How to extract structural matrices (mass,stiffness...) from Ansys and import them into Matlab. Obtention of elementary cyclic symmetric matrices from an elementary sector in Ansys.

Alain Batailly

How to extract structural matrices (mass,stiffness. . .) from Ansys and import them into Matlab. Obtention of elementary cyclic symmetric matrices from an elementary sector in Ansys.

Alain Batailly*

Abstract
The purpose of this note is to explain how to extract stiffness and mass matrices from Ansys. This can be useful for specific calculations with other codes such as Matlab. Section one focuses on structures featuring cyclic symmetric where the stiffness and mass matrices of only one elementary sector allow to obtain the global matrices. Section two presents the Ansys commands to obtain the binary files (***.emat*** and ***.full*** files) containing the matrices. Section three is devoted to the interpretation of these files.

Keywords
Cyclic symmetry, Ansys, Matlab.

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Comment extraire les matrices structurelles (masse, raideur. . .) d'Ansys pour les importer dans Matlab. Obtention des matrices cycliques élémentaires à partir d'un secteur élémentaire lu dans Ansys.

Alain Batailly*

Résumé
L'objectif de cette note technique est d'expliquer la procédure permettant d'extraire les matrices masse et raideur d'un modèle éléments finis créé avec le logiciel Ansys. Cette procédure peut être utile lorsque des manipulations sur les matrices structurelles sont requises (par exemple sous Matlab ou Python) en dehors du cadre défini par Ansys. La première section porte sur les structures à symétrie cyclique pour lesquelles les matrices masse et raideur du secteur élémentaire permettent de reconstituer les matrices masse et raideur de la structure globale. La deuxième section porte quant à elle sur les commandes Ansys permettant d'obtenir les fichiers binaires (***.emat*** et ***.full***) qui contiennent ces matrices. La dernière section est dédiée à l'interprétation de ces fichiers.

Mots-clés
Symétrie cyclique, Ansys, Matlab.

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Introduction

The purpose of this note is to explain how to extract stiffness and mass matrices from Ansys. This can be useful for specific calculations with other codes such as Matlab. Section one focuses on structures featuring cyclic symmetric where the stiffness and mass matrices of only one elementary sector allow to obtain the global matrices. Section two presents the Ansys commands to obtain the binary files (***.emat*** and ***.full*** files) containing the matrices. Section three is devoted to the interpretation of these files.

1. Structures featuring cyclic symmetry

Structures featuring cyclic symmetry require to modify some parameters in Ansys before the extraction of the matrices. That is the reason why the case of these structures is given in the first chapter. The particularity of cyclic symmetry is the definition of "boundaries" allowing the expansion of the structure around the axis of symmetry.

1.1 Defining the boundaries: manual procedure

This section explains how to manually define the boundaries of cyclic symmetric structures. However, for most of the cyclic symmetric structures, Ansys will be able to automatically define these boundaries. In that case, you only need to read the second section of this chapter. Each boundary of the structure must have exactly the same number of nodes. The matrices given by Ansys correspond to a full sector and so are different from the elementary matrices required for a

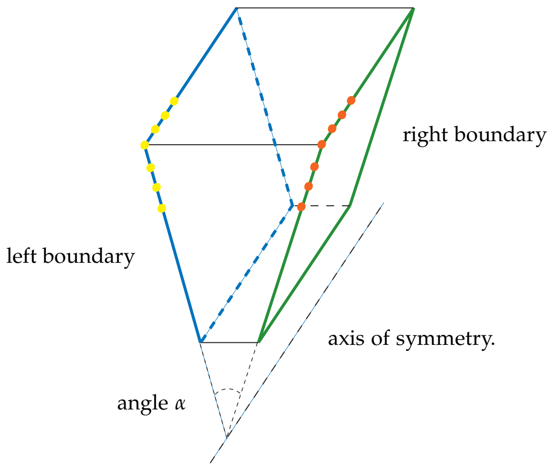


Figure 1. General representation of cyclic symmetric structures with $\frac{2\pi}{\alpha}$ sectors

cyclic symmetry study. A reorganization of the dofs must be done depending on their belonging to a boundary or not. In our case we consider cylindrical coordinates which actually makes the study easier because the elementary blocks will be obtained directly from the reorganization the dofs. Any other coordinates systems will require modifications of the boundary dofs so that the right boundary of sector i is compatible with the left boundary of sector $i+1$. Ansys can automatically generate the left and right boundaries. But with complex (for instance non planar) boundaries, this option might not include all the nodes. Depending on the orientation of the structure, the terms "CYCLIC_M01H" and "CYCLIC_M01L" are alternate if an error message appears when the analysis starts.

