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SCHOOL BUS COLLISION SUMMARY
CANADA 1989-1997

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17. Abstract

This report summarizes a select sample of school bus incidents that have occurred in Canada during the years 1989 to 1997. The cases studied were investigated by Transport Canada's Multi-Disciplinary Collision Investigation Teams. Crashes involving serious injuries are over-represented in this case series, since it is more likely that these incidents would come to the attention of the teams. The results are discussed in terms of their possible application to the improvement of safety of school buses.

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School Bus Collision Summary
Canada, 1989 - 1997

ABSTRACT

This report summarizes a select sample of school bus incidents which have occurred in Canada during the years 1989 to 1997. The cases studied were investigated by Transport Canada's Multi-Disciplinary Collision Investigation Teams. Crashes involving serious injuries are over-represented in this case series since it is more likely that these incidents would come to the attention of the teams. The results are discussed in terms of their possible application to the improvement of safety of school buses.

BACKGROUND

The safe transportation of children to and from school has been of great concern to Transport Canada for many years. The introduction of a number of safety standards in 1982 resulted in many safety improvements such as the elimination of rigid, metal backed seats with hard grab handles. Currently, 37 safety standards apply to school buses and these are constantly being reviewed and amended as necessary. Some of the more important ones involve stop arm requirements, fire retardant materials for seats, fuel retention during a collision, emergency exits, ensuring that the joints made in the construction of the bus do not separate, mirrors, energy absorbing padded seats and padding for certain areas of the bus. The requirement for seat belts on school buses was proposed in 1978 but removed from the final regulation due to adverse comments.

In 1984, a test program to determine the effects of adding lap seat belts to school buses was undertaken. Three different sizes of school buses were towed into a rigid barrier at 48 km/h to simulate a severe frontal collision. There were six test dummies on board each bus, three with belts and three across the aisle without belts. The report [1], published in 1985, has been widely quoted. The major conclusion was: "*The use of lap seat belts in any of the three sizes of recent model school bus which were tested may result in more severe head and neck injuries for a belted occupant than for an unbelted one, in a severe frontal collision*."

Despite this conclusion, the possibility existed that seat belts, known to be highly effective in preventing death and injury to occupants of passenger cars, could be of benefit to school bus

occupants. A sled test program was undertaken in 1986 to determine whether or not the potentially adverse effects of lap belts on head/neck injuries could be eliminated with the use of more heavily padded seats, by adding single or double shoulder belts or by facing the seats rearward. The only methods which appeared to increase the level of safety already provided were the use of combination lap and single shoulder belts, and the use of rearward facing seats. The use of lap-shoulder belts would require that strong supports be provided to accept the forces for the seat belt anchorages, particularly the upper anchorages. This would negate the effects of the soft, energy absorbing seats currently provided, and thus the rear facing option seemed to be the most practical solution.

In order to establish what types of operational problems might be encountered with the use of rear facing seats, a demonstration program was undertaken in the 1987-88 school year. Buses equipped with rear facing seats were used in a wide variety of locations across Canada. Only older children experienced any discomfort, indicating that the desire to face forward is learned. The few problems which were found could likely be eliminated by introducing the seats to younger children first, and following these students through the grades.

INVESTIGATIONS OF PREVIOUS COLLISIONS

The investigation of collisions involving school buses has been given the highest priority within the collision investigation program. All fatalities or injury producing collisions which involve a school bus and which come to the attention of one of our university-based research teams are investigated in depth.

A summary of 58 collisions from 1977 to 1988 was prepared and some of the results were contained in a 1989 Transport Canada publication on occupant protection in school buses [2]. Of the 58 collisions summarized, nine involved buses which were manufactured after 1982 and which received benefit from the safety standards published in the preceding period. These are referred to as “post-1980 standard” buses.

The important findings [3] determined from the nine reports involving post-1980 standard buses in the 1989 summary were:

- Since there were no cases of ejection, even though there were four severe rollovers, the windows were effective in retaining the occupants in the bus.
- No ruptures of joints occurred in any of the nine cases even though five of these cases were severe.
- Ten major injuries were sustained by the 248 occupants. Nine of these injuries were the

result of intrusion by an object or vehicle into the bus, and one was a result of the occupant lying prone and asleep on the seat. Seat belts would not likely have reduced the injury levels.

