Evaluation of Truck Escape Ramps

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Out-of-control vehicles on steep grades have the potential for and frequently do result in severe accidents. There are two truck escape ramps in Kentucky, and both were constructed as a result of severe accidents and the potential for additional accidents.

One escape ramp is on the Hyden Spur (KY 118) in Leslie County. Because of geometric conditions of the highway and topographic constraints, an arrester-type escape ramp was designed with pea gravel as the arrester material. The beginning of the ramp is a 386-foot paved section on an 8-percent downgrade; followed by a gravel bed 520 feet long on a 4-percent downgrade. This ramp was opened for use in 1980, and it has been used four times in emergency situations.

The other escape ramp is on KY 11 leading into Beattyville in Lee County and is a combination gravity and arrester design. The ramp includes a 400-foot paved approach, followed by a 700-foot arrester bed over a 1.5-percent downgrade and then a 210-foot arrester bed over a 14-percent upgrade. There has been only one reported emergency usage of this ramp since it opened in 1980.

Overall, the escape ramps have proven to be operating properly and appear to be performing as they were designed. Of the five cases where the ramps were used by out-of-control vehicles, no one has been injured and there has been very little damage to the vehicles involved.
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EVALUATION OF TRUCK ESCAPE RAMPS

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INTRODUCTION

The use of truck escape ramps has become a standard means of accommodating out-of-control trucks on steep downgrades. Trucks are usually out-of-control in these situations because they have lost part or all of their braking capabilities and an accident is usually inevitable. Truck escape ramps allow a driver to regain control by slowing or stopping at an acceptable level of deceleration.

Escape ramps are generally either gravity types, arrester types, or a combination of the two. Deceleration occurs by the force of gravity and/or by means of frictional forces due to an arrester bed. A gravity ramp typically consists of a paved roadway surface that splits away from the driving lanes and gradually ascends to a point where a very steep upgrade can be provided at the end of the ramp. In some cases, there may be gravel or sand over part of the ramp to provide increased deceleration due to rolling resistance and to hold the vehicle in place after it has stopped on a steep ramp. Escape ramps having an arrester bed are frequently used where topographic constraints preclude a gravity-type ramp. Arrester beds may or may not be built on an ascending grade and in some cases may be slightly downgrade. The lengths of gravity ramps are usually greater than arrester bed ramps since gravity ramps rely solely on the force of gravity while arrester-bed ramps utilize the increased rolling resistance obtained with various materials such as pea gravel.
Out-of-control vehicles on steep grades have the potential for and frequently do result in severe accidents. There are two truck escape ramps in Kentucky and both of these were constructed as a result of severe accidents and the potential for additional accidents. Following is a brief summary of the accident occurrences that precipitated construction of escape ramps near Hyden and Beattyville in Kentucky.

HYDEN

The Hyden Spur (KY 118) is a 3.6-mile section that connects the Daniel Boone Parkway with US 421 and KY 80 at Hyden in Leslie County. The road was opened to traffic in 1974 as a connection between the Parkway and Hyden. The section of KY 118 leading to the intersection with US 421 and KY 80 has a steep downgrade of 8 percent over a distance of 1.6 miles. As a result of several accidents, resulting in one fatality, corrective action was initiated by the Department of Highways in 1975. Warning signs and flashing lights were installed near the top of the hill after local residents complained of danger associated with the road. The intent was to determine if warning devices would suffice before consideration was given to the alternative of an escape ramp. However, after other fatal accidents occurred in August 1978 and January 1979, the decision was made to proceed with construction of a truck escape ramp. Construction of the ramp was begun in the fall of 1979 and was completed in the summer of 1980.
BEATTYVILLE

KY 11 approaching Beattyville in Lee County was a winding, two-lane road having grades of 13 percent. In September 1977, a gasoline tanker went out of control after a brake failure on a steep grade and overturned at the bottom of the hill. Gasoline spilled onto the street, leading to a fire that destroyed a block of the downtown business district and killed six people. Approximately two years after that accident, work was begun on reconstruction of a 2.6-mile section of KY 11 as it approaches Beattyville. Included in this reconstruction project was a truck escape ramp. The overall reconstruction project was completed in the summer of 1980.