1.1.1 Right boundary

Here are the steps to follow:

❶ click on ***Select¿Component Manager... ¿Create Component***

❷ quote the line ***Pick entities***

❸ enter the name ***CYCLIC_M01H*** before validation by clicking on ***OK***

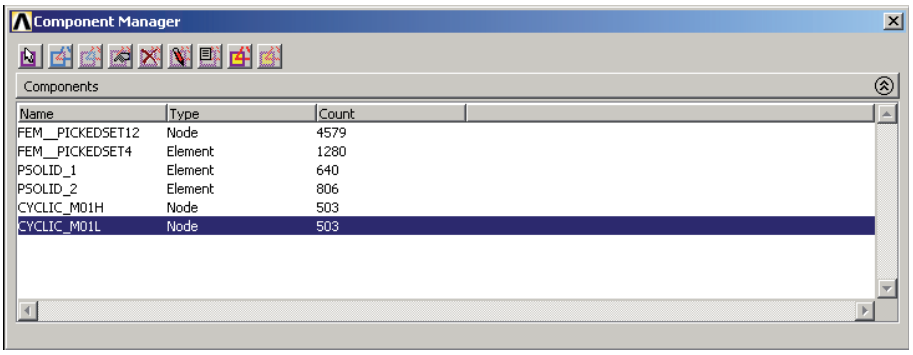
❹ select the nodes on the left boundary (see A and the procedure of ***nodes selection***)

❺ validate the selection by clicking on ***Apply***

❻ a new component should appear in the ***Component Manage*** Window named ***CYCLIC_M01H***

1.1.2 Left boundary

Follow the procedure of the previous subsection exchanging ***CYCLIC_M01H*** by ***CYCLIC_M01L***. The boundaries of the cyclic symmetry are now set. The other parameters of the cyclic symmetry study can be entered using the option ***user defined***.



Name	Type	Count
FEM__PICKEDSET12	Node	4579
FEM__PICKEDSET4	Element	1280
PSOLID_1	Element	640
PSOLID_2	Element	806
CYCLIC_M01H	Node	503
CYCLIC_M01L	Node	503

Figure 2. Window "Component Manager"

1.2 Defining the boundaries : automatic procedure

With most of the cyclic symmetric structures, the ***auto-defined*** option allows to obtain automatically the boundaries. If not, the first thing to do before using the manual procedure is to modify the ***tolerance*** for detecting the nodes on the boundary.

1.3 Linking the boundaries

Obtaining the list of the nodes on each boundary is quite easy with Ansys as explained in appendix A. However it is critical to check the correspondancy of the nodes obtained in each list such as shown in figure 3. The list of nodes can be written in a file by Ansys sorting them among different criterias (X, Y or Z position, number of nodes...). Instead of

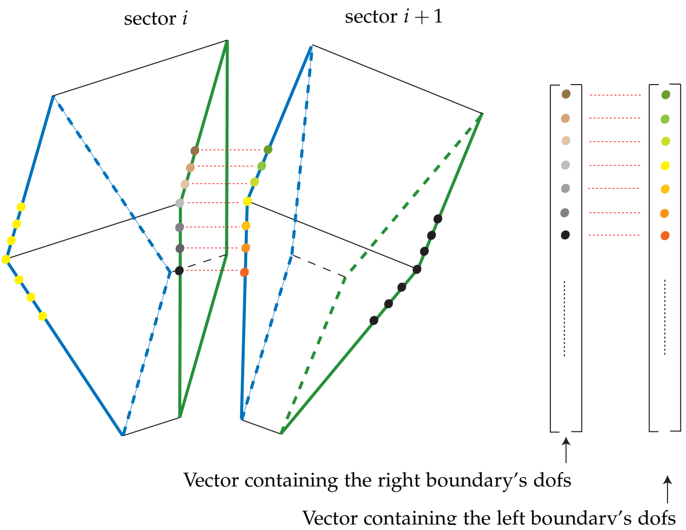

sector i
sector $i+1$
Vector containing the right boundary's dofs
Vector containing the left boundary's dofs

Figure 3. Representation of the correspondancy of the nodes between the two boundaries

complex modifications of these lists, the use of the ***STATUS*** command in Ansys will directly give the correspondance between the two boundaries. After defining all the parameters for the cyclic symmetry, the command:

$$\textit{\textbf{*STATUS,}}\underbrace{\textit{\textbf{CYCLIC}}}_{\text{variable}}\text{\_xref\_n}$$

will create the status.lis file containing the correspondance table between the nodes of the two boundaries. After deleting all the blank lines and non-numerical lines in this file, it can be saved in a ***status.txt*** file. The program ***status.m*** given in B is the Matlab program modifying this file and creating from it two vectors: cycg and cycd respectively the nodes on the left and right boundaries (considering the correspondance table: the node at the i^{th} line in vector cycg is facing the node at the i^{th} line in vector cycd.

2. Obtaining the matrices from Ansys

2.1 Writing *.emat* and *.full* files

The procedure for writing ***.emat*** and ***.full*** files containing the mass and stiffness matrices (Harwell-Boeing format) has been detailed in Cedric Rouault's report available in french.

First step Right before launching the analysis the following command must be entered in Ansys: ***EMATWRITE***, ***YES*** the effect of this command is to force Ansys to create a .emat file. Then, a modal analysis must be launched if mass matrix is needed otherwise, a simple static analysis is enough for getting the stiffness matrix. The command ***WRFULL*** makes the analysis stop after writing the files meaning that Ansys won't actually do the analysis. This command can be useful to avoid long calculations with Ansys.

