Macro-order CALC_ESSAI_GEOMECA

1 Goal

This macro-order makes it possible to simulate for a material point various ways of loading characteristic of tests géomechanics, and post-to treat the got results. The user provides as starter the behavior, the material, as of the parameter lists of loading which correspond to several occurrences of the same test. The tests available are the following:

- drained monotonous triaxial compression test
- monotonous triaxial compression test not drained
- drained cyclic shear test
- cyclic triaxial compression test not drained
- drained cyclic triaxial compression test alternate
- drained cyclic triaxial compression test nonalternate
- drained cyclic test oedometric
- test of isotropic compression cyclic drained

Product of the curves to the format xmgrace and/or the structures of data `table`.

Contents

2 Syntax

The syntax of names of test is written as follows:

$$\text{ESSAI\_}\underbrace{XXXX}_{A}\_\underbrace{XX}_{B}\_\underbrace{X}_{C}\_\underbrace{X}_{D}$$

with A indicate the type of test:

```
WITH = |  SORTED    triaxial compression test
     |  CISA    shear test
     |  OEDO    test oedometric
     |  ISOT    isotropic test
```

and B, C and D conditions of test:

```
B = |  DR.      drained test
    |  ND       test not drained

C = |  M        monotonous test
    |  C        cyclic test

D = |  D        test with imposed deformation
    |  F        test with imposed force
```

```
CALC_ESSAI_GEOMECA(

♦   MATER       = chechmate ,                              [to
subdue]
♦   BEHAVIOR= _F (see the document [U4.51.11]),
◊   CONVERGENCE = _F (
       ◊ RESI_GLOB_RELA     = 1.E-6,                  [DEFECT]
       ◊ | RESI_GLOB_MAX    = LMBOi_maxI,             [R]
         | RESI_GLOB_RELA   = LMBOi_relhas,                [R]
       ◊ ITER_GLOB_MAXI     = | 10,                 [DEFECT]
                              | nb_iter,            [I]
                   ),
```

 # Drained monotonous triaxial compression test with imposed deformation :

```
♦   |   ESSAI_TRIA_DR_M_D = _F (
           ♦  PRES_CONF   = l_sigma_conf,           [l_R]
           ♦  EPSI_IMPOSE = l_epsi_Impo,            [l_R]
           ◊  KZERO       = | 1. ,                      [DEFECT]
                            | kzero,                    [R]
           ◊   NB_INST     = | 100,                     [DEFECT]
                            | nbinst,               [I]
           ◊  TABLE_RESU  = l_tabres,               [l_CO]
           ◊  GRAPH   = | (‘P-Q’, ‘EPS_AXI-Q’, ‘EPS_AXI-EPS_VOL’,
                              ‘P-EPS_VOL’),         [DEFECT]
                        | l_graphic,                [l_Kn]
          ◊  NAME_CMP     = l_component,            [l_Kn]
           ◊  TABLE_REF   = l_tabref,               [l_table]
           ◊  PREFIXE_FICHIER = prefix,             [KN]
           ◊  COLOR     = l_color,             [l_I]
           ◊  MARKER    = l_marker,            [l_I]
           ◊  STYLE       = l_style,                    [l_I]
                              ),
```

 # Monotonous triaxial compression test not drained with imposed deformation :

```
|   ESSAI_TRIA_ND_M_D = _F (
        ♦  PRES_CONF   = l_sigma_conf,              [l_R]
        ♦  EPSI_IMPOSE = l_epsi_Impo,               [l_R]
        ◊  BIOT_COEF   = | 1. ,                         [DEFECT]
                         | biot,                        [R]
        ◊  KZERO       = | 1. ,                         [DEFECT]
                         | kzero,                       [R]
        ◊  NB_INST     = | 100,                     [DEFECT]
                         | nbinst,                  [I]
        ◊  TABLE_RESU  = l_tabres,                  [l_CO]
        ◊  GRAPH   = | ('P-Q', 'EPS_AXI-Q',
                         'EPS_AXI-PRE_EAU'),        [DEFECT]
                     | l_graphic,                   [l_Kn]
        ◊  NAME_CMP     = l_component,              [l_Kn]
        ◊  TABLE_REF   = l_tabref,                  [l_table]
        ◊  PREFIXE_FICHIER = prefix,                [KN]
        ◊  COLOR      = l_color,                 [l_I]
        ◊  MARKER     = l_marker,                [l_I]
        ◊  STYLE        = l_style,                      [l_I]
                 ),
```

 # Drained cyclic shear test with imposed deformation :

```
|   ESSAI_CISA_DR_C_D = _F (
        ♦  PRES_CONF    = l_sigma_conf,                 [l_R]
        ♦  GAMMA_IMPOSE = l_gamma_impo,                 [l_R]
        ♦  NB_CYCLE     = nbcyc,                        [I]
        ◊  TYPE_CHARGE  = | 'SINUSOIDAL'   ,            [DEFECT]
                          | ' TRIANGULAR ',
        ◊  GAMMA_ELAS   = | 1.E-7 ,                 [DEFECT]
                          | gamma_elas,                 [R]
        ◊  KZERO        = | 1. ,                        [DEFECT]
                          | kzero,                  [R]
        ◊  NB_INST      = | 25 ,                        [DEFECT]
                          | nbinst,                 [I]
        ◊  TABLE_RESU    = l_tabres,                [l_CO]
        ◊  GRAPH    = | ('GAMMA- SIG_XY', 'GAMMA-G_SUR_GMAX',
                          'GAMMA-DAMPING',
                          'G_SUR_GMAX- DAMPING'), [DEFECT]
                      | l_graph ic ,                [l_Kn]
        ◊  NAME_CMP     = l_component,              [l_Kn]
        ◊  TABLE_REF     = l_tabref,                [l_table]
        ◊  PREFIXE_FICHIER = prefix,                [KN]
        ◊  COULEUR_NIV1  = l_couleur_niv1,          [l_I]
        ◊  MARQUEUR_NIV1 = l_marqueur_niv1,             [l_I]
        ◊  STYLE_NIV1    = l_style_niv1,                [l_I]
        ◊  COULEUR_NIV2  = l_couleur_niv2,          [l_I]
        ◊  MARQUEUR_NIV2 = l_marqueur_niv2,             [l_I]
        ◊  STYLE_NIV2    = l_style_niv2,                [l_I]
                           ),
```

 # Cyclic triaxial compression test not drained with imposed force :

```
|   ESSAI_TRIA_ND_C_F = _F (
        ♦  PRES_CONF   = l_sigma_conf,              [l_R]
        ♦  SIGM_IMPOSE = l_sigmy_impo,              [l_R]
        ♦  NB_CYCLE    = nbcyc,                     [I]
            ♦  UN_SUR_K     = unsurk,                   [R]
```

```
♦  CRIT_LIQUEFACTION  = ('RU_MAX', 'EPSI_ABSO_MAX',
                         'EPSI_RELA_MAX') ,
♦  VALE_CRIT           = l_vale,                  [l_R]
◊  ARRET_LIQUEFACTION = | 'YES'    ,              [DEFECT]
                        | ' NOT ',
◊  TYPE_CHARGE  = | 'SINUSOIDAL'   ,              [DEFECT]
                  | ' TRIANGULAR ',
◊  KZERO        = | 1. ,                          [DEFECT]
                  | kzero,                     [R]
◊  NB_INST      = | 25 ,                          [DEFECT]
                  | nbinst,                    [I]
◊  NB_INST_MONO = | 400 ,                      [DEFECT]
                  | nbinst_mono,               [I]
◊  BIOT_COEF    = | 1. ,                          [DEFECT]
                  | biot,                         [R]
◊  TABLE_RESU    = l_tabres,                   [l_CO]
◊  GRAPH    = | ('P-Q', 'SIG_AXI-PRE_EAU',
                 'SIG_AXI-RU', 'EPS_AXI-PRE_EAU',
                 'EPS_AXI-Q', 'EPS_AXI-RU',
                 'NCYCL-DSIGM'),           [DEFECT]
              | l_graphic,           [l_Kn]
◊  NAME_CMP     = l_component,                 [l_Kn]
◊  TABLE_REF     = l_tabref,                   [l_table]
◊  PREFIXE_FICHIER = prefix,                   [KN]
◊  COULEUR_NIV1  = l_couleur_niv1,             [l_I]
◊  MARQUEUR_NIV1 = l_marqueur_niv1,               [l_I]
◊  STYLE_NIV1    = l_style_niv1,                  [l_I]
◊  COULEUR_NIV2  = l_couleur_niv2,             [l_I]
◊  MARQUEUR_NIV2 = l_marqueur_niv2,               [l_I]
◊  STYLE_NIV2    = l_style_niv2,                  [l_I]
      ),
```

Drained cyclic triaxial compression test with imposed deformation :

```
|   ESSAI_TRIA_DR_C_D = _F (
        ♦  PRES_CONF   = l_sigma_conf,             [l_R]
        ♦  EPSI_MAXIMUM   = l_epsi_maxi_impo,         [l_R]
        ♦  EPSI_MINIS   = l_epsi_mini_impo,           [l_R]
        ♦  NB_CYCLE    = nbcyc,                    [I]
        ◊  EPSI_ELAS   = | 1.E-7 ,                 [DEFECT]
                         | epselas,                [R]
        ◊  TYPE_CHARGE = | 'SINUSOIDAL',              [DEFECT]
                         | ' TRIANGULAR ',
        ◊  KZERO       = | 1. ,                       [DEFECT]
                         | kzero,                     [R]
        ◊  NB_INST     = | 25 ,                    [DEFECT]
                         | nbinst,                 [I]
        ◊  TABLE_RESU   = l_tabres,                [l_CO]
        ◊  GRAPH    = | ('P-Q', 'EPS_AXI-Q', 'EPS_VOL-Q',
                         'EPS_AXI-EPS_VOL', 'P-EPS_VOL',
                         'DEPSI-E_SUR_EMAX',
                         'DEPSI-DAMPING'),    [DEFECT]
                      | l_graphic,                 [l_Kn]
        ◊  NAME_CMP     = l_component,             [l_Kn]
        ◊  TABLE_REF     = l_tabref,               [l_table]
        ◊  PREFIXE_FICHIER = prefix,               [KN]
        ◊  COULEUR_NIV1  = l_couleur_niv1,         [l_I]
        ◊  MARQUEUR_NIV1 = l_marqueur_niv1,           [l_I]
```

```
        ◊  STYLE_NIV1    = l_style_niv1,                  [l_I]
        ◊  COULEUR_NIV2  = l_couleur_niv2,            [l_I]
        ◊  MARQUEUR_NIV2 = l_marqueur_niv2,               [l_I]
        ◊  STYLE_ NIV2    = l_ style_ niv2 ,              [l_ I ]
                   ),
```

 # Cyclic triaxial compression test not drained with imposed deformation :

```
  |   ESSAI_TRIA_ND_C_D = _F (
        ♦  PRES_CONF    = l_sigma_conf,               [l_R]
        ♦  EPSI_MAXIMUM   = l_epsi_maxi_impo,             [l_R]
        ♦  EPSI_MINIS   = l_epsi_mini_impo,              [l_R]
        ♦  NB_CYCLE     = nbcyc,                      [I]
        ◊  EPSI_ELAS    = | 1.E-7 ,                   [DEFECT]
                          | epselas,                  [R]
        ◊  RU_MAX       = | 0.8 ,                     [DEFECT]
                          | crit_liquefaction ,       [R]
        ◊  TYPE_CHARGE = |  'SINUSOIDAL',                 [DEFECT]
                          | ' TRIANGULAR ',
        ◊  KZERO        = | 1. ,                          [DEFECT]
                          | kzero,                        [R]
        ◊  NB_INST      = | 25 ,                      [DEFECT]
                          | nbinst,                   [I]
        ◊ TABLE_RESU    = l_tabres,                   [l_CO]
        ◊ GRAPH     = | ('NCYCL-DEPSI', 'DEPSI-RU_MAX',
                            'DEPSI-E_SUR_EMAX', 'DEPSI-DAMPING',
                            'P-Q', 'EPS_AXI-EPS_VOL'
                            'EPS_AXI-Q', 'P-EPS_VOL',
                            'EPS_AXI-PRE_EAU', 'EPS_AXI-RU',
                            'P-PRE_EAU'),             [DEFECT]
                          | l_graphic,                [l_Kn]
         ◊  NAME_CMP     = l_component,               [l_Kn]
        ◊ TABLE_REF     = l_tabref,                   [l_table]
        ◊  PREFIXE_FICHIER = prefix,                  [KN]
        ◊  COULEUR_NIV1  = l_couleur_niv1,            [l_I]
        ◊  MARQUEUR_NIV1 = l_marqueur_niv1,               [l_I]
        ◊  STYLE_NIV1    = l_style_niv1,                  [l_I]
        ◊  COULEUR_NIV2  = l_couleur_niv2,            [l_I]
        ◊  MARQUEUR_NIV2 = l_marqueur_niv2,               [l_I]
        ◊  STYLE_NIV2    = l_style_niv2,                  [l_I]
                   ),
```

 # Test oedom é cyclic cudgel drained with imposed force :

```
  |   ESSAI_OEDO_DR._C_F = _F (
        ♦  PRES_CONF    = l_sigma_conf,               [l_R]
        ♦  SIGM_IMPOSE = l_sigmy_impo,                [l_R]
        ♦  SIGM_DECH    = l_sigmy_discharge,              [l_R]
        ◊  TYPE_CHARGE = |  'SINUSOIDAL',                 [DEFECT]
                          | ' TRIANGULAR ',
        ◊  KZERO        = | 1. ,                          [DEFECT]
                          | kzero,                        [R]
        ◊  NB_INST      = | 25 ,                      [DEFECT]
                          | nbinst,                   [I]
        ◊ TABLE_RESU    = l_tabres,                   [l_CO]
        ◊ GRAPH     = | ('P-EPS_VOL',
                            'SIG_AXI-EPS_VOL'),       [DEFECT]
                          | l_graph ic ,                  [l_Kn]
```

```
            ◊  NAME_CMP     = l_component,           [l_Kn]
            ◊ TABLE_REF    = l_tabref,               [l_table]
            ◊  PREFIXE_FICHIER = prefix,             [KN]
            ◊  COLOR      = l_color,               [l_I]
            ◊  MARKER     = l_marker,              [l_I]
            ◊  STYLE        = l_style,               [l_I]
                              ),
```

Cyclic isotropic compression test drained with imposed force :

```
  |   ESSAI_ISOT_DR_C_F = _F (
            ♦  PRES_CONF   = l_sigma_conf,           [l_R]
            ♦  SIGM_IMPOSE = l_sigmy_impo,           [l_R]
            ♦  SIGM_DECH   = l_sigmy_discharge,        [l_R]
            ◊  TYPE_CHARGE = | 'SINUSOIDAL',           [DEFECT]
                             | 'TRIANGULAR ',
            ◊  NB_INST     = | 25 ,                  [DEFECT]
                             | nbinst,               [I]
            ◊ TABLE_RESU   = l_tabres,               [l_CO]
            ◊ GRAPH    = | ('P-EPS_VOL'),          [DEFECT]
                             | l_graph ic ,            [l_Kn]
            ◊  NAME_CMP     = l_component,           [l_Kn]
            ◊ TABLE_REF    = l_tabref,               [l_table]
            ◊  PREFIXE_FICHIER = prefix,             [KN]
            ◊  COLOR      = l_color,               [l_I]
            ◊  MARKER     = l_marker,              [l_I]
            ◊  STYLE        = l_style,               [l_I]
                                ),

◊   INFORMATION = | 1,
    [DEFECT]
           | 2, );
```

3 Opérandes

3.1 Operand MATER

♦ MATER = chechmate [to subdue]

This keyword makes it possible to inform the name of material defined by DEFI_MATERIAU [U4.43.01], where are provided the parameters necessary to the selected behavior.

