ADELAIDE IN-DEPTH ACCIDENT STUDY

1975-1979

PART 5: COMMERCIAL VEHICLE ACCIDENTS

by

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INFORMATION RETRIEVAL

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ABSTRACT : This report deals with accidents involving trucks, vans, buses and multi-purpose vehicles, not all of which were being used as commercial vehicles. There were relatively few single vehicle accidents, apart from those involving pedestrians, and the reluctance of semi-trailer drivers to brake hard at signalised intersections and insecure loads of some heavy vehicles distinguished these accidents from those involving only passenger cars. All but one of the drivers of these commercial vehicles were males, most of whom were aged between 20 and 50 years. None of these drivers were affected by alcohol intoxication to a significant degree, nor was fatigue a factor in any of these accidents. Although none of the commercial vehicle occupants was severely injured, the provision and use of seat belts may have avoided many of the injuries which did occur. Some multi-purpose passenger vehicles are deficient, when compared to passenger cars, in terms of protecting their occupants from injury in a crash.

*Non IRRD Keywords

Sponsored by

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FOREWORD

This study was conducted by the Road Accident Research Unit of the University of Adelaide and was jointly sponsored by the Office of Road Safety, Commonwealth Department of Transport and the Australian Road Research Board.

The general aims were to evaluate the effectiveness of many existing safety measures and to identify other factors related to accident or injury causation in road accidents in metropolitan Adelaide. The areas studied included characteristics of road users, the vehicles and the road and traffic environment.

To achieve these aims a representative sample of all road accidents to which an ambulance was called in the Adelaide metropolitan area was studied in the 12 months from March 1976. Two teams, each comprising a medical officer, an engineer and a psychologist attended 304 randomly selected accidents and collected medical, engineering and sociological data.

The findings are presented in a series of reports, each covering a specific topic. Part 1 provides an overview, and is followed by reports dealing with pedestrians, pedal cyclists, motorcyclists, commercial vehicles, passenger cars and road and traffic factors. The final report in the series provides a summary of the findings and recommendations.

Basic data from the study are held on computer by both the Road Accident Research Unit, University of Adelaide and the Australian Road Research Board. Access to these data can be arranged for bona fide research workers on application to the Australian Road Research Board. Further copies of this report and copies of other reports in the series are available from the Office of Road Safety, Commonwealth Department of Transport.

ACKNOWLEDGEMENTS

The collection of data at the scene of the accident and in the follow-up investigations was performed by:

H.S. Aust and C.T. Hall (Engineers)

N.D. Brewer and B.L. Sandow (Psychologists)

J.R. Lipert and P.J. Tamblyn (Medical Officers)

The completion of this study was due mainly to the willingness of these team members to work exceptionally long hours under difficult and often hazardous conditions.

Much of the road and traffic data was collected by W.J. Offler, who also attended the scenes of the accidents during the final three months.

The recorded information was processed by the above personnel, assisted by J.K. Darwin, G.M. Haymes, O.T. Holubowycz and C.A. Latta.

The Steering Committee for the study provided valuable assistance and advice. Its members were: Professor R.E. Luxton (Chairman), Professors: I.D. John, R.B. Potts, J.S. Robertson, A.T. Welford, Drs: B.L. Cornish (representing the Director-General of Medical Services), I.R. Johnston (D.O.T.), J.B. Metcalf (A.R.R.B.), G. Sved, A.P. Vulcan (D.O.T.), and Messrs. J.F.M. Bryant (A.R.R.B.), R. Culver, H.E. Roeger (later R.W. Scriven and then M. Knight) (representing the Commissioner for Highways), R. Ungers (D.O.T.) and F.E. Yeend (D.O.T.). The first Chairman was the late Professor N.T. Flentje.

The St. John Ambulance Transport Division played an essential role in the conduct of this study by notifying the Road Accident Research Unit when an ambulance was called to attend a road accident. The South Australian Highways Department, the Road Traffic Board, and the Police Department cooperated in many ways in the execution of this study, as did the Hospitals Department. The proprietors and operators of towing services and crash repair shops facilitated inspections of the damaged vehicles.

The sponsorship and advice of the Office of Road Safety of the Commonwealth Department of Transport and the Australian Road Research Board are gratefully acknowledged.

The final acknowledgement is due to the persons who were involved in the accidents studied and who cooperated freely with the members of the research teams.

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1. INTRODUCTION

A sample of road accidents to which an ambulance was called in the Adelaide metropolitan area was investigated at the scene by multi-disciplinary teams from the Road Accident Research Unit of the University of Adelaide. This survey, which ran for twelve months from 23 March, 1976, was sponsored by the Office of Road Safety of the Commonwealth Department of Transport and the Australian Road Research Board. Each accident was studied by an engineer, a psychologist and a medical officer. Their observations at the scene started an average of ten minutes after the ambulance was called and were supplemented by further investigations including interviews with the drivers and other active participants (pedestrians and cyclists), detailed observation of traffic behaviour at the accident site and examination of the injured persons in hospital and of the vehicles in towing service depots and elsewhere.

An eight per cent sample, totalling 304 accidents, was obtained of all road accidents as defined above. The sample was representative of this accident population by time of day and day of week. The purpose of this survey, the sampling technique and the method of investigation are described in detail in an overview report together with a review of the types of accidents investigated and an outline of the general conclusions. Twenty-nine accidents, or 9.5 per cent of the total sample, which involved a truck, bus, or multi-purpose passenger vehicle are reviewed in this report.

THE TYPES OF VEHICLES INVOLVED IN THESE ACCIDENTS

The term'multi-purpose passenger vehicle' is used here to denote a vehicle which is so-classified by the Australian Motor Vehicle Certification Board. This classification results in that vehicle being exempted from the requirement to comply with many of the Australian Design Rules for Motor Vehicle Safety. Not all, or even many, of the multi-purpose vehicles in these accidents were being used as commercial vehicles, but they are included in this report because they do differ from passenger cars in several important respects, such as compliance with the Australian Design Rules.

As can be seen in Table 1, the 30 vehicles which were classified as a truck, bus or multi-purpose passenger vehicle involved a wide range of configurations The word 'truck' in this Table is used to refer to vans as well as to tray-top configurations. These 30 vehicles represent 7.2 per cent of the motor vehicles, other than motorcycles, which were involved in the accidents covered by this survey.

TABLE 1: TYPES OF COMMERCIAL VEHICLES

Type of Vehicle	No. of Vehicles
Multi-purpose passenger vehicle	6
Light truck, unladen ≤ 1780 kg	4
Medium truck, unladen > 1780 kg, GVM ≤ 4500 kg	5
Heavy truck, GVM > 4500 kg	4
Semi-trailer	6
Prime-mover	1
Urban bus	3
Four-wheel-drive passenger vehicle	1
Total	30

2. THE ACCIDENTS

These 30 commercial vehicles were involved in 29 accidents (a bus and a prime-mover collided in one accident). Many of these accidents, most of which occurred between 8 a.m. and 3 p.m. on a weekday, are described elsewhere in other reports in this series; this section contains a general review of the types of accident in which commercial vehicles were involved, and a discussion of those aspects of these accidents which were related to the fact that a commercial vehicle was involved.

TYPES OF VEHICLE MOVEMENTS

The types of vehicle movements in these 29 accidents are listed in Table 2, with each accident being identified by number in the body of the Table. There were 21 collisions between a commercial vehicle and another vehicle. Accident 210 is counted twice in Table 2 because it was a collision between two commercial vehicles; and Accident 111 was not, in fact, a vehicular collision in the usual meaning of the term (see Note 2 of Table 2). Another two accidents out of the 20 involved commercial vehicles, one of which had been parked unattended only to then roll down a slope and crash into a parked car, and in the other accident was parked at the side of the road where it was struck by a car which was spinning round out of control. Consequently there were 19 collisions between a moving commercial vehicle which, at least initially, was controlled by its driver, and another vehicle.

The six collisions with pedestrians are described in a companion report on pedestrian accidents.

The sole non-collision accident involved a semi-trailer which rolled over when its load shifted. This accident is discussed later in this report under the heading "Load Retention".

In general, the remainder of these accidents are reviewed in the report dealing with road and traffic factors in this sample of accidents (Part 7).

INITIAL EVENT IN THE ACCIDENT

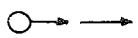
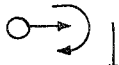
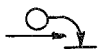
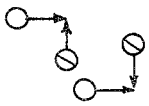
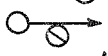
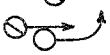
The initial event in each of these accidents is listed in Table 3. As in Table 2, the total number of cases in the Table is 30, rather than 29, because two commercial vehicles were involved in Accident 210.

These accidents differ from those involving other types of vehicles, such as cars or motorcycles, in that only a small proportion of them were single vehicle crashes (Accidents 013 and 129). There were two factors which may have been associated with this apparent under-representation of single-vehicle crashes. Most of these accidents occurred in daylight, and none of the commercial vehicle drivers was illegally intoxicated. (Single vehicle crashes tend to occur at night and to involve an intoxicated driver.) Four of the five night-time accidents in this group of 29 involved multi-purpose passenger vehicles which were being used for private purposes. The fifth involved a rented truck. In other words, all but one of the accidents in which a commercial vehicle, being used as a commercial vehicle, was involved occurred in daylight, and the only driver in this sub-group who was known to have been drinking had a BAC of 0.01. (Four drivers from whom a breath alcohol reading was not obtained all appeared to be sober.)

One of the two single vehicle crashes involved a multi-purpose passenger vehicle (a Leyland Mini Moke) which was being used for private purposes, and the other occurred when the load shifted on a semi-trailer, as noted above.

Apart from the relative paucity of single vehicle crashes, the factors which distinguished these commercial vehicle accidents from those involving, say, passenger cars, were the poor stopping characteristics of semi-trailers and the dramatic consequences of insecure loads shifting. The protection of the occupants of some of the multi-purpose vehicles from injury in an accident was also seen to be deficient when compared with the level of protection afforded by passenger cars. These matters are discussed in detail in this report.

TABLE 2: VEHICLE MOVEMENTS, LOCATION AND TYPE OF TRAFFIC CONTROL IN ACCIDENTS INVOLVING COMMERCIAL VEHICLES

Vehicle Movements (Commercial: ○→)	Location and Type of Traffic Control				
	Intersection			Midblock	
	Signalised	Sign-controlled	Uncontrolled	Uncontrolled	Total
Collision with vehicle:					
(1) 	210	053	130	-	3
(2)	210 [1]	164,240	049,161	-	5
(3) 	-	-	111 [2]	-	1
(4) 	127	-	-	-	1
(5) 	123,170 253	076 [3]	-	-	4
(6) 	-	081 [3]	-	129 [6],283 [4]	3
(7) 	-	-	-	044	1
(8) 	-	025	-	-	1
(9) 	014	-	-	-	1
(10) 	-	-	-	091	1
(11) 	-	-	-	215	1
(12) 	-	-	-	233 [5]	1
Collision with pedestrian:					
(Pedestrian: ⊘→)					
(13) 	-	-	-	037	1
(14)	305	-	-	117	2
(15) 	-	-	-	106	1
(16) 	224	-	-	-	1
(17)  (reversing)	-	-	-	262	1
Non-collision:					
(18) Rollover	-	-	-	013	1
Total	9	6	4	11	30

Notes:
1. Same accident as listed in row above (signals not operating).
2. Car struck by shifting load, no contact with truck.
3. Sign control not relevant to this accident.
4. Unattended truck rolled down slope, striking a parked car.
5. Parked Mini Moke hit by out-of-control car.
6. Mini Moke hit the back of a parked car.

