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State Practice and Experience in the Use and Location of Truck Escape Facilities

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One phase of a study undertaken to develop warrants for the use and location of truck escape ramps is described. A questionnaire submitted by mail to state highway agencies sought information on (a) the type and number of escape facilities constructed, (b) variables considered in determining the need for escape ramps, (c) factors that affect ramp location, and (d) operational experience with escape ramps. The study results indicated that, although most ramps are located on four-lane divided and two-lane highways, they can also be found on three-lane routes, in medians, and at the end of freeway off-ramps. Only two states indicated that a rational technique was used to determine the need for ramps. Both techniques made use of accident rates. Other important factors in determining the need for escape ramps included length and percentage of grade, percentage of trucks, and conditions at the bottom of grades. Topography was cited as the primary factor in ramp location. Examples of satisfactory and unsatisfactory ramp location are described.

On long, steep highway downgrades, there is the possibility of brake failure on large commercial vehicles. In such situations trucks often accelerate uncontrollably, endangering not only the lives of truck drivers but the lives of occupants of other vehicles as well. Residences and business enterprises adjacent to or at the foot of long, steep downgrades may be damaged or destroyed by runaway vehicles. A large percentage of runaway-vehicle accidents result in fatalities.

Highway agencies in states that have roadways in rugged terrain (primarily the Appalachian region and the mountainous western states) have attempted to mitigate the problem by using various types of truck escape facilities. Until recently, there had been little formal research and development in the design and construction of truck escape ramps. Since the mid-1970s, however, there has been increasing interest in all facets of truck escape facilities.

No single type of truck escape facility has been adopted nationwide, but four general types of escape facilities can be identified (see Figure 1): (a) ascending-grade ramps, (b) horizontal-grade ramps, (c) descending-grade ramps, and (d) sandpiles.

The ascending-grade ramp is probably the most common type of escape facility now in use. In general, these ramps consist of a roadway that is composed of layers of loose gravel or uncompacted sand and ascends at a very steep grade, using the force of gravity to stop moving vehicles. The length of ascending-grade ramps tends to vary considerably, depending on percentage of grade, the type of aggregate used in the arrester bed, and the land available for ramp construction.

Horizontal-grade ramps are the newest type of truck escape ramp to be constructed. They use only the resistive force of the aggregate arrester bed to stop vehicles. Horizontal-grade ramps are primarily used where the terrain precludes the construction of other types of ramps.

Descending-grade ramps, like horizontal-grade ramps, depend entirely on the resistance of the aggregate bed to stop runaway vehicles. Because of the adverse effect of the negative grade, they are generally longer than ascending or horizontal ramps.

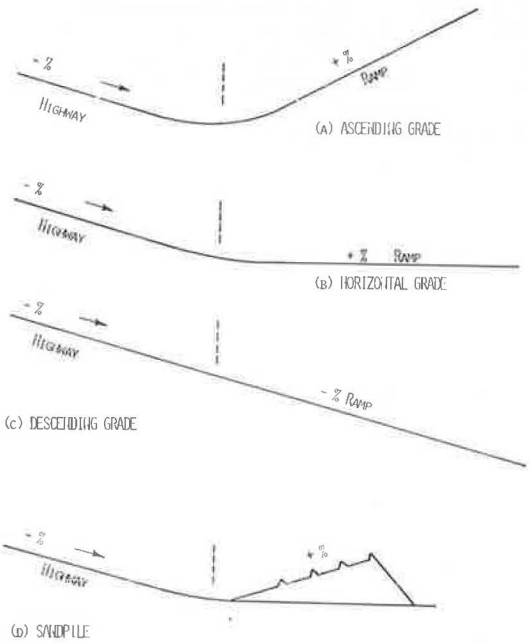
Of the four types of escape ramps, sandpiles are probably the easiest and least expensive to construct. An inclined pile of loose, dry sand provides the resistive force. The use of sandpiles is currently confined to several eastern states.

