

The use of vehicle structure in load securing on heavy goods vehicles

Prepared by the Health and Safety Executive

RR1078

Research Report

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Prepared 2016

First published 2016

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Securing loads for safe transport is a legal requirement in the UK. It helps to protect the driver of the vehicle, other road users and pedestrians during the vehicle's journey from vehicle rollover or load detachment, and the driver and unloading personnel from the risks inherent in unloading a load that has been able to move in transit.

This report assesses the legislation applicable to the transport of goods in the UK under both road traffic and health and safety at work legislation. It assesses the guidance available to operators and consignors and the methods of securing loads that are commonly-used at present.

It is suggested that the concept of the load securing system, which comprises the structure of the vehicle, physical barriers to movement, and/or lashings, be given more prominence in current practice. In order to make effective use of the vehicle structure, it is important to ensure that the structure is in sound condition, and that vehicle headboards and bulkheads, in particular, are both strong enough to resist forward movement of the load and also maintained in serviceable condition to protect the driver from ingress of the load to the cab.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

The use of vehicle structure in load securing on heavy goods vehicles

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KEY MESSAGES

Securing loads for safe transport is a legal requirement in the UK, and doing so helps to protect the driver of the vehicle and other road users and pedestrians during the vehicle's journey from vehicle rollover or load detachment, and the driver and unloading personnel from the risks inherent in unloading a load that has been able to move in transit. Securing loads also helps to prevent damage to the vehicle and to the load from unintended movement.

Industry practice has historically focused on the use of lashings to secure loads for road transport. It is suggested that the concept of the *load securing system*, which comprises the structure of the vehicle, physical barriers to movement, and/or lashings, may offer significant benefits to operators in terms of cost and time saving. Greater use of vehicle structure and physical barriers may also significantly reduce the additional risks such as working at height and manual handling typically associated with securing loads by lashings alone.

In order to make effective use of the vehicle structure, it is important to ensure that the structure is in sound condition, and that vehicle headboards and bulkheads, in particular, are both strong enough to resist forward movement of the load and also maintained in serviceable condition to protect the driver from ingress of the load to the cab.

EXECUTIVE SUMMARY

Uncontrolled load movement can have serious consequences both on the road and in the workplace. HGVs are inherently more vulnerable to rollover than many other classes of road-going vehicle, and shifting, unstable load may increase that vulnerability and render the vehicle likely to rollover even at very low speed. On any vehicle, a load which is not secured may move independently whenever the vehicle changes speed and/or direction. If an item in the load is not prevented from moving, it will either impact with the vehicle structure or another part of the load or, if the structure is not sufficient, fall from the vehicle.

This report assesses the legislation applicable to the transport of goods in the UK under both road traffic and health and safety at work legislation. It assesses the guidance available to operators and consignors and the methods of securing commonly used at present, and proposes greater use of the vehicle structure and physical barriers to movement in order to minimize both the practical difficulties of securing particular load types and the additional risks to drivers and loading/unloading personnel when accessing the load area.

It is suggested that the concept of the *load securing system* be given more prominence in current practice. Significant deficiencies were noted in the awareness of both the necessity of load securing and the means by which it could be achieved amongst drivers, operators and consignors across a number of industry sectors. Amongst drivers, awareness of the personal risk they were exposed to appeared to be low. A significant number of defects were observed in vehicle headboards and headboard upright supports which had resulted from load movement, and in many cases the damage to the headboard and/or its supports was serious enough to present an immediate risk of harm to the driver.

It is suggested that operators should consider greater use of vehicle structure when planning load securing. Vehicle structure means the vehicle headboard, sidewalls if fitted, curtains if the body structure is XL-rated, side posts, or fold up sides. Use of the structure, where appropriate, can either remove or drastically reduce the need for lashings while still providing a high level of safety. Operators may see a significant time-saving through greater use of the vehicle structure, since less time will be required to lash the load.

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1. INTRODUCTION

1.1 BACKGROUND

For many otherwise low-risk companies, the transport of goods may be their most dangerous work activity. The strength of lorry trailer structures has been identified as a significant area of concern for the transport industry. The strength of the trailer headboard, located behind the lorry cab, is of particular concern, as there have been a number of incidents where the load being carried has come through the headboard.

Securing loads for road transport is a legal requirement in the UK, and doing so helps to protect the driver of the vehicle and other road users and pedestrians during the vehicle's journey from vehicle rollover or load detachment, and the driver and unloading personnel from the risks inherent in unloading a load that has been able to move in transit. Securing loads also helps to prevent damage to the vehicle and to the load from unintended movement.

Load shift incidents can generally be divided into two categories: on-road incidents and workplace incidents.

On-road incidents include:

- Direct impact (the load strikes either another vehicle or a cyclist or pedestrian)
- Load spillage in the carriageway (loads such as loose aggregate may not cause significant issues for cars but could cause a cyclist or motorcyclist to fall or skid, resulting in an incident)
- Obstruction in the carriageway (following vehicles may take avoiding action and suffer secondary impacts with other vehicles)

Workplace incidents resulting from a load shift include:

- Load falling from or collapsing on the vehicle when the vehicle is opened or restraints are removed for unloading
- Fall from height or fall on the load bed during manual unloading when a prior load shift has rendered the load unsuitable for unloading by fork lift truck or similar.
- Manual handling injuries resulting from manually unloading a collapsed load that would normally be unloaded mechanically (for example, by fork lift truck).

Any time the vehicle changes speed or direction in transit, the load carried on or within it may move relative to the vehicle unless it is secured to prevent movement. Under braking or when a vehicle is travelling downhill, a load carried on a vehicle will tend to shift towards the front of the vehicle. If there is no restraint to movement, individual items within the load area will continue to move forward at their original speed until they impact against either the structure of the vehicle or other items. Load movement can occur at low speed and in the course of normal driving, and the consequences can be devastating.

If the load begins to move sideways and is not contained by the body structure, then a significant risk of harm to other road users is created. Even small items falling from a goods vehicle could result in serious injuries to a cyclist or pedestrian. Sideways movement of the load also increases the risk of vehicle rollover. Heavy goods vehicles are inherently more vulnerable

to rollover than passenger vehicles because of their higher centre of gravity. A moving load may cause the vehicle to suffer untrippedⁱ rollover even at low speed.

The transportation and storage sectors still account for the highest numbers and rates of injury for workplace transport reported to HSE under The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR). Even where no injuries occur as a result of load shift, incidents may carry financial and/or reputational penalties for a company.

Repeatedly damaging product may damage a business relationship with a supplier or customer, and near-misses may also have an effect on drivers' morale if they feel that they are being unnecessarily put at risk.

Vehicle rollover or load detachment may cause damage to the road infrastructure and significant congestion on the road network. The financial impact of congestion may be severe, in terms of fuel consumption and time delay. HGV drivers work under strict time limitations and may have to interrupt their journeys in order to rest if they are significantly delayed because of a load shift incident.

The most commonly used method of securing goods on vehicles in the UK is frictional lashing using webbing straps. While this method has the advantage of being relatively inexpensive and simple to apply to most loads, serious issues have been found with the number, condition and utilisation of webbing straps for load securing. While lashings alone may be sufficient for low-density, stable loads, they do not necessarily provide a good level of securing for high-density and/or inherently unstable loads and may instil a false sense of security.

Existing good practice guidance issued by the Department for Transport encourages operators to secure loads through use of a "load securing system", which typically comprises:

- The structure of the vehicle
- Intermediate bulkheads, chocks, cradles and similar
- Lashings

The construction of vehicle bodies in the UK is customer-driven, with significant variety in both the construction of the body and the equipment fitted to or within the vehicle to assist with securing the load. Awareness of UK legislation in relation to load securing, the relevance of the load securing system to meeting legal obligations to secure the load, and the potential time and cost savings available when the structure of the vehicle is used as part of the load securing system, appears to be relatively low amongst operators in general domestic haulage.

ⁱ An untripped rollover is one that occurs without contact with an object such as another vehicle or a kerb

1.2 THE UK ROAD HAULAGE INDUSTRY

The information presented in this section is intended to provide an overview of the UK road haulage industry. Road freight accounts for a substantial proportion of the goods in myriad industry sectors moved in, to and from the UK.

Between 2009 and 2010, the amount of goods movedⁱⁱ by GB-registered vehicles within the UK increased by 11% to 139 billion tonne kilometres. Over the same period, the amount of goods transported increased by 10% to 1,489 million tonnes and vehicle kilometres increased by 4% to 18.8 billion vehicle kilometres (11.7 billion vehicle miles). This increase followed a significant decrease in activity between 2008 and 2009 during which time activity regressed to levels last noted in the early 1990s.

In 2010, the amount of goods transported by UK-registered goods vehicles travelling to or from the UK was 10.6 million tonnes, a nominal 10% increase from 9.6 million tonnes in 2009. The average length of haul for heavy goods vehicles (HGVs) has increased significantly since the early 1990s to 93 kilometres (58 miles) in 2010. This may reflect the increasing development over the same time period of national and regional distribution hubs to effect the delivery of many household and commercial goods. Articulated vehicles typically have longer hauls than rigid vehicles: 122 kilometres (76 miles) on average, compared to 51 kilometres (32) miles. Certain goods – including food and drink, iron and steel, wood and timber, coal and coke, and chemicals – had significantly longer hauls than other products¹.

