



Phase-field in ABAQUS UMAT

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Introduction

Phase-field damage

$$\Pi^d = \int_{\Omega} \left[\frac{g_c}{c_{\omega} l_c} [d^2 + l_c^2 |\nabla d|^2] + g(d)H \right] d\Omega$$

$$\delta \Pi^d = 0 \quad \forall \delta d \rightarrow \frac{g_c}{l_c c_{\omega}} (2d - 2l_c^2 \Delta d) = -\frac{\partial g}{\partial d} H$$

Thermal diffusion

$$\rho c \frac{\partial T}{\partial t} = r + k \Delta T \quad (\text{energy balance})$$

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Phase-field damage

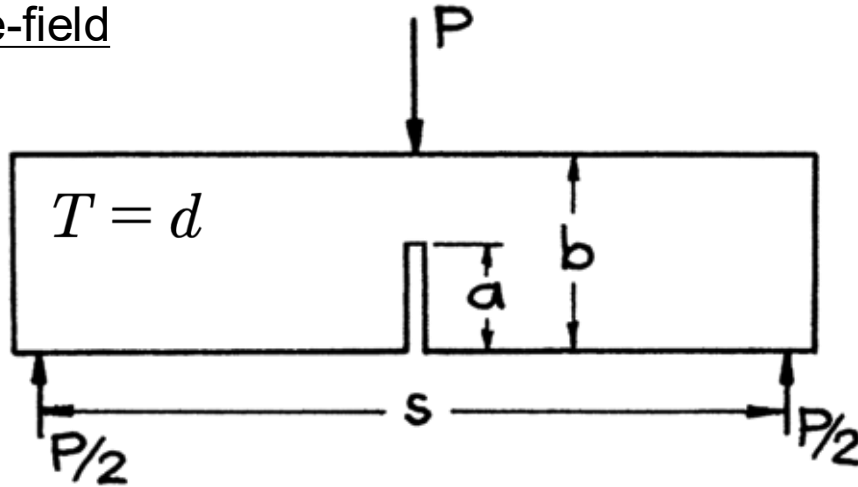
$$\frac{g_c}{l_c c_\omega} (2d - 2l_c^2 \Delta d) = -\frac{\partial g}{\partial d} H \quad / \quad \times \frac{c_\omega}{2g_c l_c}$$
$$0 = -\frac{\partial g}{\partial d} H \frac{c_\omega}{2g_c l_c} - \frac{d}{l_c^2} + \Delta d$$

$$c = 0 \quad k = 1 \quad r = -\frac{\partial g}{\partial d} H \frac{c_\omega}{2g_c l_c} - \frac{d}{l_c^2}$$



Problem statement

Phase-field



Material

$$E = 3 \text{ GPa}$$

$$\nu = 0.37$$

$$g_c = 300 \text{ J/m}^2$$

$$l_c = 0.17 \text{ mm}$$

Geometry

$$s = 40 \text{ mm}$$

$$b = 5 \text{ mm}$$

$$a = 1 \text{ mm}$$

$\epsilon, T, \text{STATEV}$

Material point

T, STATEV

UMAT

(mechanical
response)

HEATVAL

(heat generation)

$\sigma, \text{DDSDDE},$
 STATEV

r

Parameter setting

Materials

Edit Material

Name: PMMA

Description:

Material behaviors

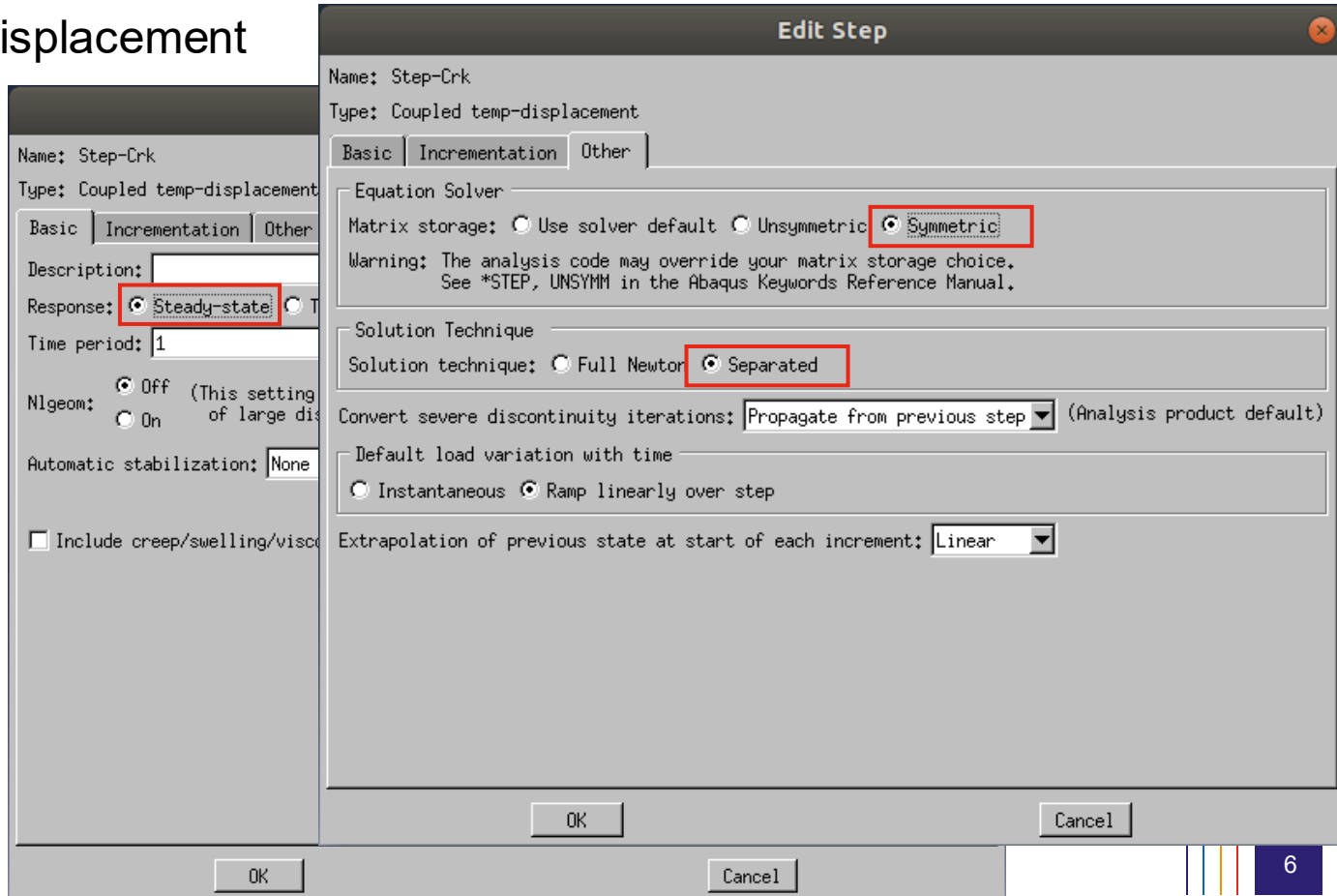
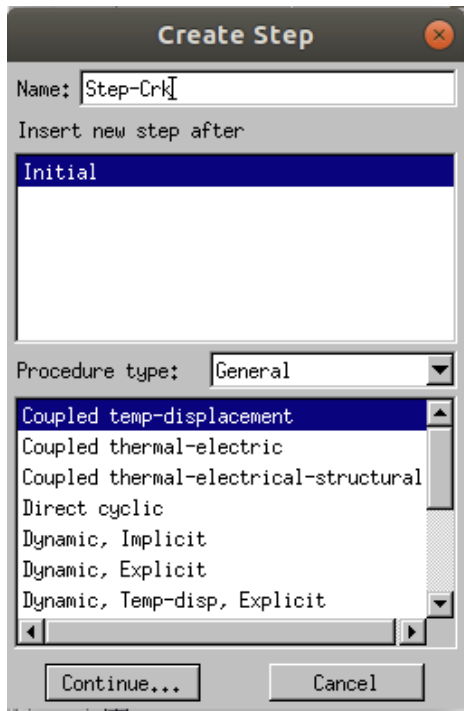
User Material	UMAT
Heat Generation	HEATVAL
Conductivity	$k = 1$
Depvar	SDV(4)

