Macro-order CALC_PRECONT

Summary

This macro-order makes it possible to put in tension the cables in a structure, so that, at the conclusion of this calculation, the structure is in balance and the tension is equal to the tension given by rules BPEL91, calculated by the order DEFI_CABLE_BP.
It also allows:

- to apply prestressing in a progressive way, in order to be able to treat the case where the concrete will plasticize or be damaged according to the model of behavior selected,
- to practise the phasage of setting in prestressing, i.e. the setting in tension of the cables in a sequential way.

In this phase of setting in tension, the behavior of steel is regarded as purely elastic.

For more details on the model implemented by the order, consult documentation entitled: “Modeling of the cables of prestressed” [R7.01.02].

1 Syntax

```
statnl [evol_noli] = CALC_PRECONT

(  ◊  reuse        =     statnl,
   ♦  MODEL     =     Mo  ,                          [model]
   ♦  CHAM_MATER   =     chmat  ,                       [cham_mater]
   ♦  CARA_ELEM    =     carac  ,                       [cara_elem]

   ♦  EXCIT        = (_F (    ♦ LOAD   =  chi           /  [char_meca]
                                                      /  [char_cine_meca]
                      ),),
   ♦  BEHAVIOR         =  (  to see the document [U4.51.11]  )
   ♦  INCREMENT =_F (
         ♦  LIST_INST    =  /litpsr8,                   [listr8]
                            /litps,                     [list_inst]
         ◊  INST_INIT    =  instini,                    [R]
         ◊  INST_FIN     =  instfin,                    [R]
         ◊  PRECISION    =  /1.0E-6,                    [DEFECT]
                            /prec,                      [R]

   ♦  CABLE_BP           =  cabl_pr,                    [cable_precont]

   ◊  CABLE_BP_INACTIF   =  cabl_pr,                    [cable_precont]

   ◊  ETAT_INIT          =  (  to see the document [U4.51.03]  ),

   ◊  METHOD          =  /  NEWTON,                  [DEFECT]
                            /  IMPLEX,

      ◊  NEWTON          =  (  to see the document [U4.51.03]  ),

   ◊  RECH_LINEAIRE      =  (  to see the document [U4.51.03]  ),

   ◊  SOLVEUR            =  (  to see the document [U4.50.01]  ),

   ◊  CONVERGENCE        =  (  to see the document [U4.51.03]  ),

   ◊  ENERGY          = _F (),

   ◊  INFORMATION              =  /  1,                          [DEFECT]
                               /  2,

   ◊  TITLE              =  tx                          [KN]
   ),
```

2 Operands

2.1 Opérandes MODEL / CHAM_MATER / CARA_ELEM

♦ MODEL = Mo

Name of the model whose elements are the object of mechanical calculation.

♦ CHAM_MATER = chmat

Name of the affected material field on the grid. Attention, all the meshs of the model must be associated with a material.

♦ CARA_ELEM = carac

Name of the characteristics of the elements of hull, beam, pipe, bars, affected cable and discrete elements on model Mo.

2.2 Keyword EXCIT

♦ EXCIT =

This keyword factor makes it possible to describe with each occurrence a load. It is necessary to provide the boundary conditions for the structure, possibly of the instantaneous loadings like gravity as well as the connections kinematics related to the cables having already been put in tension by a preceding call to CALC_PRECONT. To in no case, one should not include the loading of () the cable (S) which one wants to put in tension by the call to this macro-order, nor loadings related to (X) the cable (S) declared (S) inactive (S).

2.2.1 Operands LOAD

♦ LOAD = CH_I

CH_I ESt the mechanical loading specified with i ème occurrence of EXCIT.

2.3 Keyword BEHAVIOR

The syntax of this keyword common to the order STAT_NON_LINE is described in the document [U4.51.11].

2.4 Keyword INCREMENT

♦ INCREMENT =

Defines the time intervals taken in the incremental method.

2.4.1 Operands LIST_INST

♦ LIST_INST = /litpsr8, [listr8]
/litps, [list_inst]

♦ If LIST_INST = litpsr8 [listr8]

The moments of calculation are those defined in the concept litpsr8 by the operator DEFI_LIST_REEL [U4.34.01].