The state of the art of escape-ramp construction has advanced in recent years, but the same cannot be said of escape-ramp warrants. In most cases, the use and specific location of truck escape facilities are based on subjective judgment rather than formal engineering analysis. As resources for highway construction and maintenance become more limited, a "seat-of-the-pants" approach to locating and installing truck escape facilities is no longer justified. There is a need to develop methodologies by which optimum use and location of truck escape ramps can be determined.

The West Virginia Department of Highways, in cooperation with the Federal Highway Administration (FHWA), has sponsored a research project at West Virginia University, the overall objective of which was to develop warrants for the use and location of truck escape ramps. To accomplish this general objective, a number of detailed objectives were developed. These included

1. Use of a mail questionnaire to determine the experiences and practices of state highway agencies in re-

Figure 1. Four basic types of truck escape facilities.



lation to truck escape ramps,

2. Use of a second questionnaire to determine truck drivers' perceptions of the runaway-vehicle problem,
3. Collection of accident data for locations where there were frequent accidents involving runaway vehicles,
4. Performance of statistical analyses of the accident data to determine significant factors in runaway-vehicle accidents, and
5. Development of warrants for the use of truck escape ramps based on the collected data.

Very little published information was available on escape-ramp warrants or locational criteria, and it was felt that correspondence with state highway agencies would be a source of data and insight on this topic. This paper describes the development of the mail questionnaire for state highway agencies and discusses the results obtained. The other objectives of the project are currently being addressed in ongoing research efforts.

LITERATURE REVIEW

Present highway design criteria are not very specific about truck escape ramps. The 1974 edition of the American Association of State Highway and Transportation Officials' (AASHTO's) Highway Design and Operational Practices Related to Highway Safety (1) states only that special consideration should be given to providing escape areas for trucks on long, steep downgrades. Escape ramps are not mentioned at all in the 1965 edition of AASHTO's A Policy on Geometric Design of Rural Highways (2). The forthcoming revised edition of the AASHTO "Blue Book" will contain material on truck escape ramps, but this information will deal with the design and construction of escape facilities rather than with warrants or locational criteria. In a 1974 highway accident report (3), the National Transportation Safety Board recommended "establishment of design policy for long/steep grades that will ensure provision of escape routes when the character of the grade has a potential for contributing to the generation of runaway vehicles."

Since no national standards or policies existed for truck escape facilities, an extensive search was made of the highway engineering literature for published information on escape ramps. It was hoped that examination of case studies or data dealing with existing ramps might provide insight concerning ramp use and location. Before the mid-1970s, published information on truck escape ramps was limited to a few articles in highway engineering journals (4-7). The first comprehensive survey of truck escape ramps was that by Versteeg and Krohn (8), who noted a number of considerations that should go into the design and construction of such ramps:

1. The length of ramp depends on ramp geometry and the aggregate used.
2. The ramp should be wide enough to accommodate more than one vehicle.
3. The aggregate used for the ramp should be free draining and clean.
4. Anchors are required to secure tow trucks when they remove vehicles from the bed.
5. Surfaced road is needed, adjacent to the ramp, for use by tow trucks and maintenance vehicles.

In addition to discussing ramp characteristics, Versteeg and Krohn (8) described escape ramps used by state highway agencies throughout the country. In certain cases, locational criteria were mentioned. For example, two ascending-grade escape ramps were installed on the westbound lanes of I-80N at Emigrant Hill in Oregon. The first ramp was located approximately 3.2 km (2 miles) from the summit, the second 6.4 km (4 miles) below the summit. Experience indicated that the lower ramp was used far more (91 percent of total ramp use) than the upper ramp. This seems to indicate that drivers stay with their out-of-control vehicles as long as possible.

Brittle (9) has presented a history of sandpile escape facilities in Virginia. Along US-52 at Fancy Gap Mountain, out-of-control trucks were being driven into maintenance stone stockpiles along the 7 percent, 6.4-km (4-mile) long downgrade. It was suggested that similar stockpiles be placed at strategic locations to provide an escape mechanism for runaway vehicles. Since the downgrade lane was on the outside of the mountain, sandpiles could only be placed where there was sufficient space. Ascending-grade escape ramps were considered, but out-of-control vehicles would have to cross opposing traffic to enter the ramps.

