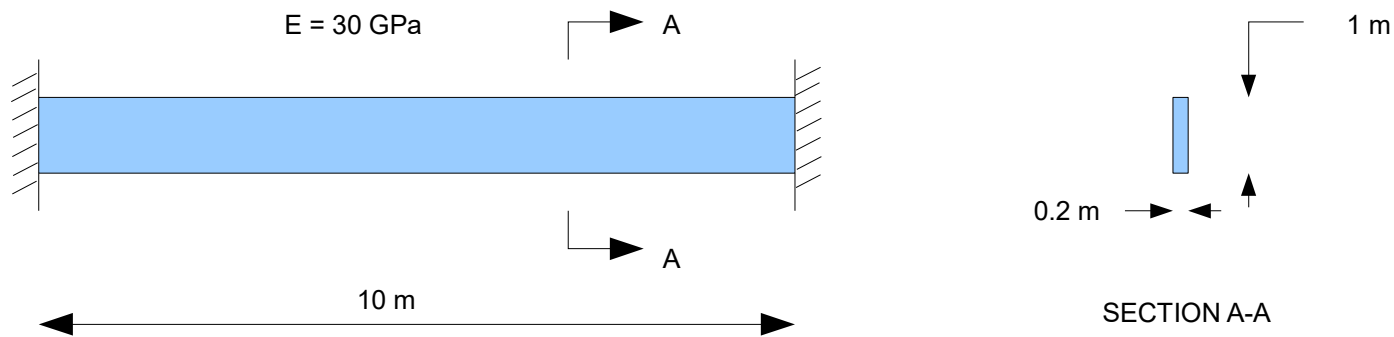


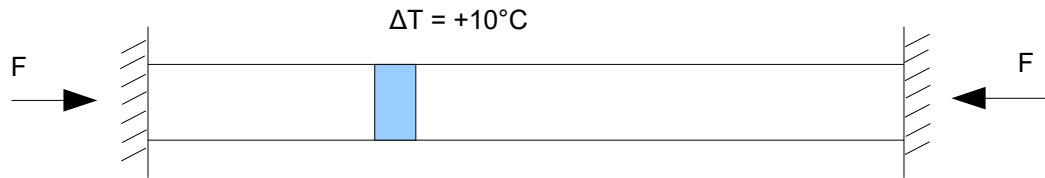
Impact of insertion point on internal forces of statically indeterminate model



The beam is subjected to the uniform temperature increase of $10 \text{ }^\circ\text{C}$ and temperature gradient loading of $10 \text{ }^\circ\text{C/m}$. Determine the resulting internal forces and reactions for the beam modeled with centroid and top center insertion point.

Theoretical solution

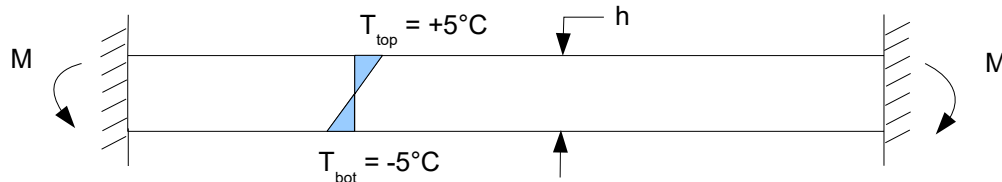
Uniform temperature increase of 10°C
(determine axial force)



$$F = \sigma A = \epsilon E \Delta T A = \frac{\Delta L}{L} EA = \frac{\alpha \Delta T L}{L} EA = \alpha \Delta T E A =$$

$$= (12 \times 10^{-6})(10^\circ\text{C})(30\text{GPa})(0.2\text{m}^2) = 720\text{ kN}$$

Temperature gradient loading of 10°C/m
(determine flexural moment)



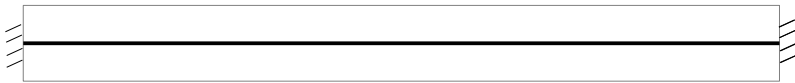
$$M = \frac{EI}{h} \alpha (T_{\text{bot}} - T_{\text{top}}) =$$

$$= \frac{(30\text{ GPa}) \frac{1}{12} (0.2\text{m})(1\text{m})^3}{1\text{m}} (12 \times 10^{-6})(-10^\circ\text{C}) = -60\text{ kN-m}$$

SAP2000 model

Case 1 (centroid insertion point)

