T-Beam - Verification and Validation

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Verification & Validation

For the case where we constrain all nodes along the knife edge, we see that there is substantial disagreement between the three-dimensional FEA predictions and both the experimental results and those predicted by one-dimensional, Euler-Bernoulli beam theory.

	Axial Stress, Bottom of Beam	Axial Stress, Top of Beam
From measured strains in mechanics lab	0.1108	-0.2464
From simple beam theory	0.1134	-0.2724
From finite element analysis with 1D beam elements	0.1134	-0.2724
From finite element analysis with 3D solid elements	0.0536	-0.2184

Reasons for this disagreement are discussed in the text in Example 4.1. Relatively substantial differences in stress can result from differences in strain that are orders of magnitude smaller. Such differences in strain can result from Poisson effects when all nodes are constrained through the thickness of the cross section. When out-of-plane curvature results as can result from said Poisson effects (see Figure 4.9 of the text), the constraint off all nodes along the knife edge may over-constrain the cross section. As a result, one can relax the simple support constraint in three-dimensions by constraining ONLY a subset of nodes along the knoef edge so as to allow this out-of-plane curvature to occur.

When this is done, the results seem more reasonable:

	Axial Stress, Bottom of Beam	Axial Stress, Top of Beam
From measured strains in mechanics lab	0.1108	-0.2464
From simple beam theory and 1D beam elements	0.1134	-0.2724
From finite element analysis with 3D solid elements and loosely pinned supports	0.0946	-0.2230
From finite element analysis with 3D solid elements and fully pinned supports	0.0536	-0.2184

As with the I-Beam Tutorial #2, loads and boundary conditions here were not originally placed along the neutral axis as prescribed by Euler-Bernoulli beam theory, yet the theory performs reasonably well when the end constraints are relaxed to allow for out-of-plane curvature as might be expected in this case. Further alternative considerations for relevant boundary conditions are considered in the Exercises.

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