TABLE 3: INITIAL EVENTS IN ACCIDENTS INVOLVING COMMERCIAL VEHICLES

Initial Event	Type of Vehicle: Multi-purpose passenger	4 w.d. passenger	Light truck	Heavier truck	Prime mover	Bus	Semi-trailer	Total
Rollover	-	-	-	-	-	-	013	1
Collision with:								
Car	049	-	164	025	-	053	123	16
	081		253	044			170	
	130			076				
	233 [1]			091				
	240			111 [2]				
				161				
Parked car	129	-	-	-	-	-	283 [3]	2
Bus	-	-	-	-	210	-	-	1
Prime-Mover	-	-	-	-	-	(210) [4]	-	(1) [4]
Motorcycle	-	-	215	014	-	-	127	3
Pedestrian	-	262	037	106	-	224	117	6
				305				
Total	6	1	4	9	1	3	6	30 [5]

Notes:
1. Parked multi-purpose vehicle struck by out-of-control car.
2. Car struck by shifting load, not by truck.
3. Driver-less semi-trailer rolled away from parked position.
4. Same accident as listed in row above.
5. Total equals total number of vehicles, not accidents (see Note 4).

3. CHARACTERISTICS OF THE DRIVERS OF COMMERCIAL VEHICLES

There were 28 drivers in the 30 commercial vehicles. One of the two remaining vehicles was parked, with a person seated behind the steering wheel, and the other was a semi-trailer which rolled away from a parked position. Its driver ran after it and was slightly injured when he tried to climb up into the cab.

3.1 BIOGRAPHICAL AND PHYSICAL CHARACTERISTICS

AGE AND SEX

Twenty-seven of these 28 drivers were males. The age distribution for all 28 drivers is shown in Table 4. There were relatively few drivers less than 20 years of age. This may have been due in part to the minimum ages at which a licence can be obtained to drive a heavy truck (17 years) or an articulated vehicle (18 years) in South Australia, but only one of the multi-purpose passenger vehicles, for which the minimum licensing age is 16, had a very young driver in these accidents.

OCCUPATION

Twelve of these drivers were engaged full-time driving commercial vehicles. These drivers reported that they drove at least 400 km per week, including private travel, as did five other drivers who regularly drove a commercial vehicle in the course of their employment. The remaining eleven drivers either drove only occasionally for business purposes or were operating a private vehicle at the time of the accident.

3.2 PHYSIOLOGICAL AND PSYCHOLOGICAL CONDITION

ALCOHOL INTOXICATION

Positive breath alcohol levels were recorded for two drivers, one of whom was a 21 year old male driver of a Volkswagen Kombi van who was involved in a collision at an uncontrolled intersection at night (Accident 130). His BAC was 0.04. The other was a 24 year old male truck driver who had a BAC of 0.01 at 10 a.m., a legacy of his drinking on the previous night. He, too, was involved in an uncontrolled intersection accident. As noted earlier in this report, breath-alcohol readings were not obtained from four drivers out of the 28, but each of these drivers appeared to be sober.

In summary, alcohol intoxication was not an important factor in the accident involvement of any of these 28 drivers of commercial vehicles.

PRE-ACCIDENT EMOTIONAL STATE

The extent to which a driver's recollection of his emotional state prior to an accident provides reliable information about the reasons for his involvement in the accident is not always clear. None of these 28 drivers could recall any emotional disturbance which could have been the main factor in determining their involvement in this accident, but one driver did say that he was worried that he was running late for a private appointment. He was driving an unfamiliar vehicle, a truck owned by his employer, along the centre lane of a four-lane undivided road, and he could see ahead to where a pedestrian was standing on the centre line. A car on his left, in the kerb lane, began to move across towards him to pass a parked car. Not wanting to slow down to allow the car room to pull across in front of him he continued on, while at the same time moving across to his right. He thought that he was allowing sufficient room to pass the pedestrian, but he had forgotten that the exterior rear vision mirror extended out beyond the right side of the truck. The mounting bracket for this mirror hit the pedestrian on the head (Accident 106).

OTHER CHARACTERISTICS

One of these drivers had poor eyesight (6:12 vision in both eyes; the driver of the prime mover in Accident 210) but this impairment was not relevant to his involvement in this accident. The 20 year old female driver of a Mini Moke which crashed into the back of a parked car had just completed an unusually long shift at work and may have been affected by fatigue (Accident 129). However she may have been trying to light a cigarette, since a cigarette with a scorched filter tip was found on the floor in front of the driver's seat.

No other physiological or psychological characteristics of these drivers appeared to play a role in the causation of their accidents.

3.3 LICENSING, EXPERIENCE AND DRIVING OFFENCES

Table 5 lists the lengths of time that these drivers had held the licence which

TABLE 4: AGE AND SEX OF DRIVERS OF COMMERCIAL VEHICLES

Age (years)	Number of Drivers
Under 17	-
17	1
18	-
19	1
20	4*
21 - 25	9
26 - 30	4
31 - 40	3
41 - 50	3
51 - 60	2
61 - 70	1
Over 70	-
Total	28

*Includes the only female driver.

TABLE 5: NUMBER OF YEARS RELEVANT LICENCE HELD

Number of Years	Number of Drivers
Less than one year	-
One to less than 2	3
2 to less than 3	1
3 to less than 4	3
4 to less than 5	-
5 to less than 10	6
10 years or greater	7
Unknown	8
Total	28

was appropriate to the type of vehicle that they were driving at the time of the accident.

For five of the eight cases where the time period was not available it is known that the driver did hold the relevant licence. In none of these 29 accidents was a lack of driving experience on the part of the commercial vehicle driver an obvious factor in the causation of the accident. ('Driving experience' is used here in the general sense, not in relation to experience with a particular vehicle.)

FAMILIARITY WITH THE VEHICLE

Twenty-one of the 28 driven commercial vehicles were owned by the driver's employer, and five were owned by the driver. Another vehicle was owned by a parent of the driver and the remaining one was a rented truck. The only accident in which the driver's lack of familiarity with his vehicle was a factor has been discussed above (Accident 106).

DRIVING OFFENCES

Four commercial vehicle drivers were charged with committing an offence against the provisions of the Road Traffic Act. Two of these charges were for failing to give way, in one case at an uncontrolled intersection (Accident 130) and in the other at an intersection at which the traffic signals had been switched off for maintenance (Accident 210). In the companion report which deals with accidents at these two types of location an argument is made for countering accidents such as these by adopting measures which reduce the demands placed on drivers.

Two other accidents resulted in the drivers of the commercial vehicles being charged with driving without due care. In Accident 127 a semi-trailer was still crossing a signalised intersection when the signal changed to green for traffic on the intersecting road. While it is possible that this driver may have been driving carelessly, and entered the intersection against a red light, the timing of the traffic signals does make it very difficult for the driver of a heavy vehicle to clear the intersection even when he is taking all reasonable care. This accident is discussed in more detail in relation to accidents at signalised locations in another report in this series.

The remaining driver to be charged, again for driving without due care, was reversing a Land Rover into a parking place when he knocked down a pedestrian who was about to complete crossing the road.

In addition to these four drivers, another five were thought, by the research team, to have been driving carelessly, two others failed to give way, and another two were operating vehicles which carried insecure loads. None of these nine drivers was charged with an offence.

4. CHARACTERISTICS OF DRIVERS WHO COLLIDED WITH COMMERCIAL VEHICLES

In 18 of these 29 accidents a commercial vehicle was involved in a collision with a car or motorcycle (excluding parked vehicles). The age and sex distributions for these 14 drivers and three riders are listed in Table 6.

When compared with the data in Table 4 it can be seen that most of the drivers of commercial vehicles were aged between 20 and 50 years, whereas the majority of the 18 drivers of these other vehicles were outside that age range, either younger or older.

ALCOHOL INTOXICATION

Breath-, or blood-alcohol readings were obtained from 12 of these 18 drivers. They were all zero. Four of the drivers from whom a BAC reading was not obtained were females, and they all appeared to be sober. One male driver, 62 years old, had been drinking and refused to blow in our breath alcohol meter.

TABLE 6: AGE AND SEX OF DRIVERS WHO COLLIDED WITH COMMERCIAL VEHICLES

Age (years)	Sex		Total
	Male	Female	
Less than 16	-	-	-
16	1	-	1
17	-	-	-
18	1	1	2
19	2	2	4
20	1	-	1
21 - 25	-	-	-
26 - 30	1	1	2
31 - 40	-	2	2
41 - 50	1	-	1
51 - 60	1	-	1
61 - 70	3	-	3
Over 70	1	-	1
Total	12	6	18

FIGURE 1: Lengths of timber slid forward under emergency braking. Accident 111.

Frontispiece

FIGURE 2: Rest positions of prime mover and bus. Accident 210.

FIGURE 3: Damage to bus in Accident 210.

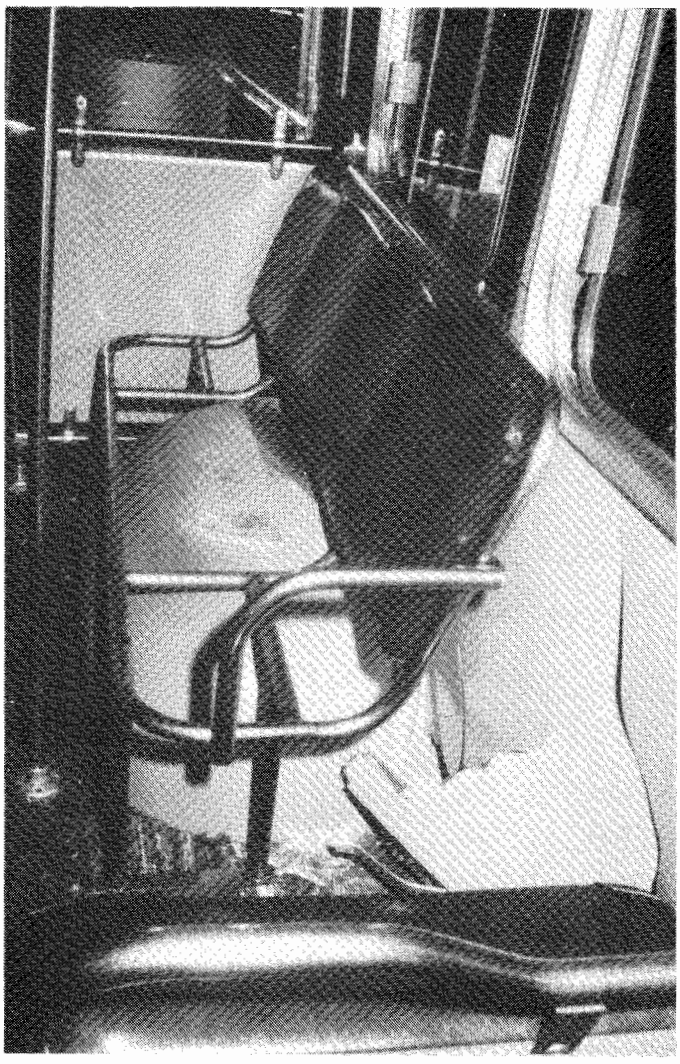


FIGURE 4: Damage to the interior of the passenger compartment of the bus in Accident 210.

5. CONSEQUENCES OF COMMERCIAL VEHICLE ACCIDENTS

5.1 THE INJURIES

OVERALL INJURY SEVERITY

The occupants of the larger commercial vehicles sustained less severe injuries than did the occupants of passenger cars and other road users (see Table 7). This result would be expected because, in general, a heavy commercial vehicle is less likely to sustain as severe a degree of damage, or be decelerated as rapidly, as is a car when the two types of vehicle collide.

The occupants of 'light trucks' (mostly multi-purpose passenger vehicles) were more likely to be injured than were the occupants of cars.

INJURY SEVERITY SCORE (ISS)

Sixty per cent of the occupants of these commercial vehicles were not injured, and a further 28 per cent had an ISS of 1, indicating a minor injury. There was only one person in this group of 47 who had an Injury Severity Score greater than five, and that was the male who was seated in the driver's seat of a parked Mini Moke which was struck by a car which was out of control following a prior collision. This person had an ISS of 13 (Accident 233).

