NAFEMS P18 T1: membrane with a circular hot spot

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1 Objective

Verify the stress produced by the discontinuous thermal strain in Test T1 of *The Standard NAFEMS Benchmarks* [1]. The automated study compares an immersed Coreform/Abaqus IGA discretization with the published solution.

2 Geometry

Two symmetry planes reduce the $20\ \mathrm{mm} \times 20\ \mathrm{mm}$ membrane to the $10\ \mathrm{mm} \times 10\ \mathrm{mm} \times 0.25\ \mathrm{mm}$ quarter model in Figure 1. The quarter-circle of radius $1\ \mathrm{mm}$ is a second material region, not a hole. Point D lies at $(x, y) = (1, 0)\ \mathrm{mm}$ on the interface.

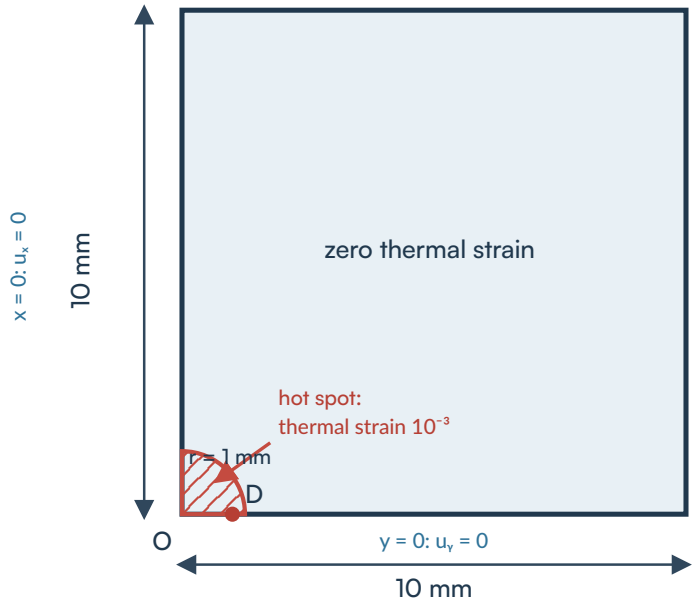

Figure 1: Quarter-symmetry model for NAFEMS P18 T1.

3 Material

Both regions are isotropic and linear elastic with $E = 100,000\,\mathrm{MPa}$ and $\nu = 0.3$. The circular region receives a uniform thermal strain of 1×10^{-3}, while the surrounding membrane has zero thermal strain.

4 Loading & boundary conditions

Symmetry conditions impose $u_x = 0$ on $x = 0$ and $u_y = 0$ on $y = 0$. The two cells belong to one multi-cell part and use different Abaqus material sections, so the thermal expansion changes discontinuously while displacement remains continuous. The reported σ_{yy} is sampled at D on the surrounding-material side.

5 Mesh & discretization

The immersed model uses a linear, C^0 spline space constructed from a uniform $44 \times 44 \times 1$ background grid. The in-plane cell size is $0.227\,\mathrm{mm}$, and no local or hierarchical refinement is used. The three-dimensional formulation constrains u_z and applies the constitutive transformation required to reproduce plane stress.

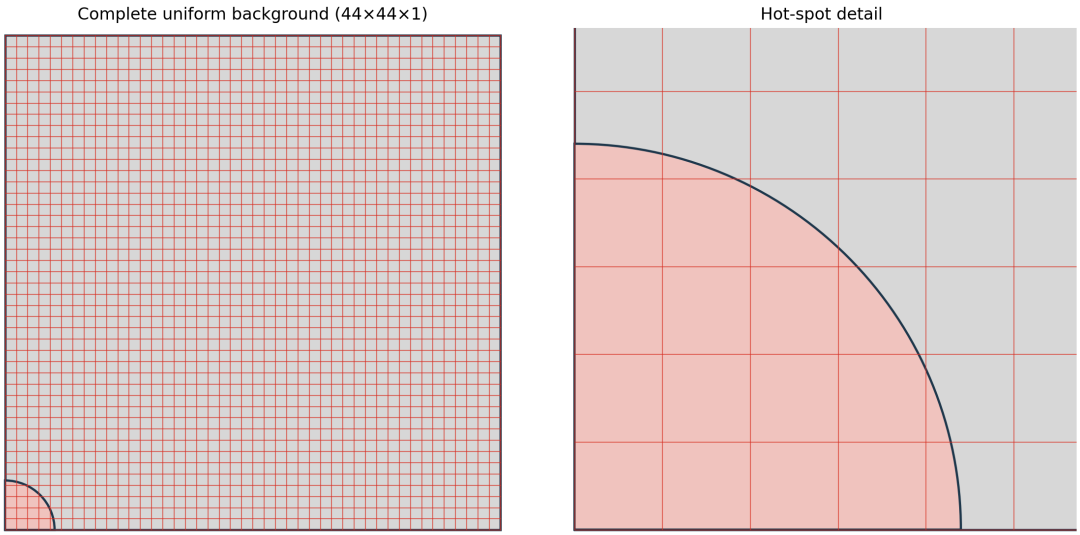

Figure 2: Exact background grid used for both immersed material regions.

6 Reference & accepted solutions

The accepted value is $\sigma_{yy}(D) = 50.0\,\mathrm{MPa}$ [1]. The Coreform IGA test enforces a 4% relative-error limit.

