TOWING - Towball Weight and Trailer Stability

We've all heard of the 10-percent rule: conventional wisdom has it that a trailer coupling should bear around 10 percent of the total trailer weight.

The purpose of this percentage is manifold: guaranteeing that the trailer won't lift the rear wheels of the towing vehicle under acceleration or when climbing a steep grade; ensuring that the trailer tracks accurately behind the towing vehicle; and preventing trailer sway.

In North America virtually all trailer and caravan makers endorse the 10-percent rule and some go so far as to suggest the towball load should be as high as 15 percent. In the case of a 2000kg trailer that means a towball load of 200kg to 300kg.

In Europe it's an entirely different story: the typical EEC car and 4x4 towball load is between 50kg and 75kg, and even heavy trailers – above 3500kg – have towball loads around 100kg.
In Australia we have largely adopted the North American model. Most trailer and caravan makers endorse the 10 percent rule, regardless of the trailer configuration and the number of axles.

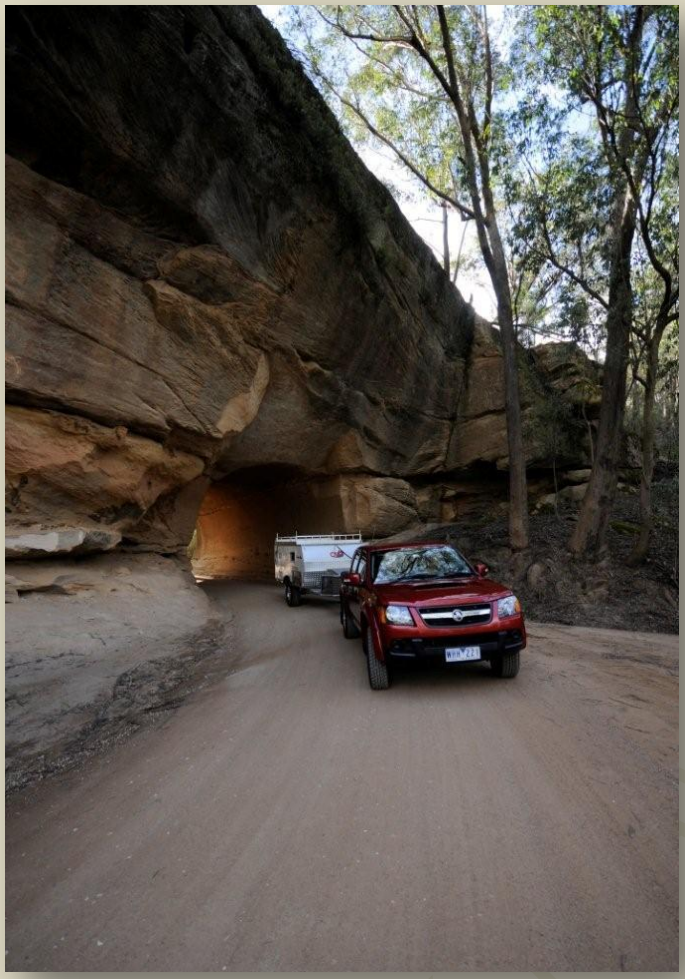
Many car and 4x4 makers hate the 10-percent rule, because it forces them to design heavier rear sections and stiffer rear suspensions than they need in most markets.

Some makers, like Subaru, limit the permissible towball load to a set figure (90kg for most models) and insist that if a Subaru is coupled to a trailer or caravan with a heavier towball load the owner must fit weight-distribution bars, to pull the towball weight back to 90kg.

We've towed a variety of caravans and camper trailers behind Subaru Outbacks, with towball weights less than 90kg and no weight-distribution bars and have had no sway issues.

Why have a heavy towball weight in the first place, many people ask.

The marketplace is full of theories, but very light on actual test results. It's a popular belief that a heavy towball load reduces the chance of trailer sway.



If that were the case the new EEC trailer regulations would surely have mandated heavy towball loads, because European caravans mix it with high-speed traffic on multi-lane roads and need all the stability they can get.

European and Australian light and heavy truck 'pig' trailers – drawbar trailers with centrally positioned tandem or tri-axle bogies – have very little or no towball weight and don't have significant sway problems.

Ongoing vehicle manufacturers' analysis and Society of Automotive Engineers' testing has shown the factors that influence trailer sway include driver skill, speed, vehicle and trailer weight, vehicle and trailer load centres of gravity, number of trailer axles, aerodynamics, heavy-vehicle air turbulence, weather conditions, road surface undulations, wheel bearing condition, trailer brake adjustment, towball to coupling clearances and friction, tyre pressures and the suspension dynamics of towing vehicle and trailer.

The prospect of negating all these factors by simply upping the towball weight is unlikely. Interestingly, on the subject of driver skill, the EEC trailer towing regulations limit car-licence drivers to 750kg trailers, with or without brakes. To tow a trailer weighing 750kg up to 1750kg requires two days of driver training and an upgraded licence test.