BODY REGIONS INJURED

The frequency of injury to each body region is shown in Table 8. The knee was the most frequently injured body region, accounting for almost one quarter of all injuries. These cases were almost all relatively minor bruises and abrasions. The causes of the more significant injuries are discussed in the following section.

5.2 OBJECTS CAUSING INJURY

The objects which were identified as having certainly, or probably, caused specific injuries are listed in Table 9. Those contacts which were rated as 'possible' are also noted in this Table.

The contact with the outside surface of the case vehicle involved the semi-trailer driver who tried to stop his runaway vehicle. He cut his hand as he tried to get up into the cab.

PENETRATING OBJECT

A car driver who turned right from the stem of a T-junction did so in front of a truck which was approaching on his right. The truck driver braked hard to avoid colliding with the car, but part of his load slid forwards and passed through the driver's window of the car, striking the driver on the jaw (Accident 111). The truck was designed to carry lengths of timber, and was fitted with a half-cab to allow the timber to extend forwards to the front of the vehicle. When bulk orders of timber are being carried the truck driver said that he had not experienced any shifting of the load, probably because the lengths of timber are strapped together before being loaded onto the truck, where they are then easily roped on as a large block. Occasionally, however, when small orders involving several pieces of different varieties are carried one or more lengths of timber might slide forwards under heavy braking, as happened in this accident when a length of mahogany weighing about 35 kg struck the driver of the turning car.

Figure 1 shows a length of timber hanging out over the front of the truck after the accident. The piece of timber which struck the car came adrift completely from the truck. It passed through the driver's window of the car, struck the driver on the jaw, continued on through the car, hitting the head restraint on the (vacant) passenger's seat and then shattering the right rear side window.

OBJECTS STRUCK BY BUS OCCUPANTS

The person who sustained minor contusions from contact with the surface of the side interior of the vehicle was a passenger in the metropolitan transit bus which was struck on the side by a prime mover (Accident 210). This person was seated adjacent to the point of impact (Figures 2 to 5).

This bus was carrying about 70 passengers at the time of the accident, but only seven of them, and the driver, remained with the bus after the crash to be treated for their injuries by ambulance officers. We have no record of the other passengers, most of whom transferred to a following bus. The seven injured passengers were seated or standing in the positions shown in Figure 5.

TABLE 7: OVERALL INJURY SEVERITY FOR EACH TYPE OF ROAD USER

Type of Road User	Overall Injury Severity (Per Cent)							Total Number of Cases
	Nil	Minor	Moderate	Severe	Serious	Critical	Fatal	
Pedestrian	2.3	25.0	20.5	19.5	11.4	4.5	6.8	44
Pedal Cyclist	4.3	21.7	39.1	21.7	8.7	4.3	-	23
Motorcyclist	3.7	37.5	30.0	16.2	7.5	-	5.0	80
Car Occupant	52.0	32.9	11.0	2.1	1.1	0.8	0.1	727
Light Commercial Vehicle Occupant	53.3	20.0	26.7	-	-	-	-	15
Heavier Commercial Vehicle Occupant	81.0	14.3	4.8	-	-	-	-	21
Bus Occupant	18.2	72.7	9.1	-	-	-	-	11
All Road Users	44.5	32.5	13.9	5.0	2.3	1.0	0.9	921

*Note: The figures for bus occupants show a higher average severity of injury that was actually the case. This is because in one accident the bus was carrying a large number of passengers, possibly as many as sixty, and when the bus stopped after the collision almost all of these passengers transferred to a following bus within a minute or so. Ten car occupants are also not represented in this Table because we were unable to examine them after the accident. One of them probably was injured, the others almost certainly were not.

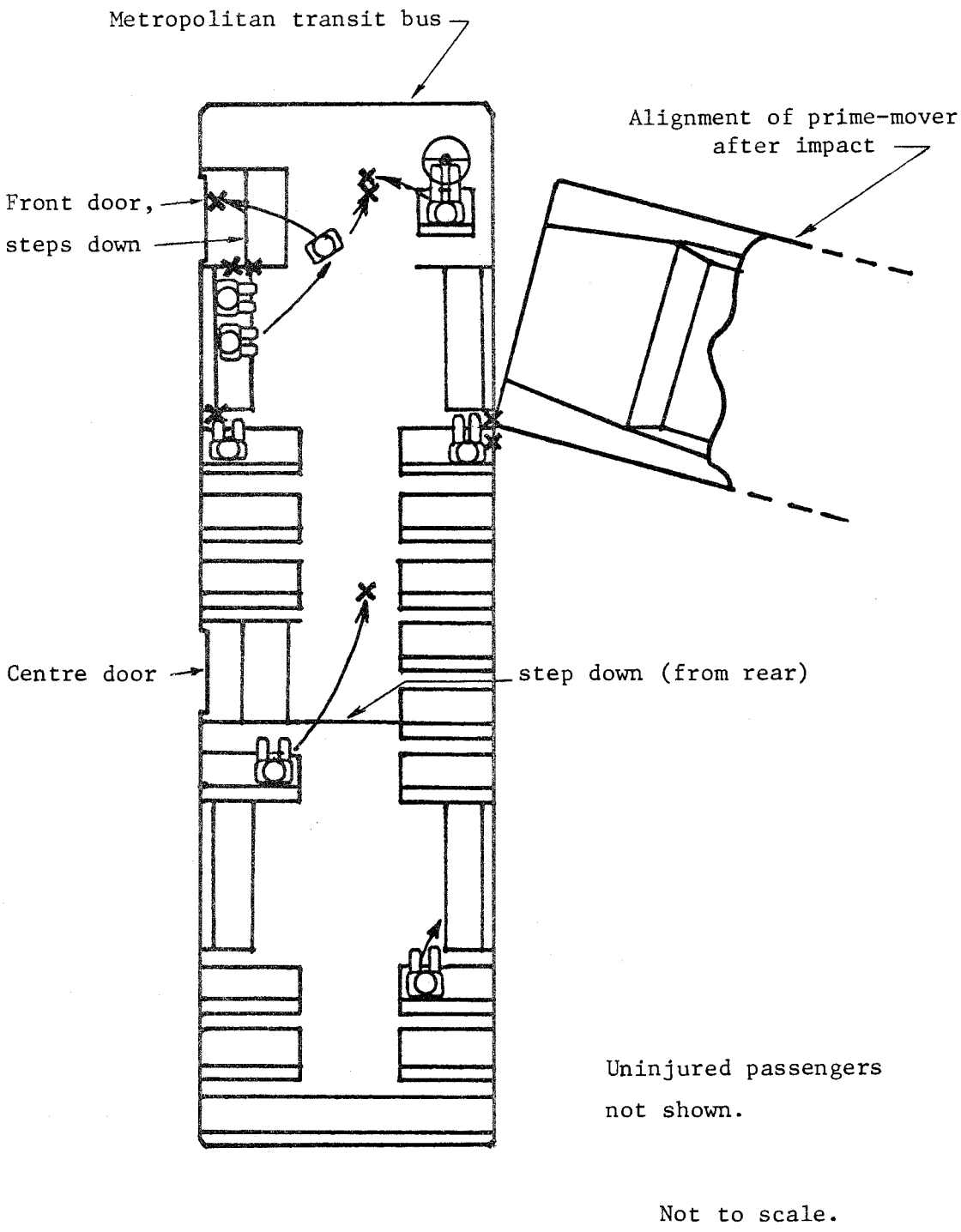


FIGURE 5: Movements of Injured Bus Occupants (Accident 210).

TABLE 8: COMMERCIAL VEHICLE OCCUPANTS: FREQUENCY OF INJURY BY BODY REGION

Body Region	All Injuries*	
	Per Cent	No. of Persons
Head	13.2	4
Face	2.6	1
Neck	-	-
Shoulder	-	-
Upper arm	5.3	2
Elbow	2.6	1
Forearm	5.3	2
Wrist/hand	7.9	2
Back	2.6	1
Chest	7.9	3
Abdomen	5.3	2
Pelvis	5.3	2
Thigh	2.6	1
Knee	23.7	7
Lower leg	10.5	3
Ankle/foot	5.3	2
Total Injuries: %	100.0	-
Total Injuries: No.	38	-

*No injury was rated AIS > 2.

Notes: These data relate to a wide range of vehicles and are not directly representative of any one type.

Some persons sustained more than one injury and so the total for the number of persons is not meaningful.

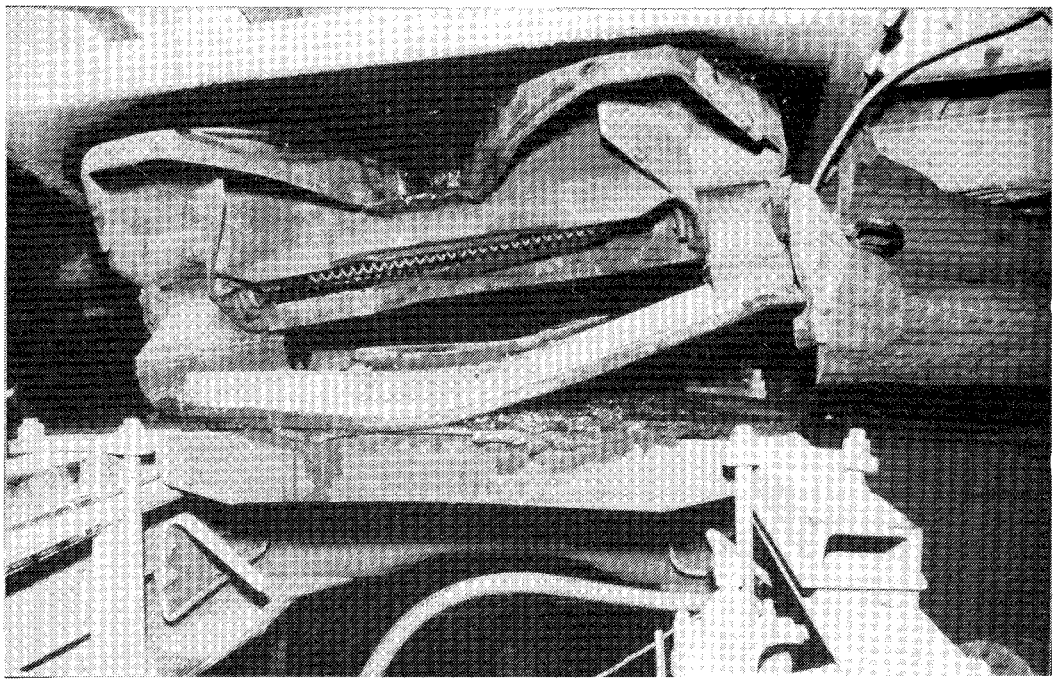


FIGURE 6: Fifth-wheel assembly deformed when load shifted and semi-trailer rolled over. Accident 013.

