

Operator MACR_ELEM_STAT

1 Drank

To create macro-elements for computations of “static substructuring” or for computations of “structural modification”.

In the case of computations of “static substructuring”, the macro-element is calculated by assembly of ordinary finite elements and condensation of the matrixes to the “external” degrees of freedom.

In the case of the “structural modification”, the macro-element is calculated by expansion and condensation of the modal model identified (measured) with the “external” degrees of freedom.

Product a data structure of the `macr_elem_stat` type.

2 Syntax

```

S1 (macr_elem_stat) =MACR_ELEM_STAT (
    ◊ reuse = S1,
    ◊ DEFINITION = _F (
        / # substructuring static :
        ◆ MODELS =mo , [model]
        ◊CHAM_MATER =chmat , [cham_mater]
        ◊CARA_ELEM =carac , [cara_elem]
        ◊CHAR_MACR_ELEM =lchar , [l_char_meca]
        ◊INST=/inst , [R]
        /0.0 , [DEFAULT]
        ◊NMAX_CAS =/10 , [DEFAULT]
        /nbcamx , [I]
        ◊NMAX_CHAR =/10 , [DEFAULT]
        / nbchmx , [I]

        / # structural modification :
        ◆ MODELS =mo , [model]
        ◊CHAM_MATER =chmat , [cham_mater]
        ◊CARA_ELEM =carac , [cara_elem]
        ◆ PROJ_MESU = repgene / [tran_gene]
        / [harm_gene]
        / [mode_gene]
        ◆MODE_MESURE =modemes/ [mode_meca]
        / [base_modale]
    )

    ◊EXTERIEUR = _F (
        | NOEUD =l_no , [l_noeud]
        | GROUP_NO =l_gno , [l_gr_noeud]
    ),

    ◊RIGI_MECA = _F (.),

    ◊ MASS_MECA = _F (.),

    ◊ AMOR_MECA = _F (.),

    # substructuring static :
    ◊CAS_CHARGE = (_F (
        ◆NOM_CAS =nocas , [k8]
        ◊SUIV=/ "OUI" , [DEFAULT]
        / "NON"
        ◊CHARGE=lchar ,
        [l_char_meca]
        ◊INST=/tps , [R]
        /0.0 , [DEFAULT]
    ),),
    )

```

3 General information

This operator is a compulsory point of **transition** for the static substructuring or a computation of structural modification by condensation of measurement.

For the static substructuring, it is useful:

- to define a macro-element (keywords: DEFINITION and EXTERIEUR),
- to ask the condensation of the stiffness matrix (or mass),
- to define (and condense) the associated loadings; the user can name on this occasion one or more loading case.

These 3 stages can be made in only one call to MACR_ELEM_STAT. But they can be made in several times thanks to the use of the key word "reuse" (enrichment of the macr_elem_stat). The stage of definition is obligatorily to realize in first. The condensation of the mass must be done after the condensation of the stiffness.

For the structural modification, it is useful:

- to define a macro-element (keywords: DEFINITION and EXTERIEUR),
- to ask the expansion and the condensation of measurement to lead to condensed stiffness matrixes and of mass.

The macr_elem_stat is a data structure which contains:

- its references: model, cara_elem, cham_mater, load,
- its topological description: external nodes,
- its condensed matrixes (stiffness, mass,...),
- a list of named condensed loadings (for the static substructuring).

The use of all the operators of static substructuring is described in the U2.07.02 note, and the approach of structural modification is described in the U2.07.03 note.

4 Operands

4.1 Key word DEFINITION

◇DEFINITION

This key word factor (not répétable) is used to define the macro-element.

4.1.1 MODEL operand

◆MODELE = Mo

Case "static substructuring":

Name of the model which one wants to condense. The matrixes (and loadings) which one condenses are always calculated on the model **as a whole**. When one wants to condense several subsets of the same mesh, it is thus necessary to create several models on different mesh groups.

Case "structural modification":

Name of the model given in key word MODELE_CALCUL of the command PROJ_MESU_MODAL associated with reppene with key word PROJ_MESU. This model is used as support for the expansion of measurement with the "external" nodes.

4.1.2 Operand CHAM_MATER

◇CHAM_MATER = chmat

Name of the material field associated with the model. This argument is useless so the model contains only static discrete elements and substructures. It is compulsory if not.

4.1.3 Operand CARA_ELEM

◇CARA_ELEM = carac

Name of the elementary characteristics however the model comprises beam elements, of plate or shell.

