POSNO in the code). It turns over the type of the node: -1 if it is slave, +1 if he is Master, as well as the zone of contact to which he belongs.

Routines of direct access (to be privileged):

```
SUBROUTINE CFZONN (DEFICO, POSNO, IZONE)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  POSNO  : INDEX IN NOEUCO OF THE NODE
    OUT IZONE  : NUMBER OF THE ZONE

SUBROUTINE CFTYPN (DEFICO, POSNO, TYPNO)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  POSNO  : INDEX IN NOEUCO OF THE NODE
    OUT TYPNO  : TYPE OF NODE 'MAIT' OR 'ESCL'
```

5.5.2 Object TYPEMA

```
(O) '.CONTACT.TYPEMA'   :    V        I  length = ZTYPM*NMACO
```

The object '.CONTACT.TYPEMA' is indexed by the number of the mesh of contact in MAILCO (number given by PSUMACO and often noted POSMA in the code). It turns over the type of the mesh: -1 if it is slave, +1 if he is Master. He is also used as pointer of access to the object MAESCL by providing the index INDMAE of a mesh slave in the whole of the meshs gathered slaves.

Routine of direct access (to be privileged):

```
SUBROUTINE CFTYPM (DEFICO, POSMA, TYPMA)
    IN  DEFICO: SD OF CONTACT (DEFINITION)
    IN  POSMA  : INDEX IN MAILCO OF THE MESH
    OUT TYPMA  : TYPE OF MESH 'MAIT' OR 'ESCL'
```

5.5.3 Object MAESCL

(O) '.CONTACT.MAESCL' : V I length = ZMAES*NTMAE

Object reached thanks to the pointer TYPEMA.

leau is built by gathering all the meshs slaves of all the zones. Of MAESCL (1) with MAESCL (NBMAE (1)), there are all the meshs slaves of the first zone of contact, then of MAESCL (NBMAE (1) +1) with MAESCL (NBMAE (2)), there are all the meshs slaves of the second zone of contact, etc the object TYPEMA provides such an index and is thus used as pointer of access to MAESCL.
This table primarily turns over various information on the meshs slaves (in formulation CONTINUOUS).

Index on the mesh slave	Description	Question MMINFM
1	Value of the index of the mesh in MAILCO	Pas d' access
2	Number of the zone to which the mesh belongs	IZONE
3	Many points of integration	NPTM
4	Element from which nodes are excluded by SANS_*_FR	NDEXFR

6 Specific objects for the formulation DISCRETE

One gives in this section the description of the objects depending on the zone on contact and dedicated to the formulation DISCRETE .

6.1 Object CARADF

(O) '.CONTACT.CARADF' : V R length = ZCMDF*NZOCO

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Contribution stamps friction	COEF_MATR_FROT	MMINFR	COEF_MATR_FROT
2	Coefficient of penalization for the contact	E_N	MMINFR	E_N
3	Coefficient of penalization for friction	E_T	MMINFR	E_T
4	Coefficient of friction of Coulomb	COULOMB	MMINFR	COEF_COULOMB
5	Parameter of alarm in bilateral contact mode (slide)	ALARME_JEU	MMINFR	ALARME_JEU
6	Bilateral contact on the zone 0 – NOT 1 – YES	SLIDE	MMINFL	GLISSIERE_ZONE

6.2 SD char_meca

(F) '.CHME' : V sd_char_meca

This SD is one sd_char_meca (*cf.* [D4.06.04]) used to impose linear relations on the nodes mediums in the presence of elements QUAD8.