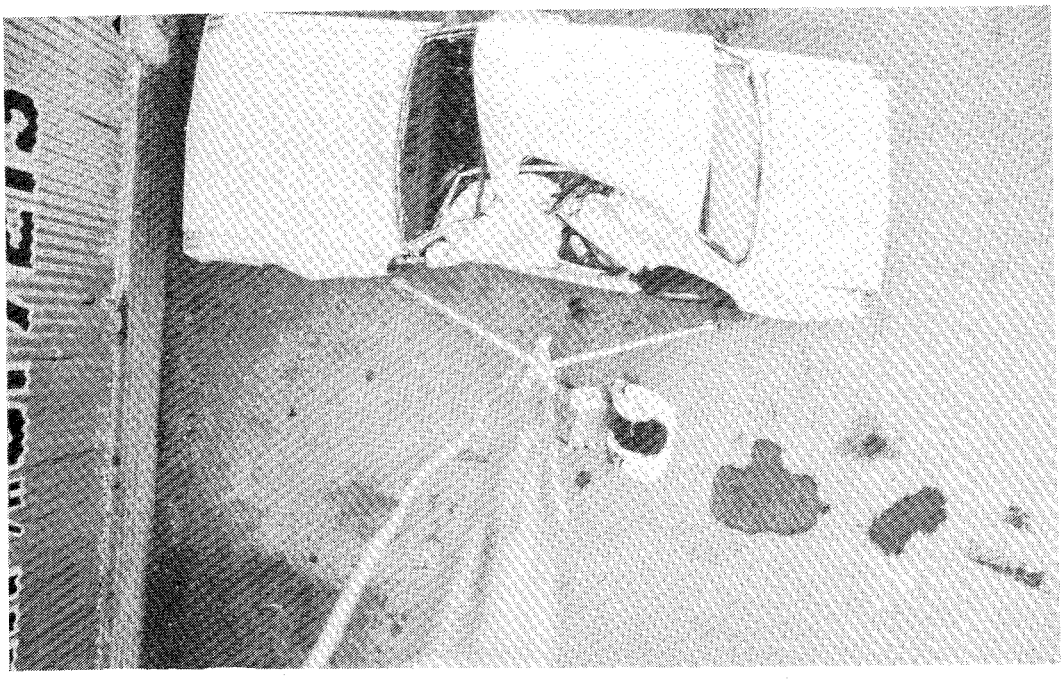


FIGURE 7: Damage resulting from a collision with a truck of the type shown in Figure 8. Accident 076.

FIGURE 8: Truck of the type involved in Accident 076 (see Figure 7).

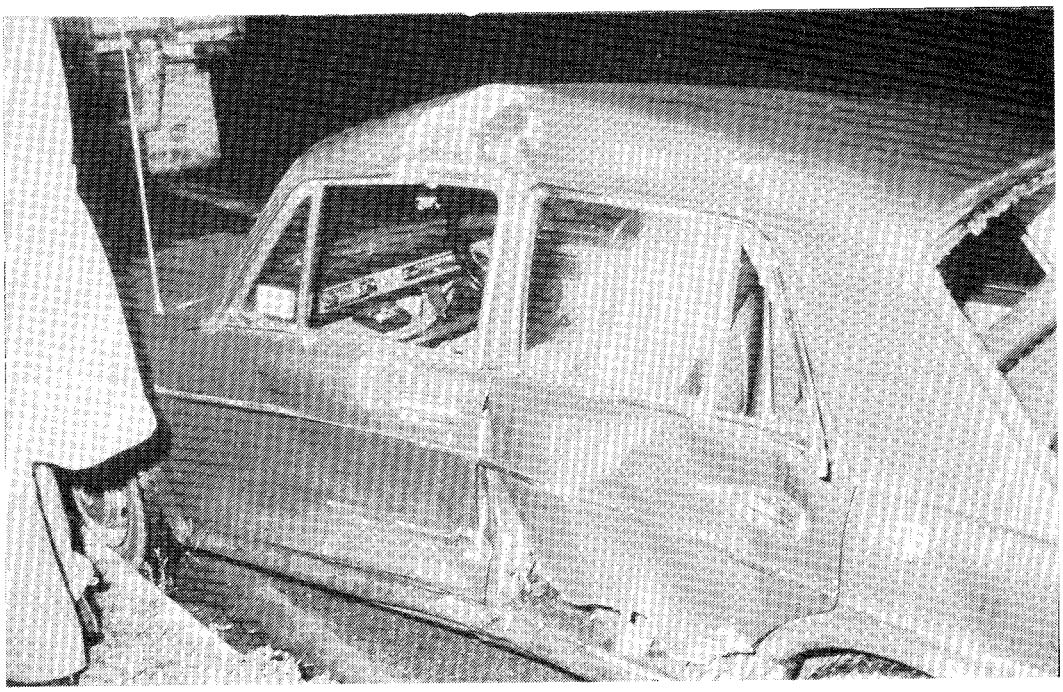


FIGURE 9: Damage resulting from collision with truck shown in Figs. 10 and 11. Accident 123.

TABLE 9: COMMERCIAL VEHICLE OCCUPANTS: FREQUENCY OF INJURY BY OBJECT CONTACTED

Object Contacted	All Injuries*		
	Contacts		Persons
	No.	%	No.
Steering column	2	5.3	1
Interior hardware (bus)	4	10.5	2
Instrument panel: lower section	3	7.9	2
: beneath panel	1	2.6	1
Parcel tray	3#	7.9	1
Floor (bus)	4	10.5	3
Restraint system webbing	4	10.5	3
Restraint system hardware	1	2.6	1
Surface of side interior	3	7.9	1
Rear vision mirror	2	5.3	1
Window glass	1	2.6	1
Front seat back	1	2.6	1
Other occupants	1	2.6	1
Penetrating object	1	2.6	1
Outside surface of case vehicle	1	2.6	1
Object not known	6	15.8	4
Total Contacts:	38	100.0	-

* No injury was rated AIS > 2.

\# Includes one contact rated as 'possible'; all other contacts are rated as 'certain' or 'probable'.

The bus driver was thrown from his seat, and fell to the floor, as shown. A passenger who had been standing alongside him was thrown off balance and fell down the steps leading to the front door of the bus. One of the two injured passengers who were seated on the longitudinal seat at the left front of the bus was thrown forwards, falling to the floor alongside the driver. The other passenger on this seat sustained bruises and abrasions from being thrown against the tubular handrails which are located between this seat and the steps down to the forward entrance. A forward-facing passenger received a bruised left knee from contact with the rails at the end of this longitudinal seat. The passenger shown near the back of the bus was concussed, but the object contacted could not be determined. The remaining passenger shown in Figure 5 was thrown from her seat behind the centre door. She tumbled down a step in the aisle and hit the floor, landing on her right knee and right elbow. She reported being unable to carry out her usual activities for four days after the accident because of her injuries.

Despite the fact that the bus was struck by a heavy vehicle the collision was not very severe because the truck, or prime-mover, was travelling slowly (the front wheels of the prime-mover were dragged sideways as the front corner snagged on the side structure of the bus). Consequently few of the bus occupants were injured at all, and those who were sustained relatively minor injuries, except for the person who was concussed. Even so, two of the passengers were injured when they were thrown against the tubular steel handrails or seat frames. The needlessly hazardous nature of such fittings has been noted previously (Hoffmann, 1975).

When the driver was thrown from his seat he received abrasions to both arms when he hit the floor. Had he been able to remain in his normal seated position it is likely that he would not have been injured, and he would have been able to control the bus after the crash. The marks on the road surface showed that the bus driver had braked just before the collision, but the resulting skid marks due to this emergency braking stopped at the collision point, when the driver was thrown sideways, away from the controls. On this occasion the bus did not travel far beyond the collision point, simply because it was dragging the striking vehicle along with it. Had this snagging between the two vehicles not occurred, it is most likely that the bus, which had an automatic transmission, would have continued on until it crashed into an object substantial enough to stop it.

A similar bus was involved in a collision with a car in Accident 053. The bus driver remained in his seat and was not injured. One passenger in the bus received a small laceration below the left knee.

The third transit bus in this sample of accidents collided with a pedestrian (Accident 224, see the report in this series on pedestrian accidents).

RESTRAINT SYSTEM WEBBING AND HARDWARE

The driver and front seat passenger of a Volkswagen Kombi van both sustained bruising across the chest from the sash of the seat belt when their vehicle struck the side of a car-type utility at an uncontrolled intersection (Accident 049). This accident is discussed in more detail later in this report, where it can be seen that this bruising from the seat belt was a desirable alternative to being thrown against the deformed frontal structure of the Microbus.

In Accident 091 the driver of a tow truck, which was about to enter the roadway from a parked position adjacent to the kerb struck his head on the upper mounting point of his seat belt when his truck was side-swiped by a passing car. He also had a bruise across his abdomen from the belt webbing.

The availability and use of seat belts in these commercial vehicles is reviewed in the concluding section of this report which also deals with other characteristics of the design and operation of these vehicles which were relevant to the causation or consequences of these accidents.

5.3 CONSEQUENCES OF INJURIES TO OCCUPANTS OF COMMERCIAL VEHICLES

LENGTH OF HOSPITAL STAY

Five of the 47 occupants of these commercial vehicles were admitted to hospital, three for one day and two for two days. As noted earlier in this report, one bus was actually carrying a full load of about 70 passengers at the time of the accident. Only the driver and six injured passengers are included in the total of 47 occupants referred to here.

PERIOD OF RESTRICTION OF NORMAL ACTIVITIES

This information was not obtained for three of the 20 injured occupants but their injuries were such as to have made it unlikely that their normal activities would have been restricted. Seven persons were affected in this way, however; five of them for a week or less, one for 28 days (the occupant of a parked Mini Moke) and one for 63 days (the driver of a Volkswagen Kombi van).

EXTENT OF RESIDUAL DISABILITY

None of the injured occupants of these commercial vehicles reported having any residual disability as a consequence of their injuries.

FIGURE 10: Truck involved in Accident 123 (see Figure 9).

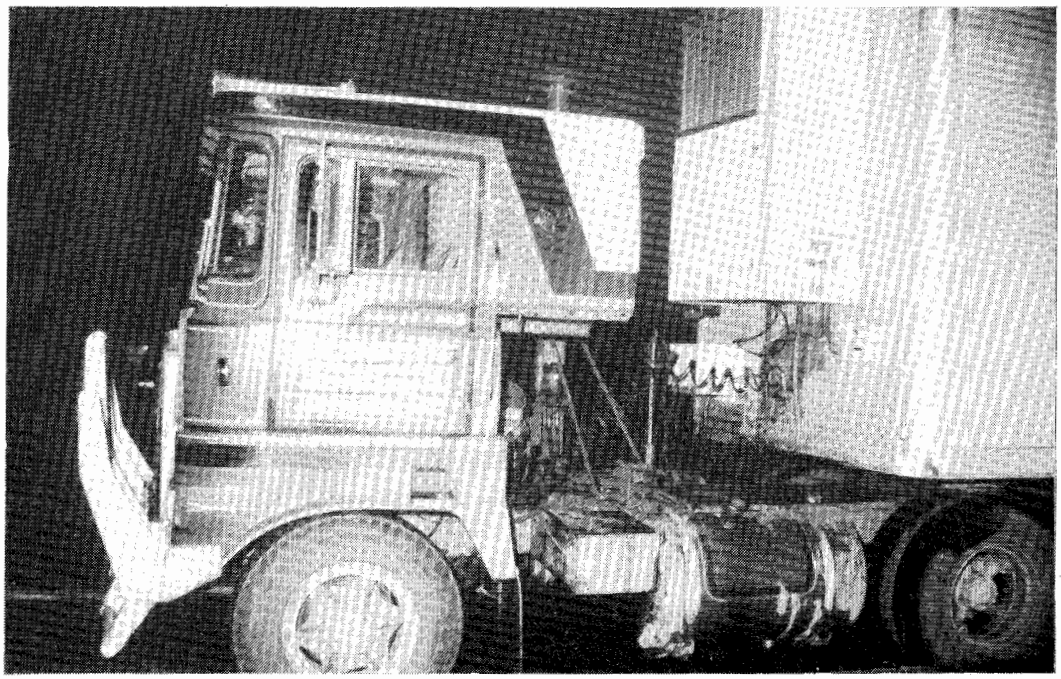


FIGURE 11: Truck involved in Accident 123 (see Figure 9).

FIGURE 12: Truck involved in Accident 170. Note damage to left end of front bumper bar. (See Figure 13).

FIGURE 13: Damage to car in Accident 170 (see Figure 12).