Obtaining the matrices In the ”menu” bar, use ***file¿list¿binary files*** then choose ***matrix***. Type in the window ***File to be read*** the link to the ***.full*** file that has been generated in the previous step. The format must be *ascii*. ***right hand side*** is not useful for getting the matrices. The only thing to do now for each matrix is to give the name wanted for each matrix created in the Ansys work directory.

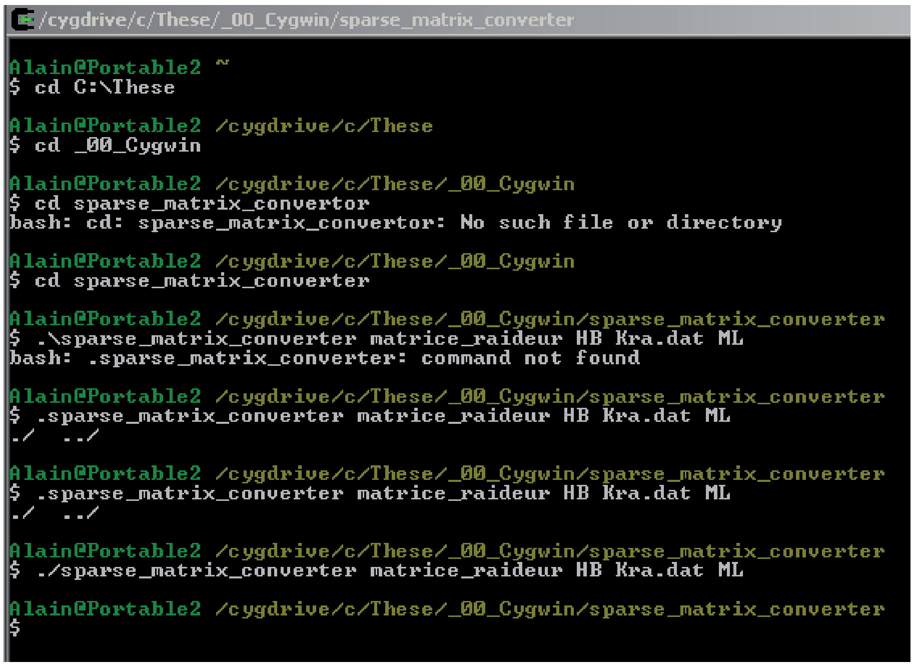
Getting the node equivalence table In the menus bar : ***file¿list¿binary files***. then choose ***other***. Select ***Records to be list*** on ***All records*** and ***amt of output per record*** on ***Entire record***. Type in the window ***file to be read*** the link to *.emat* file. The window appearing contains all the information of the analysis on the structure. The nodal equivalence table is in the Record 5. Please refer to the *’Guide to interfacing with Ansys’* for more details on the content of the *.emat* file.

Transferring the matrices in Matlab The matrices written by Ansys are compatible with the Harwell Boeing (HB) format. They must be converted in Matlab format. The program ***sparse matrix converter*** available here.

3. Converting the matrices from HB to Matlab format

3.1 The Cygwin method

As mentionned previously, this step requires a program working under Linux. The following procedure is only necessary if you work under windows environment. A Linux emulator under windows is used: Cygwin (version 3.2.15(13)-release i686-pc-cygwin). The matrices given by Ansys must be transferred in the Cygwin working folder



```
/cygdrive/c/These/_00_Cygwin/sparse_matrix_converter

Alain@Portable2 ~
$ cd C:\These

Alain@Portable2 /cygdrive/c/These
$ cd _00_Cygwin

Alain@Portable2 /cygdrive/c/These/_00_Cygwin
$ cd sparse_matrix_convertor
bash: cd: sparse_matrix_convertor: No such file or directory

Alain@Portable2 /cygdrive/c/These/_00_Cygwin
$ cd sparse_matrix_converter

Alain@Portable2 /cygdrive/c/These/_00_Cygwin/sparse_matrix_converter
$ .\sparse_matrix_converter matrice_raideur HB Kra.dat ML
bash: .sparse_matrix_converter: command not found

Alain@Portable2 /cygdrive/c/These/_00_Cygwin/sparse_matrix_converter
$ .sparse_matrix_converter matrice_raideur HB Kra.dat ML
./  ../

Alain@Portable2 /cygdrive/c/These/_00_Cygwin/sparse_matrix_converter
$ .sparse_matrix_converter matrice_raideur HB Kra.dat ML
./  ../

Alain@Portable2 /cygdrive/c/These/_00_Cygwin/sparse_matrix_converter
$ ./sparse_matrix_converter matrice_raideur HB Kra.dat ML

Alain@Portable2 /cygdrive/c/These/_00_Cygwin/sparse_matrix_converter
$
```

Figure 4. Commandes Cygwin.

”sparse_matrix_converter”. the required commands are detailed on the picture 4. The result is a dat file containing a three column table compatible with ”spconvert” function in Matlab.

