SDLS120 – Plate 2D fissured subjected to a loading in Mode I. Validation of modal calculation with X-FEM

Summary:

This CAS-test validates modal calculation for a plate 2D having a crack introduced by method X-FEM. One validates in particular the options of calculation RIGI_MECA, MASS_MECA and RIGI_GEOM lately developed for a model X-FEM. The plate presents an emerging crack horizontal and right, of the boundary conditions of embedding are applied to an edge and a loading in pressure on the other in order to open the crack in mode I .

The reference solution, which is the object of modeling A, is calculated by *Code_Aster* by using the similar model with the crack with a grid in a classical way. The first 8 modes clean are calculated and their Eigen frequencies are compared.

The operation of the orders of postprocessing for the visualization of a result of the type mode_meca calculated with a model X-FEM is also tested.

1 Problem of reference

1.1 Geometry

The structure is a plate 2D of dimensions $LX=10\,m$ and $LY=30\,m$, comprising a crack emerging right and horizontal length $a=5\,m$, being located at middle height (see [Figure 1.1-has]).
To obtain the reference solution, with the problem is dealt by the classical method of the finite elements and it crack is with a grid. On the other hand, for the validation of modal calculation with the method X-FEM, the crack is not with a grid, and the geometry is in fact a healthy plate without crack. The crack will then be introduced by functions of levels (level sets) directly into the file orders using the operator `DEFI_FISS_XFEM` [U4.82.08].

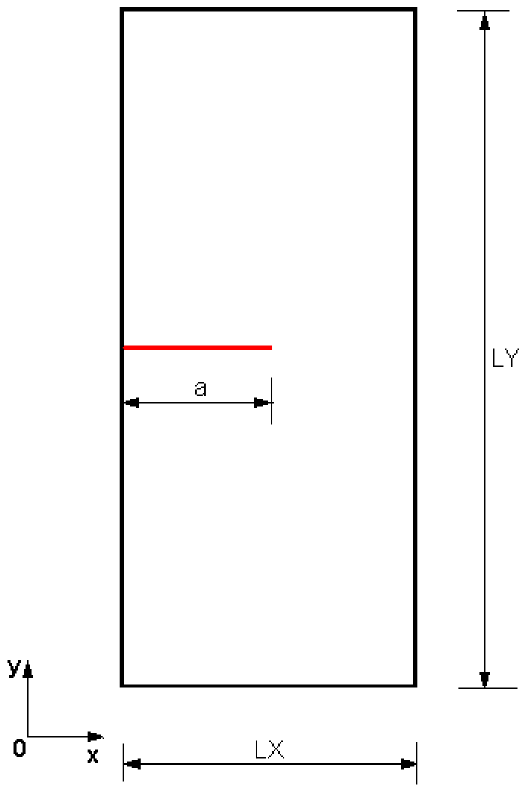


Figure -1.1-a : Geometry of the fissured plate

1.2 Properties of material

Young modulus: $E=205\,000\,MPa$ (except contrary mention)
Poisson's ratio: $\nu=0.0$
Density: $\rho=7800\,kg/m^3$

1.3 Boundary conditions and loadings

The plate is embedded on its lower edge and is subjected to a uniform pressure $P=10\,Mpa$ on its higher edge in order to open the crack (see Figure3.2-a).

2 Reference solution

The reference solution is calculated by modeling A (see the following chapter) with the classical method of the finite elements by considering the crack with a grid.

3 Modeling A

3.1 Characteristics of modeling

In this modeling one considers the framework of the plane deformations (D_PLAN), the crack is with a grid, and one uses the classical method of the finite elements to carry out calculation. This modeling will be used as reference and will allow the comparison with method X-FEM.

3.2 Characteristics of the grid

The structure is modelled by a regular grid composed of 30×50 QUAD4, respectively along the axes x, y (see [Figure 3.2-has]). The lips of the crack are generated by the two edges superimposed with middle height of the plate (milked thicker on the figure).

