1.3 汽车行驶的驱动-附着条件及汽车附着力

Driving traction, adhesive condition

adhesion
adhesive force

1. 汽车行驶驱动—附着条件

Driving traction—adhesive condition

$$\delta m \frac{\mathrm{d}u}{\mathrm{d}t} = F_t - (F_f + F_w + F_i)$$

汽车行驶必要条件:

Essential condition for vehicle driving :

$$F_t > (F_f + F_w + F_i)$$

$$i_0 \uparrow \text{或} i_g \uparrow \Rightarrow F_t \uparrow \rightarrow \frac{\mathrm{d}u}{\mathrm{d}t} \uparrow$$

$$F_Z = ?$$

轮胎与地面的附着条件

The adhesive condition of the tire on roadway

$$F_{x\max} = F_\varphi = \varphi F_Z$$

$$if \quad F_x > \varphi F_Z \Rightarrow$$ 轮胎产生滑转或者滑动现象

Tire shows the phenomenon of slide revolution on the road

后驱动汽车

$$F_{x2} = F_t - F_{f2} \le \varphi F_{Z2}$$

$$F_t \le (f + \varphi) F_{Z2}$$

$$f << \varphi \Rightarrow F_t \le \varphi F_{Z2}$$

这是汽车行驶的第二个条件！

F_{Z2} 驱动轮地面法向反作用力

$$F_f + F_w + F_i \le F_t \le F_{Z\varphi}$$ → 汽车行驶的必要充分条件

Rear drive axle MV

F_{z2}Reaction of ground on traction tire, i.e. It is controlling the second condition that MV drives. generally

$$F_f + F_w + F_i \le F_t \le F_{Z\varphi}$$

is the necessary and full conditions that the MV drives.

