THREE POINT SEAT BELTS ON COACHES - THE FIRST DECADE IN AUSTRALIA

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(Credit: Crashlab)

ABSTRACT

In July 1994 it became mandatory for Australian coaches to have three point seat belts in all passenger seats. This was the final part of a safety package that introduced improved rollover strength, improved emergency exits and other occupant protection initiatives. These measures followed two horrendous Australian bus crashes in 1989.

In Australia it is now common for groups, such as schools, to insist on coaches with three point seat belts for long trips.

The technical, operational and behavioural issues associated with three point seat belts on coaches are reviewed. Estimates of the effectiveness of these features in coach crashes are discussed.

INTRODUCTION

A serious downside with international harmonization of vehicle safety standards is that it too easily provides a "feel good" comfort zone for regulators and policy-makers. Sometimes it takes high media coverage of a tragedy to provide the political motivation to go beyond lowest common denominator (harmonization) and set a new world-leading benchmark in road user protection standards. Such a situation happened in Australia and led to the introduction of retracting three point seat belts on all passenger seats of new coaches.

Early in 1989 Australia was in the process of committing to international harmonization of coach occupant protection, with the intention of introducing a new Australian Design Rule based on ECE Regulation 80. In essence this required that coach seatbacks be strong enough and have energy absorbing properties to be able to 'catch' an occupant seated to the rear, and hence safely restrain them in a severe frontal impact.

However, late in 1989 two separate coach crashes occurred which resulted in 19 fatalities in the first crash and 35 in the second crash. Both were head-on crashes (the first with a heavy truck, the second between two coaches) in New South Wales on a two-lane national highway with a speed limit of 100km/h.

On-scene reviews by federal and state vehicle safety experts concluded that a regulation based on ECE 80 would not have been effective in these crashes.

Initial calculations indicated that nothing less than three point seat belts with a 20g crash force capability would offer adequate protection. This lead to the development of Australian Design Rule 68 (ADR 68) which became mandatory for all Australian coaches built from July 1994. Route service (urban) buses are exempt from ADR 68.

A Federal Office of Road Safety (FORS) Regulatory Impact Statement prepared in 1992 states that bus manufacturers and operators were critical of the proposed ADR and cited cost and weight penalties inherent in the package (FORS 1992). More than a decade later it is evident that those initial concerns were unfounded and acceptance of this rule by government, industry and road users is reportedly high.

In recent years consumer demands (particular school excursion/tour groups) have brought about a need for retro-fitting packages and/or phasing out of older coaches not fitted with three point seat belts.

Surprisingly, this Australian initiative has not been widely adopted internationally. Some researchers and regulators continue to debate the technical feasibility and consumer acceptance of three point seat belts on coaches, despite the use of such systems in Australia for more than 10 years

DYNAMIC TESTING OF PROTOTYPE SEATS AND SEAT BELTS

When ADR 68 was legislated coach seat manufacturers were initially reticent to conduct the necessary development work to produce seats which complied with the ADR. This had the potential to delay or abort the introduction of ADR 68 because, if

complying seats were not available, then coach manufacturers and purchasers could legitimately have requested indefinite delays in the introduction of the rule.

To prevent this occurring, the New South Wales Roads & Traffic Authority (RTA) made an offer to coach seat manufacturers that there would be no fees for testing and assessment of their developmental prototype seats by the RTA Crashlab research and test facility. Initially manufacturers were reluctant to take up this offer.

Once the industry realised that the offer was for a limited time and that it involved considerable cost savings then successful collaborative development and test programs commenced. It wasn't long before enough seat manufacturers took up the offer to ensure the availability of ADR 68 seat and seat belt products in Australia.

Another widely held industry perception was that the more than doubling of the seat strength required would lead to significant increases in the weight of seats, which in turn, would reduce passenger capacity (FORS 1992). This would have affected the economics of coach travel.

Some of the early prototype seats did indeed get heavier. Manufacturers tried to meet the new standards by 'beefing up' (strengthening) the existing product with additional steel bracing.