3.2 Word-key BEHAVIOR

The syntax of this keyword is described in the document [U4.51.11].
In the framework of this macro-order, the use of the operand RELATION keyword BEHAVIOR is limited to the elastoplastic laws of ground following:

- 'MOHR_COULOMB'
- 'CAM_CLAY'
- 'CJS'
- 'DRUCK_PRAGER'
- 'DRUCK_PRAG_N_A'
- 'HUJEUX'
- 'IWAN'
- 'MFRONT'

3.3 Keyword CONVERGENCE

◊ CONVERGENCE = _F ()

If none of the two operands following is present, then all occurs like if: RESI_GLOB_RELA = 1.E-6

3.3.1 Operand RESI_GLOB_RELA/RESI_GLOB_MAXI

◊ | RESI_GLOB_RELA = LMBOi_relhas [R]

The algorithm continues the total iterations as long as:

$$\max_{i=1,nbddl} |F_i^n| > \text{resi\_rela} \times \max|L|$$

where F^n is the residue of the iteration n and L the vector of the imposed loading and the reactions of supports (cf [R5.03.01] for more details).

When the loading and the reactions of support become worthless, i.e. when L is null (for example in the case of a total discharge), one tries to pass from the relative convergence criteria RESI_GLOB_RELA with the absolute convergence criteria RESI_GLOB_MAXI. This operation is transparent for the user (message of alarm emitted in the file .mess). When the vector L becomes again different from zero, one passes by again automatically with the relative convergence criteria RESI_GLOB_RELA.
However, this mechanism of swing cannot function with the first step of time. Indeed, to find a value of RESI_GLOB_MAXI reasonable in an automatic way (since the user did not inform it), one needs to have had at least a step converged on mode RESI_GLOB_RELA . Consequently, if the loading is null as of the first moment, calculation stops. The user must already then check that the null loading is normal from the point of view of the modeling which it carries out, and if such is the case, to find another convergence criteria (RESI_GLOB_MAXI for example).

If this operand is absent, the test is carried out with the value by default, except if RESI_GLOB_MAXI is present.

◊ | RESI_GLOB_MAXI = LMBOi_maxI [R]

The algorithm continues the total iterations as long as:

$$\max_{i=1,nbddl} |F_i^n| > \text{resi\_maxi}$$

where F^n is the residue of the iteration n (Cf. [R5.03.01] for more details). If this operand is absent, the test is not carried out.

If RESI_GLOB_RELA and RESI_GLOB_MAXI both are present, the two tests are carried out.

3.3.2 Operand ITER_GLOB_MAXI

```
◊   ITER_GLOB_MAXI = | 10                    [DEFECT]
                     | nb_iter
```

Maximum iteration count carried out to solve the total problem at every moment.

3.4 Word key ESSAI_TRIA_DR_M_D

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same drained triaxial compression test montone with imposed deformation for which one varies the parameters of loading (confining pressure and axial deformation imposed), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.4.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.
This convention applies D E m ême on the variables of predefined exits of which complete listing for this test is the following one:

- INST : moment
- EPS_AXI : axial deformation
- EPS_LAT : lateral distortion
- EPS_VOL : voluminal deformation
- SIG_AXI : axial effective constraint
- SIG_LAT : side effective constraint
- P : average effective constraint
- Q : diverter of the constraints

On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.4.6).

3.4.2 Operands PRES_CONF, EPSI_IMPOSE, NB_INST

```
♦   PRES_CONF   = l_sigma_idiotF       [l_R]
♦   EPSI_IMPOSE = l_epsi_Impo          [l_R]
◊   NB_INST     = | 100                [DEFECT]
                  | nbinst             [I]
```

The operand PRES_CONF allows to define the list of the confining pressures which will be kept with the course of each test. In the same way the operand EPSI_IMPOSE allows to define the list of the end values of the loading of compression (slope of imposed axial deformation).
For this test, one makes correspond to each confining pressure an end value for slope of axial deformation (see figure 3.4.2-a) : lists PRES_CONF and EPSI_IMPOSE must

thus have even cardinal. This cardinal corresponds to the number of simulations which will be carried out under this keyword factor.
Constraints and deformations being counted positivement in compression, values indicated for `PRES_CONF` must be strictly positives. Values indicated in `EPSI_IMPOSE` are strictly positive or negative, a negative value indicating a loading in extension.

The operand `NB_INST` allows to define the temporal discretization of the loading (see figure 3.4.2-a) , with a value by default of 100 pas de loading during the slope.

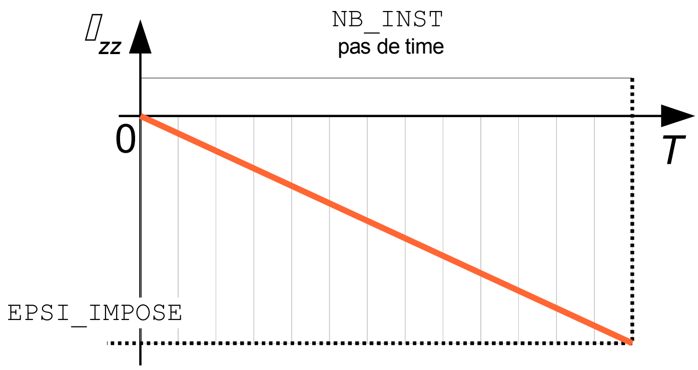

Figure 3.4.2-a: discretization and pace of the loading for the keywords `ESSAI_TD` and `ESSAI_TND`

3.4.3 Operand `KZERO`

```
◊  KZERO = | 1              [DEFECT]
           | kzero          [R]
```

Valor of the coefficient of the grounds at rest, allows to define an anisotropic state of containment: $\sigma_{xx}=\sigma_{yy}=K_0\sigma_{zz}=K_0\times\text{PRES\_CONF}$

Note: When the value of `KZERO` is well informed different from 1, the real confining pressure of the test is not more `PRES_CONF` , it becomes:

$$P_c=\frac{1+2K_0}{3}\times\text{PRES\_CONF}$$

3.4.4 Operand `TABLE_RESU`

```
◊   TABLE_RESU = l_tabres          [l_CO ]
```

This operand optional makes it possible to give the list of the names of the concepts produced by the macro-order which will be then of type `[table]` . Each produced table contains the gross profits and post-treaties of a simulation of test: the list `TABLE_RESU` must thus have even cardinal that the lists `PRES_CONF` and `EPSI_IMPOSE` .
The title of each produced table is supplemented by the macro-order, it understands:
- the name of the keyword factor (here `ESSAI_TRIA_DR_M_D`) and its number of occurrence (this one being répétable);
- the couple of values `(PRES_CONF, EPSI_IMPOSE)` characterizing it loading of the test;

Example :

```
TABRES1 =CO ('TRES1')
TABRES2 =CO ('TRES2')
TABRES3 =CO ('TRES3')
```

```
CALC _ ESSAI_GEOMECA (
…
   ESSAI_TRIA_DR_M_D = _F (
                  PRES_CONF   = (- 1.E4, -1.5E4, -2.E4) ,
                  EPSI_IMPOSE = (- 1.E-2, -1.E-2, -1.E-2) ,
                  TABLE_RESU  = ( TABRES1, TABRES2, TABRES3 ), ),
                          );
```

TABRES1 , TABRES2 , and TABRES3 are successively filled according to the order of the lists PRES_CONF and EPSI_IMPOSE , the table below specifies the test results contained in each table.

EPSI_IMPOSE / PRES_ CONF	-1.0E-2	-1.0E-2	-1.0E-2
-1.0E4	TABRES1		
-1.5E4		TABRES2	
-2. 0 E4			TABRES3

3.4.5 Operand GRAPH, PREFIXE_FICHIER

```
◊  GRAPH = | ('P-Q', 'EPS_AXI-Q', 'EPS_AXI-EPS_VOL',
                 'P-EPS_VOL')             [DEFECT]
             | l_graphic                  [l_Kn]
```

This operand makes it possible to specify the types of the graphs produced by the macro-order. These graphs recapitulate the results of the simulations carried out under the keyword current factor. U do not list by default is proposed. However, it is possible to go up an unspecified graph by giving the desired combinations of existing components in l_graphic , form: ABSC-ORDO . The indent "-" allows to separate the component requested in X-coordinate from that requested in ordinate.

Example :

```
l_graphic = ('P-Q', 'EPS_AXI-Q', 'INST-EPS_VOL', 'INST-V23')
```

The not-preset component V23 (corresponding to the plastic voluminal deformation of the law of Hujeux) must be declared in NOM_CMP (**§3.4.6**) to be taken into account. In the contrary case, the required graph did not go up.
As for the predefined components whose complete listing is given in **§3.4.1**, they will be possibly displayed with the convention of sign of the geomecanicians, i.e. with positive values in compression.
In addition, all the components required for graphic construction will be displayed in the tables of exits (**§3.4.4**).

The files containing these graphs are written with the format xmgrace in the same repertoire specified by the user (standard repe as a result in astk), and are named in the following way:

```
'prefix' _ ' nom_essai ' _ ' numéro_occurrence ' _ ' absc-ordo ' . agr
```

A prefix can be added in the name of the output file thanks to the optional keyword:

```
◊  P REFIXE_FICHIER = prefix              [ KN ]
```

3.4.6 Operand NOM_CMP

```
◊  NAME _CMP     = l_ component                   [l_Kn]
```

list of the not-preset components requested at exit. They are all the existing components contained in the fields SIGM, EPSI and VARI products by calculation. These not-preset components will be produced with the convention of sign by default, i.e. with negative values in compression.
The nonexisting components are ignored.

3.4.7 Operand TABLE_REF

```
◊   TABLE_REF = l_tabreF            [l_table]
```

This operand makes it possible to inform curves of reference (for example, experimental) tabulées and stored in the form of tables, in order to superimpose them on the curves resulting from the simulations carried out under the keyword current factor. These curves of reference are then included in the files produced by the keyword GRAPH .
Each table contained in the list TABLE_REF must be created as a preliminary using the operator CREA_TABLE [U4.33.02], and formatted in the following way:

```
tabref = CREA_TABLE (
   LIST = (_F (PARA = 'STANDARD',     LISTE_K = [typgraph,]),
             _F (PARA = 'LEGEND',  LISTE_K = [malegend,]),
             _F (PARA = 'X-COORDINATE', LISTE_R = l_absc),
             _F (PARA = 'ORDERED', LISTE_R = l_ordo),),);
```

with:

- typgraph a character string whose value belongs obligatorily to the list of values by default of the keyword GRAPH. This value makes it possible to identify the type of graph (and thus the file) to which the curve of reference must be added.
- malegend a character string which contains the legend associated with the curve with reference
- l_absc and l_ordo are lists python of real respectively containing the X-coordinates and the ordinates of the points of the curve of reference. These lists must thus have even cardinal

3.4.8 Operands COLOR, MARKER, STYLE

```
◊  COLOR   = l_ color              [l_ I ]
◊   MARKER  = l_ marker            [l_ I ]
◊   STYLE     = l_ style              [l_ I ]
```

ItS operands accept a list of entireties making it possible respectively to define the color, the type of marker and the style of the curves displayed in the graphs. The data by each entirety is given in documentation on XMGRACE U2.51.01. The length of the list must be equal to that of PRES_CONF.

3.5 Word key ESSAI_TRIA_ND_M_D

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same triaxial compression test not drained monotonous with imposed deformation (one supposes total saturation) for which one varies the parameters of loading (confining pressure and axial deformation imposed), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.5.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.
This convention applies D E m ême on the variables of predefined exits of which complete listing is the following one:

- INST : moment
- EPS_AXI : axial deformation
- EPS_LAT : lateral distortion
- EPS_VOL : voluminal deformation
- SIG_AXI : axial effective constraint
- SIG_LAT : side effective constraint
- P : average effective constraint
- Q : diverter of the constraints
- PRE_EAU : pore water pressure

On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.5.7).

3.5.2 Operands PRES_CONF, EPSI_IMPOSE, NB_INST

```
♦   PRES_CONF   = l_sigma_idiotF        [l_R]
♦   EPSI_IMPOSE = l_epsi_Impo           [l_R]
◊   NB_INST     = | 100                 [DEFECT]
                  | nbinst              [I]
```

Idem that with § 3.4.2 .

3.5.3 Operand BIOT_COEF

```
◊   BIOT_COEF = | 1                 [DEFECT]
                | biot              [R]
```

Value of the coefficient of Biot.

3.5.4 Operand KZERO

```
◊  KZERO = | 1                   [DEFECT]
           | kzero           [R]
```

Idem that with the §3.4.3.

