Mesh Convergence Studies for Thin Shell Elements Developed by the ASME Task Group on Computational Modeling

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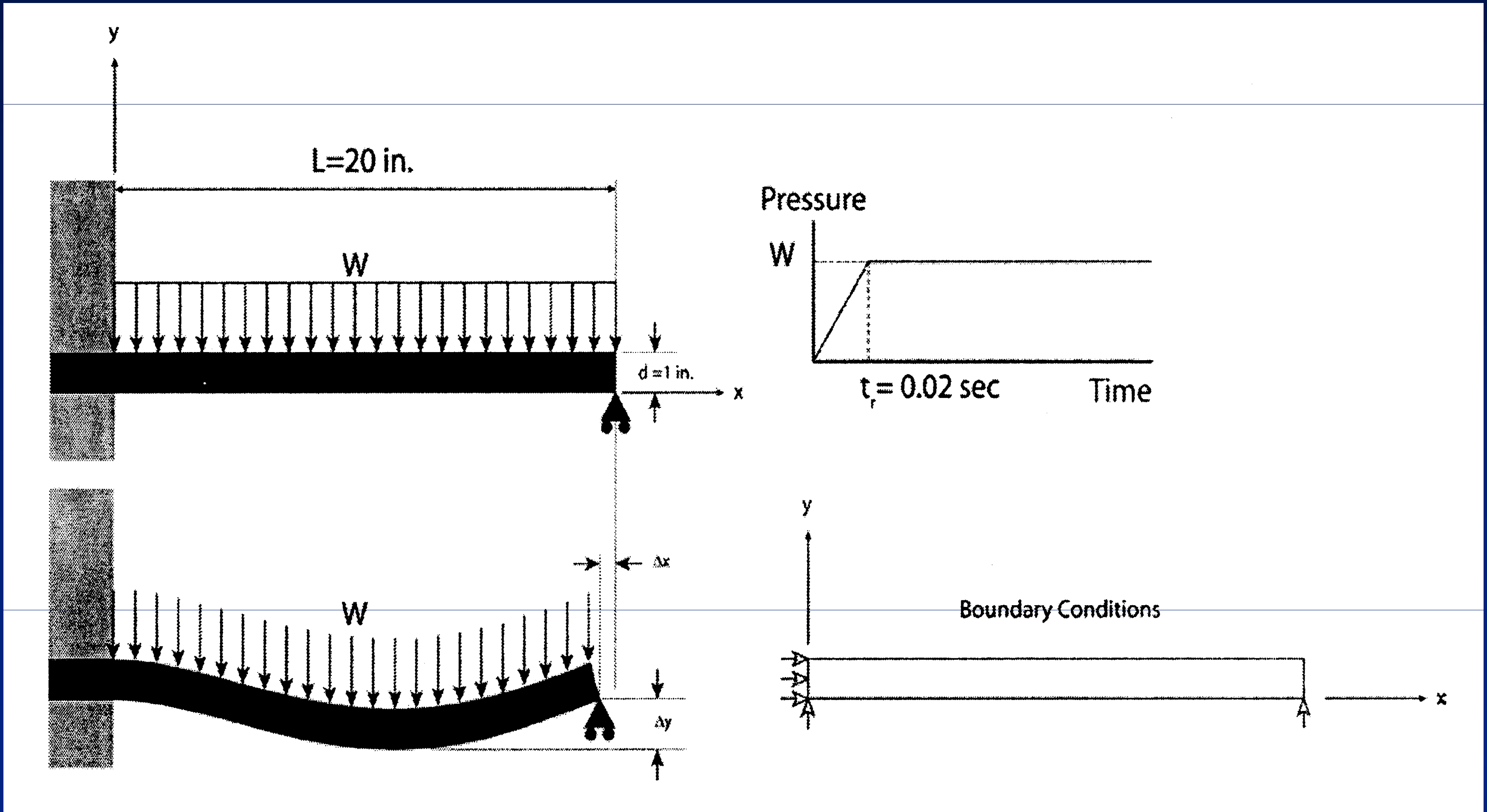
Propped Cantilever – Problem Definition