These "beefed up" prototypes did not perform well in the testing process. Coach seat designers therefore decided to start with a 'clean sheet' and modern design tools. Taking this approach, seat manufacturers soon came up with seats which were more than twice as strong, weighed less and were not significantly more expensive (excluding the cost of seat belts) to produce than the original product.

Figure 1. Wall/floor mounted bus seat with integral three point seat belts (Styleride)

Before ADR 68, Australian coach seats typically weighed 30 to 35 kg per pair. The latest Australian seats weigh as little as 25kg per pair with seat belts. For comparison, U.S. seats without seat belts are reportedly in the order of 40 kg per pair.

When ADR 68 was introduced there were approximately five coach seat manufacturers in Australia. For various reasons there are now two major suppliers of coach seats in Australia (McConnell and Styleride), with one of the bus manufacturers, Autobus, producing some of their own seats. Reportedly a very small number of bus seats are imported.

Besides new coaches, there is now also a relatively active retrofit program for ADR 68 seats in Australia.

Seat sales

Based on advice from the two major manufacturers of coach seats in Australia it is estimated that, since 1994, between 4,000 and 5,000 coaches have been fitted with ADR 68 seat and seat belt packages.

McGuire et al (2002) reported that, as at 2001, in New South Wales, 60% of registered buses (route service buses and long distance coaches) had been built before 1994 . This suggests that in 2001 about 40% of all registered coaches should have been fitted with ADR 68 seat and seat belt packages. Based on the turnover of the fleet, it is estimated that, currently, more than 60% of Australian coaches have ADR 68

Figure 2. Floor mounted bus seat with integral three points seat belts (McConnell)

seat and seat belt packages. Importantly, new buses typically travel three times further each year than buses that are ten years or older (FORS 1992). Therefore the total annual kilometres for buses equipped with three point seat belts is likely to be much higher than 60% of all long-distance bus travel in Australia.

New coach purchases

The necessary lead time for the introduction of ADR 68 may have allowed some coach operators to order additional new buses for delivery before July 1994, so that they could avoid having the buses fitted with seat belts. There was reportedly a flurry of pre July 1994 coach building and a short term downturn in the manufacture of new buses following July 1994.

At around the same time the introduction of significantly cheaper air travel in Australia led to a further downturn in the requirement for new coaches. The competition from airlines also meant that some coach operators ceased business. As a result a cheap source of pre-July 1994 coaches came onto the Australian market. This may have resulted in a temporary setback in the uptake of coaches with three point seat belts.

CRASH PERFORMANCE

Fortunately, up to the time of writing, there has been no repeat of the catastrophic 1989 crashes in Australia.

Since 1994 there have been several serious bus crashes but no seat belt wearing occupant has been reported as receiving fatal or disabling injuries in any of these crashes. Paradoxically, the lack of serious coach crashes has resulted in a low level of in-depth investigation of coach crashes since 1994.

One reported crash to a coach occurred in a predominately frontal impact with the crash pulse assessed as equivalent to a 6g peak deceleration.

This coach was built in 1996 had 52 seats with three point seat belts. It was fully occupied and according to the tachograph was travelling at approximately 85 km/hr when it impacted a culvert. Post-crash inspection of the vehicle indicated that 47 of the 52 occupants were wearing their seat belts at the time of the crash. The two fatalities occurred from an unrestrained, sleeping relief driver who was thrown forward and his head struck the base of a seat. The second was a 12 year old child sleeping in the aisle. The remaining three unrestrained occupants had impacts with the seats ahead of them.

In another sideswipe crash between a truck and a coach, only one coach occupant received significant injury. In that case, the occupant (who was a tour guide) was unrestrained and was thrown forward into the footwell of the coach where their lower leg was partially amputated by intruding objects.

Further details of these and other crashes of coaches fitted with seat belts will be available in time for presentation at the ESV Conference in June 2005.

The Regulatory Impact Statement (RIS) that was prepared for ADR 68 did not attempt to estimate the effectiveness of three point seat belts on buses (FORS 1992). Instead the RIS indicated that the costs of building buses to ADR68 would be offset if the trauma cost were reduced by 20% to 41% (for a range of assumptions that have subsequently turned out to be too conservative).

