

## Brake balance and stability – by: Dr Peter Hart

### Brake balance is a basic requirement for good truck braking, but what exactly is it?

#### Friction utilisation

To achieve excellent brake performance, a heavy vehicle needs to have reasonably well balanced brakes. That is, the braking effort on each axle should be proportional to the load carried. This allows the tyres to use all the available road friction without locking up.

$R_1, R_2, R_3$  and  $R_4$  are the retardation forces generated by the brakes and applied to the road by the tyres.  $W_1, W_2, W_3$  and  $W_4$  are the weight forces.

For each axle the ratio of brake force  $R$  divided by weight  $W$  carried is called the friction utilisation of the axle. As a guide, a truck tyre starts to skid when the friction utilisation exceeds about 0.7 on a sealed road. In contrast, a passenger car tyre has a maximum friction utilisation of at least 0.9.

On a wet road or a road with a loose surface, the available friction may limit the utilisation to 0.35 or less. Poor tread depth also reduces the friction utilisation limit.

#### Stability Under Braking

A locked wheel cannot provide sideways stabilising (or road handling) forces so vehicle directional control can be poor when brake balance is poor.

The three modes; understeer, oversteer (or in the extreme jack-knife) and trailer swing and all undesirable. They can occur when most of the wheels in an axle group lock-up. Of these modes, jack-knife is the most dangerous because it occurs rapidly and the driver may not be able to correct it.

Jack-knife is likely to occur when a semi-trailer is lightly laden and when the friction utilisation of the trailer

axles is low.

Side slipping of the drive axle occurs before full jack-knife. It is called oversteer. Any drive wheel slipping changes the orientation of the prime mover and is extremely dangerous.

If the trailer is over-braked compared to the prime mover then the trailer axles may reach the friction utilisation limit and the trailer could slip to one side. Trailer swing tends to occur relatively slowly and the driver may be able to correct it.

Whilst trailer swing is undesirable, it is better to have greater friction utilisation on the trailer than on the drive axle group of the prime mover. A trailer that is over-braked compared with the prime mover tends to pull the combination vehicle straight. However, in the extreme, trailer swing becomes likely.

A trailer that is very light compared with the pulling vehicle is likely to be unstable and swing or jump around during heavy braking.

#### Balanced Braking

A vehicle with balanced brakes makes the most use of the available friction because it does not exhibit wheel lock-up at low brake pressure. In practice, balanced braking is the ideal that cannot be achieved. Commercial vehicles usually have loads that vary greatly. The weight of an unladen semi-trailer is likely to be about one third of its fully laden weight. Therefore the brake balance changes with load.

The brake balance on unladen vehicles can be altered using load-proportioning valves. These alter the brake air pressure level at brakes on selected axles in response to the weight carried by that axle.

#### Australian Design Rules

The relevant braking design rules are 35 (motive vehicles) and 38 (trailers). These apply to new vehicles. The rules do not mandate balanced braking or limit the friction utilisation.

The ADRs set stopping distance limits for vehicles and they attempt to promote compatibility between the motive vehicle and the trailers.

Compatibility is related to brake balance in that each vehicle in a compatible combination approximately brakes the weight that its axles carry. The design rules set limits for compatibility in the laden condition only.

The recently released braking element in the Performance Based Standards (PBS) project sets a maximum average friction utilisation limit for each axle group on an unladen PBS vehicle 0.7. This standard is not in the ADRs.

There have been recent changes to ADRs 35 and 38. A significant change is that unladen compatibility limits must be met when a load-proportioning brake system is fitted. The previous impediment to the use of load-proportioning brakes on trailers has been removed.

In next month's ARTSA article, some guidelines for calculating brake balance and for setting up load-proportioning brakes will be given. Putting load-proportioning valves onto trailers without doing the calculations is fraught with danger.

