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ABSTRACT

The objective of this study is to assess the magnitude of overheight vehicle collisions with highway bridges which caused structural damage, injuries, and sometimes even fatalities at both the Maryland and national level. The seriousness of the collisions was exemplified by the case in 1999 that a truck hauling an overheight excavator struck and collapsed a pedestrian bridge over the Baltimore Beltway, killing one motorist and injuring three others. Statistics on overheight collisions in Maryland were collected from overheight vehicle detector records, the statewide accident database, and bridge inspection reports. An analysis of the data revealed that the frequency of overheight accidents reported in Maryland increased by 81% between 1995 and 2000. Of the 1496 bridges susceptible to impact by overheight vehicles statewide, 309 (20%) have been struck, with 58 (4%) having required repairs. No nationwide databases on overheight collisions exist, so a survey was sent to each state to collect national statistics. Of the 29 states responding, 18 (62%) indicated they consider overheight collisions to be a significant problem, but few were able to provide hard data.

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INTRODUCTION

Past Research

An extensive review of related literature did not reveal any systematic studies of overheight collisions with bridges. However, references to the problem appear in research relating to bridge repair and general accident trends. There are also numerous anecdotal accounts of particular accidents and frequently-struck bridges.

In a study in Virginia (Hilton 1973), "Inadequate vertical clearance" was listed as a key contributing factor in 4% and 6% of the total bridges cited by police officers and highway engineers, respectively. As part of a study (Shanafelt and Horn 1980), overheight loads were listed as the leading cause of damage (81%) to prestressed concrete. In a similar report (Shanafelt and Horn 1984), 94% of 815 damaged steel bridges reported over a 5 year period included damage due to overheight vehicles. A study (Harik et al. 1990) analyzed U. S. bridge failures over a 38 year period (1951-1988). Of the 79 bridge failures considered in the study, 11 were precipitated by truck collisions (14%) between superstructure and substructure collisions. The Michigan Department of Transportation reported a 36% increase in overheight collisions over one year ("Span" 1988). The Mississippi State Highway Department installed overheight warning systems on some rural bridges after an intensification in bridge damage by overheight logging trucks (Hanchey and Exley 1990). Of the damaged girders surveyed by one study (Feldman et al. 1998), 61% were assessed as having minor damage, defined as isolated cracks, nicks, shallow spalls, or scrapes. Moderate damage, defined as cracks or spalls large enough to expose undamaged prestressing tendons, was found in 25% of the girders. Severe damage, consisting of damaged tendons, significant concrete section loss, or lateral misalignment, made up the remaining 14% of cases. The results of another study (Bedi 2000) suggest that the damage to steel girders struck by overheight vehicles may be more severe than previously thought.

The issue of overheight permitting was addressed in a NCHRP report on uniformity in oversize and overweight permits (Humphrey 1988). A possible impediment to obtaining permits may be the necessity of obtaining a permit from each state or jurisdiction along a truck's route and the lack of consistency in overheight regulations between different states. Solutions discussed in the report include groups of states issuing regional multi-state permits or the use of private permitting organizations to obtain multiple permits.

Baltimore Beltway Pedestrian Bridge Collapse

On June 8, 1999 a Canadian commercial motor carrier hauling an improperly loaded excavator struck the prestressed concrete superstructure of a pedestrian bridge over the Baltimore Beltway (I-695) in Arbutus, Maryland. The span over the inner loop collapsed onto the evening rush hour traffic, resulting in the death of one motorist and serious injury of three others. A task force was formed to investigate the incident and to make recommendations on how to prevent this type of accident in the future. The National Transportation Safety Board (NTSB) has since drafted a series of factual reports associated with its investigation into the accident (NTSB 2000a,b).

The accident investigation team reported that the collapse was due solely to the impact of the excavator, which the driver had loaded on the trailer incorrectly. The excavator, destined to Canada via Maryland, Pennsylvania and New York, was picked up at the Port of Baltimore. The load was not inspected by any state authorities before leaving the Port; it was the driver's responsibility to ensure that the excavator was within the dimensions of the permit. The permit, issued to the carrier by the Maryland State Highway Administration (SHA), listed a height restriction of 4.1 m (13' 6") maximum. The driver loaded the excavator backwards and neglected to tuck the boom so the maximum height was actually 5.4 m (17' 9") above the roadway (NTSB 2000b). The pedestrian bridge, which had just been inspected in the month prior to the accident and found to be structurally sound, had a vertical clearance of 4.9 m (16' 0"). As the truck passed under the bridge, the high boom impacted the superstructure, collapsing it onto the roadway. The driver did not realize he had hit the bridge and continued to travel, stopping only after the excavator hit and slightly damaged another overpass.

The basic conclusion of the task force was that the accident was the result of human error on the part of the driver, who had not received adequate training regarding overheight loads. Electronic height detection devices and driver training on oversize loads were proposed to address this issue. The task force also recommended a statewide and nationwide review of similar accidents to determine the extent of the problem.

DATA COLLECTION

After the accident on the Baltimore Beltway, overheight detector systems were installed at the West Friendship Weigh Station on I-70 and at the exits to five terminals at the Port of Baltimore. All of these locations use the Safety Pass system manufactured by ASTI Transportation Systems Inc. Records from these facilities were made available by the SHA Motor Carrier Division and Office of Traffic & Safety. Overheight detectors are also in place at the approaches and tollbooths of the Baltimore Harbor Tunnel. These devices set off alarms to alert truck drivers and police, but the system does not record all overheight violations.

Accident reports filed by the State Police and other Maryland law enforcement agencies are entered into the Maryland Automated Accident Reporting System (MAARS). This database, maintained by the SHA Traffic Safety Analysis Division, can be queried to retrieve accidents meeting given criteria. Each report was reviewed individually on microfilm to identify collisions with overhead members, yielding 67 overheight accidents from 1995 to 2000, excluding Baltimore City. Combining the 49 Baltimore City accidents with the other 67, a total of 116 overheight collisions were reported statewide by the police from 1995 to 2000. It should be noted that this sample represents only those accidents reported by the police, and does not include the numerous unreported impacts discovered during bridge inspections.