6. VEHICLE FACTORS

6.1 DEFECTS IN COMMERCIAL VEHICLES

Four of these 30 commercial vehicles were found to be defective. In two cases the defect was the primary factor in the causation of the accident, in one case it may have contributed, and the defects in the fourth vehicle were not relevant to the accident in which the vehicle was involved.

The driver of an early-model Volkswagen Kombi van was surprised to find that he was not able to stop in time to avoid colliding with the back of a car which was stationary, waiting to turn right from the centre lane of a two-way four lane road. He checked to see whether it was safe to swerve across into the kerb lane, but then did not have time to do so. The front bumper of his van ran under the rear bumper of the car, which resulted in the front of the bodywork of the Volkswagen being pushed in onto the driver's legs, and also trapping the brake pedal in a semi-depressed position (Accident 081). This prevented us from being able to test the firmness, or otherwise of the brake pedal but the fluid in the master cylinder was very dirty and the level was low. There was also evidence of fluid leakage past the seals. This vehicle was carrying an unusually heavy load, and it is likely that this exacerbated the deficiencies in the braking system which may not have been very obvious in normal operation.

The driver whose semi-trailer rolled away down a slope from a parked position (Accident 283) said that he had shifted to low range and applied the parking brake before leaving the vehicle, which he was not accustomed to driving. He claimed that he learnt later that the parking brake was not functioning and that the transfer box was prone to slipping out of gear.

A malfunction of the left tail light assembly on a tip truck was possibly instrumental in the causation of a collision with a motor cycle (Accident 014). The truck was turning left from the second lane from the kerb at a signalised intersection in order to avoid roadworks in the centre of the intersecting road. Although the driver both braked and claimed to have operated the indicator stalk, neither the rear left brake nor indicator lights were operating and consequently no warning of the imminent turn was given to the motorcyclist who was attempting to overtake the truck on the left-hand side.

The remaining vehicle with defects (a truck with bald tyres, a faulty parking brake and a missing rear mud flap) had none which was relevant to the causation or consequences of the accident.

VEHICLE MODIFICATION

Modification to standard vehicle components emerged as a possibly relevant factor in only one of these accidents. This involved a VW Kombi van (Accident 130) which struck the left rear of a car which was crossing an uncontrolled intersection from the right of the van. As a result of the collision the front of the Kombi was translated to the left, thus precipitating an anti-clockwise spin which culminated with the van rolling onto its right side. The rear suspension of this van had been raised, presumably to increase the ground clearance, but this also had the effect of both increasing the static negative camber of the rear wheels and decreasing the rear track width. The consequent reduction in lateral stability aggravated the tendency to roll over in this situation.

A later model VW Kombi van was involved in a similar collision (Accident 049) but was spun around without rolling over. This difference in post-impact motions of these two vans can be attributed to the suspension modification described in the preceding paragraph and to changes in the design of the rear suspension in the later model vehicle.

6.2 HEAVY VEHICLE BRAKING

Two of these accidents involved semi-trailers which entered a signalised intersection either late in the yellow phase or against the red signal, ostensibly because the drivers considered that they were too close to the intersection to stop comfortably when the signal changed to yellow. In each case the semi-trailer crashed into a car which was completing a right-hand turn because the car driver had assumed that the heavy vehicle would slow down and stop as the cars alongside it were doing (Accidents 123 and 170).

There are several reasons why the drivers of laden semi-trailers are reluctant to make full use of the braking performance of their vehicles. These include the risk of locking one or more wheels, with the resulting reduction in stability, excessive tyre wear, and having the load slide forwards. Consequently upgrading of the braking performance of semi-trailers and other heavy vehicles must be accompanied by acceptable solutions to these associated problems, as noted in the House of Representatives Standing Committee on Road Safety report on Heavy Vehicle Safety (para. 69 et seq.).

Nevertheless such vehicles can present an exceptional hazard to other road users because of the discrepancy between their braking performance and that of passenger cars, and because they are likely to inflict extremely severe damage to another vehicle in a collision.

6.3 LOAD RETENTION

The failure to retain a load under braking was the direct cause of serious injury to the driver of a car in Accident 111, as described in Section 5.2.

One other accident (013) resulted from the load shifting on a semi-trailer, this time not as a consequence of heavy braking. This accident has been noted earlier in this report, but a more detailed description of the load is appropriate here: paper bags were packed in small bundles and stacked on pallets, which were retained by gates, ropes and tarpaulin. On entry to an off-camber right hand corner at low speed, the lack of friction between these packages allowed the top of the load to move outwards and this shift continued to the extent that the inside wheels of the trailer lifted and both the trailer and prime-mover rolled over onto the left side. The fifth wheel assembly on the prime-mover was damaged during the rollover (Figure 6). The dangerous instability of this load can be further appreciated when it is realized that the driver was intending to travel interstate but had completed less than 20 kilometres of his journey. He stated that cargoes such as this were prone to shifting and that subsequent roll-overs were not unknown.

6.4 VEHICLE DESIGN AND INJURY CONTROL

The emphasis in vehicle design to control injuries in crashes has been placed on protection of the vehicle occupant rather than on protection of other road users who may be struck by that vehicle. This latter concern is discussed at some length in the reports dealing with pedestrian and pedal cycle accidents, but it is also relevant here because, as already noted, a heavy vehicle can inflict severe damage to a passenger car in a collision.

FRONTAL DESIGN OF HEAVY VEHICLES

The extent of the damage which can result from a collision between a truck and a car is illustrated in Figure 7. The type of striking vehicle (but not the actual vehicle) is shown in Figure 8. The car had turned right, across the path of an oncoming truck which was travelling at a speed of about 60 km/h on impact (Accident 076). Note that, as shown in Figure 7, the main force of the impact was located on the side of the car above the door sill member, which remained relatively undamaged.

In a similar collision the damage to the car was far less severe, partly because the heavy vehicle was fitted with a bull bar which extended down below the standard bumper bar (Accident 123, Figures 9 to 11). The force of the impact was still above the level of the door sill of the car, but the lowest part of the bull bar hit the left rear wheel of the car, thereby pushing the car sideways without loading the upper body structure of the passenger compartment. Two other factors distinguish this accident from the previous case: the car appears to have been more nearly side on to the front of the heavy vehicle in Accident 123, and the speed of the truck on impact may have been slightly less than in Accident 076.

The third collision of this type, with a car being struck by an oncoming heavy vehicle while performing a right turn, involved a semi-trailer which was not fitted with a bull bar (Accident 170, Figures 12 and 13). The impact was located above the top of the left front wheel of the car and this meant that the front bulkhead, or lower A-pillar, of the car took the main force of the impact, unlike Accident 076 where the impact was centred further back along the side of the car. The front of the prime-mover is shown in Figure 12.

Accident 210 was an example of a bull-bar snagging on the struck vehicle (see Figure 2). Ironically enough, in this instance this was beneficial because it helped to stop the bus which might otherwise have continued on out of control, its driver having been thrown from his seat onto the floor in the collision.

In addition to the hazards presented to the occupants of passenger cars by the relatively high, standard front bumper bar of a heavy vehicle, other road users may also be adversely affected. For example the motor-cyclist who sustained extremely severe leg injuries when his motorcycle was run down from the rear by a semi-trailer might not have been run over by the front wheel of the prime-mover had a front under-ride guard been fitted (Accident 127, see frontispiece).

In summary, then, there does appear to be a need to provide front under-ride protection on heavy vehicles. Some bull-bars possibly incidentally, go some way towards meeting this need, but the conventional design of such bars leaves much to be desired with regard to impacts with pedestrians and the risk of snagging on the body structure of struck vehicles. These accidents reviewed here present no justification for bull-bars extending above the standard bumper bar.

SAFETY ASPECTS OF MULTI-PURPOSE PASSENGER VEHICLES

With the limited number of cases that can be investigated in an in-depth study it

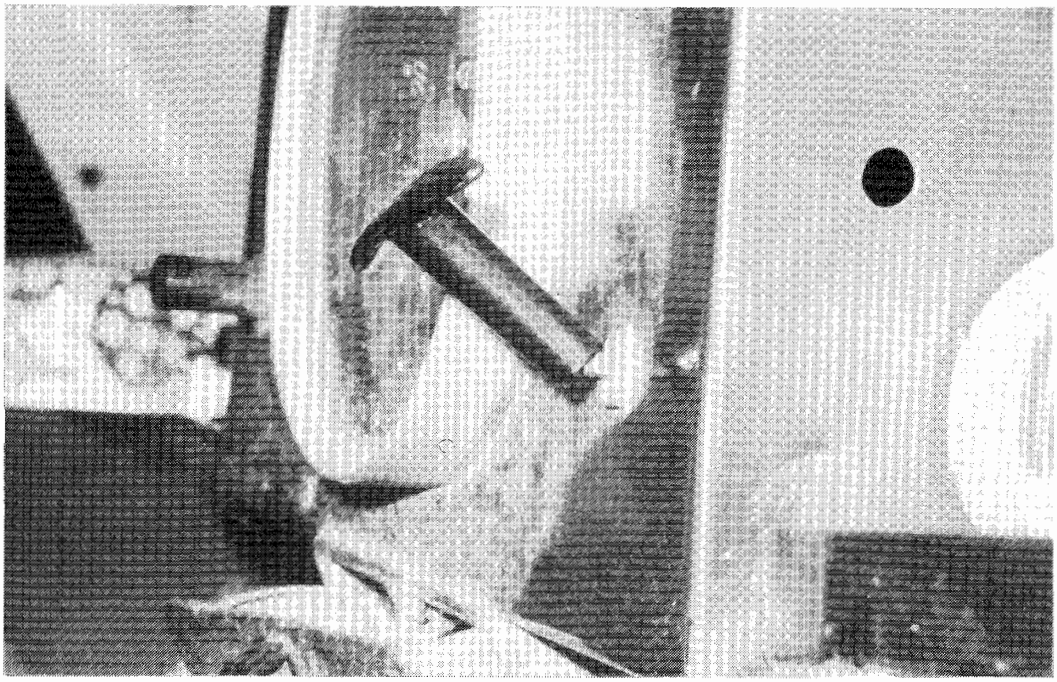


FIGURE 14: Damage to knob on instrument panel of Mini Moke due to impact by driver's knee. Accident 129. (See Figure 15).

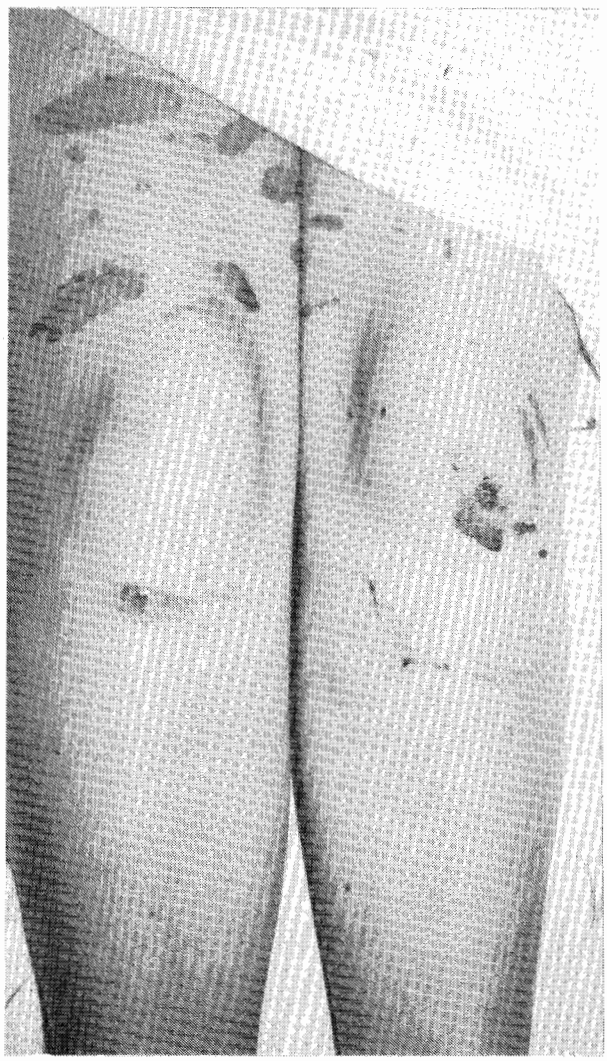


FIGURE 15:

Injuries to driver's knees due to striking the instrument panel area of a Mini Moke (see Figure 14).