- In two collisions the fuel tank was directly impacted but was protected by the cage installed in response to the standard. No leaks occurred.
- Mirrors were recognized to be a problem since two pedestrians were run over by their bus.
- Children disembarking from the bus seemed to be at greater risk than occupants of the bus.

The buses appeared to perform well from a crashworthiness perspective but improvements were indicated in order to avoid incidents involving pedestrians in close proximity to buses.

CURRENT STUDY

In this study, the criteria for a report to be included are:

- The case was investigated by one of the Multi-Disciplinary Collision Investigation teams.
- A child was involved.
- The incident occurred after January 1, 1989. (This ensured that the case had not been included in a previous summary.)
- A school bus built after December 31, 1982 was involved. These were “post-1980 standard” buses or buses built after the school bus standards became effective.

Every attempt is made by the university teams to investigate serious school bus incidents. All incidents of which the teams receive notification and in which a fatality to a student occurred through involvement with a post-1980 standard school bus, from 1989 to 1997, are included. Incidents involving injury or potential injury are included only if they came to the attention of one of the teams and the sample is not expected to be complete.

In the majority of school bus collisions there are no injuries to the occupants of the bus [4] and it is unlikely that they would be investigated. This sample is thus biased toward those incidents which produce serious injury. If the bus is not operating on a regular school route but is carrying children on an activity, it may or may not be relevant to the safety standards and the incident may or may not be included.

RESULTS

The sample represented 42 cases involving 567 students. Five bus occupants were fatally injured, two due to a side impact by a dump truck, one as a result of an external object penetrating the occupant compartment, and two in a collision-induced fire. Twelve children who had disembarked from their buses were killed, 11 being run over by the bus, and 1 who was struck by a vehicle passing the bus.

The collisions involved 8 rollover incidents, 10 frontal impacts, 9 rear impacts, 5 right side impacts and 5

left side impacts. There were two vehicle fires, and a single case of occupant ejection. This situation is summarized in Table 1 Appendix A.

The injury results are presented in Table 2, *Injuries to Occupants* and Table 3, *Injuries to Pedestrians* in Appendix A. In reporting injuries The Maximum Abbreviated Injury Scale [5] was used in the case reports for the incidents except where MAIS 6 was concerned. This rating system reports injuries by a numerical scale in which:

AIS	*CATEGORY*
0	No Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum
9	Unknown

The scale relates to injury and it is quite possible for a death to occur from a non-codeable injury such as that resulting from smoke inhalation. For clarity, therefore, in the tables found in Appendix A, AIS 1 to 5 is as in the table above, but AIS 6 is replaced with a listing of fatalities. If an AIS 1 through 5 injury results in a fatality, it appears in the column for fatalities.

One type of collision merits special mention. It is possible for school children to be transported in vehicles which do not meet the school bus standards. These buses are often used to transport school sports teams to events either during or after school hours. In two cases not included in the tables, students were injured in buses which did not meet the standards. Injuries were definitely increased by the presence of overhead racks which would not meet the requirements for head protection.

No changes to the school bus safety standards for new vehicles will improve the level of safety that non-complying buses provide school children.

Non-complying bus

The provincial/territorial authorities and school boards should be encouraged not to use vehicles that do not meet the safety standards for school buses in order to transport children.

DISCUSSION OF RESULTS

From Table 1, it is evident that cases involving pedestrians are the most prevalent in this breakdown. The types of vehicle to vehicle collisions are fairly evenly divided.

Front and rear impacts are twice as common as impacts from either side, and rollover collisions are surprisingly frequent. Fires and ejections are rare.

From Table 2, it can be seen that the majority of occupants (378 of 548) are not injured, even in this sample. Furthermore, 135 occupants in 26 crashes sustained only minor cuts and bruises while 5 received a fatal injury. Considering that many collisions occur which do not involve an occupant injury, and are thus not in this sample, occupant protection is apparently very effective in the majority of school bus crashes.

From Table 3, it is evident that the most serious problem is that of pedestrians being run over by their own school bus. Eleven of the twelve pedestrian fatalities, and several injuries to 18 children who were standing or walking, were from this cause. In 3 of 7 injury cases, the injuries resulted from the child being dragged or rolled on the pavement under the bus which struck them. This serious situation could easily have resulted in fatal injuries.

SELECTED CASE SUMMARIES

In the majority of cases, the minor injuries sustained by occupants in sometimes severe crashes indicate that the presence of seat belts on the buses would have made little difference to the outcome. However, this is not always necessarily the case.