TRUCK ESCAPE RAMP DESIGN

HYDEN

The truck escape ramp on the Hyden Spur was constructed on a section of highway having a 8.0 percent downgrade for approximately 1.6 miles. Because of geometric conditions of the highway and topographic constraints, sufficient length was not available to construct a gravity-type ramp. Instead, an arrester-type escape ramp was designed with pea gravel (uncrushed-size 9M) used as the arrester material. Total length of the escape ramp is 906 feet. Length of the gravel portion of the arrester bed is 520 feet with a 386-foot paved section at the beginning of the ramp. The ramp is on a negative grade. The paved section at the beginning of the ramp has an 8-percent downgrade while the arrester bed has a 4-percent downgrade. The design speed for this ramp was 80 mph.
Depth of the gravel arrester bed varies from 0 to 10 feet. The gravel bed was constructed so that the depth of gravel above ground was a maximum of 3.0 feet. A 5.0-foot gravel pile was placed at the end of the bed to act as a final barrier to any out-of-control vehicles traveling at excessive speeds. Perforated pipe placed at the downhill end of the arrester bed provided drainage. Figures 1 and 2 are plan and profile views of the truck escape ramp, respectively. A typical section of the ramp is shown in Figure 3.

To provide nighttime guidance, the edges of the arrester bed were marked with delineator posts and overhead lighting was included as part of the initial contract. In addition, there is a significant number of signs that alert drivers to a potentially dangerous downgrade situation. Some of the signing provided for the Hyden ramp is shown in Figures 4 through 9. A general view showing the approach to the ramp is shown in Figure 10. A side view showing depth of gravel above ground is shown in Figure 11.

BEATTYVILLE

The truck escape ramp on KY 11 was constructed on a section of highway leading into the east end of Beattyville. As KY 11 existed in 1977 at the time of the tanker-truck accident, it was the primary north-south connector between Beattyville and the Mountain Parkway. The road had a relatively heavy volume of truck traffic traveling over a winding section having a 13-percent downgrade into Beattyville. A 2.6-mile section of KY 11 was reconstructed in 1979-1980 and a truck escape ramp was included as part of the project.

Because this ramp was included in a reconstruction project and topographic conditions permitted, a combination gravity and arrester
design was used. To provide a high margin of safety, the ramp was designed to accommodate trucks with an entering velocity of 100 mph. Total length of the ramp is 1,310 feet, of which 910 is an arrester bed. The arrester bed is 24 feet wide with an 18-inch depth of loose pea gravel (uncrushed-size 9M). The width of the ramp was designed to accommodate two vehicles to provide another degree of safety. Use of the loose gravel provides drainage and minimizes the possibility of the bed not performing properly due to the surface freezing during winter months. The arrester bed section of the ramp begins on a 1.5-percent downgrade for the first 700 feet, with a 14-percent upgrade over the last 210 feet. A 400-foot paved approach section at the entrance to the ramp allows the driver of an out-of-control truck to align the wheels so they enter the arrester bed at the same time and produce a uniform deceleration. A 12-foot paved service lane is located along the length of the arrester bed to provide easy access for tow trucks. A plan and profile view of the ramp is shown in Figure 12. Figure 13 is a typical section of the ramp.

Signing is an important operational feature that contributes significantly to the success of the truck escape ramp. Signs indicating an escape ramp ahead are for the purpose of alerting drivers to be more cautious and make additional brake checks before reaching the point where use of the emergency ramp would be necessary. Signing provided for the Beattyville escape ramp is shown in Figures 14 through 16. A general view showing the approach to the ramp is shown in Figure 17.
RAMP USAGE HISTORY

As a means of documenting usage of the escape ramps, Department of Highways’ maintenance personnel were contacted in the respective Districts and requested to report when the ramps had been used. A form was provided for maintenance personnel to document results of emergency usage (Figure 18). Another form was prepared for the purpose of soliciting information from drivers who had used the ramps in emergency situations (Figure 19).

Usage of the truck escape ramps for emergency purposes has not been frequent. The ramp on Ky 118 near Hyden was opened for use in 1980 and it has been used four times in emergency situations. There has been only one reported emergency usage of the ramp on Ky 11 at Beattyville since 1980. A brief discussion of escape ramp usage at each site follows.

HYDEN

1) May 5, 1981

A tractor trailer hauling steel pipe ran into the ramp at a speed of about 30 to 35 mph. It was 4:15 pm, the weather was clear, and the pavement surface was dry. The driver, Lester Tinsley from Centralia, Illinois, indicated his brakes overheated and failed as he was going downhill. This was the driver’s first trip into the area. The driver was interviewed by John Newell with "The Thousandsticks News" in Hyden and he indicated the ramp probably saved the lives of himself and his wife (a passenger in the truck). Neither was injured even though they were not wearing safety belts. The driver told the reporter he felt the gravel may have been too deep and slowed his vehicle too quickly. He indicated the stop was similar to "hitting the water when you’re water-skiing." Minor damage to the truck was reported as a result of the load (40,000 pounds)
shifting forward and crashing into the protective metal shield on the back of the tractor cab. An accident report, maintenance report, and news article were available for this case.