7 Specific objects for the formulation CONTINUOUS

7.1 Object CARACF

(O) '.CONTACT.CARACF' : V R length = ZCMCF*NZOCO

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Type of integration 1 – 'CAR' X2 – 'GAUSS' X3 – 'SIMPSON' X4 – 'NCOTES' X - ORDRE_INT	INTEGRATION ORDRE_INT	MMINFI	INTEGRATION
2	Value of the coefficient of increase in contact	COEF_ CONT COEF_ PENA_CONT	MMINFR	COEF_ AUGM _CONT
3	Type of algorithm in contact (increased or penalized) 1 – STANDARD 3 – PENALIZATION	ALGO_CONT	MMINFI	ALGO_CONT
4	Value of the coefficient of increase in friction	COEF_ FROT COEF_ PENA_FROT	MMINFR	COEF_AUGM_ FROT
5	Type of algorithm in friction (increased or penalized) 1 – STANDARD 3 – PENALIZATION	ALGO_FROT	MMINFI	ALGO_FROT
6	Coefficient of friction of Coulomb	COULOMB	MMINFR	COEF_COULOMB
7	Initial value of the threshold of Tresca	SEUIL_INIT	MMINFR	SEUIL_INIT
8	Surfaces initially in contact 0 – NOT 1 – YES 2 - INTERPENETRATE	CONTACT_INIT	MMINFI	CONTACT_INIT
9	Bilateral contact on the zone 0 – NOT 1 – YES	SLIDE	MMINFL	GLISSIERE_ZONE
10	Elimination of nodes of the contact 0 – NOT 1 – YES	SANS_*_NO	MMINFL	SANS_GROUP_NO
11	Elimination of nodes of friction 0 – NOT 1 – YES	SANS_*_FR	MMINFL	SANS_GROUP_NO_FR
12	Many excluded directions of friction 0 – no excluded direction 1 – only one excluded direction 2 – all excluded directions	SANS_*_FR DIRE_EXCL_FROT	MMINFI	EXCL_DIR

7.2 Objects PSANOFR/SANOFR

In formulation CONTINUOUS only, the keywords are treated SANS_GROUP_NO_FR/SANS_NOEUD_FR who allow to locate nodes or particular meshs on surfaces of contact:

```
(F) '.CONTACT.PSANOFR'  :    V        I  length = 1+NZOCO
(F) '.CONTACT.SANOFR'   :    V        I  length = STOCNO
```

The storage of this information is virtually identical to the storage of the nodes excluded from the contact (*cf.* §5.4).

A utility routine makes it possible to say if a node is part of the groups previously described:

```
SUBROUTINE CFMMEX (DEFICO, TYPEXC, IZONE, NUMNOE, SUPPOK)
  IN  DEFICO: SD FOR THE DEFINITION OF CONTACT
  IN  TYPEXC: TYPE OF EXCLUSION
              'FROT' GIVES BY SANS_*_FR
              'CONT' GIVES BY SANS_*
  IN  IZONE  : NUMBER OF THE ZONE OF CONTACT
  IN  NUMNOE: ABSOLUTE NUMBER OF THE NODE TO BE SOUGHT
  OUT SUPPOK: 1 IS WORTH IF THE NODE BELONGED TO THE EXCLUDED NODES
```

7.3 Object EXCLFR

```
(F) '.CONTACT.EXCLFR'   :    V        R  length = ZEXCL*NZOCO
```

This object is used to specify the vectors of exclusion of direction of friction in the case of the option SANS_*_FR.

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Direction of exclusion according to X	DIRE_EXCL_FROT	MMINFR	EXCL_FROT_DIRX
2	Direction of exclusion according to Y	DIRE_EXCL_FROT	MMINFR	EXCL_FROT_DIRY
3	Direction of exclusion according to Z	DIRE_EXCL_FROT	MMINFR	EXCL_FROT_DIRZ

7.4 SD ligrel

```
(O) '.CHME.LIGRE'       :    V        sd_ligrel
```

This SD of the type sd_ligrel(*cf.* [D4.06.02]) contains the definition of Lagrange late added to the model on the nodes slaves by the formulation continues.

8 Specific objects for the formulation XFEM

8.1 Object MODELX

```
(O) '.CONTACT.MODELX'   :   V       Long K8 = 1
```

This object contains the name of the model XFEM . It is used for the checking when LIAISON_XFEM=OUI .

8.2 Object CARAXF

```
(O) '.CONTACT.CARAXF'   :   V       R  length = ZCMXF*NZOCO
```

Object indexed by the number of the zone of contact.

