

# **NATIONAL TRANSPORTATION SAFETY BOARD**

WASHINGTON, D.C. 20594

## **HIGHWAY ACCIDENT REPORT**

**GATEWAY TRANSPORTATION CO., INC.,  
TRACTOR-SEMITRAILER PENETRATION OF  
MEDIAN BARRIER AND COLLISION WITH  
AUTOMOBILE, I-70,  
ST. LOUIS, MISSOURI  
SEPTEMBER 25, 1977**

**UNITED STATES GOVERNMENT**

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HIGHWAY ACCIDENT REPORT

Adopted: March 22, 1979

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GATEWAY TRANSPORTATION COMPANY, INC., TRACTOR-  
SEMITRAILER PENETRATION OF MEDIAN BARRIER AND  
COLLISION WITH AUTOMOBILE, I-70,  
ST. LOUIS, MISSOURI  
SEPTEMBER 25, 1977

SYNOPSIS

At 8:07 p.m. on Sunday, September 25, 1977, an empty tractor-semitrailer was traveling eastbound on I-70 in downtown St. Louis, Missouri, when the truckdriver lost control of his vehicle on wet concrete pavement. The tractor struck, broke, and overrode a concrete median barrier, vaulted into the westbound lanes, and collided with a westbound automobile. All three occupants in the automobile died; the truckdriver was injured slightly.

The National Transportation Safety Board determines that the probable cause of this accident was the loss of tractor-semitrailer control during evasive maneuvers made by the truckdriver in response to improper lane changes by an eastbound automobile driver. Contributing to the severity of the accident were the barrier impact speed and attack angle of the tractor-semitrailer which may have only slightly exceeded the design limits of the functional "New Jersey" concrete barrier.

INVESTIGATION

The Accident

About 8:00 p.m. c.d.t. <sup>1/</sup> the truckdriver left the St. Louis Gateway terminal with an empty semitrailer bound for Jonesboro, Arkansas -- a distance of 244 miles. He had delayed his departure since 7:45 p.m. because of heavy rain. The truck entered eastbound Interstate 70 from Adelaide Avenue, which was about three-fourths of a mile from the terminal and 4.0 miles from the accident site.

On I-70, traffic volume was moderate to heavy in both directions and a light rain was falling. Upon passing a point where an express lane became the eastbound median lane, the truck ascended a grade onto a 0.6-mile-long elevated viaduct and continued in the center traffic lane. The truckdriver stated that he was traveling about 50 mph when he noticed

1/ All times herein are central daylight time.

an automobile to his left in the median lane. He stated that the automobile moved forward in the median lane until it was to the left and just ahead of the front of his tractor. The automobile then slowed and fell back to a point where the front of the automobile was beside the tractor's rear axles. The automobile was then accelerated forward and again began pacing the truck while in a position where the right rear corner of the automobile was abreast of the left front corner of the tractor. As he watched the automobile, the truckdriver thought that its driver was "...looking for something."

After crossing the elevated viaduct, the truck began to descend a grade which gradually decreased from level to 6.0 percent as the roadway changed to a below-ground-level section. Near the top of the descending grade, an on-ramp from Delmar Avenue entered I-70 from the right. (See figure 1.) As the truckdriver neared the weave area where vehicles changed lanes to enter from this on-ramp and exit to an exit-ramp to Pine Street and Memorial Drive, he looked to his right for traffic entering from Delmar Avenue. When he redirected his attention to the road ahead, he realized that the automobile had moved into the center lane, that it was an estimated 20 to 25 feet ahead of his truck, and that its brake lights were on. He realized that he couldn't stop, so he steered to the right to move onto the exit ramp. As he did so, he looked into the right side mirror and saw the headlights of a vehicle immediately to the right of the semitrailer. He believed that he was going to "...run over..." that vehicle, so he steered quickly to his left and applied the brakes of the tractor and semitrailer. He did not recall in what order he took these actions. He characterized his left steering maneuver as the type that would turn the steering wheel about 180° to the left, maximum.

Two witnesses were traveling as right front and left rear passengers in an automobile that was about 300 feet behind the truck. They noted that the truck was one of two Gateway Transportation, Inc., trucks that had passed their vehicle at or on the viaduct and that these trucks were traveling above the speed limit. These witnesses stated that the truck was traveling in the center lane and that they did not see a vehicle to the left of the truck just before it lost control. A third witness was standing at a window on the 16th floor of an apartment building adjacent to the eastbound lanes of the highway. His view was limited to about 350 to 400 feet of the highway before impact. He stated that the truck was traveling in the median lane and that he did not see a vehicle traveling to the left of the truck.