Williams of the Tennessee Department of Transportation (DOT) is currently preparing a state-of-the-art survey of escape-ramp design, construction, and operation. In field visits, Williams has been able to obtain detailed information on most escape ramps in the United States. When his report is published, it will be an important reference for highway engineers involved with truck escape facilities.

The literature review on truck escape facilities showed that, although advances have been made in ramp design and construction in recent years, there are still no criteria for determining the need for escape ramps, and ramp location is usually based on finding a convenient site that will minimize earthwork and construction costs. Apparently no attempt has been made to develop a rational cost-benefit procedure for locating escape ramps. For these reasons, a survey was made of state highway engineers to determine the factors that are currently being considered in ramp installation.

DEVELOPMENT OF QUESTIONNAIRE

Shortly after the decision was made to use a mail questionnaire to obtain information from state highway agencies, Williams of the Tennessee DOT distributed his

own brief questionnaire on the use of vehicle arrester beds. In this questionnaire, highway departments were asked (a) whether emergency escape ramps were used in a given state, (b) if there was sufficient operational experience to evaluate the effectiveness of the ramps, and (c) if design plans or reports were available on existing ramps. The main purpose of Williams' questionnaire was to lay the groundwork for future field visits. To avoid duplication of effort, I obtained the results of the Tennessee study and compared them with my anticipated needs before developing the questionnaire described in this paper.

Response to the Tennessee questionnaire indicated that 23 highway agencies in the United States had constructed or were planning to construct truck escape ramps. States that have or plan to build truck escape ramps are given below:

State	No. of Ramps	State	No. of Ramps
Alabama	1	Pennsylvania	9
Alaska	2	Puerto Rico	4
California	3	South Dakota	2
Colorado	3	Tennessee	1
Hawaii	4	Texas	2
Idaho	6	Utah	2
Kentucky	1	Vermont	1
Montana	2	Virginia	10
Nevada	1	Washington	1
New York	2	West Virginia	2
North Carolina	3	Wyoming	3
Oregon	5		

To reduce the number of questionnaires to be completed by highway agency engineers, it was decided to send questionnaires only to these 23 states. In an effort to minimize internal transmittal of the questionnaire within state agencies and ensure that the appropriate person in each agency received it, cover letters were addressed to the persons who had responded to the Tennessee DOT questionnaire.

The questionnaire sought information on (a) the type and number of escape facilities constructed; (b) how the need for escape ramps is determined, i.e., what variables are considered in determining whether an escape facility should be installed; (c) factors that enter into the decision on where to locate such facilities; (d) operational and accident experience with the ramps; and (e) techniques for monitoring use of the ramps.

QUESTIONNAIRE RESULTS

Responses were received from 19 of the 23 state highway agencies that received the questionnaire. In addition to returning the questionnaire, many states sent accident records, unpublished reports, photographs, and plans and specifications for existing or planned truck escape ramps. The results obtained from the completed questionnaires are discussed below.

Types of Ramps

Engineers of the various state highway agencies were asked to list the types of escape facilities used and the number of each type that had been installed. These results are given below:

Type of Escape Facility	Number Existing and Planned in United States	Number of States Using
Gravel bed	11	5
Ramp	39	13
Sandpile	11	3
Total	61	19

Since the questionnaire did not list specific types of facilities, a wide variety of responses was expected (it was felt that listing types of escape ramps on the questionnaire form might create confusion in that the type of ramp visualized by the investigator might differ from that visualized by the respondent). However, only the three types of escape facilities given above were listed by respondents. A total of 61 escape facilities had been built or were planned in the 19 states that responded. As the third column in the table indicates, some states use more than one type of ramp. Since different terminology is used in different regions of the United States, gravel beds and ramps probably refer to the same type of facility. Sandpile ramps appear to be used exclusively in the East (in North Carolina, Pennsylvania, and Virginia).

When asked about typical sections and profiles for escape facilities, most respondents referred to plans and drawings, which they included with the questionnaire. No new or unique approaches to ramp design and construction were found in the questionnaire results that had not been found in the literature review. The state-of-the-art report by Versteeg and Krohn (8) gives detailed information on ramp cross sections and profiles.

