THE TORQUE IN THE CROSS-SECTION IS GIVEN BY

$$T = 2\cdot\left[\frac{\pi}{2}\cdot(0.225m)^2\cdot q_1 + (0.2m\cdot 0.3m + 0.2m\cdot 0.15m)\cdot q_2 + \frac{1}{2}\cdot 0.3m\cdot 0.9m\, q_3\right]$$

$$12(10^3)\,N\cdot m = 0.1590\,m^2\cdot q_1 + 0.180\,m^2\cdot q_2 + 0.120\,m^2\cdot q_3 \qquad (1)$$

SINCE THE ANGLE OF TWIST IN EACH SECTION IS THE SAME, THREE MORE EQUATIONS CAN BE WRITTEN. STARTING WITH THE FIRST CELL

CELL 1:

$$\frac{\Phi}{L} = \frac{1}{2\cdot G\cdot \bar{A}_1}\cdot\left[q_1\cdot\frac{\pi\cdot 0.225m}{0.002m} + (q_1 - q_2)\cdot\frac{0.450m}{0.003m}\right]$$

$$\frac{\Phi}{L}\cdot 2\cdot 80(10^9)\frac{N}{m^2}\cdot\frac{\pi}{2}(0.225m)^2 = 117.8\cdot q_1 + (q_1 + q_2)\cdot 150$$

$$12.72(10^9)N\,\frac{\Phi}{L} = 267.8\cdot q_1 - 150\cdot q_2 \qquad (2)$$

CELL 2:

$$\frac{\Phi}{L} = \frac{1}{2\cdot 80(10^9)\frac{N}{m^2}\cdot(0.2m\cdot 0.3m + 0.2m\cdot 0.15m)}\left[(q_2 - q_1)\overset{150}{\frac{0.45m}{0.003m}} + 2\cdot q_2\cdot\overset{35.6}{\frac{0.2136m}{0.006m}} + (q_2 - q_3)\cdot\overset{100}{\frac{0.300m}{0.003m}}\right]$$

$$14.40(10^9)N\cdot\frac{\Phi}{L} = -150 q_1 + 321\cdot q_2 - 100\cdot q_3 \qquad (3)$$

CELL 3:

$$\frac{\Phi}{L} = \frac{1}{2\cdot 80(10^9)\frac{N}{m^2}\cdot\frac{1}{2}\cdot 0.3m\cdot 0.4m}\cdot\left[(q_3 - q_1)\frac{0.300m}{0.003m} + 2\cdot\frac{0.4\cancel{25}m}{0.006m}\cdot q_3\right]$$

$$9.60(10^9)N\cdot\frac{\Phi}{L} = -100 q_2 + 242.4\cdot q_3 \qquad (4)$$

EQUATIONS (1)-(4) CAN NOW BE REWRITTEN IN A FORM THAT ~~allows~~ ENABLES A NUMERICAL SOLUTION

$$12\times 10^3 N\cdot m = 0.1590\cdot m^2\cdot q_1 + 0.180 m^2\cdot q_2 + 0.120 m^2\cdot q_3$$

$$0 = 267.8\cdot q_1 - 150.0\cdot q_2 + 0\cdot q_3 - 12.72(10^9)N\cdot\frac{\Phi}{L}$$

$$0 = -150\cdot q_1 + 321\cdot q_2 - 100\cdot q_3 - 14.40(10^9)N\cdot\frac{\Phi}{L}$$

$$0 = 0\cdot q_1 - 100\cdot q_2 + 242.4\cdot q_3 - 9.60(10^9)N\,\frac{\Phi}{L}$$