Index on the zone	Description	DEFI_CONTACT	Question MMINF*	
1	Type of integration	INTEGRATION	MMINFI	INTEGRATION
2	Value of the parameter COEF_REGU_CONT	COEF_REGU_CONT	MMINFR	COEF_AUGM_CONT COEF_REGU_CONT
3	Value of the parameter COEF_REGU_FROT	COEF_REGU_FROT	MMINFR	COEF_AUGM_FROT COEF_REGU_FROT
4	Coefficient of friction of Coulomb	COULOMB	MMINFR	COEF_COULOMB
5	Friction in the zone 0 – NOT 3 – YES	FRICTION	MMINFI	FROTTEMENT_ZONE
			MMINFL	FROTTEMENT_ZONE
6	Initial value of the threshold of Tresca	SEUIL_INIT	MMINFR	SEUIL_INIT
7	Surfaces initially in contact 0 – NOT 1 – YES	CONTACT_INIT	MMINFI	CONTACT_INIT
8	*Not used*			
9	Algorithm of suppression LBB 0 – NOT 1 – VERSION1 2 – VERSION2	ALGO_LAGR	MMINFI	ALGO_LAGR
10	Bilateral contact on the zone 0 – NOT 1 – YES	SLIDE	MMINFL	GLISSIERE_ZONE
11	Value of the parameter COEF_STAB_CONT	COEF_STAB_CONT	MMINFR	COEF_STAB_CONT
12	Value of the parameter COEF_PENA_CONT	COEF_PENA_CONT	MMINFR	COEF_PENA_CONT
13	Value of the parameter COEF_STAB_FROT	COEF_STAB_FROT	MMINFR	COEF_STAB_FROT
14	Value of the parameter COEF_PENA_FROT	COEF_PENA_FROT	MMINFR	COEF_PENA_FROT
15	Parameter projection out-mesh	TOLE_PROJ_EXT	MMINFR	TOLE_PROJ_EXT
16	Type of relation for CZM 0 – NOT OF CZM 1 – CZM_EXP_REG 2 – CZM_LIN_REG	RELATION	MMINFR	RELATION
			MMINFL	CONT_XFEM_CZM

17	Algorithm for the contact 1 – STANDARD 2 – ADVANCE 3 – PENALIZATION 4 – CZM	ALGO_CONT	MMINFR MMINFL	CZM_FERMETURE ALGO_CONT_PENA
18	Algorithm for friction 1 – STANDARD 2 – ADVANCE 3 – PENALIZATION	ALGO_FROT	MMINFL	ALGO_FROT_PENA

8.3 Object XFIMAI

```
(O) '.CONTACT.XFIMAI'   :   V       Long K8 = NZOCO
```

Object indexed by the number of the zone of contact.

This object stores the main number of the crack associated with each zone of contact. It is used to find it
name of a crack associated with a zone with contact given.

8.4 Object XNRELL

```
(O) '.CONTACT.XNRELL'   :   V       Long K24 = NFIS
```

This object stores for each crack Master the name of the object..LISEQ associated with this crack. That is to say NFIS the number of cracks of model X-FEM (object NFIS model X-FEM) and is fiss the crack of index I in the list of the cracks of model X-FEM. (object .FISS model X-FEM). That is to say finally v_sdline a pointer giving access the object XNRELL. One has then:

```
v_sdline (I) = fiss//'.LISEQ'
```

The object .LISEQ associated with a crack stores the relations of equality to be applied to satisfy condition LBB within the framework with a mixed formulation for the contact in X-FEM (*cf.* [D4.10.02], §3.5.2 for description supplements this object). The relations of equality to be applied are calculated by xconta. F90. The relations of equality are applied either:

- by xrela_elim. F90 , if one wishes to preserve one degree of freedom, among the whole of the degrees of freedom bound by the relation of equality, at the time of the writing of the linear system to solve (ELIM_ARETE = 'ELIM' , in DEFI_CONTACT);
- by xfem_rel_lin. F90 , if one wishes to preserve the whole of the degrees of freedom in the writing of the linear system to solve and that one impose the conditions of equality by using multipliers of Lagrange (ELIM_ARETE = 'DUAL' , in DEFI_CONTACT).

8.5 Object MAESCX

```
(O) '.CONTACT.MAESCX'   :   V       Long K24 = ZMESX*NTMAE
```

This object is the equivalent, within the framework of the formulation of contact X-FEM in great slips, of the object MAESCL, used in formulations FEM. It should be noted that in the case of multi-cracking, all the elements nouveau riches X-FEM associated with a given crack necessarily will not calculate contributions to the integrals of contact (*cf.* [D4.10.02], §3.3.8 for more details). These elements are characterized by the fact that they do not define facets of contact, *i.e.* subelements used to calculate an integral on the surface of the crack (*cf.* [D4.10.02], §4.4).

