Definition of an initial stress field and a field of intern variables

Résumé:

It is explained how manufacture two of the fields constituting the initial state of a nonlinear computation (STAT_NON_LINE): the stress field and the field of intern variables.

the components of the stress field have an "analytical" form (for example: state of a ground subjected to the "weight of the grounds"),
the components of the field of intern variables are non-zero constants.

In both cases, the solution consists in connecting a certain number of commands CREA_CHAMP.

For the stress field, the difficulty consists in evaluating "analytical formulas" (OPERATION='EVAL').
For the field of intern variables, the difficulty comes owing to the fact that the quantity associated with intern variables (VARI_R) has a number a priori undetermined of components : "V1", "V2",...

Les solutions suggested are implementations in test ZZZZ130A.

1 Definition of the analytical stress field

One supposes that models it contains finite elements of continuum (`MODELISATION='3D'`).
It is wanted that in each point of Gauss, the components of the stresses have the following statements:

```
SIZZ = RHO*G*Z
SIXX = SIYY = KP*SIZZ
```

where:
`RHO` : density
`G` : acceleration of gravity
`Z` : 3rd coordinate of space
`KP` : coefficient of "pushed" of the grounds

the solution suggested consists with:

1) define three functions "formulas" corresponding to `SIXX`, `SIYY` and `SIZZ`,
2) constitute a field whose components are the preceding functions,
3) evaluate the formulas of the field by providing him the field of geometry necessary to their evaluation.

1.1 Stage 1: define formulas

```
RHO=1000.
G=10.
KP=3.

SIZZ = FORMULA (REEL= """ (REEL: Z) = RHO*G*Z   """)
SIXX = FORMULA (REEL= """ (REEL: Z) = KP*SIZZ (Z)   """)
SIYY = FORMULA (REEL= """ (REEL: Z) = KP*SIZZ (Z)   """)
```

1.2 Stage 2: create the field of formulas `SIG1`

```
SIG1=CREA_CHAMP (OPERATION='AFFE', TYPE_CHAM='ELGA_NEUT_F',
                MODELE=MO,  PROL_ZERO='OUI',
     AFFE=_F (TOUT = "OUI", NOM_CMP = ("X1", "X2", "X3",),
                            VALE_F  = (SIXX, SIYY, SIZZ,)))
```

Remarks

the field `SIG1` which one creates is `a cham_elem` at Gauss points (`ELGA`),
the only fields being able to have components of the type "functions" are the fields of quantity `NEUT_F`. It will thus have to be remembered that the component "`X1`" of `SIG1` is actually "`SIXX`" , etc…,
key word `PROL_ZERO='OUI'` is compulsory because for all the types of element, `the cham_elem_NEUT_R` currently have 6 components: "`X1`" , "`X2`" ,…, "`X6`" . It is thus necessary to agree "to prolong" by zero the field out of the 3 nonaffected components. The prolongation by "zero" for a field whose components are texts (names of the functions) consists in assigning the warp" "to each component absent from the field. Attention thus, it does not act of a null function. One can note it by using `INFO=2` to print field `SIG1` .

1.3 Stage 3: to evaluate the formulas of field SIG1

field SIG1 is a field known at the Gauss points of the elements of the model. In each point, one will want to evaluate functions SIXX, SIYY and SIZZ. For that, it is necessary to have the values of all the variables appearing in functions (here Z). These variables must be known on the same points as the field of functions. It is thus necessary to have a field containing the geometry of the Gauss points (cham_elem_GEOM_R / ELGA).

This field of geometry of Gauss points (CHXG) is obtained starting from the mesh (MA) by the 2 following commands:

```
CHXN=CREA_CHAMP (OPERATION='EXTR', TYPE_CHAM='NOEU_GEOM_R',
      NOM_CHAM='GEOMETRIE', MAILLAGE=MA)

CHXG=CREA_CHAMP (OPERATION='DISC', TYPE_CHAM='ELGA_GEOM_R',
      MODELE=MO,   CHAM_GD=CHXN
```

the first command extracts the field from geometry (with the nodes) of the mesh. The second transforms the field of geometry to the nodes into a field of geometry at the Gauss points by using the shape functions of the finite elements of the model.