Rollover

In one incident, a large bus left the road and rolled on its right side, slid down an embankment and hit a drainage ditch. Six children received minor injuries but one child suffered a lacerated spleen when she was thrown into the door area. Although spleen injuries sometimes result from seat belts, it is more likely that she would not have been injured had she been restrained.

In another case, a school bus entered a ditch on its left side and was in the process of rolling onto its roof when it struck an earth ridge with the roof. The bus rotated about the front of the roof and completed a pitch pole revolution, striking the ground violently with the rear bumper. Due to the complex and violent dynamics of the collision, the 17- and 18-year-old students would be thrown upward and forward and then forced violently down and across toward the rear of the bus. The major damage to the interior of the bus consisted of deformation to the seat backs on the rear right side.

Deformation to seat backs

The collision resulted in a moderate laceration to the back of one student, and a broken collar

bone to another, plus several minor injuries to the 15 students involved. Considering the complex and violent dynamics of the collision, the injuries were neither frequent nor severe. The occupant compartment functioned well in preventing injuries but the injuries which did occur may have been prevented had seat belts been present.

Side Impact

In two side impact cases, children were injured due to contact with other children. These children may not have received injuries, or their injuries may have been less severe, if they had worn belts.

Ejection

In 26 collisions involving 548 children, 8 of which were severe rollovers, only one case of ejection occurred.

In the only case of occupant ejection, a child was thrown onto the roadway when a school bus was impacted in the side by an ambulance and the rear emergency exit came open.

Emergency exit opened

The child suffered critical, non-fatal head injuries from impact with the roadway. She would not have been ejected had she worn a seat belt.

Intrusion

It is possible that seat belts could, by limiting the motion of a child when an object intrudes into the bus, cause injury. In one case the occupied rear seat was pushed into the seat in front by an intruding tractor-trailer.

The child was trapped but uninjured. This illustrates why seat belts, if installed, must be attached to the seats of the bus, and not the floor.

Bus struck by tractor-trailer

Forward deformation of bus seats

Intrusion was the cause of two fatalities. The head of one child suffered direct contact with the intruding hood of a loaded gravel truck.

Bus struck by gravel truck

In a second incident, a child was killed by a steel plate entering the bus after the plate fell off a passing truck.

Fire

Fire was a factor in two cases. In one, a school bus hit a passenger car and a fuel fire resulted. The driver opened the front door but, on seeing the fire, had the children leave through the rear emergency exit. Both doors were left open, allowing the flames to enter and travel the length of the bus above the seats. The interior of the bus was engulfed in flame within the six minutes that it took the fire department to respond.

Seats burned from the top

All of the seat backs and part of the cushions burned after being ignited from the top. The quick exit of the children prevented injury.

In the other case, a large tractor-trailer carrying fuel hit a small stationary school bus causing severe damage to the bus and propelling it through a guard rail into a field. A fitting on tanks mounted under the bus broke causing a propane flame to be directed forward on the floor of the bus. Two unconscious children died in the fire.

Visibility

Visibility was a factor in several incidents.

In one collision, through poor choice of route, a school bus was attempting to cross four lanes of traffic when it was hit on the side by a gravel truck.

Poor visibility

Fuel tank impact

It was determined that the bus driver would have had difficulty seeing the approaching truck due to the arrangement of the window frames and mirrors on the right side of the bus. Two other collisions were attributed to right side visibility.

Pedestrians

Most of the pedestrian incidents resulted from the bus driver not seeing the children who stopped to pick up a dropped book or who fell.

The combination of a number of children in close proximity to large school buses was a factor in three cases. Two school buses ran over children after being struck by another school bus. In the other case a child ran out from between two school buses and was struck by another bus.

REGULATORY IMPACT

In two cases, school buses were struck very hard in the area of the fuel tank without loss of fuel.

The fuel integrity standard appears to be effective in protecting non-pressurized fuel tanks. The fact that two children died in a propane fire indicate that the design of this type of fuel system bears consideration. Of concern is the fact that in one case the seat covering material burned from the top down in approximately six minutes when ignited by a flame above the seats. The requirements for fire resistant seat covering should be re-examined.

In all of the cases in which the primary exit was blocked, occupants were able to leave the bus through the emergency exits. In the case of the propane fatality, children were able to escape via the rear emergency exits. In one case, investigators expressed concern that the rear door might be too heavy to open if the bus had rolled on the other side but the exits seemed to be effective.