Aside from UK-registered vehicles, Polish-registered vehicles transported the largest tonnage of goods into or out of the UK (7.3 million tonnes in 2010, a 16% increase from 2009)². The majority of foreign-registered vehicles travelling to mainland Europe from the UK in 2010 were Polish (250,000), Dutch (194,000), German (152,000) and French (132,000).

1.3 TERMINOLOGY

Certain terms are used throughout this report and, to avoid confusion, will be defined here.

- Load restraint** – preventing the load from moving relative to the vehicle it is transported on
- Load containment** – preventing a load from being ejected from a vehicle by restricting its movement with the vehicle structure such as box sided vehicles.
- Rigid** - a rigid vehicle is one where the tractor unit and the load-bearing chassis constitute one indivisible vehicle
- Articulated** - an articulated vehicle is one where the tractor unit is a distinct unit from the load-bearing chassis (the trailer), and the two are connected by a coupling known as the fifth wheel

ⁱⁱ 'Goods moved' is a measure of activity taking into account the weight of the load and distance through which it is hauled, measured in tonne kilometres.

1.4 VEHICLE BODY TYPES

This section provides an overview of the most common vehicle body types used to transport goods in the UK. The photographs used in this section were taken by the author.

1.4.1 Flatbed

Flatbed bodies are commonly used to transport a wide variety of loads. The open load area means that goods can be easily loaded by fork lift truck or crane, and the load bed can be easily accessed by loading personnel. Figure 1 below shows a typical flatbed body loaded with a palletised load.



Figure 1 – Flatbed body type

Flatbeds usually feature a headboard between the load bed and the driver's cab. This headboard may be very low (<0.5m).

1.4.2 Curtain-sided

Curtain-sided vehicles are essentially flatbed vehicles with a weather-protection structure mounted on top of the load area. The headboard is full height. The weather-protection structure may be designed to have little structural strength, as its primary purpose is to protect the load area from inclement weather without adding excess weight to the vehicle and/or reducing the payload. Figure 2 shows a typical curtain-sided body.

Curtain-sided vehicles are almost as versatile as flatbeds in terms of the loads that can be transported on them, however it is usually not possible to load via the roof and side support pillars for the roof may impinge on the ability to load from the side. Curtain-sided vehicles can be single or double-decked.



Figure 1 – Curtain-sided body type

1.4.3 Box-sided

Box-sided vehicles enclose the load area in a solid-sided box that provides both weather protection and load containment. When the load area is filled completely by the load, so that the load cannot move in any direction, the load is generally considered to be secured. This is referred to as form fit, or positive fit.

1.5 PREVIOUS HSE RESEARCH AND STUDIES

Previous research carried out by HSE researchers (Day *et al*^{3, 4} and Corbett *et al*⁵) indicates that, for many otherwise low-risk companies, loading vehicles and transporting goods on the road may be their most dangerous work activity. HSE's previous work has shown that three categories of reportable incidents are strongly linked to load shifts.

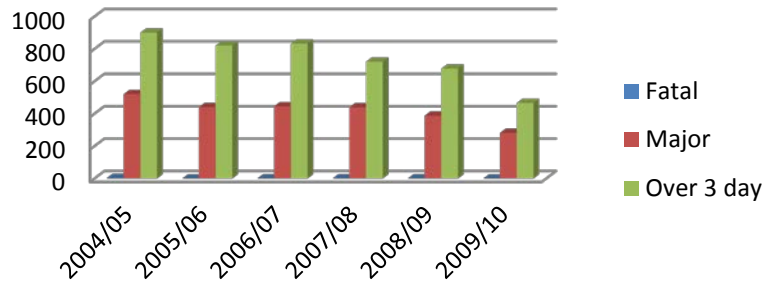
These are:

- Struck by falling object,
- Fall from height,
- Slip or Trip

National trends relating to these incident types are shown in Chart 1. The number of incidents reported to HSE involving employees, the self-employed or members of the public has declined significantly from 1426 in 2004/05 to 749 in 2009/10ⁱⁱⁱ.

ⁱⁱⁱ Source data: HSE

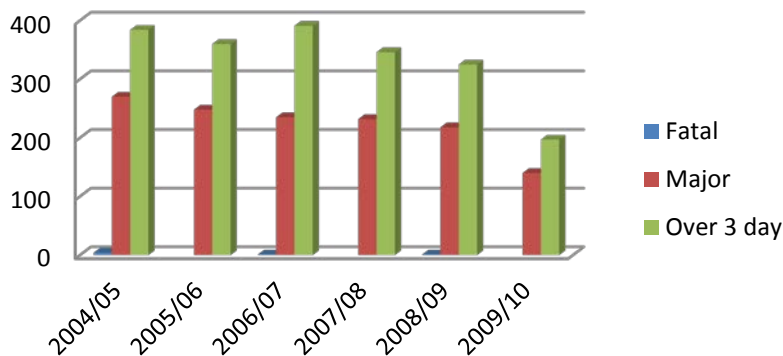
Chart 1 - Injuries and fatalities involving struck by, slip/trip or fall from height incidents reported to HSE & local authorities 2004 - 2010



Loads that have become unstable in transit may fall from the vehicle during unloading, even if they initially appear stable. Load shift may also mean that the load cannot be unloaded mechanically (i.e. by fork lift truck) and workers instead have to access the load bed of the trailer to manually unload or move the load into a position where it can be mechanically unloaded, putting themselves at risk of falling from the load bed.

Filtering the results shown in Chart 1 using the process code^{iv} *loading/unloading* (Chart 2) indicates that nearly 50% of these injury type incidents occur during loading or unloading.

Chart 2 - Injuries and fatalities over the same time period for loading/unloading



^{iv} The process code is a means of identifying the work activity being undertaken at the time of the incident.

Examples of comments included within RIDDOR reports have been reproduced here for information^v.

IP was unloading a lorry. It appears that the IP unloaded one side first and left an unsafe load on the lorry; so when the IP went to undo the curtains on the other side of the lorry the load shifted and fell on top of him. (A)

The DP was lifting a load onto the back of his lorry with a hiab and the load fell onto the DP. We are unaware how the load fell.^{vi} (B)

He was loading twin drum onto lorry, it fell he was clear of the roller but banged head on floor. (C)

Was strapping his excavator to lorry bed to secure load, when he accidentally stepped over the edge of the lorry bed falling 1metre to ground. (D)

IP was re-securing the load on his lorry, whilst doing so he got crushed between the skids of lorry and the equipment he was securing. (E)

A vehicle came out in front of our truck and because the breaks (sic) were applied a small pack of steel sheets on the back of our vehicle shifted to the headboard. IP decided to move the load manually to make safe but unfortunately slipped while on the back of our lorry cutting his leg and knocking himself out. (F)

(A) and (C) appear to represent examples of incidents that typically occur when loads become unstable during loading and unloading. This can result from insufficient or unsuitable securing, or an unsuitable system of work for unloading the vehicle.

(B) was an unusual incident in that it resulted directly from poor maintenance of lifting equipment and inadequate management systems.

(D) and (E) appear to represent examples of injuries typically sustained while securing loads using lashings (falls from height, crushing – although this may also be an unintended load movement).

(F) represents an example of injuries typically resulting when manual intervention is required following a load shift. Slips and trips on the load bed, and falls from the load bed, are commonly seen in these circumstances.

HSE carried out a series of pilot roadside assessments in conjunction with what was then the Vehicle and Operator Services Agency (VOSA – now the Driver and Vehicle Standards Agency, DVSA) and HSE in 2009 and 2010 to collect information on current practice with regard to transporting goods on the UK road network. HSE has subsequently carried out further work in this area with DVSA and several police forces in the UK, and with An Garda Síochana and the Health and Safety Authority (HSA) in the Republic of Ireland.

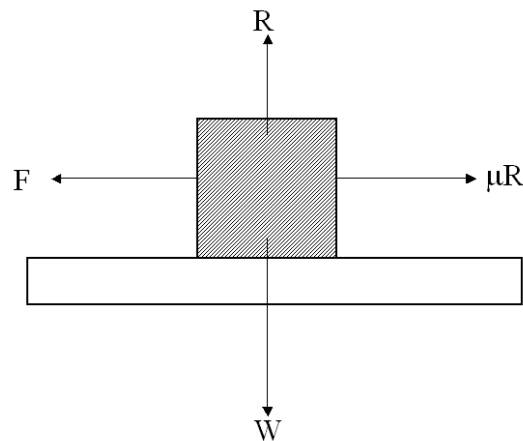
^v It should be noted that RIDDOR reports generally do not mention load securing explicitly or in detail, and these comments are therefore provided solely for information in order to illustrate typical incidents.