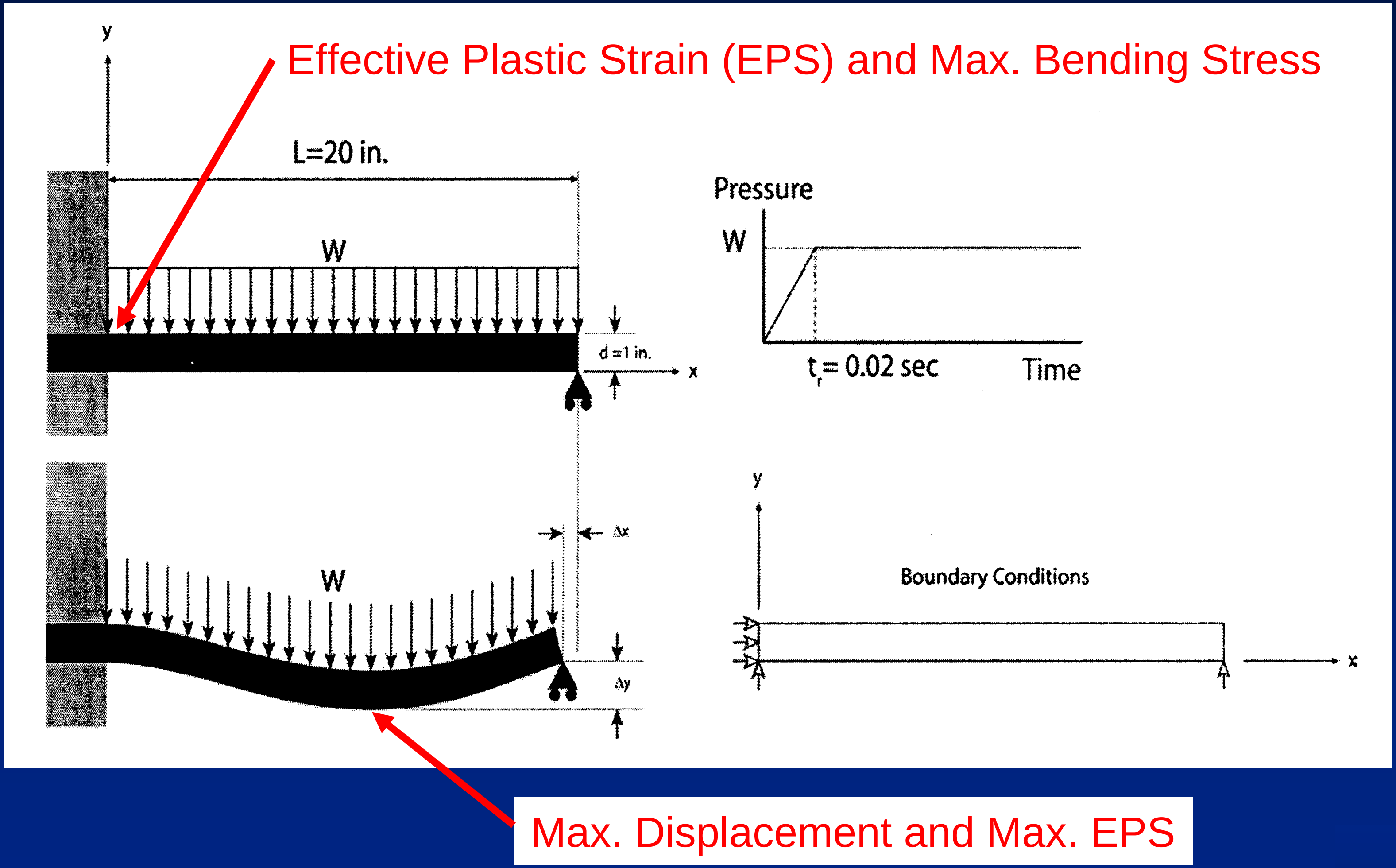


Three Pressure Loadings Considered

- W = 100 psi - Elastic Response
- W = 240 psi - Limited Plastic Response
- W = 500 psi - Large Plastic Strains

- Only show results for 500 psi case.

Responses Computed and Locations



Material Properties

- Type 304 Stainless Steel
- Power Law Material Model
  - $\sigma = \sigma_y + A\varepsilon^n$
  - $\sigma_y = 30$ ksi, A = 192 ksi, n = 0.748

Thin Shell Element Formulations (LS-DYNA)

- Type 2 – single point Integration (Belytschko-Tsay)
- Type 16 – fully integrated with four in-plane integration points averaged to the center of the shell.