The Maryland Bridge Inventory (MBI) contains 5056 structures with spans of 6.1 m (20 feet) or more and thus designated as bridges in accordance with the National Bridge Inspection Standards (NBIS). Not all of these bridges are susceptible to impact. The Maryland NBIS bridges include 1336 that cross roadways and 160 that have a limited overhead clearance, resulting in a total of 1496 bridges that could be involved in an overheight collision.

The SHA bridge inspection database contains inspection report verbiage categorized by structural element. The verbiage for girders, stringers, and truss members were queried. Bridges determined to have no overheight damage were eliminated, leaving 294 unique SHA bridges and 15 MdTA bridges found to be damaged by overheight vehicles.

To obtain data for the nationwide case study, national agencies and organizations such as the FHWA, NHTSA, FMCSA, and AASHTO were first solicited for information. The FHWA Bridge Management Information Systems Laboratory provided information on the vertical clearance of highway bridges in the National Bridge Inventory (NBI). Bridges with highway service both over and under the structure were selected from the database, yielding about 79,000 records.

It was determined that neither the federal government nor any national organization collects statistics on overheight collisions. To obtain nationwide data, each state was contacted directly. A survey form was drawn up and sent to the bridge engineering, traffic safety, and transportation research divisions in each state's Department of Transportation (DOT). It was also posted on the World Wide Web to allow the states to submit their responses electronically. The survey is divided into two sections: Overheight Regulations and Overheight Collisions.

DISCUSSION OF FINDINGS

Maryland Case Study

As described above, Maryland data was collected from overheight vehicle detector records, the state accident database, and the bridge inventory. The overheight detector records provide information on the percentage of overheight vehicles with permits, as well as the types of overheight loads detected. The accident data was used to determine trends in overheight collisions over time, the distribution of accidents by county, and the types of overheight vehicles involved. The bridge inventory and inspection reports provided information on bridges struck by overheight vehicles, including their geographic distribution, vertical clearances, and damage severity. Finally, the accident and bridge damage datasets were merged to investigate correlations between the two.

The overheight detectors at the West Friendship Weigh Station are set at a height of 4.15 m (13' 8"), providing a buffer of 50 mm (two inches) over the maximum legal height of 4.1 m (13' 6"). Records are available for May through July, 2001. During this time there were twenty confirmed overheight vehicles. Five trucks had overheight permits (25%), four were issued citations (20%), nine received written warnings (45%), and two belonged to the US Army (10%). The citations were issued for the more serious violations of 4.25 m (14') or more. The most common load was car/truck carrier with eight cases (40%), followed by heavy equipment with four cases (20%). The tallest vehicle detected was 4.5 m (14' 8") high.

The Maryland Port Administration (MPA) installed overheight detection devices at the exit gates of the Dundalk, Seagirt, and North and South Locust Point marine terminals, as well as the Intermodal Transfer Container Facility. The detectors are set at a height of 4.12 m (13' $6^1/_4$"), only 6 mm (a quarter of an inch) over the legal height. The systems went into operation in January, 2001. Records are available for January through June, 2001. During this six-month period, 1584 overheight vehicles were detected. Of these, 227 had overheight permits (14%).

Most of the remaining cases were addressed by adjusting the air suspension, rearranging the load, offloading some cargo, or waiting to obtain an overheight permit. The most common load was 654 high cube containers (41%), followed by 259 machineries (16%) and 252 car carriers (16%).

The 116 overheight accidents reported from 1995 to 2000 were broken down by year. The annual number of accidents has noticeably increased over the six-year period: the total for the year 2000 is 81% higher than that for 1995. This increase is greater than that for more general accident categories reported in the MAARS database. Figure 1 compares the trend in overheight collisions to the trends in all truck collisions with bridges, all truck accidents, and all vehicle accidents. The numbers have been normalized by their 1995 values so they can be compared on the same scale (there are about 7000 truck accidents and 100,000 total vehicle accidents in Maryland each year). Over the same six-year period, truck collisions with bridges increased by 35%, truck accidents in general climbed by 27%, and the total number of accidents rose by only 3%.

Statistics on injuries and fatalities in overheight accidents were compiled. From 1995 to 1998 there were an average of two injuries per year, but the number jumps higher in 1999 and 2000, with five injuries and one fatality in 1999 and six injuries in 2000. Overall, there were 19 injuries from overheight collisions during the six years studied.

The distribution of overheight accidents by county was analyzed. The highest concentration occurred in urban areas. One rural county surprisingly had a high number of accidents; closer inspection revealed that over half of these accidents occurred at the same low bridge. The general geographical trend in overheight accidents appears to be toward urban areas where there is more traffic, but also toward some rural areas with frequently-struck low bridges.

The accident reports also include information on vehicle type, which can be used to classify the types of loads involved in overheight collisions. The specific vehicle type is unknown for 48 of the accidents (mostly in Baltimore City). Of the remaining 68 accidents, the largest group (36%) consists of 24 enclosed box trucks and trailers. Most of these are legal height trucks that strike railroad bridges or other low overpasses. The next largest group (31%) is comprised of 21 flatbed trailers carrying oversized loads, most of which are construction equipment, like the excavator involved in the Baltimore Beltway accident. Dump trucks account for 11 of the accidents (16%). These vehicles collide with bridges when the dump beds are left extended or accidentally raised during transit. Another 12 accidents involve mobile homes, refuse trucks, and other large vehicles (17%).

Of the 67 accidents outside Baltimore City, 18 (27%) occurred at railroad bridges. Railroad bridges are struck most often by box trucks and trailers, with 12 of the 18 accidents involving enclosed boxes (67%). Railroad bridges are often below the legal vehicle height of 4.1 m (13’ 6”). The accident reports do not regularly indicate if the bridge clearance is posted.