3.5.5 Operand TABLE_RESU

```
◊   TABLE_RESU = l_tabres           [l_CO ]
```

Idem that with § 3.4.4 .

3.5.6 Operand GRAPH, PREFIXE_FICHIER

```
◊   GRAPH = | ('P-Q', 'EPS_AXI-Q',
                 'EPS_AXI-PRE_EAU')              [DEFECT]
              | l_graphic                 [l_Kn]
```

◊ PREFIXE_FICHIER = prefix [KN]

Idem that with the §3.4.5.

3.5.7 Operand NOM_CMP

◊ NAME _CMP = l_ component [l_Kn]

Idem that with the §3.4.6.

3.5.8 Operand TABLE_REF

◊ TABLE_REF = l_tabreF [l_table]

Idem that with §3.4.7.

3.5.9 Operands COLOR, MARKER, STYLE

◊ COLOR = l_ color [l_ I]
◊ MARKER = l_ marker [l_ I]
◊ STYLE = l_ style [l_ I]

Idem that with the §3.4.8.

3.6 Word key ESSAI_CISA_DR._C_D

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same drained cyclic shear test with shearing strain imposed for which one varies the parameters of loading (confining pressure, amplitude of shearing strain and many cycles), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.6.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.
This convention applies DE même on the predefined variables of exit. On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.6.7).
In this test, one distinguishes the variables from exit predefined of level 2 which corresponds to the variables produced by the test whose complete listing is the following one:

- INST : moment
- GAMMA : deformation of shearing $\gamma = 2\epsilon_{xy}$
- SIG_XY : shear stress

And predefined variables of exit of level 1 which corresponds to curves whose points represent the result of a test (e.g. the curve $\frac{G}{G_{\max}} - \gamma$) . L has complete listing variables of level 1 is the following one:

- G_SUR_GMAX : $\frac{G}{G_{\max}}$
- DAMPING : damping hysteretic $\frac{\Delta W}{\pi W}$

3.6.2 Operands PRES_CONF, GAMMA_IMPOSE, NB_CYCLE, NB_INST, TYPE_CHARGE

```
♦   PRES_CONF     = l_sigma_conf          [l_R]
♦   GAMMA_IMPOSE  = l_gamma_impo          [l_R]
♦   NB_CYCLE      = nbcyc                 [I]
◊   NB_INST       = | 25                     [DEFECT]
                    | nbinst              [I]
◊   TYPE_CHARGE   = | 'SINUSOIDAL'           [DEFECT]
                    | 'TRIANGULAR'        [ KN ]
```

These operands make it possible to define the loading of each simulation to be carried out under the keyword factor running, like its discretization. Their significance is summarized with the figure 3.6.2-a and below detailed:

- PRES_CONF allows to define the list of the confining pressures (strictly pOSItives) which will be maintained during each test;
- GAMMA_IMPOSE allows to define the list of the amplitudes (strictly positive) of shearing strain $\gamma=2\varepsilon_{xy}$ imposed cyclic loading;
- NB_CYCLE corresponds to the number of cycles, fixed for all simulations.
- NB_INST allows to define the temporal discretization of the loading, and corresponds to the number of steps of loading per quarter of cycle
- TYPE_CHARGE indicate the type of desired loading: sinusoidal or triangular;

For each confining pressure PRES_CONF, as many simulations are carried out as there are elements in the list GAMMA_IMPOSE. Contrary to the tests TRIA_DR_M_D and TRIA_ND_M_D (see respectively §3.4 and §3.5), these lists are not in bijection and there is on the whole

$card(\text{PRES\_CONF}) \times card(\text{GAMMA\_IMPOSE})$ simulations carried out.

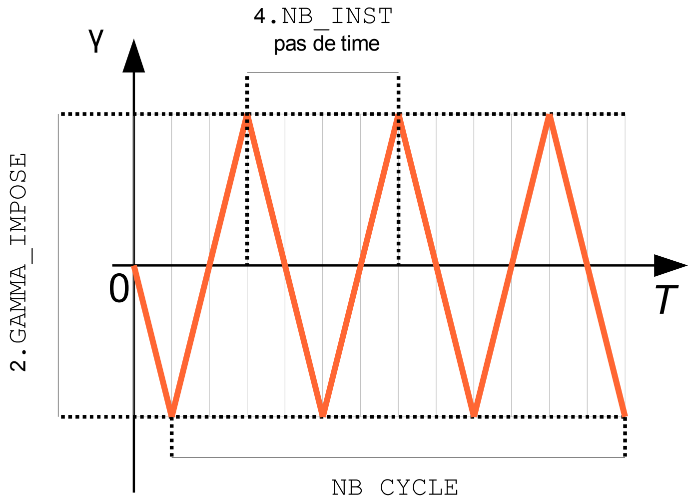

Figure 3.6.2-a: discretization and pace of the loading of triangular type for the keyword ESSAI_CISA_DR._C_D for 3 cycles of loading

3.6.3 Operand GAMMA_ELAS

```
◊   GAMMA_ELAS    = | 1.E-7               [DEFECT]
                    | gamma_elas          [R]
```

For each confining pressure, the modulus of maximum secant rigidity (i.e. healthy material) are given by simulating a slope of imposed shearing strain (in terms of distortion) whose end value is GAMMA_ELAS. This value must be such as material remains in its field of elasticity (linear or not, according to the relation of behavior used). GAMMA_ELAS is worth 1.E-7 by default, and any value indicated by the user must be lower to him. If the well informed value does not make it possible to remain in the field of elasticity, the code stops in fatal error.

3.6.4 Operand KZERO

```
◊  KZERO = | 1                [DEFECT]
           | kzero            [R]
```

Idem that with the §3.4.3.

3.6.5 Operand TABLE_RESU

```
◊   TABLE_RESU = l_tabres          [l_CO ]
```

This operand optional makes it possible to give the list of the names of the concepts produced by the macro-order which will be then of type [table] . The size of this list must check:

$$card(\text{TABLE\_RESU}) = card(\text{PRES\_CONF}) + 1$$

Indeed, each produced table gathers the gross profits of all the simulations carried out for the same confining pressure (PRES_CONF), in which each simulation corresponds to a package of contiguous columns whose titles all are indexed by the same entirety (index of the value considered in the list GAMMA_IMPOSE). An additional table recapitulating the postprocessings carried out at the conclusion of all simulations is also produced. This table contains for each confining pressure (PRES_CONF) values of the modulus of standardized secant rigidity $\frac{G}{G_{max}}$ and of the rate of depreciation hysteretic $\frac{\Delta W}{\pi W}$ in with respect to the amplitudes of imposed distortion (GAMMA_IMPOSE). L'damping hysteretic $\frac{\Delta W}{\pi W}$ for the last simulated cycle Ecalculated St according to Kohusho [] in the following way (Figure 3.6.5-a) :

- $\Delta W = \int_C \delta \sigma_{xy} \delta \gamma$ the surface of the last bouvle of hysteresis;
- $W = \Delta \sigma_{xy} \Delta \gamma$ associated elastic energy

This table corresponds in the name of concept given in last position in the list TABLE_RESU . Extracts of these tables are presented in the example below.

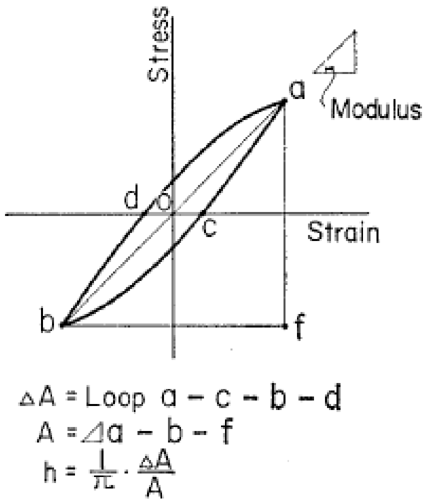

Figure 3.6.5-a: Hysteretic definition of damping according to Kokusho []

Example :

```
TABRES1=CO ('TRES1')
TABRES2 =CO ('TRES2')
TABBILA =CO ('TBILA ')

CALC_ESSAI_GEOMECA (
…
   ESSAI_CISA_ DR. _C_ D = _F (
          PRES_CONF    = (1.E5, 2.05E5,),
          GAMMA_IMPOSE = (1.E-5, 5.E-5, 1.E-4, 1.E-3) ,
          NB_CYCLE     = 3,
          TABLE_RESU   = ( TABRES1, TABRES2, TABBILA ), ),
…
                    );
```

The table below specifies for this example the results of simulations contained in the tables TABRES1 and TABRES2 , as well as the order in which these tables are filled out.

GAMMA_IMPOSE / PRES_ CONF	1.E-5	5.E-5	1.E-4	1.E-3
1.E5	TABRES1	TABRES1	TABRES1	TABRES1
2.05E5	TABRES2	TABRES2	TABRES2	TABRES2

An extract of the table below is presented TABRES1 containing the gross profits of the simulations carried out for the first value of PRES_CONF (TABRES2 being built same manner, for the second value of PRES_CONF).

```
#
#----------------------------------------------------------------------------
#
#Resultats rough: ESSAI_CISA_C number 1/PRES_CONF = -1.000000E+05
#
 GAMMA_IMPOSE_1 INST_1       GAMMA_1      SIG_XY_1     GAMMA_IMPOSE_2 INST_2       GAMMA_2      SIG_XY_2    …
   1.00000E-05  0.00000E+00  0.00000E+00  0.00000E+00   5.00000E-05  0.00000E+00  0.00000E+00  0.00000E+00…
  -             4.00000E-01 -4.00000E-07 -3.79317E+01   -            4.00000E-01 -2.00000E-06 -1.89658E+02…
  -             8.00000E-01 -8.00000E-07 -7.58633E+01   -            8.00000E-01 -4.00000E-06 -3.79317E+02…
  -             1.20000E+00 -1.20000E-06 -1.13795E+02   -            1.20000E+00 -6.00000E-06 -5.50536E+02…
  -             1.60000E+00 -1.60000E-06 -1.51727E+02   -            1.60000E+00 -8.00000E-06 -7.19697E+02…
```

-	2.00000E+00	-2.00000E-06	-1.89658E+02	-	2.00000E+00	-1.00000E-05	-8.88778E+02…
-	2.40000E+00	-2.40000E-06	-2.27590E+02	-	2.40000E+00	-1.20000E-05	-1.05778E+03…
-	2.80000E+00	-2.80000E-06	-2.65522E+02	-	2.80000E+00	-1.40000E-05	-1.22670E+03…
-	3.20000E+00	-3.20000E-06	-3.03453E+02	-	3.20000E+00	-1.60000E-05	-1.39554E+03…
-	3.60000E+00	-3.60000E-06	-3.41385E+02	-	3.60000E+00	-1.80000E-05	-1.56429E+03…
-	4.00000E+00	-4.00000E-06	-3.79317E+02	-	4.00000E+00	-2.00000E-05	-1.73297E+03…
-	4.40000E+00	-4.40000E-06	-4.15150E+02	-	4.40000E+00	-2.20000E-05	-1.90156E+03…
-	4.80000E+00	-4.80000E-06	-4.49001E+02	-	4.80000E+00	-2.40000E-05	-2.07007E+03…
-	5.20000E+00	-5.20000E-06	-4.82849E+02	-	5.20000E+00	-2.60000E-05	-2.23850E+03…
-	5.60000E+00	-5.60000E-06	-5.16693E+02	-	5.60000E+00	-2.80000E-05	-2.40684E+03…
-	6.00000E+00	-6.00000E-06	-5.50535E+02	-	6.00000E+00	-3.00000E-05	-2.57510E+03…
-	6.40000E+00	-6.40000E-06	-5.84374E+02	-	6.40000E+00	-3.20000E-05	-2.74327E+03…
-	6.80000E+00	-6.80000E-06	-6.18209E+02	-	6.80000E+00	-3.40000E-05	-2.91136E+03…
-	7.20000E+00	-7.20000E-06	-6.52041E+02	-	7.20000E+00	-3.60000E-05	-3.07937E+03…
-	7.60000E+00	-7.60000E-06	-6.85870E+02	-	7.60000E+00	-3.80000E-05	-3.24729E+03…
-	8.00000E+00	-8.00000E-06	-7.19695E+02	-	8.00000E+00	-4.00000E-05	-3.41511E+03…
-	8.40000E+00	-8.40000E-06	-7.53517E+02	-	8.40000E+00	-4.20000E-05	-3.58284E+03…
-	8.80000E+00	-8.80000E-06	-7.87336E+02	-	8.80000E+00	-4.40000E-05	-3.75049E+03…
-	9.20000E+00	-9.20000E-06	-8.21152E+02	-	9.20000E+00	-4.60000E-05	-3.91805E+03…
-	9.60000E+00	-9.60000E-06	-8.54965E+02	-	9.60000E+00	-4.80000E-05	-4.08436E+03…
-	1.00000E+01	-1.00000E-05	-8.88774E+02	-	1.00000E+01	-5.00000E-05	-4.24698E+03…
-	1.04000E+01	-9.60000E-06	-8.50842E+02	-	1.04000E+01	-4.80000E-05	-4.05732E+03…
-	1.08000E+01	-9.20000E-06	-8.12911E+02	-	1.08000E+01	-4.60000E-05	-3.86767E+03…
-	1.12000E+01	-8.80000E-06	-7.74979E+02	-	1.12000E+01	-4.40000E-05	-3.67801E+03…
-	1.16000E+01	-8.40000E-06	-7.37047E+02	-	1.16000E+01	-4.20000E-05	-3.48835E+03…
-	1.20000E+01	-8.00000E-06	-6.99116E+02	-	1.20000E+01	-4.00000E-05	-3.31514E+03…
-	1.24000E+01	-7.60000E-06	-6.61184E+02	-	1.24000E+01	-3.80000E-05	-3.14591E+03…
-	1.28000E+01	-7.20000E-06	-6.23252E+02	-	1.28000E+01	-3.60000E-05	-2.97673E+03…
-	1.32000E+01	-6.80000E-06	-5.85321E+02	-	1.32000E+01	-3.40000E-05	-2.80759E+03…
-	1.36000E+01	-6.40000E-06	-5.47389E+02	-	1.36000E+01	-3.20000E-05	-2.63849E+03…
-	1.40000E+01	-6.00000E-06	-5.09458E+02	-	1.40000E+01	-3.00000E-05	-2.46942E+03…
-	1.44000E+01	-5.60000E-06	-4.71526E+02	-	1.44000E+01	-2.80000E-05	-2.30040E+03…
-	1.48000E+01	-5.20000E-06	-4.33594E+02	-	1.48000E+01	-2.60000E-05	-2.13142E+03…
-	1.52000E+01	-4.80000E-06	-3.95663E+02	-	1.52000E+01	-2.40000E-05	-1.96247E+03…
-	1.56000E+01	-4.40000E-06	-3.57731E+02	-	1.56000E+01	-2.20000E-05	-1.79357E+03…
-	1.60000E+01	-4.00000E-06	-3.19799E+02	-	1.60000E+01	-2.00000E-05	-1.62471E+03…
-	1.64000E+01	-3.60000E-06	-2.81868E+02	-	1.64000E+01	-1.80000E-05	-1.45589E+03…
-	1.68000E+01	-3.20000E-06	-2.43936E+02	-	1.68000E+01	-1.60000E-05	-1.28711E+03…
-	1.72000E+01	-2.80000E-06	-2.06004E+02	-	1.72000E+01	-1.40000E-05	-1.11836E+03…
-	1.76000E+01	-2.40000E-06	-1.68073E+02	-	1.76000E+01	-1.20000E-05	-9.49666E+02…
-	1.80000E+01	-2.00000E-06	-1.30141E+02	-	1.80000E+01	-1.00000E-05	-7.81009E+02…
-	1.84000E+01	-1.60000E-06	-9.23287E+01	-	1.84000E+01	-8.00000E-06	-6.12391E+02…
…	…	…	…	…	…	…	…