3.2 The RBio Matlab routine

Using the Matlab RBio routine (available here or here) is definitely the fastest way to deal with Harwell-Boeing (HB) or Rutherford-Boeing (RB) format matrices under Matlab. However, the conversion of the matrices from HB/RB format to Matlab format is slightly different from the one obtain in the previous subsection. **Results with matrices from this routine have not been checked.**

4. Description of the matrices

4.1 What Ansys gives

The three matrices which can be obtained from Ansys (stiffness, mass and damping) might have less lines and columns than the total number of dofs of the structure. This comes from the fact that Ansys provides the matrices after considering the boundary conditions. For instance, if some nodes of the structure are built in, then they won’t appear in the matrices given by Ansys. However, it is important to notice that the other tables such as the nodal equivalence table contain ***all*** the dofs. Consequently, it is not possible to directly link the matrices with this table.

4.2 Reading the *.emat* file

The ***.emat*** file is a binary file that can be read with Ansys using the following procedure:

❶ Click on ***File¿List. . . ¿Binary files . . .*** [1]

❷ Choose ***Other¿ok***

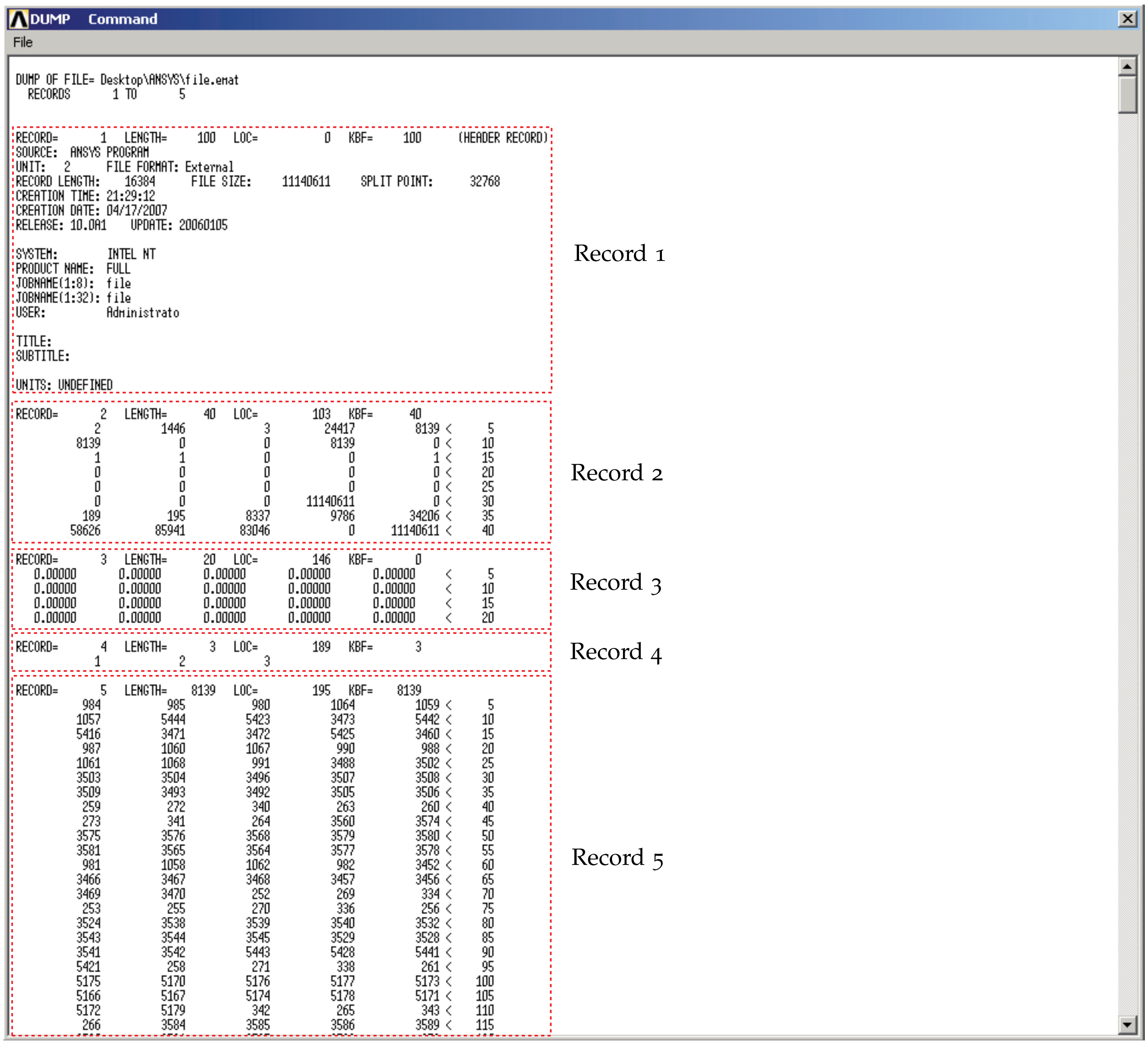
❸ In ***Records to be listed***, choose ***All records***. This field allows to choose the data to be plotted among all the available ones in the ***.emat*** file. Fields 1 to 5 are the ones to focus on