Highway agencies were asked to indicate whether escape facilities were on two-lane roads or divided highways. Forty-two of the 61 escape ramps were classified according to type of roadway. However, Pennsylvania and Virginia, which have the largest number of escape ramps (9 and 10 ramps, respectively) did not give detailed breakdowns. Out of 42 ramps, 26, or 62 percent, were located on divided highways; 15, or 36 percent, were located on two-lane roads; and 1 was on a three-lane undivided highway. Both Pennsylvania and Virginia indicated that they had ramps on two-lane and four-lane divided highways, and Virginia noted having ramps on three-lane undivided routes. But the exact number of ramps in each of these categories is not known.

From the data, it is not possible to determine the reason for the large number of ramps on four-lane divided highways. Four-lane divided highways would normally be expected to have better geometrics than two- or three-lane roadways. However, higher speeds and greater traffic volumes may increase the probability of runaway-vehicle accidents. There is also the possibility that the four-lane divided highways were built recently and it may have been convenient and economical to include escape ramps at the construction stage.

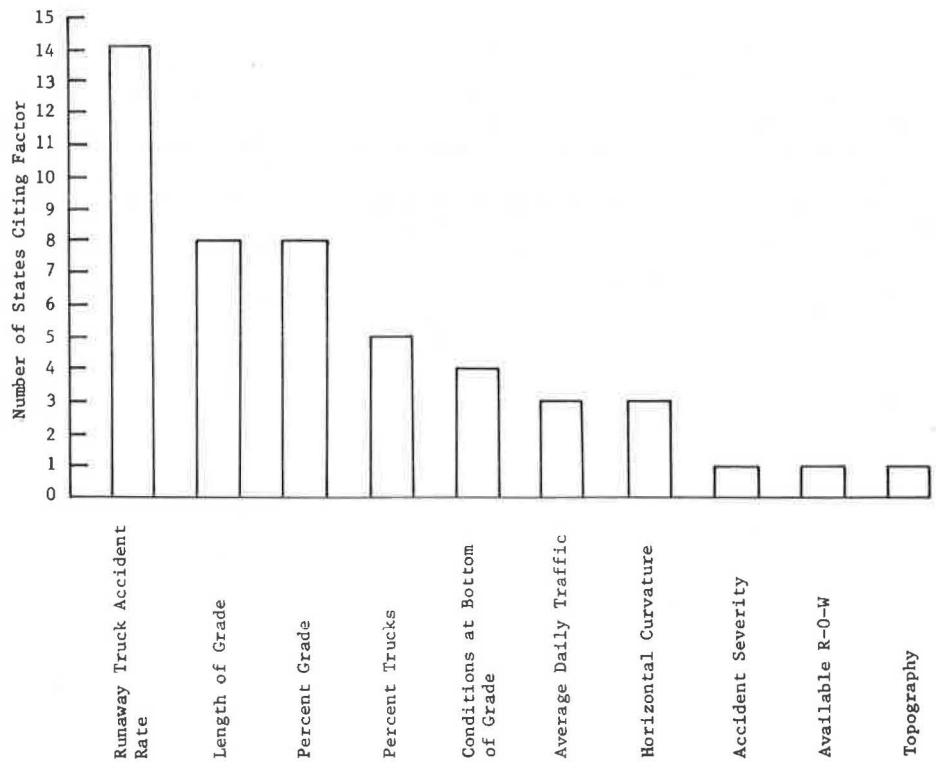
Ramp Warrants

In response to a question as to whether or not a rational technique was used in determining the need for escape facilities, only 2 of the 19 responding states, or 10.5 percent, said yes. Colorado indicated that a three-year study was made of accident history at problem locations. Oregon stated that the traffic engineering branch maintained current accident records. When high-accident locations were identified, a detailed study was made to identify causes and potential solutions.

Those states that do not have a rational technique for determining the need for escape facilities were asked to list the variables they considered in determining whether an escape facility should be installed. Figure 2 shows the factors cited by state highway agencies and the number of agencies that cited them. Several states noted certain factors as being more important than others, but lack of additional data made it difficult to assign a numerical weight to the importance of each factor. Each factor listed by the states was thus given equal weight in formulating the plot shown in the figure.

