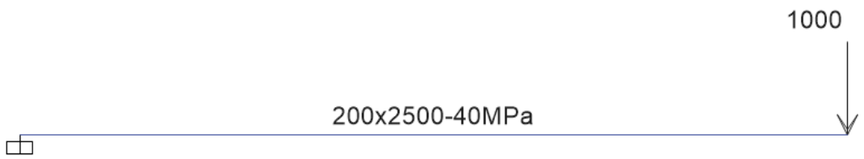
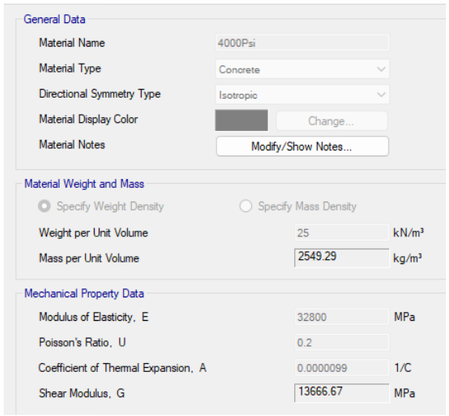
ETABS®

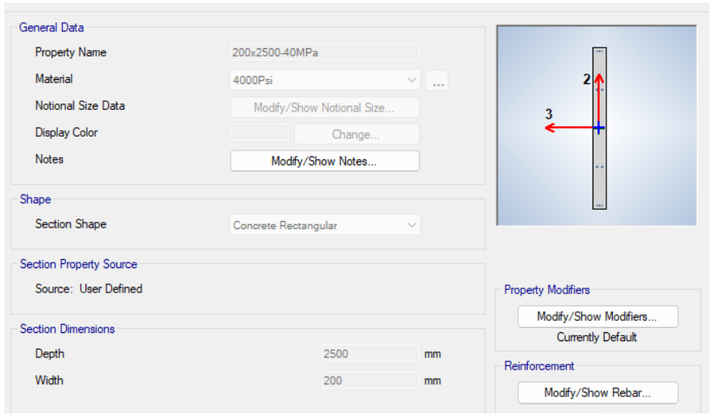
4 m Span Cantilever, section size = 200 wide x 2500 Deep



Loading and section assignment

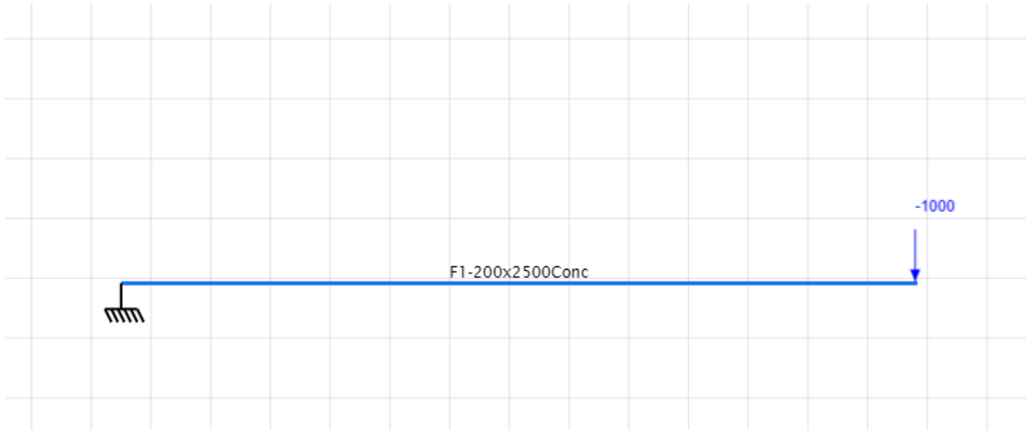


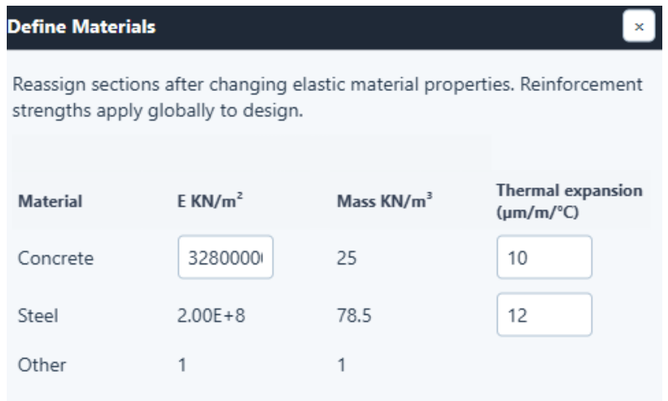
Materials



Section Definitions

FEAKalc 3D



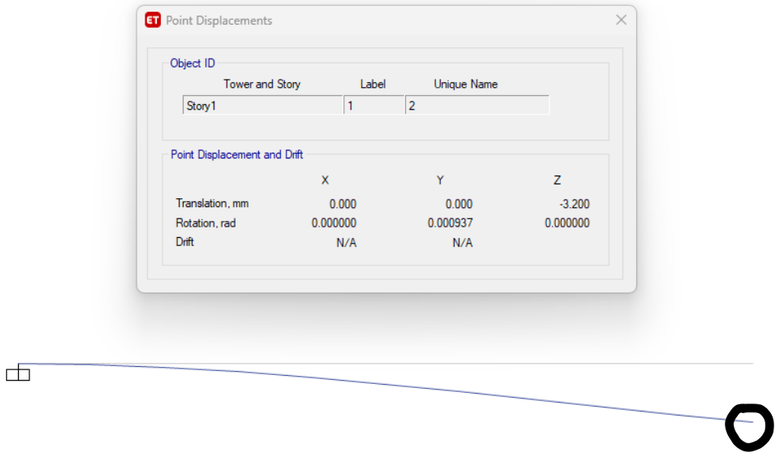


Materials



Section Definitions

ETABS®



FEAKalc 3D



ALL RESULTS ARE IDENTICAL

FEAKalc 3D and ETABS both give a free-end displacement of 3.200 mm downward under the Live load. We matched the span, section, end restraint, load and elastic properties in both models, then included transverse shear deformation in the FEAKalc 3D frame element.

Hand calculation

The benchmark uses a 4.0 m fixed-free cantilever with a 200 × 2,500 mm rectangular concrete section and a 1,000 kN downward tip load. The elastic modulus is 32,800 MPa and Poisson's ratio is 0.20.

$$I = \frac{bh^3}{12} = 2.60417 \times 10^{11}\, mm^4,\ A_s = \frac{5bh}{6} = 416{,}667\, mm^2$$

$$G = \frac{E}{2(1+\nu)} = 13{,}666.7\, MPa$$

$$\delta_{flexure} = \frac{PL^3}{3EI} = 2.498\, mm,\ \delta_{shear} = \frac{PL}{GA_s} = 0.702\, mm$$

$$\delta_{total} = \delta_{flexure} + \delta_{shear} = 3.200\, mm\ downward$$

Why short deep beams matter

Flexural deflection scales with the cube of the span, while shear deflection scales linearly with span. For a given section and material, shortening the span increases the shear-to-flexure deflection ratio in proportion to $1/L^2$. Here the span-to-depth ratio is 1.6, and shear adds about 28% to the flexural deflection.