Structure of data `sd_macr_elem_stat`

Summary:

The structure of data sd_macr_elem_stat represents a macro element in static under-structuring. A macro element is to some extent a finite element whose mesh support has an unspecified number of nodes. “To manufacture it”, one starts from a model finite elements and one “condenses it” on some of these nodes (which one calls “external”). This condensation is done by elimination of the ddls carried by the internal nodes. This technique is described for example in the book of J-F. Imbert “Analyzes structures by finite elements” with editions CEPADUES year 1991. At the end of this condensation, the macro element is represented by condensed matrices and loadings. The matrices (rigidity, mass and damping) are full and symmetrical of dimension nddle if nddle is the external number of ddls macronutrient.

Contents

1 The SD in some lines

The structure of data `sd_macr_elem_stat` represent a macro element in static under-structuring.

A macro element is to some extent a finite element whose mesh support has an unspecified number of nodes. "To manufacture it", one starts from a model finite elements and one "condenses it" on some of these nodes (which one calls "external"). This condensation is done by elimination of the ddls carried by the internal nodes. This technique is described for example in the book of J-F. Imbert "Analyzes structures by finite elements" with editions CEPADUES year 1991. At the end of this condensation, the macro element is represented by condensed matrices and loadings. The matrices (rigidity, mass and damping) are full and symmetrical of dimension `nddle` if `nddle` of ddls external macronutrient is the number.

The structure of data contains following information:

- definition of the external nodes of the macronutrient,
- references "upstream" with `sd_maillage` , `sd_modele` , `sd_cham_mater` and `sd_cara_elem` ,
- references "upstream" to `sd_char_meca` conditions kinematics,
- a matrix of condensed rigidity,
- a matrix of condensed mass,
- condensed loadings.

It should be noted that these external nodes are not all of the "physical" nodes: owing to the fact that one can impose conditions kinematics (dualized) on one `sd_macr_elem_stat` , certain nodes of the macro element are of type "Lagrange".

A macro element behaves then as a finite element which could calculate only certain options: `RIGI_MECA` , `MASS_MECA` , `AMOR_MECA` and `CHAR_MECA` .

2 Tree structure

```
sd_macr_elem_stat (K8):: = record

       % description geometrical and topological:
          ♦  '.DESM'    :   OJB   S   V   I        long=10
             '.LINO'    :   OJB   S   V   I
             '.REFM'    :   OJB   S   V   K8
             '.VARM'    :   OJB   S   V   R        long=2
          ◊  '.CONX'    :   OJB   S   V   I

       % condensed rigidity:
          ◊  '.RIGIMECA'   : sd_matr_asse
             '.MAEL_RAID_VALE'    :    OJB    S    V   R
             '.PHI_IE'            :    OJB    XD   V   R   NAKED   long=cste

      % masses condensed and damping:
          ◊  '.MASSMECA'   : sd_matr_asse
             '.MAEL_MASS_VALE'    :    OJB    S    V   R
          ◊  '.MAEL_AMOR_VALE'    :    OJB    S    V   R

       % description of the loadings:
          ◊  '.LICA'              :    OJB    XD   V   R    NO   long=cste
             '.LICH'              :    OJB    XC   V   K8   NO   long=cste

       % if use of DEFINITION/PROJ_MESU:
          ◊  '.PROJM'             :    sd_proj_mesu
```

3 Contents of the objects

`'.DESM ' : OJB S V I long=10`

- DESM (1) : (vacuum)
- DESM (2) : many external nodes to the grid (nbnoe)
- DESM (3) : many internal nodes grid (nbnoi)
  (node grid = physical node or Lagrange node)
- DESM (4) : number of ddls external. total (nddle)
- DESM (5) : number of ddls internal. total (nddli)
- DESM (6) : number of sd_char_meca kinematics. (nbchar)
- DESM (7) : many definite loading cases. (nbcas)
- DESM (8) : number of external lagranges (nlage)
- DESM (9) : number of lagranges relations (nlagl)
- DESM (10) : number of lagranges internal (nlagi)

