Vibrations, Wheelbase and Chassis Strength

This article is about truck and trailer vibration modes. It also gives an outline of attachment designs for bodies that are mounted to trucks and trailers.

Road undulations cause three main "full-body" reactions on trucks and trailers, including Bounce, Pitch and Twist.

The diagrams to the right illustrate the first two of these for a prime-mover. Bouncing can be controlled to some extent by all the axle suspensions working together to damp out the bounce. Pitching is more difficult to avoid, as the suspensions do not work in unison. The pitching sensation is a fore-aft movement of the cabin, which is disturbing for the driver. Pitching excitation of many roads is in the range three to five Hertz, which tends to excite the pitching mode of short wheelbase prime-movers.

The primary isolation between road vibrations is provided by the tyres and the axle suspension working in combination.

It is desirable to get the natural frequency of the suspension system as low as possible. The constraint is always the need to design for adequate strength and roll stiffness. The tyres have little damping and alone, they have a natural frequency at about 10 Hz. Without suspension damping, the axle will bounce on the tyres and the vehicle will tend to bounce on the road. You have probably seen tractors, which have no suspensions, doing this. Ultimately a vehicle that bounces needs to be driven slowly because it will not hold the road at speed.

Additional axle mass limits are available in Australian for 'road-friendly suspensions'. A road-friendly suspension must have a natural frequency that is less than 2 Hz when the axle is at full weight. It must also have a damping rate that is more than 20 per cent of the critical value. Critical damping would occur when there is no overshoot on the first response). Fortunately good RFS performance is good for both the road and the truck.

Truck frames also have a 'natural frequency'. This is called the beaming frequency and it is illustrated in the diagram at the bottom. Typically it is in the range 6 – 9 Hz. So road vibrations that get through the suspension at this frequency can excite beaming. For reference, a vehicle that encounters road bumps that are 2m apart when it travels at 70 km/h will experience road bumps at 8 Hz.

The stiffer the chassis, the less beaming

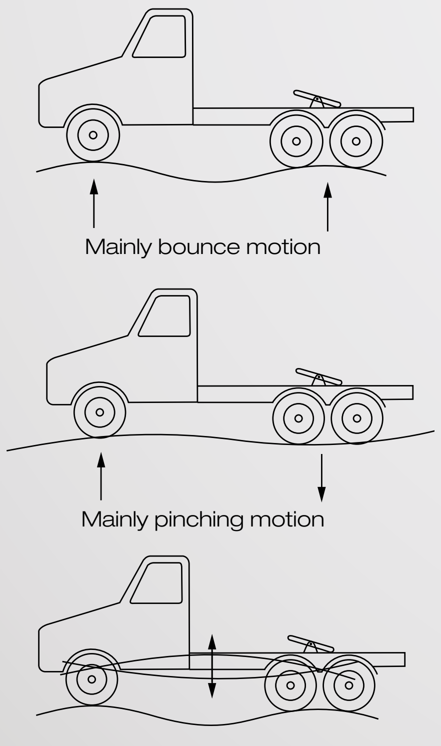


Illustration of the chassis beaming vibration

can occur. Occasionally, a truck has a particularly bad beaming tendency and the driver will complain that it jumps around on the road. Beaming tendency is the other consideration when selecting the wheelbase. The rails must be adequately stiff for the longer wheelbases.

Good road handling can only occur with a relatively stiff chassis structure because any excessive bends and twists cause the road handling and braking forces at the wheels to vary, which is destabilizing.

On trailers and rigid body trucks the stiffness of the body can be a key factor in stiffening up the chassis.

An adequate design for the mechanical attachment of the body to the chassis rails of a truck or a trailer is essential for safety. It also may determine the life expectancy of the chassis rails and affect the roll stability of the vehicle. Some basics follow:

The diagram on the right shows the three main attachment types. Mounts can be classified as stiff or flexible. Most trucks and trailers need a mix of mount types because the design should avoid sharp changes in torsional and vertical stiffness.

