

Operator TO SOLVE

1 Goal

To solve a system of linear equations (direct or iterative method)

Methods of resolutions established in *Code_Aster* and usable by this order are:

- 1) method `MULT_FRONT` (direct method),
- 2) method `LDLT` (direct method),
- 3) method `MUMPS` (direct method),
- 4) method `GCPC` (iterative method),
- 5) method `PETSC` (iterative method).

The effective choice of the method is done through the order `TO FACTORIZE` [U4.55.01].

For the direct methods, the matrix must be factorized beforehand by the order `TO FACTORIZE` [U4.55.01]. In the case of the iterative methods with prepacking, the matrix of pre conditioning is provided it-also by the operator `TO FACTORIZE` [U4.55.01].

The operator allows complex resolutions for the “direct” methods (not for the iterative methods).

Product a structure of data of the type `cham_no`.

2 Syntax

```

U [cham_no_*] = TO SOLVE
(
  ◇ reuse = U,
  ◆ MATR = With,
  # If method LDLT, MULT_FRONT, MUMPS:
                                     / [matr_asse_DEPL_R]
                                     / [matr_asse_DEPL_C]
                                     / [matr_asse_TEMP_R]
                                     / [matr_asse_TEMP_C]
                                     / [matr_asse_PRES_R]
                                     / [matr_asse_PRES_C]
  # If method GCPC or PETSC:
                                     / [matr_asse_DEPL_R]
                                     / [matr_asse_TEMP_R]
                                     / [matr_asse_PRES_R]
  ◆ CHAM_NO = B, / [cham_no]
  ◇ CHAM_CINE = vcine, / [cham_no]
  # if method PETSC :
  ◇ ALGORITHM = / 'GMRES', [DEFECT]
                 / 'CG',
                 / 'CR',
                 / 'GCR',
  # if method MUMPS, GCPC, PETSC :
  ◇ RESI_RELA = / 1.e-6, [DEFECT]
                / eps, [R]
  # if method GCPC or PETSC :
  ◇ ◆ MATR_PREC = precondition, / [matr_asse_DEPL_R]
                                     / [matr_asse_TEMP_R]
                                     / [matr_asse_PRES_R]
  ◇ NMAX_ITER = / niter, [I]
                 / 0, [DEFECT]
  # if method MUMPS :
  ◇ POSTTRAITEMENTS = ... (see keyword SOLVEUR [U4.50.01])
  ◇ TITLE = titr , [1_K80]
  ◇ INFORMATION = / 1 , [DEFECT]
                  / 2 ,
)

If CHAM_NO: [cham_no_DEPL_R] then (*) → DEPL_R
             [cham_no_TEMP_R] → TEMP_R
             [cham_no_PRES_C] → PRES_C

```

3 General information

This order makes it possible to solve:

- by a direct method, the linear system $\mathbf{AX}=\mathbf{B}$, where \mathbf{A} is a matrix “factorized beforehand” by the order TO FACTORIZE [U4.51.01.],
- by an iterative method (GCPC or PETSC), the linear system $\mathbf{P}^{-1}\mathbf{AX}=\mathbf{P}^{-1}\mathbf{B}$, where \mathbf{P}^{-1} is a matrix of prepacking determined by the order TO FACTORIZE [U4.51.01] and \mathbf{A} the initial assembled matrix.

The resolution is possible for boundary conditions of Dirichlet (boundary conditions kinematics) dualized or eliminated [U2.01.02]. In this last case, if the loading $\mathbf{X}=\mathbf{X}_0$ on the “edge” Γ_0 is applied with a kinematic load (operator AFFE_CHAR_CINE [U4.44.03]) taken into account in the assembled matrix (operator ASSE_MATRICE [U4.61.22]), the “value” of this loading (\mathbf{X}_0) , calculated by the operator CALC_CHAR_CINE [U4.61.03] must be provided by the keyword CHAM_CINE.

4 Operands

4.1 Operand MATR

♦ MATR = With,

Name of the matrix of the system to be solved:

- For the direct methods, one provides to MATR the concept modified by the operator TO FACTORIZE ; this matrix can be real or complex, symmetrical or not.
- For the iterative methods, one provides to MATR the initial matrix. The matrix of prepacking is to be provided with the keyword MATR_PREC.

4.2 Operand CHAM_NO

♦ CHAM_NO = B,

Name of the vector second member (in general obtained by the order ASSE_VECTEUR).

4.3 Operand CHAM_CINE

♦ CHAM_CINE = vcine,

Name of the vector representing the “value” of the boundary conditions of Dirichlet eliminated (i.e. applied with one from the orders AFFE_CHAR_CINE or AFFE_CHAR_CINE_F).