Index on the mesh slave	Description
1	Value of the index of the mesh in the grid
2	Number of the zone to which the mesh belongs
3	Many points of integration *If the element does not contribute to the integrals of contact: 1 is stored*
4	Statute of the enriched mesh • 1: enriched mesh Heaviside, • 2: enriched mesh Ace-Tip, • 3: enriched mesh Heaviside-Ace-Tip. *If the element does not contribute to the integrals of contact: the opposite of the statute is stored. That is to say:* • *-1: enriched mesh Heaviside,* • *-2: enriched mesh Ace-Tip,* • *-3: enriched mesh Heaviside-Ace-Tip.*
5	Value of the index of the crack in the list of the cracks seen by the mesh (object XMAFIS model X-FEM, *cf.* [D4.10.02], §4.6.4)

9 Specific objects for the formulation LIAISON_UNIL

9.1 Object NDIMCU

```
(O) '.UNILATE.NDIMCU'   :    V       I  length = 2
```

Index	Description	Question CUDISI
1	Full number of unilateral connections	NNOCU
2	Full number of ddls implied in the unilateral connections	NCMPG

9.2 Object COEFD

```
(O) '.UNILATE.COEFD'    :    V       Long K8 = NNOCU
```

This object stores the name of the functions giving the coefficient of the unilateral conditions to the member of right-hand side.

9.3 Object LISNOE

```
(O) '.UNILATE.LISNOE'   :    V       I  length = NNOCU
```

This object stores the number of the nodes implied under the unilateral conditions.

9.4 Object POINOE

```
(O) '.UNILATE.POINOE'   :    V       I  length = NNOCU+1
```

This object is used as pointer of access to the objects CMPGCU and COEFG.

Shift JDECMP for the first component of the unilateral condition INO :
JDECMP = ZI (JPOIN+INO-1)

Number NCMP components for implied under the unilateral condition INO :
NCMP = ZI (JPOIN+INO) – ZI (JPOIN+INO-1)

9.5 Objects CMPGCU and COEFG

```
(O) '.UNILATE.CMPGCU'   :    V       Long K8 = NCMPG
(O) '.UNILATE.COEFG'    :    V       Long K8 = NCMPG
```

These objects make it possible to store the degrees of freedom to which apply the unilateral conditions as well as the name of the functions which are the coefficients of these conditions (with the member of left thus).

ICMP- eme component of INO- ème unilateral condition:
CMP = ZK8 (JCMPG+JDECMP-1+ICMP)

Coefficient function of ICMP- eme component of INO- ème unilateral condition:
COEFG = ZK8 (JCOEFG+JDECMP-1+ICMP)

9.6 Object COEFPE

```
(O) '.UNILATE.COEFPE'   :    V       R  length = NNOCU
```

This object stores itS values of the coefficients of penalty.

10 Elementary fields for resolution of the continuous contact

ON describes the routine here `mmchml` who is used to store the specific quantities of the late elements of contact. One distinguishes the quantities specific to the method LAKE and those of the method conti naked.

10.1 Elementary quantities for continuous method resolution: routine `mmchml_c`

It is the field associated with the parameter `'PCONFR'`.

Index field	Description
1(resp 38)	First parametric coordinate of the point slave running (resp. precedent)
2(resp 39)	Second parametric coordinate of the point slave of contact (resp. precedent)
3(resp 40)	First parametric coordinate of the point main project (resp. precedent)
4(resp 41)	Second parametric coordinate of the point main project (resp. precedent)
5(resp 32)	First coordinate first tangent vector in the total reference mark (resp. precedent)
6(resp 33)	Second coordinate first tangent vector in the total reference mark (resp. precedent)
7(resp 34)	Third coordinate first tangent vector in the total reference mark (resp. precedent)
8(resp 35)	First coordinate second tangent vector in the total reference mark (resp. precedent)
9(resp 36)	Second coordinate second tangent vector in the total reference mark (resp. precedent)
10(resp 37)	Third coordinate second tangent vector in the total reference mark (resp. precedent)
11	Weight associated with the point with Gauss
12 (resp 27)	Indicator running (resp. precedent) of contact
13 (resp 26)	Contact pressure (resp. precedent)
14	Additional game of contact
15	Standard algorithm of contact (`STANDARD/PENALISATION`)
16	Coefficient of regularization of contact (`COEF_CONT/COEF_PENA_CONT`)
17	Do not buckle fixes friction
18	Standard algorithm of friction (`STANDARD/PENALISATION`)
19	Coefficient of regularization of friction (`COEF_FROT/COEF_PENA_FROT`)
20	Coefficient of friction
21	Not excluded in friction
22	Dynamics or quasi-static
23	Increment of time
24	Not used
25	Do not buckle fixes geometry
26	Not used
27	Not used
28	Not used
29	Not used

