$$= \delta_{ij} - (\hat{e}_i \cdot \hat{f}_b)(\hat{e}_j \cdot \hat{f}_b). \quad \text{Thus, } T_{ij} = 3\delta_{ij} - \sum_b (\hat{e}_i \cdot \hat{f}_b)(\hat{e}_j \cdot \hat{f}_b).$$

We see immediately $T_{i3} = T_{3i} = 0$ for $i \neq 3$, and $T_{33} = 3$, since $\hat{e}_3 \cdot \hat{f}_b = 0 \ \forall\, b$. Next,

$$T_{12} = T_{21} = -\sum_b (\hat{e}_1 \cdot \hat{f}_b)(\hat{e}_2 \cdot \hat{f}_b) = -\left\{ 1 \times 0 + \left(-\tfrac{1}{2}\right)\left(\tfrac{\sqrt{3}}{2}\right) + \left(-\tfrac{1}{2}\right)\left(-\tfrac{\sqrt{3}}{2}\right) \right\} = 0.$$

Finally, $T_{11} = 3 - \sum_b (\hat{e}_1 \cdot \hat{f}_b)(\hat{e}_1 \cdot \hat{f}_b) = 3 - \left\{ 1 + \tfrac{1}{4} + \tfrac{1}{4} \right\} = \tfrac{3}{2}$

$$T_{22} = 3 - \sum_b (\hat{e}_2 \cdot \hat{f}_b)(\hat{e}_2 \cdot \hat{f}_b) = 3 - \left\{ 0 + \tfrac{3}{4} + \tfrac{3}{4} \right\} = \tfrac{3}{2}.$$

Thus $V_{Rot} = \dfrac{kad}{4} \left\{ 2\epsilon_3^2 + \epsilon_1^2 + \epsilon_2^2 \right\} + \text{const} + O(\epsilon^3)$

and

$$\boxed{\mathcal{L} = \left[\tfrac{1}{2} m \dot{\vec{R}}_{CM}^2 - \tfrac{3}{2} k \vec{R}_{CM}^2 \right] + \left[\frac{ma^2}{48} (\dot{\epsilon}_1^2 + \dot{\epsilon}_2^2 + 2\dot{\epsilon}_3^2) - \frac{kad}{4} (\epsilon_1^2 + \epsilon_2^2 + 2\epsilon_3^2) \right] + O(\epsilon^3).}$$