`'.REFM ' : OJB S V K8 LONG=9+nbchar`

- REFM (1): sd_modele
- REFM (2): sd_maillage
- REFM (3): sd_cham_mater
- REFM (4): sd_cara_elem
- REFM (5): sd_nume_ddl
- REFM (6): "OUI_RIGI"/"NON_RIGI"
- REFM (7): "OUI_MASS"/"NON_MASS"
- REFM (8): "OUI_AMOR"/"NON_AMOR"
- REFM (9) : name of the structure of data provided by the user behind the keyword DEFINITION/PROJ_MESU (type mode_gene , tran_gene ,…)
- REFM (9 +1): char_cinema_1
- REFM (9 +2): char_cinema_2
- …
- REFM (9 +nchar): char_cinema_N

`'.LINO' : OJB S V I`

LINO the list of the external physical nodes contains.
The real number of these nodes (LONUTI) is also in DESM (2) .
The order of the nodes in . LINO is that of appearance in . CONX

`'.CONX' : OJB S V I`

Notice :

This object is actually obligatory. But it appears in the structure of data only at the time of condensation of rigidity and like sd_macr_elem_stat is a réentrant object which one can build in several stages, it can happen that the object . CONX that is to say absent from the SD.

nbnoe = lonuti (LINO)
nbnoet = nbnoe + nlage + nlagl : it is the full number of external nodes.
CONX is dimensioned with 3*nbnoet

The external nodes are numbered in the order of appearance in initial classification (condensed matrix).

```
CONX (1, inoe): ili = number of ligrel of .LILI (nume_ddl)
                      containing the external node inoe
CONX (2, inoe): ino = number of inoe in ligrel ili
CONX (3, inoe): = 0 if physical node
                = -1 if this node of Lagrange is a node "before"
                = -2 if this node of Lagrange is a node "after"
```

`'.VARM ' : OJB S V R LONG=2`

`VARM (1)` size of the blocks of the matrix of factorized rigidity (`LDLT`) and cuts blocks of the matrix `PHI_IE` . This size is given in kilo r8.
`VARM (2)` moment of calculation (`DEFINITION/INST`)

`'.PHI_IE ' : OJB XD V R long=cste NAKED ()`

`PHI_IE` is the matrix: `PHI_IE = K_II ** (- 1) *K_IE`
or `K_II` : submatrix of the internal ddls.
or `K_IE` : submatrix of the internal/external couplings.
`PHI_IE` is a matrix of dimensions `nddle X nddli` . It is stored as a dispersed collection because this object can be very bulky. In each object of the collection (of size maximum `VARM (1)`), one stores a certain number (`nlblph`) lines of the matrix `PHI_IE` . Each line is length `nddle` .
Lines of `PHI_IE` are of course stored consecutively in the objects of the collection. The 1 [er] object contains the lines 1 with `nlblph` , 2 [eme] object contains the lines `nlblph+1` with `2*nlblph` ,…

`'.MAEL_RAID_VALE' : OJB S V R`

Matrix of condensed rigidity (which one calls `KP_EE`).
`KP_EE` is the matrix: `KP_EE = K_EE – K_EI*PHI_IE`

This matrix is stored "symmetrical" by columns:
`KP_EE (I, J) = KP_EE (j* (j-1)/2 +i)` for `j≥i`

`KP_EE` is a vector length `nddle* (nddle+1)/2`

`'.MAEL_MASS_VALE' : OJB S V R`

Matrix of condensed mass (which one calls `MP_EE`).
`MP_EE` is the matrix:
⇒ `MP_EE = M_EE + PHI_EI*M_II*PHI_IE - M_EI*PHI_IE - PHI_EI*M_EI`

This matrix is stored "symmetrical" like `KP_EE`

`'.MAEL_AMOR_VALE' : OJB S V R`

Matrix of damping condensed (which one calls `AP_EE`).
This matrix is stored "symmetrical" like `KP_EE`

Note:
The order `MACR_ELEM_STAT` *does not allow (for the moment) to calculate* `.MAEL_AMOR_VALE` *. But there exists one (or several?) orders dynamic in which one makes pass one* `sd_macr_elem_dyna` *for one* `sd_macr_elem_stat` *. The object* `.MAEL_AMOR_VALE` *, if it is present, is then assembled in the total matrix of damping .*

`'.LICH' : OJB XC V K8 LONG (cste) NO ()`

This collection is oversize compared to the number of the loading cases.