30	Adaptation in cycling
31	Convex coefficient of combination for friction
42	Not used
43	Not used
44	Preceding indicator of adherence
45	Robust mode of adaptive contact: automatic swing in penalization
46	Robust mode of friction only for the adaptive mode : `ALGO_CONT=' PENALISATION'`, `ALGO_FROT=' STANDARD' ADPATATION=' ADAPT_COEF'`.
47	Indicator of adherence in adaptive mode: `ALGO_CONT=' PENALISATION'`, `ALGO_FROT=' STANDARD' ADPATATION=' ADAPT_COEF'`.
48-60	Not used

10.2 Elementary quantities for resolution method LAKE: routine mmchml_l

It is the field associated with the parameter `'PCONFR'`.

Index field	Description
1	Smoothed normal or not
2	Jacobien type
3	Not used
10	State of cycling of the patch
11	Coefficient of intersection of the patch
12 (resp 37)	Statute of contact of the patch (resp. precedent)
13 (resp 38)	Multiplier of Lagrange (resp. precedent)
14	Axis or not?
15	gap_curr
16	Measurement = 0.0
17	rho_n (envisaged for coefficient of regularization) = 0.0
18	eval (envisaged for algorithm of Bussetta) = 0.0
19-24	Not used
25	Buckle geometrical contact
26	Not used

11 Algorithms specific to the treatment of the statutes of contact : continuous method

11.1 Objects specific to cycling

They is the jeveux objects `'CYCHIS','CYCNBR','CYCETA','CYCLIS','CYCCOE'`.
- `'CYCHIS'` is the object which stores the history of the values associated with a point with contact .
- `'CYCLIS'` is the object which is used to make the detection of a cycling statute
- `'CYCNBR'` is the object which account cycles of 3 iterations (statutes varying from 0 1 0 or 1 0 1).
- `'CYCETA'` is the object which stores it state running of cycling at a point of contact .
- `'CYCCOE'` is the object which stores values specific to the coefficients of regularization ofa point of contact .

Index object CYCHIS	Description (For the point of contact)
1	Indicator of current contact
2	Coefficient of contact running
3	Contact pressure running
4	Game running
5	Indicator running of friction
6	Coefficient of friction
7	Pressure current of friction standardized : component 1 in the total reference mark
8	Pressure current of friction standardized : component 2 in the total reference mark
9	Current pressure of friction standardized: component 3 in the total reference mark
10	Current slip of friction : component 1 in the total reference mark
11	Slip running of friction: component 2 in the total reference mark
12	Current slip of friction : component 3 in the total reference mark
13	Tangent current n°1: component n°1 in the total reference mark
14	Tangent current n°1: component n°2 in the total reference mark
15	Tangent current n°1: component n°3 in the total reference mark
16	Tangent current n°2: component n°1 in the total reference mark
17	Tangent current n°2: component n°2 in the total reference mark
18	Tangent current n°2: component n°3 in the total reference mark
19	Coordinate current parametric n°1 of the point of current contact slave
20	Coordinate current parametric n°2 of the point of current contact slave
21	Coordinate current parametric n°1 of the point main project running
22	Coordinate current parametric n°2 point main project running
23	Not used
24	Number running main element paired at the point slave
25	Indicator of preceding contact
26	Coefficient of contact precedent