The right rear passenger in the automobile and the witness in the apartment building both reported seeing a vehicle to the right of the truck. The witness in the apartment building reported that an automobile was moving up along the right side of the truck and was passing the truck. According to this witness, the automobile was moving from right to left as though it was entering the through traffic lanes from the

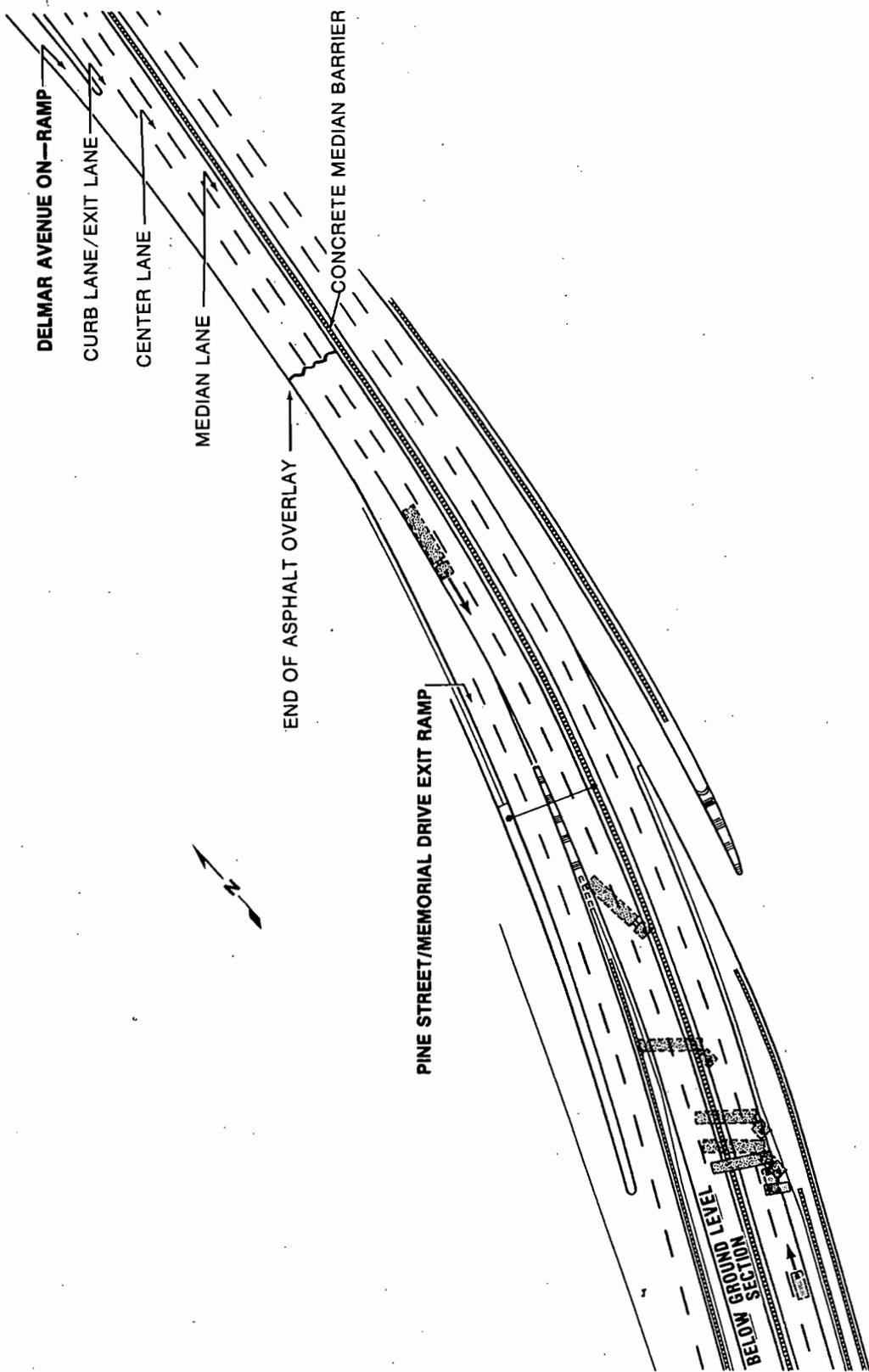


Figure 1. Accident site, on Interstate-70, St. Louis, Missouri.

Delmar on-ramp. The automobile moved into the lane occupied by the truck, so close in front of the truck that the witness thought there had been a collision between the two vehicles. He stated that the automobile had definitely "cut the truckdriver off" and that he saw the tractor veer to the left in an apparent attempt to avoid the automobile. As the tractor veered to the left, the semitrailer began to rotate counterclockwise. The trailing witnesses first noticed the loss of control when they saw the rear of the semitrailer "break to the right."

The truckdriver reported that he attempted to steer to the right upon loss of control and as the vehicle moved toward the median barrier. The tractor first hit the median barrier with the left front wheel and immediately began to climb the barrier wall at a vertical climb angle of  $21^{\circ}$  to  $22^{\circ}$ . Although the climb angle began to level off as the left front wheel climbed to near the top of the barrier, the barrier broke near a joint between two sections of the barrier, permitting the wheel to penetrate beyond the barrier. (See figure 2.) The left rear wheels followed by the right front tire and right rear wheels of the tractor then successively contacted and overrode the barrier without substantial damage to the concrete. The tractor was in continuous contact with the barrier for about 85 feet. After the tractor had overridden the median barrier, the semitrailer contacted the median barrier. The suspension, tires, and wheels of the trailer hit, but did not override, the barrier. The tractor was airborne and was aligned in direct opposition to westbound traffic in the curb lane.