♦ If LIST_INST = litps [list_inst]

The moments of calculation are those defined in the concept litps by the operator DEFI_LIST_INST [U4.34.03].

Notice :

Even if calculation is carried out with several steps of time, only the last step of time is stored in the concept result.
During the process of setting in tension of the cables, moments are generated automatically besides those provided by the user. It is thus completely normal to see to appear in the file of message of calculations with STAT_NON_LINE at moments that the user did not specify. These moments are not stored in the concept result.

2.4.2 Operands INST_INIT/INST_FIN

◊ INST_INIT = instini

The initial moment of the calculation (which thus (Re) is not calculated) must be indicated by its value.

If this initial moment is not specified, the defect is calculated in the following way:

- if an initial state is specified (operand ETAT_INIT) and if it defines one corresponding moment (by EVOL_NOLI or INST_ETAT_INIT) then the initial moment is that defined by the initial state,
- if there is no initial state or that it does not define a moment corresponding (the fields are given in ETAT_INIT without specifying INST_ETAT_INIT), then one takes the first moment of the list of moments litps (NUME_INST_INIT =0).

◊ INST_FIN = instfin

The final moment (last calculated step) is indicated same manner as the initial moment, except that it is not not possible to refer to the moment of the initial state.

2.4.3 Operand PRECISION

◊ PRECISION = prec

2.5 Keyword CABLE_BP

♦ CABLE_BP = cabl_pr

It is a question here of providing a list of the concepts of the type cabl_precont products by the operator DEFI_CABLE_BP [U4.42.04]. All the cables concerned will be tended at the conclusion of this calculation.

2.6 Keyword CABLE_BP_INACTIF

◊ CABLE_BP_INACTIF = cabl_pr

It is a question here of providing a list of the concepts of the type cabl_precont products by the operator DEFI_CABLE_BP [U4.42.04]. The macro-order is given the responsibility to generate the connections kinematics dependentS with these inactive cables, and does not take into account the rigidity of these cables.

2.7 Keyword METHOD

◊ METHOD = /NEWTON , [DEFECT]
/IMPLEX,

This keyword makes it possible to define the method of resolution of the problem. By default, it is the exact iterative method of Newton which is used. If the user wishes it, it can use the robust method MaySapproximate IMPLEX.

2.8 Keyword NEWTON

The syntax of this keyword common to the order STAT_NON_LINE is described in the document [U4.51.03]. It is usable only if the required method is NEWTON.

2.9 Keyword ETAT_INIT

The syntax of this keyword common to the order STAT_NON_LINE is described in the document [U4.51.03].

2.10 Keyword RECH_LINEAIRE

The syntax of this keyword common to the order STAT_NON_LINE is described in the document [U4.51.03].

2.11 Keyword SOLVEUR

The syntax of this keyword common to several orders is described in the document [U4.50.01].

2.12 Keyword CONVERGENCE

The syntax of this keyword common to the order STAT_NON_LINE is described in the document [U4.51.03].

2.13 Keyword ENERGY

This keyword makes it possible to activate the calculation of the assessment of energy and its posting during the calculation of the stages of setting in prestressed concrete and swing of the external efforts in interior efforts (see the document [R4.09.01]).
This assessment is stored in the table of name PARA_CALC from where it can be extracted using the order RECU_TABLE [U4.71.02]. The assessment at the last moment corresponds only to the assessment of energy of the stage of the swing of the external efforts in interior efforts. As mentioned in Doc. [R7.01, 02] this stage is a digital artifice being used to make it possible to continue calculation thereafter and thus the assessment of energy is negligible there. The assessment of energy at the conclusion of the phase of prestressing is that observed at the previous moment.

2.14 Operand INFORMATION

The syntax of this keyword common to the order STAT_NON_LINE is described in the document [U4.51.03].

2.15 Operand TITLE

◊ TITLE = tx

tx is the title of calculation. It will be printed at the top of the results. See [U4.03.01].