^{vi} The author provided technical support to HSE in respect of this incident. In the course of legal proceedings it was concluded that inappropriate repairs had been carried out to lifting equipment and that this led directly to the load falling from the vehicle

1.6 RELEVANCE OF STRUCTURAL STRENGTH TO VEHICLE AND LOAD SAFETY

The effect of load movement on vehicle stability was assessed by Day (2012)⁶. Heavy goods vehicles are inherently more vulnerable to rollover than passenger vehicles and an unsecured item on a vehicle, which is not part of the vehicle and may tend to move independently from the vehicle unless it is prevented from doing so, and adversely affect the stability of the vehicle. On the road, loads tend to shift when the vehicle is changing speed, direction or both.

In transit, the weight of a load, W , pushes down on the load bed of the vehicle it is carried on, as shown in the diagram below. An equal and opposite force, R , pushes up to stop the load falling through the load bed.



As the vehicle speeds up, slows down, or negotiates a corner, forces will act on the load. Each applied force, F , is resisted by an opposing force, μR where μ is the coefficient of friction between the load and the load bed. If the opposing force is not sufficient to resist the applied force, the load will start to move.

There are four ways of preventing load movement:

- Loading up against the vehicle structure (positive fit)
- Physical barriers to movement such as chocks, blocking or intermediate bulkheads
- Increasing the value of R , as discussed below
- Increasing the value of μ , as discussed below

Increasing the value of R can be achieved by increasing the downwards force on the load bed by frictional lashing. Frictional lashing is the lashing method by which a webbing or chain lashing is passed from one side of the vehicle to the other, over the load. A downwards force is thus applied to the load.

Increasing the value of μ by using high-friction flooring or matting is possible, however as a general rule friction should not be solely relied on as the load may not always be in contact with the load bed while the vehicle is in transit.

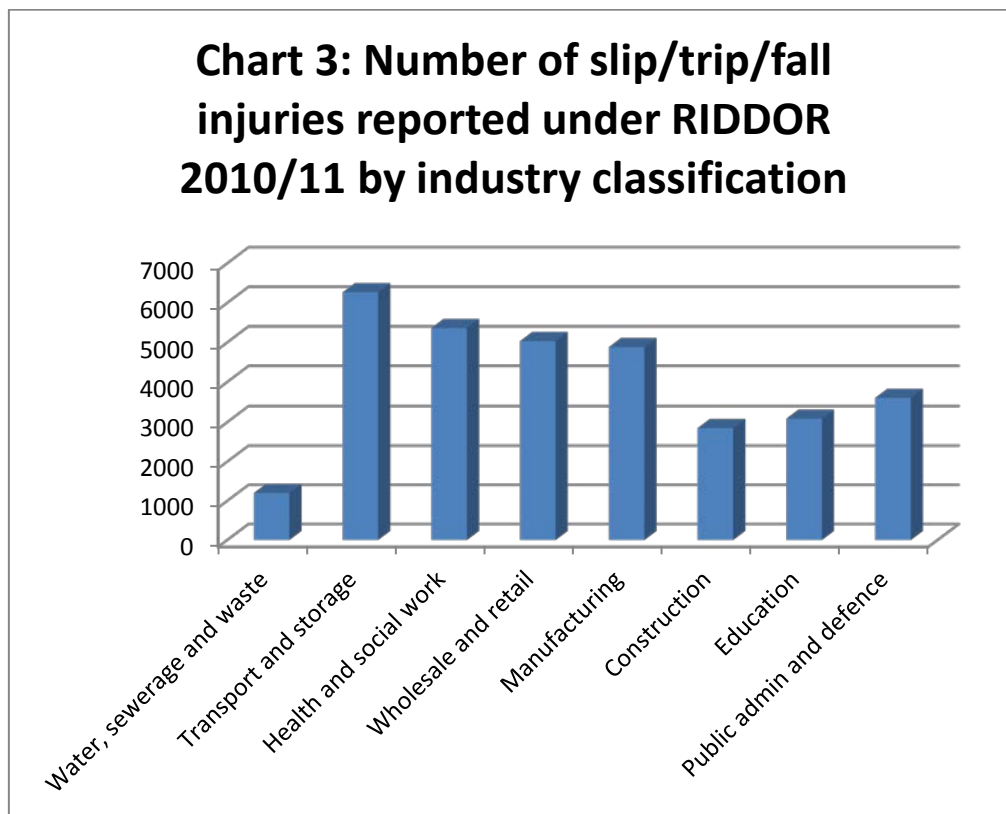
It is usual to secure loads through a combination the strength of the vehicle structure and any additional fixtures such as intermediate bulkheads or side posts, chocking or blocking if

necessary to fill gaps between the load and the body structure, and lashings. Heavy loads are difficult to secure through lashings alone, as the number of lashings required may be impractical. The fixing of lashings may also be problematic on some types of vehicle body due to lack of access and suitable attachment points.

When loads move on the vehicle they are transported on, there is an immediate risk to the driver and to other road users from either the load movement itself or a vehicle rollover initiated by load movement. However, an insecure load may not move to the extent that it becomes a danger on the road, yet still present a danger when the vehicle arrives at its destination. Loads may slide or topple so that they are resting on a movable part of the vehicle body, such as the side curtain, and then fall from the vehicle when the vehicle is opened for unloading. Such incidents typically result in injuries reported under 'struck by falling object' or 'slip/trip/fall'. Injuries caused by falling loads can be relatively minor, however HSE has had direct involvement in the investigation of fatalities and major injury incidents involving falling loads.

Shifted loads may cause additional issues even if they do not fall from the vehicle during unloading. Significant load shift may result in difficulties unloading, and subsequently personal may seek to access the load area in situations where they would otherwise not do so. This can result in either falls on the load area, reported under 'slip/trip/fall', or falls from the load area, reported under 'falls from height',

According to HSE's RIDDOR statistics for 2010/11, the industry classification *Transportation & Storage* has relatively high rates of injury. The distribution of slip/trip/fall injuries across industry sectors is shown for comparison in Chart 3.



The transportation and storage sectors still account for the highest numbers and rates of injury for workplace transport, with both the highest numbers and rates of injury. In 2010/11, there were 8 employee deaths, 434 major and 1,199 over 3 day injuries in Transportation and storage.

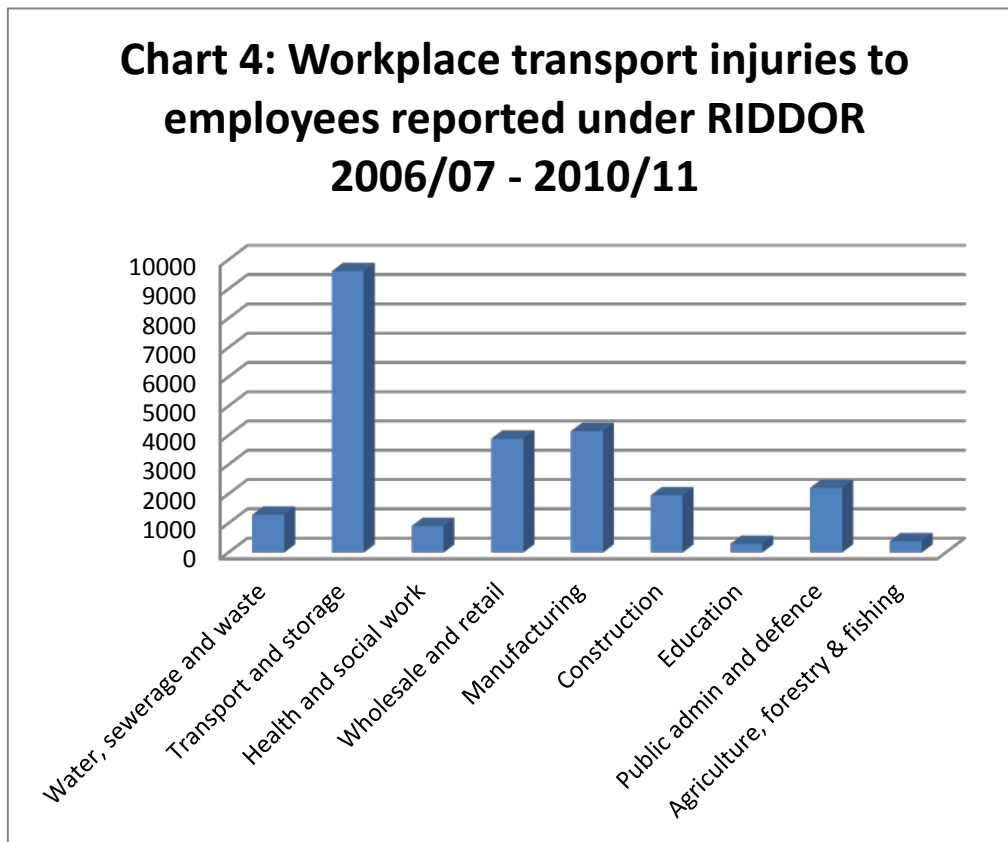


Chart 4 shows the distribution by industry classification of workplace transport incidents reported under RIDDOR from 2006/07-2010/11.

2. METHODOLOGY

In order to compare current design and practice in the UK in comparison with that in other EU countries, Australia and New Zealand, information was obtained from a variety of sources. A literature review was carried out to identify Standards and guidance relevant to the design of body structure, and also to establish what guidance vehicle and trailer manufacturers provided regarding the strength of body structure.