Data

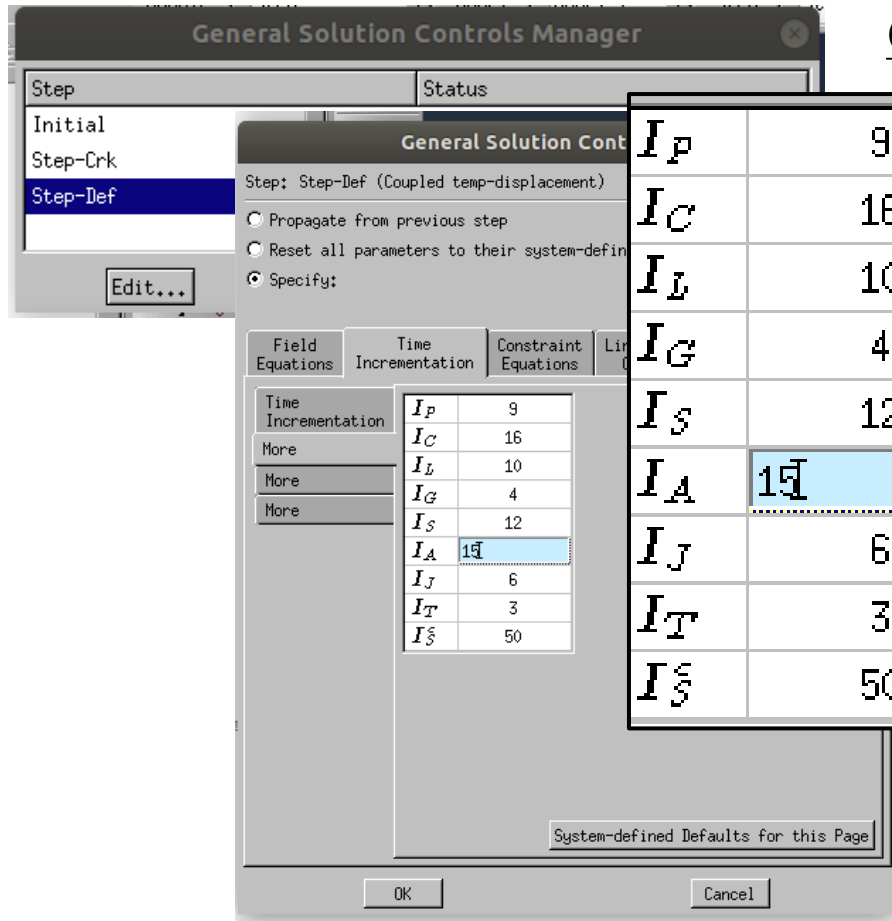
	Mechanical Constants	
1	3000	Young's modulus (E)
2	0.37	Poisson's ratio (ν)
3	0.17	Phase-field length (l_c)
4	300e-3	Fracture toughness (g_c)
5	0	Time integration (0 – auto, 1 – fixed)

Parameter setting

Step Coupled temp-displacement (Steady-state)



