SECTION G

Vehicle Structures

CONTENTS

Section G - Vehicle Structures

This Section contains general vehicle body design requirements to enable the appropriate selection by manufacturers, suppliers and vehicle owners.

Vehicle structures considered in this Section include fixed and movable restraint structures, and fixed anchor points for securing devices. Restraint structures include tanks, tipping bodies, van bodies, sided bodies, headboards, bulkheads, coaming rails, loading racks, gates, doors and side curtains. Anchor points include tie rails, tie-down attachment points and twist locks.

The design requirements for special structures to prevent a load penetrating the vehicle cabin in the event of an accident or the failure of any load restraint device, can exceed the Performance Standards and are beyond the scope of this guide.

Section B 'Arranging Loads on Vehicles', and *Section C 'Restraining Loads on Vehicles'* contain the requirements which should be taken into account when considering vehicle suitability and the use of vehicle structures.

Section F 'Calculating Restraint Requirements', contains the methods of determining the forces exerted on vehicle structures.

The National Code of Practice Heavy Vehicle Modifications (see Section J) contains other requirements which should be taken into account when considering body and anchor point attachments. (*Vehicle Standards Bulletin No. 6*).

All vehicle structures and their attachment to the vehicle chassis must be strong enough to provide the load restraining forces.

The design of any supporting structure must take into account the torsional and bending strength and stiffness of the vehicle structure. Any recommendations of the vehicle manufacturer must be taken into account.

The mounting of anchor points should not weaken the vehicle chassis or body structure. Drilling or welding of chassis flanges is not permitted without approval of the vehicle manufacturer.

1 TIE-RAILS AND LOAD ANCHOR POINTS

Lashings can be attached to a vehicle at any point along a tie-rail or at fixed anchor points such as lashing rings (see Page 233), hooks, tie-rail support points.

These attachment points should have a suitable rating for the intended operational use of the vehicle and methods of load restraint to be used.

To withstand the restraint forces applied by lashings in normal circumstances, tie rails and anchor points should be capable of providing adequate restraint in the direction of any attached lashing.

The maximum restraint force for tie-down applications where load shift cannot occur is the maximum pre-tension force exerted by the operator when tensioning the lashings. Typical forces are listed in Table C.2 on page 65 of this guide.

The maximum restraint force for direct restraint applications (mobile equipment) and tie-down applications where load shift can occur (tested and certified applications) is the effective Lashing Capacity of the lashing (usually chain). For example: 8 mm Transport chain has Lashing Capacity of 3.8 tonnes (some 4 tonnes) and its strength is de-rated to 2.85 tonnes when passed around edges, coaming rails etc.

Lashing points on vehicles carried on Roll On-Roll Off vessels and on rail rollingstock require specific ratings for the application.

See Section J for details of various standards that cover tie-rails and load anchor points.

2 WINCH TRACKS

The design of winch tracks must take into account the magnitude and direction of the lashing force, and spacing of the track supports.

The rated track capacity should be clearly and permanently marked on the vehicle.

3 CONTAINER TWIST LOCKS

Container twist locks must be compatible with the dimensional requirements of *AS/NZS 3711* series of standards for freight containers (see Section J).

Where the twist lock support structure is only designed for restraining empty containers or other light loads, the maximum weight should be clearly marked on the vehicle. Failure to mark the weight could have serious consequences if an accident occurred.

4 HEADBOARDS, LOADING RACKS AND BARRIERS

The use of headboards, loading racks and barriers can reduce the number of tie-down lashings required for forward restraint.

If the load is tied down to 0.5'g' in the forward, sideways and rearward direction, the front structure can provide the additional 0.3'g' required for forward restraint. In such cases, the strength of the front structure does not need to be as great as that required for an otherwise unrestrained load.

When designing headboards, loading racks and barriers, the 'loading cases' described in Section F.4, page 199 'Design for containing or blocking' should be taken into account.

The cantilevered structure of a headboard or movable barrier can be easily modified to a supported structure by chaining each side of the headboard or barrier to the tie rail support points. The use of a single long chain from tie-rail to tie-rail around the front of the structure will absorb shock more effectively than two shorter chains. Details are shown in Section C 4.4, page 73.

The chain should be kept below 30 degrees to the horizontal to maintain its effectiveness and to minimise the vertical force at the chain support points. An 8 mm transport chain can provide a total additional restraint of at least 6.5 tonnes angled at 30 degrees on both sides.

5 CURTAIN SIDES, SIDE GATES AND DROP SIDES

When designing curtain sides, side gates and drop sides the 'loading cases' described in Section F.4 page199 'Design for containing or blocking' should be taken into account.