Given the lack of severe coach crashes since 1994 and the lack of in-depth studies it is not possible to estimate the effectiveness of three point seat belts from Australian data. An estimate can, however, be made from US reports that have evaluated school bus crashes (Paine 2004, Peder 2002).

Crashes potentially influenced by lap/sash seat belts

Lap/sash seat belts could be expected to reduce injuries in frontal, side and rollover crashes of buses. Of crashes in which US school bus passengers were killed, 33% were frontal collisions and 26% were side collision (NHTSA 2002) . The number of rollovers (without prior frontal or side collision) is unknown but is no more than a few percent. It is therefore estimated that about 60% of all bus crashes in which passengers are injured could be expected to be influenced by lap/sash seat belts.

Effectiveness of three point seat belts in relevant crashes

NHTSA estimates that lap/sash seat belts would be 50% effective in reducing passenger fatalities in frontal crashes (NHTSA 2002). No estimate is given for other crash configurations but the authors note "properly used lap/shoulder belt systems have the potential to be effective in reducing fatalities and injuries in other (non-frontal) crashes. Belt systems are particularly effective in reducing ejection in rollover crashes" (NHTSA 2002).

Assuming these values also apply to Australian long distance coaches then three point seat belts could be expected to save about 30% of all fatal and serious injuries to coach occupants. This is within the range

for cost effectiveness derived by FORS (1992) and based on very conservative assumptions about costs. This indicates that the lighter, cheaper seats that are now being installed in Australia are cost effective *on long-distance coaches*. This is regarded as a bonus because the original justification for ADR 68 was based, in part, on public expectation of higher standards of safety for coach passengers (FORS 1992).

These estimates are based on the assumption that all coach occupants wear their seat belts. Additionally it is noted that unrestrained occupants become a hazard to restrained occupants in severe crashes. Seat belt wearing rates are therefore an important factor in the continued success of the coach safety improvements.

SEAT BELT WEARING RATES

When the ADR 68 package was first introduced in Australia in 1994, the New South Wales Department of Transport (DOT), in conjunction with the RTA, committed to introduce programs to encourage high seat belt wearing rates, once coaches became available with seat belts.

It was envisaged that the seat belt wearing programs would be based on aircraft safety style briefings at the commencement of a journey.

There were already a number of activities which were prohibited on coach travel, and which, if breached, meant that a passenger would be offloaded, that is, they were essential conditions of travel. These included:-

- no alcohol consumption
- no smoking, etc.

It was planned to give a briefing where passengers were told that it was a condition of travel that the seat belt be kept fastened at all times, unless they were en route to a onboard rest room.

The planned briefings were to be standardized video presentations, where the development and supply of the videos was to be undertaken by the RTA. Where video facilities were not available on a coach (anticipated to be extremely rare for new coaches), then a standard briefing would be required to be read by the driver. As the bus regulator, the DOT had the authority to make it a condition of operation that these briefings were given at the commencement of a journey.

Unfortunately organisational changes within both departments during the 1990s meant that these commitments were not implemented. Furthermore we are not aware of any objective observational studies of the use of seat belts in coaches in normal charter or inter-city coach operations in Australia.

School bus trial

In a review of school bus safety in Queensland in 2001 by the School Transport Safety Task Force, the prospect of seat belts on school buses was examined.

Despite receiving evidence to the contrary, the Taskforce recommended a gradual introduction of seat belted buses into the school bus fleet.

In response to the recommendation, the Queensland government conducted a trial between January and June 2003. Seat belts were fitted to 12 school buses operating on long, steep and very steep routes in Queensland. An automatic mechanical/electronic seat belt wearing detection system was developed and fitted to six of the buses (Roper 2003). It had a switch in each seat belt buckle to determine whether the belt was fastened. Cabling was used from each individual buckle to data logging equipment at the rear of the bus.

Wearing rates varied widely from 14% to 89% with an average of 45%. Encouragement to wear the belts by teachers and parents had little effect on compliance. Teachers and parents interviewed and surveyed showed a tendency to significantly over-estimate wearing rates.