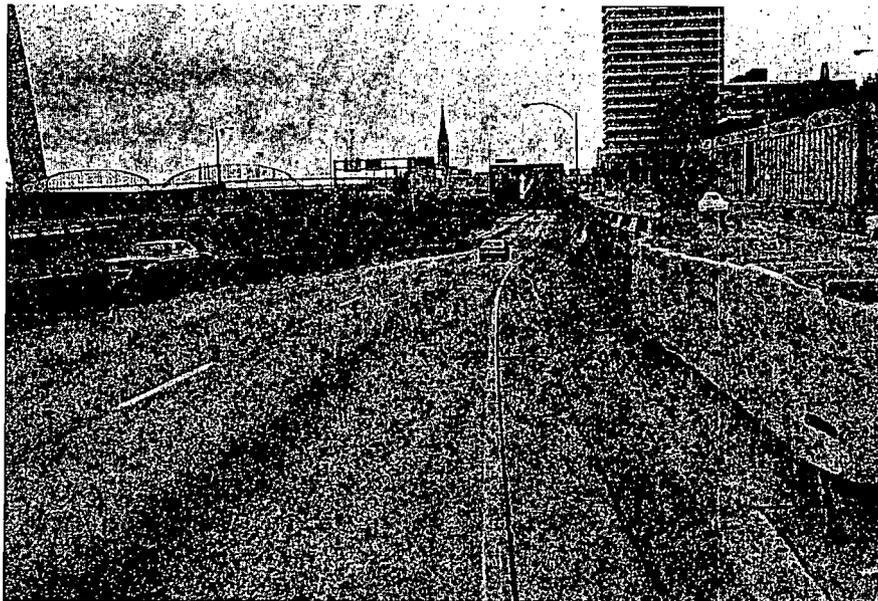


Figure 2. Damage to concrete median barrier; note tire scuffs and breaks in the barrier.

Witnesses stated that an automobile, traveling westbound in the curb lane at 35 to 50 mph, was struck by the truck. There was no evidence of any avoidance action by the automobile driver. The right front wheel of the tractor struck the front of the automobile about 1 foot to the right of center of the automobile. The tractor continued forward for about 15 feet and stopped with its left front tire on the mountable curb. The automobile moved rearward about 14 feet while rotating counterclockwise; it came to rest across the westbound curb lane and shoulder facing nearly perpendicular to the roadway. The three occupants of the automobile were killed.

#### Vehicle Information

The tractor-semitrailer -- The tractor was a 1977 Ford 9000, cab-behind-engine, 3-axle truck, VIN-W91UV087404, manufactured in December 1976. (See figure 3.) The odometer indicated 96,924 miles. The tractor was owned by Gateway Transportation Company, Inc., of La Crosse, Wisconsin. It was equipped with the following: A turbocharged Cummins NTC290 engine, a Spicer 5-speed transmission, rear axles that were both powered, air-mechanical drum brakes on the front and the two rear axles, Eaton antilock brake valves and controllers on the two rear axles, a sliding fifth wheel, and 11R-22.5 steel radial tubeless tires. The front axle brake system was not equipped with an antilock system or a brake limiting valve. These items were then and are currently offered as optional equipment by the manufacturer. The tractor's cab contained only a driver's seat which was equipped with a lapbelt restraint.

The semitrailer was a 1974 Theurer semitrailer chassis with a Tokyu detachable container; it was owned by United States Lines, Inc., of Jefferson, Maine. (See figure 4.) The semitrailer was not equipped with antilock braking systems.

Tire tread depths, tire inflation pressures for undamaged tires, brake slack adjustments, and brake lining thicknesses were all within acceptable levels for both the tractor and the semitrailer.

Two deficiencies were noted in the tractor braking system. The left front brake linings were contaminated with wheel bearing oil over about 10 percent of the surface area and the brake linings at the forward right rear wheel were contaminated with wheel bearing oil over 75 percent of the surface area. No malfunctioning steering, antilock, or air brake system components were detected.

The combined weight of the tractor and empty semitrailer was 31,950 pounds.



Figure 3. View of tractor.

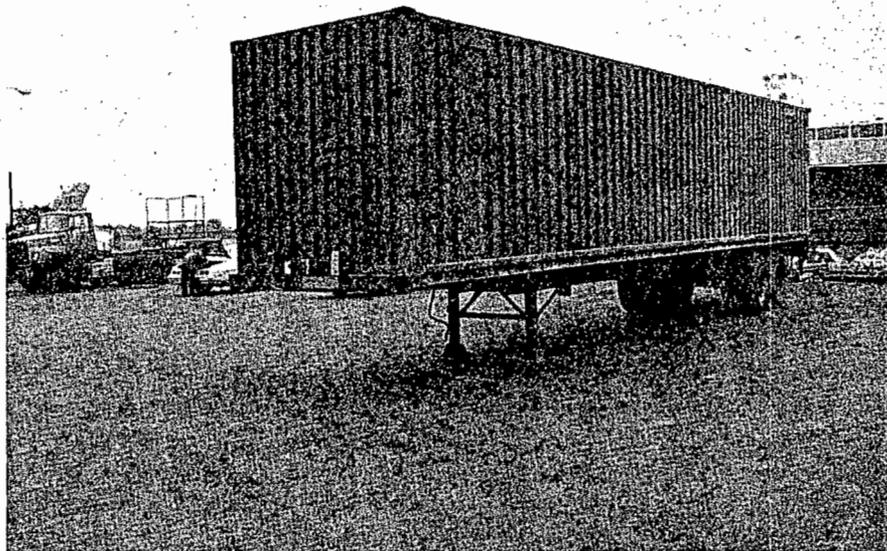


Figure 4. View of trailer.