The amount of sideways deflection of any part of a curtain, gate or drop-side should be limited to 100 mm for determining its load restraint capacity at 0.5 'g' sideways.

Where vehicles with curtain sides are designed for load restraint purposes (with or without gates), the system should be tested and certified in accordance with requirements set out in Section F - Calculating Restraint Requirements and Section I - How to Certify a Load Restraint System.

Side gates and loading racks that depend on interlinking with adjacent gates for their strength and stability, should be positively locked or tied into position without relying on tie-down lashings or tarpaulins to prevent them from lifting or bowing.

Side gates supported sideways at the top by curtains should be positively locked in position to prevent them dislodging from the bottom coaming rail supports over bumps or rough roads.

Where side gates and drop-sides are designed to restrain a load without any tie-down, the top of each side should be well above the base of any item of load to be carried. This is to ensure that loads do not become dislodged on bumps or rough roads, especially when cornering.

When evaluating the suitability of sides for a particular application, the manufacturer, supplier and vehicle owner should take into account the following factors:

- The height of the load (whether the load is on the deck or stacked).
- The type of load (whether the load is on wheels, 'bouncy', or likely to be affected by air flow).
- The type of suspension (vehicles with stiff suspensions will require higher gates or sides, especially when travelling near empty).
- The rear overhang of the body (long rear overhangs can magnify the effect of bumps and rough roads).

6 STAKES, PINS, PEGS, POSTS AND STANCHIONS

Vehicles regularly carrying loose plate, sheets, boards, rods, pipes and other similar items should be fitted with pockets along the sides and across the deck in various positions so that stakes, pins, pegs, posts or stanchions can be fitted where required to provide direct restraint.

Any removable stake, pin, peg, post and stanchion must be designed to prevent it from becoming dislodged during a journey by adequate engagement length in its socket or by the use of a positive locking method.

Separate detachable frames which are adjustable in position with provision for stakes, pins, pegs, posts or stanchions can be used as an alternative to fixed pockets on the vehicle.

7 CRADLES, CHOCKS, A-FRAMES AND TRESTLES

Cradles should be designed to prevent cylindrical objects from rolling.

If the cradle prevents the cylinder from rolling, fewer lashings may be required or lower strength lashings may be used.

Cylindrical items will not roll if the ratio of the distance between the cradle/cylinder contact lines (W) to the diameter of the cylinder (D) is equal to, or greater than 5:8 which is equivalent to a wedge angle of 39 degrees (see Figure G.1).

Thus, to prevent rolling:

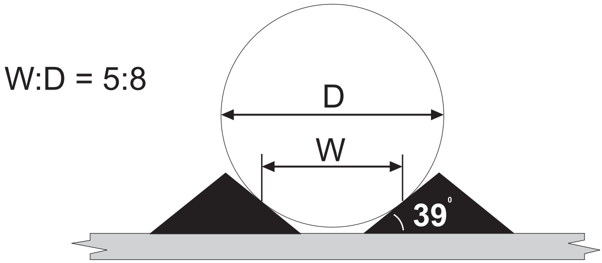

Fig G.1 **CRADLE DIMENSIONS**

Where cradles, chocks, A-frames and trestles are fabricated from metal, designers should take into account the low friction between them and metal decks (and also, the low friction between the load and the metal frame). Provision should be made for capping or facing with timber or rubber to increase the friction.

Cradles can be designed to allow them to be adjusted for different sized coils, to prevent any tendency to roll and therefore to reduce the forces in the lashings. The cradles should be adjusted so the coil rests on the edges and not the bottom of the cradle.

Where tie-down lashings are used to restrain loaded cradles, A-frames or trestles, the direction of the lashings should be as vertical as possible between the cradle or trestle contact point and vehicle tie point (see Figure G.2).

Where direct lashings are used to restrain loaded cradles, A-frames or trestles, the direction of the lashings should be opposite to the expected direction of movement which would result if the load were unrestrained. For example, sideways facing chains attached to a trestle have no load restraint capacity in the forward direction.

