Data format sd_macr_elem_stat

Summarized:

The data structure sd_macr_elem_stat represents a macro element in static substructuring. 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 “Structural analysis by finite elements” with editions CEPADUES year 1991. At the end of this condensation, the macro element is represented by condensed matrixes and loadings. The matrixes (stiffness, mass and damping) are full and symmetric of dimension nddle if nddle is the external number of ddls macro-element.

Contents

1 SD in some lines

the data structure `sd_macr_elem_stat` represents a macro element in static substructuring.

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 "Structural analysis by finite elements" with editions CEPADUES year 1991. At the end of this condensation, the macro element is represented by condensed matrixes and loadings. The matrixes (stiffness, mass and damping) are full and symmetric of dimension `nddle` if `nddle` is the external number of ddls macro-element.

The data structure contains following information:

- definition of the external nodes of the macro-element,
- the references "upstream" to `the sd_maillage` , `sd_modele` , `sd_cham_mater` and `sd_cara_elem` ,
- of the references "upstream" to `the sd_char_meca` of kinematical conditions,
- a condensed stiffness matrix,
- a condensed mass matrix,
- 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 kinematical conditions (dualized) on `a sd_macr_elem_stat` , some 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 stiffness:
         ◊  ".RIGIMECA"  : sd_matr_asse
            ".MAEL_RAID_VALE"    :    OJB    S    V    R
            ".PHI_IE"            :    OJB    XD   V    R   NU   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 Contained objects

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

- `DESM (1)` : (vacuum)
- `DESM (2)` : many external nodes to the mesh (`nbnoe`)
- `DESM (3)` : many internal nodes mesh (`nbnoi`)
  (node physical mesh = 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` kinematical. (`nbchar`)
- `DESM (7)` : many definite loading cases. (`nbcas`)
- `DESM (8)` : number of lagranges external (`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 data structure provided by L" user behind key word `DEFINITION/PROJ_MESU` (standard `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` contains the list of the external physical nodes.
The real number of these nodes (`LONUTI`) is also in `DESM (2)` .
L" order of the nodes in . `LINO` is that D" appearance in . `CONX`

`".CONX" : OJB S V I`

Note: :

This object is actually compulsory. But it N" appears in data structure that at the time of condensation of the stiffness and as `the sd_macr_elem_stat` is a reentrant object which one can build in several stages, it can happen that the object . `CONX` is absent from SD.

`nbnoe = lonuti (LINO)`
`nbnoet = nbnoe + nlage + nlagl` : it is the nombre total 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 `the ligrel` of `.LILI (nume_ddl)` containing the external node `inoe`
`CONX (2, inoe): ino =` number of `inoe` in `the 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) cuts blocks of the factorized stiffness matrix (LDLT) and cuts blocks of matrix PHI_IE . This size is given in kilo r8.
VARM (2) time of computation (DEFINITION/INST)

“.PHI_IE ` : OJB XD V R long=cste NU ()

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 maximum size VARM (1)), one stores a certain number (nlblph) of lines of matrix PHI_IE . Each line is length nddle .
The lines of PHI_IE are of course stored consecutively in the objects of the collection. The 1st object contains lines 1 with nlblph , the 2nd object contains the lines nlblph+1 with 2*nlblph ,…

” .MAEL_RAID_VALE” : OJB S V R

condensed Stiffness matrix (that L” one calls KP_EE).
KP_EE is the matrix: KP_EE = K_EE – K_EI*PHI_IE

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

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

“.MAEL_MASS_VALE” : OJB S V R

condensed Mass matrix (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 “symmetric” like KP_EE

“.MAEL_AMOR_VALE” : OJB S V R

condensed Damping matrix (which one calls AP_EE).
This matrix is stored “symmetric” as KP_EE

Note:
Command MACR_ELEM_STAT *does not make it possible (for time) to calculate* . MAEL_AMOR_VALE *. But there exists one (or several?) orders dynamic in which one makes pass* a sd_macr_elem_dyna *for* a sd_macr_elem_stat *. The object* . MAEL_AMOR_VALE *, if it is present, will then be assembled in the total damping matrix* .

“.LICH” : OJB XC V K8 LENGTH (cste) NO ()

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

It is named by the names of the nomcas `loading cases` .
`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 nomcas `loading case` .

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

```
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 corresponding 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` of test `SSLP100B`

Data format: S_1

```
--------------------------------------------------------------------------------
 PRINTING SEGMENT 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
--------------------------------------------------------------------------------
 PRINTING SEGMENT OF VALUES >S_1     .DESM                  <
 >>>>>
      1 -           0            8            4           16           12
      6 -           1            2            0            0            4
--------------------------------------------------------------------------------
 PRINTING OF THE COLLECTION: S_1     .LICA

 PRINTING SEGMENT OF VALUES >S_1     .LICA           $$NOM   <
 >>>>> NAME DIRECTORY OF THE COLLECTION: S_1     .LICA
      1 - >CHF1    <>CHF2    <

 PRINTING OBJET 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

 PRINTING OBJET 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
--------------------------------------------------------------------------------
 PRINTING OF THE COLLECTION: S_1     .LICH

 PRINTING SEGMENT OF VALUES >S_1     .LICH          $$NOM   <
 >>>>> NAME DIRECTORY OF THE COLLECTION: S_1     .LICH
     1 - >CHF1    <>CHF2    <

 PRINTING OBJET OF COLLECTION CONTIGUE>S_1     .LICH           <  OC:      1
 >>>>>
     1 - >OUI_SUIV<>CHBL_1  <>CHF1_1  <>        <>        <>        <>        <
     8 - >        <>        <>        <

 PRINTING OBJET OF COLLECTION CONTIGUE>S_1     .LICH           <  OC:      2
 >>>>>
     1 - >NON_SUIV<>CHF2_1  <>        <>        <>        <>        <>        <
     8 - >        <>        <>        <
--------------------------------------------------------------------------------
 PRINTING SEGMENT OF VALUES >S_1     .LINO                  <
 >>>>>
     1 -            1            3            4            7            9
     6 -            6           10           12
--------------------------------------------------------------------------------
 PRINTING SEGMENT 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
--------------------------------------------------------------------------------
 PRINTING OF THE COLLECTION: S_1     .PHI_IE

 PRINTING OBJET 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
--------------------------------------------------------------------------------

 PRINTING SEGMENT OF VALUES >S_1     .REFM                  <
 >>>>>
      1 - >MO_1    <>MA      <>CHMAT   <>        <>S_1     <>OUI_RIGI<>NON_MASS<
      8 - >NON_AMOR<>        <>CHBL_1  <
--------------------------------------------------------------------------------
 PRINTING SEGMENT OF VALUES >S_1     .RIGIMECA  .REFA       <
 >>>>>
      1 - >MA                     <>S_1                     <
      3 - >                       <>RIGI_MECA               <
      5 - >                       <>                        <
      7 - >                       <>DECP                    <
      9 - >MS                     <>NOEU                    <
--------------------------------------------------------------------------------
 PRINTING OF THE COLLECTION: S_1     .RIGIMECA  .UALF

 PRINTING OBJET 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
--------------------------------------------------------------------------------
 PRINTING OF THE COLLECTION: S_1     .RIGIMECA  .VALM

 PRINTING OBJET 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
--------------------------------------------------------------------------------
 PRINTING SEGMENT OF VALUES >S_1     .VARM                  <
 >>>>>

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