Data was collected from site visits, and roadside stop checks carried out by the Vehicle and Operator Services Agency (VOSA) and the Metropolitan and Suffolk Police forces, to identify the types of body structure in use by UK and non-UK operators and identify issues. Site visits and roadside stop checks were also used to identify common issues with body structure design.

Initially it was intended to carry out finite element analysis (FEA) to model the effects of loading on trailer structure, building on computer models developed for previous research projects. FEA analysis is typically used during the design and manufacturing process^{vii} or HGV collision simulation^{viii}. However, it was not possible to use existing models to accurately model dynamic loading in a cost-effective manner and it was therefore decided to use calculation to assess the magnitude of forces likely to be exerted on the front bulkhead of a trailer under braking.

A practical demonstration of the forces exerted on the bulkhead by an unrestrained load was also carried out to assess the potential for damage to the bulkhead and ingress to the driver's cab. This full scale braking demonstration was performed by TRL Ltd on behalf of HSE using a 7.5 tonne curtain-sided goods vehicle. The vehicle was loaded with an unrestrained load of four concrete blocks, weighing a total of approximately 3,200 kg, stacked in a single row in the centre of the vehicle load bed.

^{vii} Turner, M. & Boyce, G; *ROADLITE: Manufacture of a lightweight, cost effective, polymer composite road trailer (2005)*

^{viii} Anderson, J; *Dynamic Simulations of Heavy Goods Vehicles*; SAE Technical Paper 1999-01-3776, 1999

3. LITERATURE REVIEW

3.1 LEGISLATION

The legal requirement to secure loads transported on the roads in the UK is set out in the Construction and Use Regulations 1986 and the Road Traffic Act 1991.

Regulation 40A of the Road Traffic Act 1988 introduced by the Road Traffic Act 1991 states:

A Person is guilty of an offence if he uses, or causes or permits another to use, a motor vehicle or trailer on a road when:

(a) the condition of the motor vehicle or trailer, or of its accessories or equipment, or

(b) the purpose for which it is used, or

(c) the number of passengers carried by it, or the manner in which they are carried, or

(d) the weight, position or distribution of its load, or the manner in which it is secured,

is such that the use of the motor vehicle or trailer involves a danger of injury to any person.

Regulation 100 of the Road Vehicles (Construction and Use) Regulations 1986 – SI 1986 No 1078 states:

(1) A motor vehicle, every trailer drawn thereby and all parts and accessories of such vehicle and trailer shall at all times be in such condition, and the number of passengers carried by such vehicle or trailer, the manner in which any passengers are carried in or on such vehicle or trailer, and the weight, distribution, packing and adjustment of the load of such vehicle or trailer shall at all times be such that no danger is caused or is likely to be caused to any person in or on the vehicle or trailer or on a road.

(2) The load carried by a motor vehicle or trailer shall at all times be so secured, if necessary by physical restraint other than its own weight, and be in such a position, that neither danger nor nuisance is likely to be caused to any person or property by reason of the load or any part thereof falling or being blown from the vehicle or by reason of any other movement of the load or any part thereof in relation to the vehicle.

(3) No motor vehicle or trailer shall be used for any purpose for which it is so unsuitable as to cause or be likely to cause danger or nuisance to any person in or on the vehicle or trailer or on a road.”

In both cases, the load does not necessarily need to have already moved relative to the vehicle it is transported on to constitute a danger to either the driver of the vehicle or other persons.

3.2 GUIDANCE AND CODES OF PRACTICE

Generally, the recognised means of demonstrating compliance with the Road Traffic Act and the Construction and Use Regulations in the UK is by following the general guidance set out in the Department for Transport Code of Practice *Safety of Loads on Vehicles*⁷ ('the DfT guidance'). This states:

Friction alone cannot be relied upon to keep the load in place. When the vehicle is moving, vertical movement caused by bumps will reduce any restraining force due to friction. This can reduce to zero if the load even momentarily leaves the bed of the truck.

And:

...the combined strength of the load restraint system must be sufficient to withstand a force not less than ... half the (total) weight of the load backwards and sideways.

And:

The total load restraint system will generally consist of a combination of:

- a. lashings secured to anchorage points attached to the vehicle chassis, which includes cross bearers, outriggers etc;*
- b. bulking arrangements including headboards, bulkheads, spigots, transverse beams, shoring bars etc which are securely attached to the vehicle;*
- c. friction between the load and the vehicle platform.*

In most circumstances it would be appropriate to obtain the majority of the total restraint required from (a), and the remaining part from (b). Benefits accrued from (c) should be regarded as a bonus.

The DfT guidance also states:

If practicable ... the load should be placed in contact with a headboard. Where this is not practicable then additional means of securing must be used. Possible methods include:

- a. Effectively moving the headboard rearwards, i.e. fitting an obstacle across the vehicle platform which should be firmly attached to the chassis frame;*
- b. Blocks, scotches, bolsters or wedges to prevent individual items of a load moving in any direction. Care must be taken to ensure that these are adequately secured to the vehicle platform;*
- c. Additional lashing*

The Heavy Goods Vehicle Inspection Manual⁸, the reference manual for HGV annual testing, states:

Check for defective items which would make the vehicle dangerous to other road users and pedestrians. The cumulative effect of any defects found must be considered or their influence on other items. Superficial damage which does not affect the strength of a

component or which does not pose a danger to other road users is not a reason for failure.

1. Check any headboard, rive, cross or longitudinal member, hinge or retaining device, tipping gear, glass panel or any part of the body designed to carry or contain the load (including the floor and main support pillars) for:

- a. security.
- b. fractures or cracks.
- c. distortions, excessive wear or damage.

2. Check for leaks from the load carrying compartment.

‘Reasons for failure’ are listed as:

1. Any headboard, rive, cross or longitudinal member, hinge or retaining device, tipping gear, glass panel or any part of the body designed to carry or contain the load (including the floor and main support pillars):

- a. insecure.
- b. fractured or cracked.
- c. distorted, excessively worn or damaged.

and which in each case would make the vehicle dangerous to other road users and pedestrians.

2. A leak from the load carrying compartment.

The condition of the body structure is addressed in the Categorisation of Defects⁹ manual^{ix}, and the relevant section has been reproduced for information:

Part 1: Public Service, Heavy Goods and Agricultural Vehicles			IM 20
			Condition of Body
Description of Defect	Severity of Defect	Action	Notes
Body Panelling			
Exterior body panel damaged/ missing/ protruding/ insecure	Likely to become detached or to cause injury or permit the load to be shed or leaked	I	1. The presence of some defects does not necessarily mean that the body is in such a condition that it would be dangerous for other road users. The cumulative effect of any defects found, or their effect on other items, is the criterion to be used when judging this item.
	Otherwise than above (See Notes 1 and 2)	IN	
Any embellishment protruding/ damaged/ insecure (Specify component)	Likely to become detached and/ or cause injury	I	2. Any superficial damage that does not affect the strength of the component is not to be regarded as a defect.
	Otherwise than above	IN	
Part of body designed to carry or contain the load missing or damaged	Load likely to become detached or to cause injury or permit it to be shed or leaked	I	
	Otherwise than above	IN	

Where a defect is considered to be of concern but not likely to present a danger, a Vehicle Inspection Notice (IN) is issued by the VOSA examiner. Where the defect is such that it constitutes a danger, a prohibition (I) is issued. The Defects manual states:

A Prohibition Notice (PG9) is a ban on the use of a vehicle on a public road. A prohibition will normally be issued where a vehicle is found by an Examiner to be, or likely to become, unfit for use or where driving of the vehicle would involve a risk of injury to any person.

^{ix} This manual forms the basis of roadside enforcement by the Vehicle and Operator Services Agency (VOSA)

Driving Standards Agency guidance¹⁰ states:

When securing a load you need to take into account

- *The nature of the load*
- *The suitability of the vehicle*
- *The stability of the load*
- *The type of restraint*
- *Protection from weather*
- *Prevention of theft*
- *Ease of delivery*

...

A load may consist of large heavy pieces of machinery but that doesn't mean it will stay in place throughout a journey. Fatal accidents have occurred through such items falling from a vehicle or shifting under braking or cornering, therefore they should always be secured solidly and carefully.

The *European Best Practice Guidelines on Cargo Securing for Road Transport*¹¹ produced by the European Commission generally echo the requirements of the DfT guidance. The Guidelines state:

Legal requirements and common sense demand that all loads carried on vehicles are secured, whatever the journey. This is to protect the people involved in loading, unloading and driving the vehicle, together with other road users, pedestrians, the load itself and the vehicle.

...

Friction alone cannot be relied upon to prevent unsecured cargo from sliding. When the vehicle is moving, vertical movements caused by bumps and vibrations from the road will reduce the restraining force due to friction. Friction can even be reduced to zero if the load momentarily leaves the bed of the truck.

...

The cargo should be blocked against the headboard either directly or by the use of filler material in between.