From the inspection reports, a total of 309 unique bridges were found to have some degree of overheight impact damage: 294 owned by the SHA and 15 owned by the MdTA. Of the 1496 bridges with vertical clearance over a roadway, over 20% have been struck by overheight vehicles at some point in time.

The distribution of damaged bridges by county was determined. As with the distribution of accidents, the counties with the most bridges struck are those in more metropolitan areas. A significant difference from the distribution of accidents is that the accident figures include several collisions at the same bridges. The bridge distribution counts each structure only once even if it has been hit on multiple occasions. The distribution revealed that the more urbanized counties have the greatest numbers of bridges struck by overheight vehicles; however, these areas have more bridges to begin with. The total number of overpasses in each county must also be considered before any trends can be discerned. Compared to their total number of bridges, the urban counties have encountered proportionately more overheight collisions. For example, 27% of the bridges damaged by overheight vehicles statewide are in Baltimore County, which has only 21% of the overpasses in the state. This evidence suggests that bridges in more urban areas have a greater likelihood of being struck by overheight vehicles.

The MBI includes extensive information about each bridge. The most useful statistic in relation to overheight collisions is vertical clearance. The vertical underclearance is provided for each overpass. The vertical clearance over the roadway is listed for through-trusses or other bridges with overhead members. Using this data, the impact-damaged bridges were grouped by clearance in 150 mm (six-inch) intervals. The resulting histogram is shown in Figure 2. For comparison, the distribution for all vertical clearances in the MBI is plotted on a separate axis. The two plots follow the same basic trend. Both have peaks at 4.4 and 5.0 m (14.5 and 16.5 feet). Above 5.0 m (16.5 feet), the number of bridges struck drops off sharply, while the number of bridges in the MBI descends gradually, tapering off around 5.8 m (19 feet). Bridges in this range are struck much less frequently.

The two distinct peaks in Figure 2 indicate the existence of two different populations of bridges: those designed for a standard vertical clearance around 4.4 m (14.5 feet), and those designed for a clearance around 5.0 m (16.5 feet). These two groups can be isolated by classifying the type of route underneath the bridge. Minimum

design clearances for new overpasses in Maryland are 5.1 m (16.75 feet) on the National Network and 4.6 m (15 feet) off the Network. The National Network includes Interstate Highways and sections of the Federal-Aid Primary System on which large dimension trucks designated under the Surface Transportation Assistance Act (STAA) are authorized to travel. The MBI indicates if the route on the bridge is part of the National Network, but not always for the route under the bridge. The bridges were separated into two groups: those crossing Interstate, U.S., and Maryland routes (223 bridges); and those crossing County, Municipal, or other routes (86 bridges). The resulting distributions are plotted in Figures 3 and 4. The results of such a classification separate these two peaks. The 5.0 m (16.5 feet) high bridges are mostly over the Interstates and State routes, while the 4.4 m (14.5 feet) bridges are more common on the local roads. A comparison between the distribution of bridges struck and the overall MBI distribution draws attention to the number of 4.9 m (16 feet) bridges hit on IS/US/MD routes and the number of 4.4 m (14.5 feet) bridges on local routes. These bridge clearances appear to receive a slightly disproportionate number of strikes.

To quantify the interrelation between vertical clearance and vulnerability to impact, the percentage of bridges struck at each height interval was calculated. Over Interstate, U.S., and Maryland routes, 33% of bridges with 4.9 m (16 feet) of clearance have been struck by overheight vehicles. For 5.0 m (16.5 feet) bridges, the percentage drops to 27%, and then to 17% for 5.2 m (17 feet) bridges. The pattern is similar over local routes but at lower heights: 33% of bridges with 4.4 m (14.5 feet) of clearance have been hit, dropping to 25% at 4.6 m (15 feet), and 15% at 4.7 m (15.5 feet). In both cases an increase of 0.3 m (one foot) in vertical clearance cuts in half the proportion of bridges struck. Overall, bridges over IS/US/MD routes are more likely to be struck, with 24% having been hit, as opposed to 17% on local routes.

Damage severity was broken into three categories. The first consists of superficial scrapes and gouges. The second category refers to minor bends, tears, or cracks not needing immediate repairs. The third level is defined as any damage for which repairs were deemed necessary. Of the 309 bridges struck by overheight vehicles, 144 received scrapes only (47%), 107 sustained minor damage (34%), and 58 required repairs (19%). This distribution is similar to that observed by Feldman et al. for damaged prestressed concrete girders in Texas (61% minor, 25% moderate, 14% severe). To better gauge the magnitude of overheight damage statewide, these numbers can be compared to the total of impact-susceptible bridges. Of the 1496 bridges that could be struck by overheight vehicles statewide, 1187 (79%) have no observable impact damage, 144 (10%) have scrapes only, 107 (7%) have sustained minor damage, and 58 (4%) have required repairs. To observe any correlation between damage severity and vertical clearance, the distribution of clearances was plotted for each level of damage (Figure 3).

Scrapes are the most common form of damage to bridges with 4.9 to 5.2 m (16 to 17 feet) of clearance. In the range of 4.3 to 4.6 m (14 to 15 feet), however, minor damage is as prevalent as scrapes, and a greater proportion of bridges had repairs made. No bridge with clearance over 5.2 m (17 feet) required repairs due to an overheight collision. The higher proportion of serious damage to lower bridges suggests that they sustain more direct impacts, while higher bridges receive more glancing strikes.

Combining the accident and bridge inventory data revealed several bridges that were struck in more than one accident. Specific bridges for the accidents in Baltimore City could not be determined from the accident database, but an examination of the city route numbers reveals that the 49 accidents in Baltimore City took place on only 13 different streets, suggesting that many occurred at the same locations. Merging the two sets of data made it possible to examine correlations between overheight accident data and bridge damage severity. A total of 32 overheight accidents correspond to bridges listed as damaged in the inspection reports: 8 with scrapes only (25%), 14 with minor damage (44%), and 10 with repairs made (31%). Compared to the overall distribution of overheight damage found in the inspection reports (47% scrapes, 34% minor damage, and 19% repaired), the bridges included in the accident reports have a higher proportion of more serious damage, indicating that overheight collisions reported by the police tend to be more severe. No significant correlations were observed between vehicle type and specific degree of damage.