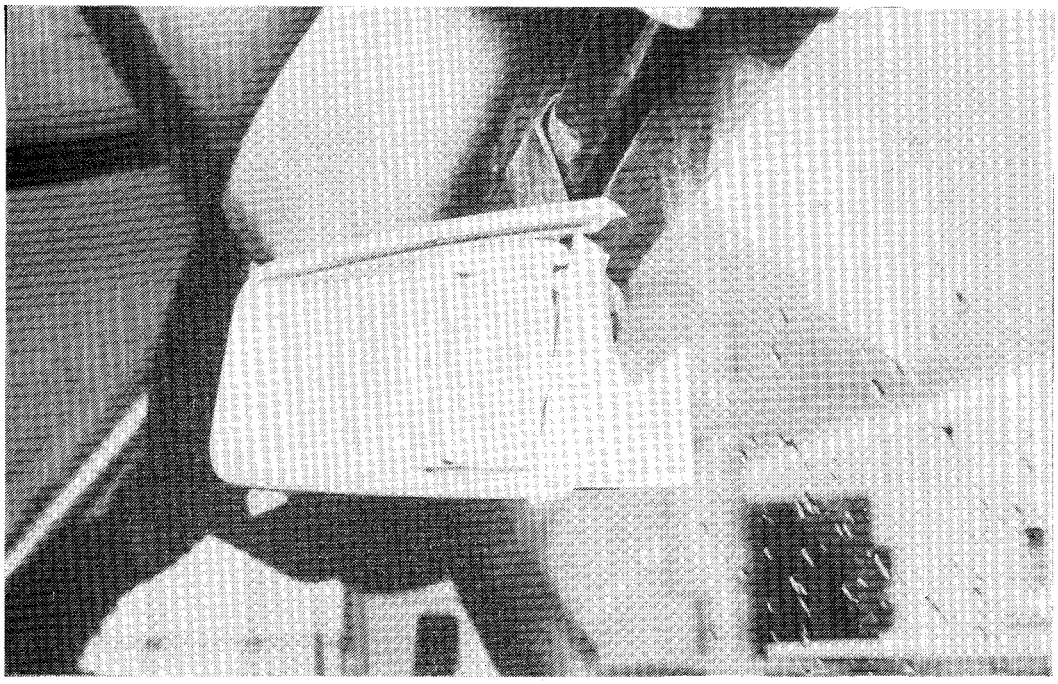


FIGURE 16: Rear vision mirror of Mini Moke after being struck by driver's face. Accident 129.

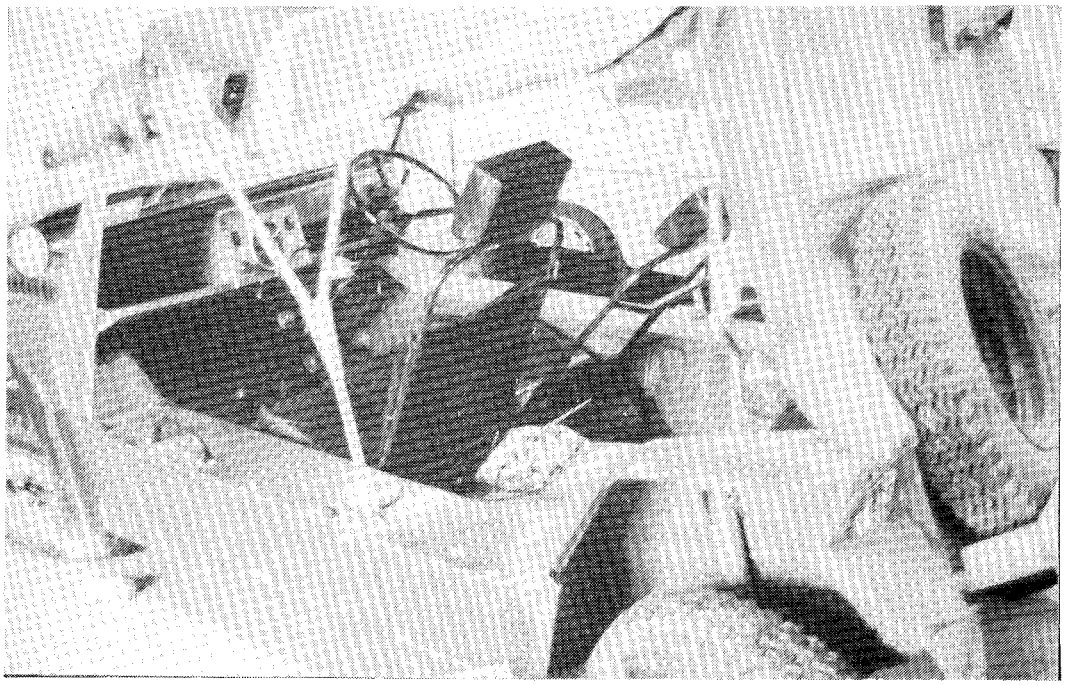


FIGURE 17: Mini Moke in Accident 233. Note damage to back of driver's seat.

is inevitable that not all makes and models of vehicles will be represented. Nevertheless the deficiencies of particular models of vehicles are of interest insofar as they are amenable to change, and because they may be common to a general class of vehicle.

The Leyland Mini Moke is classified as a multi-purpose passenger vehicle by the Australian Motor Vehicle Certification Board. Because the Mini Moke has no superstructure, apart from the windscreen frame and the frame for the folding soft top, it is not required to be fitted with lap and sash seat belts, simply because there is no structure which can act as a satisfactory upper anchorage for the sash belt. The lap belts which are fitted will prevent the wearer from being ejected from the vehicle, but they may not provide adequate protection against head, facial and chest injuries arising from striking those parts of the vehicle structure which are in front of the occupants.

In Accident 129, in which a Mini Moke crashed into the back of a parked car, the driver was not wearing the lap seat belt because she was concerned that if she did so she would be at greater risk of sustaining a facial injury in a frontal impact. The validity of this opinion is arguable, the alternative total lack of any restraint not being a desirable option, but this driver said that she always wore the more common lap and sash belt when it was available in other cars. In this accident she was thrown forwards in the impact, striking her knees on the instrument panel on the left (Figure 14) and on the metal edge of the parcel shelf on the right, sustaining the contusions and abrasions shown in Figure 15. She then pivoted forwards and to her left, striking her face on the rear vision mirror. This vehicle was manufactured in 1975, and so was required to comply with ADR14 which specifies, inter alia, that the internal rear vision mirror break away from its mounting when struck, which it did not do in this accident. Indeed it is difficult to see how it could have broken away because the mirror is located almost touching the windscreen (Figure 16). This meant that the driver's face, on hitting the mirror, immediately wedged the mirror against the windscreen. The glass in the mirror broke, and the driver sustained lacerations to the left side of her face.

The second Mini Moke in this survey was, as has been noted, parked at the side of the road with a person seated behind the steering wheel (Accident 233). When the Mini Moke was hit by a car which was spinning out of control the person in the driver's seat was ejected, after striking his legs and ankles on the parcel shelf and bruising his back on the tubular steel frame of the seat when the hammock-type fabric seat back tore away (Figures 17 and 18).

The Mini Moke, and similar vehicles, are commonly used as passenger cars. It is therefore unfortunate that the level of occupant protection is below that required for passenger cars.

The Volkswagen Transporter can be classified in three ways for the purpose of compliance with the Australian Design Rules: as a commercial vehicle of less than 4.5 tonnes GVM, as a bus, or as a multi-purpose passenger vehicle, depending on the configuration of the particular vehicle, but these specifications have little bearing on the level of risk to which the occupants are exposed in a collision, in the sense that the basic vehicle is the same.

Three of these Volkswagen vehicles were involved in collisions, all with passenger cars, in this survey. One of these accidents has been discussed in the section on defects in commercial vehicles (Accident 081). It was the only one of the three in which there was serious encroachment into the driver's compartment as a direct consequence of deformation of the front of the vehicle, which had struck the rear of a stationary car (Figures 19 and 20). As can be seen in Figure 20, the front bumper bar of the van ran under the rear bumper of the car. The driver, who was braking hard, had his right tibia fractured by the headlamp housing as it was pushed back. Figure 21 shows the deformed area with the driver still in the vehicle. The steering column is not visible in this illustration, being hidden from view by the driver's left leg. The dent in the headlamp housing was probably the consequence of the housing being pushed back onto the drivers leg. Had the driver not been injured he would have been able to extricate himself from the damaged vehicle without any assistance, but the leg injury necessitated the use of a long hydraulic ram to push the damaged body section away from his broken leg to enable him to be lifted out. No seat belts were fitted to this vehicle, which was a 1963 model.

Each of the other two of these Volkswagen Transporters, both Microbuses, struck the side of a car at an uncontrolled intersection. In Accident 130 the driver of the Microbus was wearing a lap and sash seat belt. He was concussed, from hitting his head on the side window glass, and sustained bruises to his legs from striking the steering column and the damaged frontal section of his vehicle. This case differs from Accident 081 in that the front bumper bar, and its supports, took much of the force of the impact (Figures 22 and 23).

The remaining accident in this group of three is of greater interest in that it involved a later model (1971) Kombi van (Accident 049). The two occupants were both wearing lap and sash seat belts and they both sustained bruises from the webbing of the belts. The impacted area extended above the bumper bar (Figure 24) because the other vehicle, a Ford Falcon utility, was struck on its right side on and behind the rear wheel, and the rear overhang of the utility rode up over the front bumper bar of the Volkswagen. The left front door of the microbus was buckled

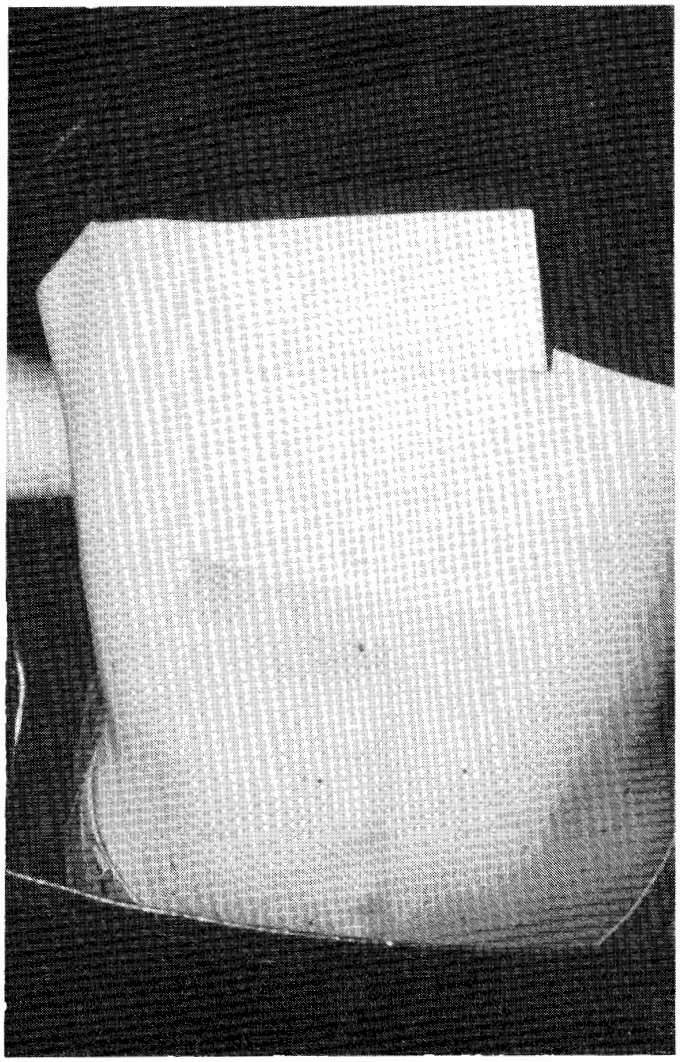


FIGURE 18:

Abrasions to driver's back caused by failure of Mini Moke seat back. Accident 233 (see Figure 17).