The automobile -- The automobile was a 1977 Pontiac Grand Prix, 2-door sedan, VIN 2J57Y7A253896. (See figures 5 and 6.) This vehicle was last inspected in the State of Missouri in June 1977 and had 1,800 miles registered on its odometer. Equipment included power brakes, power steering, bench seats with locking and folding seatbacks, integral lapbelt and shoulderbelt restraints that were chassis-sensitive at the outboard front seat positions, lapbelts only at all other seat positions, adjustable head restraints that were adjusted down, padded dash and sunvisors, and an energy-absorbing steering column.

There was extensive damage to the entire front half of the car. Frontal crush was produced by head-on contact (12 o'clock force direction) and was 43.5 inches on the right side and 28.5 inches on the left, with roughly a straight line between the two points. The front bumper was scratched on the top about 19 inches to the right of center, and a small portion of rubber trim was torn from the face of the bumper. The bumper did not engage any substantial parts of the truck tractor in the collision, but was torn loose during disengagement and postcrash movement. This evidence indicated the tractor was airborne at the point of impact with the automobile. The hood was buckled upward and pushed rearward; the trailing edge of the hood did not penetrate the windshield. The roof and both A-pillars were buckled by longitudinal compression of the upper portions of the body. The engine block was fractured in several places and the drive shaft was buckled in compression. The steering column energy-absorbing device inside the car had collapsed to the maximum limit permitted by other crash damage and the steering column energy-absorbing device in the engine compartment was compressed to within 1 1/4 inches of its minimum length. The universal joint of the steering shaft was torn but was not disengaged. The forward frame was buckled at the base of the firewall and the toeboard was almost vertical. Undercarriage, motor, and exhaust system components had contacted the pavement at several points.

No defects were discovered during postcrash inspection of the steering, suspension, and brakes. Damage to the vehicle prevented dynamic testing of the steering and braking systems. The tires were GR78-15 Uniroyal steel radials, and all had acceptable tread depths.

#### Driver Information

The 38-year-old truckdriver held a valid Missouri chauffeur's license <sup>2/</sup> with no restrictions. He was subject to Federal Motor Carrier Safety Regulations (FMCSR) since his employer operated in interstate commerce. He had a current medical certificate as required. There was no evidence of any medical condition which would disqualify him as a driver of heavy trucks.

2/ Permits the driving of vehicles and combination vehicles (including buses and schoolbuses), except motorcycles.



Figure 5. Front view of automobile.



Figure 6. Rear view of automobile.

He had a total of 23 years' driving experience, and he had been a professional truckdriver for about 18 years. He had not taken formal driver education courses, nor had he ever attended a defensive driving course. His driver training was on-the-job as an apprentice driver. In recent years, he averaged between 125,000 to 130,000 miles of driving per year, about 120,000 miles of which was spent driving large trucks.

He had driven trucks equipped with antilock brakes many times and was familiar with the operation of these brakes. He had also driven vehicle combinations with antilock brakes on the tractor and conventional airbrakes on the semitrailer and had no difficulties with this combination. He was not aware that the tractor had brakes on the front steering axle. He had a strong dislike for driving trucks with front axle brakes because he believed they had an adverse effect on controlling the truck during braking. If possible, he would have shut off the air supply to these brakes before operating the vehicle.

He had been off duty for 41 continuous hours before reporting for duty on the evening of the accident. During that time, he had generally remained at home and had not participated in any strenuous or fatiguing activities. He stated that he had not consumed any alcoholic beverages within the 24 hours before reporting for work and had not taken any drugs or medications.

His Missouri driving record revealed no violations. He informed Safety Board investigators that he had received seven violations for speeding over the years, all of which were while driving a truck and none of which were in the State of Missouri. Missouri is not a member of the reciprocity agreement between 30 States which exists for the exchange of traffic citation data. Therefore, citations received in other States would not appear on a Missouri driver's record. He had not been involved in any other previous accidents.

The 31-year-old driver of the Pontiac held a valid Missouri operator's <sup>3/</sup> license with no restrictions. His driving record showed two convictions -- one for following too close on August 11, 1970, and one for a stop sign violation on July 17, 1971. His operator's license was revoked on January 20, 1972, surrendered on September 11, 1972, and reinstated on January 19, 1973. No reason was given for the revocation in his driving record.

Injuries to Persons

<u>Injuries</u>	<u>Drivers</u>	<u>Passengers</u>	<u>Others</u>
Fatal	1	2	0
Nonfatal	1	0	0
None	0	0	0

3/ Permits the operation of all vehicles except vehicles carrying persons or property for hire and motorcycles.

### Medical and Pathological Information

The truckdriver received minor contusions and superficial abrasions. There was no chemical analysis for alcohol or drugs; the investigating police officers reported that there was no reason to suspect involvement of alcohol or drugs.