❹ In order to plot specific lists or data, choose ***Specified records*** then type the number of the first list to plot in the ***NSTRT Starting record*** field and the number of the last list to plot in the ***Nstop ending record*** field

❺ In the ***FORM*** field, choose the option ***entire records***. Without this option, Ansys will only write the header of each list without the content

❻ in ***[FILEAUX2] Binary file to list***, point at the folder containing the ***.emat*** file and click ***ok***

❼ The file should now appears in a separate windows



```
DUMP OF FILE= Desktop\ANSYS\file.emat
  RECORDS       1 TO       5

RECORD=       1   LENGTH=     100   LOC=           0   KBF=     100      (HEADER RECORD)
SOURCE:  ANSYS PROGRAM
UNIT:   2      FILE FORMAT: External
RECORD LENGTH:    16384      FILE SIZE:     11140611     SPLIT POINT:      32768
CREATION TIME: 21:29:12
CREATION DATE: 04/17/2007
RELEASE: 10.0A1    UPDATE: 20060105

SYSTEM:        INTEL NT
PRODUCT NAME:  FULL
JOBNAME(1:8):  file
JOBNAME(1:32): file
USER:          Administrato

TITLE:
SUBTITLE:

UNITS: UNDEFINED

RECORD=       2   LENGTH=      40   LOC=         103   KBF=      40
            2           1446              3          24417          8139 <     5
         8139              0              0           8139             0 <    10
            1              1              0              0             1 <    15
            0              0              0              0             0 <    20
            0              0              0              0             0 <    25
            0              0              0       11140611             0 <    30
          189            195           8337           9786         34206 <    35
        58626          85941          83046              0      11140611 <    40

RECORD=       3   LENGTH=      20   LOC=         146   KBF=       0
   0.00000        0.00000        0.00000        0.00000        0.00000     <     5
   0.00000        0.00000        0.00000        0.00000        0.00000     <    10
   0.00000        0.00000        0.00000        0.00000        0.00000     <    15
   0.00000        0.00000        0.00000        0.00000        0.00000     <    20

RECORD=       4   LENGTH=       3   LOC=         189   KBF=       3
            1              2              3

RECORD=       5   LENGTH=    8139   LOC=         195   KBF=    8139
          984            985            980           1064          1059 <     5
         1057           5444           5423           3473          5442 <    10
         5416           3471           3472           5425          3460 <    15
          987           1060           1067            990           988 <    20
         1061           1068            991           3488          3502 <    25
         3503           3504           3496           3507          3508 <    30
         3509           3493           3492           3505          3506 <    35
          259            272            340            263           260 <    40
          273            341            264           3560          3574 <    45
         3575           3576           3568           3579          3580 <    50
         3581           3565           3564           3577          3578 <    55
          981           1058           1062            982          3452 <    60
         3466           3467           3468           3457          3456 <    65
         3469           3470            252            269           334 <    70
          253            255            270            336           256 <    75
         3524           3538           3539           3540          3532 <    80
         3543           3544           3545           3529          3528 <    85
         3541           3542           5443           5428          5441 <    90
         5421            258            271            338           261 <    95
         5175           5170           5176           5177          5173 <   100
         5166           5167           5174           5178          5171 <   105
         5172           5179            342            265           343 <   110
          266           3584           3585           3586          3589 <   115
```

Figure 5. Description of the 5 first "record" of the ".emat" file.

4.3 Interpreting the *.emat* file

Figure 5 shows the Ansys window where is written the ***.emat*** file. Only the 5 first records of this file will be detailed in this section.

Record 1 This list contains general information on the ***.emat*** file such as creation time of the analysis. . .

Record 2 this list is actually a table containing data linked with the analysis. In our case, here is the meaning of some of the number appearing:

[1] Do not pay attention to the error message *This function requires that files currently open be closed. Executing the function will exit the preprocessor* that might appear

- 1446 : number of elements
- 3 : number of dofs per node
- 24417 : total number of dofs...

More details about this record can be found in the ”ANSYS Interfacing Guide” (chapter 1.6.2 page 1-29).

Record 3 This list is relative to time as a parameter of a dynamic analysis.

Record 4 Only a few details are given about this record. It is mainly a code linked with the nature of the dofs for each node. In our case, (1,2,3) means three displacements in a cartesian basis.

Record 5 **This list is essential for the analysis of the matrices given by Ansys** The list is composed of 5 columns of numbers plus a sixth column containing indices of position. It must be seen as a classical single column vector that would be spread on 5 columns to save some space. In the case of figure 5, the list represents a vector ”**V**” which dimensions are $[8139 \times 1]$. This must be read as follow: ***node*** $V(i,1)$ ***(number of the node that would appear in Ansys while selected) is actually at the*** i^{th} ***line/column of the matrices.*** This information is linked with the nodes, in order to have the position of the dofs we must know that node $V(i,1)$ is linked to the dofs $3V(i)-2$, $3V(i)-1$ and $3V(i)$. This dofs will be found on lines/columns $3i-2$, $3i-1$ and $3i$ of the **full** matrices (meaning that there is a shift in these numbers if some nodes are built in for instance).