There were no children ejected through any of the bus body joints nor were any injured by separated joints. In one case, however, a body joint separated above the entrance door and presented a sharp edge.

Joint separation

The location of the separation was not considered to be covered by the standard because it was in a maintenance area. Perhaps this exemption should be reconsidered.

The visibility standards came into question in two cases where the bus was impacted by a truck approaching from the right side. A recent modification to the design of one type of new bus reduces the width of the front vertical structure considerably with the result that the right side visibility is greatly improved.

Improved visibility

The problems associated with children being run over by their own school bus must be addressed. A passenger control device to ensure that disembarking children must stay far enough in front of a bus to remain visible to the driver should be considered for all buses. Amendments to the requirements for mirrors designed to improve the driver's ability to see a child in front of or beside the bus became effective in 1997 [6]. Further improvements in this area, such as retro-fitting new mirror systems, and the use of monitors, will likely fall into the area of provincial/territorial jurisdiction since these jurisdictions deal with the operation of school buses.

Seat belts were an issue in four cases. One injury from a one quarter rollover and two cases of injury in side impact may have been prevented by seat belts. The single case of ejection is of concern. However, the small number of serious injuries which are thought to have been preventable by seat belts seems to indicate that current buses perform very well in protecting occupants from injury.

The safety standards currently rely on providing passive safety in the form of a padded compartment to reduce injuries. The provision of a passive protection compartment appears to work well for most occupants but the integrity of the compartment must be maintained. In the case where a child was ejected through the rear emergency exit, the child would not have received the critical head injuries had she been retained within the compartment with the other three children.

The compromising of the occupant compartment in the one

case of ejection through the rear emergency exit is being investigated to ensure that current requirements are adequate. In this case the large windows in the rear exit came free of the rubber molding and openings were provided which were sufficiently large that a child could easily have been ejected. The child was, in fact, ejected through the door, not the window, but there is still room for concern over a trend to larger windows in rear exits.

Larger windows

The latch requirements are being reviewed.

The fact that only one ejection was found in the study indicates that the side windows and frames continue to maintain the structural integrity of the compartment.

CONCLUSION

- Considering that this study is presumed to contain the most severe collisions during the eight-year period, Canadian school buses provide excellent occupant protection.

RECOMMENDATIONS

- The requirements for door latches, rear windows, joint separation, fire retarding materials and visibility out the right side should be reviewed.

- Although new requirements for school bus mirrors have been put into place, consideration of additional requirements that attempt to reduce the likelihood of the bus running over a child after stopping to allow a child to enter or leave the bus should continue to be a priority.

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SCHOOL BUS RELATED INJURIES, 1989-1997

Table 1 - Collision Types

Year	Front	Left	Right	Back	Rollover	Fire	Ejection	Pedestrian
1989	1	0	0	0	1	0	0	2
1990	1	0	1	0	0	0	0	1
1991	1	1	1	2	0	0	0	2
1992	0	1	0	1	1	0	0	5
1993	0	0	0	0	0	0	0	1
1994	1	0	1	2	1	1	0	0
1995	0	0	0	1	2	0	0	3
1996	1	0	1	0	1	0	0	4
1997	5	3	1	3	2	1	1	0
TOTAL	10	5	5	9	8	2	1	18

Table 2 - Injuries to Occupants

Year	C	O	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
1989	2	2	2	0	0	0	0	0	0
1990	2	35	26	6	2	1	0	0	0
1991	5	57	32	17	7	1	0	0	0
1992	2	32	27	5	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
1994	4	117	80	24	4	2	2	0	5
1995	3	122	88	33	0	1	0	0	0
1996	2	52	29	22	0	1	0	0	0
1997	5	107	94	28	6	2	0	1	0
Total	26	548	378	135	19	8	2	1	5

C = Number of collisions except those involving only a pedestrian
O = Number of occupants excluding the driver in the vehicle

Table 3 - Injuries to Pedestrians

Year	P	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
1989	2	0	0	0	0	0	0	2
1990	1	0	0	0	0	0	0	1
1991	2	0	0	0	0	0	0	2
1992	5	0	1	0	1	0	0	3
1993	1	0	0	1	0	0	0	0
1994	0	0	0	0	0	0	0	0
1995	3	0	2	1	0	0	0	0
1996	5	0	0	0	1	0	0	4
1997	0	0	0	0	0	0	0	0
Total	19	0	3	2	2	0	0	12

P = Number of pedestrians involved