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# Design Requirements for a Personal Mobility Vehicle (PMV) with an Inward Tilt Mechanism to Maintain Straight Running on Slant Roads and Rutted Roads

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## INSTRUCTION

In the references, one of the authors had described the behavior of passenger cars on a slant road(1) and on a rutted road(2). Although, automobile tires have a significant ground camber angle when traveling on rutted roads, they do not have it on slant roads because the vehicle body tilts along the road surface. On the other hand, in Personal Mobility Vehicle (PMV) that tilts inward when turning like motorcycles, the vehicle body always keeps upright when traveling both on slant roads and on rutted roads. Therefore, the tires have ground camber angles on both types of road surface. In this paper, we describe the requirements for maintaining stable straight running even under such road surface disturbances.

## OVERVIEW

In order for the PMV to maintain straight running on a slant road, it is required that the lateral force is balanced without steering operation, no yaw moment is generated, and no steering moment is generated. The design requirements are the same as the following method for minimizing the steering axial disturbance caused by the vertical load reaction force, which is shown in Ref.(3).

1) The caster trail ($T_\xi$) cancels out the pneumatic trail ($e_\gamma$) caused by the camber angle. The value of $T_\xi$ is given by Eq.(1).

$$T_\xi = -e_\gamma = 26.7\text{mm} \quad (1)$$

$T_\xi$: caster trail　$e_\gamma$: pneumatic trail on camber angle

2) The kingpin offset ($D_\psi$) on the ground plane is determined from the viewpoint of stability during braking and vibration suppression during ABS operation. (Eq.(2))

$$D_\psi \approx -5\text{mm} \quad (2)$$

$D_\psi$: kingpin offset on ground plane

3) The relationship between the caster angle ($\xi$) and the kingpin angle ($\psi$) is given by Eq.(3).

$$\tan\xi/\tan\psi \approx T_\xi/D_\psi \approx 5.34 \quad (3)$$

$\xi$: caster angle　$\psi$: kingpin angle

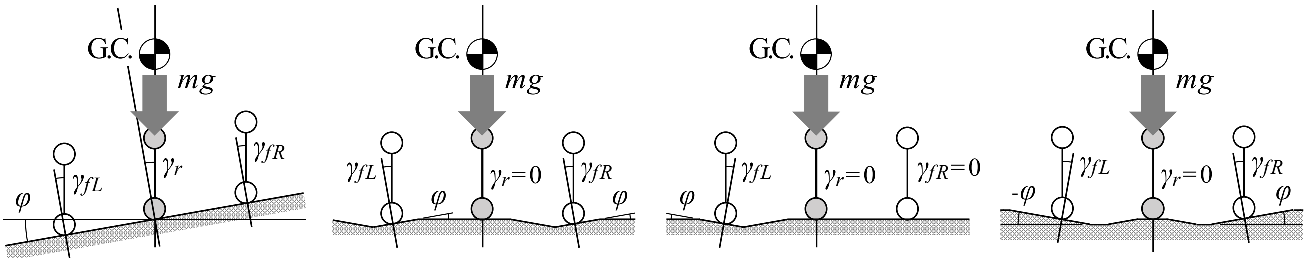
4) From Eq.(4), the caster angle (ξ) and kingpin angle (ψ) can be obtained using the tire crown radius ($CR$). (Eq.(5))

$$CR = \frac{T_\xi}{tan\xi} = \frac{D_\psi}{tan\psi} \quad (4)$$

$CR$: tire crown radius

$$\xi \approx 25\text{deg} \quad \psi \approx 5\text{deg} \quad (5)$$

Road slant is a typical disturbance as shown in Fig.1(a) and ruts are also typical disturbances as shown in Figs.1(b) - (d). It is necessary to consider the ruts in valious cases, such as the difference in tread and the ruts formed by the double tires of hevy and large vehicles. By using Eqs.(1)-(5), it is possible to avoid the generation of lateral force and steering axis moment independently for each wheel, therefore straight running is maintained under all rut conditions. This straight running ability is a remarkable strong point of PMV.




(a) Slant road　(b) Same tread as ruts　(c) Narrower tread than ruts　(c) PMV on twin wheel ruts

Fig. 1 PMV running on a slant road and typical rutted roads

## REFERENCE

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