As drawn in the program and analytical model

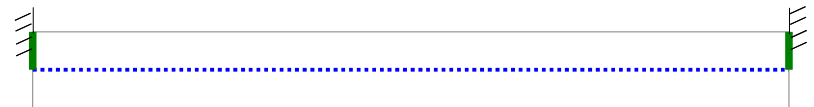


Case 2 (top center insertion point)

As drawn in the program



Analytical model



Legend



Outline of the beam



Restained joint



Frame element as drawn in SAP2000



Frame element (line represents its center of gravity) used for analytical model



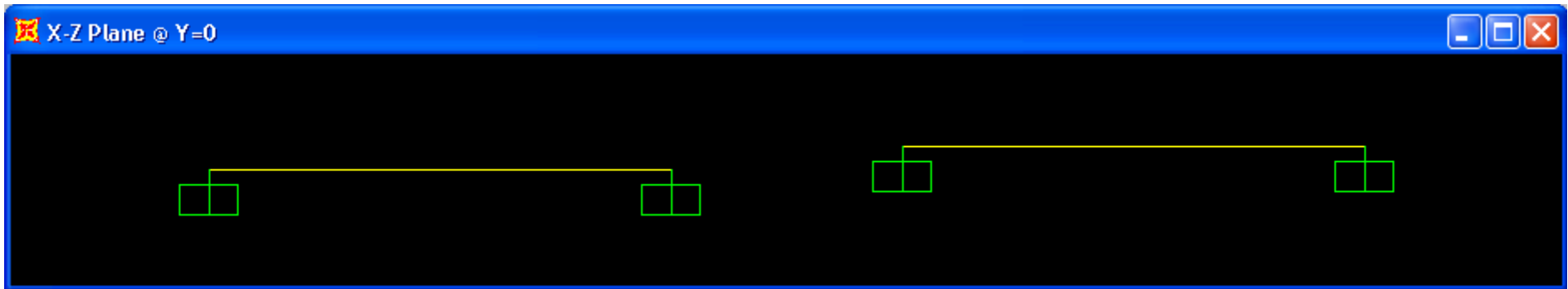
Internal rigid constraint

SAP2000 model results

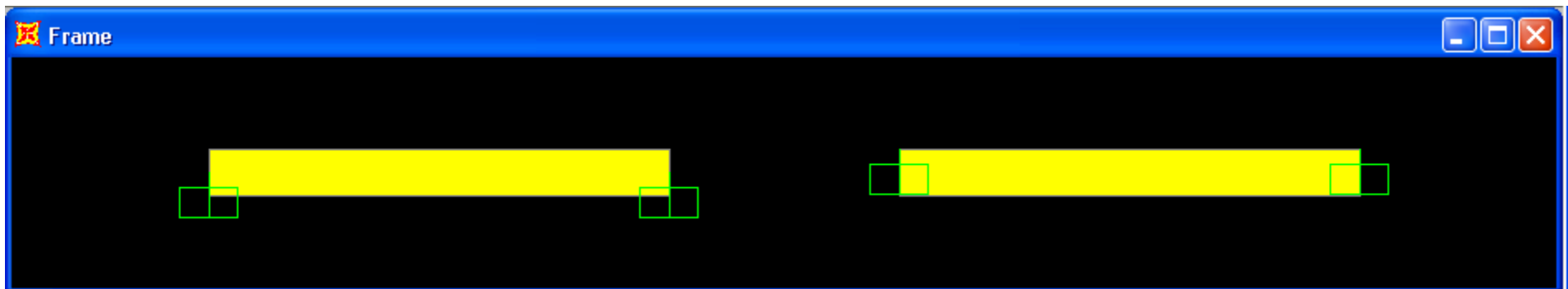
Case 1 (centroid insertion point)

Case 2 (top center insertion point)

