

Abridgment

Magnitude and Severity of Drainage-Structure-Related Highway Accidents

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The Federal Highway Administration sponsored a study to determine the nature and magnitude of accidents related to roadside drainage structures. Accident data from national and state databases for the years 1981–1984 were analyzed with respect to their relationship to drainage structures. The findings revealed that drainage structures were involved in approximately 9 percent of all accidents on Federal-aid roads and were the first object struck in approximately 4.5 percent of all accidents. A high incidence of fatalities and serious injuries were associated with these accidents. Most of the accidents involved a single vehicle that struck a curb, ditch, embankment, or culvert. Drainage-structure-related accidents predominantly involved a single vehicle and occurred in a higher proportion at night and in adverse weather compared to the same characteristics for all accidents. Based on the findings related to roadway characteristics, drainage-structure accidents were over-represented on Federal-aid secondary roads, at non-junctions, in curves and on grades, and on wet surfaces. This paper contains a brief summary of the study results. A complete documentation of the methodology and findings may be found in FHWA Report DTFH61-85-C-00065.

Safety enhancement is a high priority on federally funded 3R and 4R (resurfacing, restoration, rehabilitation, and reconstruction) programs. Much effort has been directed at reducing roadside hazards through removing, relocating, or protecting fixed objects from errant vehicles. In spite of these improvements, fixed objects were the most harmful event in 47.1 percent of the fatal single-vehicle accidents in 1983.

Research to date has focused largely on improvements to utility poles, sign supports, guardrails, median barriers, and bridge rails. Concern has been expressed that drainage structures may also pose significant safety hazards in run-off-road accidents. Thus the Federal Highway Administration (FHWA) sponsored a study to determine the nature and magnitude of accidents in which drainage structures were involved.

To identify the nature and magnitude of hazardous conditions that are associated with drainage structures is neither a straightforward nor an easy task. While there is a tremendous amount of data available on highway accidents, there are no known accident databases that either uniformly or directly code accidents involving vehicles that strike the various types of drainage structures. The information contained in those databases that code drainage structures is limited and generic in nature.

FINDINGS

The following discussion is based on the results of an analysis of the 1982, 1983, and 1984 National Accident Sampling System (NASS) raw data files and the 1983 NASS weighted data file, which contains an estimate of total accidents and their characteristics. The NASS data are for Federal-aid roads only and represent police-reported accidents where the first harmful event was coded as a collision with a drainage structure. In addition, the NASS raw data files contain information on situations where one or more of the first four objects contacted by any vehicle involved in the accident was a drainage structure.

Computer printouts of one-way and two-way variable tables were obtained from the 1983 NASS weighted data file for both drainage-structure-related accidents and for all accidents on Federal-aid roads. The following discussion summarizes the key findings from an analysis of those tables.

The first question addressed was, "What is the magnitude of drainage-structure-related accidents?" The answer is summarized in table 1. Drainage-structure-related accidents, as defined by first harmful event, constitute approximately 4.5 percent of annual accidents on Federal-aid roads in the United States, or 176,120 of the 3,934,006 police-reported accidents. Accidents involving curbs are the most frequently occurring, representing 31.5 percent of drainage-structure-related accidents and 1.4 percent of all accidents.

The question that came to mind, however, was just how well did the first-harmful-event criterion serve as an indicator of drainage-structure-related accidents? To answer that question, further analyses were performed, using first the 1983 NASS raw data file.

A search of the vehicle file revealed 664 cases in which one or more of the up to four objects struck was either a culvert, ditch, curb, or soft embankment. A cross check of these same cases in the accident file revealed that in 333 of the 664 cases (50 percent) the first harmful event was either a culvert, ditch, curb, or soft embankment. The immediate conclusion, then, was that first harmful event underestimated the number of drainage-structure-related accidents by a factor of two.

To ensure that this was not an anomaly in the 1983 data, a similar analysis was performed on the 1982 and the just-completed 1984 NASS data files. In both cases, drainage structure first harmful events occurred in 51 percent of the cases where a drainage structure was coded as one or more of the objects struck in the vehicle file. Thus, it was concluded

TABLE 1 DRAINAGE STRUCTURE ACCIDENTS BY FIRST HARMFUL EVENT

Object Struck	Frequency	Percent	% of Total Accidents*
Curb	55,440	31.5	1.41
Ditch	37,282	21.2	0.95
Embankment (soft)	33,313	18.9	0.85
Culvert	24,885	14.1	0.63
Wall	20,790	11.8	0.53
Embankment (hard)	4,410	2.5	0.11
Total	176,120	100.0	4.48

* 1983 NASS estimate of 3,934,006 police-reported accidents on Federal-aid roads.

TABLE 2 SEVERITY OF DRAINAGE STRUCTURE ACCIDENTS

Injury-Severity	Frequency	Percent	% Of Total Accidents*	% Of Total Accidents w/ Same Severity
Fatal	2,136	1.2	0.06	9.3
Incapacitating	18,152	10.5	0.47	7.2
Non-incapacitating	26,327	15.3	0.69	5.0
Possible	39,470	23.0	1.03	6.8
None	85,753	50.0	2.24	3.5

*1983 NASS weighted estimate of 3,831,841 accidents on Federal-aid roads with known accident severity.