2. 汽车附着力 MV adhesive force

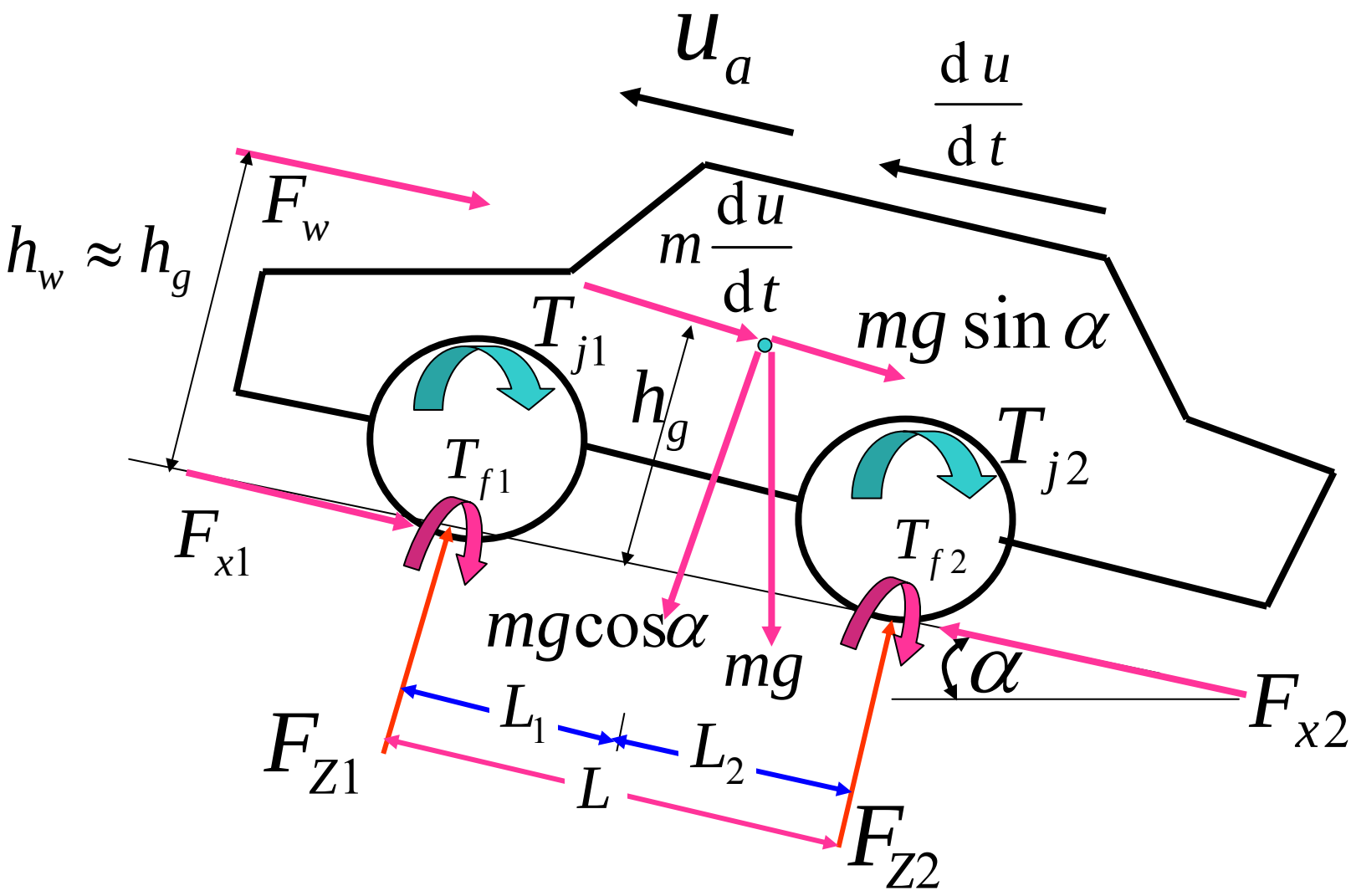
$$F_{\varphi} = \varphi F_{Z\varphi}$$

在硬路面上，φ主要取决路面的种类和状况，也与u_a有关。On the hard roadway, it depends mainly on the category and conditions of road surface, also is relevant with the velocity

路面类型	混凝土（干）	混凝土（湿）
附着系数	0.7~0.8	0.5~0.6

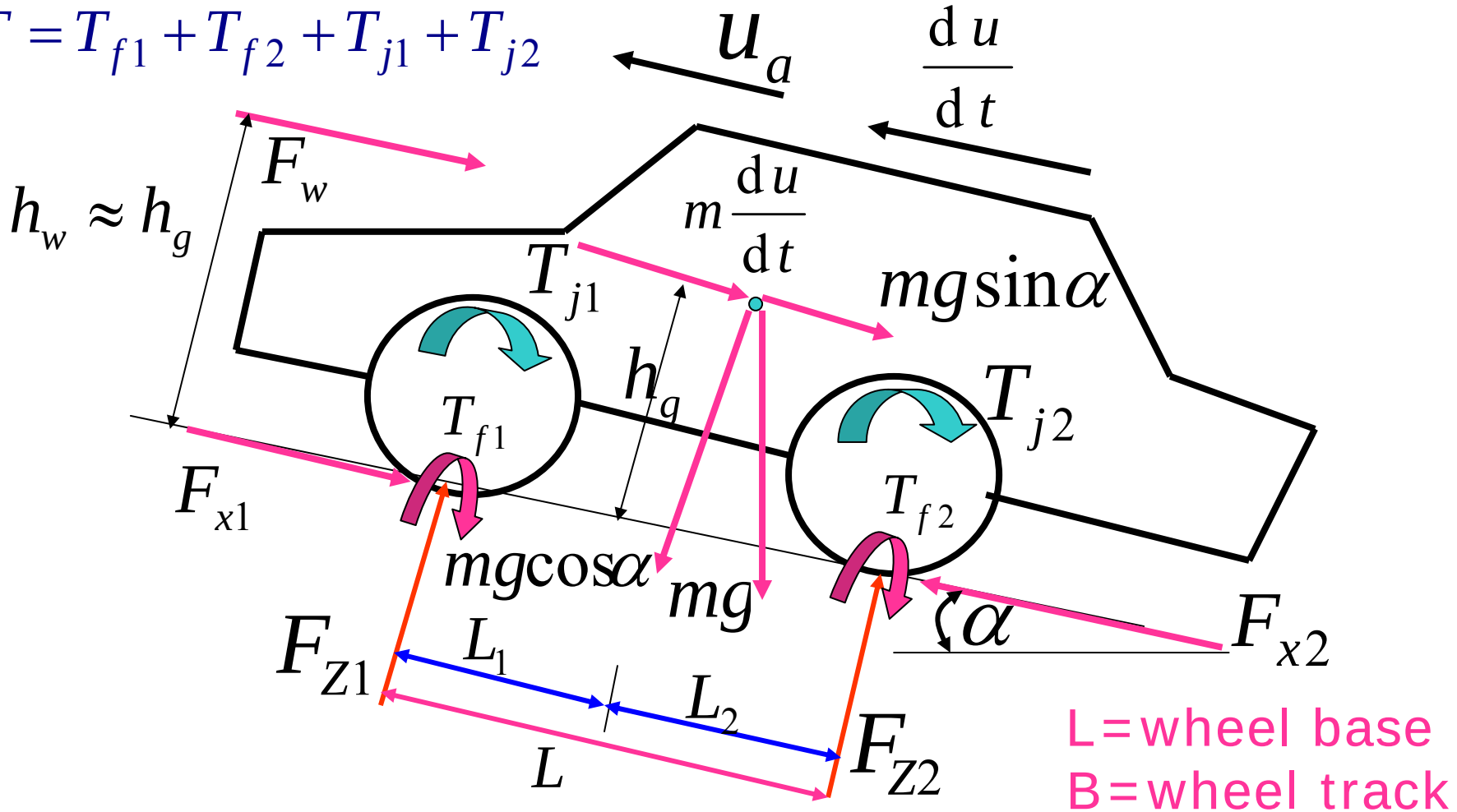
路面类型	碎石	土路（干）	土路（湿）
附着系数	0.6~0.7	0.5~0.6	0.2~0.4