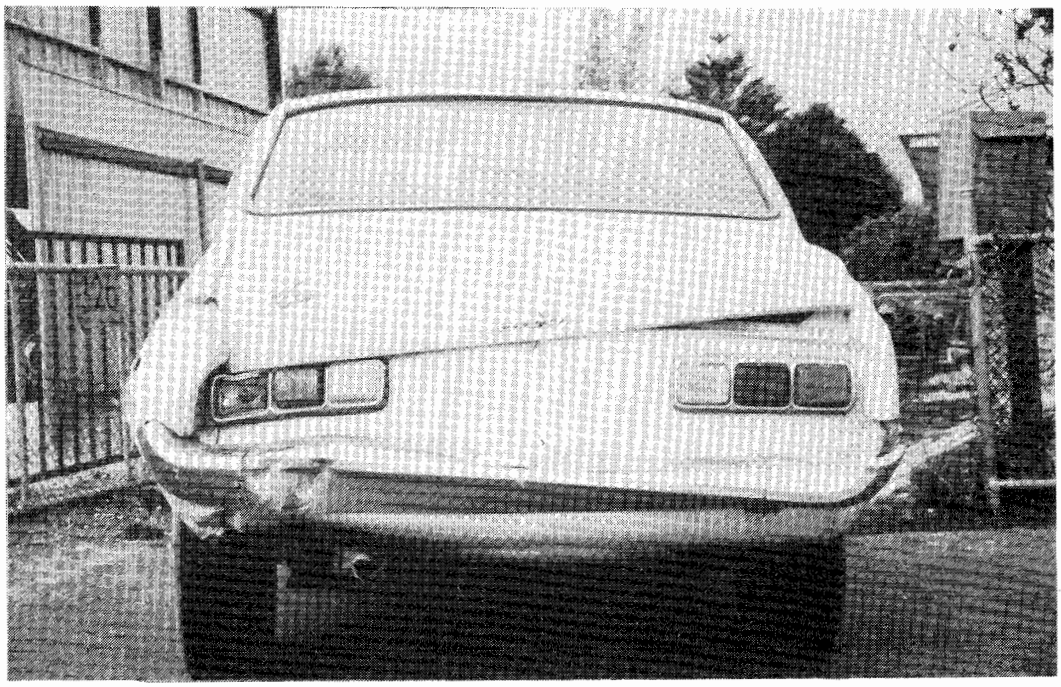


FIGURE 19: Rear of car struck by Volkswagen van. Accident 081.

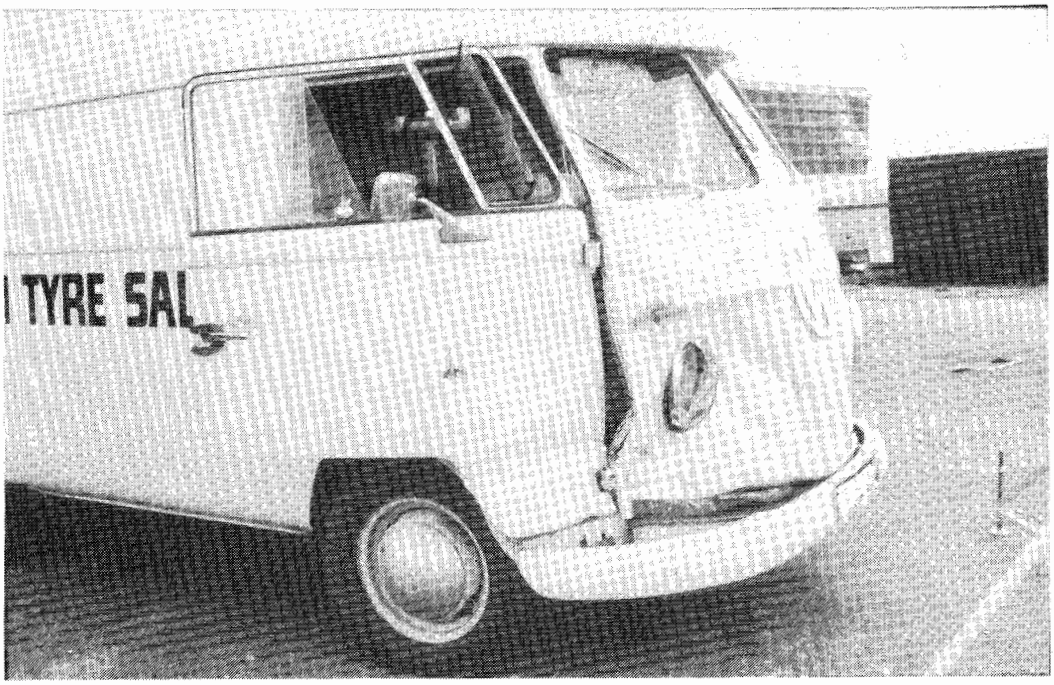


FIGURE 20: Damage to front of Volkswagen van. Accident 081 (damaged area has been forced forwards again to extricate driver).

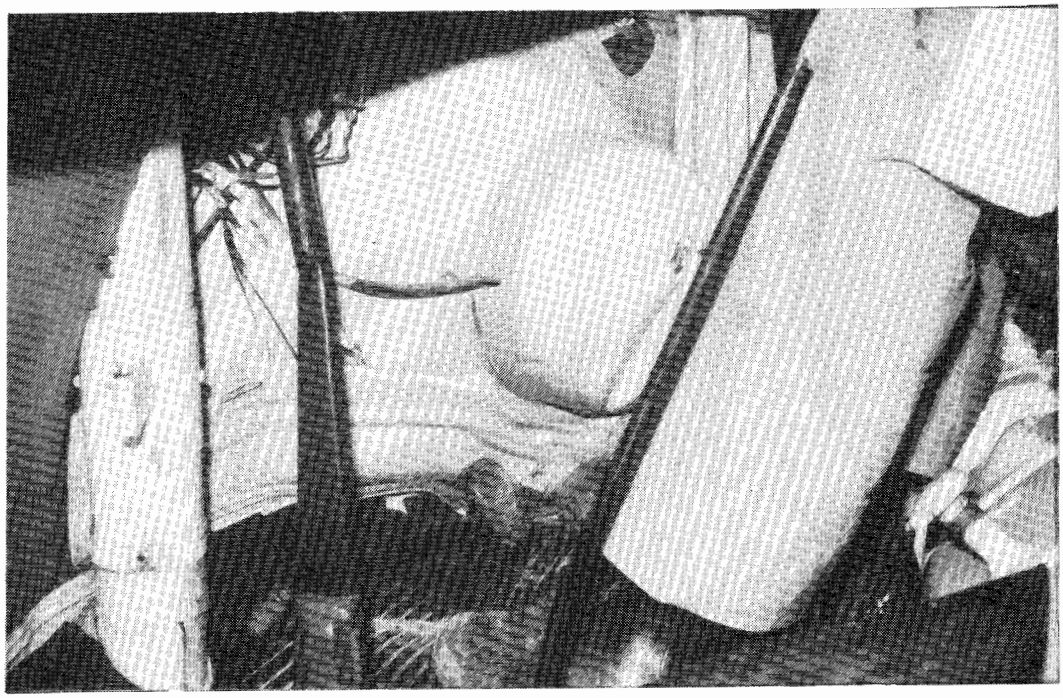


FIGURE 21: Legs of injured driver, trapped in Volkswagen van. Accident 081.

outwards as a consequence of the deformation due to the collision rather than from the left front passenger being thrown against it (Figure 25). This does illustrate the role that longitudinal stiffening of the door structure could play in resisting collapse of the front of the passenger compartment in vehicles of this configuration when involved in frontal collisions.

Even with additional reinforcement of the frontal structure it is difficult to envisage a satisfactory solution to the problems associated with impacts located above the front bumper bar, or with collisions with a pole or a tree, on a forward control vehicle of this type, simply because little deformation distance is available without encroaching on the passenger compartment. In this respect the situation is similar to that of impacts on the side of the passenger compartment of a car. The compliance test for ADR29 (side door strength) requires the use of a concentrated load rather than a flat barrier.

SEAT BELT AVAILABILITY AND USAGE

The availability of seat belts for the drivers of these commercial vehicles is shown in Table 10, together with the usage of these belts. The four drivers who were wearing, or probably wearing, a seat belt had belts which complied with either ADR4, 4A or 4B. Two of the available belts which were not worn, or not known if worn, complied with ADR4A, in one case, and 4C in another. Two of the five belts which showed signs of never having been used complied with ADR4A. The other belts were all fitted to pre-ADR vehicles.

There were six left front passengers involved, of whom four had belts fitted and available for use and three of these four were probably wearing them. Six vehicles had no left front seat, and in one other case no record was made of whether or not a belt was fitted. Twenty-four commercial vehicles did have a left front passenger's seat and 13 of them had a belt fitted to that seat, but four of these 13 belts appeared never to have been used. There were three impacts in which the use of a seat belt probably protected the wearer from injury, or from more severe injury. In one of these cases (Accident 049) both the driver and the left front passenger sustained bruising from the belts, as has been noted previously.

TABLE 10: SEAT BELT AVAILABILITY AND USAGE: DRIVERS OF COMMERCIAL VEHICLES[1]

	Availability of Belt				
	Belt fitted				
Usage of Belt	Available for use	Evidence of never being used	No belt fitted	Not known if fitted	Total
Worn	3	-	-	-	3
Probably worn	2	-	-	-	2
Probably not worn	-	1	-	-	1
Not worn	3	4	-	-	7
No belt available	-	-	12	-	12
Seat not occupied	-	-	1	-	1
Not known if worn	2	-	-	2	4
Total	10	5	13	2	30

Note: [1] Includes person in the driver's seat of a parked Mini Moke.

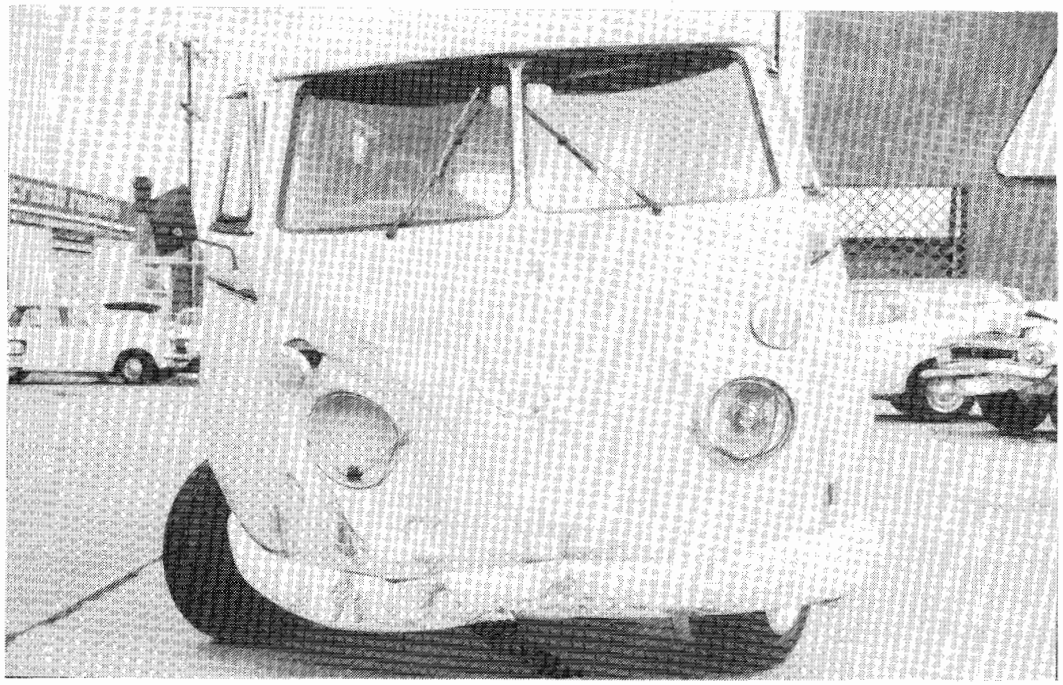


FIGURE 22: Damage to Volkswagen van in Accident 130.

