Buckling : STABI

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1. Introduction

Due to the optimization of the structures, designers are building parts, which support static loads, but due to their elongation, they buckle.

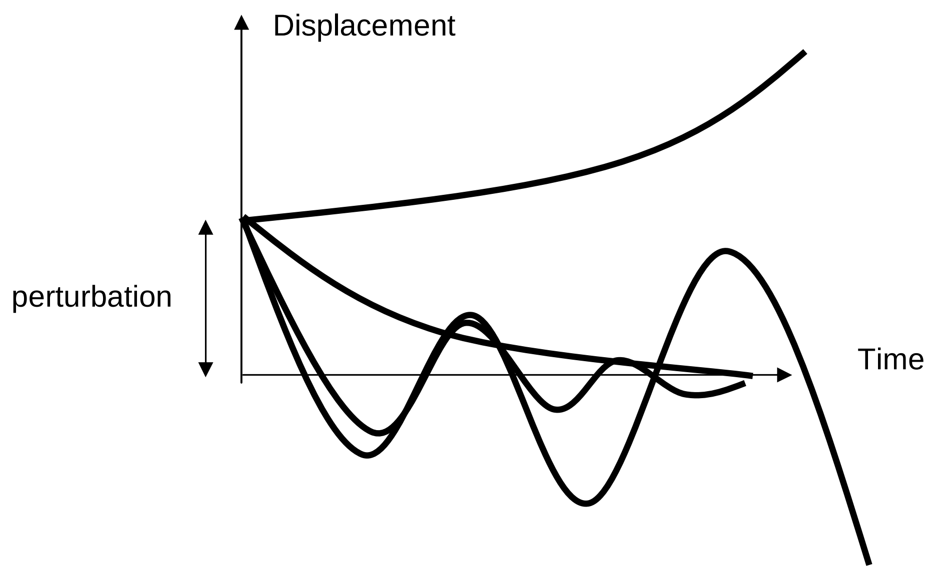
The main reasons are:

- We deal with the flexibility of the part.
- Parts are always unperfectly build.

The consequence is that the part collapse under an admissible static load.

1.1. Position of the problem

We consider a small perturbation on a system in static equilibrium. The behavior of the part can be stable or unstable and it can vibrate or not. So it exists 4 possibilities:



This phenomenon can be study with a non-linear analysis program (MECANO), but in many cases, we only wants to know the critical load and the shape of the mode.

To find the critical load, we can completely estimate the critical path (MECANO + STABI) or to find an estimation of the critical load (ASEF + STABI).

1.2. Hypotheses and Equation

As basic hypothesis, we consider a quasi-static approach (the distribution of mass is not modifying the behavior).

From this quasi-static approach and the linear hypothesis of proportionality between loads and response, we can suppress the time in the equations.

The eigensolution problem consists of solving the equations:

$$(K - \lambda S)\, q = 0$$

Where:

K is the linear stiffness matrix
S the stability matrix = the tangent stiffness matrix of a non-linear analysis.
q the displacement vectors
λ the critical factor.

The stability criterion is to test the positive character of the S matrix.

The stability can have maximum 3 terms:

$$S = K\sigma + (Kp + Ku)$$

$K\sigma$ = geometric stiffness matrix (always computed), is the modification of the bending behavior induced by a tensile or compression stress field.

Kp = follower pressure stiffness matrix (only if **.AEL MKP**), is the variation of pressure induced by the deformation.

Ku = initial rotations stiffness matrix (only if **.AEL MKU**), is the variation induced by initial rotations (reference frame for the stress tensor).

A critical load and a deformation characterize a buckling mode.

Using the same algorithms as a modal extraction, the main difference is that the only mode of interest for a buckling analysis is the first one.

In order to build the stability matrix, we need to perform a linear static analysis. Based on the compression stress field, we build the geometrical stiffness matrix.

The meaning of λ is the factor you have to apply on the load to reach the buckling.

2. Generalities

2.1. Output results of STABI

- Displacements of the eigenmodes;
- Critical loads;

2.2. The materials

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

2.3. The physical properties

- Thickness **(.CAP, .PHP)**
- Characteristics of beams **(.CAP, .BPR)**

2.4. The boundary conditions and loads

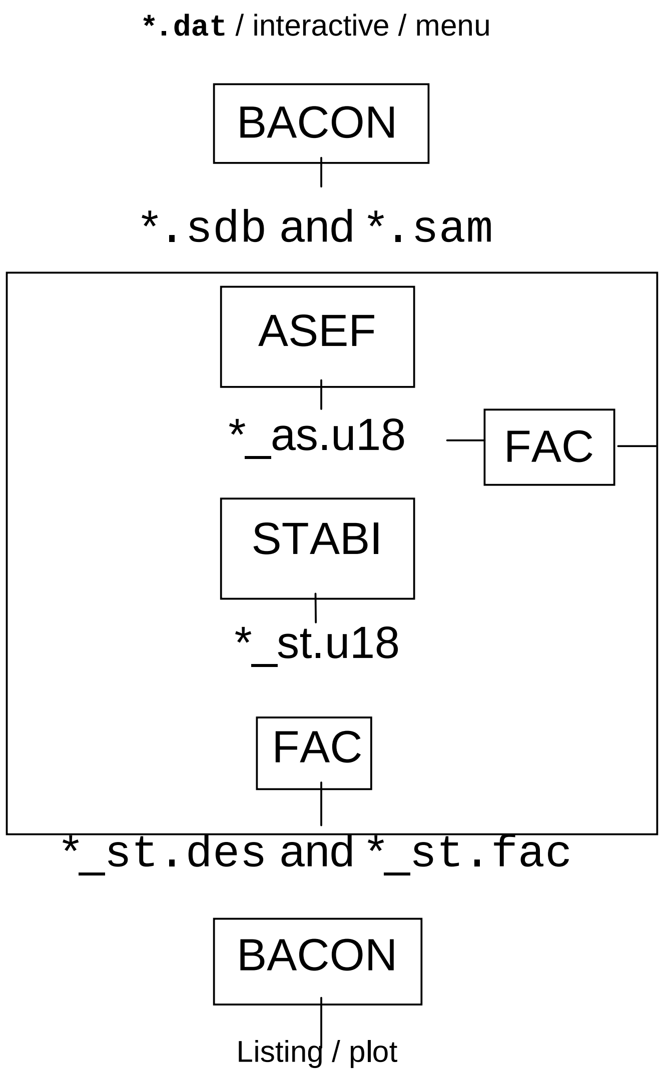
- Linear relations **(.LIA, .CLI)**
- Rigid bodies **(.RBE)**
- Any load available in ASEF.

2.5. The execution parameters

- Algorithm **(.SAM NALG, .ALGO)**
- Number of modes to extract **(.SAM NVAL, .ALGO)**
- Chaining parameter **(.SAM IFPR 19 NPR - PRNO -1)**

3. Organisation of Buckling computation

3.1. Organisation chart



Notes:

- We can post treat the results of the linear static computation.
- Same model must be used for ASEF and STABI with same element ordering.

3.2. Steps of STABI analysis

- Data analysis ;
- Generation of elements ;
- Inspection of the diagonal ;
- Assembly and resolution ;
- Computation of critical loads;
- Computation of eigenmodes;
- Normalisation, printing and storage

Commands **(.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.

Data and Results

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

Optional Files

Stability matrix:	***_st.u12**
Stiffness matrix:	***.u11**
Direct access file:	***.u52**