SSNP139 – Cracking of a beam DCB with a cohesive model

Summary:

This test makes it possible to model the propagation of a rectilinear crack in a beam DCB (Double Beam Cantilever) two-dimensional with the finite elements of interface (modeling PLAN_INTERFACE) and of joint (modeling PLAN_JOINT).

Modeling a: cohesive Law CZM_OUV_MIX , propagation by brittle fracture in the presence of plasticity and test of the order POST_CZM_FISS (OPTION = ‘LENGTH’) with an elastic material.

Modeling b: cohesive Law CZM_FAT_MIX , propagation by tiredness in the presence of plasticity

Modeling C: Cohesive law CZM_LIN_REG, propagation by brittle fracture with an elastic behavior and test of the order POST_CZM_FISS (OPTION = ‘LENGTH’).

Local classification *ad hoc* cohesive elements is ensured by the order MODI_MAILLAGE and the keyword ORIE_FISSURE.

1 Problem of reference

1.1 Geometry and loading

That is to say a beam DCB having an initial crack length a_0, subjected to an imposed displacement U at an end.

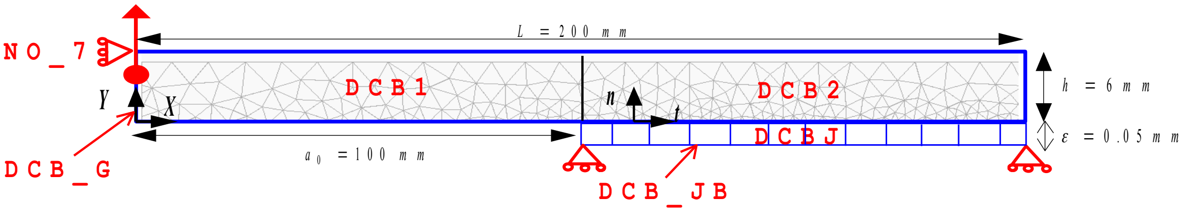

Figure 1.1-a : Diagram of the beam DCB, boundary conditions and loading.

Elements stop cohesive of interface are laid out along the axis of symmetry of the beam in the prolongation of the initial crack. The beam DCB is with a grid with quadratic triangular elements, it has an elastoplastic behaviour with isotropic linear work hardening. The symmetry of the problem makes it possible to carry out calculations on half of the beam, the crack is requested in mode I pure, to see figure 1.1-a.

The boundary conditions are the following ones:

- Imposed displacement U : DY imposed on the face DCB_G
- Condition of symmetry: $DY=0$ on DCB_JB
- Blocking of the movements of rigid body: $DX=0$ on NO_7

For modeling A and C the loading is monotonous, it grows of $DY=0$ with $DY=3.5\,mm$ moment 0 at moment 10.

For modeling B the loading is cyclic in teeth of saw (tops at the odd moments: 1.3 and 5 and hollow at the even moments: 2 and 4). The amplitude of the loading is of $0.4\,mm$ and the report of load is null.

2 Reference solution

In elasticity the solution approximate beam (valid if $h \ll L$) connect kindness $C=U/F$ (displacement imposed on resultant of the force) with the length of crack a , with the geometry and the Young modulus E :

$$a=(3\text{C.E.I})^{(1/3)}$$

with I moment of inertia of the beam $I=Bh^3/12$, B the thickness (unit in 2D) and h the half-height. This solution is used in modelings A and C to validate the option of postprocessing `OPTION = 'LENGTH'` macro-order `POST_CZM_FISS` (calculation length of cohesive crack).

There is no reference solution for the problem where the DCB has an elastoplastic behavior, tests of nonregression are carried out.

3 Parameters material

Values of the Young modulus, the Poisson's ratio, the constraint threshold of elasticity, the plastic module, critical stress and tenacity of material are in the following way selected:

$E=200000\,MPa$	$\nu=0.3$
$S_y=30\ MPa$	$E_{plas}=3577\ MPa$
$\sigma_c=35\ MPa$	$G_c=0.259\ Mpa.mm$

They are values “tests” which do not correspond to any material in particular.

