

Research Report
451

HIGHWAY ACCIDENTS AT BRIDGES

by

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INTRODUCTION

Grade-separation structures (bridges) at interchanges, crossroads, over streams, railroads, etc., which are intended to provide greater convenience and safety, otherwise involve features which either obstruct the range of free travel or serve as containment barriers. The objective of this study was to identify those principal features of bridges and appurtenances which may be related to accident frequency and severity and to provide some further insights toward highway safety.

PROCEDURE

Accident reports on file with the state police were searched for those identifying a bridge (underpasses and overpasses) being involved. Interstate routes and parkways (toll roads) were grouped together and analyzed as one system; accident records and total accident statistics were compiled for the 2-year period 1972-1973. Fatal accident data for the primary and secondary systems covered the same 2-year period; however, non-fatal accident summary statistics were compiled for only 1 year (1972) from about one-third of the counties. The accidents were divided into several types, and the severity of each type was determined by means of a severity index (SI) (1). Roadway and environmental conditions at the time of the accidents were also noted.

RESULTS

INTERSTATES AND PARKWAYS

Number of Bridges -- As of the end of the study period (1973), there were approximately 350 overpasses and 360 underpasses on the interstate and parkway system (dual bridges were counted as one). About 35 percent of the overpasses had full-width shoulders. Approximately ten percent of the overpass accidents occurred on those overpasses which had full-width shoulders. Ninety-eight percent of the underpasses had a pier in the median. The desirable clearance from the right-hand edge of the roadway to the shoulder pier should be 30 feet (9 meters). This was the case for only about eight percent of the underpasses. The average lateral clearance rightward was slightly more than 14 feet (4 meters).

Number of Accidents -- Almost eight percent of all accidents involved bridges. Of the 438 accidents involving bridges, only 31 involved underpasses. Over 14 percent of all fatal-type accidents involved bridges while over 17 percent of all fatalities involved bridges. Almost nine percent of the injuries were in accidents involving bridges. These percentages show that bridge-related accidents comprise a significant portion of the total accident experience and a significant portion of the more severe accidents. The severity index of bridge-related accidents was 3.24 compared to 2.75 for all accidents.

Types of Accidents -- Discussions of each type of accident follow.

Collision with Bridge Pier -- This type of accident resulted in six fatalities during the 2-year study period. Five of the fatalities occurred where there was no safeguard about the piers. Of 14 accidents involving bridge piers (SI = 7.00), there were three fatal, nine injury, and two non-injury accidents. Severity was reduced significantly when the pier was shielded with guardrail (SI = 4.77) or an earth mound (SI = 1.00) (2). A very limited number of accidents involved earth mounds. Two reported accidents at earth mound locations were non-injury. Accidents involving guardrails at bridge piers indicated there are some continuing problems with this method of diverting vehicles away from bridge piers because of ineffective guardrail end treatment. Of the 11 accidents involving guardrails at bridge piers, there were one fatal and six injury accidents. In the fatal accident, the vehicle mounted the approach end of the guardrail, became airborne, and impacted the shoulder pier. In another accident involving a severe injury, the vehicle became airborne and hit the center pier. In two other accidents, vehicles hit the shoulder pier after first mounting the end of the guardrail and then going over the guardrail.

Gap between Bridge Openings -- Of five accidents involving a wall built to close the gap (SI = 8.30), there were three fatal-type (resulted in eight fatalities) and two injury-type accidents. Bushes had been planted ahead of the wall to retard encroaching vehicles at two of the locations, but one of the two accidents at those locations still resulted in a fatality.

Guardrails ahead of the gap were found to be only partially effective; the newer and longer rails are much better than the short sections previously used. Of a total of 15 accidents, there were six fatal accidents (11 fatalities) involving guardrails. In five of the fatal accidents, the vehicle went over the guardrail; in one instance, the vehicle went around the guardrail. The guardrail completely stopped the vehicle from going through the gap in only five cases, and these cases involved the newer design.

Collision with Entrance Posts and Wing Walls -- Of 29 accidents (SI = 6.67), there were nine fatal (nine fatalities), sixteen injury, and four non-injury accidents. Twelve of the accidents involved collision with the right-hand entrance. At all of these locations, the shoulder narrowed at the bridge. Only two of the remaining 17 accidents, which involved the left-hand entrance, involved a bridge which had a full-width shoulder. Light and visibility conditions appeared to be a contributing factor. Only nine of the 29 accidents (and one of the nine fatal accidents) occurred during daylight. Three of the nighttime fatal accidents were attributed to the driver going to sleep. In the majority of locations where guardrail was provided, it was not attached to the bridge to prevent "pocketing". In newer installations, the guardrail is attached and should reduce the severity of these accidents.