Lines representing frame elements as drawn in SAP2000



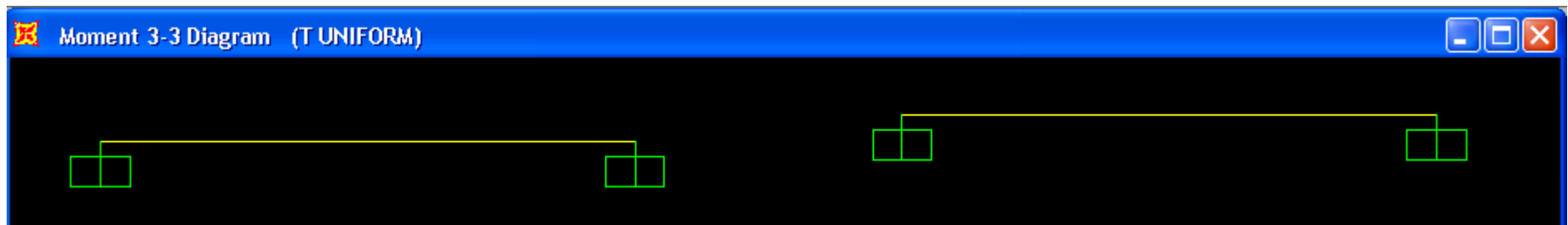
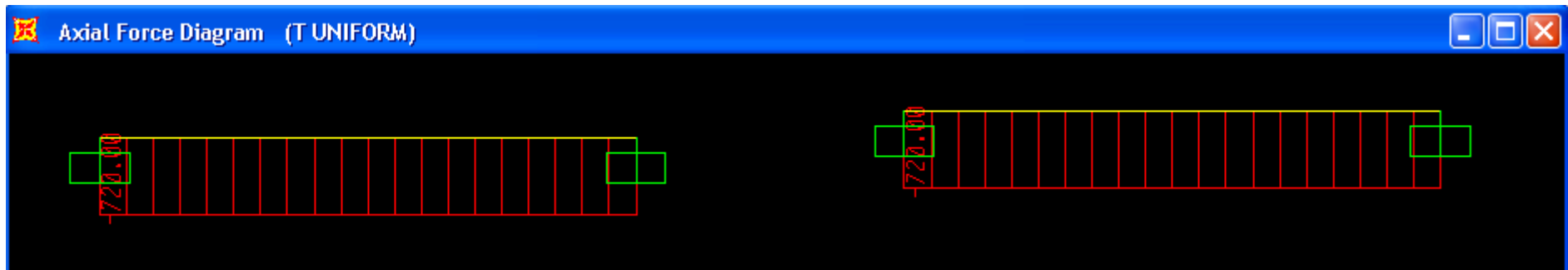
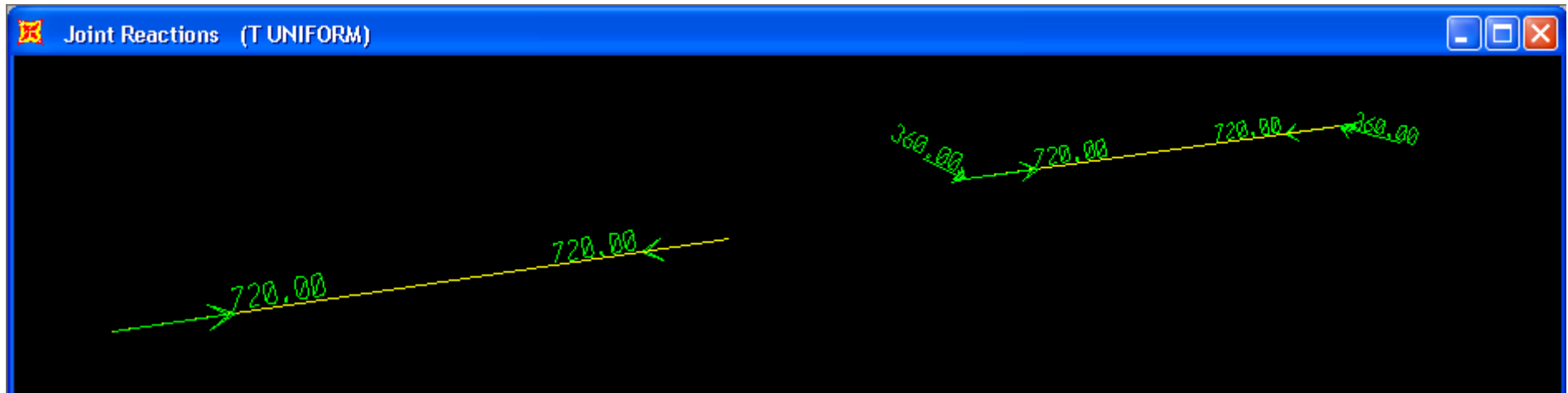
Extruded view of the frame elements



SAP2000 model results (uniform temperature load)

Case 1 (centroid insertion point)