4.1.4 Operands CHAR_MACR_ELEM / INST

◇ CHAR_MACR_ELEM = lchar

This argument is used to define:

- the thermal loading which modifies possibly the characteristics of the material, when those depend on the temperature; one will specify if necessary the time of the thermal evolution (key word INST),
- the kinematical conditions applied to **the internal nodes** (cf key word EXTERIEUR) of the macro element.

◇INST = inst

During a computation for which the characteristics of material depend on the temperature, one specifies the field of temperature here to be used. The field used is that corresponding to time inst of the thermal evolution referred in the list of the loads lchar (to refer to command CALC_MATR_ELEM ("RIGI_MECA")) [U4.61.01].

Remarks on the kinematical conditions:

In the operators of static substructuring, the kinematical conditions of the type "Dirichlet" are always dualisées, ever eliminated.

*In general one will apply the kinematical conditions to **the external nodes** at the higher level of substructuring. Thus they will not appear in the loads of lchar.*

On the other hand, the kinematical conditions that it is necessary to give before condensation (lchar) are those which one will not be able to give any more afterwards:

- *the conditions implying of the internal nodes (linear d.o.f. imposed or relations) because these nodes will be eliminated,*
- *the conditions defined starting from **edges** of the finite elements (FACE_IMPO) because these finite elements will not exist any more after condensation.*

Notice on the argument lchar :

The loads which appear in the list lchar , which is those make it possible to calculate the stiffness matrixes and of mass:

- *possible load of temperature modifying the characteristics of material,*
- *kinematical conditions (dualisation).*

on the other hand, these loads intervene of nothing in the definition the loadings (second members).

*For example, thermal expansions due to the field of temperature will be taken into account in a loading case only if the load containing this field of temperature is explicitly given in the definition of this loading case (key keys CAS_CHARGE and CHARGE). In the same way **the non-zero kinematical conditions** must be given again in the definition of the loading cases.*

4.1.5 Operands NMAX_CAS / NMAX_CHAR

◇NMAX_CAS = nbcamx

One gives one here **raising** amongst loading case which the user will define on the macro-element (cf argument CAS_CHARGE). This number is taken by default with 10.

◇NMAX_CHAR = nbchmx

One gives one here **raising** amongst concepts of the type charges that one will assign to **each** loading case (cf argument CAS_CHARGE). This number is taken by default with 10.

4.1.6 Operand PROJ_MESU

◆PROJ_MESU = repgene

repgene of the command indicates the name of the concept resulting PROJ_MESU_MODAL [U4.73.01] which made it possible to define measurement and projection base.

4.1.7 Operand MODE_MESURE

◆MODE_MESURE = modemes

One gives here the name of the concept containing in experiments identified eigen modes. These eigen modes make it possible the model to build modal initial structure which will be then condensed with the "external" nodes.

4.2 Key word EXTERIEUR

◆EXTERIEUR =

This key word factor (not répétable) is used to define all the "external" nodes where will be condensed the matrixes and the loadings (the other nodes will be known as "interns"). This key word must appear in the first call to command MACR_ELEM_STAT (one defines the outside of a macro-element in only once).

Each external node carries the same degrees of freedom which the node corresponding of the model M_0 . A macro - element (and geometrically) entirely is topologically defined by the set of its external nodes.

4.2.1 Remarks on the definition of the "outside" of a macro element

- the outside of a macro-element is all the "external" nodes which define the topology and the geometry of the macro-element,
- each "external" node carries **all** the degrees of freedom which exist on this node in the model under - unclaimed. Macro-elements produced by *Aster* are usable that by resticking their external nodes and consequently all the degrees of freedom which it carry. Other computer codes operate differently. For certain modelizations (sliding, pinned end,...), one will be led not to restick some nodes and to use, on the level of under - structuring superior, the linear relations between the degrees of freedom of the external nodes several macro-elements,
- at the time of the definition of the external nodes of a macro-element, if a node appears several times, one counts it only once,
- for reasons of programming, it is necessary that there exist at the same time external nodes and internal nodes: none the families can be empty.

4.2.2 Operands NOEUD/GROUP_NO

| NOEUD = l_noeu

List of the names of nodes which one wishes "external".

| GROUP_NO = l_grno

List of the names of the nodes groups which one wishes "external".

4.3 Key keys RIGI_MECA / MASS_MECA

◆RIGI_MECA

This key word is used to specify that one wants to condense the stiffness matrix.

Case “static substructuring”:

This matrix is calculated on all the elements of the model like on the elements of LAGRANGE of the kinematical conditions contained in the argument of CHAR_MACR_ELEM.

Case “structural modification”:

The condensed stiffness matrix is calculated by expansion of the spectral matrix measured with the “external” nodes.