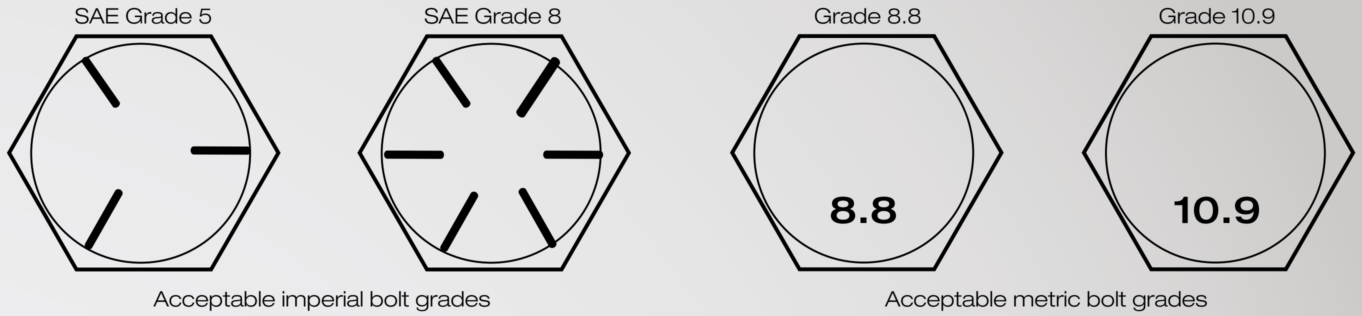
The art of good design is to gradually change the strengths to avoid high stress locations that might occur if when high loads are applied across dramatic changes of strengths.

U-bolts are the traditional attachment method. They allow the body to flex sideways because there is limited side stiffness.

When used on C-section chassis rails, they must have spacer inserts to prevent the rail section being distorted in. Even when tight, a distorted rail will spring on the road and work the U-bolt loose.

U-bolts used alone also allow some rocking backwards and forwards.

There must be two diagonal bracing straps



used each side to prevent this happening. The rail must be protected against clashes with U-bolts to prevent any crack development.

Side-plates attach the sub-frame and bolt through the web of the chassis rail. For heavy-duty trucks and trailers, 10 mm thick mild steel is often used with four high-tensile strength bolts through the rail. Side-plates are usually welded onto the sub-frame of the body, which is also usually made from mild steel.

Welding side-plates onto the high-tensile chassis rails is not advisable because of the danger of heat damage to the rail steel. Furthermore, bolted connections onto the rails allow the body to be removed.

Protrusion attachment brackets are welded or bolted onto both the sub-frame and the chassis rails. They have horizontal mounting surfaces that allow a compliant material to be inserted.

Compliant mounts are useful for isolating the body from the chassis. The one or two high-tensile bolts are tightened down and provide the ultimate attachment strength.

As with all bolted attachments, strong bolts must be used. As a minimum, grade 8.8 mounting hardware is needed. Grade 10.9 mounting hardware is preferred (see diagram above).

Overcoat mounts can be used for side-lifter cranes and lifting arms. They provide an extremely strong mount with no flexibility. A cross-member is built in underneath. Flexibility cannot be tolerated when stabilizer legs are used.

As a guide, an attachment point is required about every 1000mm along each side. These need to be positioned to avoid existing features and should be kept away from cross member bolts and axle mounting bolts.

When the attachment method causes the weight on the body to rest directly on top of the upper chassis-rail flange, a protective strip must be used. It is essential that any protrusions on the sub-frame that could apply point-loads onto the rail flange are avoided. Point load or pinch-points will, in time cause the rail flange to crack.

Wooden runners have traditionally be used. Urethane spacer strips are a preferred material. Aluminium should not be used as it is likely to suffer corrosion in contact with the steel. Whatever spacing method is used, gradual transitions are necessary. The space between the rear of the cabin and the front of the sub-frame is particularly vulnerable to torsional stress. The body sub-frame tends to give the rear chassis torsional rigidity, and the cabin stiffens up the front. Some flexibility should be provided in the front body mounts to avoid twisting failure behind the cabin.

The main message is to keep the chassis and body structure reasonably stiff, make transitions of section strength gradual and avoid any point loads or pinch points on the chassis rails. The front mounts should have some compliance.