前轮驱动和后轮驱动时的地面反力



$$F_{Z1}L+\Sigma T+F_w h_w+m\frac{\mathrm{d}u}{\mathrm{d}t}h_g+h_g mg\sin\alpha-L_2 mg\cos\alpha=0$$

$$\Sigma T=T_{f1}+T_{f2}+T_{j1}+T_{j2}$$



L=wheel base
B=wheel track

$$F_{Z2}L-\Sigma T-F_w h_w-m\frac{\mathrm{d}u}{\mathrm{d}t}h_g-h_g mg\sin\alpha-L_1 mg\cos\alpha=0$$

前轮驱动和后轮驱动时的地面反力

Road Reactions on front/rear drive tire

所有力对后轮取矩，得到

Torque received on rear axle , given

$$F_{Z1}L+F_w h_w+T_f+T_j+m\frac{\mathrm{d}u}{\mathrm{d}t}h_g+h_g G\sin\alpha-L_2 G\cos\alpha=0$$

$G=mg$ $\quad h_w \approx h_g$

$$F_{Z1}=\frac{G(L_2-f)\cos\alpha-Gh_g\sin\alpha-F_w h_g-\delta m h_g\dfrac{\mathrm{d}u}{\mathrm{d}t}}{L}$$

$F_{Z1}\Downarrow!$

对前轮取矩求后轮地面法向反力，得到

Torque received on front axle, given

$$F_{Z2}L-L_1G\cos\alpha-F_wh_w-T_f-T_j-m\frac{\mathrm{d}u}{\mathrm{d}t}h_g-h_gG\sin\alpha-F_wh_w=0$$

$$\cos\alpha\approx 1,\sin\alpha\approx\alpha\approx i$$

$$F_{Z2}=\frac{1}{L}(L_1G\cos\alpha+F_wh_w+fG\cos\alpha+\delta mh_g\frac{\mathrm{d}u}{\mathrm{d}t}+Gh_g\sin\alpha)$$

$$F_{Z2}=\frac{G(L_1-f)\cos\alpha+Gh_g\sin\alpha+F_wh_g+\delta mh_g\dfrac{\mathrm{d}u}{\mathrm{d}t}}{L}$$

$F_{Z2}\Uparrow!$

良好路面

$$F_{Z1} = \frac{mgL_2}{L} - \frac{h_g}{L}\left(\delta m \frac{\mathrm{d}u}{\mathrm{d}t} + F_i + F_w\right)$$

$$= F_{Z10} - \Delta F_Z$$

$$F_{Z2} = \frac{mgL_1}{L} + \frac{h_g}{L}\left(\delta m \frac{\mathrm{d}u}{\mathrm{d}t} + F_i + F_w\right)$$