Parameter setting

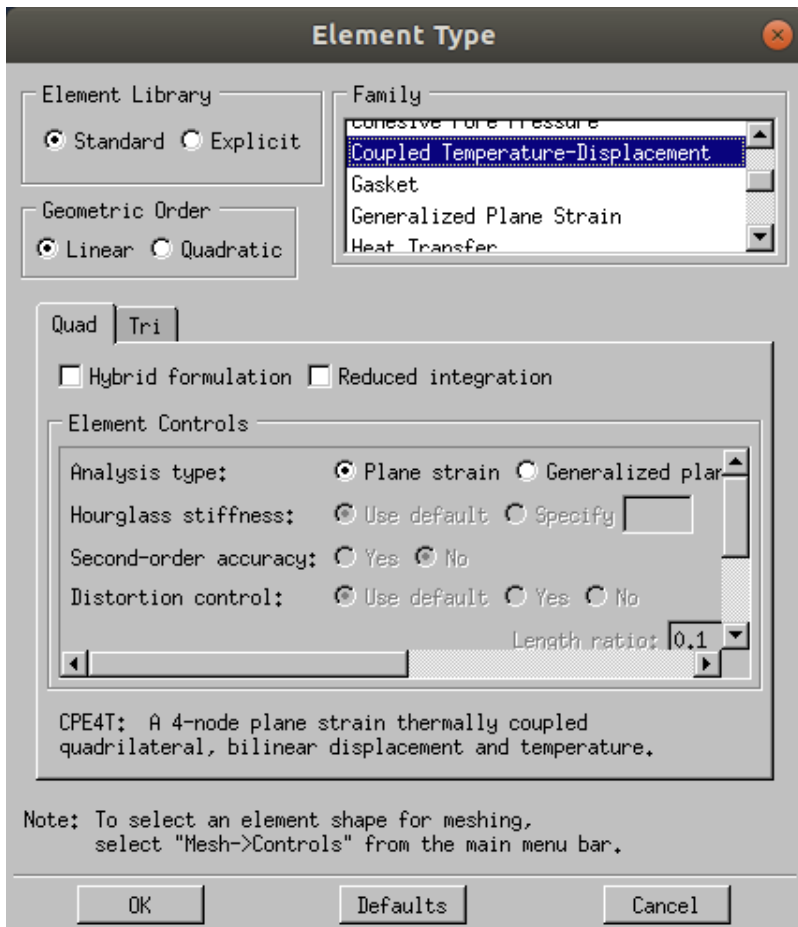


General solution control

I_P	9
I_C	16
I_L	10
I_G	4
I_S	12
I_A	15
I_J	6
I_T	3
I_ξ	50

Number of
of attempt
allowed to
reduce the
time step

Parameter setting

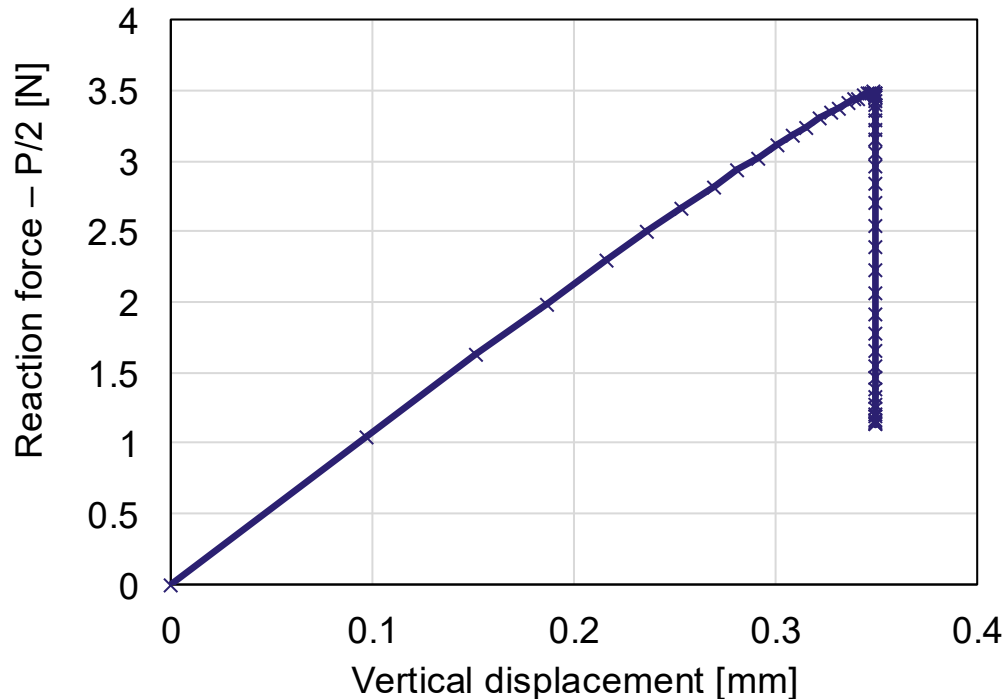


Mesh

- Fully integrated
- Coupled Temperature-Displacement



Summary



Phase-field:

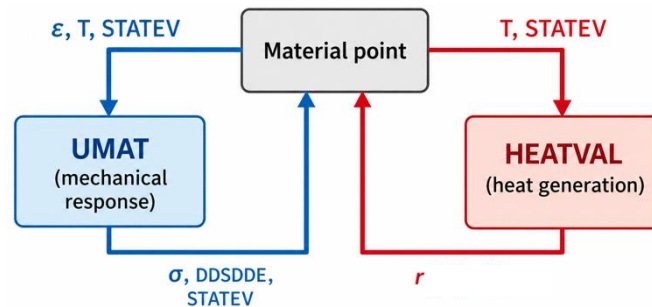
$$\frac{P_{PF}}{2} = 3.5 \text{ N} \rightarrow P_{PF} = 7 \text{ N}$$



Coupled criterion:

$$P_{CC} = 7.15 \text{ N}$$

http://www.molnar-research.com/tutorials_T1.html



$$T = d$$