Nationwide Case Study

Nationwide data was collected from the National Bridge Inventory (NBI) and from a survey sent to each state. The NBI data provided the distribution of vertical clearances for all overpasses in the country. The survey responses were used to characterize the overheight regulations established by different states, examine trends in overheight collisions over time, and compile overheight countermeasure strategies in place around the country.

The NBI includes the vertical clearance of all bridges in the country. As with the Maryland data, the NBI clearance distribution can be broken down by type of highway. The data provided by the FHWA includes a breakdown by functional classification. The bridges are separated into two groups: Interstates and Freeways; and Other Arterials, Collectors, and Locals. The results, plotted in Figure 4, are similar to those for Maryland (Figures 3

and 4). The division is not exactly identical to that used for the Maryland bridges, but the trend remains the same. Bridges with a clearance around 5.0 m (16.5 feet) are more common over Interstates and freeways, while 4.4 and 4.7 m (14.5 and 15.5 feet) are predominant on more local roads. The two peaks around 4.4 and 4.7 m in the NBI plot suggest that these are two standard clearances used by different states, while Maryland clearly favors a 4.4 m (14.5 feet) clearance.

Survey responses were received from 29 different states. A few states sent more than one response; multiple replies were combined into one record for each state. Most states were able to answer the questions in Section I. Very few states provided the statistics requested in Section II, so a rigorous analysis of national trends in overheight collisions is not possible. However, a general picture of overheight accidents around the country can be drawn by summarizing the responses.

The first question relates to design clearances for bridges. As discussed in reference to the NBI, these standards vary by state. Most states (64%) reported a design clearance of 5.0 m (16.5 feet) for bridges on the National Network, with other responses ranging from 4.9 to 5.2 m (16 to 17 feet). *A Policy on Geometric Design of Highways and Streets* (AASHTO 1994) calls for a minimum vertical clearance of 4.9 m (16') for structures over freeways, but goes on to state "Because of their lesser resistance to impacts, the vertical clearance to sign trusses and pedestrian overpasses should be 5.1 m" (16' 9"). AASHTO also recommends an extra 150 mm (six inches) of clearance for future resurfacing. For bridges off the National Network, responses ranged from 4.3 to 5.2 m (14 to 17 feet).

The second question asked about state policies on signing bridge clearances. Half of the respondents listed 4.4 m (14.5 feet) as the maximum clearance for which a sign is posted; other responses ran from 4.1 to 5.5 m (13.5 to 18 feet). The Manual on Uniform Traffic Control Devices (MUTCD) recommends that warning signs be posted on all bridges that have less than 0.3 m (12 inches) of clearance above the maximum legal vehicle height (FHWA 2000b). When asked by how much do signs under-report the actual clearance, answers ranged from 0 to 150 mm (zero to six inches), with 75 mm (three inches) as the most common response (35%).

Next, each state was asked for its maximum vehicle height allowed without a permit. The majority (65%) listed 4.1 m (13.5 feet), while others allow up to 4.4 m (14.5 feet). In accordance with the MUTCD, those states with higher allowable heights also post higher bridge clearances. For vehicles with a permit, most states replied that there is no fixed upper limit and that it varies by the particular route.

An area of wide disparity between states is overheight fines. Among those states that responded, the fine for carrying an overheight load without a permit or violating the terms of a permit ranges from $20 to $1000, with a mean value around $300. To enforce overheight laws, almost every state responded that they use roving patrols and manual spot checks at weigh stations. Sixteen states (55%) reported using some form of automated detection systems, and most were satisfied with their performance. Very few of the respondents were able to provide statistics on overheight violations, and no trends were evident.

Seventeen states indicated that they maintain records on overheight collisions. Of these states, four collect their data from accident reports only (24%), five from bridge inspections only (29%), and eight from both sources (47%). Only six other states reported using a computerized accident database like Maryland's MAARS program. Twelve states provided numbers of overheight collisions for the years requested. The records for each particular state vary over the study period, with some increases and some decreases over time. On average, there is a slight increase over the five-year period. The average number of overheight collisions is about five percent greater for 1999 than for 1995, an increase of 1.3% per year. To compare this to the general trend in truck accidents, statistics for these twelve states were taken from the Truck Crash Profile maintained by the Federal Motor Carrier Safety Administration (FMCSA). The Truck Crash Profile contains annual data on truck accidents from 1996 to 1999, drawn from the Fatality Analysis Reporting System (FARS) and the Motor Carrier Management Information System (MCMIS). For the same twelve states considered above, the average number of reported truck accidents decreased by five percent from 1996 to 1999, a drop of 1.7% per year. The two trends are plotted in Figure 5.

As noted above, different states derive their overheight collision figures from various sources: some from accidents, some from inspections, and some from both. The three states with the greatest number of reported overheight collisions (California, Connecticut, and Illinois) all indicated that they use a computerized database, while most of the other states responding do not. These different methods of collecting data must be considered when comparing the reported number of collisions between states.

Six states provided data on injuries and fatalities in overheight accidents. Overall, there are no significant trends. With such a small sample the numbers are highly variable. The total number of injuries decreased in 1996 and 1997, then increased in 1998 and 1999. The lowest number of fatalities is reported for 1998, while the highest number is reported for 1999. California reported the greatest number of fatalities. Other states indicated very few deaths in overheight accidents.