$$= F_{Z20} + \Delta F_Z$$

$$\Delta F = \frac{h_g}{L}\left(F_j + F_i + F_w\right)$$

结论：轴距增加和重心高度小，动载荷减小。

Static load on axle

$$F_{Z10} = \frac{mgL_2}{L}$$ → 前轮静载荷 static load front tire

$$F_{Z20} = \frac{mgL_1}{L}$$ → 后轮静载荷 static load rear tire

Dynamic load on axle

前后轮的动载荷(动轴荷)

$$\Delta F_Z = \frac{h_g}{L}(F_j + F_i + F_w)$$

前减
后增

$$F_t = F_f + F_w + F_i + F_j \longrightarrow F_{tmax} = F_\varphi$$

$$F_\varphi = F_f + F_w + F_i + F_j$$

$$F_j + F_w + F_i = F_\varphi - F_f \approx F_\varphi$$

由此得到　Getting from above equations

$$F_{Z1} = \frac{mgL_2}{L} - \frac{h_g}{L}(F_\varphi - F_f)$$

$$F_{Z2} = \frac{mgL_1}{L} + \frac{h_g}{L}(F_\varphi - F_f)$$

$$\Delta F \propto \begin{cases} F_t \\ \dfrac{h_g}{L} \end{cases}$$

这就是货车采用后驱的原因！

后驱动 For rear drive

$$F_Z = \varphi mg$$

$$F_{\varphi 2} = \varphi F_{Z2}$$

$$F_{\varphi 2} = \varphi\left[\frac{mgL_1}{L} + \frac{h_g}{L}\left(F_{\varphi 2} - F_f\right)\right]$$

$$F_{\varphi 2} - \frac{\varphi h_g}{L} F_{\varphi 2} = \varphi \frac{mgL_1 - mgfh_g}{L}$$

$$F_{\varphi 2} = \frac{\frac{\varphi mg}{L}\left(L_1 - fh_g\right)}{1 - \frac{\varphi h_g}{L}} = \frac{\varphi mg\left(L_1 - fh_g\right)}{L - \varphi h_g}$$

后驱动地面附着力
Adhesive force of rear drive

$$F_{\varphi 2} = \frac{\varphi mg\left(L_1 - fh_g\right)}{L - \varphi h_g}$$

$$L_1 >> fh_g \qquad L >> \varphi h_g$$

$$\uparrow F_{\varphi 2} \approx \frac{\varphi mgL_1}{L - \varphi h_g} > \frac{\varphi mgL_1}{L}$$

前驱动　For rear drive

$$F_Z = \varphi mg$$

$$F_{\varphi 1} = \varphi F_{Z1}$$

$$F_{\varphi 1} = \varphi\left[\frac{mgL_2}{L} - \frac{h_g}{L}(F_{\varphi 1} - F_f)\right]$$

$$F_{\varphi 1}(1 + \varphi\frac{h_g}{L}) = \frac{\varphi mg}{L}(L_2 + h_g f)$$

$$F_{\varphi 1} = \frac{mg\,\varphi(L_2 + h_g f)}{L + h_g\varphi}$$

前驱动地面附着力
adhesive force of front drive

$$F_{\varphi 1} = \frac{\varphi mg\left(L_2 + fh_g\right)}{L + \varphi h_g}$$

$$L_2 >> fh_g \qquad L >> \varphi h_g$$

$$\downarrow \quad F_{\varphi 1} \approx \frac{\varphi mgL_2}{L + \varphi h_g} < \frac{\varphi mgL_2}{L}$$

全轮驱动：For 4WD(AWD)

$$F_{\varphi} = \varphi(F_{Z1} + F_{Z2}) = \varphi F_Z$$

其前提条件是当：Prior condition

$$F_{Z1} = \frac{mgL_2}{L} \text{且} F_{Z2} = \frac{mgL_1}{L}$$

才能充分利用 φ

Then it can fully make use of φ

前轮、后轮驱动附着利用率

Utilization of MV adhesives with front or rear axle drive

后轮驱动：

For RWD

$$\frac{F_{\varphi 2}}{F_{\varphi}} = \frac{L_1 - fh_g}{L - h_g\varphi} \approx \frac{L_1}{L - h_g\varphi}$$

前轮驱动：

For FWD

$$\frac{F_{\varphi 1}}{F_{\varphi}} = \frac{L_2 + fh_g}{L + h_g\varphi} \approx \frac{L_2}{L + h_g\varphi}$$