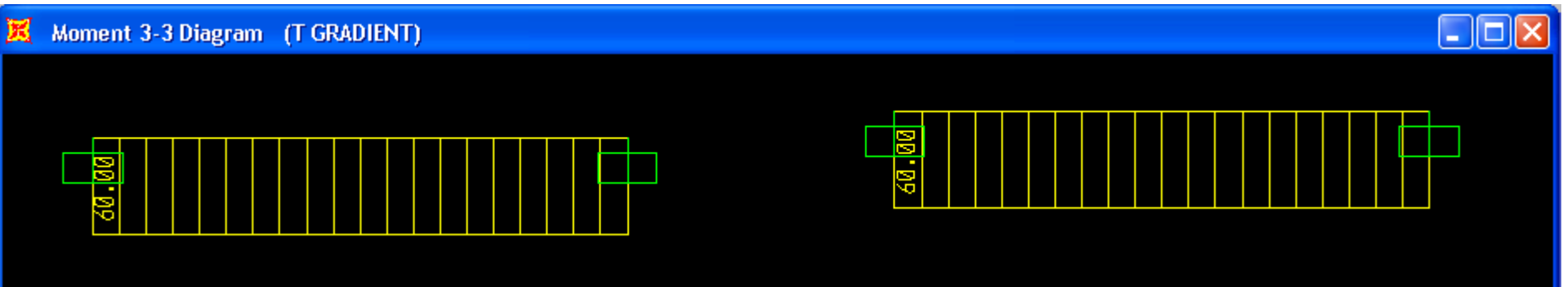
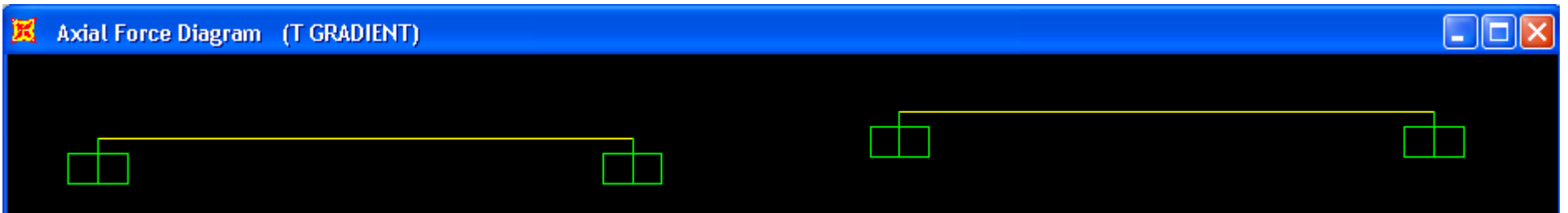
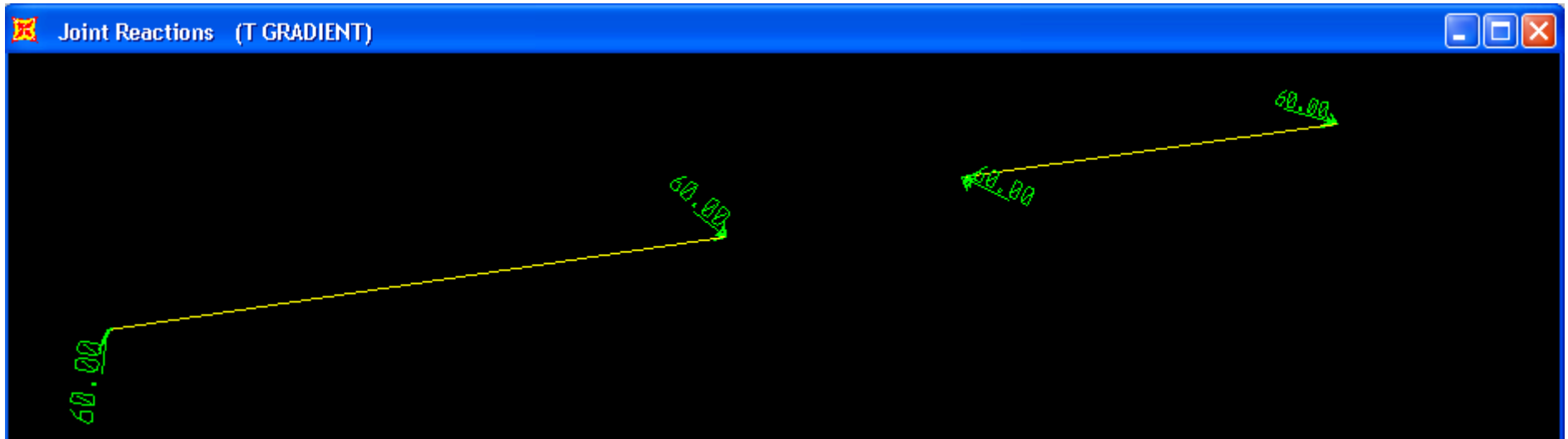
Case 2 (top center insertion point)



SAP2000 model results (gradient temperature load)

Case 1 (centroid insertion point)

Case 2 (top center insertion point)



Conclusion

- The SAP2000 results match the theoretical solution.