Highway Accidents at Bridges

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

PROCEDURE

State police files were searched for accident reports identifying a bridge (underpasses and overpasses) as 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 to 1973. Data on fatal accidents on primary and secondary systems covered the same 2-year period; however, nonfatal 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

At 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 10 percent of the overpass accidents occurred on those overpasses that had full-width shoulders. Ninety-eight percent of the underpasses had a pier in the median. The desirable clearance from the right edge of the roadway to the shoulder pier should be 9 m (30 ft). This was the case for only about 8 percent of the underpasses. The average lateral clearance rightward was slightly more than 4 m (14 ft).

Number of Accidents

Almost 8 percent of all accidents involved bridges. Of the 438 accidents involving bridges, only 31 involved underpasses. More than 14 percent of all fatal accidents involved bridges, and more than 17 percent of all fatalities involved bridges. Almost 9 percent of the injuries occurred in accidents involving bridges. These percentages show that bridge-related accidents compose 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. Discussions of each type of accident follow.

1. 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 noninjury 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 noninjury. Accidents involving guardrails at bridge piers indicated that end treatment of guardrails continues to be a problem with this method of diverting vehicles away from bridge piers. 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

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the shoulder pier after first mounting the end of the guardrail and then vaulting it.

2. Gap between bridge openings—Of five accidents involving a wall built to close the gap (SI = 8.30), there were three fatal (resulting in eight fatalities) and two injury accidents. Bushes had been planted in front 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 15 accidents involving guardrails, six were fatal (11 fatalities). 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 a vehicle from going through the gap in only five cases, and these cases involved the newer design.

3. Collision with entrance posts and wing walls—Of 29 accidents (SI = 6.67), there were 9 fatal (nine fatalities), 16 injury, and 4 noninjury accidents. Twelve of the accidents involved collision with the right entrance. At all of these locations, the shoulder narrowed at the bridge. Only two of the remaining 17 accidents, which involved the left entrance, involved a bridge that had a full-width shoulder. Light and visibility conditions appeared to be a contributing factor. Only 9 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's 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.

4. Collision with bridge railing or curb—Collision with the bridge railing or pier 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 redirectional qualities.

5. 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 fatality, which resulted when the driver was thrown from his vehicle when it overturned after striking a guardrail.

6. Collision with guardrail—In most of collisions with the guardrail, the driver lost control of his vehicle on an icy bridge and then struck 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.

7. Collision with another vehicle—Inclement weather 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.

8. No contact with bridge, guardrail, or vehicle—In accidents in which no contact was made with bridges, guardrails, or vehicles, drivers lost control and proceeded into the median or off the shoulder. Icy conditions existed in 79 percent of these accidents.

Roadway and Environmental Conditions

The percentages of each accident type were compared to that of 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 during snowy or icy conditions (46 percent) was considerably higher than that for the total system (17 percent). Also, the percentage of nondaylight accidents (54 percent) was higher than the corresponding percentage for the entire system (40 percent). The percentage of nondaylight accidents that involved icy conditions (65 percent) was more than 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. The year before the signs were placed seven ice-related accidents occurred; the year after, only two. However, ice-related accidents have continued to occur at two of the locations since placement of the signs. 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 kilometer on the primary and secondary system (about 0.19 bridge/km or 0.3 bridge/mile) as compared to the Interstate and parkway system (about 0.43 bridge/km or 0.7 bridge/mile). Bridges were involved in 3 percent of all accidents and 4 percent of fatal accidents. Accidents involving bridges resulted in about 4 percent of all fatalities and of all injuries. As on Interstates and parkways, the severity of bridge-related accidents was shown to be high: SI = 3.26 compared to SI = 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).

Discussions of each type of accident follow.

1. Collision with bridge pier—There were only nine reported collisions with bridge piers. Four were fatal accidents. The pier had no guardrail in seven of the accidents, three of which were fatal accidents. In the other fatal accident, the vehicle hit the approach terminal of the guardrail, became airborne, and turned over.

2. Collision with bridge entrance post or wing wall—Collisions with entrance posts or wing walls were the most severe accidents (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).

3. Collision with bridge railing or curb—As on Interstates and parkways, collisions with bridge railing or curb were the most frequent type of accident. Many of these accidents (44 percent) occurred during inclement weather, particularly icy conditions. 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.

4. Collision with bridge railing and guardrails—Only seven accidents involving collision with bridge railing occurred where guardrail had been used in conjunction with bridges.

5. Collision with guardrails—Most of the collisions with guardrail (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.

6. Collision with another vehicle—Collisions with another vehicle were another common type of accident. The two primary causes were icy or wet conditions (49 percent) and a narrow bridge.

7. No contact with bridge, guardrail, or vehicle—As on Interstates and parkways, icy or wet conditions were the cause of the majority of accidents involving no contact with the bridge, guardrail, or other vehicle (69 percent).

8. 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 during snowy or icy road surface conditions was only 4 for the total system compared to 20 for bridge-related accidents. The percentage of bridge-related accidents at night (43 and 55 percent) was also shown to be much higher than that 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 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 that on the Interstate and parkway system.

5. Collisions with entrance posts and wing walls resulted in more fatalities than did 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 on overpasses having full-width shoulders demonstrated the benefits obtained when this safety feature was added.

7. Guardrail protection at bridge piers has proved 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 proved to be sufficient. Guardrail protection was found to be only partially effective, although the newer design, which involves 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. An exceptionally high percentage of accidents 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. Primary and secondary bridges with curved approaches deserve particular attention because of the high number of fatal accidents that 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 is replacement of deficient bridges.

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