Photographs showing the truck mired in the gravel are shown in Figures 20 through 23. To reach the point shown in the photographs, the truck traveled 386 feet on the paved part of the ramp and 110 feet in gravel.

2) May 12, 1982

A tractor trailer hauling 40,000 pounds of roofing shingles ran into the ramp at an estimated speed of 15 to 20 mph (driver's estimate). The truck ran into the ramp at 1:30 pm; therefore, visibility was not a factor. Terry Hagle, from Crown Point, Indiana, was the driver, making his first trip into the area. He stated his brakes were getting hot and he decided to use the escape ramp even though he was going downhill in low gear. The driver was not injured and there was no damage to the truck. A driver report, maintenance report, and a newspaper article were available for this case.

A photograph showing the truck mired in the gravel is presented in Figure 24. The truck's final position was 85 feet into the gravel section, meaning the truck traveled 471 feet from the ramp's beginning (including the paved section).
3) Winter 1982-83

A tractor trailer loaded with salt traveled to the end of the ramp. Total length traveled in the gravel portion was 520 feet. A photograph showing damage to the ramp is presented as Figure 25. It may be seen that the surrounding hills were snow-covered and weather may have been a factor contributing to the truck's use of the ramp and the unusually long travel distance in the ramp.

4) September 27, 1984

A three-axle truck ran into the ramp and traveled 50 to 75 feet into the gravel portion before stopping. No other information is available on this usage.

BEATTYVILLE
March 6, 1981

A tractor trailer hauling 40,000 pounds of potatoes ran into the ramp at an estimated speed (by the driver) of 75 mph. The driver estimated his truck traveled approximately 300 feet into the gravel portion of the ramp before stopping. He probably traveled about 700 feet from the start of the ramp. The driver was Curt Karpinske from Clark, South Dakota, and he had not traveled the route previously. Brake failure due to a loose hose to the trailer caused the driver to use the ramp. The driver was not injured; however, the truck's frame was twisted and repair costs were $2,500. On the form completed by the driver, it was noted the truck bounced at the start of the ramp and vibrated until it came to a stop. The driver indicated the ramp was effective and more advance signing could improve effectiveness. A maintenance report and a driver report were available for this case.
SUMMARY

Out-of-control vehicles on a steep grade have the potential for and frequently do result in severe accidents. The two truck escape ramps in Kentucky were constructed as a result of severe accidents. The escape ramp on the Hyden Spur (KY 118) was designed as an arrester-type ramp due to geometric and topographic constraints. The Hyden ramp is 906 feet long, with the arrester bed being 520 feet long. The paved section of the beginning of the ramp has an 8-percent downgrade while the arrester bed portion has a 4-percent downgrade. The gravel arrester bed varies from 0 to 10 feet in depth and has a 5-foot pile of gravel at the end. The escape ramp at Beattyville is a combination gravity and arrester-bed design. Total length of that ramp is 1,310 feet, of which 910 is an arrester bed. The arrester bed begins on a 1.5-percent downgrade for 700 feet, with a 14-percent upgrade over the last 210 feet. Loose pea gravel is used at a depth of 18 inches for the arrester bed.

Usage of the truck escape ramps for emergency situations has not been frequent. The Hyden ramp has been used four times and the Beattyville ramp only once. Two of the four cases at Hyden were well documented and indicated successful functioning of the arrester-type ramp. The other two cases were not as well documented, but they appear to represent successful usage of the ramp. The only documented usage of the ramp at Beattyville indicated proper functioning.

Overall, the escape ramps have proven to be operating properly and appear to be performing as they were designed. Of the five cases where the ramps were used by out-of-control vehicles, no one was injured and there was only minor damage to the vehicles involved.
IMPLEMENTATION

As a result of their successful functioning at Hyden and Beattyville, truck escape ramps will be considered at other locations. These locations should be steep grades with heavy truck volumes where the potential for accidents is high. The method of designing for out-of-control trucks at Hyden was an arrester-type ramp with pea gravel as the arrester material. At Beattyville, the ramp was a combination gravity and arrester design.

