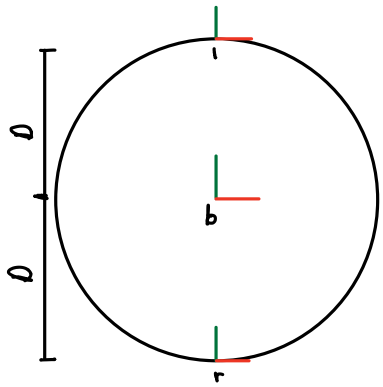

$$T_{bl} = (0, 0, D) \qquad T_{br} = (0, 0, -D)$$

$$V_b = \begin{bmatrix} \dot\theta \\ \dot x \\ \dot y \end{bmatrix} \qquad \begin{bmatrix} v_x \\ v_y \end{bmatrix} = \begin{bmatrix} r\dot\phi \\ 0 \end{bmatrix}$$

$$A_{bl} = \begin{bmatrix} 1 & 0 & 0 \\ D & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad A_{lb} = \begin{bmatrix} 1 & 0 & 0 \\ -D & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$A_{br} = \begin{bmatrix} 1 & 0 & 0 \\ -D & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad A_{rb} = \begin{bmatrix} 1 & 0 & 0 \\ D & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$V_l = A_{lb} V_b = \begin{bmatrix} 1 & 0 & 0 \\ -D & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot\theta \\ \dot x \\ \dot y \end{bmatrix} = \begin{bmatrix} \dot\theta \\ -D\dot\theta + \dot x \\ \dot y \end{bmatrix} \rightarrow \begin{bmatrix} \dot\theta \\ r\dot\phi \\ 0 \end{bmatrix} = \begin{bmatrix} \dot\theta \\ -D\dot\theta + \dot x \\ \dot y \end{bmatrix} \rightarrow \dot\phi = \frac{-D\dot\theta + \dot x}{r}$$

$$V_r = A_{rb} V_b = \begin{bmatrix} 1 & 0 & 0 \\ D & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot\theta \\ \dot x \\ \dot y \end{bmatrix} = \begin{bmatrix} \dot\theta \\ D\dot\theta + \dot x \\ \dot y \end{bmatrix} \rightarrow \begin{bmatrix} \dot\theta \\ r\dot\phi \\ 0 \end{bmatrix} = \begin{bmatrix} \dot\theta \\ D\dot\theta + \dot x \\ \dot y \end{bmatrix} \rightarrow \dot\phi = \frac{D\dot\theta + \dot x}{r}$$

$$u = H V_b$$

$$\begin{bmatrix} u_l \\ u_r \end{bmatrix} = \frac{1}{r} \begin{bmatrix} -D & 1 & 0 \\ D & 1 & 0 \end{bmatrix} \begin{bmatrix} \dot\theta \\ \dot x \\ \dot y \end{bmatrix} = \begin{bmatrix} \frac{-D\dot\theta + \dot x}{r} \\ \frac{D\dot\theta + \dot x}{r} \end{bmatrix}$$

$$u_l = \frac{-D\dot\theta + \dot x}{r} \rightarrow r u_l + D\dot\theta = \dot x \rightarrow \dot x = r u_l + D\left(\frac{r u_r - r u_l}{2D}\right) \rightarrow \dot x = \frac{r u_r + r u_l}{2}$$

$$u_r = \frac{D\dot\theta + \dot x}{r} \rightarrow u_r = \frac{D\dot\theta + r u_l + D\dot\theta}{r} \rightarrow \dot\theta = \frac{r u_r - r u_l}{2D}$$

$$H^+ = \frac{r}{2} \begin{bmatrix} -\frac{1}{D} & \frac{1}{D} \\ 1 & 1 \\ 0 & 0 \end{bmatrix}$$

$$V_b = H^+ u$$

$$\begin{bmatrix} \dot\theta \\ \dot x \\ \dot y \end{bmatrix} = \frac{r}{2} \begin{bmatrix} -\frac{1}{D} & \frac{1}{D} \\ 1 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} u_l \\ u_r \end{bmatrix} = \begin{bmatrix} \frac{r u_r - r u_l}{2D} \\ \frac{r u_r + r u_l}{2} \\ 0 \end{bmatrix}$$

$$\Delta q = A(\theta, 0, 0)\, \Delta q_b$$

$$\begin{bmatrix} \Delta\theta \\ \Delta x \\ \Delta y \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \Delta\theta_b \\ \Delta x_b \\ \Delta y_b \end{bmatrix} = \begin{bmatrix} \Delta\theta_b \\ \Delta x_b \cos\theta - \Delta y_b \sin\theta \\ \Delta x_b \sin\theta + \Delta y_b \cos\theta \end{bmatrix}$$