3 Example

One details here the principal stages of a structural analysis containing of the cables of prestressed (CAS-test SSNV164)

3.1 Before using the macro-order

- **Definition of the cables**

In the event of setting in not-simultaneous tension of all the cables, it is necessary to make (at least) as much DEFI_CABLE_BP that stages of loading.

```
CAB_BP1=DEFI_CABLE_BP (MODELE=MO,
                       CHAM_MATER=CMAT,
                       CARA_ELEM=CE,
                       GROUP_MA_BETON=' VOLTOT',
                       DEFI_CABLE= (_F (GROUP_MA=' CAB1',
                                        GROUP_NO_ANCRAGE= ('PC1D', 'PC1F',),
                                        TYPE_ANCRAGE= ('ACTIVE', 'PASSIVE',),),
                                    _F (GROUP_MA=' CAB2',
                                        GROUP_NO_ANCRAGE= ('PC2D', 'PC2F',),
                                                    TYPE_ANCRAGE= ('ACTIVE',
'PASSIVE',),),),),
                       TENSION_INIT=3.750000E6,
                       RECUL_ANCRAGE=0.001,)

CAB_BP3=DEFI_CABLE_BP (MODELE=MO,
                        CHAM_MATER=CMAT,
                        CARA_ELEM=CE,
                        GROUP_MA_BETON=' VOLTOT',
                        DEFI_CABLE= (_F (GROUP_MA=' CAB3',
                                         GROUP_NO_ANCRAGE= ('PC3D', 'PC3F',),
                                                    TYPE_ANCRAGE= ('ACTIVE',
'PASSIVE',),),
                                     _F (GROUP_MA=' CAB4',
                                         GROUP_NO_ANCRAGE= ('PC4D', 'PC4F',),
                                                    TYPE_ANCRAGE= ('ACTIVE',
'PASSIVE',),),),),
                        TENSION_INIT=3.750000E6,
                        RECUL_ANCRAGE=0.001,)

CAB_BP5=DEFI_CABLE_BP (MODELE=MO,
                       CHAM_MATER=CMAT,
                       CARA_ELEM=CE,
                       GROUP_MA_BETON=' VOLTOT',
                       DEFI_CABLE=_F (GROUP_MA=' CAB5',
                                      GROUP_NO_ANCRAGE= ('PC5D', 'PC5F',),
                                     TYPE_ANCRAGE= ('ACTIVE', 'ACTIVE',),),
                       TENSION_INIT=3.750000E6,
                       RECUL_ANCRAGE=0.001,
                       )
```

- **Definition of the loadings**

It is necessary to distinguish:
- *loadings related to the boundary conditions plus the possible instantaneous loadings,*
- *the loading related to the cables containing only the connections kinematics,*
- *posterior not-instantaneous loadings with the setting in tension of the cables.*

```
AIR CONDITIONING =AFFE_CHAR_MECA (MODELE=MO,
                      DDL_IMPO= (
                             _F (GROUP_NO=' PP',
                                DX=0.0, DY=0.0,),
                             _F (GROUP_NO=' PX',
                                DY=0.0,),
                             _F (GROUP_NO=' PY',
                                DX=0.0,),
                             _F (GROUP_NO=' SU3',
                                DZ=0.0,),),
                    PESANTEUR= (9.81, 0.0, 0.0, - 1.0,),)

CMCAB1=AFFE_CHAR_MECA (MODELE=MO,
                       RELA_CINE_BP=_F (CABLE_BP=CAB_BP1,
                                        SIGM_BPEL=' NON',
                                        RELA_CINE=' OUI',),)
CMCAB3=AFFE_CHAR_MECA (MODELE=MO,
                       RELA_CINE_BP=_F (CABLE_BP=CAB_BP3,
                                        SIGM_BPEL=' NON',
                                        RELA_CINE=' OUI',),)
CMCAB5=AFFE_CHAR_MECA (MODELE=MO,
                       RELA_CINE_BP=_F (CABLE_BP=CAB_BP5,
                                        SIGM_BPEL=' NON',
                                        RELA_CINE=' OUI',),)

CHMECA =AFFE_CHAR_MECA (MODELE=MO,
                        DDL_IMPO=_F (GROUP_NO=' SU2',
                                     DZ=1.0,),)
```

