Q1.

local matrices:

triangle 1,2,3

$\nabla\alpha_1 = \langle y_2 - y_3, x_3 - x_2 \rangle \cdot \frac{1}{2A}$ | $x_1 = 0$ $y_1 = 0.02$

$\nabla\alpha_2 = \langle y_3 - y_1, x_1 - x_3 \rangle \cdot \frac{1}{2A}$ | $x_2 = 0$ $y_2 = 0$

$\nabla\alpha_3 = \langle y_1 - y_2, x_2 - x_1 \rangle \cdot \frac{1}{2A}$ | $x_3 = 0.02$ $y_3 = 0$

$\nabla\alpha_1 = \langle 0, 0.02 \rangle \cdot \frac{1}{2A}$

$\nabla\alpha_2 = \langle -0.02, -0.02 \rangle \cdot \frac{1}{2A}$ | $A = \frac{(0.02)^2}{2} = 0.2\,mm$

$\nabla\alpha_3 = \langle 0.02, 0 \rangle \cdot \frac{1}{2A}$

$S_{ij} = \nabla\alpha_i \cdot \nabla\alpha_j \cdot A$

$$S^{(1)} = \begin{bmatrix} 0.5 & -0.5 & 0 \\ -0.5 & 1 & -0.5 \\ 0 & -0.5 & 0.5 \end{bmatrix}$$

triangle 4,5,6

$\nabla\alpha_4 = \langle y_5 - y_6, x_6 - x_5 \rangle$ | $x_4 = 0.02$ $y_4 = 0.02$

$\nabla\alpha_5 = \langle y_6 - y_4, x_4 - x_6 \rangle$ | $x_5 = 0$ $y_5 = 0.02$

$\nabla\alpha_6 = \langle y_4 - y_5, x_5 - x_4 \rangle$ | $x_6 = 0.02$ $y_6 = 0$

$\nabla\alpha_4 = \langle 0.02, 0.02 \rangle \cdot \frac{1}{2A}$

$\nabla\alpha_5 = \langle -0.02, 0 \rangle \cdot \frac{1}{2A}$

$\nabla\alpha_6 = \langle 0, -0.02 \rangle \cdot \frac{1}{2A}$

$$S^{(2)} = \begin{array}{c|c} & \begin{matrix} 4 & 5 & 6 \end{matrix} \\ \begin{matrix} 4 \\ 5 \\ 6 \end{matrix} & \begin{bmatrix} 1 & -0.5 & -0.5 \\ -0.5 & 0.5 & 0 \\ -0.5 & 0 & 0.5 \end{bmatrix} \end{array}$$

Global matrix:

$$S_G = C^T \cdot S_{dis} \cdot C$$

$$S_{dis} = \begin{bmatrix} S^{(1)} & \\ & S^{(2)} \end{bmatrix} = \begin{bmatrix} 0.5 & -0.5 & 0 & & & \\ -0.5 & 1 & -0.5 & & \emptyset & \\ 0 & -0.5 & 0.5 & & & \\ & & & 1 & -0.5 & -0.5 \\ & \emptyset & & -0.5 & 0.5 & 0 \\ & & & -0.5 & 0 & 0.5 \end{bmatrix}$$

$$C = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$S_{global} = C^T \cdot S_{dis} \cdot C = \begin{bmatrix} 1 & -0.5 & 0 & -0.5 \\ -0.5 & 1 & -0.5 & 0 \\ 0 & -0.5 & 1 & -0.5 \\ -0.5 & 0 & -0.5 & 1 \end{bmatrix}$$