Brake Calculations

Bias:

$A_f = \pi r_f^{\,2} = (\pi)(0.3125)^2 = 0.307in^2 = 0.000198m^2$

$A_r = \pi r_r^{\,2} = (\pi)(0.5)^2 = 0.785in^2 = 0.000506m^2$

Bias = $\frac{1}{1+\frac{A_f}{A_r}} = \frac{1}{1+\frac{0.307}{0.785}} =$ 0.719 or 71.9% natural bias

Pressure:

Driver input: 475N

Pedal ratio: 3.4:l

$Force\ by\ pedal = (3.4) * (475) = 1615N$

$Force\ on\ each\ circuit$ = (1615)/(2) = 807.5N

$Pressure\ in\ front\ circuit = (force\ on\ each\ circuit)/(area\ of\ front\ master\ cylinder) =$

$(807.5)/(0.000198) = 4.08\ MPa\ or\ 591.8\ psi$

$Pressure\ in\ rear\ circuit = (force\ one\ each\ circuit)/(area\ of\ rear\ master\ cylinder)$ =

$(807.5)/(0.000506) = 1.59\ MPa\ or\ 230.6\ psi$

Dynamics:

Average deceleration: 1.5g

Total weight (with driver): 317.5 kg

Center of mass height: 0.294m

Wheelbase: 1.528m

$weight\ transfer = (average\ deceleration)(total\ weight)(center\ of\ mass\ height)/(wheelbase)$

$= (1.5)(317.5)(0.294)/(1.528) = 91.63\ kg$

$Dynamic\ load\ (front) = (normal\ load,\ front) + (weight\ transfer)$

$= (149.225) + (91.63) = 240.855\ kg$

$Dynamic\ load\ (rear) = (normal\ load,\ rear) - (weight\ transfer)$

$= (168.275) - (91.63) = 76.645\ kg$

Tire coefficient of friction (μ_t): 1.4

$Front\ wheel\ frictional\ force = (\mu_t)(dynamic\ load,\ front) = (1.4)(240.855) = 337.197\ kg$

$Rear\ wheel\ frictional\ force = (\mu_t)(dynamic\ load,\ rear) = (1.4)(76.645) = 107.303\ kg$

$Front\ wheel\ torque = (front\ wheel\ frictional\ force)(g)(radius\ of\ wheel) =$

$= (337.197)(9.81)(0.2032) = 672.165\ Nm\ or\ 336.083\ Nm\ per\ front\ wheel$

$Rear\ wheel\ torque = (rear\ wheel\ frictional\ force)(g)(radius\ of\ wheel) =$

$= (107.303)(9.81)(0.2032) = 213.896\ Nm\ or\ 106.948\ Nm\ per\ rear\ wheel$

For proper braking: braking torque > wheel torque, front braking torque > front wheel torque,

and rear braking torque > rear wheel torque

Effective radius of rotor: 0.080m

$Front\ braking\ torque = (effective\ radius\ of\ rotor)(frictional\ force\ on\ front\ brake\ rotor)$

$Rear\ braking\ torque = (effective\ radius\ of\ rotor)(frictional\ force\ on\ rear\ brake\ rotor)$

Therefore,

$Frictional\ force\ on\ front\ brake\ brake\ rotor > 4201.038\ Nm$

and

$Frictional\ force\ on\ rear\ brake\ rotor > 1336.85\ Nm$

<u>Caliper:</u>

Front Specifications: 4 piston ISR caliper with 25mm diameter piston

Rear Specifications: 2 piston ISR caliper with 25mm diameter piston

N: normal reaction force of the pistons on the disc

Brake pad coefficient of friction (μ_b): 0.4

$$Frictional\ force\ on\ front\ brake\ rotor\ =\ (\mu_b)(N_{front})$$

$$(N_{front})\ =\ (Frictional\ force\ on\ front\ brake\ rotor)/(\mu_b)\ =\ (4201.038)/(0.4)\ =\ 10502.595\ N$$

$$Required\ area\ of\ front\ caliper\ piston\ =\ (N_{front})/(pressure\ in\ circuit)$$

$$=\ (10503.4375)/(4080000)\ =\ 2574.44mm^2$$

$$Frictional\ force\ on\ rear\ brake\ rotor\ =\ (\mu_b)(N_{rear})$$

$$(N_{rear})\ =\ (Frictional\ force\ on\ rear\ brake\ rotor)/(\mu_b)\ =\ (1336.85)/(0.4)\ =\ 3342.125\ N$$

$$Required\ area\ of\ rear\ caliper\ piston\ =\ (N_{rear})/(pressure\ in\ circuit)$$

$$=\ (3342.125)/(1590000)\ =\ 2101.97mm^2$$

$$Front\ caliper\ piston\ total\ area\ =\ (\pi)(r_{piston})^2(number\ of\ piston)\ =\ (\pi)(12.5)^2(4)\ =$$

$$=\ 1963.495\ mm^2\ <\ 2574.44mm^2$$

$$Rear\ caliper\ piston\ total\ area\ =\ (\pi)(r_{piston})^2(number\ of\ piston)\ =\ (\pi)(12.5)^2(2)\ =$$

$$=\ 981.74\ mm^2\ <\ 2097.19mm^2$$

In conclusion, the brakes equipped on EV24 are a little smaller than our calculated above in the maximum braking scenario. However, in most cases the car will be lighter than this with other drivers and we typically will not see decelerations as aggressive as the one calculated above. With these considerations it is safe to say that the brakes on EV24 are appropriate for most driving scenarios.

References:

- https://honeykumarv.wordpress.com/wp-content/uploads/2018/03/brakes.pdf
- https://www.isrbrakes.se/products/calipers/22-048.html
- https://www.isrbrakes.se/products/calipers/22-049.html