Transportation Research Part A 67 (2014) 59–68

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Reduction of capacity and projected costs associated with seat belt installation on school buses

Saravanan Gurupackiam [a,*], Daniel S. Turner [b], Jay K. Lindly [b], Steven Jones [b], Elsa Tedla [b]

[a] School of Science, Engineering, and Technology, Penn State Harrisburg, W215 Olmsted Building, Middletown, PA 17057, USA
[b] Department of Civil Construction & Environmental Engineering, University of Alabama, Box 870205, Tuscaloosa, AL 35487, USA

ARTICLE INFO

Article history:
Received 22 June 2013
Received in revised form 13 June 2014
Accepted 16 June 2014

Keywords:
Seat belt
School bus
Capacity
Cost
Pupil

ABSTRACT

This study examines the potential effects the installation of seat belts on school buses would have on the fleet capacity in Alabama and the resulting cost implications. The study also documents the myriad research studies and professional opinions offered on the potential safety effects of equipping school buses with safety restraints/seat belts. Four seat configurations for the school buses were analyzed. The first configuration represents the most common current bus seating configuration without seat belts, 3 seats on each side of the aisle and 12 rows (3/3-12). The physical space required for seat belt hardware may result in a loss of a row of seats and may reduce the number of students seated per row. Thus, three more configurations were studied: loss of a row of seats (3/3-11), loss of one seat per row (3/2-12), and loss of both a row of seats and a seat per row (3/2-11). The capacity for each configuration for each bus using current pupil loads was determined. The costs associated with installation of seat belts, and purchase and operation of new buses were obtained. Should school bus seat belts become mandatory in Alabama, the results obtained in this study can be used by any school system to determine the optimum configuration for their pupils, which will identify the number of additional buses that must be purchased by the school system. This study found that many of the buses that would become overloaded due to seat belt installation and the resultant loss of seating will be carrying only a few excess pupils. Transportation supervisors may be able to handle such overloads by transferring these pupils to other buses or by adjusting their bus routes to minimize purchase of new buses. Additional suggestions for handling bus overloads were offered in the body of this report.

1. Introduction

School bus transportation is reported to be one of the safest modes of transportation in the U.S. (Hinch et al., 2002). Nonetheless, there are numerous accounts of tragic crashes involving schoolchildren on school buses (NTSB, 1989; Dornin, 2006; Berning and Yablonski, 2010; Carpenter, 2012; Taylor, 2012; Porter, 2013; Pizzi, 2013). Accordingly, there has been considerable research effort focused on school bus safety. Of particular interest in this paper are the myriad research studies and professional opinions offered on the potential safety effects of equipping school buses with safety restraints or seat belts (Severy et al., 1967; Wineland, 1986; Spital et al, 1986; Widome, 1988; Hall, 1996; McCray and Barsan-Anelli, 2001; TRB,

* Corresponding author. Tel.: +1 717 948 6493.
E-mail address: szg10@psu.edu (S. Gurupackiam).

http://dx.doi.org/10.1016/j.tra.2014.06.005
0965-8564/

2002; Lapner et al., 2003; Griffiths et al., 2005; Turner et al., 2005; Graham and Tsai, 2006; McGeehan et al., 2006; AAP, 2007; Tedla et al., 2009; Frisman, 2010; Lou et al., 2011).

Understandably, education administrators and politicians throughout the U.S. have expressed interest in determining the feasibility and benefit of equipping school buses with seat belts. The purpose of this paper is not to establish or disprove potential safety benefits of equipping school buses with safety belts. Rather, this paper examines the potential effects the installation of seat belts on school buses would have on the fleet capacity in Alabama and the resulting cost implications.

2. Background

The capacity implications of modifying school bus seating configurations to accommodate the installation of seat belts have potentially significant financial impacts. To date, there have been no conclusive studies on the seating capacity loss attributable to school bus seat belt installation. Previous studies (see Table 1) have estimated capacity reductions ranging up to 33% per vehicle.

2.1. School bus configurations and seating capacity

In order to assess the potential impacts of seat belt related modifications in Alabama, a set of standard (typical) bus configurations were identified. The study was constrained to large school buses with existing seating capacities of 71–72 passengers across 12 rows, as these comprised the majority of buses in the statewide fleet.

Modern school buses have rows of seats flanking a central aisle. Seats are roughly 1 m wide and typically hold three elementary children per seat. Rows are 0.53–0.61 m apart, and the aisle is 0.30–0.35 m wide. Three small pupils can sit on each side of the aisle, so this is called a 3/3 configuration. Another configuration allows five pupils per row with three on one side of the aisle and two on the other. This is called a 3/2 configuration and has 1 fewer seats per row than the 3/3 configuration. Seatbacks for current buses are 0.50 m and taller, but a recent NHTSA regulation raised the minimum height to 0.61 m (NHTSA, 2008) for new bus purchases. Seatbacks must be at least 0.71 m high to accommodate the installation of belt systems. Seat belt buckles are placed 0.38 m apart, so three belts cannot be placed on a 1 m wide seat, and fewer children can be accommodated on each row when belts are installed.

3. Analysis

3.1. Route report data

Annual school Route Reports were obtained from the Alabama State Department of Education (ALSDE) that contained details of 7327 school buses for 67 counties and 66 cities from 2008 to 2009. For each bus, its report contained the bus number, route type, and number of pupils in addition to the numbers and grade levels (elementary, middle, and high) of schools served.

A range of potential seat configurations were analyzed to reflect: (a) number of rows and seats/row, (b) pupils per seat based on grade level (size), and (c) the number of pupils currently assigned to each specific route. For each bus, the analysis compared the current configuration with potential configurations after seat belt installation. Since no exact data exists on how many of each student grade level ride each bus, assumptions regarding the mix of student grade levels on buses were made based on observations and findings in the literature (ITRE, 2007). The resulting analysis was based on the following assumed seating capacities:

- For a 3/3 configuration, the seats on both sides of the bus can hold either three elementary pupils or two high/middle school pupils.
- For a 3/2 configuration, the wider seat can hold three elementary or two high/middle school pupils. The narrower seat can hold two pupils of any age (size).

If a bus transported pupils exclusively to one grade level (elementary, middle, or high school), all pupils on the bus were assumed to be in that grade level. For buses transporting pupils to more than one grade level, the following scenarios were analyzed:

Table 1
Reported potential bus capacity reductions attributable to installation of 3-point seat belts.

Study cites	Possible reduction in seating capacity	Cost to install belts per bus
NHTSA Report to Congress (NHTSA, 2002)	17%	$2440–$3550
Indiana School Bus Study (Steiger, 2005)	0–33%	–
NC State School Bus Study (ITRE, 2007)	8–17%	$7700
CRS Report for Congress (Peterman, 2007)	16–33%	$8000 to $15,000
Texas State Government (LBBS, 2009)	–	$9300 to $14,000