Only four states were able to provide numbers for damage costs due to overheight accidents. The amounts are drawn from different sources; Kentucky and Mississippi listed cost of bridge repairs, while Iowa and Louisiana reported property damage in overheight accidents. Due to a particularly high figure for Mississippi in 1999, average annual damage for the four states doubled from $250 thousand to $500 thousand over the five-year period. As with the injury and fatality statistics, this high variability is due to the small sample size.

Vehicle types involved in overheight collisions were reported by eight states. The totals are broken down by percentage as follows: 16% box trailers, 51% flatbed trailers, 9% dump trucks, and 24% other. (Three states listed all or most vehicles as "Other/Unknown" and are not included here). Compared to the numbers for Maryland alone (31% flatbeds), many more overheight accidents were caused by loads on flatbed trailers. This difference may be exaggerated. Overheight accidents involving heavy equipment on flatbed trailers tend to be more severe and thus may be reported more often than less serious collisions by box trailers. For example, half of the accidents reported by Kentucky involved flatbeds; however, they noted that their sample included only those impacts requiring extensive bridge repair.

Each state was asked if it perceived overheight collisions to be a significant problem. The responses are shown if Figure 6. Of the 29 states that responded, 18 (62%) stated they consider it to be a problem. Except for Connecticut and the Carolinas, the 11 states that do not feel overheight collisions to be a problem are located mostly in the Midwest and Northwest.

This distribution concurs somewhat with the trend observed for Maryland in which overheight collisions are less common in rural areas, which is most likely due to differences in traffic volume. To compare traffic volume for these 29 states, Annual Average Daily Traffic per Lane Mile (AADT/mile) figures were taken from *Highway Statistics 1999* by the FHWA Office of Highway Policy Information (FHWA 2000a). For the 18 states that consider overheight collisions to be a significant problem, the average AADT/mile is 40% greater than that for the other 11 states.

The final question on the survey requested a description of any specific actions taken by each state to reduce the frequency of overheight collisions. Nine states (31%) replied that they had installed more signs posting clearances on or in advance of bridges. Most felt that these were effective in reducing accidents. Seven states (24%) responded that they had increased vertical clearances by grinding pavement or raising overpasses, and that this was very effective in reducing overheight collisions. This response was unanticipated, as it was assumed to be impractical except in extreme cases. However, one state (Georgia) replied that in fact they have a program in place to raise all existing Interstate bridges to clearances over 5.0 m (16' 6"). Only three states mentioned overheight detection systems in response to this question.

In general, most states believe overheight collisions to be a problem, but not all have undertaken statewide actions to reduce their occurrence. Many states deal with the problem on a case-by-case basis; frequent accidents at a particular bridge are addressed at that location only. No states provided statistics to quantify the effectiveness of any specific countermeasure strategies.

SUMMARY AND CONCLUSIONS

The pedestrian bridge collapse on the Baltimore Beltway is an extreme example of an overheight collision. However, less severe impacts are a common type of accident. Approximately one out of every five overpasses in Maryland has been struck by an overheight vehicle at some point. Half of these bridges received scrapes only, but a third sustained minor damage, and a sixth required repairs. Bridges that are hit are more likely to be located over Interstates or other major highways in metropolitan areas. Based on accident reports, the number of overheight collisions per year in Maryland appears to be increasing. Overheight sensor data reveals that most overheight vehicles do not have permits.

Survey results revealed that a variety of different standards governing bridge clearances and overheight vehicles are used around the country. Not many states were able to provide extensive statistics on overheight accidents. The limited data received does seem to indicate a slight increase in overheight collisions in recent years. Most states are concerned about this problem, and have addressed it through enforcement, warning signs, and increasing bridge clearances.

This study has been successful in compiling data on overheight collisions at the Maryland State level. Maryland's computerized accident database and bridge inventory were essential to this task. Of the 1496 bridges in Maryland that cross roadways or have overhead members, 1231 are owned by the SHA or MdTA (82%), so it is believed that this sample adequately represents bridges in the state.

Correspondence with national agencies such as the FHWA and NHTSA confirmed that no nationwide data on overheight collisions is maintained. The 1998 Model Minimum Uniform Crash Criteria recommends that "Collision with fixed object – Bridge overhead structure" be included as a harmful event category in accident

reports, but this is not required by the federal government. The only way to obtain national statistics is by contacting each state directly. This was the purpose of the nationwide survey.

When the survey form was prepared, it was assumed that many states utilized computerized accident databases like Maryland's MAARS program, and would have easy access to statistics related to overheight collisions such as casualties, vehicle types, and highway classifications. However, of the 29 states that responded, only seven (including Maryland) indicated having such a system in place, so few were able to provide all the information requested. In all, twelve states provided annual numbers of overheight accidents. The source of this data varies by state, ranging from organized accident databases to occasional reports of damaged bridges. This makes it difficult to compare overheight collision statistics between states. In the absence of hard data, the severity of overheight collisions at the national level can only be speculated. If the trend in Maryland is representative, a significant number of bridges have been struck by overheight vehicles, and the occurrence of such accidents is rising.

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FIGURE CAPTIONS

Figure 1. Normalized Accident Trends in Maryland, 1995-2000

Figure 2. Vertical Clearance of Maryland Bridges Struck by Overheight Vehicles

Figure 3. Vertical Clearance of Maryland Bridges Classified by Damage Severity

Figure 4. Vertical Clearance of Bridges in NBI by Functional Classification

Figure 5. Average Overheight Accidents and Truck Accidents per State Responding

Figure 6. State Perceptions on the Significance of the Problem of Overheight Collisions