The European Guidelines recommends that trailers are constructed to the standards set out in the European Standard EN 12642 (BS EN 12642:2001^x in the UK), which specifies performance criteria for the trailer structure. For the headboard of a standard trailer, the Guidelines give the example shown in Figure 2 on the following page:

^x BS EN 12642:2001; *Securing of cargo on road vehicles – Body structure of commercial vehicles – Minimum requirements*; British Standards Institution

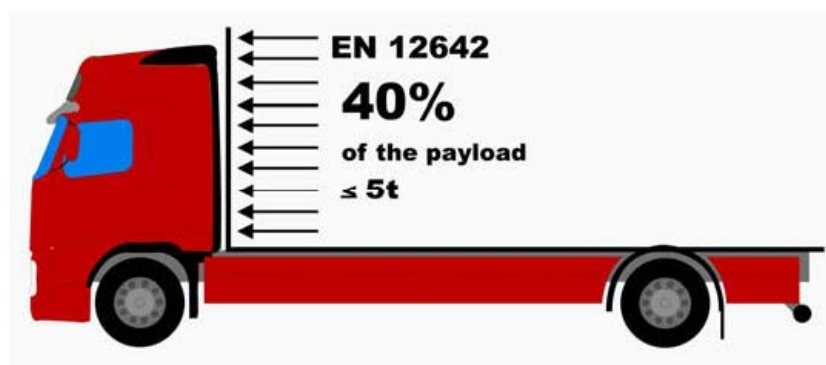


Figure 2 – Example performance criteria for ‘L’-type headboard

With respect to curtain-sided body types, the Guidelines state:

As a general rule, goods carried within curtain-sided vehicles should be secured as if they were being carried on a flat, open-bed vehicle. If the loading configuration, or its securing, would cause concern when used on an open vehicle, then it should be considered equally unacceptable with a curtainsided vehicle.

And:

*Unless they are purposely designed according to EN12642-XL, the curtains of curtain-sided vehicles **MUST NOT** be considered as part of any load restraint system. If the curtains have been designed as a restraint system, the load capability should be clearly marked on the vehicle – if no mark can be seen, then it should be assumed that the curtain has **NO** load-bearing function.*

*Similarly, where vertical inner curtains are fitted and they are not purposely designed for a specific load, they also **MUST NOT** be considered as part of the load restraining system. Curtains and vertical inner curtains should be considered purely as a means of containing within the vehicle any small, loose items that may have become dislodged during the journey.*

The HSE website gives specific guidance^{xi} for the haulage industry to help operators comply with their legal duties. The free guidance leaflets *Health & Safety in Road Haulage*¹² and *Workplace Transport Safety*¹³ and the information sheet *Delivering safely: Co-operating to prevent workplace vehicle accidents*¹⁴ are available on the HSE website. A joint HSE/DfT publication, *Driving at work: Managing work-related road safety*¹⁵, is also available on the HSE website. This states:

The Health and Safety at Work etc Act 1974 requires you to ensure, so far as is reasonably practicable, the health and safety of all employees while at work. You also have a responsibility to ensure that others are not put at risk by your work-related driving activities. (Self-employed people have a similar responsibility to that of employers.)

Under the Management of Health and Safety at Work Regulations 1999, you have a responsibility to manage health and safety effectively. You need to carry out an assessment of the risks to the health and safety of your employees, while they are at

^{xi} <http://www.hse.gov.uk/haulage/index.htm>

work, and to other people who may be affected by their work activities. The Regulations require you to periodically review your risk assessment so that it remains appropriate.

...

Risk assessments for any work-related driving activity should follow the same principles as risk assessments for any other work activity. You should bear in mind that failure to properly manage work-related road safety is more likely to endanger other people than a failure to properly manage risks in the workplace.

Risk assessment of work activities is an important part of complying with the legal requirements of the Health & Safety at Work Act. HSE guidance¹⁶ states:

As part of managing the health and safety of your business, you must control the risks in your workplace. To do this you need to think about what might cause harm to people and decide whether you are taking reasonable steps to prevent that harm.

This is known as risk assessment and it is something you are required by law to carry out.

...

Generally, you need to do everything ‘reasonably practicable’ to protect people from harm.

‘Reasonably practicable’ means that action should be taken to control health and safety risks in the workplace except where the cost of doing so, in terms of time and effort, is grossly disproportionate to the actual reduction in risk.

3.3 BRITISH AND EUROPEAN STANDARDS

The British and European Standard BS EN 12195, *Load Restraint Assemblies on Road Vehicles*¹⁷, states in Part 1:

The general requirements for safe transport are:

- *the sum of forces in any direction equals zero*
- *the sum of moments in any plane equals zero*

Generally, load securing consists of balancing the forces of a load by locking, blocking and/or lashing. Locking, a completely positive connection, is mainly used in the transport of containers and is not usually combined with lashings. Blocking results in a positive connection in the blocked direction only and therefore is often combined with lashings.

...

The two basic lashing methods are:

- *frictional lashing is characterized by a restraint that is produced by force on the loading area and a positive connection in the direction vertically down;*

- *direct lashing is a completely positive connection which permits the load to make small movements, the magnitudes of which depend on the flexibility of the lashing and forces acting on the load.*

The Standard provides a series of formulae to allow the number of lashings required to secure a load.

The Standard applies to goods transported by road, rail and sea, and lists a series of what are known as *acceleration coefficients* to take account of the different modes of transport. For road transport, the forward acceleration coefficient is 0.8. This means that 80% of the load weight should be secured against forward movement. The sideways coefficient is 0.5, meaning that half the weight of the load should be secured against sideways movement.

The British and European Standard BS EN 12642:2006, *Securing of cargo on road vehicles. Body structure of commercial vehicles*¹⁸, sets out performance criteria for vehicle bodies. The scope of the Standard is set out as:

This European Standard applies to body structures on commercial vehicles and on trailers with a maximum total weight of more than 3 500 kg.

This European Standard sets out basic minimum requirements for standard vehicle bodies (side walls, front and rear walls) and for reinforced vehicle bodies and specifies appropriate tests.

This European Standard does not apply to swap bodies, nor to box type vans, i.e. vehicles where the driver cabin and the cargo space form one unit^{xii}.

The Standard allows vehicle body builders to construct two types of vehicle body: standard ('L') and reinforced ('XL'). The respective performance criteria for each type have been reproduced here for information.

Component		Standard structure code L	Reinforced structure code XL
Front wall	Requirement	0,4P and max. limit	0,5P without max. limit
	Section	5.2.2	5.3.2
Rear wall	Requirement	0,25P and max. limit	0,3P without max. limit
	Section	5.2.3	5.3.3
Side walls	Requirement	up to 0,3P	0,4P ^a
	Section	5.2.4	5.3.4
^a Except for double-decker.			

Where *P* is the weight of the vehicle at rated payload.

The headboard strength of a standard body type is limited to 5,000 daN, regardless of actual construction.

The strength of a reinforced structure is proved by calculation, static testing and dynamic (driving) testing. Where static and/or dynamic testing is utilised, the Standard states:

^{xii} E.g. Luton or Bedford-type vans

After finishing the tests ... the body structure shall show neither permanent deformation nor other changes which would impair its intended use. Compliance with the following criteria is required:

- *elastic deformation occurring during the test shall not exceed 300 mm;*
- *at a test force of 85 % of the 100 % to be used for testing there shall be no permanent deformation;*
- *at 100 % of the test force permanent deformation may at maximum be of 20 mm, however, aptitude for the intended function shall not be impaired.*

These performance criteria apply to all body types, however the Standard specifies that, for non-reinforced curtain-sided vehicles:

Lashing points for securing of cargo are mandatory for vehicles with curtainsiders. Such fittings shall fulfil the requirements of EN 12640. The tarpaulin need not be in compliance with EN 12641-2, but provides weather protection only and is not designed to take forces for securing of the cargo.

For the L-type body structure, the curtain should not see any loading. A trailer designed and tested to the XL-type can utilise the curtain to provide a degree of load containment.

It can be seen from the above that the requirements of the Standard do not necessarily ensure compliance with the Code of Practice in resisting a force equal to half the weight of the load. In addition, containment within the trailer structure does not necessarily mean that the load will remain in a stable condition, and all or part of the load may topple when the trailer is opened for unloading. The photograph shown below in Figure 3 illustrates the limitations of containment for preventing load movement.



Figure 3 – Load movement

Vehicle bodies do not have to be constructed to meet the Standard in the UK and, historically, have not been so.

3.4 INDUSTRY RESEARCH AND GUIDANCE

A search was carried out to identify specific guidance available to companies in relation to the loading and structural strength of vehicles.

NSL, a training provider for the oil and gas offshore industries, produce a guide to load handling, *Safe cargo handling - Good & Bad Practice*¹⁹, that states:

When loading trucks, for standard or normal cargo, place the items on the truck in the reverse order of removal, i.e. first off, should be the last on.

The first items loaded should be placed hard against the headboard of the trailer, so that in the event of heavy braking, they cannot slide forward gaining momentum. This is particularly important when loading bundles of tubulars, which can turn into missiles under heavy braking (sic)

WARNING : never use a trailer that doesn't have a robust headboard. Wooden headboards are acceptable, but steel or steel covered headboards are preferred

The Australian ARTSA^{xiii} guidance²⁰ states:

All loads should be packed tightly and firmly in the vehicle body “containing” the load. If the load does not fill all available space, then restraint, blocking or filling the empty spaces is required.