One can then evaluate the functions thanks to operator CREA_CHAMP / OPERATION='EVAL' :

```
SIG2=CREA_CHAMP (OPERATION='EVAL', TYPE_CHAM='ELGA_NEUT_R',
      MODELE=MO, CHAM_F=SIG1,  CHAM_PARA= (CHXG,)   )
```

field (SIG2) obtained by rating of a field of quantity NEUT_F is a field of the quantity NEUT_R whose components have the same names as the components of NEUT_F : "X1", "X2",..., "X6".

Caution:

The components "X4" , "X5" , "X6" are indefinite (actually they contain the largest possible reality), because they correspond to a non-existent function.

It still remains to change the quantity of field SIG2 (NEUT_R - > SIEF_R) to finish the manufacture of our analytical stress field:

```
SIGINI=CREA_CHAMP (OPERATION='ASSE', TYPE_CHAM='ELGA_SIEF_R',
      MODELE=MO,  PROL_ZERO='OUI',
      ASSE=_F (TOUT = "OUI",   CHAM_GD = SIG2,
            NOM_CMP = ("X1",  "X2",  "X3",),
            NOM_CMP_RESU = ("SIXX", "SIYY", "SIZZ",)))
```

Note:

only the components "X1" , "X2" and "X3" of field SIG2 are recopied in this operation to give components "SIXX" , "SIYY" , "SIZZ" of field SIGINI . This stress field must also contain the components related to the shears ("SIXY" , "SIYZ" , "SIXZ"). To obtain them (with a zero value), it is necessary to use the prolongation by zero (PROL_ZERO='OUI'),
handling made to obtain the null components of shears, would have been simpler if there were explicitly affected on these 3 components a null function. One would not have had "to play" with the prolongations. But one would have profited from the coincidence which quantities SIEF_R and NEUT_R have all the two 6 components for cham_elem (ELGA) on the elements of the model.

2 Definition of the non-zero field of intern variables

2.1 Problème

One wants to create a field of initial intern variables for command `STAT_NON_LINE`. This field should not be null everywhere. More precisely, one wants:

```
STAT_NON_LINE:
    COMP_INCR= (_F (GROUP_MA='MASSIF', RELATION = "CJS"),
                _F (GROUP_MA='BETON', RELATION = "ENDO_LOCAL"),),
```

for behavior model "`CJS`" (16 intern variables), one wants to affect:

```
V1 = 1.0   and  V9 = 9.0
```

for behavior model "`ENDO_LOCAL`" (2 intern variables), one wants to affect:

```
V2 = 2.0
```

2.2 1st method

the operator to be used is `CREA_CHAMP / OPERATION='AFFE'`. It makes it possible to affect (by mesh or `GROUP_MA`) the values which one wishes. The difficulty comes owing to the fact that the quantity associated with intern variables (`VARI_R`) is different from the different one: one does not know a priori which are its components. Moreover the name of its components translates this ignorance: "`V1`", "`V2`",...
Selon the behavior which the user in STAT_NON_LINE `will choose`, the number of intern variables change. In our example, behavior "`CJS`" requires 16 variables whereas "`ENDO_LOCAL`" uses only 2 of them.

The operation of assignment is done in the following way:

```
VAIN1=CREA_CHAMP (OPERATION='AFFE', TYPE_CHAM='ELGA_VARI_R',
       MODELE=MO, PROL_ZERO='OUI',
       AFFE= (
         _F (GROUP_MA= "BETON", NOM_CMP= "V2", VALE = 2.),
         _F (GROUP_MA= "MASSIF",
              NOM_CMP= ("V1", "V9", "V16",),
              VALE =     (1. ,  9. ,   0. ,)),
    )
)
```

important Remarks:

> *Key word `PROL_ZERO='OUI'` allows to affect only the non-zero components. But as the command is not informed amongst intern variables carried by the meshes, it is based on the affected number highest.*
> *In the example above, on group " `MASSIF`" , it is important to affect "`V16`" (here to 0.) so that the field has 16 components.*
> *It is mportant for the nonlinear computation which will follow that the field of intern variables is coherent with the behaviors which one will choose. I*
> *Ici, it is necessary that the meshes of group "`BETON`" have 2 intern variables (and only 2) and those of group "`MASSIF`" have 16 of them.*

Caution:

> *If models it comprises other types of behavior (for which one does not wish to initialize the field with non-zero values), it is also necessary to affect zero values explicitly to them. This disadvantage (have to know TOUS behaviors used and their number of intern variables) can be raised below with the 2nd method (but it is more intricate).*

2.3 2nd method

Cette method (more intricate) makes it possible to affect explicitly only the meshes which have non-zero components.