It is named by the names of loading case `nomcas` .
`LICH ( nomcas )` is of dimension `n_char_max+1`
`LICH (nomcas) (1) =/'NON_SUIV '` nonfollowing loading ' `OUI_SUIV` ' following loading
`LICH (nomcas) (1<i≤n_char_max+1)` = name of the load `i-1`

`'.LICA' : OJB XD V R LONG (cste) NO ()`

This collection is oversize compared to the number of the loading cases.
It is named by the names of loading case `nomcas` .

`LICA ( nomcas )` is of dimension `2*nddlt= 2* (nddli+ nddle)`

Each object `LICA (nomcas)` is made of 2 of the same segments length (`nddli+ nddle`) stored end to end.

In the 1 er segment, one finds the second member corresponding to the loading case `nomcas` :

```
LICA (nomcas) (1 ≤ I ≤ nddli) = F_I
LICA (nomcas) (nddli+1 ≤ I ≤ nddli+nddle) = F_E
```

In the second segment, one finds the second member condensed correspondent with `nomcas` :

```
LICA (nomcas) (nddlt+1 ≤ I ≤ nddlt+nddli) = (K_II ** - 1) *F_I
LICA (nomcas) (nddlt+nddli+1 ≤ I ≤ nddlt+nddle) = FP_E
```