...

If the loads are not loaded and packed tightly ... then substantial load shift can occur. The body type does not matter as the load can commence moving sideways, causing a rollover.

...

Well-designed headboards greatly reduce the number of tie-down lashings required to meet forward direction restraint ... When the front headboard is used in conjunction with lashing tie-downs its strength does not need to be as great as that required for an otherwise unrestrained load.

Similarly, the Transport Safety Group (TSG) guidance, *Buying a Safer Heavy Trailer*²¹, states:

Depending on the load, effective load restraint can require the provision of front headboards, load racks, winch tracks, curtain sides, drop sides, side gates, stanchions, pins and posts. The trailer manufacturer must design the restraint components for the intended loads.

Some of the basic things to consider are:

- *Well-designed fixed or removable headboards greatly reduce the number of tie downs needed*
- *Side gates and drop-sides should be high enough to “contain” the load*

^{xiii} Australian Road Transport Suppliers Association

- *Vehicles that carry loose steel plate, sheets, pipe etc require stakes, pins, pegs or posts to provide direct restraint*
- *Metal Cradles, Chocks and A-Frames need capping or load bearing surfaces with timber or rubber to increase friction.*

Unless curtain sided vehicles are certified for load restraint – the load must be restrained as if the curtain did not exist.

A well designed trailer will allow the driver to work from the ground and avoid lifting heavy gates and other equipment.

The websites of seven UK-based trailer body builders were surveyed on the information currently provided to purchasers of their vehicles with regard to the strength of the vehicle structure and load securing. All of the companies assessed built curtain-sided and box-sided vehicles.

Two companies explicitly provided load securing equipment as an option on their curtain-sided vehicles. One did not mention load securing. Three mentioned load securing, either indirectly in remarks such as *GRP Panels to withstand load impact* (on a box-sided trailer), or directly (*...the curtain provides) load safety retention*. One offered curtain-sided trailers constructed and tested to meet the ‘XL’ provisions of BS EN 12642.

Much of the literature offered by the companies surveyed appeared to focus on the fuel/weight-savings offered by a lightweight body structure and aerodynamic efficiency, with remarks such as, *All headboards feature weight-saving, high-strength, light-weight aluminum construction. This helps to reduce fuel costs and increase vehicle carrying capacity.*

For comparison purposes, the websites of two companies based in mainland Europe were also surveyed. In both cases, although the same attention was given to fuel/weight saving, there was also noticeable attention given to the strength of the body structure and design features that would allow easy load securing, with options for particularly high-risk loads such as steel in the form of additional headboard bracing, reinforced sideposts, and additional lashing points.

4. SITE AND ROADSIDE STUDIES

4.1 SCOPE OF STUDIES

Site and roadside studies were carried out in order to identify issues with both the perception of load securing and current practice on the road.

Site visits were carried out to ten companies in England. The companies visited were a mixture of HSE-enforced premises and local authority-enforced premises. Six of the companies visited were large national or multinational companies; four were small or medium-sized enterprises (SMEs).

Roadside studies were carried out at a number of vehicle check sites operated by either VOSA or police forces. An average of ten vehicles was assessed at each of the six check days. In each case, the vehicle was assessed for the security of the load, the arrangement of the load on the vehicle, and the condition of the vehicle body structure.

Many of the issues found during both site visits and roadside studies were consistent across operators, industry sectors, and vehicle types. These areas of concern are discussed in the following sections. To avoid identifying individual companies and/or drivers, responses have been collated.

4.2 ISSUES FOUND AND AREAS OF CONCERN

4.2.1 Vehicle purchase, specification, and awareness

Of the ten companies visited during the site study phase of the research, only one had carried out their own assessment of the vehicles they were using to transport loads and whether those vehicles were suitable for the purpose. It should be noted in this case that the vehicles used did not belong to the consignor company and were instead operated by contracted hauliers.

Four other companies had carried out some assessment of load securing and issued instructions to their hauliers, however it was noted that there was some lack of appreciation of their own legal responsibilities as dutyholders in the transport chain.

Awareness of the importance of load securing was generally very low in the companies visited and amongst the drivers at roadside checks. The majority of drivers did not appear to be aware of the legal requirements to secure loads on their vehicle, nor of the guidance available from the Department for Transport since the early 1970s. There was an accompanying lack of appreciation of how easily loads can move even at low speed, with a number of drivers remarking that loads would only move in an accident situation. When shown examples of incidents resulting from load shifts in transit, the most common reaction amongst drivers was an assumption that the driver concerned was at fault in some way.

Five companies had not carried out their own assessment of load securing and relied on their hauliers and the drivers to ensure that the loads were secured for road transport. However, at four companies, goods were loaded by the consignor and the vehicle sealed so that the driver did not have an opportunity to inspect the load before he took the vehicle onto the public highway.

None of the companies visited carried out systematic inspection of the vehicles to check for defects and/or damage, however in one case this was largely irrelevant as the company utilised its own dedicated bulkhead solution independent of the vehicle structure.

Amongst all the companies visited and drivers at roadside checks, there was a general reliance on lashings to secure loads. A number of issues were noted; these included:

- Risk of crushing or otherwise damaging fragile loads
- Sharp-edged or abrasive load types damaging webbing lashings
- Difficulties finding suitable attachment points on the vehicle
- Difficulties passing lashings over tall loads on curtain-sided vehicles
- Difficulties accessing load bed to secure loads
- Time taken to secure the load

It should be noted that there was some confusion amongst both operators and drivers regarding the suitability of non-locking buckle straps suspended from roof rails for load securing (shown below in Figure 4). These straps are often supplied with curtain-sided vehicles but are typically not rated for the forces required to secure a load and cannot be locked in the same way that a ratchet lashing can.



Figure 4 – Non-locking straps

Discussions with vehicle body builders indicated that the fitting of buckle straps was often a customer specification at the purchasing stage, although a number of the body builders admitted that they were aware that there was little strength inherent in this type of strap. Customer awareness – which drives purchasing decisions – would therefore appear to be a significant area of concern.

In discussions with the companies and also with vehicle body builders, it became apparent that the two most significant factors when making a purchase decision are cost and weight. The economics of transporting goods means that there is an incentive to ensure that the weight of the body structure is as low as possible so that it does not affect the payload that can be carried.

Purchasing decisions did not appear to necessarily involve personnel with technical knowledge of loading and/or load movement. Decisions were also made partly on the basis of the versatility of the body structure so that the vehicle could be used to transport different loads. This could, however, sometimes lead to unsuitable vehicles being used to transport certain loads.

Purchasing decisions could also be influenced by the anticipated area of operation. Companies delivering to certain countries within mainland Europe, and specifically operating within Germany, appeared to be significantly more aware of load securing in general and more proactive in specifying vehicles to minimise difficulties in securing their loads. This may be a direct result of the high level of enforcement with regard to load securing that is carried out in Germany. The German model of load securing is heavily based on EN 12195 (BS EN 12195) and EN 12642 (BS EN 12642), with specific consignor, operator and driver responsibilities set out in the German Criminal Code.

Four vehicle body builders were visited during the course of the research project and a common approach was noted that the builders were very much customer-driven. In mainland Europe, vehicle body builders generally construct a standard body type and the degree of customisation is relatively limited. In the UK, a customer may have considerably more leeway in specifying particular features.

The three most common factors influencing vehicle purchase appeared to be:

- Cost
- Weight
- Customer demand

It was noted that, increasingly, customers are asking hauliers to use vehicles constructed to the BS EN 12642 'XL' standard. However, there were issues with this, and these are discussed further in Section 5.2.3.

Operators generally did not appear to ask questions at the purchase stage regarding the strength of the vehicle headboard and the strength of sidewalls or side posts. Four operators stated at roadside checks that their vehicles were fitted with "load retention" curtains; however, on inspection these curtains were not attached to a reinforced structure that would offer any kind of load retention capability in line with BS EN 12642.

4.2.2 Use of the vehicle

Issues were found with the vehicle types used to transport goods. These issues can be broadly divided into two groups:

- inappropriate vehicle for the load type
- chosen vehicle type leads to additional issues

In the first instance, inappropriate vehicles for the load type could include plant machinery being transported on standard flatbed trailers rather than low loader trailers. The subsequent high centre of gravity render these vehicles extremely vulnerable to rollover.

In the second instance, using an inappropriate vehicle type led to additional issues that directly increased the risk for loading bay personnel. For example, one company visited were using curtain-sided trailers to transport machinery parts in stillages. The stillages were secured by frictional lashing. Goods were loaded onto the trailers via the rear doors, however the curtains of the trailer were then opened so that loading bay personnel could secure the load. The company had an accident history of loading bay personnel falling from the load beds during load securing.

The company subsequently chose to use box-sided trailers, which were available to them from the haulier, removing the need to lash the stillages and hence eliminating their work at height issues.

4.2.3 Use of side structural containment

Significant issues were noted with the use of side structural containment. These issues can be broadly divided into three areas: use of a curtain-sided vehicle when a box-sided vehicle would be more appropriate, lack of side containment when transporting unstable loads, and lack of awareness regarding the strength of a curtain-sided vehicle.