The problem is to obtain a field containing a good amount of intern variables for each mesh according to the behavior which will be affected for him in `STAT_NON_LINE`. To solve this problem, one will carry out a fictitious nonlinear computation (with the real behaviors). The field of intern variables produced will be then a "model" good of field.

One will thus make:

1) fictitious nonlinear computation => `UBID`
2) extraction of the field of intern variables (VBID) of result `UBID`
3) assignment of the non-zero values in field `VAIN2`
4) put at zero of `VBID` + overload of the values of `VAIN2` to produce result `VAIN22`

2.3.1 nonlinear Computation fictitious

```
BETON=DEFI_MATERIAU (ELAS=_F (E = 20000. , NU = 0.),
               ECRO_LINE=_F (  SY = 6. , D_SIGM_EPSI = -10000.)  )

 MASSIF=DEFI_MATERIAU (    ELAS=_F (  E = 35.E3, NU = 0.15),
     CJS=_F (  BETA_CJS = -0.55, GAMMA_CJS = 0.82, PA = -100.0,
                RM = 0,289, N_CJS = 0.6, KP = 25.5E3, RC = 0,265, A_CJS =
0.25,))

CHMAT=AFFE_MATERIAU (  MAILLAGE=MA, AFFE= (
       _F (GROUP_MA = "MASSIF", MATER = MASSIF),
       _F (GROUP_MA = "BETON", MATER = BETON),))

TEMPS1=DEFI_LISTE_REEL (  VALE= (0. , 1.) )
CHAR_U1=AFFE_CHAR_MECA (MODELE=MO,
         DDL_IMPO=_F (NODE = ("N1", "N2", "N3",), DX=0., DY=0., DZ=0.) )

UBID=STAT_NON_LINE (MODELE=MO, CHAM_MATER=CHMAT,
       EXCIT= _F (LOAD = CHAR_U1,),
       COMP_INCR= (_F (GROUP_MA='MASSIF', RELATION = "CJS"),
                  _F (GROUP_MA='BETON', RELATION = "ENDO_LOCAL"),),
       NEWTON=_F (  MATRIX = "ELASTIQUE"),
       CONVERGENCE=_F (ARRET = "NON",  # to continue without convergence
                ITER_GLOB_MAXI = 1, ITER_INTE_MAXI = 1),
      INCREMENT=_F (LIST_INST = TEMPS1),
              )
```

2.3.2 Récupération of the "model" field of intern variables

```
VABID=CREA_CHAMP (OPERATION='EXTR', TYPE_CHAM='ELGA_VARI_R', INFO=1,
      NOM_CHAM='VARI_ELGA', RESULTAT=UBID, NUME_ORDRE=1,)
```

Note::

VABID is not null.

2.3.3 Assignment of the non-zero values in a card of NEUT_R

```
VAIN2=CREA_CHAMP (OPERATION='AFFE', TYPE_CHAM='CART_NEUT_R', MODELE=MO,
     AFFE= (
           _F (GROUP_MA= "BETON", NOM_CMP= ("X2",), VALE = (2. ,)),
              _F (GROUP_MA= "MASSIF", NOM_CMP= ("X1", "X9",), VALE = (1. ,
9. ,)),
          )
     )
```

2.3.4 Resetting of the "model" field of intern variables and overloads non-zero values

```
VAIN22=CREA_CHAMP (OPERATION='ASSE', TYPE_CHAM='ELGA_VARI_R', MODELE=MO,
      # bet to zero:
      ASSE= (_F (TOUT= = "OUI", CHAM_GD = VABID, CUMUL='OUI', COEF_R=0.),
      # overload non-zero values:
            _F (GROUP_MA= "BETON", CHAM_GD = VAIN2, CUMUL='OUI', COEF_R=1.,
               NOM_CMP= ("X2",), NOM_CMP_RESU= ("V2",),),
            _F (GROUP_MA= "MASSIF", CHAM_GD = VAIN2, CUMUL='OUI', COEF_R=1.,
               NOM_CMP= ("X1", "X3"), NOM_CMP_RESU= ("V1", "V9",),),
           )
      )
```

Notices;

For the resetting and overloads it non-zero values, one uses key words CUMUL='OUI' and COEF_R=0 .