Several states added comments that might be useful

Figure 2. Factors considered by state highway agencies in determining the need for truck escape facilities.



to engineers who deal with escape ramps. One state highway agency noted that percentage and length of grade should be considered in designing the length and grade of the escape ramp. It was also felt that the horizontal alignment of the roadway should be considered in designing the width and alignment of the escape ramp. One engineer noted three criteria that should be used to determine whether an escape facility should be installed:

1. Is there a problem with runaway trucks?
2. Can the problem be corrected by signing or delineation?
3. If the problem cannot be corrected by signing, where should the facility be built to best fit the conditions?

It was noted that escape ramps were built so infrequently that each case was considered on its own merits.

In still another instance, an agency noted that, although no rational criteria existed, the two escape ramps in the state were both installed at high-accident locations where there was a long downgrade leading to a T-intersection in the center of a small community. The respondent stated that both projects were initiated to solve a demonstrated problem rather than to analytically appraise a design.

Among other states that discussed the problem of determining the need for escape ramps, one southern state listed six factors as important and then stated that "all are important and are used in determining a need. A definite problem exists when there is a combination of long, steep grade and long, continuously curving alignment. In hot weather, most all trucks will exhibit some type of brake problems on this type of highway." On the other hand, one engineer noted that "truck escape ramps are constructed based upon the incidence of truck accidents downgrade on any hill if the conditions are applicable for their use. Percent grade, length of grade, or horizontal alignment are not in themselves criteria for the construction of a truck escape ramp."

Ramp Location

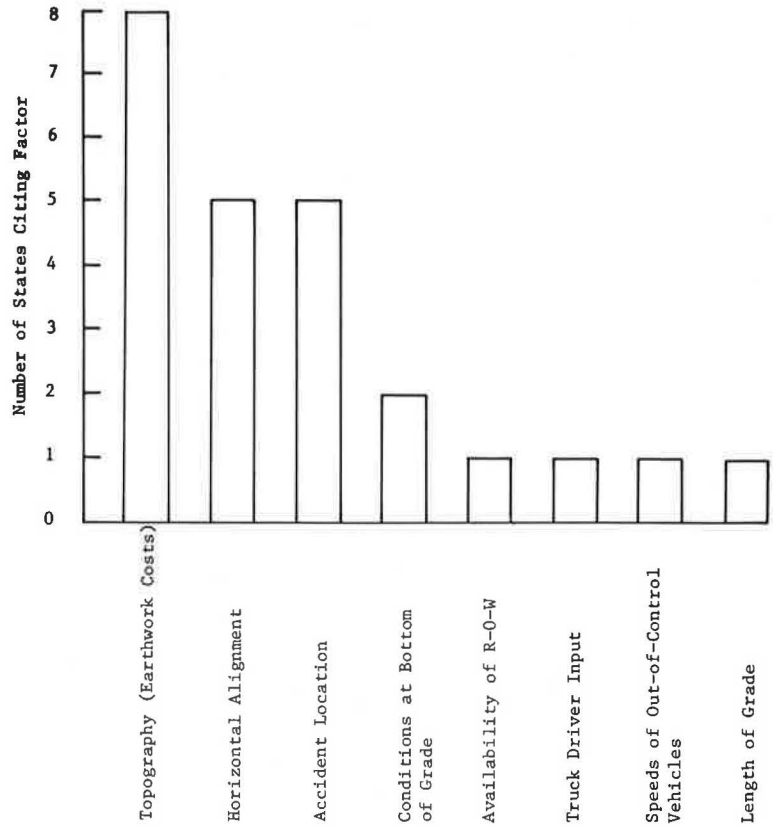
Engineers were asked to specify factors that enter into the decision on where to locate an escape facility once it is determined that one is needed on a particular downgrade. Figure 3 shows the factors cited and the frequency at which states cited them. The most frequently mentioned factor was topography because of its obvious effect on construction costs. Horizontal alignment and accident location were the second most frequently cited factors. Several respondents noted that ramps should be located upgrade from sharp horizontal curvature, since runaway trucks would not be able to negotiate these curves at high speeds. Since runaway-vehicle accidents are usually run-off-the-road accidents caused by failure to negotiate horizontal alignment, accident location is probably closely related to horizontal alignment. Right-of-way availability, truck driver input, speeds of out-of-control vehicles, and length of grade were each cited once.