27	Contact pressure precedent
28	Game precedent
29	Indicator precedent of friction
30	Coefficient of friction precedent
31	Pressure the preceding one of friction standardized : component 1 in the total reference mark
32	Pressure the preceding one of friction standardized: component 2 in the total reference mark
33	Pressure the preceding one of friction standardized: component 3 in the total reference mark
34	Slip precedent of friction : component 1 in the total reference mark
35	Slip precedent of friction: component 2 in the total reference mark
36	Slip precedent of friction : component 3 in the total reference mark
37	Tangent precedentE n°1: component n°1 in the total reference mark
38	Tangent the preceding one n°1: component n°2 in the total reference mark
39	Tangent the preceding one n°1: component n°3 in the total reference mark
40	Tangent the preceding one n°2: component n°1 in the total reference mark
41	Tangent the preceding one n°2: component n°2 in the total reference mark
42	Tangent the preceding one n°2: component n°3 in the total reference mark
43	Coordinates the preceding one parametric n°1 of the point of current contact slave
44	Coordinates the preceding one parametric n°2 of the point of current contact slave
45	Coordinates the preceding one parametric n°1 of the point main project running
46	Coordinates the preceding one parametric n°2 point main project running
47	Number precedent main element running
48	Number precedent main element paired at the point slave
50	Cycling friction actiF : 1 yes 0 not
51	Robust mode of contact: swing in penalization
52	Robust mode of friction: swing in penalization
53	Non Utilisé
54	Choice of `alpha` for vectors of friction
55	Choice of `alpha` for the matrices of friction
56	Choice of `alpha` for vectors of contact
57	Cycling contact actiF : 1 yes 0 not
58	Non Utilisé
59	Choice of `alpha` for the matrices of contact
60	Not uses
61	Coordinates current point slave in physical space: component n°1
62	Coordinates current point slave in physical space: component n°2
63	Coordinates current point slave in physical space: component n°3
64	Coordinates current main point in physical space: component n°1
65	Coordinates current main point in physical space: component n°2
66	Coordinates current main point in physical space: component n°3

67	Coordinates the preceding one point slave in physical space: component n°1
68	Coordinates the preceding one point slave in physical space: component n°2
69	Coordinates the preceding one point slave in physical space: component n°3
70	Coordinates the preceding one main point in physical space: component n°1
71	Coordinates the preceding one main point in physical space: component n°2
72	Coordinates the preceding one main point in physical space: component n°3

The detection of cycling proceeds on 3 iterations of Newton.

Index object `CYCLIS`	**Description (For the point of contact)**
1	Coded entirety $\text{cycl\_ecod}=2^0*statut(It_{k-2})+2^1*statut(It_{k-1})+2^2*statut(It_k)$ for cycling in contact. For example: if the point oscillated in statutes of contact: 101 then cycl_ecod=5, 010 then cycl_ecod=2.
2	Coded entirety for cycling adherence-slip
3	Coded entirety for cycling slip before – back slip
4	Flip Flop

Index object `CYCNBR`	**Description (For the point of contact)**
1	Counting of a cycle of oscillation for the contact. After 3 iterations of Newton, the meter goes back to zero
2	Counting of a cycle of oscillation for cycling adhérence-slip
3	Counting of a cycle of oscillation for cycling slip before – back slip
4	Flip Flop

Index object `CYCETA`	**Description (For the point of contact)**
1	Safeguard of the state of cycling of contact point. It is the effective detection of the cycling which occurs all the 3 iterations of Newton. If a point is detected as cycling then it is kept as cycling until it stabilizes in statutes.
2	Safeguard of the state of cycling adhérence-slip
3	Safeguard of the state of cycling slip before – back slip
4	Flip Flop

11.2 The algorithm of cycling : `ALGO_CONT=STANDARD/PENALISATION`

The algorithm will adapt the calculation of the matrices of contact-friction following the cases of cycling . It also makes it possible to make the heuristic particular ones (case of the flip-flop) to help with convergence on the statutes of contact. Method also allows to make an optimal research of the coefficient of It is also in this routine that one makes sure of the convergence of the loop on the statutes.

Principle n°1 : To make a convex combination of the current elementary matrices + the preceding ones. standard CAS-test shaving contact : ssnv128z

$$MATRCF[It_K]=ALPHA*MATRCF[It_{K-1}]+(1-ALPHA)*MATRCF[It_K]$$

Here $MATRCF$ is the elementary matrix associated with the point of contact current slave with $alpha<1$.

When does one make adaptation of the matrices of contact-friction?

CA 1: adaptation = ‘CYCLWithGE' + Some is ALGO_CONT/ALGORITHME_FROT

CA 2: adaptation = ‘ALL’ + NEWT_FROT, type_adap=5

CA 3: adaptation = ‘ALL’ + NEWT_FROT, ALGO_CONT = PENALIZATION

CA 4: adaptation = ‘ALL’ + POINT_FIXE_FROT OR NOT OF FROT + ALGO_CONT = PENALIZATION

CA 5: all other cases of the moment or adaptation = ‘ALL’ type_adap=4

To detect a statute cycling in contact, one makes a zoning of the law of contact of Signorini:

- Zone 1: The point of contact slave has a contact pressure and a game such as it is in situation of frank separation with the main body.