Ci below, one also presents the contents of the additional table `TABBILA` , recapitulating postprocessings ($\frac{G}{G_{max}}$ and $DAMPING$) realized at the conclusion of all simulations. Each package of contiguous columns whose titles are indexed by the same entirety (index of the value considered in the list `PRES_CONF`) corresponds to the postprocessings carried out for the same confining pressure.

```
#
#------------------------------------------------------------------------------
#
#Resultats total: ESSAI_CISA_C number 1
#
```

PRES_CONF_1	GAMMA_IMPOSE_1	G_SUR_GMAX_1	DAMPING_1	PRES_CONF_2	GAMMA_IMPOSE_2	G_SUR_GMAX_2	DAMPING_2
-1.00000E+05	1.00000E-05	9.37244E-01	1.79484E-02	-2.00000E+05	1.00000E-05	9.65623E-01	1.30248E-02
-	5.00000E-05	8.95847E-01	7.93301E-03	-	5.00000E-05	9.26152E-01	6.34512E-03
-	1.00000E-04	7.91534E-01	5.24988E-02	-	1.00000E-04	8.82990E-01	2.26809E-02
-	1.00000E-03	2.81687E-01	2.16980E-01	-	1.00000E-03	3.69590E-01	1.89750E-01

3.6.6 Operand GRAPH, PREFIXE_FICHIER

```
◊  GRAPH = | ('GAMMA-SIG_XY', 'GAMMA-G_ SUR_GMAX ',
                'GAMMA-D AMPING ' ,
                'G_ SUR_GMAX - D AMPING ' )              [DEFECT]
             | l_graphic                     [l_Kn]

◊  P REFIXE_FICHIER = prefix                 [ KN ]
```

Idem that with the § 3.4.5 , except that contrary to the graphs of level 2 which can be unspecified, the graphs of level 1 are to be selected in the list:

- 'GAMMA-G_ SUR_GMAX ' ;
- 'GAMMA-D AMPING ' ;
- 'G_ SUR_GMAX - D AMPING '

3.6.7 Operand NOM_CMP

```
◊  NAME _CMP     = l_ component                   [l_Kn]
```

Idem that with the §3.4.6.

3.6.8 Operand TABLE_REF

```
◊   TABLE_REF = l_tabreF            [l_table]
```

Idem that with §3.4.7.

3.6.9 Operands COULEUR_NIV1, MARQUEUR_NIV1, STYLE_NIV1, COULEUR_NIV2, MARQUEUR_NIV2, STYLE_NIV2

```
◊  COULEUR_ NIV1   = l_ couleur_ niv1            [l_ I ]
◊   MARQUEUR_ NIV1  = l_ marker _ niv1           [l_ I ]
◊   STYLE_ NIV1     = l_ style _ niv1                [l_ I ]
◊  COULEUR_ NIV2   = l_ couleur_ niv2            [l_ I ]
◊   MARQUEUR_ NIV2  = l_ marker _ niv2           [l_ I ]
◊   STYLE_ NIV2     = l_ style _ niv2                [l_ I ]
```

It S operands accept a list of entireties making it possible respectively to define the color, the type of marker and the style of the curves displayed in the graphs. The data by each entirety is given in documentation on XMGRACE U2.51.01. The length of the list of level 1 must be equal to that of PRES_CONF. The length of the list of level 2 must be equal to that of GAMMA_IMPOSE .

3.7 Word key ESSAI_TRIA_ND_C_F

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same triaxial compression test not drained (total saturation is supposed) cyclic with imposed force for which one varies the parameters of loading (confining pressure, imposed amplitude of axial constraint effective, and many cycles), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.7.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.

This convention applies D E m ême on the predefined variables of exit. On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.7.9).

In this test, one distinguishes the variables from exit predefined of level 2 which corresponds to the variables produced by the test of which complete listing is the following one:

- INST : moment
- EPS_AXI : deformation axial
- EPS_LAT : lateral distortion
- EPS_VOL : voluminal deformation
- SIG_ AXI : constraint effective axial
- SIG_LAT : side effective constraint
- P : average effective constraint

- `Q` : diverter of the constraints
- `PRE_EAU` : pore water pressure
- `R U` : coefficient of pore water pressure equalize with $r_u=\frac{3}{1+2K_0}\frac{\Delta u_w}{\sigma'_{v,0}}$

And predefined variables of exit of level 1 which corresponds to curves whose points represent the result of a test (e.g. the curve $CRR-N_{cyc}$) . L has complete listing variables of level 1 is the following one:

- `NCYCL` : many cycles of loading to liquefaction
- `D SIGM` : constraint maximum imposed standardized by the initial average effective constraint $DSIGM=CRR=\frac{Q_{max}}{P'_0}$

3.7.2 Operands PRES_CONF, SIGM_IMPOSE, NB_CYCLE, NB_INST, NB_INST_MONO, TYPE_CHARGE

```
♦   PRES_CONF   = l_sigma_conf          [l_R]
♦   SIGM_IMPOSE = l_sigma_impo          [l_R]
♦   NB_CYCLE    = nbcyc                 [I]
◊   NB_INST     = | 25                  [DEFECT]
                  | nbinst              [I]
◊   NB_INST_MONO= | 400                 [DEFECT]
                  | nbinst_mono         [I]
◊   TYPE_CHARGE = | 'SINUSOIDAL'        [DEFECT]
                  | 'TRIANGULAR'        [ KN ]
```

These operands make it possible to define the loading of each simulation to be carried out under the keyword factor running, like its discretization. Their significance is summarized with the figure 3.7.2-a ET detailed below:

- `PRES_CONF` allows to define the list of the confining pressures (strictly pOSItives) which will be maintained during each test;
- `SIGM_IMPOSE` allows to define the list of the amplitudes of axial effective constraint of the cyclic loading imposed (with `PRES_CONF` the average constraint). A strictly positive value indicates a first loading in compression, a strictly negative value a first loading in extension ;
- `NB_CYCLE` corresponds to the number of cycles, fixed for all simulations;
- `NB_INST` allows to define the temporal discretization of the loading, and corresponds to the number of steps of loading per quarter of cycle ;
- `NB_INST_MONO` the temporal discretization D makes it possible to definebe loadingS monotonous with deformation imposed after detection of an instability, and corresponds to the number of steps of loading per quarter of cycle. The number of moments must be sufficiently large (>100) for a sufficiently precise detection of the attack of the instruction in force ;
- `TYPE_CHARGE` indicate the type of desired loading: sinusoidal or triangular;

For each confining pressure `PRES_CONF`, as many simulations are carried out as there are elements in the list `SIGM_IMPOSE`. Contrary to the tests `TRIA_DR_M_D` and `TRIA_ND_M_D` (see respectively §3.4 and §3.5), these lists are not in bijection and there is on the whole
$card(\mathrm{PRES\_CONF})\times card(\mathrm{SIGM\_IMPOSE})$ simulations carried out.

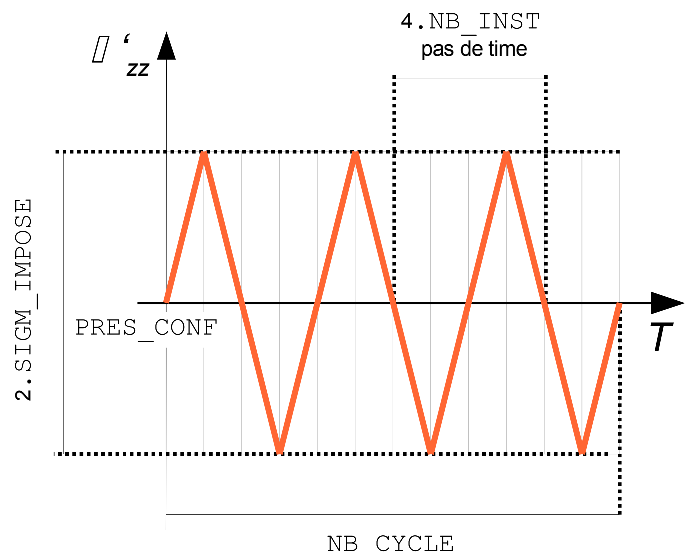

Figure 3.7.2-a: discretization and pace of the loading of triangular type for the keyword `ESSAI_TRIA_ND_C_D` for 3 cyclesof loading

Note:

For loose sands, control in constraint of the test raises difficulties at the time of the crossing of the two lines of instability, represented blue on the Figure 3.7.2-c. Indeed, the imposition of an instruction of maximum constraint higher than the acceptable maximum constraint on the line of instability led either to a divergence, or with a solution distorts (brutal jump of visible constraint on the Figure 3.7.2-c). Indeed, the line of instability represents the place of all the maximum acceptable ones of constraints of a test `TRIA_ND_M_D` monotonous for various values of initial consolidation (black curve).

The problem does not arise for a dense sand, because there are no maximum constraints in this case, as one can see it the black curve of the Figure 3.7.2-b.

*For this test, there thus exists a procedure **automatic** of management of the unstable situations. It consists in detecting instability and continuing the test in controlled deformation. The criteria of detection are the following:*

not convergence of calculation

$$\frac{\Delta Q}{\Delta P} < 0.25 \text{ and } \frac{\Delta \epsilon_{zz}^{+}}{\Delta \epsilon_{zz}^{-}} > 10$$

One continues on the remaining number of cycles per sequence of tests `TRIA_ND_M_D` monotonous with controlled deformation, at a rate of two tests per cycle ($\pm\epsilon_{max}$ to reach $\pm\sigma_{max}$). The instruction of maximum deformation ϵ_{max} imposed is of 4%, or 12% if the preceding instruction were insufficient. The list of moments for these tests `TRIA_ND_M_D` spread out from 0 to 100 seconds per 0.2 seconds temporal step (or 0.1 seconds if the instruction is $\epsilon_{max} = 12\%$).

The sequence of a test `TRIA_ND_M_D` with deformation controlled with the other is carried out by a resumption of calculation as from the last moment when the instruction in constraint $\pm\sigma_{max}$ is reached.

On the Figure 3.7.2-d, one shows on an example of sand releases (CAS-test comp012c) the solution obtained with or without the procedure of management of instability.

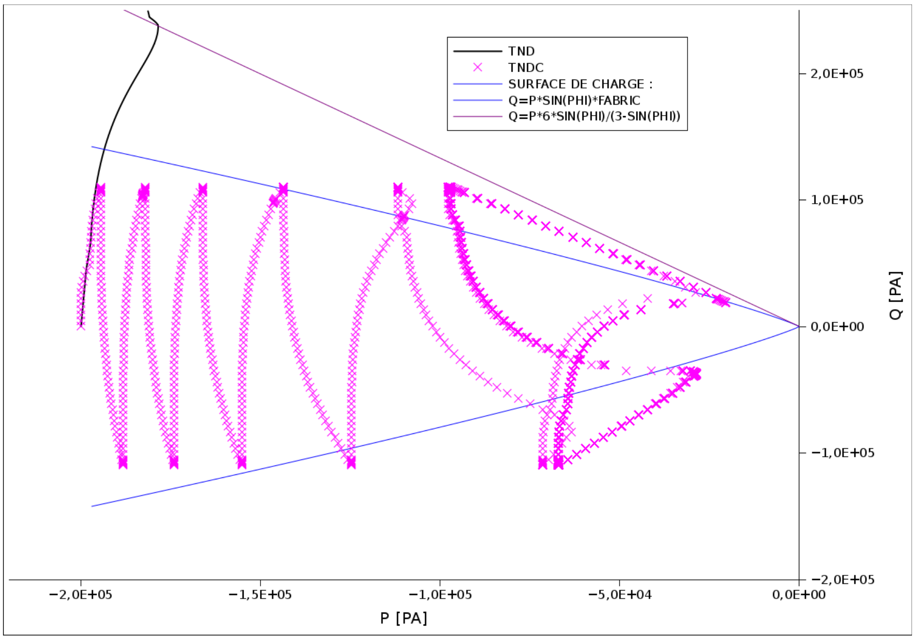

Figure 3.7.2-b: Result of the tests *TRIA_ND_M_D* (black) and *TRIA_ND_C_F* (pink) for a dense sand. The state of rupture is represented by the line violet, and the lines of instability are blue.