5. From Ansys to Matlab: general program

This chapter briefly describes the Matlab program used to calculate the eigenfrequencies of a cyclic symmetric structure created with Ansys. The inputs of this program are:

- the mass and stiffness matrices of the structure’s elementary sector (see 4),
- the list of built-in nodes: encas.txt (see A).
- the status.txt file (see B),
- the record5 vector modified as a column vector in a ”.txt” file (see C),

```
clear;
    clc;
    % Reading status.lis file which non numerical lines have been removed
    % The extension of the file is now ".dat"
load status.txt;
    A=size(status);
    a=A(1,1);
    b=A(1,2);
    % We only keep the columns giving the node numbers
    Cor1=status(:,3:4);
    % The lines containing virtual negative values are deleted
    k=1;
    for i=1:a
        if (Cor1(i,2)<=0)
            if (floor(i/2)==i/2)
                Cor1(i,2)=0;
                Cor1(i-1,2)=0;
            else
                Cor1(i,2)=0;
                Cor1(i+1,2)=2;
            end
        end
    end
    % Fitting in two columns
    for i=1:a/2
        Cor2(i,1)=Cor1(2*i-1,2);
        Cor2(i,2)=Cor1(2*i,2);
    end
    % Deleting the "0" lines
    for i=1:a/2
        if Cor2(i,1)>0
            Correspondance(k,1)=Cor2(i,1);
            Correspondance(k,2)=Cor2(i,2);
            k=k+1;
            end
        end
        % Checking
        size(Correspondance)
        % The "Correspondance" vector actually contains the two boundaries:
        % cyc_g and cyc_d
        % The boundary "M01H" is the left column, the boundary "M01L" is the
        % right column.
        cycg=Correspondance(:,2);
        cycd=Correspondance(:,1);
        save cycg.txt cycg -ascii
        save cycd.txt cycd -ascii
        save Correspondance.txt Correspondance -ascii
        % Memory clear
        clear;clc;
    %
    % Creating the cyclic symmetry elementary blocks: K0, K1, M0 and M1
    %

    load encas.txt
        encas_ddl=zeros(3*length(encas),1);
        for i=1:length(encas)
            encas_ddl(3*(i-1)+1,1)=3*encas(i,1)-2;
            encas_ddl(3*(i-1)+2,1)=3*encas(i,1)-1;
            encas_ddl(3*(i-1)+3,1)=3*encas(i,1);
        end;
        % Considering built-in nodes : modifications of the numbers
    load record5.txt % loading Record5.txt from Ansys
        col=record5;
        col_ddl=zeros(3*length(col),1);
        for i=1:length(col)
            col_ddl(3*(i-1)+1,1)=3*col(i,1)-2;
            col_ddl(3*(i-1)+2,1)=3*col(i,1)-1;
            col_ddl(3*(i-1)+3,1)=3*col(i,1);
        end;
        kk=1;
        for i=1:length(col_ddl)
            test=0;
            % is dof "i" built in ?
            for j=1:length(encas_ddl)
                if (col_ddl(i,1)==encas_ddl(j,1))
                    test=1;
                end;
            end;
            % if dof "i" is built in then here is its actual position in the
            % matrices given by Ansys
            if (test==0)
                col2_ddl(kk,1)=col_ddl(i,1);
                kk=kk+1;
            end;
        end;
        % Modifying CYCD
        load cycd.txt

        % Deleting nodes appearing twice (Ansys bug)
        k=1;
        cycd_corrige(1,1)=cycd(1,1);
        for i=2:length(cycd)
            testb=0;
            testb=size(find(cycd(1:i-1,1)==cycd(i,1)));
        if testb(1,1)==0
            cycd_corrige(k,1)=cycd(i,1);
            k=k+1;
        end
        test=0;
    end
    clear cycd
    cycd=cycd_corrige;
    clear cycd_corrige

    cycd_ddl=zeros(3*length(cycd),1);
    for i=1:length(cycd)
        cycd_ddl(3*(i-1)+1,1)=3*cycd(i,1)-2;
        cycd_ddl(3*(i-1)+2,1)=3*cycd(i,1)-1;
        cycd_ddl(3*(i-1)+3,1)=3*cycd(i,1);
    end;
    jj=1;
    for i=1:length(cycd_ddl)
        for j=1:length(col2_ddl(:,1))
            if (col2_ddl(j,1)==cycd_ddl(i,1))
                cycd2_ddl(jj,1)=j;
                jj=jj+1;
            end;
        end;
    end;
    % CYCD2_DDL vector contains the position of the right
    % boundary dofs in the matrices given by Ansys
    %
    % Modifying CYCG
    load cycg.txt

    % Deleting nodes appearing twice (Ansys bug)
    k=1;
    cycg_corrige(1,1)=cycg(1,1);
    for i=2:length(cycg)
        testb=0;
        testb=size(find(cycg(1:i-1,1)==cycg(i,1)));
        if testb(1,1)==0
            cycg_corrige(k,1)=cycg(i,1);
            k=k+1;
        end
        test=0;
    end
    clear cycg
    cycg=cycg_corrige;
    clear cycg_corrige

    cycg_ddl=zeros(3*length(cycg),1);
    for i=1:length(cycg)
        cycg_ddl(3*(i-1)+1,1)=3*cycg(i,1)-2;
        cycg_ddl(3*(i-1)+2,1)=3*cycg(i,1)-1;
        cycg_ddl(3*(i-1)+3,1)=3*cycg(i,1);
    end;
    jj=1;
    for i=1:length(cycg_ddl)
        for j=1:length(col2_ddl(:,1))
            if (col2_ddl(j,1)==cycg_ddl(i,1))