7 Results

7.1 Stress at point D

Table 1: NAFEMS P18 T1 verification results.

Discretization	$\sigma_{yy}(D)$ (MPa)	Relative error	Limit
Immersed Coreform/Abaqus IGA	48.503	2.99%	4%

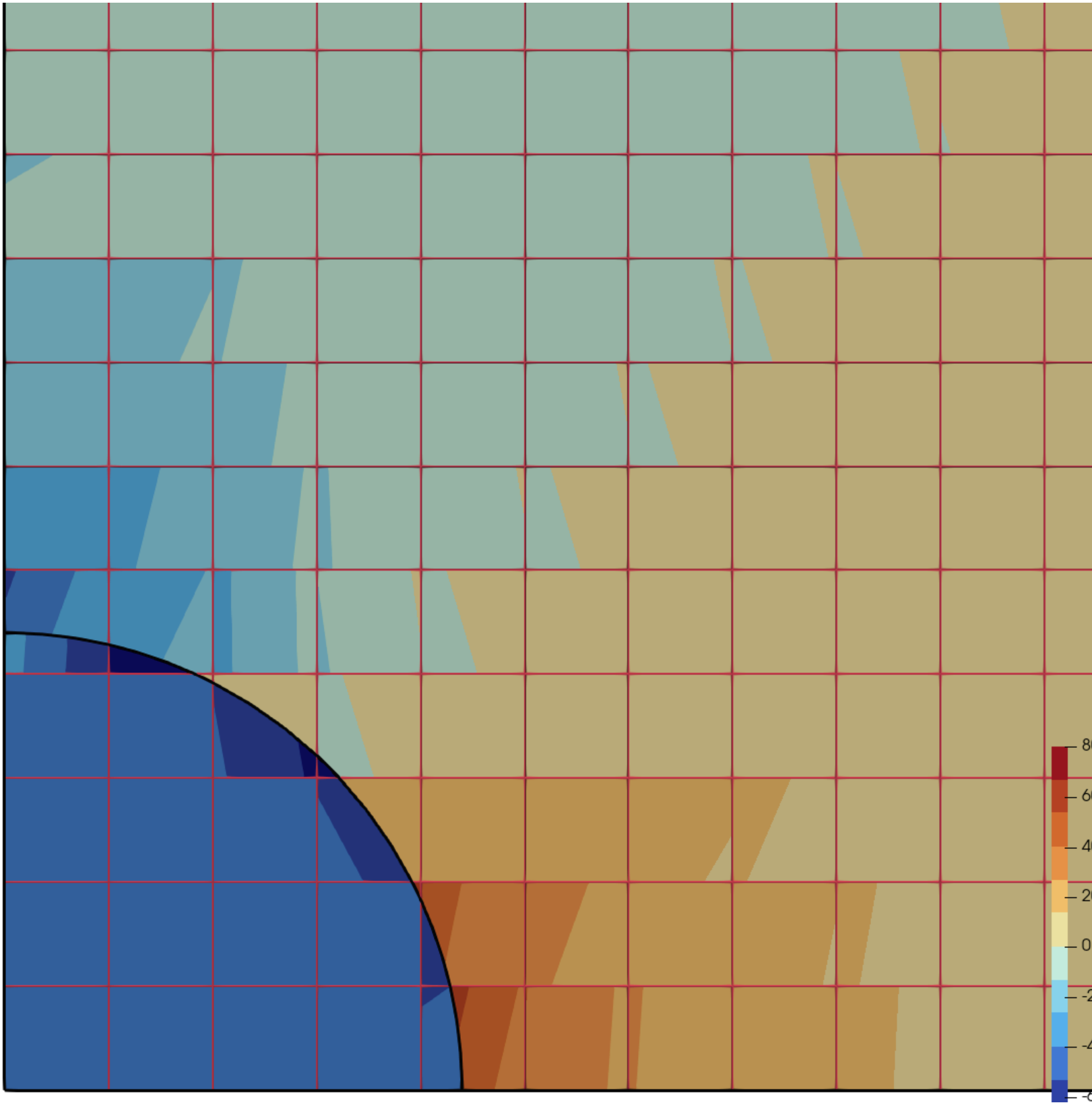

Figure 3: Immersed Coreform/Abaqus IGA stress field near the circular interface.

8 Discussion

The immersed result satisfies the accepted value and verifies displacement continuity across the multi-cell material interface together with the discontinuous thermal-strain assignment.

References

[1] *The standard NAFEMS benchmarks*. NAFEMS.

Appendix

8.1 Download artifacts

Download artifacts are available from the HTML version of this page.

8.1.a Geometry CAD files

Geometry CAD downloads are available from the HTML version of this page.

8.1.b Abaqus/CAE journal files

Individual journal downloads are available from the HTML version of this page.

8.2 Provenance

The record below identifies the Coreform/Abaqus verification evidence used by this page.

ℹ Test_abaqus_verification_nafems_p18_t1

Parameter	Value
Evidence type	Numerical verification
CTest result	Passed (Release)
Verification result	Passed — 1/1 enforced criterion passed
Test date	10-Sep-2026 15:59:15
Operating system	Ubuntu 22.04.4 LTS
Coreform IGA version	`2026.9+69838`
Source revision	`d88163e59ac0`
Abaqus version	`Abaqus 6.26-4`