Modal Extraction : DYNAM

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1. Introduction

Goal:

Compute the natural frequencies and the eigen modes of a structure.

Why ?

The structures are lighter and the rotation speeds are also greater than in the past.

So, the gap between the frequencies of the loading and the natural frequencies of the structures become smaller witch induces resonance problems.

The interests of a modal extraction are then:

- to better know the physical behavior of a part
- to set a modal basis for a dynamic response.

Equation:

$$Kq = -M\omega^2 = -F_{inertial}$$

Where K is the stiffness matrix
M the mass matrix
q the displacement vectors
ω the pulsation [rad/sec].

We can consider it is a particular state where the elastic loads are balanced by the inertial loads induced by the masses.

A natural frequency and a deformation characterize a mode.

From the equation we can see that:

There is **NO external forces**
There is **NO damping**.

So the real amplitude (and the sign) of a mode is not known.

Some properties:

- Orthogonality between modes.
- Principle of Rayleigh (ω^2 modified > ω^2 initial) and the displacement method (restrained displacements to shape functions) imply that the frequencies of a discretised system are always higher than the real frequencies. This property can be violated if the compatibility is no more assumed (lumped masses).
- A rigid mode is a mode with a null frequency and can be extracted with DYNAM.
- The mass matrices are consistent for the elements so we can have better results.
- Several methods exist to extract the eigenmodes but Lanczos method is widely used because it iterates on the whole matrix. The other methods are using a static condensation of the matrices which imply a choice of dofs.

2. Generalities

2.1. Output results of DYNAM

- Displacements of the eigenmodes;
- Natural frequencies;
- Modal reactions
- Effective masses and inertial properties.

2.2. The materials

- Isotropic ;
- Orthotropic ;
- Anisotropic ;
- Composite laminate or wound filament.

2.3. The physical properties

- Thickness **(.PHP)**
- Characteristics of beams **(.BPR)**
- Lumped masses **(.MASS)**

2.4. The boundary conditions

- Linear relations **(.LIA, .MPL)**
- Rigid bodies **(.RBE)**

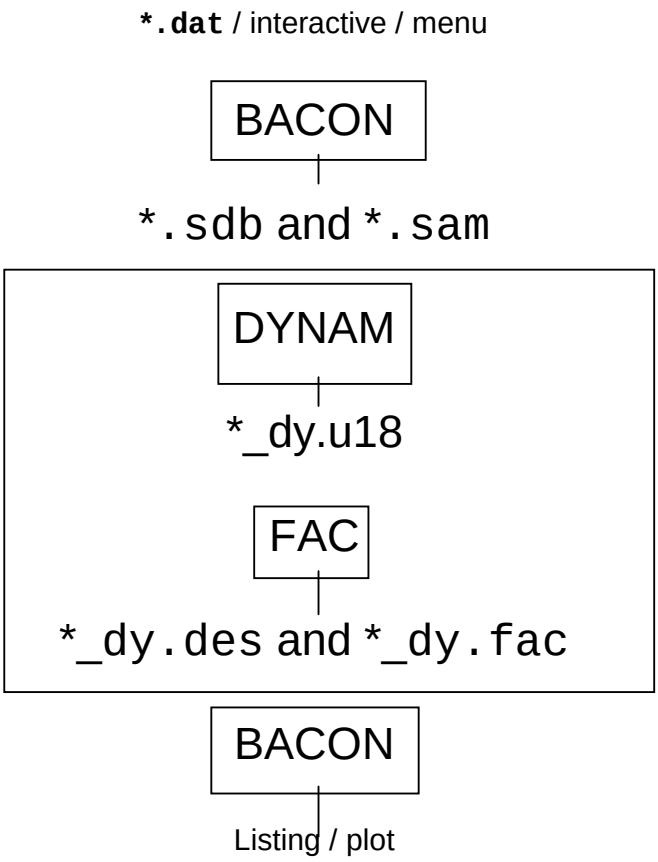
Note: Linear constraints without second hand $\Sigma \alpha_i q_i = 0$

2.5. The execution parameters

- Algorithm **(.SAM NALG or .ALGO)**
- Number of modes to extract **(.SAM NVAL or .ALGO)**

3. Organisation of Dynamic computation

3.1. Organisation chart



Notes:

- ***.sdb** is rewritable in ***.fdb** portable on all stations or PC's.
- ***_dy.fac** is rewritable in ***.fmt,** portable on all stations or PC's
- ***_dy.fac. and *_dy.des** contain visible results.
- Printing formats are Postscript.

3.2. Steps of DYNAM analysis

- Data analysis ;
- Generation of elements ;
- Inspection of the diagonal ;
- Assembly and resolution ;
- Computation of natural frequencies;
- Computation of eigenmodes;
- Normalisation, computation of effective masses and energy ratios

- The computation can be stopped after a step. This allows easy restarts and data sharing between modules.

Command **(.SAM)**

Stops **(ISTO)** at step n (between 1 and 7) and restarts **(ISTA)**
Printing **(NOPi)** i varying between 1 (minimum) and 5 (maximum)

3.3. The files

***** is the name of the problem.

3.3.1. Data and Results

BACON file:	***.sam**
Data base:	***.sdb**
Listing:	***_dy.res**
Storage file:	***_dy.u18**
Description File:	***_dy.des**
File FAC:	***_dy.fac**

3.3.2. Optional Files

Mass matrix:	***_dy.u12**
Stiffness matrix:	***.u11**
Direct access file:	***.u52**
Element kinematic Modes:	***_dy.u68**

4. Lanczos Methods

4.1. Basic Method

The Lanczos method is for solving the problem of eigenvalues in large systems of the type

$$Kq = \omega^2 M q$$

It is based on an iterative scheme of the form

$$Kq_{p+1} = Mq_p$$

The iterative process is initialized using trial vector q_0 whose components are randomly generated.

The frontal method used here is the same as that employed for solving static problems in the *ASEF* module.

4.2. Block Lanczos Method

The block Lanczos method is a variation of the Lanczos method where a group of vectors rather than one single vector are iterated.

The number of vectors to a block (**NTRI**) is set by default to 3 and can be changed using the **.SAM** command's **NTRI** parameter.

When compared with the Lanczos method, the block Lanczos method has the following advantages:

- Convergence in the case of multiple eigenvalues problem.
- In the case of problems without multiple eigenvalues, when the number of vectors to a block is increased the block Lanczos method enables resident time to be reduced even though there is an increase in CPU time. An optimal value in this respect is about 6 vectors per block.

We suggest using the Block Lanczos Method by default.

4.3. Some Important Aspects

Convergence rate
The maximum number of iterations is automatically fixed by the program in accordance with the required number of frequencies.

Solution:

> The maximum number of iterations can be imposed by the user via the **.SAM** command's **NMAX** parameter

Presence of multiple eigenvalues

The Basic Lanczos method is theoretically unsuitable for separating modes corresponding to a multiple eigenvalue.

Solution:

> The Lanczos block method is however better suited in that respect.

Presence of kinematic modes
Kinematic modes are automatically detected during the triangularization of the K stiffness matrix, because the latter must have the same number of singularities (zero pivots) as kinematic modes.
In practice, it may happen that some kinematic modes are not correctly identified. They appear among the lowest frequency vibration modes.

Solution:

> Modifying the method of subdividing into substructures is generally sufficient to remedy this situation (**.RET** command in which we specify the translation components of some nodes uniformly distributed over the structure).