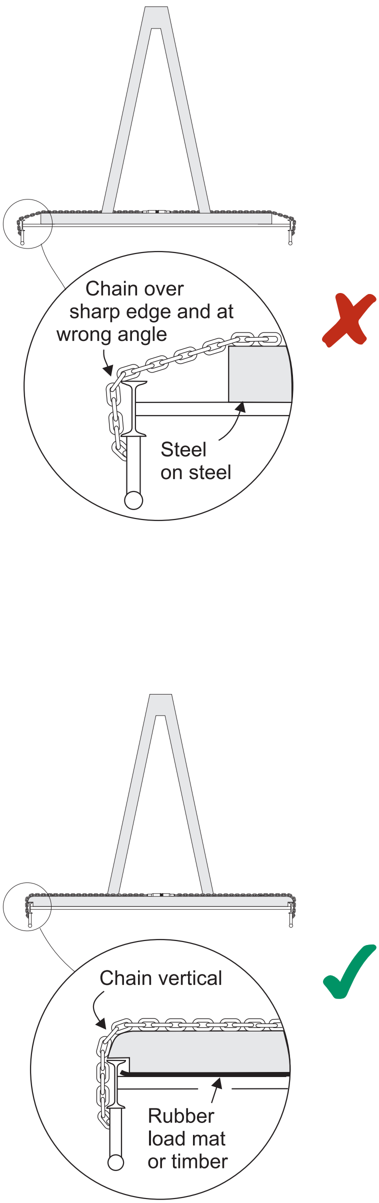

Fig G.2 **A-FRAME RESTRAINT**

Chocks should have high friction contact surfaces and provision for attaching lashings to secure the chocks onto the vehicle. Sandbags and sawdust bags are only suitable for use as chocks during loading and unloading, but not during transport, because they can deform and move under road-induced vibration. When carried, these bags must be restrained on the vehicle as they are also an item of load.

8 CONTAINMENT BODIES

Bodies designed to contain loose bulk loads or general freight without the need for securing devices must not allow the load to become dislodged. Any movement of the load must not reduce the stability of the vehicle.

Heavy individual loads are generally not suitable for restraint by containment unless the restraining structure prevents all horizontal load movement.

Open bodies designed for loose bulk loads should be fitted with covers to prevent load loss from the effects of air flow and rough roads. If the covers are fitted with fixed tracks, winches or handles, they must not make the vehicle be overwidth or overlength.

9 TANKS AND TANKERS

Tanks and tankers can be designed for bulk liquids and finely divided solids including powders.

Where tanks or tankers are required to travel partially full, baffles and compartments should be fitted to prevent any movement of the contents that could cause the vehicle to become unstable especially during cornering.

The load restraint design forces should take into account the dynamic nature of the load eg. the effect of liquid surge in all directions.

All tanks should be designed so that the centre of mass of the laden vehicle is as low as possible.

Loaded ISO tank containers should be transported on low trailers (see Figure G.3).

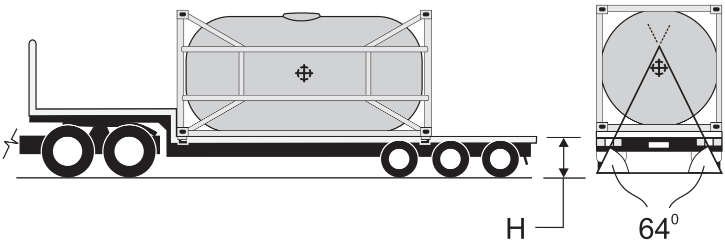

Fig. G.3 **ISO TANK CONTAINER ON A 'DROP - DECK' TRAILER**

The height of the centroid of the tank container cross-section at the tank half length should fall within an isosceles triangle having a base length at ground level equal to the overall width between the outside tyres of the main load-bearing axle groups and base angles not exceeding 64 degrees. (See Section J AS/NZS 2809.1 Road Tank Vehicles for Dangerous Goods - General Requirements).

This requirement will be met if the height (H) from the ground to the bottom of the container corner casting, measured when fully laden, is no greater than 1100 mm. Table G.1 contains measurements that give a stability angle of 64 degrees.

TANK HEIGHT FOR STABILITY						
Width between the outside of the outside tyres (mm)	2300	2400	2425	2450	2475	2500
Maximum height of tank centroid (mm)	2360	2460	2490	2510	2535	2560

Table G.1

Demountable tanks should be secured by twist locks or other positive locking devices. Alternatively, lashings can be used, provided that both the tank and vehicle are equipped with suitable anchor points. If direct lashings are used, each anchor point should be positioned on the support structure so that the lashing angle is low (direct lashing angle effect is high). If tie-down is used, the tank should be placed on timber or rubber load mat and each anchor point should be positioned on the support structure so that the tie-down lashing angle is high (tie-down lashing angle effect is high).

The Australian Code for the Transport of Dangerous Goods by Road and Rail (see Section J) contains construction requirements for tanks and tank vehicles carrying dangerous goods.

10 LATCHES, LOCKS AND HINGES

Latches, locks, hinges and other attachments should be designed to prevent them separating by road induced vibration and impact loads. These items can suffer fatigue cracking if not properly designed. If failure occurs, the load can dislodge from the vehicle. An unsecured swinging door or gate can cause severe injury and damage.