Toxicological analysis of the automobile driver's blood showed a blood alcohol level of 0.092 gram-percent and a 3.4-percent saturation of carbon monoxide (CO). The National Highway Traffic Safety Administration's Highway Safety Program Standard on alcohol defines a driver as "intoxicated" or "under the influence" of alcohol when he exhibits blood alcohol concentrations at or higher than 0.10 percent by weight. <sup>4/</sup> According to medical experts, a 5-percent carboxyhemoglobin saturation level represents little more than a trace. Any heavy smoker would probably have this amount present in his blood.

### Survival Aspects

The three occupants in the automobile were not wearing the available restraints. The driver died from a crushed chest and internal abdominal injuries induced when he struck the steering wheel and column. Both passengers died of head injuries induced from striking interior vehicle components.

### Roadway Information

Interstate 70 was a multilane, divided highway constructed in the late 1950's. The number of travel lanes varied from two to five lanes for each direction of travel, and lane widths varied from 11.2 to 12.0 feet. In the immediate vicinity of the accident, the highway had from 2.5- to 8.0-foot paved shoulders. The posted speed limit was 55 mph with a posted minimum speed limit of 40 mph. The pavement was marked with solid yellow median edge lines, white lane lines, and solid white edge lines that were clearly visible.

The total maximum length of the weaving section between the on-ramp and exit-ramp where the tractor-semitrailer lost control was about 620 feet. When the roadway was constructed, design policy called for a desirable weaving length of 600 feet. <sup>5/</sup> However, current design policy <sup>6/</sup> states: "Where weaving takes place directly on the freeway lanes, the weaving section should have a length based on the level of service... but desirably not less than 1,000 feet."

<sup>4/</sup> "Highway Safety Program Standard No. 8, Alcohol in Relation to Highway Safety," U.S. Department of Transportation, National Highway Traffic Safety Administration, October 1, 1973.

<sup>5/</sup> "A Policy on Arterial Highways in Urban Areas, 1957," American Association of State Highway Officials, 1957.

<sup>6/</sup> "A Policy on Design of Urban Highways and Arterial Streets, 1973," American Association of State Highway Officials, 1973.

During the on-scene investigation of this accident, Safety Board personnel noted many instances in which weaving maneuvers disrupted through traffic and ramp traffic flow. The Delmar Avenue on-ramp has been scheduled for removal during 1980 or 1981, which should reduce weaving maneuvers and traffic conflicts and improve traffic flow at this location.

The eastbound and westbound lanes along the viaduct had been resurfaced with a 0.75- to 1.0-inch asphalt overlay. In the eastbound lanes, the overlay ended about 530 feet before the point where the truck first hit the median barrier. (See figure 1.) From the overlay to impact, the highway surface was Portland cement concrete, the surface apparently placed when the roadway was first constructed. The surface was smooth and traffic-polished. Ruts in the wheel paths ranged from 1/16- to 3/16-inch deep in all traffic lanes.

The questionable skid resistance properties of the concrete surface prompted the Safety Board to request the Missouri State Highway Commission (MSHC) to conduct skid tests. The MSHC did not conduct any tests after the accident and an FHWA skid trailer was not available. The MSHC reported a coefficient of friction in the range of 0.25 to 0.30 for that section of roadway, based on tests made in August 1975 -- 25 months before the accident. The MSHC had used a locked wheel skid trailer that met the requirements of the American Society of Testing and Materials Standard E 274-70 (as revised July 1974) for measuring the coefficient of friction. In October 1978, 38 months after the skid tests were made, the MSHC reported that no improvement in the pavement surface had been made since the tests or the accident, nor was any improvement scheduled.

Information furnished by the St. Louis Police Department indicated that 84 accidents had occurred on eastbound I-70 in the vicinity of the Delmar Avenue entrance ramp and the Pine Street/Memorial Drive exit ramp, a distance of 0.18 mile (950 ft.), during calendar year 1977. Of the 84 accidents, 50 occurred on wet pavement (60 percent of all accidents) and 3 occurred on a snow-covered pavement.

The opposing traffic lanes were separated by a "New Jersey" concrete median barrier that was 24 inches wide at its base and anchored in the pavement. The barrier was cast in place by the slip form method in 1975. Contraction joints were provided at 15-foot intervals. A horizontal No. 4 steel reinforcing bar was located 6 inches  $\pm$  1 inch from the top of the barrier. No vertical steel was used. Reinforcing ended 1 inch before the contraction joint. The barrier was designed to crack at the contraction joint from thermal expansion and contraction. As a result, there was little or no physical interlocking of the joints other than that produced by anchoring, mechanical cohesion, and aggregate interlock.

No tire marks were found in the travel lanes on either side of the barrier. Damage to the hub and lugbolts on the left front wheel of the tractor and the first tire scuffs on the median barrier indicated that the front wheels were turned right and the left front tire was not rotating.

Three sections of concrete were separated from the median barrier. (See figure 2.) The concrete first broke where the tractor's left front wheel penetrated the barrier at a joint between two sections of the barrier. The second and third breaks occurred as the semitrailer's suspension and wheels hit the barrier. The barrier had not been displaced laterally or tipped, and there were no signs of inherent material weakness or deterioration of the barrier.