- For this problem Type 2 and Type 16 results were identical.

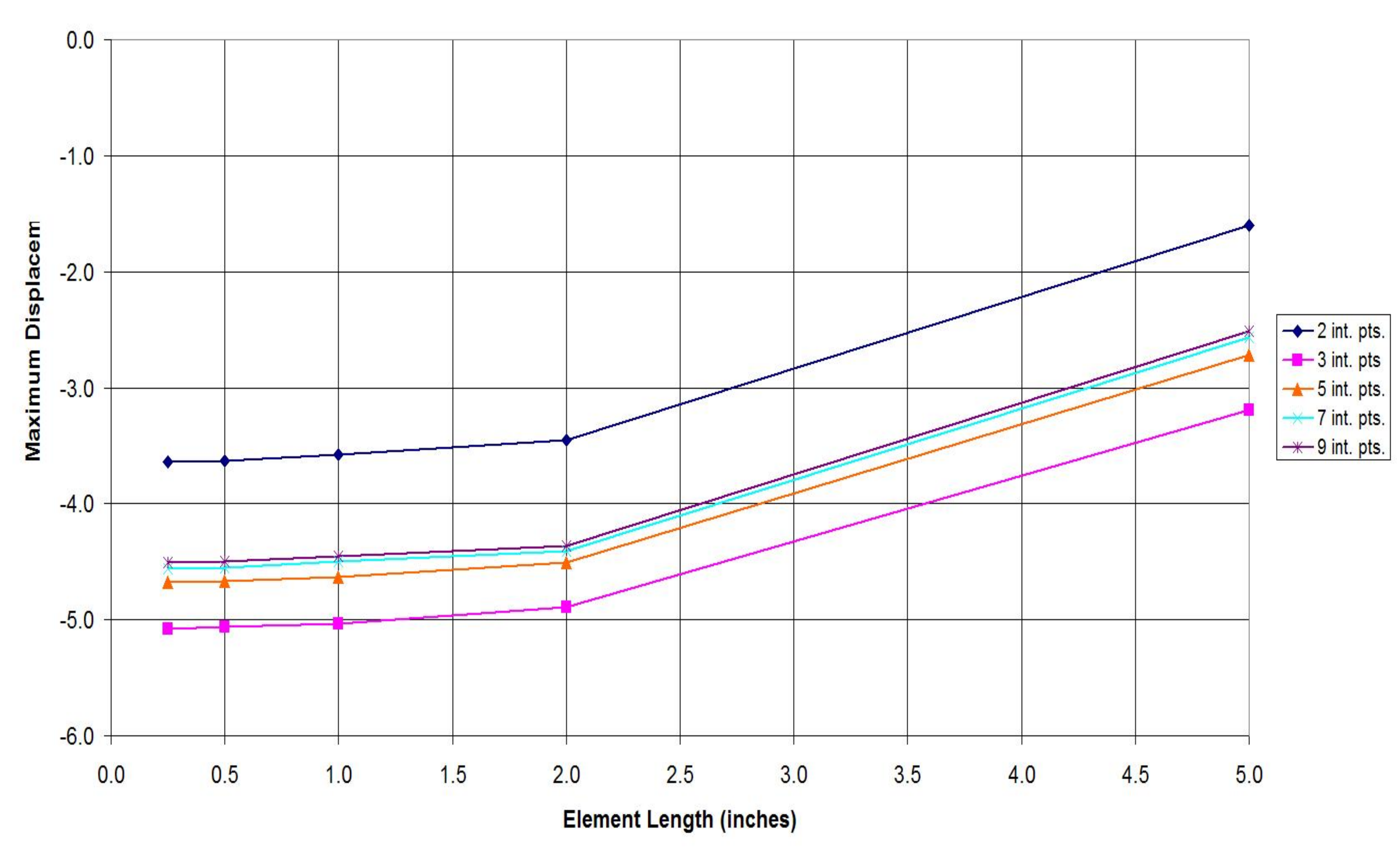
Convergence Studies

- Parameters to be varied:

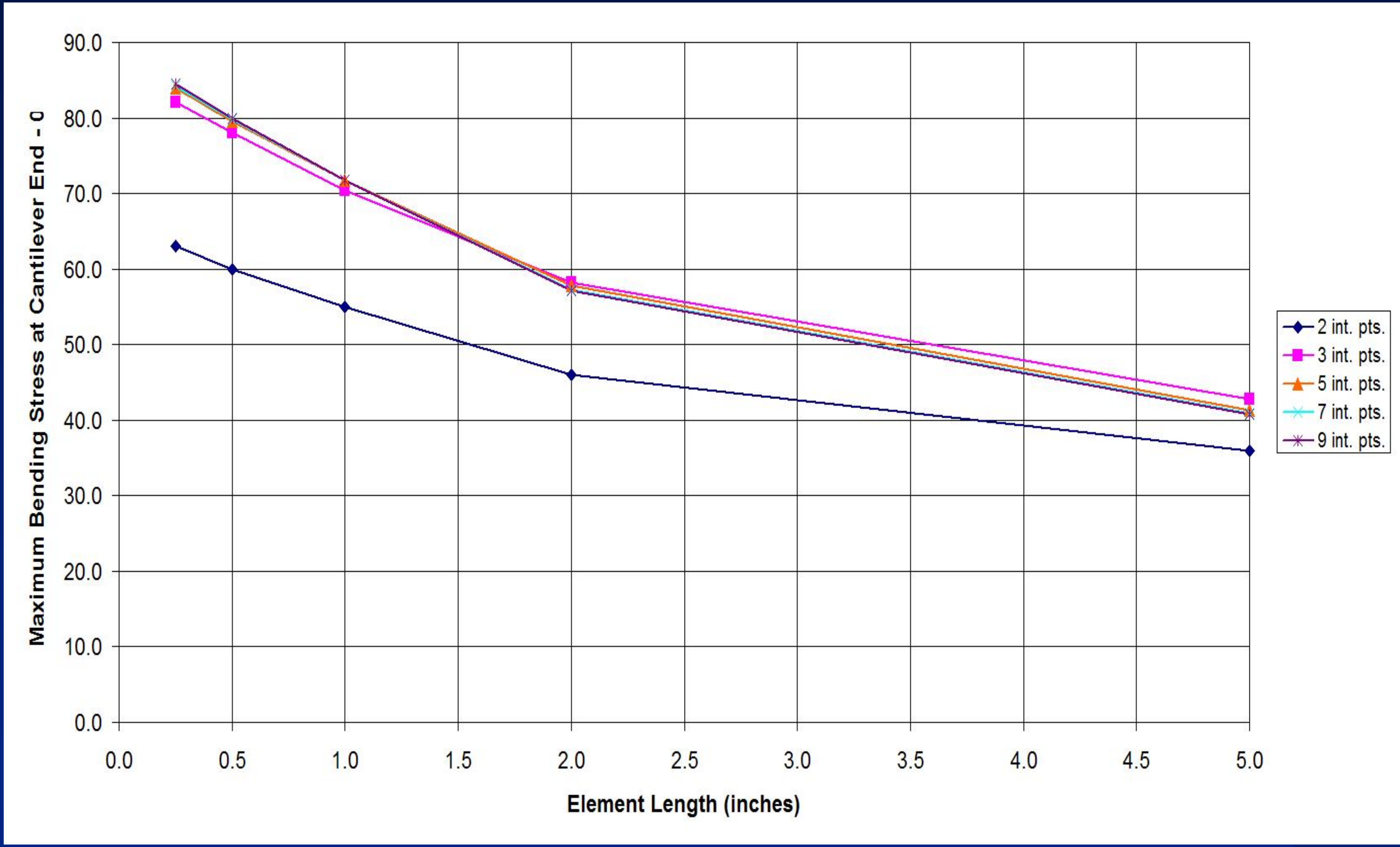
- Number of elements along the beam, or element length (size) - 5.0” to 0.25”

- Number of integration points through the thickness – 2, 3, 5, 7 and 9.