                cycg2_ddl(jj,1)=j;
                jj=jj+1;
            end;
            end;
        end;
        % CYCG2_DDL vector contains the position of the left
        % boundary dofs in the matrices given by Ansys
        %
        % Creating the inversion matrix (reorganizing lines and columns)
        k1=0;
        u=1;
        compteur=0;
        clear vect_int
        vect_int=zeros(length(col2_ddl)-length(cycd2_ddl)-length(cycg2_ddl),1);
        kk=1;
        for i=1:length(col2_ddl)
            test=0;
            for j=1:length(cycg2_ddl)
                if (cycg2_ddl(j,1)==i)
                    test=1;
                end;
                if (cycd2_ddl(j,1)==i)
                    test=1;
                end;
            end;
            if (test==0)
                vect_int(kk,1)=i;
                kk=kk+1;
            end;
        end;
        % VECT_INT contains the position of all the dofs being "internal"
        % (neithe boundary conditions neither cyclic boundaries)
        temp=zeros(length(col2_ddl),3);
        for i=1:length(cycg2_ddl)
            temp(i,1)=i;
            temp(i,2)=cycg2_ddl(i,1);
            temp(i,3)=1;
        end;
        for i=length(cycg2_ddl)+1:length(col2_ddl)-length(cycd2_ddl)
            temp(i,1)=i;
            temp(i,2)=vect_int(i-length(cycg2_ddl),1);
            temp(i,3)=1;
        end;
        for i=length(col2_ddl)-length(cycd2_ddl)+1:length(col2_ddl)
            temp(i,1)=i;
            temp(i,2)=cycd2_ddl(i-length(col2_ddl)+length(cycd2_ddl),1);
            temp(i,3)=1;
        end;
        % Reorganizing mass and stiffness matrices
        L=spconvert(temp);
        % Kra.dat and Mra.dat are stiffness and mass matrices given by Ansys
        % after conversion from HB format to Matlab format.
    load Kra.dat load Mra.dat
        K=spconvert(Kra);
        M=spconvert(Mra);
        Kreo=L*K*L';
        Mreo=L*M*L';
        % Defining the blocks
        Mgg=Mreo(1:length(cycg2_ddl),1:length(cycg2_ddl));
        Mgi=Mreo(1:length(cycg2_ddl),length(cycg2_ddl)+1:length(cycg2_ddl)+...
            length(vect_int));
        Mgd=Mreo(1:length(cycg2_ddl),length(cycg2_ddl)+length(vect_int)+1:end);
        Mii=Mreo(length(cycg2_ddl)+1:length(cycg2_ddl)+length(vect_int),...
        length(cycg2_ddl)+1:length(cycg2_ddl)+length(vect_int));
    Mid=Mreo(length(cycg2_ddl)+1:length(cycg2_ddl)+length(vect_int),...
        length(cycg2_ddl)+length(vect_int)+1:end);
    Mdd=Mreo(length(cycg2_ddl)+length(vect_int)+1:end,length(cycg2_ddl)+...
        length(vect_int)+1:end);
    Kgg=Kreo(1:length(cycg2_ddl),1:length(cycg2_ddl));
    Kgi=Kreo(1:length(cycg2_ddl),length(cycg2_ddl)+1:length(cycg2_ddl)+...
        length(vect_int));
    Kgd=Kreo(1:length(cycg2_ddl),length(cycg2_ddl)+length(vect_int)+1:end);
    Kii=Kreo(length(cycg2_ddl)+1:length(cycg2_ddl)+length(vect_int),...
        length(cycg2_ddl)+1:length(cycg2_ddl)+length(vect_int));
    Kid=Kreo(length(cycg2_ddl)+1:length(cycg2_ddl)+length(vect_int),...
        length(cycg2_ddl)+length(vect_int)+1:end);
    Kdd=Kreo(length(cycg2_ddl)+length(vect_int)+1:end,length(cycg2_ddl)+...
        length(vect_int)+1:end);
    % Defining elementary cyclic symmetry blocks
    LL=speye(length(col2_ddl)-2*length(cycg2_ddl),length(col2_ddl)-2*...
        length(cycg2_ddl));
    for i=1:length(col2_ddl)-2*length(cycg2_ddl)
        LL(i,i)=0;
    end;

    a=size(Mid);
    MAT_O=zeros(length(cycg2_ddl),a(1,2));

    M0=[Mgg+Mdd Mgi; Mgi' Mii];
    M1=[Mgd MAT_O;Mid LL];
    K0=[Kgg+Kdd Kgi; Kgi' Kii];
    K1=[Kgd MAT_O;Kid LL];

    save BLOCS K0 M0 K1 M1

    % Harmonic blocks and calculation of the eigenfrequencies

    K_0=K0+(K1+K1');
    M_0=M0+(M1+M1');

    clear LL Kdd Kid Kii Kgd Kgg Kreo Mreo Mgg Mgi Mgd Mii Mid Mdd K M temp

    [Z,W]=eigs(K_0,M_0,10,'sm');
    F=sqrt(diag(W))/2/pi;
    clear K_0 M_0
    clear K0 M0 K1 M1
    nd=0;
    file=['Blocs_harmonique_',num2str(nd)]
    save (file,'F','Z','W')
    nd
    for nd=1:27
        nd
        load BLOCS
        K=[K0+(K1+K1')*cos(nd*2*pi/56) (K1-K1')*sin(nd*2*pi/56); ...
            (K1'-K1)*sin(nd*2*pi/56) K0+(K1+K1')*cos(nd*2*pi/56)];
        M=[M0+(M1+M1')*cos(nd*2*pi/56) (M1-M1')*sin(nd*2*pi/56); ...
            (M1'-M1)*sin(nd*2*pi/56) M0+(M1+M1')*cos(nd*2*pi/56)];
        clear K0 K1 M0 M1
        [Z,W]=eigs(K,M,10,'sm');
        F=sqrt(diag(W))/2/pi;

        clear K M
```

```
        file=['Blocs_harmonique_',num2str(nd)]
        save (file,'F','Z','W')

        clear F
    end

    load BLOCS
    K_0=K0-(K1+K1');
    M_0=M0-(M1+M1');
    clear K0 K1 M0 M1
    [Z,W]=eigs(K_0,M_0,10,'sm');
    F=sqrt(diag(W))/2/pi;
    clear K_0 M_0
    nd=28;
    nd
    file=['Blocs_harmonique_',num2str(nd)]
    save (file,'F','Z','W')
```