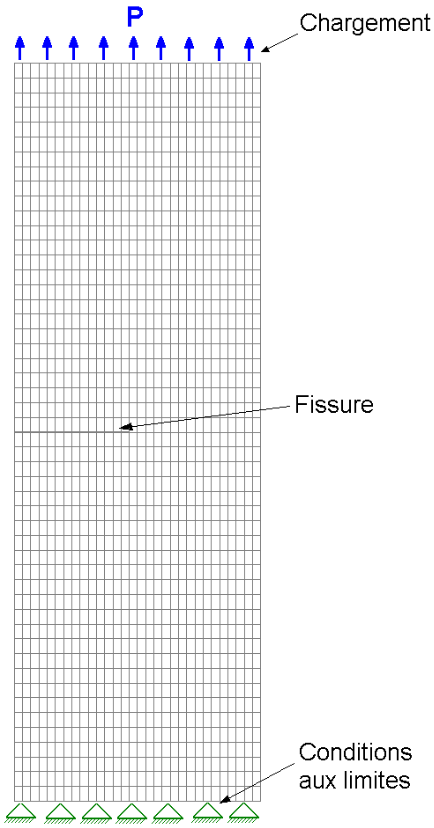


Figure 3.2-a: Grid for modeling A. Illustration of the boundary conditions and the loading

3.3 Features tested

One calculates the first 8 modes clean of the structure by considering the contribution of geometrical rigidity due to the prestressing induced with balance by the loading considered.

Orders		
CALC_MATR_ELEM		OPTION = 'RIGI_MECA' OPTION = 'MASS_MECA' OPTION = 'RIGI_GEOM'
CALC_MODES		OPTION = 'PLUS_PETITE'
	CALC_FREQ	NMAX_FREQ = 8
	SOLVEUR_MODAL	METHOD = 'SORENSEN'

3.4 Sizes tested and results

For this modeling one considers tests of not-regression on the Eigen frequencies of the first 8 modes.

Identification	Reference	*Code_Aster*	% difference
Frequency mode 1	7.005	7.005	0.
Frequency mode 2	24,895	24,895	0.
Frequency mode 3	41,820	41,820	0.
Frequency mode 4	84,905	84,905	0.
Frequency mode 5	106,179	106,179	0.
Frequency mode 6	134,298	134,298	0.
Frequency mode 7	166,198	166,198	0.
Frequency mode 8	181,048	181,048	0.

4 Modeling B

4.1 Characteristics of modeling

In this modeling, always D_PLAN, case X-FEM is considered. The crack is not with a grid any more, it is introduced into the healthy grid by the operator DEFI_FISS_XFEM.

4.2 Characteristics of the grid

The structure is modelled by a regular grid composed of 30×50 QUAD4, respectively along the axes x, y (see [Figure 4.2-has]). One can observe that the meshs affected by the crack are partitionnées in triangles by operators X-FEM for needs for digital integration of the quantities as the mass and rigidity.

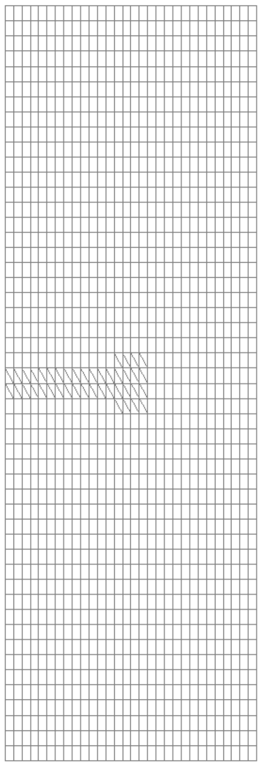


Figure 4.2-a: Grid for modeling B

4.3 Features tested

One calculates the first 8 modes clean of the structure by considering the contribution of geometrical rigidity due to the prestressing induced with balance by the loading considered.