#### Meteorological Information

There was 100 percent cloud cover and thunderstorms and rain showers in the area with locally heavy rainfall. The temperature was 71° F at 9 p.m. The wind was from the south-southeast at 8 mph at 6 p.m. and had changed to south-southwest at the same velocity at 9 p.m. A heavy rainfall in the vicinity of the accident had abated about 10 to 15 minutes before the accident. At the time of the accident there was a light rain falling, and the road surface was wet. Water reportedly was running downgrade in the traffic lanes. The rain stopped and the sky cleared shortly after the accident. It had also rained on the day before the accident, reducing the probability that foreign material could have accumulated and made the roadway surface slippery.

#### ANALYSIS

##### The Accident

No witness confirmed the truckdriver's report that an automobile traveling to his left had initiated the accident sequence. Witnesses did report that an automobile had entered the freeway to the truckdriver's right and one witness said that automobile changed lanes and "cut the truckdriver off." Possibly, the witnesses' views of the automobile traveling to the left of the truck were blocked by such factors as the relative positions of the truck and the automobile, water spray, or their seating positions. In addition, the automobile which suddenly appeared in front of the truckdriver may not have cut in from his left as he thought, but may have cut in from his right out of a "blind spot" alongside of the truck as he initially looked to his right for entering traffic. No one described any lack of stability of the tractor or semitrailer before an automobile began to maneuver in front of it. Therefore, the Safety Board concludes that the truckdriver lost control of his vehicle as a result of an evasive maneuver made in response to improper lane changes by an eastbound automobile driver.

While an improper lane change was the single factor that began the loss of control sequence, the short weaving section between the ramps and the operating speed of the truck may have contributed to the loss of control. Many weaving maneuver conflicts have been observed at this location. Two witnesses reported that the truckdriver was traveling above the 55-mph speed limit, a higher speed than other traffic, just before loss of control. This type of aggressive driving and the short

weaving section could have increased the probability for an improper lane change by the automobiles that were reported by the truckdriver and witnesses. The MSHC has planned to close the on-ramp in 1980 or 1981, which should reduce the influence of the short weaving section. However, the high accident rate and the high number of weaving conflicts at this location warrant an acceleration of this planned action.

Excessive operating speed, marginal wet pavement frictional quality, and suspect tire frictional quality were identified as factors that had some potential to limit or reduce vehicle performance during any evasive maneuvers made by the truckdriver. First, as operating speed increases, tire-to-pavement frictional quality decreases for steering and stopping. The frictional quality is further reduced on wet pavement. Second, the pavement frictional quality at the accident site was already low 2 years before the accident. Since the MSHC did not test the site and an FHWA skid trailer was not available, the exact surface quality at the time of the accident could not be determined. However, the frictional quality was low enough -- from 0.25 to 0.30 -- for it to be a recognized potential hazard by the FHWA and other States even when the pavement tests were made. For example, according to Utah Department of Transportation criteria, the pavement surface would be classified "critical" with "slipperiness failure indicated." <sup>7/</sup>

Third, tire frictional quality could not be established because of the limited availability of test equipment and research data. However, current unpublished National Highway Traffic Safety Administration (NHTSA) studies indicate that some truck tires have less wet traction capability than the test tire used on ASTM locked-wheel skid trailers. It is also suspected, but not yet verified, that on wet pavement surfaces, the tires on an empty vehicle may have less traction capability than tires on a fully loaded vehicle. Such reduced tire frictional quality would further reduce overall tire-to-pavement frictional quality.

A lack of sufficient research and test data, combined with a lack of precise information on the truckdriver's evasive maneuvers and vehicle trajectory, prevented the Safety Board from evaluating the influence of these three factors on the tractor-semitrailer's loss of control. This lack of data also prevented the Safety Board from determining improvements to prevent or reduce the severity of this type of accident.

Although a similar lack of data prevented a full evaluation of the influence of the contaminated brake linings and the tractor front axle brake system, a partial evaluation was possible. The witnesses described the first unusual vehicle movement as a rapid, simultaneous movement of the front of the tractor to the left and the rear of the semitrailer to the right. Overall vehicle rotation can result when all brakes are

<sup>7/</sup> "Highway Accident Report -- Osterkamp Trucking, Inc., Truck/Full Trailer and Dodge Van Collision, U.S. 91 near Scipio, Utah, August 26, 1977," (NTSB-HAR-79-1).

first applied on a combination vehicle. The truckdriver reported that he applied the brakes early in his evasive maneuver. At worst, the contaminated brake linings would have had some tendency to magnify tractor rotation or pull the front of the tractor to the left during hard continuous braking. However, calculations based on the worst conditions of imbalance indicate that the degree of such pull, alone, would not have been significant toward producing loss of control. <sup>8/</sup> The tractor was equipped with front axle brakes but had no front brake limiting valve. Although the truckdriver could not recall the amount of brake application he made, imminent contact with the vehicle ahead probably dictated a hard emergency brake application. Such an application would have overridden a brake limiting valve. Even a light brake application could have locked the wheels because of the relative aggressiveness of an airbrake system on the unloaded vehicle and the low tire-to-pavement frictional quality. Therefore, a front brake-limiting valve probably would not have been useful.