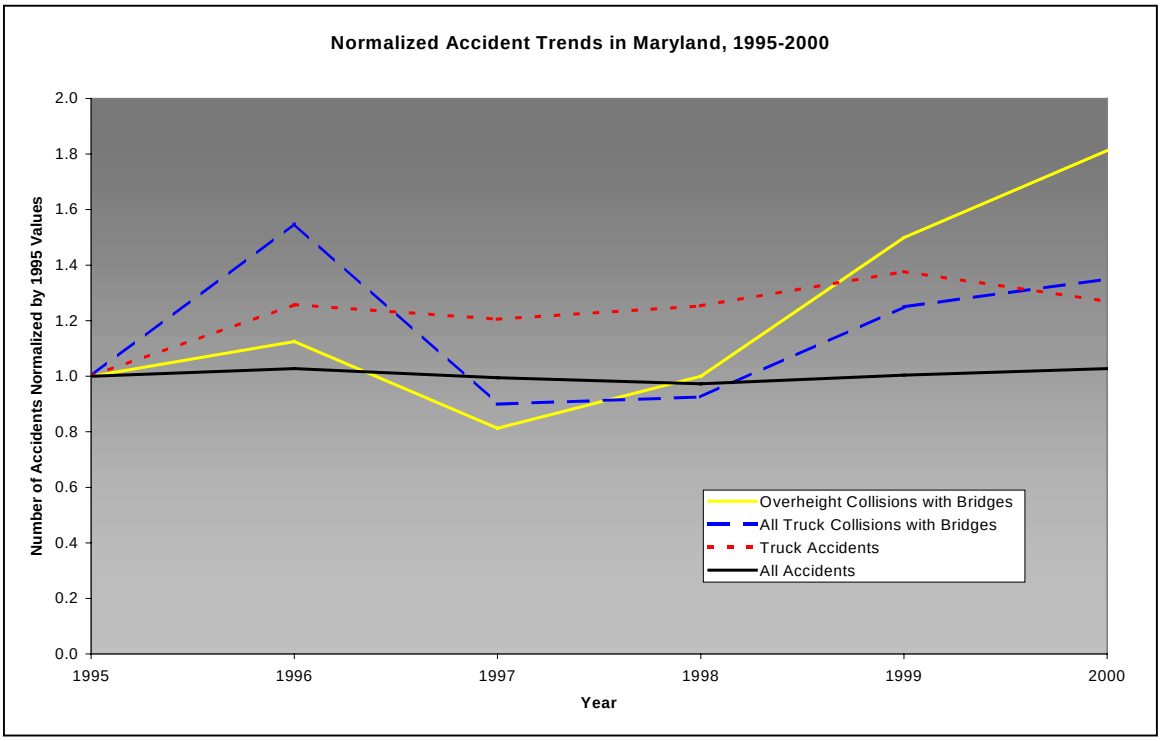

Figure 1. Normalized Accident Trends in Maryland, 1995-2000

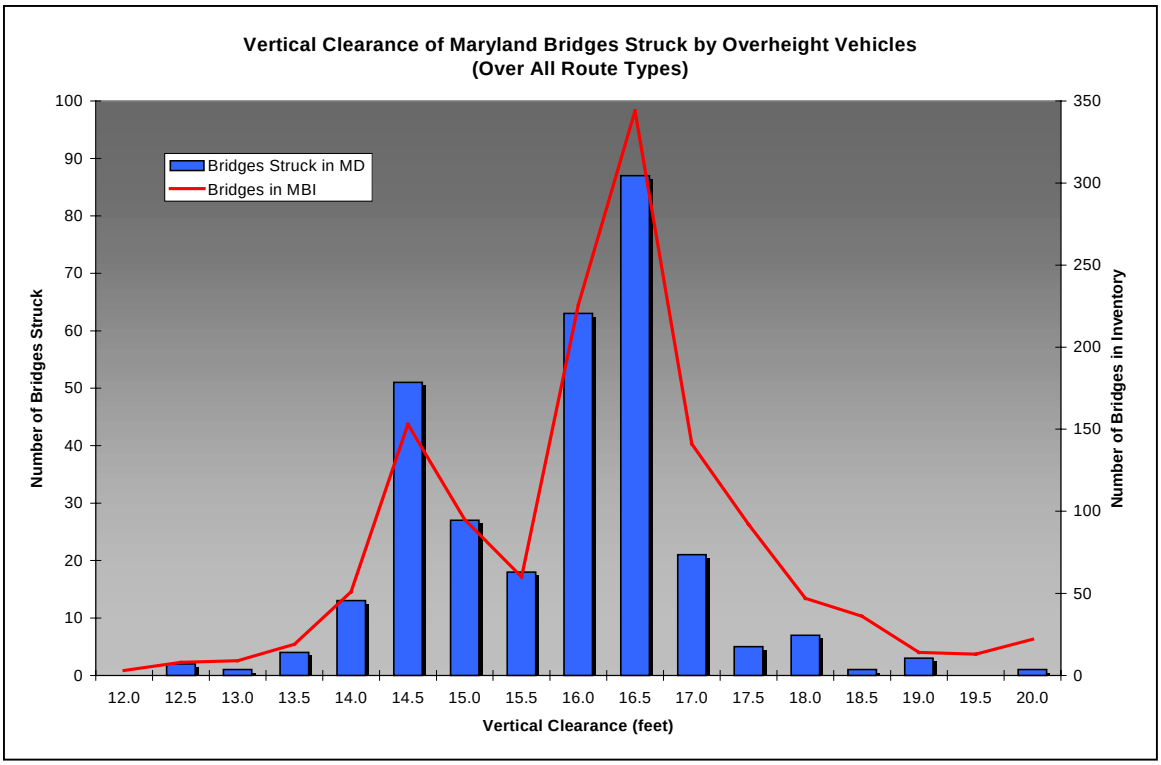

Figure 2. Vertical Clearance of Maryland Bridges Struck by Overheight Vehicles