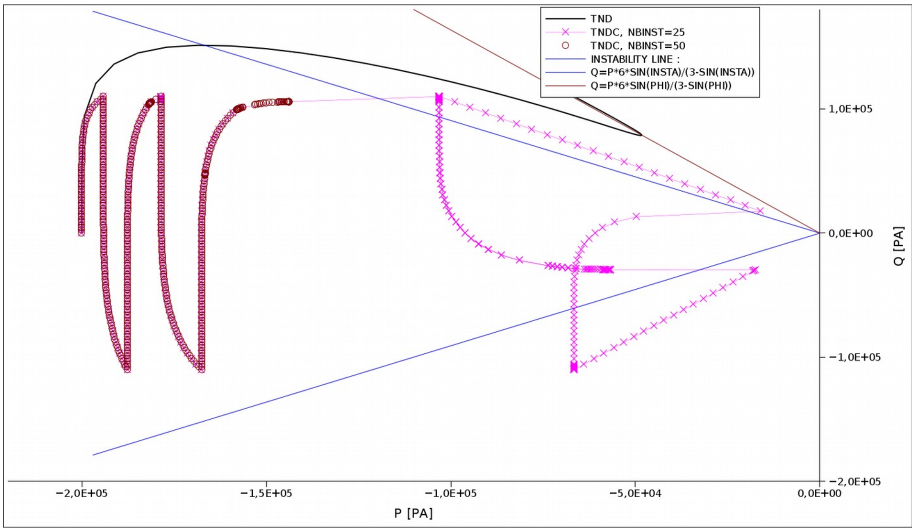

Figure 3.7.2-c: Result of the tests *TRIA_ND_M_D* (black) and *TRIA_ND_C_F* (pink) for a loose sand. The state of rupture is represented by the line violet, and the lines of instability are blue.

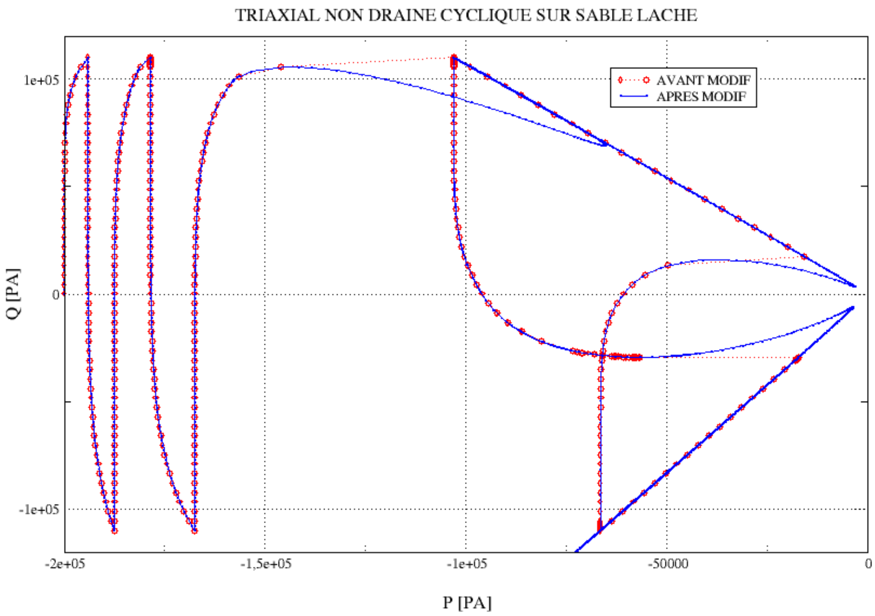

Figure 3.7.2-d: Result of a test *TRIA_ND_C_F* for a sand releases with (blue) or without (red) the procedure of management of instability.

3.7.3 Operand CRIT_LIQUEFACTION, VALE_CRIT, ARRET_LIQUEFACTION

```
♦  CRIT_LIQUEFACTION = ('RU_MAX', 'EPSI_ABSO_MAX',
                        'EPSI_RELA_MAX')
♦  VALE_CRIT          = l_vale                  [l_R]
◊  ARRET_LIQUEFACTION = |  'YES'                [DEFECT]
                        | ' NOT '
```

Maximum value of the criterion of liquefaction, to compare with: $r_u = \left| \frac{u}{P_0} \right|$

In CRIT_LIQUEFACTION, one chooses a combination criteria in the following list:

- RU_MAX corresponds to the coefficient of liquefaction equal to $r_u = \frac{3}{1+2K_0} \frac{\Delta u_w}{\sigma'_{v,0}}$, necessarily understood enters $]0,1]$ (Figure 3.7.3-a);
- EPSI_ABSO_MAX corresponds to the threshold in axial deformation said "individual amplitude", positive in compression and negative in extension in the interval $]-5,5]$ $(\%)$ (Figure 3.7.3-b) ;
- EPSI_RELA_MAX corresponds to the criterion in amplitude of axial deformation over one period, known as "double amplitude", necessarily positive and lower than 5 % (Figure 3.7.3-b) ;

The list of the values, of the same cardinal, is given in VALE_CRIT. The order of the criteria must correspond to the order of the digital values.

If several criteria are chosen, liquefaction is stipulated to take place when all the criteria were reached successively. Calculation is arrếté with the last cycle where the last criterion is reached, if it is possible, if ARRET_LIQUEFACTION = 'YES'. If ARRET_LIQUEFACTION = 'NOT', the test is continued until the number of cycles indicated in NB_CYCLE.

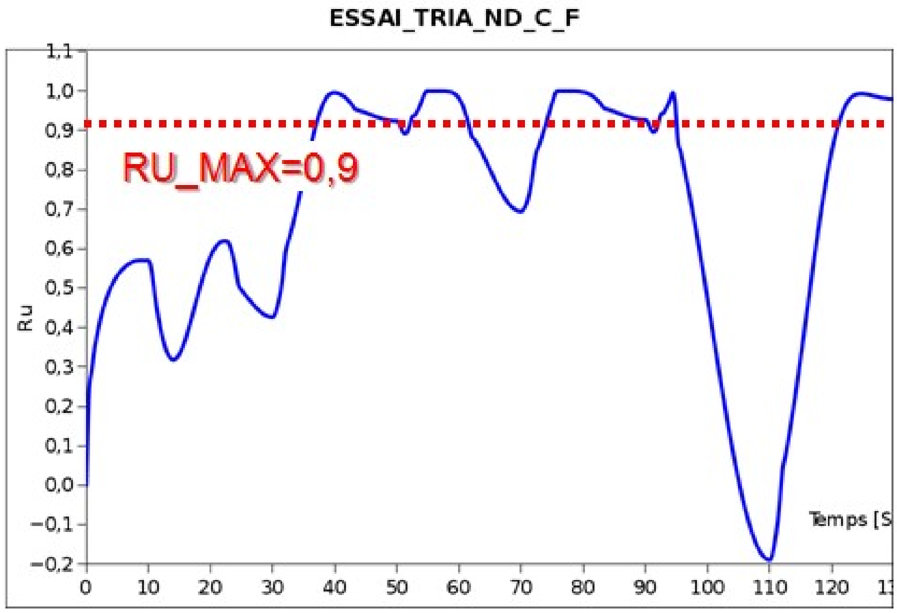

Figure 3.7.3-a: Criterion `RU_MAX=0.9`

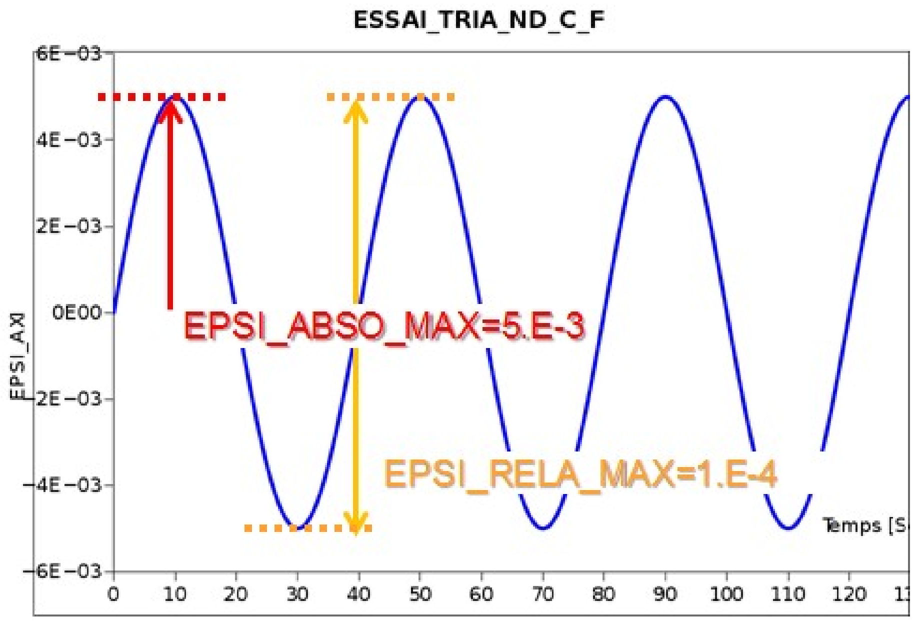

Figure 3.7.3-b: Criteria `EPSI_ABSO_MAX = 5TH-3` and `EPSI_RELA_MAX = 1E-4`

3.7.4 Operand `BIOT_COEF`

```
◊    BIOT_COEF = | 1                  [DEFECT]
                 | biot               [R]
```

Value of the coefficient of Biot.

3.7.5 Operand `KZERO`

```
◊    KZERO = | 1                  [DEFECT]
             | kzero              [R]
```

Idem that with the §3.4.3.

3.7.6 Operand UN_SUR_K

♦ `UN_SUR_K = unsurk` [R]

Value of the reverse of the module of compressibility of water.

3.7.7 Operand TABLE_RESU

◊ `TABLE_RESU = l_tabres` [l_CO]

This operand optional makes it possible to give the list of the names of the concepts produced by the macro-order which will be then of type [table] . The size of this list must check:

$$card(\text{TABLE\_RESU}) = card(\text{PRES\_CONF}) + 1$$

Indeed, each produced table gathers the gross profits of all the simulations carried out for the same confining pressure (PRES_CONF), in which each simulation corresponds to a package of contiguous columns whose titles all are indexed by the same entirety (index of the value considered in the list SIGM_IMPOSE). An additional table recapitulating the postprocessings carried out with the exit of all simulations is also produced. This table contains for each confining pressure (PRES_CONF) the number of cycles to the end of which the criterion of liquefaction of the ground was reached NCYCL, in with respect to the amplitudes of imposed effective constraint (SIGM_IMPOSE). Lhas liquefaction is consideredE to take place when all criteria chosen in the paragraph §3.7.3 are reached successively.
This table corresponds in the name of concept given in last position in the list TABLE_RESU . Extracts of these tables are presented in the example below.

Example :

```
TABRES1=CO ('TRES1')
TABRES2=CO ('TRES2')
TABRES3=CO ('TRES3')
TABBILA=CO ('TBILA')

CALC_ESSAI_GEOMECA (
…
   ESSAI_TRIA_ND_C_F = _F (
        PRES_CONF   = (3.E4, 3.25E4, 3.5E4),
        SIGM_IMPOSE = (1.E4, 1.1E4, 1.2E4, 1.3E4, 1.6E4),
        UN_SUR_K    = 1E-12,
        TABLE_RESU  = (TABRES1, TABRES2, TABRES3, TABBILA) ),
…
                            );
```

The table below specifies for this example the results of simulations contained in the tables TABRES1, TABRES2 and TABRES3, as well as the order in which these tables are filled out.

SIGM_IMPOSE → / PRES_CONF ↓	1.E4	1.1E4	1.2E4	1.3E4	1.6E4
3.E4	TABRES1	TABRES1	TABRES1	TABRES1	TABRES1
3.25E4	TABRES2	TABRES2	TABRES2	TABRES2	TABRES2
3.5E4	TABRES3	TABRES3	TABRES3	TABRES3	TABRES3