Benefits from the truck escape ramps at Hyden and Beattyville are apparent in terms of reduced accident severity. Prior to construction of Hyden ramp in 1980, there had been three fatal accidents since 1975. The Beattyville ramp was also constructed in 1980 and there was one accident in 1977 which resulted in six fatalities. Since being opened to traffic, the Hyden ramp has been used four times and the Beattyville ramp only once. None of the accidents resulted in any injuries.
Figure 1. Plan View of Hyden Spur Truck Escape Ramp.
Figure 2. Profile View of Hyden Spur Truck Escape Ramp.
Figure 3. Typical Section for Hyden Spur Truck Escape Ramp.
Figure 4. Signing for Hyden Spur Truck Escape Ramp. (Symbolic Hill Sign)

Figure 5. Signing for Hyden Spur Truck Escape Ramp. (Message Sign, "Warning All Vehicles Must Stop 1.4 Miles Ahead")
Figure 6. Signing for Ryden Spur Truck Escape Ramp. (Symbolic Hill Sign and Message Sign, "Trucks Use Lower Gear, 7% Grade - 1.3 Miles")

Figure 7. Signing for Hyden Spur Truck Escape Ramp. (Message Sign, "Runaway Truck Ramp 1 Mile")
Figure 8. Signing for Hyden Spur Truck Escape Ramp. (Symbolic Hill Sign and Message Sign, "Trucks Use Lower Gear")

Figure 9. Signing for Hyden Spur Truck Escape Ramp. (Message Sign, "Runaway Vehicles Only")
Figure 10. General View Showing Approach to Hyden Ramp.

Figure 11. Side View Showing Depth of Gravel Above Ground at Hyden Ramp.
Figure 12. Plan and Profile View of Beattyville Truck Escape Ramp.
Figure 13. Typical Section of Beattyville Ramp.
Figure 14. Signing for Beattyville Truck Escape Ramp. (Message Sign, "Runaway Truck Ramp 1 Mile")

Figure 15. Signing for Beattyville Truck Escape Ramp. (Message Sign, "Runaway Truck Ramp 1/2 Mile").
Figure 16. Signing for Beattyville Truck Escape Ramp. (Message Sign with Arrow, "Runaway Truck Ramp")

Figure 17. General View Showing Approach to Beattyville Ramp.
TRUCK ESCAPE RAMP ACCIDENT

MAINTENANCE REPORT

Ramp Location ____________________________________________________________

Date of Accident ___________________________ Time of Accident ___________________________

Date Vehicle Removed ___________________________ Time Vehicle Removed ___________________________

Describe Damage to Ramp _______________________________________________________

Estimated Cost to Repair Ramp ________________________________________________

Distance Travelled in Ramp Before Stopping __________ Feet

Describe Any Problems in Removing Vehicle from Ramp ____________________________

Ramp Gravel Condition at Time of Accident Smooth ______ Rutted ______

Ramp Surface Condition at Time of Accident: Dry ______

Wet ______

Icy ______

Snow ______ ___ Inches

General Comments ____________________________________________________________

-----------------------------------------------------------------------------

Figure 18: Ramp Usage Maintenance Report Form
TRUCK ESCAPE RAMP ACCIDENT
DRIVER REPORT

Ramp Location

Date of Accident________________________ Time of Accident________________________

Truck Year-Model________________________ Number of Axles________________________

Gross Weight________________________ lbs.

Cargo Description________________________________ Cargo Weight________________________ lbs.

Type of Trailer________________________ Type of Brakes________________________

Truck Owner________________________________________ Address________________________

Driver's Name________________________ Address________________________ Birth Date________________________

Truck Driving Experience__________ Years Number of Previous Trips Over Route________________________

Estimated Speed Upon Entering Ramp________________________ MPH

Estimated Distance Travelled in Ramp Before Stopping________________________ feet

Were Brakes Applied While Vehicle Was in Ramp?________________________

Summarize Damage to Vehicle________________________

Estimated Cost to Repair Vehicle________________________

Distance from Ramp When Driver Became Aware of Problem________________________ miles

Describe Action of Vehicle After Entering Ramp________________________

Describe Injuries Sustained: Driver________________________ Wearing Seat Belt? Driver________________________

Passenger________________________ Passenger________________________

Describe Any Difficulties in Removing Vehicle from Ramp________________________

Estimated Cost to Remove Vehicle from Ramp________________________

Driver's Comments Concerning:

Adequacy of Advance Signing________________________

Ramp Configuration________________________

Delineation of Ramp (Markings)________________________

General Comments________________________

Figure 19: Ramp Usage Driver Report Form
Figure 20. Path of Tractor-Trailer in Gravel at Hyden Ramp (May 5, 1981).

Figure 21. Tractor-Trailer Mired in Gravel at Hyden Ramp (May 5, 1981).
Figure 22. Depth of Gravel Along Right-Side of Tractor-Trailer at Hyden Ramp (May 5, 1981).

Figure 23. Another View Showing Rear of Tractor-Trailer and Wheelpaths in Gravel at Hyden Ramp (May 5, 1981).
Figure 24. Tractor-Trailer Mired in Gravel at Hyden Ramp (May 12, 1982).

Figure 25. Damage to Hyden Ramp Resulting from Usage by Tractor-Trailer Hauling Salt (Winter 1982-83).