- **Preliminary calculation before setting in tension of the cables (optional)**

It is a question here of taking into account the loadings which apply to the structure before the setting in tension of the cables. Not to take into account the rigidity of the cables, and not to introduce a loading on the cables, it is necessary to carry out calculation either on a model not containing the cables or in their affecting a law of behavior WITHOUT, which imposes that the constraint remains worthless in these elements.

```
RES1 = STAT_NON_LINE (MODELE=MO,
                      CHAM_MATER=CMAT,
                      CARA_ELEM=CE,
                      COMPORTEMENT= (_F (RELATION = 'ELAS',),
                                     _F (RELATION = 'WITHOUT',
                                         GROUP_MA= ('CAB1', 'CAB3', 'CAB5'),),),
                      EXCIT   = (_F (LOAD = AIR CONDITIONING,),
                                 _F (LOAD = CMCAB1),
                                 _F (LOAD = CMCAB3),
                                 _F (LOAD = CMCAB5),),
                      INCREMENT=_F (LIST_INST = LINST,
                                    INST_FIN = 150.),)
```

3.2 Use of the macro-order: setting in successive tension of the 5 cables

One appeals with the macro-order as many times as necessary.

```
RES1 =  CALC_PRECONT (reuse=RES1,
                            ETAT_INIT=_F (EVOL_NOLI=RES1),
                            MODELE=MO,
                            CHAM_MATER=CMAT,
                            CARA_ELEM=CE,
                            COMPORTEMENT= (_F (RELATION = 'ELAS',),),
                            EXCIT   = (_F (LOAD = AIR CONDITIONING,),),
                            CABLE_BP   = (CAB_BP1,),
                            CABLE_BP_INACTIF = (CAB_BP3, CAB_BP5,),
                            INCREMENT=_F (LIST_INST = LINST,
                                          INST_FIN  = 300. ,
                                          ),)
RES1 =  CALC_PRECONT (reuse=RES1,
                            ETAT_INIT=_F (EVOL_NOLI=RES1),
                            MODELE=MO,
                            CHAM_MATER=CMAT,
                            CARA_ELEM=CE,
                            COMPORTEMENT= (_F (RELATION = 'ELAS',),),
                            EXCIT    = (_F (LOAD = AIR CONDITIONING,),
                                        _F (LOAD = CMCAB1,),
                            CABLE_BP   = (CAB_BP3,),
                            CABLE_BP_INACTIF = (CAB_BP5,),
                            INCREMENT=_F (LIST_INST = LINST,
                                          INST_FIN  = 450. ,
                                          ),)
RES1 =  CALC_PRECONT (  reuse=RES1,
                             ETAT_INIT=_F (EVOL_NOLI=RES1),
                             MODELE=MO,
                             CHAM_MATER=CMAT,
                             CARA_ELEM=CE,
                             COMPORTEMENT= (_F (RELATION = 'ELAS',),),
                             EXCIT   = (_F (LOAD = AIR CONDITIONING,),
                                        _F (LOAD = CMCAB1,),
                                        _F (LOAD = CMCAB3,),
                             CABLE_BP   = (CAB_BP5,),
                             INCREMENT=_F (LIST_INST = LINST,
                                           INST_FIN = 600. ,
                                           ),)
```

3.3 Continuation of the loading after setting in tension of the cables

The cables being tended, there is not any more but to continue calculation by always including the connections kinematics binding the nodes of the cable to the concrete.

```
RES1 = STAT_NON_LINE (reuse = RES1,
                      ETAT_INIT=_F (EVOL_NOLI=RES1),
                      MODELE=MO,
                      CHAM_MATER=CMAT,
                      CARA_ELEM=CE,
                      COMPORTEMENT=_F (RELATION = 'ELAS'),
                      EXCIT   = (_F (LOAD = AIR CONDITIONING,),
                                 _F (LOAD = CMCAB1),
                                 _F (LOAD = CMCAB3),
                                 _F (LOAD = CMCAB5),
                                 _F (CHARGE=CHMECA,
                                     FONC_MULT = FUNCTION,),
                      INCREMENT=_F (LIST_INST = LINST,),)
```