It cham_no comes from the execution of the operator CALC_CHAR_CINE on the list of char_cine (loadings kinematics) associated with the assembled matrix With [U2.01.02].

4.4 Operand ALGORITHM

```
♦ ALGORITHM =/ 'GMRES' [DEFECT]
              / 'CG'
              / 'CR'
              / 'GCR'
```

This keyword is used to choose the algorithm of the iterative method `PETSC`. The various algorithms available are documented in the keyword `SOLVEUR[U4.50.01]`.

4.5 Operand `MATR_PREC`

◇ `MATR_PREC = precondition`

Matrix of prepacking, obtained by the operator `TO_FACTORIZE [U4.55.01]`.

Prepacking is necessary in the iterative methods to obtain a good convergence with a minimum of iterations.

With the method `GCPC`, the matrix of prepacking is a matrix distinct from the matrix of the problem (keyword `MATR`).

On the other hand, with the method `PETSC`, one uses the same matrix for `MATR_PREC` and `MATR`, which wants to say that the order `TO_FACTORIZE` must be made "places from there" (with the keyword `reuse`). See example below.

4.6 Operand `RESI_RELA`

◇ `RESI_RELA = / 1.e-6, [DEFECT]`
`/ eps, [R]`

This keyword is described in `[U4.50.01]`

For the iterative methods `GCPC` and `PETSC`, it is the convergence criteria of the algorithm. For the method `MUMPS`, this keyword makes it possible to check the quality of the solution.

4.7 Operand `NMAX_ITER`

◇ `NMAX_ITER = niter`

Maximum iteration count of the iterative algorithm.

If `niter = 0` then the algorithm chooses an iteration count by default.

4.8 Operand `TITLE`

◇ `TITLE = titr,`

Title which one wants to give to the produced result `[U4.03.01]`.

4.9 Operand `INFORMATION`

◇ `INFORMATION =`

1 : no impression.

2 : impressions

5 Examples

5.1 Resolution by the direct method MULT_FRONT

- Constitution of the assembled matrix and the second member:

The elementary terms before were calculated KEL, FEL.

```
NAKED =NUMÉRIQUE_DDL (MATR_RIGI=KEL)
K =ASSE_MATRICE (MATR_ELEM=KEL, NUME_DDL=NU,)
F =ASSE_VECTEUR (MATR_ELEM=FEL, NUME_DDL=NU,)
```

- Factorization:

```
K =FACTORISER (reuse=K, MATR_ASSE=K, METHODE=' MULT_FRONT',)
```

- Resolution:

```
U =RESOUDRE (MATR=K, CHAM_NO=F,)
```

- for the use of the loads kinematics (with elimination of the imposed degrees of freedom), to see the example set in the order AFFE_CHAR_CINE [U4.44.03].

5.2 Resolution by method MUMPS

```
NAKED = NUME_DDL (MATR_RIGI= KEL)

K = ASSE_MATRICE ( MATR_ELEM= KEL, NAKED NUME_DDL=)
F = ASSE_VECTEUR ( VECT_ELEM= FEL, NAKED NUME_DDL=)
K = TO FACTORIZE ( reuse= K, MATR_ASSE= K, METHODE= 'MUMPS' )
EPD. = TO SOLVE ( CHAM_NO = F , MATR= K )
```

5.3 Resolution by the method of the conditioned pre combined gradient

```
NAKED = NUME_DDL (MATR_RIGI= KEL)

K = ASSE_MATRICE ( MATR_ELEM= KEL, NAKED NUME_DDL=)
F = ASSE_VECTEUR ( VECT_ELEM= FEL, NAKED NUME_DDL=)
KPREC = TO FACTORIZE ( MATR_ASSE= K, METHODE= 'GCPC',
PRE_COND=' LDLT_INC' )
EPD. = TO SOLVE ( CHAM_NO = F , MATR= K, MATR_PREC= KPREC,
NMAX_ITER= 1000 , RESI_RELA= 1e-07
)
```

5.4 Resolution by method PETSC

```
NAKED = NUME_DDL (MATR_RIGI= KEL)

K = ASSE_MATRICE ( MATR_ELEM= KEL, NAKED NUME_DDL=)
F = ASSE_VECTEUR ( VECT_ELEM= FEL, NAKED NUME_DDL=)
K = TO FACTORIZE ( reuse=K, MATR_ASSE= K, METHODE= 'PETSC' )
EPD. = TO SOLVE ( CHAM_NO = F , MATR= K, MATR_PREC= K,
ALGORITHM=' GMRES',
NMAX_ITER= 1000 , RESI_RELA= 1e-07 )
```