TABLE 3 COMPARISON OF THE SEVERITY OF DRAINAGE-STRUCTURE ACCIDENTS TO THE SEVERITY OF ALL ACCIDENTS (IN PERCENT)

Injury Severity	Drainage Structure	All Accidents
Fatal	1.2	0.6
Incapacitating	10.5	6.6
Non-incapacitating	15.3	13.8
Possible	23.0	15.0
None	50.0	64.0
Total	100.0	100.0

that drainage-structure-related accidents are involved in approximately 8 to 9 percent of all police-reported accidents on Federal-aid roads.

In addition to occurrence, it is important to assess the severity of these accidents. Table 2 shows that one or more fatalities occurred in 1.2 percent of and incapacitating injuries occurred in 10.5 percent of the drainage-structure-related accidents based on the first-harmful-event criterion from the 1983 NASS weighted data file. In terms of all accidents, fatal accidents represented 0.06 percent and incapacitating injuries represented 0.47 percent. The last column of table 2 indicates that

drainage-structure-related accidents represent 9.3 percent of all fatal accidents and 7.2 percent of all incapacitating injury accidents on Federal-aid roads. On the other hand, they represent only 3.5 percent of the accidents with no injuries.

To provide yet another perspective and a basis of comparison, table 3 shows the distribution of all accidents and reveals that drainage accidents are almost twice as severe, in terms of fatalities and incapacitating injuries, as all accidents. One-half of all drainage-structure accidents involve injuries compared to 38 percent of all accidents.

Table 4 characterizes the relative severity of the accidents

TABLE 4 SEVERE (FATAL OR INCAPACITATING INJURY) ACCIDENTS BY TYPE OF DRAINAGE OBJECT STRUCK

Object Struck	Frequency	Percent of Type Object
Embankment (hard)	1,349	30.6
Embankment (soft)	4,425	13.3
Curb	7,324	13.2
Ditch	3,694	9.9
Wall	1,805	8.7
Culvert	1,691	6.8

TABLE 5 COMPARISON OF LIGHT CONDITIONS (IN PERCENT)

Light Condition	Drainage Structure Accidents	All Accidents
Daylight	44.5	62.2
Dark	28.1	11.0
Dark, Lighted	22.8	22.4
Dawn	1.8	1.0
Dusk	2.8	3.4
Total	100.0	100.0

TABLE 6 COMPARISON OF WEATHER CONDITIONS (IN PERCENT)

Weather	Drainage Structure Accidents	All Accidents
No Adverse	69.3	78.4
Rain	18.2	14.8
Sleet	1.6	0.3
Snow	3.7	5.7
Fog	6.6	0.6
Other	0.6	0.2
Total	100.0	100.0

involving each of the drainage-structure types. It shows the number of fatal or incapacitating-injury accidents for each object type and the percent they represent of the total accidents of that type. For example, 30.6 percent (1,349) of the total hard embankment accidents (4,410 from table 1) involve fatalities or incapacitating injuries. While hard embankments exhibit the highest proportion of severe accidents, they occur with the lowest frequency.

It must be remembered that this analysis does not account for exposure. For example, there are more miles of soft embankment than hard ones; therefore, the rate of occurrence (per vehicle miles traveled) might not be the lowest. From table 4, it appears that curb-related accidents are severe and occur with the greatest frequency of all the drainage structure categories.

The remaining findings are based on selected general accident characteristics of drainage accidents compared and contrasted to the same characteristics of all accidents from the 1983 NASS weighted data file. These findings in part describe the nature of drainage-structure-related accidents.

Drainage structure accidents occur at a higher proportion in the dark than all accidents, 28 percent compared to 11 percent (table 5). Table 6 indicates that a higher proportion of drainage-structure accidents occurs in adverse weather than is the case for all accidents.

The incidence of drainage-structure accidents in curves and on grades is twice that of all accidents (tables 7 and 8). Finally, table 9 shows that a higher proportion of drainage structure accidents occurs on a wet road surface than is the case for all accidents.

TABLE 7 COMPARISON OF ROADWAY ALIGNMENT (IN PERCENT)

Alignment	Drainage Structure Accidents	All Accidents
Straight	62.1	83.0
Curved	37.0	17.0
Total	100.0	100.0

TABLE 8 COMPARISON OF ROADWAY PROFILE (IN PERCENT)

Grade	Drainage Structure Accidents	All Accidents
Level	57.7	75.1
Grade (-2%)	40.3	23.0
Hillcrest	0.8	1.0
Sag	1.2	0.9
Total	100.0	100.0

TABLE 9 COMPARISON OF ROADWAY SURFACE CONDITION (IN PERCENT)

Surface Condition	Drainage Structure Accidents	All Accidents
Dry	64.8	70.2
Wet	27.8	21.5
Snow or Slush	3.0	4.5
Ice	4.4	3.8
Total	100.0	100.0

CONCLUSIONS

Based on the findings of the NASS accident data analysis, drainage-structure-related accidents represent eight to nine percent of the total highway safety problem on Federal-aid roadways. These accidents are quite severe. In terms of all accidents, those involving curbs occur most frequently, while in terms of accident severity, hard embankments are the most dangerous. The review of scene photographs suggests that curb design improvements and, in some cases, curb removal would have reduced the severity, if not the occurrence, of many of the curb accidents reviewed.

Drainage-structure-related accidents occur in a higher proportion at night and in adverse weather compared to the same characteristics for all accidents. Based on the findings related

to roadway characteristics, drainage-structure accidents are overrepresented in curves, on grades, and on wet surfaces.

REFERENCES

1. *Fatal Accident Reporting System*. National Highway Traffic Safety Administration, Washington, D.C., 1983.
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