Collision with Bridge Railing or Curb -- This was the most frequent type of accident and was a low-severity type (SI = 2.16). The majority of these accidents (61 percent) occurred during inclement weather. The railing design appeared structurally adequate; only three accidents (one fatality) involved

a vehicle going through or over the railing. These three accidents (2 percent of the total of this type) involved a semitrailer, bus, and sedan. The curb and safety walk combination, formerly a design standard, did not provide good redirection qualities.

Collision with Bridge Railing and Guardrail -- A high percentage of these accidents occurred during icy or wet conditions (43 percent). The average severity was not high (SI = 2.85). There was only one fatal accident which resulted when the driver was thrown from his vehicle when it overturned after striking a guardrail.

Collision with Guardrail -- Most of these accidents involved a driver losing control of his vehicle on an icy bridge and then striking a guardrail. Icy or wet conditions were a factor in 80 percent of the accidents. In three accidents, the driver lost control after hitting the "bump" at the end of the bridge.

Collision with Another Vehicle -- Inclement weather conditions was a factor in 58 percent of this type of accident. Wet-road conditions were the cause of the only fatal accident. Lack of room was mentioned on some of these accident reports; the driver could not avoid another vehicle because the bridge was narrow.

Did Not Hit Bridge, Guardrail, or Vehicle -- In this type of accident, drivers lost control and proceeded ahead and into the median or off the shoulder. Icy conditions existed in 79 percent of these accidents.

Roadway and Environmental Conditions -- The percentages of these accidents were compared to all accidents on the interstate and parkway system (3). The percentage of accidents related to road character was very similar to that found for the total system. However, differences were found for road surface and light conditions. The percentage of accidents which occurred during snowy or icy conditions (46 percent) was considerably higher than that for the total system (17 percent). Also, the percentage of non-daylight accidents (54 percent) was above the corresponding percentage for the entire system (40 percent). The percentage of non-daylight accidents which involved icy conditions (65 percent) was above that of all bridge-related accidents, indicating that the problem of ice-related accidents is greater at night.

Attempts to alleviate the hazards from ice on bridge decks with warning signs have been moderately successful. Investigation of three locations where "Ice on Bridge" signs were placed indicated some accident reduction. Seven icy-condition accidents the year before placement of the signs reduced to two the year after. However, icy-condition accidents have continued to occur at two of the locations in the succeeding years. Flashing "Ice on Bridge" signs, activated by detectors in the bridge decks, have been installed at two locations. Problems with the detectors have made operation undependable -- one is now being activated manually. Accidents during icy conditions have continued to occur at these locations in spite of the flashing signs.

PRIMARY AND SECONDARY HIGHWAYS

Number of Accidents -- The percentage of bridge-related accidents was considerably less on primary and secondary highways than on interstates and parkways. This seems to be related to the smaller number of bridges per mile (kilometer) on the primary and secondary system (about 0.3 bridges per mile (0.19 bridges per kilometer)) as compared to the interstate and parkway system (about 0.7 bridges per mile (0.43 bridges per kilometer)). Bridges were involved in three percent of all accidents and four percent of fatal accidents. Accidents involving bridges resulted in about four percent of all fatalities and of all injuries. As on interstates and parkways, the severity of bridge-related accidents was shown to be high -- a severity index of 3.26 compared to 2.86 for all accidents. The severity of bridge-related accidents on primary and secondary highways (SI = 3.26) was almost identical to that of the bridge-related accidents on the interstate and parkway system (SI = 3.24).

Type of Accidents -- Discussions of each type of accident follow.

Collision with Bridge Pier -- There were only nine reported accidents of this type. Four were fatal accidents. The pier had no guardrail in seven of the accidents -- three were fatal accidents. In the other fatal accident, the vehicle hit the approach terminal of the guardrail, became airborne, and turned over.

Collision with Bridge Entrance Post or Wing Wall -- This type of accident was the most severe (SI = 5.65). The high severity resulted from direct collision with entrance posts or wing walls; none of the 27 fatal accidents of this type involved guardrail protection. A very high percentage of these accidents occurred at night (61 percent).