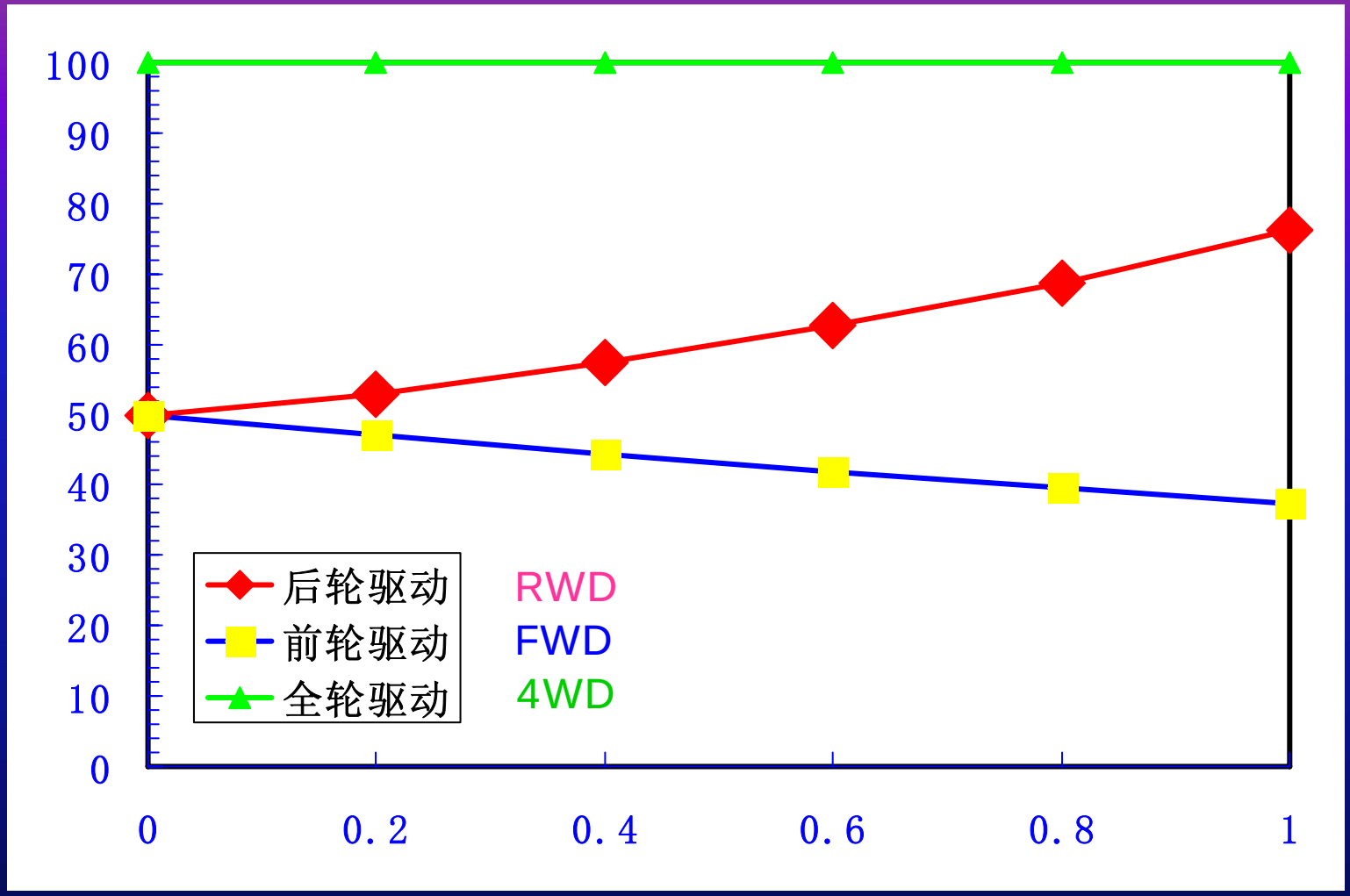
通常前驱动汽车(轿车)的前轴静载荷大于后轴。$L_1 < L_2$

×质心的位置可用称重法确定。

$F_{Z1} > F_{Z2}$

Usually for front drive MV , the static load of front axle larger then that of rear axle. The position of the mass center can be determined by means of weighing.

附着利用率 Adhesive utilization



附着系数 φ Adhesive factor

不同驱动形式汽车的附着利用率曲线

Adhesive utilization depending on drive type