If doors, gates and drop sides are designed for travel in the open position, the vehicle must meet the legal length and width limits when they are both open and closed. They must be capable of being positively restrained when travelling so as to stop them swinging out into the path of other road users.

11 LOADING EQUIPMENT

Where loading equipment such as side loaders and crane stabilising legs protrude outside the vehicle for loading, it should be designed so that the vehicle cannot be moved or an audible and visual indicator operates inside the cabin, if the equipment is not retracted into its travel position.

12 STORAGE OF EQUIPMENT

Where loose restraint equipment, such as lashings, dunnage, chocks, sandbags, stakes, blocks, beams and bars are not in use, special provision should be made for securing or containing this loose material. Purpose-built bins or boxes should be fully enclosed, or if open, should be deep enough to allow adequate height above the base of any loose object to prevent it dislodging on bumps or rough roads.

13 LOAD DISTRIBUTION

To maintain safe steering performance, the weight on a single steer axle of a rigid vehicle or prime mover should be at least 20% of the total vehicle weight over all axles.

For a twin-steer truck or prime mover, the total weight on the steer axles should be at least 30% of the total vehicle weight over all axles.

To maintain vehicle stability, the weight on the rear axle(s) of a rigid vehicle or prime mover should be at least 40% of the total vehicle weight over all axles.

To determine axle weight resulting from the position of a load, either weigh the vehicle or refer to a load distribution graph.

A load distribution graph shows the maximum load that can be carried at each position of the centre of mass of the load along the vehicle, without exceeding legal axle load limits and without reducing the weight on the steer axle(s) below the safe limit. Graphs should be obtained from the vehicle or body manufacturer or a vehicle engineer.

Figure G.4 is a load distribution graph for a typical three-axle rigid truck with an 8-metre tray and having a tare weight of 9 tonnes. The front and rear legal axle load limits are taken to be 6 tonnes and 16.5 tonnes respectively.

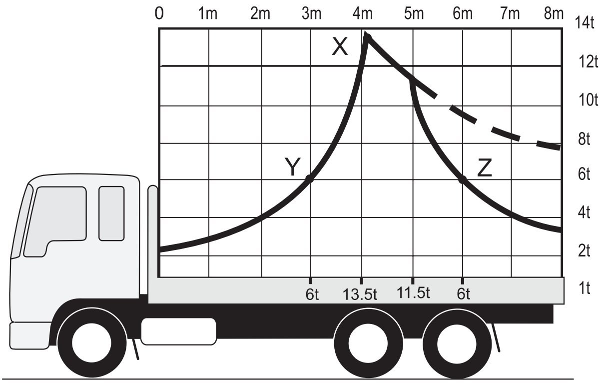

Fig G.4 **TYPICAL LOAD DISTRIBUTION GRAPH**

For example, to correctly position a load of 6 tonnes on the vehicle:

(i) find where the horizontal line through '6t' on the graph crosses the unbroken curved lines (the two points 'Y' and 'Z' on the graph);

(ii) using the top scale (0⟶ 8 m) determine the distance of each of these two points from the headboard, ie. 3 m and 6 m; and position the 6-tonne load with its centre of mass anywhere between these two points.

Note: In this example the centre of mass of the maximum allowable load, 13.5 tonnes, can be placed at only one position, 'X', about 4.1 metres along the tray.

Note also that loads above half the maximum load (6.75 tonnes) are limited to a narrow range of positions along the tray.

Figure G.4 also shows the vehicle's minimum front axle loading required for safe steering (weight on steer axle at least 20% of the total of all axles), by showing a much reduced weight which can be carried behind the rear axle group. The unbroken line between the 5 metre and 8 metre positions shows the range of weights which can be carried whilst maintaining safe steering. Those allowable weights (limited by safe steering requirements) are much less than the weights that could be carried without overloading the axles (which are shown by the broken line).

Using a load distribution graph, the vehicle can be marked with maximum weights at different positions along the deck. This will assist drivers to avoid overloading when positioning loads.

Plastic wrapping did not contain this load. The wrapping should not be relied upon as a restraint system unless certified by the consignor as suitable for the purpose.

Tilting the load inwards on the truck will not provide the required amount of sideways restraint. Additional restraint such as sides or gates is required. *(Photo courtesy John Brentnall).*

A few ropes will not restrain these wool bales.

Chains can be used to secure freight containers although in this case where two chains are used, check the anchor point strength first.

Loads in skips or tippers must be restrained if there is any possibility of the contents coming out.