An extract of the table below is presented `TABRES2` containing the gross profits of the simulations carried out for the second value of `PRES_CONF`.

```
#
#-----------------------------------------------------------------------------
#
#Resultats rough: ESSAI_TND_C number 1/PRES_CONF = -3.250000E+04
#
 SIGM_IMPOSE_1 INST_1       EPS_AXI_1    EPS_LAT_1     … PRE_EAU_1    SIGM_IMPOSE_2 INST_2        …
   1.00000E+04  0.00000E+00  0.00000E+00  0.00000E+00  … -0.00000E+00  1.10000E+04  0.00000E+00  …
  -             4.00000E-01  2.37788E-06 -1.18887E-06  … -1.33316E+02  -            4.00000E-01  …
  -             8.00000E-01  5.27009E-06 -2.63491E-06  … -2.66632E+02  -            8.00000E-01  …
  -             1.20000E+00  8.17434E-06 -4.08697E-06  … -3.99948E+02  -            1.20000E+00  …
  -             1.60000E+00  1.10910E-05 -5.54522E-06  … -5.33263E+02  -            1.60000E+00  …
  -             2.00000E+00  1.40203E-05 -7.00984E-06  … -6.66579E+02  -            2.00000E+00  …
  -             2.40000E+00  1.69628E-05 -8.48101E-06  … -7.99895E+02  -            2.40000E+00  …
  -             2.80000E+00  1.99187E-05 -9.95886E-06  … -9.33211E+02  -            2.80000E+00  …
  -             3.20000E+00  2.30002E-05 -1.14996E-05  … -1.06631E+03  -            3.20000E+00  …
  -             3.60000E+00  2.65689E-05 -1.32839E-05  … -1.19796E+03  -            3.60000E+00  …
  -             4.00000E+00  3.06705E-05 -1.53346E-05  … -1.32706E+03  -            4.00000E+00  …
  -             4.40000E+00  3.53282E-05 -1.76634E-05  … -1.45247E+03  -            4.40000E+00  …
  -             4.80000E+00  4.05684E-05 -2.02834E-05  … -1.57305E+03  -            4.80000E+00  …
  -             5.20000E+00  4.64193E-05 -2.32088E-05  … -1.68756E+03  -            5.20000E+00  …
  -             5.60000E+00  5.29170E-05 -2.64576E-05  … -1.79469E+03  -            5.60000E+00  …
  -             6.00000E+00  6.01011E-05 -3.00496E-05  … -1.89303E+03  -            6.00000E+00  …
  -             6.40000E+00  6.80160E-05 -3.40070E-05  … -1.98113E+03  -            6.40000E+00  …
  -             6.80000E+00  7.67173E-05 -3.83576E-05  … -2.05731E+03  -            6.80000E+00  …
  -             7.20000E+00  8.62682E-05 -4.31330E-05  … -2.11975E+03  -            7.20000E+00  …
  -             7.60000E+00  9.67455E-05 -4.83717E-05  … -2.16636E+03  -            7.60000E+00  …
  -             8.00000E+00  1.08244E-04 -5.41211E-05  … -2.19469E+03  -            8.00000E+00  …
  -             8.40000E+00  1.20878E-04 -6.04380E-05  … -2.20193E+03  -            8.40000E+00  …
  -             8.80000E+00  1.34791E-04 -6.73947E-05  … -2.18477E+03  -            8.80000E+00  …
  -             9.20000E+00  1.50170E-04 -7.50842E-05  … -2.13899E+03  -            9.20000E+00  …
  -             9.60000E+00  1.67253E-04 -8.36253E-05  … -2.05939E+03  -            9.60000E+00  …
  -             1.00000E+01  1.86360E-04 -9.31790E-05  … -1.93918E+03  -            1.00000E+01  …
  -             1.04000E+01  1.84117E-04 -9.20575E-05  … -1.80586E+03  -            1.04000E+01  …
  -             1.08000E+01  1.81336E-04 -9.06674E-05  … -1.67255E+03  -            1.08000E+01  …
  -             1.12000E+01  1.78318E-04 -8.91580E-05  … -1.53923E+03  -            1.12000E+01  …
  -             1.16000E+01  1.75296E-04 -8.76474E-05  … -1.40592E+03  -            1.16000E+01  …
  -             1.20000E+01  1.72272E-04 -8.61353E-05  … -1.27260E+03  -            1.20000E+01  …
  -             1.24000E+01  1.69244E-04 -8.46217E-05  … -1.13928E+03  -            1.24000E+01  …
  -             1.28000E+01  1.66214E-04 -8.31066E-05  … -1.00597E+03  -            1.28000E+01  …
  -             1.32000E+01  1.63181E-04 -8.15900E-05  … -8.72652E+02  -            1.32000E+01  …
  -             1.36000E+01  1.60145E-04 -8.00719E-05  … -7.39335E+02  -            1.36000E+01  …
  -             1.40000E+01  1.57105E-04 -7.85523E-05  … -6.06019E+02  -            1.40000E+01  …
  -             1.44000E+01  1.54063E-04 -7.70311E-05  … -4.72703E+02  -            1.44000E+01  …
  -             1.48000E+01  1.51017E-04 -7.55085E-05  … -3.39387E+02  -            1.48000E+01  …
  -             1.52000E+01  1.47969E-04 -7.39842E-05  … -2.06071E+02  -            1.52000E+01  …
  -             1.56000E+01  1.44857E-04 -7.24283E-05  … -7.26273E+01  -            1.56000E+01  …
  …          …          …          …          …                …          …
```

Ci below, one also presents the contents of the additional table `TABBILA`, recapitulating the postprocessings (many cycles to liquefaction) carried out at the conclusion of all simulations. Each package of contiguous columns whose titles are indexed by the same entirety (index of the value considered in the list `PRES_CONF`) corresponds to the postprocessings carried out for the same confining pressure.

```
#
#-----------------------------------------------------------------------------
#
#Resultats total: ESSAI_TND_C number 1
#
 PRES_CONF_1   NCYCL_1        SIGM_IMPOSE_1  PRES_CONF_2   NCYCL_2        SIGM_IMPOSE_2  PRES_CONF_3   NCYCL_3
SIGM_IMPOSE_3
 -3.00000E+04   1.10000E+01    1.00000E+04  -3.25000E+04   1.50000E+01    1.00000E+04  -3.50000E+04   2.10000E+01
1.00000E+04
 -              7.00000E+00   1.10000E+04  -              1.10000E+01   1.10000E+04  -              1.50000E+01
1.10000E+04
 -              6.00000E+00   1.20000E+04  -              8.00000E+00   1.20000E+04  -              1.10000E+01
1.20000E+04
 -              4.00000E+00   1.30000E+04  -              6.00000E+00   1.30000E+04  -              8.00000E+00
1.30000E+04
 -              3.00000E+00   1.60000E+04  -              3.00000E+00   1.60000E+04  -              4.00000E+00
1.60000E+04
#
```

3.7.8 Operand **GRAPH**

```
◊   GRAPH = | ('P-Q', 'SIG_AXI-PRE_EAU',
                    'SIG_AXI-RU', 'EPS_AXI-PRE_EAU',
                    'EPS_AXI-Q', 'EPS_AXI-RU',
```

```
                    'NCYCL-DSIGM' )              [DEFECT]
                  | l_graphic                    [l_Kn]

◊  P REFIXE_FICHIER = prefix                  [ KN ]
```

Idem that with the §3.4.5, except that contrary to the graphs of level 2 which can be unspecified, the graphs of level 1 are to be selected in the list:

- ` NCYCL-DSIGM `

3.7.9 Operand NOM_CMP

```
◊ NAME _CMP     = l_ component                    [l_Kn]
```

Idem that with the §3.4.6.

3.7.10 Operand TABLE_REF

```
◊   TABLE_REF = l_tabreF            [l_table]
```

Idem that with §3.4.7.

3.7.11 Operands COULEUR_NIV1, MARQUEUR_NIV1, STYLE_NIV1, COULEUR_NIV2, MARQUEUR_NIV2, STYLE_NIV2

```
◊  COULEUR_ NIV1   = l_ couleur_ niv1            [l_ I ]
◊   MARQUEUR_ NIV1  = l_ marker _ niv1           [l_ I ]
◊   STYLE_ NIV1     = l_ style _ niv1                [l_ I ]
◊  COULEUR_ NIV2   = l_ couleur_ niv2            [l_ I ]
◊   MARQUEUR_ NIV2  = l_ marker _ niv2           [l_ I ]
◊   STYLE_ NIV2     = l_ style _ niv2                [l_ I ]
```

Idem that with the §3.4.8.

3.8 Word key ESSAI_TRIA_DR._C_D

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same cyclic drained triaxial compression test with imposed deformation for which one varies the parameters of loading (confining pressure, axial deformation imposed, and many cycles), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.8.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.

This convention applies D E m ême on the predefined variables of exit. On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.8.7).

In this test, one distinguishes the variables from exit predefined of level 2 which corresponds to the variables produced by the test of which complete listing is the following one:

- INST : moment
- EPS_AXI : deformation axial
- EPS_LAT : lateral distortion
- EPS_VOL : voluminal deformation

- `SIG_ AXI` : constraint effective axial
- `SIG_LAT` : side effective constraint
- `P` : average effective constraint
- `Q` : diverter of the constraints

And predefined variables of exit of level 1 which corresponds to curves whose points represent the result of a test (e.g. the curve $\frac{E^*}{E^*_{\max}} - \Delta\epsilon_v$). L has complete listing variables of level 1 is the following one:

- `E _SUR_ E MAX` : $\frac{E^*}{E^*_{\max}}$ with $E^* = \frac{|\Delta(\sigma_v - \sigma_h)|}{|\Delta\epsilon_v|}$ the apparent module test;
- `DAMPING` : damping hysteretic $\frac{\Delta W}{\pi W}$

3.8.2 Operands PRES_CONF, EPSI_MAXIMUM, EPSI_MINI, NB_CYCLE, NB_INST

```
♦   PRES_CONF     = l_sigma_conf           [l_R]
♦   EPSI_MAXIMUM    = l_epsi_maxi_impo        [l_R]
♦   EPSI_MINIS    = l_epsi_mini_impo         [l_R]
♦   NB_CYCLE      = nbcyc                  [I]
◊   NB_INST       = | 25                   [DEFECT]
                    | nbinst               [I]
◊   TYPE_CHARGE   = | 'SINUSOIDAL'         [DEFECT]
                    | 'TRIANGULAR'         [ KN ]
```

These operands make it possible to define the loading of each simulation to be carried out under the keyword factor running, like its discretization. Their significance is summarized with the figure 3.6.2-a and below detailed:

- `PRES_CONF` allows to define the list of the confining pressures (strictly pOSItives) which will be maintained during each test;
- `EPSI_MAXIMUM` and `EPSI_MINI` allowstent to define the list of the deformationS axial maximum and minimal, respectively, imposed cyclic loading. The cardinal of `EPSI_MAXIMUM` must be equal to that of `EPSI_MINI`. The condition $\Delta\epsilon_v = EPSI\_MAXI - EPSI\_MINI > 0$ must be respected term in the long term ;
- `NB_CYCLE` corresponds to the number of cycles, fixed for all simulations.
- `NB_INST` allows to define the temporal discretization of the loading, and corresponds to the number of steps of loading per quarter of cycle
- `TYPE_CHARGE` indicate the type of desired loading: sinusoidal or triangular;

For each confining pressure `PRES_CONF`, as many simulations are carried out as there are elements in the list `GAMMA_IMPOSE`. Contrary to the tests `TRIA_DR_M_D` and `TRIA_ND_M_D` (see respectively §3.4 and §3.5), these lists are not in bijection and there is on the whole
$card(\mathrm{PRES\_CONF}) \times card(\mathrm{EPSI\_MAXI})$ simulations carried out.

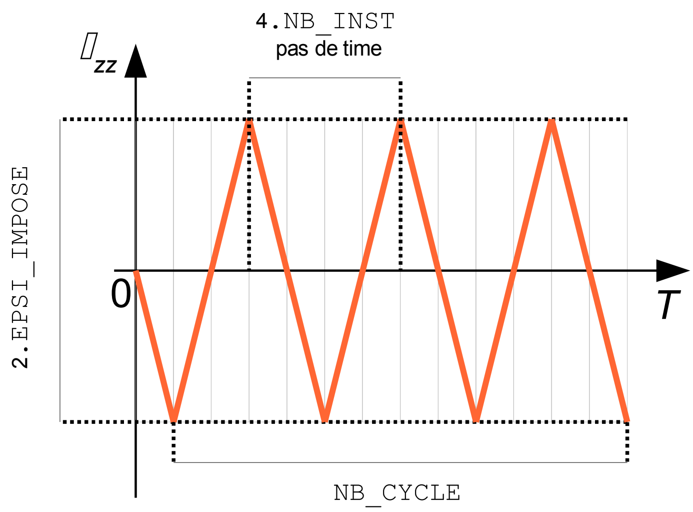

Figure 3.8.2-a: discretization and pace of the loading for the keyword `ESSAI_TD_A`, for 3 cycles

3.8.3 Operand `EPSI_ELAS`

```
◊    EPSI_ELAS      = | 1.E-7                     [DEFECT]
                      | epsi_elas                 [R]
```

For each confining pressure, the cyclic modulus Young are equivalent maximum (i.e. of healthy material) is given by simulating a cycle of alternate loading controlled in axial deformation imposed up to the value EPSI_ELAS. This value must be such as material remains in its field of elasticity (linear or not, according to the relation of behavior used). EPSI_ELAS is worth 1.E-7 by default, and any value indicated by the user must be lower to him. If the well informed value does not make it possible to remain in the field of elasticity, the code stops in fatal error.

3.8.4 Operand `KZERO`

```
◊   KZERO = | 1                [DEFECT]
            | kzero            [R]
```

Idem that with the §3.4.3.

3.8.5 Operand `TABLE_RESU`

```
◊    TABLE_RESU = l_tabres             [l_CO]
```

This operand optional makes it possible to give the list of the names of the concepts produced by the macro-order which will be then of type [table] . The size of this list must check:

$$card(\mathrm{TABLE\_RESU}) = card(\mathrm{PRES\_CONF}) + 1$$

Indeed, each produced table gathers the gross profits of all the simulations carried out for the same confining pressure (PRES_CONF), in which each simulation corresponds to a package of contiguous columns whose titles all are indexed by the same entirety (index of the value considered in the list EPSI_ MAXIMUM). An additional table recapitulating the postprocessings carried out at the conclusion of all simulations is also produced. This table contains for each confining pressure (PRES_CONF) the values D E:

- module has relative cyclic standardized equivalent $\frac{E*}{E*_{\max}}$ for the last simulated cycle, in with respect to the imposed amplitudes of deformation (EPSI_ MAXIMUM). $E*$ and $E*_{max}$ are calculated in the following way:
  $E*=\frac{|\Delta(\sigma_v-\sigma_h)|}{|\Delta\epsilon_v|}$
  with $\Delta\sigma=\sigma_{max}-\sigma_{min}$ and $\Delta\epsilon_v=\epsilon_{v,max}-\epsilon_{v,min}$;
- damping hysteretic $\frac{\Delta W}{\pi W}$ for the last simulated cycle, in with respect to the imposed amplitudes of deformation (EPSI_ MAXIMUM). W Is calculated in the following way:
  - $\Delta W=\int_C \delta(\sigma_v-\sigma_h).\delta(\epsilon_v-\epsilon_h)$ the surface of the last bou C of hysteresis
  - $W=\Delta(\sigma_v-\sigma_h).\Delta(\epsilon_v-\epsilon_h)$ associated elastic energy

This table corresponds in the name of concept given in last position in the list TABLE_RESU . Extracts of these tables are presented in the example below.

<u>Example</u> :

```
TABRES1=CO ('TRES1')
TABRES2=CO ('TRES2')
TABBILA=CO ('TBILA')

CALC_ESSAI_GEOMECA (
…
   ESSAI_TRIA_DR_C_D = _F (
       PRES_CONF  = (3.E4, 5.E4),
       EPSI_MAXIMUM  = (1.E-4, 5.E-4, 1.E-3, 2.E-3, 5.E-3),
       EPSI_MINIS  = (- 1.E-4, -5.E-4, -1.E-3, -2.E-3, -5.E-3),
        NB_CYCLE   = 3,
       TABLE_RESU = (TABRES1, TABRES2, TABBILA), ),
…
                        );
```

The table below specifies for this example the results of simulations contained in the tables TABRES1, TABRES2, as well as the order in which these tables are filled out.