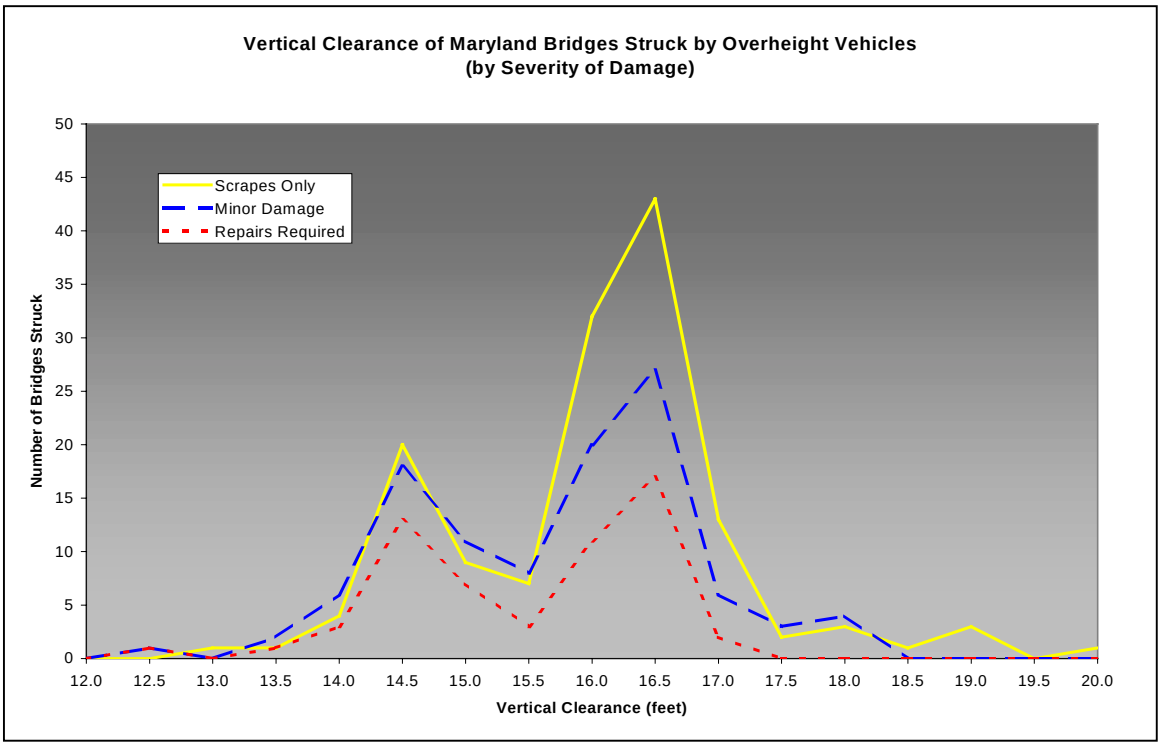

Figure 3. Vertical Clearance of Maryland Bridges Classified by Damage Severity

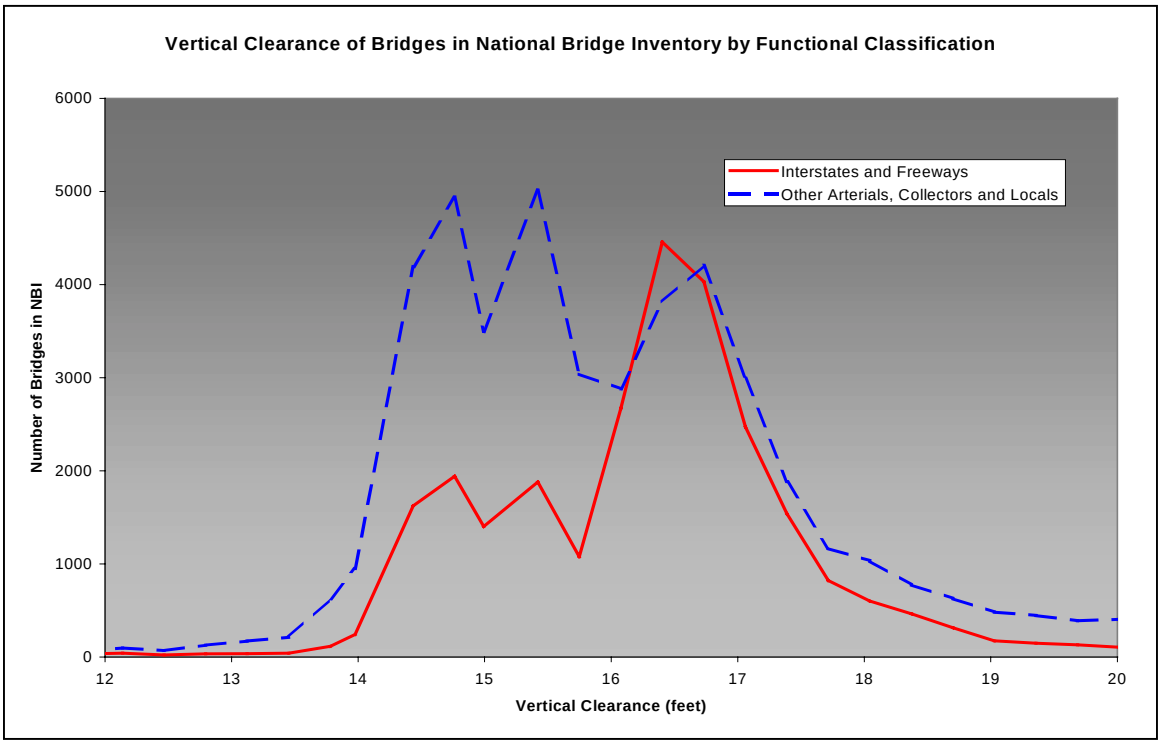

Figure 4. Vertical Clearance of Bridges in NBI by Functional Classification