A. Nodes selection procedure

This procedure describes how to obtain a file containing a list of nodes picked manually using Ansys interface. This can also be useful to get any kind of list such as built-in nodes or nodes on a boundary. On the main Ansys window, follow these steps:

❶ Click on ***Select¿Entities. . .***

❷ Check that the following options are selected : ***Nodes***, ***By Num/Pick*** and ***From Full*** and Click on ***ok***

❸ Pick with the cursor (one by one or a group using the ***box*** option) the nodes you need

❹ Click on ***Apply*** and Click on ***ok***

❺ Click on ***List¿Nodes. . .***

❻ Choose your organization options and click on ***ok***: the list of the selected nodes appear in an Ansys window

❼ Save it with the following extension: ***.lis***. In order to use these files with Matlab they must be modified by deleting all the non numerical lines.

B. status.m program

```
clear;
    clc;
    % Reading status.lis file which non numerical lines have been removed
    % The extension of the file is now ".txt"
load status.txt;
    A=size(status);
    a=A(1,1);
    b=A(1,2);
    % We only keep the columns giving the node numbers
    Cor1=status(:,3:4);
    % The lines containing virtual negative values are cancelled
    k=1;
    for i=1:a
        if (Cor1(i,2)<=0)
            if (floor(i/2)==i/2)
                Cor1(i,2)=0;
                Cor1(i-1,2)=0;
            else
```

```
                Cor1(i,2)=0;
                Cor1(i+1,2)=2;
            end
        end
    end
    % Fitting in two columns
    for i=1:a/2
        Cor2(i,1)=Cor1(2*i-1,2);
        Cor2(i,2)=Cor1(2*i,2);
    end
    % Deleting the "0" lines
    for i=1:a/2
        if Cor2(i,1)>0
            Correspondance(k,1)=Cor2(i,1);
            Correspondance(k,2)=Cor2(i,2);
            k=k+1;
        end
    end
    % Checking
    size(Correspondance)
    % The "Correspondance" vector actually contains the two boundaries:
    % cyc_g and cyc_d
    % The boundary "M01H" is the left column, the boundary "M01L" is the
    % right column.
    cycg=Correspondance(:,2);
    cycd=Correspondance(:,1);
    save cycg.txt cycg -ascii
    save cycd.txt cycd -ascii
    save Correspondance.txt Correspondance -ascii
    % Memory clear
    clear;clc;
```

C. record5.m program

The following code is a very shot program to reorganize the record5.txt file obtained from Ansys.

```
clear; clc;
% This program requires the file to be cleared (last two columns filled
% with '<' and line numbers must be erased). "0" must be added if the last
% line contains less than 5 numbers.
load record_5.txt a=length(record_5);
b=length(find(record_5(a,:)>0)); L=5*(a-1)+b;
record_modify=zeros(L,1);

for i=1:5
    for j=1:a
        k=(j-1)*5+i;
        if k>L
            save record_modify.txt record_modify -ascii
            break;
        end
        record_modify(k,1)=record_5(j,i);
    end
end

length(record_modify)
nnz(record_5)
nnz(record_modify)
```