Notice :

The mechanical problem is symmetrized: one models only half of a crack (only one lip). The latter dissipates an energy twice less important than a complete crack. To model a material of tenacity given G_c *, it is thus necessary to carry out simulation with a value of* $G_c/2$ *.*
The digital parameters of the model of interface are those proposed by default with the user.

4 Modeling A

4.1 Characteristics of modeling

The simulation of the propagation of crack by brittle fracture is carried out with modeling PLAN_INTERFACE and the law of behavior CZM_OUV_MIX for the cohesive meshs.

Two calculations are carried out.
- One with voluminal elements, in plane deformations D_PLAN, and a behaviour elastoplastic with isotropic linear work hardening: law VMIS_ISOT_LINE.
- The other with voluminal elements in plane deformations D_PLAN and an elastic behavior.

In two calculations one calculates the length of the cohesive crack with the macro one POST_CZM_FISS.

4.2 Characteristics of the grid

One carries out a quadratic grid not structured of the half-beam and potential crack.
Voluminal elements (DCB): 8060 TRIA6
Elements of interface (way of crack): 500 QUAD8

4.3 Sizes tested and results

For elastoplastic calculation one carries out tests of nonregression. One tests F^R the resultant of the force corresponding to imposed displacement U, as well as the jump of normal displacement on the first mesh of interface to be opened ($V7$ on the mesh $M9788$).

For the elastic design one carries out tests of nonregression and tests to validate the option of postprocessing OPTION = 'LENGTH' macro-order POST_CZM_FISS starting from the analytical solution presented partly 2.

Size tested	analytical
LONG_FIS at moment 10	110.2

5 Modeling B

5.1 Characteristics of modeling

The simulation of the propagation of crack by tiredness is carried out with modeling PLAN_INTERFACE and the law of behavior CZM_FAT_MIX for the cohesive meshs. Voluminal elements, in plane deformations D_PLAN, are elastoplastic with isotropic linear work hardening, law VMIS_ISOT_LINE.

5.2 Characteristics of the grid

The grid is identical to that of modeling A.

5.3 Sizes tested and results

Tests of nonregression are carried out. One tests F^R the resultant of the force corresponding to imposed displacement U, displacement at a top of the loading, as well as the jump of normal displacement on the first mesh of interface to be opened ($V7$ on the mesh $M9788$).

6 Modeling C

6.1 Characteristics of modeling

The simulation of the propagation of crack by brittle fracture is carried out with modeling PLAN_JOINT and the law of behavior CZM_LIN_REG for the cohesive meshs. Voluminal elements in plane deformations D_PLAN have an elastic behavior.

The length of the cohesive crack is calculated with the macro one POST_CZM_FISS.

6.2 Characteristics of the grid

One carries out a linear grid not structured of the half-beam and potential crack.
Voluminal elements (DCB): 8060 TRIA3
Elements of joint (way of crack): 500 QUAD4

6.3 Sizes tested and results

One carries out tests of nonregression on the mechanical answer as well as a test our to validate the option of postprocessing OPTION = ‘LENGTH’ macro-order POST_CZM_FISS starting from the analytical solution presented partly 2.

Size tested	analytical
LONG_FIS at moment 10	110.2

7 Summary of the results

The model cohesive of joint and interface make it possible qualitatively to simulate the propagation of crack in brittle fracture or tiredness with or without plasticity. The introduction of nona linearity material disturbs the convergence of calculations slightly. The time necessary is a little longer than for a linear material.

It is necessary however simultaneously to take some care during the use of the two types of nonlinearity (CZM and plasticity). One advises to refer to the documentation of use of the cohesive models U2.05.07.

This test in addition makes it possible to validate the option of postprocessing `OPTION = 'LENGTH'` macro-order `POST_CZM_FISS` in 2D on an approximate analytical solution.