Heat Conduction in a Square Steel Plate - FEM Report

# Problem Setup

A square steel plate of dimensions 1 m × 1 m × 1 cm is analyzed under a 2D steady-state heat conduction assumption. A heat input of 1000 W/m² is applied at the center of the plate, modeled as a Dirac delta function. Material thermal conductivity is 50 W/m·K. The study involves different mesh resolutions and boundary conditions.

# Case 1 – Bottom Side at 25°C, Others Insulated

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Case | Mesh | # Elements | Assumptions | Observations | Accuracy |
| (a) | 2 triangles | 2 | Very coarse, center node shared | High T, blocky gradient | Very Low |
| (b) | 4 triangles | 4 | Better center resolution | Unrealistic T gradients | Low |
| (c) | ~10 elements | 18 | Center aligned with node | Smoother profile | Moderate |
| (d) | ~100 elements | 200 | Fine structured mesh | Accurate, smooth | High |

# Case 2 – Convection at Bottom Edge

In this case, the bottom edge is subject to convective heat transfer: q\_n = h(T - T0), with h = 10 W/(m²·K) and T0 = 25°C. Other edges are insulated. The mesh is the same as in Case 1(d) with ~100 elements (200 triangles).

Key Observations:

* • Peak temperature is higher than Case 1(d) due to less aggressive cooling.
* • More realistic boundary behavior using convective condition.

## Temperature Centerline Comparison

|  |  |  |
| --- | --- | --- |
| Location (x @ y=0.5) | Case 1(d) - Dirichlet | Case 2 - Convection |
| Center (x=0.5) | Lower peak T | Higher peak T |
| Edges (x ~ 0 or 1) | Similar trend | Slightly warmer |

## Accuracy Summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Case | Mesh Quality | Captures Gradient | Local Heat Source | Accuracy |
| 1(a) | Very coarse | No | No | Very Low |
| 1(b) | Coarse | No | No | Low |
| 1(c) | Moderate | Partially | Yes | Medium |
| 1(d) | Fine | Yes | Yes | High |
| 2 | Fine + Convection | Yes | Yes | High |

# Recommendations

* • Use fine mesh (~100+ elements) for accurate results with localized sources.
* • Apply convection boundaries for more realistic heat transfer modeling.
* • Consider higher-order elements or adaptive refinement for sharp gradients.