EPSI_IMPOSE → / PRES_CONF ↓	1.E-4	5.E-4	1.E-3	2.E-3	5.E-3
3.E4	TABRES1	TABRES1	TABRES1	TABRES1	TABRES1
5.E4	TABRES2	TABRES2	TABRES2	TABRES2	TABRES2

An extract of the table below is presented TABRES2 containing the gross profits of the simulations carried out for the second value of PRES_CONF.

```
#
#---------------------------------------------------------------------------
#
#Resultats rough: ESSAI_TD_A number 1/PRES_CONF = -5.000000E+04
#
EPSI_IMPOSE_1 INST_1       EPS_AXI_1    EPS_LAT_1      …      EPSI_IMPOSE_2 INST_2       …
  1.00000E-04  0.00000E+00  0.00000E+00  0.00000E+00  …      5.00000E-04  0.00000E+00  …
 -             4.00000E-01 -4.00000E-06 -1.97971E-06  …      -             4.00000E-01…
```

```
-          8.00000E-01 -8.00000E-06 -3.80754E-06  …     -          8.00000E-01…
-          1.20000E+00 -1.20000E-05 -5.47994E-06  …     -          1.20000E+00…
-          1.60000E+00 -1.60000E-05 -7.15274E-06  …     -          1.60000E+00…
-          2.00000E+00 -2.00000E-05 -8.82571E-06  …     -          2.00000E+00…
-          2.40000E+00 -2.40000E-05 -1.04989E-05  …     -          2.40000E+00…
-          2.80000E+00 -2.80000E-05 -1.21721E-05  …     -          2.80000E+00…
-          3.20000E+00 -3.20000E-05 -1.38456E-05  …     -          3.20000E+00…
-          3.60000E+00 -3.60000E-05 -1.55192E-05  …     -          3.60000E+00…
-          4.00000E+00 -4.00000E-05 -1.71930E-05  …     -          4.00000E+00…
-          4.40000E+00 -4.40000E-05 -1.88669E-05  …     -          4.40000E+00…
-          4.80000E+00 -4.80000E-05 -2.05409E-05  …     -          4.80000E+00…
-          5.20000E+00 -5.20000E-05 -2.22151E-05  …     -          5.20000E+00…
-          5.60000E+00 -5.60000E-05 -2.38895E-05  …     -          5.60000E+00…
-          6.00000E+00 -6.00000E-05 -2.55640E-05  …     -          6.00000E+00…
-          6.40000E+00 -6.40000E-05 -2.72385E-05  …     -          6.40000E+00…
-          6.80000E+00 -6.80000E-05 -2.88926E-05  …     -          6.80000E+00…
-          7.20000E+00 -7.20000E-05 -3.04742E-05  …     -          7.20000E+00…
-          7.60000E+00 -7.60000E-05 -3.19868E-05  …     -          7.60000E+00…
-          8.00000E+00 -8.00000E-05 -3.34349E-05  …     -          8.00000E+00…
-          8.40000E+00 -8.40000E-05 -3.48219E-05  …     -          8.40000E+00…
-          8.80000E+00 -8.80000E-05 -3.61512E-05  …     -          8.80000E+00…
-          9.20000E+00 -9.20000E-05 -3.74257E-05  …     -          9.20000E+00…
-          9.60000E+00 -9.60000E-05 -3.86481E-05  …     -          9.60000E+00…
-          1.00000E+01 -1.00000E-04 -3.98209E-05  …     -          1.00000E+01…
-          1.04000E+01 -9.60000E-05 -4.10210E-05  …     -          1.04000E+01…
-          1.08000E+01 -9.20000E-05 -4.23186E-05  …     -          1.08000E+01…
-          1.12000E+01 -8.80000E-05 -4.36541E-05  …     -          1.12000E+01…
-          1.16000E+01 -8.40000E-05 -4.49913E-05  …     -          1.16000E+01…
-          1.20000E+01 -8.00000E-05 -4.63303E-05  …     -          1.20000E+01…
-          1.24000E+01 -7.60000E-05 -4.76712E-05  …     -          1.24000E+01…
-          1.28000E+01 -7.20000E-05 -4.90139E-05  …     -          1.28000E+01…
-          1.32000E+01 -6.80000E-05 -5.03585E-05  …     -          1.32000E+01…
-          1.36000E+01 -6.40000E-05 -5.17050E-05  …     -          1.36000E+01…
-          1.40000E+01 -6.00000E-05 -5.30534E-05  …     -          1.40000E+01…
-          1.44000E+01 -5.60000E-05 -5.44039E-05  …     -          1.44000E+01…
-          1.48000E+01 -5.20000E-05 -5.54605E-05  …     -          1.48000E+01…
-          1.52000E+01 -4.80000E-05 -5.38679E-05  …     -          1.52000E+01…
-          1.56000E+01 -4.40000E-05 -5.22783E-05  …     -          1.56000E+01…
-          1.60000E+01 -4.00000E-05 -5.06917E-05  …     -          1.60000E+01…
-          1.64000E+01 -3.60000E-05 -4.91081E-05  …     -          1.64000E+01…
-          1.68000E+01 -3.20000E-05 -4.75276E-05  …     -          1.68000E+01…
-          1.72000E+01 -2.80000E-05 -4.59671E-05  …     -          1.72000E+01…
-          1.76000E+01 -2.40000E-05 -4.44567E-05  …     -          1.76000E+01…
-          1.80000E+01 -2.00000E-05 -4.29952E-05  …     -          1.80000E+01…
  …        …         …          …          … …            …     …
```

Ci below, one also presents the contents of the additional table `TABBILA`, recapitulating postprocessings $\frac{E*}{E*_{\max}}$ and $\frac{\Delta W}{\pi W}$ realized at the conclusion of all simulations. Each package of contiguous columns whose titles are indexed by the same entirety (index of the value considered in the list `PRES_CONF`) corresponds to the postprocessings carried out for the same confining pressure.

```
#
#-----------------------------------------------------------------------------
#
#Resultats total: ESSAI_TD_A number 1
#
PRES_CONF_1  EPSI_IMPOSE_1 E_SUR_EMAX_1 PRES_CONF_2  EPSI_IMPOSE_2 E_SUR_EMAX_2
-3.00000E+04   1.00000E-04  4.08330E-01 -5.00000E+04   1.00000E-04  4.30922E-01
-              5.00000E-04  1.72000E-01 -              5.00000E-04  2.05213E-01
-              1.00000E-03  1.13241E-01 -              1.00000E-03  1.38724E-01
-              2.00000E-03  7.38666E-02 -              2.00000E-03  9.14469E-02
-              5.00000E-03  4.33285E-02 -              5.00000E-03  5.32730E-02
```

3.8.6 Operand `GRAPH`, `PREFIXE_FICHIER`

```
◊   GRAPH = | ('P-Q', 'EPS_AXI-Q', 'EPS_VOL-Q',
                'EPS_AXI-EPS_VOL', 'P-EPS_VOL',
                ' D EPSI-E_ SUR_EMAX ',
                ' D EPSI- DAMPING ' )                [DEFECT]
            | l_graphic                           [l_Kn]

◊   P REFIXE_FICHIER = prefix                 [ KN ]
```

Idem that with the §3.4.5, except that contrary to the graphs of level 2 which can be unspecified, the graphs of level 1 are to be selected in the list:

- `' D EPSI-E_ SUR_EMAX '`

- ` D EPSI- DAMPING `

3.8.7 Operand NOM_CMP

◊ NAME _CMP = l_ component [l_Kn]

Idem that with the §3.4.6.

3.8.8 Operand TABLE_REF

◊ TABLE_REF = l_tabreF [l_table]

Idem that with §3.4.7.

3.8.9 Operands COULEUR_NIV1, MARQUEUR_NIV1, STYLE_NIV1, COULEUR_NIV2, MARQUEUR_NIV2, STYLE_NIV2

◊ COULEUR_ NIV1 = l_ couleur_ niv1 [l_ I]
◊ MARQUEUR_ NIV1 = l_ marker _ niv1 [l_ I]
◊ STYLE_ NIV1 = l_ style _ niv1 [l_ I]
◊ COULEUR_ NIV2 = l_ couleur_ niv2 [l_ I]
◊ MARQUEUR_ NIV2 = l_ marker _ niv2 [l_ I]
◊ STYLE_ NIV2 = l_ style _ niv2 [l_ I]

Idem that with the §3.4.8.

3.9 Word key ESSAI_TRIA_ND_C_D

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same triaxial compression test not drained cyclic with imposed deformation for which one varies the parameters of loading (confining pressure, axial deformation imposed, and many cycles), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.9.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.
This convention applies D E m ême on the predefined variables of exit. On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.9.10).
In this test, one distinguishes the variables from exit predefined of level 2 which corresponds to the variables produced by the test of which complete listing is the following one:

- INST : moment
- EPS_AXI : deformation axial
- EPS_LAT : lateral distortion
- EPS_VOL : voluminal deformation
- SIG_ AXI : constraint effective axial
- SIG_LAT : side effective constraint
- P : average effective constraint
- Q : diverter of the constraints
- PRE_EAU : pore water pressure

- `R U` : coefficient of pore water pressure equalize with $r_u=\frac{3}{1+2K_0}\frac{\Delta u_w}{\sigma'_{v,0}}$

And predefined variables of exit of level 1 which corresponds to curves whose points represent the result of a test (e.g. the curve $CRR-N_{cyc}$) . L has complete listing variables of level 1 is the following one:

- `NCYCL` : many cycles of loading to liquefaction
- `DEPSI` : amplitude of imposed axial deformation
  $\Delta\epsilon_v = \text{EPSI\_MAX} - \text{EPSI\_MIN}$
- `RU_MAX` : maximum of `RU`
- `E_SUR_EMAX` : $\frac{E*}{E*_{\max}}$ with $E*=\frac{|\Delta(\sigma_v-\sigma_h)|}{|\Delta\epsilon_v|}$
- `DAMPING` : damping hysteretic $\frac{\Delta W}{\pi W}$

3.9.2 Operands PRES_CONF, EPSI_MAXIMUM, EPSI_MINI, NB_CYCLE, NB_INST

```
♦   PRES_CONF    = l_sigma_conf            [l_R]
♦   EPSI_MAXIMUM    = l_epsi_maxi_impo        [l_R]
♦   EPSI_MINIS    = l_epsi_mini_impo          [l_R]
♦   NB_CYCLE     = nbcyc                   [I]
◊   NB_INST      = | 25                    [DEFECT]
                   | nbinst                [I]
◊   TYPE_CHARGE  = | 'SINUSOIDAL'          [DEFECT]
                   | 'TRIANGULAR'          [ KN ]
```

Idem that with the §3.8.2.

3.9.3 Operand EPSI_ELAS

```
◊   EPSI_ELAS    = | 1.E-7                 [DEFECT]
                   | epsi_elas             [R]
```

Idem that with the §3.9.3.

3.9.4 Operand BIOT_COEF

```
◊   BIOT_COEF = | 1                 [DEFECT]
                | biot              [R]
```

Value of the coefficient of Biot.

3.9.5 Operand KZERO

```
◊  KZERO = | 1              [DEFECT]
           | kzero          [R]
```

Idem that with the §3.4.3.

3.9.6 Operand UN_SUR_K

```
♦   UN_SUR_K = unsurk           [R]
```

Value of the reverse of the module of compressibility of water.

3.9.7 Operand **RU_MAX**

```
◊ RU_MAX      = | 0.8                          [DEFECT]
                | crit_liquefaction            [R]
```

Value of the criterion of liquefaction in RU.

3.9.8 Operand **TABLE_RESU**

```
◊   TABLE_RESU = l_tabres ,          [l_CO]
```

This operand optional makes it possible to give the list of the names of the concepts produced by the macro-order which will be then of type [table] . The size of this list must check:

$$card(\texttt{TABLE\_RESU}) = card(\texttt{PRES\_CONF}) + 1$$

Indeed, each produced table gathers the gross profits of all the simulations carried out for the same confining pressure (PRES_CONF), in which each simulation corresponds to a package of contiguous columns whose titles are all indexed by the same entirety (index of the value considered in the list EPSI_ MAXIMUM). An additional table recapitulating the postprocessings carried out at the conclusion of all simulations is also produced. This table contains for each confining pressure (PRES_CONF) the values D E:

- module apparent cyclic standardized equivalent $\frac{E^*}{E^*_{\max}}$ for the last simulated cycle, in with respect to the imposed amplitudes of deformation (EPSI_ MAXIMUM). E^* and E^*_{max} are calculated in the following way:
$$E^* = \frac{|\Delta(\sigma_v - \sigma_h)|}{|\Delta \epsilon_v|}$$
with $\Delta\sigma = \sigma_{max} - \sigma_{min}$ and $\Delta\epsilon_v = \epsilon_{v,max} - \epsilon_{v,min}$;
- damping hysteretic $\frac{\Delta W}{\pi W}$ for the last simulated cycle, in with respect to the imposed amplitudes of deformation (EPSI_ MAXIMUM). W Is calculated in the following way:
  - $\Delta W = \int_C \delta(\sigma_v - \sigma_h) . \delta(\epsilon_v - \epsilon_h)$ the surface of the last bouvle of hysteresis
  - $W = \Delta(\sigma_v - \sigma_h) . \Delta(\epsilon_v - \epsilon_h)$ associated elastic energy
- many cycles to liquefaction NCYCL

This table corresponds in the name of concept given in last position in the list TABLE_RESU .

3.9.9 Operand **GRAPH, PREFIXE_FICHIER**

```
◊   GRAPH = | ( 'NCYCL-DEPSI', 'DEPSI-RU_MAX',
                'DEPSI-E_SUR_EMAX', 'DEPSI-DAMPING',
                'P-Q', 'EPS_AXI-EPS_VOL'
                'EPS_AXI-Q', 'P-EPS_VOL',
                'EPS_AXI-PRE_EAU', 'EPS_AXI-RU',
                'P-PRE_EAU' )                  [DEFECT]
```

```
| l_graphic                          [l_Kn]
```

```
◊  P REFIXE_FICHIER = prefix             [ KN ]
```

Idem that with the §3.4.5, except that contrary to the graphs of level 2 which can be unspecified, the graphs of level 1 are to be selected in the list:

- ' NCYCL-D EPSI '
- ' D EPSI-RU_MAX '
- ' D EPSI-E_SUR_EMAX '
- ' D EPSI-DAMPING '

3.9.10 Operand NOM_CMP

```
◊ NAME _CMP    = l_ component                  [l_Kn]
```

Idem that with the §3.4.6.