As already discussed in Section 5.2.2, the use of a curtain-sided vehicle in situations where there is no need to do so may introduce additional risks in terms of personnel accessing the load area. A box-sided vehicle may significantly decrease loading times and reduce the risk of injury to personnel.

When transporting unstable loads, the use of load restraint alone may introduce significant risks for the driver and/or others when the vehicle is unloaded. When transporting high-density loads such as steel, there is an accident history of drivers being killed by collapsing loads when lashings are removed. The use of side containment for such loads provide a degree of protection for the driver and for anyone else who may be in the vicinity of the vehicle.

During the roadside checks, it was noted that a significant number of tall, high-density mixed loads were being transported on curtain-sided or flatbed vehicles secured by lashings alone, with no physical support up to the position of the centre of gravity of elements of the load. As such, elements of the load could topple from the vehicle or become unstable under sideways loading.



Figure 5 – Curtain-sided vehicle with no load securing

Significant and wide-ranging issues were noted with awareness of the inherent strength of curtain-sided vehicles and the appropriate use of such vehicles. The photograph shown in Figure 5 is typical of loads transported on curtain-sided vehicles in that the operator believed that the load was appropriately secured by a curtain and wooden slats. The majority of curtain-sided vehicles examined during the roadside checks were carrying unsecured loads.

In the course of the research project, considerable confusion was noted regarding the BS EN 12642 "XL" standard, particularly in regard to what this meant in terms of transporting goods without lashings. Manufacturers' certificates supplied with reinforced trailers typically state a number of conditions that must be fulfilled to allow a load to be transported without additional restraint: these may include minimising the gap between the sides of the load and the curtain (80mm is a commonly quoted value), using friction matting between the load and the load bed to increase the coefficient of friction, and ensuring that the load completely fills the load area from the headboard to the rear doors. A substantial number of operators did not appear to appreciate the implications of such requirements.

4.2.4 Vehicle damage and fatigue crack growth

During the course of the research project, two distinct types of damage to vehicle structures were noted: impact damage to vehicle headboards and fatigue crack growth where lifting equipment was used to secure loads^{xiv}.

Structures and components can fail through overload – the application of a very large force – and they can also fail through fatigue, or through a combination of both. Fatigue failure can occur at stresses much lower than that required to cause a sudden, single-stage failure. Fatigue cracks typically occur in joints, changes in section and other stress raisers in a component.

^{xiv} For example, where lifting arms are used as anchorage points for lashings

Examples of vehicle structure damage is shown in the following photographs.

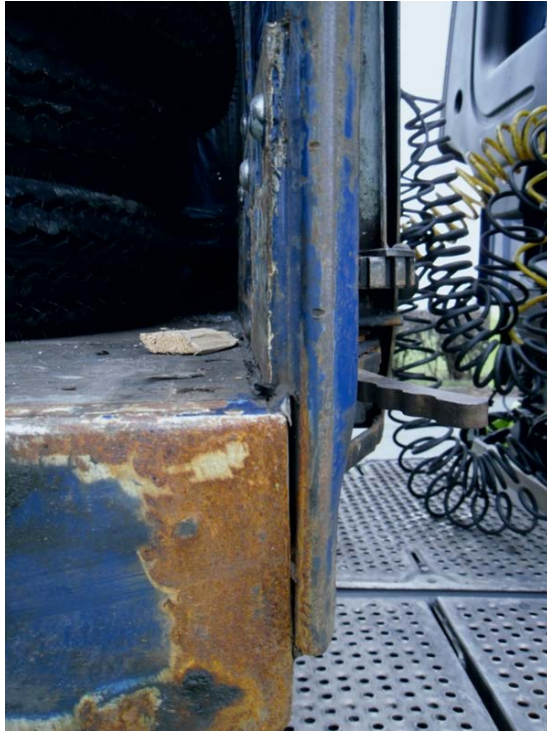


Figure 6 – Damage to headboard

Figure 6 shows impact damage to a trailer headboard, resulting in partial separation of the headboard from the vehicle chassis.



Figure 7 – Damage to headboard upright

Figure 7 shows pre-existing impact damage to a trailer headboard, resulting in buckling of both supporting uprights and separation of the wire mesh bulkhead from the offside upright (Figure 8).

Figure 9 shows impact damage to a vehicle headboard, resulting in buckling of the headboard, and partial separation of the headboard from the chassis.



Figure 8 – Damage to wire mesh headboard



Figure 9 – Further example of damage to headboard



Figure 10 – Crack in lifting arm

Figure 10 shows a crack in the lifting arm of a skip lorry, where the lifting arms were used to secure stacked skips. The crack could have been caused by single-stage overload, fatigue, or a combination of both.



Figure 11 – Crack in lifting equipment

Figure 11 shows severe cracking in part of an item of lifting equipment being used to secure a load. The crack had resulted in partial separation of the lifting equipment from the vehicle chassis.

4.2.5 Risk assessment

Risk assessment is a legal requirement for employers and can be a tool to identify potential issues before they become problems.

While all of the companies visited were very aware of their legal responsibilities to carry out risk assessments in other areas of their activity, loading and transportation were not necessarily considered as carefully as other activities and there appeared to be a general reliance on the experience and expertise of the haulier to avoid problems. The issues around risk assessment of the loading and unloading process appeared to result from confusion and lack of awareness of the roles and responsibilities that each party in the transport chain has under both road transport and workplace safety law.

During the course of the roadside checks, three risk assessments were received from operators that explicitly stated that the driver alone was responsible for the load and it was entirely the driver's responsibility to ensure that the load remained in a safe condition at all times. When contacted subsequently, all three operators expressed ignorance of the legal responsibilities placed on all dutyholders in the transport chain.

5. DEMONSTRATION OF LOAD MOVEMENT

5.1 METHODOLOGY

A full scale braking demonstration from 30 mph was performed by TRL Ltd on behalf of HSE using a 7.5 tonne curtain-sided goods vehicle. The vehicle was loaded with an unrestrained load of four concrete blocks, weighing a total of approximately 3,200 kg, stacked in a single row in the centre of the vehicle load bed. The vehicle was loaded such that its overall weight, as well as the individual axle weights, did not exceed the maximum permitted weights. The vehicle is shown in Figure 12.



Figure 12 – Demonstration vehicle (Image supplied by TRL Ltd)

The preparation of the vehicle prior to the demonstration included:

- Removing the curtains from the load bay to allow the payload to be seen during the demonstration.
- Installation of an automated system to fully depress the brake pedal during the demonstration.
- Installation of brackets to mount an onboard high speed digital video camera and associated equipment.
- Set up of triggering systems to activate the braking system, onboard and external cameras at pre-determined points.

The Target Test Speed (TTS) was 48.3 kph (30mph). The vehicle was attached to TRL's vehicle winching system in order to guide and accelerate the vehicle up to the required speed. Shortly before the pre-determined trigger point, the vehicle was detached from the towing system. An automated braking system was then used to rapidly depress the brake pedal and therefore apply

heavy braking to the vehicle. The demonstration vehicle's engine was running during this demonstration in order to ensure that the brakes were fully operational.

5.2 DEMONSTRATION

The Actual Test Speed (ATS) was 47.8 kph (29.7 mph) at the point at which the automated braking system was triggered. The difference between the TTS and ATS was considered to be small enough to be negligible.

The stopping distance was approximately 17 metres. Given an initial speed of 47.8 kph, or 13.28 metres/second, the retardation was calculated to be approximately -5 m/s^2 .



Figure 13 – Vehicle following test (Image supplied by TRL Ltd)

The payload shifted forward during the braking event, impacting the bulkhead resulting in bulkhead failure as shown in Figures 13, 14 and 15.



Figure 14 – Damage to headboard (Image supplied by TRL Ltd)

The supporting structure of the bulkhead on the right hand side of the HGV was also bent outwards as it was impacted by the payload.



Figure 15 – Damage to headboard (Image supplied by TRL Ltd)

Loading back from the headboard is commonly done when transporting high-density loads, as loading against the headboard may overload the front axle. However, as this example shows, loading back from the headboard can result in severe damage to the headboard if the load moves forward. Substantial load shift can occur even at low speed.

6. FORCES ACTING ON A VEHICLE STRUCTURE

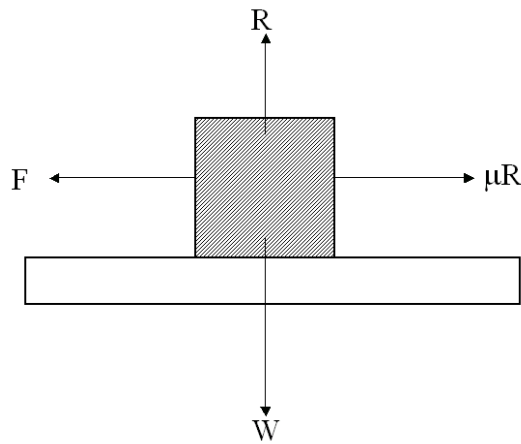
The calculations given in this section are intended to provide an illustration of the forces that may act on a vehicle structure during normal road transport, and the number of lashings that may be required to secure a load if the vehicle headboard or similar barrier to forward movement is not used as part of the load restraint system.