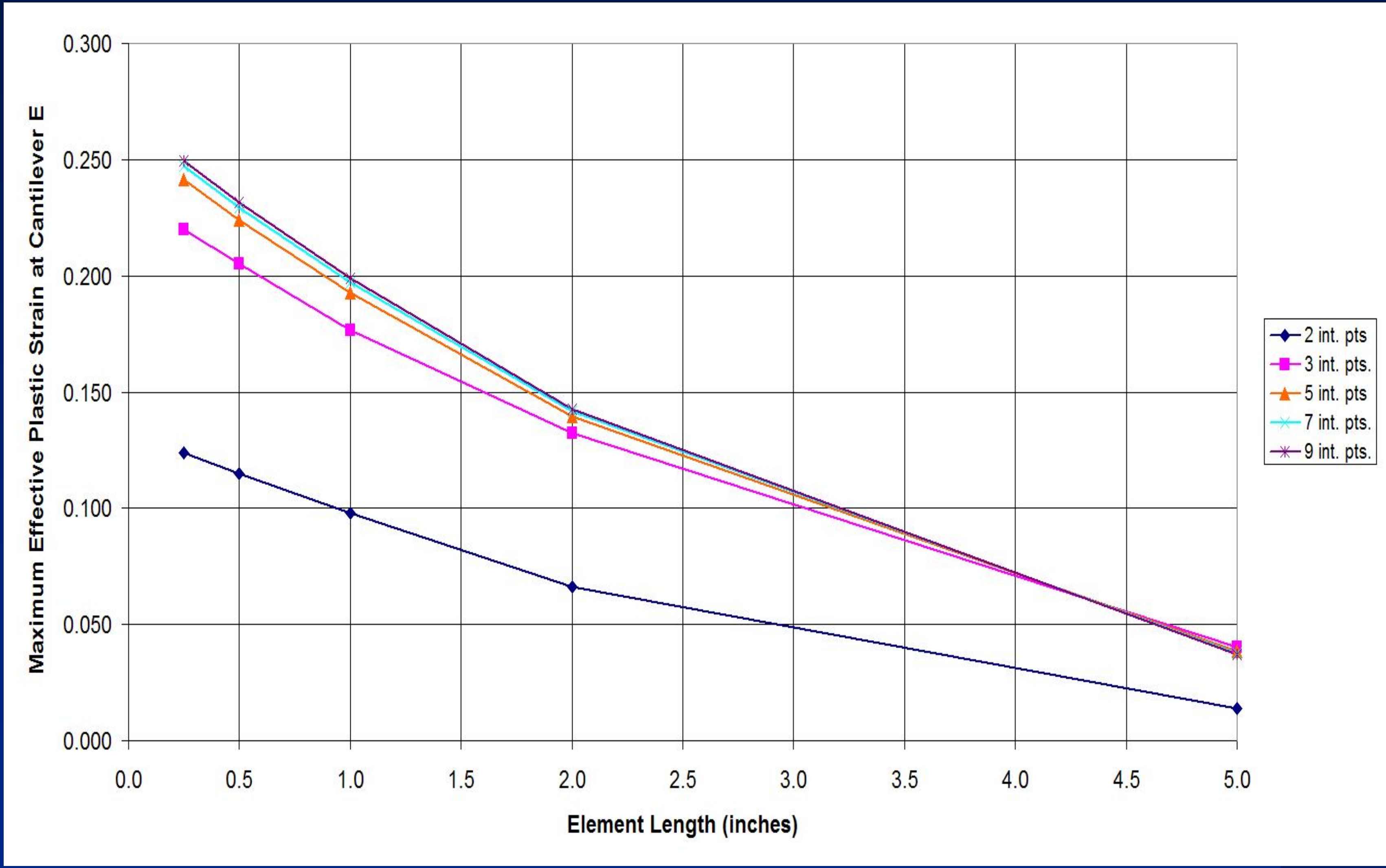
Maximum Displacement vs. Element Length



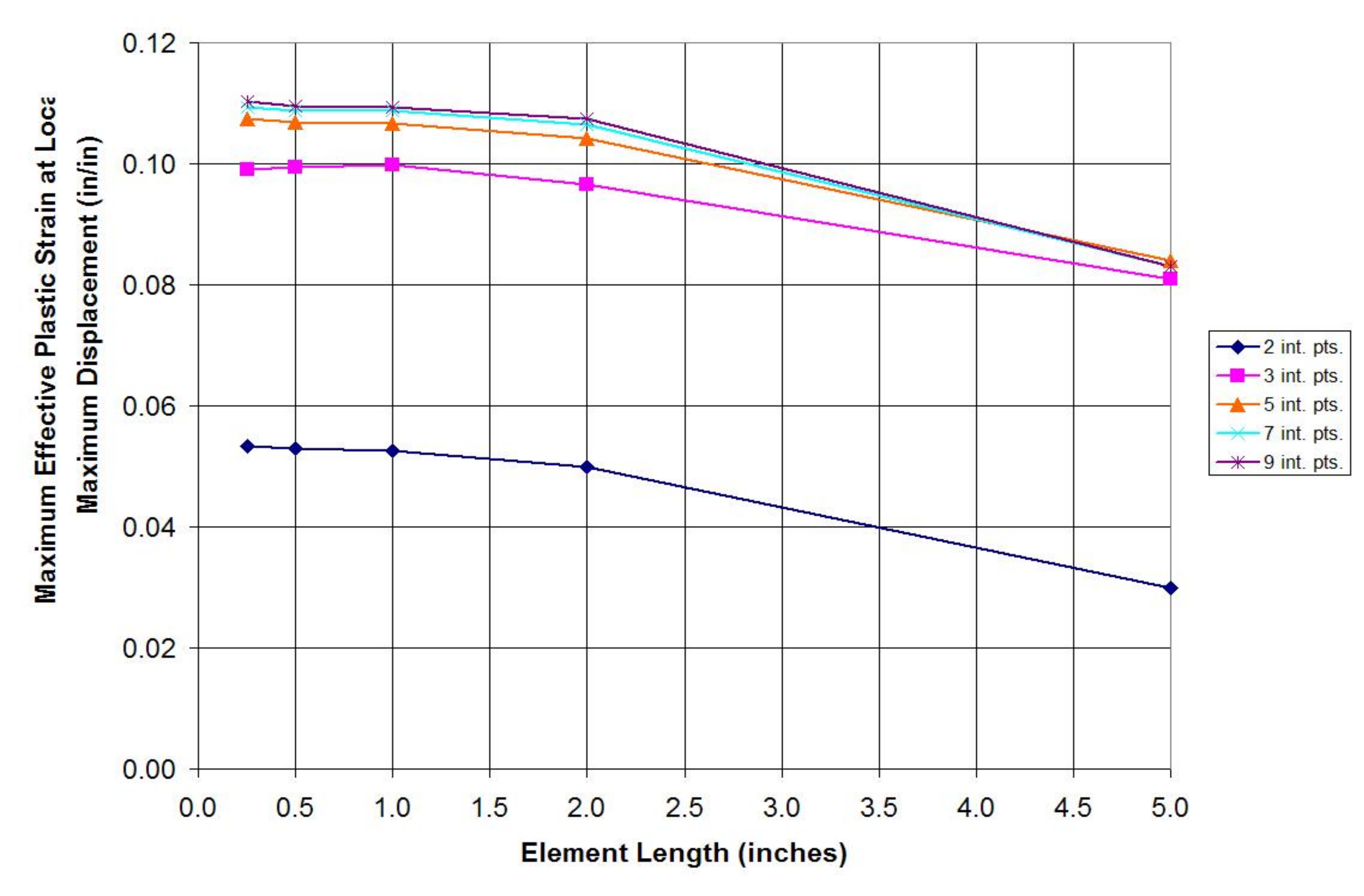
Max. Bending Stress at Fixed End



Max. Effective Plastic Strain at Fixed End



Max. Effective Plastic Strain at Location of Max. Displacement



Comparison of Thin Shell and Hexahedron Results

Table 1: Comparison of Thin Shell and Hexahedron Results

	Thin Shell	Hexahedron
Loading (psi)	500	500
No. Elements through Thickness	1	9
No. Integration Points per Element	9	1
Element Length (inches)	0.250	0.222
Max. Bending Stress[(1)] (ksi)	84.5	83.3
Max. Effective Plastic Strain[(1)] (in/in)	0.250	0.246
Max. Displacement	-4.51	-5.32

(1) Result is at the top integration point in the element closest to the fixed end.

Conclusions

- To achieve reasonable accuracy under bending requires at least 5 integration points through the thickness of a thin shell element.
- The maximum element length in regions of high strain gradients should be less than the half thickness of the element.

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