The strain energy is given by

$$U = \frac{K}{2}(\frac{1}{2}(J^2-1) - \ln J) + \frac{G}{2}(J^{-2/3}C_{pp} - 3) \tag{1}$$

Calculate the stress response

$$S_{ij} = 2\frac{\partial U}{\partial C_{ij}} = \frac{K}{2}(J^2-1)C_{ij}^{-1} + GJ^{-2/3}(\delta_{ij} - \frac{C_{pp}}{3}C_{ij}^{-1}) \tag{2}$$

where it was used that

$$\frac{\partial J}{\partial C_{ij}} = \frac{J}{2}C_{ij}^{-1} \tag{3}$$

Calculate the material stiffness

$$\begin{aligned} D_{ijkl} &= 4\frac{\partial^2 U}{\partial C_{ij} C_{kl}} \\ &= a_1 C_{ij}^{-1}C_{kl}^{-1} - a_2(\delta_{ij}C_{kl}^{-1} + C_{ij}^{-1}\delta_{kl}) + a_3(C_{ik}^{-1}C_{jl}^{-1} + C_{il}^{-1}C_{jk}^{-1}) \end{aligned} \tag{4}$$

where

$$\begin{aligned} a_1 &= KJ^2 + \frac{2G}{9}J^{-2/3}C_{pp} \\ a_2 &= \frac{2G}{3}J^{-2/3} \\ a_3 &= \frac{G}{3}J^{-2/3}C_{pp} - \frac{K}{2}(J^2-1) \end{aligned}$$

where it was used that

$$\frac{\partial C_{ij}^{-1}}{\partial C_{kl}} = -\frac{1}{2}(C_{ik}^{-1}C_{lj}^{-1} + C_{il}^{-1}C_{jk}^{-1}) \tag{5}$$

The matrix for plane problem becomes

$$\mathbf{D} = \begin{bmatrix} D_{1111} & D_{1122} & D_{1112} \\ D_{2211} & D_{2222} & D_{2212} \\ D_{1211} & D_{1222} & D_{1212} \end{bmatrix} \tag{6}$$