Insufficient data prevented further analysis to determine whether front axle antilock brakes or the absence of front axle brakes would have been of some benefit.

#### Improvement of Wet Pavement Frictional Quality

Although the Safety Board could not determine if the pavement surface directly contributed to this accident or whether improvements in wet pavement frictional quality would have prevented or reduced the severity of this accident, improved wet pavement frictional quality is known to prevent, or reduce the severity of, accidents on wet pavement. Improvements are normally made either when the measured wet coefficient of friction falls below a predetermined value or when wet weather accidents are a relatively high percentage of all accidents at a given location, or both.

MSHC policy for correcting pavement surfaces is: "Major emphasis should be developed on wet weather high accident areas occurring on curves, intersections, etc. Any program to resurface existing pavements due to some 'magic' coefficient of friction value without high accidents would be seriously objectionable because of cost." <sup>9/</sup> The Pennsylvania Department of Transportation has had a firm policy since 1975 for correcting pavement surfaces having a coefficient of friction of 0.30 or less, which was the condition of the pavement at this accident scene. For those locations with at least 35 percent of all accidents related to wet pavement, <sup>10/</sup> the Penn DOT policy states: "Immediate Corrective Action (must be placed on

<sup>8/</sup> See NTSB Public Docket HY-66-77 for these calculations.

<sup>9/</sup> Missouri State Highway Commission Letter of January 27, 1978, to FHWA Docket No. 77-16 -- Skid Accident Reduction Program, Advance Notice of Proposed Rulemaking.

<sup>10/</sup> State of Pennsylvania Department of Transportation Letter of February 15, 1978, to FHWA Docket No. 77-16 -- Skid Accident Reduction Program, Advance Notice of Proposed Rulemaking.

an approved program within one year of date of notification of test results). Corrective action must be completed within the next year following programming, but in no case shall be greater than two years after the date of notification of test results." For those locations with less than 35 percent of all accidents related to wet pavement, this policy states: "Corrective work should be completed as soon as fiscally possible."

According to MSHC policy, there is no coefficient of friction value that would signal the need for corrective action, leaving the driving public unknowingly exposed to a potentially dangerous wet roadway when low values are detected. Accidents must occur in sufficient numbers before corrective measures are taken. This type of policy is contrary to the goals of accident prevention and severity reduction and should be replaced with a more progressive philosophy similar to that of Penn DOT.

There is also some evidence that either the MSHC is not consistently following its own pavement surface improvement policy or its resources for pavement improvement are extremely scarce. Even with a low wet coefficient of friction, a high general accident rate of 84 accidents in a year and a high wet pavement accident rate of 60 percent of all accidents, the MSHC has not improved or scheduled improvement of the pavement surface at this location. Therefore, the FHWA and MSHC should direct efforts toward establishing whether: (1) The MSHC is consistently following its own policy, (2) a more progressive policy level is attainable within existing resources, and (3) additional resources are necessary to achieve a progressive policy at a level similar to that of other States. This accident site and other similar sites should be re-analyzed for possible corrective action upon, or in conjunction with, establishing a new pavement improvement policy.

#### Median Barrier Failure

Calculations and physical evidence indicated that the tractor-semitrailer was traveling no faster than 55 mph when it first contacted the "New Jersey" concrete median barrier and that the attack angle between the tractor and the barrier was between 16° to 23°. <sup>11/</sup> The FHWA has crash tested the "New Jersey" barrier with tractor-semitrailers traveling at lower impact speeds and attack angles, and the barrier did contain and redirect these vehicles. However, the FHWA has not yet established the limits of speed or attack angles beyond which the barrier can no longer contain and redirect these vehicles. The impact speed and attack angle in this accident probably did exceed the design limits of the "New Jersey" barrier and, therefore, contributed to the severity of the accident. At the same time, there was some evidence that the design limits were not significantly exceeded and that minimal limitations in the "New Jersey" barrier design may have permitted the tractor-semitrailer to penetrate and vault the barrier.

<sup>11/</sup> See NTSB Public Docket HY-66-77.

The tractor's left front tire scuff along the face of the barrier indicated that the climb angle of the tire began to level off and that the vehicle was beginning to be contained and redirected when the top of the barrier broke away at a contraction joint. In tests of a more massive "Texas" barrier that: (1) had no contraction joints over a 150-foot length, (2) was continuously reinforced, and (3) was 3 inches wider at the base and 2 inches wider at the top, a 48,800-pound tractor-semitrailer was contained and redirected by the barrier at an attack angle of 15° and an impact speed of about 45 mph. <sup>12/</sup> The 30,850-pound vehicle involved in this accident had nearly the same momentum at 55 mph as the test vehicle in the "Texas" barrier tests. Therefore, a barrier only slightly stronger, particularly at the joints, and/or larger than the one in place may have prevented the truck from entering the opposing traffic lanes.