Several states cited specific examples of ramp locations. Some of the more important ones are discussed here.

Hawaii stated that the preferred location was near the end of a downhill tangent where there was a curve to the left and that the ramp grade was at least 15 percent uphill. Because Hawaii does not have a readily available source of rounded aggregate for the arrester bed, it is very important that the escape ramp have an uphill grade.

Idaho attempted to place its first escape ramp on a given grade about 0.8-1.2 km (0.5-0.75 mile) from the summit of the grade. The second ramp was then located approximately 3.2 km (2 miles) downgrade from the first ramp. The suitability of the topography usually dictated the exact location. Oregon indicated that 6.4 km (4 miles) from the summit of a grade was the most desirable location. New York attempted to locate escape facilities as close as possible to the bottom of downgrades (assuming that poor horizontal alignment did not force the truck off the road prior to this point), whereas

Figure 3. Factors considered by state highway agencies in determining the location of truck escape facilities.



Colorado noted that each site required an individual study based on grade, alignment, and accident reports.

Respondents were asked to indicate the number of escape facilities in each of six specified locations. The results are given below:

Location of Escape Facility	Number of Facilities
On tangent	25
On curve	29
In cut	29
On fill	15
In median	1
Left side of highway	1
End of off-ramp	2

An unknown number of ramps were double counted; for example, a ramp located in a cut section on a tangent would receive two citations.

The greatest number of ramps were located on curves and/or in cuts. Ramps on tangents were also commonly used. Although ramps on tangents may be more desirable from the viewpoint of the driver, the widespread use of ramps on curves is not surprising. A large percentage of highway kilometers in mountainous terrain consists of horizontal curvature. In addition, the fact that a roadway is in a cut makes it easier to achieve the desired uphill gradient for the escape ramp.

Fifteen escape facilities were located on fills, and many of these were sandpile ramps. It will be recalled that Virginia developed sandpile ramps for use in locations where inadequate space existed for a typical escape ramp. Thus, a common location for sandpile ramps is on small fills where the downgrade lane or lanes are on the outside of the mountain.

Two states, California and Virginia, have escape facilities at the end of freeway off-ramps. California also has a ramp in the median. An escape ramp at Parley's Canyon in Utah is also located in a median but, since Utah did not return the questionnaire, this facility is not included in the results given in the table above.

It is interesting to note that, based on the results of the questionnaire, there is only one escape facility in the United States that is located on the left side of a two-way highway: Wyoming constructed a left-hand ramp on a low-volume route. The reluctance of state highway agencies to use left-hand ramps is probably attributable to serious questions about liability (should a runaway truck heading for an escape ramp strike an oncoming vehicle), signing problems, and the reaction of truck drivers to this type of ramp.

Operational Experience with Escape Ramps

States were asked whether any of the six suggested ramp locations were unsatisfactory in terms of operational or accident experience. Eight states indicated that there were no operational or accident problems with the ramps. Five states did not respond to the question, which could be interpreted to mean that they did not have sufficient data to reach a conclusion. Six states noted problems with their escape facilities. These difficulties are discussed here in the hope that similar problems can be avoided in the future.

Idaho, North Carolina, and Pennsylvania cited problems with aggregate arrester beds. In Idaho, one ascending-grade ramp was surfaced with compacted gravel. After stopping on this ramp, trucks rolled backwards and jackknifed. Pennsylvania also stated that there is a need for suitable arrester beds on ascending-grade ramps to prevent trucks from rolling backwards. Another problem experienced in both Pennsylvania and North Carolina was freezing of arrester

beds or sandpiles. North Carolina experienced problems with compaction of sandpiles. These are essentially construction and maintenance, rather than locational, problems in that they would occur whether the ramp was located on a fill, in a cut, on a tangent, or on a curve.