◇MASS_MECA

This key word is used to specify that one wants to condense the mass matrix.

Case “static substructuring”:

This matrix is calculated on all the elements of the model (condensation of GUYAN).

Case “structural modification”:

The condensed mass matrix is obtained by expansion of the mass matrix generalized measured with the “external” nodes.

◇AMOR_MECA

This key word is used to specify that one wants to condense the damping matrix.

This functionality is not available in “static substructuring”:

Case “structural modification”:

The condensed damping matrix is obtained by expansion of the matrix of the generalized depreciation measured with the “external” nodes.

4.4 Key word CAS_CHARGE.

◇CAS_CHARGE

This key word factor makes it possible to define a set of named **loading cases** (key word NOM_CAS). These loading cases could be applied to the model of higher level (CALC_VECT_ELEM [U4.61.02]).

In general, one will seek to apply the nodal loadings (FORCE_NODALE) at the higher level of substructuring.

On the other hand all the loadings defined on the finite elements must be applied before any condensation: (PESANTEUR, ROTATION, FORCE_FACE, FORCE_CONTOUR, FORCE_INTERNE, FORCE_COQUE, FORCE_POUTRE, PRES_REP,...) since these finite elements “will have disappeared” after condensation.

Let us note that for a macro-element, there is no notion of contour, directional sense, of face,...

4.4.1 Operand NOM_CAS

◆NOM_CAS = nocas

the loading condensed under the name `nocas` (between "quotes") corresponds to the loading defined by the arguments of `CHARGE` and `INST` to which one systematically **adds** the loadings of name `nocas` possibly present on under structures of lower level contained in the model `Mo`.

4.4.2 Operand SUIV

◇SUIV = "OUI"/"NON"

This key word says if the loading case "follows" the macro-element in its geometrical transformations: translation, rotation, (cf operator `DEFI_MAILLAGE` [U4.23.01]). For example, the loading due to a rotation (centrifugal force), a pressure (or an opposed thermal expansion) is "following" because its direction is related to the position of under - structure. On the other hand, gravity is a loading "not follower" (its direction is absolute).

Caution:

The kinematical loadings are always "following" because their taking into account is made in the stiffness matrix (dualisation) and this matrix is "following" by nature.

4.4.3 Operands CHARGE / INSTS

◇CHARGE = lchar,
◇INST = tps,

key keys `CHARGE` and `INST` have the same meaning as in operator `CALC_VECT_ELEM` [U4.61.02].

5 Examples of definition of a macro element

5.1 To define the outside of a macro-element

```
sup1 =MACR_ELEM_STAT      (
    DEFINITION = _F      ( MODELS = Mo,          CHAM_MATER = chmat),
    EXTERIEUR = _F      ( GROUP_NO = EXT.),
)

sup3 =MACR_ELEM_STAT      (
    DEFINITION = _F      ( MODELS = Mo,          CHAM_MATER = chmat, ),
    EXTERIEUR = _F      ( NOEUD = ("N3", "N4") , GROUP_NO = ("L1",
"L3"), )
)
```

5.2 To condense stiffness matrixes and of mass

```
sup1 =MACR_ELEM_STAT      (reuse = sup1,
    RIGI_MECA = _F ( ),    MASSE_MECA = _F ( ),
)
```

5.3 reuse To define a loading on

```
the macro-element sup1      =MACR_ELEM_STAT (= sup1,
    CAS_CHARGE = ( NOM_CAS = "ch1" ,    CHARGE = ch1, ),
)
```

5.4 To define the macro-element, its loadings, and to ask the condensation of the matrixes

```
sup2 =MACR_ELEM_STAT          (  
  
    DEFINITION=      _F ( MODELS = Mo      ,      CHAM_MATER = chmat),  
    EXTERIEUR=      _F ( GROUP_NO = EXT.),  
    RIGI_MECA=      _F ( ),  
    MASSE_MECA      = _F ( ),  
    CAS_CHARGE=     _F ( NOM_CAS = "ch1"  ,      CHARGE = ch1),  
                      )
```

5.5 To define a macro-element for a computation of structural modification and to ask the condensation of the matrixes

```
Sup4 =MACR_ELEM_STAT          (  
  
    DEFINITION=      _F ( MODELS = Mo      ,      CHAM_MATER = chmat  
                          PROJ_MESU=repgene, MODE_MESURE=modemes),  
    EXTERIEUR=      _F ( GROUP_NO = EXT.),  
    RIGI_MECA=      _F ( ),      MASSE_MECA = _F ( ),  
                      )
```