Limited data collected by the Southwest Research Institute for the FHWA <sup>13/</sup> indicated that concrete barrier failures are caused primarily by trucks. Several barriers failed at joints in a pattern similar to that observed at St. Louis. The Institute recommended that "open joints in CMB (Concrete Median Barrier) construction should be spaced at maximum intervals to take advantage of barrier mass and to minimize reinforcement required at joints to effect consistent strength. The option of using contraction joints in the barrier should take advantage of aggregate interlock and reinforcement should be continuous across these joints." <sup>14/</sup>

While the research may indicate that containment of large trucks can be improved through slight design changes, additional necessary research is being conducted by the FHWA to insure that safety will be enhanced by increasing the strength or size of these barriers. For example, these changes might increase the risk of rollover during impacts by small automobiles. Also, this research will determine what other design limits may exist and should be corrected in an overall design update.

Currently, there is no known program to develop design alternatives to improve the performance of concrete barrier systems already in place. Such a program seems appropriate to insure that locations with high accident rates or hazardous materials routes can be updated.

<sup>12/</sup> "Truck Tests on Texas Concrete Median Barrier," Edward R. Post and Teddy J. Hirsch, Texas Transportation Institute, Texas A&M University; and John F. Nixon, Texas Highway Department, Highway Research Board, 1973.

<sup>13/</sup> "Concrete Median Barrier Research," Report No. FHWA RD-77-4, Volume 2, Research Report, March 1976.

<sup>14/</sup> "Concrete Median Barrier Research," Report No. FHWA RD-77-3, Volume 1, Executive Summary, June 1976.

### Influence of Alcohol on Automobile Driver Evasive Actions

Although sufficient alcohol was present in the automobile driver's blood to have potentially impaired his driving ability, an analysis of the crash did not indicate that alcohol played a significant role in inhibiting evasive action by the automobile driver. The tractor apparently vaulted from on top of the barrier to hit the automobile in a time span of about 1 1/2 to 2 seconds. Normal perception-reaction time is about 1 1/2 seconds and can be longer for unexpected events. Therefore, it was not likely that even an unimpaired driver could have been expected to take any significant evasive action.

### Crash Survivability

Empirical full crash tests using anthropometric dummies have demonstrated that adequately restrained front seat occupants had some chance of surviving a barrier collision with a 40-mph change in velocity. The change in velocity of the automobile was calculated to be between 35 and 45 mph. While it could not be accurately determined whether the collision would have been survivable if the automobile occupants had been wearing the available restraints, failure to use restraints left them with little chance of surviving the collision.

## CONCLUSIONS

### Findings

1. The truckdriver lost control of his vehicle as a result of an evasive maneuver made in response to improper lane changes by an eastbound automobile driver.
2. Although excessive speed, marginal pavement frictional quality, and suspect tire frictional quality could have reduced vehicle performance during any evasive maneuvers made by the truckdriver, a lack of data prevented determining their influence in this accident.
3. Although contaminated brake linings on the left front wheel and forward right rear wheel of the tractor could have magnified tractor rotation or pull to the left, they alone would not have been significant toward producing loss of control.
4. A front brake limiting valve probably would not have been useful.
5. Although the impact speed and attack angle of the tractor-semitrailer probably exceeded the design limits of the functional "New Jersey" barrier, there was evidence that the design limits of the barrier were only slightly exceeded.

6. Design alternatives should be developed to improve the performance of concrete barrier systems already in place.
7. The Missouri State Highway Commission should determine whether it is consistently following its current wet pavement surface improvement policy, develop a more progressive policy, and determine whether additional resources are necessary to attain a policy consistent with other States.
8. Alcohol probably did not play a significant role in preventing evasive action by the automobile driver.
9. Failure to wear available restraints left the automobile occupants little chance of surviving the collision.

#### Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the loss of tractor-semitrailer control during evasive maneuvers made by the truckdriver in response to improper lane changes by an eastbound automobile driver. Contributing to the severity of the accident were the barrier impact speed and attack angle of the tractor-semitrailer which may have only slightly exceeded the design limits of the functional "New Jersey" concrete barrier.

#### RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended:

-- to the Federal Highway Administration:

"Determine what improvements should and can be made to insure a more progressive pavement surface improvement program by the Missouri State Highway Commission.  
(Class II, Priority Action) (H-79-18)

"Establish a program to examine the feasibility of developing design alternatives to improve the performance of concrete barrier systems already in place. (Class II, Priority Action) (H-79-19)"

-- to the Missouri State Highway Commission:

"Accelerate the planned closure of the Delmar Avenue on-ramp on I-70. (Class II, Priority Action) (H-79-20)

"Upon or in conjunction with establishing a new pavement surface improvement policy, re-analyze eastbound I-70 at the Delmar on-ramp and other similar sites for possible corrective action. (Class II, Priority Action) (H-79-21)

"Insure that the current MSHC wet pavement surface improvement policy is being consistently followed. (Class II, Priority Action) (H-79-22)

"Develop a more progressive wet pavement surface improvement policy that will insure that the driving public is not unknowingly exposed to a potentially dangerous wet roadway when low wet pavement frictional qualities have been detected. (Class II, Priority Action) (H-79-23)

"Determine whether additional resources are necessary to attain a wet pavement surface improvement policy level that is consistent with other States. (Class II, Priority Action) (H-79-24)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING  
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/s/ ELWOOD T. DRIVER  
Vice Chairman

/s/ FRANCIS H. McADAMS  
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/s/ PHILIP A. HOGUE  
Member

March 22, 1979