6.1.1 Force required to initiate load movement

The force, F , required to overcome the friction so that the load may begin to move can be found using the equation:

$$F = \mu R$$

Where μ is the friction between the load and the load bed and R is the reaction force, equal and opposite to the weight of the load.



Assuming a coefficient of friction of 0.3^{xv} and a reaction force of 10,000 N^{xvi}, the force required to overcome friction on an unsecured load would be 3000 N. Any applied force in excess of this would be likely to cause the load to move relative to the vehicle.

To find the deceleration that would produce a force of this magnitude, Newton's Second Law is used, where:

$$F = ma$$

Where $F = 3000$ N

$m = 1000$ kg

Using the calculated value of F of 3,000 N, deceleration is then:

$$-a = \frac{3000}{1000} = 0.3 \text{ m/s}^2 \text{ (nominally } 0.3g)$$

^{xv} Friction testing carried out previously by HSE has indicated that this is a representative value for a wooden pallet on a wooden load bed. However, metal loads and/or contamination of the load bed will result in much lower friction.

^{xvi} This assumes a load mass of 1,000 kg (1 tonne) and a value of g of 10 m/s²

This is well below the acceleration coefficient specified by the DfT guidance (1g for a load placed away from the headboard, 0.5g when the load is in contact with the headboard). This indicates that forces likely to lead to load movement can and will be experienced during normal road driving.

It should be noted that this effect is independent of load mass - the same value will be obtained for the above equation if the unsecured load mass is increased to 10,000 kg (10 tonnes).

Frictional lashing is effective at preventing load movement because it increases the reaction force R . If the same 1,000 kg (1 tonne) mass is secured by frictional lashings that increased R to 20,000 N, for example, the deceleration required to initiate load movement would be:

$$-a = \frac{6000}{1000} = 0.6 \text{ m/s}^2 \text{ (0.6g)}$$

A similar effect can be achieved through increasing the coefficient of friction between the load and the load bed.

6.1.2 Effect of use of the vehicle structure in load securing

The British Standard BS EN 12195-1:2010 provides an equation to calculate the number of webbing straps required to secure a load for road transport by frictional lashing. This equation assumes that the load is inherently stable and is loaded so that the weight is distributed evenly, as far as is possible, across the width of the load bed.

The equation for calculating the number of lashings required, n , is:

$$n \geq \frac{(c_{x,y} - \mu \times c_z)mg}{2 \times \mu \times \sin \alpha \times F_T} \times f$$

Many of the values are known or can be assumed:

If the load is loaded away from the headboard, without blocking, chocks, or an intermediate headboard, then $c_{x,y}$ is 0.8. If it is loaded to the headboard, $c_{x,y}$ is 0.5

- The coefficient of friction, μ , between the load and the load bed can normally be assumed to be 0.2, unless there is metal-to-metal contact, in which case it will be lower. High-friction floor surfaces and friction matting will raise the coefficient of friction
- C_z is 1 for road transport
- The mass of the load, m (in kilograms), is multiplied by g (9.81 m/s²)
- The angle α is the angle between the strap and the load bed (the α of a vertical strap would be 90°)
- F_T is the tension force of the strap. This is often shown on the strap label, or can be obtained from the manufacturer. It is usually quoted in decaNewtons (daN) and should be multiplied by 10 when used in this equation (no conversion is necessary if it is already quoted in Newtons)
- The final value is the safety factor, f , which is 1.25

Using an example^{xvii} where a single load item with a mass of 2 tonnes (2000kg) is transported on a flatbed vehicle, loaded away from the headboard with no blocking, the number of webbing straps required would be 11.

Placing the same load in contact with the headboard of the vehicle would reduce the number of straps required to 6.

Using friction matting between the load and the load bed to increase the value of the coefficient of friction in addition to placing the load against the headboard would reduce the number of straps required to 2.

For some loads, particularly very heavy indivisible loads or loads where the coefficient of friction between the load and the load bed is extremely low, the equation will indicate that a very large number of lashings are required to secure the load.

If the number of straps appears to be impractical, there are a number of possible reasons:

- The load is not loaded or blocked to the headboard (doing so reduces the number of straps required)
- The coefficient of friction is too low. Friction matting between the load and the load bed may reduce the number of straps required
- The tension force in the strap is too low. Straps with higher tension forces could be used
- The angle of the straps relative to the load bed is too shallow. The height of the load can be increased using packing to increase the angle of the straps

If the number of straps required still appears to be impractical, it is likely that frictional lashing is not a suitable means of securing for that particular load and an additional or replacement method should be considered. For example, substantial steel sections or bars may be best secured through a combination of chain belly-wrapping (loop lashing), webbing frictional lashing, friction matting, and the use of a bulkhead directly in front of the load to protect the driver against failure of the lashings.

^{xvii} The coefficient of friction between the load and the load bed is assumed to be 0.2. The angle of the straps relative to the trailer bed is 70°. The tension force of the strap is 350 daN (3500 N).

7. MITIGATION MEASURES AND IMPLICATIONS

For many companies, the moving of goods may be their highest risk work activity. Accidents during loading, transport and unloading can have significant economic, reputational and personal repercussions. The adverse publicity surrounding a fatal road accident may have a significant effect on company reputation, particularly if legal proceedings are taken against the company.

For those injured, an accident can be personally devastating and have significant repercussions for the individual's well-being and financial security. Witnesses to an accident may find it personally traumatising and company morale may suffer. A company may suffer financial penalties in the form of the loss of the individual's labour, damage to product, equipment and vehicles, and damage to the company reputation and business relationships.

Even where no injuries occur, accidents may carry financial and/or reputational penalties for a company. Repeatedly damaging product, for example, may damage a business relationship with a supplier or customer. Near-misses may also have an effect on drivers' morale if they feel that they are being put at risk.

Vehicle rollover or load spill may cause damage to the road infrastructure and significant congestion on the road network. The financial impact of congestion may be severe, in terms of fuel consumption and time delay. HGV drivers work under strict time limitations and may have to interrupt their journeys in order to rest if they are significantly delayed. Many companies operate on the "just in time" principle, where goods are delivered as they are required, minimising storage requirements, and hence delays may have serious implications for the running of the business.

Securing a load so that it remains in a safe and stable condition throughout its journey and can be unloaded safely can be a daunting task for operators transporting high-density or otherwise high-risk loads. The use of load restraint alone may be impracticable. In these cases, the use of the vehicle structure may offer a simple, cost-effective means of reducing the reliance on load restraint alone and allow increased safety to be achieved while at the same time increasing operational efficiency.

For operators transporting low-density, low-risk loads, the use of the structure to secure the load may remove the necessity of using lashings, significantly increasing operational efficiency and removing the necessity for loading personnel and/or drivers to access the load area in order to secure the load.

The essential principles of load securing are well-established in the UK and, increasingly, operators and drivers are becoming more aware of the need to secure their loads for road transport. Historically, lashings have been used to secure loads and these can work very well, however it is suggested that lashings alone may not be the most suitable method of securing certain loads.

For high-density loads, the use of lashings alone may necessitate an extremely high number of lashings in order to achieve the securing standard set out in BS EN 12195:2010. This may become impracticable very quickly, and present a risk of harm to the personnel securing the load in terms of manual handling, working at height, and repetitive strain injury. Reliance on lashings alone may also result in a residual risk of harm if some or all of the lashings fail in transit. Load containment, in this case, can act as a secondary system to prevent injury to either the driver or to other road users.

Some loads are inherently liable to move and inherently unstable. Lashings alone cannot be relied upon to maintain load stability, since the lashings must be removed in order to unload the vehicle. In these cases, containment in the form of vehicle structure, can help to protect the driver and/or loading bay personnel from a collapsing load.

For low-density loads, particularly palletised low-density loads, the risks inherent in personnel accessing the load area in order to secure the load will most likely outweigh the risk of the load itself falling. Using a vehicle body type that provides containment may mean that the load can be transported without lashings, significantly reducing the risk to loading bay personnel.

When using the structure of the vehicle to secure the load, it is important to take into account the distribution of the load on the load area, in order to ensure that maximum axle weights are not exceeded and that the handling of the vehicle is not compromised.

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The use of vehicle structure in load securing on heavy goods vehicles

Securing loads for safe transport is a legal requirement in the UK. It helps to protect the driver of the vehicle, other road users and pedestrians during the vehicle's journey from vehicle rollover or load detachment, and the driver and unloading personnel from the risks inherent in unloading a load that has been able to move in transit.

This report assesses the legislation applicable to the transport of goods in the UK under both road traffic and health and safety at work legislation. It assesses the guidance available to operators and consignors and the methods of securing loads that are commonly-used at present.

It is suggested that the concept of the load securing system, which comprises the structure of the vehicle, physical barriers to movement, and/or lashings, be given more prominence in current practice. In order to make effective use of the vehicle structure, it is important to ensure that the structure is in sound condition, and that vehicle headboards and bulkheads, in particular, are both strong enough to resist forward movement of the load and also maintained in serviceable condition to protect the driver from ingress of the load to the cab.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.