Several states mentioned operational problems with escape facilities. Idaho indicated that one ramp had a problem with poor visibility. At one Tennessee location, where a ramp exited the roadway at the right-hand side and the main line curved to the left, some vehicles at night mistook the escape ramp for the through roadway.

North Carolina noted that terrain conditions have limited the length of sandpiles. The piles work satisfactorily for trucks traveling slower than 129 km/h (80 miles/h), but they would have to be longer to bring a truck traveling faster than 129 km/h to a complete stop. Tennessee also stated that some vehicles have penetrated barriers at the end of ramps.

New York reported that, since an escape ramp was installed in 1964 on NY-10 at Richmondville, four trucks have lost control and entered the community. Two trucks have overturned on a lawn near the center of the village, and two trucks have gone through a T-intersection. To eliminate this situation, NY-10 will be relocated. Although New York furnished the plans for this escape ramp, no geometric data—such as location of summit or percentage or length of grade—were available. However, since the escape facility is located approximately 1.9 km (1.2 miles) upgrade from the town of Richmondville, it is probable that drivers of out-of-control vehicles bypass the escape ramp in an attempt to "ride out" the grade.

States were asked whether use of escape ramps was monitored in a formal manner. If a formal monitoring program was in effect, the states were asked to describe the reporting procedure. Fifteen of the 19 responding states indicated that they did not formally monitor the use of escape ramps. Three states did have a formal monitoring procedure, and one state did not respond to the question.

North Carolina reported using three different monitoring mechanisms: The highway patrol completed accident report forms for each incident, a traffic services technician prepared special reports on ramp use, and at one ramp there was surveillance by a vehicle-actuated time-lapse camera. In Tennessee, accident reports were filled out by state police, and special forms were completed by maintenance foremen. Colorado indicated only that ramp use was monitored by state police.

Although they indicated no formal monitoring program, several states described procedures that they used to gain information about the use of escape ramps. California noted that the escape ramp on old CA-99 was monitored for 18 months by a radar unit to determine entry speeds. The maximum speed recorded for a ramp entry was 113 km/h (70 miles/h). Speeds claimed by drivers were consistently 8-32 km/h (5-20 miles/h) higher than those recorded by the radar unit.

Oregon's monitoring program consisted of observation by maintenance crews on routine field duties and by state police. Oregon also noted that, since most trucks were equipped with citizens band radios, truck drivers contacted tow trucks on their own. Wyoming stated that ramp use was indicated by a broken wire and tire marks; no further explanation was provided.

States that indicated that they did not formally monitor escape ramps were asked to state whether they felt there was significant unreported use of the ramps. Of the 15 states that did not monitor ramp use, 7 stated that there was not significant unreported use of the ramps, 2 indicated that there was significant unreported use, 3 did not know, and 3 others did not respond.

The final question on the form asked engineers of state highway agencies whether before-and-after accident data were available for escape facilities. Seven states have collected such data: Colorado, North Carolina, Pennsylvania, Tennessee, Texas, Virginia, and Washington. Ten states had no data available, and two states did not respond to the question. Colorado, North Carolina, Virginia, and Washington sent accident reports and accident statistics to the investigator. Some of this information will be used in later stages of the research on warrant development. Pennsylvania did not furnish specific data but stated that accident experience indicated a reduction in the number of downgrade truck accidents in most cases. It was noted that some truck drivers still show ignorance of the escape ramp as a safety device.

SUMMARY AND CONCLUSIONS

Based on the results of a questionnaire regarding the practices and experiences of state highway agencies with truck escape ramps, a number of conclusions can be drawn. Escape ramps are felt to be effective as an accident countermeasure and are becoming more common on long, steep downgrades. Several types of ramps are used, the specific type for a given application depending primarily on site conditions. Most ramps have been constructed on four-lane highways. Two-lane highways ranked second in terms of frequency. Escape ramps have also been built on three-lane undivided routes, in medians, and at the end of freeway off-ramps.

Only two of the states that responded to the questionnaire stated that they had a rational technique for determining the need for an escape facility. Both used accident rates to detect problem locations. Among those states that did not use a rational criterion, accident rate was also the most frequently mentioned factor. Other important factors appeared to be length and percentage of grade, percentage of trucks, and conditions at the bottom of grades.