- Zone 2: The point of contact slave has a contact pressure and a game such as it is in situation of nonfrank separation with the main body.

- Zone 3: The point of contact slave has a contact pressure and a game such as it is in situation of contact shaving with the main body.

- Zone 4: The point of contact slave has a contact pressure and a game such as it is in situation of frank contact with the main body.

Statutes of cycling of contact of a point slave itsT itS according to:

- Object `CYCETA//CONTACT//cycl_stat = 11` the point oscillated between zone 3 and zones it 2, it is the shaving zone. It is one of the situations more penalizing.

- Object `CYCETA//CONTACT//cycl_stat = 12` the point oscillated between zone 2 and zones it 4, the contact has evil to be established.

- Object `CYCETA//CONTACT//cycl_stat = 13` the point oscillated between zone 1 and zones it 3, separation has evil to be established.

- Object `CYCETA//CONTACT//cycl_stat = 14` the point oscillated between zone 1 and zones it 4, the point is not stable in contact.

- Object `CYCETA//CONTACT//cycl_stat = 15` all other cases of cycling. For example, one maintains the statute cycling until the point converged in statutes.

- Object `CYCETA// CONTACT //cycl_stat = 10` all other cases.

- `CYCETA// CONTACT // FLIP-FLOP` The Flip-flop is a particular mode of detection of cycling in statute of contact. It is about a point which cycles or not and which moreover has very a low pressure of contact. Here the concept of counting periodic on 3 iterations of Newton disappears. It is known just that the statute of preceding contact is not pas le even as that running. The pressure is known as low if the value of the current pressure is 1.D-6 time lower than the average of contact pressures of all the zones.

The detection of member-slipping cycling is made only if the point of contact remained stable in statute of contact on 3 iterations and that the point running is really in contact. If these two conditions are met then, the zoning of the law of Coulomb is done as follows:

- Zone 1: The point of contact slave has a pressure of friction below threshold of Coulomb and a slip such as it is in situation of adherence in a frank way.

- Zone 2: The point of contact slave has a pressure of friction close to the threshold of Coulomb such as it is in situation of adherence with weak potential slip.

- Zone 3: The point of contact slave has a pressure of friction close to the threshold of Coulomb and a slip quasi-no one such as it is in situation of adherence potential.

- Zone 4: The point of contact slave has a contact pressure and a game such as it is in situation of frank contact with the main body.

Statutes of cycling of friction adherence-slip of a point slave itsT itS according to:

- Object `CYCETA//ADHE_GLIS//cycl_stat = 11` the point oscillated between zone 3 and zones it 2, it is one of the situations more penalizing owing to the fact that the point has much evil to be stabilized.

- Object `CYCETA//ADHE_GLIS//cycl_stat = 12` the point oscillated between zone 1 and zones it 3, case where adherence has evil to be established.

- Object `CYCETA//ADHE_GLIS//cycl_stat = 13` the point oscillated between zone 2 and zones it 4, the point has evil to establish a slip in a frank way.

- Object `CYCETA//ADHE_GLIS//cycl_stat = 14` the point oscillated between zone 1 and zones it 4, the point is not stable in adherence-slip.

The detection of cycling front slip- glissement postpones is made only if the point of contact remained stable in statute of contact and not of adherence-slip on 3 iterations and that the point running is really in contact. If these three conditions are met then one uses the scalar product between the vector slip before and the back vector slip to determine the cycling statute.

- Object `CYCETA//GLIAV_GLIAR//cycl_stat = 11` the point is oscillating very slightly around an adherent stable position.

- Object `CYCETA//GLIAV_GLIAR//cycl_stat = 12` the point is oscillating around an adherent stable position with a great slip follow-up of small slips.

- Object `CYCETA//GLIAV_GLIAR//cycl_stat = 13` the point is oscillating around an adherent stable position with great slips

Principle n° 2 : Optimal research of the coefficient of contact for the penalization . standard CAS-test : ssnv128y

Principle n° 3 : Case specific to the geometrical flip-flop/statute of contact . standard CAS-test ssnv504 H, K