3.9.11 Operand TABLE_REF

```
◊   TABLE_REF = l_tabreF            [l_table]
```

Idem that with §3.4.7.

3.9.12 Operands COULEUR_NIV1, MARQUEUR_NIV1, STYLE_NIV1, COULEUR_NIV2, MARQUEUR_NIV2, STYLE_NIV2

```
◊  COULEUR_ NIV1   = l_ couleur_ niv1          [l_ I ]
◊  MARQUEUR_ NIV1  = l_ marker _ niv1          [l_ I ]
◊  STYLE_ NIV1     = l_ style _ niv1           [l_ I ]
◊  COULEUR_ NIV2   = l_ couleur_ niv2          [l_ I ]
◊  MARQUEUR_ NIV2  = l_ marker _ niv2          [l_ I ]
◊  STYLE_ NIV2     = l_ style _ niv2           [l_ I ]
```

Idem that with the §3.4.8.

3.10 Word key ESSAI_OEDO_DR._C_F

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same drained test oedometric Cyclic with imposed force for which one varies the parameters of loading (pressure of initial consolidation isotropic, imposed amplitude of axial constraint effective, and amplitude of axial constraint effective at the end of the discharge), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.10.1 Convention of sign of the entries and exits

The convention of sign of the geomecanicians applies to the parameters of entry in constraints or imposed deformations, i.e. that the values are positive S in compression.
This convention applies D E m ême on the variables of predefined exits of which complete listing for this test is the following one:

- INST : moment
- EPS_VOL : voluminal deformation
- SIG_AXI : axial effective constraint
- SIG_LAT : side effective constraint
- P : average effective constraint

On the other hand, this convention does not apply to the nonpredefined variables required at exit in NOM_CMP (§ 3.10.6).

3.10.2 Operands PRES_CONF, SIGM_IMPOSE, SIGM_DECH, NB_CYCLE, NB_INST, TYPE_CHARGE

```
♦    PRES_CONF   = l_sigma_conf              [l_R]
♦    SIGM_IMPOSE = l_sigma_impo              [l_R]
♦    SIGM_DECH   = l_sigma_discharge         [l_R]
♦    NB_CYCLE    = nbcyc                     [I]
◊    NB_INST     = | 25                      [DEFECT]
                   | nbinst                  [I]
◊    TYPE_CHARGE = | 'SINUSOIDAL'            [DEFECT]
                   | 'TRIANGULAR'            [KN]
```

These operands make it possible to define the loading of each simulation to be carried out under the keyword factor running, like its discretization. Their significance is summarized with the figure 3.10.2-a and below detailed:

- PRES_CONF allows to define the list of the pressures of consolidation verticals initial (strictly positives). The initial average constraint will be thus equal to $\frac{1+2K_0}{3}\times\text{PRES\_CONF}$;
- SIGM_IMPOSE allows to define the list of imposed values of axial stress (strictly positiveS and supérieures with SIGM_DECH);
- SIGM_DECH allows to define the list of the values strictly (positives) of the axial stress of discharge, fixed for all the cycles of loading, with a pressure of initial consolidation given. Lists PRES_CONF and SIGM_DECH must have the same cardinal;
- NB_INST allows to define the temporal discretization of the loading, and corresponds to the number of steps of loading per half of cycle;
- TYPE_CHARGE indicate the type of desired loading: sinusoidal or triangular;

For each pressure of initial consolidation PRES_CONF, and each constraint of discharge SIGM_DECH, as many cycles are carried out as there are elements in the list SIGM_IMPOSE. Contrary to the tests TRIA_DR_M_D and TRIA_ND_M_D (see respectively §3.4 and §3.5), these lists are not in bijection and there is on the whole $card(\text{PRES\_CONF})=card(\text{SIGM\_DECH})$ simulations carried out, each simulation comprising $card(\text{SIGM\_IMPOSE})$ cycles.

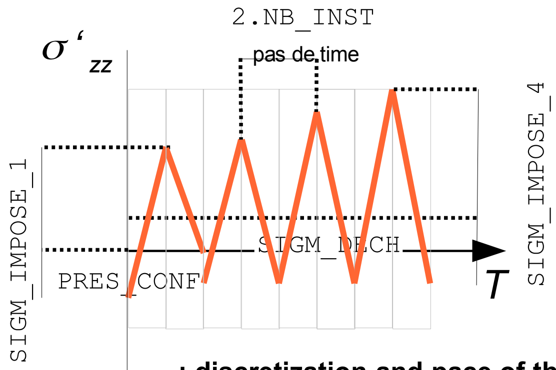

Figure : discretization and pace of the loading for the keyword ESSAI_OEDO_C , for 4 cycles

3.10.3 Operand KZERO

```
◊   KZERO = | 1                  [DEFECT]
            | kzero              [R]
```

Idem that with the §3.4.3.

3.10.4 Operand TABLE_RESU

```
◊    TABLE_RESU = l_tabres             [l_CO]
```

This operand optional makes it possible to give the list of the names of the concepts produced by the macro-order which will be then of type `[table]` . The size of this list must check:

$$card(\mathrm{TABLE\_RESU}) = card(\mathrm{PRES\_CONF})$$

Indeed, each produced table gathers the gross profits of the simulation carried out for the same pressure of initial consolidation (`PRES_CONF`) and the same value of constraint at the end of the discharge (`SIGM_DECH`), each cycle of this simulation corresponds to a value (`SIGM_IMPOSE)` .

Example :

```
TABRES1=CO ('TRES1')
TABRES2=CO ('TRES2')

CALC_ESSAI_GEOMECA (
…
ESSAI_OEDO_DR._C_F = _F (
      PRES_CONF   = (1.E5, 2.E5),
      SIGM_DECH   = (2.E5, 3.E5),
      SIGM_IMPOSE = (3.E5, 4.E5, 5.E5),
…
                     );
```

The ways of loading are illustrated on the Figure 3.10.4-a.

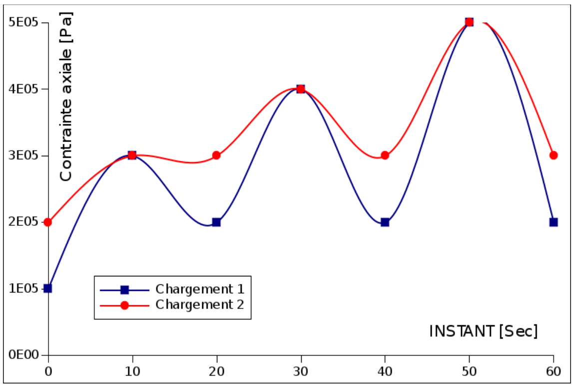

Figure 3.10.4-a: Loadings oedometric

The table below specifies for this example the results of simulations contained in the tables TABRES1 and TABRES2 , as well as the order in which these tables are filled out.

SIGM_IMPOSE		3.E5	4.E5	5.E5
PRES_CONF	SIGM_DECH			
1.E5	2.E5	TABRES1	TABRES1	TABRES1
2.E5	3.E5	TABRES2	TABRES2	TABRES2

An extract of the table below is presented TABRES2 containing the gross profits of the simulations carried out for the second value of PRES_CONF, and of SIGM_DECH

```
#
#-------------------------------------------------------------------------------
#
# ESSAI_OEDO_C number 1/PRES_CONF = -2.000000E+05/SIGM_DECH = -3.000000E+05
#
SIGM_IMPOSE_2 INST_2       EPS_VOL_2    P_2          SIG_AXI_2    SIG_LAT_2
-3.00000E+05  0.00000E+00  0.00000E+00 -2.00000E+05 -2.00000E+05 -2.00000E+05
-3.00000E+05  4.00000E-01 -7.39723E-05 -2.01077E+05 -2.12000E+05 -1.95616E+05
-3.00000E+05  8.00000E-01 -1.75678E-04 -2.02549E+05 -2.24000E+05 -1.91824E+05
-3.00000E+05  1.20000E+00 -3.18644E-04 -2.04590E+05 -2.36000E+05 -1.88885E+05
-3.00000E+05  1.60000E+00 -4.99908E-04 -2.07143E+05 -2.48000E+05 -1.86714E+05
-3.00000E+05  2.00000E+00 -7.15464E-04 -2.10149E+05 -2.60000E+05 -1.85224E+05
-3.00000E+05  2.40000E+00 -9.61164E-04 -2.13554E+05 -2.72000E+05 -1.84332E+05
-3.00000E+05  2.80000E+00 -1.23276E-03 -2.17306E+05 -2.84000E+05 -1.83959E+05
-3.00000E+05  3.20000E+00 -1.52656E-03 -2.21361E+05 -2.96000E+05 -1.84041E+05
-3.00000E+05  3.60000E+00 -1.83869E-03 -2.25674E+05 -3.08000E+05 -1.84511E+05
-3.00000E+05  4.00000E+00 -2.16608E-03 -2.30211E+05 -3.20000E+05 -1.85317E+05
 …            …            …            …            …            …
 …            …            …            …            …            …
 …            …            …            …            …            …
-3.00000E+05  2.00000E+01 -6.04300E-03 -2.76465E+05 -3.00000E+05 -2.64698E+05
-4.00000E+05  2.04000E+01 -6.11132E-03 -2.80404E+05 -3.16000E+05 -2.62606E+05
-4.00000E+05  2.08000E+01 -6.19529E-03 -2.81924E+05 -3.32000E+05 -2.56886E+05
-4.00000E+05  2.12000E+01 -6.28651E-03 -2.83575E+05 -3.48000E+05 -2.51363E+05
-4.00000E+05  2.16000E+01 -6.39457E-03 -2.85529E+05 -3.64000E+05 -2.46293E+05
-4.00000E+05  2.20000E+01 -6.51836E-03 -2.87762E+05 -3.80000E+05 -2.41643E+05
-4.00000E+05  2.24000E+01 -6.65666E-03 -2.90254E+05 -3.96000E+05 -2.37381E+05
-4.00000E+05  2.28000E+01 -6.80833E-03 -2.92984E+05 -4.12000E+05 -2.33476E+05
-4.00000E+05  2.32000E+01 -6.97209E-03 -2.95933E+05 -4.28000E+05 -2.29900E+05
 …            …            …            …            …            …
 …            …            …            …            …            …
 …            …            …            …            …            …
-4.00000E+05  3.96000E+01 -1.01176E-02 -3.27727E+05 -3.16000E+05 -3.33591E+05
-4.00000E+05  4.00000E+01 -9.76282E-03 -3.20137E+05 -3.00000E+05 -3.30206E+05
-5.00000E+05  4.04000E+01 -9.84598E-03 -3.24672E+05 -3.20000E+05 -3.27007E+05
-5.00000E+05  4.08000E+01 -9.94584E-03 -3.26579E+05 -3.40000E+05 -3.19868E+05
-5.00000E+05  4.12000E+01 -1.00631E-02 -3.28816E+05 -3.60000E+05 -3.13225E+05
-5.00000E+05  4.16000E+01 -1.02034E-02 -3.31485E+05 -3.80000E+05 -3.07228E+05
  …            …            …            …            …            …
```

3.10.5 Operand GRAPH, PREFIXE_FICHIER

```
◊   GRAPH = | ('P-EPS_VOL', 'SIG_AXI-EPS_VOL') [DEFECT]
              | l_graphic                       [l_Kn]
```

```
◊  PREFIXE_FICHIER = prefix                 [KN]
```

Idem that with the §3.4.5.

3.10.6 Operand NOM_CMP

```
◊ NAME _CMP    = l_ component                    [l_Kn]
```

Idem that with the §3.4.6.

3.10.7 Operand TABLE_REF

```
◊   TABLE_REF = l_tabreF            [l_table]
```

Idem that with §3.4.7.

3.10.8 Operands COLOR, MARKER, STYLE

```
◊  COLOR   = l_ color              [l_ I ]
◊   MARKER  = l_ marker             [l_ I ]
◊   STYLE     = l_ style               [l_ I ]
```

Idem that with the § 3.4.8 .

3.11 Word key ESSAI_ISOT_DR._C

This keyword factor (répétable) makes it possible to carry out a series of simulations of the same test of cyclic drained isotropic compression for which one varies them parameters of loading (pressure of initial isotropic consolidation, amplitude of effective constraint isotropic imposed, and isotropic amplitude of constraint of discharge), post-to treat the got results and to write them in the form of graphs (with the format xmgrace) and/or of tables.

3.11.1 Convention of sign of the entries and exits

Idem that with the §3.10.1.

3.11.2 Operands PRES_CONF, SIGM_IMPOSE, SIGM_DECH, NB_CYCLE, NB_INST, TYPE_CHARGE

```
♦   PRES_CONF   = l_sigma_conf             [l_R]
♦   SIGM_IMPOSE = l_sigma_impo             [l_R]
♦   SIGM_DECH   = l_sigma_discharge        [l_R]
♦   NB_CYCLE    = nbcyc                    [I]
◊   NB_INST     = | 25                     [DEFECT]
                  | nbinst                 [I]
◊   TYPE_CHARGE = | 'SINUSOIDAL'           [DEFECT]
                  | 'TRIANGULAR'           [KN]
```

Idem that with the §3.10.2 with $K_0=1$.

3.11.3 Operand TABLE_RESU

```
◊   TABLE_RESU = l_tabres           [l_CO]
```

Idem that with the § 3.10.4 .

3.11.4 Operand GRAPH, PREFIXE_FICHIER

```
◊   GRAPH = | ‘P-EPS_VOL’               [DEFECT]
            | l_graphic                    [l_Kn]

◊  PREFIXE_FICHIER = prefix                [KN]
```

Idem that with the §3.4.5.

3.11.5 Operand NOM_CMP

```
◊  NAME _CMP     = l_ component                 [l_Kn]
```

Idem that with the §3.4.6.

3.11.6 Operand TABLE_REF

```
◊    TABLE_REF = l_tabreF            [l_table]
```

Idem that with §3.4.7.

3.11.7 Operands COLOR, MARKER, STYLE

```
◊  COLOR   = l_ color              [l_ I ]
◊   MARKER  = l_ marker            [l_ I ]
◊   STYLE     = l_ style              [l_ I ]
```

Idem that with the § 3.4.8 .