Orders		
CALC_MATR_ELEM		OPTION = 'RIGI_MECA' OPTION = 'MASS_MECA' OPTION = 'RIGI_GEOM'
CALC_MODES		OPTION = 'PLUS_PETITE'
	CALC_FREQ	NMAX_FREQ = 8
	SOLVEUR_MODAL	METHOD = 'SORENSEN'
POST_CHAM_XFEM		RESULT = sd_mode_meca

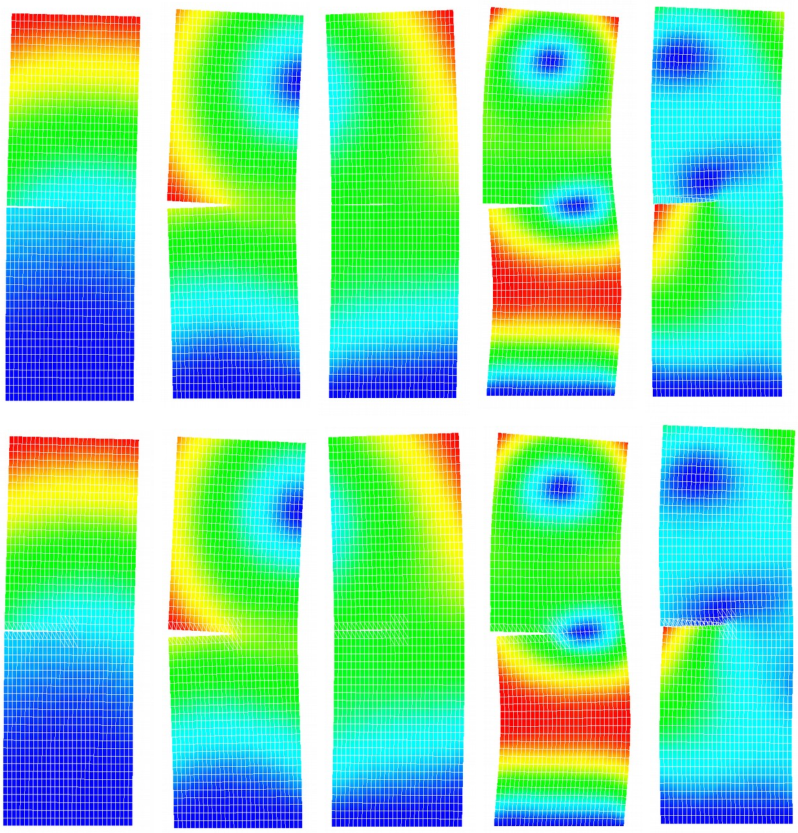
4.4 Sizes tested and results

For this modeling one regards tests on the Eigen frequencies of the first 8 modes with as reference the results resulting from modeling A.

Identification	Reference	*Code_Aster*	% difference
Frequency mode 1	7.005	6,902	1.5
Frequency mode 2	24,895	24,984	0.36
Frequency mode 3	41,820	41,143	1.6
Frequency mode 4	84,905	84,661	0.29
Frequency mode 5	106,179	103,269	2.7
Frequency mode 6	134,298	135,242	0.70
Frequency mode 7	166,198	165,284	0.55
Frequency mode 8	181,048	181,556	0.28

4.5 Remarks

As one can observe it in comparative results for this modeling, one obtains differences enter the Eigen frequencies calculated with model X-FEM and those calculated with the classical model. These differences are normal knowing that the mass, elastic rigidity as well as the geometrical contribution of rigidity are calculated in way different for elements X-FEM. Those are partitionnées in triangles on which one considers diagrams of integration at 12 points. On the other hand, for the classical elements one uses the diagram at 4 points. For certain clean modes (in particular mode 5 here) the difference is even larger because in this case the contribution of geometrical rigidity plays a more important part. As for the reference solution the network is rather coarse around the point of the crack, the stress field is not calculated with the same precision as in case X-FEM where special functions of enrichment allow a more exact evaluation. Concerning the modal deformations, one notes (see the Figure 4.5-a) a very good agreement between the results resulting from classical calculation and those resulting from calculation X-FEM.



mode 1 mode 2 mode 3 mode 4 mode 5

Figure 4 .5 - a: modal deformations for the first 5 clean modes. On the line of in top are the "classical" modes and on the line of in bottom those "X-FEM"

5 Summary of the results

This CAS-test allowed the validation of the modal calculation of a structure 2D presenting a crack introduced by method X-FEM. The comparative one of the results considered here, the Eigen frequencies of the first 8 modes, shows a good agreement between "classical" calculation where the crack is with a grid and calculation with X-FEM.