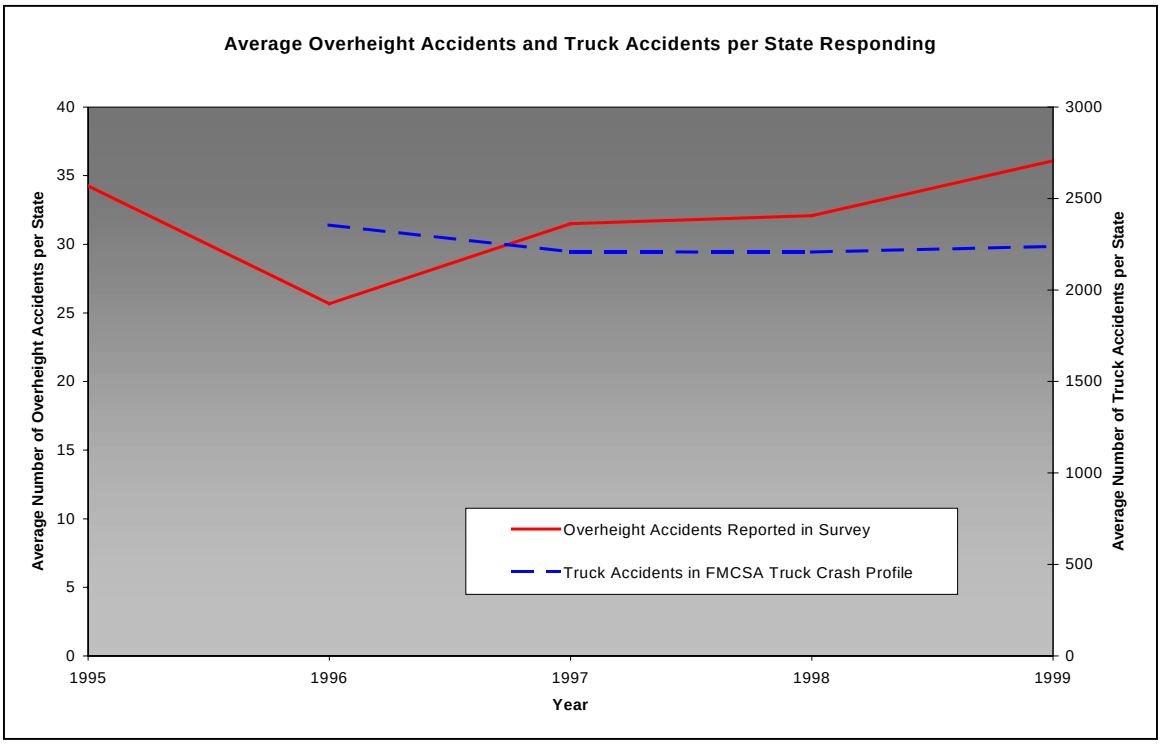

Figure 5. National Average Overheight Accidents and Truck Accidents per State Responding

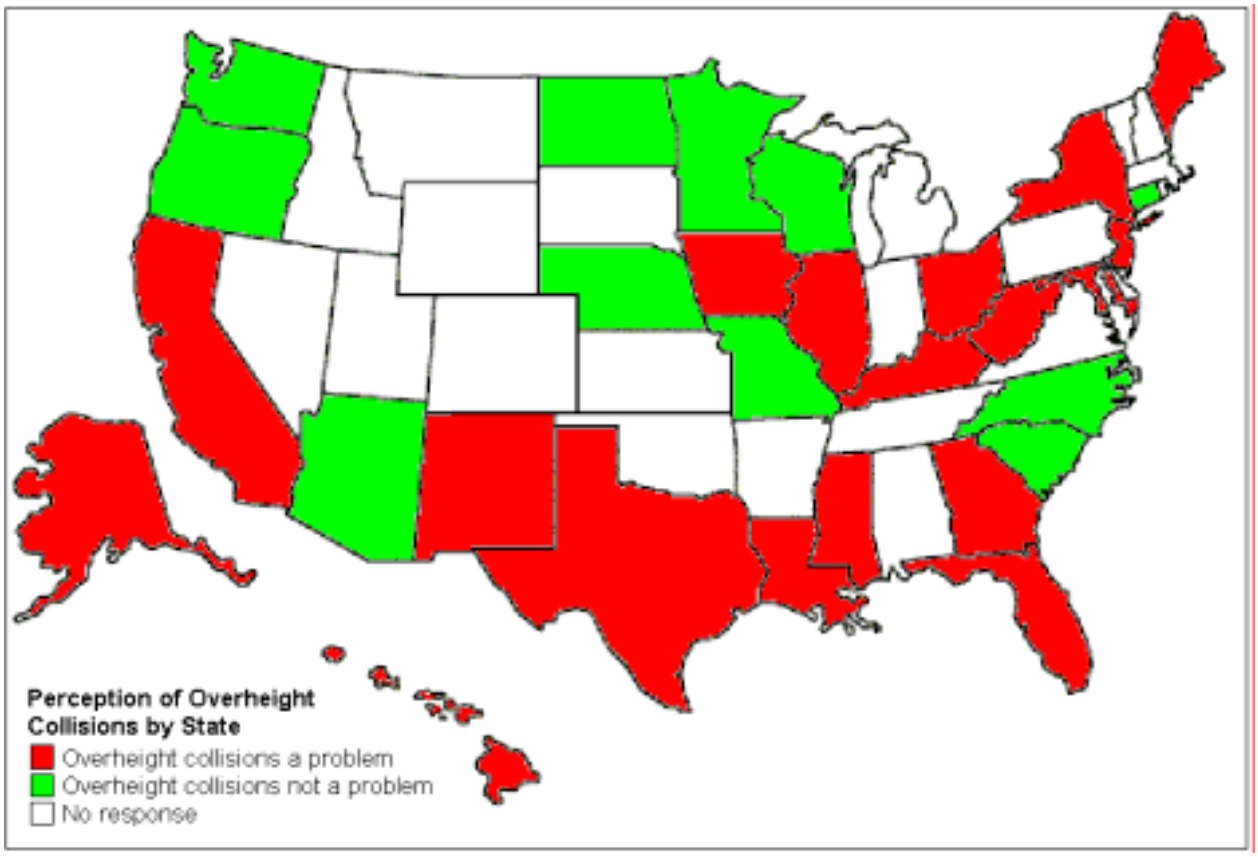

Figure 6. State Perceptions on the Significance of the Problem of Overheight Collisions