Towing trailers that weigh more than 1750kg requires a truck licence. Can you imagine our weak-kneed pollies implementing such 'repressive' legislation?

European police regularly spot-check trailers for roadworthiness, gross mass violations and excess towball loading. All cars or 4x4s towing trailers above 80km/h, up to a maximum of 100km/h in Germany, must have a friction-type coupling to reduce the likelihood of trailer sway.

North American and European vehicle makers are increasingly turning to electronic stability control (ESC) to counter trailer instability.

As with solo-vehicle ESC the system applies selective wheel braking to towing vehicle and trailer, to prevent a ‘pendulum’ effect developing. Trailer ESC is activated when the trailer plug is connected to the towing vehicle.

We’ve driven a 42-tonne EEC-spec’ prime mover and trailer combination fitted with ESC on all axles and found the stability improvement almost unbelievable, but European truck makers stress the point that ESC won’t make up for a poorly loaded or badly driven combination.

Rather than relying on electronic intervention we really need to settle the towball weight question.

Towball Weight Research

Until 2009 year there was virtually nothing published anywhere in the world on the topic of real-world, light vehicle and trailer towing stability, although it’s known that some vehicle makers have done considerable R&D in this area. In contrast, heavy truck and trailer R&D is well documented and all new prime movers and semi-trailers sold in Europe can be ordered with stability control.

A paper entitled “An experimental investigation of car-trailer high-speed stability” was published in mid-2009 by the Department of Mechanical Engineering at Bath University in the UK.
The paper, by J Darling, D Tilley and B Gao, summarises the findings of tests carried out on a standard UK-built caravan and on an adjustable trailer, in which different dimensional and mass factors could be evaluated.

The tests began with matching the adjustable trailer so that it replicated the dynamic behaviour of the caravan, then altering one dimension change and one mass change at a time, to evaluate the results of the changes. More than 600 different trailer parameters were examined.

In summary, the engineers discovered that the three most significant parameters affecting trailer stability were trailer yaw inertia, nose mass and trailer axle position. Interestingly, the total weight of the trailer wasn't a stability issue of itself, but weight distribution was critical.

Weight Distribution in Trailer Design and Loading

The researchers concluded that the best way to minimise trailer yaw inertia – the tendency for the trailer to sway laterally - was to position any trailer load at or near the centre of gravity. Loads fore and aft of that position increased the likelihood of towing instability.

The optimum nose mass (ball load) was found to be 6-8 percent of the trailer's gross mass. This is quite different from the common 'rule of thumb' relied on in Australia and the USA, where ball loads of 10-15 percent are common.

Provided the measurement didn't increase the ball weight beyond eight percent of trailer gross mass the greater the distance between the coupling and the axle, the more stable the trailer was in test manoeuvres.

The researchers evaluated car ESC, by performing stability manoeuvres with ESC alternately switched on and off. The trailers did not have TSC, yet even without this program, car-only ESC produced more stable behaviour than did the non-ESC tests.

Trailer Stability Control

Trailer Stability Control (TSC) is an extension of the towing vehicle's ESC program and is designed to intervene when vehicle sensors detect a dangerous yawing ('snaking') movement of the trailer. If a yawing movement begins and exceeds a certain limit, the towing vehicle is decelerated within milliseconds by throttle closure and brake application, until stability is restored.

By taking advantage of the ESC system's ability to manipulate engine output and apply wheel-specific braking, TSC seeks to extend the control-enhancing abilities of ESC to the vehicle's trailer.

Trailer sway can be caused by crosswinds, improper loading of the trailer, incorrect tyre pressure, road conditions or even the 'wind wave' from a passing heavy vehicle.

In general, TSC monitors the side-to-side motion of the tow vehicle to determine if the trailer is swaying. If the sensor detects yaw that isn't caused by the driver's steering inputs, it begins working to control the unwanted motion. Moderate brake pressure is applied to a single front wheel in an alternating fashion dictated by the severity and direction of the sway. Light brake pressure is applied to the other three wheels, helping reduce vehicle speed in a controlled manner.

In Europe, that's as far as TSC has gone, because override brakes dominate and driver-controlled electric trailer brakes aren't permitted in the EEC.

There is a push for automated electric trailer brakes within the EEC, so that the towing vehicle's TSC could be coupled to the trailer's electric braking.

AL-KO Trailer Control

Some European trailer makers are working on different stand-alone trailer stability systems and one prominent maker, AL-KO, has released a trailer stability braking system.

AL-KO is best known in Australia for its rubber-bushed, independently-suspended, torsion-bar trailer axles, but the company produces a range of caravan and motorhome chassis in Europe and is well advanced in trailer dynamics R&D. A recent product release is a trailer stability system called AL-KO Trailer Control (ATC), consisting of an axle-mounted sensor connected to an electro-mechanical actuator.

ATC monitors trailer stability in a similar manner to vehicle ESC and if a snaking motion starts the ATC sensor activates the trailer brakes, to slow the combination and eliminate the yawing action of the trailer.

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