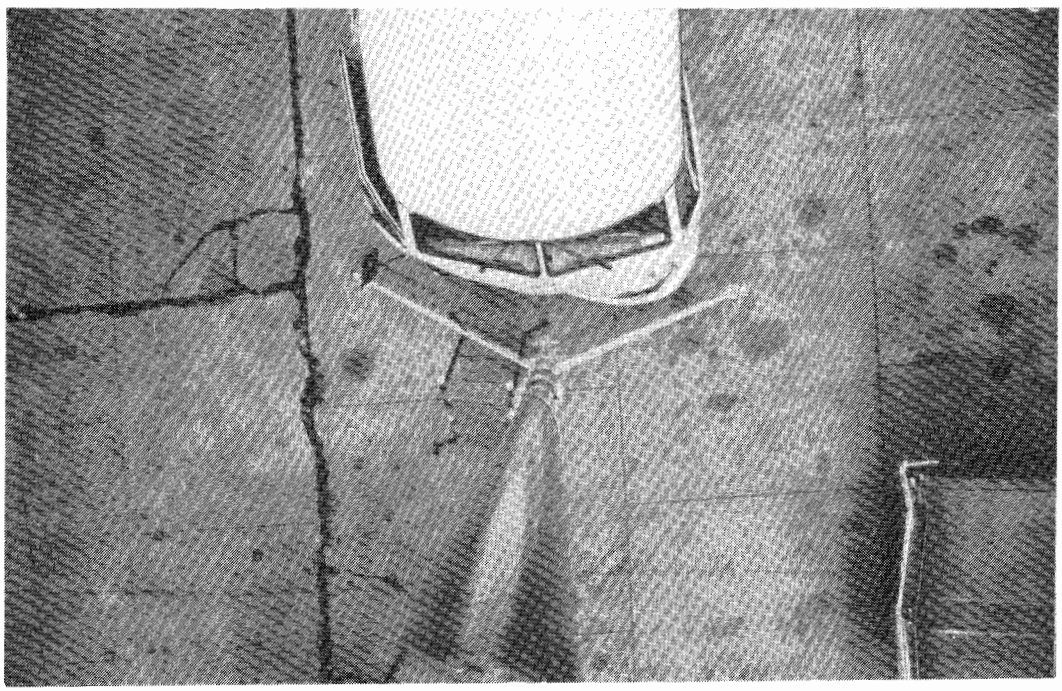


FIGURE 23: Damage to Volkswagen van in Accident 130.

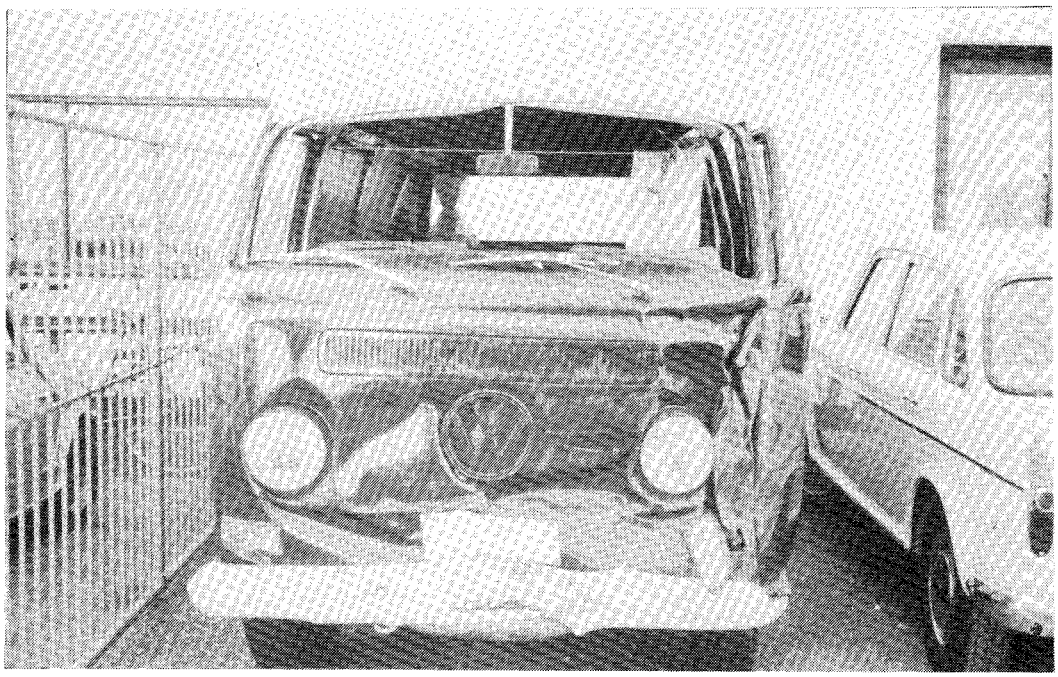


FIGURE 24: Damage to Volkswagen van in Accident 049.

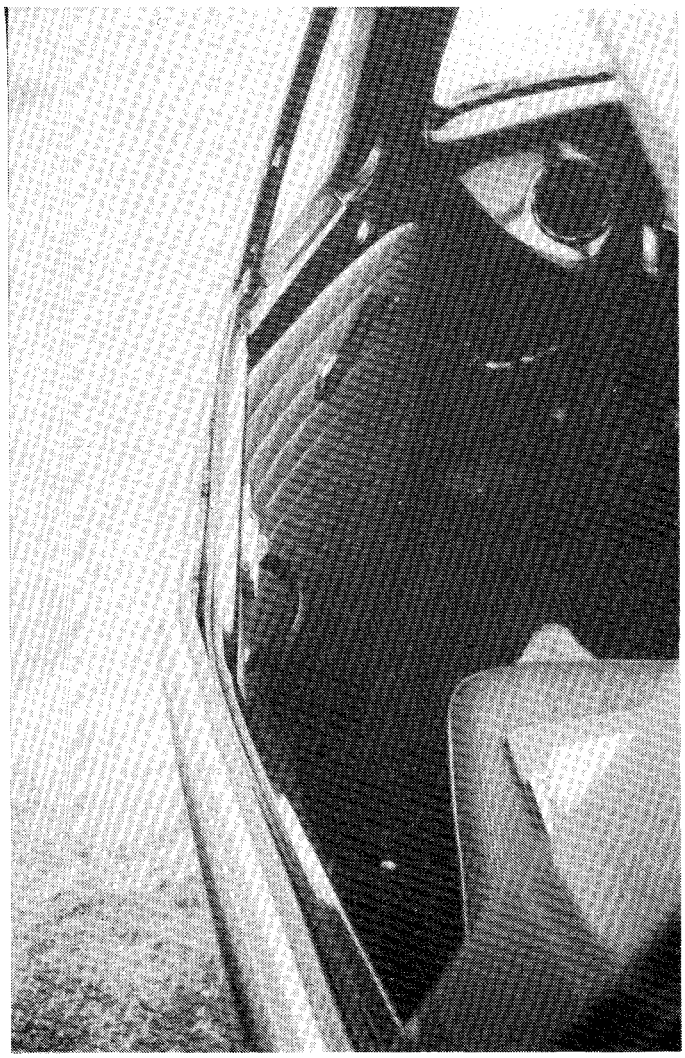


FIGURE 25:

Buckling of door of Volkswagen van involved in a frontal collision. Accident 049.

7. CONCLUSIONS

The accidents involving heavy vehicles in this survey were characterised by the relatively poor braking performance of the heavy vehicle, when compared to that of other vehicles in the traffic stream, by insecure loads and by the tendency for the heavy vehicle to over-ride a struck car, or motorcycle, because of the height of its front bumper bar.

The multi-purpose passenger vehicle's accident experience was closer to that of the car, but the basic configuration of the forward control vehicles and the absence from other multi-purpose vehicles of some now-elementary crash-injury protection features resulted in a higher average severity of injury to the occupants than would have been expected had they been in passenger cars.

These accidents mostly occurred between 8 a.m. and 3 p.m. This time distribution is reflected in the fact that alcohol intoxication was not an important factor and there were, in consequence, few single vehicle crashes.

8. RECOMMENDATIONS

Heavy vehicles are likely to inflict extremely severe damage to another vehicle in a collision and so it is recommended that:

> *In addition to actively pursuing all practicable means of further improving the braking performance of heavy vehicles, continuing consideration be given to other measures, such as loading restrictions and differential speed limits, which might decrease the hazards arising from the present discrepancy between the braking performance of heavy vehicles and that of passenger cars.*

Two of the accidents reviewed in this report were primarily a consequence of loads shifting. We therefore recommend that:

> *The consideration being given by the Advisory Committee on Vehicle Performance to the development of a national code of safe loading practice be expedited.*

and, in particular, that:

> *Half-cab trucks which are used to carry cargoes such as lengths of timber be required to be fitted with a forward-mounted barrier which will adequately restrain the load from shifting forwards under heavy braking and in collisions of moderate severity.*

In one accident the driver of a bus containing about 70 passengers was thrown onto the floor in a collision at an intersection. While the risk of a bus driver being dislodged from his seat in a collision may be low, the potential consequences could be very serious and so it is suggested that:

> *Seat belts be provided for the drivers of metropolitan transit buses to protect the driver from injury and to enable him to continue to control the bus after a collision, and that the wearing of these belts be required by law.*

In collisions involving such buses the passengers are likely to be thrown against objects inside the bus. It is therefore desirable for:

> *The fittings and seating of metropolitan transit buses to be designed in such a way as to minimize the risk of injury to passengers who may be thrown against them in a collision.*

The accidents in this study which involved a collision with the front of a heavy vehicle showed that there can be hazards associated with the relatively high front bumper bar on these vehicles and with snagging on protruding fittings. It is therefore recommended that:

> *The Advisory Committee on Vehicle Performance review the desirability of regulating the frontal design of heavy vehicles, including the design of components such as bullbars, so as to ensure that the damage inflicted in a collision on passenger cars and on other road users, including cyclists and pedestrians, is minimized.*

Multipurpose passenger vehicles are commonly used as passenger cars, but they are permitted to have a level of occupant protection which is below that of passenger cars. The special nature of some of these vehicles does distinguish them from other passenger cars but nevertheless it is suggested that:

> *Multipurpose passenger vehicles, and any vehicle which can, in one of its variations, be classified as a multipurpose passenger vehicle, be required to comply with the Australian Design Rules for Motor Vehicle Safety which are applicable to passenger cars.*

Forward-control multipurpose passenger vehicles may satisfy frontal barrier collision tests but not provide adequate protection against more concentrated frontal impacts. As there is no compliance test relating to such impacts for passenger cars it is suggested that:

> *Consideration be given to the advisability of introducing a compliance test involving a frontal collision with a narrow barrier, or pole, and that this test be applicable to multipurpose passenger vehicles in addition to passenger cars and passenger car derivatives.*

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