with `FP_E = F_E - K_EI* (K_II ** - 1) *F_I`

4 Example: sd_macr_elem_stat S_1 test SSLP100B

Structure of Data: S_1

```
--------------------------------------------------------------------------------
 SEGMENT IMPRESSION OF VALUES >S_1     .CONX                   <

      1 -            1            1            0            1            3
      6 -            0            1            4            0            1
     11 -            7            0            1            9            0
     16 -            1            6            0            1           10
     21 -            0            1           12            0
--------------------------------------------------------------------------------
 SEGMENT IMPRESSION OF VALUES >S_1     .DESM                   <

      1 -            0            8            4           16           12
      6 -            1            2            0            0            4
--------------------------------------------------------------------------------
 IMPRESSION OF THE COLLECTION: S_1     .LICA

 SEGMENT IMPRESSION OF VALUES >S_1     .LICA           $$NOM   <
 >>>>> REPERTOIRE OF NAMES OF THE COLLECTION: S_1     .LICA
      1 - >CHF1    <>CHF2    <

 OBJECT IMPRESSION OF COLLECTION >S_1     .LICA           <  OC:      1

      1 -  3.53553D+00  1.46447D+00  0.00000D+00  0.00000D+00  0.00000D+00
      6 -  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
     11 -  0.00000D+00  0.00000D+00  1.91342D+00  3.80604D-01  1.62212D+00
     16 -  1.08386D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
     21 -  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
     26 -  0.00000D+00  0.00000D+00  0.00000D+00  2.39508D-01  9.92075D-02
```

```
    31 -  2.98282D-02  1.23552D-02 -1.97778D-19 -7.02300D-20  2.95966D-03
    36 -  7.14525D-03 -3.06170D-19 -5.50571D-21  2.95966D-03  7.14525D-03
    41 -  2.64693D+00  1.18501D+00  2.70958D+00  1.03373D+00  8.48546D-01
    46 - -3.31522D-01  1.30381D-01 -6.22318D-02  4.81890D-02  1.36198D-01
    51 -  3.65592D-01  8.34435D-01 -1.16015D-18  8.41068D-19  4.58200D-20
    56 -  2.87916D-20

 OBJECT IMPRESSION OF COLLECTION >S_1     .LICA           <  OC:      2

     1 -  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
     6 - -2.00000D+01  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
    11 -  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
    16 -  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
    21 -  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00  0.00000D+00
    26 -  0.00000D+00  0.00000D+00  0.00000D+00 -1.61431D-18 -7.81792D-19
    31 - -6.45718D-18 -2.26429D-18  3.01596D-01 -1.61168D+00 -8.43526D-02
    36 - -1.00331D-01 -1.59744D-17 -1.28342D-17 -8.43526D-02 -1.00331D-01
    41 - -2.64622D-17 -4.13600D-17 -5.05295D-17  1.06224D-17 -9.17765D-17
    46 - -1.39652D-16 -4.67445D+00 -7.31983D+00  3.49452D+00 -1.72624D+00
    51 - -1.21457D-16  2.45518D-17  2.19705D+00 -4.60236D+00  3.50220D+00
    56 - -2.55199D+00
--------------------------------------------------------------------------------
 IMPRESSION OF THE COLLECTION: S_1     .LICH

 SEGMENT IMPRESSION OF VALUES >S_1     .LICH           $$NOM   <
 >>>>> REPERTOIRE OF NAMES OF THE COLLECTION: S_1     .LICH
     1 - >CHF1    <>CHF2    <

 OBJECT IMPRESSION OF COLLECTION CONTIGUE>S_1     .LICH           <  OC:      1

     1 - >OUI_SUIV<>CHBL_1  <>CHF1_1  <>        <>        <>        <>        <
     8 - >        <>        <>        <

 OBJECT IMPRESSION OF COLLECTION CONTIGUE>S_1     .LICH           <  OC:      2

     1 - >NON_SUIV<>CHF2_1  <>        <>        <>        <>        <>        <
     8 - >        <>        <>        <
--------------------------------------------------------------------------------
 SEGMENT IMPRESSION OF VALUES >S_1     .LINO                  <

     1 -            1            3            4            7            9
     6 -            6           10           12
--------------------------------------------------------------------------------
 SEGMENT IMPRESSION OF VALUES >S_1     .MAEL_RAID_VALE        <

     1 -  6.41345D+00  1.76677D+00  9.20402D+00 -1.81735D+00  1.25037D+00
     6 -  9.57550D+00  1.00328D+00 -4.07100D+00 -1.39527D+00  6.04196D+00
    11 - -2.86996D+00 -2.86915D-01 -2.19245D+00  1.87984D+00  1.43014D+01
    …
   131 -  2.36288D-18 -3.29156D-18 -5.30569D-01 -4.81304D-01  2.71008D+00
   136 -  1.03411D+01
--------------------------------------------------------------------------------
 IMPRESSION OF THE COLLECTION: S_1     .PHI_IE

 OBJECT IMPRESSION OF COLLECTION >S_1     .PHI_IE         <  OC:      1

     1 - -2.11984D-01  1.09032D-02 -9.57179D-02 -1.05534D-01 -1.51204D-18
     6 - -6.17392D-19 -8.67300D-03 -2.98079D-02 -2.08419D-18 -7.70800D-19
    …
   186 - -1.27599D-01 -1.52778D-01  4.83504D-03  4.08788D-19 -1.44063D-17
```

```
    191 - -1.52778D-01  4.83504D-03
--------------------------------------------------------------------------------

 SEGMENT IMPRESSION OF VALUES >S_1     .REFM                  <

      1 - >MO_1    <>MA      <>CHMAT   <>        <>S_1     <>OUI_RIGI<>NON_MASS<
      8 - >NON_AMOR<>        <>CHBL_1  <
--------------------------------------------------------------------------------
 SEGMENT IMPRESSION OF VALUES >S_1     .RIGIMECA  .REFA        <

      1 - >MA                    <>S_1                  <
      3 - >                      <>RIGI_MECA            <
      5 - >                      <>                     <
      7 - >                      <>DECP                 <
      9 - >MS                    <>NOEU                 <
--------------------------------------------------------------------------------
 IMPRESSION OF THE COLLECTION: S_1     .RIGIMECA  .UALF

 OBJECT IMPRESSION OF COLLECTION >S_1     .RIGIMECA  .UALF<  OC:      1

      1 -  1.77687D+01 -3.40898D-01  2.78185D+01 -1.18521D-01 -1.90123D-01
      6 -  3.20885D+01 -2.57251D-01  1.96913D-01 -7.70137D-02  3.68408D+01
     11 -  …
    341 -  0.00000D+00  0.00000D+00  2.77973D+00  1.12895D+01
--------------------------------------------------------------------------------
 IMPRESSION OF THE COLLECTION: S_1     .RIGIMECA  .VALM

 OBJECT IMPRESSION OF COLLECTION >S_1     .RIGIMECA  .VALM<  OC:      1

      1 -  1.77687D+01 -6.05732D+00  2.98834D+01 -2.10596D+00 -4.57102D+00
      6 -  3.33437D+01 -4.57102D+00  7.03607D+00 -2.97096D+00  3.92857D+01
     11 -  …
    166 -  1.12895D+01
--------------------------------------------------------------------------------
 SEGMENT IMPRESSION OF VALUES >S_1     .VARM                  <


      1 -  8.00000D+02  0.00000D+00
--------------------------------------------------------------------------------
```