Overall, the study reported:-

- *The seat belt wearing rates recorded by this new system during the trial were generally low, even in areas of high encouragement. This indicates that some form of regulation is required to persuade students to wear the seat belts.*
- *The low wearing rates may also be the result of the design of the seats and belts, with many students reporting that they were uncomfortable and difficult to take on and off. This is compounded by the attempts of students to move around and talk to their peers around the high back seats.*
- *The misconceptions in the school community about seat belt wearing rates on the buses show that parents and schools are often unaware of what occurs on the school bus. This also indicates that there is a need for these groups to be more involved in the issue of school bus safety in order to increase wearing rates.*
- *Ultimately seat belts will not provide any safety benefits on school buses if they are not worn by the passengers. The results of this (Queensland) study show that the issue of seat belts on school*

buses is a complex one, requiring commitment from government, bus operators, schools, parents and students to achieve an effective compliance system.

Ultimately, the findings of this study identified many issues concerning the mandatory installation of seat belts on selected school buses.

Given the nature of the expert submissions made to the Queensland School Transport Safety Taskforce (that there are much more effective areas in which to spend money to improve safety of transport of children to and from school) this is probably a good outcome.

Wearing rates in Australian coaches

The information on wearing rates from those very few coach crashes that have been investigated shows a very wide disparity. The 1996 Tenterfield case showed a wearing rate of 47 out of 52(90%), whereas (unpublished) Police anecdotal records of several other coach crashes indicate wearing rates of less than 20%.

As stated earlier, no objective scientific observational studies have been conducted of seat belt wearing rates on coaches in Australia.

Three point seat belt equipped coaches were provided for delegate transportation to social functions at the 1996 ESV Conference in Australia, and ICrash 2002 in Australia. During these trips two of us observed wearing rates of well under 50%, despite the conference attendees being mostly experienced crash injury researchers.

It appears that the situation is very similar that of car seat belts in the mid-1960s - the technology has been sorted out but users are unaware of the severe injuries that can be sustained by (and due to) unrestrained occupants in crashes of relatively low severity.

There is clearly a need for an education program to encourage seat belt wearing by coach occupants.

CONCLUSIONS

During the research for this paper it became evident that registration and certification systems in Australia were no longer capable of easily identifying the individual or collective compliance of buses and coaches with individual design rules. What this means is that in any review of their relative safety, it is difficult to conduct comparative analysis of their performance.

In terms of monitoring the usage and effectiveness of seat belts on coaches in Australia, it became clear that there are no:-

- objective scientific observational studies of the usage of seat belts on coaches in normal use, and
- routine evaluations of the usage of seat belts on coaches involved in injury causing crashes in Australia.

However, it is likely that typical wearing rates are low (maybe 20%) and plans, developed in the early 1990s, to encourage coach occupants to wear seat belts should be resurrected. The need for such a program was notably absent from an RTA paper on heavy vehicle safety issued in 2003. The paper mentioned the widespread availability of seat belts on coaches but failed to acknowledge the potential problem of low wearing rates (RTA 2003).

Initial concerns about the cost and weight of seats fitted with three point seat belts have proved to be unfounded. The breakthrough was to abandon traditional seat designs and to develop new seats using modern engineering design tools. The resulting seats, fitted with seat belts, are no heavier (actually lighter in some cases) and not significantly more expensive than their predecessors. The importance of this outcome should not be underestimated - the potential benefits of seat belt restrained coach occupants has been achieved without increasing the cost of coach travel in Australia.

Australian coach seat suppliers report that typical ‘no frills’ ADR 68 seats with integrated seat belts but no accessories weigh approximately 25kg for a double, whilst a top of the range ADR 68 seat with accessories (recliner, footrest, trays etc.) weighs in at 30kg. This is significantly less than the 40kg typically reported for a double coach seat without seatbelts in North America.

The favourable weight and cost issues make it all the more surprising that this proven measure has not been more widely adopted elsewhere in the world The “not invented here” syndrome can lead to unfavourable outcomes for road safety.

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