Responding states indicated that topography was the primary factor in determining ramp location because of the direct relationship between topography and earthwork costs. Horizontal alignment and accident location were also cited frequently by states as factors considered in locating escape ramps. Almost as many ramps have been built on tangents as on curve sections, but nearly twice as many ramps are in cuts as on fills. The widespread use of ramps in cuts is attributable to more favorable conditions for ramp grade and difficulties in constructing ramps on the outside of mountains.

The questionnaire results tend to confirm the fact that most escape ramps are installed on the basis of judgment rather than formal engineering analyses. Responses indicate that, as problems are encountered with specific ramp designs or locations, modifications are made and thus the state of the art is advanced.

In view of the various procedures used to determine the need for and location of escape ramps and the variation in experience with ramps, there is a need to develop methodologies by which optimum use and location of truck escape ramps can be determined. Elements of risk and economic costs and benefits should be included in any such methodology. The fact that several states have already collected before-and-after accident data on long, steep downgrades will help in the development and verification of rational criteria for escape ramps.

Based on the results of the questionnaire discussed in this paper, several additional recommendations can be made. There appears to be wide variation among states in the signing of escape facilities. Sandpile, escape ramp, runaway truck ramp, and other terms may be used to refer to essentially similar facilities. Some

states indicate the type of ramp surfacing on advance signs whereas others do not. Such variation may create uncertainty on the part of truck drivers when they are faced with using escape ramps. It is recommended that more uniform signing policies be developed.

Although there is only a limited amount of information on truck escape ramps in the technical literature, it is apparent from the results of the questionnaire that many states have conducted research on the topic. Much of this work involves selection and testing of arrester-bed aggregate and construction and maintenance policies. There is a need for better dissemination of information on studies that deal with truck escape ramps. Personnel of state highway agencies should report on the results of their research and development activities so that duplication of effort can be avoided.

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Performance of a Gravel-Bed Truck-Arrester System

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The testing of a truck-arrester system that consists of a 158-m (528-ft) long bed of 0.6-m (2-ft) deep screened gravel, backed up by an array of 88 sand-filled plastic barrels, is described. The system was constructed on NY-28 east of Utica, New York, on a steep downgrade where geometric restrictions precluded building a conventional uphill escape lane. Three trial runs with a 16 650-kg (37 000-lb) dump truck, at speeds of 34, 66, and 90 km/h (21, 41, and 56 miles/h) demonstrated the ability of the gravel bed to stop runaway vehicles. The decelerations experienced in these tests were similar to those experienced in panic stops on dry pavement.

Truck escape lanes are constructed so that runaway trucks descending long, steep grades can stop safely. These lanes, which sometimes use uphill ramps to decelerate trucks, may also contain loose sand or gravel to increase deceleration by imparting drag forces to the wheels of the vehicle (1). A device with steel nets and cables was once designed for an installation in Puerto Rico but was apparently never constructed.

A long history of runaway trucks led to the construction of an escape lane on the downslope of what is locally known as Vickerman Hill on NY-28 near the village of Mohawk, New York, 16 km (10 miles) east of Utica, under a New York State Department of Transportation (NYSDOT) contract. Selection of a design for this escape lane was complicated by site geometry. The village is located in a valley, and NY-28 descends on a long downgrade. Just south of the village limits, at the site of the escape lane, the downgrade is 10 percent. Because the highway is in a sidehill cut with the downhill lane on the fill side, an uphill ramp would require placement of excessively high fill. Thus, another design approach was necessary. A steel-net system was considered, but the idea was abandoned because of potential maintenance difficulty and a lack of data on the performance of such a system.

The design finally selected consists of two stages: a gravel arrester bed and an array of sand-filled plastic drums (see Figure 1). The 158-m (528-ft) long gravel bed—5.4 m (18 ft) wide at the entry point and tapering to 3.6 m (12 ft) near the end—consists of screened, rounded pea gravel (see Figure 2). The depth of the gravel increases from 0 to 0.6 m (0-2 ft) in the first 15