Collision with Bridge Railing or Curb -- As on interstates and parkways, this was the most frequent type of accident. Inclement weather, particularly icy conditions, accounted for a large percentage of the accidents (44 percent). This type of accident was not usually severe (SI = 2.64). The exceptions were accidents where the vehicle went through the bridge railing or hit another vehicle on the bridge. Several fatal accidents resulted because of inadequate containment by the railing.

Collision with Bridge Railing and Guardrails -- Only seven accidents of this type occurred where guardrail had been used in conjunction with bridges.

Collision with Guardrails -- Most of these accidents (75 percent) involved a driver losing control of the vehicle on an icy or wet bridge and then striking a guardrail. There were two fatal accidents. One involved a vehicle jumping the guardrail; in the other, the vehicle went through the guardrail.

Collision with Another Vehicle -- This was another common type of accident. The two primary causes were icy or wet conditions (49 percent) and a narrow bridge.

Did Not Hit Bridge, Guardrail, or Vehicle -- As on interstates and parkways, icy or wet conditions were the cause of the majority of these accidents (69 percent).

One-Lane Bridges -- A number of one-lane bridges exist on the secondary systems. As would be expected, the most frequent type of accident involved two vehicles meeting on the bridge. Five fatal accidents were attributed to the absence of safety rails.

Investigation of six locations where "Narrow Bridge" signs were installed showed that signing does alleviate this problem. There were 41 accidents before compared to 27 accidents after installation of the warning signs.

Roadway and Environmental Conditions -- The percentages of bridge-related accidents were ordered according to road character, road surface, and light conditions. These percentages were compared to values found for all state police reported accidents on the primary and secondary system. The only difference found with respect to road character was the percentage of fatal accidents on curves (48 percent) -- it was higher than for the entire system (33 percent). The percentage of wet-weather accidents (31 percent) was slightly higher than that for the entire system (23 percent). The percentage of accidents which occurred during snowy or icy road surface conditions was only four percent for the total system compared to 20 percent for bridge-related accidents. The percentage of bridge-related accidents which occurred at night (43 and 55 percent) was also shown to be much higher than for the total system (27 percent).

DISCUSSION, SUMMARY, AND RECOMMENDATIONS

1. Bridge-related accidents were a significant percentage of the total accidents on interstates and parkways.
2. The lesser number of bridges per mile (kilometer) on the primary and secondary highway system, together with generally lower traffic volumes and speeds, appeared to be related to fewer accidents involving bridges on those systems as compared to the numbers of bridges and accidents on interstates and parkways.
3. The severity of bridge-related accidents was generally higher than the severity of all accidents.
4. The severity of bridge-related accidents on primary and secondary highways was almost identical to the bridge-related accidents on the interstate and parkway system.
5. Collisions with entrance posts and wing walls resulted in more fatalities than other accidents involving other features of bridges. Inadequate protection from direct collision with rigid elements at bridge entrances, particularly on primary and secondary highways, resulted in high severity. Lack of adequate shoulder width resulted in a large number of accidents. Where paved shoulders are provided, a means of alerting errant drivers by means of grooved sections or raised rumble strips on the shoulder in advance of the bridge would be desirable.
6. The small percentage of accidents which occurred on overpasses having full-width shoulders illustrated the benefits obtained when this safety feature was added.

7. Guardrail protection at bridge piers has proven less than totally effective.
8. Openings between parallel bridges on divided highways are recognized hazards. When a wall is built to close this gap, some type of arresting barrier is necessary; shrubbery has not proven to be sufficient. Guardrail protection was found to be only partially effective, although the newer design, which involved a longer guardrail section, appears to be much more effective than previous designs.
9. The high percentage of nighttime accidents suggests a problem with visual perception of the structure ahead and the need for better delineation.
10. There was an exceptionally high percentage of accidents which resulted from snowy or icy conditions, particularly on the interstate and parkway system. This is attributable to icing of bridge decks. This commonly occurs on the bridge decks while the approach pavement remains ice-free.
11. Particular attention is invited to primary and secondary bridges with curved approaches because of the high number of fatal accidents which occurred at this type of location. Improved delineation could reduce accidents.
12. Bridge railings were inadequate on some primary and secondary highway bridges. In some cases it consists of guardrail. Some fatal accidents resulted from the apparent absence of railing on some one-lane bridges.
13. One-lane bridges remaining on the secondary system constitute a recognized hazard. Warning signs were shown to be essential. Of course, the most effective solution would be to replace deficient bridges.

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